L-LINE AND A-LINE WORKSHOP MANUAL

Models: A9500
A9522
L7500
L7501
L8500
L8511
L8513
L9500
L9501
L9511
L9513
L9522

STI-384, S26 (11/10P)

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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 Sterling Trucks or the component manufacturer.

Maintenance schedules and additional service information are included in the *L-Line and A-Line Maintenance Manual*.

IMPORTANT: Descriptions and specifications in this manual were in effect at the time of printing. Sterling Trucks reserves the right to discontinue models, and to change specifications or design at any time 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** 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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Service Systems and Documentation (CVI-SSD)
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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, specifications, and troubleshooting.

Maintenance Manual

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

Driver's/Operator's Manual

Driver's/operator's manuals contain information needed to enhance the driver's understanding of how to operate and care for the vehicle and its components. Each manual contains a chapter that covers pretrip 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.

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

Parts Technical Bulletins

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

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

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. 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 Sterling, Freightliner, 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.

Descriptions of Service Publications

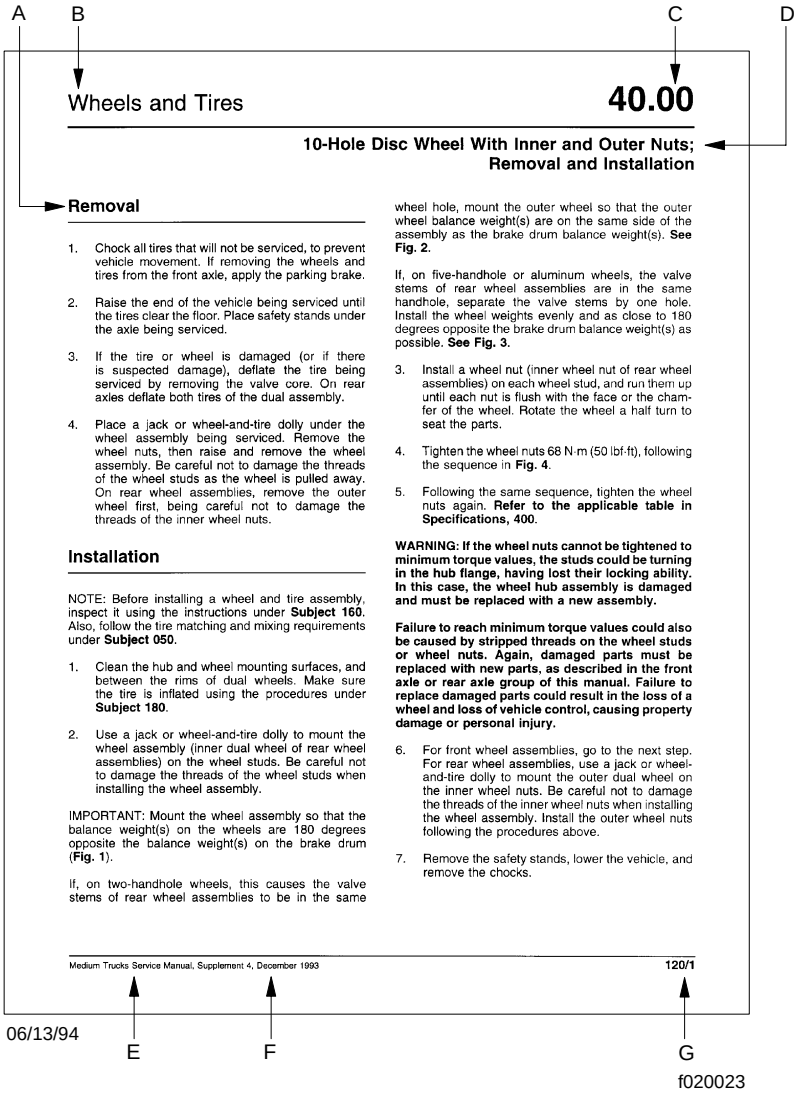
Warranty-related service information available on the AccessSterling.com website includes the following documentation.

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.

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

Page Description

For an example of an *L-Line and A-Line Workshop Manual* page, see **Fig. 1**.



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

Fig. 1, Example of an L-Line and A-Line 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
88	Hood, Grille, and Cab Fenders
91	Seats and Restraint Systems
98	Paint

Jacking

WARNING

Do not run the engine when jacking the vehicle. Contact of the wheels with the ground can cause the vehicle to move, which could result in personal injury.

Support the vehicle prior to performing any procedure requiring the vehicle to be jacked above the ground. Failure to properly support the vehicle could result in personal injury or damage to the vehicle.

Make sure the jacks and jack stands are properly located to prevent the vehicle from falling. Failure to properly locate the jacks and jack stands could result in personal injury or damage to the vehicle.

Wheel chocks must be used to prevent the vehicle from rolling and falling off the jack. Failure to properly chock the vehicle wheels could result in personal injury or damage to the vehicle.

CAUTION

If the vehicle is equipped with traction control, disable the traction system before performing any dynamic driveline maintenance, or damage to the traction control system could result.

NOTE: To raise vehicles with floor jacks, follow the jack manufacturer's recommendations for placement of the jack. Do not exceed the rated lift capacity of any jack.

1. See **Fig. 1** for the front jacking points.

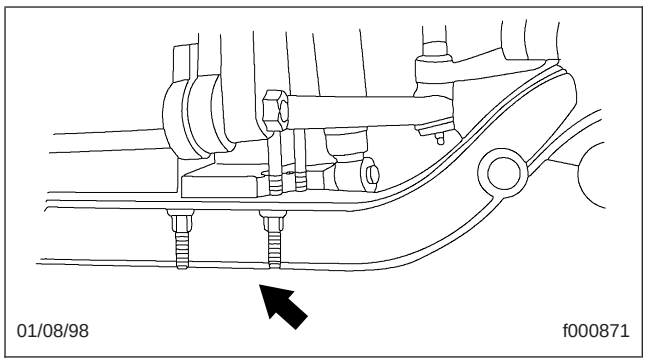


Fig. 1, Front Jacking Points

2. See **Fig. 2** for the rear jacking points.

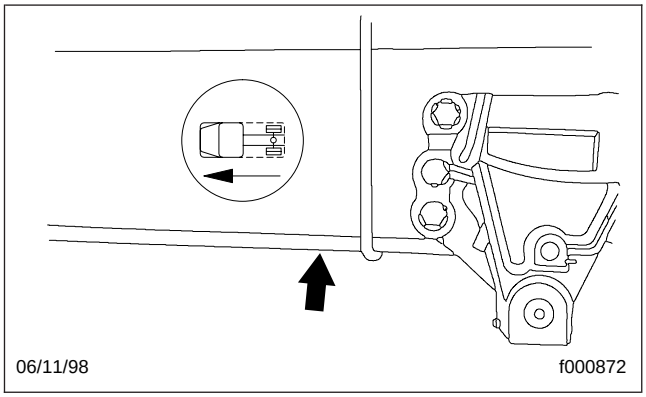


Fig. 2, Rear Jacking Points

Lifting

CAUTION

If the vehicle is equipped with traction control, disable the traction system before performing any dynamic driveline maintenance, or damage to the traction control system could result.

Damage to the vehicle can occur if care is not used when positioning the hoist adaptors prior to lifting the vehicle.

NOTE: Position the hoist adaptors for heavy-duty hoists according to the hoist manufacturer's recommendations. Be sure the hoist has an adequate lifting capacity for the vehicle being lifted.

1. See **Fig. 3** for the front lifting points.

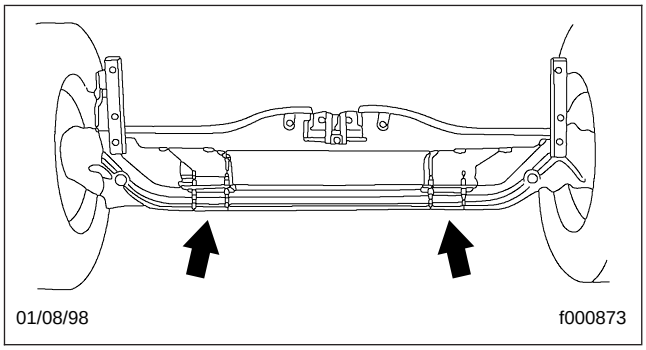


Fig. 3, Front Lifting Points

2. See **Fig. 4** for the rear lifting points.

Jacking and Lifting

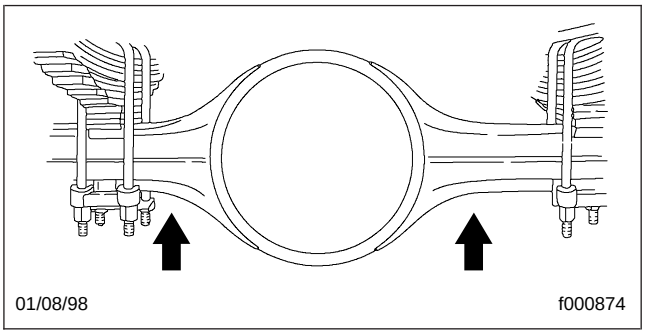


Fig. 4, Rear Lifting Points

NOTE: On vehicles equipped with tandem axles, position the hoist on the rearmost axle.

VIN for Vehicles Built through April 30, 2000

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

Federal Motor Vehicle Safety Standard 115 specifies that all vehicles sold in the U.S. be assigned a 17-character Vehicle Identification Number (VIN). Using a combination of letters and numerals, the VIN defines the manufacturer, model, and major characteristics of the vehicle. See **Table 1** for the character positions of a typical Sterling VIN, 480ALEBDXWA345678.

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.

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**	**—**
Code Description									
Manufacturer, Make, Vehicle Type									
Chassis, Front Axle Position, Brakes									
Vehicle Model Series, Cab									
Engine Model, Horsepower Range									
Gross Vehicle Weight Rating (GVWR)									
Check Digit									
Vehicle Model Year									
Plant of Manufacture									
Production Number									

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

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

VIN Positions 1, 2, and 3 (Manufacturer, Make, Vehicle Type)			
Code	**Vehicle Manufacturer**	**Vehicle Make**	**Vehicle Type**
2FW	Sterling, Canada-built	Sterling	Truck-Tractor
2FZ	Sterling, Canada-built	Sterling	Incomplete Vehicle
480	Sterling, U.S.-built	Sterling	Truck-Tractor

VIN for Vehicles Built through April 30, 2000

VIN Positions 1, 2, and 3 (Manufacturer, Make, Vehicle Type)			
Code	**Vehicle Manufacturer**	**Vehicle Make**	**Vehicle Type**
49H	Sterling, U.S.-built	Sterling	Incomplete Vehicle

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

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

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

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

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
L	L8501
M	L8513
N	L9511
R	L7501
S	ST9500
W	SC8000
2	SC6000
7	SC7000

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

VIN for Vehicles Built through April 30, 2000

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

VIN for Vehicles Built through April 30, 2000

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

VIN for Vehicles Built through April 30, 2000

VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)			
Code	**Engine Manufacturer**	**Engine Model**	**HP Range**
7D	Cummins	ISX Signature	336–407
7E	Cummins	ISX Signature	408–495
7W	Cummins	ISX Signature	496–605
8Y	Detroit Diesel	8V–92	302–364
9Y	Detroit Diesel	8V–92	447–522
0Y	No Engine	—	—

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

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

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

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

Table 7, 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 8, VIN Position 11 (Plant of Manufacture)

VIN for Vehicles Built from May 1, 2000

IMPORTANT: A revised VIN-code structure is 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. 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.

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	**Configuration**	**Chassis**
A	4x2	Truck
B	4x2	Truck/Tractor
D	4x4	Truck
E	4x4	Truck/Tractor
F	6x2	Truck
G	6x2	Truck/Tractor

VIN Position 4 (Chassis Configuration)		
Code	**Configuration**	**Chassis**
H	6x4	Truck
J	6x4	Truck/Tractor
K	6x6	Truck
L	6x6	Truck/Tractor
M	8x4	Truck
N	8x4	Truck/Tractor

VIN for Vehicles Built from May 1, 2000

VIN Position 4 (Chassis Configuration)		
Code	**Configuration**	**Chassis**
P	8x6	Truck
R	8x6	Truck/Tractor
S	10x4	Truck
T	10x4	Truck/Tractor
U	10x6	Truck
V	10x6	Truck/Tractor
W	12x4	Truck
X	Glider	Glider
Y	8x2	Truck

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	SC 8000 Cargo	COE	Class 7
AE	SC 8000 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
AP	L 7500 Series	Conventional	Class 5
AR	L 7500 Series	Conventional	Class 6
AS	L 7500 Series	Conventional	Class 7
AT	L 7500 Series	Conventional	Class 8
AU	L 7500 Series Glider	Conventional	Glider
AV	L 8500 Series	Conventional	Class 7
AW	L 8500 Series	Conventional	Class 8
AX	L 8500 Series Glider	Conventional	Glider
AY	L 9500 Series	Conventional	Class 7

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
AZ	L 9500 Series	Conventional	Class 8
A1	L 9500 Series Glider	Conventional	Glider
A2	A 9500 Series	Conventional	Class 7
A3	A 9500 Series	Conventional	Class 8
A4	A 9500 Series Glider	Conventional	Glider
A5	ST 9500 Series	Conventional	Class 7
A6	ST 9500 Series	Conventional	Class 8
A7	ST 9500 Series Glider	Conventional	Glider
A8	L 7501	Conventional	Class 6
A9	L 7501	Conventional	Class 7
A0	L 7501	Conventional	Class 8
BA	L 8501	Conventional	Class 6
BB	L 8501	Conventional	Class 7
BC	L 8501	Conventional	Class 8
BD	L 8511	Conventional	Class 7
BE	L 8511	Conventional	Class 8
BF	L 8513	Conventional	Class 7
BG	L 8513	Conventional	Class 8
BH	L 9501	Conventional	Class 7
BJ	L 9501	Conventional	Class 8
BK	L 9511	Conventional	Class 7
BL	L 9511	Conventional	Class 8
BM	A 9513	Conventional	Class 7
BN	A 9513	Conventional	Class 8
BP	A 9522	Conventional	Class 7
BR	A 9522	Conventional	Class 8
BS	L 9522	Conventional	Class 7
BT	L 9522	Conventional	Class 8
BU	Condor	Coe	Class 7
BV	Condor	Coe	Class 8
BW	L 9513	Conventional	Class 7
BY	M7500 Acterra	Conventional	Class 8
BZ	M6500 Acterra	Conventional	Class 7
B1	6500 Sportchassis	Conventional	Class 5
B2	6500 Sportchassis	Conventional	Class 6

VIN for Vehicles Built from May 1, 2000

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
B3	M5500 Acterra	Conventional	Class 6
B4	M6500 Acterra Glider	Conventional	Glider
B5	M7500 Acterra Glider	Conventional	Glider
B6	M8500 Acterra Glider	Conventional	Glider
B7	Atego 6500	COE	Class 6
B8	Atego 6500 Glider	COE	Glider
B9	Atego 7500	COE	Class 7
CA	Atego 7500 Glider	COE	Glider
CB	Atego 8500	COE	Class 8
CD	Atego 8500 Glider	COE	Glider
CE	Acterra	Conventional	Class 5
CF	Acterra	Conventional	Class 6
CG	Acterra	Conventional	Class 7
CH	Acterra	Conventional	Class 8

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
CJ	Condor Glider	COE	Glider
CK	SC 8000 Cargo	COE	Class 6
CL	Acterra Glider	Conventional	Glider
CM	LC Series Car Hauler	Conventional	Class 8
CN	LC Series Car Hauler Glider	Conventional	Glider
CP	SC 8000 Cargo Glider	COE	Glider
CR	LC Series Car Hauler	Conventional	Class 7

* 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**	**Displacement (L)**	**Configuration**	**Brakes**
AA	Caterpillar 3176	Diesel	10.3	I–6	Air
AB	Caterpillar 3176	Diesel	10.3	I-6	Hydraulic
AC	Caterpillar 3176	Diesel	10.3	I-6	Air/Hydraulic
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 3406 E	Diesel	15.8	I-6	Air
AH	Caterpillar 3406 E	Diesel	15.8	I-6	Hydraulic
AJ	Caterpillar 3406 E	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

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement (L)**	**Configuration**	**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	I-6	Air
BB	Cummins NTC	Diesel	14	I-6	Hydraulic
BC	Cummins NTC	Diesel	14	I-6	Air/Hydraulic
BD	Cummins N14	Diesel	14	I-6	Air
BE	Cummins N14	Diesel	14	I-6	Hydraulic
BF	Cummins N14	Diesel	14	I-6	Air/Hydraulic
BG	Cummins ISX/Signature	Diesel	14.9	I-6	Air
BH	Cummins ISX/Signature	Diesel	14.9	I-6	Hydraulic
BJ	Cummins ISX/Signature	Diesel	14.9	I-6	Air/Hydraulic
BK	Cummins C8.3	Diesel	8.3	I-6	Air
BL	Cummins C8.3	Diesel	8.3	I-6	Hydraulic
BM	Cummins C8.3	Diesel	8.3	I-6	Air/Hydraulic
BN	Cummins B5.9	Diesel	5.9	I-6	Air
BP	Cummins B5.9	Diesel	5.9	I-6	Hydraulic
BR	Cummins B5.9	Diesel	5.9	I-6	Air/Hydraulic
BS	Cummins ISC	Diesel	8.3	I-6	Air
BT	Cummins ISC	Diesel	8.3	I-6	Hydraulic
BU	Cummins ISC	Diesel	8.3	I-6	Air/Hydraulic
BV	Cummins ISB	Diesel	5.9	I-6	Air
BW	Cummins ISB	Diesel	5.9	I-6	Hydraulic
BX	Cummins ISB	Diesel	5.9	I-6	Air/Hydraulic

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement (L)**	**Configuration**	**Brakes**
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 Diesel Series 50	Diesel	8.5	I-4	Air
B9	Detroit Diesel Series 50	Diesel	8.5	I-4	Hydraulic
B0	Detroit Diesel Series 50	Diesel	8.5	I-4	Air/Hydraulic
CA	Detroit Diesel Series 55	Diesel	12	I-6	Air
CB	Detroit Diesel Series 55	Diesel	12	I-6	Hydraulic
CC	Detroit Diesel Series 55	Diesel	12	I-6	Air/Hydraulic
CD	Detroit Diesel Series 60	Diesel	11.1	I-6	Air
CE	Detroit Diesel Series 60	Diesel	11.1	I-6	Hydraulic
CF	Detroit Diesel Series 60	Diesel	11.1	I-6	Air/Hydraulic
CG	Detroit Diesel Series 60	Diesel	12.7	I-6	Air
CH	Detroit Diesel Series 60	Diesel	12.7	I-6	Hydraulic
CJ	Detroit Diesel Series 60	Diesel	12.7	I-6	Air/Hydraulic
CK	Detroit Diesel Series 60	Diesel	14.0	I-6	Air
CL	Detroit Diesel Series 60	Diesel	14.0	I-6	Hydraulic
CM	Detroit Diesel 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	12.8	I-6	Air
CW	Mercedes-Benz MBE4000	Diesel	12.8	I-6	Hydraulic
CX	Mercedes-Benz MBE4000	Diesel	12.8	I-6	Air/Hydraulic
CY	Cummins ISL	Diesel	8.9	I-6	Air
CZ	Cummins ISL	Diesel	8.9	I-6	Hydraulic
C1	Cummins ISL	Diesel	8.9	I-6	Air/Hydraulic

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement (L)**	**Configuration**	**Brakes**
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 ISB3.9	Diesel	3.9	I-4	Air
C6	Cummins ISB3.9	Diesel	3.9	I-4	Hydraulic
C7	Cummins ISB3.9	Diesel	3.9	I-4	Air/Hydraulic
DA	Caterpillar C9	Diesel	8.8	I-6	Air
DB	Caterpillar C9	Diesel	8.8	I-6	Hydraulic
DC	Caterpillar C7	Diesel	7.2	I-6	Air
DD	Caterpillar C7	Diesel	7.2	I-6	Hydraulic
DE	Caterpillar C13	Diesel	12.5	I-6	Air
DF	Caterpillar C13	Diesel	12.5	I-6	Hydraulic
DG	Mercedes-Benz MBE900	Diesel	4.8	I-4	Air
DH	Mercedes-Benz MBE900	Diesel	4.8	I-4	Hydraulic
DJ	Mercedes-Benz MBE900	Diesel	7.2	I-6	Air
DK	Mercedes-Benz MBE900	Diesel	7.2	I-6	Hydraulic
DL	Caterpillar C11	Diesel	11.1	I-6	Air
DM	Caterpillar C11	Diesel	11.1	I-6	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
8	2008
9	2009
A	2010

Table 6, VIN Position 10 (Vehicle Model Year)

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

Table 7, VIN Position 11 (Build Location)

VIN for Vehicles Built through April 30, 2000

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

Federal Motor Vehicle Safety Standard 115 specifies that all vehicles sold in the U.S. be assigned a 17-character Vehicle Identification Number (VIN). Using a combination of letters and numerals, the VIN defines the manufacturer, model, and major characteristics of the vehicle. See **Table 1** for the character positions of a typical Sterling VIN, 480ALEBDXWA345678.

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.

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**	**—**
Code Description									
Manufacturer, Make, Vehicle Type									
Chassis, Front Axle Position, Brakes									
Vehicle Model Series, Cab									
Engine Model, Horsepower Range									
Gross Vehicle Weight Rating (GVWR)									
Check Digit									
Vehicle Model Year									
Plant of Manufacture									
Production Number									

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

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

VIN Positions 1, 2, and 3 (Manufacturer, Make, Vehicle Type)			
Code	**Vehicle Manufacturer**	**Vehicle Make**	**Vehicle Type**
2FW	Sterling, Canada-built	Sterling	Truck-Tractor
2FZ	Sterling, Canada-built	Sterling	Incomplete Vehicle
480	Sterling, U.S.-built	Sterling	Truck-Tractor

VIN for Vehicles Built through April 30, 2000

VIN Positions 1, 2, and 3 (Manufacturer, Make, Vehicle Type)			
Code	**Vehicle Manufacturer**	**Vehicle Make**	**Vehicle Type**
49H	Sterling, U.S.-built	Sterling	Incomplete Vehicle

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

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

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

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

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
L	L8501
M	L8513
N	L9511
R	L7501
S	ST9500
W	SC8000
2	SC6000
7	SC7000

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

VIN for Vehicles Built through April 30, 2000

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

VIN for Vehicles Built through April 30, 2000

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

VIN for Vehicles Built through April 30, 2000

VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)			
Code	**Engine Manufacturer**	**Engine Model**	**HP Range**
7D	Cummins	ISX Signature	336–407
7E	Cummins	ISX Signature	408–495
7W	Cummins	ISX Signature	496–605
8Y	Detroit Diesel	8V–92	302–364
9Y	Detroit Diesel	8V–92	447–522
0Y	No Engine	—	—

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

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

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

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

Table 7, 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 8, VIN Position 11 (Plant of Manufacture)

VIN for Vehicles Built from May 1, 2000

IMPORTANT: A revised VIN-code structure is 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. 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.

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	**Configuration**	**Chassis**
A	4x2	Truck
B	4x2	Truck/Tractor
D	4x4	Truck
E	4x4	Truck/Tractor
F	6x2	Truck
G	6x2	Truck/Tractor

VIN Position 4 (Chassis Configuration)		
Code	**Configuration**	**Chassis**
H	6x4	Truck
J	6x4	Truck/Tractor
K	6x6	Truck
L	6x6	Truck/Tractor
M	8x4	Truck
N	8x4	Truck/Tractor

VIN for Vehicles Built from May 1, 2000

VIN Position 4 (Chassis Configuration)		
Code	**Configuration**	**Chassis**
P	8x6	Truck
R	8x6	Truck/Tractor
S	10x4	Truck
T	10x4	Truck/Tractor
U	10x6	Truck
V	10x6	Truck/Tractor
W	12x4	Truck
X	Glider	Glider
Y	8x2	Truck

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	SC 8000 Cargo	COE	Class 7
AE	SC 8000 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
AP	L 7500 Series	Conventional	Class 5
AR	L 7500 Series	Conventional	Class 6
AS	L 7500 Series	Conventional	Class 7
AT	L 7500 Series	Conventional	Class 8
AU	L 7500 Series Glider	Conventional	Glider
AV	L 8500 Series	Conventional	Class 7
AW	L 8500 Series	Conventional	Class 8
AX	L 8500 Series Glider	Conventional	Glider
AY	L 9500 Series	Conventional	Class 7

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
AZ	L 9500 Series	Conventional	Class 8
A1	L 9500 Series Glider	Conventional	Glider
A2	A 9500 Series	Conventional	Class 7
A3	A 9500 Series	Conventional	Class 8
A4	A 9500 Series Glider	Conventional	Glider
A5	ST 9500 Series	Conventional	Class 7
A6	ST 9500 Series	Conventional	Class 8
A7	ST 9500 Series Glider	Conventional	Glider
A8	L 7501	Conventional	Class 6
A9	L 7501	Conventional	Class 7
A0	L 7501	Conventional	Class 8
BA	L 8501	Conventional	Class 6
BB	L 8501	Conventional	Class 7
BC	L 8501	Conventional	Class 8
BD	L 8511	Conventional	Class 7
BE	L 8511	Conventional	Class 8
BF	L 8513	Conventional	Class 7
BG	L 8513	Conventional	Class 8
BH	L 9501	Conventional	Class 7
BJ	L 9501	Conventional	Class 8
BK	L 9511	Conventional	Class 7
BL	L 9511	Conventional	Class 8
BM	A 9513	Conventional	Class 7
BN	A 9513	Conventional	Class 8
BP	A 9522	Conventional	Class 7
BR	A 9522	Conventional	Class 8
BS	L 9522	Conventional	Class 7
BT	L 9522	Conventional	Class 8
BU	Condor	Coe	Class 7
BV	Condor	Coe	Class 8
BW	L 9513	Conventional	Class 7
BY	M7500 Acterra	Conventional	Class 8
BZ	M6500 Acterra	Conventional	Class 7
B1	6500 Sportchassis	Conventional	Class 5
B2	6500 Sportchassis	Conventional	Class 6

VIN for Vehicles Built from May 1, 2000

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
B3	M5500 Acterra	Conventional	Class 6
B4	M6500 Acterra Glider	Conventional	Glider
B5	M7500 Acterra Glider	Conventional	Glider
B6	M8500 Acterra Glider	Conventional	Glider
B7	Atego 6500	COE	Class 6
B8	Atego 6500 Glider	COE	Glider
B9	Atego 7500	COE	Class 7
CA	Atego 7500 Glider	COE	Glider
CB	Atego 8500	COE	Class 8
CD	Atego 8500 Glider	COE	Glider
CE	Acterra	Conventional	Class 5
CF	Acterra	Conventional	Class 6
CG	Acterra	Conventional	Class 7
CH	Acterra	Conventional	Class 8

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
CJ	Condor Glider	COE	Glider
CK	SC 8000 Cargo	COE	Class 6
CL	Acterra Glider	Conventional	Glider
CM	LC Series Car Hauler	Conventional	Class 8
CN	LC Series Car Hauler Glider	Conventional	Glider
CP	SC 8000 Cargo Glider	COE	Glider
CR	LC Series Car Hauler	Conventional	Class 7

* 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**	**Displacement (L)**	**Configuration**	**Brakes**
AA	Caterpillar 3176	Diesel	10.3	I–6	Air
AB	Caterpillar 3176	Diesel	10.3	I-6	Hydraulic
AC	Caterpillar 3176	Diesel	10.3	I-6	Air/Hydraulic
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 3406 E	Diesel	15.8	I-6	Air
AH	Caterpillar 3406 E	Diesel	15.8	I-6	Hydraulic
AJ	Caterpillar 3406 E	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

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement (L)**	**Configuration**	**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	I-6	Air
BB	Cummins NTC	Diesel	14	I-6	Hydraulic
BC	Cummins NTC	Diesel	14	I-6	Air/Hydraulic
BD	Cummins N14	Diesel	14	I-6	Air
BE	Cummins N14	Diesel	14	I-6	Hydraulic
BF	Cummins N14	Diesel	14	I-6	Air/Hydraulic
BG	Cummins ISX/Signature	Diesel	14.9	I-6	Air
BH	Cummins ISX/Signature	Diesel	14.9	I-6	Hydraulic
BJ	Cummins ISX/Signature	Diesel	14.9	I-6	Air/Hydraulic
BK	Cummins C8.3	Diesel	8.3	I-6	Air
BL	Cummins C8.3	Diesel	8.3	I-6	Hydraulic
BM	Cummins C8.3	Diesel	8.3	I-6	Air/Hydraulic
BN	Cummins B5.9	Diesel	5.9	I-6	Air
BP	Cummins B5.9	Diesel	5.9	I-6	Hydraulic
BR	Cummins B5.9	Diesel	5.9	I-6	Air/Hydraulic
BS	Cummins ISC	Diesel	8.3	I-6	Air
BT	Cummins ISC	Diesel	8.3	I-6	Hydraulic
BU	Cummins ISC	Diesel	8.3	I-6	Air/Hydraulic
BV	Cummins ISB	Diesel	5.9	I-6	Air
BW	Cummins ISB	Diesel	5.9	I-6	Hydraulic
BX	Cummins ISB	Diesel	5.9	I-6	Air/Hydraulic

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement (L)**	**Configuration**	**Brakes**
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 Diesel Series 50	Diesel	8.5	I-4	Air
B9	Detroit Diesel Series 50	Diesel	8.5	I-4	Hydraulic
B0	Detroit Diesel Series 50	Diesel	8.5	I-4	Air/Hydraulic
CA	Detroit Diesel Series 55	Diesel	12	I-6	Air
CB	Detroit Diesel Series 55	Diesel	12	I-6	Hydraulic
CC	Detroit Diesel Series 55	Diesel	12	I-6	Air/Hydraulic
CD	Detroit Diesel Series 60	Diesel	11.1	I-6	Air
CE	Detroit Diesel Series 60	Diesel	11.1	I-6	Hydraulic
CF	Detroit Diesel Series 60	Diesel	11.1	I-6	Air/Hydraulic
CG	Detroit Diesel Series 60	Diesel	12.7	I-6	Air
CH	Detroit Diesel Series 60	Diesel	12.7	I-6	Hydraulic
CJ	Detroit Diesel Series 60	Diesel	12.7	I-6	Air/Hydraulic
CK	Detroit Diesel Series 60	Diesel	14.0	I-6	Air
CL	Detroit Diesel Series 60	Diesel	14.0	I-6	Hydraulic
CM	Detroit Diesel 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	12.8	I-6	Air
CW	Mercedes-Benz MBE4000	Diesel	12.8	I-6	Hydraulic
CX	Mercedes-Benz MBE4000	Diesel	12.8	I-6	Air/Hydraulic
CY	Cummins ISL	Diesel	8.9	I-6	Air
CZ	Cummins ISL	Diesel	8.9	I-6	Hydraulic
C1	Cummins ISL	Diesel	8.9	I-6	Air/Hydraulic

VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displacement (L)**	**Configuration**	**Brakes**
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 ISB3.9	Diesel	3.9	I-4	Air
C6	Cummins ISB3.9	Diesel	3.9	I-4	Hydraulic
C7	Cummins ISB3.9	Diesel	3.9	I-4	Air/Hydraulic
DA	Caterpillar C9	Diesel	8.8	I-6	Air
DB	Caterpillar C9	Diesel	8.8	I-6	Hydraulic
DC	Caterpillar C7	Diesel	7.2	I-6	Air
DD	Caterpillar C7	Diesel	7.2	I-6	Hydraulic
DE	Caterpillar C13	Diesel	12.5	I-6	Air
DF	Caterpillar C13	Diesel	12.5	I-6	Hydraulic
DG	Mercedes-Benz MBE900	Diesel	4.8	I-4	Air
DH	Mercedes-Benz MBE900	Diesel	4.8	I-4	Hydraulic
DJ	Mercedes-Benz MBE900	Diesel	7.2	I-6	Air
DK	Mercedes-Benz MBE900	Diesel	7.2	I-6	Hydraulic
DL	Caterpillar C11	Diesel	11.1	I-6	Air
DM	Caterpillar C11	Diesel	11.1	I-6	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
8	2008
9	2009
A	2010

Table 6, VIN Position 10 (Vehicle Model Year)

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

Table 7, VIN Position 11 (Build Location)

General Information

NOISE

Noise is defined as an unpleasant sound. Noises (or sounds) are subjective and are often described by people differently and in a variety of ways (for example: tapping, whistling, whining, buzzing, humming, clunking, booming, etc.). Therefore, when diagnosing noise concerns, it is important to have a complete description of the noise and the vehicle's operating condition. Listed below are some suggested questions to narrow the search area.

Does the noise occur:

- At a constant speed or rpm?
- On a level road or on a grade?
- During an acceleration or deceleration (coast)?
- During full or part throttle?
- While braking or turning?
- After a change in vehicle loading?

Most noises have a generally recognizable problem area (such as engine, driveline, wind, and road surface) and, based on experience, the description of the noise will often be of assistance in isolating the problem and correcting it. It is also important to note that some amount of noise (such as tire noise on newly paved blacktop) is considered normal, and is in no way detrimental to the operation of the vehicle.

VIBRATION

Vibration can be defined as periodic movement or oscillation, a trembling, shaking, or grounding condition that can be felt. Vehicle vibrations can be constant or variable in both frequency and intensity. As described in the vehicle noise section, the vehicle operating conditions are important and should be recorded.

Vehicle vibrations can also be subdivided into those that occur at low speeds and those that are most noticeable at higher speeds. Since the dividing line between low and higher speed vibrations is not clear, there will be vibrations that overlap the two ranges.

Typical Low-Speed Vibrations

Low-speed vibrations occur at vehicle speeds below 40 mph (72 km/h).

Typical low-speed vibrations are the result of one or more of the following:

- exhaust vibration
- engine harshness
- driveline vibration due to improper driveline angles
- air conditioner compressor or drive belt vibrations
- take-off shudder (clutch)
- brake roughness or harshness
- driveline roughness
- clutch torsion vibration
- driveline slip-yoke or U-joints
- automatic transmission clutch slippage

Typical High-Speed Vibrations

High-speed vibrations occur at vehicle speeds above 40 mph (72 km/h).

Typical high-speed vibrations are the result of one or more of the following:

- axle and companion flange runout or imbalance
- driveshaft imbalance or improper angles
- excessive tire-wheel and drum assembly imbalance
- tire roughness due to high nonuniformity (force variation) or out-of-balance condition
- driveline vibration due to improper driveline angles
- driveline slip-yoke or U-joints
- automatic transmission clutch slippage
- rear axle pinion gear pitch line runout
- excessive tire and wheel runout
- worn suspension components
- front end accessory vibrations
- exhaust vibration (greatly reduced in exhaust systems decoupled by a flexible coupling and mounted with blade and block hangers)

General Information

HARSHNESS

Harshness is the term commonly used to describe the ride quality of the vehicle. A hard or "harsh" ride is usually caused by the tires or the cab and vehicle suspension system. Some items to note are:

- tire manufacturer, type, size, and pressure
- load distribution
- suspension components

Some common terms to describe ride motions are:

- Vehicle bounce—the vertical motion of a vehicle on its suspension system, front and rear in phase. A low frequency "float," or an intermediate frequency "kick";
- Vehicle pitch—an out-of-phase vertical motion of the front and rear of the vehicle. A flat ride is considered the opposite of a pitch ride;
- Vehicle roll—the side-to-side rotation of the vehicle body about the front and rear axles.

WEIGHT DISTRIBUTION

Weight properly distributed to front and rear axles gives the best ride and steerability, and eliminates premature failures due to overloaded axles, springs, tires, etc.

Payload distribution has a definite influence on vehicle performance. Even if the total vehicle is not loaded beyond the recommended maximum gross vehicle weight, this does not mean that individual components are not overloaded.

Overloading can be due to the improper positioning of heavy materials so that the load is centered over one rear tire or so far forward in the body that the front axle and tires are overloaded.

Unloaded or diminishing load type operations also affect the ride characteristics of a vehicle. Road vibrations and shock, for example, are not dampened in a light vehicle to the extent that they are under heavily loaded conditions.

Troubleshooting

INSPECTION AND VERIFICATION

Noise, vibration, and harshness (NVH) concerns usually occur in four areas: tires, engine accessories, suspension, and drivetrain. It is important that these problems be isolated into one specific area as soon as possible. The easiest and quickest way to do this is to perform a road test.

Interview the owner to get a thorough description of the conditions under which the problem occurs. Road test the vehicle. Duplicate, as closely as possible, the conditions the owner described.

1. Make a visual inspection as part of the preliminary diagnostic routine, writing down anything that does not look right. Note, but do not correct:
   - Tire pressures;
   - Loose bolts or brackets;
   - Bright spots where components may be rubbing against each other;
   - Stains caused by leaking fluids or exhaust gases;
   - Frame attitude or angle;
   - General suspension condition and lubrication;
   - Driveline condition and lubrication;
   - General vehicle maintenance.
2. Do not make any repairs or adjustments until a road test and a thorough visual inspection of the vehicle have been performed. Do not change tire pressure or vehicle load. Adjusting tire pressures or vehicle load, or making some other adjustment, can reduce the condition's intensity to a point where it cannot be identified clearly. It can also inject a new condition into the system, preventing proper diagnosis.
3. Make notes throughout the diagnostic routine. It will help when starting to compile the data. Use a road test form that includes space for comments. Write down even the smallest bit of information, as it can turn out to be most important.

NOISE DIAGNOSIS PROCEDURE

Noise Conditions

If noise is produced as part of a vibration condition, correcting the vibration will eliminate the noise. If the noise is related to a specific component or system, refer to the appropriate workshop manual section for further diagnosis.

Vibration Conditions

The following charts are designed to take the technician through a step-by-step diagnosis procedure to determine the cause of a condition. It may not always be necessary to follow a chart to its conclusion. Perform only the steps necessary to correct the condition. Then check the operation of the system to make sure the condition has been corrected.

It is sometimes necessary to remove various vehicle components to gain access to the component to be tested. Refer to the applicable section in this manual for removal and installation of components.

⚠ WARNING

If only one drive wheel is allowed to rotate, speed must be limited to 34 mph (55 km/h) using the speedometer reading, since actual wheel speed will be twice that indicated on the speedometer. Exceeding a speed of 34 mph (55 km/h) or allowing the drive wheel to hang unsupported can result in tire disintegration or differential failure, which can cause serious personal injury and extensive vehicle damage.

Problem—High-Speed Shake

Problem—High-Speed Shake	
Possible Cause	**Remedy**
Wheel bearings.	Spin the front tires by hand to check for wheel bearing roughness. Check the bearing end play. Adjust or replace and lubricate the bearings as necessary. Road test.

Troubleshooting

Problem—High-Speed Shake	
Possible Cause	**Remedy**
Tires/wheels.	Check the tire runout on the vehicle. Measure the wheel/tire assembly runouts on the vehicle. Refer to **Group 40** in this manual. If the measurement is within specification, check the rear brake drums and linings. Repair the drums and brakes as necessary. Refer to **Group 42** in this manual. Road test. If the measurement is not within specification, check the match mounting. Mark the high runout location on the tire and also on the wheel. Break the assembly down and rotate the tire 180 degrees (halfway around) on the wheel. Inflate the tire and measure the runouts. If the measurement is within specification, balance the assembly and install on the vehicle. Road test. If the measurement is not within specification and the high spot is not within 4 inches (101.6 mm) of the first high spot on the tire, check the wheel runout. Dismount the tire and mount the wheel on a wheel balancer. Measure the runouts on both flanges. Refer to **Group 40** in this manual. If the runout is not proper, replace the wheel. Check the runouts on the new wheel, using the dial indicator with bracketry. If the new wheel is within limits, locate and mark the low spot. Install the tire, matching the high spot of the tire with the low spot of the wheel. Balance the assembly and install on the vehicle. Road test. If the runout is proper, locate and mark the low spot on the wheel and install the tire, matching the high spot on the wheel. Balance the assembly and road test.
Brakes.	Check the rear brake drums and linings. Repair the drums and brakes as necessary. Refer to **Group 42** in this manual. Road test. If brakes are OK, check the front tires. Spin the front tires with a wheel balancer while the vehicle is raised on a hoist. Feel for vibration in the front fender or while seated in the vehicle. If the vibration is felt, balance the front wheels. Road test. If the vibration is not felt, check the rear tires. Engage the drivetrain while the vehicle is raised on a hoist. Carefully accelerate the drive wheels while checking for vibration. If the vibration is present, check the drivetrain. Remove the rear wheels, and secure the brake drums by installing wheel hub bolt nuts, reversed. Carefully accelerate the drivetrain while checking for vibration. If the vibration is not present, balance the rear wheels. Road test. If the vibration is present, substitute a known good set of wheels and tires. Road test the vehicle. If the vibration is present, check for driveline or accessory drive conditions. If the vibration is not present, install the original tire/wheel assemblies, one by one, road testing at each step, until the problem tire(s) is identified. Replace the tire(s) as necessary and retest.

Problem—Tip-In Moan

Problem—Tip-In Moan	
Possible Cause	**Remedy**
Air cleaner installed improperly.	Check the engine air cleaner for proper installation of the cover, the element, and the engine air cleaner intake tube and duct assembly. Correct the condition and road test.
Exhaust system clearance or leaks.	Check the exhaust system for leaks or contact from the pipe to the frame or the muffler to the frame. Loosen all exhaust system clamps, Adjust the pipes and the muffler for sufficient clearance and Retighten the clamps. See **Group 49** in this manual.

Problem—Tip-In Moan	
Possible Cause	**Remedy**
Engine mount grounding.	Replace worn rubber cab or engine mounting parts. See **Group 60** in this manual.
Cab-mounted brackets (metal-on-metal contact between cab and brackets).	

Problem—Idle Boom/Shake/Vibration

Problem—Idle Boom/Shake/Vibration	
Possible Cause	**Remedy**
Cables/hoses (control cables, air conditioning hoses, accelerator cable, etc.).	Check the cable/hoses. Check the engine compartment for any component that may be grounded between the engine and the body or chassis. Correct the condition and road test.
Exhaust system clearance or leaks.	Check the exhaust system for leaks or contact from the pipe to the frame or the muffler to the frame. Loosen all exhaust system clamps, Adjust the pipes and the muffler for sufficient clearance and Retighten the clamps. See **Group 49** in this manual.
Drive belts and pulleys.	Check the drive belt and pulleys. With the engine idling, visually check all drive belts and pulleys for misalignment, runout, or irregular motion. Correct the condition. Refer to **Group 01** in this manual. If no problem is found, refer to "Problem—Engine/Transmission-Related Noise/Vibration" chart in this subject.

Problem—Front Brake Vibration/Shudder

Problem—Front Brake Vibration/Shudder	
Possible Cause	**Remedy**
Front brake drums and shoes.	Refer to **Group 42** in this manual.

Troubleshooting

Problem—Engine/Transmission-Related Noise/Vibration

Problem—Engine/Transmission-Related Noise/Vibration	
Possible Cause	**Remedy**
Engine/transmission mounts.	**CAUTION** **While performing the engine run-up check in the drive range, do not hold the throttle open for more than 5 seconds at a time. Make sure to move the selector lever to Neutral and run the engine at 1000 rpm for 15 seconds to cool the converter and transmission fluid, or damage to the transmission could result.** Perform an engine run-up check. Make sure the vehicle is stationary, the wheels are blocked, and the brakes are applied. For automatic transmissions: place the transmission in "Park" or "Neutral" and operate the engine at the rpm at which the condition occurs. Repeat this procedure with the vehicle in "Drive" and the parking brake applied. If the vibration still exists, check the air conditioning (refer to **Group 83** in this manual) and check the engine (refer to the applicable section in **Group 01** in this manual). If the vibration does not exist, check the engine/transmission mounts and exhaust system components. For manual transmissions: place the transmission in "Neutral" and operate the engine at the rpm at which the condition occurs. Perform this procedure with the clutch engaged and disengaged. If the vibration still exists, check the air conditioning (refer to **Group 83** in this manual), check the engine (refer to the applicable section in **Group 01** in this manual), and check the clutch (refer to **Group 25** in this manual). If the vibration does not exist, check the engine/transmission mounts and exhaust system components.
Exhaust system components.	
Air conditioning system.	
Clutch concern.	
Engine/transmission.	

Problem—Driveline Concerns

Problem—Driveline Concerns	
Possible Cause	**Remedy**
Driveshaft.	Refer to **Group 41** in this manual.

Problem—Wheel/Tire Vibration

Problem—Wheel/Tire Vibration	
Possible Cause	**Remedy**
Wheel/tire runout.	Refer to **Group 40** in this manual.

Problem—Engine Accessory Vibration

Problem—Engine Accessory Vibration	
Possible Cause	**Remedy**
Worn drive belt, pulley or hardware.	Refer to **Group 01** in this manual.

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 *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 *Warranty Manual* for instructions on storage of new vehicles.

Pre-Delivery Information

All pre-delivery inspections and services must be performed at an authorized Daimler Trucks North America 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 *Warranty Manual* for details.

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

List of Abbreviations

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

A ..... amperes
ABS ..... antilock braking system
ABS ..... acrylonitrile-butadiene-styrene
A/C ..... air conditioner
AC ..... alternating current
acc ..... accessories
ACPU ..... air conditioning protection unit
ADLO ..... auto-disengagement lockout
AGS ..... automated gear shift
a.m. ..... *ante meridiem* (midnight to noon)
AM ..... amplitude modulation
amp(s) ..... ampere(s)
AMT ..... automated mechanical transmission
AMU ..... air management unit
ANSI ..... American National Standards Institute
API ..... American Petroleum Institute
API ..... application programming interface
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
ATD ..... aftertreatment device
ATF ..... automatic transmission fluid
ATS ..... aftertreatment system
attn ..... attention
aux. ..... auxiliary
av ..... *avoirdupois* (British weight system)
AWD ..... all-wheel drive
AWG ..... American wire gauge
AWS ..... American Welding Society
BAT ..... battery
BBC ..... bumper-to-back-of-cab
BHM ..... bulkhead module
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
CBE ..... cab behind engine
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
CHM ..... chassis module
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
CRT ..... cathode ray tube
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 (obs)
DDC ..... Detroit Diesel Corporation
DDE ..... Detroit Diesel Engines
DDEC ..... Detroit Diesel Electronic (engine) Control
DDR ..... diagnostic data reader
DDU ..... driver display unit
def ..... defrost
DFI ..... direct fuel injection
DGPS ..... differential global positioning system
dia. ..... diameter
DIAG ..... diagnosis
DIP ..... dual inline package (switch)
DLM ..... datalink monitor
DLU ..... data logging unit
DMM ..... digital multimeter
DOC ..... diesel oxidation catalyst
DOT ..... Department of Transportation
DPF ..... diesel particulate filter
DRL ..... daytime running lights
DRM ..... dryer reservoir module
DSM ..... district service manager
DTC ..... diagnostic trouble code
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
ECL ..... engine coolant level
ECM ..... electronic control module
ECT ..... engine coolant temperature
ECU ..... electronic control unit
EDM ..... electronic data monitor
EEPROM .. electrically erasable programmable read-only memory
EGR ..... exhaust gas recirculation
EMC ..... electromagnetic compatibility
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
ESD ..... electrostatic discharge
ESS ..... engine syncro shift (transmission)
etc. ..... *et cetera* (and so forth)
ETEC ..... electronic truck engine control
EUI ..... electronic unit (fuel) injectors

List of Abbreviations

EXM ..... (chassis) expansion module
FAS ..... Freightliner air suspension
FET ..... field effect transistor
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
FMEA ..... failure mode effects analysis
FMI ..... failure mode indicator
FMSI ..... Friction Materials Standards Institute
FMVSS .... Federal Motor Vehicle Safety Standard
FRP ..... fiberglass reinforced plastic
FSA ..... field service authorization
FSM ..... fleet service manager
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
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
HCOE ..... high cab over engine
HCU ..... hydraulic control unit
HD ..... heavy-duty
HEPA ..... high-efficiency particulate air (filter)
HEST ..... high exhaust system temperature
HFC ..... hydrogenated fluorocarbons (refrigerant-134a)
hp ..... horsepower
hp ..... high pressure
HRC ..... Rockwell "C" hardness
hr(s) ..... hour(s)
HSD ..... high-side driver
htr. ..... heater
HVAC ..... heating, ventilating, and air conditioning
H/W ..... hardware
Hz ..... hertz
ICU ..... instrumentation control unit
i.d. ..... inside diameter
ID ..... identification
IFI ..... Industrial Fasteners Institute
IGN ..... ignition
ILO ..... *in lieu of* (in the place of)
in ..... inches
in^3 ..... cubic inches
Inc. ..... incorporated
inH_2O ..... inches of water
inHg ..... inches of mercury
I/O ..... input/output
IP ..... instrument panel
ISO ..... International Organization for Standardization
IVS ..... idle validation switch
k ..... kilo (1000)
kg ..... kilograms
km ..... kilometers
km/h ..... kilometers per hour
kPa ..... kilopascals
kW ..... kilowatts
L ..... liters
lb ..... pounds
lbf·ft ..... pounds force feet
lbf·in ..... pounds force inches
LCD ..... liquid crystal display
LCOE ..... low cab over engine
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
LSD ..... low-side driver
LVD ..... low-voltage disconnect
m ..... meters
max. ..... maximum
M-B ..... Mercedes-Benz
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
MSF ..... modular switch field
MSHA ..... Mining Safety and Health Administration
MVDA ..... Motor Vehicle Dealers Association
n ..... negative (front axle wheel alignment specification)
N ..... nitrogen
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
NT ..... nylon tube or nylon tubing
obs ..... obsolete
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

List of Abbreviations

p ..... positive (front axle wheel alignment specification)
PACE ..... programmable electronically controlled engine
parm ..... parameter
PC ..... personal computer
PCB ..... printed circuit board
PDC(s) .... parts distribution center(s)
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
PRD ..... product requirements document
PSA ..... pressure-sensitive adhesive
psi ..... pounds per square inch
psia ..... pounds per square inch, atmosphere
psig ..... pounds per square inch, gauge
pt ..... pints
PTCM ..... pressure time control module
PTO ..... power takeoff
pvc ..... polyvinyl chloride
PWM ..... pulse width modulation
pwr ..... power
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)
regen ..... regeneration
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
RSM ..... regional service manager
RTV ..... room temperature vulcanizing
RV ..... recreational vehicle
SA ..... source address
SAE ..... Society of Automotive Engineers
SB ..... service bulletin
SCU ..... system control unit (speedometer)
SD ..... severe-duty
SDU ..... step deployment unit
SEL ..... shutdown engine light
SEM ..... switch expansion module
SHM ..... switch hub module
SI ..... service information
SI ..... *Système International*
SID ..... subsystem identifier
SM ..... system malfunction
SMC ..... sheet molded compound
S/N ..... serial number
SPACE .... seat pretensioner activation for crash survival enhancement
SPN ..... suspect parameter number
sq in ..... square inches
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 specification order
TSU ..... transmission shift unit
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
VCU ..... vehicle control unit
VDC ..... vehicle data computer
Vdc ..... volts, direct current
VIMS ..... vehicle information management system
VIN ..... vehicle identification number
VIP ..... vehicle instrumentation and protection (Kysor)
VIW ..... vehicle interface wiring (connector)
VOC ..... volatile organic compounds
VOM ..... volt-ohmmeter
VRS ..... variable resistance sensor
VSG ..... variable speed governor
VSS ..... vehicle speed sensor
VSU ..... vehicle security unit
WB ..... wire braid
WI ..... work instructions
WIF ..... water-in-fuel
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

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.

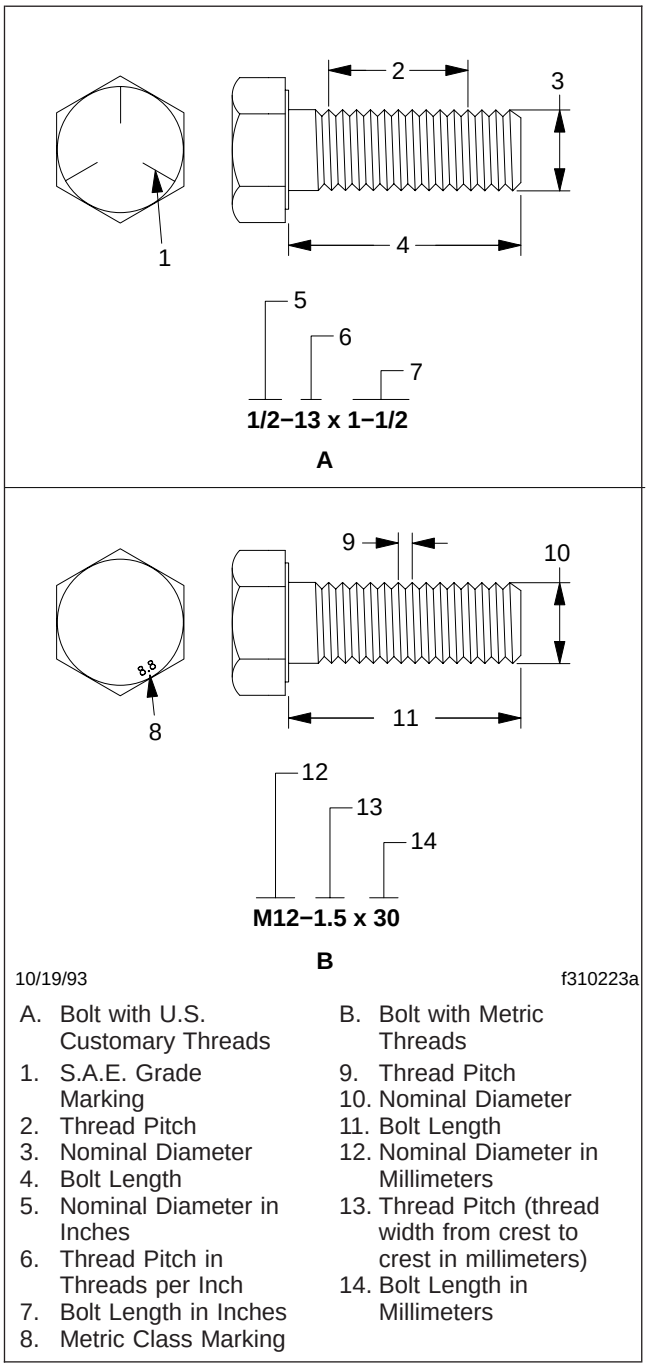
Some fasteners smaller than 1/2-inch diameter are flanged fasteners, which have integral flanges that fit against the parts being fastened. The flanges eliminate the need for washers.

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 31.02** in this manual.

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.

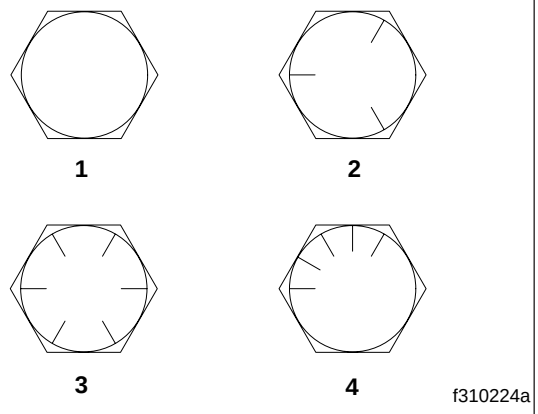
Fasteners with metric threads are divided into classes adopted by the American National Standards Institute (ANSI). The higher the class number, the stronger the fastener. Bolt classes can be identified by the numbers forged on the head of the bolt. See **Fig. 4**. Hexnut (and locknut) classes can be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

General Information

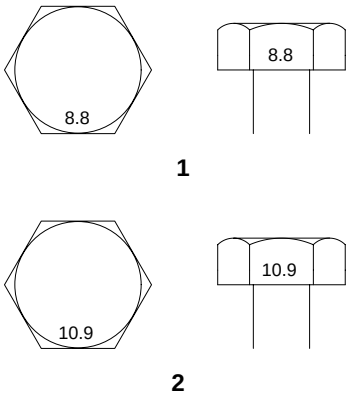


NOTE: Grade 2 bolts have no grade marking; grade 2 bolts are rarely used by Sterling. These grade markings are used on plain hex-type and flanged bolts (cap-screws). In addition to the grade markings, the bolt head must also carry the manufacturer's trademark or identification.

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

Fig. 2, Bolt Grades

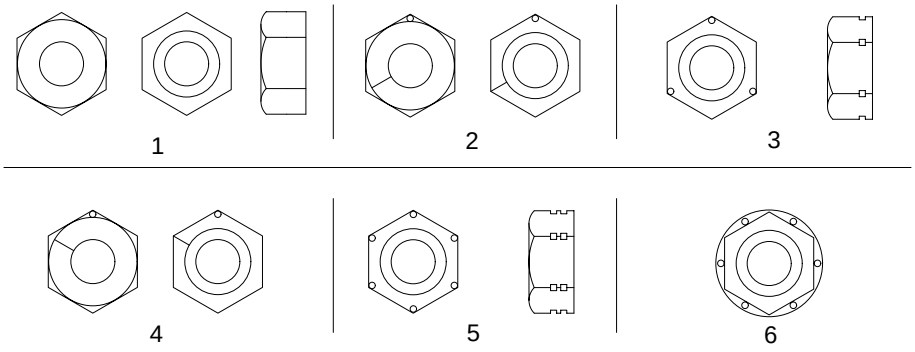
nut. See **Fig. 5**. Class 8 hexnuts are always used with class 8.8 bolts; class 10 hexnuts with class 10.9 bolts.



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

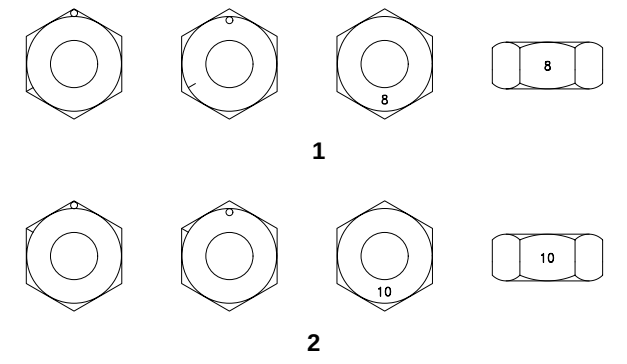
Fig. 4, Bolt Classes



NOTE: Grade 2 (S.A.E.) and grade A (I.F.I.) nuts have no identification marks or notches; they are rarely used by Sterling. 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



1. Class 8 Nut
2. Class 10 Nut

Fig. 5, Nut Classes

Frame Fasteners

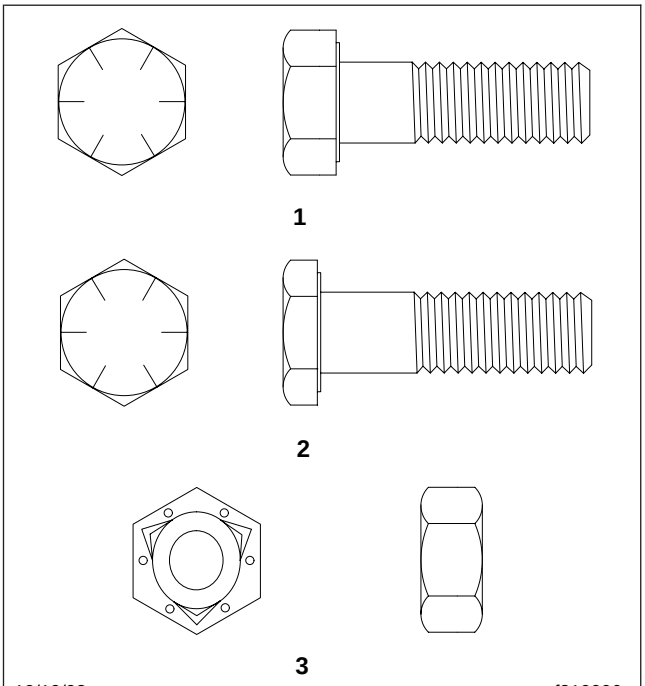
The standard fasteners used to assemble the vehicle frame and to attach most components to the vehicle frame are threaded lockbolts (Spin Hucks). These fasteners are covered in **Section 31.02**.

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.



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

Fig. 6, Frame Fastener Identification

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

General Information

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

Fastener Replacement

When replacing fasteners, use only identical bolts, washers, and nuts; they must be the same size, strength, and finish as originally specified. See the Sterling 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; do not 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.

Do not use lockwashers (split or toothed) next to aluminum surfaces.

When installing studs that do not 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. Do not use locknuts, because they tend to loosen the studs during removal. Do not use plain washers (flatwashers).

Do not 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, Sterling 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. Do not overtorque fasteners; overtightening causes permanent stretching of the fasteners, which can result in breakage of the parts or fasteners.

If specific torque values are not 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 are not distorted.

Thread Locking Compound Application

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

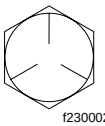
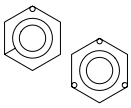
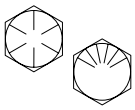
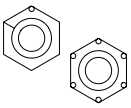
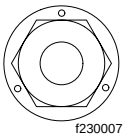
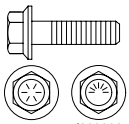
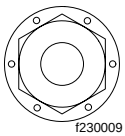
NOTE: Follow the safety precautions given on the locking compound container.

General Instructions

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 three or four 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.

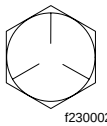
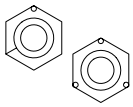
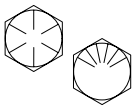
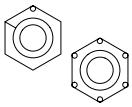
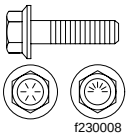
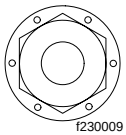
Specifications

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

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

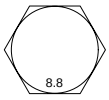
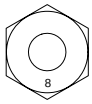
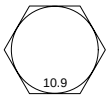
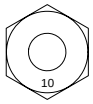
Table 1, Torque Values for U.S. Customary Thread Fasteners with Lubricated or Plated Threads

Specifications

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

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

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

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

* Sterling 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

Metric/U.S. Customary Conversion					
When You Know U.S. Customary	**Multiply By**	**To Get Metric**	**When You Know Metric**	**Multiply By**	**To Get U.S. Customary**
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)		0.155	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 millimeter (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 (floz)	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)

Table 1, Metric/U.S. Customary Conversion

General Information

Temperature Conversion							
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)

Table 2, Temperature Conversion

General Information

This section covers the removal and installation of the engine and transmission as a powertrain assembly. For the diagnosis and testing, removal, installation and in-vehicle repair procedures for Cummins supplied components, refer to the appropriate Cummins repair manual.

There are four models of Cummins engines available in the L-Line and A-Line vehicles: the ISB, ISC, M11 Plus and N14 Plus diesel engines.

The ISB diesel engine is a 5.9-liter, in-line, 6-cylinder, turbocharged, electronically controlled, mid-range diesel engine with charge air cooling.

The ISC diesel engine is an 8.3-liter, in-line, 6-cylinder, turbocharged, electronically controlled, mid-range diesel engine with charge air cooling.

The M11 Plus diesel engine is an 11-liter, in-line, 6-cylinder, turbocharged, electronically controlled diesel engine with charge air cooling. Cruise control is standard on M11 Plus engines, but is rendered inoperative if the vehicle is equipped with an HT series automatic transmission. See **Fig. 1** .

The N14 Plus diesel engine (see **Fig. 2**) is a 14-liter, in-line, 6-cylinder, turbocharged, electronically controlled diesel engine with charge air cooling. Speed/cruise control is standard on N14 Plus engines, but is rendered inoperative if the vehicle is equipped with an HT-series automatic transmission.

General Information

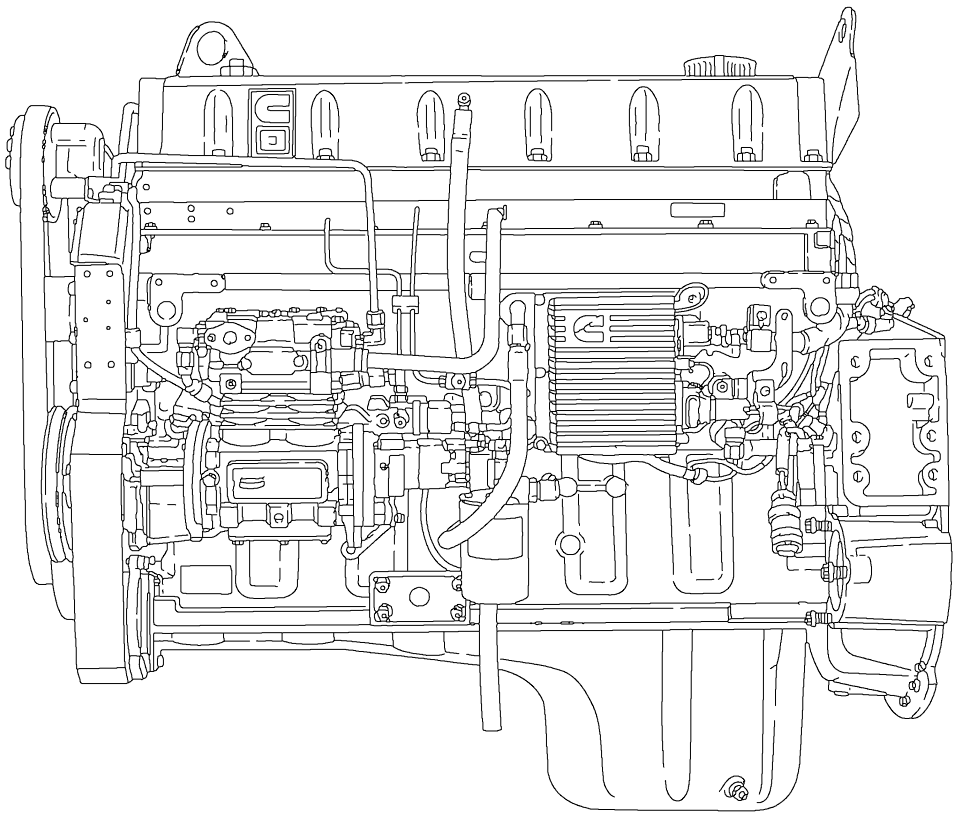


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Fig. 1, Cummins M11 Plus Diesel Engine

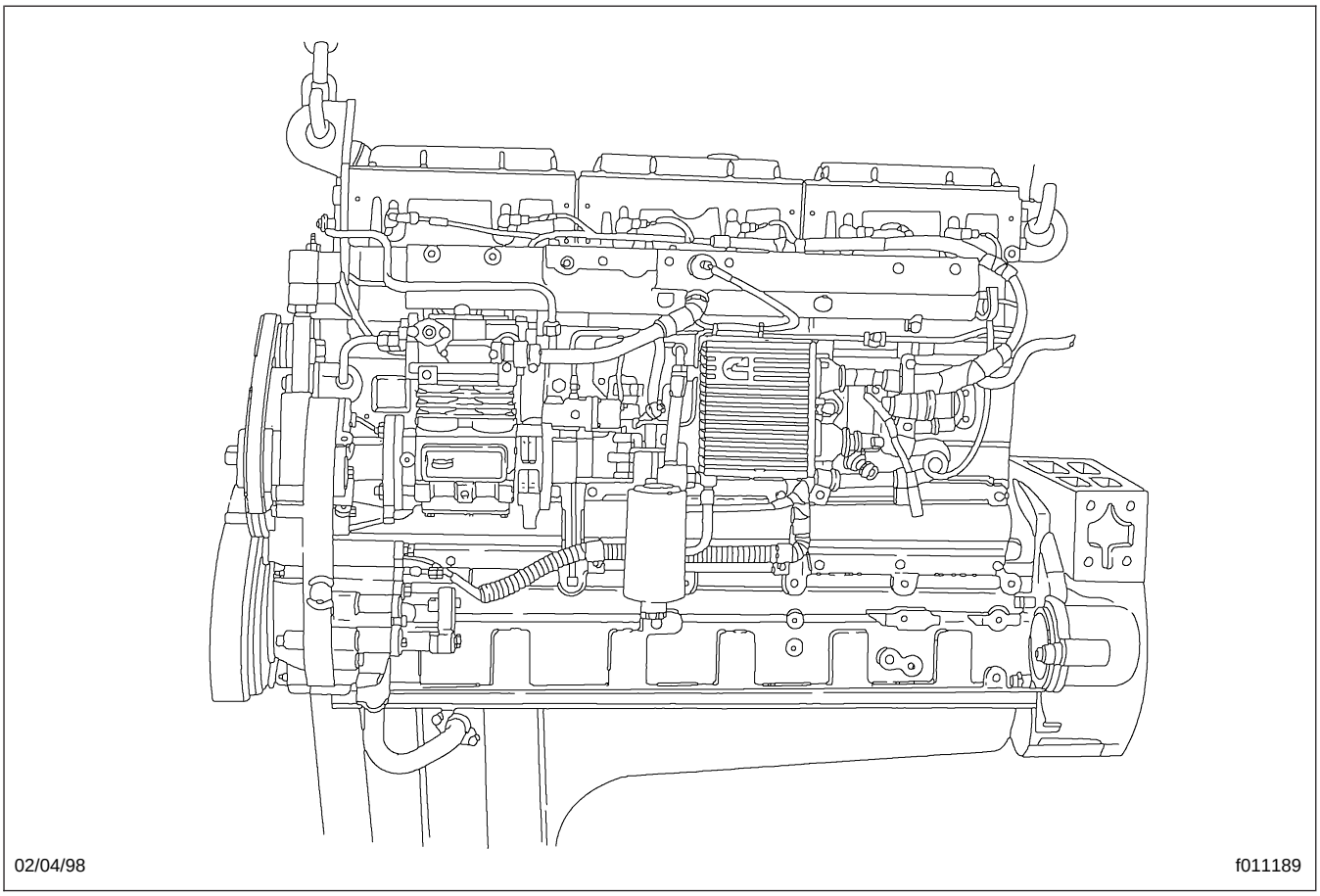


Fig. 2, Cummins N14 Plus Diesel Engine

Removal

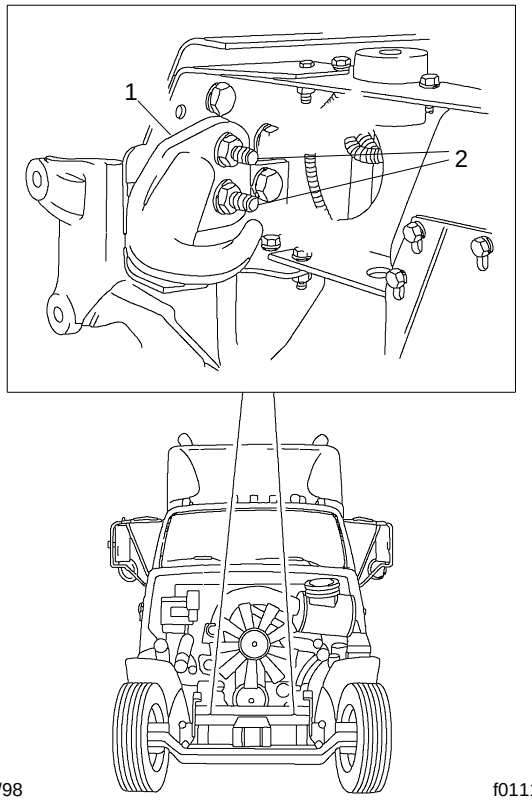
1. Prepare the vehicle for engine removal.
   - 1.1 Disconnect the battery ground cable(s).
   - 1.2 Remove the bumper. Refer to **Group 31**.
   - 1.3 Remove the hood. Refer to **Group 88**.
   - 1.4 Drain the engine cooling system. Refer to **Group 20**.
   - 1.5 Drain the engine oil.
   - 1.6 If the vehicle is equipped with an A/C system, recover the refrigerant. Refer to **Group 83**.
   - 1.7 If the vehicle is equipped with a transmission cooler or an automatic transmission, drain the transmission oil. Refer to the appropriate **Group 26** transmission section.
   - 1.8 Drain the air system.
   - 1.9 Remove the cooling module. Refer to **Group 20**.
   - 1.10 Remove the air intake tube and air cleaner assembly as an assembly. Refer to **Group 09**.
   - 1.11 Remove the engine cover. Refer to **Group 60**.
2. If the vehicle is equipped with front pintle hooks, remove six bolts, 10 washers, four nuts and two pintle hooks. See **Fig. 1**.

NOTE: The brake valves shown are for a 2-channel ABS system. All other configurations are similar.

3. Isolate the brake valves on the No. 1 crossmember. See **Fig. 2**.
   - 3.1 Remove the retaining clamp bolts.
   - 3.2 Disconnect the electrical connector.
   - 3.3 Label and disconnect the four air lines.

NOTE: The steering gear is shown, the rotary assist cylinder is similar.

4. If the vehicle is equipped with dual steering gears, disconnect the power steering lines from the steering gear and the rotary assist cylinder. Remove the power steering lines. See **Fig. 3**.



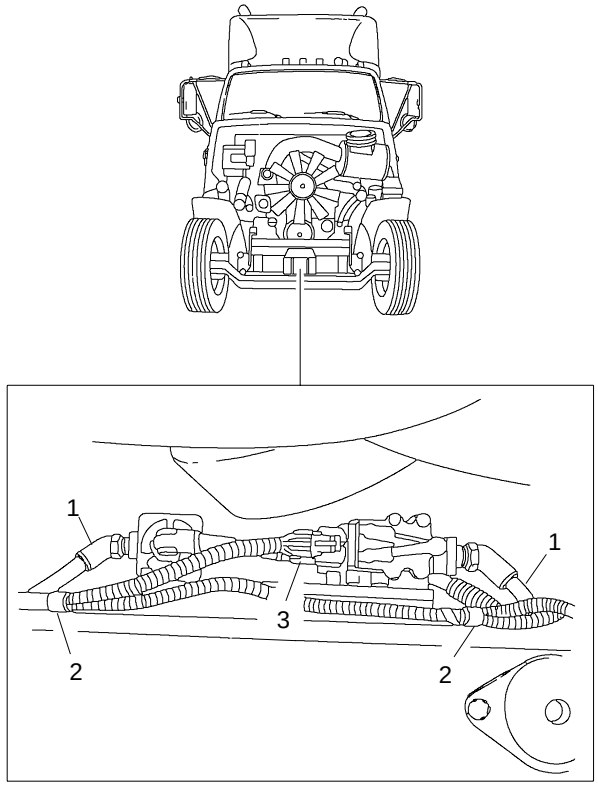
1. Pintle Hook
2. Bolt

Fig. 1, Pintle Hook

NOTE: If the vehicle has a 101-inch BBC chassis, perform the next two steps.

5. Remove the eight bolts, 16 washers, eight nuts and the No. 1 crossmember. See **Fig. 4**.
6. Remove the four nuts, eight washers, four bolts and the top two No. 1 crossmember gussets. See **Fig. 5**.
7. If the vehicle has a 113- to 122-inch BBC chassis, remove the four bolts, eight washers, four nuts, two bumper brackets and the No. 1 crossmember. See **Fig. 6**.
8. Disconnect the refrigerant line. Plug and cap the open lines and fittings. See **Fig. 7**.
9. Remove the turbocharger outlet tube. See **Fig. 8**.
10. Disconnect the exhaust outlet tube. See **Fig. 9**.
11. Disconnect the heater water hose. See **Fig. 10**.

ISB Engine Removal and Installation



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1. Air Line
2. Retaining Clamp
3. Electrical Connector

Fig. 2, Brake Valves

12. Remove the bolt and the upper radiator tube. See **Fig. 11**.
13. Remove the charge air cooler outlet tube. See **Fig. 12**.
14. Remove the six screws and the left-side splash shield. See **Fig. 13**.
15. If the vehicle is equipped with a manual transmission, disconnect the clutch cable or linkage and position it aside. See **Fig. 14**.
16. Disconnect the two electrical connectors. See **Fig. 15**.
    - 16.1 Remove the bolt and nut.
    - 16.2 Loosen the bolt and nut.
    - 16.3 Position the brace aside.

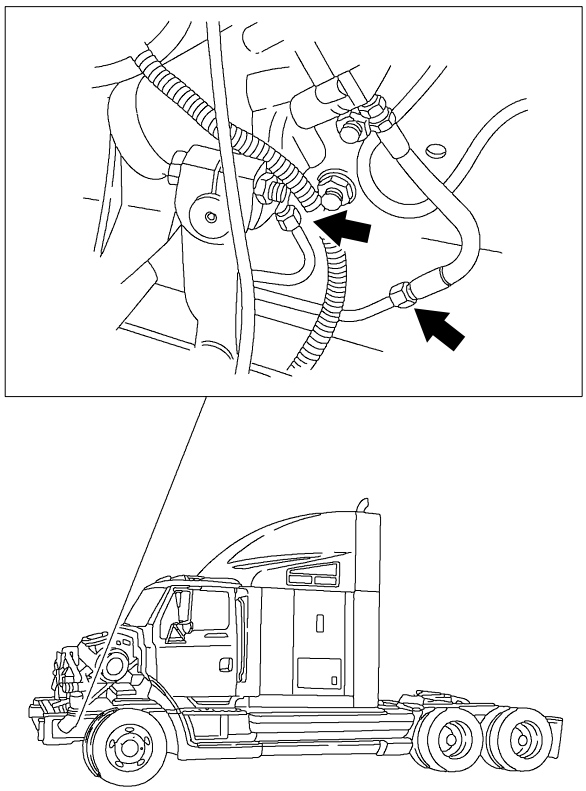

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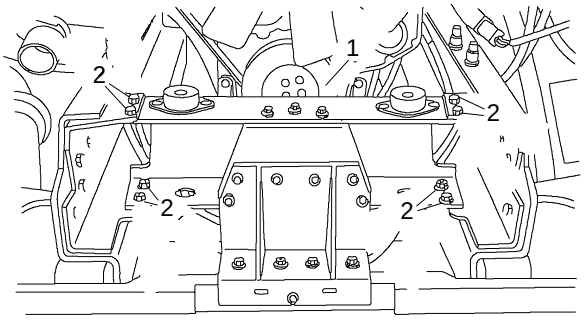
Fig. 3, Power Steering Lines



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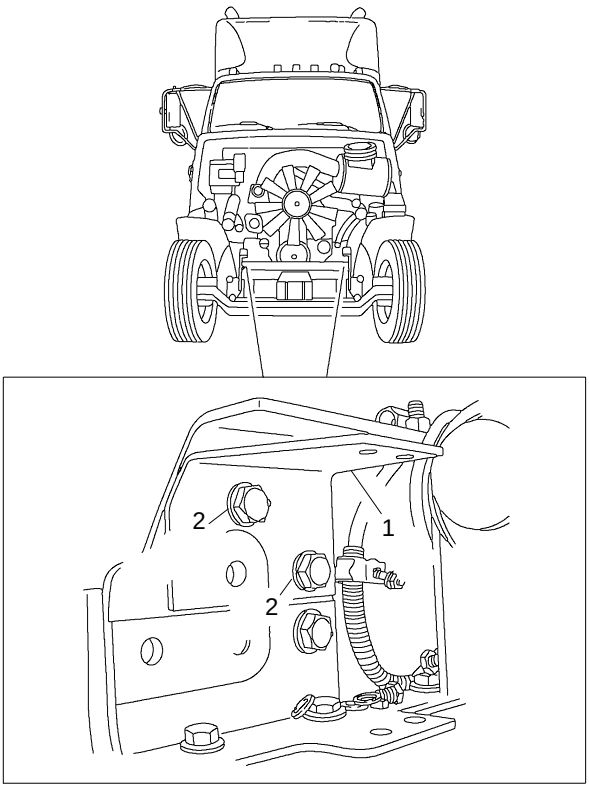
1. No. 1 Crossmember
2. Bolt (8 qty.)

Fig. 4, No. 1 Crossmember

- 16.4 Disconnect the bulkhead connector and position aside.



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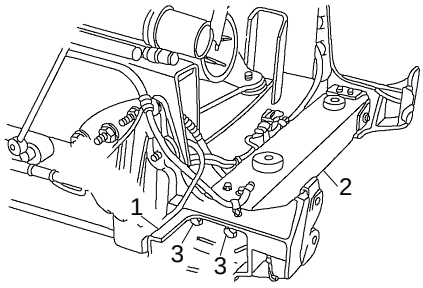
1. No. 1 Crossmember Gusset
2. Bolt

Fig. 5, No. 1 Crossmember Gusset



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1. Bumper Bracket
2. No. 1 Crossmember
3. Bolt (4 qty.)

Fig. 6, Bumper Bracket

16.5 Disconnect the electrical connector and position aside.

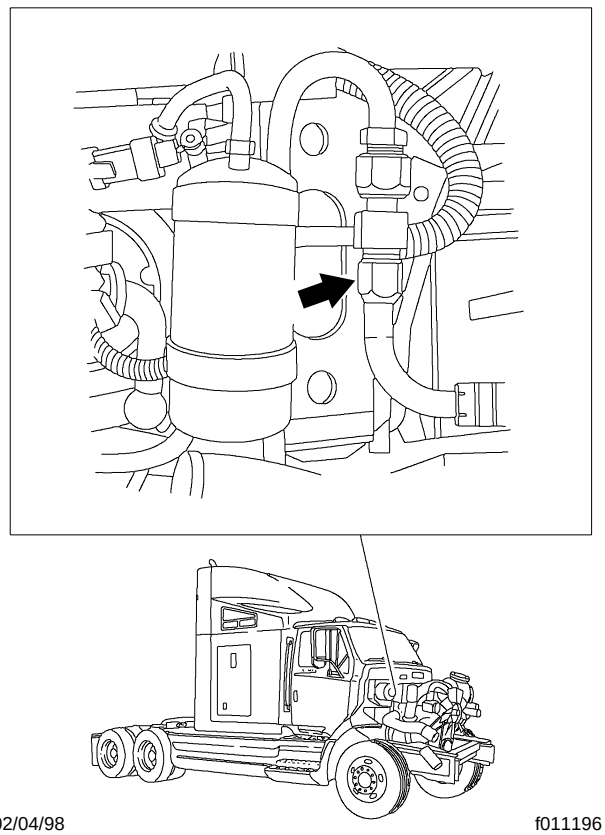

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Fig. 7, Refrigerant Line

17. Remove the bolts and the relay covers. See **Fig. 16**.
18. Label and disconnect the intake air heating grid relay electrical leads. See **Fig. 17**.
19. Disconnect the starter relay electrical leads and position aside. See **Fig. 18**.
    - 19.1 Remove the protective caps.
    - 19.2 Label and disconnect the starter relay electrical leads.
20. Remove the megafuse cover. See **Fig. 19**.
21. Disconnect the megafuse electrical lead and position it aside. See **Fig. 20**.
22. Disconnect the ground strap and position it aside. See **Fig. 21**.
23. Remove the megafuse cover. See **Fig. 22**.

ISB Engine Removal and Installation

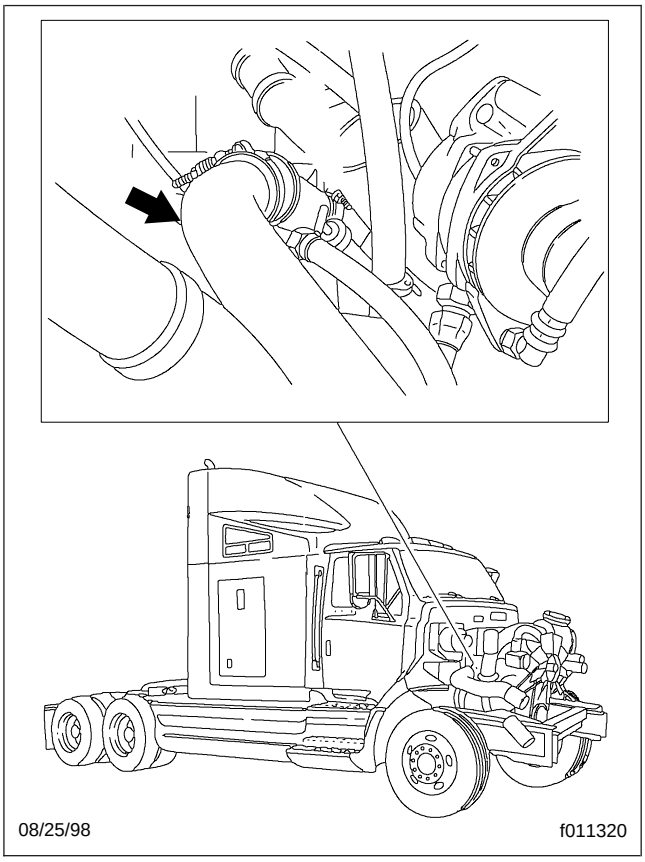


Fig. 8, Turbocharger Outlet Tube

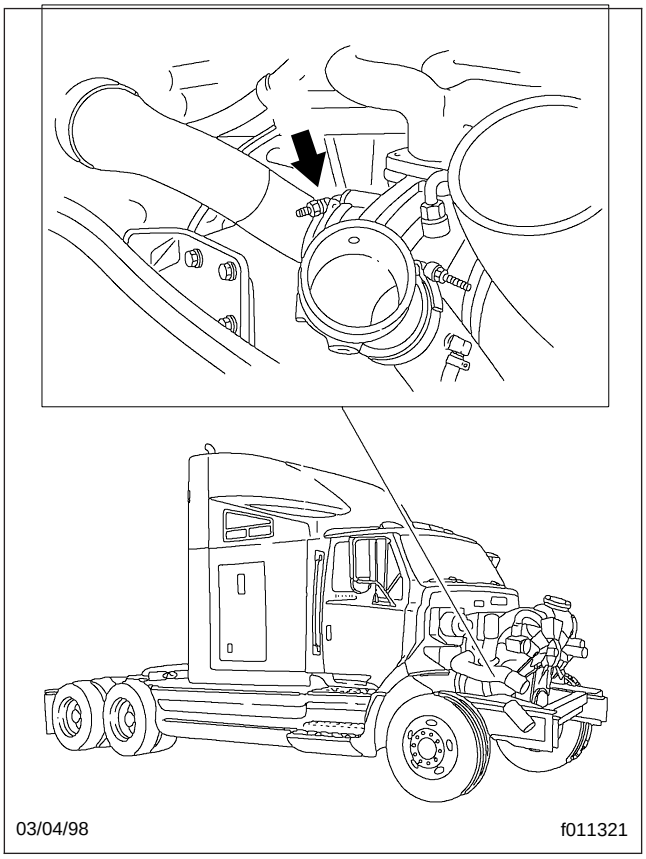


Fig. 9, Exhaust Tube

24. Disconnect the megafuse electrical lead and position it aside. See **Fig. 23**.
25. Disconnect the air compressor governor air lines and position them aside. See **Fig. 24**.
26. Disconnect the power steering high pressure line and position it aside. See **Fig. 25**.
27. Disconnect the power steering low pressure line and position it aside. See **Fig. 26**.
28. Disconnect the oil gauge line. See **Fig. 27**.
29. Remove the retaining clamp bolt. See **Fig. 28**.
30. Remove the retaining clamp and position the electrical wiring harness aside. See **Fig. 29**.
31. Remove the bolt. Disconnect the electrical connectors and position them aside. See **Fig. 30**.
32. Disconnect the electrical connector. See **Fig. 31**.
33. Remove the air compressor discharge line retaining clamp bolt. See **Fig. 32**.
34. Remove the air compressor discharge line and position it aside. See **Fig. 33**.

NOTE: If the vehicle is equipped with a manual transmission, then perform the next five steps.

35. Remove the gear shift assembly. Remove the screws and separate the shift lever boot from the floor. Refer to **Group 60** to remove interior trim as required. Remove the transmission floor cover plate if additional access is required.
36. If the vehicle is equipped with the Roadranger® air system, disconnect the vehicle air and the Roadranger air system at the transmission. Refer to **Group 26**.
37. Remove the shift lever assembly. See **Fig. 34**.
    - 37.1 Remove the capscrews.
    - 37.2 Position the shift lever assembly aside. Cover the hole in the shift control housing to prevent any contamination.

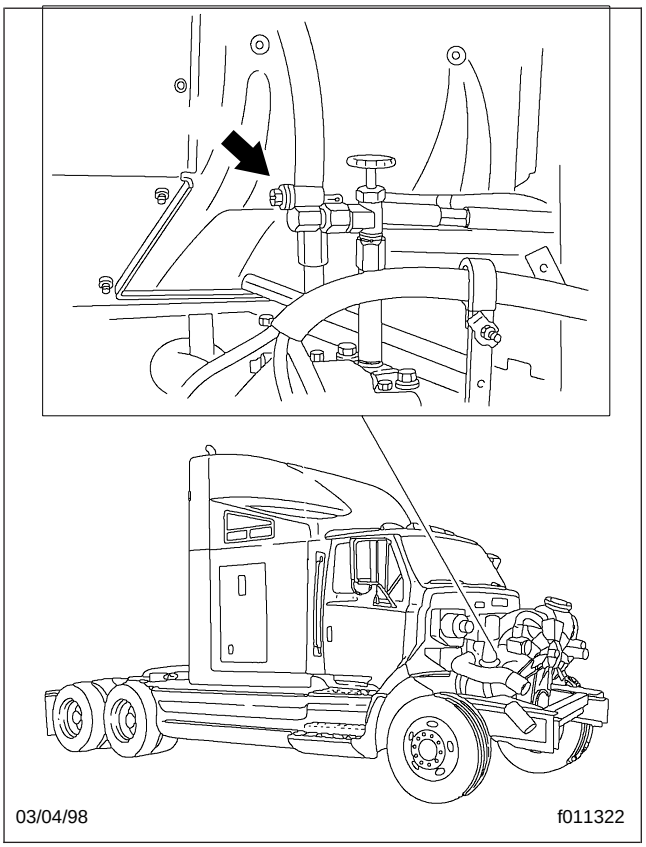


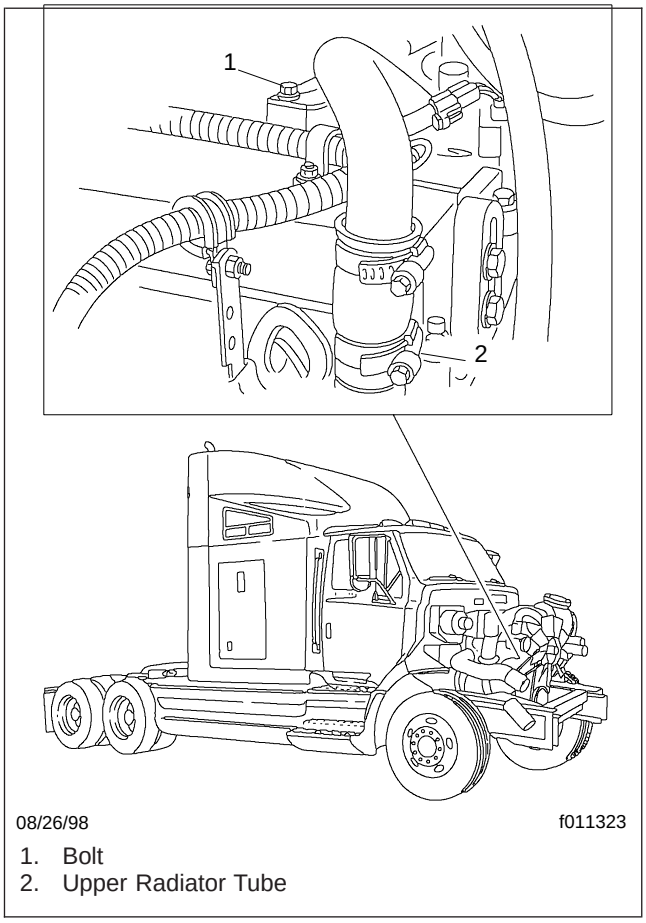
Fig. 10, Heater Water Hose

38. If the vehicle is equipped with a clutch cable, remove the three bolts from the clutch cable mounting bracket. See **Fig. 35**.
39. If the vehicle is equipped with a clutch linkage, remove the clutch linkage. See **Fig. 36**.
40. If the vehicle is equipped with an AT, HT, or MT series automatic transmission, disconnect the selector control cable. See **Fig. 37**.

NOTE: If the vehicle is equipped with an HD or MD series automatic transmission, then perform the next three steps.

41. Remove the interior trim and floor mat.
42. Remove the screws and the transmission floor cover plate.
43. Disconnect the electrical connectors. See **Fig. 38**.

NOTE: The HD series automatic transmission is shown, all others are similar.



1. Bolt
2. Upper Radiator Tube

Fig. 11, Upper Radiator Tube

44. If the vehicle is equipped with a transmission oil cooler, disconnect the transmission oil cooler lines. See **Fig. 39**.
    - Remove all retaining clamps.
    - Disconnect the transmission oil cooler lines.
45. If the vehicle is equipped with a single fuel tank, disconnect the fuel supply and return lines and position the fuel lines aside. See **Fig. 40**.
    - Remove any retaining clamps securing the fuel lines to the frame.
    - Note the location of the retaining clamps during removal.
46. If the vehicle is equipped with dual fuel tanks, disconnect the fuel supply and return lines. See **Fig. 41**.

ISB Engine Removal and Installation

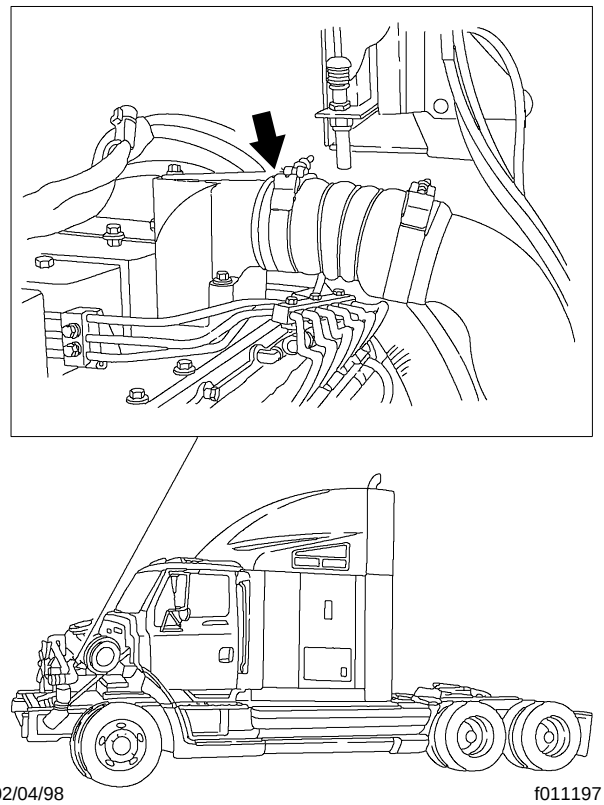
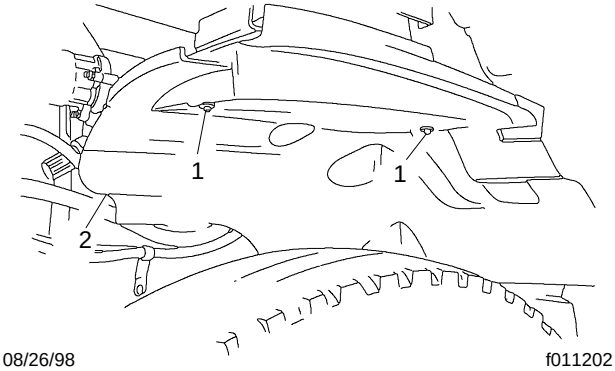


Fig. 12, Charge Air Cooler Outlet Tube



1. Screws (6 qty.)
2. Splash Shield

Fig. 13, Splash Shield

47. Disconnect the ground strap. See **Fig. 42**.
48. Label and disconnect the starter electrical leads and in-line electrical connectors. See **Fig. 43**.

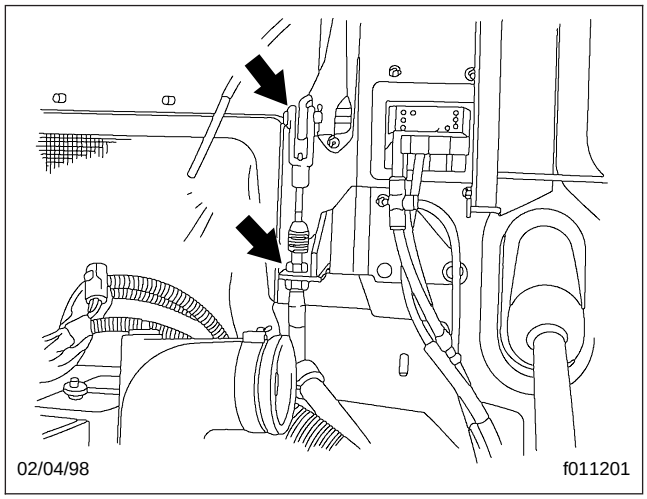
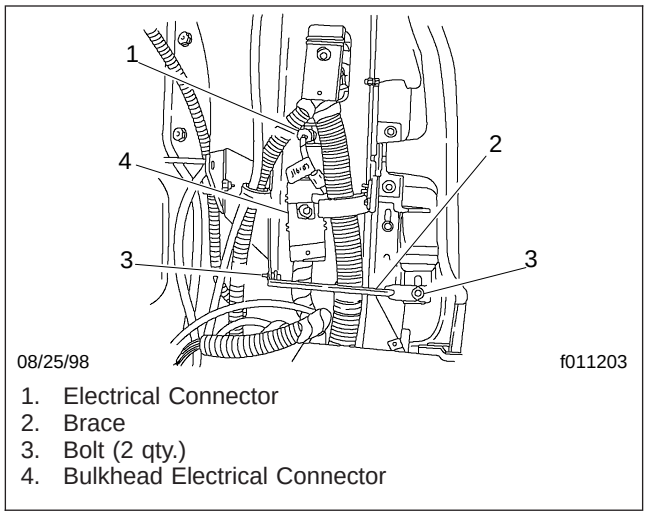


Fig. 14, Clutch Cable Linkage



1. Electrical Connector
2. Brace
3. Bolt (2 qty.)
4. Bulkhead Electrical Connector

Fig. 15, Electrical Connectors

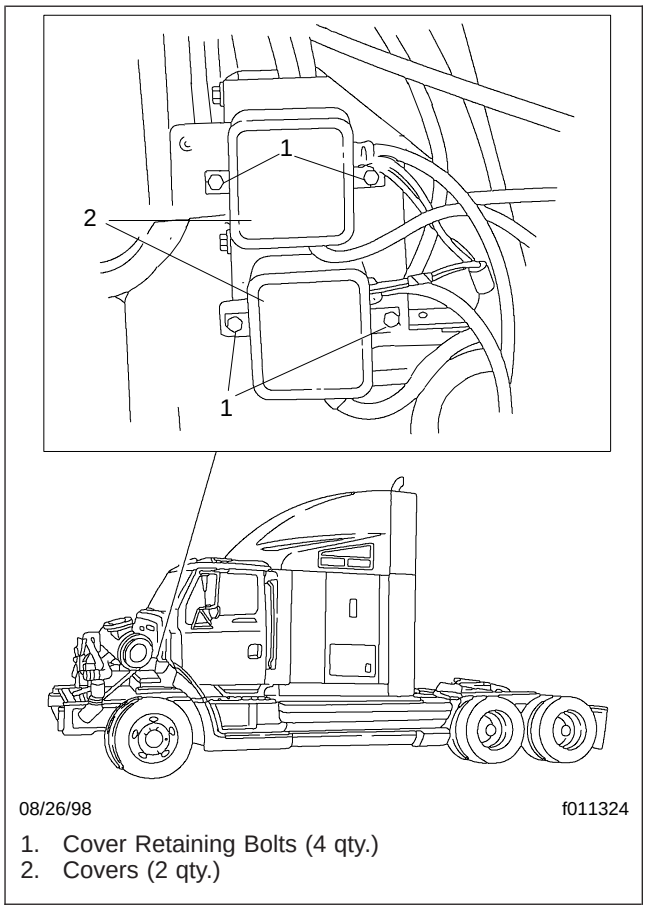
49. Remove the battery cable retaining clamps from the transmission. See **Fig. 44**.
50. Disconnect the driveshaft; refer to **Group 41**.

NOTE: The left-side rear support bracket is shown. The right-side is similar.

51. Remove four bolts, eight washers, four nuts and the two rear support brackets. See **Fig. 45**.
52. Support the powertrain assembly. See **Fig. 46**.

    Install the engine lifting equipment.

    - Use a suitable lifting chain connected to the two lifting eyes and lifting crane rated



1. Cover Retaining Bolts (4 qty.)
2. Covers (2 qty.)

Fig. 16, Relay Cover

at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.

- Position a suitable transmission jack under the transmission. Secure the transmission to the jack.

53. If the vehicle has a 101-inch BBC chassis, remove the nuts and flag bolts. See **Fig. 47**.
54. Remove the eight bolts, 16 washers, eight nuts and the No. 2 crossmember. See **Fig. 48**.
55. Move the powertrain assembly forward until the transmission jack reaches the front axle. Raise the powertrain assembly to gain access over the rear engine mount insulators.
56. Lower the engine and support the front engine mount. Use a suitable jack rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.
57. Remove the power steering line. See **Fig. 49**.

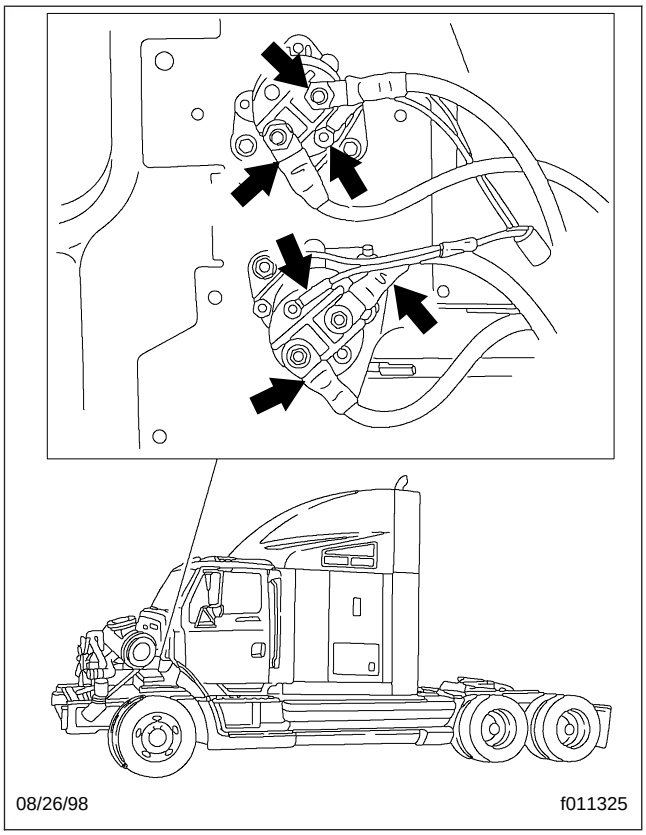
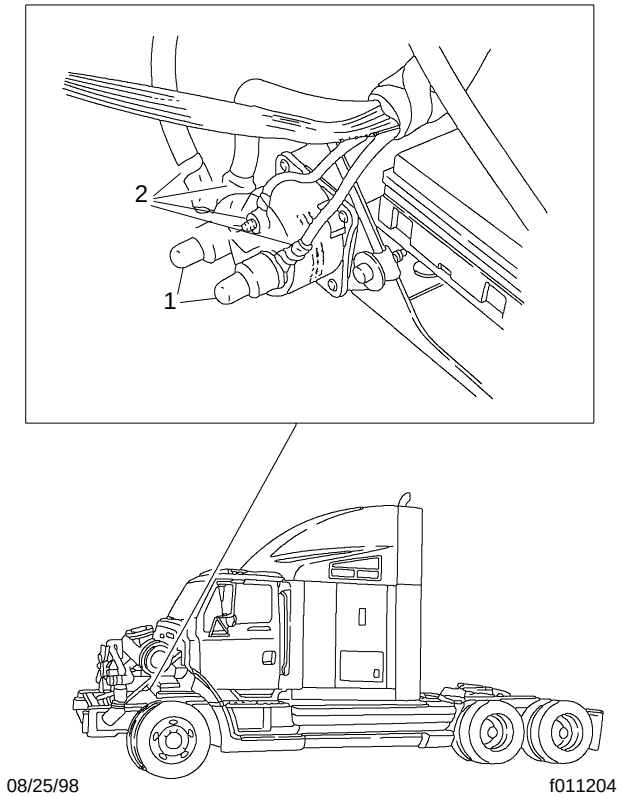


Fig. 17, Intake Air Heating Grid Electrical Leads

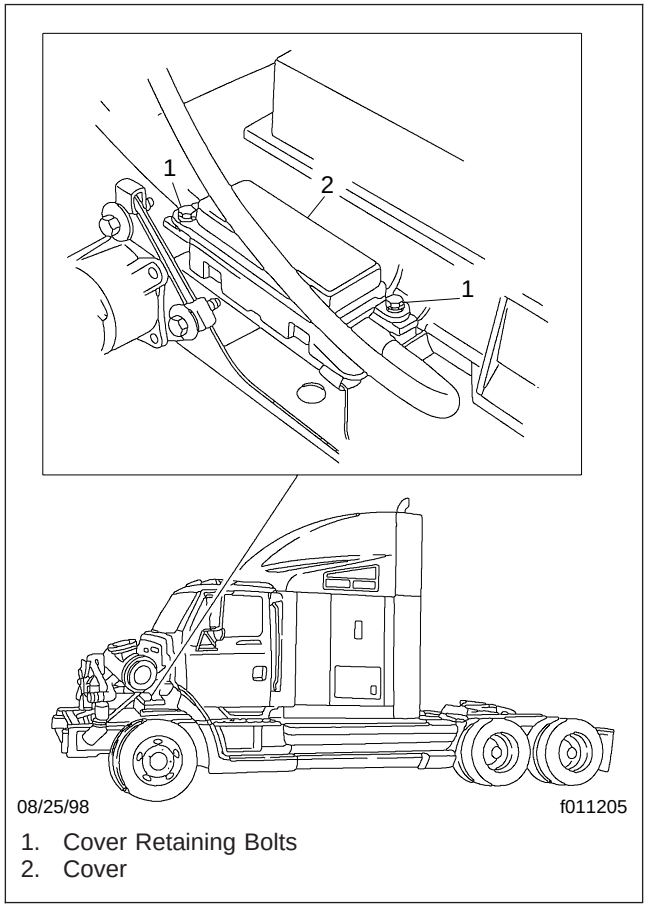
58. Remove the powertrain assembly from the vehicle.
    - 58.1 Remove the lifting chain. Install a load leveling engine sling. Use a suitable load leveling engine sling rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.
    - 58.2 Raise the engine.
    - 58.3 Remove the strap from the transmission.
    - 58.4 Level the powertrain assembly.
    - 58.5 Remove the transmission jack.
    - 58.6 Move the powertrain assembly out of the vehicle.
59. Support the powertrain assembly. See **Fig. 50**.
    - Use two suitable jack stands rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.

ISB Engine Removal and Installation



1. Protective Caps
2. Starter Relay Electrical Leads

Fig. 18, Starter Relay Electrical Leads



1. Cover Retaining Bolts
2. Cover

Fig. 19, Megafuse Cover

- Use a suitable transmission jack.

Installation

1. Raise the powertrain assembly and remove the jack stands and the transmission jack.

   Use a suitable load leveling sling and lifting crane rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.

IMPORTANT: Use care not to damage any engine components, lines, filters, and electrical wiring during installation of the powertrain assembly.

2. Move the powertrain assembly into the vehicle until the transmission is behind the front axle.
3. Support the powertrain assembly.

   3.1 Install a suitable transmission jack under the transmission.

   Secure the transmission to the jack.

   3.2 Lower the engine and support the front engine mount.

   Use two suitable jack stands rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer and a suitable length of wood with a minimum 4-inch (10 mm) x 6-inch (15 mm) dimension.

4. Install the power steering line. See **Fig. 49**.
5. Remove the load leveling sling and install a lifting chain.

   Use a suitable lifting chain rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer connected to the front lifting eye.

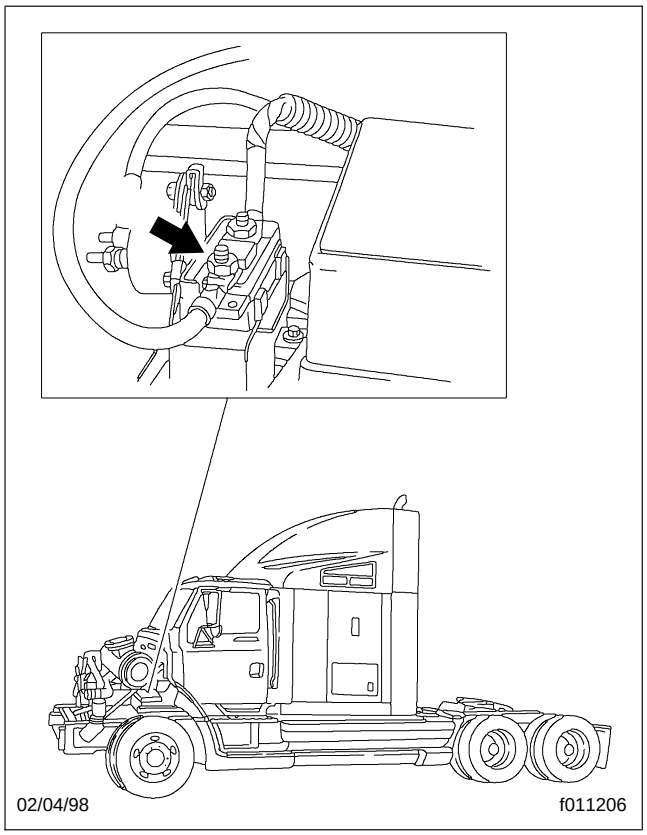


Fig. 20, Megafuse Electrical Lead

6. Move the powertrain assembly back to the rear engine mount insulators.
7. Install the No. 2 crossmember, eight bolts, 16 washers, and eight nuts. Tighten 75 to 105 lbf·ft (102 to 138 N·m). See **Fig. 48**.

   A suitable porta-power unit may be necessary to spread the frame side rails if the frame has settled.
8. If the vehicle has a 101-inch BBC chassis, install the bolts and flag nuts. Tighten 150 to 205 lbf·ft (204 to 277 N·m). See **Fig. 47**.
9. Remove the transmission jack and the engine lifting equipment.

NOTE: The left-side rear support bracket is shown. The right-side is similar.

10. Install the two rear support brackets, four bolts, eight washers and four nuts. Tighten 75 to 105 lbf·ft (102 to 138 N·m). See **Fig. 45**.

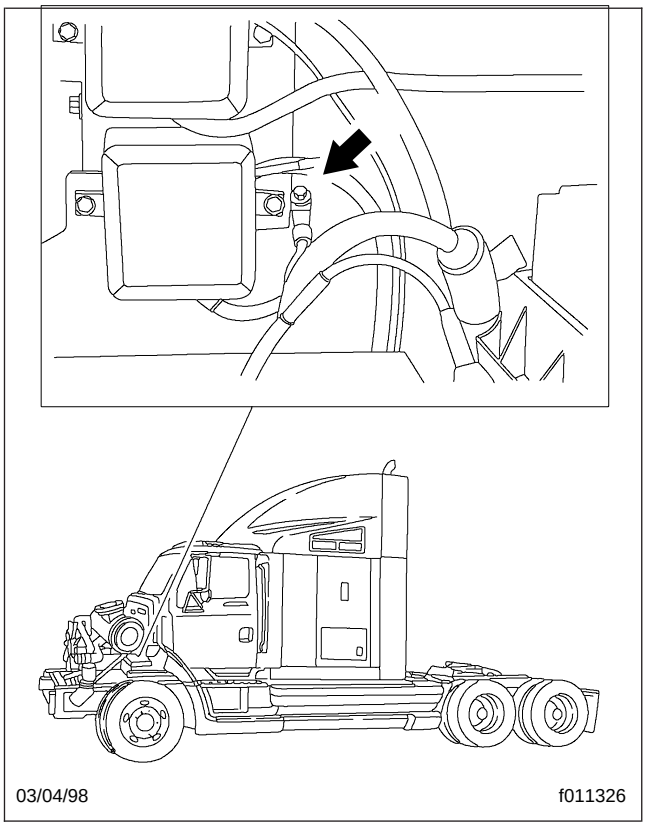


Fig. 21, Ground Strap

11. Connect the driveshaft. Refer to **Group 41**.
12. Install the battery clamps as noted during removal. See **Fig. 44**.
13. Connect the starter solenoid electrical leads and in-line electrical connectors. See **Fig. 43**.

    Apply Silicone Dielectric Compound or equivalent meeting specification ESE–M1C171–A to all of the starter motor electrical connections.
14. Connect the ground strap. See **Fig. 42**.
15. If the vehicle is equipped with dual fuel tanks, connect the fuel supply and return lines. See **Fig. 41**.
16. If the vehicle is equipped with a single fuel tank, connect the fuel supply and return lines. See **Fig. 40**.

    Install the retaining clamps as noted during removal.

ISB Engine Removal and Installation

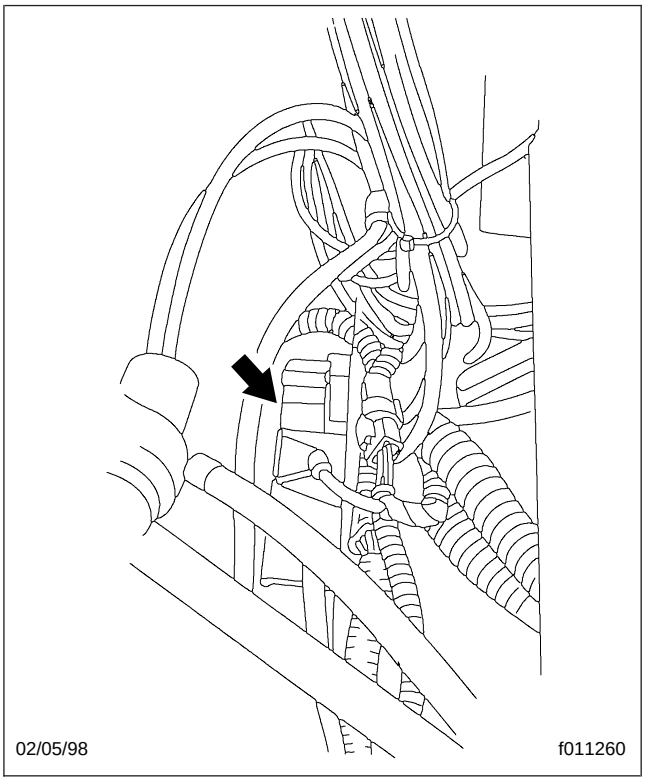


Fig. 22, Megafuse Cover

NOTE: The HD series automatic transmission is shown. All others are similar.

17. If the vehicle is equipped with a transmission oil cooler, connect the transmission oil cooler lines. See **Fig. 39**.
    - Connect the transmission oil cooler lines.
    - Install the retaining clamps.

NOTE: If the vehicle is equipped with an HD or MD series automatic transmission, then perform the next three steps.

18. Connect the electrical connectors. See **Fig. 38**.
19. Install the transmission floor cover plate and the screws.
20. Install the floor mat and interior trim. Refer to **Group 60**.
21. If the vehicle is equipped with an AT, HT or MT series automatic transmission, connect the selector cable. See **Fig. 37**.

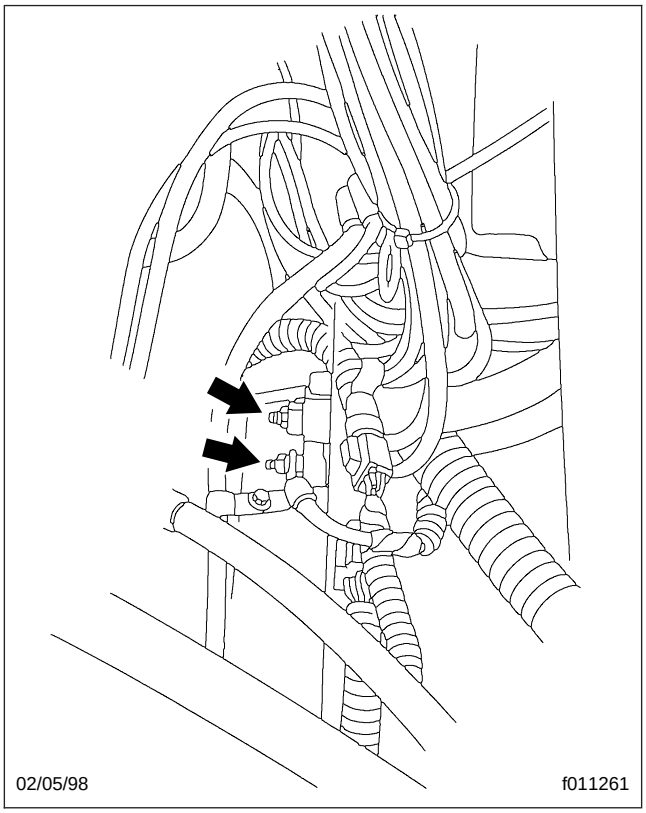


Fig. 23, Megafuse Electrical Lead

NOTE: If the vehicle is equipped with a manual transmission, then perform the next eight steps.

22. If the vehicle is equipped with a clutch linkage, install the clutch linkage. See **Fig. 36**.
23. If the vehicle is equipped with a clutch cable, install the clutch cable mounting bracket and three bolts. See **Fig. 35**.
24. Align the shift block and yoke notches in the neutral position. See **Fig. 51**.
25. Position the gasket on the shift control housing.
26. Position the shift lever housing.

    Fit the shift lever into the shift block and yoke notches. See **Fig. 52**.
27. Install the capscrews. See **Fig. 34**.

    Use Threadlock®and Sealer or equivalent meeting specification WSK–M2G315–A5 on the threads.

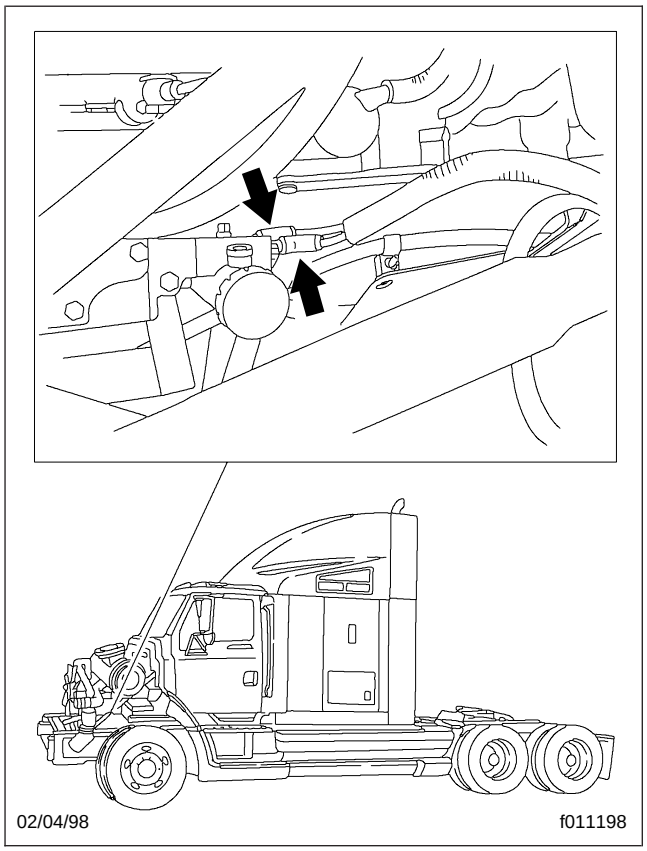


Fig. 24, Air Compressor Governor Air Lines

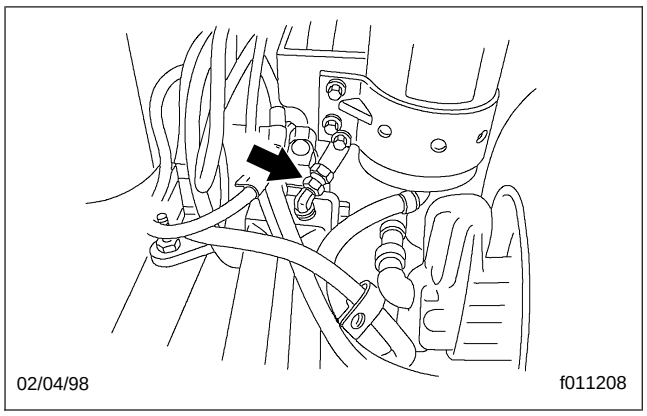


Fig. 25, Power Steering High Pressure Line

28. If the vehicle is equipped with the Roadranger® air system, connect the vehicle air and the Roadranger air system to the transmission. Refer to **Group 26**.
29. Install the shift lever boot.

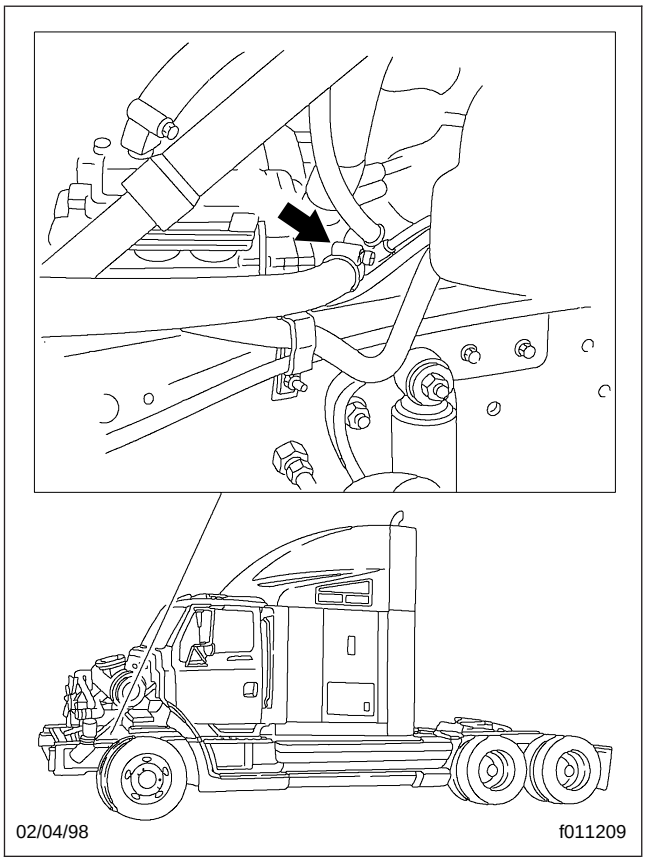


Fig. 26, Power Steering Low Pressure Line

If removed, install the transmission floor cover plate and interior trim. Refer to **Group 60**.

30. Connect the air compressor discharge line. See **Fig. 33**.
31. Install the air compressor discharge line clamp bolt. See **Fig. 32**.
32. Connect the electrical connector. See **Fig. 31**.
33. Connect the electrical connectors. Install the bolt. See **Fig. 30**.
34. Route the wiring harness and install the retaining clamp bolt. See **Fig. 29**.
35. Install the retaining clamp bolt. See **Fig. 28**.
36. Connect the engine oil pressure gauge line. See **Fig. 27**.
37. Connect the power steering low pressure line. See **Fig. 26**.

ISB Engine Removal and Installation

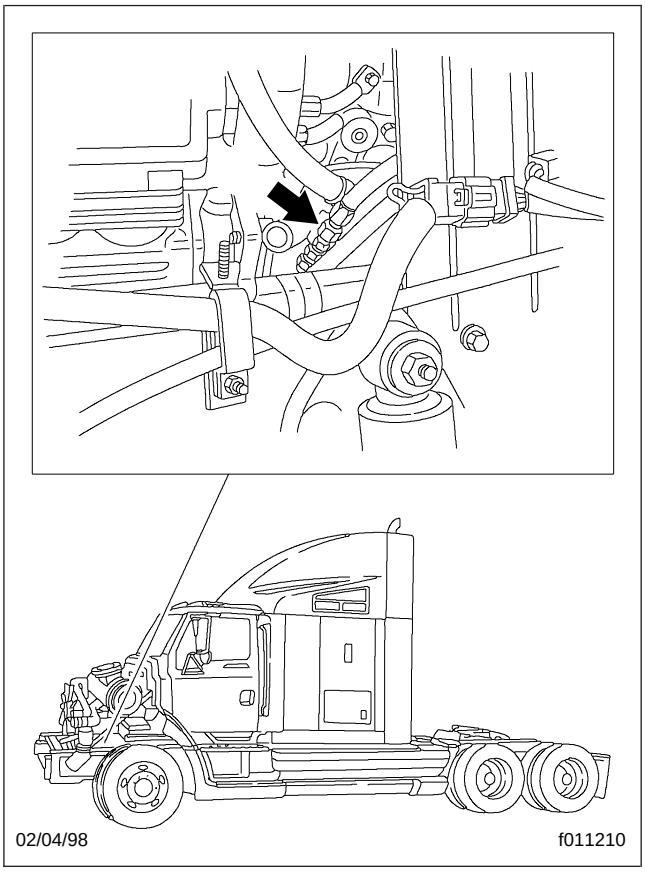


Fig. 27, Oil Gauge Line

38. Connect the power steering high pressure line. See **Fig. 25**.
39. Connect the megafuse electrical lead. See **Fig. 23**.
40. Install the megafuse cover. See **Fig. 22**.
41. Connect the air compressor governor air lines. See **Fig. 24**.
42. Connect the ground strap. See **Fig. 21**.
43. Connect the megafuse electrical lead. See **Fig. 20**.
44. Install the megafuse cover. See **Fig. 19**.
45. Connect the starter relay electrical leads. See **Fig. 18**.
    - 45.1 Connect the starter relay electrical leads to the terminals noted during removal.
    - 45.2 Install protective caps.

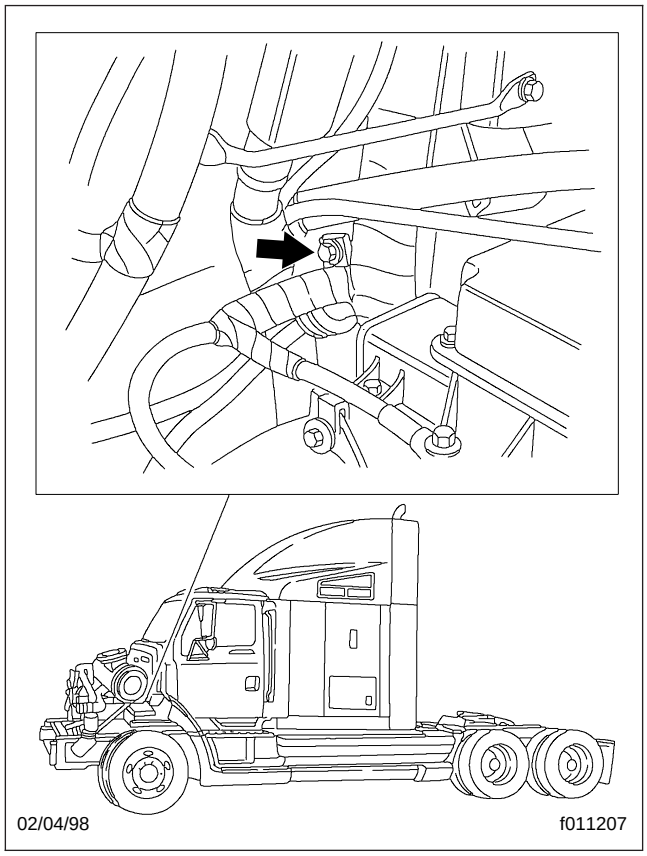


Fig. 28, Retaining Clamp Bolt

46. Connect the intake air heating grid relay electrical leads as noted during removal. See **Fig. 17**.
47. Install the relay covers and bolts. See **Fig. 16**.
48. Connect the electrical connectors. See **Fig. 15**.
    - 48.1 Connect the electrical connector.
    - 48.2 Connect the bulkhead electrical connector.
    - 48.3 Position the brace.
    - 48.4 Install and tighten the nuts and bolts.
49. If the vehicle is equipped with a manual transmission, connect the clutch cable. See **Fig. 14**.
50. Install the left-side splash shield and six screws. See **Fig. 13**.
51. Install the charge air outlet tube. See **Fig. 12**.
52. Install the upper radiator tube and bolt. See **Fig. 11**.
53. Connect the heater water hose. See **Fig. 10**.

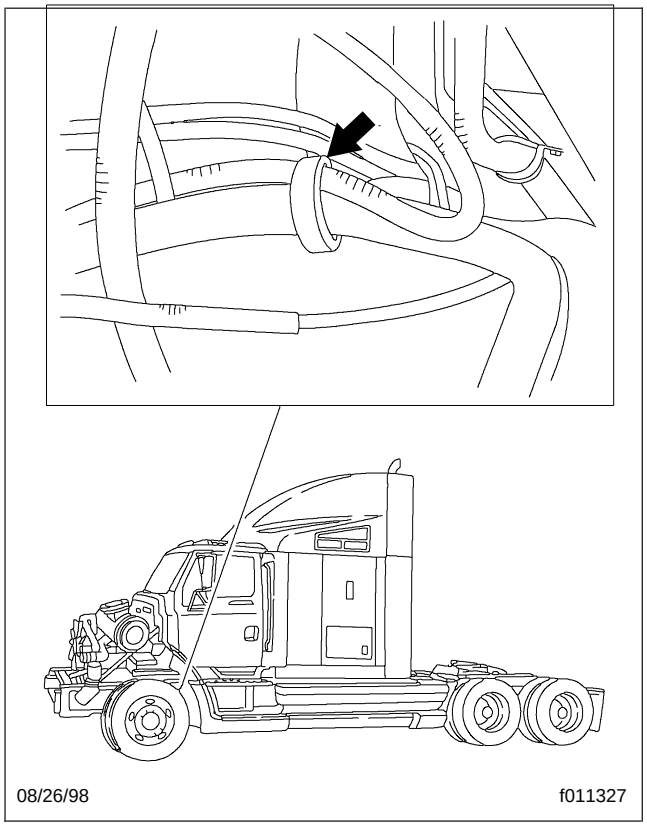


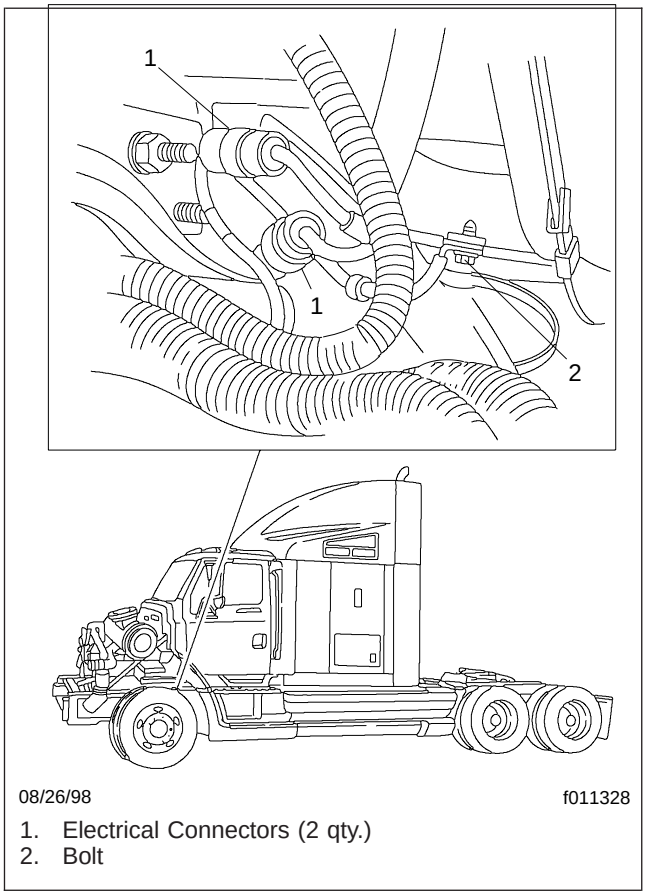
Fig. 29, Retaining Clamp

54. Install the exhaust outlet tube. See **Fig. 9**.
55. Install the turbocharger outlet tube. See **Fig. 8**.
56. Connect the refrigerant line. See **Fig. 7**.

    Install a new captured O-ring lubricated with clean Heavy Truck PAG Oil or equivalent meeting specification EST–M1C231–B2.
57. If the vehicle has a 113- to 122-inch BBC chassis, install the No. 1 crossmember, two bumper brackets, four bolts, eight washers and four nuts. See **Fig. 6**.

NOTE: If the vehicle has a 101-inch BBC chassis, then perform the next two steps.

58. Install the top two No. 1 crossmember gussets, four bolts, eight washers and four nuts. See **Fig. 5**.
59. Install the No. 1 crossmember and eight bolts, 16 washers and eight nuts. See **Fig. 4**.



1. Electrical Connectors (2 qty.)
2. Bolt

Fig. 30, In-Line Electrical Connectors

NOTE: The steering gear is shown. The rotary assist cylinder is similar.

60. If the vehicle is equipped with dual steering gears, route the power steering lines and connect the power steering lines to the steering gear and rotary assist cylinder. See **Fig. 3**.

NOTE: The brake valves shown are for a 2-channel ABS system. All other configurations are similar.

61. Connect the air valve assembly. See **Fig. 2**.
    - Connect the air lines.
    - Connect the electrical connector.
    - Install the retaining clamp bolts.
62. If the vehicle is equipped with front pintle hooks, install the two pintle hooks, six bolts, 10 washers

ISB Engine Removal and Installation

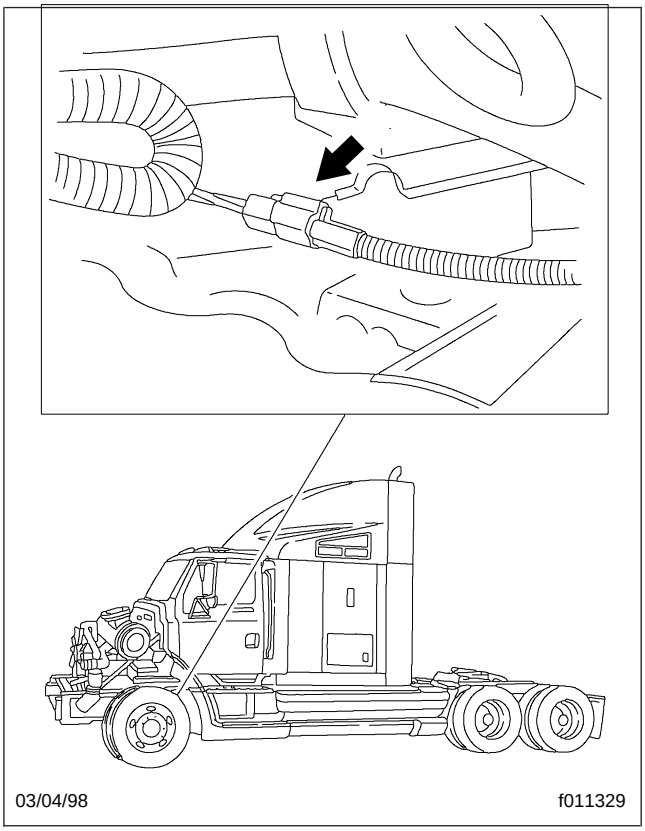


Fig. 31, Electrical Connector

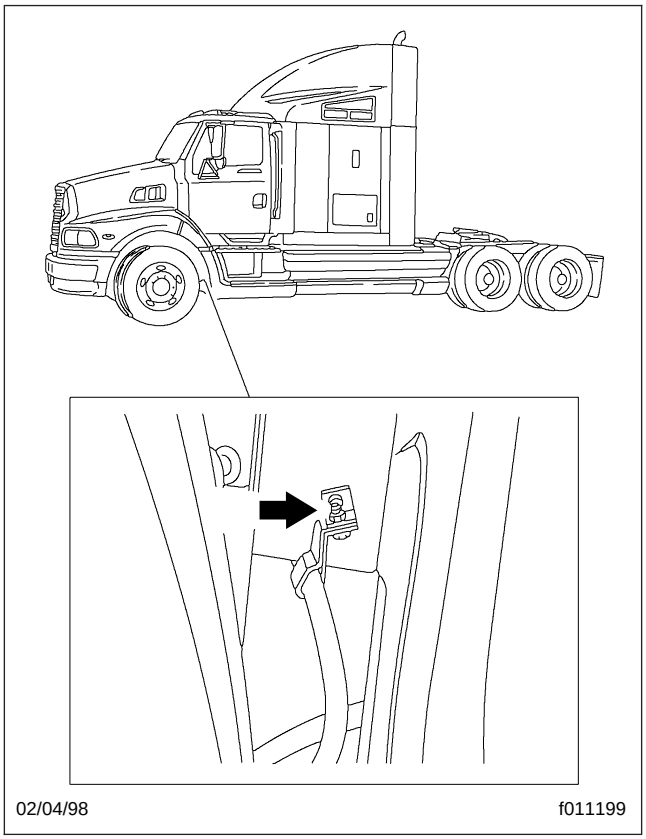


Fig. 32, Retaining Clamp Bolt

and four nuts. Tighten 220 to 300 lbf·ft (298 to 406 N·m). See **Fig. 1**.

63. Restore the vehicle to operating condition.
    - 63.1 Install the air intake tube and air cleaner assembly as an assembly. Refer to **Group 09**.
    - 63.2 Install the cooling module. Refer to **Group 20**.
    - 63.3 If the vehicle is equipped with a transmission cooler or an automatic transmission, fill the transmission oil. Refer to the appropriate **Group 26** transmission section.
    - 63.4 Fill the engine with oil.
    - 63.5 Fill the engine cooling system; refer to **Group 20**.
    - 63.6 Repressurize the air system with clean, dry air.
    - 63.7 If the vehicle is equipped with an A/C system, evacuate, charge and leak test the A/C system; refer to **Group 83**.
    - 63.8 Check the engine drive belts for proper adjustment.
    - 63.9 Check the accelerator and hand throttle linkages for proper adjustment; refer to **Group 30**.
    - 63.10 Check the transmission cables and linkages for proper adjustment. Refer to the appropriate **Group 26** transmission section.
    - 63.11 Check the clutch cables and linkages for proper adjustment; refer to **Group 25**.
    - 63.12 Connect the battery ground cables.
    - 63.13 Start the engine and check the powertrain assembly for leaks.

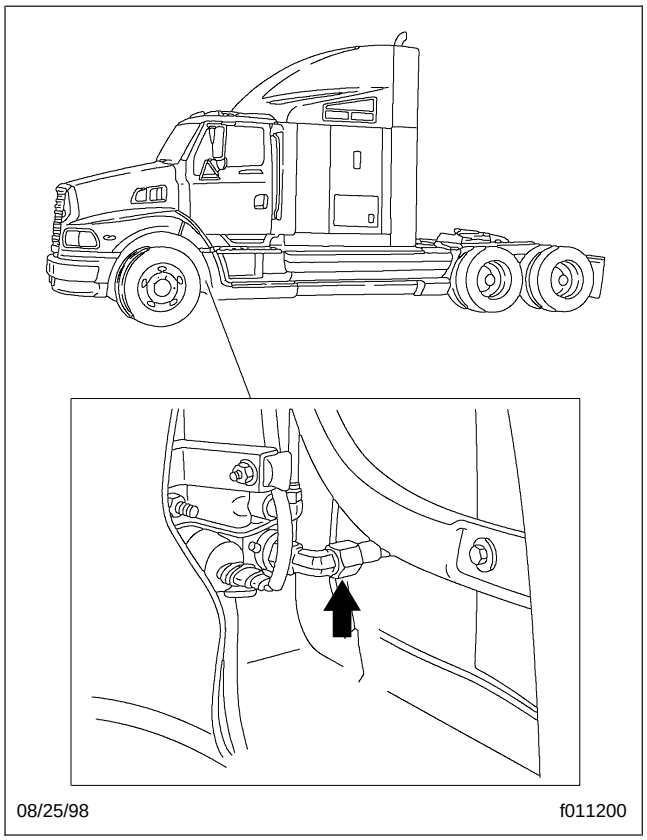
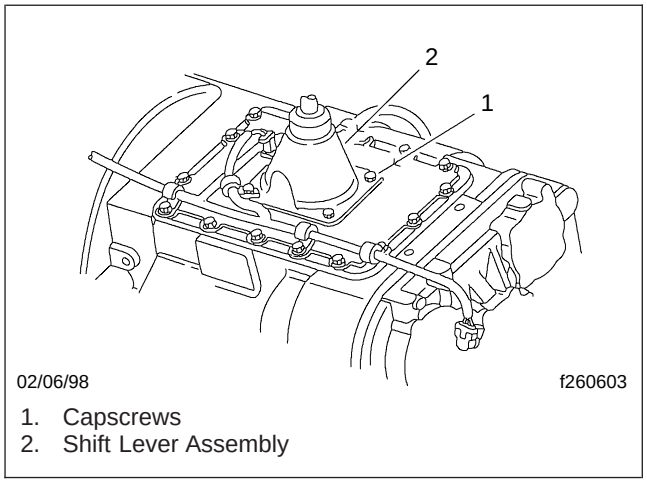


Fig. 33, Air Compressor Discharge Line



1. Capscrews
2. Shift Lever Assembly

Fig. 34, Shift Lever Assembly

63.14 Install the engine cover; refer to **Group 60**.

63.15 Install the hood; refer to **Group 88**.

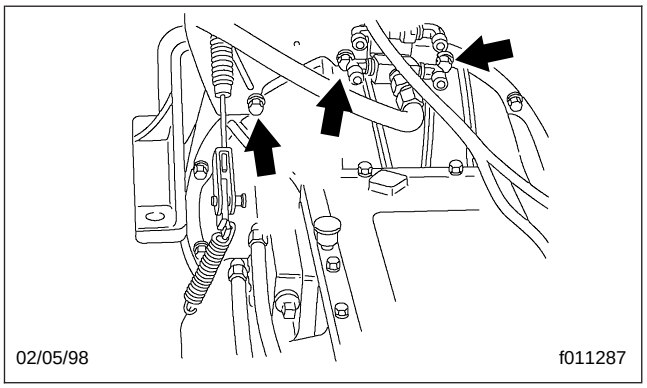


Fig. 35, Clutch Cable Mounting Bracket

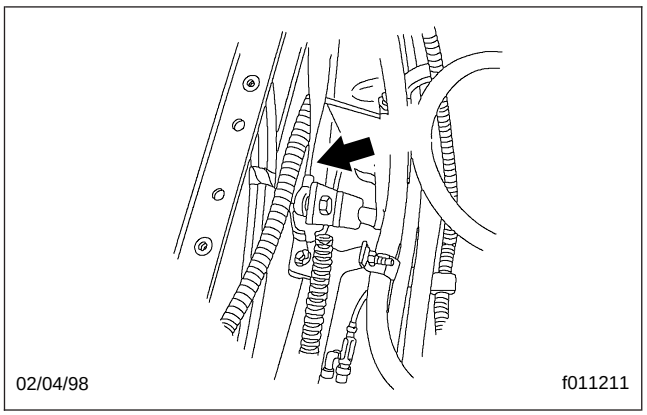


Fig. 36, Clutch Linkage

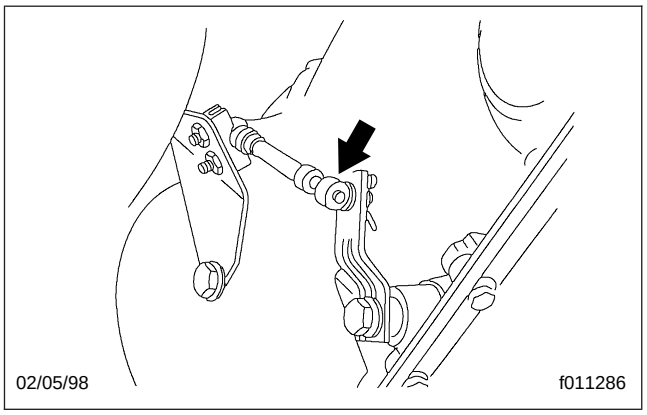


Fig. 37, Selector Control Cable

63.16 Install the bumper; refer to **Group 31**.

ISB Engine Removal and Installation

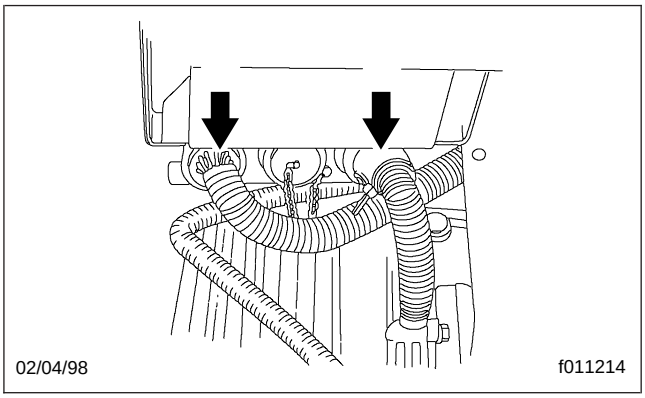


Fig. 38, Electrical Connectors

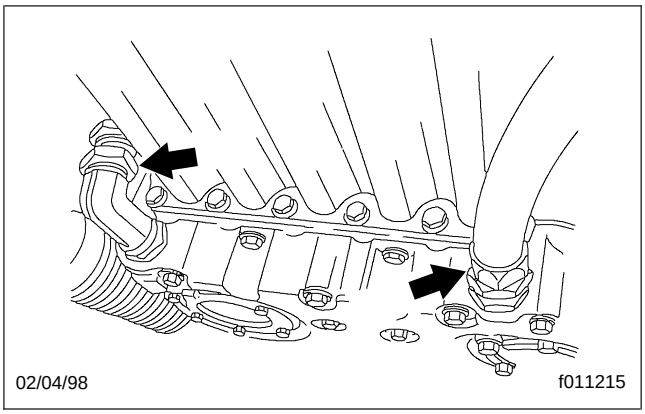


Fig. 39, Transmission Cooler Lines

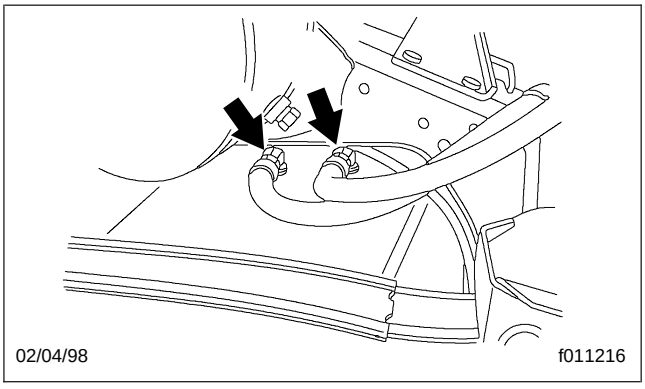


Fig. 40, Fuel Lines, Single Fuel Tank

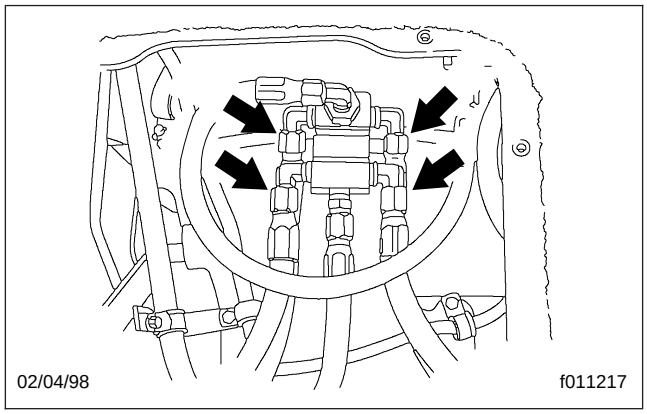


Fig. 41, Fuel Lines, Dual Fuel Tanks

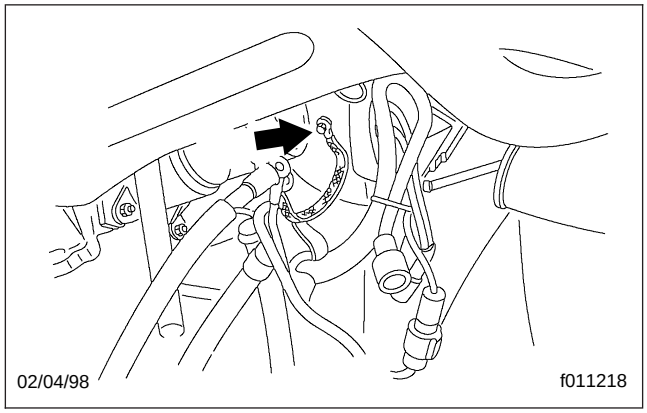
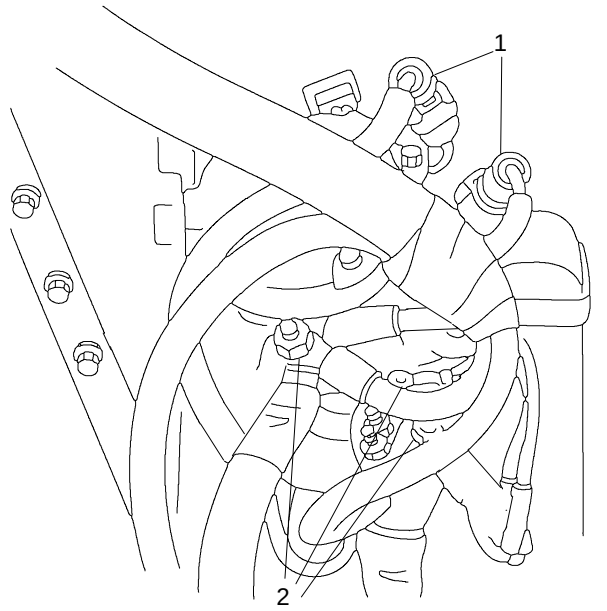


Fig. 42, Ground Strap



1. In-Line Electrical Connector (2 qty.)
2. Starter Electrical Leads

Fig. 43, Starter Electrical Leads

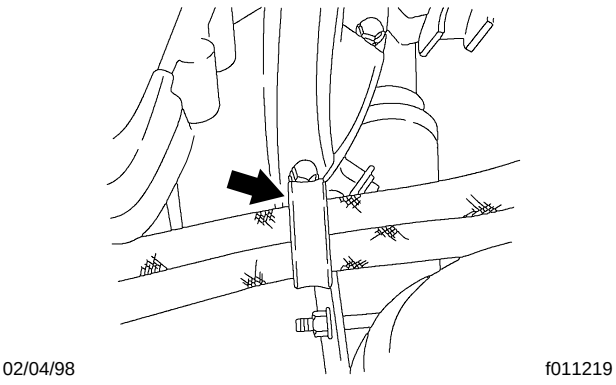


Fig. 44, Battery Cable Retaining Clamp

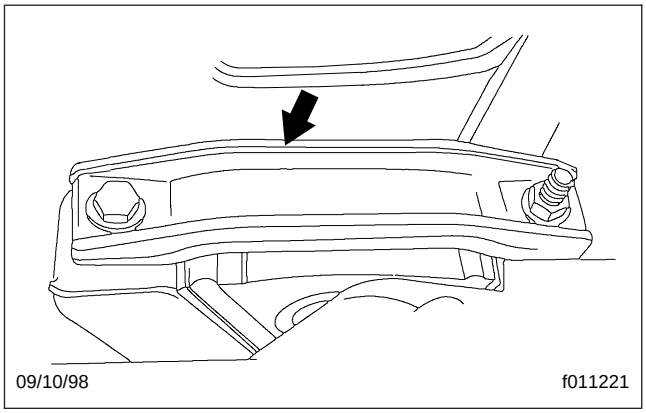


Fig. 45, Rear Support Bracket

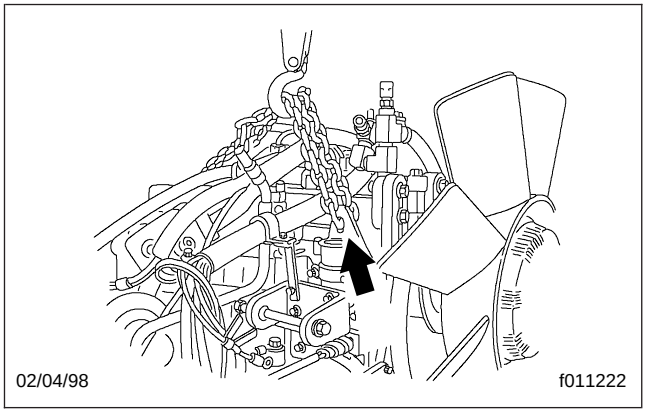


Fig. 46, Supporting the Powertrain Assembly

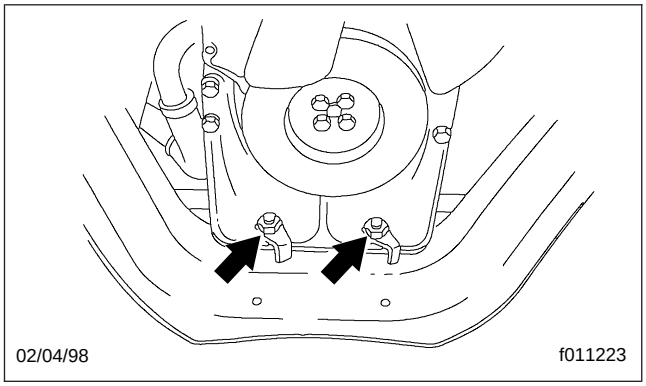
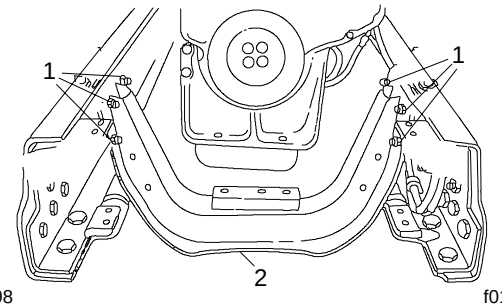


Fig. 47, Flag Bolt and Nut Assembly

ISB Engine Removal and Installation



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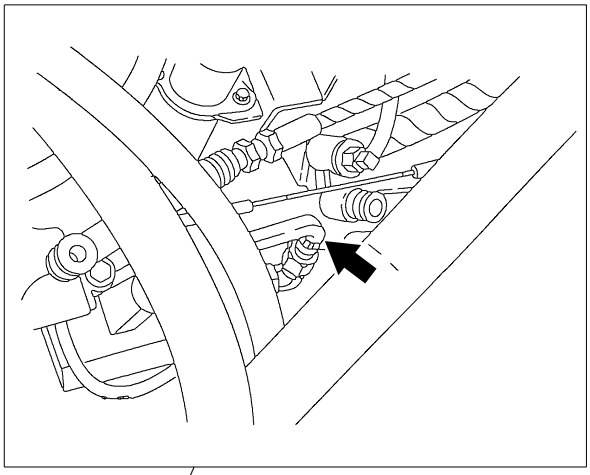
1. Bolts (8 qty.)
2. No. 2 Crossmember

Fig. 48, No. 2 Crossmember



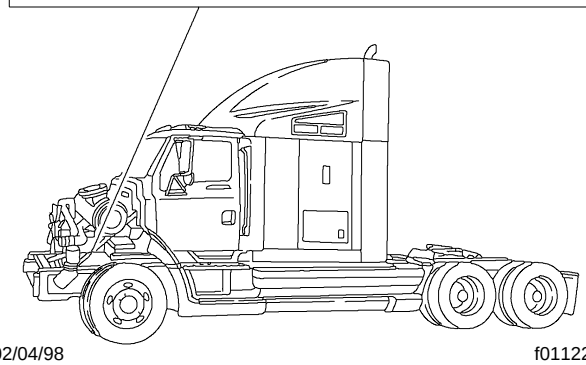


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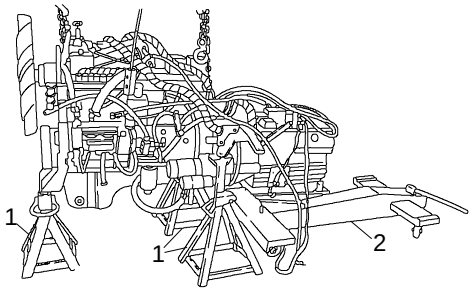
Fig. 49, Power Steering Line



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1. Jack Stand
2. Floor Jack

Fig. 50, Supporting the Powertrain Assembly

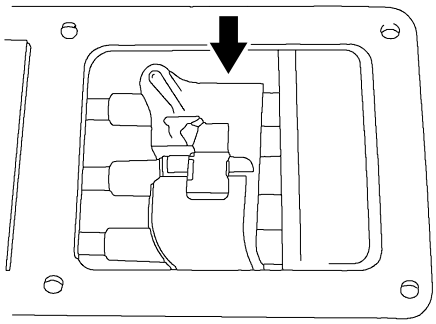

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Fig. 51, Aligning the Shift Block and Yoke

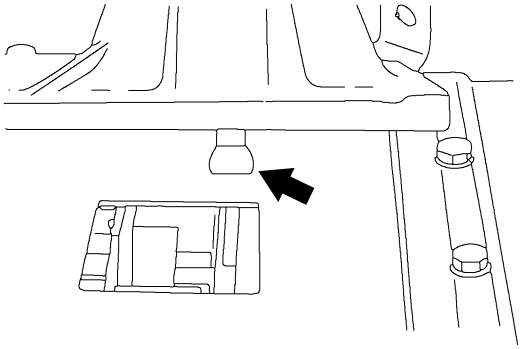

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Fig. 52, Positioning the Shift Lever

Removal

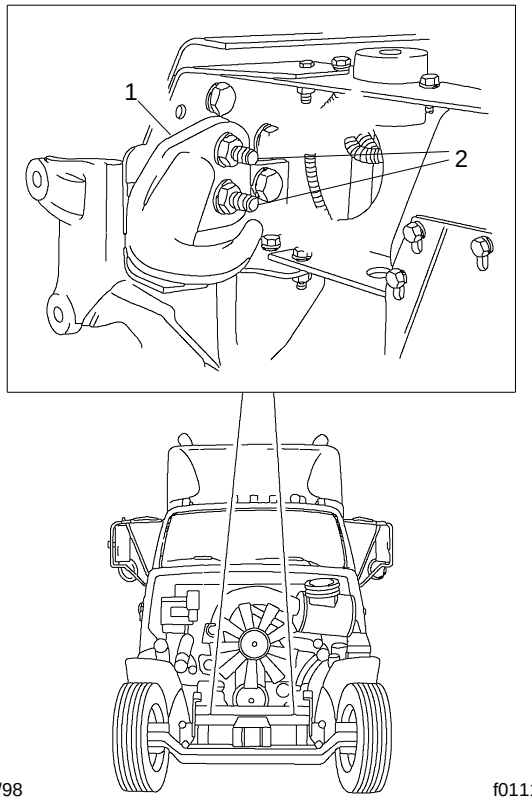
1. Prepare the vehicle for engine removal.
   - 1.1 Disconnect the battery ground cable(s).
   - 1.2 Remove the bumper. Refer to **Group 31**.
   - 1.3 Remove the hood. Refer to **Group 88**.
   - 1.4 Drain the engine cooling system. Refer to **Group 20**.
   - 1.5 Drain the engine oil.
   - 1.6 If the vehicle is equipped with an A/C system, recover the refrigerant. Refer to **Group 83**.
   - 1.7 If the vehicle is equipped with a transmission cooler or an automatic transmission, drain the transmission oil. Refer to the appropriate **Group 26** transmission section.
   - 1.8 Drain the air system.
   - 1.9 Remove the cooling module. Refer to **Group 20**.
   - 1.10 Remove the air intake tube and air cleaner assembly as an assembly. Refer to **Group 09**.
   - 1.11 Remove the engine cover. Refer to **Group 60**.
2. If the vehicle is equipped with front pintle hooks, remove six bolts, 10 washers, four nuts and two pintle hooks. See **Fig. 1**.

NOTE: The brake valves shown are for a 2-channel ABS system. All other configurations are similar.

3. Isolate the brake valves on the No. 1 crossmember. See **Fig. 2**.
   - 3.1 Remove the retaining clamp bolts.
   - 3.2 Disconnect the electrical connector.
   - 3.3 Label and disconnect the four air lines.

NOTE: The steering gear is shown, the rotary assist cylinder is similar.

4. If the vehicle is equipped with dual steering gears, disconnect the power steering lines from the steering gear and the rotary assist cylinder. Remove the power steering lines. See **Fig. 3**.



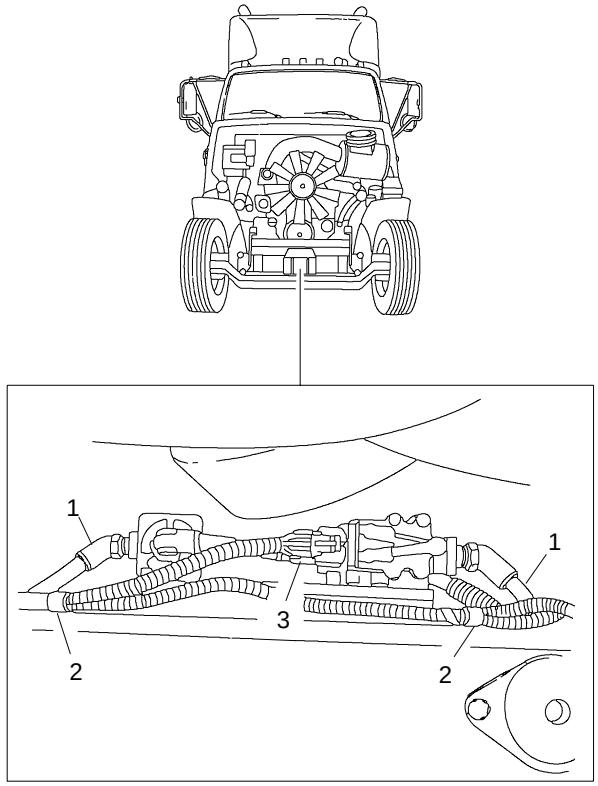
1. Pintle Hook
2. Bolt

Fig. 1, Pintle Hook

NOTE: If the vehicle has a 101-inch BBC chassis, perform the next two steps.

5. Remove the eight bolts, 16 washers, eight nuts and the No. 1 crossmember. See **Fig. 4**.
6. Remove the four nuts, eight washers, four bolts and the top two No. 1 crossmember gussets. See **Fig. 5**.
7. If the vehicle has a 113- to 122-inch BBC chassis, remove the four bolts, eight washers, four nuts, two bumper brackets and the No. 1 crossmember. See **Fig. 6**.
8. Disconnect the refrigerant line. Plug and cap the open lines and fittings. See **Fig. 7**.
9. Remove the turbocharger outlet tube. See **Fig. 8**.

ISC Engine Removal and Installation



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1. Air Line
2. Retaining Clamp
3. Electrical Connector

Fig. 2, Brake Valves

10. Disconnect the exhaust outlet tube. See **Fig. 9**.
11. Remove the lower radiator tube. See **Fig. 10**.
12. Loosen the hose clamp. See **Fig. 11**.
13. Disconnect the heater water hose. See **Fig. 12**.
14. Remove the cooling fan. Refer to **Group 20**.
15. Disconnect the fan clutch air line. See **Fig. 13**.
16. Remove the bolts. Position the fan clutch air line aside. See **Fig. 14**.
17. Remove the charge air cooler outlet tube. See **Fig. 15**.
18. Remove the bolt and the upper radiator tube. See **Fig. 16**.

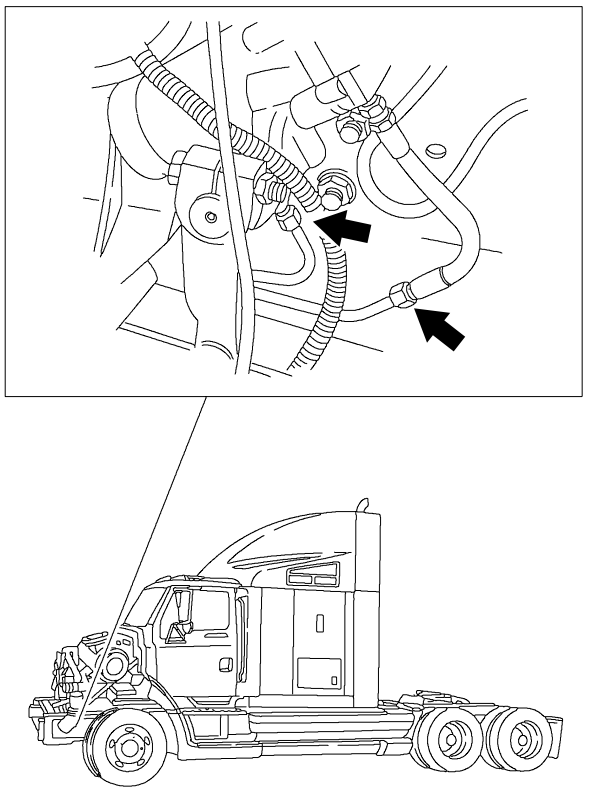

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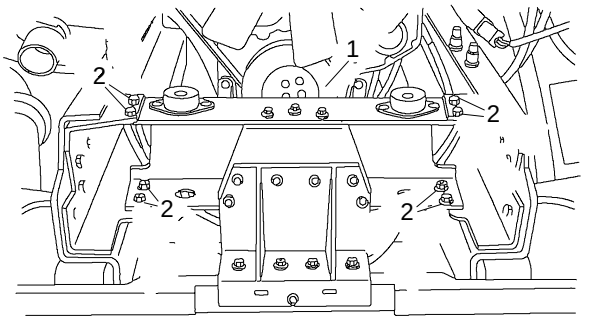
Fig. 3, Power Steering Lines



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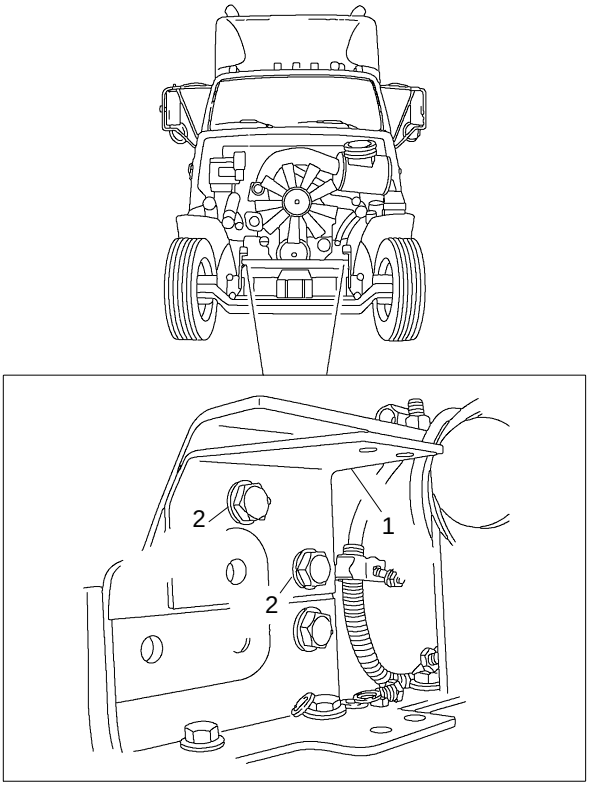
1. No. 1 Crossmember
2. Bolt (8 qty.)

Fig. 4, No. 1 Crossmember

19. Remove the six screws and the left-side splash shield. See **Fig. 17**.



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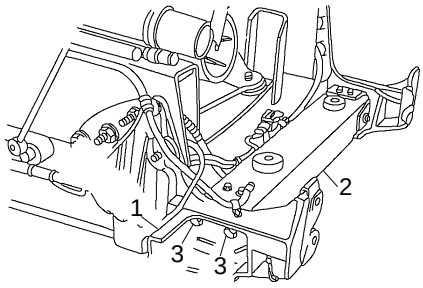
1. No. 1 Crossmember Gusset
2. Bolt

Fig. 5, No. 1 Crossmember Gusset



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1. Bumper Bracket
2. No. 1 Crossmember
3. Bolt (4 qty.)

Fig. 6, Bumper Bracket

20. If the vehicle is equipped with a manual transmission, disconnect the clutch cable or linkage and position it aside. See **Fig. 18**.

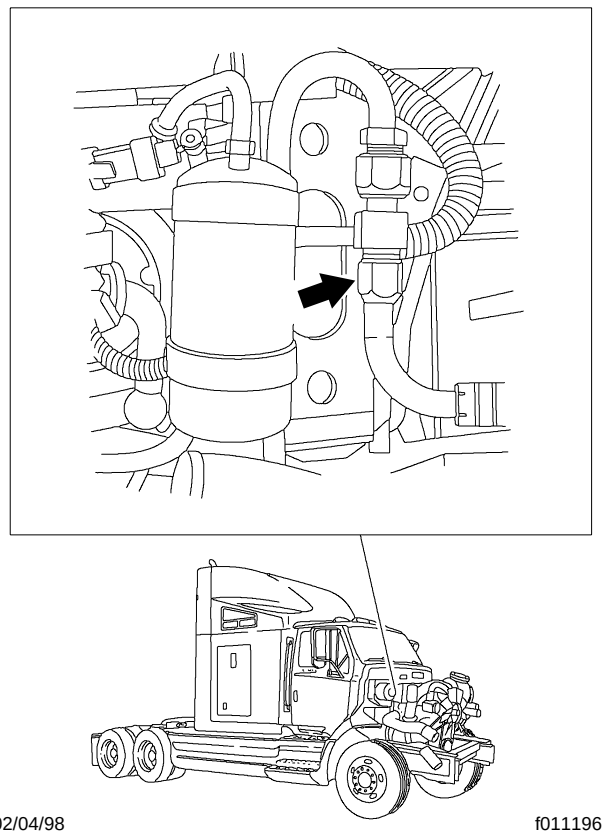

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Fig. 7, Refrigerant Line

21. Disconnect the starter relay electrical leads and position aside. See **Fig. 19**.
    - 21.1 Remove the protective caps.
    - 21.2 Label and disconnect the starter relay electrical leads.
22. Disconnect the two electrical connectors. See **Fig. 20**.
    - 22.1 Remove the bolt and nut.
    - 22.2 Loosen the bolt and nut.
    - 22.3 Position the brace aside.
    - 22.4 Disconnect the bulkhead connector and position aside.
    - 22.5 Disconnect the electrical connector and position aside.
23. Disconnect the ground strap and position it aside. See **Fig. 21**.

ISC Engine Removal and Installation

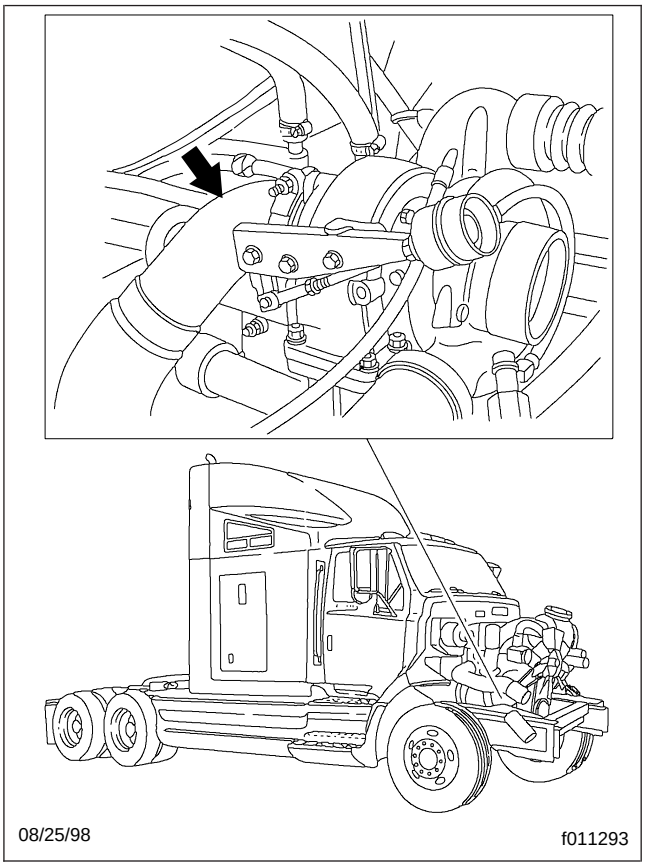


Fig. 8, Turbocharger Outlet Tube

24. Remove the megafuse cover. See **Fig. 22**.
25. Disconnect the megafuse electrical lead and position it aside. See **Fig. 23**.
26. Disconnect the air compressor discharge and governor air lines and position them aside. See **Fig. 24**.
27. Disconnect the power steering low and high pressure lines and position them aside. See **Fig. 25**.
28. Disconnect the engine oil pressure gauge line. See **Fig. 26**.
29. If the vehicle is equipped with a single fuel tank, label and disconnect the fuel lines and position them aside. See **Fig. 27**.
30. Disconnect the electrical connectors. See **Fig. 28**.
31. Remove the retaining clamp. See **Fig. 29**.

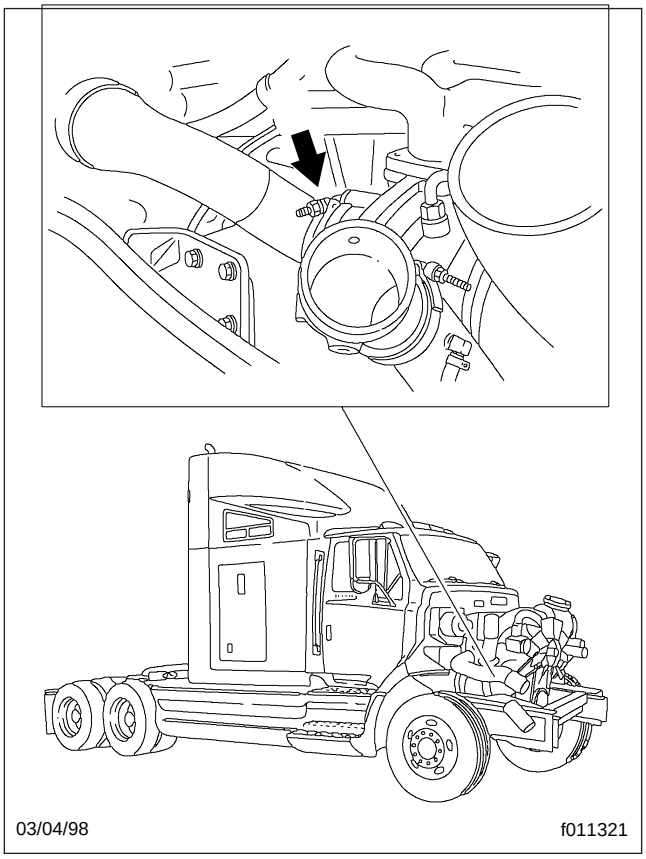


Fig. 9, Exhaust Outlet Tube

NOTE: If the vehicle is equipped with a manual transmission, then perform the next four steps.

32. Remove the gear shift assembly. Remove the screws and separate the shift lever boot from the floor. Refer to **Group 60** to remove interior trim as required. Remove the transmission floor cover plate if additional access is required.
33. If the vehicle is equipped with the Roadranger® air system, disconnect the vehicle air and the Roadranger air system at the transmission. Refer to **Group 26**.
34. Remove the shift lever assembly. See **Fig. 30**.
    - 34.1 Remove the capscrews.
    - 34.2 Position the shift lever assembly aside. Cover the hole in the shift control housing to prevent any contamination.

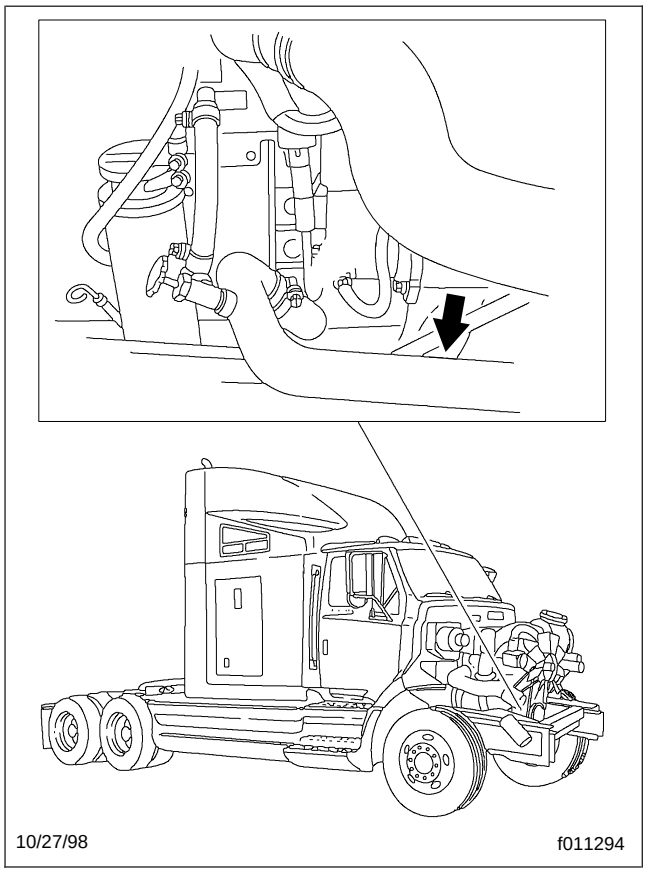


Fig. 10, Lower Radiator Tube

35. If the vehicle is equipped with a clutch cable, remove the three bolts from the clutch cable mounting bracket. See **Fig. 31**.
36. If the vehicle is equipped with a clutch linkage, remove the clutch linkage. See **Fig. 32**.
37. If the vehicle is equipped with an AT, HT, or MT series automatic transmission, disconnect the selector control cable. See **Fig. 33**.

NOTE: If the vehicle is equipped with an HD or MD series automatic transmission, then perform the next three steps.

38. Remove the interior trim and floor mat.
39. Remove the screws and the transmission floor cover plate.
40. Disconnect the electrical connectors. See **Fig. 34**.

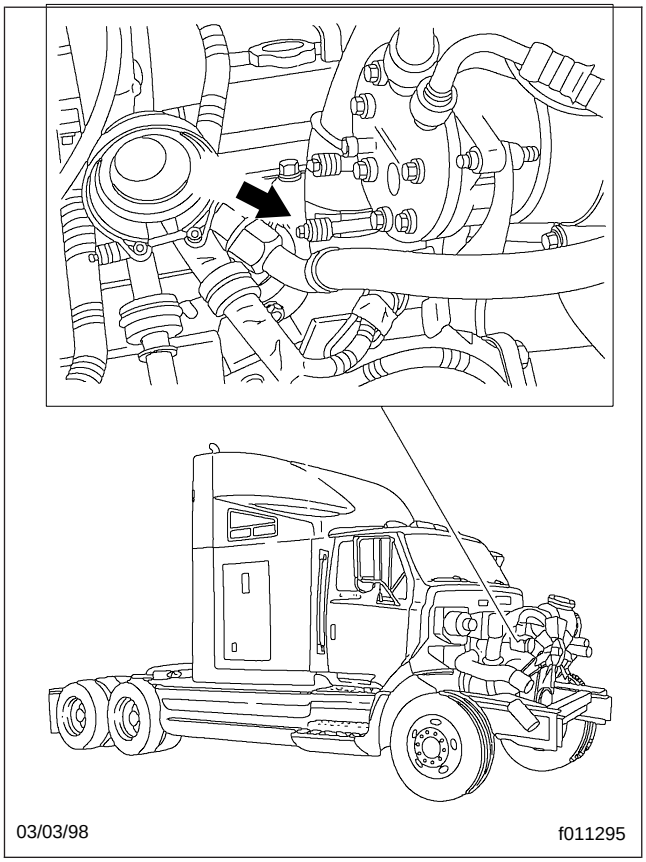


Fig. 11, Hose Clamp

NOTE: The HD series automatic transmission is shown, all others are similar.

41. If the vehicle is equipped with a transmission oil cooler, disconnect the transmission oil cooler lines. See **Fig. 35**.
    - Remove all retaining clamps.
    - Disconnect the transmission oil cooler lines.
42. If the vehicle is equipped with dual fuel tanks, disconnect the fuel supply and return lines, and position them aside. See **Fig. 36**.
43. Remove the nuts, U-bolt, bolts and bracket. See **Fig. 37**.
44. Remove the exhaust outlet tube. See **Fig. 38**.
45. Disconnect the ground strap. See **Fig. 39**.
46. Label and disconnect the starter motor electrical leads. See **Fig. 40**.

ISC Engine Removal and Installation

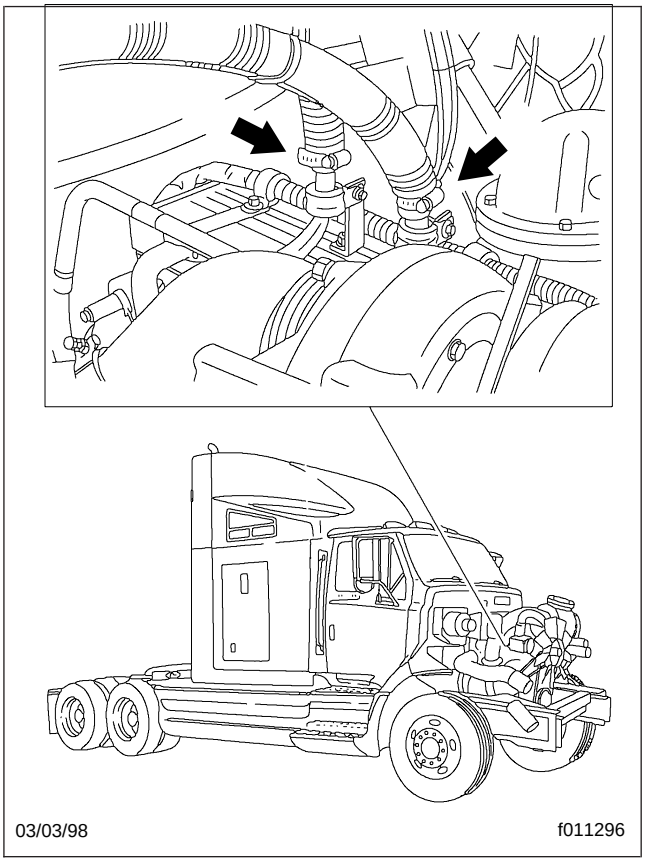


Fig. 12, Heater Water Hose

47. Label and disconnect the electrical connectors. See **Fig. 41**.
48. Remove the battery cable retaining clamp(s) from the transmission. See **Fig. 42**.
49. Remove the fuel line retaining clamp(s) from the transmission and position the battery cables aside. See **Fig. 43**.
50. Disconnect the driveshaft; refer to **Group 41**.
51. Remove four bolts, eight washers, four nuts and the two rear support brackets. See **Fig. 44**.
52. Support the powertrain assembly.

    Install the engine lifting equipment.

    - Use a suitable lifting chain connected to the two lifting eyes and lifting crane rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.

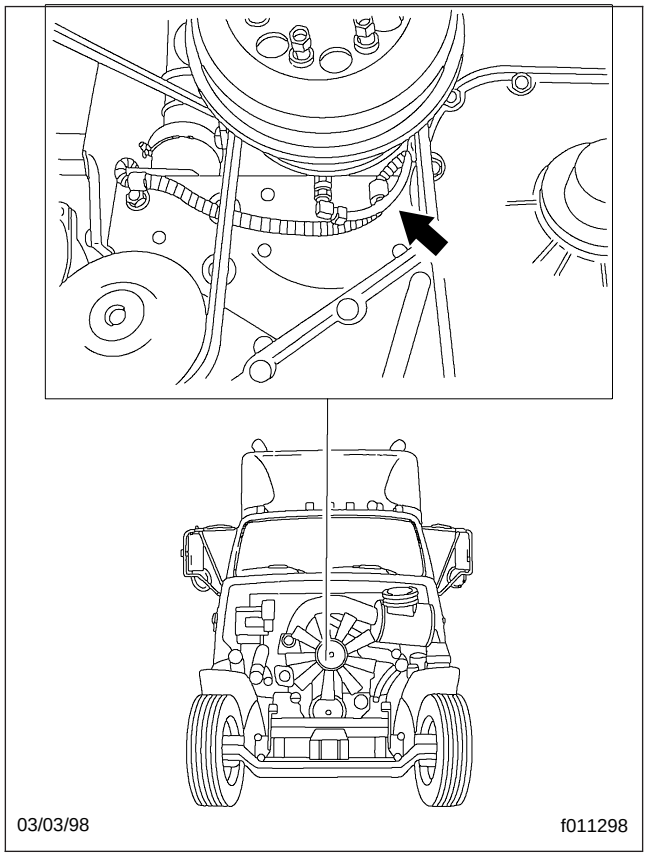
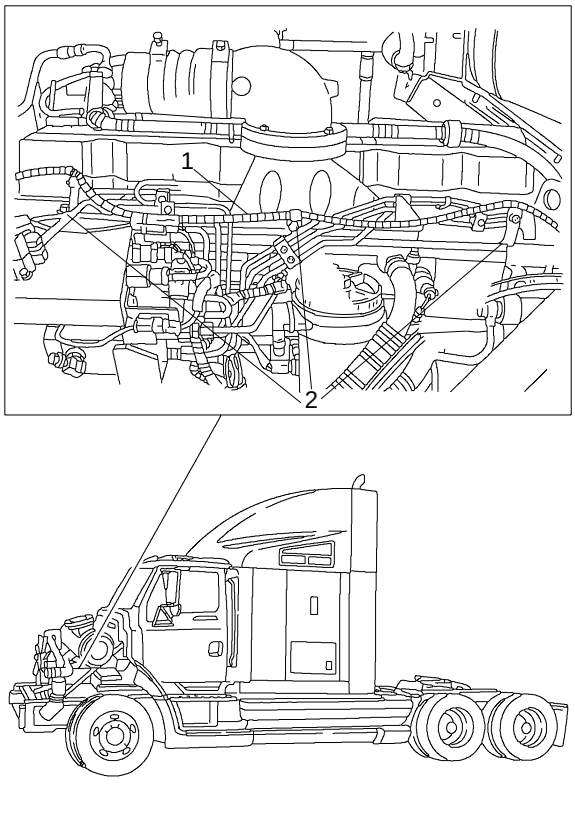


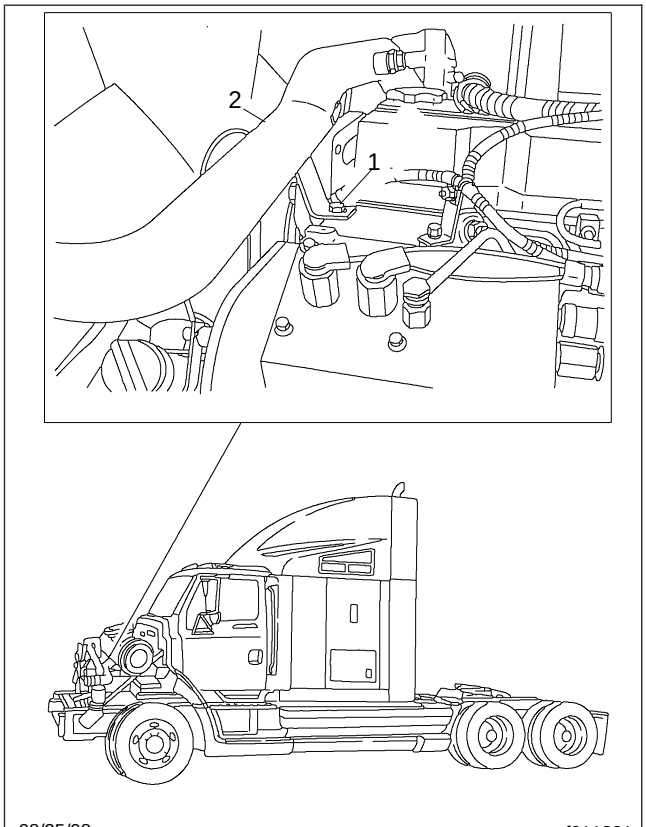
Fig. 13, Fan Clutch Air Line

    - Position a suitable transmission jack under the transmission. Secure the transmission to the jack.
53. Remove the nuts and flag bolts. See **Fig. 45**.
54. Remove the eight bolts, 16 washers, eight nuts and the No. 2 crossmember. See **Fig. 46**.
55. Move the powertrain assembly forward until the transmission jack reaches the front axle. Raise the powertrain assembly to gain access over the rear engine mount insulators.
56. Lower the engine and support the front engine mount. Use two suitable jack stands rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer and a suitable length of wood with a minimum 4-inch (10 mm) x 6-inch (15 mm) dimension.
57. Remove the powertrain assembly from the vehicle.



1. Fan Clutch Air Line
2. Retaining Bolts

Fig. 14, Fan Clutch Air Line Bolts



1. Bolt
2. Upper Radiator Tube

Fig. 16, Upper Radiator Tube

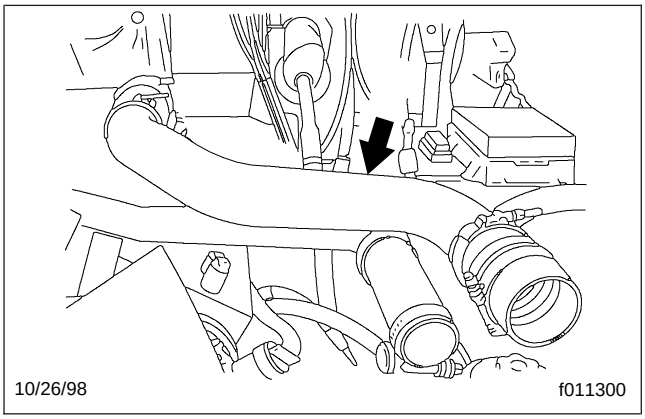
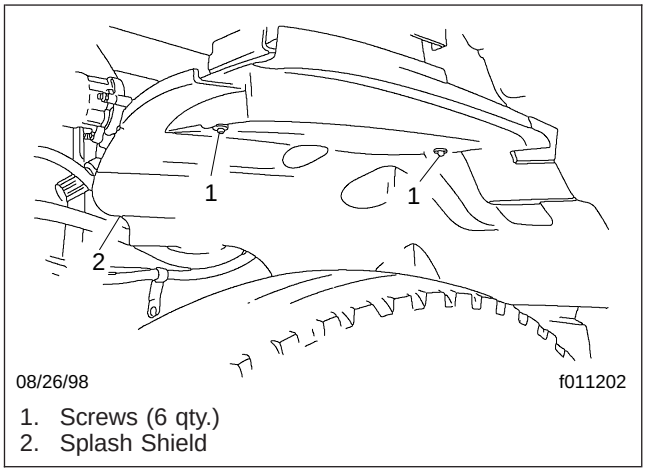


Fig. 15, Charge Air Cooler Outlet Tube

57.1 Remove the lifting chain. Install a load leveling engine sling.



1. Screws (6 qty.)
2. Splash Shield

Fig. 17, Splash Shield

ISC Engine Removal and Installation

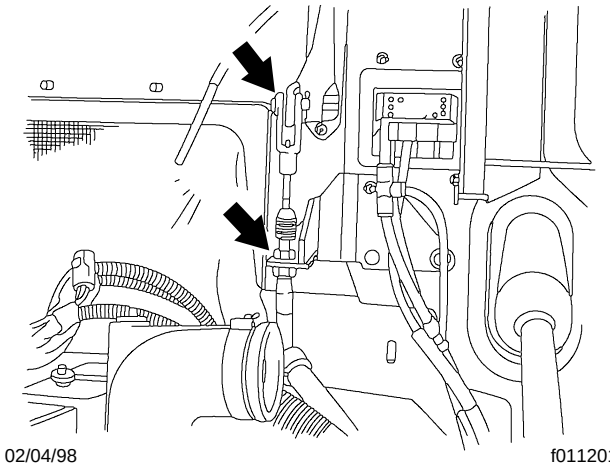
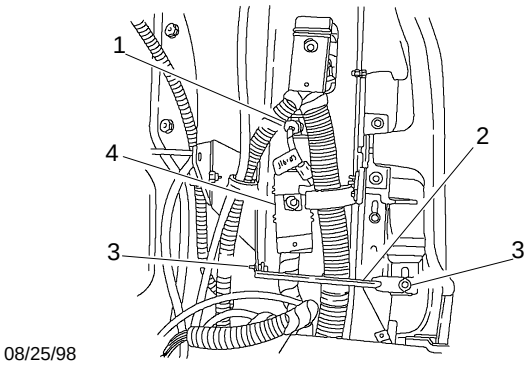
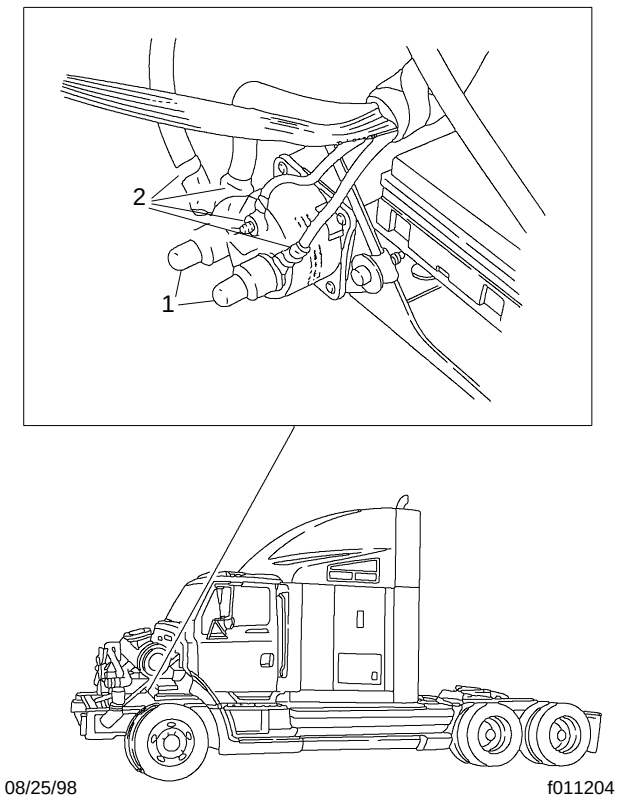


Fig. 18, Clutch Cable Linkage



1. Electrical Connector
2. Brace
3. Bolt (2 qty.)
4. Bulkhead Electrical Connector

Fig. 20, Electrical Connectors



1. Protective Caps
2. Starter Relay Electrical Leads

Fig. 19, Starter Relay Electrical Leads

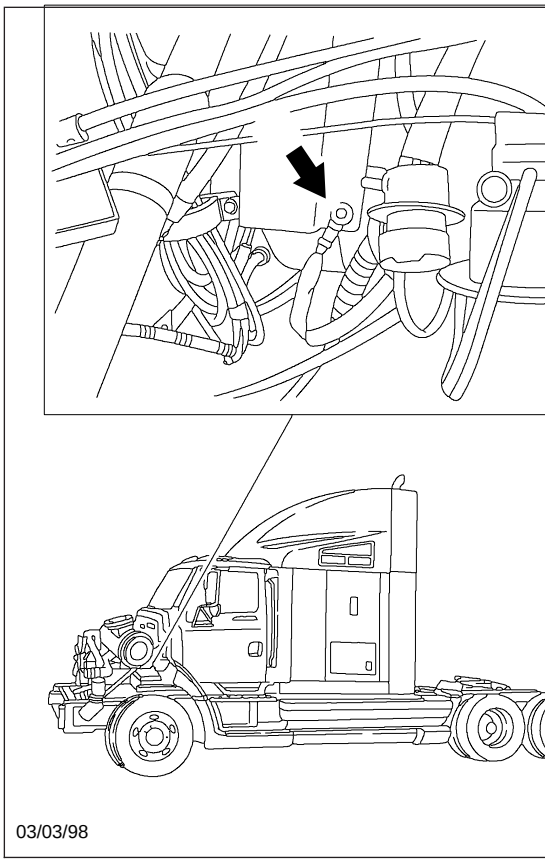


Fig. 21, Ground Strap

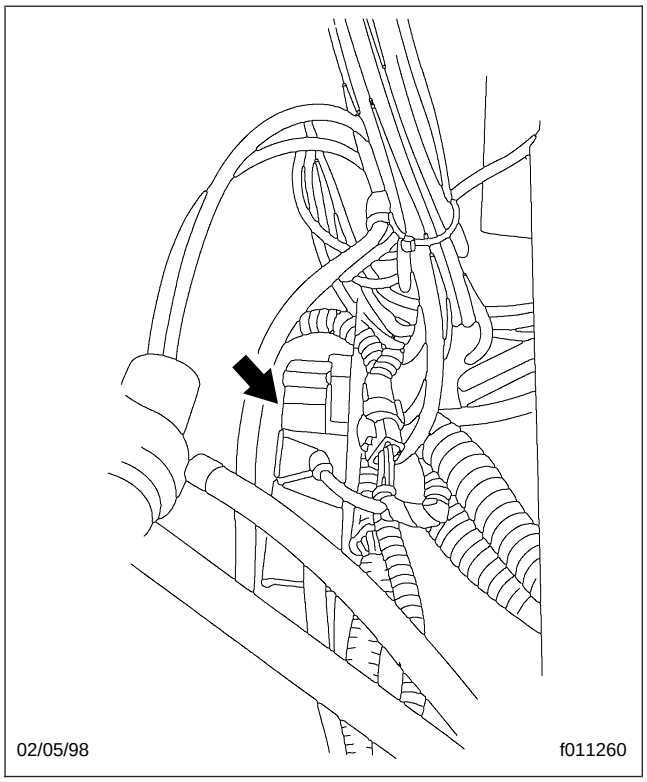


Fig. 22, Megafuse Cover

Use a suitable load leveling engine sling rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.

57.2 Raise the engine.

57.3 Remove the strap from the transmission.

57.4 Level the powertrain assembly.

57.5 Remove the transmission jack.

57.6 Move the powertrain assembly out of the vehicle.

58. Support the powertrain assembly. See **Fig. 47**.

- Use two suitable jack stands rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.
- Use a suitable transmission jack.

Installation

1. Raise the powertrain assembly and remove the jack stands and the transmission jack.

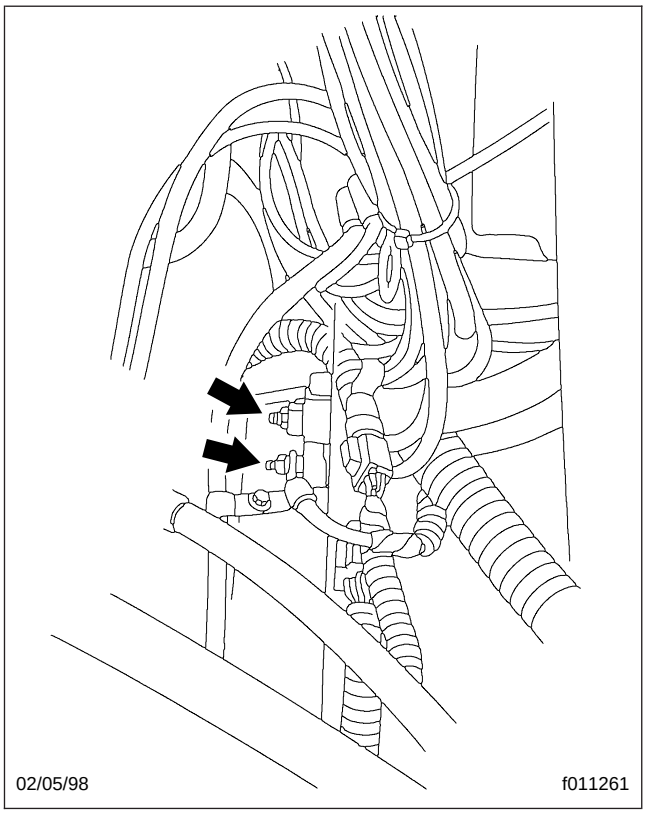


Fig. 23, Megafuse Electrical Lead

Use a suitable load leveling sling and lifting crane rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.

IMPORTANT: Use care not to damage any engine components, lines, filters, and electrical wiring during installation of the powertrain assembly.

2. Move the powertrain assembly into the vehicle until the transmission is behind the front axle.
3. Support the powertrain assembly.

3.1 Install a suitable transmission jack under the transmission.

Secure the transmission to the jack.

3.2 Lower the engine and support the front engine mount.

Use two suitable jack stands rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer and a suitable length of

ISC Engine Removal and Installation

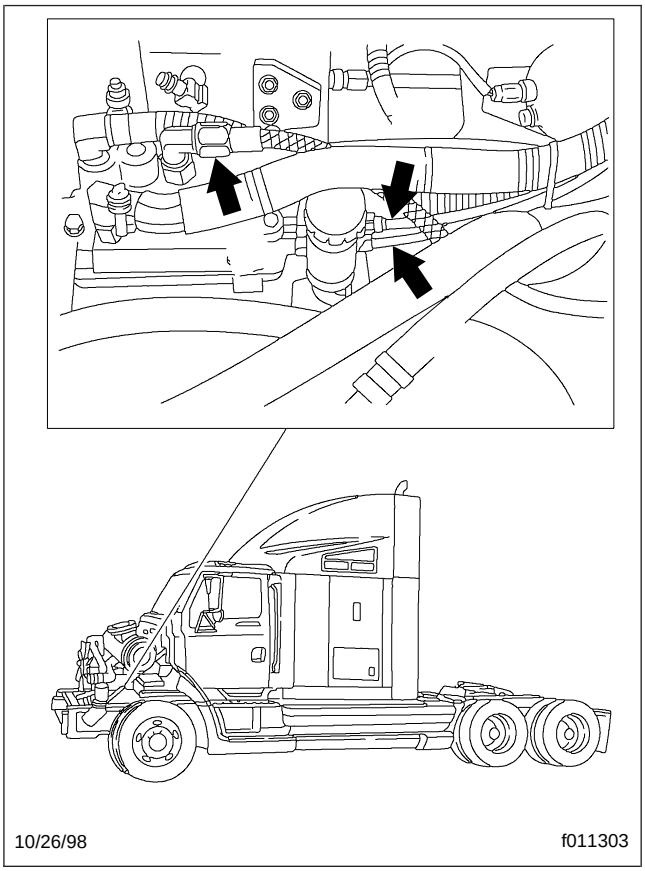


Fig. 24, Air Compressor Discharge and Governor Air Lines

wood with a minimum 4-inch (10 mm) x 6-inch (15 mm) dimension.

4. Remove the load leveling sling and install a lifting chain.

   Use a suitable lifting chain rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer connected to the front lifting eye.

5. Move the powertrain assembly back to the rear engine mount insulators.

6. Install the No. 2 crossmember, eight bolts, 16 washers, and eight nuts. Tighten 75 to 105 lbf·ft (102 to 138 N·m). See **Fig. 46** .

   A suitable porta-power unit may be necessary to spread the frame side rails if the frame has settled.

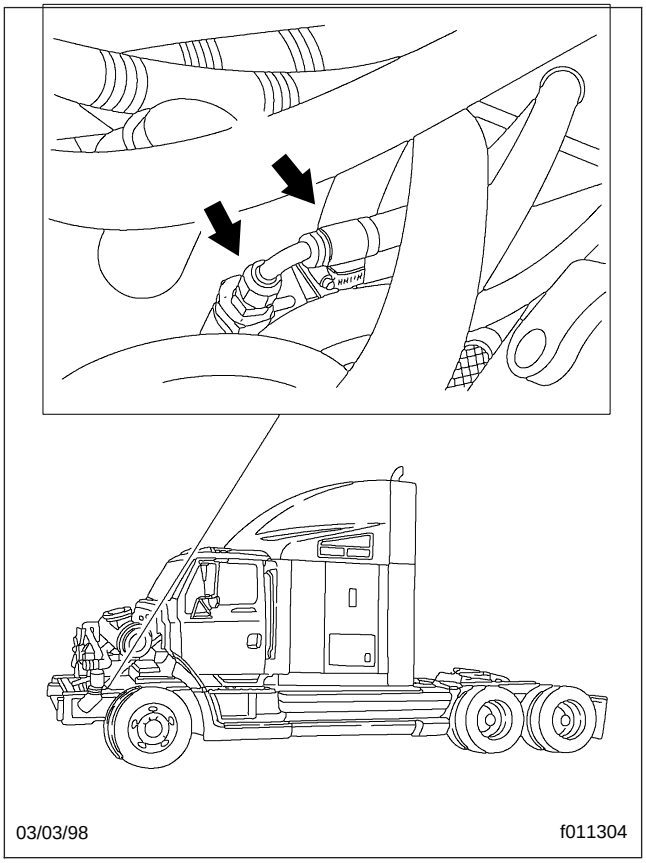


Fig. 25, Power Steering Low and High Pressure Lines

7. Install the bolts and flag nuts. Tighten 150 to 205 lbf·ft (204 to 277 N·m). See **Fig. 45**

8. Remove the transmission jack and the engine lifting equipment.

9. Install the two rear support brackets, four bolts, eight washers and four nuts. Tighten 75 to 105 lbf·ft (102 to 138 N·m). See **Fig. 44 .**.

10. Connect the driveshaft. Refer to **Group 41**.

11. Route the fuel lines and install the fuel line retaining clamps. See **Fig. 43** .

12. Route the battery cables and install the battery cable clamps. See **Fig. 42** .

13. Connect the electrical connectors. See **Fig. 41** .

14. Connect the starter solenoid electrical leads. See **Fig. 40** .

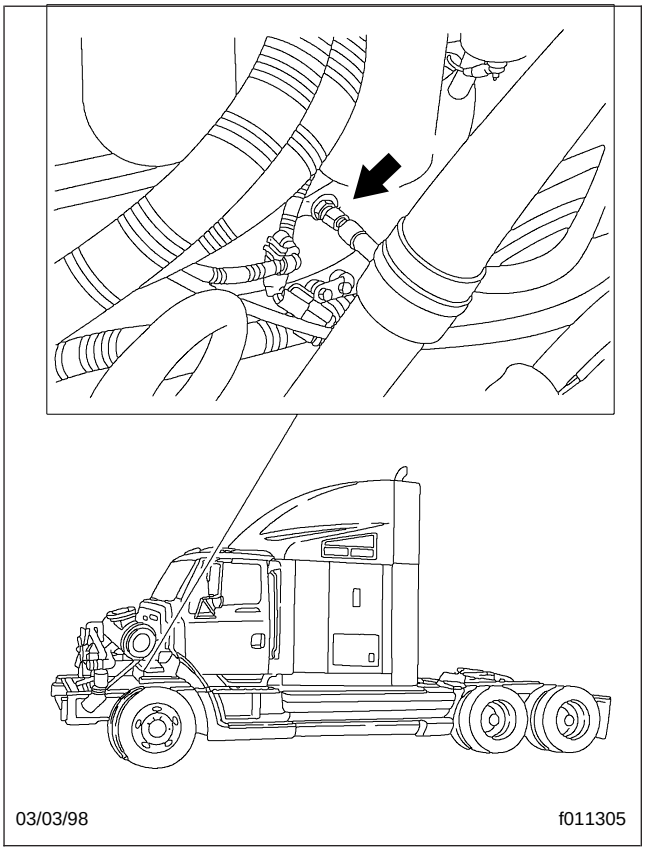


Fig. 26, Oil Pressure Gauge Line

Apply Silicone Dielectric Compound or equivalent meeting specification ESE–M1C171–A to all of the starter motor electrical connections.

15. Connect the ground strap. See **Fig. 39** .
16. Install the exhaust outlet tube. See **Fig. 38** .
17. Install the bracket, bolts, U-bolt and nuts. See **Fig. 37** .
18. If the vehicle is equipped with dual fuel tanks, connect the fuel supply and return lines. See **Fig. 36** .

NOTE: The HD series automatic transmission is shown. All others are similar.

19. If the vehicle is equipped with a transmission oil cooler, connect the transmission oil cooler lines. See **Fig. 35** .
    - Connect the transmission oil cooler lines.
    - Install the retaining clamps.

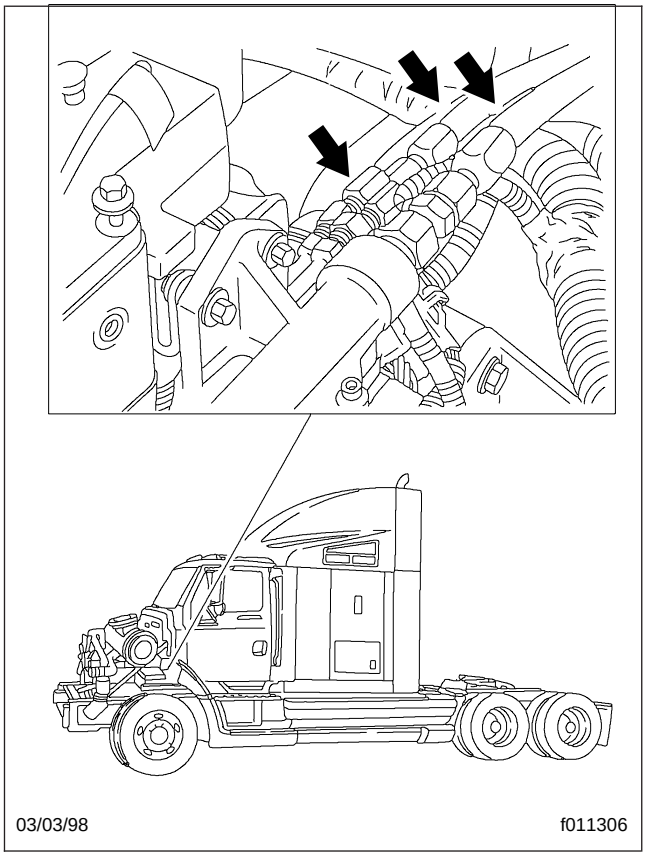


Fig. 27, Fuel Lines, Single Fuel Tank

NOTE: If the vehicle is equipped with an HD or MD series automatic transmission, then perform the next three steps.

20. Connect the electrical connectors. See **Fig. 34** .
21. Install the transmission floor cover plate and the screws.
22. Install the floor mat and interior trim. Refer to **Group 60**.
23. If the vehicle is equipped with an AT, HT or MT series automatic transmission, connect the selector cable. See **Fig. 33** .

NOTE: If the vehicle is equipped with a manual transmission, then perform the next eight steps.

24. If the vehicle is equipped with a clutch linkage, install the clutch linkage. See **Fig. 32** .

ISC Engine Removal and Installation

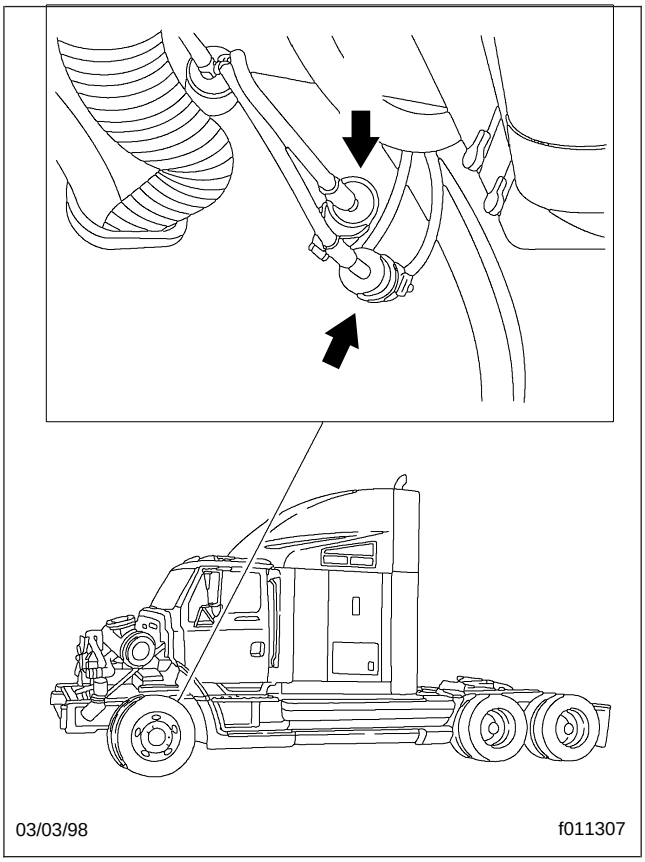


Fig. 28, Electrical Connectors

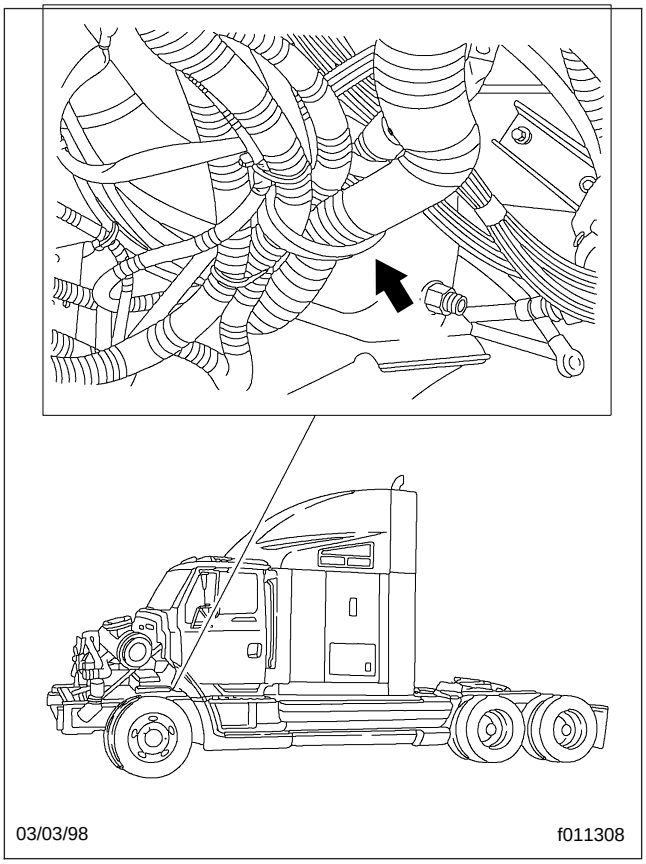
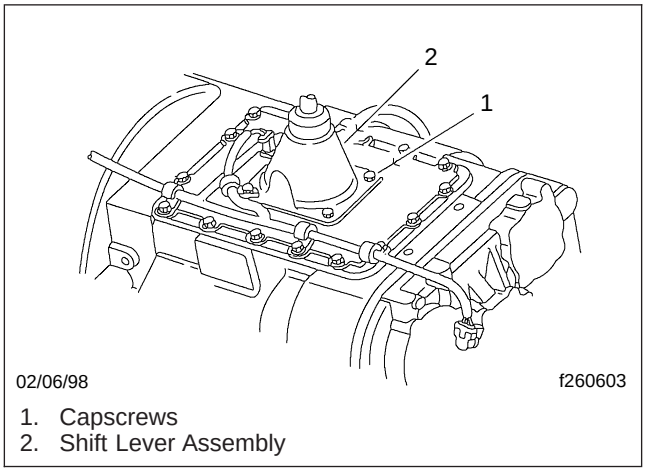


Fig. 29, Retaining Clamp

25. If the vehicle is equipped with a clutch cable, install the clutch cable mounting bracket and three bolts. See **Fig. 31** .
26. Align the shift block and yoke notches in the neutral position. See **Fig. 48** .
27. Position the gasket on the shift control housing.
28. Position the shift lever housing.

    Fit the shift lever into the shift block and yoke notches. See **Fig. 49** .
29. Install the capscrews. See **Fig. 30** .

    Use Threadlock® and Sealer or equivalent meeting specification WSK–M2G315–A5 on the threads.
30. If the vehicle is equipped with the Roadranger® air system, connect the vehicle air and the Roadranger air system to the transmission. Refer to **Group 26**.



1. Capscrews
2. Shift Lever Assembly

Fig. 30, Shift Lever Assembly

31. Install the shift lever boot.

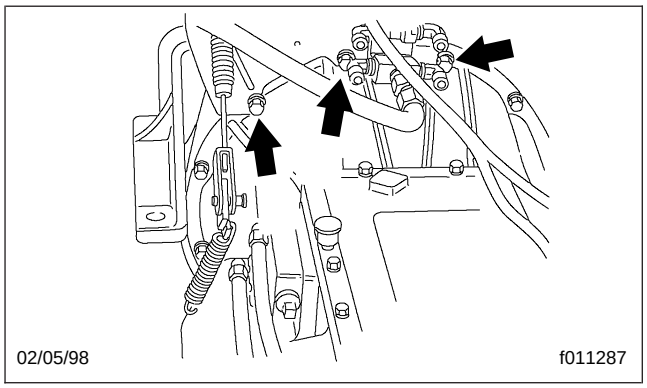


Fig. 31, Clutch Cable Mounting Bracket Bolts

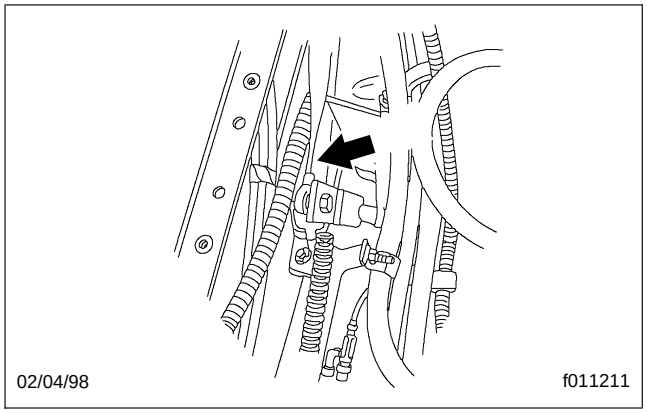


Fig. 32, Clutch Linkage

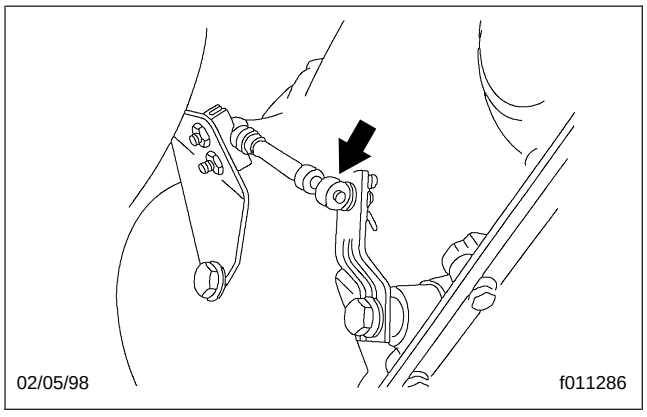


Fig. 33, Selector Control Cable

If removed, install the transmission floor cover plate and interior trim. Refer to **Group 60**.

32. Install the retaining clamp. See **Fig. 29** .
33. Connect the electrical connectors. See **Fig. 28** .

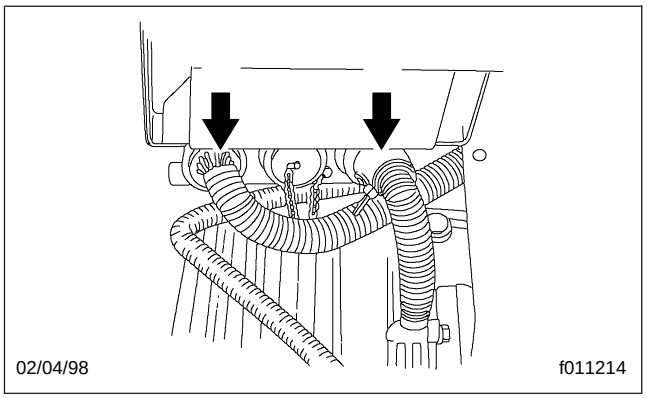


Fig. 34, Electrical Connectors

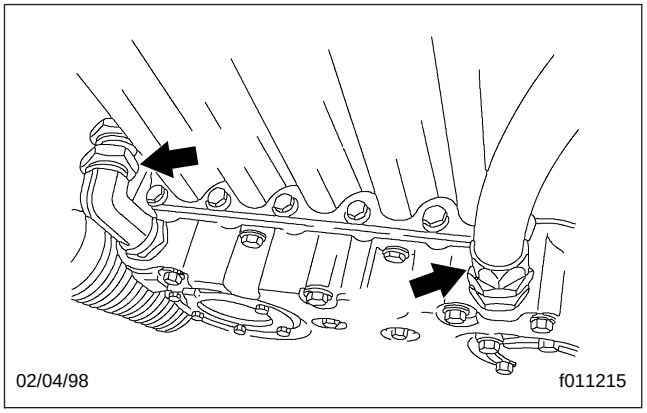


Fig. 35, Transmission Cooler Lines

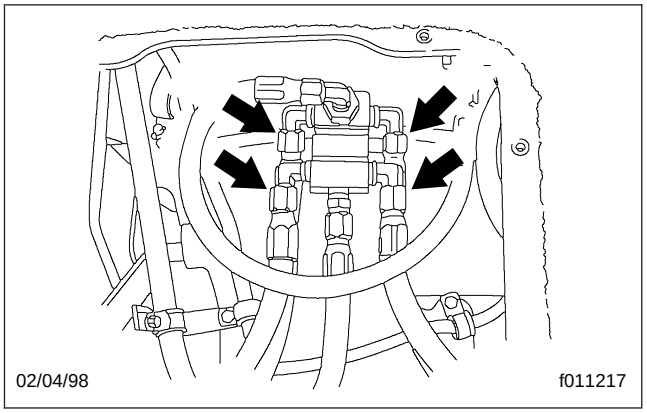


Fig. 36, Fuel Lines, Dual Fuel Tanks

34. If the vehicle is equipped with a single fuel tank, connect the fuel lines. See **Fig. 27** .
35. Connect the engine oil pressure gauge. See **Fig. 26** .

ISC Engine Removal and Installation

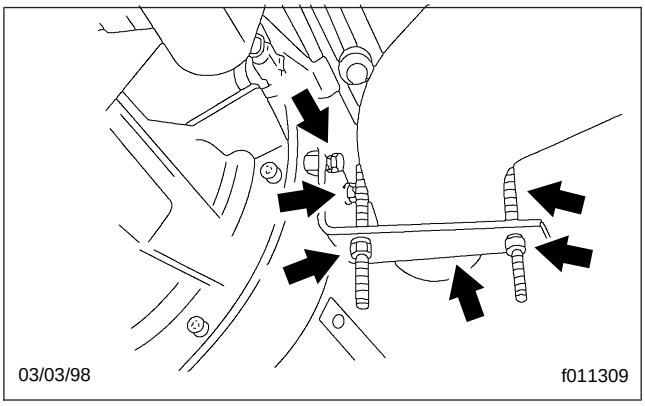


Fig. 37, Exhaust Bracket and Fasteners

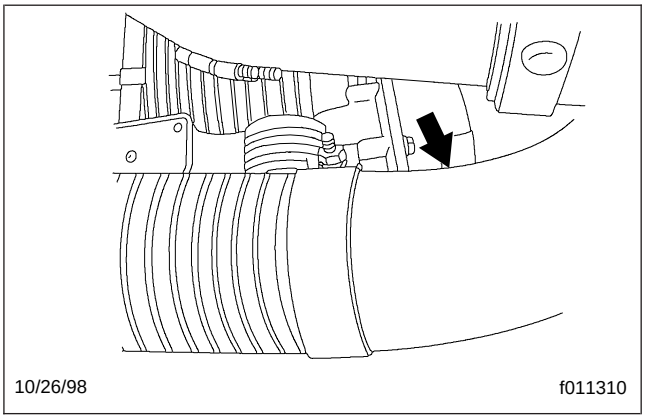


Fig. 38, Exhaust Outlet Tube

36. Connect the power steering low and high pressure lines. See **Fig. 25** .
37. Connect the air compressor governor air lines and discharge line. See **Fig. 24** .
38. Connect the megafuse electrical lead. See **Fig. 23** .
39. Install the megafuse cover. See **Fig. 22** .
40. Connect the ground strap. See **Fig. 21** .
41. Connect the electrical connectors. See **Fig. 20** .
    - 41.1 Connect the electrical connector.
    - 41.2 Connect the bulkhead electrical connector.
    - 41.3 Position the brace.
    - 41.4 Install and tighten the nuts and bolts.

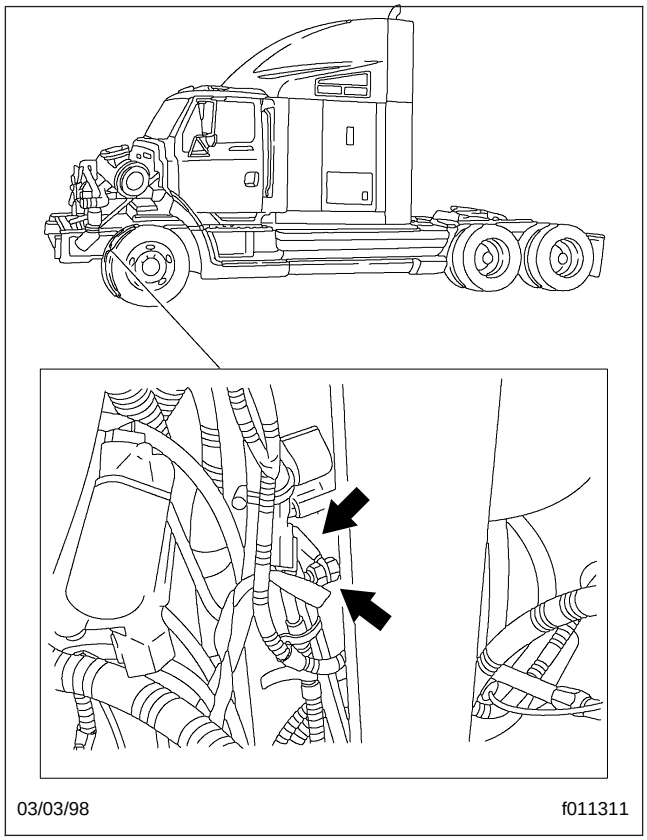


Fig. 39, Ground Strap

42. Connect the starter relay electrical leads. See **Fig. 19** .
    - 42.1 Connect the starter relay electrical leads to the terminals noted during removal.
    - 42.2 Install protective caps.
43. If the vehicle is equipped with a manual transmission, connect the clutch cable or linkage. See **Fig. 18** .
44. Install the left-side splash shield and six screws. See **Fig. 17** .
45. Install the upper radiator tube. See **Fig. 16** .
46. Install the charge air outlet tube. See **Fig. 15** .
47. Route the fan clutch air line and install the bolts. See **Fig. 14** .
48. Connect the fan clutch air line. See **Fig. 13** .
49. Install the cooling fan; refer to **Group 20**.

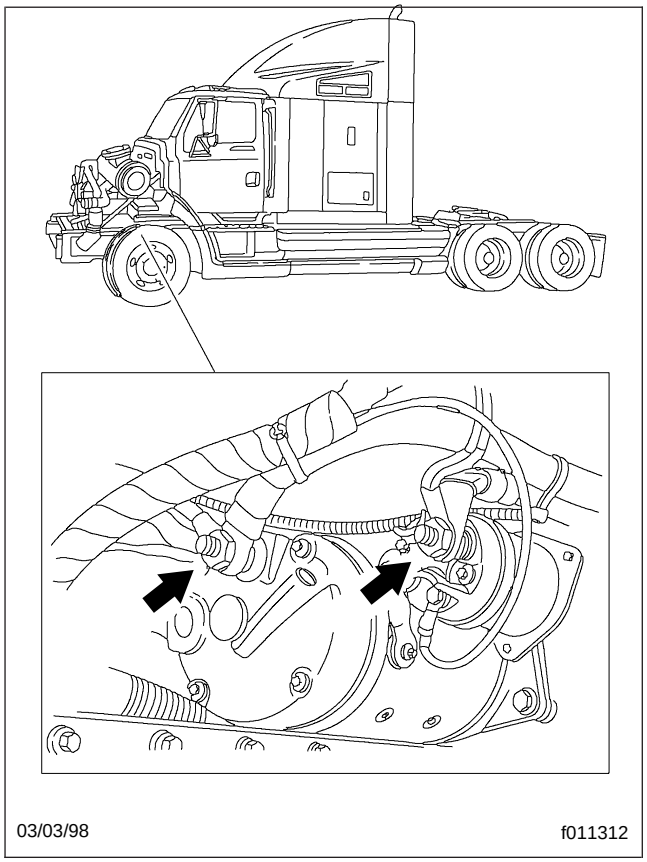


Fig. 40, Starter Motor Electrical Leads

50. Install the heater water hoses. See **Fig. 12** .
51. Tighten the hose clamp. See **Fig. 11** .
52. Install the radiator lower tube. See **Fig. 10** .
53. Connect the exhaust outlet tube. See **Fig. 9** .
54. Install the turbocharger outlet tube. See **Fig. 8** .
55. Connect the refrigerant line. See **Fig. 7** .

    Install a new captured O-ring lubricated with clean Heavy Truck PAG Oil or equivalent meeting specification EST–M1C231–B2.
56. If the vehicle has a 113- to 122-inch BBC chassis, install the No. 1 crossmember, two bumper brackets, four bolts, eight washers and four nuts. See **Fig. 6** .

NOTE: If the vehicle has a 101-inch BBC chassis, then perform the next two steps.

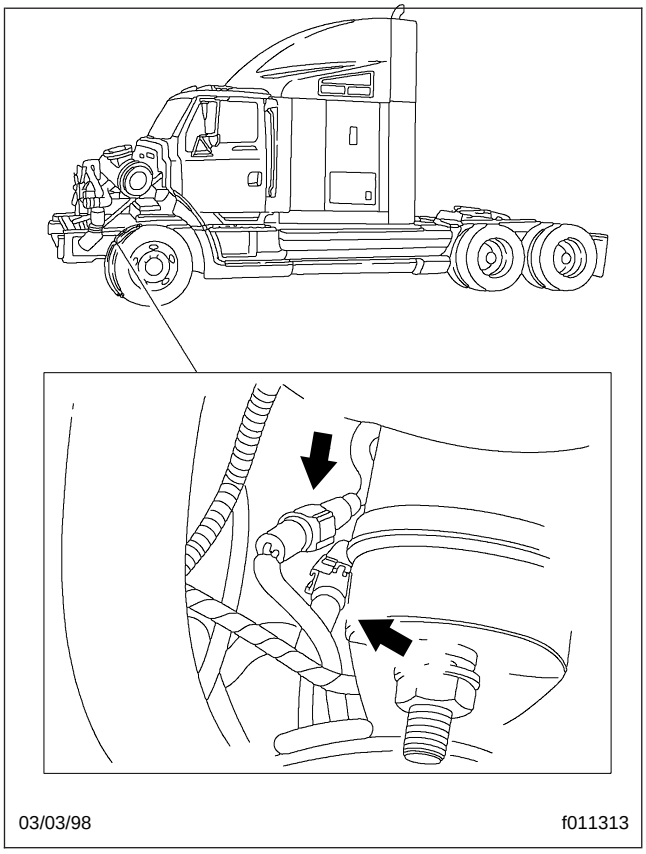


Fig. 41, Electrical Connectors

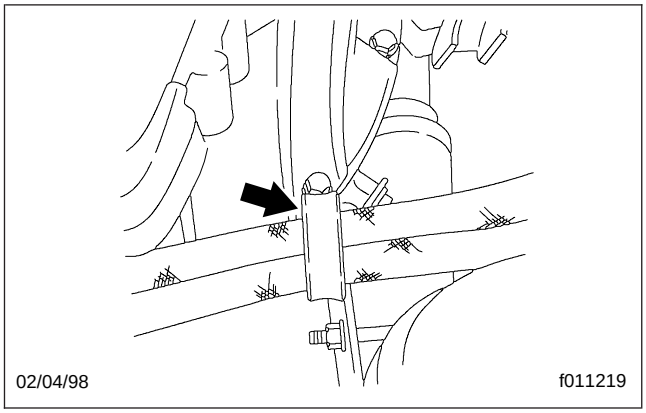


Fig. 42, Battery Cable Retaining Clamp

57. Install the top two No. 1 crossmember gussets, four bolts, eight washers and four nuts. See **Fig. 5** .
58. Install the No. 1 crossmember and eight bolts, 16 washers and eight nuts. See **Fig. 4** .

ISC Engine Removal and Installation

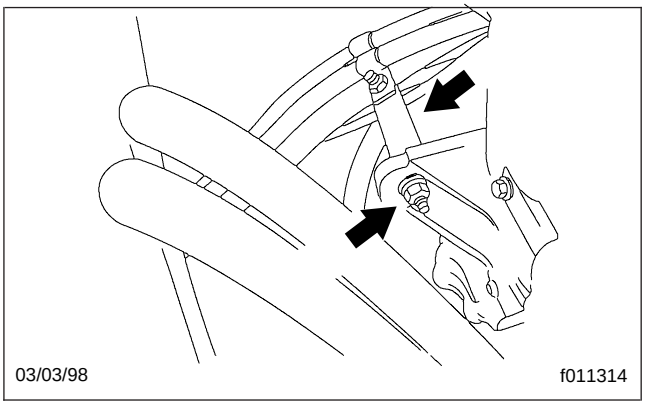


Fig. 43, Fuel Line Retaining Clamp

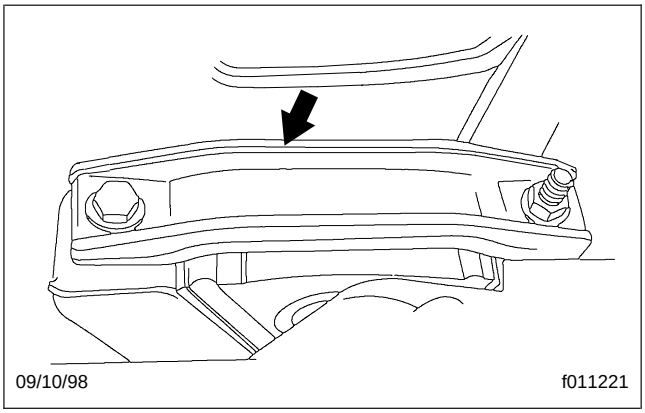


Fig. 44, Rear Support Bracket

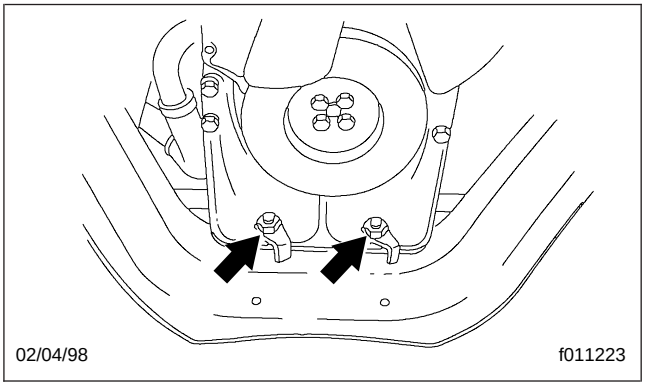


Fig. 45, Flag Bolt and Nut Assembly

NOTE: The steering gear is shown. The rotary assist cylinder is similar.

59. If the vehicle is equipped with dual steering gears, route the power steering lines and connect the power steering lines to the steering gear and rotary assist cylinder. See **Fig. 3** .

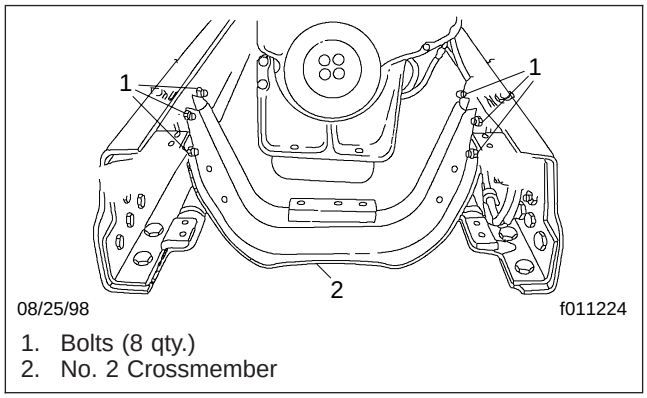


Fig. 46, No. 2 Crossmember

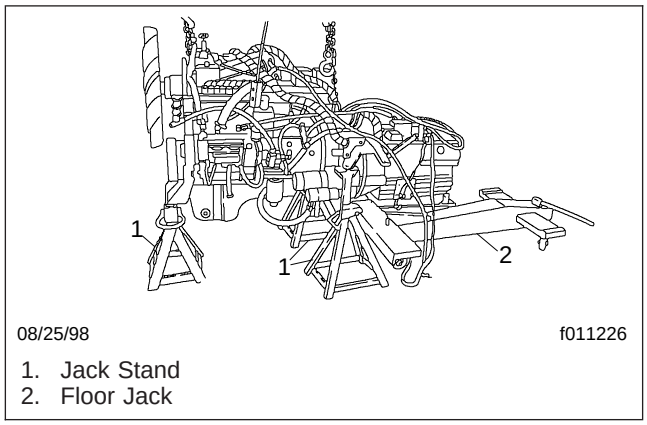


Fig. 47, Supporting the Powertrain Assembly

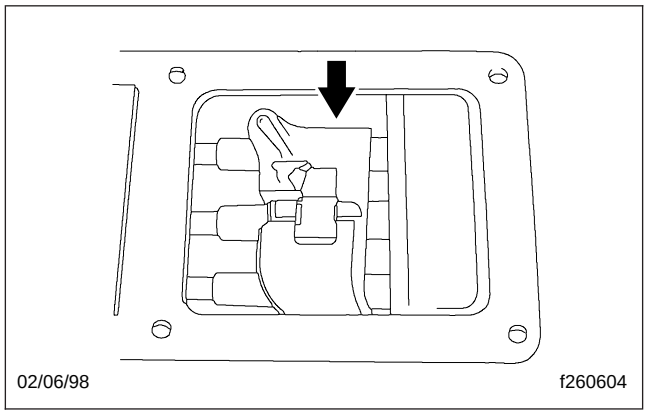


Fig. 48, Aligning the Shift Block and Yoke

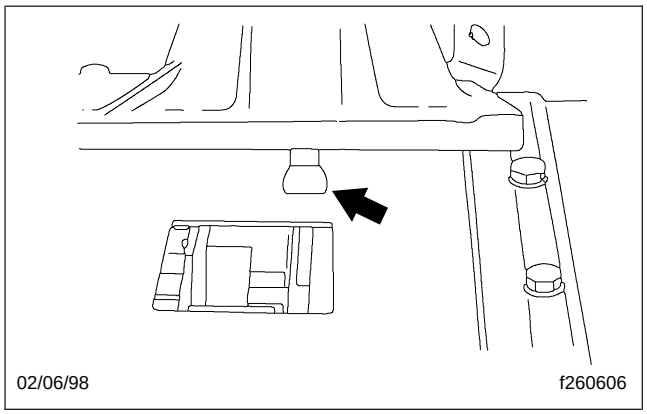


Fig. 49, Positioning the Shift Lever

NOTE: The brake valves shown are for a 2-channel ABS system. All other configurations are similar.

60. Connect the air valve assembly. See **Fig. 2** .
    - Connect the air lines.
    - Connect the electrical connector.
    - Install the retaining clamp bolts.
61. If the vehicle is equipped with front pintle hooks, install the two pintle hooks, six bolts, 10 washers and four nuts. Tighten 220 to 300 lbf·ft (298 to 406 N·m). See **Fig. 1** .
62. Restore the vehicle to operating condition.
    - 62.1 Install the air intake tube and air cleaner assembly as an assembly. Refer to **Group 09**.
    - 62.2 Install the cooling module. Refer to **Group 20**.
    - 62.3 If the vehicle is equipped with a transmission cooler or an automatic transmission, fill the transmission oil. Refer to the appropriate **Group 26** transmission section.
    - 62.4 Fill the engine with oil.
    - 62.5 Fill the engine cooling system; refer to **Group 20**.
    - 62.6 Repressurize the air system with clean, dry air.
    - 62.7 If the vehicle is equipped with an A/C system, evacuate, charge and leak test the A/C system; refer to **Group 83**.
    - 62.8 Check the engine drive belts for proper adjustment.
    - 62.9 Check the accelerator and hand throttle linkages for proper adjustment; refer to **Group 30**.
    - 62.10 Check the transmission cables and linkages for proper adjustment. Refer to the appropriate **Group 26** transmission section.
    - 62.11 Check the clutch cables and linkages for proper adjustment; refer to **Group 25**.
    - 62.12 Connect the battery ground cables.
    - 62.13 Start the engine and check the powertrain assembly for leaks.
    - 62.14 Install the engine cover; refer to **Group 60**.
    - 62.15 Install the hood; refer to **Group 88**.
    - 62.16 Install the bumper; refer to **Group 31**.

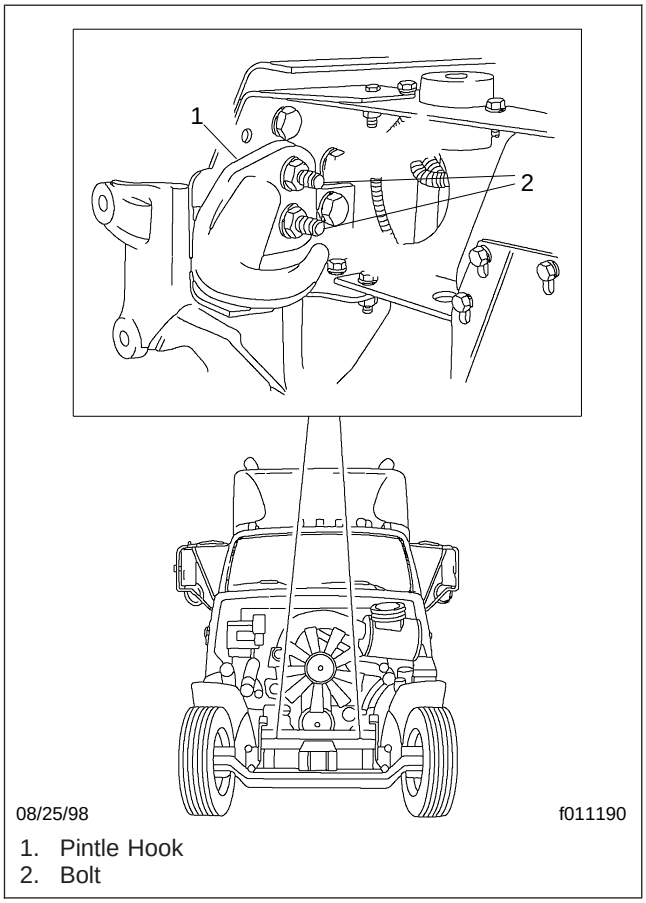
Removal

NOTE: The removal of the Cummins N14 Plus diesel engine is shown below. For removal and installation of a Cummins M11 Plus diesel engine, use the following procedures as a reference.

1. Prepare the vehicle for engine removal.
   - 1.1 Disconnect the battery ground cable(s).
   - 1.2 Remove the bumper. Refer to **Group 31**.
   - 1.3 Remove the hood. Refer to **Group 88**.
   - 1.4 Drain the engine cooling system. Refer to **Group 20**.
   - 1.5 Drain the engine oil.
   - 1.6 If the vehicle is equipped with an A/C system, recover the refrigerant. Refer to **Group 83**.
   - 1.7 If the vehicle is equipped with a transmission cooler or an automatic transmission, drain the transmission oil. Refer to the appropriate **Group 26** transmission section.
   - 1.8 Drain the air system.
   - 1.9 Remove the cooling module. Refer to **Group 20**.
   - 1.10 Remove the cooling fan. Refer to **Group 20**.
   - 1.11 Remove the air intake tube and air cleaner assembly as an assembly. Refer to **Group 09**.
   - 1.12 Remove the engine cover. Refer to **Group 60**.
2. If the vehicle is equipped with front pintle hooks, remove six bolts, 10 washers, four nuts and two pintle hooks. See **Fig. 1**.

NOTE: The brake valves shown are for a 2-channel ABS system. All other configurations are similar.

3. Isolate the brake valves on the No. 1 crossmember. See **Fig. 2**.
   - 3.1 Remove the retaining clamp bolts.



1. Pintle Hook
2. Bolt

Fig. 1, Pintle Hook

   - 3.2 Disconnect the electrical connector.
   - 3.3 Label and disconnect the four air lines.

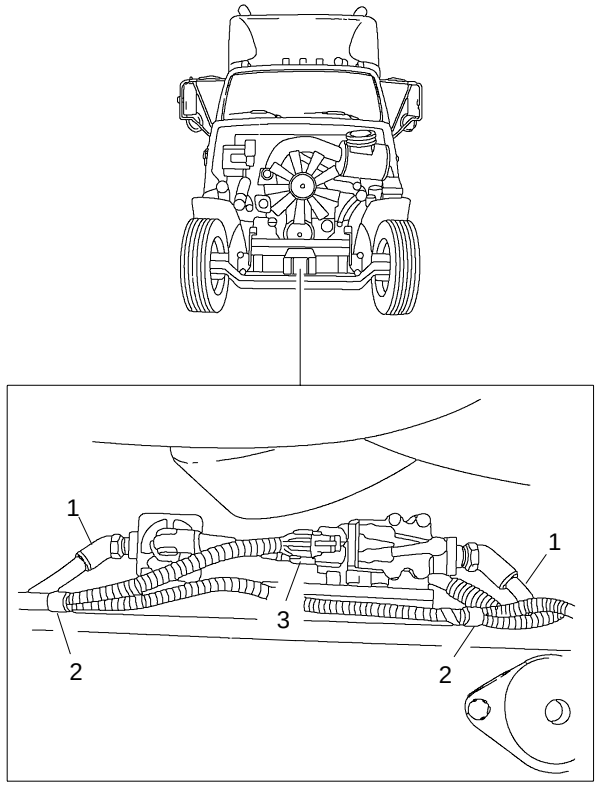
NOTE: The steering gear is shown, the rotary assist cylinder is similar.

4. If the vehicle is equipped with a rotary assist cylinder, disconnect the power steering lines from the steering gear and the rotary assist cylinder. Remove the power steering lines. See **Fig. 3**.

NOTE: If the vehicle has a 101-inch BBC chassis, perform the next two steps.

5. Remove the eight bolts, 16 washers, eight nuts and the No. 1 crossmember. See **Fig. 4**.
6. Remove the four nuts, eight washers, four bolts and the top two No. 1 crossmember gussets. See **Fig. 5**.

N14 Plus Engine Removal and Installation



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1. Air Line
2. Retaining Clamp
3. Electrical Connector

Fig. 2, Brake Valves

7. If the vehicle has a 113- to 122-inch BBC chassis, remove the four bolts, eight washers, four nuts, four bumper brackets and the No. 1 crossmember. See **Fig. 6**.
8. Disconnect the refrigerant line. Plug and cap the open lines and fittings. See **Fig. 7**.
9. Remove the turbocharger outlet tube. See **Fig. 8**.
10. Remove the lower radiator tube. See **Fig. 9**.
11. Disconnect the radiator upper tube. See **Fig. 10**.
12. Disconnect the water heater hoses. See **Fig. 11**.

NOTE: On 101-inch BBC vehicles it may be necessary to access the auxiliary heater water hose and clamps from inside the vehicle.

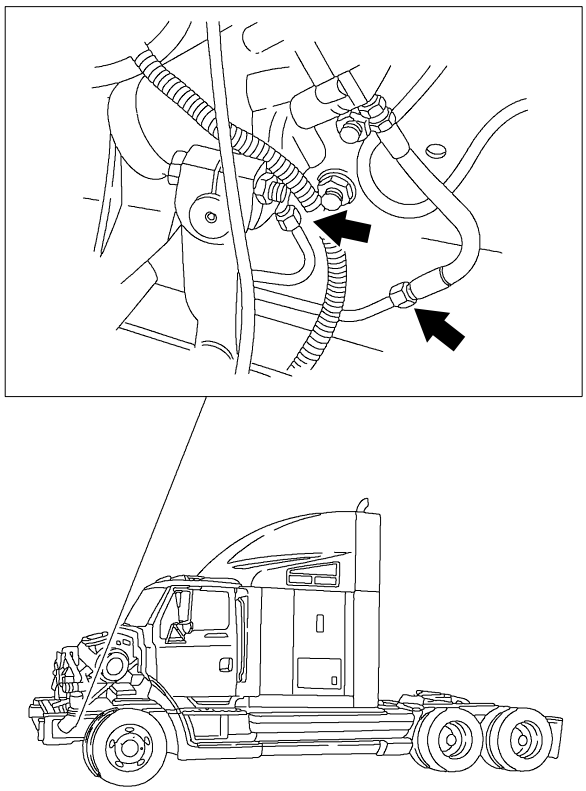

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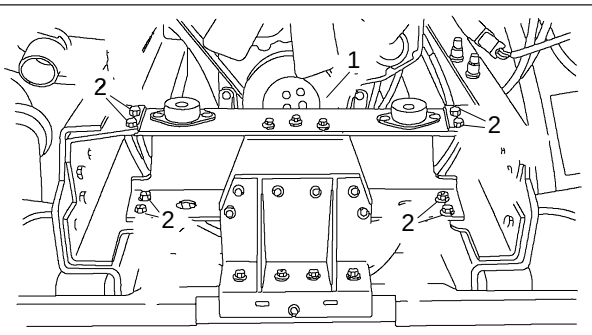
Fig. 3, Power Steering Lines



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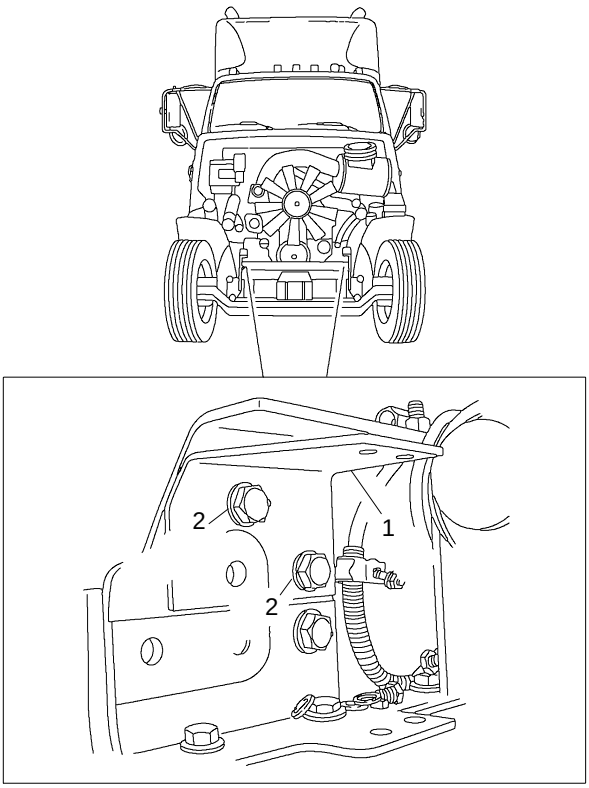
1. No. 1 Crossmember
2. Bolt (8 qty.)

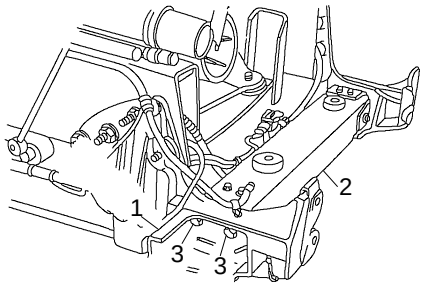
Fig. 4, No. 1 Crossmember

13. If the vehicle is equipped with a sleeper, disconnect the auxiliary heater water hoses and remove the clamps. See **Fig. 12**.



1. No. 1 Crossmember Gusset
2. Bolt

Fig. 5, No. 1 Crossmember Gusset



1. Bumper Bracket
2. No. 1 Crossmember
3. Bolt (4 qty.)

Fig. 6, Bumper Bracket

NOTE: On 101-inch BBC vehicles, it may be necessary to access the block heater electrical connector and clamp from inside the vehicle. See **Fig. 13**.

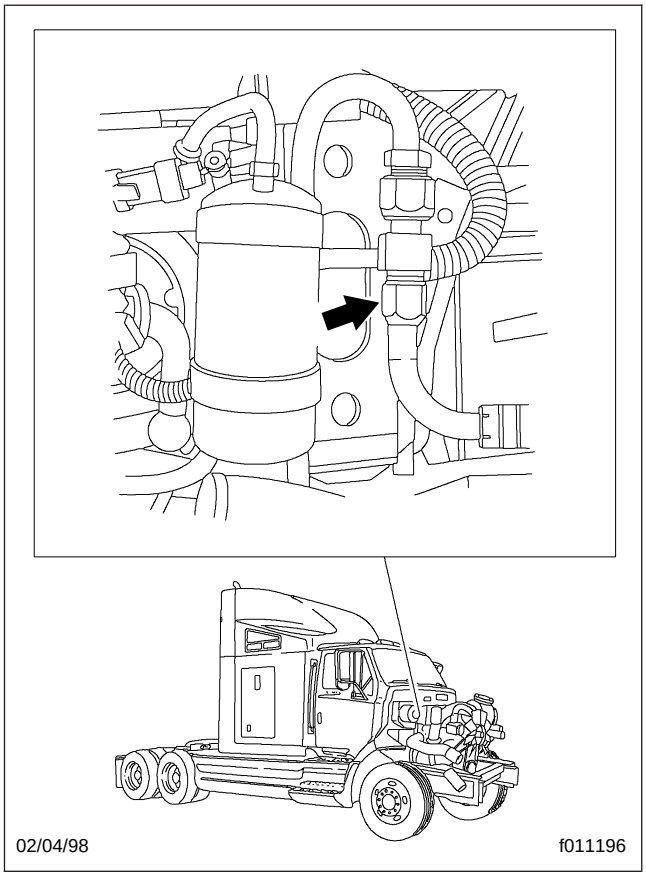


Fig. 7, Refrigerant Line

14. If the vehicle is equipped with a block heater, disconnect the block heater electrical connector and remove the clamp.

NOTE: On 101-inch BBC vehicles, it may be necessary to access the turbocharger outlet tube from inside the vehicle. See **Fig. 14**.

15. Disconnect the pyrometer and the exhaust outlet tube.
16. If the vehicle is equipped with an air actuated cooling fan clutch, disconnect the cooling fan clutch air line. See **Fig. 15**.
17. Loosen the bolts and rotate the alternator towards the engine.
18. If the vehicle is equipped with an air actuated cooling fan clutch, remove the retaining clamp

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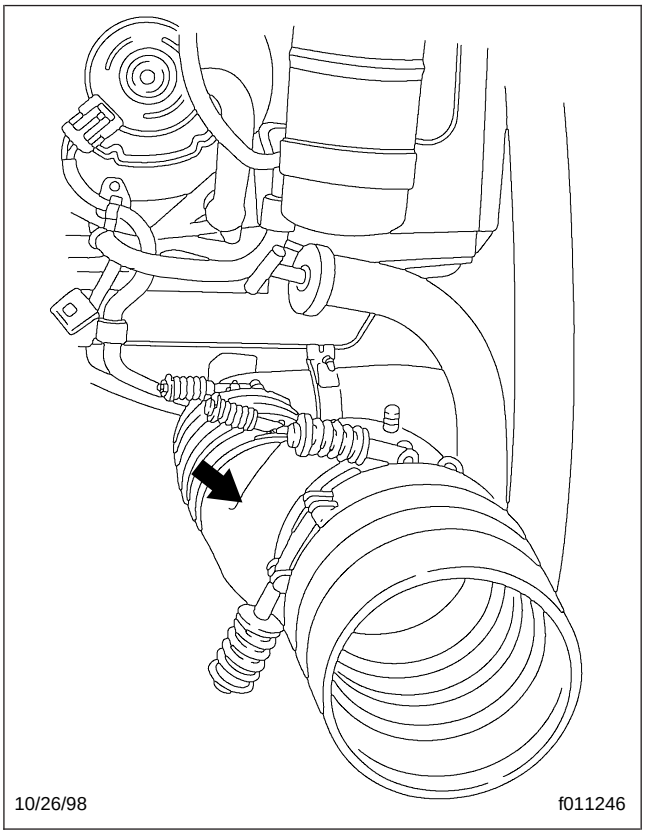


Fig. 8, Turbocharger Outlet Tube

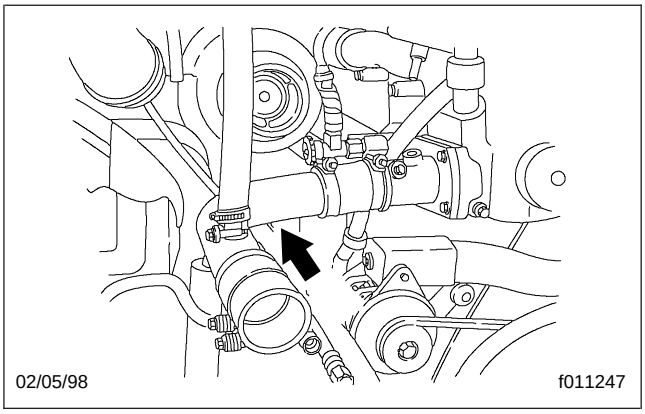


Fig. 9, Lower Radiator Tube

bolts and position the fan clutch air line aside. See **Fig. 16**.

19. Remove the charge air cooler outlet tube. See **Fig. 17**.

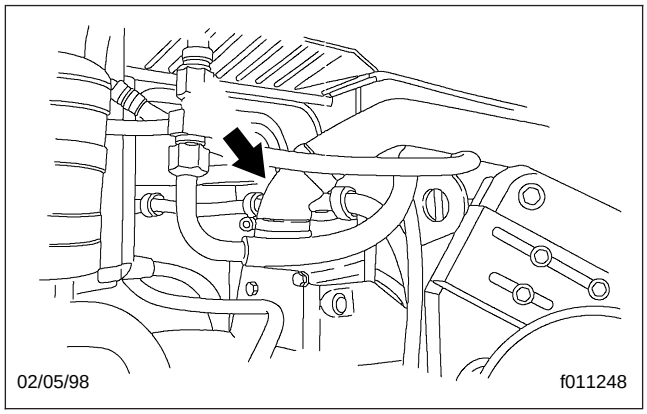


Fig. 10, Radiator Upper Tube

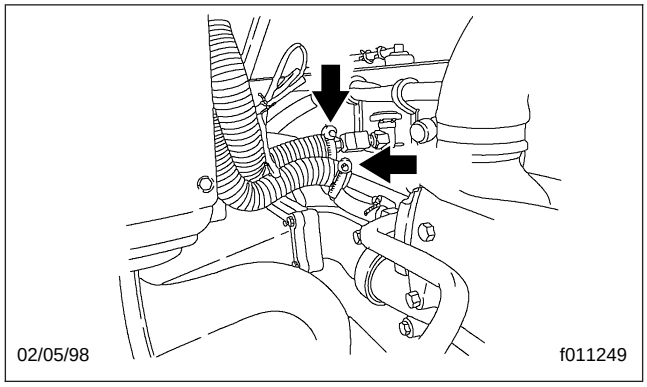


Fig. 11, Heater Water Hoses

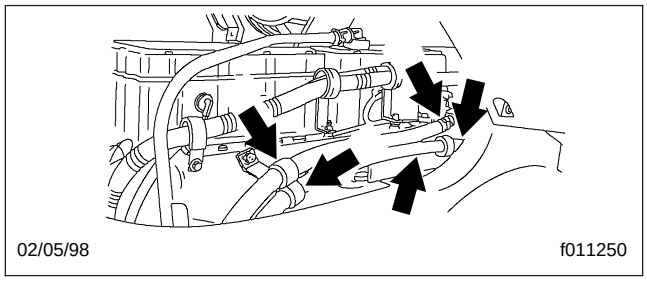
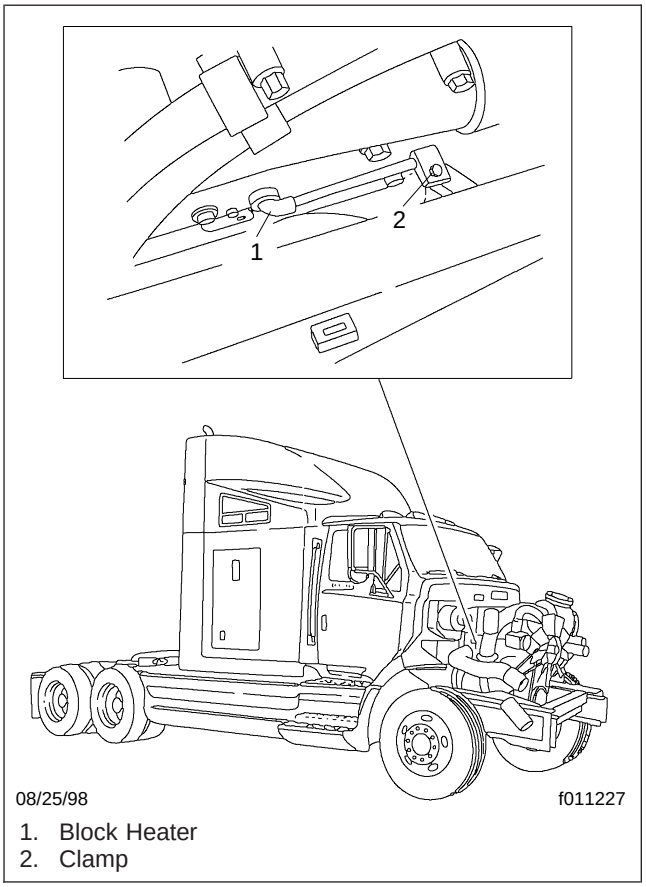


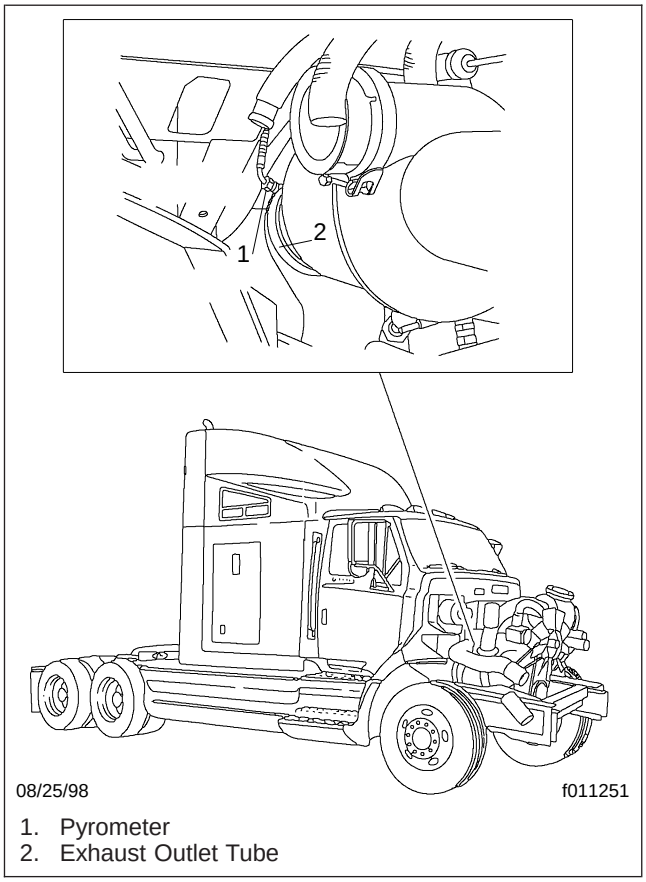
Fig. 12, Auxiliary Heater Water Hoses

20. Remove the six screws and the drivers side splash shield. See **Fig. 18**.
21. Disconnect the compressor air lines. See **Fig. 19**.
22. Disconnect the power steering high pressure line and position it aside. See **Fig. 20**.
23. Disconnect the power steering low pressure line and position it aside. See **Fig. 21**.



1. Block Heater
2. Clamp

Fig. 13, Block Heater



1. Pyrometer
2. Exhaust Outlet Tube

Fig. 14, Turbocharger Outlet Tube

24. If the vehicle is equipped with a manual transmission, disconnect the clutch cable or linkage and position it aside. See **Fig. 22**.
25. Disconnect the two electrical connectors. See **Fig. 23**.
    - 25.1 Remove the bolt and nut.
    - 25.2 Loosen the bolt and nut.
    - 25.3 Position the brace aside.
    - 25.4 Disconnect the bulkhead connector and position aside.
    - 25.5 Disconnect the electrical connector and position aside.
26. Disconnect the starter relay electrical leads and position aside. See **Fig. 24**.
    - 26.1 Remove the protective caps.

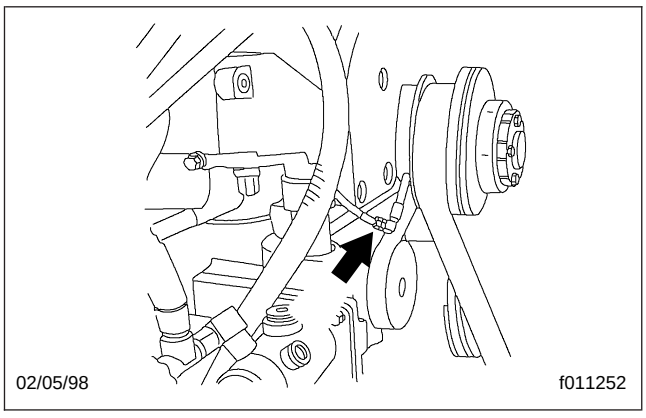


Fig. 15, Cooling Fan Clutch Air Line

    - 26.2 Label and disconnect the starter relay electrical leads.
27. Disconnect the ground strap and position it aside and remove the clamp. See **Fig. 25**.

N14 Plus Engine Removal and Installation

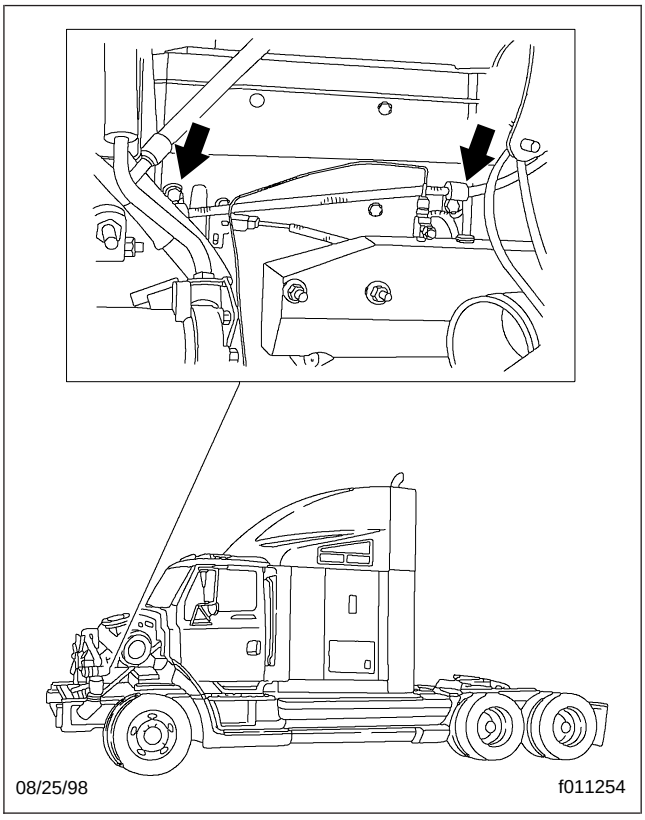


Fig. 16, Cooling Fan Clutch Air Line Retaining Clamps

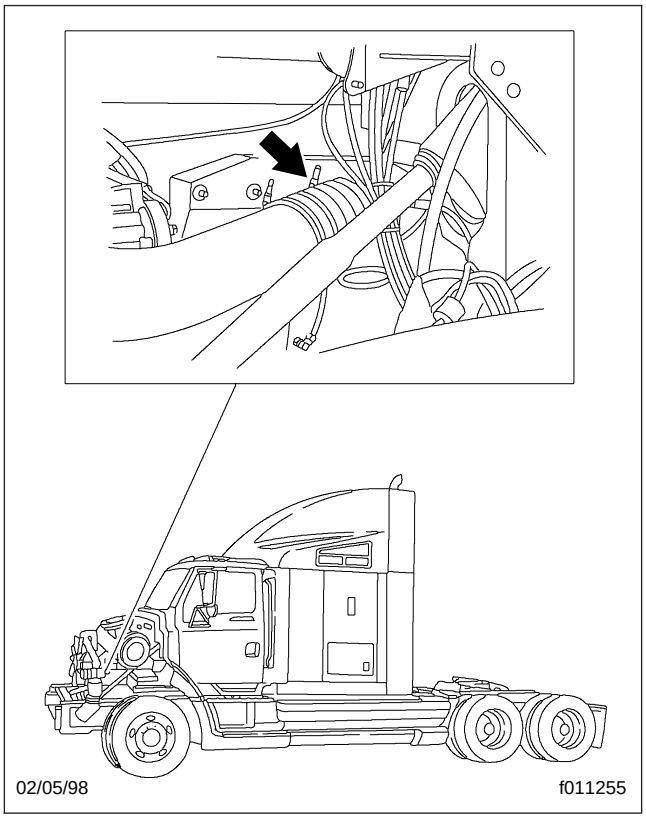


Fig. 17, Charge Air Cooler Outlet Tube

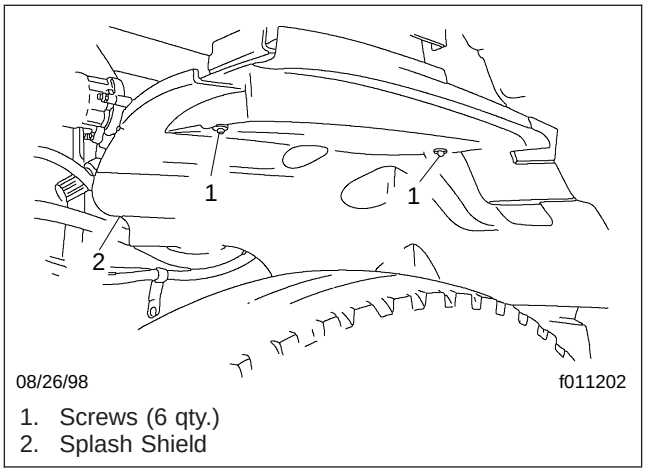
28. Remove the megafuse cover. See **Fig. 26**.
29. Disconnect the megafuse electrical lead and position it aside. See **Fig. 27**.
30. Disconnect the three in-line electrical connectors. See **Fig. 28**.

NOTE: If the vehicle is equipped with a sleeper, perform the next two steps.

31. Remove the megafuse cover. See **Fig. 29**.
32. Disconnect the megafuse electrical lead and position it aside. See **Fig. 30**.
33. Disconnect the engine oil pressure gauge line. See **Fig. 31**.

NOTE: If the vehicle is equipped with a manual transmission, perform the next five steps.

34. Remove the gear shift assembly. Remove the screws and separate the shift lever boot from the floor. Refer to **Group 60** to remove interior trim as required. Remove the transmission floor cover plate if additional access is required.
35. If the vehicle is equipped with the Roadranger® air system, disconnect the vehicle air and the



1. Screws (6 qty.)
2. Splash Shield

Fig. 18, Splash Shield

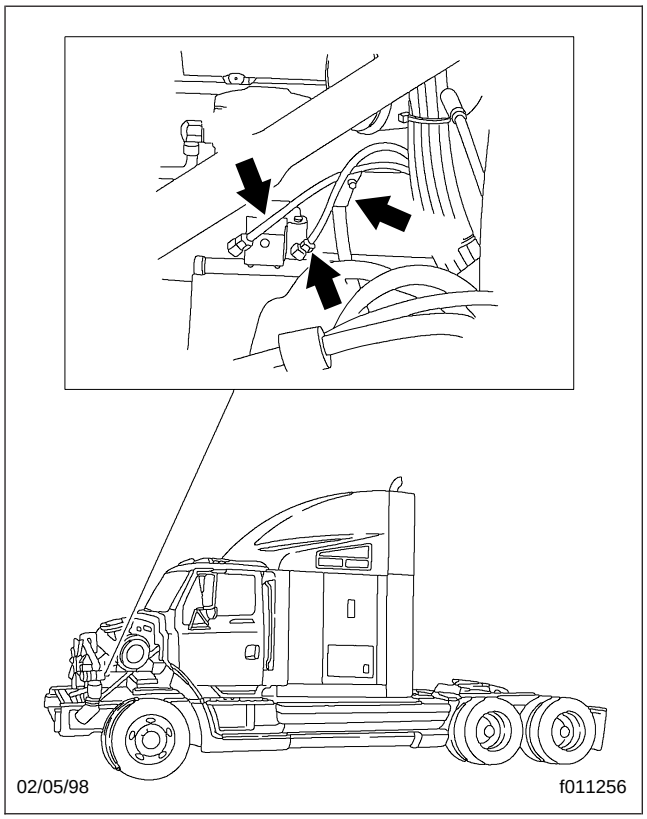


Fig. 19, Compressor Air Lines

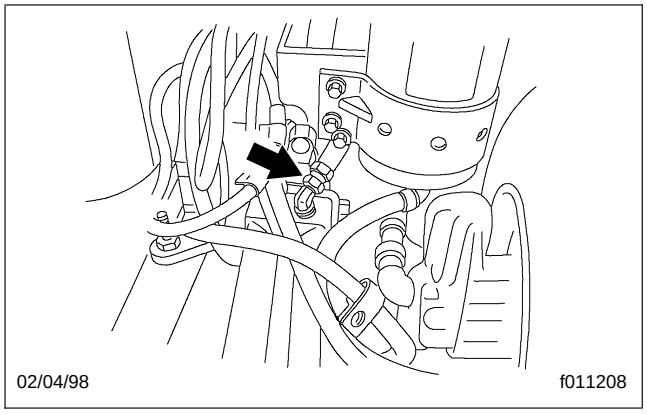


Fig. 20, Power Steering High Pressure Line

Roadranger air system at the transmission. Refer to **Group 26**.

36. Remove the shift lever assembly. See **Fig. 32**.
    - 36.1 Remove the capscrews.
    - 36.2 Position the shift lever assembly aside.

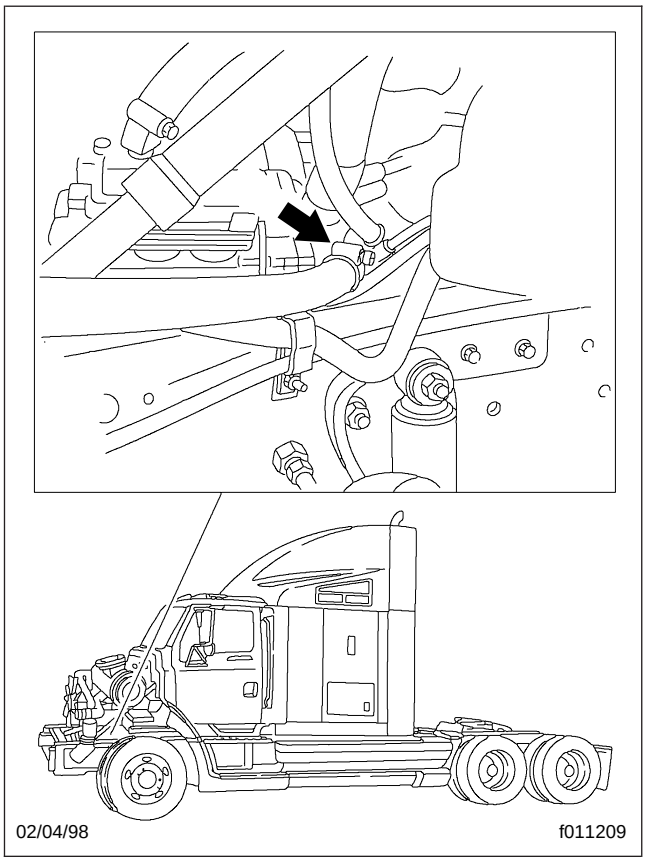


Fig. 21, Power Steering Low Pressure Line

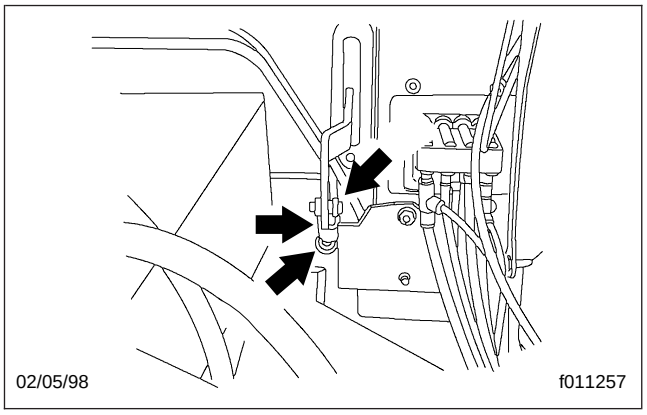
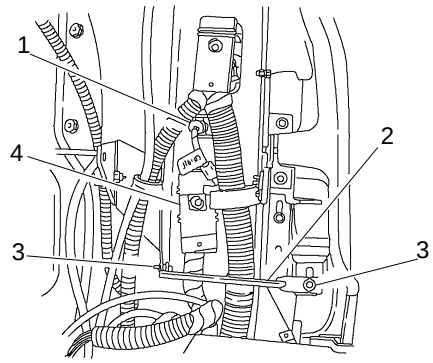


Fig. 22, Clutch Cable Linkage

Cover the hole in the shift control housing to prevent any contamination.

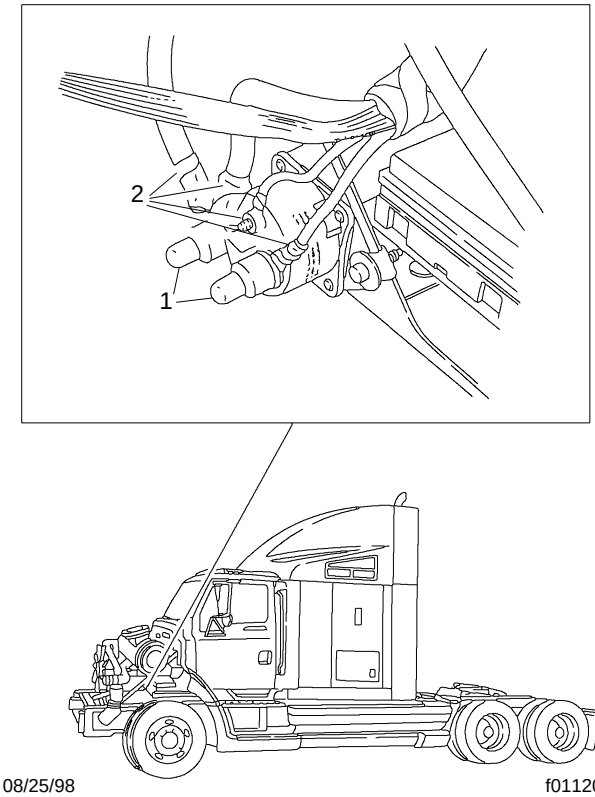
37. If the vehicle is equipped with a clutch linkage, remove the clutch linkage. See **Fig. 33**.

N14 Plus Engine Removal and Installation



1. Electrical Connector
2. Brace
3. Bolt (2 qty.)
4. Bulkhead Electrical Connector

Fig. 23, Electrical Connectors



1. Protective Caps
2. Starter Relay Electrical Leads

Fig. 24, Starter Relay Electrical Leads

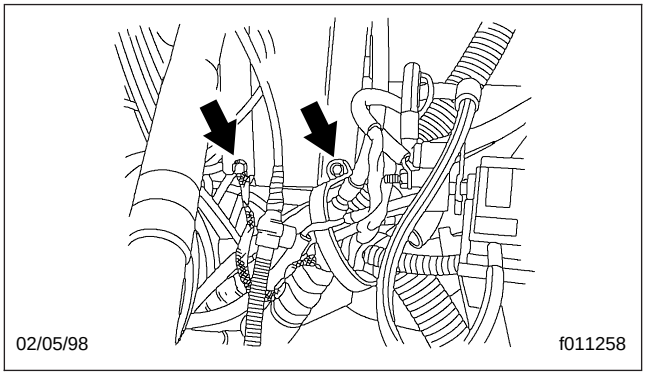
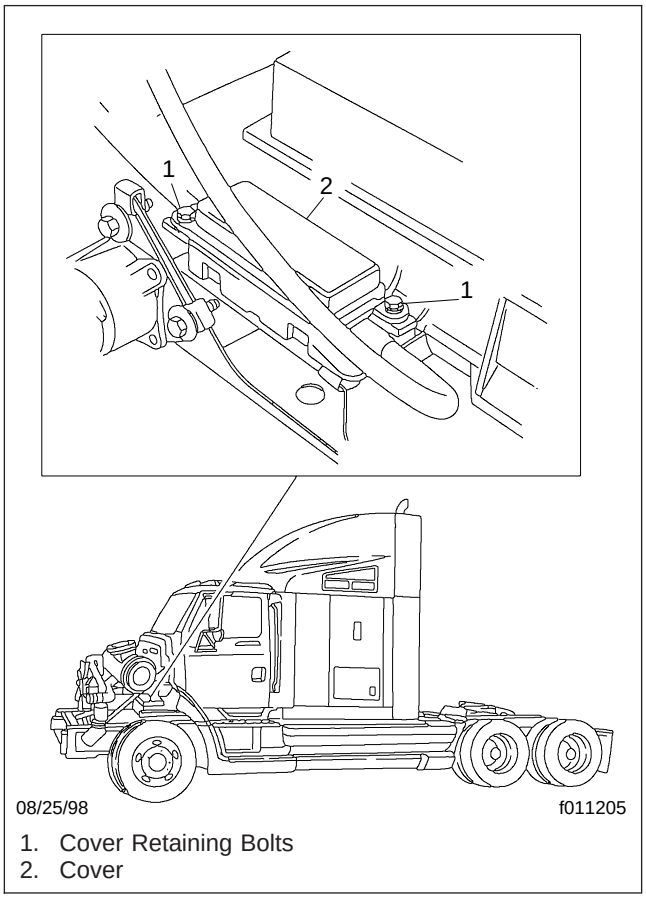


Fig. 25, Ground Strap



1. Cover Retaining Bolts
2. Cover

Fig. 26, Megafuse Cover

38. If the vehicle is equipped with an AT, HT, or MT series automatic transmission, disconnect the selector control cable. See **Fig. 34**.

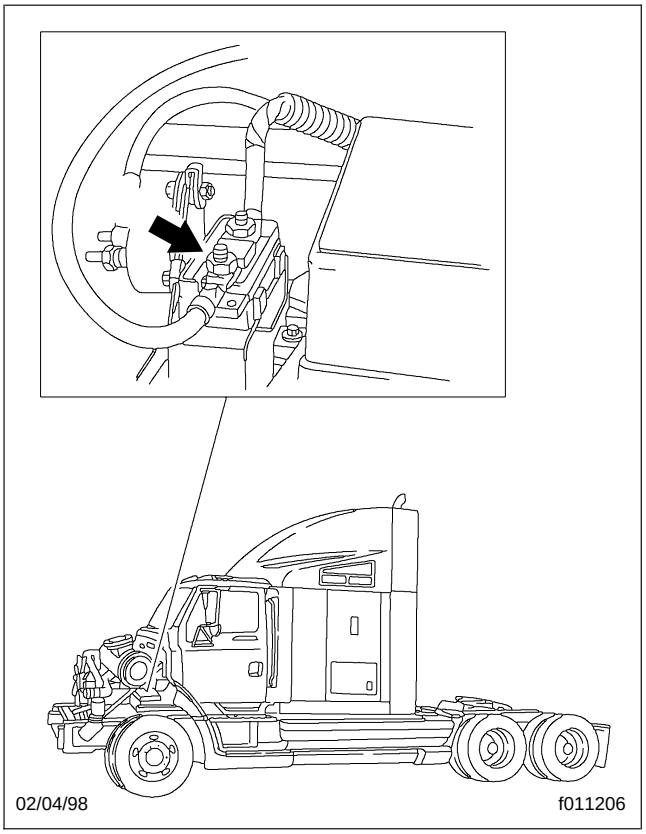


Fig. 27, Megafuse Electrical Lead

NOTE: If the vehicle is equipped with an HD or MD series automatic transmission, then perform the next three steps.

39. Remove the interior trim and floor mat.
40. Remove the screws and the transmission floor cover plate.
41. Disconnect the electrical connectors. See **Fig. 35**.

NOTE: The HD series automatic transmission is shown, all others are similar.

42. If the vehicle is equipped with a transmission oil cooler, disconnect the transmission oil cooler lines. See **Fig. 36**.
    - Remove all retaining clamps.
    - Disconnect the transmission oil cooler lines.

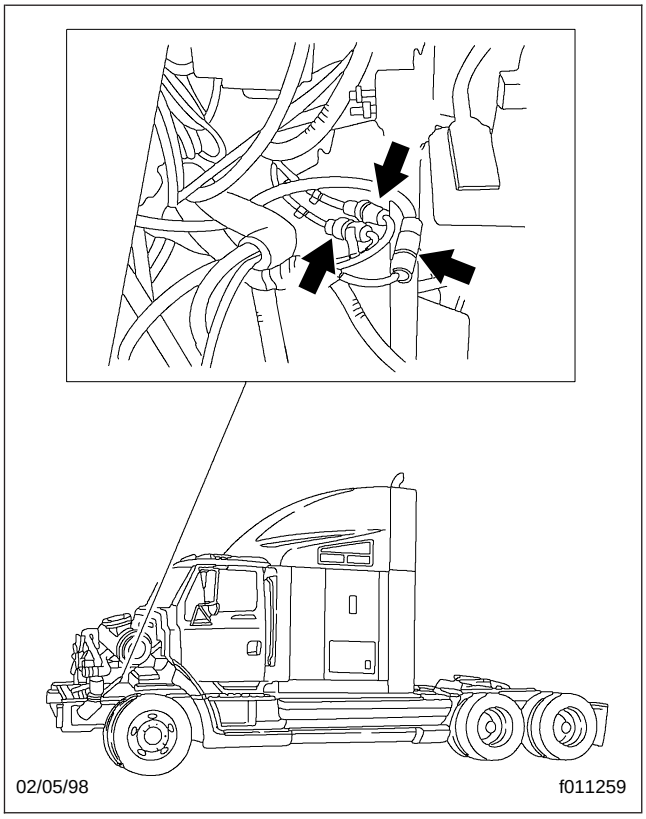


Fig. 28, In-Line Electrical Connectors

NOTE: If the vehicle is equipped with a single fuel tank, perform the next two steps.

43. Disconnect the fuel supply line. See **Fig. 37**.

NOTE: If the vehicle is equipped with a single fuel tank, perform the next two steps.

44. Disconnect the fuel return line. See **Fig. 38**.
45. If the vehicle is equipped with dual fuel tanks, disconnect the fuel supply and return lines. See **Fig. 39**.
46. Remove the exhaust outlet tube.
47. Disconnect the ground strap. See **Fig. 40**.
48. Disconnect the starter motor electrical leads. See **Fig. 41**.
49. Disconnect the starter solenoid electrical leads. See **Fig. 42**.
50. Disconnect the in-line electrical connector. See **Fig. 43**.

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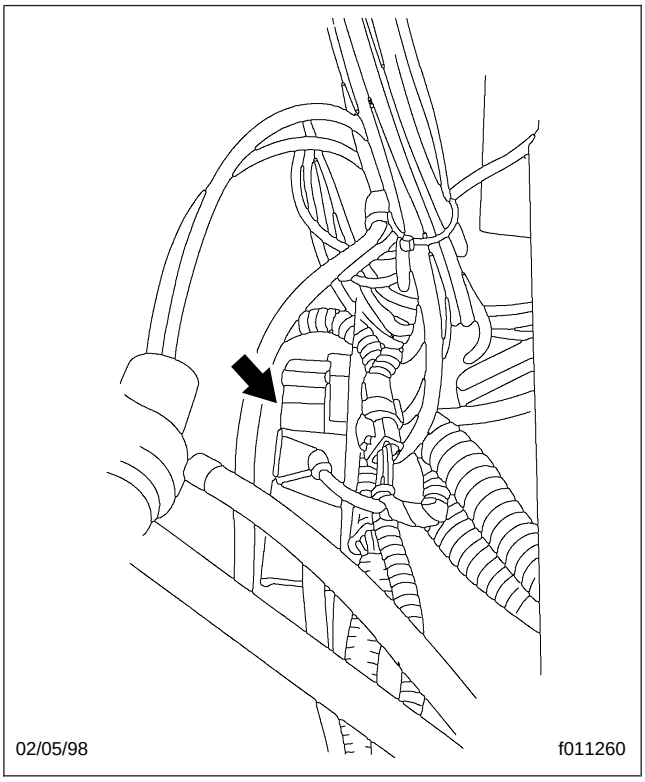


Fig. 29, Megafuse Cover

51. Remove the battery cable retaining clamp(s) from the transmission. See **Fig. 44**.
52. Disconnect the driveshaft; refer to **Group 41**.

NOTE: The left-side rear support bracket is shown. The right-side is similar.

53. Remove four bolts, eight washers, four nuts and the two rear support brackets. See **Fig. 45**.
54. Support the powertrain assembly.

    Install the engine lifting equipment.

    - Use a suitable lifting chain connected to the two lifting eyes and lifting crane rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.
    - Position a suitable transmission jack under the transmission. Secure the transmission to the jack.

NOTE: The left rear engine mount is shown. The right-side is similar.

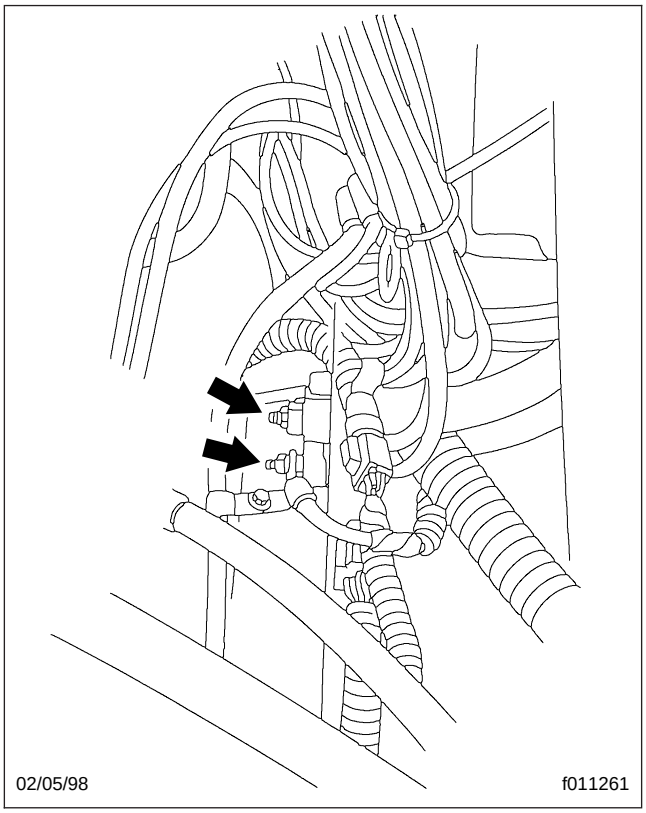


Fig. 30, Megafuse Electrical Lead

The compression-type front engine mount is shown. The focal-type front engine mount is similar.

55. Remove the 10 bolts, washers, and two rear engine mounts. Raise the transmission to lift the two rear engine mounts off of the insulators. See **Fig. 46**.

NOTE: The compression-type front engine mount is shown. The focal-type front engine mount is similar.

56. If the vehicle has a 101-inch BBC chassis, remove the nuts and flag bolts. See **Fig. 47**.
57. Remove the eight bolts, 16 washers, eight nuts and the No. 2 crossmember. See **Fig. 48**.
58. Move the powertrain assembly forward until the transmission jack reaches the front axle.
59. Lower the engine and support the front engine mount. Use a suitable jack rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer

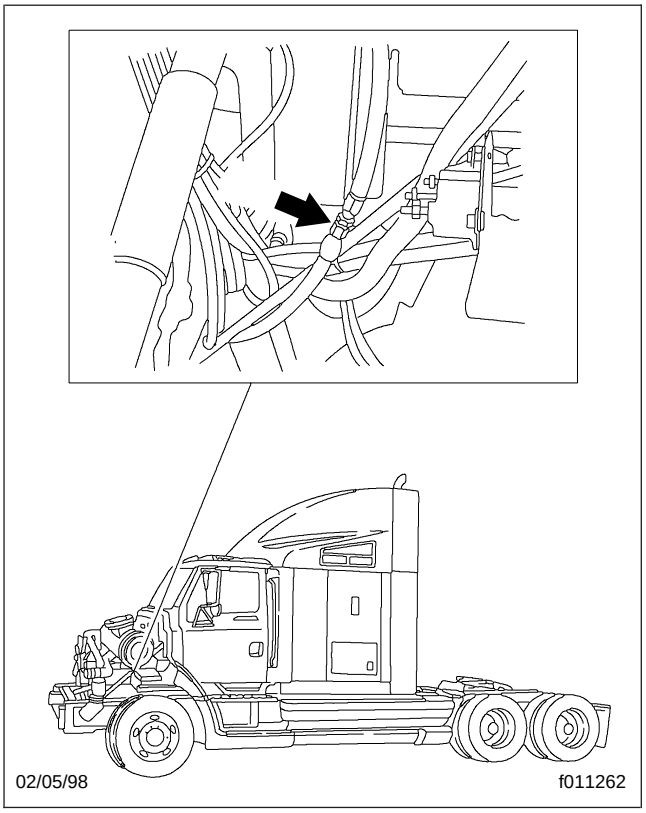
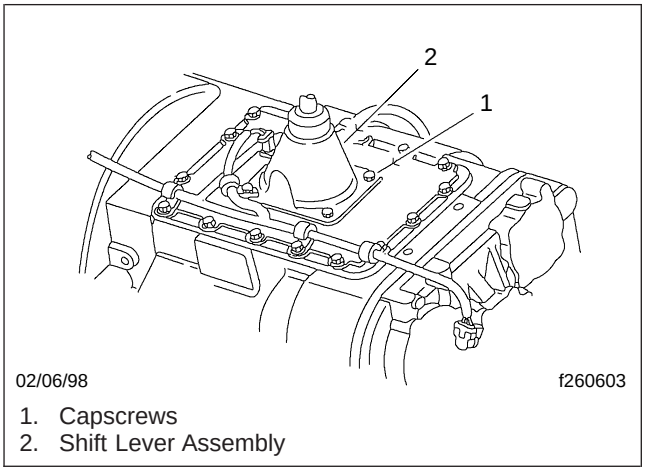


Fig. 31, Oil Pressure Gauge Line



1. Capscrews
2. Shift Lever Assembly

Fig. 32, Shift Lever Assembly

and a suitable length of wood with a minimum 4-inch (10 mm) x 6-inch (15 mm) dimension.

60. Remove the power steering line. See **Fig. 49**.

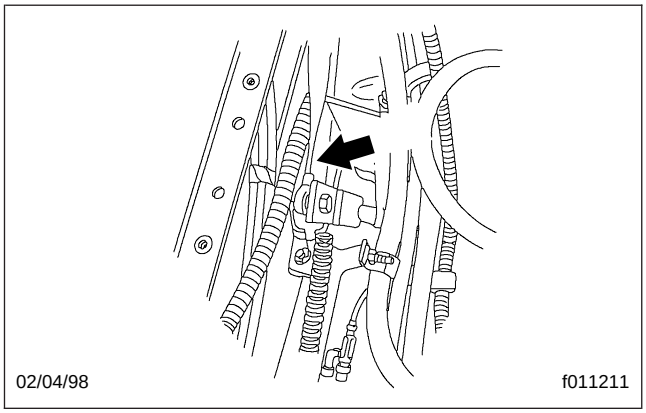


Fig. 33, Clutch Linkage

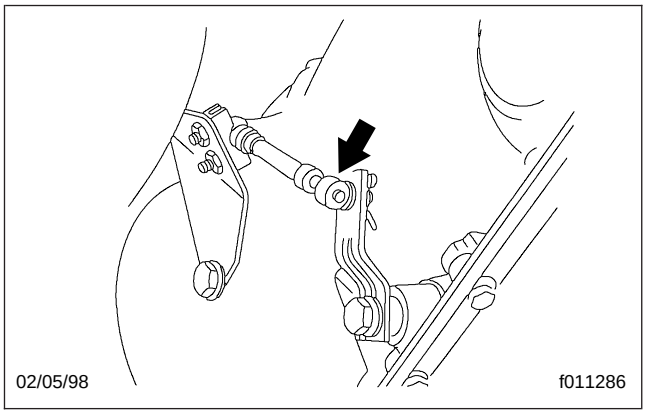


Fig. 34, Selector Control Cable

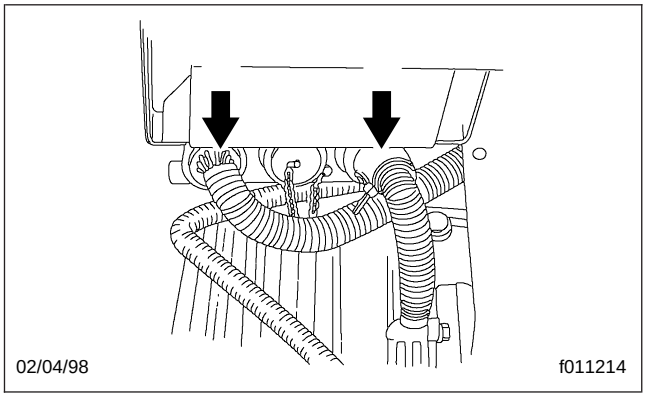


Fig. 35, Electrical Connectors

61. Remove the powertrain assembly from the vehicle.

    61.1 Remove the lifting chain. Install a load leveling engine sling.

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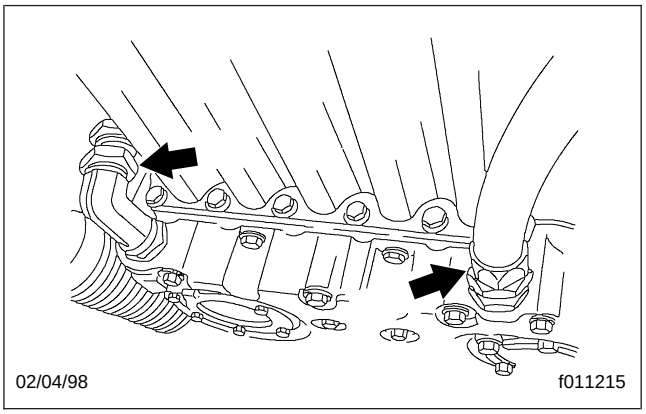


Fig. 36, Transmission Cooler Lines

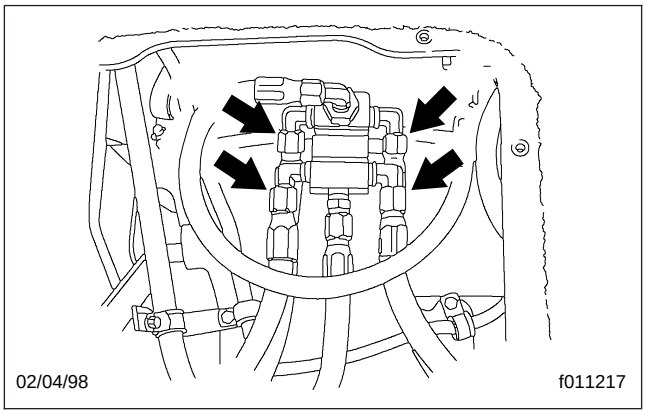


Fig. 39, Fuel Lines, Dual Fuel Tanks

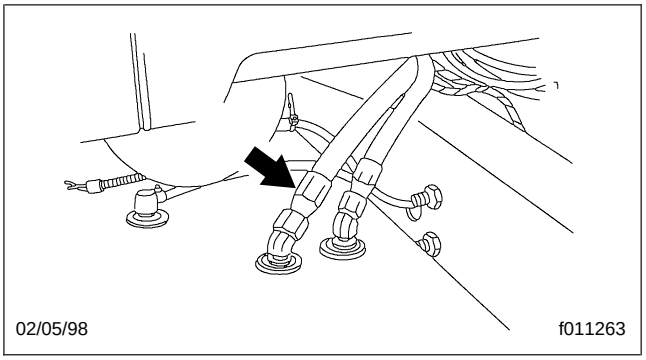


Fig. 37, Fuel Supply Line, Single Fuel Tank

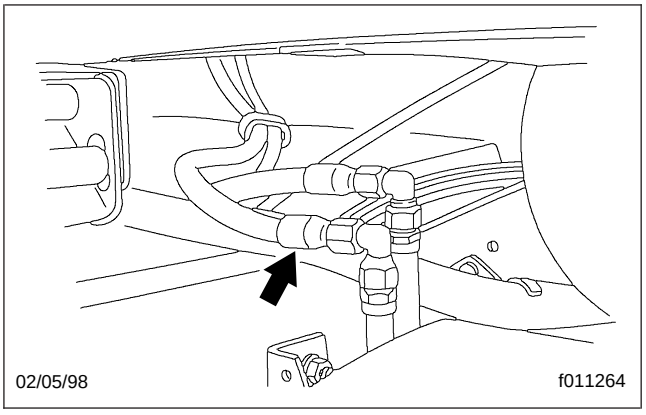


Fig. 38, Fuel Return Line, Single Fuel Tank

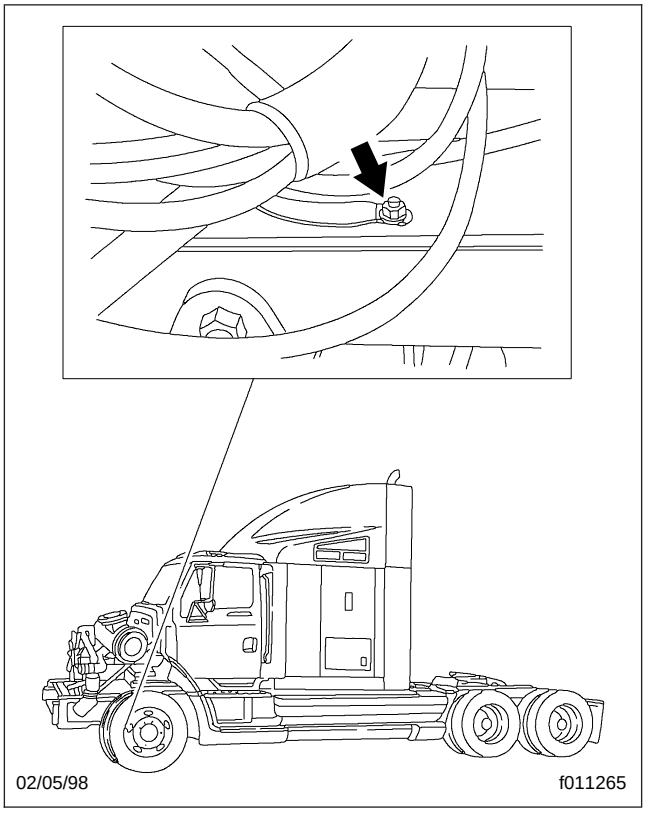


Fig. 40, Ground Strap

Use a suitable load leveling engine sling rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.

61.2 Raise the engine.

61.3 Remove the strap from the transmission.

61.4 Level the powertrain assembly.

61.5 Remove the transmission jack.

61.6 Move the powertrain assembly out of the vehicle.

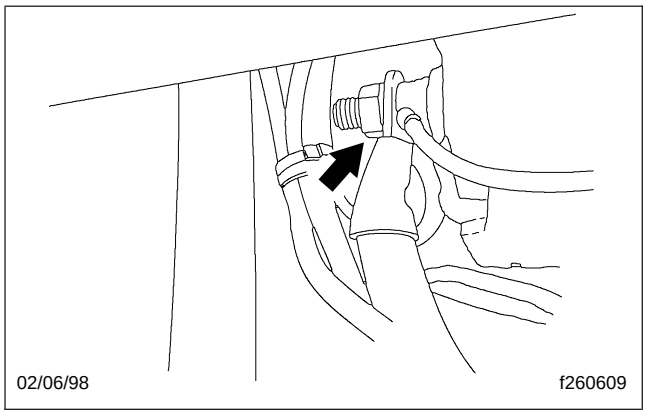


Fig. 41, Starter Motor Electrical Leads

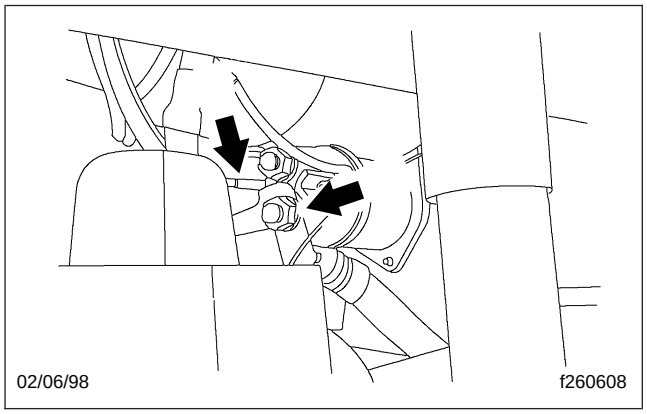


Fig. 42, Starter Solenoid Electrical Leads

NOTE: The left rear engine mount is shown. The right-side is similar.

The compression-type front engine mount is shown. The focal-type front engine mount is similar.

62. Install the 10 bolts, washers, and two rear engine mounts. See **Fig. 50**.
63. Support the powertrain assembly. See **Fig. 51**.
    - Use suitable jack stands rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.
    - Use a suitable transmission jack.

Installation

1. Raise the powertrain assembly and remove the jack stands and the transmission jack.

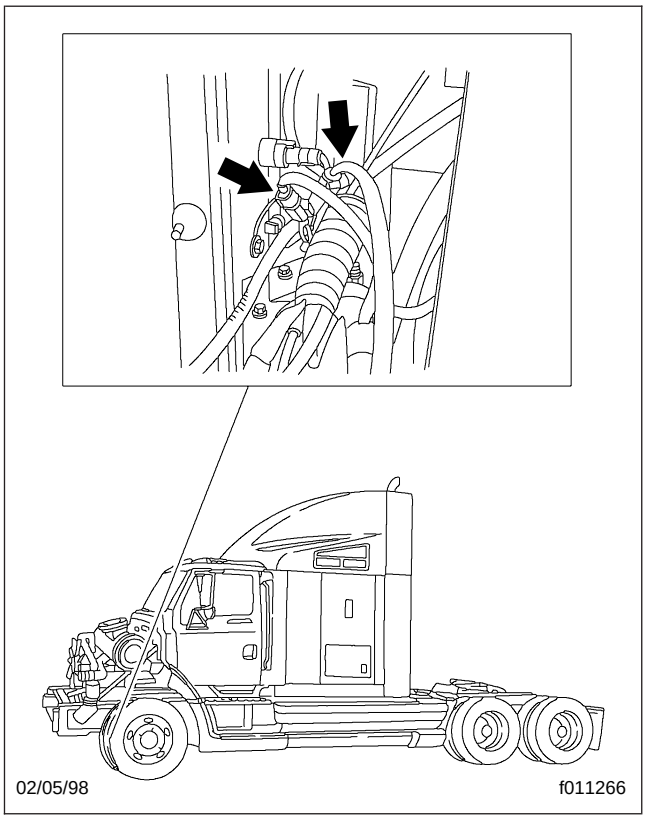


Fig. 43, In-Line Electrical Connector

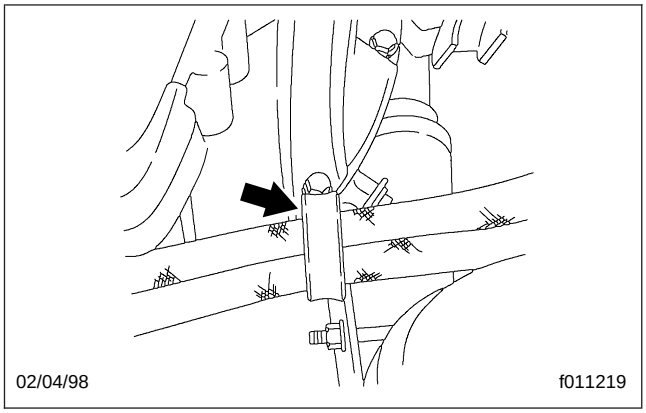


Fig. 44, Battery Cable Retaining Clamp

Use a suitable load leveling sling and lifting crane rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.

NOTE: The left rear engine mount is shown. The right-side is similar. See **Fig. 50**.

N14 Plus Engine Removal and Installation

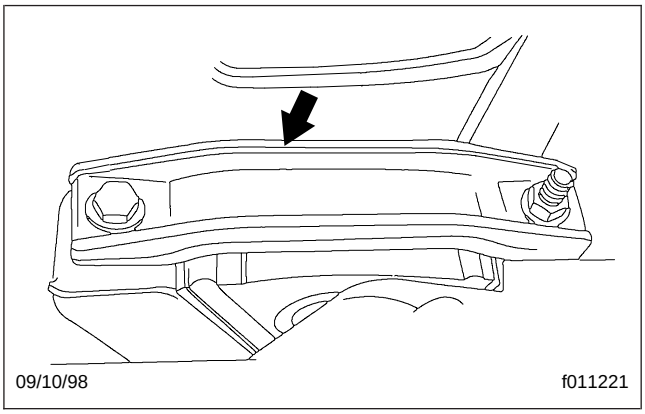
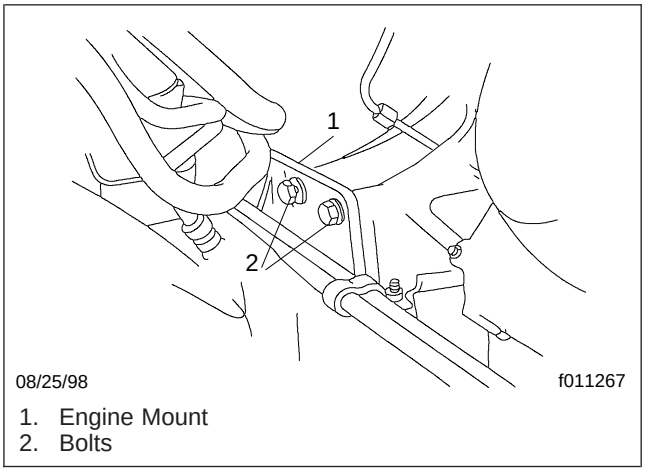


Fig. 45, Rear Support Bracket



1. Engine Mount
2. Bolts

Fig. 46, Rear Engine Mount

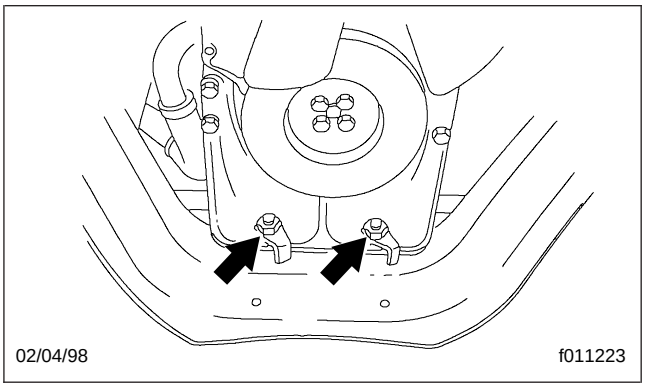
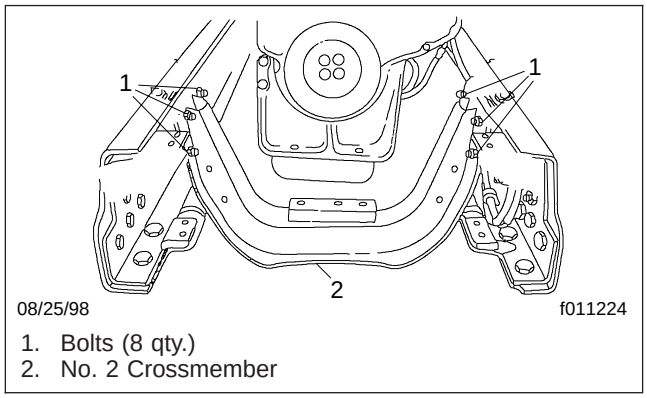


Fig. 47, Flag Bolt and Nut Assembly

2. Remove the 10 bolts, washers and the two rear engine mounts.



1. Bolts (8 qty.)
2. No. 2 Crossmember

Fig. 48, No. 2 Crossmember

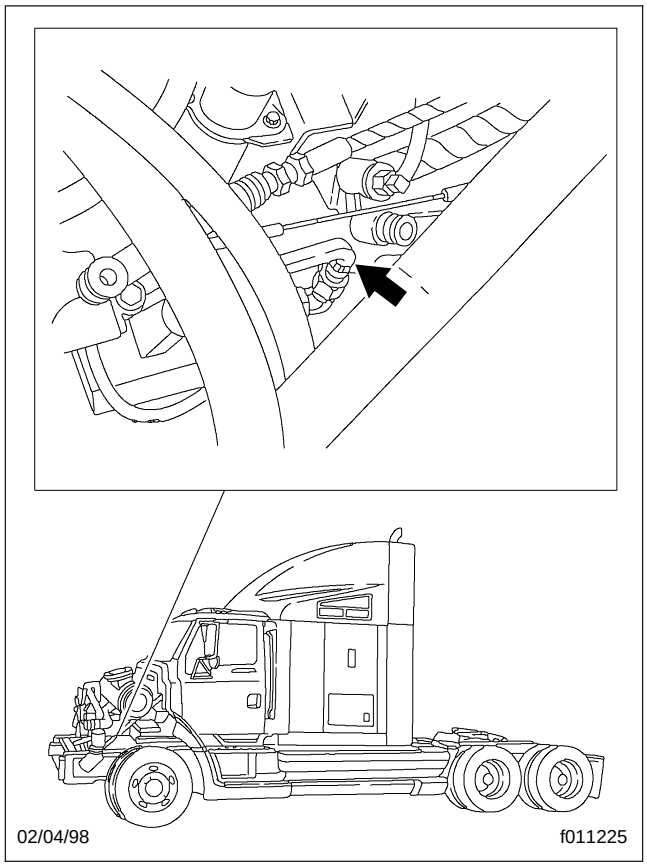
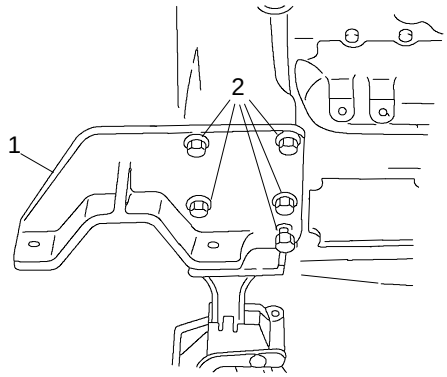


Fig. 49, Power Steering Line

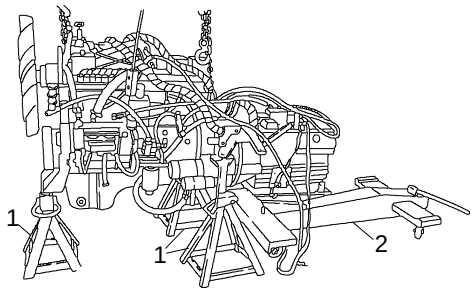
IMPORTANT: Use care not to damage any engine components, lines, filters, and electrical wiring during installation of the powertrain assembly.



08/26/98 f011360

1. Engine Mount
2. Bolts

Fig. 50, Rear Engine Mount



08/25/98 f011226

1. Jack Stand
2. Floor Jack

Fig. 51, Supporting the Powertrain Assembly

3. Move the powertrain assembly into the vehicle until the transmission is behind the front axle.
4. Support the powertrain assembly.
   - 4.1 Install a suitable transmission jack under the transmission. Secure the transmission to the jack.
   - 4.2 Lower the engine and support the front engine mount.

     Use two suitable jack stands rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer and a suitable length of wood with a minimum 4-inch (10 mm) x 6-inch (15 mm) dimension.
5. Install the power steering line. See **Fig. 49**.
6. Remove the load leveling sling and install a lifting chain.

   Use a suitable lifting chain rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer connected to the front lifting eye.
7. Move the powertrain assembly back to the rear engine mount insulators.
8. Install the No. 2 crossmember, eight bolts, 16 washers, and eight nuts. Tighten 75 to 105 lbf·ft (102 to 138 N·m). See **Fig. 48**.

   A suitable porta-power unit may be necessary to spread the frame side rails if the frame has settled.

NOTE: The compression-type front engine mount is shown. The focal-type front engine mount is similar.

9. If the vehicle has a 101-inch BBC chassis, install the bolts and flag nuts. Tighten 150 to 205 lbf·ft (204 to 277 N·m). See **Fig. 47**.

NOTE: The left-side rear engine mount is shown. The right-side is similar. See **Fig. 46**.

10. Install the two engine mounts, 10 washers and bolts. Tighten 150 to 205 lbf·ft (203 to 278 N·m).

NOTE: The left-side rear support bracket is shown. The right-side is similar.

11. Install the two rear support brackets, four bolts, eight washers and four nuts. Tighten 75 to 105 lbf·ft (102 to 138 N·m). See **Fig. 45**.
12. Connect the driveshaft. Refer to **Group 41**.
13. Install the battery clamp(s) on the transmission. See **Fig. 44**.
14. Connect the in-line electrical connectors. See **Fig. 43**.
15. Connect the starter solenoid electrical leads. See **Fig. 42**. Apply Silicone Dielectric Compound or equivalent meeting specification ESE–M1C171–A to all of the starter motor electrical connections.
16. Connect the starter motor electrical leads. See **Fig. 41**. Apply Silicone Dielectric Compound or equivalent meeting specification ESE–M1C171–A to all of the starter motor electrical connections.
17. Connect the ground strap. See **Fig. 40**.

N14 Plus Engine Removal and Installation

NOTE: On 101-inch BBC vehicles it may be necessary to access the exhaust outlet tube from inside the vehicle.

18. Install the exhaust outlet tube and connect the pyrometer.

NOTE: If the vehicle is equipped with a single fuel tank, perform the next two steps.

19. Connect the fuel return line. See **Fig. 38**.

    Install the retaining clamps as noted during removal.

20. Connect the fuel supply line. See **Fig. 37**.

    Install the retaining clamps as noted during removal.

21. If the vehicle is equipped with dual fuel tanks, connect the fuel supply and return lines. See **Fig. 39**.

NOTE: The HD series automatic transmission is shown. All others are similar.

22. If the vehicle is equipped with a transmission oil cooler, connect the transmission oil cooler lines. See **Fig. 36**.
    - Connect the transmission oil cooler lines.
    - Install the retaining clamps.

NOTE: If the vehicle is equipped with an HD or MD series automatic transmission, then perform the next three steps.

23. Connect the electrical connectors. See **Fig. 35**.
24. Install the transmission floor cover plate and the screws.
25. Install the floor mat and interior trim. Refer to **Group 60**.
26. If the vehicle is equipped with an AT, HT or MT series automatic transmission, connect the selector cable. See **Fig. 34**.

NOTE: If the vehicle is equipped with a manual transmission, then perform the next seven steps.

27. If the vehicle is equipped with a clutch linkage, install the clutch linkage. See **Fig. 33**.
28. Align the shift block and yoke notches in the neutral position. See **Fig. 52**.

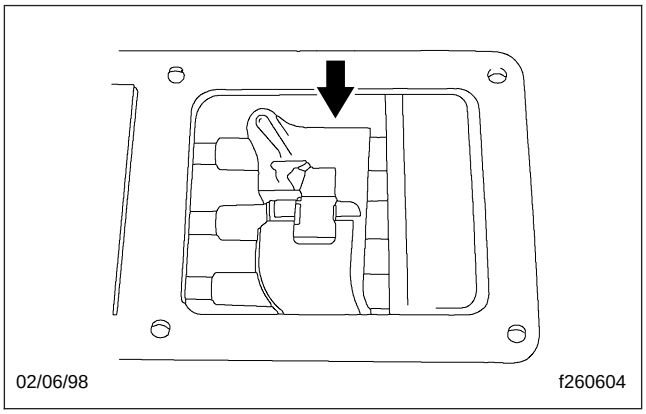


Fig. 52, Aligning the Shift Block and Yoke

29. Position the gasket on the shift control housing.
30. Position the shift lever housing.

    Fit the shift lever into the shift block and yoke notches. See **Fig. 53**.

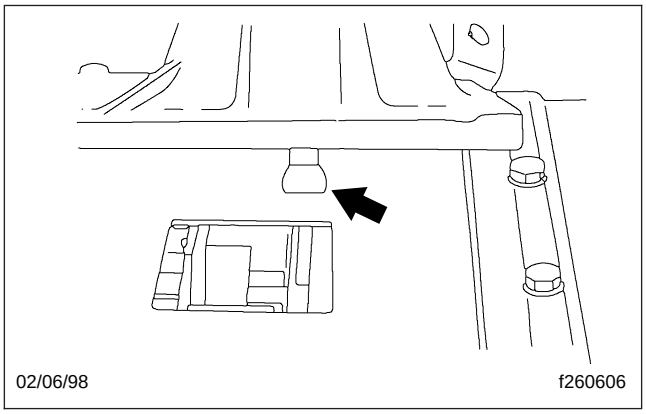


Fig. 53, Positioning the Shift Lever

31. Install the capscrews. See **Fig. 32**.

    Use Threadlock®and Sealer or equivalent meeting specification WSK–M2G315–A5 on the threads.

32. If the vehicle is equipped with the Roadranger® air system, connect the vehicle air and the Roadranger air system to the transmission. Refer to **Group 26**.
33. Install the shift lever boot.

    If removed, install the transmission floor cover plate and interior trim. Refer to **Group 60**.

34. Connect the engine oil pressure gauge line. See **Fig. 31**.

NOTE: If the vehicle is equipped with a sleeper, perform the next two steps.

35. Connect the megafuse electrical lead. See **Fig. 30**.
36. Install the megafuse cover. See **Fig. 29**.
37. Connect the three in-line electrical connectors. See **Fig. 28**.
38. Connect the megafuse electrical lead. See **Fig. 27**.
39. Install the megafuse cover. See **Fig. 26**.
40. Install the clamp and connect the ground strap. See **Fig. 25**.
41. Connect the starter relay electrical leads. See **Fig. 24**.
    - 41.1 Connect the starter relay electrical leads to the terminals noted during removal.
    - 41.2 Install protective caps.
42. Connect the electrical connectors. See **Fig. 23**.
    - 42.1 Connect the electrical connector.
    - 42.2 Connect the bulkhead electrical connector.
    - 42.3 Position the brace.
    - 42.4 Install and tighten the nuts and bolts.
43. If the vehicle is equipped with a manual transmission, connect the clutch cable. See **Fig. 22**.
44. Connect the power steering low pressure line. See **Fig. 21**.
45. Connect the power steering high pressure line. See **Fig. 20**.
46. Connect the compressor air lines. See **Fig. 19**.
47. Install the driver side splash shield and six screws. See **Fig. 18**.
48. Install the charge air outlet tube. See **Fig. 17**.
49. If the vehicle is equipped with an air actuated cooling fan clutch, route the cooling fan clutch air line and install the retaining clamps bolts. See **Fig. 16**.
50. Rotate the generator outward.
51. If the vehicle is equipped with an air actuated cooling fan clutch, Connect the cooling fan clutch air line. See **Fig. 15**.

NOTE: On 101-inch BBC vehicles, it may be necessary to access the block heater electrical connector and clamp from inside the vehicle.

52. Connect the block heater electrical connector and install the clamp. See **Fig. 13**.

NOTE: On 101-inch BBC vehicles, it may be necessary to access the auxiliary heater water hose and clamps from inside the vehicle.

53. If the vehicle is equipped with a sleeper, connect the auxiliary heater water hoses and install the clamps. See **Fig. 12**.
54. Connect the heater water hoses. See **Fig. 11**.
55. Install the radiator upper tube and bolt. See **Fig. 10**.
56. Install the radiator lower tube. See **Fig. 9**.
57. Install the turbocharger outlet tube. See **Fig. 8**.
58. Connect the refrigerant line. See **Fig. 7**.

    Install a new captured O-ring lubricated with clean Heavy Truck PAG Oil or equivalent meeting specification EST–M1C231–B2.
59. If the vehicle has a 113- to 122-inch BBC chassis, install the No. 1 crossmember, two bumper brackets, four bolts, eight washers and four nuts. See **Fig. 6**.

NOTE: If the vehicle has a 101-inch BBC chassis, then perform the next two steps.

60. Install the top two No. 1 crossmember gussets, four bolts, eight washers and four nuts. See **Fig. 5**.
61. Install the No. 1 crossmember and eight bolts, 16 washers and eight nuts. See **Fig. 4**.

NOTE: The steering gear is shown. The rotary assist cylinder is similar.

62. If the vehicle is equipped with a rotary assist cylinder, route the power steering lines and connect the power steering lines to the steering gear and rotary assist cylinder. See **Fig. 3**.

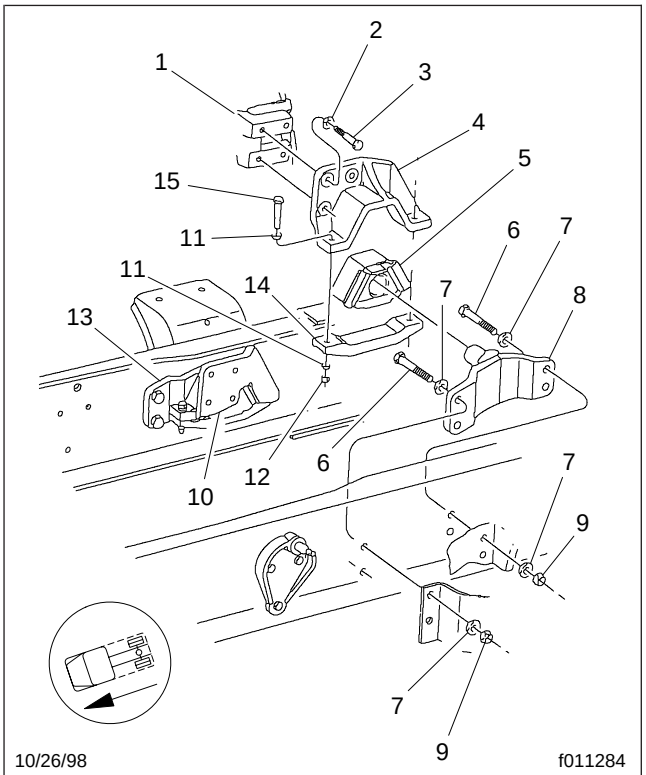
N14 Plus Engine Removal and Installation

NOTE: The brake valves shown are for a 2-channel ABS system. All other configurations are similar.

63. Connect the air valve assembly. See **Fig. 2**.
    - Connect the air lines.
    - Connect the electrical connector.
    - Install the retaining clamp bolts.
64. If the vehicle is equipped with front pintle hooks, install the two pintle hooks, six bolts, 10 washers and four nuts. Tighten 220 to 300 lbf·ft (298 to 406 N·m). See **Fig. 1**.
65. Restore the vehicle to operating condition.
    - 65.1 Install the air intake tube and air cleaner assembly as an assembly. Refer to **Group 09**.
    - 65.2 Install the cooling fan. Refer to **Group 20**.
    - 65.3 Install the cooling module. Refer to **Group 20**.
    - 65.4 If the vehicle is equipped with a transmission cooler or an automatic transmission, fill the transmission oil. Refer to the appropriate **Group 26** transmission section.
    - 65.5 Fill the engine with oil.
    - 65.6 Fill the engine cooling system; refer to **Group 20**.
    - 65.7 Repressurize the air system with clean, dry air.
    - 65.8 If the vehicle is equipped with an A/C system, evacuate, charge and leak test the A/C system; refer to **Group 83**.
    - 65.9 Check the engine drive belts for proper adjustment.
    - 65.10 Check the accelerator and hand throttle linkages for proper adjustment; refer to **Group 30**.
    - 65.11 Check the transmission cables and linkages for proper adjustment. Refer to the appropriate **Group 26** transmission section.
    - 65.12 Check the clutch cables and linkages for proper adjustment; refer to **Group 25**.
    - 65.13 Connect the battery ground cables.
    - 65.14 Start the engine and check the powertrain assembly for leaks.
    - 65.15 Install the engine cover; refer to **Group 60**.
    - 65.16 Install the hood; refer to **Group 88**.
    - 65.17 Install the bumper; refer to **Group 31**.

Rear Engine Mount Replacement

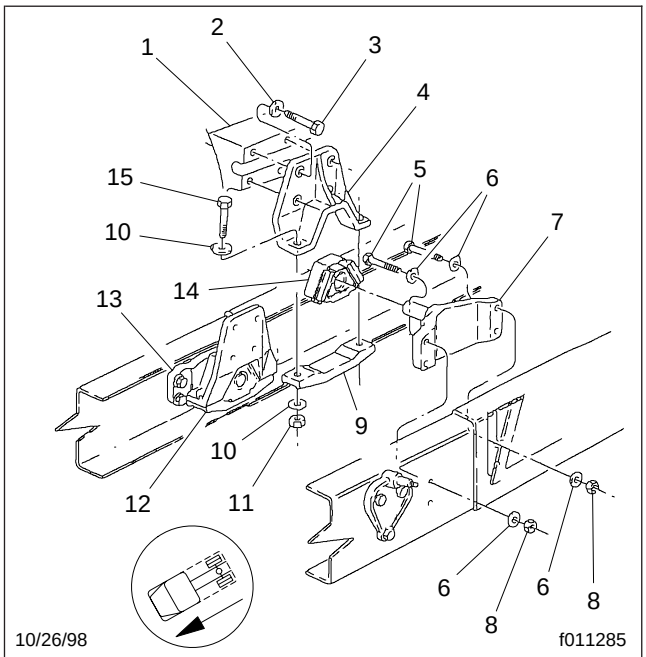
NOTE: See **Fig. 1, Fig. 2 or Fig. 3** for this procedure.



1. Flywheel Housing
2. Flatwasher (12 mm x 24 x 2.75)
3. Hexhead Bolt (M12 x 1.75 x 55)
4. Rear Engine Support Bracket (left-hand)
5. Engine Support Isolator
6. Hexhead Bolt (5/8–11 x 3.50)
7. Flatwasher (5/8 x 1.18 x 0.13)
8. Engine Support Bracket (left-hand)
9. Locknut (5/8–11)
10. Rear Engine Support Bracket (right-hand)
11. Flatwasher (1/2 x 1.06 x 0.10)
12. Locknut (1/2–13)
13. Engine Support Bracket (right-hand)
14. Engine Support-to-Frame Cap
15. Hexhead Bolt (1/2–13 x 2.50)

Fig. 1, Rear Engine Support Isolators, ISB Engines

1. Apply the parking brakes, shut down the engine, chock the tires, and if applicable, drain the air brake system.



1. Flywheel Housing
2. Flatwasher (12 mm x 24 x 2.75)
3. Hexhead Bolt (M12 x 1.75 x 55)
4. Engine Leg (left-hand)
5. Hexhead Bolt (5/8–11 x 3.50)
6. Flatwasher (5/8 x 1.18 x 0.13)
7. Engine Support Bracket (left-hand)
8. Locknut (5/8–11)
9. Engine Support-to-Frame Cap
10. Flatwasher (1/2 x 1.06 x 0.10)
11. Locknut (1/2–13)
12. Engine Leg (right-hand)
13. Engine Support Bracket (right-hand)
14. Engine Support Isolator
15. Hexhead Bolt (1/2–13 x 2.50)

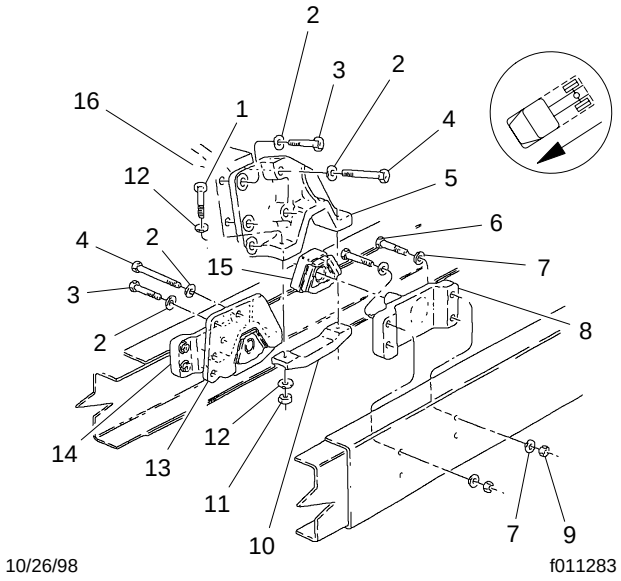
Fig. 2, Rear Engine Support Isolators, ISC Engines

⚠ 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 component damage, personal injury or death.

2. Disconnect the engine from the rear engine support-to-frame bracket(s).

Engine Mount Replacement



1. Hexhead Bolt (1/2–13 x 2.50)
2. Flatwasher (3/4 x 1.44 x 0.13)
3. Hexhead Bolt (3/4–10 x 2.25)
4. Hexhead Bolt (3/4–10 x 3.00)
5. Rear Engine Support Bracket (left-hand)
6. Hexhead Bolt (5/8–11 x 3.50)
7. Flatwasher (5/8 x 1.18 x 0.13)
8. Engine Support-to-Frame Bracket (left-hand)
9. Hex Locknut (5/8–11)
10. Engine Support-to-Frame Cap
11. Hex Locknut (1/2–13)
12. Flatwasher (1/2 x 1.06 x 0.10)
13. Rear Engine Support Bracket (right-hand)
14. Engine Support-to-Frame Bracket (right-hand)
15. Rear Engine Support Isolator
16. Flywheel Housing

Fig. 3, Rear Engine Support Isolators, M11 Plus and N14 Plus Engines

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

2.2 Remove the nuts, bolts and washers that attach the engine support-to-frame cap to the rear engine support bracket(s). Save the fasteners.

3. Disconnect the engine support-to-frame bracket(s) from the frame rail.

3.1 Remove the bolts that secure the rear engine support-to-frame bracket(s) to the frame rail.

3.2 Lift the engine slightly to take its weight off the rear engine support-to-frame bracket(s). Place engine stands under the engine to keep the engine off of the engine support-to-frame bracket(s).

3.3 Remove the rear engine support-to-frame bracket(s) from the frame rail.

3.4 Remove the rear engine support isolator from the rear engine support-to-frame bracket(s).

4. If necessary, remove the bolts that secure the engine leg(s) to the flywheel housing, and remove the leg(s) from the engine.

5. Inspect the rear engine support isolators for wear or damage and replace them, if necessary.

⚠ CAUTION

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

6. Install the rear engine support isolator on a new rear engine support-to-frame bracket(s). Align the isolator on the bracket(s) so the wide side of the isolator is at the bottom of the bracket(s).

7. If removed, install the engine leg(s) on the flywheel housing. Apply thread lock compound to the mounting bolts, and tighten them as follows:

   For ISB and ISC engines: Tighten the bolts 180 to 220 lbf·ft (244 to 298 N·m).

   For N14. M11, ISM, and ISX engines: Tighten the bolts 190 lbf·ft (258 N·m).

8. Place the new engine support-to-frame bracket(s), with the isolator aligned properly, against the inside of the frame rail, and secure it with bolts, washers, and nuts. Tighten the nuts 120 to 152 lbf·ft (163 to 206 N·m).

⚠ 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 component damage, personal injury or death.

9. Connect the engine to the engine support-to-frame bracket(s).

   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(s).

   NOTE: The bolt at the rear of the cap is installed from the bottom. The bolt at the front of the cap is installed from the top.

   9.3 Holding the rear engine support-to-frame cap in place, install the bolts that attach the cap to the rear engine support bracket(s), and secure them with a nut and hardened washer. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

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

Front Engine Mount Replacement

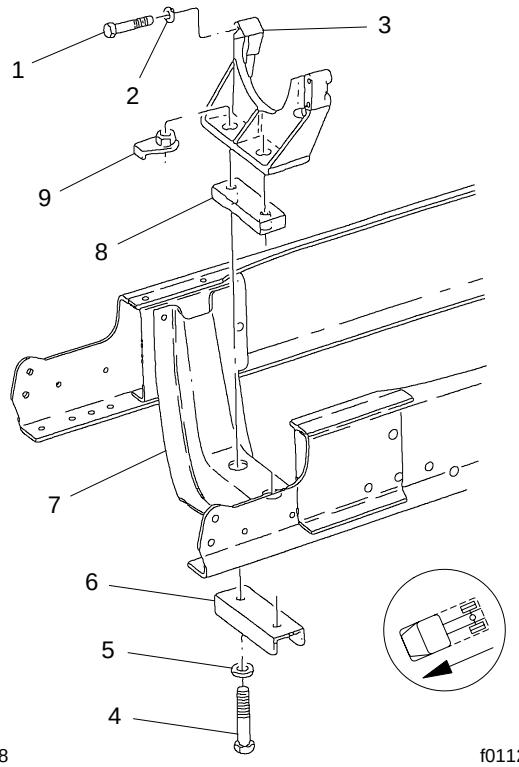
NOTE: Both compression-type and focal-type engine support isolators are used in all L-Line and A-Line vehicles. See **Fig. 4** for ISB engines. See **Fig. 5** and **Fig. 6** for ISC engines. See **Fig. 7** and **Fig. 8** for M11 Plus engines. See **Fig. 9** and **Fig. 10** for N14 Plus engines.

1. Apply the parking brakes, shut down the engine, chock the tires, open the hood, and if applicable, drain the air brake system.

⚠ WARNING

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

2. Disconnect the engine from the front engine mount(s).



1. Hexhead Bolt (M12 x 1.75 x 100 mm)
2. Flatwasher (12 mm x 24 x 2.75)
3. Engine Front Support Bracket
4. Hexhead Bolt (5/8–11 x 3.50)
5. Flatwasher (5/8 x 1.18 x 0.13)
6. Front Support Isolator
7. Engine Front Support Member
8. Front Support Isolator
9. Nut and Retainer (5/8–11)

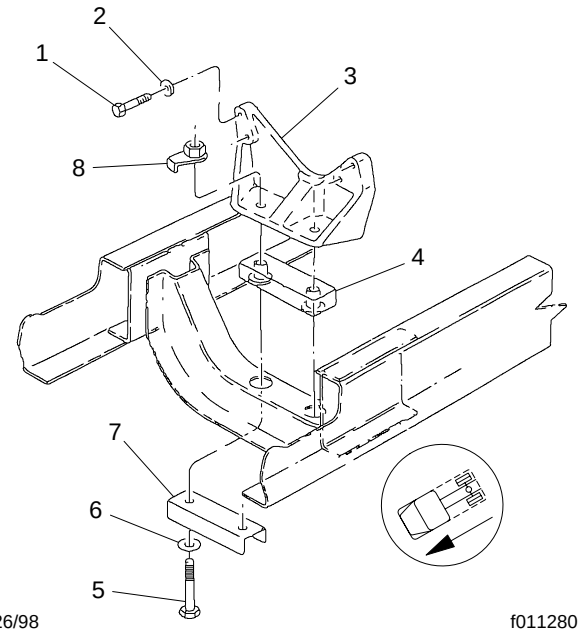
Fig. 4, Front Engine Support Isolators, ISB Engines

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

   2.2 Remove the nuts and bolts from the front engine mount(s). Save the fasteners.

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

Engine Mount Replacement



1. Hexhead Bolt (M12 x 1.75 x 100 mm)
2. Flatwasher (12 mm x 24 x 2.75)
3. Engine Front Support Bracket
4. Isolator
5. Hexhead Bolt (5/8–11 x 3.50)
6. Flatwasher (5/8 x 1.18 x 0.13)
7. Rebound Puck
8. Nut and Retainer (5/8–11)

Fig. 5, Front Engine Support Isolators, Compression, ISC Engines

3. If you are replacing the front engine support bracket, refer to the engine manufacturer's service literature.
4. Inspect the engine mount rubber isolator(s) for wear or damage and replace it, if necessary.

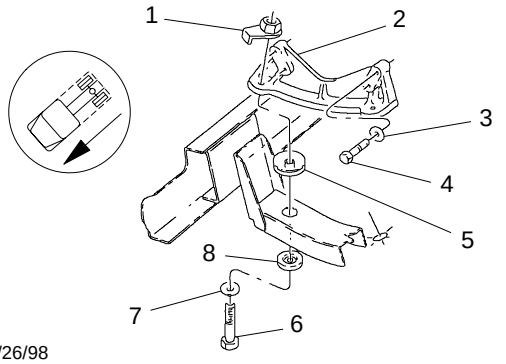
⚠ CAUTION

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

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

⚠ WARNING

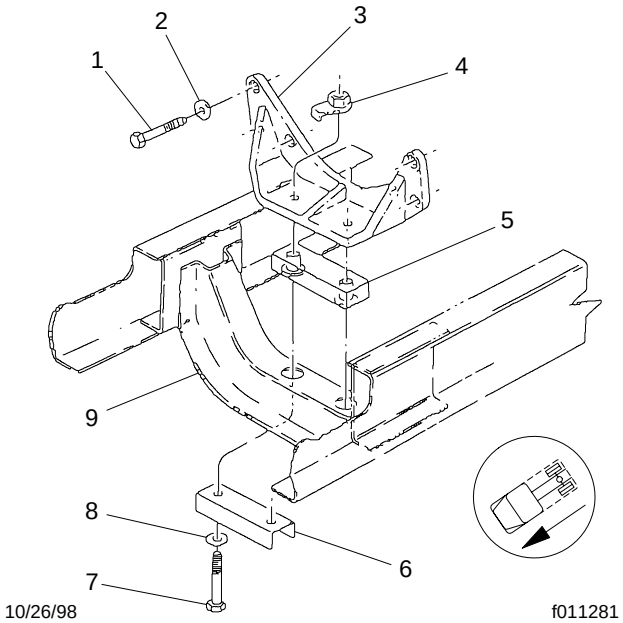
The lifting device and chain used to lower the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mount. An unsecured engine may fall, causing component damage,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



1. Nut and Retainer (5/8–11)
2. Engine Front Support Bracket
3. Flatwasher (12 mm x 24 x 2.75)
4. Hexhead Bolt (M12 x 1.75 x 100 mm)
5. Isolator
6. Hexhead Bolt (5/8–11 x 3.50)
7. Flatwasher (5/8 x 1.18 x 0.13)
8. Rebound Puck

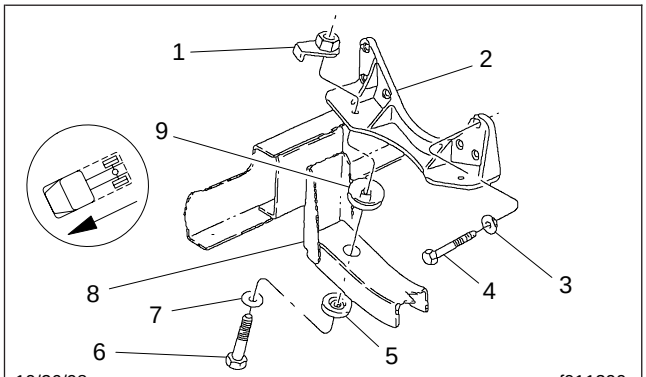
Fig. 6, Front Engine Support Isolators, Focal, ISC Engines

6. Secure the engine to the front engine mount(s).
   - 6.1 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount(s).
   - 6.2 Install the bolts in the front engine mount(s) and secure them with the nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).
   - 6.3 Remove the lifting chain from the engine lifting hooks.
7. Close the hood and remove the chocks from the tires.



1. Hexhead Bolt (7/16–20 x 3.00)
2. Flatwasher (7/16 x 0.94 x 0.10)
3. Engine Front Support Bracket
4. Nut and Retainer (5/8–11)
5. Front Isolator
6. Rebound Puck
7. Hexhead Bolt (5/8–11 x 3.50)
8. Flatwasher (5/8 x 1.18 x 0.13)
9. Engine Front Support Member

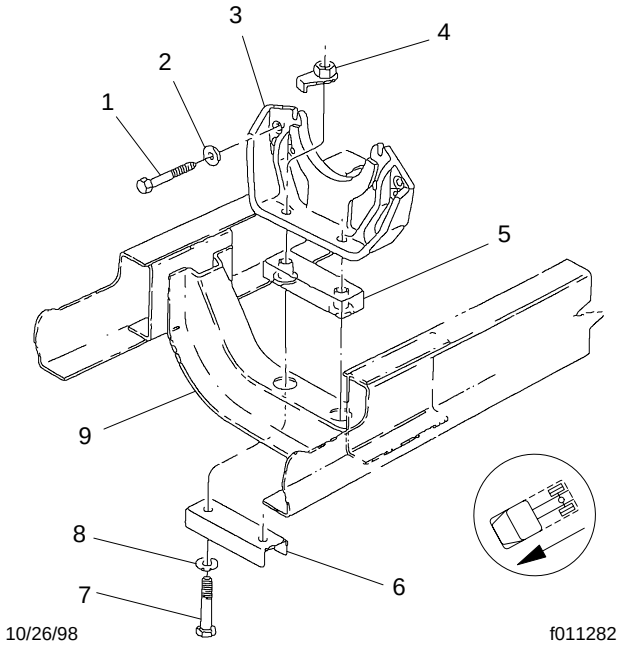
Fig. 7, Front Engine Support Isolators, Compression, M11 Plus Engines



1. Nut and Retainer (5/8–11)
2. Bracket
3. Flatwasher (10 mm x 21 x 2.25)
4. Bolt (10 mm x 3.00)
5. Rebound Puck
6. Bolt (5/8–11 x 3.50)
7. Flatwasher (5/8 x 1.18 x 0.13)
8. Engine Front Support Member
9. Front Isolator

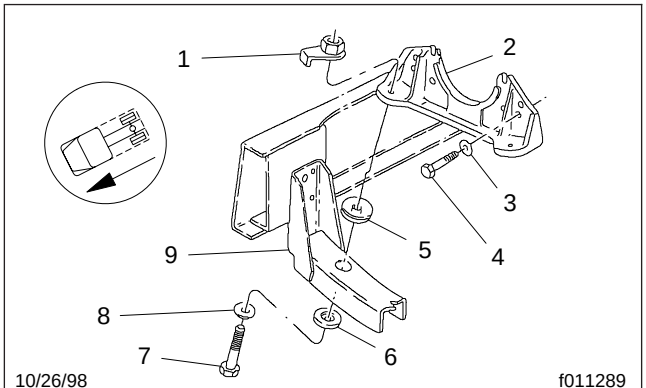
Fig. 8, Front Engine Support Isolators, Focal, M11 Plus Engines

Engine Mount Replacement



1. Hexhead Bolt (7/16–20 x 3.00)
2. Flatwasher (7/16 x 0.94 x 0.10)
3. Engine Front Support Bracket
4. Nut and Retainer (5/8–11)
5. Front Isolator
6. Rebound Puck
7. Hexhead Bolt (5/8–11 x 3.50)
8. Flatwasher (5/8 x 1.18 x 0.13)
9. Engine Front Support Member

Fig. 9, Front Engine Support Isolators, Compression, N14 Plus Engines



1. Nut and Retainer (5/8–11)
2. Bracket
3. Flatwasher (7/16 x 0.94 x 0.10)
4. Bolt (7/16–20 x 3.00)
5. Front Isolator
6. Rebound Puck
7. Bolt (5/8–11 x 3.50)
8. Flatwasher (5/8 x 1.18 x 0.13)
9. Engine Front Support Member

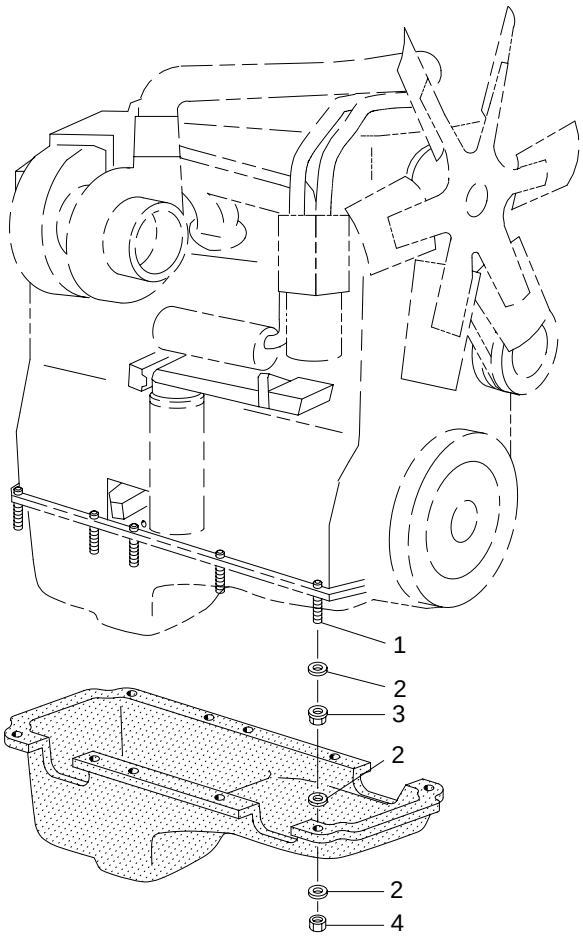
Fig. 10, Front Engine Support Isolators, Focal, N14 Plus Engines

Oil Pan Noise Panel Replacement (See Fig. 1)

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

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

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the locknuts and washers that attach the oil pan noise panel to the oil pan.
3. Remove the noise panel.
4. Place the new noise panel into position under the oil pan.
5. Install the washers and locknuts. Tighten the locknuts 15 lbf·ft (20 N·m).
6. Remove the chocks from the tires.



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NOTE: Not all fasteners are shown.

1. Mounting Stud
2. Washer
3. Flanged Nut
4. Locknut

Fig. 1, Oil Pan Noise Panel

General Specifications	
Item	**Specification**
Lubricants	
Pipe Sealant with Teflon® D8AZ–19554–A	WSK–M2G350–AZ and ESR–M18P7–A
Silicone Dielectric Compound D7AZ–19A331–A	ESE–M1C171–A
Threadlock® and Sealer EOAZ–19554–AA	WSK–M2G315–A5
Heavy Truck PAG Oil F4HZ–19577–A	EST–M1C231–B2

Table 1, General Specifications

Torque Specifications, ISB and ISC Diesel Engines *	
Description	**Torque lbf·ft (N·m)**
A/C Compressor Suction Line	30–35 (41–47)
A/C Compressor Retaining Nuts	44–70 (60–95)
Air Compressor Bracket Mounting Bolts (lower)	44–70 (60–95)
Air Compressor Bracket Mounting Bolts (upper)	40–60 (54–82)
Alternator Bracket Mounting Bolts (lower)	21–31 (28–42)
Alternator Bracket Mounting Bolts (upper)	21–31 (28–42)
Alternator Bracket Thru-Bolt	31–42 (42–57)
Engine Mount Mounting Bolts	150–205 (203–277)
Front Engine Mount Insulator Mounting Bolts	150–205 (204–277)
Front Engine Support Bracket Mounting Bolts	75–105 (102–142)
Lower Radiator Tube Mounting Bolts	40–60 (54–82)
Number One Crossmember Mounting Bolts (113 to 122-inch BBC)	150–205 (204–277)
Number One Crossmember Mounting Bolts (101-inch BBC)	150–205 (204–277)
Number One Crossmember Gusset Mounting Bolts	150–205 (204–277)
Number Two Crossmember Mounting Bolts	75–105 (102–142)
Power Steering Pump Mounting Bolts	155–205 (204–277)
Engine Leg-to-Flywheel Housing Bolts†	60 (81)
Starter Motor Mounting Bolts	30–46 (40–64)
Tow Pintle Hook Mounting Bolts	220–300 (298–406)

* ISL engine similar

† The bolt size is M12.

Table 2, Torque Specifications, ISB and ISC Diesel Engines

Specifications

Torque Specifications, N14 Plus Diesel Engine	
Description	**Torque lbf·ft (N·m)**
A/C Compressor Suction Line	30–35 (41–47)
A/C Compressor Mounting Bracket Mounting Bolts	75–105 (102–138)
Alternator Bracket Mounting Bolts (lower)	31–42 (42–57)
Alternator Bracket Mounting Bolts (upper)	50–70 (67–95)
Engine Mount Mounting Bolts	150–205 (203–277)
Front Engine Mount Insulator Mounting Bolts	150–205 (203–277)
Front Engine Support Bracket Mounting Bolts	75–105 (102–142)
Number One Crossmember Mounting Bolts (113 to 122-inch BBC)	150–205 (203–277)
Number One Crossmember Mounting Bolts (101-inch BBC)	150–205 (203–277)
Number One Crossmember Gusset Mounting Bolts	150–205 (204–277)
Number Two Crossmember Mounting Bolts	75–105 (102–138)
Power Steering Pump Mounting Bolts	155–205 (204–277)
Rear Engine Mount Support Brackets	75–105 (102–138)
Engine Leg-to-Flywheel Housing Bolts*	190 (258)
Starter Motor Mounting Bolts	70–90 (95–120)
Tow Pintle Hook Mounting Bolts	220–300 (298–406)
Vibration Dampener Mounting Bolts	150–205 (203–277)

* The bolt size is 3/4–10 x 1.75 inches.

Table 3, Torque Specifications, N14 Plus Diesel Engine

General Information

This section covers the removal and installation of the engine and transmission as a powertrain assembly. For the diagnosis and testing, removal, installation and in-vehicle repair procedures for Caterpillar supplied components, refer to the appropriate Caterpillar service manual.

There are six models of Caterpillar engines available in the L-Line and A-Line vehicles: the C10, C12, 3126, 3306, 3406C and 3406E diesel engines.

The C10 diesel engine (previously 3176B) is a 10-liter, in-line, 6-cylinder, turbocharged, electronically controlled diesel engine with charge air cooling. Cruise control is standard on C10 engines, but is rendered inoperative if the vehicle is equipped with an HT series automatic transmission. See **Fig. 1** .

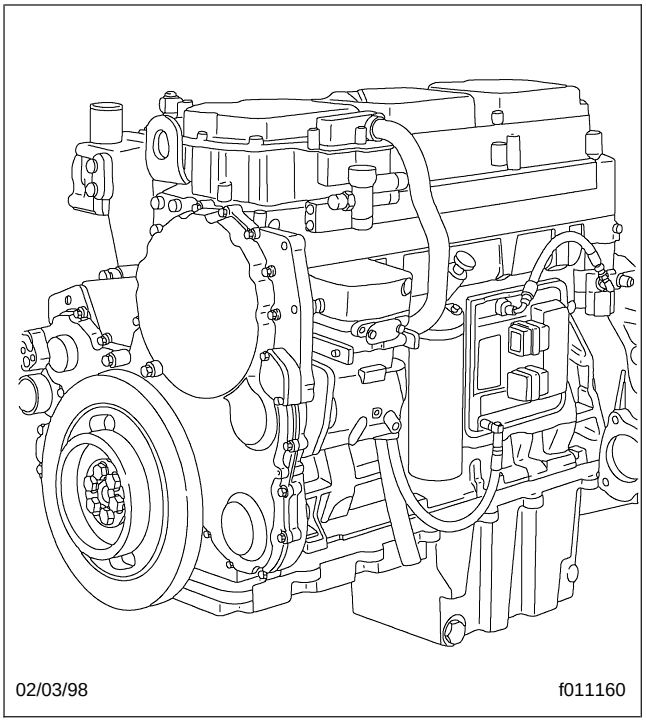

Fig. 1, Caterpillar C10 and C12 Diesel Engine

The C12 diesel engine (previously 3176L) is a 12-liter, in-line, 6-cylinder, turbocharged, electronically controlled diesel engine with charge air cooling. Cruise control is standard on C12 engines, but is rendered inoperative if the vehicle is equipped with an HT series automatic transmission. See **Fig. 1** .

The 3126 diesel engine is a 7.2-liter, in-line, 6-cylinder, turbocharged, hydraulically actuated, electronically-controlled, unit injection (HEUI) diesel engine with charge air cooling. See **Fig. 2** .

The 3306 diesel engine is a 638 CID, in-line, 6-cylinder, turbocharged, mechanically controlled diesel engine with charge air cooling. See **Fig. 3** .

The 3406E diesel engine is a 893 CID, in-line, 6-cylinder, turbocharged, electronically controlled diesel engine with charge air cooling. Cruise control is standard on 3406E engines, but is rendered inoperative if the vehicle is equipped with a HT series automatic transmission. See **Fig. 4** .

The 3406E diesel engine is a 14.6-liter, in-line, 6-cylinder, turbocharged, electronically controlled diesel engine with charge air cooling. Cruise control is standard on 3406E engines, but is rendered inoperative if the vehicle is equipped with an HT series automatic transmission. See **Fig. 5** .

General Information

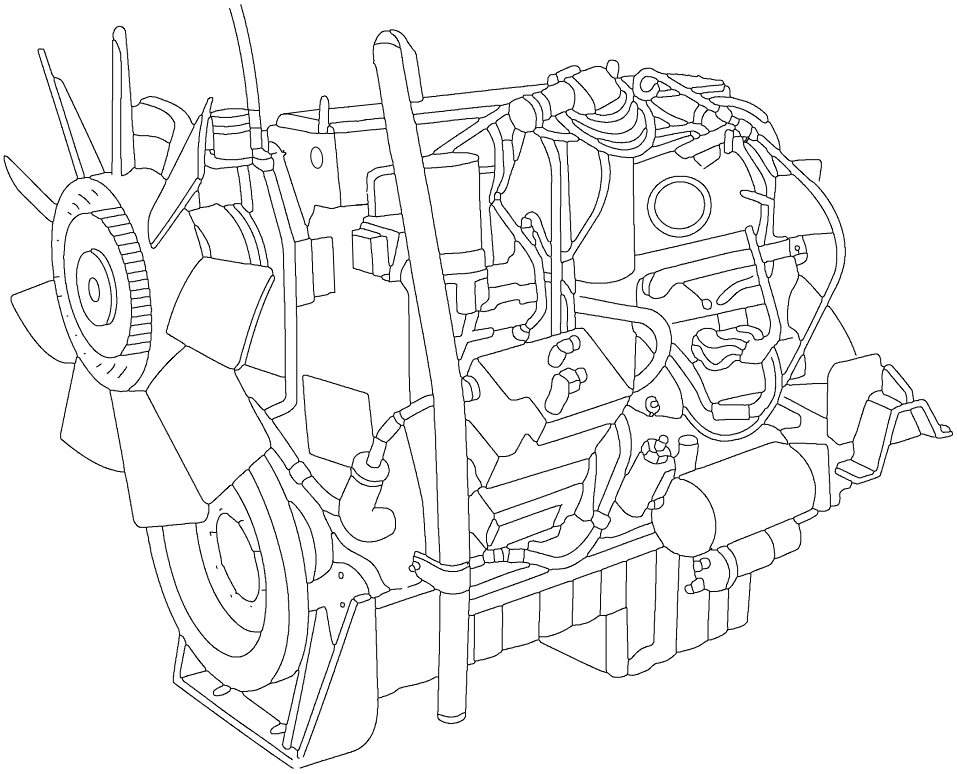

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Fig. 2, Caterpillar 3126 Diesel Engine

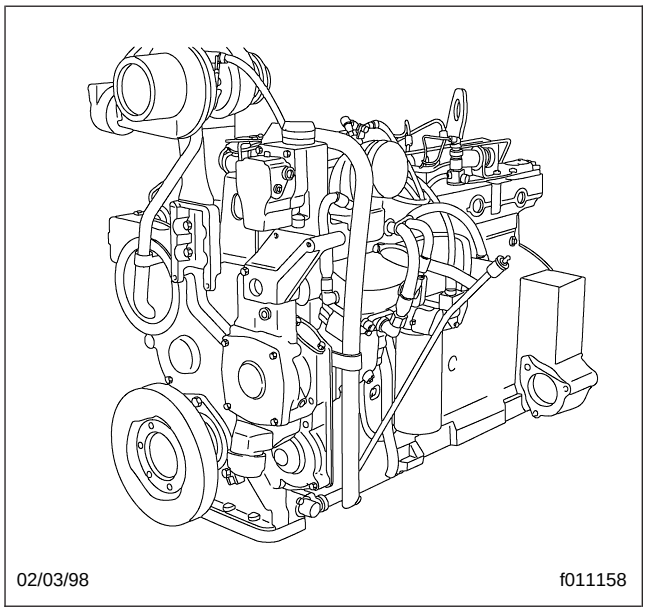

Fig. 3, Caterpillar 3306 Diesel Engine

General Information

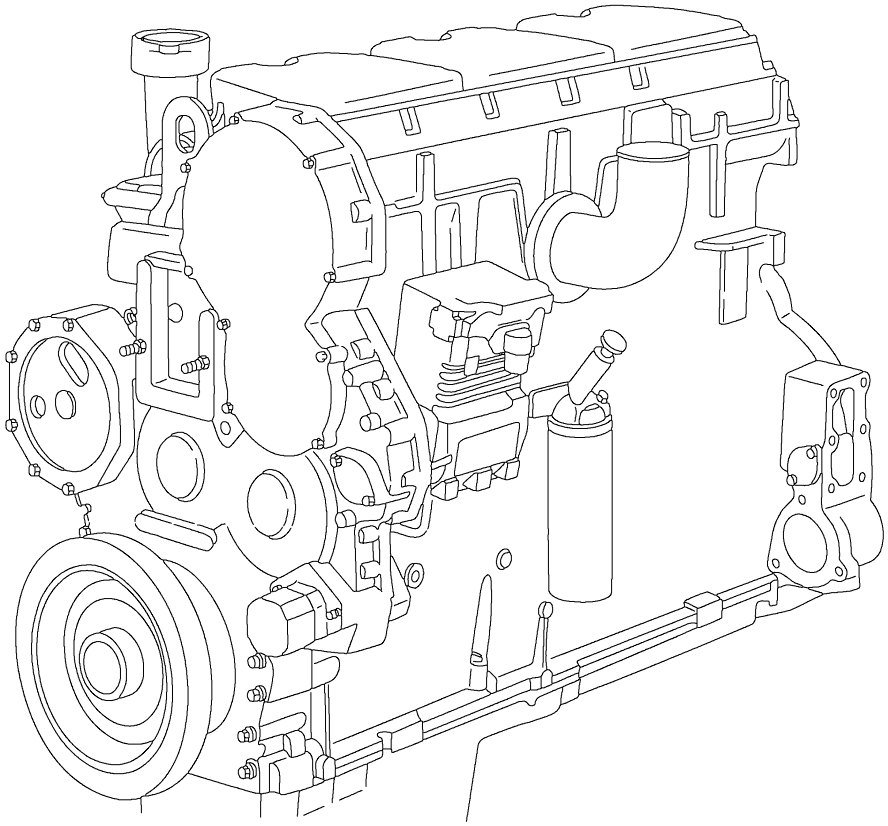

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Fig. 4, Caterpillar 3406C Diesel Engine

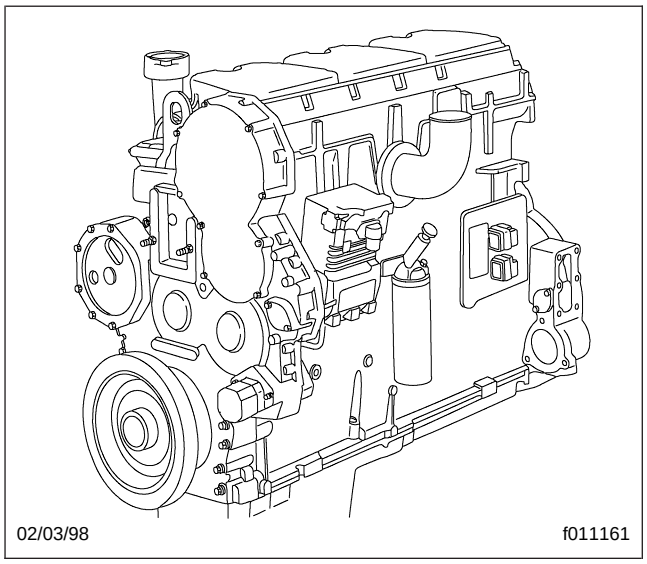
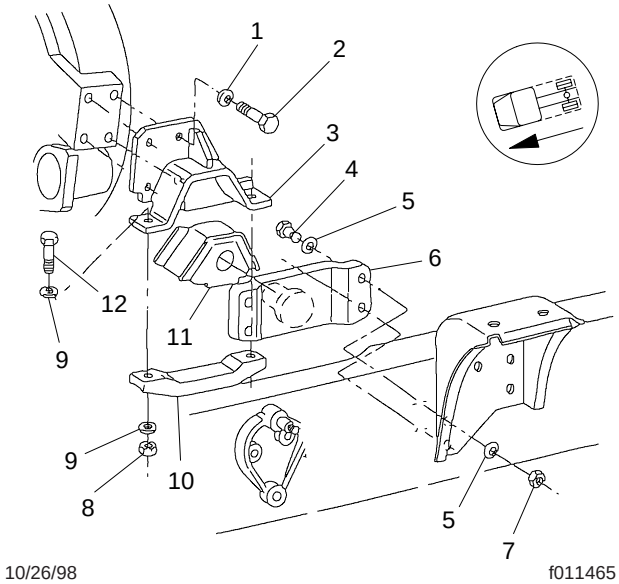


Fig. 5, Caterpillar 3406E Diesel Engine

Rear Engine Mount Replacement (See Fig. 1)



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1. Flatwasher (14 x 28 x 2.5)
2. Bolt (M14 x 2.0 x 35)
3. Engine Leg (left-hand)
4. Bolt (5/8–11 x 3.50)
5. Flatwasher (5/8 x 1.18 x 13)
6. Engine Support-to-Frame Bracket (left-hand)
7. Locknut (5/8 x 11)
8. Locknut (1/2 x 13)
9. Flatwasher (1/2 x 1.06 x 0.10)
10. Engine Support-to-Frame Cap
11. Rear Engine Support Isolator
12. Bolt (1/2–13 x 2.50)

Fig. 1, Rear Engine Support Isolators, 3126 Engines (left-hand side shown; right-hand side similar)

1. Apply the parking brakes, shut down the engine, chock the tires, and if applicable, drain the air brake system.

⚠ 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 component damage, personal injury or death.

2. Disconnect the engine from the rear engine support-to-frame bracket(s).
   - 2.1 Place a jack under the rear of the engine, and raise the jack until it is braced against the engine.
   - 2.2 Remove the nuts, bolts and washers that attach the engine support-to-frame cap to the rear engine support bracket(s). Save the fasteners.
3. Disconnect the engine support-to-frame bracket(s) from the frame rail.
   - 3.1 Remove the bolts that secure the rear engine support-to-frame bracket(s) to the frame rail.
   - 3.2 Lift the engine slightly to take its weight off the rear engine support-to-frame bracket(s). Place engine stands under the engine to keep it off the engine support-to-frame bracket(s).
   - 3.3 Remove the rear engine support-to-frame bracket(s) from the frame rail.
   - 3.4 Remove the rear engine support isolator from the rear engine support-to-frame bracket(s).
4. If necessary, remove the bolts that secure the engine leg(s) to the flywheel housing, and remove the leg(s) from the engine.
5. Inspect the rear engine support isolators for wear or damage and replace them if necessary.

⚠ CAUTION

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

6. Install the rear engine support isolator on a new rear engine support-to-frame bracket(s). Align the isolator on the bracket so the wide side of the isolator is at the bottom of the bracket.
7. If removed, install the engine leg(s) on the flywheel housing. Apply thread-lock compound to the bracket mounting bolts, and tighten them as follows:

   For C-7 and 3126 engines: 100 lbf·ft (136 N·m).

Engine Mount Replacement

For all other Caterpillar engines: 190 lbf·ft (258 N·m).

8. Place the new engine support-to-frame bracket(s), with the isolator aligned properly, against the inside of the frame rail, and secure it with bolts, washers, and nuts. Tighten the nuts 120 to 152 lbf·ft (163 to 206 N·m).

⚠ 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 component damage, personal injury or death.

9. Connect the engine to the engine support-to-frame bracket(s).

   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(s).

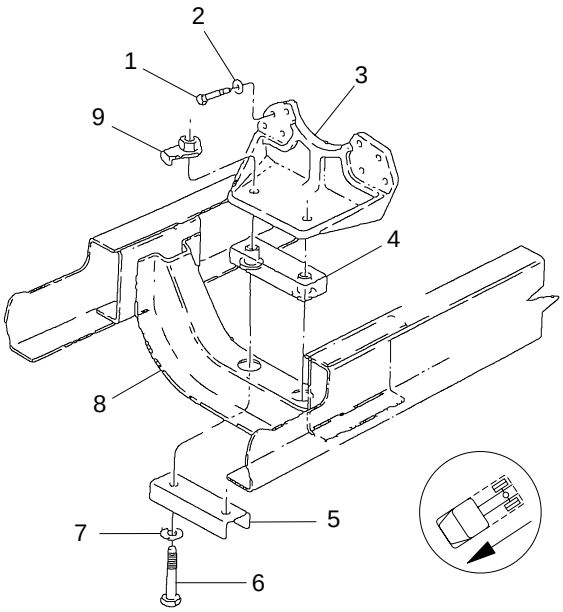
   NOTE: The bolt at the rear of the cap is installed from the bottom. The bolt at the front of the cap is installed from the top.

   9.3 Holding the rear engine support-to-frame cap in place, install the bolts that attach the cap to the rear engine support bracket(s), and secure them with a nut and hardened washer. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

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

Front Engine Mount Replacement

NOTE: Both compression-type and focal-type engine support isolators are used in all L-Line and A-Line vehicles. See **Fig. 2** and **Fig. 3** for C10 and C12 engines. See **Fig. 4** for 3126 engines. See **Fig. 5** and **Fig. 6** for 3306 engines. See **Fig. 7** and **Fig. 8** for 3406 engines.



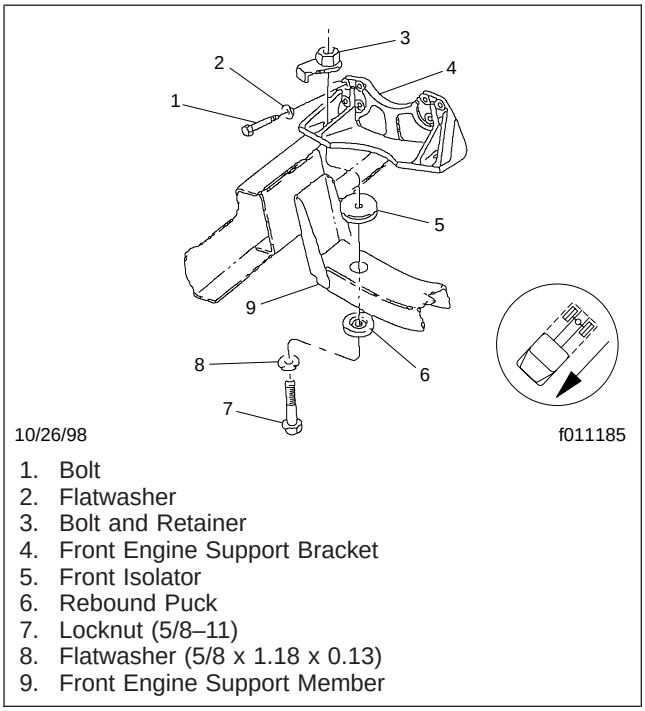
1. Bolt
2. Washer
3. Front Engine Support Bracket
4. Isolator
5. Rebound Puck
6. Hexhead Bolt (5/8–11 x 3.50)
7. Washer
8. Front Engine Support Member
9. Nut and Retainer (5/8–11)

Fig. 2, Front Engine Support Isolators, Compression, C10 and C12 Engines

1. Apply the parking brakes, shut down the engine, chock the tires, open the hood, and if applicable, drain the air brake system.

⚠ WARNING

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



1. Bolt
2. Flatwasher
3. Bolt and Retainer
4. Front Engine Support Bracket
5. Front Isolator
6. Rebound Puck
7. Locknut (5/8–11)
8. Flatwasher (5/8 x 1.18 x 0.13)
9. Front Engine Support Member

Fig. 3, Front Engine Support Isolators, Focal, C10 and C12 Engines

2. Disconnect the engine from the front engine mount(s).

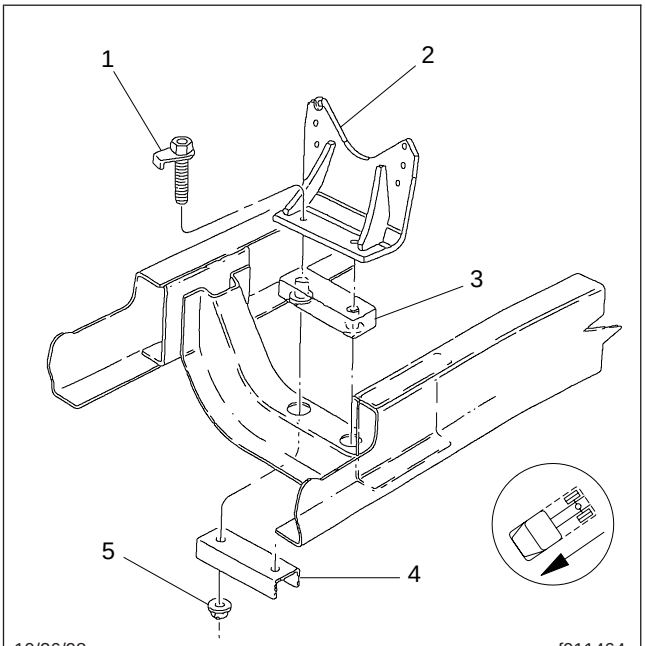
   2.1 Attach a chain to the front engine lifting hook(s), and position a lifting device to lift the engine. Attach the chain to the lifting device, and raise the chain to remove any slack.

   2.2 Remove the nuts and bolts from the front engine mount(s). Save the fasteners.

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

3. If you are replacing the front engine support bracket, refer to the engine manufacturer's service literature.

4. Inspect the engine mount rubber isolator(s) for wear or damage and replace it, if necessary.



1. Bolt and Retainer (5/8–11 x 3.50)
2. Front Engine Support Bracket
3. Front Isolator
4. Engine Support-to-Frame Bracket
5. Locknut (5/8–11)

Fig. 4, Front Engine Support Isolators, 3126 Engines (Left-Hand Side Shown, Right-Hand Side Similar)

⚠ CAUTION

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

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

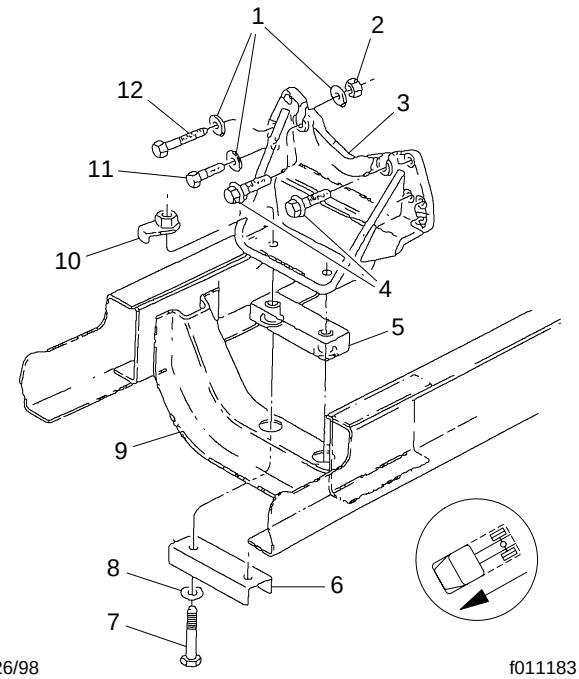
⚠ WARNING

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

6. Secure the engine to the front engine mount(s).

   6.1 Lift the engine slightly to remove the engine stands. Remove the stands, and

Engine Mount Replacement



1. Flatwasher
2. Locknut (3/8–16)
3. Front Engine Support Bracket
4. Hexhead Bolt (1/2–16 x 3.25)
5. Front Isolator
6. Engine Support-to-Frame Bracket
7. Locknut (5/8–11)
8. Flatwasher
9. Front Engine Support Member
10. Bolt and Retainer (5/8–11 x 3.50)
11. Hexhead Bolt (3/8–16 x 1.50)
12. Bolt

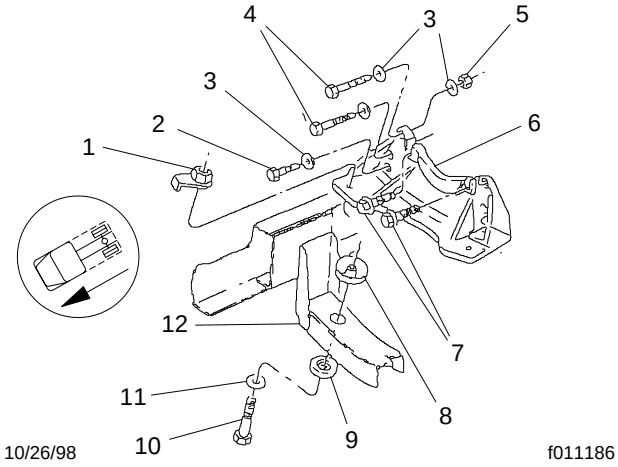
Fig. 5, Front Engine Support Isolators, Compression, 3306 Engines

carefully lower the engine onto the engine mount(s).

6.2 Install the bolts in the front engine mount(s) and secure them with the nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

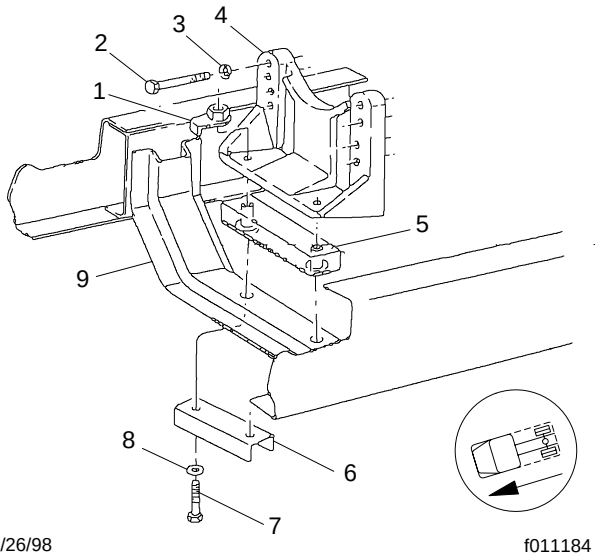
6.3 Remove the lifting chain from the engine lifting hooks.

7. Close the hood and remove the chocks from the tires.



1. Nut and Retainer (5/8–11)
2. Bolt (3/8–16 x 1.50)
3. Front Engine Support Bracket
4. Bolt
5. Locknut (3/8–16)
6. Front Engine Support Bracket
7. Bolt (1/2–16 x 3.25)
8. Front Isolator
9. Rebound Puck
10. Bolt (5/8–11 x 3.50)
11. Flatwasher (5/8 x 1.18 x 0.13)
12. Front Engine Support Member

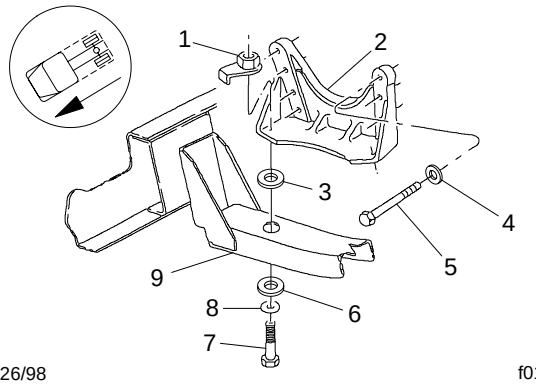
Fig. 6, Front Engine Support Isolators, Focal, 3306 Engines



10/26/98 f011184

1. Bolt and Retainer (5/8–11 x 3.50)
2. Hexhead Bolt (1/2–13 x 5.50)
3. Flatwasher (1/2 x 1.06 x 0.10)
4. Front Engine Support Bracket
5. Isolator
6. Rebound Puck
7. Nut (5/8–11)
8. Flatwasher (5/8 x 1.18 x 0.13)
9. Front Engine Support Member

Fig. 7, Front Engine Support Isolators, Compression, 3406 Engines



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1. Bolt and Retainer (5/8–11)
2. Front Engine Support Bracket
3. Front Isolator
4. Flatwasher (1/2 x 1.06 x 0.10)
5. Bolt (1/2–13 x 5.50)
6. Rebound Puck
7. Nut (5/8–11 x 3.50)
8. Flatwasher (5/8 x 1.18 x 0.13)
9. Front Engine Support Member

Fig. 8, Front Engine Support Isolators, Focal, 3406 Engines

Removal

1. Prepare the vehicle for engine removal.
   - 1.1 Disconnect the battery ground cable(s).
   - 1.2 Remove the bumper. Refer to **Group 31**.
   - 1.3 Remove the hood. Refer to **Group 88**.
   - 1.4 Drain the engine cooling system. Refer to **Group 20**.
   - 1.5 Drain the engine oil.
   - 1.6 If the vehicle is equipped with an A/C system, recover the refrigerant. Refer to **Group 83**.
   - 1.7 If the vehicle is equipped with a transmission cooler or an automatic transmission, drain the transmission oil. Refer to the appropriate **Group 26** transmission section.
   - 1.8 Drain the air system.
   - 1.9 Remove the cooling module. Refer to **Group 20**.
   - 1.10 Remove the air intake tube and air cleaner assembly as an assembly. Refer to **Group 09**.
   - 1.11 Remove the engine cover. Refer to **Group 60**.

NOTE: If the vehicle is equipped with front pintle hooks, then perform this step.

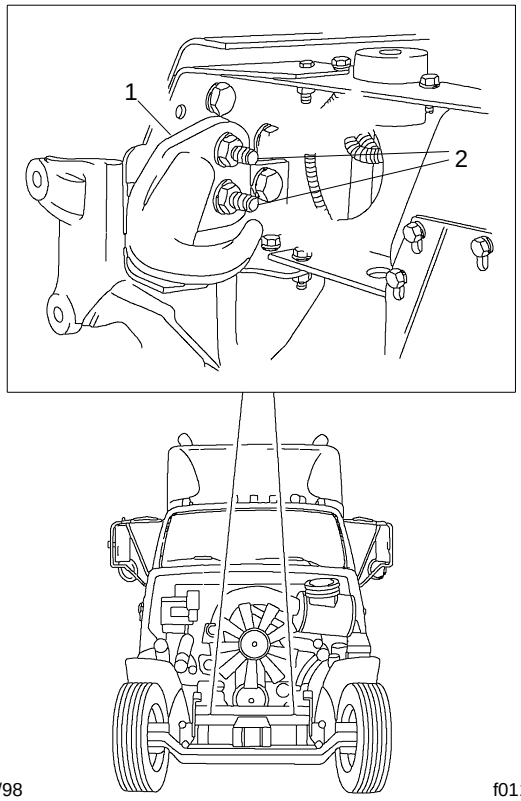
2. Remove the six bolts, 10 washers, four nuts and two pintle hooks. See **Fig. 1** .

NOTE: The brake valves shown are for a 2-channel ABS system. All other configurations are similar.

3. Isolate the brake valves on the No. 1 crossmember. See **Fig. 2** .
   - Remove the retaining clamp bolts.
   - Disconnect the electrical connector.
   - Label and disconnect the four air lines.

NOTE: The steering gear is shown, the rotary assist cylinder is similar.

4. If the vehicle is equipped with dual steering gears, disconnect the power steering lines from the steering gear and rotary assist cylinder, and remove the power steering lines. See **Fig. 3** .



1. Pintle Hook
2. Bolt

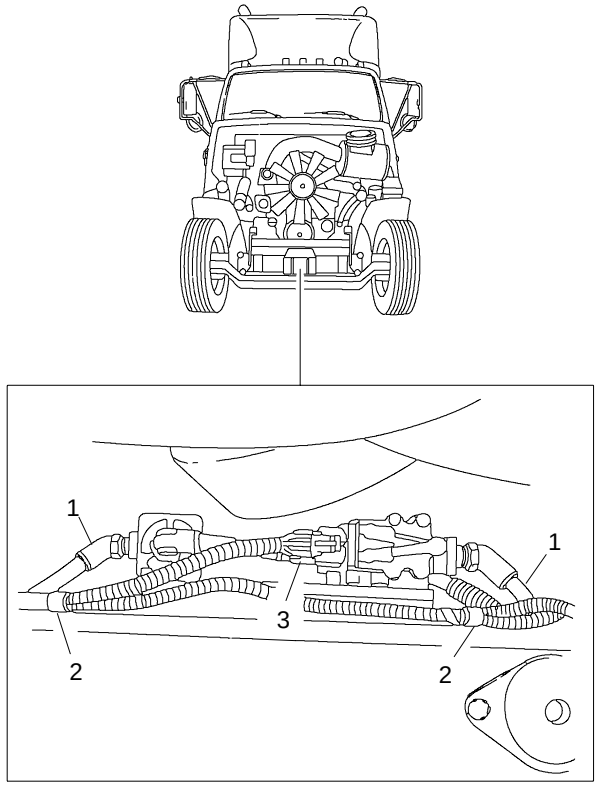
Fig. 1, Pintle Hook

NOTE: If the vehicle has a 101-inch BBC chassis, then perform the next two steps.

5. Remove the eight bolts, 16 washers, eight nuts and the No. 1 crossmember. See **Fig. 4** .
6. Remove the four nuts, eight washers, four bolts and the top two No. 1 crossmember gussets. See **Fig. 5** .
7. If the vehicle has a 113- to 122-inch BBC chassis, remove the four bolts, eight washers, four nuts, two bumper brackets and the No. 1 crossmember. See **Fig. 6** .
8. Disconnect the refrigerant line. See **Fig. 7** .

   Plug and cap the open lines and fittings.

3126 Engine Removal and Installation



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1. Air Line
2. Retaining Clamp
3. Electrical Connector

Fig. 2, Brake Valves

9. Remove the turbocharger outlet tube. See **Fig. 8 .**.
10. Remove the exhaust outlet tube. See **Fig. 9** .
11. Remove the lower radiator tube. See **Fig. 10** .
12. Disconnect the heater water hoses. See **Fig. 11** .
13. Remove the upper radiator tube. See **Fig. 12** .
14. Remove the charge air cooler outlet tube. See **Fig. 13** .
15. Remove the six screws and the left-side splash shield. See **Fig. 14** .
16. Remove the air compressor discharge line retaining clamp bolt. See **Fig. 15** .
17. Disconnect the compressor discharge line and position it aside. See **Fig. 16** .

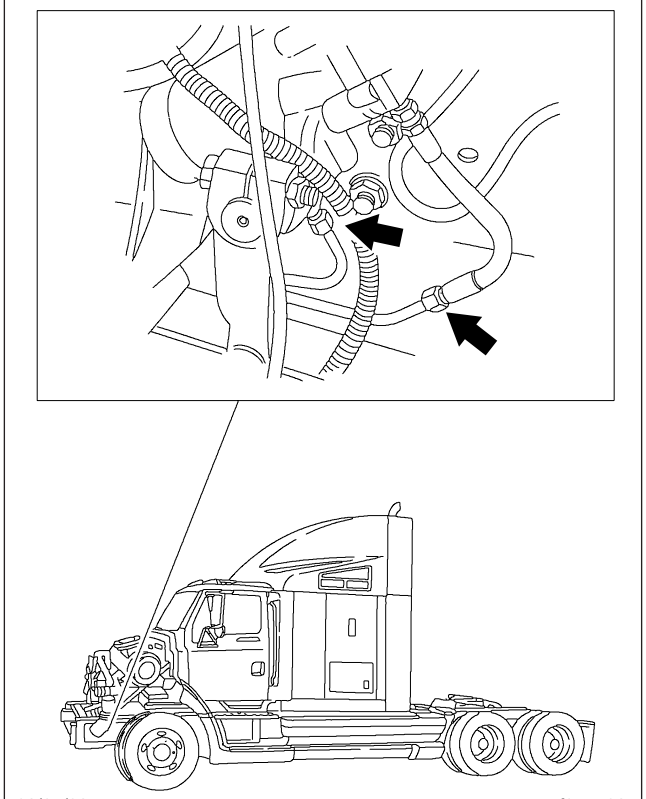

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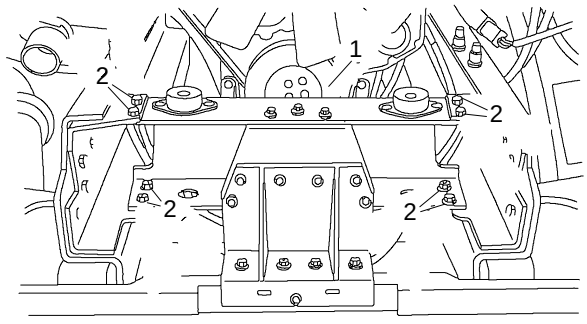
Fig. 3, Power Steering Lines



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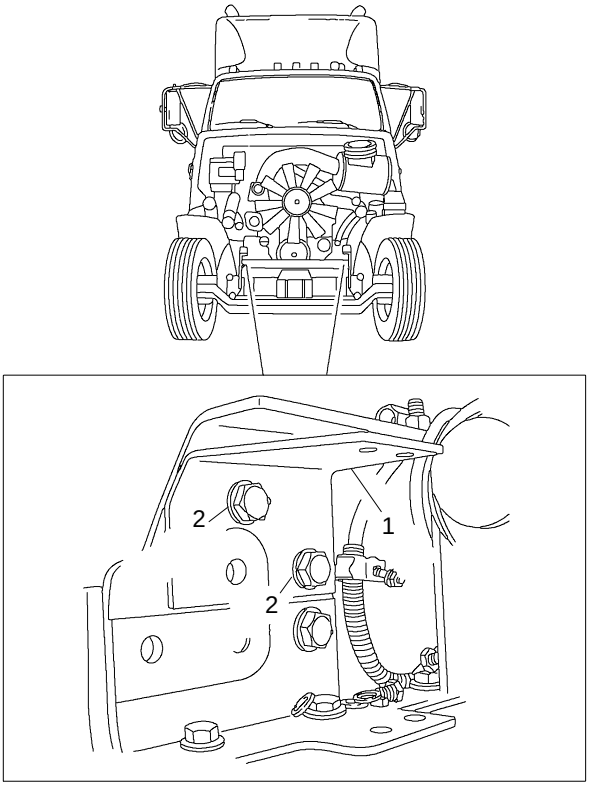
1. No. 1 Crossmember
2. Bolt (8 qty.)

Fig. 4, No. 1 Crossmember

18. If the vehicle is equipped with a manual transmission, disconnect the clutch cable or linkage and position the clutch cable or linkage aside. See **Fig. 17** .



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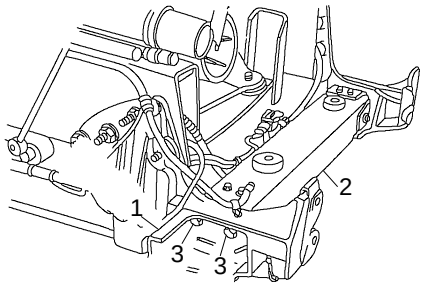
1. No. 1 Crossmember Gusset
2. Bolt

Fig. 5, No. 1 Crossmember Gusset



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1. Bumper Bracket
2. No. 1 Crossmember
3. Bolt (4 qty.)

Fig. 6, Bumper Bracket

19. Disconnect the starter relay electrical leads and position them aside. See **Fig. 18** .

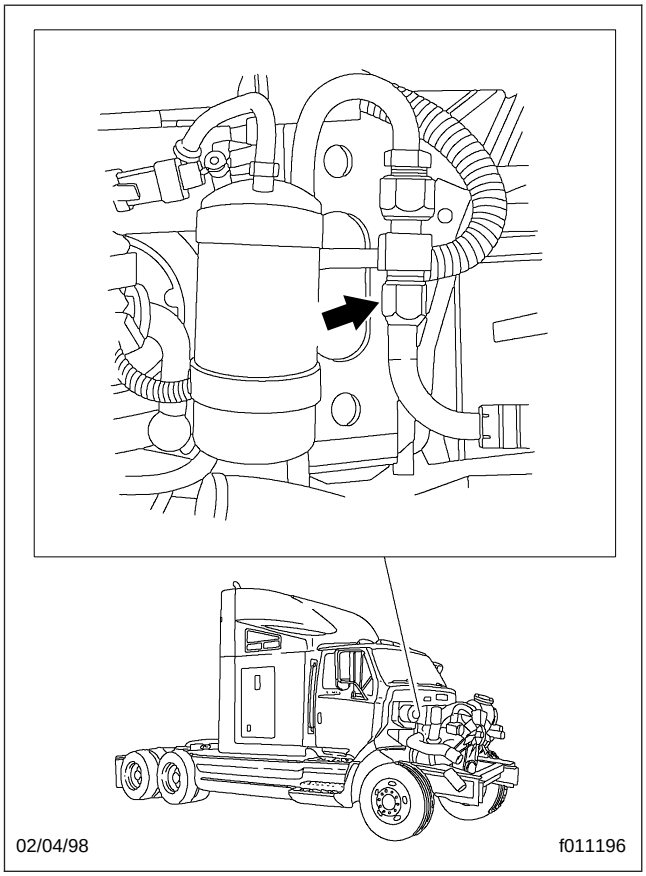

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Fig. 7, Refrigerant Line

19.1 Remove the protective caps.

19.2 Label and disconnect the starter relay electrical leads.

20. Disconnect the two electrical connectors. See **Fig. 19** .

20.1 Remove the bolt and nut.

20.2 Loosen the bolt and nut.

20.3 Position the brace aside.

20.4 Disconnect the bulkhead connector and position it aside.

20.5 Disconnect the electrical connector and position it aside.

21. Disconnect the ground strap and position it aside. See **Fig. 20** .

22. Disconnect the air compressor governor air lines and position them aside. See **Fig. 21** .

3126 Engine Removal and Installation

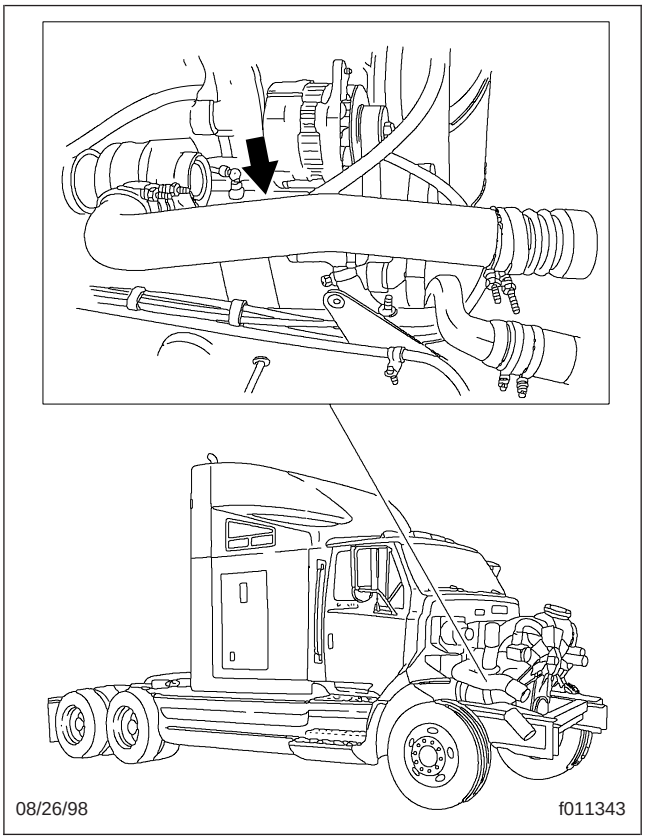

Fig. 8, Turbocharger Outlet Tube

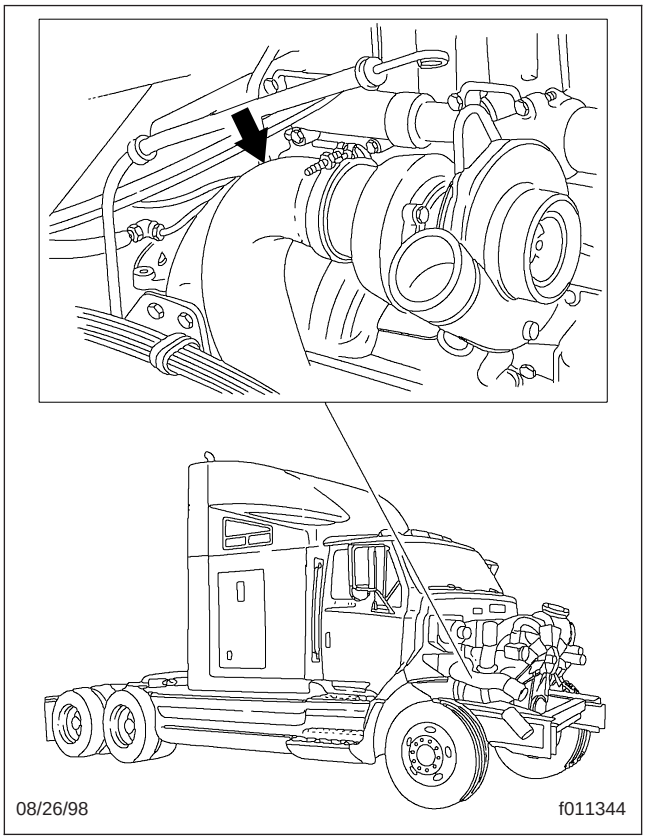

Fig. 9, Exhaust Outlet Tube

23. Remove the megafuse cover. See **Fig. 22** .
24. Disconnect the megafuse electrical lead. See **Fig. 23** .
25. Disconnect the oil pressure gauge line and position it aside. See **Fig. 24** .
26. Disconnect the power steering lines and position them aside. See **Fig. 25** .
27. Remove the retaining clamp and position the electrical wiring harnesses aside. See **Fig. 26** .
28. Disconnect the electrical connectors. See **Fig. 27** and **Fig. 28** .

NOTE: If the vehicle is equipped with a sleeper, then perform the next two steps.

29. Remove the megafuse cover. See **Fig. 29** .
30. Disconnect the megafuse electrical lead. See **Fig. 30** .

NOTE: If the vehicle is equipped with a manual transmission, then perform the next four steps.

31. Remove the gear shift assembly. Remove the screws and separate the shift lever boot from the floor; refer to **Group 60** to remove the interior trim as required. Remove the transmission floor cover plate if additional access space is required.
32. Disconnect the vehicle air and the Roadranger® air system at the transmission. Refer to **Group 26**.
33. Remove the shift lever assembly. See **Fig. 31** .
    - 33.1 Remove the cap screws.
    - 33.2 Position the shift lever assembly aside. Cover the hole in the shift control housing to prevent contamination.
34. If the vehicle is equipped with a clutch cable, remove the three bolts from the clutch cable mounting bracket. See **Fig. 32** .

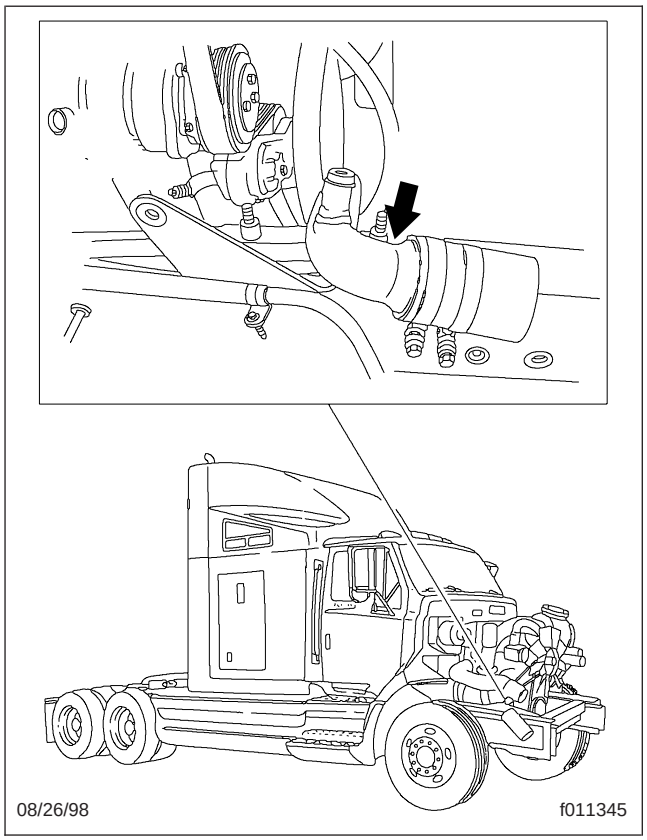

Fig. 10, Lower Radiator Tube

35. If the vehicle is equipped with clutch linkage, remove the clutch linkage. See **Fig. 33** .
36. If the vehicle is equipped with an AT, HT, or MT series automatic transmission, disconnect the selector control cable. See **Fig. 34 ..**

NOTE: If the vehicle is equipped with an HD or MD series automatic transmission, then perform the next three steps.

37. Remove the interior trim and floor mat.
38. Remove the screws and the transmission floor cover plate.
39. Disconnect the electrical connectors. See **Fig. 35** .

NOTE: The HD series automatic transmission is shown, all others are similar.

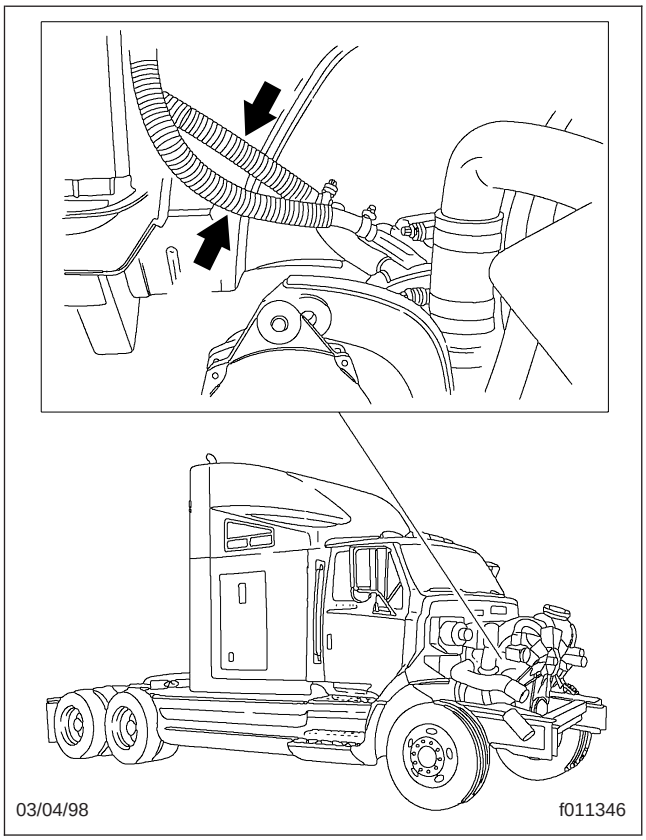

Fig. 11, Heater Water Hoses

40. If the vehicle is equipped with a transmission oil cooler, disconnect the transmission oil cooler lines. See **Fig. 36** .
    - 40.1 Remove all retaining clamps.
    - 40.2 Disconnect the transmission oil cooler lines.
41. Disconnect the fuel supply line and return lines. See **Fig. 37** and **Fig. 38** .
42. Disconnect the ground strap. See **Fig. 39** .
43. Disconnect the battery cable clamp(s) from the transmission. See **Fig. 40** .
44. Remove the transmission bolts. See **Fig. 41** .
45. Disconnect and remove the exhaust outlet tube. See **Fig. 42** .
46. Disconnect the starter electrical leads. See **Fig. 43** .

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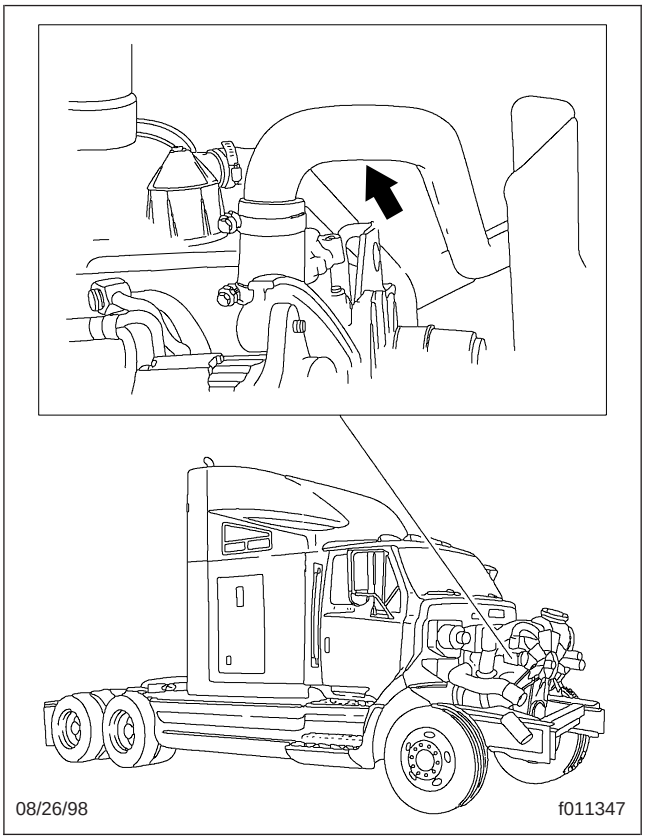


Fig. 12, Upper Radiator Tube

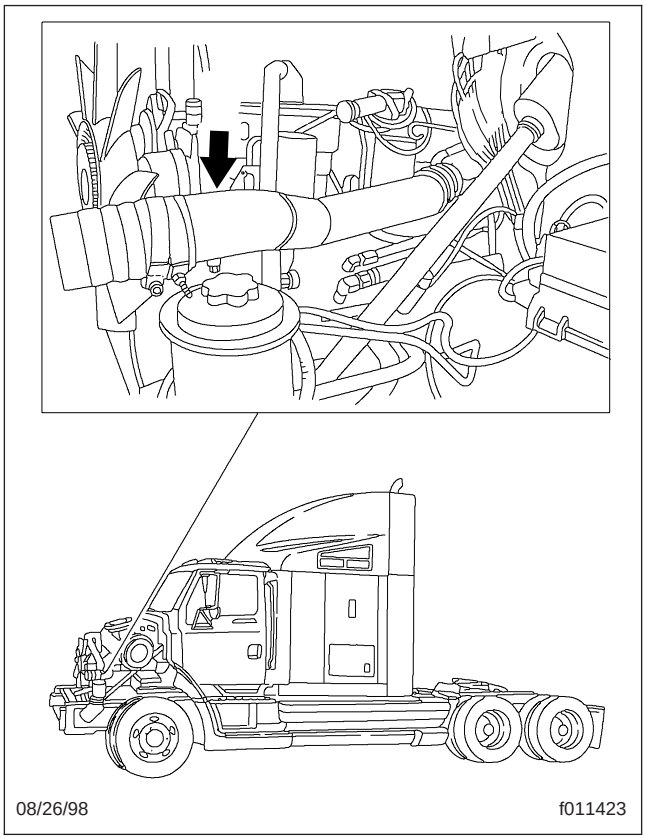
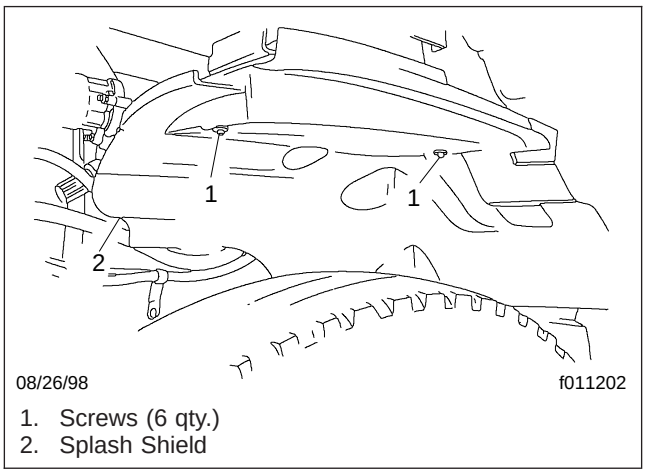


Fig. 13, Charge Air Cooler Outlet Tube

47. Disconnect the electrical connectors. See **Fig. 44** .
48. Disconnect the ground strap. See **Fig. 45** .
49. Remove the fuel filter. See **Fig. 46** .
50. Disconnect the driveshaft. Refer to **Group 41**.

NOTE: The left-side rear support bracket is shown, the right-side is similar.

51. Remove the four bolts, eight washers, four nuts and two rear support brackets. See **Fig. 47** .
52. Support the powertrain assembly.
    - Install the engine lifting equipment.
    - Use a suitable lifting chain connected to the two lifting eyes and lifting crane rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.
    - Position a suitable transmission jack under the transmission.



1. Screws (6 qty.)
2. Splash Shield

Fig. 14, Splash Shield

    - Secure the transmission to the jack.
53. Remove the bolts and the flag nuts. See **Fig. 48** .

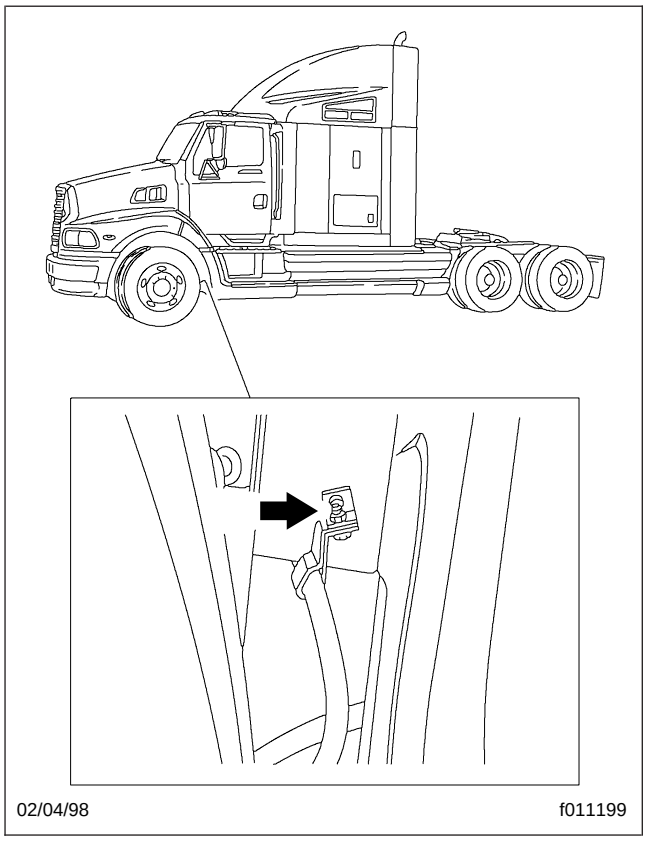


Fig. 15, Discharge Line Retaining Clamp Bolt

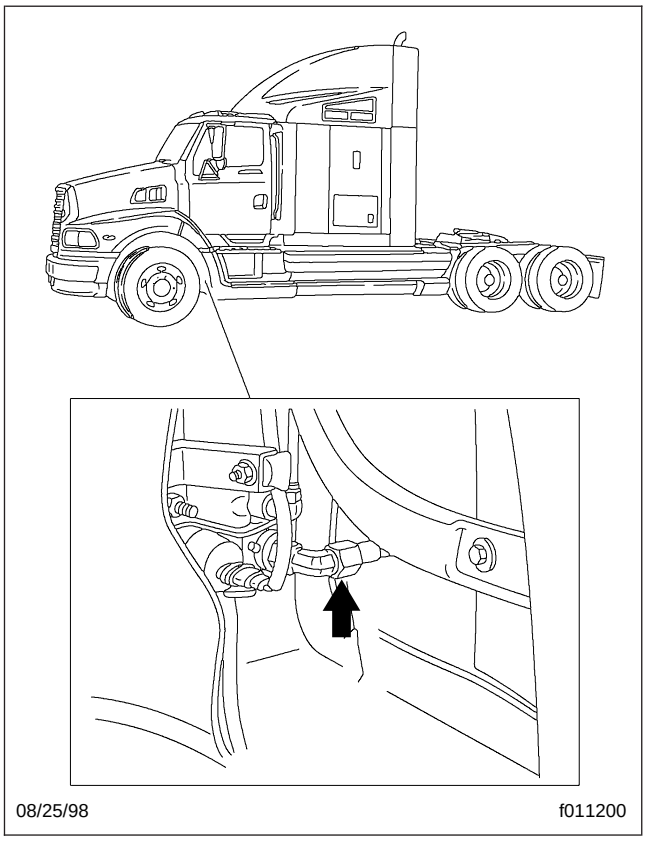


Fig. 16, Air Compressor Discharge Line

54. Remove the eight bolts, 16 washers, eight nuts and the No. 2 crossmember. See **Fig. 49** .
55. Move the powertrain assembly forward until the transmission jack reaches the front axle.
56. Lower the engine and support the front engine mount. Use two suitable jack stands rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer and a suitable length of wood with a minimum 4-inch (10 mm) x 6-inch (15 mm) dimension.
57. Remove the powertrain assembly from the vehicle.
    - 57.1 Remove the lifting chain and install a load leveling engine sling. Use a suitable load leveling engine sling rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.
    - 57.2 Raise the engine.

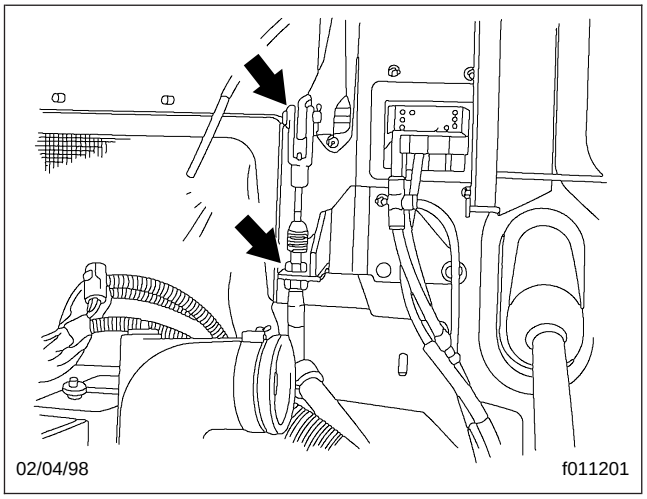


Fig. 17, Clutch Cable or Linkage

    - 57.3 Remove the strap from the transmission.
    - 57.4 Level the powertrain assembly.

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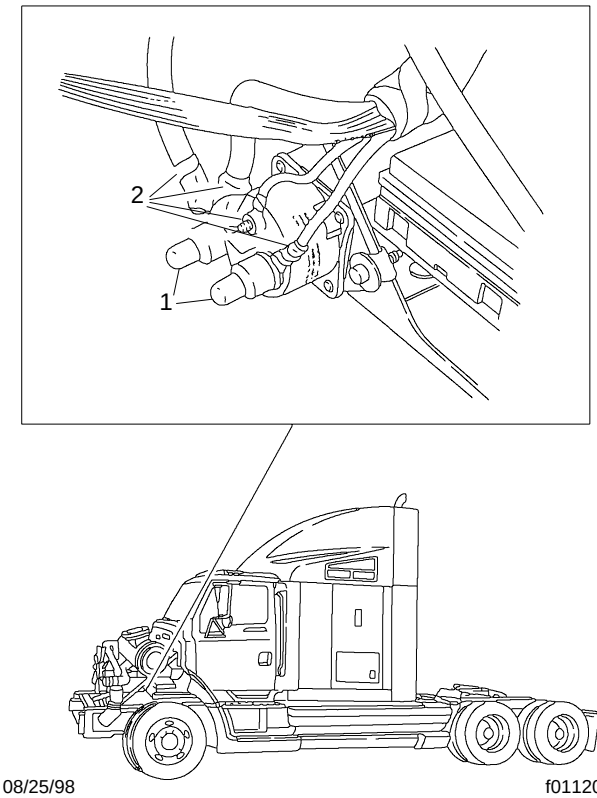
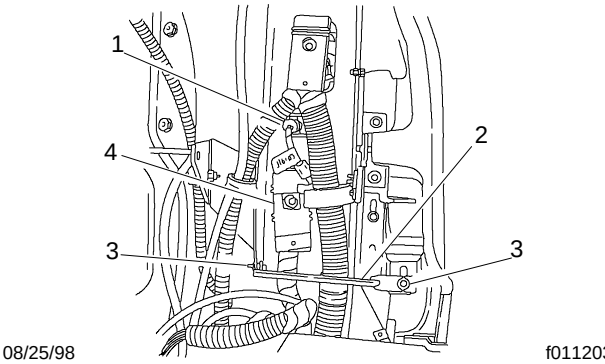


1. Protective Caps
2. Starter Relay Electrical Leads

Fig. 18, Starter Relay Electrical Leads



1. Electrical Connector
2. Brace
3. Bolt (2 qty.)
4. Bulkhead Electrical Connector

Fig. 19, Electrical Connectors

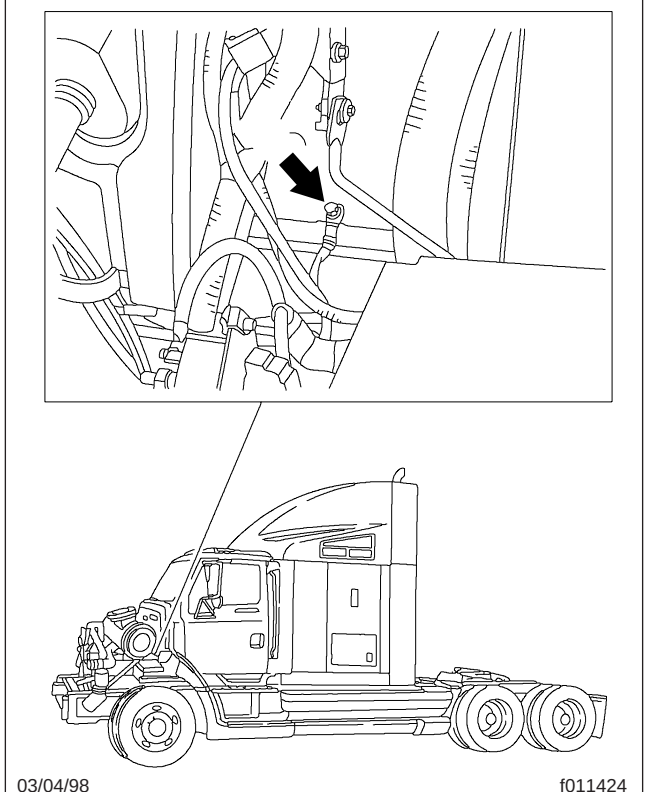


Fig. 20, Ground Strap

57.5 Remove the transmission jack.

57.6 Move the powertrain assembly out of the vehicle.

58. Support the powertrain assembly. See **Fig. 50** .
    - Use suitable jack stands rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.
    - Use a suitable transmission jack.

Installation

1. Raise the powertrain assembly and remove the jack stands and the transmission jack. Use a suitable load leveling sling and lifting crane rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.

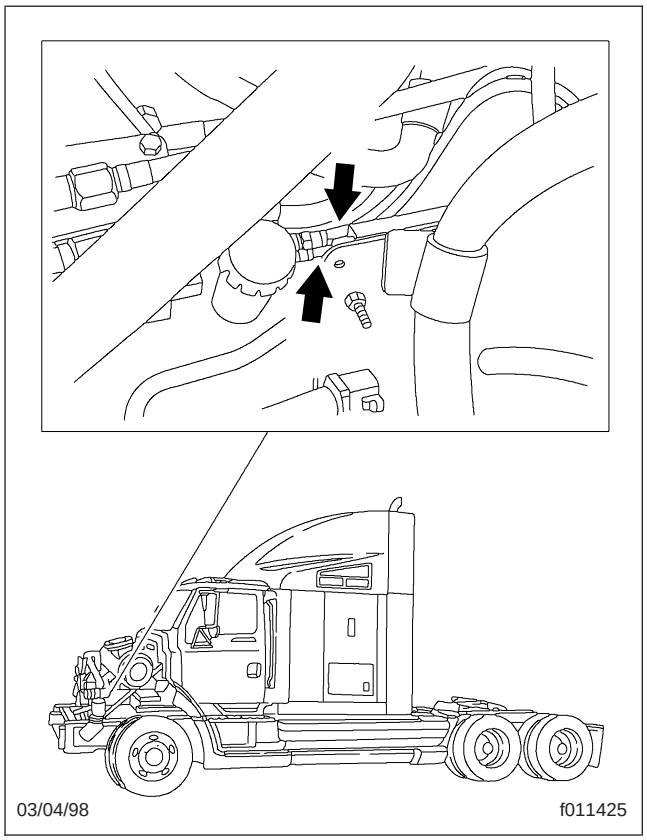
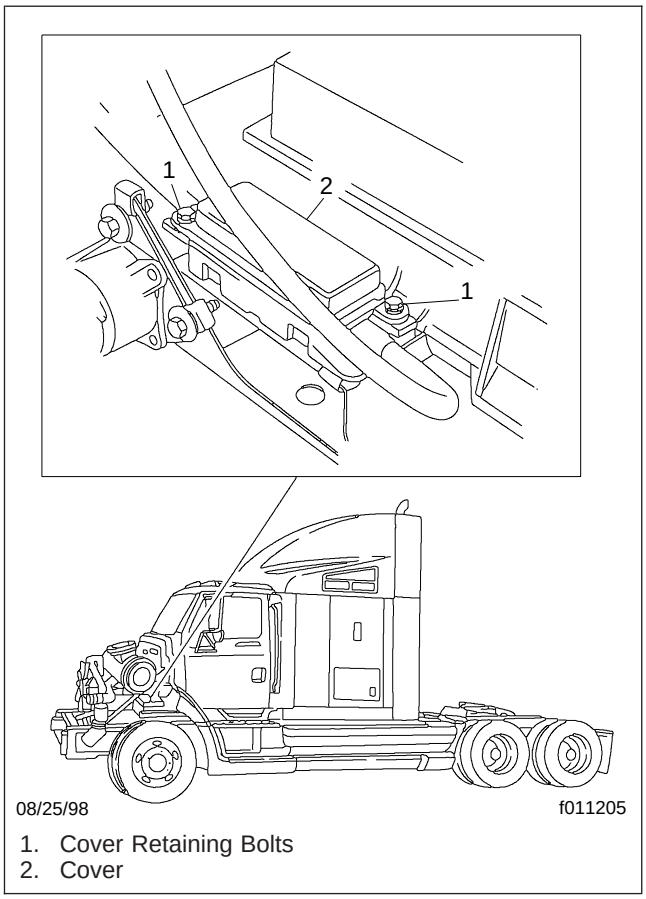


Fig. 21, Air Compressor Governor Lines

IMPORTANT: Use care not to damage any engine components, lines, filters, and electrical wiring during installation of the powertrain assembly.

2. Move the powertrain assembly into the vehicle until the transmission is behind the front axle.
3. Support the powertrain assembly.
   - 3.1 Install a suitable transmission jack under the transmission. Secure the transmission to the jack.
   - 3.2 Lower the engine and support the front engine mount.

     Use two suitable jack stands rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer and a suitable length of wood with a minimum 4-inch (10 mm) x 6-inch (15 mm) dimension.



1. Cover Retaining Bolts
2. Cover

Fig. 22, Megafuse Cover

4. Remove the load leveling sling and install a lifting chain. Use a suitable lifting chain rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer connected to the front lifting eye.
5. Move the powertrain assembly back to the rear engine mount insulators.
6. Install the No. 2 crossmember, eight bolts, 16 washers, and eight nuts. Tighten 75 to 105 lbf·ft (102 to 138 N·m). See **Fig. 49** . A suitable portapower unit may be necessary to spread the frame side rails if the frame has settled.
7. Install the bolts and flag nuts. See **Fig. 48** .
8. Remove the transmission jack and the engine lifting equipment.
9. Install the two rear support brackets, four bolts, eight washers and four nuts. Tighten 75 to 105 lbf·ft (102 to 138 N·m). See **Fig. 47** .

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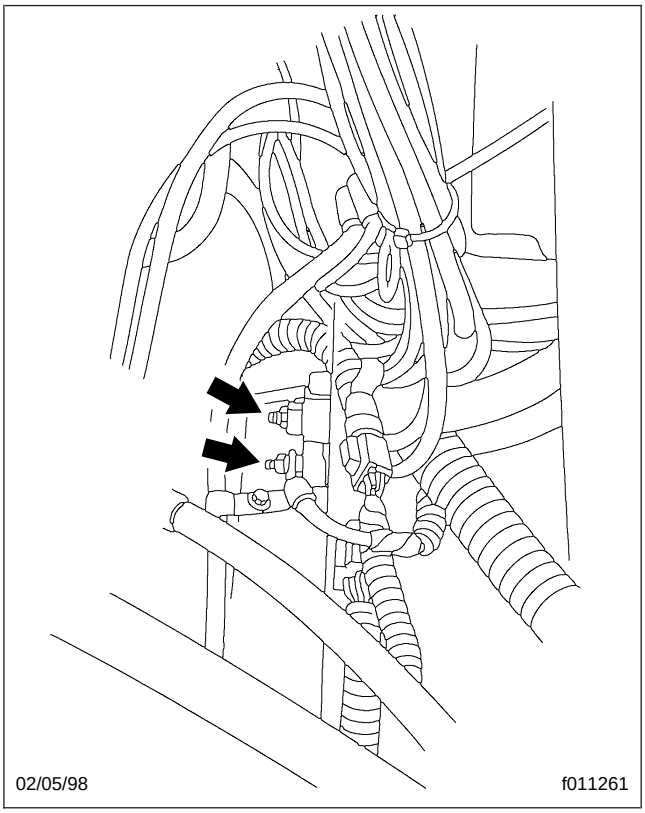


Fig. 23, Megafuse Electrical Lead

10. Connect the driveshaft; refer to **Group 41**.
11. Install the fuel filter. See **Fig. 46** .
12. Connect the ground strap. See **Fig. 45** .
13. Connect the electrical connectors. See **Fig. 44** .
14. Connect the starter electrical leads. See **Fig. 43** . Apply Silicone Dielectric Compound D7AZ–19A331–A or equivalent meeting specification ESE–M1C171–A to all of the starter motor electrical connections.
15. Install the exhaust outlet tube. See **Fig. 42** .
16. Install the bolts. See **Fig. 41** .
17. Install the battery cable clamp(s) on the transmission. See **Fig. 40** .
18. If the vehicle is equipped with a single fuel tank, connect the fuel lines. Install the retaining clamp(s) as noted during removal. See **Fig. 37** .

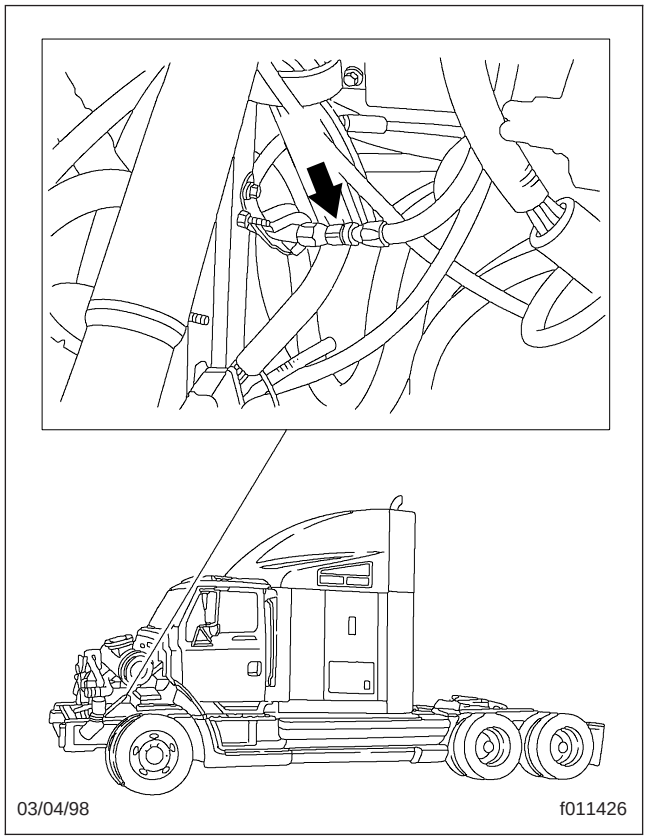


Fig. 24, Oil Pressure Gauge Line

19. If the vehicle is equipped with dual fuel tanks, connect the fuel supply and return lines. See **Fig. 38** .

NOTE: The HD series automatic transmission is shown, all others are similar.

20. If the vehicle is equipped with a transmission oil cooler, connect the transmission oil cooler lines. See **Fig. 36** .
    - Connect the transmission oil cooler lines.
    - Install the retaining clamps.

NOTE: If the vehicle is equipped with an HD or MD series automatic transmission, then perform the next three steps.

21. Connect the electrical connectors. See **Fig. 35** .
22. Install the transmission floor cover plate and the screws.

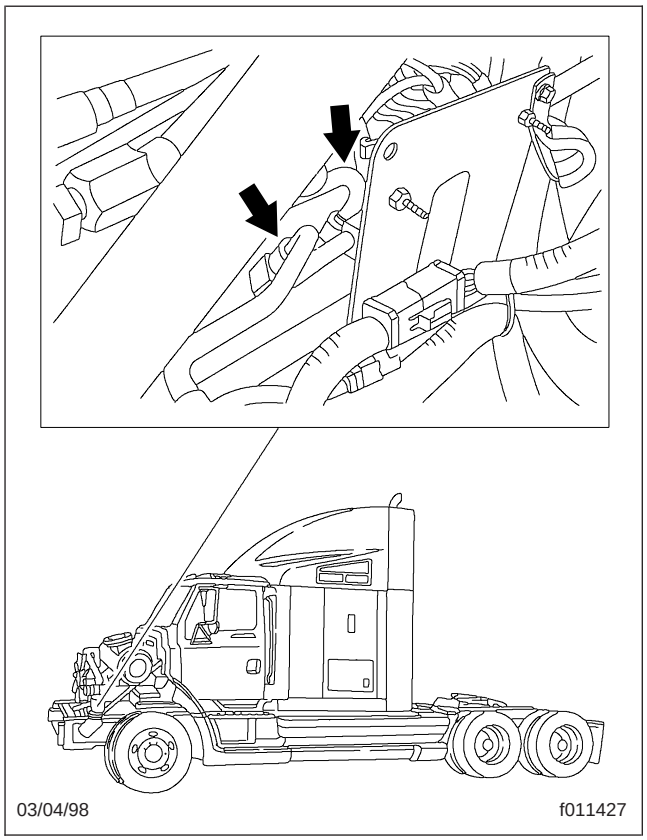


Fig. 25, Power Steering Lines

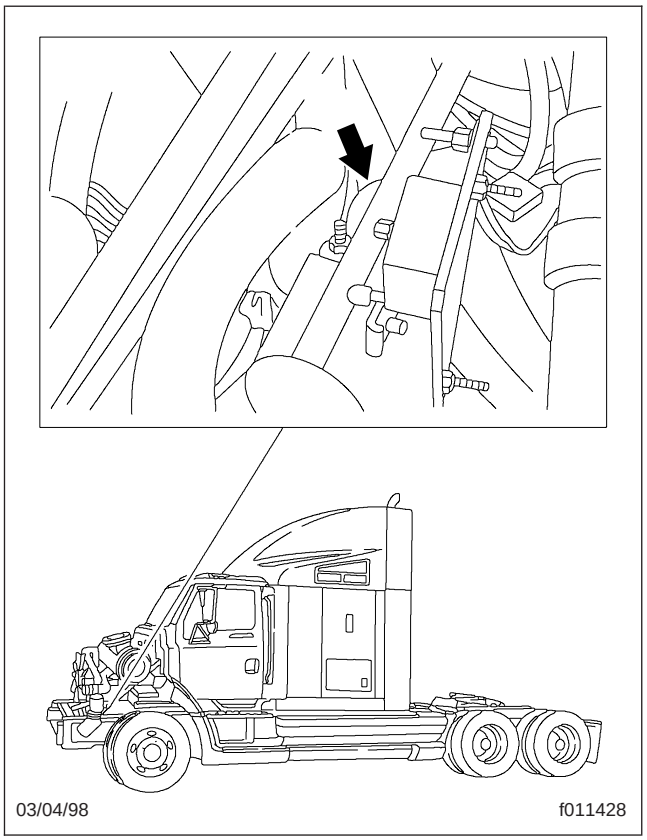


Fig. 26, Wiring Harness Retaining Clamp

23. Install the floor mat and interior trim; refer to **Group 60**.
24. If the vehicle is equipped with an AT, HT or MT series automatic transmission, then perform this step. connect the selector cable. See **Fig. 34** .

NOTE: If the vehicle is equipped with a manual transmission, then perform the next seven steps.

25. If the vehicle is equipped with a clutch linkage, install the clutch linkage. See **Fig. 33** .
26. If the vehicle is equipped with a clutch cable, install the clutch cable mounting bracket. See **Fig. 32** .
27. Align the shift block and yoke notches in the neutral position. See **Fig. 51** .
28. Position the gasket on the shift control housing.
29. Position the shift lever housing. See **Fig. 52** . Fit the shift lever into the shift block and yoke notches.
30. Install the cap screws. See **Fig. 31** . Use Threadlock® and Sealer EOAZ–19554–AA or equivalent meeting specification WSK–M2G315–A5 on the threads.
31. Connect the vehicle air and the Roadranger® air system to the transmission. Refer to **Group 26**.
32. Install the shift lever boot. If removed, install the transmission floor cover plate and interior trim. Refer to **Group 60**.
33. Connect the electrical connectors. See **Fig. 27** and **Fig. 28** .
34. Route the electrical wiring harness and install the retaining clamp. See **Fig. 26** .
35. Connect the power steering lines. See **Fig. 25** .

3126 Engine Removal and Installation

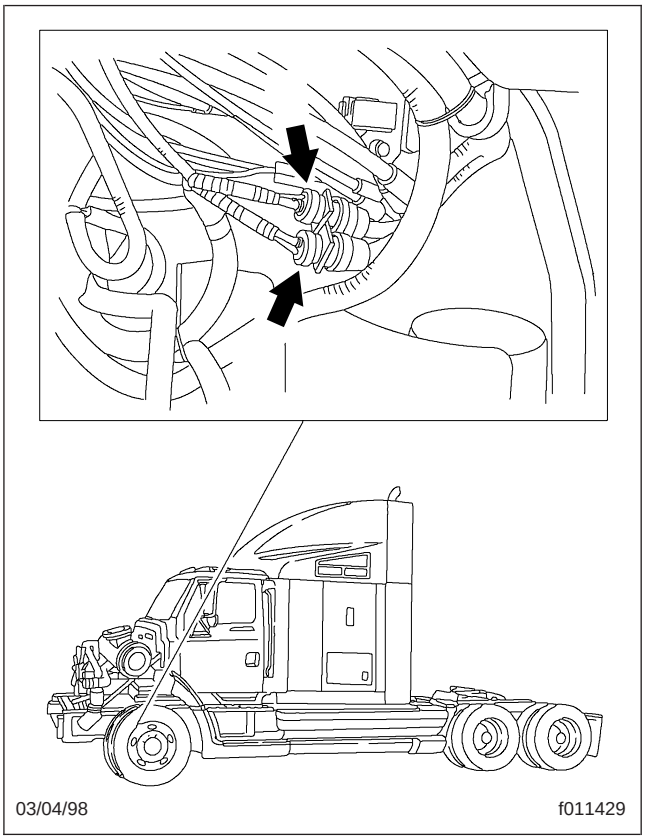


Fig. 27, Electrical Connector

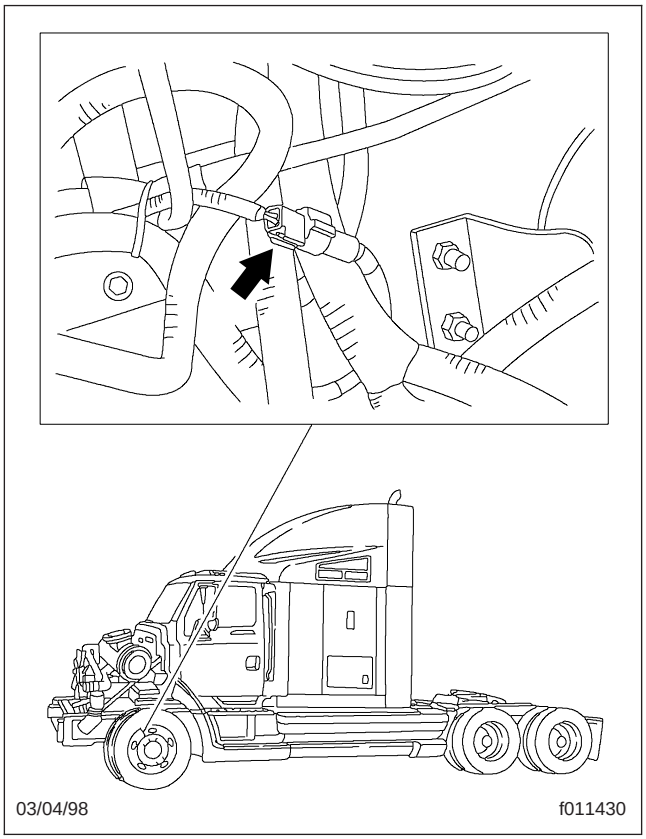


Fig. 28, Electrical Connector

36. Connect the oil pressure gauge line. See **Fig. 24** .
37. Connect the megafuse electrical lead. See **Fig. 23** .
38. Install the megafuse cover. See **Fig. 22** .
39. Connect the air compressor governor air lines. See **Fig. 21** .
40. Connect the ground strap. See **Fig. 20** .
41. Connect the electrical connectors. See **Fig. 19** .
    - 41.1 Connect the electrical connector.
    - 41.2 Connect the bulkhead electrical connector.
    - 41.3 Position the brace.
    - 41.4 Tighten the nut and bolt.
    - 41.5 Install the nut and bolt.
42. Connect the starter relay electrical leads. See **Fig. 18** .
    - 42.1 Connect the starter relay electrical leads to the terminals noted during removal.
    - 42.2 Install the protective caps.
43. If the vehicle is equipped with a manual transmission, connect the clutch cable or linkage. See **Fig. 17** .
44. Connect the air compressor discharge line. See **Fig. 16** .
45. Install the air compressor discharge line clamp. See **Fig. 15** .
46. Install the left-side splash shield and six screws. See **Fig. 14** .
47. Install the charge air cooler outlet tube. See **Fig. 13** .
48. Install the upper radiator tube. See **Fig. 12** .

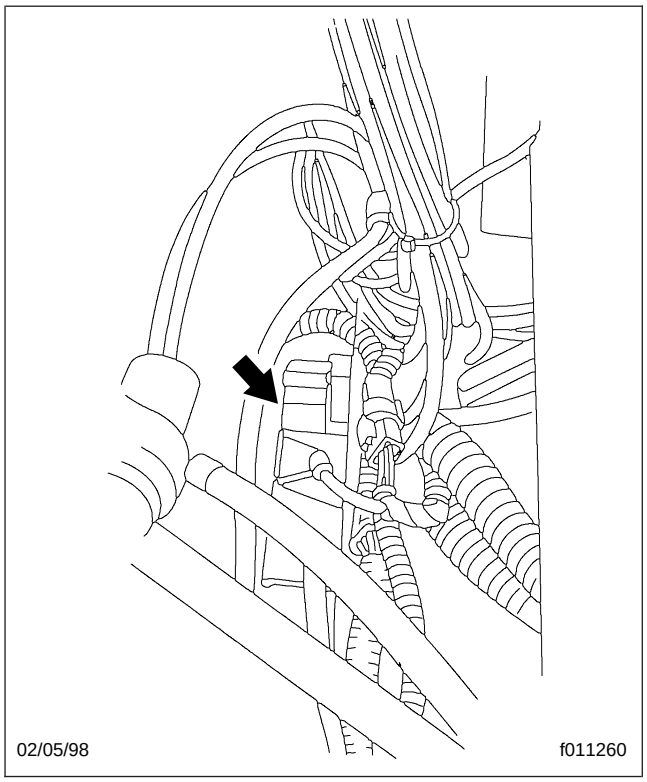


Fig. 29, Megafuse Cover

49. Connect the heater water hoses. See **Fig. 11** .
50. Install the lower radiator tube. See **Fig. 10** .
51. Install the exhaust outlet tube. See **Fig. 9** .
52. Install the turbocharger outlet tube. See **Fig. 8** .
53. Connect the refrigerant line. Tighten line to 30 to 35 lbf·ft (41 to 47 N·m). See **Fig. 7** .

    Install a new captured O-ring lubricated with clean Heavy Truck PAG Oil, F4HZ–19577–A or equivalent meeting specification EST–M1C231–B2.
54. If the vehicle has a 113- to 122-inch BBC chassis, install the No. 1 crossmember, two bumper brackets, four bolts, eight washers and four nuts. Tighten 150 to 205 lbf·ft (204 to 277 N·m). See **Fig. 6** .

NOTE: If the vehicle has a 101-inch BBC chassis, then perform the next two steps.

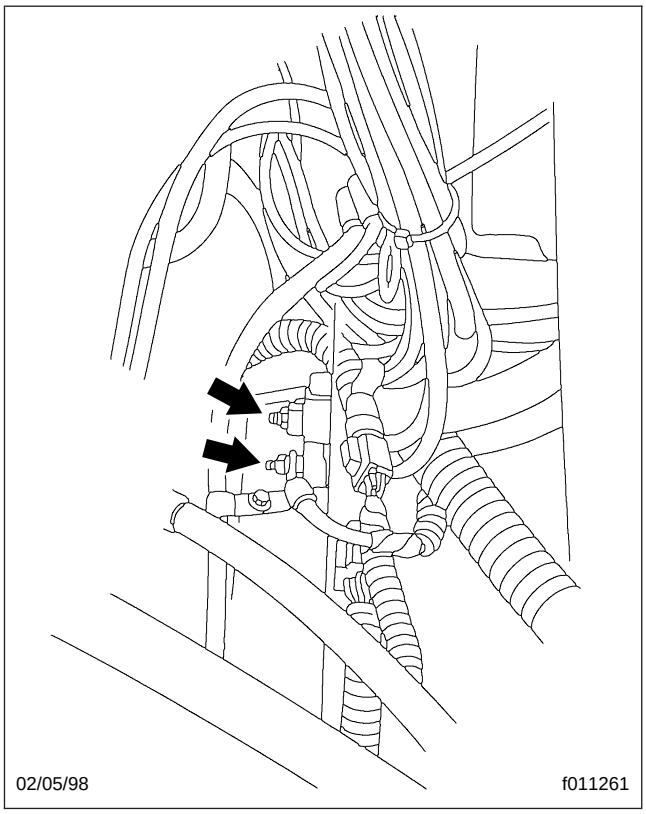
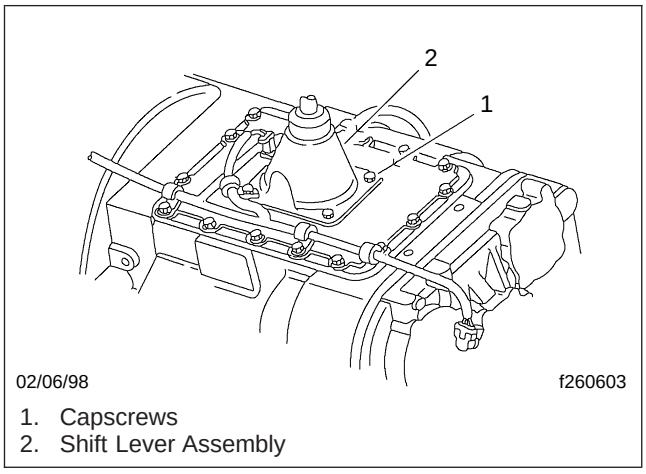


Fig. 30, Megafuse Electrical Lead



1. Capscrews
2. Shift Lever Assembly

Fig. 31, Shift Lever Assembly

55. Install the top two No. 1 crossmember gussets, four bolts, eight washers and four nuts. Tighten bolts to 150 to 205 lbf·ft (204 to 277 N·m). See **Fig. 5** .

3126 Engine Removal and Installation

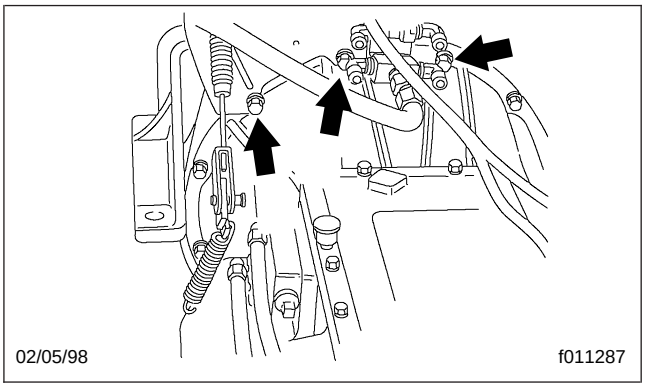


Fig. 32, Clutch Cable Mounting Bracket

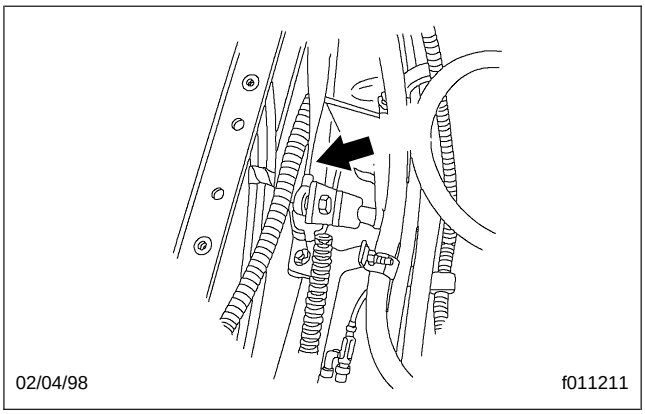


Fig. 33, Clutch Linkage

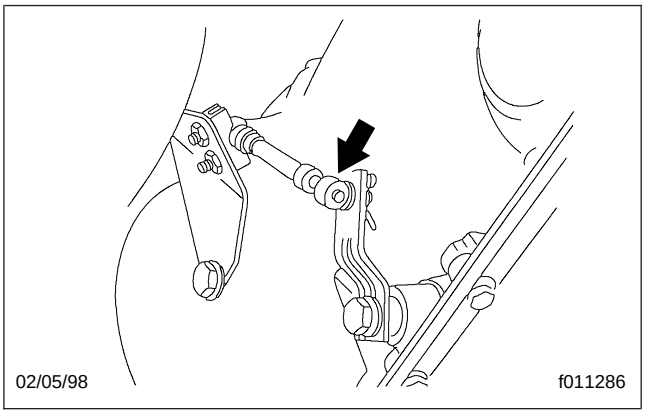


Fig. 34, Selector Control Cable

56. Install the No. 1 crossmember and eight bolts, 16 washers and eight nuts. Tighten bolts to 150 to 205 lbf·ft (204 to 277 N·m). See **Fig. 4** .

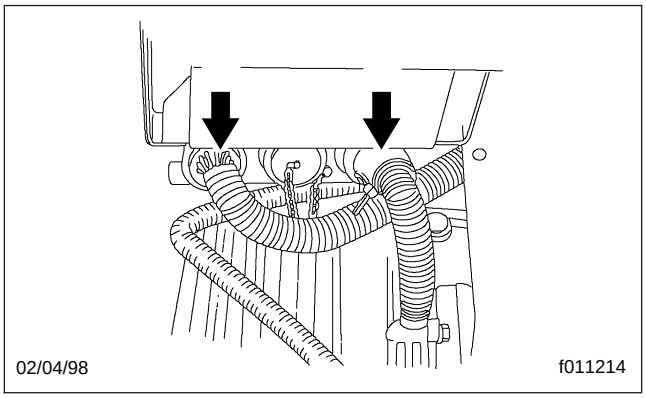


Fig. 35, Electrical Connectors

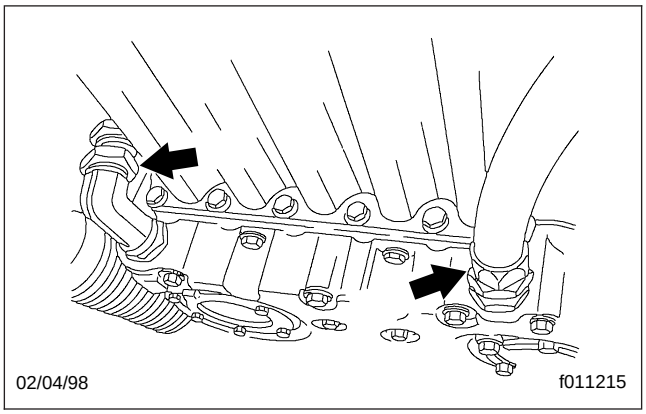


Fig. 36, Transmission Cooler Lines

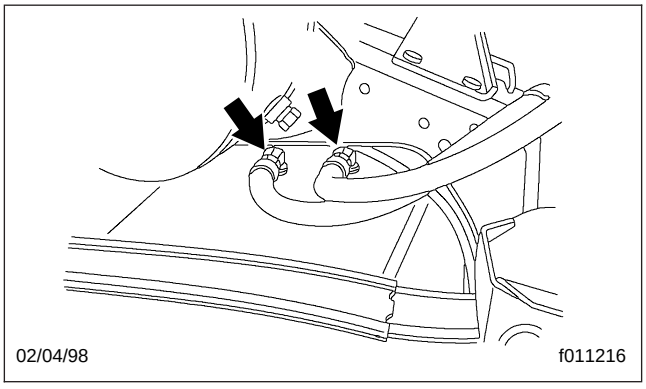


Fig. 37, Fuel Lines, Single Fuel Tank

NOTE: The steering gear is shown, the rotary assist cylinder is similar.

57. If the vehicle is equipped with dual steering gears, route the power steering lines and con-

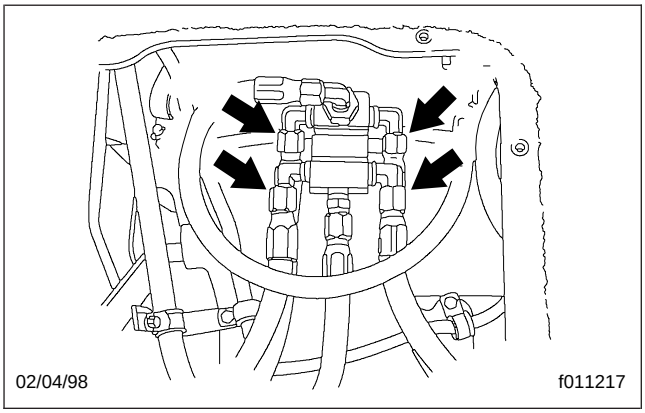


Fig. 38, Fuel Lines, Dual Fuel Tanks

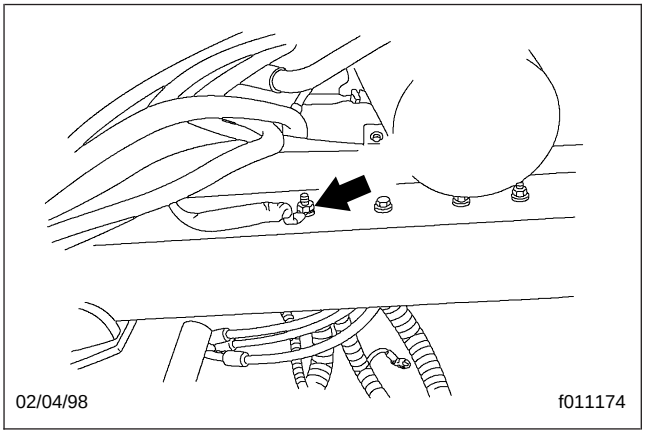


Fig. 39, Ground Strap

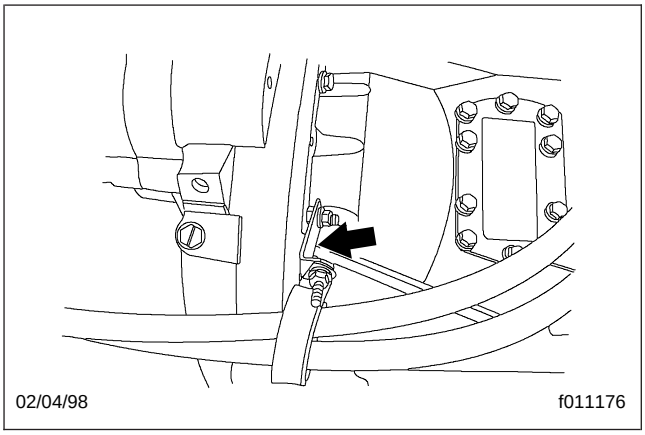


Fig. 40, Battery Cable Clamp

nect the power steering lines to the steering gear and the rotary assist cylinder. See **Fig. 3** .

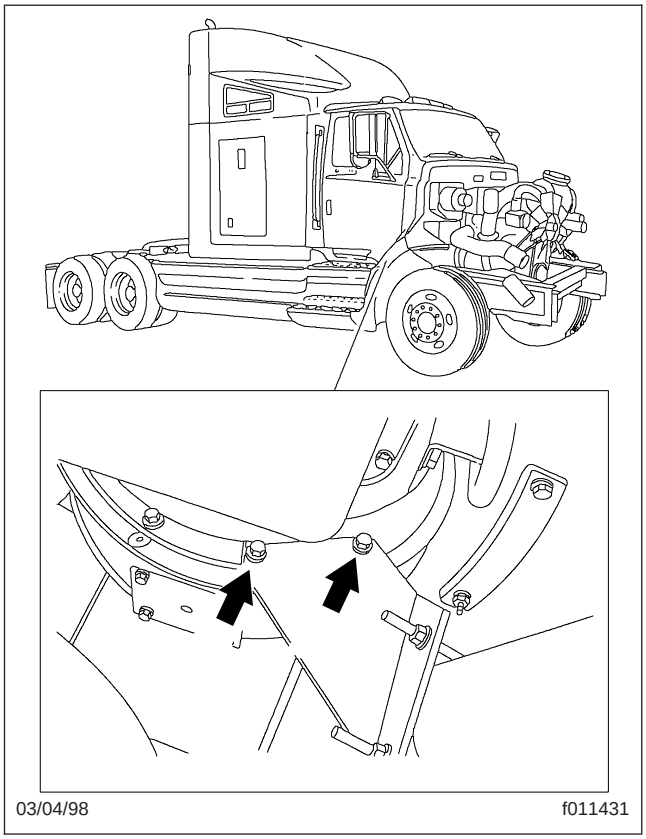


Fig. 41, Transmission Bolts

NOTE: The brake valves shown are for a 2-channel ABS system. All other configurations are similar.

58. Connect the air valve assembly. See **Fig. 2** .
    - Connect the air lines.
    - Connect the electrical connector.
    - Install the retaining clamp bolts.
59. If the vehicle is equipped with front pintle hooks, install the two pintle hooks, six bolts, 10 washers and four nuts. Tighten 220 to 300 lbf·ft (298 to 406 N·m). See **Fig. 1** .
60. Restore the vehicle to operating condition.
    - 60.1 Install the air intake tube and air cleaner assembly as an assembly. Refer to **Group 09**.
    - 60.2 Install the cooling module. Refer to **Group 20**.

3126 Engine Removal and Installation

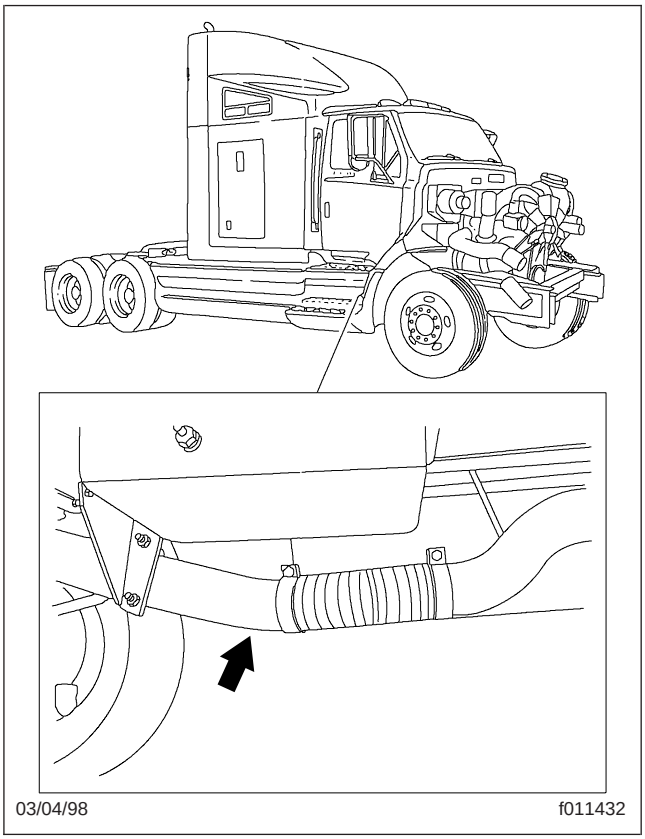


Fig. 42, Exhaust Outlet Tube

60.3 If the vehicle is equipped with a transmission cooler or an automatic transmission, fill the transmission oil. Refer to the appropriate **Group 26** transmission section.

60.4 Fill the engine with oil.

60.5 Fill the engine cooling system. Refer to **Group 20**.

60.6 Fill the air system.

60.7 If the vehicle is equipped with an A/C system, evacuate, charge and leak test the A/C system. Refer to **Group 83**.

60.8 Check the engine drive belts for proper adjustment.

60.9 Check the transmission cables and linkages for proper adjustment. Refer to the appropriate **Group 26** transmission section.

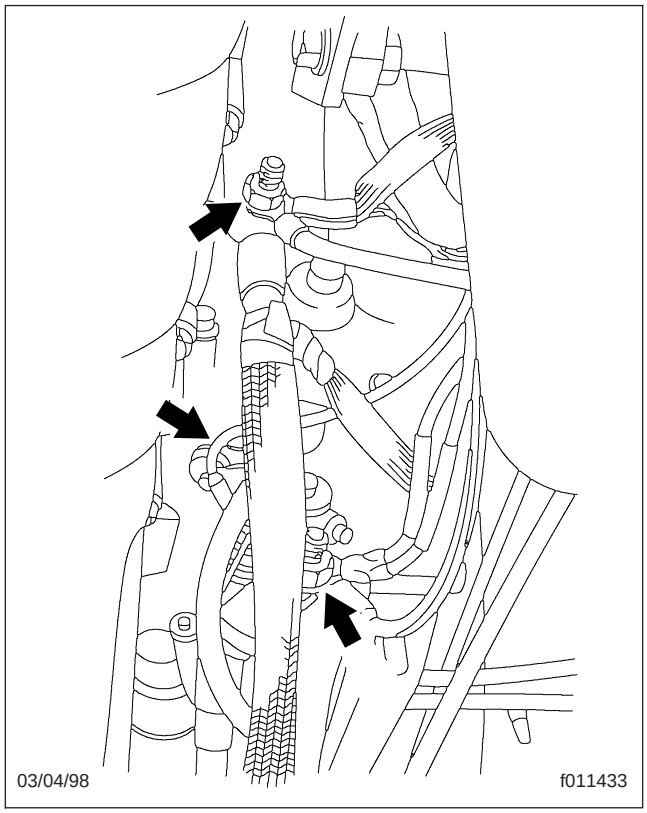


Fig. 43, Starter Electrical Leads

60.10 Check the clutch cables and linkages proper adjustment. Refer to **Group 25**.

60.11 Connect the battery ground cables.

60.12 Start the engine and check the powertrain assembly for leaks.

60.13 Install the engine cover. Refer to **Group 60**.

60.14 Install the hood. Refer to **Group 88**.

60.15 Install the bumper. Refer to **Group 31**.

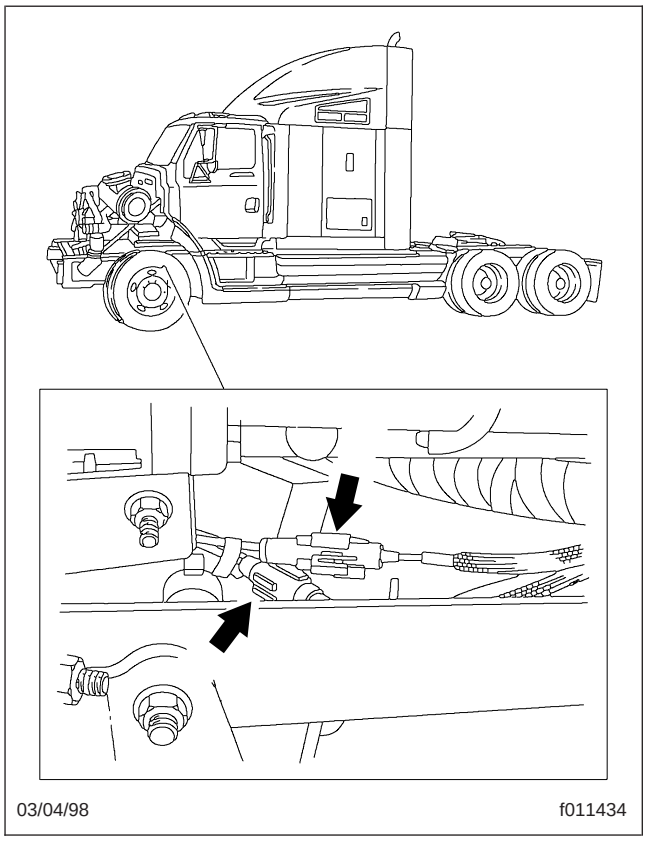


Fig. 44, Electrical Connectors

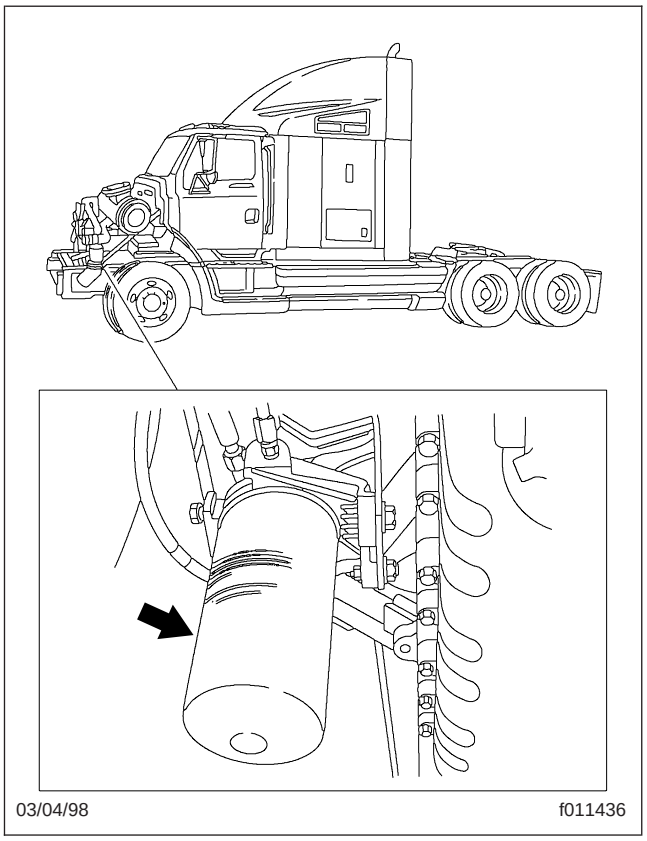


Fig. 46, Fuel Filter

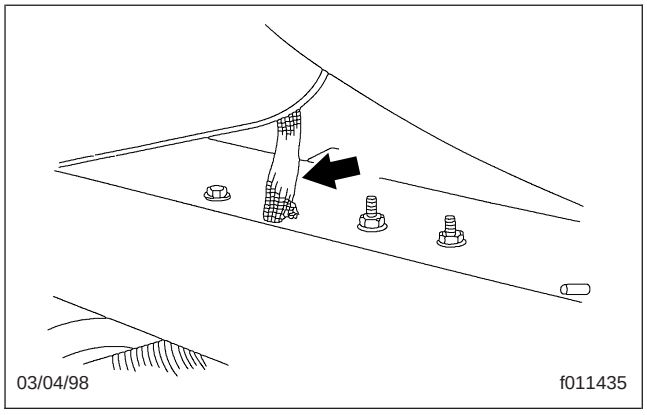


Fig. 45, Ground Strap

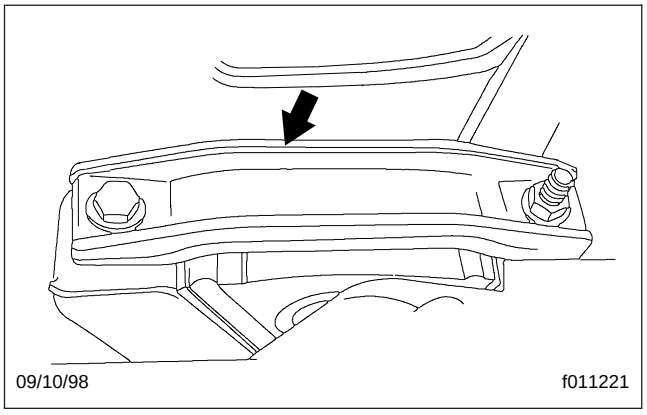


Fig. 47, Rear Support Bracket

3126 Engine Removal and Installation

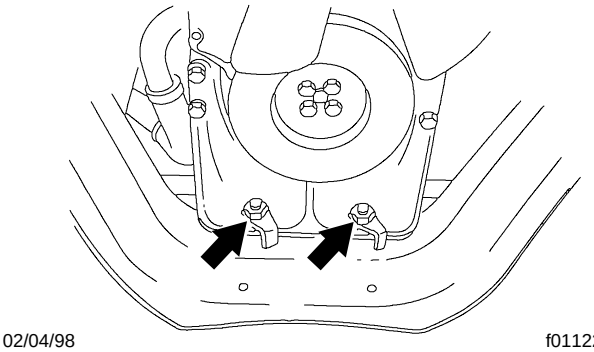
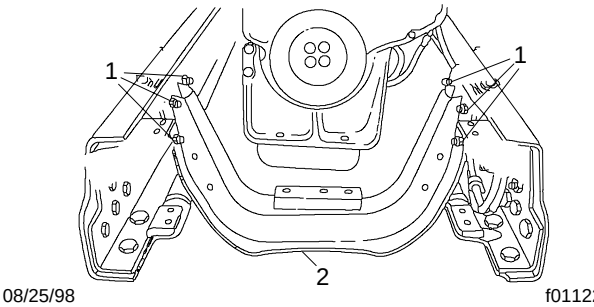
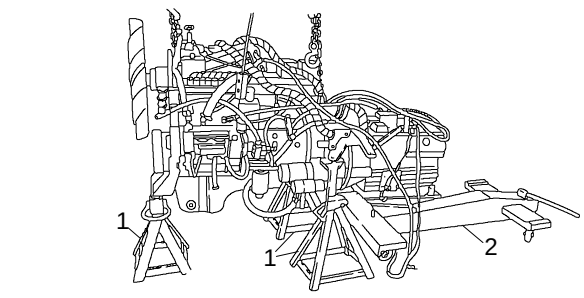


Fig. 48, Flag Bolt and Nut Assembly



1. Bolts (8 qty.)
2. No. 2 Crossmember

Fig. 49, No. 2 Crossmember



1. Jack Stand
2. Floor Jack

Fig. 50, Supporting the Powertrain Assembly

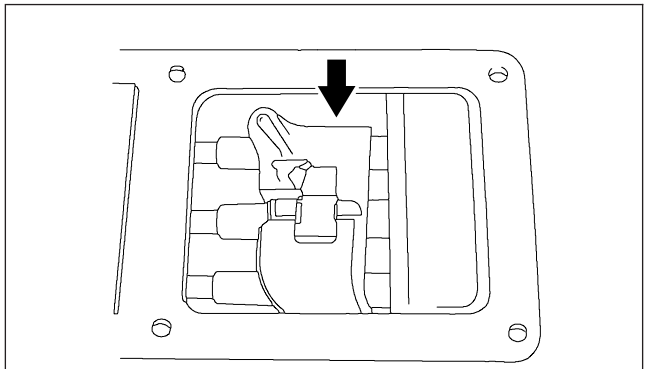


Fig. 51, Aligning the Shift Block and Yoke

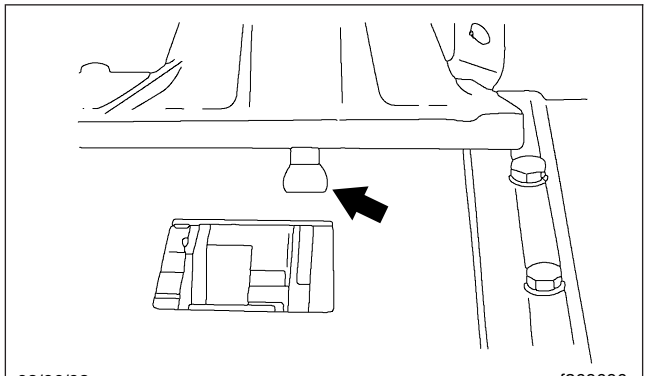
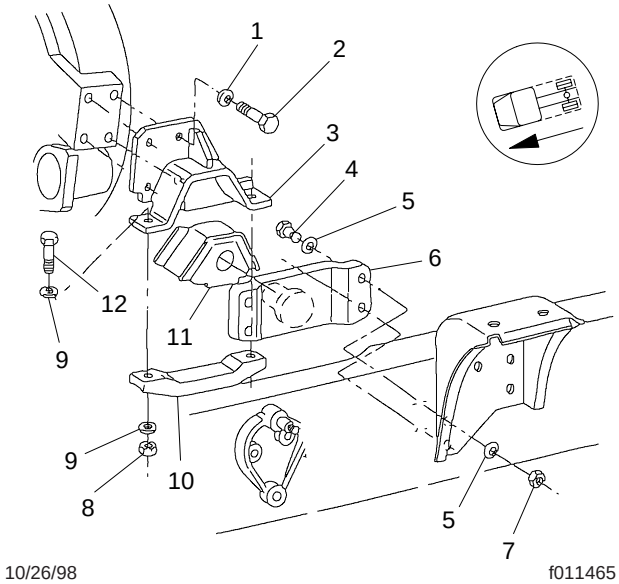


Fig. 52, Positioning the Shift Lever

Rear Engine Mount Replacement (See Fig. 1)



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1. Flatwasher (14 x 28 x 2.5)
2. Bolt (M14 x 2.0 x 35)
3. Engine Leg (left-hand)
4. Bolt (5/8–11 x 3.50)
5. Flatwasher (5/8 x 1.18 x 13)
6. Engine Support-to-Frame Bracket (left-hand)
7. Locknut (5/8 x 11)
8. Locknut (1/2 x 13)
9. Flatwasher (1/2 x 1.06 x 0.10)
10. Engine Support-to-Frame Cap
11. Rear Engine Support Isolator
12. Bolt (1/2–13 x 2.50)

Fig. 1, Rear Engine Support Isolators, 3126 Engines (left-hand side shown; right-hand side similar)

1. Apply the parking brakes, shut down the engine, chock the tires, and if applicable, drain the air brake system.

⚠ 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 component damage, personal injury or death.

2. Disconnect the engine from the rear engine support-to-frame bracket(s).
   - 2.1 Place a jack under the rear of the engine, and raise the jack until it is braced against the engine.
   - 2.2 Remove the nuts, bolts and washers that attach the engine support-to-frame cap to the rear engine support bracket(s). Save the fasteners.
3. Disconnect the engine support-to-frame bracket(s) from the frame rail.
   - 3.1 Remove the bolts that secure the rear engine support-to-frame bracket(s) to the frame rail.
   - 3.2 Lift the engine slightly to take its weight off the rear engine support-to-frame bracket(s). Place engine stands under the engine to keep it off the engine support-to-frame bracket(s).
   - 3.3 Remove the rear engine support-to-frame bracket(s) from the frame rail.
   - 3.4 Remove the rear engine support isolator from the rear engine support-to-frame bracket(s).
4. If necessary, remove the bolts that secure the engine leg(s) to the flywheel housing, and remove the leg(s) from the engine.
5. Inspect the rear engine support isolators for wear or damage and replace them if necessary.

⚠ CAUTION

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

6. Install the rear engine support isolator on a new rear engine support-to-frame bracket(s). Align the isolator on the bracket so the wide side of the isolator is at the bottom of the bracket.
7. If removed, install the engine leg(s) on the flywheel housing. Apply thread-lock compound to the bracket mounting bolts, and tighten them as follows:

   For C-7 and 3126 engines: 100 lbf·ft (136 N·m).

Engine Mount Replacement

For all other Caterpillar engines: 190 lbf·ft (258 N·m).

8. Place the new engine support-to-frame bracket(s), with the isolator aligned properly, against the inside of the frame rail, and secure it with bolts, washers, and nuts. Tighten the nuts 120 to 152 lbf·ft (163 to 206 N·m).

⚠ 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 component damage, personal injury or death.

9. Connect the engine to the engine support-to-frame bracket(s).

   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(s).

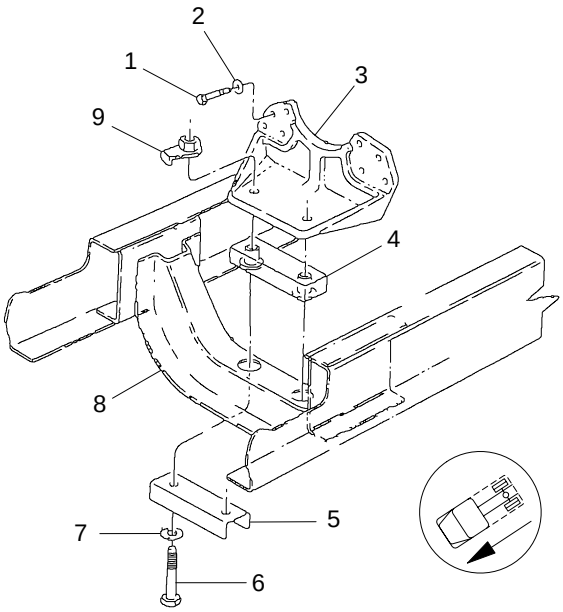
   NOTE: The bolt at the rear of the cap is installed from the bottom. The bolt at the front of the cap is installed from the top.

   9.3 Holding the rear engine support-to-frame cap in place, install the bolts that attach the cap to the rear engine support bracket(s), and secure them with a nut and hardened washer. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

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

Front Engine Mount Replacement

NOTE: Both compression-type and focal-type engine support isolators are used in all L-Line and A-Line vehicles. See **Fig. 2** and **Fig. 3** for C10 and C12 engines. See **Fig. 4** for 3126 engines. See **Fig. 5** and **Fig. 6** for 3306 engines. See **Fig. 7** and **Fig. 8** for 3406 engines.



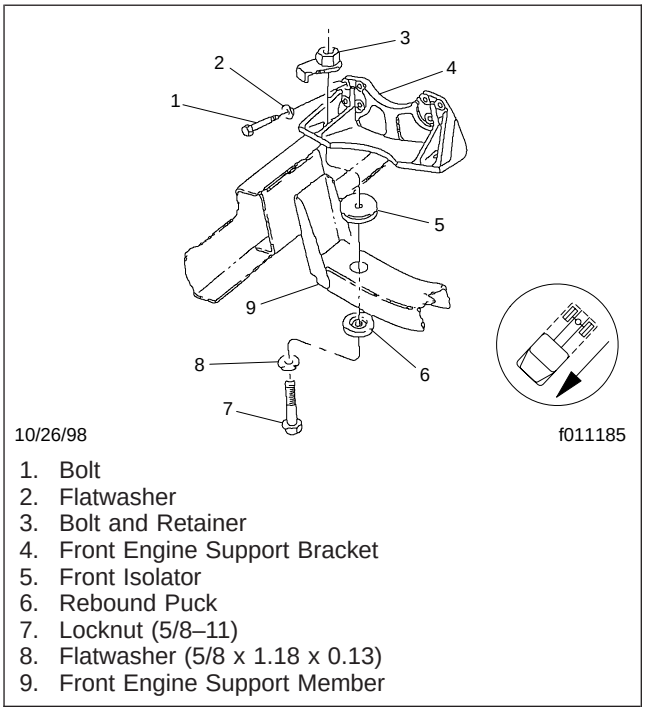
1. Bolt
2. Washer
3. Front Engine Support Bracket
4. Isolator
5. Rebound Puck
6. Hexhead Bolt (5/8–11 x 3.50)
7. Washer
8. Front Engine Support Member
9. Nut and Retainer (5/8–11)

Fig. 2, Front Engine Support Isolators, Compression, C10 and C12 Engines

1. Apply the parking brakes, shut down the engine, chock the tires, open the hood, and if applicable, drain the air brake system.

⚠ WARNING

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



1. Bolt
2. Flatwasher
3. Bolt and Retainer
4. Front Engine Support Bracket
5. Front Isolator
6. Rebound Puck
7. Locknut (5/8–11)
8. Flatwasher (5/8 x 1.18 x 0.13)
9. Front Engine Support Member

Fig. 3, Front Engine Support Isolators, Focal, C10 and C12 Engines

2. Disconnect the engine from the front engine mount(s).

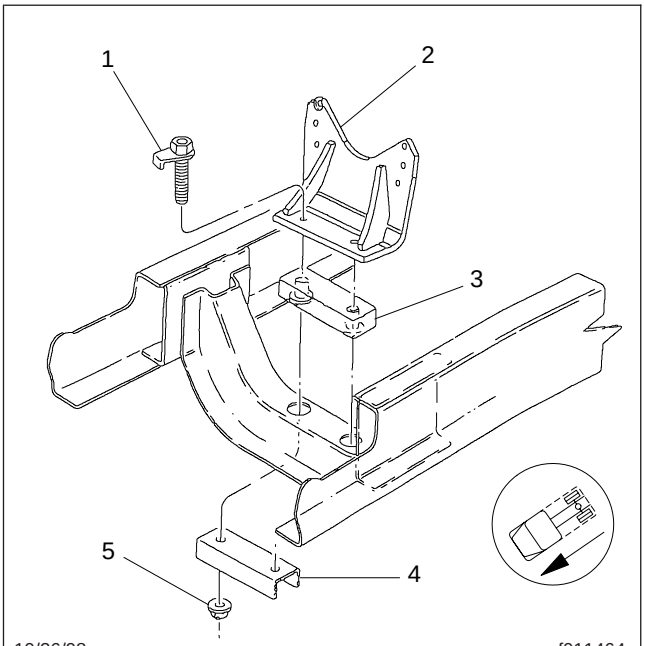
   2.1 Attach a chain to the front engine lifting hook(s), and position a lifting device to lift the engine. Attach the chain to the lifting device, and raise the chain to remove any slack.

   2.2 Remove the nuts and bolts from the front engine mount(s). Save the fasteners.

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

3. If you are replacing the front engine support bracket, refer to the engine manufacturer's service literature.

4. Inspect the engine mount rubber isolator(s) for wear or damage and replace it, if necessary.



1. Bolt and Retainer (5/8–11 x 3.50)
2. Front Engine Support Bracket
3. Front Isolator
4. Engine Support-to-Frame Bracket
5. Locknut (5/8–11)

Fig. 4, Front Engine Support Isolators, 3126 Engines (Left-Hand Side Shown, Right-Hand Side Similar)

⚠ CAUTION

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

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

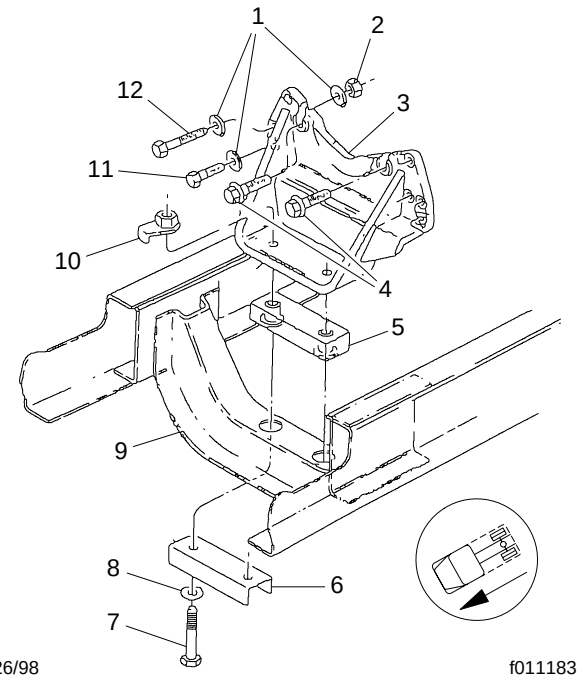
⚠ WARNING

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

6. Secure the engine to the front engine mount(s).

   6.1 Lift the engine slightly to remove the engine stands. Remove the stands, and

Engine Mount Replacement



1. Flatwasher
2. Locknut (3/8–16)
3. Front Engine Support Bracket
4. Hexhead Bolt (1/2–16 x 3.25)
5. Front Isolator
6. Engine Support-to-Frame Bracket
7. Locknut (5/8–11)
8. Flatwasher
9. Front Engine Support Member
10. Bolt and Retainer (5/8–11 x 3.50)
11. Hexhead Bolt (3/8–16 x 1.50)
12. Bolt

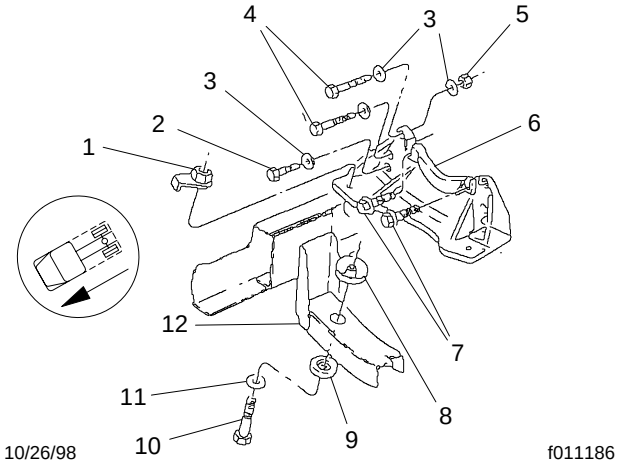
Fig. 5, Front Engine Support Isolators, Compression, 3306 Engines

carefully lower the engine onto the engine mount(s).

6.2 Install the bolts in the front engine mount(s) and secure them with the nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

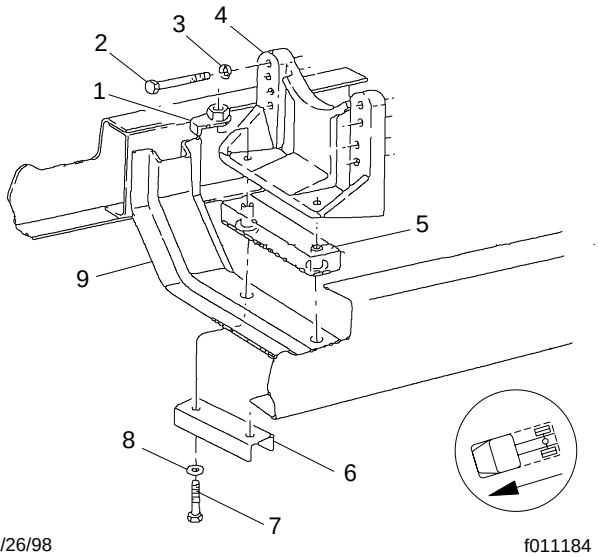
6.3 Remove the lifting chain from the engine lifting hooks.

7. Close the hood and remove the chocks from the tires.



1. Nut and Retainer (5/8–11)
2. Bolt (3/8–16 x 1.50)
3. Front Engine Support Bracket
4. Bolt
5. Locknut (3/8–16)
6. Front Engine Support Bracket
7. Bolt (1/2–16 x 3.25)
8. Front Isolator
9. Rebound Puck
10. Bolt (5/8–11 x 3.50)
11. Flatwasher (5/8 x 1.18 x 0.13)
12. Front Engine Support Member

Fig. 6, Front Engine Support Isolators, Focal, 3306 Engines



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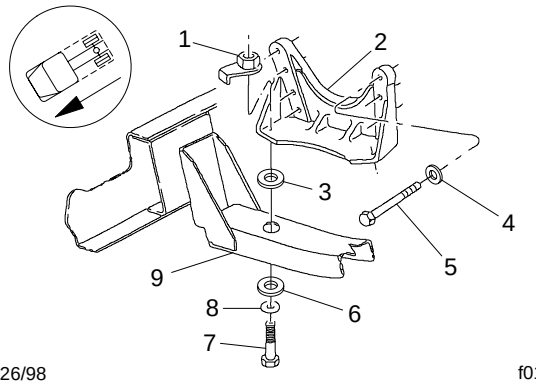
1. Bolt and Retainer (5/8–11 x 3.50)
2. Hexhead Bolt (1/2–13 x 5.50)
3. Flatwasher (1/2 x 1.06 x 0.10)
4. Front Engine Support Bracket
5. Isolator
6. Rebound Puck
7. Nut (5/8–11)
8. Flatwasher (5/8 x 1.18 x 0.13)
9. Front Engine Support Member

Fig. 7, Front Engine Support Isolators, Compression, 3406 Engines



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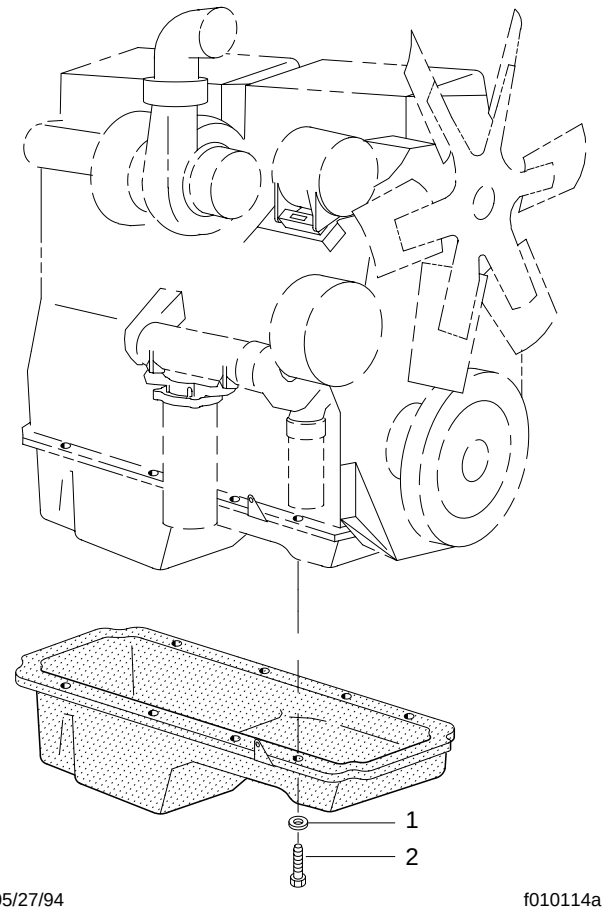
1. Bolt and Retainer (5/8–11)
2. Front Engine Support Bracket
3. Front Isolator
4. Flatwasher (1/2 x 1.06 x 0.10)
5. Bolt (1/2–13 x 5.50)
6. Rebound Puck
7. Nut (5/8–11 x 3.50)
8. Flatwasher (5/8 x 1.18 x 0.13)
9. Front Engine Support Member

Fig. 8, Front Engine Support Isolators, Focal, 3406 Engines

Oil Pan Noise Panel Replacement (See Fig. 1)



NOTE: Not all fasteners are shown.
1. Washer
2. Bolt

Fig. 1, Oil Pan Noise Panel

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

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

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the bolts and washers that attach the oil pan noise panel to the oil pan.
3. Remove the noise panel.
4. Place the new noise panel into position under the oil pan.
5. Install the washers and bolts. Tighten the bolts until secure.
6. Remove the chocks from the tires.

Front Cover Noise Panel Replacement (See Fig. 2)

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

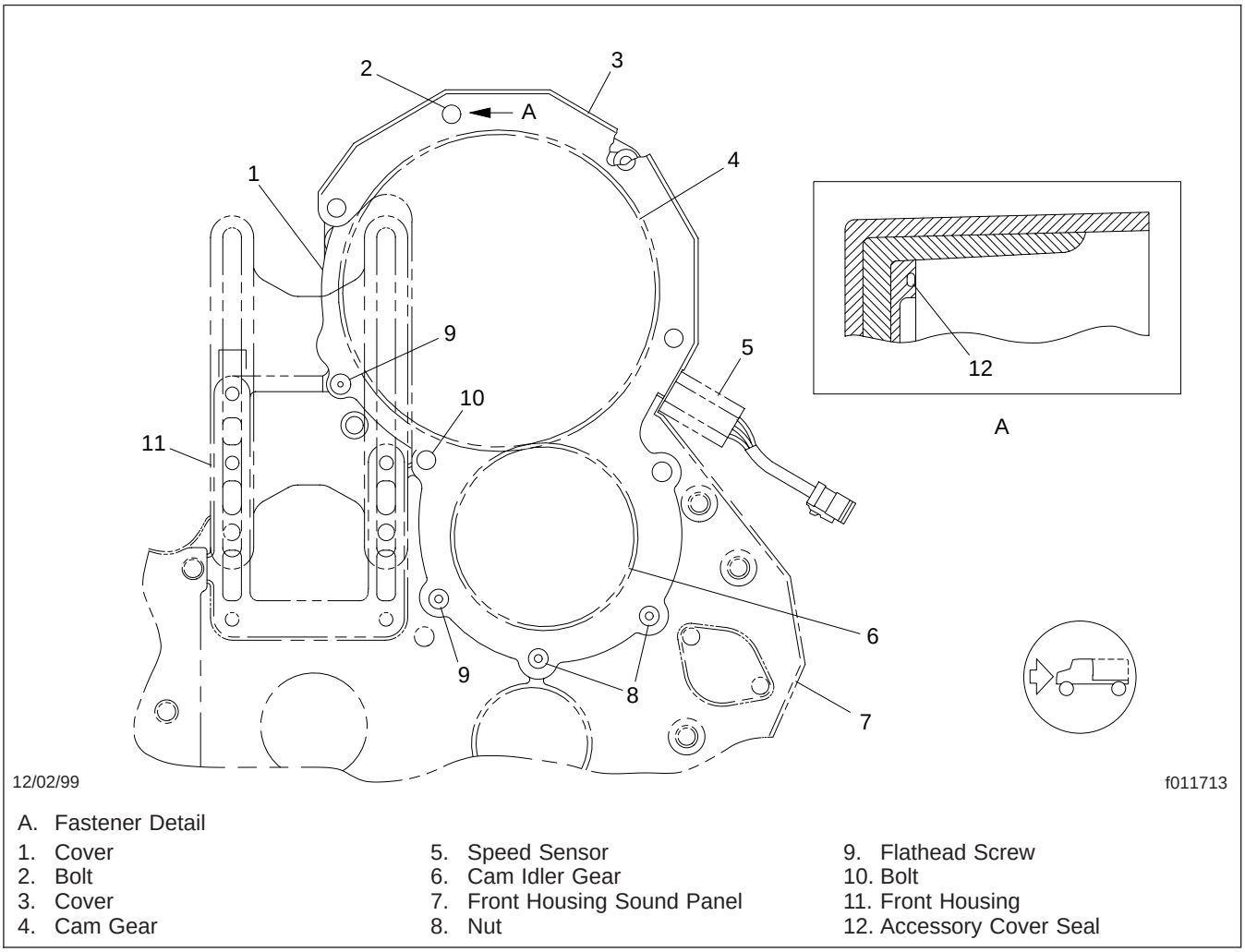
IMPORTANT: If any of the engine noise panels are damaged, replace them. Failure to do so could result in non-compliance with federal and California noise emissions standards.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Move any hoses or electrical wiring out of the way.
3. Remove the fasteners that attach the noise panel to the front cover.
4. Remove the noise panel.
5. Place the new noise panel on the front gear cover.
6. Install the fasteners and tighten them.
7. Replace any hoses or electrical wiring moved out of the way for panel replacement.
8. Remove the chocks from the tires.

Engine Block Noise Panel Replacement

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

Engine Noise Panel Replacement



A. Fastener Detail
1. Cover
2. Bolt
3. Cover
4. Cam Gear
5. Speed Sensor
6. Cam Idler Gear
7. Front Housing Sound Panel
8. Nut
9. Flathead Screw
10. Bolt
11. Front Housing
12. Accessory Cover Seal

Fig. 2, Front Cover Noise Panel

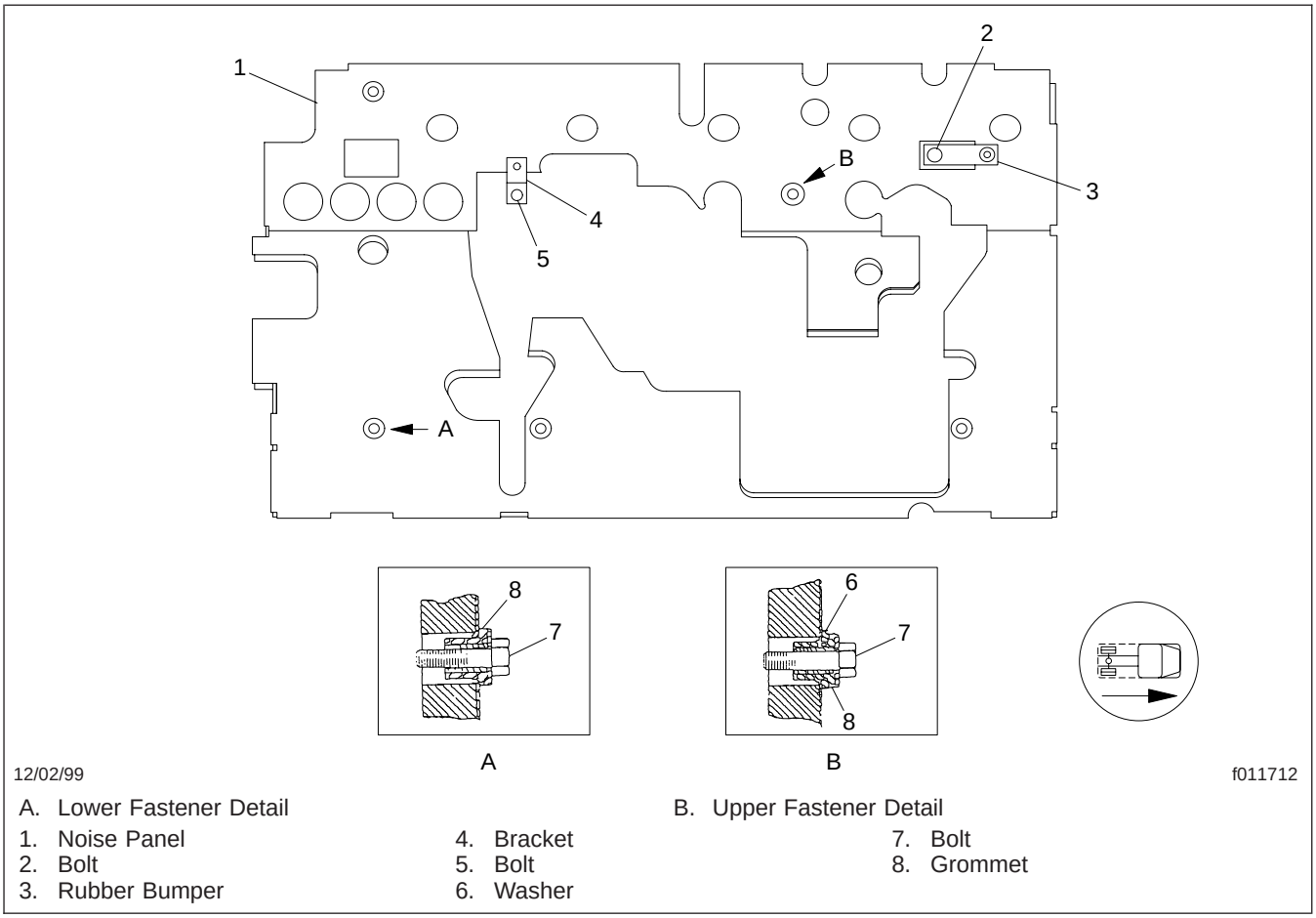
IMPORTANT: If any of the engine noise panels are damaged, replace them. Failure to do so could result in non-compliance with federal and California noise emissions standards.

RIGHT-SIDE NOISE PANEL (See Fig. 3)

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Move any hoses or electrical wiring out of the way.
3. Remove the fasteners that attach the right-side noise panel to the engine block.
4. Remove the noise panel.
5. Place the new noise panel on the engine block.
6. Install the fasteners and tighten them.
7. Replace any hoses or electrical wiring moved out of the way for panel replacement.
8. Remove the chocks from the tires.

LEFT-SIDE NOISE PANEL (See Fig. 4)

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.



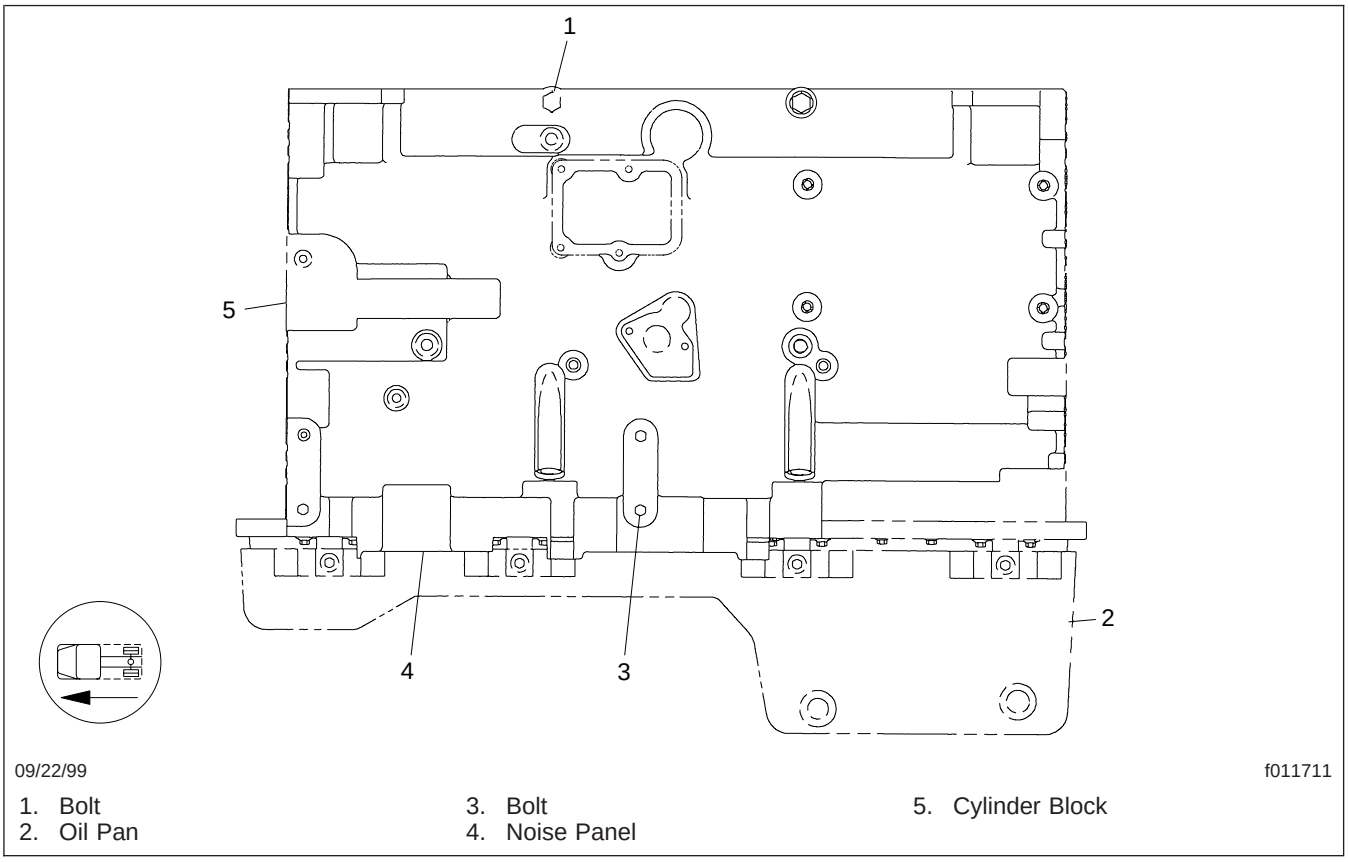
A. Lower Fastener Detail
B. Upper Fastener Detail

1. Noise Panel
2. Bolt
3. Rubber Bumper
4. Bracket
5. Bolt
6. Washer
7. Bolt
8. Grommet

Fig. 3, Right-Side Noise Panel

2. Move any hoses or electrical wiring out of the way.
3. Remove the fasteners that attach the left-side noise panel to the engine block.
4. Remove the noise panel.
5. Place the new noise panel on the engine block.
6. Install the fasteners and tighten them.
7. Replace any hoses or electrical wiring moved out of the way for panel replacement.
8. Remove the chocks from the tires.

Engine Noise Panel Replacement



1. Bolt
2. Oil Pan
3. Bolt
4. Noise Panel
5. Cylinder Block

Fig. 4, Left-Side Noise Panel

General Specifications	
Item	**Specification**
Heavy Truck PAG Oil	EST–M1C231–B2
Pipe Sealant with Teflon®	WSK–M2G350–AZ and ESR–M18P7–A
Silicone Dielectric Compound	ESE–M1C171–A
Threadlock®and Sealer	WSK–M2G315–A5

Table 1, General Specifications

Torque Specifications, C10 and C12	
Description	**Torque lbf·ft (N·m)**
A/C Compressor Suction Line	30–35 (41–47)
Alternator and A/C Compressor Mounting Bracket Mounting Bolts (1/2-inch Bolts)	75–105 (102–142)
Alternator and A/C Compressor Mounting Bracket Mounting Bolts (M10 Bolts)	30–46 (40–64)
Engine Mount Mounting Bolts	150–205 (203–277)
Front Engine Mount Insulator Mounting Bolts	150–205 (204–277)
Front Engine Support Bracket Mounting Bolts	75–105 (102–142)
Engine Leg-to-Flywheel Housing Bolts*	190 (258)
Number One Crossmember Mounting Bolts (113- to 122-inch BBC)	150–205 (204–277)
Number One Crossmember Mounting Bolts (101-inch BBC)	150–205 (204–277)
Number One Crossmember Gusset Mounting Bolts	150–205 (204–277)
Number Two Crossmember Mounting Bolts	75–105 (102–138)
Power Steering Pump Mounting Bolts	150–205 (204–277)
Rear Engine Mount Support Brackets	75–105 (102–138)
Shift Lever Housing Capscrews	35–45 (47–61)
Starter Motor Mounting Bolts	70–90 (95–120)
Tow Pintle Hook Mounting Bolts	220–300 (298–406)

* The bolt size is 3/4–10 x 2 inches.

Table 2, Torque Specifications, C10 and C12

Torque Specifications, 3126/C7	
Description	**Torque lbf·ft (N·m)**
A/C Compressor Suction Line	30–35 (41–47)
Engine Mounting Bolts	74–110 (100–149)
Engine Leg-to-Flywheel Housing Bolts*	100 (136)
Front Engine Mount Insulator Mounting Bolts	150–205 (204–277)

Specifications

Torque Specifications, 3126/C7	
Description	**Torque lbf·ft (N·m)**
Front Engine Support Bracket Mounting Bolts	75–105 (102–142)
Number One Crossmember Mounting Bolts (113- to 122-inch BBC)	150–205 (204–277)
Number One Crossmember Mounting Bolts (101-inch BBC)	150–205 (204–277)
Number One Crossmember Gusset Mounting Bolts	150–205 (204–277)
Number Two Crossmember Mounting Bolts	75–105 (102–138)
Power Steering Pump Mounting Bolts	150–205 (204–277)
Rear Engine Mount Support Brackets	75–105 (102–138)
Shift Lever Housing Capscrews	35–45 (47–61)
Starter Motor Mounting Bolts	40–70 (54–94)
Tow Pintle Hook Mounting Bolts	220–300 (298–406)

* The bolt size is M14 x 2 x 45 mm)

Table 3, Torque Specifications, 3126/C7

General Information

This section covers the removal and installation of the engine and transmission as a powertrain assembly. For diagnosis and testing, removal, installation and in-vehicle repair procedures for Detroit Diesel-supplied components, refer to the appropriate Detroit Diesel service manual.

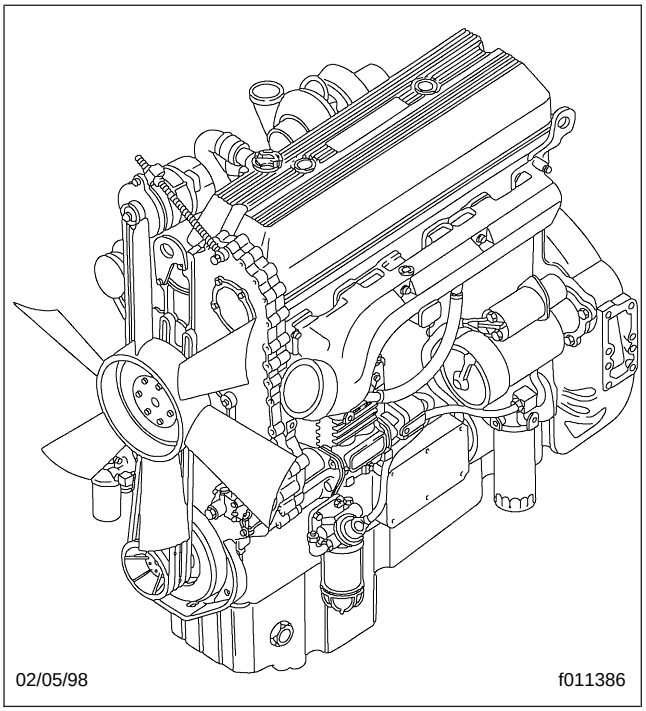


Fig. 1, Detroit Diesel 60 Series

The Detroit Diesel 60 Series engines are available in the L-Line and A-Line vehicles (see **Fig. 1**). The DDC 60 Series is available in either 11.1L or 12.7L displacement. They are 6-cylinder, in-line, turbocharged, electronically controlled diesel engines with charge air cooling.

All DDC 60 Series are equipped with an engine warning and shutdown system, cruise control and engine diagnostics capability. The cruise control is rendered inoperative if the vehicle is equipped with either an HT series automatic transmission or a pressure governor system.

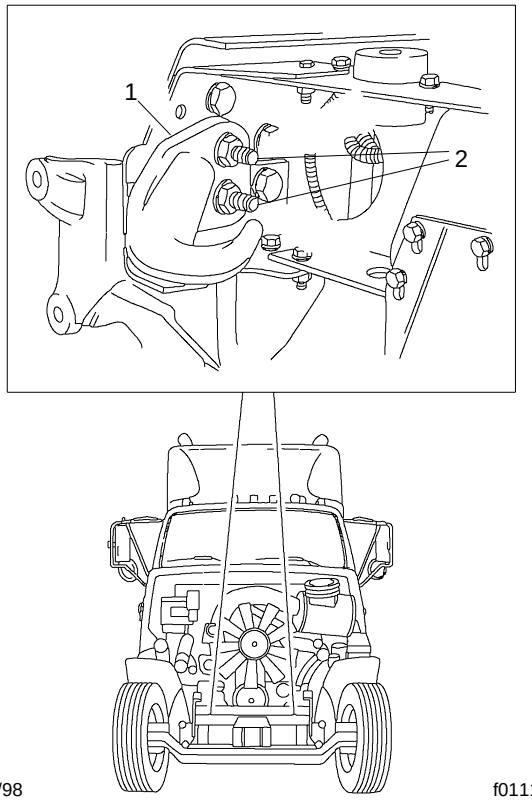
Removal

1. Prepare the vehicle for engine removal.
   - 1.1 Disconnect the battery ground cable(s).
   - 1.2 Remove the bumper. Refer to **Group 31**.
   - 1.3 Remove the hood. Refer to **Group 88**.
   - 1.4 Drain the engine cooling system. Refer to **Group 20**.
   - 1.5 Drain the engine oil.
   - 1.6 If the vehicle is equipped with an A/C system, recover the refrigerant. Refer to **Group 83**.
   - 1.7 If the vehicle is equipped with a transmission cooler or an automatic transmission, drain the transmission oil. Refer to the appropriate **Group 26** transmission section.
   - 1.8 Drain the air system.
   - 1.9 Remove the cooling module. Refer to **Group 20**.
   - 1.10 Remove the cooling fan. Refer to **Group 20**.
   - 1.11 Remove the air intake tube and air cleaner assembly as an assembly. Refer to **Group 09**.
   - 1.12 Remove the engine cover. Refer to **Group 60**.
2. If the vehicle is equipped with front pintle hooks, remove six bolts, 10 washers, four nuts and two pintle hooks. See **Fig. 1** .

NOTE: The brake valves shown are for a 2-channel ABS system. All other configurations are similar.

3. Isolate the brake valves on the No. 1 crossmember. See **Fig. 2** .
   - Remove the retaining clamp bolts.
   - Disconnect the electrical connector.
   - Label and disconnect the four air lines.

NOTE: The steering gear is shown, the rotary assist cylinder is similar.



1. Pintle Hook
2. Bolt

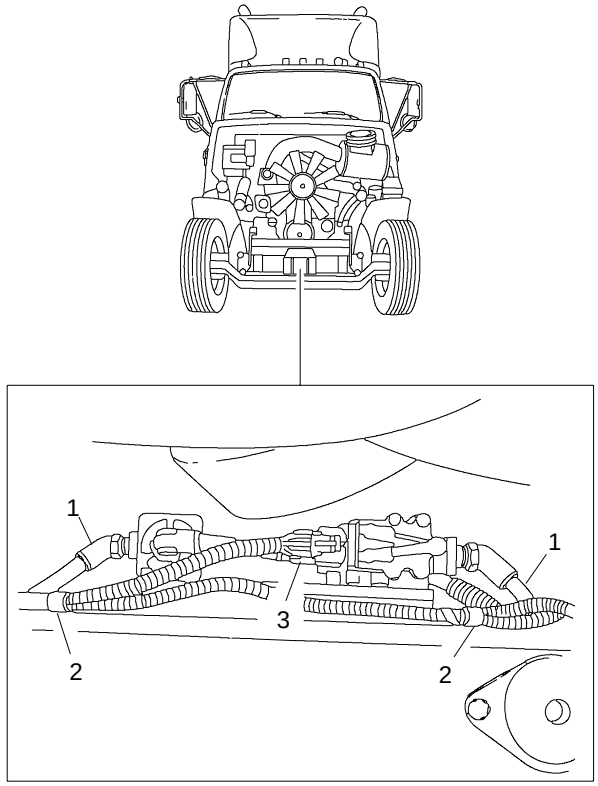
Fig. 1, Pintle Hook

4. If the vehicle is equipped with dual steering gears, disconnect the power steering lines from the steering gear and the rotary assist cylinder. Remove the power steering lines. See **Fig. 3** .

NOTE: If the vehicle has a 101-inch BBC chassis, perform the next two steps.

5. Remove the eight bolts, 16 washers, eight nuts and the No. 1 crossmember. See **Fig. 4** .
6. Remove the four nuts, eight washers, four bolts and the top two No. 1 crossmember gussets. See **Fig. 5** .
7. If the vehicle has a 113- to 122-inch BBC chassis, remove the four bolts, eight washers, four nuts, two bumper brackets and the No. 1 crossmember. See **Fig. 6** .
8. Disconnect the refrigerant line. Plug and cap the open lines and fittings. See **Fig. 7** .

Engine Removal and Installation



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1. Air Line
2. Retaining Clamp
3. Electrical Connector

Fig. 2, Brake Valves

9. Remove the turbocharger outlet tube. See **Fig. 8** .

10. Remove the lower radiator tube. See **Fig. 9** .

11. Disconnect the heater water hoses. See **Fig. 10** .

NOTE: On 101-inch BBC vehicles, it may be necessary to access the auxiliary heater water hose and clamps from inside the vehicle.

12. If the vehicle is equipped with a sleeper, disconnect the auxiliary heater water hoses. Remove the clamp(s).

NOTE: On 101-inch BBC vehicles, it may be necessary to access the block heater electrical connector and clamp from inside the vehicle.

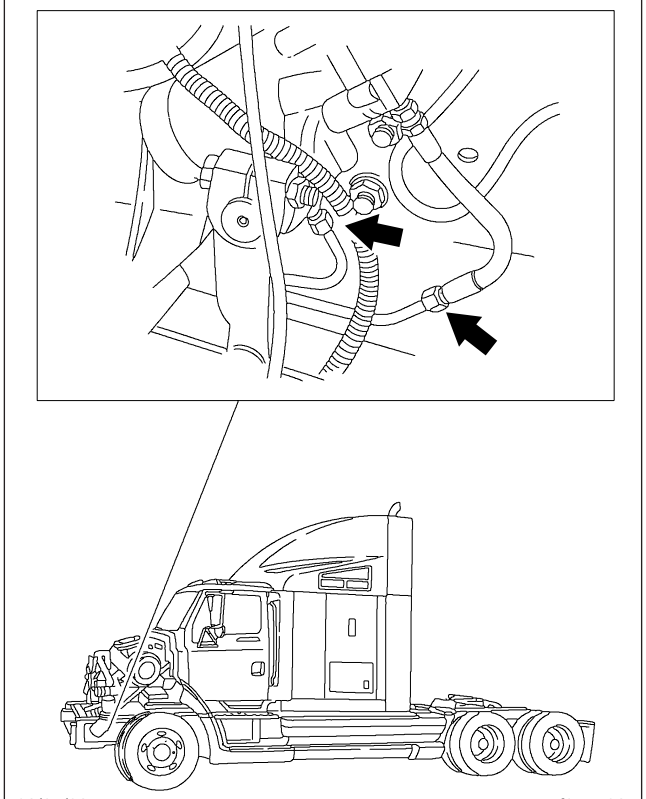

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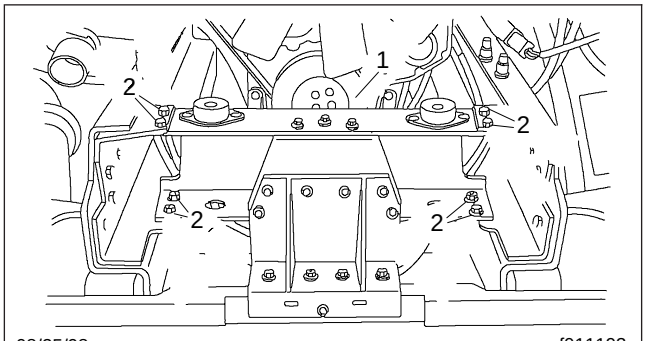
Fig. 3, Power Steering Lines



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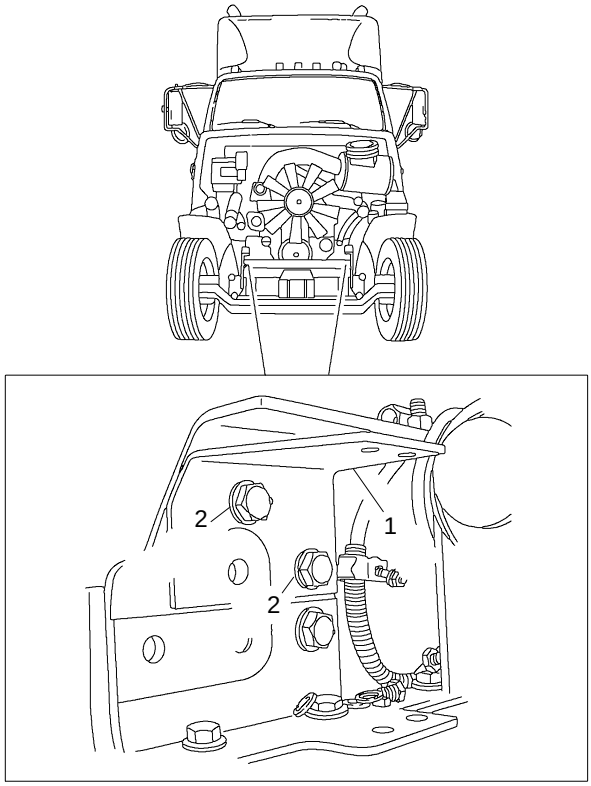
1. No. 1 Crossmember
2. Bolt (8 qty.)

Fig. 4, No. 1 Crossmember

13. If the vehicle is equipped with a block heater, disconnect the block heater electrical connector. Remove the clamp. See **Fig. 11** .



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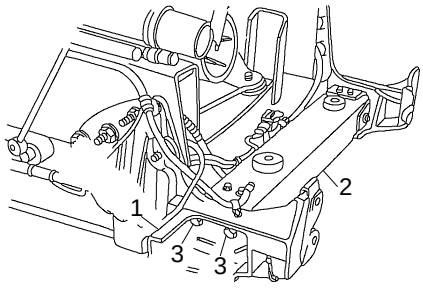
1. No. 1 Crossmember Gusset
2. Bolt

Fig. 5, No. 1 Crossmember Gusset



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1. Bumper Bracket
2. No. 1 Crossmember
3. Bolt (4 qty.)

Fig. 6, Bumper Bracket

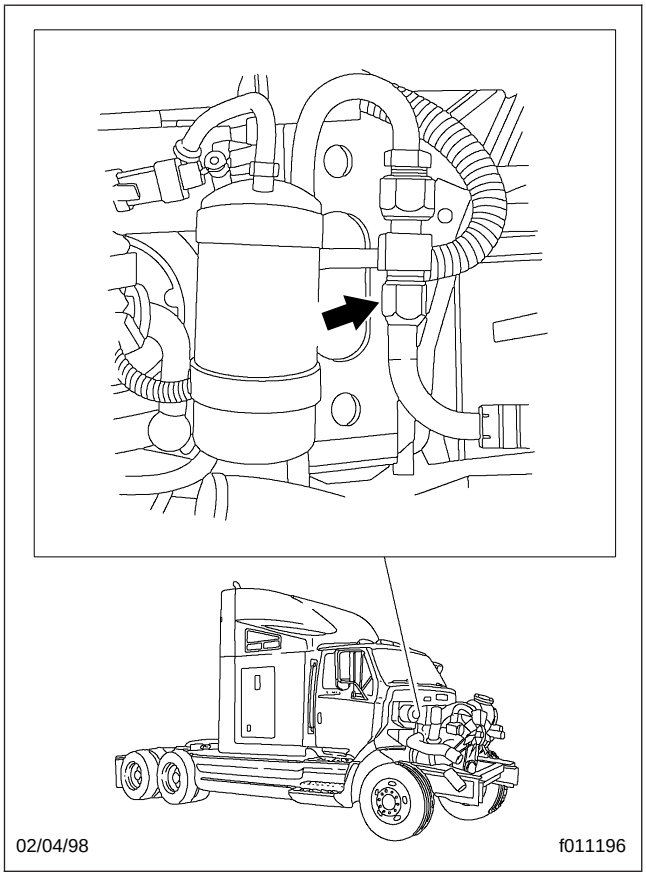

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Fig. 7, Refrigerant Line

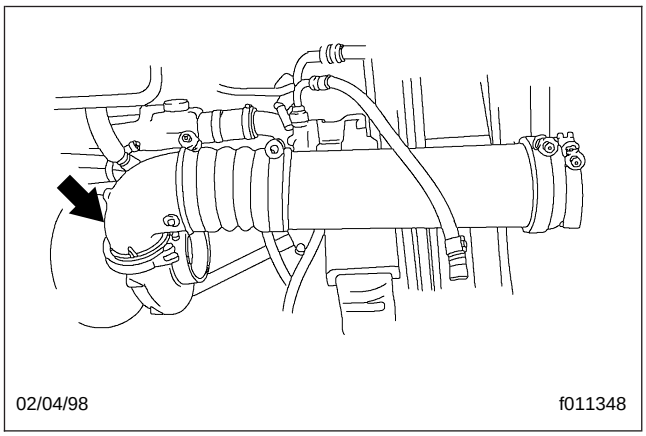

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Fig. 8, Turbocharger Outlet Tube

NOTE: On 101-inch BBC vehicles, it may be necessary to access the exhaust outlet tube from inside the vehicle.

Engine Removal and Installation

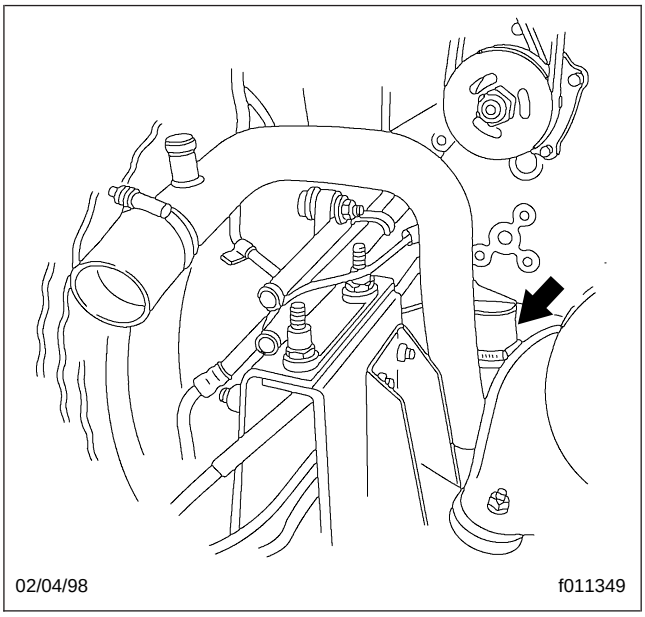


Fig. 9, Lower Radiator Tube

14. Disconnect the exhaust outlet tube and pyrometer. See **Fig. 12** .
15. Remove the upper radiator tube and the charge air cooler outlet tube. See **Fig. 13** .
16. If the vehicle is equipped with an air-actuated cooling fan clutch, disconnect the cooling fan clutch air line. Remove the retaining clamp bolts. Position the fan clutch air line aside. See **Fig. 14** .
17. Disconnect the power steering high- and low-pressure lines. Position them aside. See **Fig. 15** .
18. Remove the six screws and the left-side splash shield. See **Fig. 16** .
19. Disconnect the clutch cable or linkage and position it aside. See **Fig. 17** .
20. Disconnect the compressor air lines. See **Fig. 18** .
21. Disconnect the engine oil pressure (EOP) gauge line. See **Fig. 19** .
22. Disconnect the two electrical connectors. See **Fig. 20** .
    - 22.1 Remove the bolt and nut.
    - 22.2 Position the brace aside.

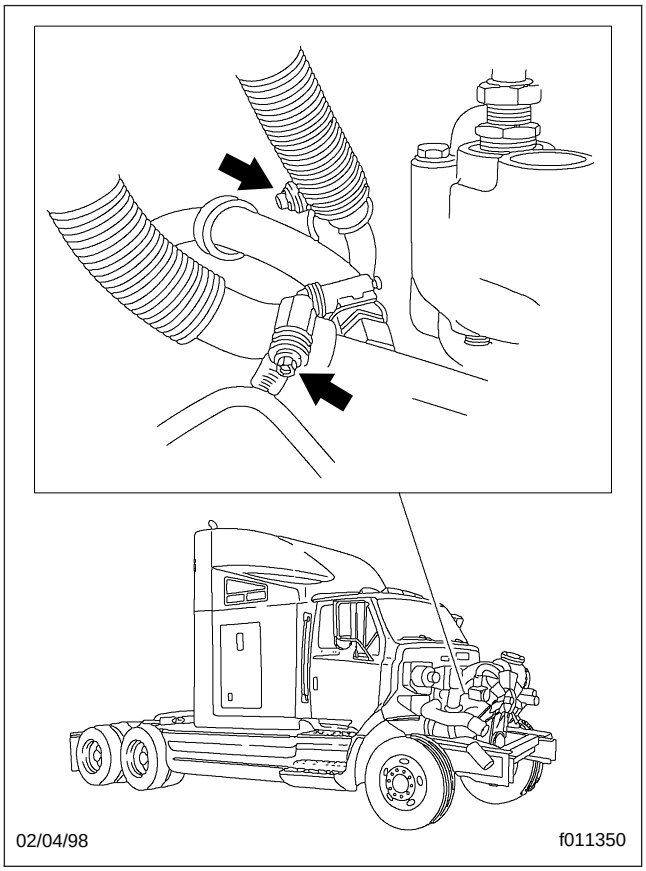


Fig. 10, Heater Water Hoses

    - 22.3 Disconnect the bulkhead connector and position aside.
    - 22.4 Disconnect the electrical connector and position aside.
23. Disconnect the starter relay electrical leads and position aside. See **Fig. 21** .
    - 23.1 Remove the protective caps.
    - 23.2 Label and disconnect the starter relay electrical leads.
24. Disconnect the ground strap and position aside. Remove the clamp. See **Fig. 22** .
25. Remove the megafuse cover. See **Fig. 23** .
26. Disconnect the megafuse electrical lead. See **Fig. 24** .
27. Disconnect the three in-line electrical connectors. Remove the retaining clamp bolt. See **Fig. 25** .

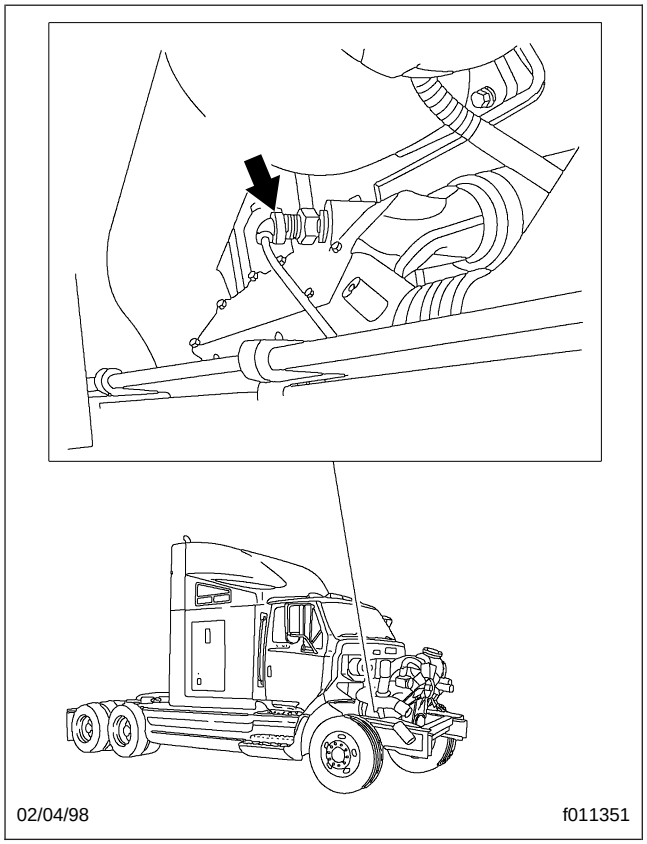


Fig. 11, Block Heater Electrical Connector

If the vehicle is equipped with a sleeper then perform the next two steps.

28. Remove the megafuse cover. See **Fig. 26** .
29. Disconnect the megafuse electrical lead. See **Fig. 27** .
30. Disconnect the starter motor and starter solenoid electrical leads. See **Fig. 28** .

NOTE: If the vehicle is equipped with a manual transmission, perform the next four steps.

31. Remove the gearshift assembly. Remove the screws and separate the shift lever boot from the floor; refer to **Group 60** to remove the interior trim as required. Remove the transmission floor cover plate if additional access space is required.
32. Disconnect the vehicle air and the Roadranger® air system at the transmission; refer to **Group 26**.

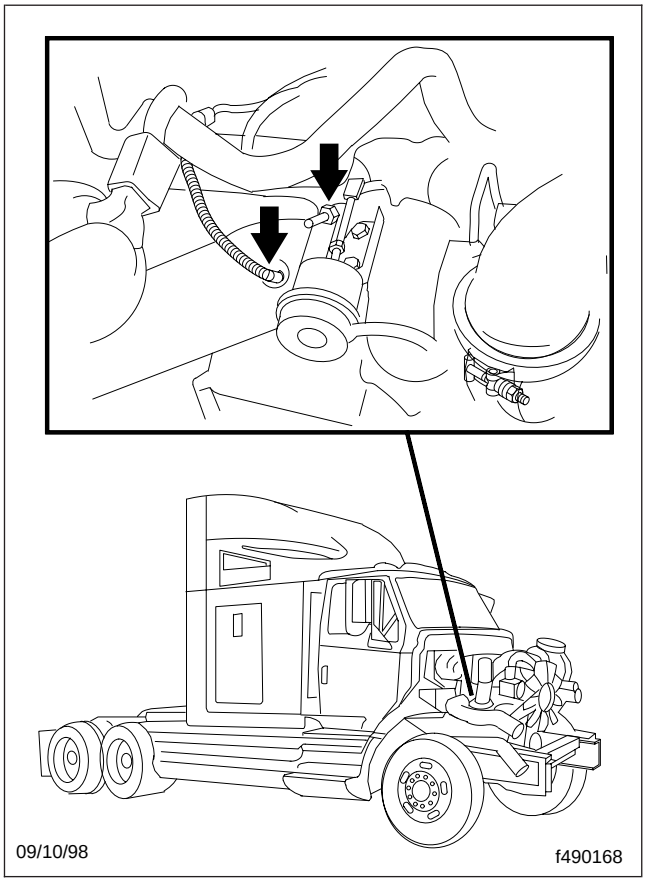
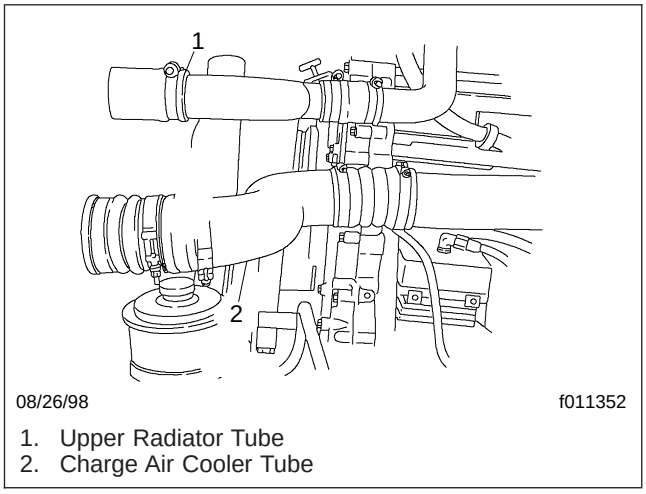


Fig. 12, Exhaust Outlet Tube

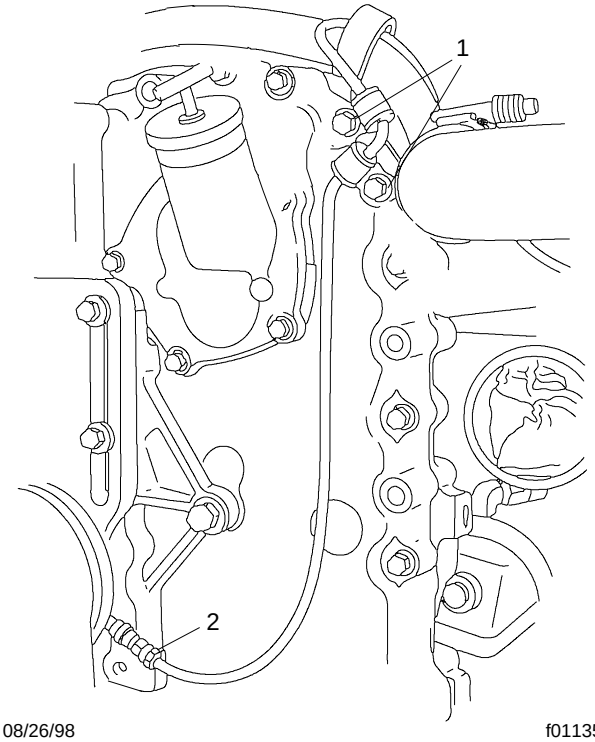


1. Upper Radiator Tube
2. Charge Air Cooler Tube

Fig. 13, Upper Radiator Tube and Charge Air Cooler Tube

33. Remove the shift lever assembly. See **Fig. 29** .

Engine Removal and Installation



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1. Retaining Clamps
2. Cooling Fan Clutch Air Line

Fig. 14, Cooling Fan Clutch Air Line

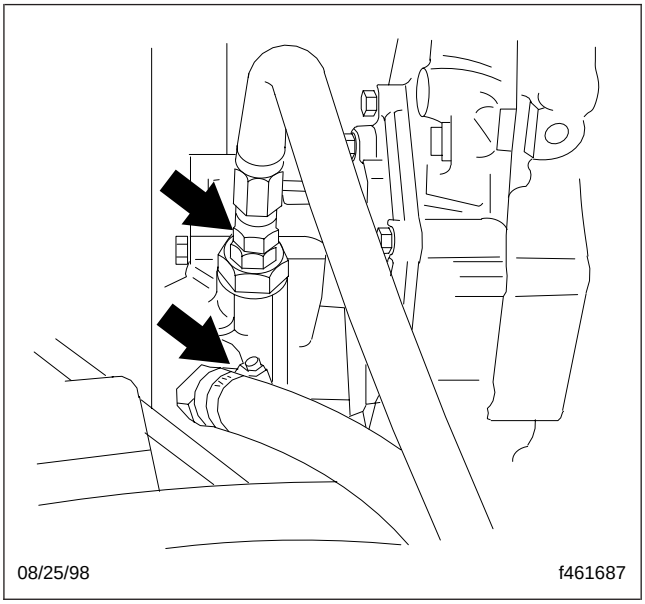

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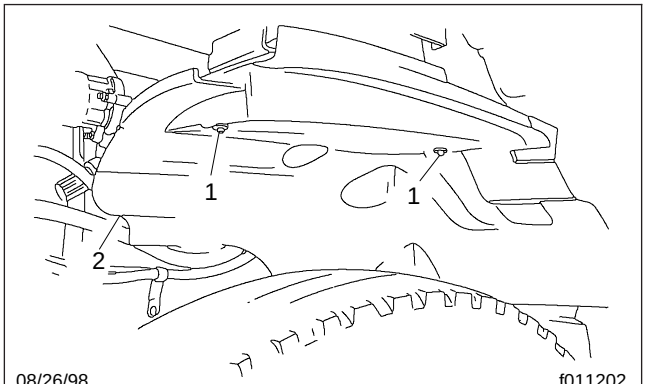
Fig. 15, Power Steering Lines



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1. Screws (6 qty.)
2. Splash Shield

Fig. 16, Splash Shield

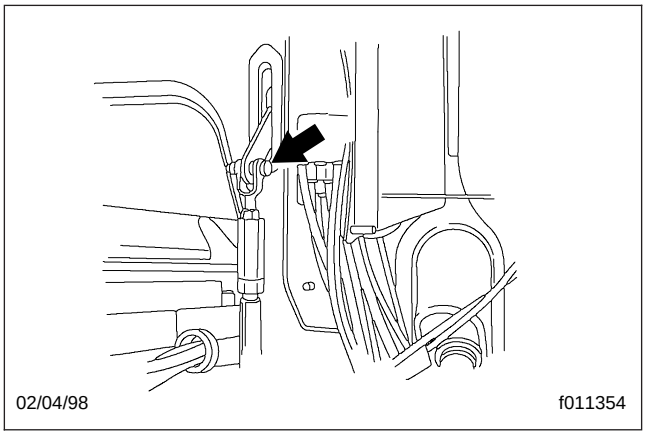

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Fig. 17, Clutch Cable or Linkage

33.1 Remove the capscrews.

33.2 Position the shift lever assembly aside. Cover the hole in the shift control housing to prevent contamination.

34. If the vehicle is equipped with a clutch linkage, remove the clutch linkage. See **Fig. 30** .

35. If the vehicle is equipped with an AT, HT, or MT Series automatic transmission, disconnect the selector cable. See **Fig. 31**.

NOTE: If the vehicle is equipped with an HD or MD Series automatic transmission, perform the next three steps.

36. Remove the interior trim and floor mat; refer to **Group 60**.

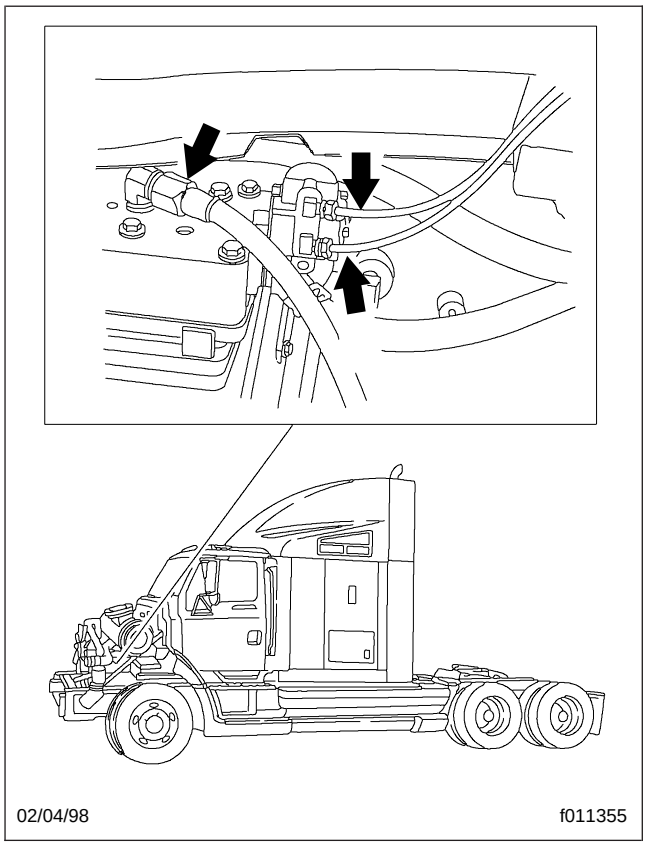


Fig. 18, Air Compressor Lines

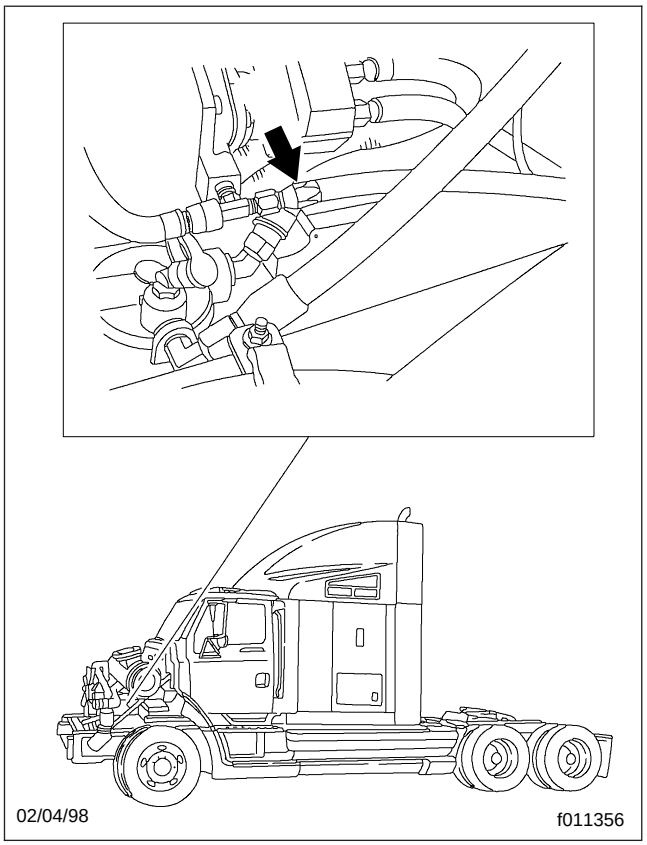


Fig. 19, Oil Pressure Gauge Line

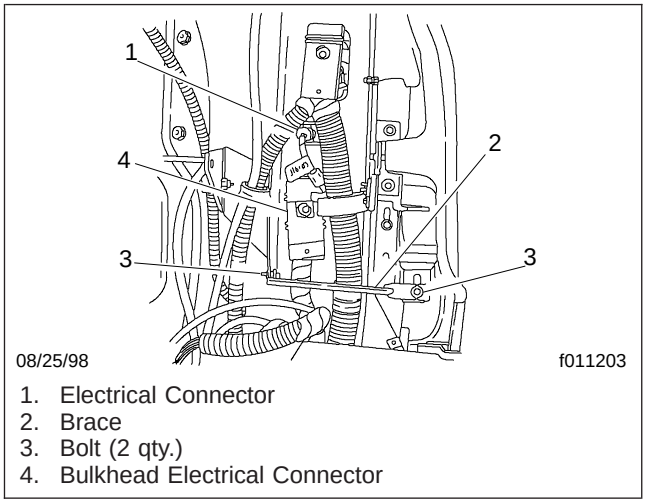
37. Remove the screws and the transmission floor cover plate.
38. Disconnect the electrical connectors. See **Fig. 32** .

NOTE: The HD-5460 automatic transmission is shown, all others are similar.

39. If the vehicle is equipped with a transmission oil cooler, disconnect the transmission oil cooler lines. See **Fig. 33** .
    - Remove all retaining clamps.
    - Disconnect the transmission oil cooler lines.

NOTE: If the vehicle is equipped with a single fuel tank, perform the next two steps.

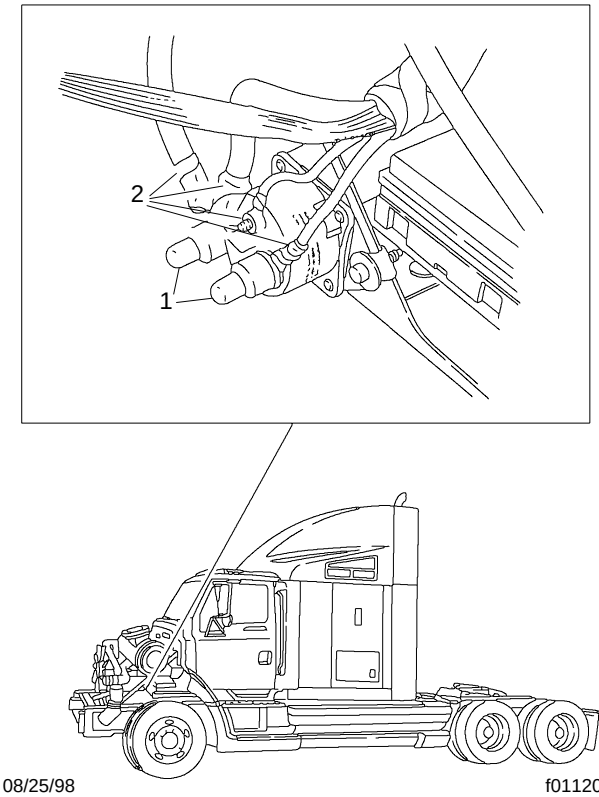
40. Disconnect the fuel supply line. See **Fig. 34** .
41. Disconnect the fuel return line. See **Fig. 35** .



1. Electrical Connector
2. Brace
3. Bolt (2 qty.)
4. Bulkhead Electrical Connector

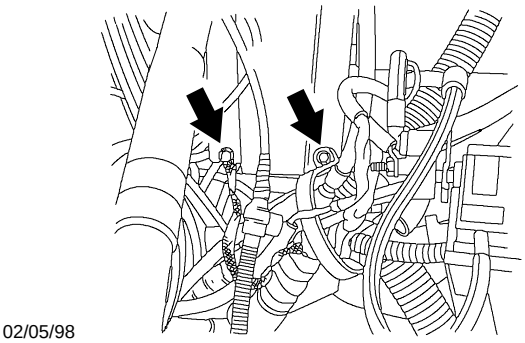
Fig. 20, Electrical Connectors

Engine Removal and Installation



1. Protective Caps
2. Starter Relay Electrical Leads

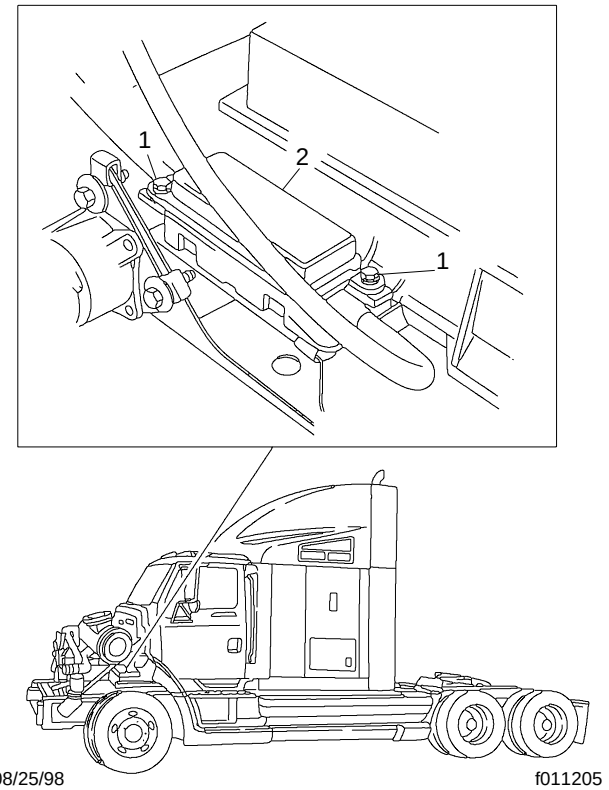
Fig. 21, Starter Relay Electrical Leads



1. Ground Strap
2. Clamp

Fig. 22, Ground Strap and Clamp

42. If the vehicle is equipped with dual fuel tanks, disconnect the fuel supply and return lines. See **Fig. 36** .



1. Cover Retaining Bolts
2. Cover

Fig. 23, Megafuse Cover

43. Remove the exhaust outlet tube.
44. Disconnect the ground strap. See **Fig. 37** .
45. Disconnect the battery cable clamp(s) from the transmission. See **Fig. 38** .
46. Disconnect the driveshaft.

NOTE: The left-side rear support bracket is shown. The right-side is similar.

47. Remove four bolts, eight washers, four nuts and two rear support brackets. See **Fig. 39** .
48. Support the powertrain assembly.
    - Install the engine lifting equipment.
    - Use a suitable lifting chain connected to the two lifting eyes and a lifting crane rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.

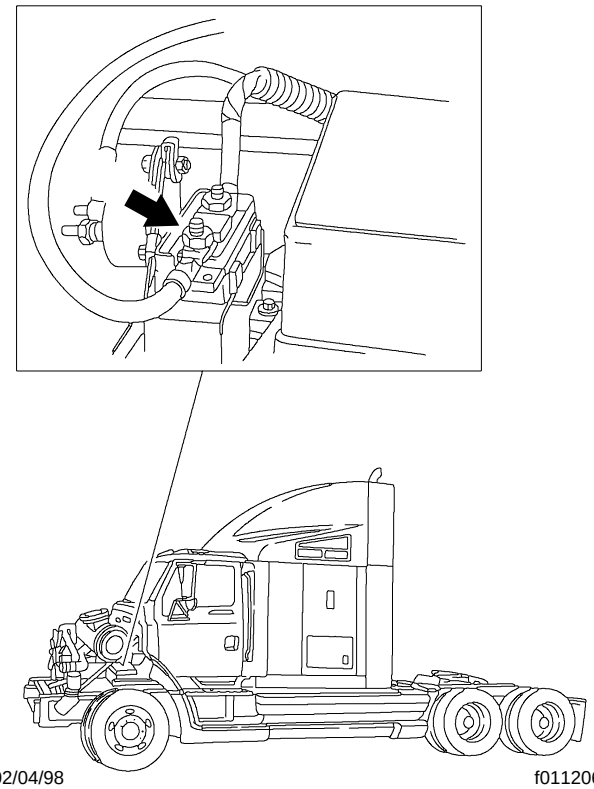


Fig. 24, Megafuse Electrical Lead

- Position a suitable transmission jack under the transmission.
- Secure the transmission to the jack.

NOTE: The left rear engine mount is shown. The right-side is similar.

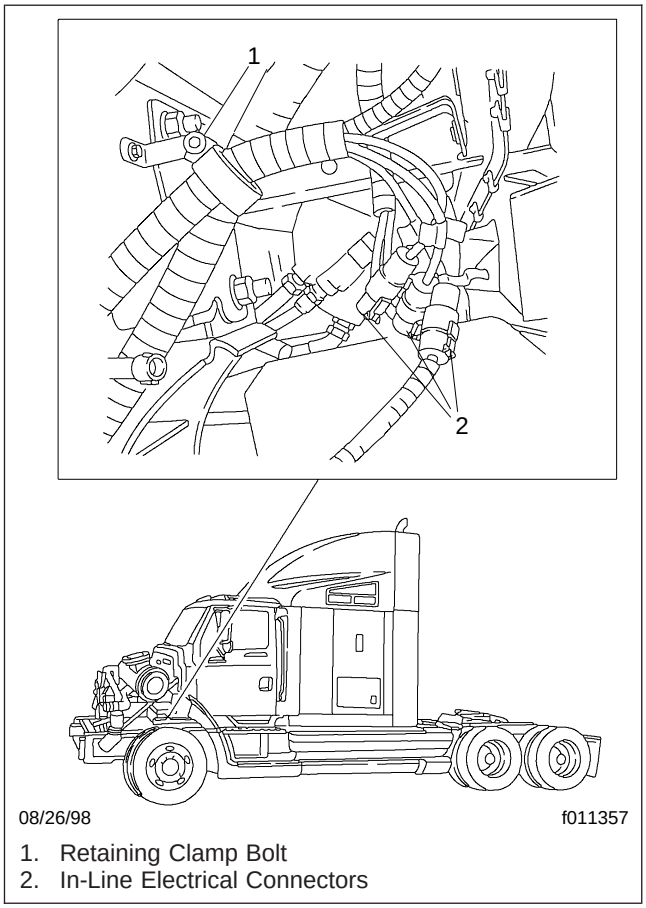
49. Remove the 10 bolts, washers, and two rear engine mounts. See **Fig. 40** .

    Raise the transmission to lift the two rear engine mounts off of the insulators.

NOTE: The compression-type front engine mount is shown. The focal-type front engine mount is similar.

50. If the vehicle has a 101-inch BBC chassis, remove the bolts and flag nuts. See **Fig. 41** .

51. Remove the eight bolts, 16 washers, eight nuts and the No. 2 crossmember. See **Fig. 42** .



1. Retaining Clamp Bolt
2. In-Line Electrical Connectors

Fig. 25, In-Line Electrical Connectors

52. Remove the powertrain assembly from the chassis.

    52.1 Move the powertrain assembly forward until the transmission jack reaches the front axle.

    52.2 Lower the engine. Support the front engine mount. Use two suitable jack stands rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer and a suitable length of wood with a minimum 4-inch x 6-inch dimension.

    52.3 Remove the lifting chain. Install a load leveling engine sling. Use a suitable load leveling engine sling rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.

    52.4 Raise the engine.

Engine Removal and Installation

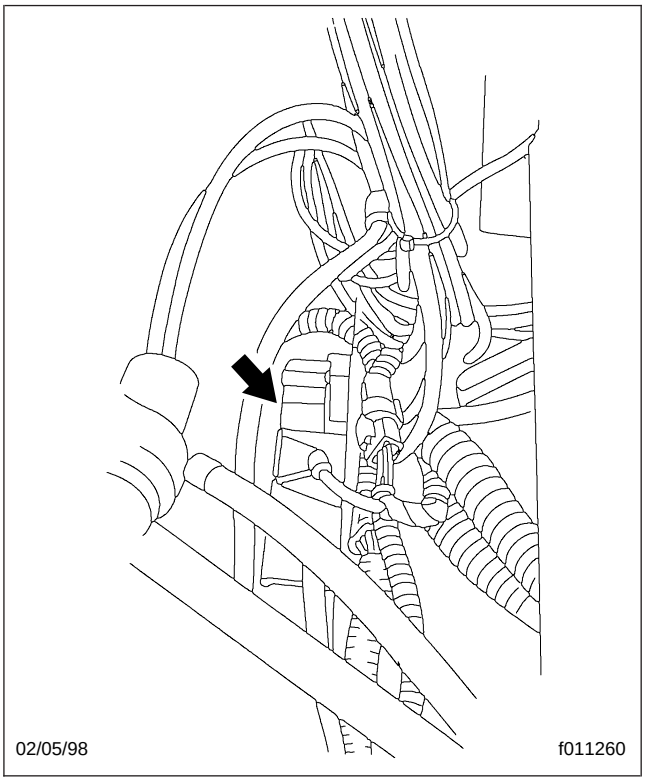


Fig. 26, Megafuse Cover

52.5 Remove the strap from the transmission.

52.6 Level the powertrain assembly.

52.7 Remove the transmission jack.

52.8 Move the powertrain assembly out of the vehicle.

53. Support the powertrain assembly. See **Fig. 43** .
    - Use suitable jack stands rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.
    - Use a suitable transmission jack.

Installation

1. Raise the powertrain assembly. Remove the jack stands and the transmission jack. Use a suitable load leveling sling and lifting crane rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer.

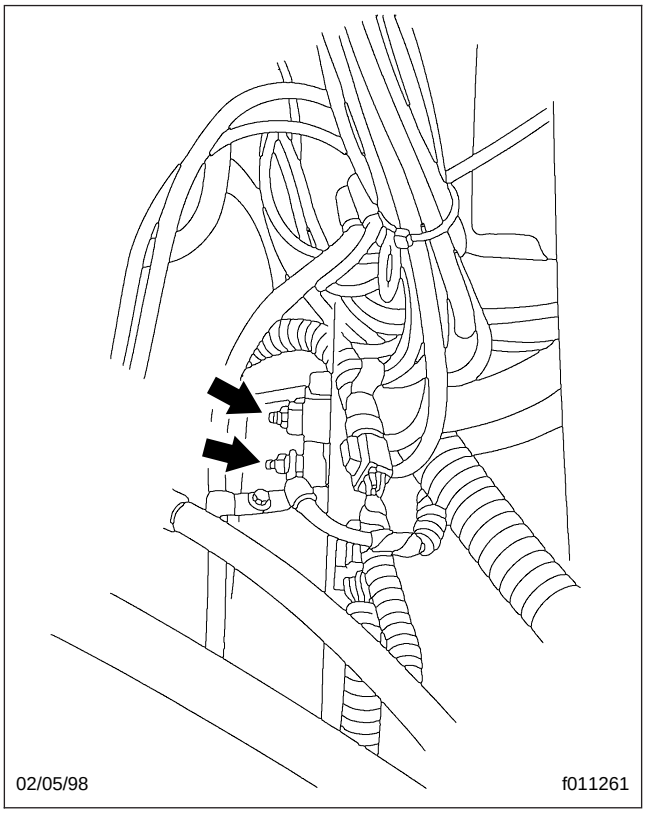


Fig. 27, Megafuse Electrical Lead

NOTE: The left rear engine mount is shown. The right-side is similar.

2. Remove 10 bolts, washers and the two rear engine mounts. See **Fig. 44** .

IMPORTANT: Use care not to damage any engine components, lines, filters and electrical wiring during installation of the powertrain assembly.

3. Move the powertrain assembly into the vehicle until the transmission is behind the front axle.

4. Support the powertrain assembly.

   4.1 Install a suitable transmission jack under the transmission. Secure the transmission to the jack.

   4.2 Lower the engine. Support the front engine mount. Use two suitable jack stands rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer and a suit-

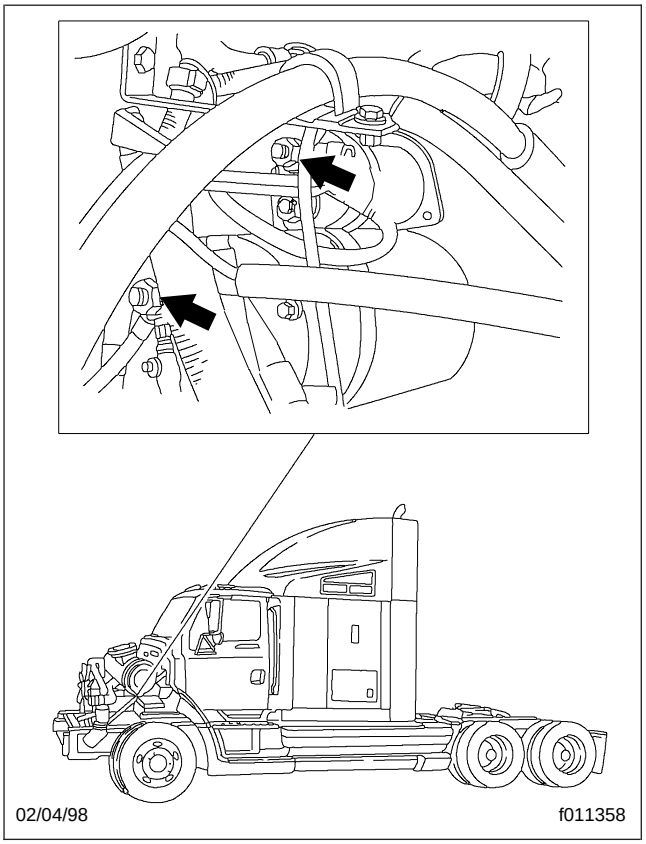
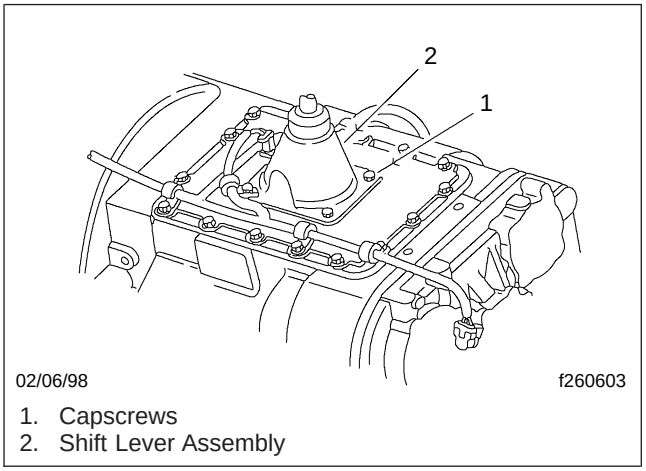


Fig. 28, Starter Motor and Solenoid Electrical Leads



1. Capscrews
2. Shift Lever Assembly

Fig. 29, Shift Lever Assembly

able length of wood with a minimum 4-inch (10 mm) x 6-inch (15 mm) dimension.

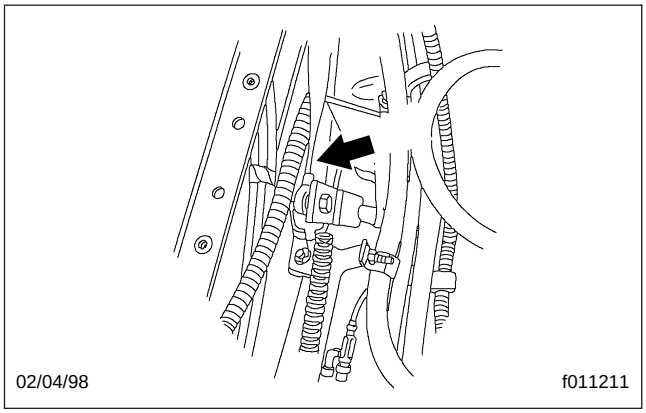


Fig. 30, Clutch Linkage

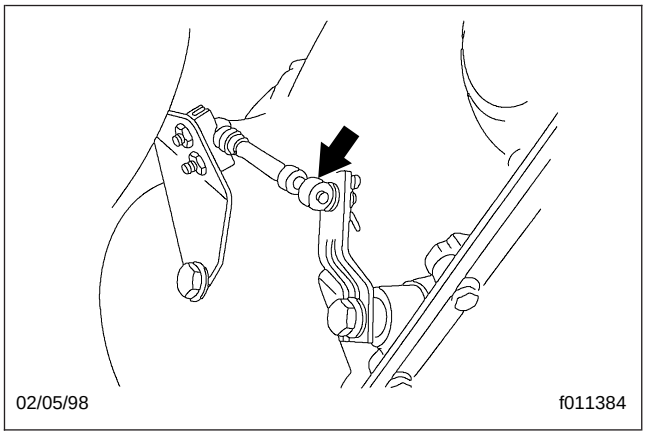


Fig. 31, Selector Control Cable

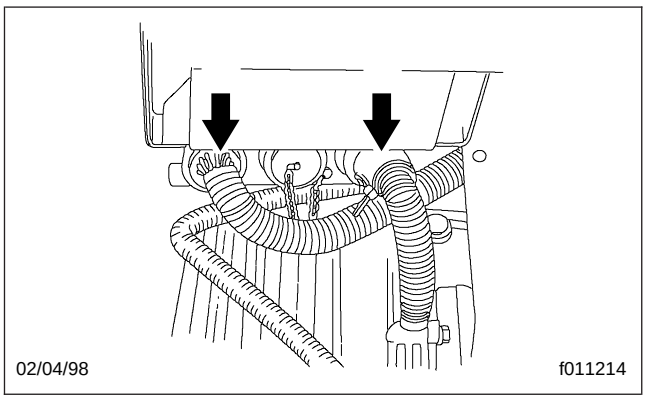


Fig. 32, Electrical Connectors

5. Remove the load leveling sling. Install a lifting chain. Use a suitable lifting chain rated at a minimum 6,000-lb (2722 kg) capacity by the manufacturer, and connect to the front lifting eye.

Engine Removal and Installation

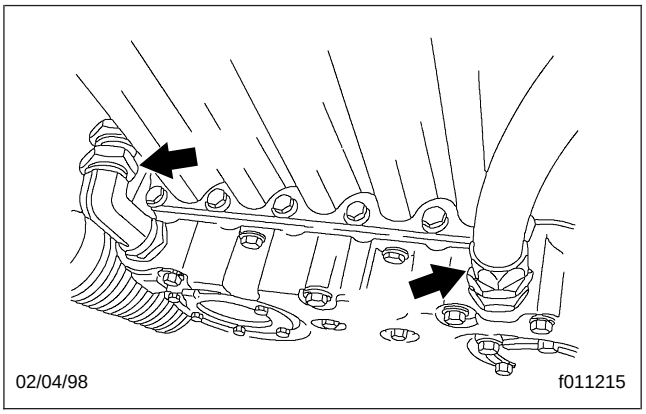


Fig. 33, Transmission Cooler Lines

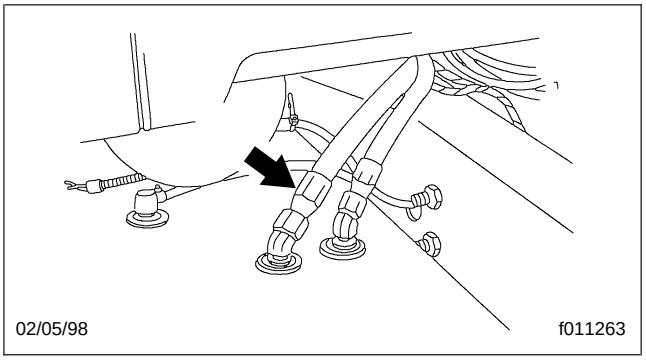


Fig. 34, Fuel Supply Line, Single Fuel Tank

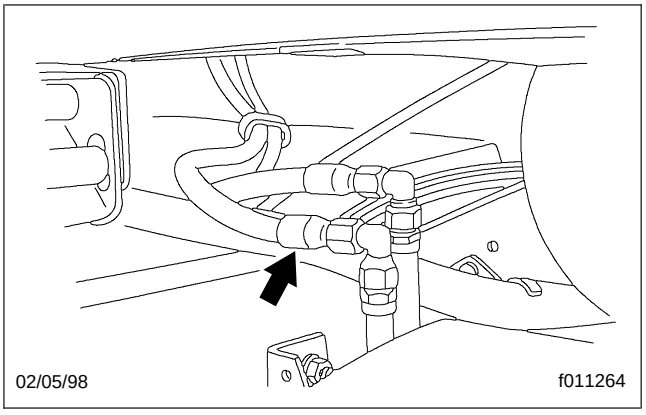


Fig. 35, Fuel Return Line, Single Fuel Tank

6. Move the powertrain assembly back to the rear engine mount insulators.
7. Install the No. 2 crossmember, eight bolts, 16 washers and eight nuts. Tighten bolts 75 to 105 lbf·ft (102 to 138 N·m). See **Fig. 42** . A suitable porta-power unit may be necessary to spread the frame side rails if the frame has settled.

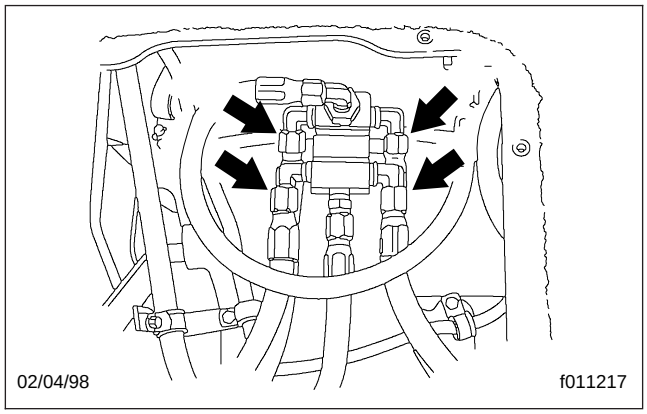


Fig. 36, Fuel Lines, Dual Fuel Tanks

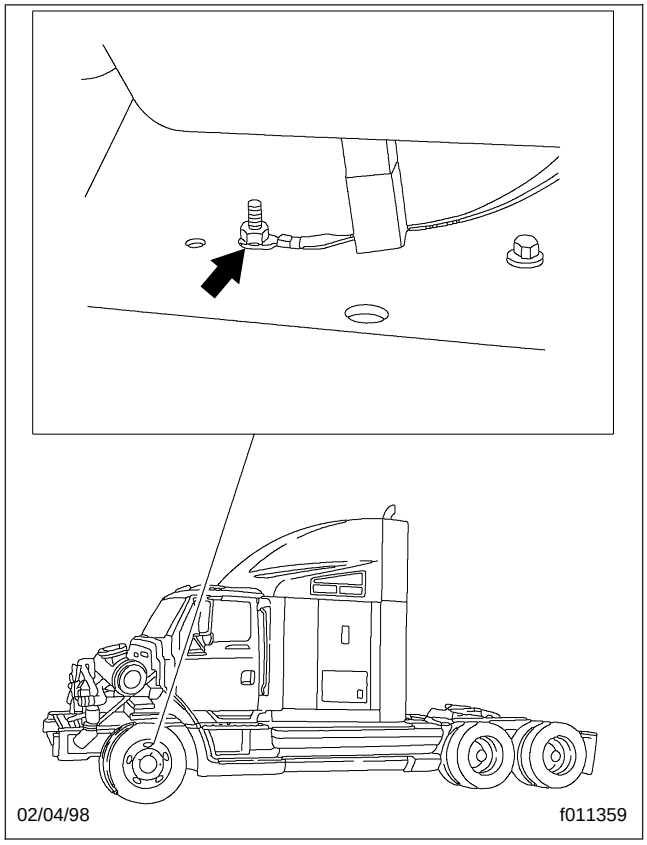


Fig. 37, Ground Strap

NOTE: The compression-type front engine mount is shown. The focal-type front engine mount is similar.

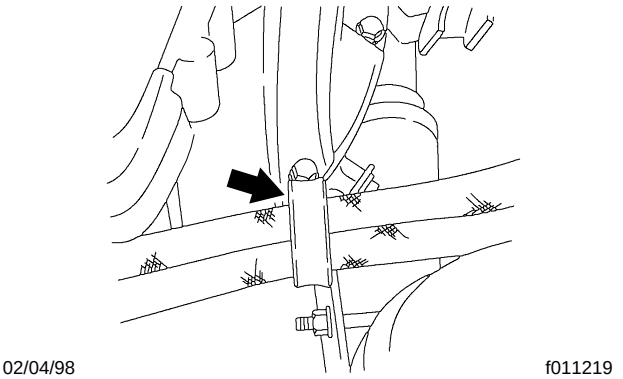


Fig. 38, Battery Cable Retaining Clamp(s)

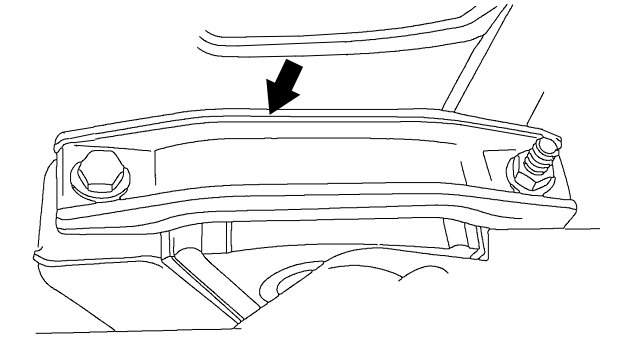
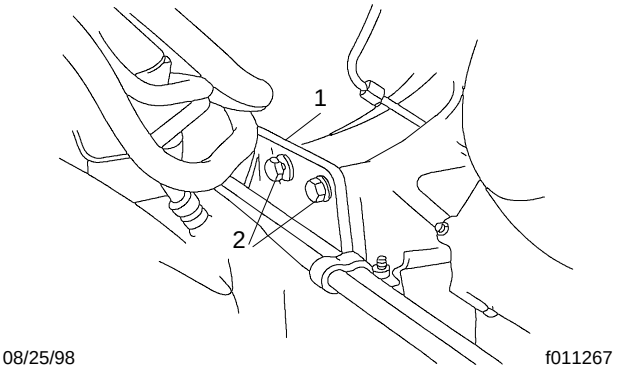


Fig. 39, Rear Support Bracket



1. Engine Mount
2. Bolts

Fig. 40, Rear Engine Mount

Fig. 41, Flag Bolt and Nut Assembly

1. Bolts (8 qty.)
2. No. 2 Crossmember

Fig. 42, No. 2 Crossmember

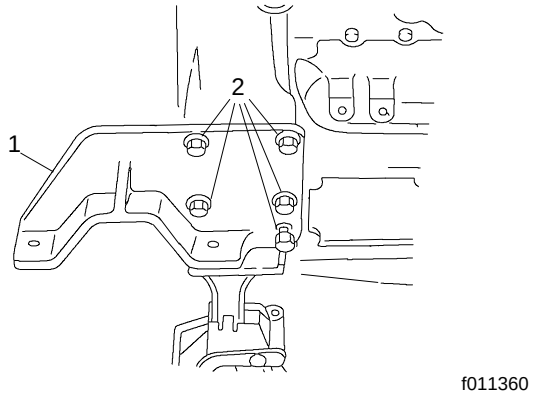
1. Jack Stand
2. Floor Jack

Fig. 43, Supporting the Powertrain Assembly

8. If the vehicle has a 101-inch BBC chassis, install the bolts and flag nuts. Tighten bolts 150 to 205 lbf·ft (204 to 277 N·m). See **Fig. 41**.

NOTE: The left rear engine mount is shown. The right-side is similar.

Engine Removal and Installation



1. Engine Mount
2. Bolts

Fig. 44, Rear Engine Mount

9. Install the two engine support brackets, 10 washers and bolts. Tighten bolts 150 to 205 lbf·ft (203 to 278 N·m). See **Fig. 40** .
10. Remove the transmission jack and the engine lifting equipment.

NOTE: The left-side rear support bracket is shown. The right-side is similar.

11. Install the two rear support brackets, four bolts, eight washers and four nuts. See **Fig. 39** .
12. Connect the driveshaft.
13. Install the battery cable clamp(s) on the transmission. See **Fig. 38** .
14. Connect the ground strap. See **Fig. 37** .

NOTE: On 101-inch BBC vehicles, it may be necessary to access the exhaust outlet tube from inside the vehicle.

15. Install the exhaust outlet tube and pyrometer. See **Fig. 12** .

NOTE: If the vehicle is equipped with a single fuel tank, perform the next two steps.

16. Connect the fuel return line. See **Fig. 35** . Install the retaining clamp(s) as noted during removal.
17. Connect the fuel supply line. See **Fig. 34** . Install the retaining clamp(s) as noted during removal.
18. If the vehicle is equipped with dual fuel tanks, connect the fuel supply and return lines. See **Fig. 36** .

NOTE: The HD-5460 automatic transmission is shown. All others are similar.

19. If the vehicle is equipped with a transmission oil cooler, connect the transmission oil cooler lines. See **Fig. 33** .
    - Connect the transmission oil cooler lines.
    - Install the retaining clamps.

NOTE: If the vehicle is equipped with an HD or MD Series automatic transmission, perform the next three steps.

20. Connect the electrical connectors. See **Fig. 32** .
21. Install the transmission floor cover plate and the screws.
22. Install the floor mat and interior trim. Refer to **Group 60**.
23. If the vehicle is equipped with an AT, HT or MT Series automatic transmission, connect the selector cable. See **Fig. 31** .

NOTE: If the vehicle is equipped with a manual transmission, perform the next seven steps.

24. If the vehicle is equipped with a clutch linkage, install the clutch linkage. See **Fig. 30** .
25. Align the shift block and yoke notches in the neutral position. See **Fig. 45** .

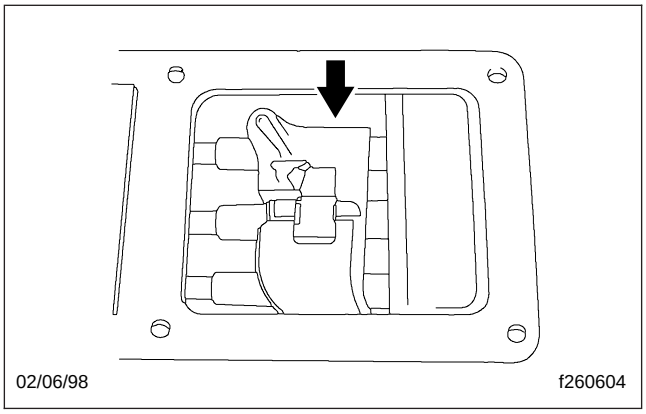


Fig. 45, Aligning the Shift Block and Yoke

26. Position the gasket on the shift control housing.

27. Position the shift lever housing. See **Fig. 46** . Fit the shift lever into the shift block and yoke notches.

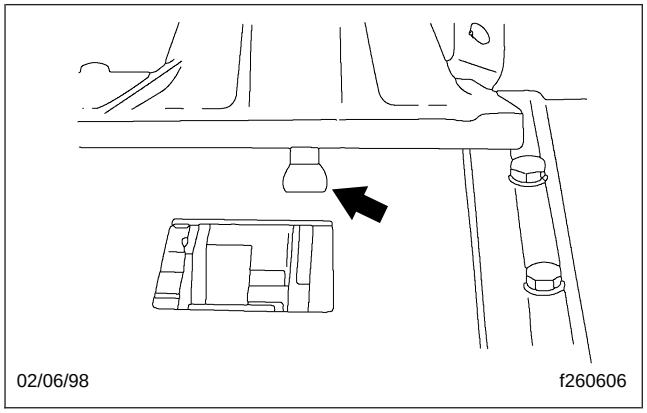


Fig. 46, Positioning the Shift Lever

28. Install the capscrews. See **Fig. 29** . Use Threadlock® and Sealer or equivalent meeting specification WSK–M2G315–A5 on the threads.
29. Connect the vehicle air and the Roadranger® air system to the transmission. Refer to **Group 26**.
30. Install the shift lever boot. If removed, install the transmission floor cover plate and interior trim.
31. Connect the starter solenoid and starter motor electrical leads. See **Fig. 28** . Apply Silicone Dielectric Compound or equivalent meeting specification ESE–M1C171–A to all of the starter motor electrical connections.

NOTE: If the vehicle is equipped with a sleeper, perform the next two steps.

32. Connect the megafuse electrical lead. See **Fig. 27** .
33. Install the megafuse cover. See **Fig. 26**.
34. Connect the three in-line electrical connectors. Install the retaining clamp bolt. See **Fig. 25** .
35. Connect the megafuse electrical lead. See **Fig. 24** .
36. Install the megafuse cover. See **Fig. 23** .
37. Install the clamp. Connect the ground strap. See **Fig. 22** .
38. Connect the starter relay electrical leads. See **Fig. 21** .
    - 38.1 Connect the starter relay electrical leads to the terminals noted during removal.
    - 38.2 Install the protective caps.
39. Connect the electrical connectors. See **Fig. 25** .
    - 39.1 Connect the electrical connector.
    - 39.2 Connect the bulkhead electrical connector.
    - 39.3 Position the brace.
    - 39.4 Tighten the nut and bolt.
    - 39.5 Install the nut and bolt.
40. Connect the engine oil pressure (EOP) gauge line. See **Fig. 19** .
41. Connect the air compressor lines. See **Fig. 18** .
42. Connect the clutch cable or linkage. See **Fig. 17** .
43. Install the left-side splash shield and six screws. See **Fig. 16** .
44. Connect the power steering low- and high-pressure lines. See **Fig. 15** .
45. If the vehicle is equipped with an air-actuated cooling fan clutch, connect the fan clutch air line. Install the retaining clamp bolts. See **Fig. 14** .
46. Install the charge air cooler outlet tube and the upper radiator tube. See **Fig. 13** .

NOTE: On 101-inch BBC vehicles, it may be necessary to access the block heater electrical connector and clamp from inside the vehicle.

47. Connect the block heater electrical connector. Install the clamp. See **Fig. 11** .

NOTE: On 101-inch BBC vehicles, it may be necessary to access the auxiliary heater water hose and clamps from inside the vehicle.

48. If the vehicle is equipped with a sleeper, connect the auxiliary heater water hoses. Install the clamp(s).
49. Connect the heater water hoses. See **Fig. 10** .
50. Install the lower radiator tube. See **Fig. 9** .
51. Install the turbocharger outlet tube. See **Fig. 8** .
52. Connect the refrigerant line. See **Fig. 7** . Install a new green O-ring lubricated with Heavy Truck

Engine Removal and Installation

PAG Oil or equivalent meeting specification EST–M1C231–B2.

53. If the vehicle has a 113- to 122-inch BBC chassis, install the No. 1 crossmember, two bumper brackets, four bolts, eight washers and four nuts. Tighten 150 to 205 lbf·ft (204 to 277 N·m). See **Fig. 6** .

NOTE: If the vehicle has a 101-inch BBC chassis, perform the next two steps.

54. Install the top two No. 1 crossmember gussets, four bolts, eight washers and four nuts. Tighten 150 to 205 lbf·ft (204 to 277 N·m). See **Fig. 5** .

55. Install the No. 1 crossmember and eight bolts, 16 washers and eight nuts. Tighten 150 to 205 lbf·ft (204 to 277 N·m). See **Fig. 4** .

NOTE: The steering gear is shown. The rotary assist cylinder is similar.

56. If the vehicle is equipped with dual steering gears, route the power steering lines. Connect the power steering lines to the steering gear and rotary assist cylinder. See **Fig. 3** .

NOTE: The brake valves shown are for a 2-channel ABS system. All other configurations are similar.

57. Connect the air valve assembly. See **Fig. 2** .
    - Connect the air lines.
    - Connect the electrical connector.
    - Install the retaining clamp bolts.

58. If the vehicle is equipped with front pintle hooks, install the two pintle hooks, six bolts, 10 washers and four nuts. Tighten 220 to 300 lbf·ft (298 to 406 N·m). See **Fig. 1** .

59. Restore the vehicle to operating condition.

    59.1 Install the air intake tube and air cleaner assembly as an assembly. Refer to **Group 09**.

    59.2 Install the cooling fan. Refer to **Group 20**.

    59.3 Install the cooling module. Refer to **Group 20**.

    59.4 If the vehicle is equipped with a transmission cooler or an automatic transmission, fill the transmission oil. Refer to the appropriate **Group 26** transmission section.

    59.5 Fill the engine with oil.

    59.6 Fill the engine cooling system. Refer to **Group 20**.

    59.7 Fill the air system.

    59.8 If the vehicle is equipped with an A/C system, evacuate, charge and leak test the A/C system. Refer to **Group 83**.

    59.9 Check the engine drive belts for proper adjustment.

    59.10 Check the accelerator and hand throttle linkages for proper adjustment. Refer to **Group 30**.

    59.11 Check the transmission cables and linkages for proper adjustment. Refer to the appropriate **Group 26** transmission section.

    59.12 Check the clutch cables and linkages for proper adjustment. Refer to **Group 25**.

    59.13 Connect the battery ground cables.

    59.14 Start the engine and check the powertrain assembly for leaks.

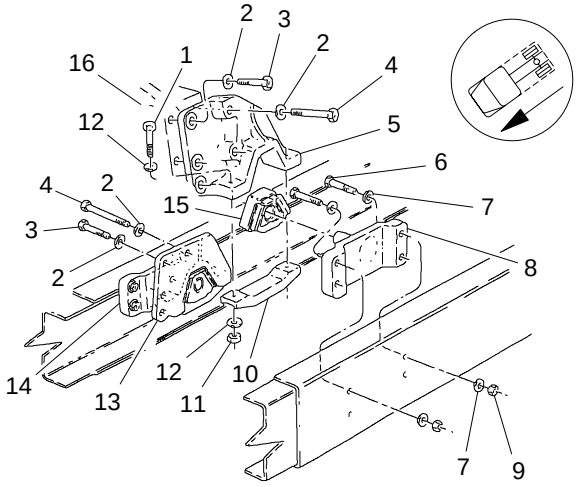
    59.15 Install the engine cover. Refer to **Group 60**.

    59.16 Install the hood. Refer to **Group 88**.

    59.17 Install the bumper. Refer to **Group 31**.

Rear Engine Mount Replacement

NOTE: See **Fig. 1** for this procedure.



1. Hexhead Bolt (1/2–13 x 2.50)
2. Flatwasher (3/4 x 1.44 x 0.13)
3. Hexhead Bolt (3/4–10 x 2.25)
4. Hexhead Bolt (3/4–10 x 3.00)
5. Engine Leg (left-hand)
6. Hexhead Bolt (5/8–11 x 3.50)
7. Flatwasher (5/8 x 1.18 x 0.13)
8. Engine Support-to-Frame Bracket (left-hand)
9. Hex Locknut (5/8–11)
10. Engine Support-to-Frame Cap
11. Hex Locknut (1/2–13)
12. Flatwasher (1/2 x 1.06 x 0.10)
13. Rear Engine Support Bracket (right-hand)
14. Engine Support-to-Frame Bracket (right-hand)
15. Rear Engine Support Isolator
16. Flywheel Housing

Fig. 1, Rear Engine Support Isolators

1. Apply the parking brakes, shut down the engine, chock the tires, and if applicable, drain the air brake system.

⚠ 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 component damage, personal injury or death.

2. Disconnect the engine from the rear engine support-to-frame bracket(s).
   - 2.1 Place a jack under the rear of the engine, and raise the jack until it is braced against the engine.
   - 2.2 Remove the nuts, bolts and washers that attach the engine support-to-frame cap to the rear engine support bracket(s). Save the fasteners.
3. Disconnect the engine support-to-frame bracket(s) from the frame rail.
   - 3.1 Remove the bolts that secure the rear engine support-to-frame bracket(s) to the frame rail.
   - 3.2 Lift the engine slightly to take its weight off the rear engine support-to-frame bracket(s). Place engine stands under the engine to keep it off the engine support-to-frame bracket(s).
   - 3.3 Remove the rear engine support-to-frame bracket(s) from the frame rail.
   - 3.4 Remove the rear engine support isolator from the rear engine support-to-frame bracket(s).
4. If necessary, remove the bolts that secure the engine leg(s) to the flywheel housing, and remove the leg(s) from the engine.
5. Inspect the rear engine support isolators for wear or damage and replace them if necessary.

⚠ CAUTION

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

6. Install the rear engine support isolator on a new rear engine support-to-frame bracket(s). Align the isolator on the bracket so the wide side of the isolator is at the bottom of the bracket.
7. If removed, install the engine legs(s) on the flywheel housing. Apply thread-lock compound to the bracket mounting bolts, and tighten them 136 lbf·ft (184 N·m).

Engine Mount Replacement

8. Place the new engine support-to-frame bracket(s), with the isolator aligned properly, against the inside of the frame rail, and secure it with bolts, washers, and nuts. Tighten the nuts 120 to 152 lbf·ft (163 to 206 N·m).

⚠ 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 component damage, personal injury or death.

9. Connect the engine to the engine support-to-frame bracket(s).

   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(s).

   NOTE: The bolt at the rear of the cap is installed from the bottom. The bolt at the front of the cap is installed from the top.

   9.3 Holding the rear engine support-to-frame cap in place, install the bolts that attach the cap to the rear engine support bracket(s). Secure them with a nut and hardened washer. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

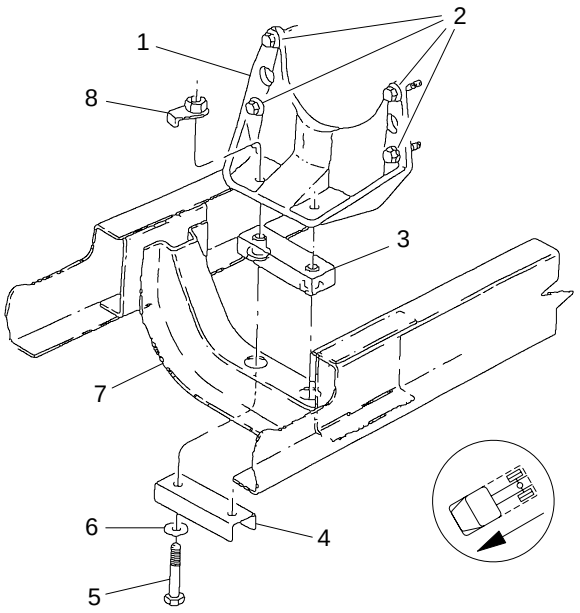
10. Remove the jack from under the engine, and remove the chocks from the tires.

Front Engine Mount Replacement

NOTE: See **Fig. 2** or **Fig. 3** for this procedure.

NOTE: Both compression-type and focal-type engine support isolators are used in all L-Line and A-Line vehicles.

1. Apply the parking brakes, shut down the engine, chock the tires, open the hood, and if applicable, drain the air brake system.



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1. Front Engine Support Bracket
2. Bolt
3. Front Engine Support Bracket Isolator
4. Rebound Puck
5. Bolt
6. Flatwasher
7. Front Crossmember
8. Nut

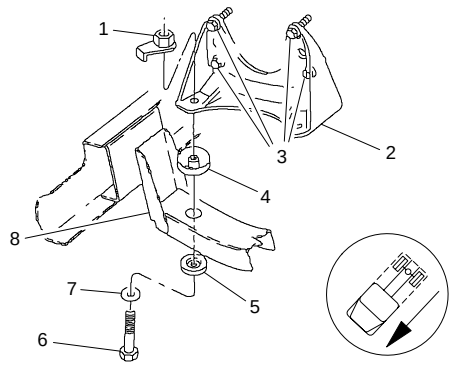
Fig. 2, Front Engine Support Isolators, Compression

⚠ 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 component damage, personal injury or death.

2. Disconnect the engine from the front engine mount(s).

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



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1. Nut and Retainer (5/8–11)
2. Front Engine Support Bracket
3. Hexhead Bolt (1/2–16 x 3.25)
4. Front Engine Support Isolator
5. Rebound Puck
6. Hexhead Bolt (5/8–11 x 3.50)
7. Flatwasher (5/8 x 1.18 x 0.13)
8. Front Engine Support Member

Fig. 3, Front Engine Support Isolators, Focal

2.2 Remove the nuts and bolts from the front engine mount(s). Save the fasteners.

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

3. If you are replacing the front engine support bracket, refer to the engine manufacturer's service literature.

4. Inspect the engine mount rubber isolator(s) for wear or damage and replace it, if necessary.

⚠ CAUTION

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

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

⚠ WARNING

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

6. Secure the engine to the front engine mount(s).

6.1 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount(s).

6.2 Install the bolts in the front engine mount(s) and secure them with the nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

6.3 Remove the lifting chain from the engine lifting hooks.

7. Close the hood and remove the chocks from the tires.

Oil Pan Noise Panel Replacement

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

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

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the locknuts and washers that attach the oil pan noise panel to the oil pan.
3. Remove the noise panel.
4. Place the new noise panel into position under the oil pan.
5. Install the washers and locknuts. Tighten the locknuts 15 lbf·ft (20 N·m).
6. Remove the chocks from the tires.

General Specifications	
Item	**Specification**
Lubricants	
Pipe Sealant with Teflon® D8AZ–19554–A	WSK–M2G350–AZ and ESR–M18P7–A
Silicone Dielectric Compound D7AZ–19A331–A	ESE–M1C171–A
Heavy Truck PAG Oil F4HZ–19577–A	EST–M1C231–B2
Threadlock® and Sealer EOAZ–19554–AA	WSK–M2G315–A5

Table 1, General Specifications

Torque Specifications	
Description	**Torque lbf·ft (N·m)**
A/C Compressor Suction Line	30–35 (41–47)
Alternator and A/C Compressor Mounting Bracket Mounting Bolts	50–70 (68–95)
Engine Mount Mounting Bolts	150–205 (203–278)
Engine Leg-to-Flywheel Housing Bolts*	136 (184)
Front Engine Mount Insulator Mounting Bolts	150–205 (204–277)
No. 1 Crossmember Mounting Bolts (113- to 122-inch BBC)	150–205 (204–277)
No. 1 Crossmember Mounting Bolts (101-inch BBC)	150–205 (204–277)
No. 1 Crossmember Gusset Mounting Bolts	150–205 (204–277)
No. 2 Crossmember Mounting Bolts	75–105 (102–138)
Power Steering Pump Mounting Bolts	150–205 (204–277)
Rear Engine Mount Support Brackets	75–105 (102–138)
Starter Motor Mounting Bolts	70–90 (95–120)
Tow Pintle Hook Mounting Bolts	220–300 (298–406)
Vibration Damper Mounting Bolts	134–155 (180–210)

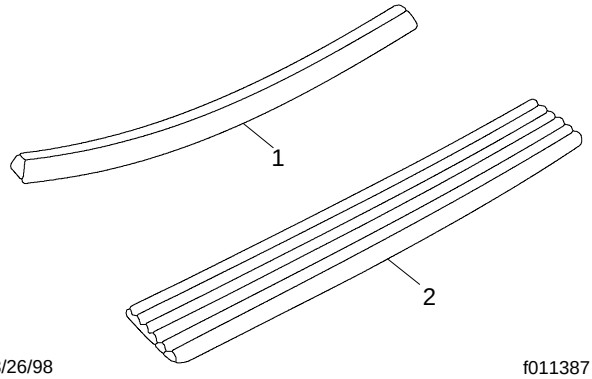
* The bolt size is 5/8–11 x 1.75 inches

Table 2, Torque Specifications

General Information

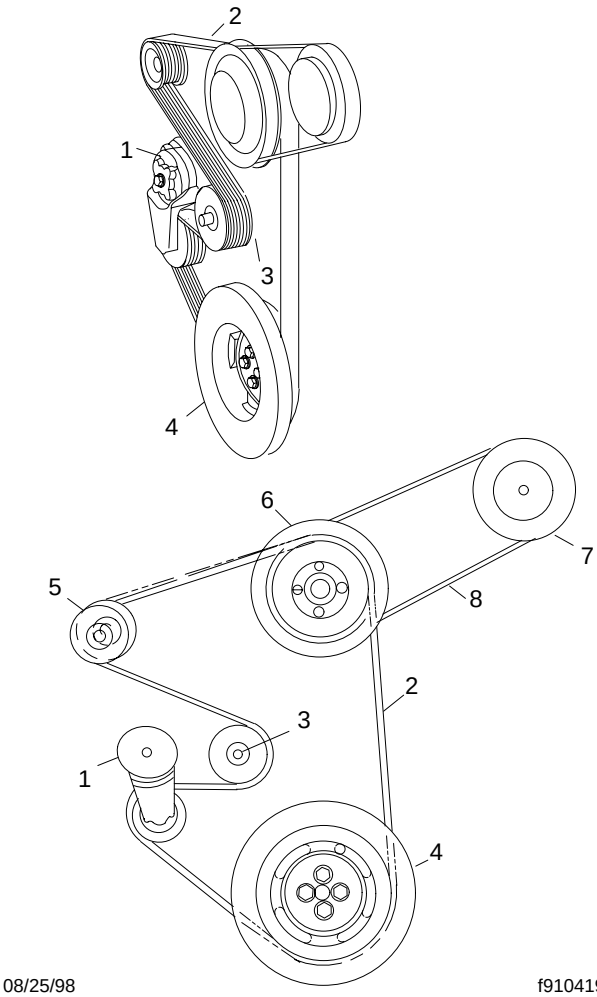
Two types of accessory drive belts are used, poly-V and V-belt (see **Fig. 1**). The belt size is selected for each engine based on performance requirements. The accessory drive belts are used to transmit engine power to the engine accessories. These belts must be properly adjusted at all times. Loose belts will result in slippage that can cause a noise complaint or improper accessory operation (generator will not charge, etc.). Overly tightened belts will place severe loads on the accessory bearings and cause premature belt failure.

For accessory installation views and belt routing, see **Fig. 2** (Cummins ISB), **Fig. 3** (Cummins ISC), **Fig. 4** (Cummins M11), **Fig. 5** (Cummins N14), **Fig. 6** (Caterpillar 3126), **Fig. 7** (Caterpillar 3306), **Fig. 8** (Caterpillar 3406E and 3406C), **Fig. 9** (Caterpillar C10, C12) and **Fig. 10** (Detroit Diesel Series 60).



1. V-Belt
2. Poly-V Belt

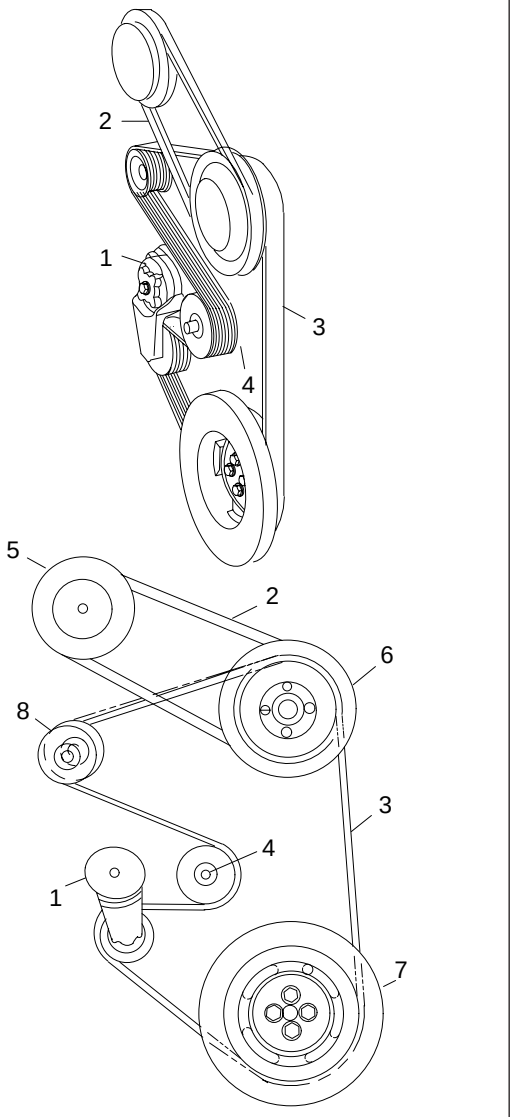
Fig. 1, Drive Belt Types



1. Automatic Belt Tension
2. Engine Drive Belt, Poly-V
3. Water Pump Pulley
4. Crankshaft Pulley
5. Generator Pulley
6. Fan Drive Pulley
7. A/C Compressor Pulley
8. Air Conditioning Drive Belt

Fig. 2, Accessory Drive, Cummins ISB

General Information



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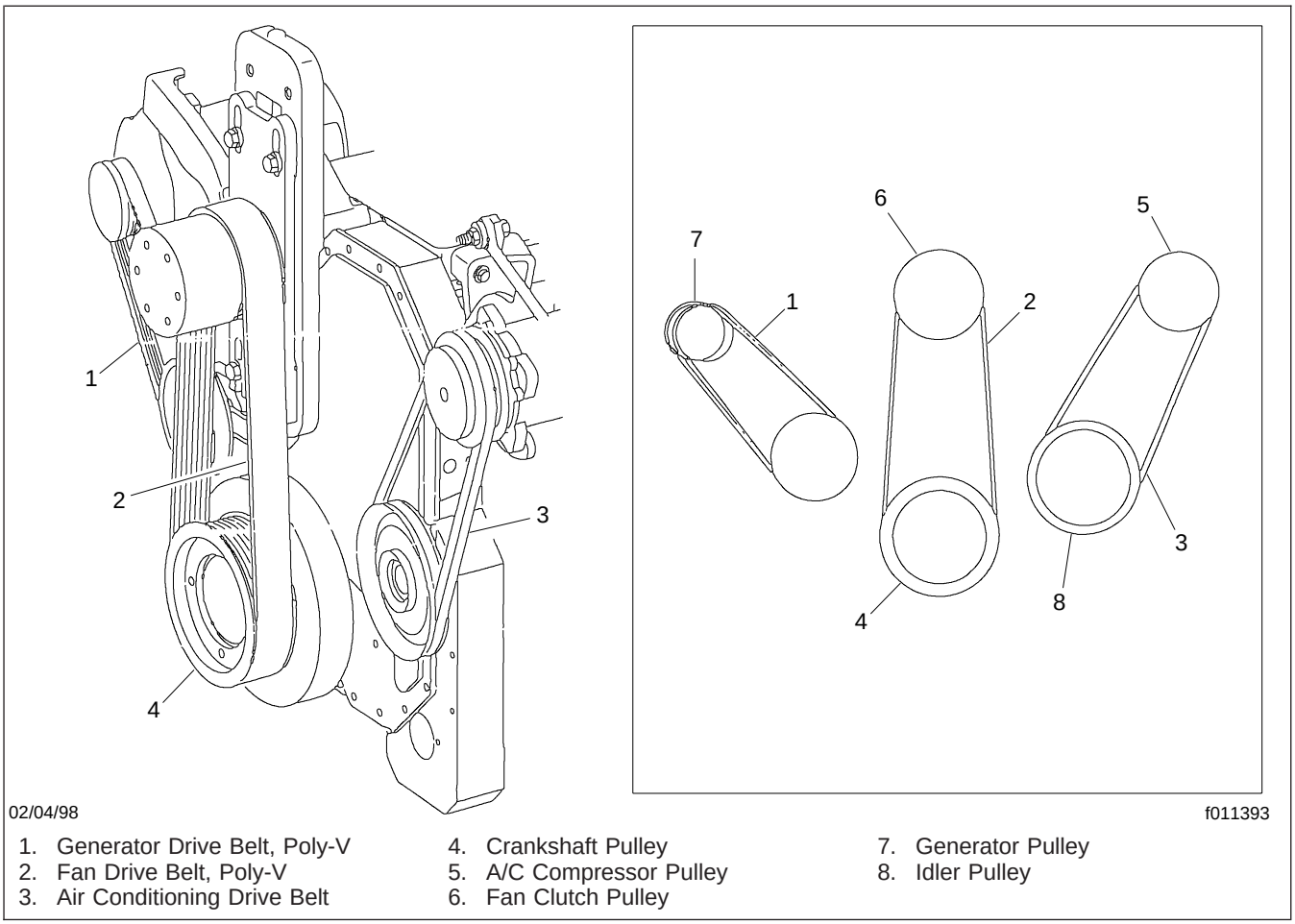
1. Automatic Belt Tensioner
2. Air Conditioning Drive Belt
3. Engine Drive Belt, Poly-V
4. Water Pump Pulley
5. A/C Compressor Pulley
6. Fan Clutch Pulley
7. Crankshaft Pulley
8. Generator Pulley

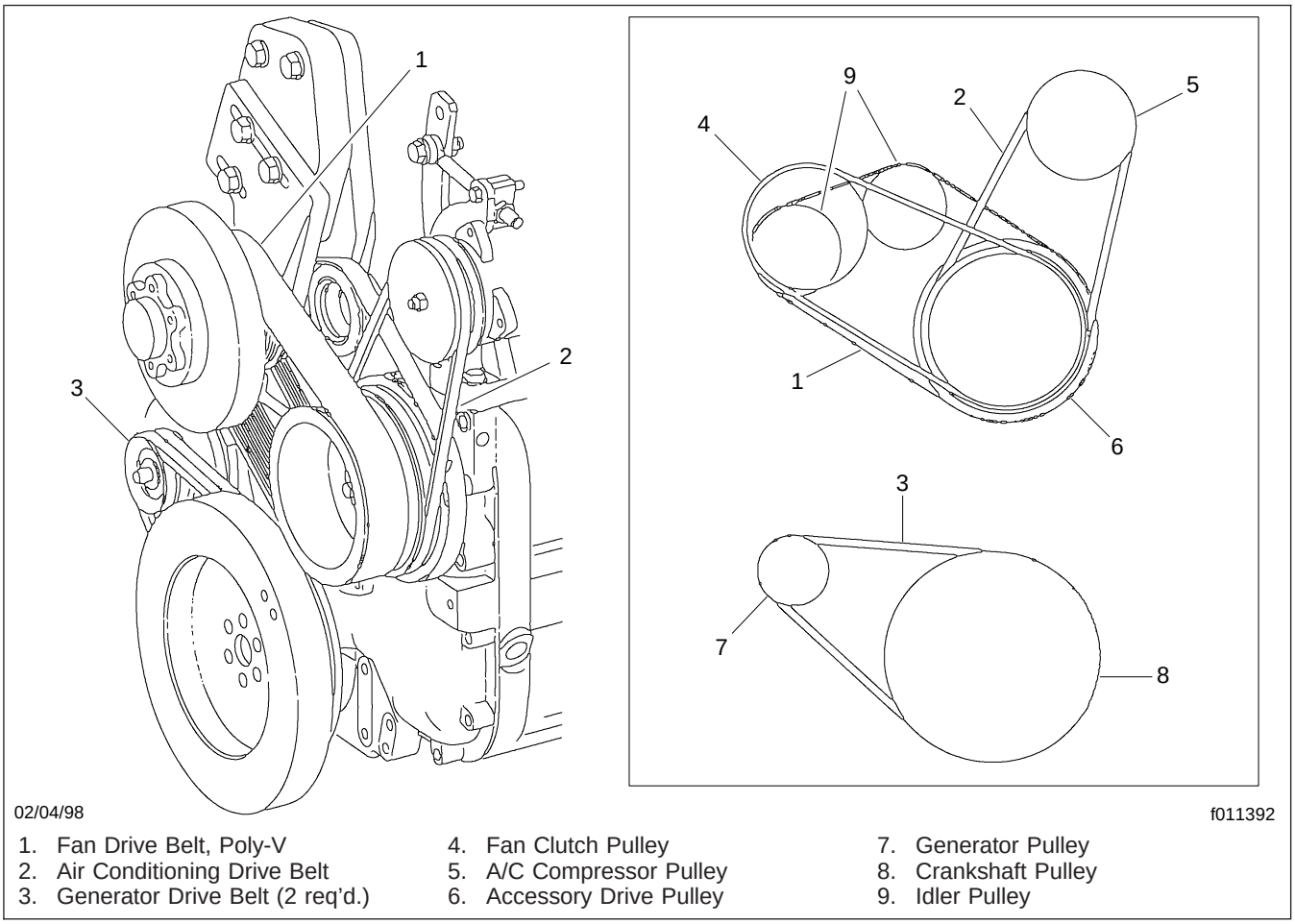
Fig. 3, Accessory Drive, Cummins ISC



1. Generator Drive Belt, Poly-V
2. Fan Drive Belt, Poly-V
3. Air Conditioning Drive Belt
4. Crankshaft Pulley
5. A/C Compressor Pulley
6. Fan Clutch Pulley
7. Generator Pulley
8. Idler Pulley

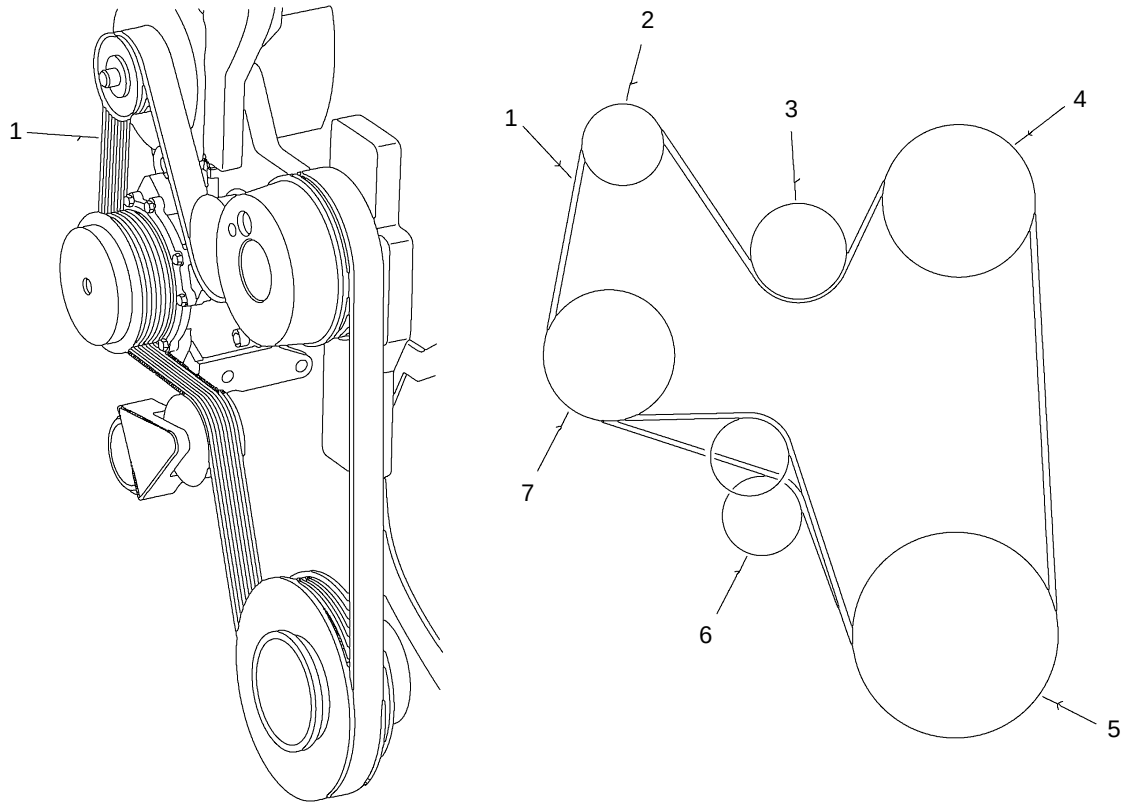
Fig. 4, Accessory Drive, Cummins M11

General Information



1. Fan Drive Belt, Poly-V
2. Air Conditioning Drive Belt
3. Generator Drive Belt (2 req'd.)
4. Fan Clutch Pulley
5. A/C Compressor Pulley
6. Accessory Drive Pulley
7. Generator Pulley
8. Crankshaft Pulley
9. Idler Pulley

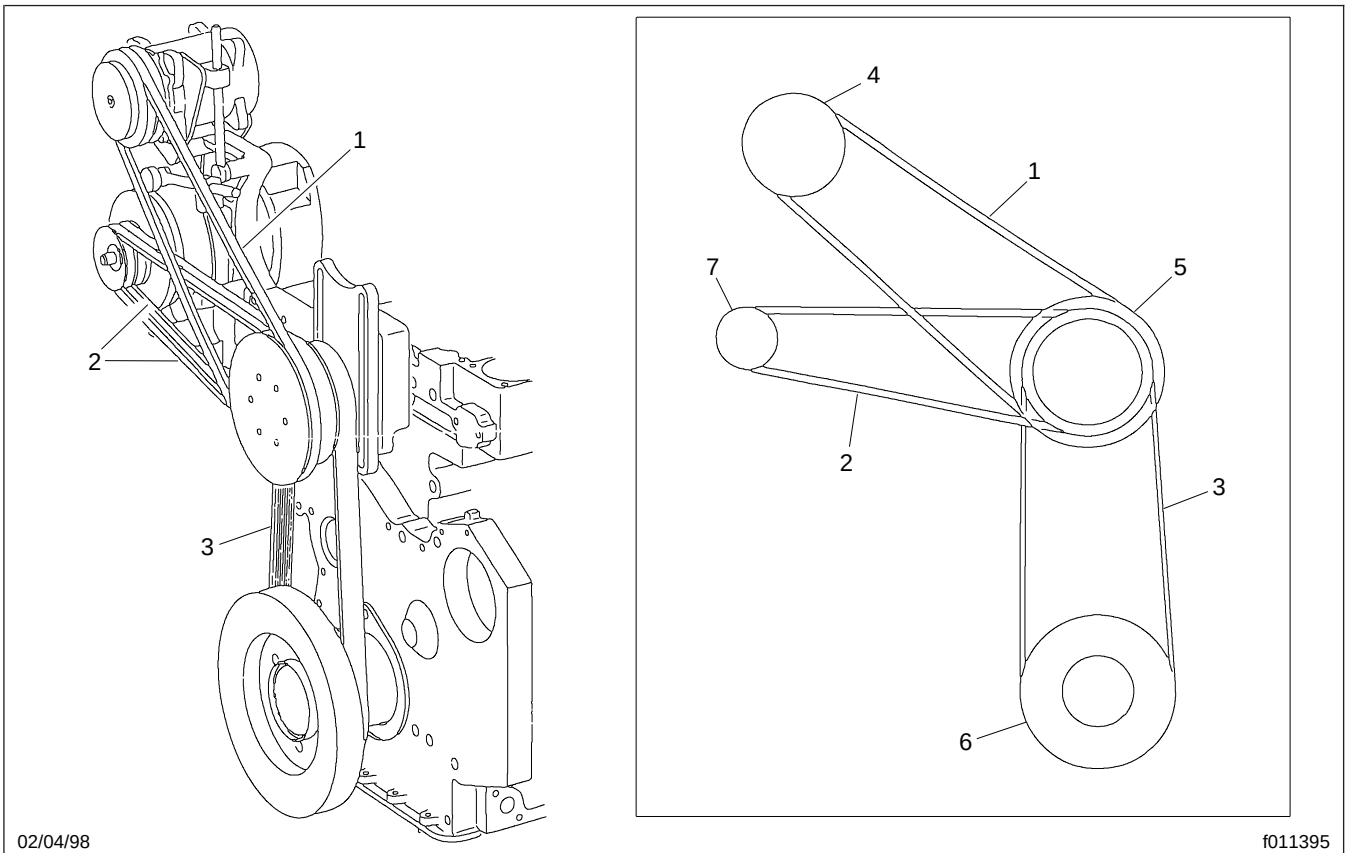
Fig. 5, Accessory Drive, Cummins N14



1. Air Conditioning Drive Belt
2. Generator Drive Pulley
3. Accessory Drive Pulley
4. Fan Clutch Pulley
5. Crankshaft Pulley
6. Automatic Belt Tensioner
7. A/C Compressor Pulley

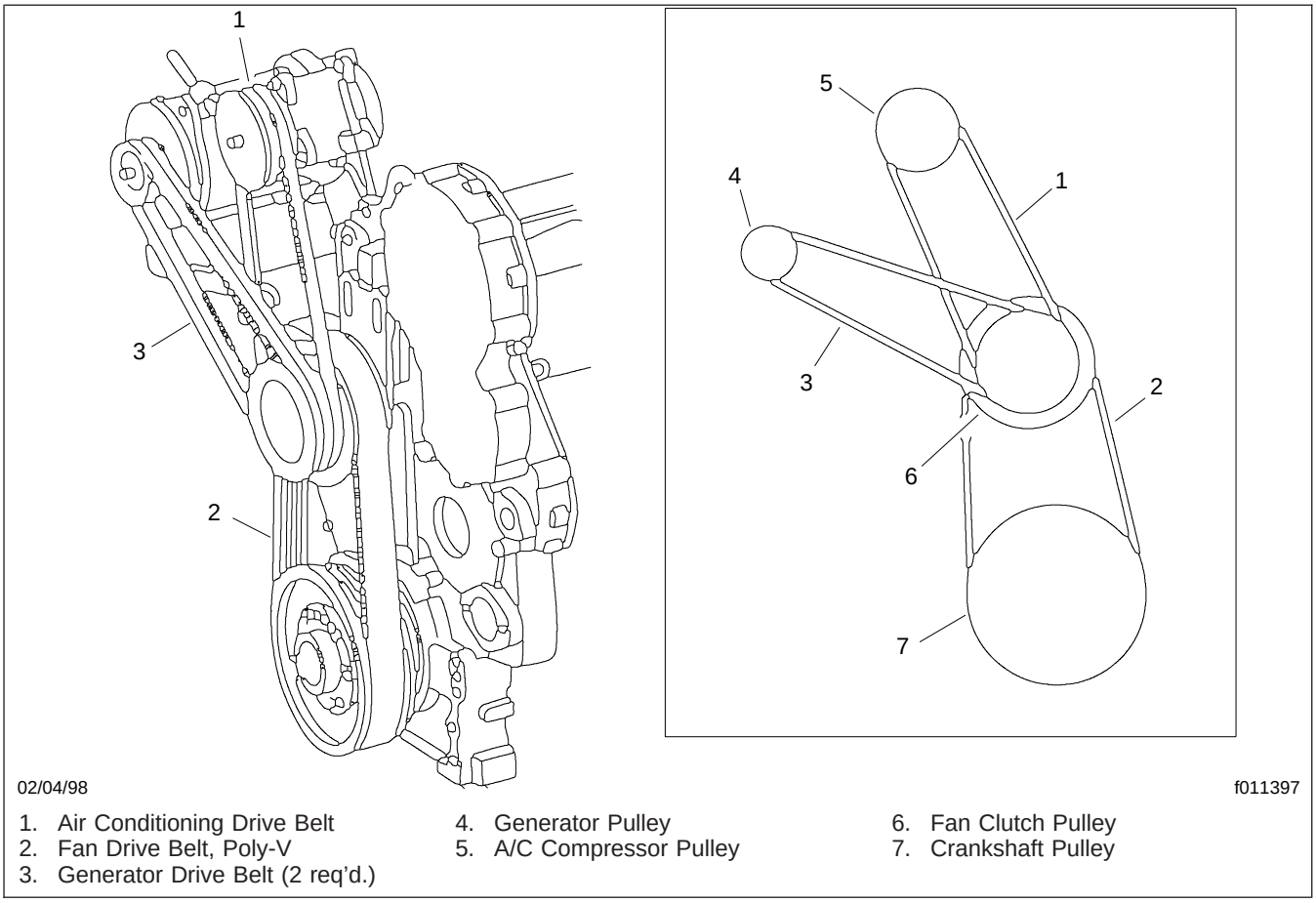
Fig. 6, Accessory Drive, Caterpillar 3126

General Information



1. Air Conditioning Drive Belt
2. Generator Drive Belt (2 req'd.)
3. Fan Drive Belt, Poly-V
4. A/C Compressor Pulley
5. Fan Clutch Pulley
6. Crankshaft Pulley
7. Generator Pulley

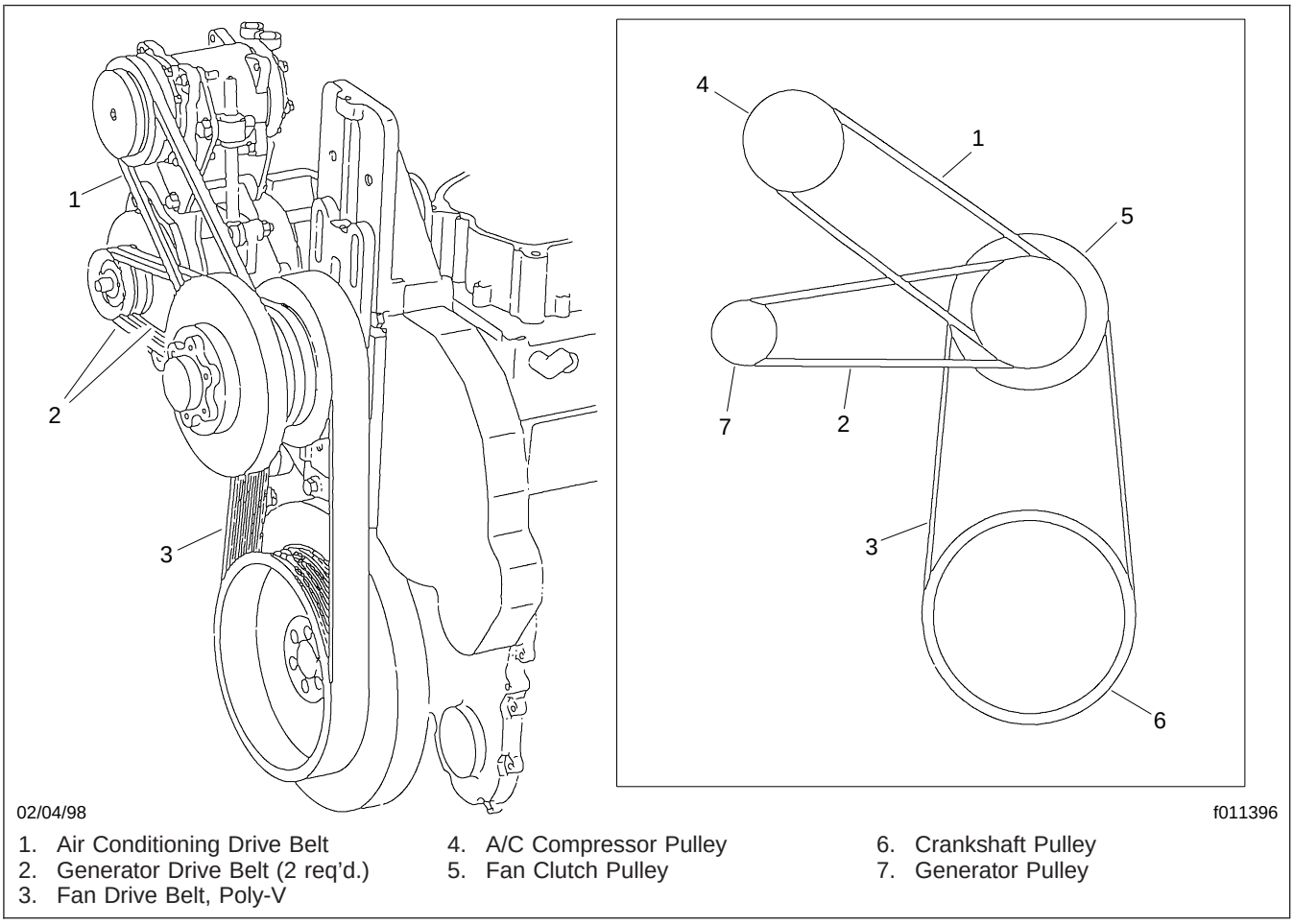
Fig. 7, Accessory Drive, Caterpillar 3306



1. Air Conditioning Drive Belt
2. Fan Drive Belt, Poly-V
3. Generator Drive Belt (2 req'd.)
4. Generator Pulley
5. A/C Compressor Pulley
6. Fan Clutch Pulley
7. Crankshaft Pulley

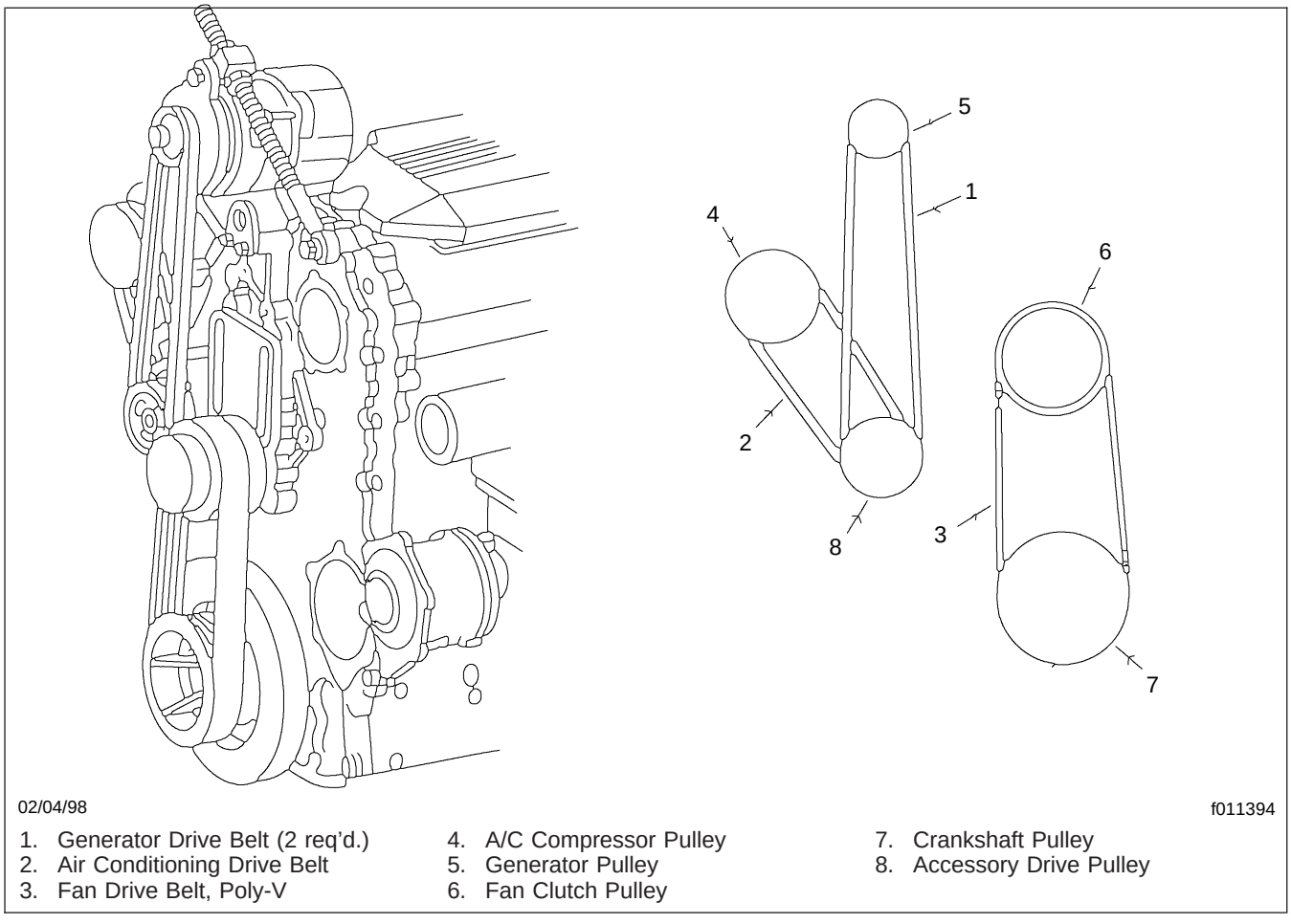
Fig. 8, Accessory Drive, Caterpillar 3406C and 3406E

General Information



1. Air Conditioning Drive Belt
2. Generator Drive Belt (2 req'd.)
3. Fan Drive Belt, Poly-V
4. A/C Compressor Pulley
5. Fan Clutch Pulley
6. Crankshaft Pulley
7. Generator Pulley

Fig. 9, Accessory Drive, Caterpillar C10, C12



1. Generator Drive Belt (2 req'd.)
2. Air Conditioning Drive Belt
3. Fan Drive Belt, Poly-V
4. A/C Compressor Pulley
5. Generator Pulley
6. Fan Clutch Pulley
7. Crankshaft Pulley
8. Accessory Drive Pulley

Fig. 10, Accessory Drive, Detroit Diesel Series 60

Poly-V Belt, Typical (Except Caterpillar 3126, Cummins ISB and ISC)

REMOVAL

NOTE: This procedure is a typical poly-V belt removal and installation. Refer to the illustrations in **Subject 050** of this section for accessory installation views and belt routing.

NOTE: On some engines, it may be required to remove additional drive belts before the poly-V drive belt can be removed.

1. Loosen the fan clutch mounting bolts. See **Fig. 1**.

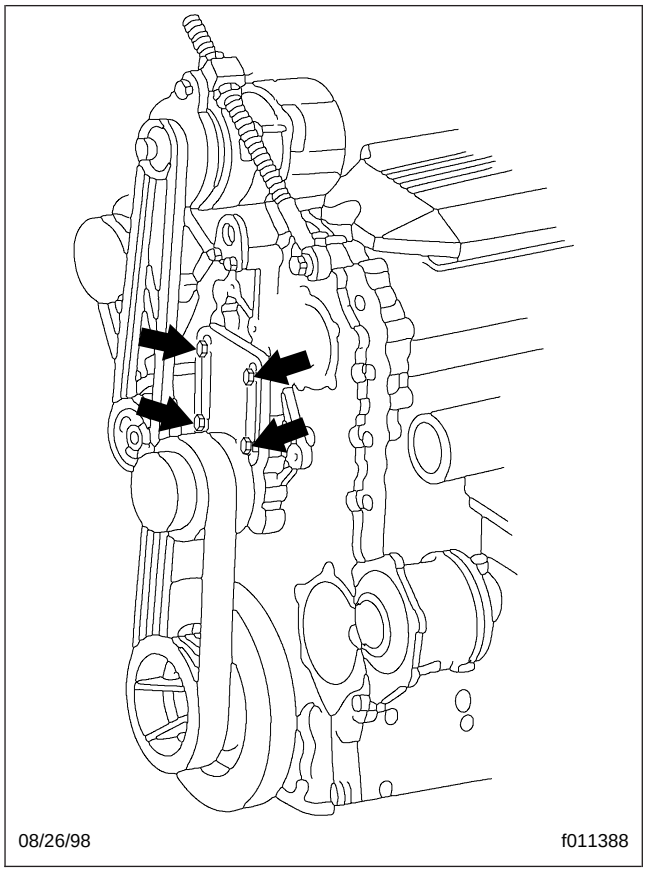
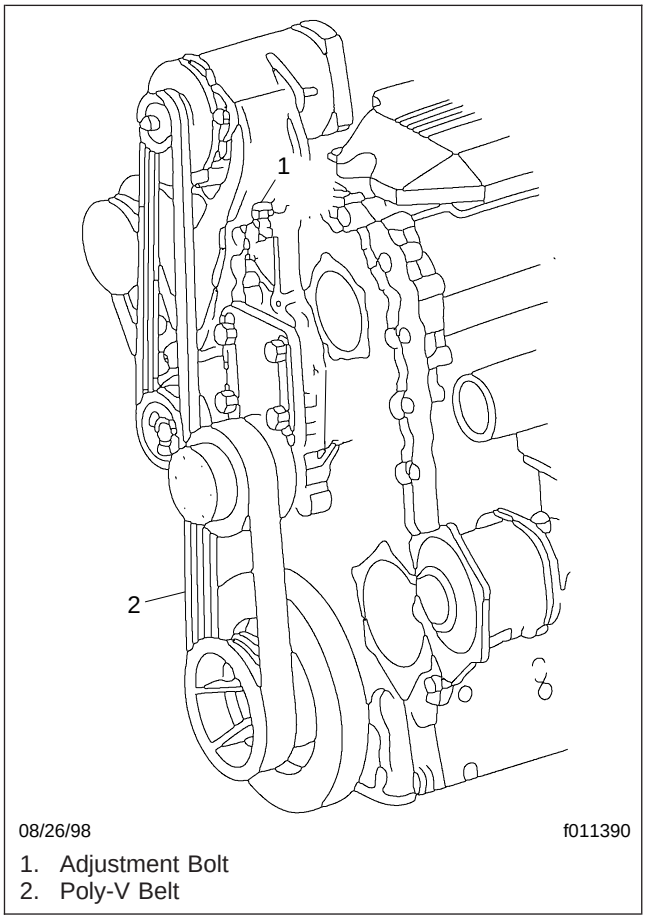


Fig. 1, Fan Clutch Mounting Bolts, Typical (Except Caterpillar 3126, Cummins ISB and ISC)

2. Loosen the adjustment bolt, and remove the poly-V drive belt. See **Fig. 2**.



1. Adjustment Bolt
2. Poly-V Belt

Fig. 2, Poly-V Belt Adjustment Bolt, Typical (Except Caterpillar 3126, Cummins ISB and ISC)

INSTALLATION

1. Position the poly-V drive belt, and tighten the adjustment bolt until the drive belt tension is within specification. See **Fig. 2**.
   - Use a suitable gauge to check belt tension.
   - Refer to **Specifications, 400**.
2. Tighten the fan clutch mounting bolts 75 to 105 lbf·ft (102 to 142 N·m). See **Fig. 1**.

Drive Belt Removal and Installation

Caterpillar 3126, Cummins ISB and ISC Poly-V Belt, Typical

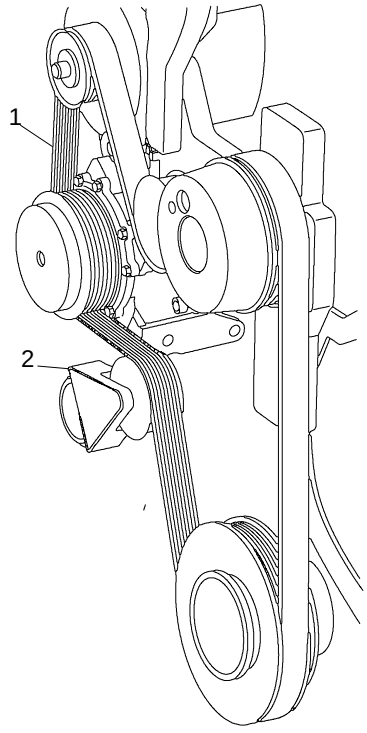
REMOVAL

CAUTION

Do not allow the belt tensioner to snap back into the relaxed position, or force the tensioner to travel beyond its limit. Severe damage will occur to the belt tensioner.

NOTE: This procedure is for Caterpillar 3136, Cummins ISB and ISC engines only. Refer to the illustrations in **Subject 050** of this section for accessory installation views and belt routing.

1. Rotate the belt tensioner. See **Fig. 3**.



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1. Poly-V Belt
2. Belt Tensioner

Fig. 3, Caterpillar 3126, Cummins ISB and ISC Poly-V Belt Tensioner, Typical

2. Remove the poly-V belt.

INSTALLATION

CAUTION

Do not allow the belt tensioner to snap back into the relaxed position, or force the tensioner to travel beyond its limit. Severe damage will occur to the belt tensioner.

NOTE: This ease installation, route the drive belt around all accessory drive pulleys first, then position the drive belt onto the belt tensioner pulley.

1. Route the drive belt around the accessory drive pulleys.
2. Rotate the belt tensioner. See **Fig. 3**.
3. Place the drive belt around the belt tensioner pulley, then release the belt tensioner.

A/C Compressor Drive Belt, V-Belt, Typical

REMOVAL

NOTE: This procedure is a typical A/C compressor drive belt removal and installation. Refer to the illustrations in **Subject 050** of this section for compressor location and belt routing.

1. Loosen the pivot bolts and nuts. See **Fig. 4**.
2. Loosen the jam nut on the adjustment rod, then loosen the adjustment nut until the drive belt can be removed. See **Fig. 5**.

INSTALLATION

1. Position the drive belt, and turn the adjustment nut until the drive belt tension is within specification.
   - Use a suitable gauge to check the belt tension.
   - Refer to **Specifications, 400**.
2. Tighten the jam nuts. See **Fig. 5**.
3. Tighten the pivot bolts and nuts. See **Fig. 4**.

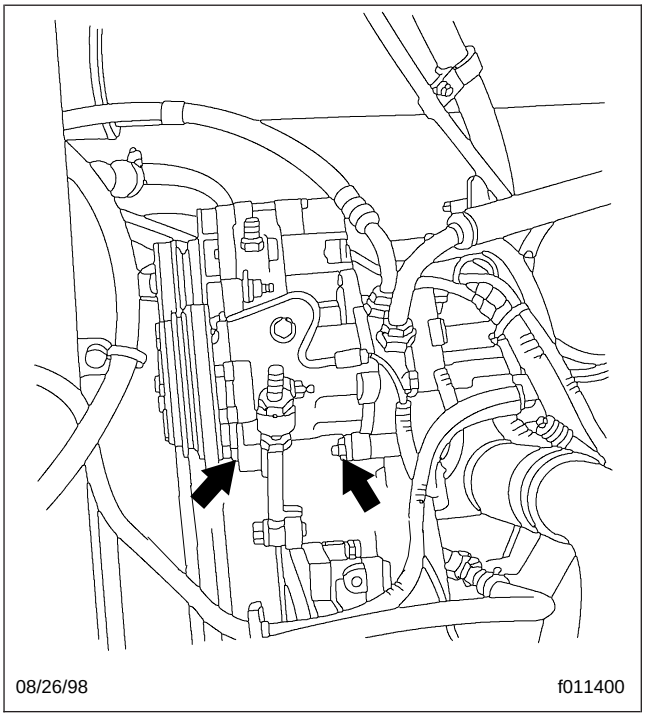
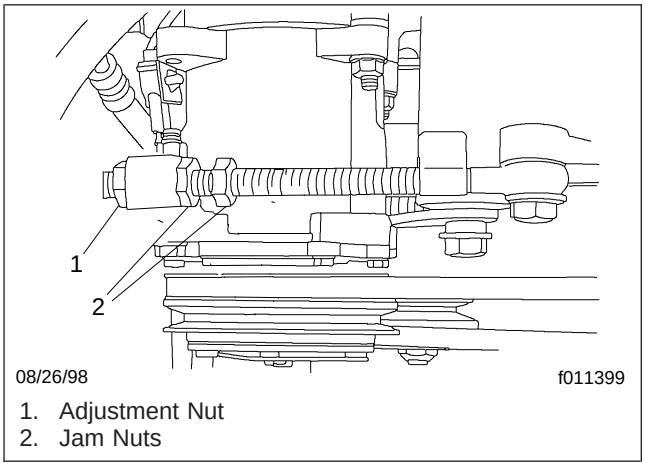


Fig. 4, A/C Compressor Pivot Bolts and Nuts



1. Adjustment Nut
2. Jam Nuts

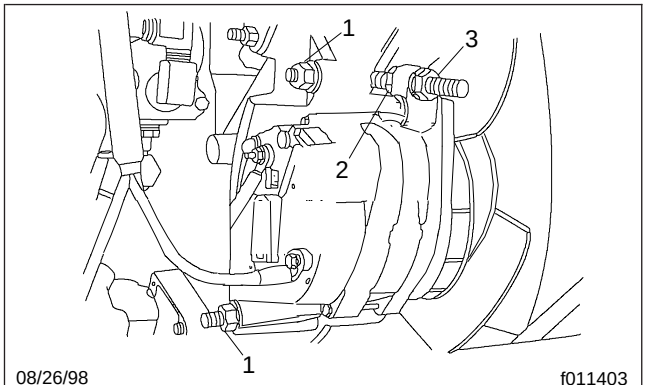
Fig. 5, A/C Compressor Drive Belt Adjustment Nut

Generator Drive Belt, V-Belts, (Except Cummins N14 Engines)

REMOVAL

NOTE: This procedure is a typical generator drive belt removal and installation. Refer to the illustrations in **Subject 050** of this section for generator location and belt routing.

1. Loosen the pivot bolts and nuts, the jam nut and the adjustment nut. See **Fig. 6**.



1. Pivot Bolts and Nuts
2. Jam Nut
3. Adjustment Nut

Fig. 6, Generator Bolts and Nuts (Except Cummins N14 Engines)

2. Remove the drive belts.

INSTALLATION

1. Position the drive belts onto the generator and the fan drive.
2. Turn the adjustment nut until the drive belt tension is within specification.
   - Use a suitable gauge to check belt tension.
   - Refer to **Specifications, 400**.
3. Tighten the jam nut and the pivot bolts and nuts. See **Fig. 6**. Refer to **Specifications, 400**.

Drive Belt Removal and Installation

Cummins N14 Engines Generator Drive Belt, V-Belts

REMOVAL

NOTE: This procedure is for Cummins N14 engines only. Refer to the illustrations in **Subject 050** of this section for accessory installation views and belt routing.

1. Loosen the pivot bolt and the retaining bolt. See **Fig. 7**.

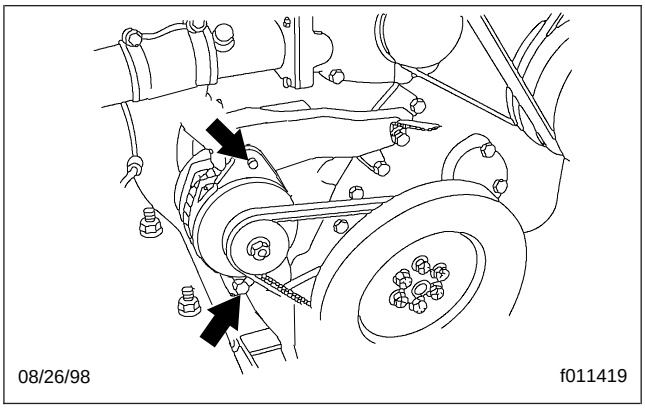


Fig. 7, Cummins N14 Engines Generator Pivot Bolts and Nuts

2. Turn the adjustment bolt until the V-belts can be removed. See **Fig. 8**.

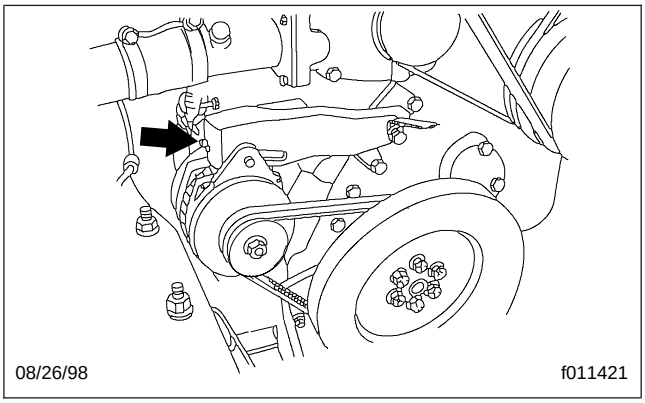


Fig. 8, Generator Adjustment Bolt, Cummins N14 Engines

INSTALLATION

1. Position the V-belts onto the crankshaft pulley and the generator pulley.
2. Turn the adjustment bolt until the V-belts are within proper tension. Refer to **Specifications, 400**. See **Fig. 8**.
3. Tighten the retaining bolt 75 to 105 lbf·ft (102 to 142 N·m). Tighten the pivot bolt 55 to 70 lbf·ft (75 to 94 N·m). See **Fig. 7**.

Generator V-Belts, Typical

1. Using a belt tension adjustment gauge, record the tension reading from the V-belts.
2. Loosen the pivot bolt and nut. See **Fig. 1**.

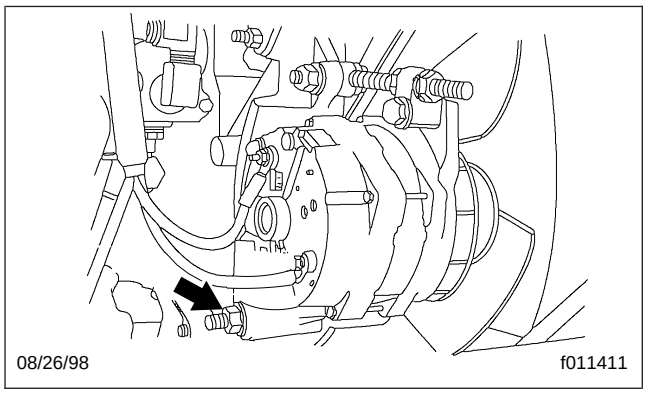


Fig. 1, Pivot Bolt and Nut

3. Loosen the jam nut on the adjustment rod, and turn the adjustment nut to increase or decrease the drive belt tension. See **Fig. 2**.
4. Tighten the jam nut 110 to 150 lbf·ft (150 to 203 N·m). See **Fig. 2**.
5. Tighten the pivot bolt and nut 55 to 70 lbf·ft (75 to 94 N·m). See **Fig. 1**.

A/C Compressor V-Belts, Typical

1. Using a tension adjustment gauge, record the tension reading from the V-belts.
2. Loosen the pivot bolts and nuts. See **Fig. 3** and **Fig. 4**.
3. Loosen the jam nut on the adjustment rod, and turn the adjustment nut to increase or decrease the drive belt tension. See **Fig. 5**.
4. Tighten the jam nut 75 to 105 lbf·ft (102 to 142 N·m). See **Fig. 5**.
5. Tighten the pivot bolts and nuts 30 to 40 lbf·ft (40 to 55 N·m). See **Fig. 3** and **Fig. 4**.

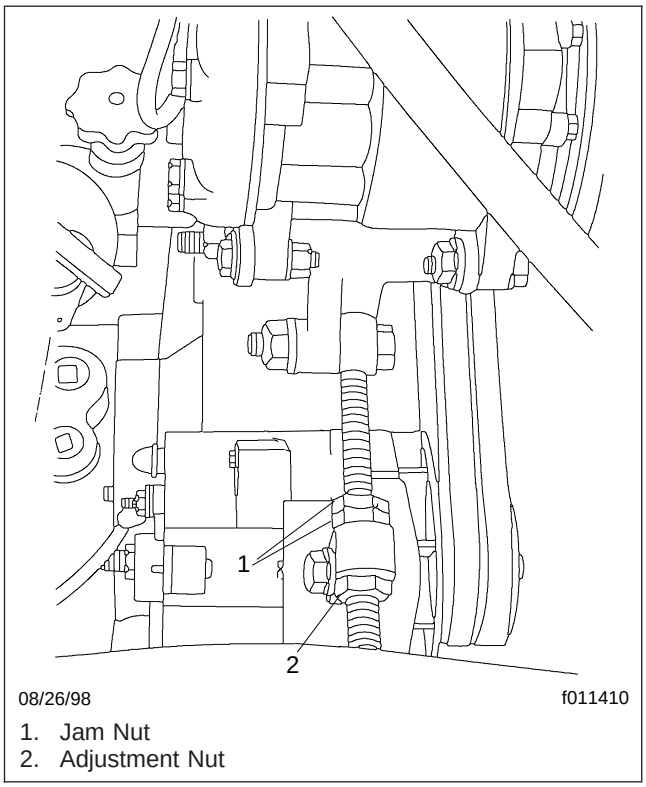


Fig. 2, Adjustment Nut

Poly-V, Typical (Except Caterpillar 3126, Cummins ISB and ISC)

1. Using a belt tension adjustment gauge, record the tension reading from the poly-V drive belt.
2. Loosen the four fan clutch mounting bolts. See **Fig. 6**.
3. Turn the fan drive adjustment bolt to increase or decrease the drive belt tension. See **Fig. 7**.
4. Tighten the four fan clutch mounting bolts 75 to 105 lbf·ft (102 to 142 N·m). See **Fig. 6**.

Caterpillar 3126, Cummins ISB and ISC Poly-V, Typical

NOTE: The belt tension on the poly-V belt used on the CAT 3126, Cummins ISB and ISC en-

Drive Belt Adjustment

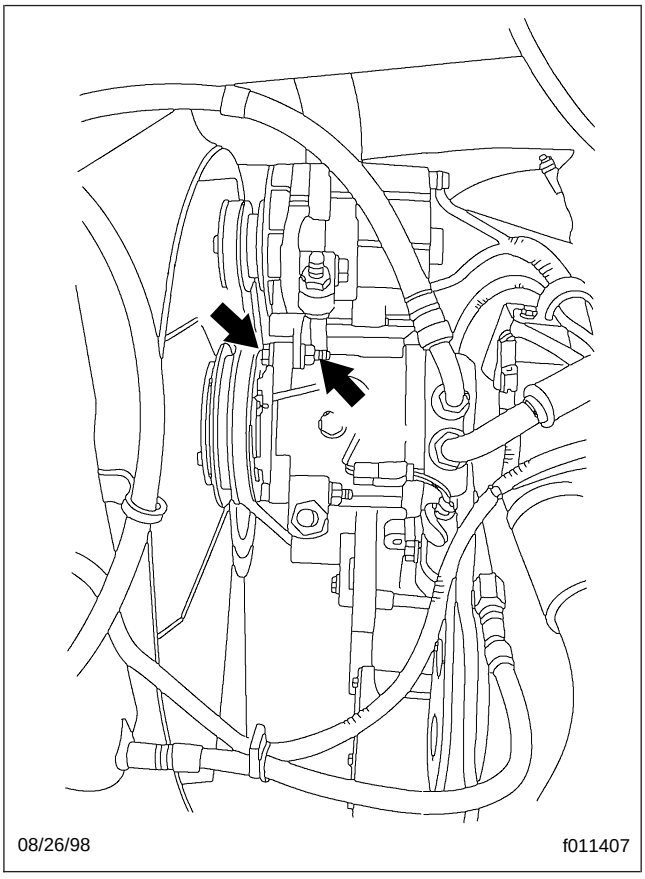


Fig. 3, Pivot Bolts and Nuts

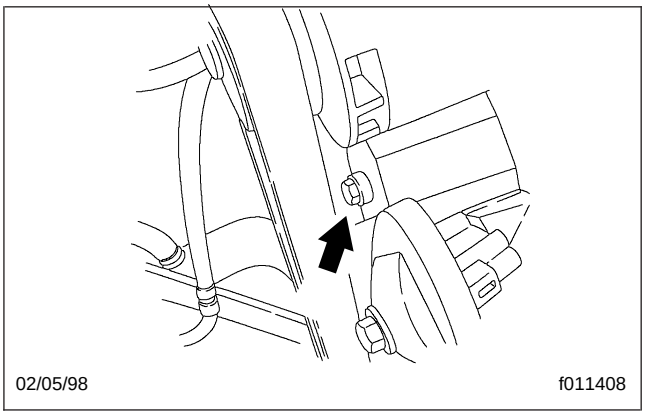
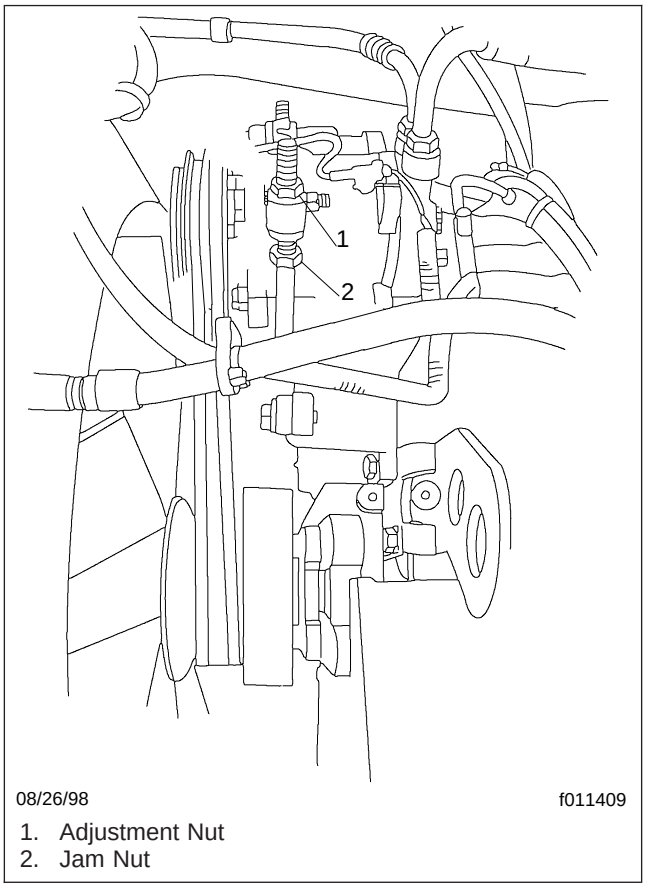


Fig. 4, Pivot Bolts and Nuts

gines is not adjustable. These engines use a constant tension belt tensioner.



1. Adjustment Nut
2. Jam Nut

Fig. 5, Adjustment Nut

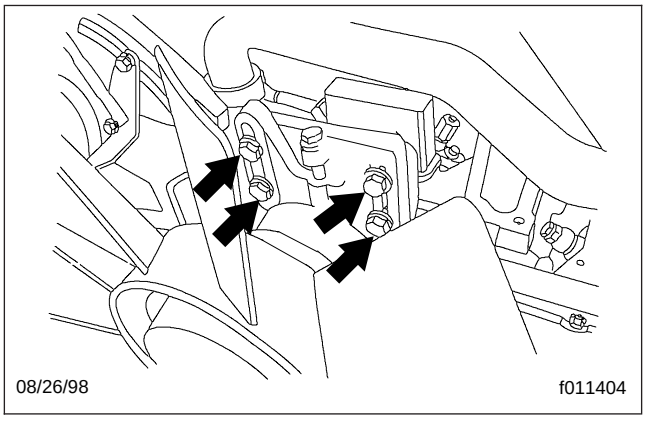


Fig. 6, Fan Clutch Mounting Bolts

If the belt tension is not within specification, check the belt for stretch. If the belt is not stretched, replace the tensioner.

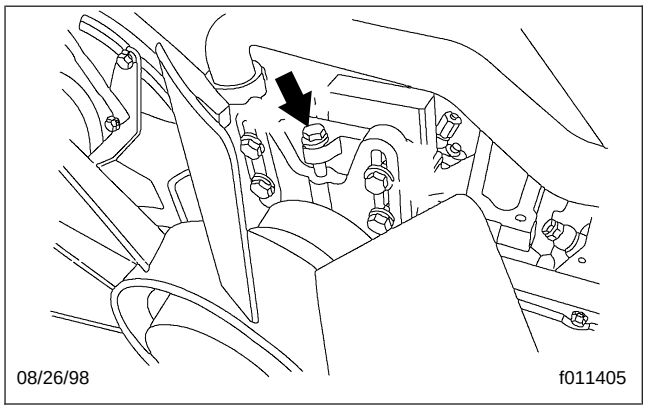


Fig. 7, Adjustment Bolt

Troubleshooting

INSPECTION AND VERIFICATION

Drive Belt Cracking/Chunking/Wear

Under severe operating conditions (high temperatures, low humidity), drive belt rib cracking can occur at less than 60,000 miles (96 000 km). Cracking perpendicular to the belt ribs is not a reason for concern and has no detrimental effect on belt performance. Cracks parallel to the ribs are not acceptable.

Drive belt chunking is the condition in which the rubber material actually chunks out between the cracks. This condition requires that the drive belt be replaced, if the chunkout section is 1/2 an inch long across two or more adjacent ribs.

Drive Belt Noise/Flutter

Drive belt chirp is a common indicator that one or more of the following conditions may exist:

- accessory drive pulley misalignment
- bent or improperly installed pulley

To correct the drive belt chirp complaint, perform the following:

- determine the area where the noise comes from
- place a straightedge between each pulley and the crankshaft pulley to check that all of the pulleys are aligned
- if any pulley is misaligned, correct the alignment and run the engine to determine if the complaint has been corrected

Drive belt squeal is an indication that the drive belt is slipping on a pulley, usually during the following conditions:

- cold engine start-up
- rapid engine acceleration
- A/C clutch engagement

Drive belt squeal can also occur under the following conditions:

- A/C discharge pressure exceeds 420 psi (2895 kPa)
- A/C equalized pressure exceeds 140 psi (965 kPa)
- damaged accessories
- fluids on the drive belt
- drive belt too long

If any of these conditions exist, repair and retest the system to verify that the complaint is corrected.

Problem—Excessive Noise/Belt Squeal

Problem—Excessive Noise/Belt Squeal	
Possible Cause	**Remedy**
Seized accessory	Check all accessories for free rotation and replace the accessory if necessary. Replace the drive belt.
Loose drive belt	Check the condition and tension of all drive belts. Replace the drive belts or adjust tension of the manually tensioned drive belts as necessary.
Worn or frozen automatic belt tensioner	Replace the tensioner.

Problem—Rattle

Problem—Rattle	
Possible Cause	**Remedy**
Loose pulley or accessory	Check for looseness and tighten.

Troubleshooting

Problem—Severe Belt Flutter

Problem—Severe Belt Flutter	
Possible Cause	**Remedy**
Loose drive belt	Check the belt tension and adjust if necessary. Check the condition of the drive belt and replace if necessary.
Worn or frozen automatic belt tensioner	Replace the tensioner.

Problem—Frayed Drive Belt

Problem—Frayed Drive Belt	
Possible Cause	**Remedy**
Drive belt not installed correctly (poly-V belt)	Replace the drive belt and verify correct belt seating.
Severely misaligned pulley	Check with a straightedge for severe angular misalignment between adjacent pulleys. Repair as necessary.

Problem—Severely Glazed Drive Belt

Problem—Severely Glazed Drive Belt	
Possible Cause	**Remedy**
Seized accessory	Check the drive belt for looseness or glazing and replace or adjust the tension as necessary.
Worn or frozen automatic belt tensioner	Replace the tensioner.

Problem—Improper Accessory Operation (Air Conditioning Does Not Work, Engine Overheats or Battery Does Not Charge)

Problem—Improper Accessory Operation (Air Conditioning Does Not Work, Engine Overheats or Battery Does Not Charge)	
Possible Cause	**Remedy**
Loose drive belt	Check the drive belt for looseness or glazing and replace or adjust the tension as necessary.
Worn or frozen automatic belt tensioner	Replace the tensioner.

Problem—Drive Belt Jumps Off Pulley

Problem—Drive Belt Jumps Off Pulley	
Possible Cause	**Remedy**
Greatly misaligned pulleys	Check for misalignment between adjacent pulleys.
Drive belt not installed correctly (poly-V belt)	Replace the drive belt and verify correct seating.

Problem—Drive Belt Jumps Off Pulley	
Possible Cause	**Remedy**
Pulley wobble	Verify that no pulley wobbles during engine operation. Conditions causing wobble are: a bent pulley, a bent accessory shaft, and/or the rear face of the pulley is not seated flat against the mating surface.
Excessive crankshaft end play	Rebuild the engine.

COMPONENT TEST

Drive Belt Misalignment

⚠ CAUTION

Incorrect drive belt installation will cause excessive drive belt wear and can cause the drive belt to come off of the pulleys.

NOTE: Original equipment drive belts are made of a special cord construction and are subjected to special testing before they are approved for use. Replacement drive belts other than OEM drive belts are not recommended.

1. To check drive belt alignment, perform the following:
   - 1.1 Start the engine.
   - 1.2 Observe the drive belt tracking on all of the pulleys.
   - 1.3 Observe the accessory drive pulley's grooves (not the pulley flange) for excessive wobble.
   - 1.4 Observe all accessories' mounting brackets and hardware for looseness or flexing.
2. If any of these conditions exist, repair as necessary and retest the system.

Specifications

Drive Belt Tension Specifications, Poly-V		
Belt Type	**New Belt lbs (m-kg)**	**Used Belt lbs (m-kg)**
8-Rib	200-240 (27.66-33.19)	200 (27.66)
10-Rib	250–300 (34.58–41.49)	250 (34.58)
12-Rib	250–300 (34.58–41.49)	250 (34.58)
14-Rib	250–300 (34.58–41.49)	250 (34.58)

Table 1, Drive Belt Tension Specifications, Poly-V

Drive Belt Tension Specifications, V-Belt		
Belt Type	**New Belt Lbs (m-kg)**	**Used Belt Lbs (m-kg)**
1/4-inch	90–105 (12.45–14.52)	60–65 (8.30–9.00)
5/16-inch	110–125 (15.21–17.29)	75–80 (10.37–11.06)
3/8-inch	110–125 (15.21–17.29)	75–80 (10.37–11.06)
7/16-inch	135–150 (18.67–20.75)	90–95 (12.45–13.14)
1/2-inch	135–150 (18.67–20.75)	90–95 (12.45–13.14)
11/16-inch	135–150 (18.67–20.75)	90–95 (12.45–13.14)
3/4-inch	150–160 (20.75–22.13)	100–110 (13.83–15.21)
7/8-inch	150–160 (20.75–22.13)	100–110 (13.83–15.21)
1-inch	150–160 (20.75–22.13)	100–110 (13.83–15.21)

Table 2, Drive Belt Tension Specifications, V-Belt

Torque Specifications	
Description	**lbf·ft (N·m)**
Generator Pivot Bolt and Nut	55–70 (75–94)
Generator Adjustment Rod Jam Nuts	110–150 (150–203)
A/C Compressor Pivot Bolts and Nuts	30–40 (40–55)

Torque Specifications	
Description	**lbf·ft (N·m)**
A/C Compressor Adjustment Rod Jam Nuts	75–105 (102–142)
Fan Clutch Mounting Bolts	75–105 (102–142)

Table 3, Torque Specifications

Troubleshooting

Removal and installation information for Sterling-installed components is included in the appropriate section. For service procedures covering manufacturer's installed components, refer to the engine manufacturer's service manual.

Diagnosis and testing procedures for Sterling-installed components are covered in the appropriate section.

Refer to the applicable engine manufacturer's service manual for diagnosis and testing, adjustments, disassembly and assembly, cleaning and inspection, overhaul specifications, and wear limits.

Electronic Engine Components, Cummins Engines	
Sterling-Installed Components	**Cummins-Installed Components**
Vehicle Speed Sensor	Engine Position Sensor
Throttle Position Sensor	Boost Pressure Sensor
Coolant Level Sensor	Ambient Air Pressure
Idle Validation Switch	Coolant Temperature Sensor
Brake Switch	Manifold Air Temperature Sensor
Clutch Switch (manual transmission equipped vehicles only)	Oil Pressure Sensor
Cruise ON/OFF Switch	Oil Temperature Sensor
Cruise SET, ACCEL/RES, COAST Switch	Fuel Shutoff Solenoid
Engine Brake ON/OFF Switch (if applicable)	Injectors
Engine Brake Selector Switch (if applicable)	Engine Control Module (ECM)
Engine Brake Relay (if applicable)	Actuator Harness
Idle INC/DEC Switch (if applicable)	Sensor Harness
Stop Engine Lamp	—
Check Engine Lamp	—
Engine Fluids Lamp	—
Data Link Connector	—
Diagnostic Test Input Connector and Shorting Plug	—
Wire Harness	—

Table 1, Electronic Engine Components, Cummins Engines

Diagnostic Trouble Codes for Sterling-Installed Components, Cummins Engines		
Sterling Components	**DTC Codes**	**Diagnostic Trouble Code Description**
Vehicle Speed Sensor	241	Vehicle speed signal on Pin 3 and Pin 7 of OEM harness lost.
Throttle Position Sensor	131	High voltage detected at throttle position signal Pin 11 of OEM harness.
Throttle Position Sensor	132	Low voltage detected at TPS Pin 11 of the OEM harness.
Throttle Position Sensor	431	Idle validation switch error. Voltage on both on/off idle signal.

Troubleshooting

Diagnostic Trouble Codes for Sterling-Installed Components, Cummins Engines		
Sterling Components	**DTC Codes**	**Diagnostic Trouble Code Description**
Throttle Position Sensor	432	Idle validation signal = IDLE when TPS is off idle, or idle validation = off idle when TPS is at idle.
Coolant Level Sensor	235	Voltage detected on coolant level low signal Pin 9 of sensor harness indicates low coolant level on vehicle.
Coolant Level Sensor	422	Voltage detected simultaneously on both HI and LO coolant level signal Pin 18 and Pin 9 of the sensor harness or no voltage on either pin.
Engine Brake Relay	243	Less than 6 volts detected at Pin 18 of the actuator harness. Indicates current draw 2.0A or faulty engine control module (ECM) power supply.
Supply Voltage for All Switches	352	No outgoing voltage detected at engine control module (ECM) switch supply Pin 10 of the OEM harness or low voltage detected at engine control module (ECM) sensor supply pins of sensor harness.
Data Link Connector	412 and 414	Data transmission error on vehicle data link Pin 27 and Pin 8 of the OEM harness.

Table 2, Diagnostic Trouble Codes for Sterling-Installed Components, Cummins Engines

Diagnostic Trouble Codes for Cummins Components		
DTC Codes	**Diagnostic Trouble Code Description**	**Troubleshooting**
115	No engine speed signal detected at Pins 1 and 15 or 11 and 14 of the sensor harness.	Refer to *Cummins Troubleshooting and Repair Manual*.
121	No engine speed signal detected at one pair of Pins either 1 and 15 or 11 and 14 of sensor harness.	
122	High voltage detected at boost pressure signal Pin 26 of sensor harness.	
123	Low voltage detected at boost pressure signal Pin 26 of sensor harness.	
135	High voltage detected at oil pressure signal Pin 07 of sensor harness.	
141	Low voltage detected at oil pressure signal Pin 07 of sensor harness.	
143	Voltage signal at oil pressure signal Pin 07 of SH indicates oil pressure lower than 8 psi (55 kpa) at Idle; 8 to 25 psi (55 to 172 kpa) at 800 to 1200 rpms; 25 to 30 psi (172 to 207 kpa) at 1200 to 2400 rpms.	
144	High voltage detected at coolant temperature signal Pin 17 of sensor harness.	
145	Low voltage detected at coolant temperature signal Pin 17 of sensor harness.	
151	Voltage signal at coolant temperature signal Pin 17 of SH indicates coolant temperature above 220° F (104° C).	
153	High voltage detected at manifold air temperature signal Pin 25 of sensor harness.	
154	Low voltage detected at manifold air temperature signal Pin 25 of sensor harness.	
155	Voltage signal at manifold air temperature signal Pin 25 of SH indicates air temperature above 180° F (82° C).	
212	High voltage detected at oil temperature signal Pin 06 of sensor harness.	
213	Low voltage detected at oil temperature signal Pin 06 of sensor harness.	
214	Voltage signal at oil temperature signal Pin 06 of SH indicates oil temperature above 285° F (125° C).	
221	High voltage detected at ambient air pressure signal Pin 27 of sensor harness.	
222	Low voltage detected at ambient air pressure signal Pin 27 of sensor harness.	
234	Engine speed signal on Pins 1 and 15 or 11 and 14 of SH indicates engine speed greater than 2730 rpm.	
245	Less than 6 volts detected at fan clutch supply Pin 07 of the actuator harness. Indicates current draw 2.0A or faulty ECM power supply.	
254	Less than 6 volts detected at fuel shutoff solenoid Pin 16 of the actuator harness. Indicates current draw 2.0A or faulty ECM power supply.	

Troubleshooting

Diagnostic Trouble Codes for Cummins Components		
DTC Codes	**Diagnostic Trouble Code Description**	**Troubleshooting**
255	Externally supplied voltage detected going into ECM fuel shutoff solenoid Pin 16, fan clutch supply Pin 07, or engine brake relay supply Pin 18.	Refer to *Cummins Troubleshooting and Repair Manual*.
311	Current detected at No. 1 Injector return Pin 10 of AH when voltage supply at Pin 01 of AH is off.	
312	Current detected at No. 5 Injector return Pin 02 of AH when voltage supply at Pin 11 of AH is off.	
313	Current detected at No. 3 Injector return Pin 12 of AH when voltage supply at Pin 03 of AH is off.	
314	Current detected at No. 6 Injector return Pin 04 of AH when voltage supply at Pin 13 of AH is off.	
315	Current detected at No. 2 Injector return Pin 14 of AH when voltage supply at Pin 05 of AH is off.	
321	Current detected at No. 4 Injector return Pin 06 of AH when voltage supply at Pin 15 of AH is off.	
322	No current detected at No. 1 Injector return Pin 10 of AH when voltage supply at Pin 01 of AH is on.	
323	No current detected at No. 5 Injector return Pin 02 of AH when voltage supply at Pin 11 of AH is on.	
324	No current detected at No. 3 Injector return Pin 12 of AH when voltage supply at Pin 03 of AH is on.	
325	No current detected at No. 6 Injector return Pin 04 of AH when voltage supply at Pin 13 of AH is on.	
331	No current detected at No. 2 Injector return Pin 14 of AH when voltage supply at Pin 05 of AH is on.	
332	No current detected at No. 4 Injector return Pin 06 of AH when voltage supply at Pin 15 of AH is on.	
333	No voltage detected on one or more of the injector supply Pins 01, 03, 05, 11, 13 or 15 of AH when power is commanded.	
335	RAM memory read/write error inside ECM.	
341	ROM memory checksum error inside ECM.	
342	ECM not calibrated with ESDN or internal EEPROM memory error.	
343	Microprocessor communication error inside ECM.	
351	Injector power supply below specifications inside ECM.	
411/413	Data transmission error on control data link Pins 10 and 20 of sensor harness.	
433	Voltage signal at boost pressure signal Pin 26 of sensor harness indicates high boost pressure but other engine characteristics indicate that the boost pressure should be lower.	
434	Battery supply voltage at Pins 20, 21, 22, 23 of AH relative to Pins 09, 25, 27 of AH fell below 6.2 volts for a fraction of a second or ECM was not allowed to power down properly.	

Table 3, Diagnostic Trouble Codes for Cummins Components

Electronic Engine Components, Caterpillar Engines	
Sterling-Installed Components	**Caterpillar-Installed Components**
Vehicle Speed Sensor	Engine Speed Timing Sensor
Dash Data Link	Engine Data Link Connector
Diagnostic Lamp	Engine Control Module (ECM)
Warning Lamp	Coolant Temperature Sensor
Cruise ON/OFF Switch	Oil Pressure Sensor
Cruise SET/CST, ACCL/RSM Switch	Transducer Module
Coolant Level Sensor	Inlet Air Temperature Sensor
Service Brake Switch	Injectors
Parking Brake Switch	Personality Module
Clutch Switch	—
Engine Brake "On/Off" Switch	—
Engine Brake Relay	—
Engine Brake LO/MED/HI Switch	—
Throttle Position Sensor (installed on Sterling pedal assembly, Caterpillar component)	—
Vehicle Speed Buffer (supplied by Caterpillar)	—

Table 4, Electronic Engine Components, Caterpillar Engines

Diagnostic Trouble Codes for Sterling-Installed Components, Caterpillar Engines		
Sterling Components	**DTC Codes**	**Diagnostic Trouble Code Description**
Vehicle Speed Sensor	31	Loss of vehicle speed signal.
Vehicle Speed Sensor	36	Vehicle speed signal: out of range or rate of change.
Vehicle Speed Sensor	41	Vehicle over speed warning.
Parking Brake Switch	57	Parking brake switch fault.
Coolant Level Sensor	12	Coolant level sensor fault.
Coolant Level Sensor	62	Low coolant level warning or very low coolant level.

Table 5, Diagnostic Trouble Codes for Sterling-Installed Components, Caterpillar Engines

Troubleshooting

Diagnostic Trouble Codes for Components Installed By Caterpillar		
DTC Codes	**Diagnostic Trouble Code Description**	**Troubleshooting**
01	Idle shutdown override.	Refer to *Caterpillar 3176/3406 Electronic Troubleshooting Manual*.
21	5-volt short circuit.	
22	Rack position sensor fault—3406 only.	
24	Oil pressure sensor open circuit or short circuit.	
25	Boost pressure sensor open circuit or short circuit.	
26	Atmospheric pressure sensor fault—3176 only.	
27	Coolant temperature sensor open circuit or short circuit.	
28	Check throttle sensor adjustment.	
32	Throttle position sensor fault.	
33	Engine rpm signal out of range—3406 only.	
34	Loss of engine rpm signal.	
35	Engine overspeed warning.	
38	Inlet air temperature sensor open circuit or short circuit—3176 only.	
42	Check timing sensor calibration or boost pressure calibration.	
43	Rack subsystem fault—3406 only.	
44	Timing subsystem fault—3406 only.	
45	Shutoff solenoid fault—3406 only.	
46	Low oil pressure warning or very low oil pressure.	
47	Idle shutdown occurrence.	
48	Excessive engine power—3406 only.	
51	Intermittent battery power to PCM.	
52	PCM or personality module fault.	
53	PCM fault.	
55	No detected fault.	
56	Check customer/system parameters	
57	Parking brake switch fault—3176 only.	
58	Powertrain Data Link—3176 only.	
61	High coolant temperature warning or very high coolant temperature.	
72	Cylinder No. 1 fault or Cylinder No. 2 fault—3176.	
73	Cylinder No. 3 fault or Cylinder No. 4 fault—3176.	
74	Cylinder No. 5 fault or Cylinder No. 6 fault—3176.	

Table 6, Diagnostic Trouble Codes for Components Installed By Caterpillar

Electronic Engine Components, Detroit Diesel	
Sterling-Installed Components	**DDC-Installed Components**
Vehicle Speed Sensor	Synchronous Reference Sensor
Throttle Position Sensor	Timing Reference Sensor
Coolant Level Probe	Turbo Boost Pressure Sensor
Coolant Level Module	Coolant Temperature Sensor
Brake Switch	Pressure Sensor (firetrucks only)
Clutch Switch	Oil Pressure Sensor
Cruise ON/OFF Switch	Fuel Temperature Sensor
Cruise SET/CST, ACCL/RSM Switch	Fuel Pressure Sensor
Cruise Control Relay	Electronic Unit Injectors
Engine Brake ON/OFF Switch	—
Engine Brake Selector Switch	—
Diagnostic Request Switch	—
Shutdown Override Switch	—
Stop Engine Lamp	—
Check Engine Lamp	—
Engine Fluids Lamp	—
Data Link Connector	—

Table 7, Electronic Engine Components, Detroit Diesel

Diagnostic Trouble Codes for Sterling-Installed Components, Detroit Diesel Engines		
Sterling-Installed Components	**DTC Codes**	**Fault Code Description**
Vehicle Speed Sensor	54	Vehicle speed sensor fault or failure.
Throttle Position Sensor	21	High voltage detected at throttle position signal input to the electronic control module.
Throttle Position Sensor	22	Low voltage detected at throttle position signal input to the electronic control module.
Coolant Level Sensor	13	Low voltage detected at the electronic control module input.
Coolant Level Sensor	16	High voltage detected at the electronic control module input.
Coolant Level Sensor	43	System running with low coolant for 7 seconds. Battery voltage greater than 11 volts.
Stop Engine Lamp	31	Open or short circuit.
Check Engine Lamp	31	Open or short circuit.
Cruise Active Lamp	31	Open or short circuit.
Cruise Control Switches	58	Illegal switch combination due to open or short circuits.

Troubleshooting

Diagnostic Trouble Codes for Sterling-Installed Components, Detroit Diesel Engines		
Sterling-Installed Components	**DTC Codes**	**Fault Code Description**
Battery Supply Voltage	46	Engine running with low battery voltage (less than 10 volts) for more than 30 seconds.

Table 8, Diagnostic Trouble Codes for Sterling-Installed Components, Detroit Diesel Engines

Diagnostic Trouble Codes for DDEC-IV Components		
DTC Codes	**Diagnostic Trouble Code Description**	**Troubleshooting**
11	Power take-off speed adjust — low input voltage at the PTOSA input to the ECM.	Refer to *DDC DDEC-IV Troubleshooting Guide*.
12	Power take-off speed adjust—high input voltage at the PTOSA input to the ECM.	
14	Oil or coolant sensor—engine running for 8 minutes with too high a voltage at the ECM input.	
15	Oil or coolant sensor—engine running for 8 minutes with too low a voltage at the ECM input.	
23	Fuel temperature sensor—engine running for 8 minutes with too high a voltage at the ECM input.	
24	Fuel temperature sensor—engine running for 8 minutes with too low a voltage at the ECM input.	
25	No codes—no faults have been detected by DDEC-IV since the last time the codes were cleared.	
26	Power control switch—indicates that the power control switch has been used—this will turn on both the SEL and CEL, the engine will begin to power down and shutdown if equipped with the shutdown feature.	
31	Fault on auxiliary output—one of the following faults has been detected: open circuit in the CEL or SEL, short to ground in the CEL, SEL, cruise active, or 1 of 3 auxiliary drive circuits.	
32	ECM failure—the backup system in the ECM has failed.	
33	Turbo boost sensor—engine running for 5 seconds with too high a voltage at the TBS input to the ECM.	
34	Turbo boost sensor—engine running for 2 seconds with too low a voltage at the TBS input to the ECM.	
36	Oil pressure sensor—engine running for 2 seconds with too low a voltage at the OPS input to the ECM.	
37	Fuel pressure sensor—engine running for 2 seconds with too high a voltage at the input to the ECM.	
38	Fuel pressure sensor—engine running for 2 seconds with too low a voltage at the input to the ECM.	
41	Timing reference sensor—the number of TRS pulses per revolution was incorrect.	
42	Synchronous reference sensor—did not receive an SRS pulse on every firing of the number 1 cylinder.	
43	Low coolant—system running with low coolant for 7 seconds. This will turn on both the CEL, SEL and eventually power down and shut down the engine.	
44	Oil or coolant overtemp—system running for 2 seconds with the oil or coolant temperature greater than calibrated limits, this will turn on both the CEL, SEL and eventually power down and shut down the engine.	
45	Low oil pressure—engine running with the oil pressure less than the calibrated limit for 7 seconds.	

Troubleshooting

Diagnostic Trouble Codes for DDEC-IV Components		
DTC Codes	**Diagnostic Trouble Code Description**	**Troubleshooting**
46	Low battery voltage—engine running with low battery voltage for more than 30 seconds (less than 10 volts).	Refer to *DDC DDEC-IV Troubleshooting Guide*.
47	High fuel pressure—engine running with high fuel pressure for more than 30 seconds.	
48	Low fuel pressure—engine running with low fuel pressure for more than 30 seconds.	
51	EEPROM—an error has been detected in the EEPROM inside the ECM.	
52	ECM failure—the ECM was unable to correctly convert sensor voltages into numbers for computer usage.	
53	EEPROM memory failure—an error has been detected in the EEPROM inside the ECM which affects the logging of trouble codes.	
55	Proprietary communication link failure—an error has occurred in the communication link used between two ECMs on a dual engine set-up.	
56	ECM failure—the ECM was unable to correctly convert voltages into numbers for computer usage.	
61-68	Response time too long—the injector response time was too long or failed to respond.	
71-78	Response time too short—the response time of the injector was under the specified limit.	
81	Crankcase monitor sensor—engine running for 2 seconds with too high a voltage at the CCM input to the ECM.	
82	Crankcase monitor sensor—engine running for 2 seconds with too low a voltage at the CCM input to the ECM.	
84	Crankcase monitor tripped—this indicates the CCM has tripped due to high crankcase pressure (149 series engine only).	
85	Engine has been operating over 2500 rpm for at least two seconds.	

Table 9, Diagnostic Trouble Codes for DDEC-IV Components

Cold Starting Aid Systems

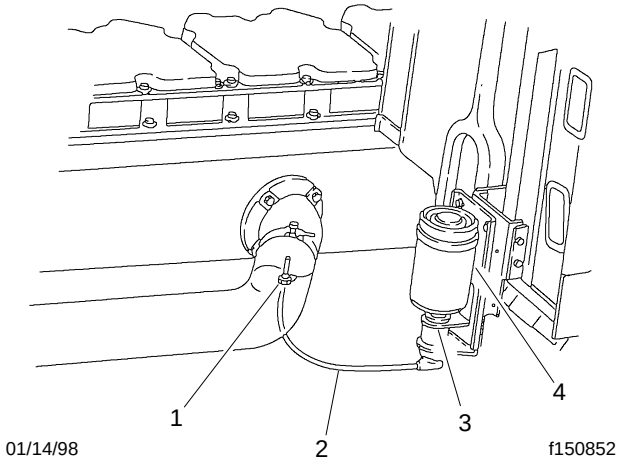
ETHER STARTING AID SYSTEM

The ether starting aid system consists of the following:

- ether supply cylinder
- actuator valve
- engine temperature sensor
- nozzle

The ether starting aid system is a fully automatic engine starting fluid system designed to spray a controlled amount of starting fluid into the air intake system of an engine during and immediately after cranking. See **Fig. 1** and **Fig. 2** for typical installations.

The system's engine temperature sensor switch determines when the system should function. When needed, the actuator valve is activated automatically during engine cranking. The starting fluid is released from the ether supply cylinder, flows through the valve, the vaporizing fitting and the nylon tubing and out of the nozzle located in the engine's air intake system. A reservoir in the valve maintains a flow of starting fluid after cranking to prevent the just started engine from faltering or stalling.



1. Nozzle
2. Supply Tube
3. Control Valve
4. Ether Cylinder

Fig. 1, Ether Cold Starting Aid, Typical Installation

Safety Precautions

WARNING

Ether is extremely flammable, toxic, and harmful or fatal if swallowed. If splashed in the eyes, ether can cause serious injury or blindness. Perform all service operations in a well ventilated area away from heat, open flames, or sparks; wear goggles to prevent eye injury. Make sure the valve, tube, and atomizer openings are pointed away from you and other persons.

AIR INTAKE HEATER STARTING AID SYSTEM

The air intake heater starting aid system consists of the following (see **Fig. 3**):

- starter switch
- engine coolant temperature (ECT) sensor
- engine oil pressure (EOP) switch
- glow plug relay
- fuel solenoid valve
- wait-to-start lamp
- electronic controller

The air intake heater system improves cold weather starting and reduces the white smoke after a cold engine start. The system is activated by an electronic controller when the engine coolant temperature (ECT) is below 45°F (7°C). The intake air is heated by burning a small amount of diesel fuel in the intake manifold. This fuel is ignited by a pair of glow plugs installed in the intake manifold.

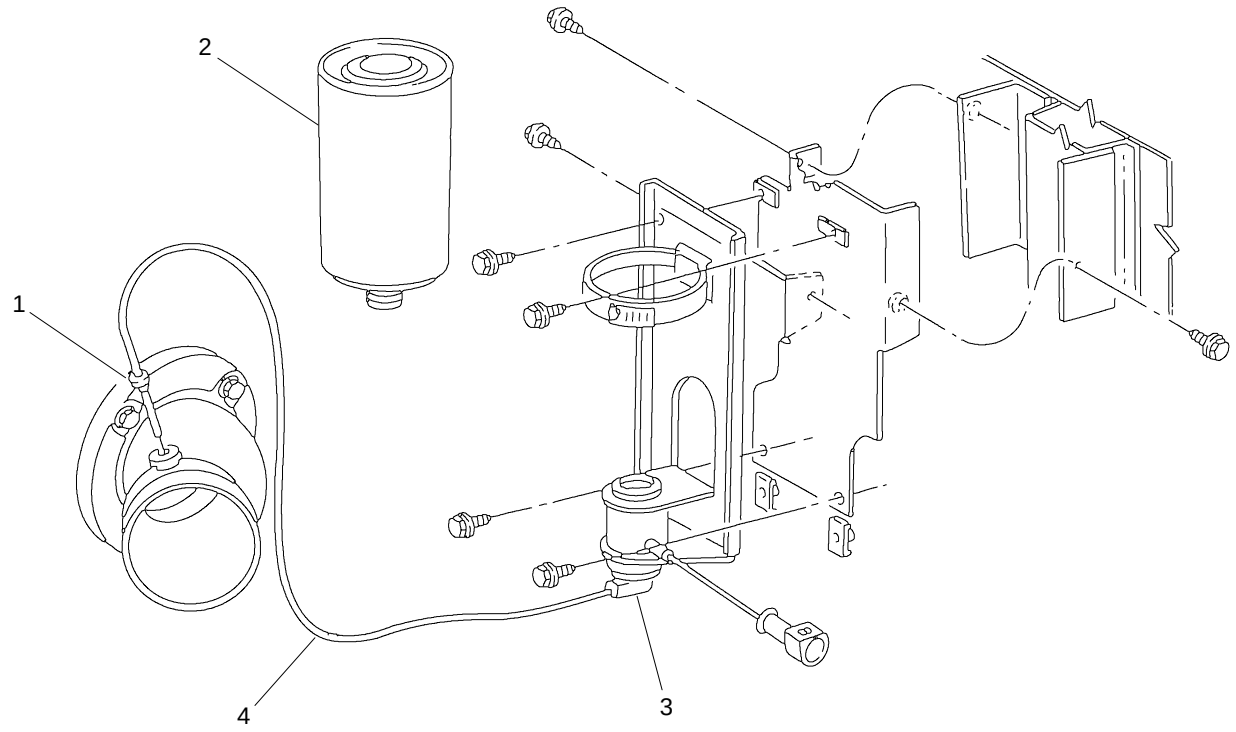
The air intake heater starting aid system operates in two cycles: pre-heat and post-heat. During pre-heat, the wait-to-start light is illuminated while the glow plugs reach operating temperature. After the engine has started, the electronic controller maintains a post-heat cycle for two to three minutes, depending on engine temperature.

ELECTRONIC CONTROLLER INPUTS

The electronic controller input consists of:

- An engine coolant temperature (ECT) sensor: The ECT sensor is installed in the engine

General Information



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1. Nozzle
2. Ether Cylinder
3. Control Valve
4. Supply Tube

Fig. 2, Ether Cold Starting Aid, (Typical Disassembled View)

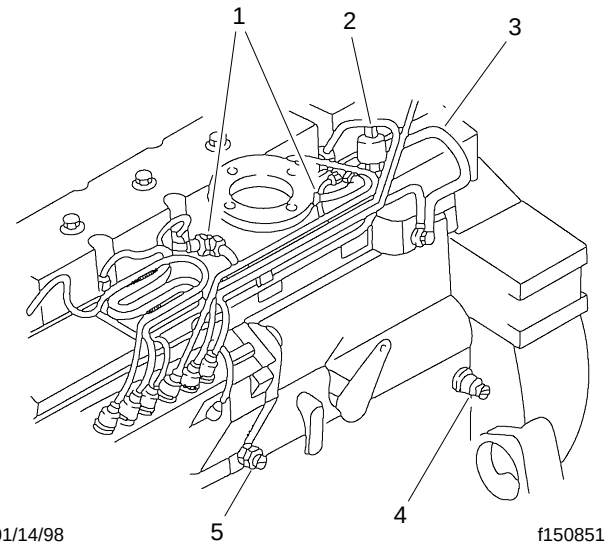
block. Based on this input, the system will activate when the ECT is below 45°F (7°C);

- An engine oil pressure (EOP) switch: The EOP switch provides the electronic controller with the engine running signal. When the electronic controller receives this signal, it switches into the post-heat cycle;
- Engine cranking: The electronic controller is spliced into the starter relay circuit for the engine cranking signal. Based on this input, the electronic controller will open the fuel valve.

ELECTRONIC CONTROLLER OUTPUTS

The electronic controller output consists of:

- Wait-to-start light: The length of time that the wait-to-start light remains on depends on the ECT. This waiting period allows the glow plugs to reach operating temperature. Any diagnostic test codes generated during on-board diagnosis will flash on the wait-to-start light;
- Glow plug relay: The electronic controller provides battery positive voltage to the glow relay coil. When the relay contacts are closed, the glow plugs are connected to battery positive voltage;
- Fuel solenoid valve: Fuel from the multiport fuel injection system enters the glow plugs when the fuel solenoid valve is open. The electronic controller provides battery positive voltage to the fuel solenoid valve when the engine is cranking.



1. Glow Plugs
2. Fuel Solenoid
3. Fuel Supply Hose
4. Oil Pressure Switch
5. Temperature Sensor

Fig. 3, Air Intake Heater Components

ELECTRONIC CONTROLLER OBD

The electronic controller has on-board diagnostic (OBD) capabilities and will perform on-board diagnostics whenever the ignition key is set to "Run". If a fault is detected, the electronic controller will not activate the system and the wait-to-start lamp will flash for ten seconds whenever the key is set to "Run". For more information on the OBD capabilities, see **Subject 300**.

Troubleshooting

Ether Starting Aid System

Inspection and Verification

⚠ WARNING

Ether is extremely flammable, toxic, and harmful or fatal if swallowed. If splashed in the eyes, ether can cause serious injury or blindness. Perform all service operations in a well ventilated area away from heat, open flames, or sparks; wear goggles to prevent eye injury. Make sure the valve, tube, and atomizer openings are pointed away from you and other persons.

1. The owner's concern will typically relate to hard starting in cold weather. Verify the concern by attempting to start the engine with the engine coolant temperature (ECT) below 40°F (4°C).
2. Inspect to determine if any of the following mechanical or electrical concerns apply:
3. If the concern(s) remains after the inspection, determine the symptoms and go to the appropriate problem chart.

Visual Inspection Chart	
Mechanical	**Electrical**
Empty or missing ether cylinder Plugged metering orifice Disconnected or damaged supply tube	Wiring to the control valve Wiring to the engine temperature switch

Table 1, Visual Inspection Chart

Problem—Hard Starting, Cold Conditions

Problem—Hard Starting, Cold Conditions	
Possible Cause	**Remedy**
Defective ether start system	Check for battery voltage at the control valve. Remove the ether reservoir. Disconnect the wire at the starter relay S-terminal. Measure the voltage between the control valve electrical connector, Circuit 32 (R/BL), and a clean chassis ground. If the voltage is less than 10 volts, repair the open in Circuit 32 (R/BL). Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 32 (R/BL) for an open between the control valve and the temperature switch. Measure resistance between the control valve connector and the temperature switch connector, Circuit 32 (R/BL). If the resistance is greater than 5 ohms, repair the open in Circuit 32 (R/BL). Test the system for normal operation. If the resistance is less than 5 ohms, check the control valve function. Install a jumper across the temperature switch connector. The valve should make an audible click when it opens. If the control valve opens, replace the temperature switch. Test the system for normal operation. If the control valve does not open, check the temperature switch ground for an open. Measure the resistance between the temperature switch connector, Circuit 57 (BK), and a clean chassis ground. If the resistance is less than 5 ohms, replace the control valve. Test the system for normal operation. If the resistance is greater than 5 ohms, repair the open in Circuit 57 (BK). Test the system for normal operation.
Engine cranks slowly	Refer to the starter motor problem charts in **Group 15**.
Air in the fuel system	Bleed the fuel system.
Engine mechanical problem	Refer to the engine manufacturer's service literature.

Intake Air Heater Starting Aid System

Inspection and Verification

1. Visually inspect each component for a condition that may prevent system operation. Refer to the following list:
   - blown fuse
   - damaged wiring
   - loose or corroded connections
2. If a visual inspection does not isolate a condition preventing the system operation, go to the "On-Board Diagnostics (OBD)" procedure.

ON-BOARD DIAGNOSTICS (OBD)

1. Place the diagnostic switch in the "On" position. The switch is located under the instrument panel.
2. Turn the ignition switch to the "Run" position. The wait-to-start (WTS) light should come on for 10 seconds and then go out. If the light does not come on, go to the problem charts in this section.
3. Place the diagnostic switch in the "Off" position. Wait one second and place the switch in the "On" position. The wait-to-start light should flash for 10 seconds at a rate of four flashes per second, indicating the controller has entered the system self test.
4. If a fault has occurred, the wait-to-start light will flash one of the following codes.
5. At the end of the self test, the WTS light will flash four times per second, indicating that the controller has reached the crank signal input test. Crank engine for several seconds. If the controller receives a crank signal, the WTS light will go out, ending the self test.
6. If the controller does not receive a crank signal, the WTS light will flash for an additional 20 seconds.

Fault Code Chart	
Code	**Fault**
1	Relay Coil Output
2	Fuel Solenoid Output
3	Oil Pressure Switch Input
4	Temperature Sensor Input
5	Battery Feed to Glow Plugs

Table 2, Fault Code Chart

DIAGNOSTIC TEST CODE CHART

Diagnostic Test Code Chart	
Result	**Flash Code**
Relay Coil Output	1/2-second flash "On", 1/2-second flash "Off" with a 2 second delay before the next set of code flashes.
Fuel Solenoid Output	Two 1/2-second flashes "On" with a 2 second "Off" delay between sets of code flashes.
Oil Pressure Switch Input	Three 1/2-second flashes "On" with a 2 second "Off" delay between sets of code flashes.
Temperature Sensor Input	Four 1/2-second flashes "On" with a 2 second "Off" delay between sets of code flashes.
Battery Feed to Glow Plugs	Five 1/2-second flashes "On" with a 2 second "Off" delay between sets of code flashes.

Table 3, Diagnostic Test Code Chart

Problem—Fuel Solenoid Fault Code

Problem—Fuel Solenoid Fault Code	
Possible Cause	**Remedy**
Fuel solenoid defective	Check Circuit 455 (GR/R) for an open. Measure the resistance between connector C156, Terminal D and the solenoid feed wire Circuit 455 (GR/R). If the resistance is greater than 5 ohms, repair the open in Circuit 455 (GR/R). Test the system for normal operation. If the resistance is less than 5 ohms, check the fuel solenoid ground. Measure the resistance between the solenoid case and a clean chassis ground. If the resistance is greater than 5 ohms, clean the solenoid to ground surface. Test the system for normal operation. If the resistance is less than 5 ohms, check the fuel solenoid function. Connect a wire between the solenoid battery feed terminal and the battery positive (+) post. Connect a wire between a clean chassis ground and the solenoid ground terminal. If the solenoid clicks, replace the controller. Test the system for normal operation. If the solenoid does not click, replace the fuel solenoid. Test the system for normal operation.

Problem—Oil Pressure Switch Fault Code

Problem—Oil Pressure Switch Fault Code (See Fig. 1)	
Possible Cause	**Remedy**
Oil pressure switch defective	Check for continuity at the oil pressure switch. Start the engine. Measure the resistance between the pressure switch terminals. If the resistance is greater than 5 ohms, replace the oil pressure switch. Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 868 (R/BR) for an open. Measure the resistance between connector C155, Terminal C, Circuit 868 (R/BR) and the oil pressure switch connector. If the resistance is greater than 5 ohms, check Circuit 937 (BK) for an open. Measure the resistance between connector C156, Terminal B and the oil pressure switch Circuit 937 (BK). If the resistance is less than 5 ohms, replace the controller. Test the system for normal operation. If the resistance is greater than 5 ohms, repair the open in Circuit 937 (BK). Test the system for normal operation.

Troubleshooting

Problem—Battery Feed to Glow Plugs Fault Code

Problem—Battery Feed to Glow Plugs Fault Code	
Possible Cause	**Remedy**
Battery feed to glow plugs fault	Check Circuit 37 (BK/Y) for an open. Measure the voltage at the glow plug relay, Circuit 37 (BK/Y). If the battery voltage is less than 10 volts, repair the open in Circuit 37 (BK/Y). Test the system for normal operation. If the voltage is greater than 10 volts, check the relay. Connect a 6-gauge wire between Circuit 37 (BK/Y) and the glow plug terminal Circuit 118 (R). Measure the voltage at the glow plugs. If voltage is greater than 10 volts, replace the relay. Test the system for normal operation. If the voltage is less than 10 volts, check circuit 118 (R). Measure the resistance between the relay terminal Circuit 118 (R) and the glow plug wiring terminal Circuit 118 (R). If the resistance is greater than 5 ohms, repair the open on Circuit 118 (R). Test the system for normal operation. If the resistance is less than 5 ohms, check the glow plug ground Circuit 57 (BK). Measure the resistance between the glow plug case and a clean chassis ground. If the resistance is less than 5 ohms, replace the glow plug. If the resistance is greater than 5 ohms, repair open in Circuit 57 (BK). Test the system for normal operation.

Problem—System Inoperative, Wait-to-Start Light Does Not Come On

Problem—System Inoperative, Wait-to-Start Light Does Not Come On (See Fig. 1)	
Possible Cause	**Remedy**
System fault	Check the wait-to-start light. Connect a jumper between the controller connector Terminal F of connector C156 and a clean chassis ground. If the wait-to-start light does not come on, check Circuit 709 (W/BL). Replace the wait-to-start bulb with a known good bulb. Connect a jumper wire between connector C156, Terminal F, Circuit 709 (W/BL) and a clean chassis ground. If the wait-to-start light comes on, run a self test to verify normal operation. If the wait-to-start light does not come on, check for continuity on Circuit 709 (W/BL). Measure the resistance between connector C156, Terminal F, Circuit 709 (W/BL) and the wait-to-start bulb socket terminal. If there is continuity, repair the open in the battery feed to the bulb. Test the system for normal operation. If there is no continuity, repair the open on Circuit 709 (W/BL). Test the system for normal operation. If the wait-to-start light comes on, check for battery voltage at Circuit 717 (BL/R). Measure the voltage at connector C155, Terminal A, Circuit 717 (BL/R). If the voltage is greater than 10 volts, check Circuit 25 (BK/O) for an open. Measure the resistance between connector C156, Terminal C, Circuit 25 (BK/O) and a clean chassis ground. If there is no continuity, repair the open in Circuit 25 (BK/O). Test the system for normal operation. If there is continuity, check for battery voltage on Circuit 32 (R/BL). Measure the voltage at connector C155, Terminal B, Circuit 32 (R/BL) while cranking the engine. Measure the voltage at connector C155, Terminal B, Circuit 32 (R/BL). If battery voltage is present, replace the controller. Test the system for normal operation. If battery voltage is not present, repair the open in Circuit 37 (R/LB). Test the system for normal operation. If the voltage is less than 10 volts, check for battery voltage to Fuse 7. Measure battery voltage at Fuse 7 battery feed terminal. If the voltage is less than 10 volts, repair the open in the battery feed to Fuse 7. Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 717 (BL/R) for an open. Measure the resistance between connector C155, Terminal A, Circuit 717 (BL/R) and the Fuse 7 terminal. If the resistance is less than 5 ohms, replace the controller. Test the system for normal operation. If the resistance is greater than 5 ohms, repair the open in Circuit 717 (BL/R). Test the system for normal operation.

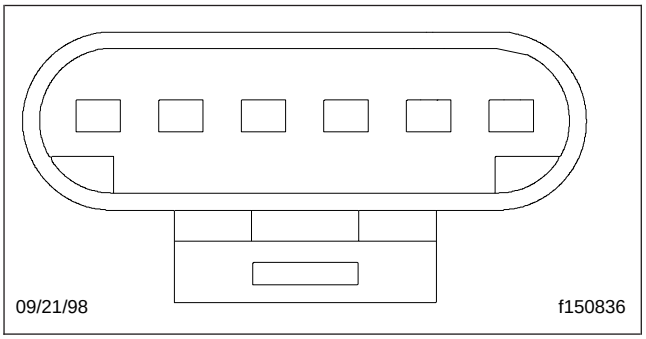
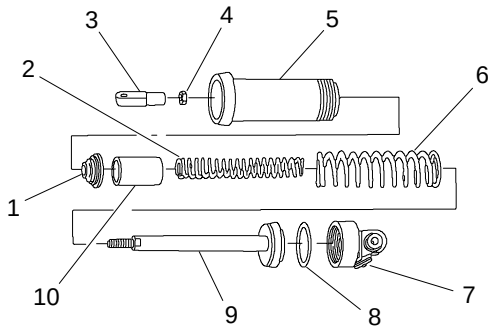


Fig. 1, Connector C155 and C156

General Information

An exhaust brake is an auxiliary braking system that attaches to the engine exhaust system. The exhaust brake functions by partially closing off the exhaust pipe, creating an increase in exhaust pressure.

During vehicle deceleration, the engine must turn against this back pressure creating a braking effect on the drive wheels. The effect of the exhaust brake is to make the engine act as a compressor. The exhaust brake is used to aid the service brakes in slowing the vehicle down, reducing service brake wear. The maximum allowable exhaust back pressure is 35 psi (241 kPa) at 2860 rpm. Refer to **Fig. 1** for exhaust brake air cylinder components.



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1. Spring Cap
2. Small Spring
3. Clevis
4. Jam Nut
5. Cylinder
6. Large Spring
7. Supply End of Cylinder
8. O-Ring
9. Push Rod and Seal
10. Locator

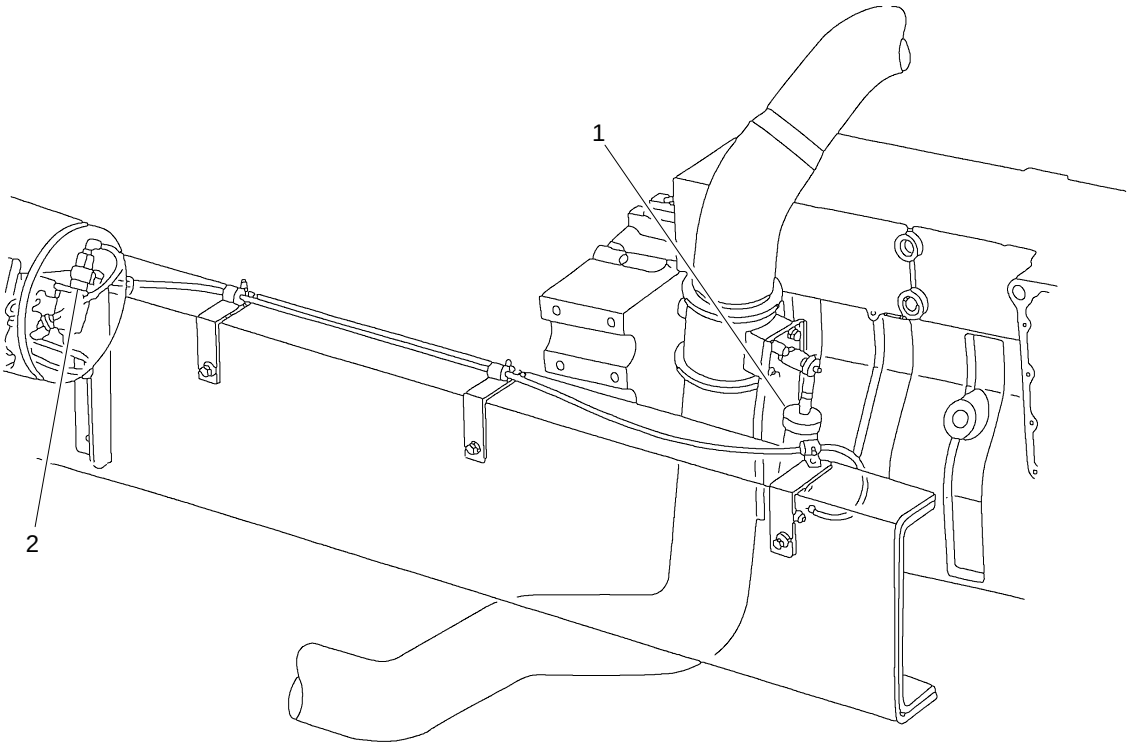
Fig. 1, Exhaust Brake Air Cylinder

The exhaust brake consists of an air actuated cylinder attached to a butterfly type valve. The air cylinder is controlled by a pneumatic valve mounted to the frame rail. The pneumatic valve is controlled by the engine control module (ECM) through the exhaust brake relay.

With the exhaust brake "On/Off" switch in the "On" position, the accelerator pedal released and the clutch pedal in the "Up" (clutch engaged) position, the exhaust brake will be activated. When the accelerator pedal or the clutch pedal is depressed, or when the antilock brake system (ABS) is activated, the exhaust brake will deactivate.

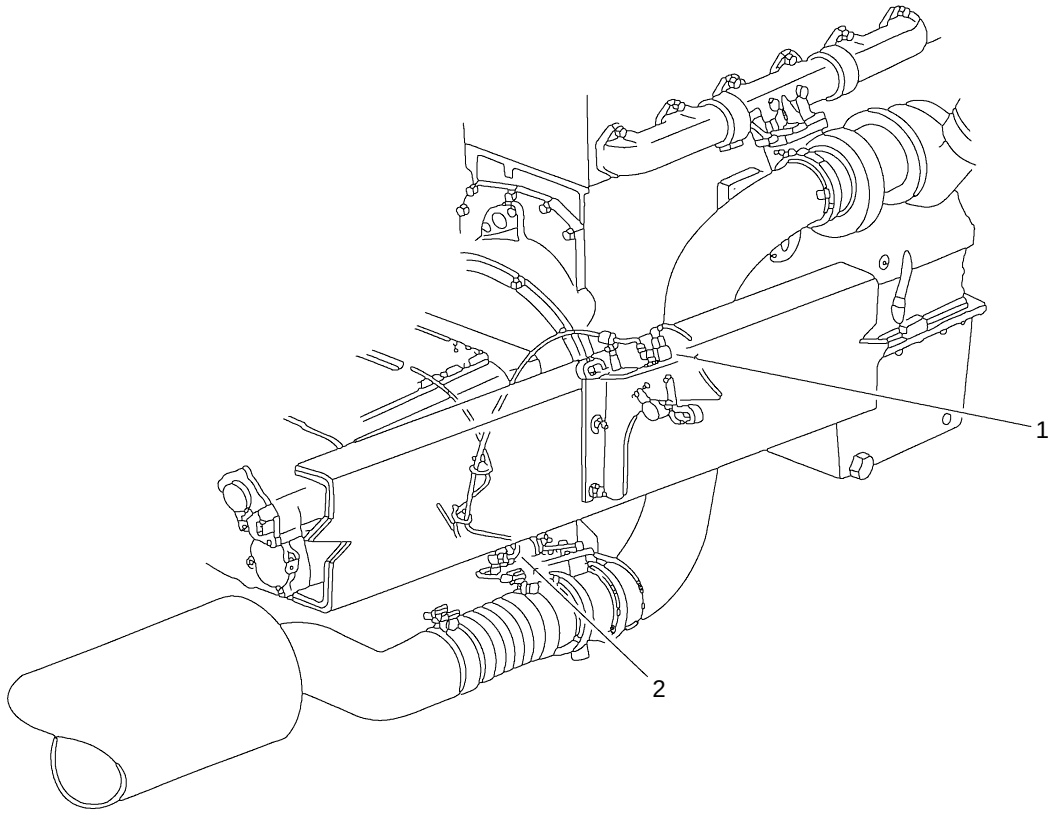
See **Fig. 2**, **Fig. 3** and **Fig. 4** for specific engine model locations.

General Information



1. Exhaust Brake Assembly
2. Control Valve

Fig. 2, Exhaust Brake Horizontal Exhaust, Cummins ISC Engine and Caterpillar 3126 Engine (Cummins ISC Engine Shown)



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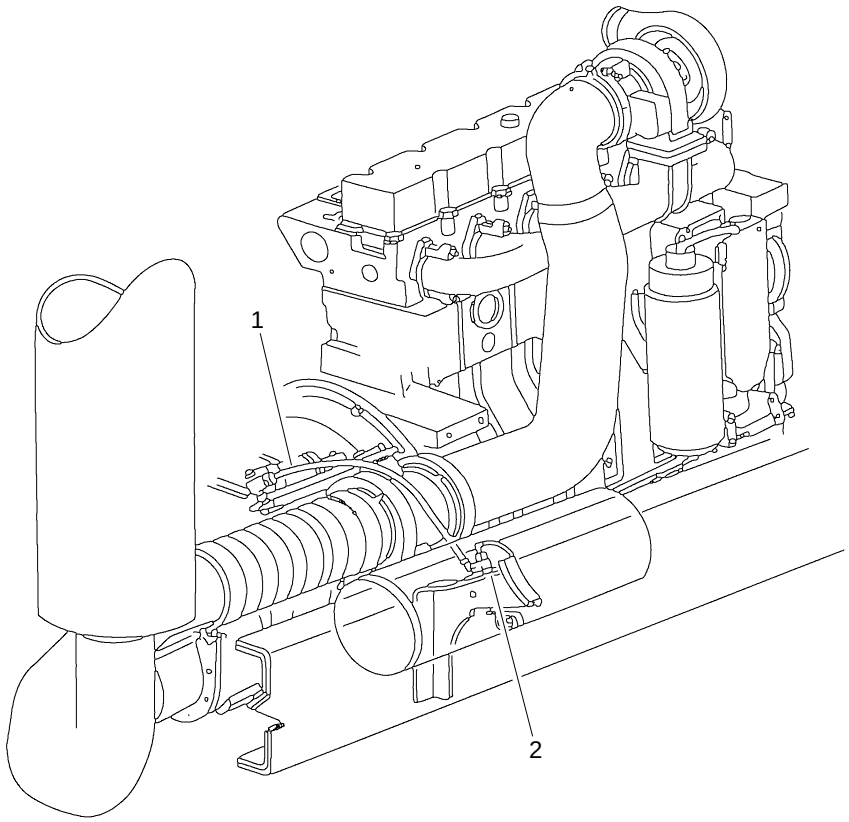
1. Exhaust Brake Assembly
2. Control Valve

Fig. 3, Exhaust Brake Horizontal Exhaust, Cummins ISB

General Information



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1. Exhaust Brake Assembly
2. Control Valve

Fig. 4, Exhaust Brake Vertical Exhaust, Cummins ISC Engine and Caterpillar 3126 Engine (Cummins ISC Engine Shown)

Exhaust Brake Assembly Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Bleed the air storage tanks.
3. Disconnect the air line. See **Fig. 1**.

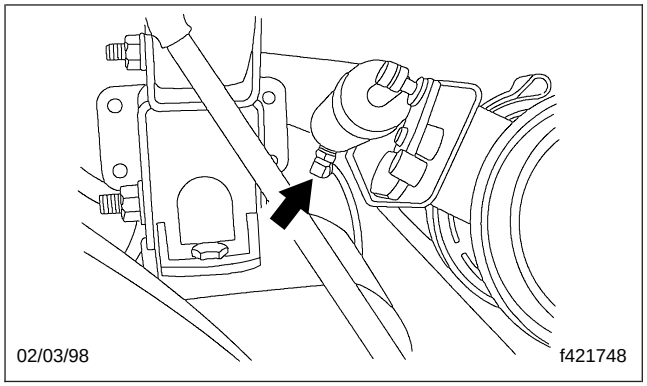


Fig. 1, Air Line

4. Loosen the two clamps retaining the exhaust brake valve body to the exhaust pipes. See **Fig. 2**.

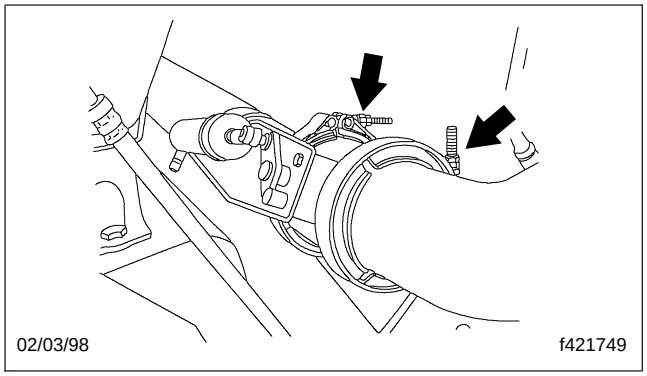


Fig. 2, Clamps

5. Remove the exhaust brake valve from the exhaust pipes.

Installation

1. Position the exhaust brake valve in the exhaust system.
2. Tighten the two clamps retaining the exhaust brake valve body to the exhaust pipes. See **Fig. 2**.
3. Connect the air line. See **Fig. 1**.
4. Remove the chocks from the tires.

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Bleed the air storage tanks.
3. Disconnect the air line.
4. Remove the two roll pins. See **Fig. 1**.

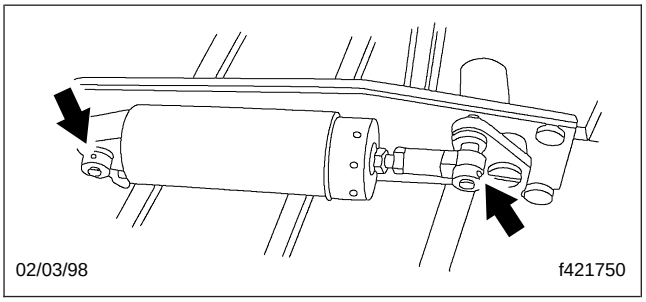


Fig. 1, Roll Pins

WARNING

The accumulator spring is under strong compression. Use caution when removing the retaining ring and cover. Wear safety glasses. If the spring is accidentally discharged, personal injury may result.

5. Remove the actuating cylinder.

Installation

WARNING

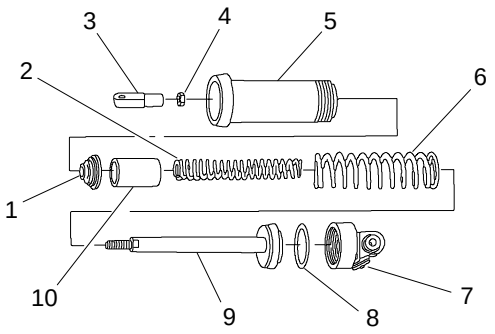
The accumulator spring is under strong compression. Use caution when removing the retaining ring and cover. Wear safety glasses. If the spring is accidentally discharged, personal injury may result.

1. Position the actuating cylinder into the body of the exhaust brake assembly.
2. Install the two roll pins. See **Fig. 1**.
3. Connect the air line.
4. Remove the chocks from the tires.

Actuating Cylinder Disassembly and Assembly

Disassembly (See Fig. 1)

NOTE: For component locations see **Subject 050**.



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1. Spring Cap
2. Small Spring
3. Clevis
4. Jam Nut
5. Cylinder
6. Large Spring
7. Supply End of Cylinder
8. O-Ring
9. Push Rod and Seal
10. Locator

Fig. 1, Exhaust Brake Air Cylinder

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Mount the actuator valve in a vise.
3. Measure and record the assembled length of the valve.
4. Remove the jam nut and the clevis from the rod.
5. Remove the supply end from the cylinder.
6. Remove the O-ring from the cylinder.
7. Remove the push rod and seal from the cylinder.
8. Remove the two springs from the cylinder.
9. Remove the locator and the spring cap from the cylinder.

Assembly

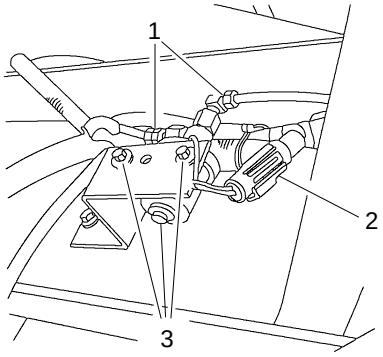
1. Mount the actuator valve in a vise.
2. Install the locator and the spring cap on the cylinder.
3. Install the two springs on the cylinder.
4. Install the push rod and seal on the cylinder.
5. Install the O-ring on the cylinder.

   Lubricate the seal and the O-ring with Silicone Lubricant COAZ-19553-AA or equivalent meeting Sterling specification ESR-M13P4-A.
6. Install the supply end on the cylinder.
7. Install the jam nut and the clevis on the rod.
8. Remove the chocks from the tires.

Pneumatic Solenoid Control Valve Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Bleed the air storage tanks.
3. Remove the solenoid valve. See **Fig. 1**.



1. Air Line
2. Electrical Connector
3. Bolts, Nuts and Valve

Fig. 1, Solenoid Valve

3.1 Disconnect the two air lines.

3.2 Disconnect the electrical connector.

3.3 Remove the two nuts, bolts and the valve.

Installation

1. Install the two nuts, bolts and the valve.
2. Connect the two air lines.
3. Connect the electrical connector.
4. Install the solenoid valve. See **Fig. 1**.
5. Remove the chocks from the tires.

Accelerator Switch Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Disconnect the electrical connector. See **Fig. 1.**

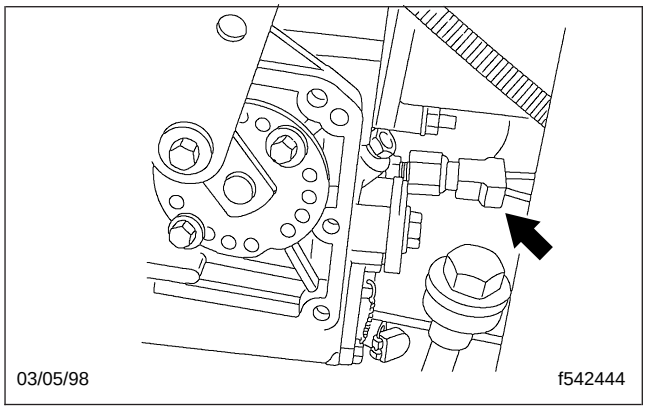
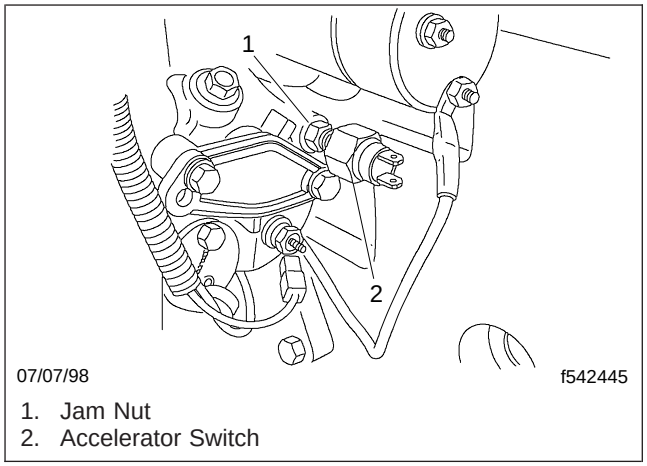


Fig. 1, Accelerator Switch Electrical Connector

3. Remove the accelerator switch. See **Fig. 2.**
   - 3.1 Loosen the jam nut.
   - 3.2 Remove the switch.



1. Jam Nut
2. Accelerator Switch

Fig. 2, Accelerator Switch

Installation

1. Loosen the jam nut.
2. Install the accelerator switch.
3. Adjust the accelerator switch. See "Accelerator Switch Adjustments" in **Subject 160**.
4. Tighten the jam nut.
5. Remove the chocks from the tires.

Exhaust Brake "On/Off" Switch Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Remove the T-handle from the trailer brake lever, if so equipped.
3. Remove the eight screws retaining the instrument panel center panel. See **Fig. 1**.

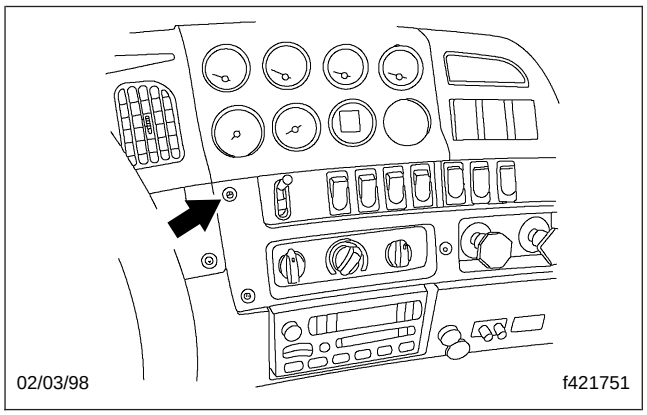


Fig. 1, Instrument Panel Screws (Eight)

4. Raise the panel.
5. Disconnect the electrical connector. See **Fig. 2**.

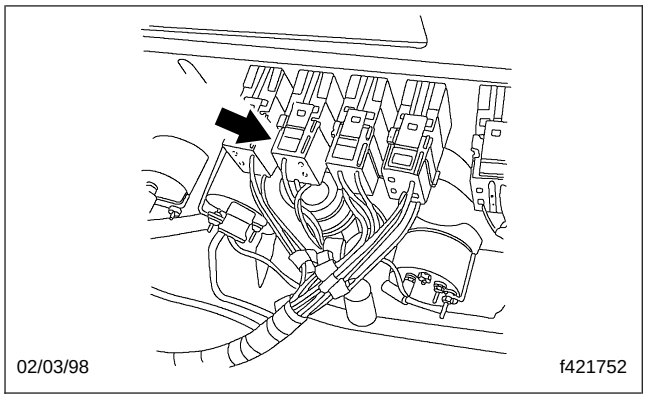


Fig. 2, Electrical Connector

6. Depress the retaining clips and remove the switch from the panel. See **Fig. 3**.

Installation

1. Raise the instrument panel.

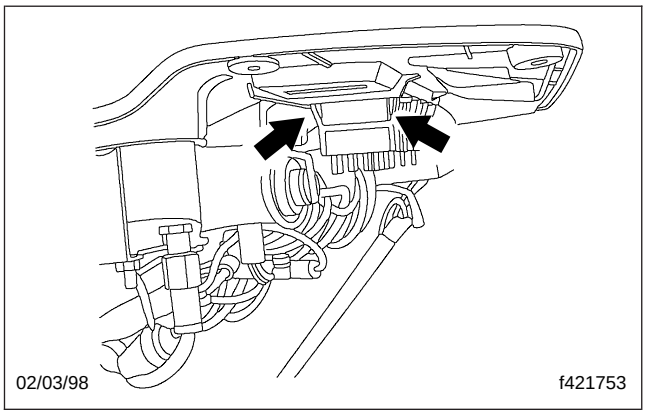


Fig. 3, Exhaust Brake Switch Retaining Clips

2. Depress the retaining clips and install the switch into the instrument panel. See **Fig. 3**.
3. Connect the electrical connector. See **Fig. 2**.
4. Install the eight screws retaining the instrument panel center panel. See **Fig. 1**.
5. Install the T-handle onto the trailer brake lever, if so equipped.
6. Remove the chocks from the tires.

Brake Body Valve Adjustments

The exhaust brake valve is factory pre-adjusted. No adjustment is necessary, and no adjustment should be attempted.

Accelerator Switch Adjustments

NOTE: The exhaust brake switch must be adjusted with the engine running.

Adjust the exhaust brake switch using the following procedure:

1. Loosen the jam nut.
2. Turn the switch until the engine idle rpm is within the manufacturer's specifications.
3. Tighten the jam nut.

Troubleshooting

Diagnosis and testing procedures for Sterling-installed components are covered in this section.

Diagnosis, testing, and specifications for all other components are detailed in the appropriate engine manufacturer's service literature.

INSPECTION AND VERIFICATION, EXHAUST BRAKE

⚠ CAUTION

Never operate the exhaust brake if the engine condition is in doubt. Do not operate the vehicle if the exhaust brake is stuck in the "On" position or engine damage can occur.

1. Verify the customer's concern by operating the exhaust brake system to duplicate the condition.

   Before road testing the vehicle to test operation of the exhaust brake:

   - Inspect the exhaust system for leaks;
   - Bring the engine up to operating temperature;
   - Make sure the vehicle air system is at full operating pressure.

2. Inspect to determine if one of the following mechanical or electrical concerns applies:

Visual Inspection Chart	
Mechanical	**Electrical**
Actuator cylinder is not working	Fuse 9
Valve is stuck	Connections that are not clean and tight
Air line is loose or restricted	Wiring that is broken, shorted or corroded
Switches are not working	Control solenoid is not working

Table 1, Visual Inspection Chart

3. If inspection reveals obvious concerns, correct the concerns before proceeding.
4. If the concern(s) remains after the inspection, determine the symptom(s) and go to the problem charts.

Problem—Exhaust Brake Does Not Operate

Problem—Exhaust Brake Does Not Operate	
Possible Cause	**Remedy**
Damaged or binding actuating cylinder	Replace the actuating cylinder.
Electrical component	Check the exhaust brake control solenoid function. Disconnect the control solenoid connector. Connect a jumper wire from a B+ source to the exhaust brake control solenoid terminal for Circuit 162 (GR/R). Connect a jumper wire to the control solenoid terminal for Circuit 57 (BK) and a clean chassis ground. If the solenoid does not click, replace the control solenoid. Test the system for normal operation. If the solenoid clicks, check the exhaust brake control solenoid ground circuit. Measure the resistance between the control solenoid terminal for Circuit 57 (BK) and a clean chassis ground. If the resistance is greater than 5 ohms, repair the open in Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check the battery feed circuit to the exhaust brake relay.

Troubleshooting

Problem—Exhaust Brake Does Not Operate	
Possible Cause	**Remedy**
Electrical component *(cont.)*	Turn the ignition switch to the "On" position. Measure the voltage at the exhaust brake relay socket for Circuit 670 (PK). If the voltage is less than 10 volts, repair the open in Circuit 670 (PK). Test the system for normal operation. If the voltage is greater than 10 volts, check the exhaust brake relay ground circuit for continuity. Measure the resistance between the exhaust brake relay socket for Circuit 57 (BK) and a clean chassis ground. If the resistance is greater than 5 ohms, repair the open in Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check the exhaust brake relay coil for continuity. Measure the resistance between the exhaust brake relay coil terminals. If the resistance is greater than 5 ohms, replace the relay. Test the system for normal operation. If the resistance is less than 5 ohms, isolate the exhaust brake relay. Replace the exhaust brake relay with a known good relay. If the system operates normally, return the vehicle to service. If the system is not operating normally, check the continuity of Circuit 162 (GN/R) exhaust brake relay to control solenoid circuit. Measure the resistance between the exhaust brake relay socket and the control solenoid terminal for Circuit 162 (GN/R). If the resistance is greater than 5 ohms, repair the open in Circuit 162 (GR/N). Test the system for normal operation. If the resistance is less than 5 ohms and the vehicle is not equipped with ABS brakes, check the exhaust brake relay coil feed circuit for continuity. If equipped with a Caterpillar engine, disconnect the exhaust brake control switch. Measure the resistance between the exhaust brake switch connector, C2017 and the exhaust brake relay coil feed socket, Circuit 162 (GN/R). If equipped with a Cummins engine, disconnect the ECM. Measure the resistance between Pin C1270–9 and the exhaust brake relay coil feed socket, Circuit 162 (GR/N). If the resistance is greater than 5 ohms, repair the open in Circuit 162 (GR/N). Test the system for normal operation. If the resistance is less than 5 ohms, check the exhaust brake switch continuity. Disconnect the exhaust brake switch connector (Cummins engine). Measure the resistance across the exhaust brake switch. If the ohmmeter does not indicate continuity, replace the exhaust brake switch. Test the system for normal operation. If the ohmmeter indicates continuity, check for continuity between the exhaust brake switch and the ECM. Disconnect the ECM electrical connector. If equipped with a Caterpillar engine, measure the resistance between Pin C110–12 and Pin C2017–3, Circuit 162 (GN/R). If equipped with a Cummins engine, measure the resistance between Pin C170–34 and Pin C2017–3 Circuit 911 (O/W). If the resistance is greater than 5 ohms, repair the open in Circuit 162 (GN/R) or Circuit 911 (BK/W). Test the system for normal operation. If the resistance is less than 5 ohms, and the vehicle is equipped with a Caterpillar engine, refer to the engine manufacturer's service literature for test procedures related to the ECM. If the resistance is less than 5 ohms, and the vehicle is equipped with a Cummins engine, check the exhaust brake switch ground Circuit 937 (BK). Measure the resistance between exhaust brake switch connector C2017, Circuit 937 (BK) and a clean chassis ground. If the resistance is greater than 5 ohms, repair the open in Circuit 937 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, refer to the engine manufacturer's service literature for test procedures related to the ECM. If the resistance is less than 5 ohms and the vehicle is equipped with ABS brakes, check the exhaust brake cutout relay contacts for continuity.

Problem—Exhaust Brake Does Not Operate	
Possible Cause	**Remedy**
Electrical component *(cont.)*	Remove the exhaust brake cutout relay. Measure the resistance across the exhaust brake cutout relay contact terminals. If the resistance is greater than 5 ohms, replace the relay. Test the system for normal operation. If the resistance is less than 5 ohms, check the exhaust brake relay coil for continuity. Measure the resistance across the exhaust brake cutout relay coil terminals. If the resistance is greater than 5 ohms, replace the relay. Test the system for normal operation. If the resistance is less than 5 ohms, check the exhaust brake cutout relay coil Circuit 670 (PK) for a short to ground. Measure the resistance across the exhaust brake cutout relay socket for Circuit 670 (PK) and a clean chassis ground. If the resistance is less than 5 ohms, repair the short to ground. Test the system for normal operation. If the resistance is greater than 5 ohms, check Circuit 162 (GN/R) for continuity (exhaust brake cutout relay to exhaust brake relay circuit). Measure the resistance across the exhaust brake cutout relay terminal for Circuit 162 (GN/R) and the exhaust brake relay terminal for Circuit (162). If the resistance is greater than 5 ohms, repair the open in Circuit 162 (GN/R). Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of Circuit 162 (GN/R) to the exhaust brake cutout relay contacts. If equipped with a Caterpillar engine, measure the resistance between exhaust brake switch connector C2017–3 and the exhaust brake cutout relay socket for Circuit 162 (GN/R). If equipped with a Cummins engine, measure the resistance between ECM connector C170–9 and the exhaust brake cutout relay socket for Circuit 162 (GN/R). If the resistance is greater than 5 ohms, repair the open in Circuit 162 (GN/R). Test the system for normal operation. If the resistance is less than 5 ohms, check the exhaust brake switch continuity. Disconnect the exhaust brake switch connector (Cummins engine). Measure the resistance across the exhaust brake switch. If the ohmmeter does not indicate continuity, replace the exhaust brake switch. Test the system for normal operation. If the ohmmeter indicates continuity, check for continuity between the exhaust brake switch and the ECM. Disconnect the ECM electrical connector. If equipped with a Caterpillar engine, measure the resistance between Pin C110–12 and Pin C2017–3, Circuit 162 (GN/R). If equipped with a Cummins engine, measure the resistance between Pin C170–34 and Pin C2017–3 Circuit 911 (O/W). If the resistance is greater than 5 ohms, repair the open in Circuit 162 (GN/R) or Circuit 911 (BK/W). Test the system for normal operation. If the resistance is less than 5 ohms and the vehicle is equipped with a Caterpillar engine, refer to the engine manufacturer's service literature for test procedures related to the ECM. If the resistance is less than 5 ohms and the vehicle is equipped with a Cummins engine, check the exhaust brake switch ground Circuit 937 (BK). Measure the resistance between exhaust brake switch connector C2017, Circuit 937 (BK) and a clean chassis ground. If the resistance is greater than 5 ohms, repair the open in Circuit 937 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, refer to the engine manufacturer's service literature for test procedures related to the ECM.

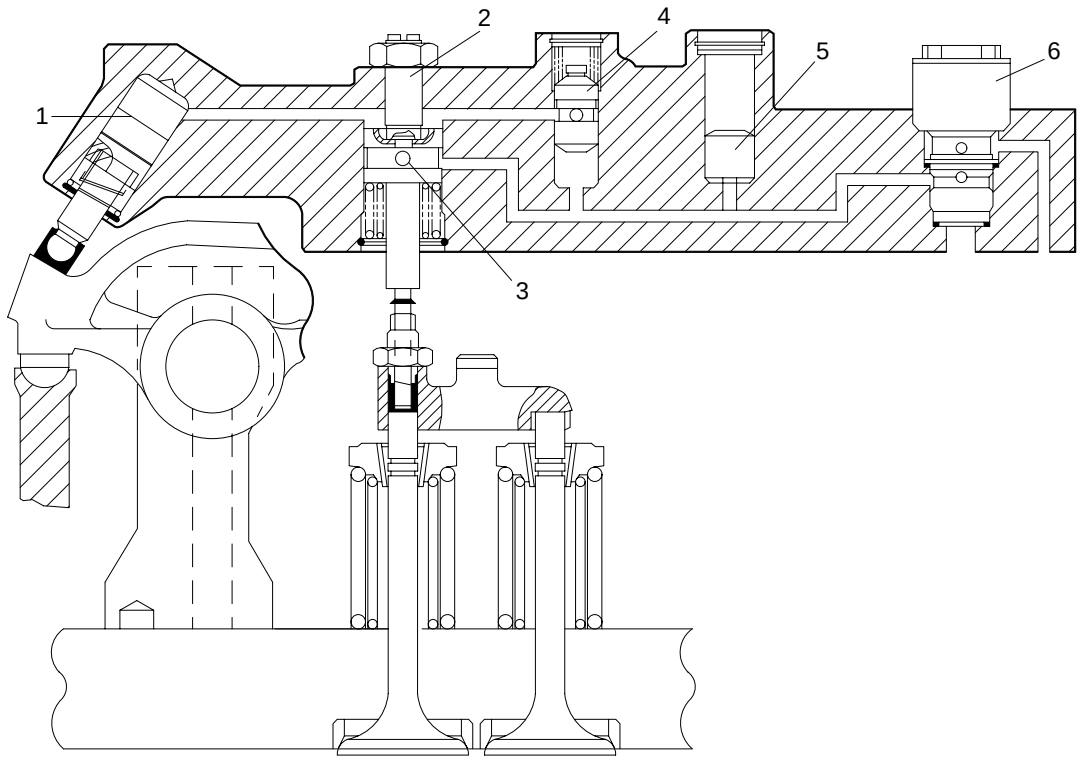
Specifications

General Specifications	
Item	**Part Number**
Silicone Lubricant COAZ–19553–AA	ESR–M13P4–A

Table 1, General Specifications

General Information

MODEL 310A AND 312 (See Fig. 1)



1. Master Piston Assembly
2. Power-Lash™ Slave Piston Adjusting Screw
3. Slave Piston
4. Control Valve
5. Accumulator
6. Solenoid Valve

Fig. 1, Engine Brake Model 310A

The Jacobs engine brake models 310A (installed on Caterpillar™ C-10 engines) and 312 (installed on Caterpillar C-12 engines) slow the vehicle by converting a power-producing diesel engine into a power-consuming air compressor. The brake does this by opening the cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust.

The release or "blowdown" of compressed air to atmosphere prevents the return of energy to the engine piston on the expansion stroke. The effect is a net energy loss, because the work done in compressing the cylinder charge is not returned during the expansion process.

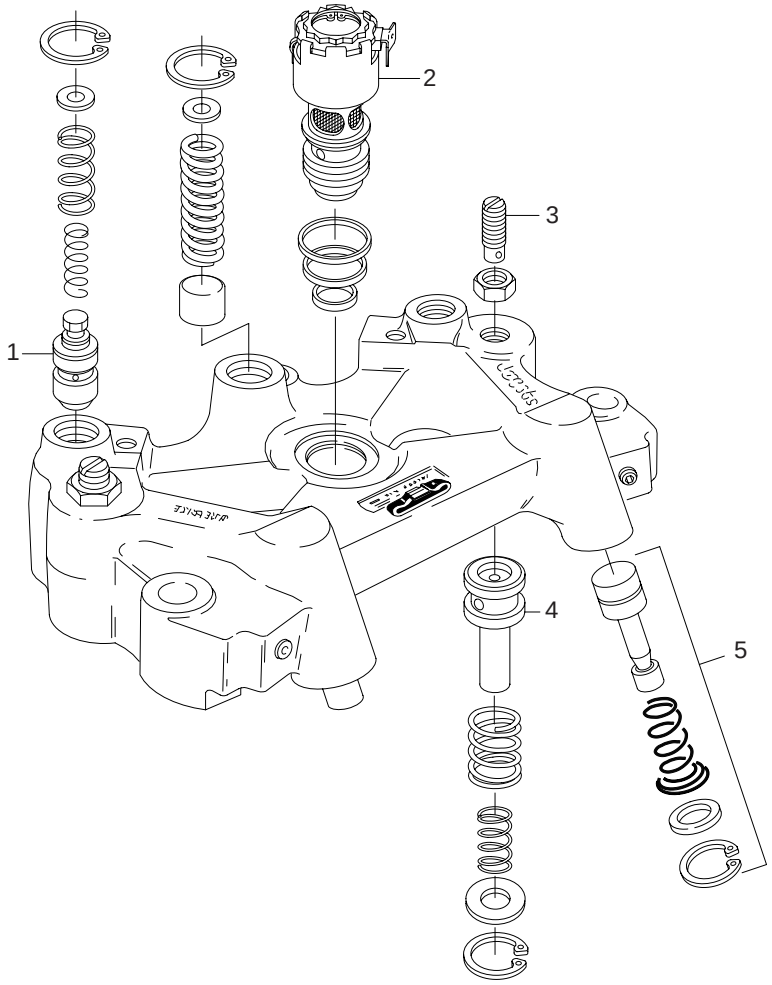
Exhaust blowdown of the braking cylinder is accomplished by using the injector arm motion of that cylinder. See **Fig. 2.**

Energizing the solenoid valve permits engine lube oil to flow under pressure through the control valve to the master piston, slave piston, and accumulator.

Oil pressure makes the master piston move down, coming to rest on the corresponding injector rocker arm.

The injector rocker arm moves (as in a normal injector cycle), forcing the master piston upward and creating a high pressure oil flow to the slave piston of the braking cylinder. The ball check valve in the control valve traps high pressure oil in the master/slave piston system.

General Information



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1. Control Valve
2. Solenoid Valve
3. Power-Lash Slave Piston Adjusting Screw
4. Slave Piston
5. Master Piston Assembly

Fig. 2, Model 310A Engine Brake Components

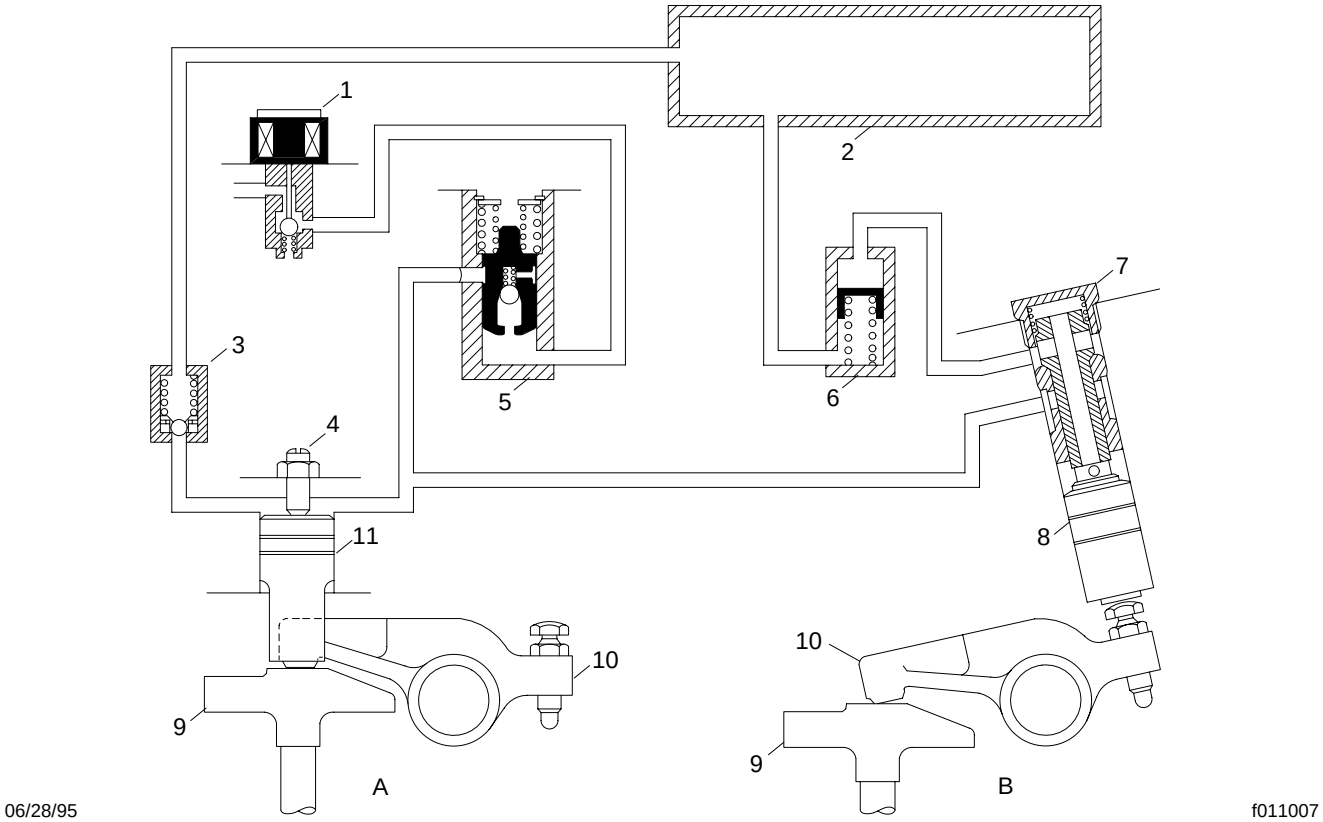
Under the influence of the high pressure oil flow, the slave piston moves down, momentarily opening the exhaust valves at a pre-determined amount of slave stroke. The Power-Lash™ uncovers a passageway in the slave piston, thus allowing oil to flow back to the undersides of the control valve and accumulator piston, where it is stored for the next cycle. Prior to top dead center position, the exhaust valve is forced open, releasing the compressed cylinder air to the exhaust manifold.

Compressed air escapes into the atmosphere, completing the braking cycle.

MODEL 349A (See Fig. 3)

The Jacobs engine brake model 349A is installed on Caterpillar 3406 engine, and slows the vehicle by converting a power-producing diesel engine into a power-consuming air compressor. The brake does this by opening the cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust.

The release or "blowdown" of compressed air to atmosphere prevents the return of energy to the engine piston on the expansion stroke. The effect is a



A. Cylinder Number Three (typical)
B. Cylinder Number One (typical)

1. Solenoid Valve
2. Plenum
3. Check Valve
4. Slave Piston Adjusting Screw
5. Control Valve
6. Delay Piston
7. Trigger Valve
8. Master Piston
9. Bridge
10. Exhaust Rocker Arm
11. Slave Piston

Fig. 3, Model 349A Engine Brake Components

net energy loss, because the work done in compressing the cylinder charge is not returned during the expansion process.

Exhaust blowdown of the braking cylinder is accomplished by using the pushrod motion of an exhaust valve of another cylinder during its normal exhaust cycle. See **Fig. 3**. Cylinder number one exhaust pushrod opens the exhaust valves of cylinder number three in this sequence.

1. Energizing the solenoid valve permits engine lube oil to flow under pressure through the control valve to the master piston and the slave piston.
2. Oil pressure makes the master piston move down, coming to rest on the corresponding exhaust rocker arm adjusting screw.
3. The exhaust rocker pushrod begins upward travel (as in a normal exhaust cycle) forcing the master piston upward and creating a high pressure oil flow to the delay piston.
4. The delay piston moves and compresses the plenum oil to high pressure. The delay piston and plenum act as a high pressure "spring" to activate the slave piston at the appropriate time.
5. The master piston moves upward, and at the appropriate time, opens the trigger valve.

General Information

6. High pressure oil flows from the delay piston through the trigger valve to the slave piston.
7. The slave piston moves down, contacts the exhaust valve bridge, and opens the exhaust valves, releasing compressed air to the exhaust manifold.
8. Compressed air escapes to atmosphere, completing a compression braking cycle.

MODEL 411 (See Fig. 4)

Jacobs engine brake housings are installed on the engine rocker housings. Model 411 (used on Cummins ISM engines with CELECT) has two engine brake housings that operate three cylinders each. Each engine brake housing has a solenoid valve, control valve, ball check valve, master piston, and slave piston.

Engine brake controls consist of: two dash-mounted toggle switches, a clutch switch mounted under the dash, and the throttle switch. The switches are wired in series so that all of the switches must be closed to operate the engine brake. The engine brake is activated when one or both of the dash switches is on (up), and the clutch and throttle pedals are released. The dash switches enable the driver to operate the engine brake partially or fully.

Model 411 engine brakes can be operated at one-half or full capacity (three or six cylinders).

When activated, the engine brake converts a power-producing diesel engine to a power absorbing air compressor. This is accomplished by motion transfer through a master-slave piston arrangement which opens the engine cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust. The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion (power) stroke. This results in a net energy loss because the work done in compressing the cylinder charge is not returned during the expansion process. Exhaust blowdown occurs as follows:

1. Activating the engine brake energizes the solenoid valve, allowing engine oil to flow under pressure through the control valve to both the master piston and the slave piston.
2. Oil pressure causes the master piston to move down, coming to rest on the injector rocker lever adjusting screw.
3. The injector rocker lever adjusting screw begins upward travel (as in the normal injection cycle) forcing the master piston upward and creating a high-pressure oil flow to the slave piston. The ball check valve in the control valve holds the high-pressure oil in the master-slave piston system.
4. When the engine piston is near top dead center, the slave piston moves down under the influence of the high-pressure oil flow. This momentarily opens one of the exhaust valves, releasing compressed cylinder air to the exhaust manifold.
5. Compressed air is released to the atmosphere, completing a compression braking cycle.

MODEL 760A AND 765

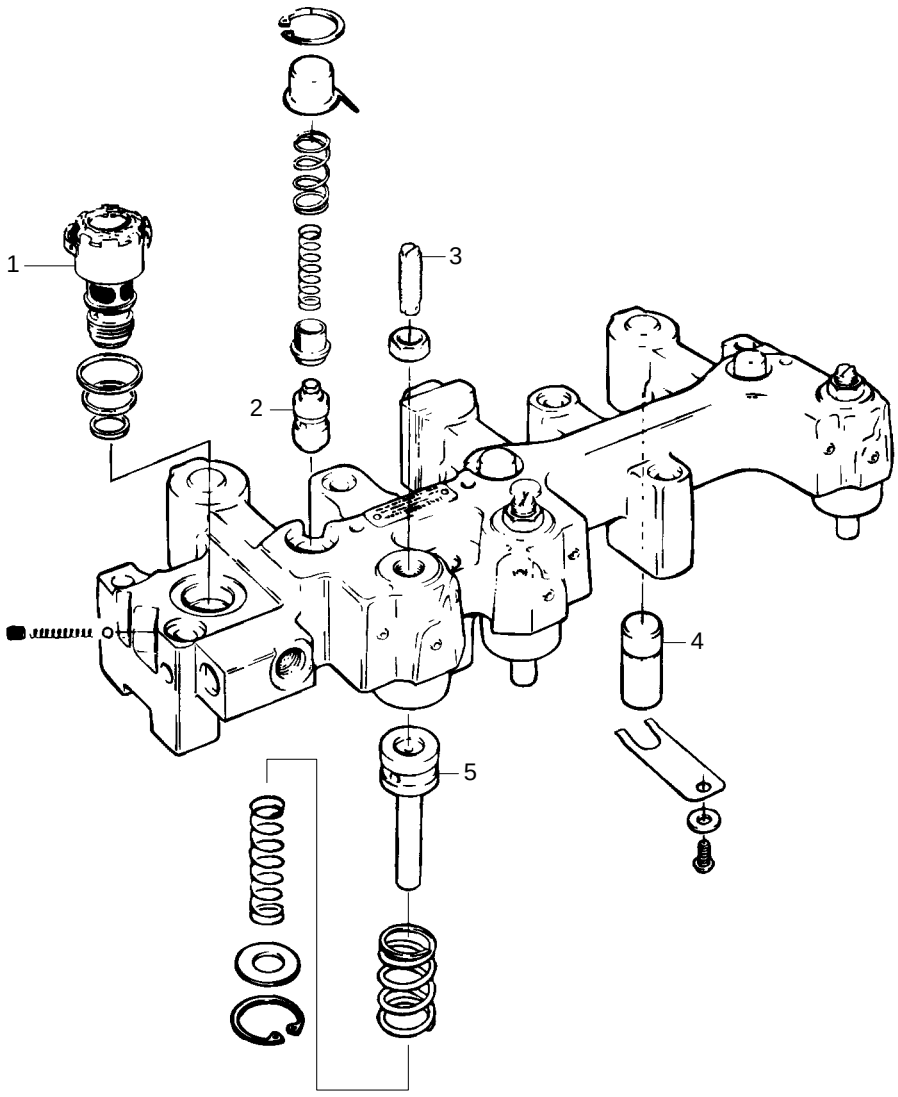
Jacobs engine brake housings are installed on the engine rocker housings. Model 760A (used on Detroit Diesel Series 60 11.1 liter engines) and Model 765 (used on Detroit Diesel Series 60 12.7 liter engines) have three engine brake housings that operate two cylinders each. Each engine brake housing has a solenoid valve, control valves, ball check valves, master pistons, and slave pistons. See **Fig. 5**.

Engine brake controls consist of: dash switches and a clutch switch. The clutch switch is mounted under the dash. The engine brake is activated when the dash switches are on and the clutch and throttle pedals are released. The dash switches enable the driver to operate the engine brake partially or fully.

The engine brake can be operated at one-third, two-thirds, or full capacity (two, four, or six cylinders).

When activated, the engine brake converts a power-producing diesel engine to a power-absorbing air compressor. This is accomplished by motion transfer through a master-slave piston arrangement which opens the engine cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust. The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion (power) stroke. This results in a net energy loss because the work done in compressing the cylinder charge is not returned during the expansion process. Exhaust blowdown occurs as follows (see **Fig. 6**):

1. Activating the engine brake energizes the solenoid valve, allowing engine oil to flow under



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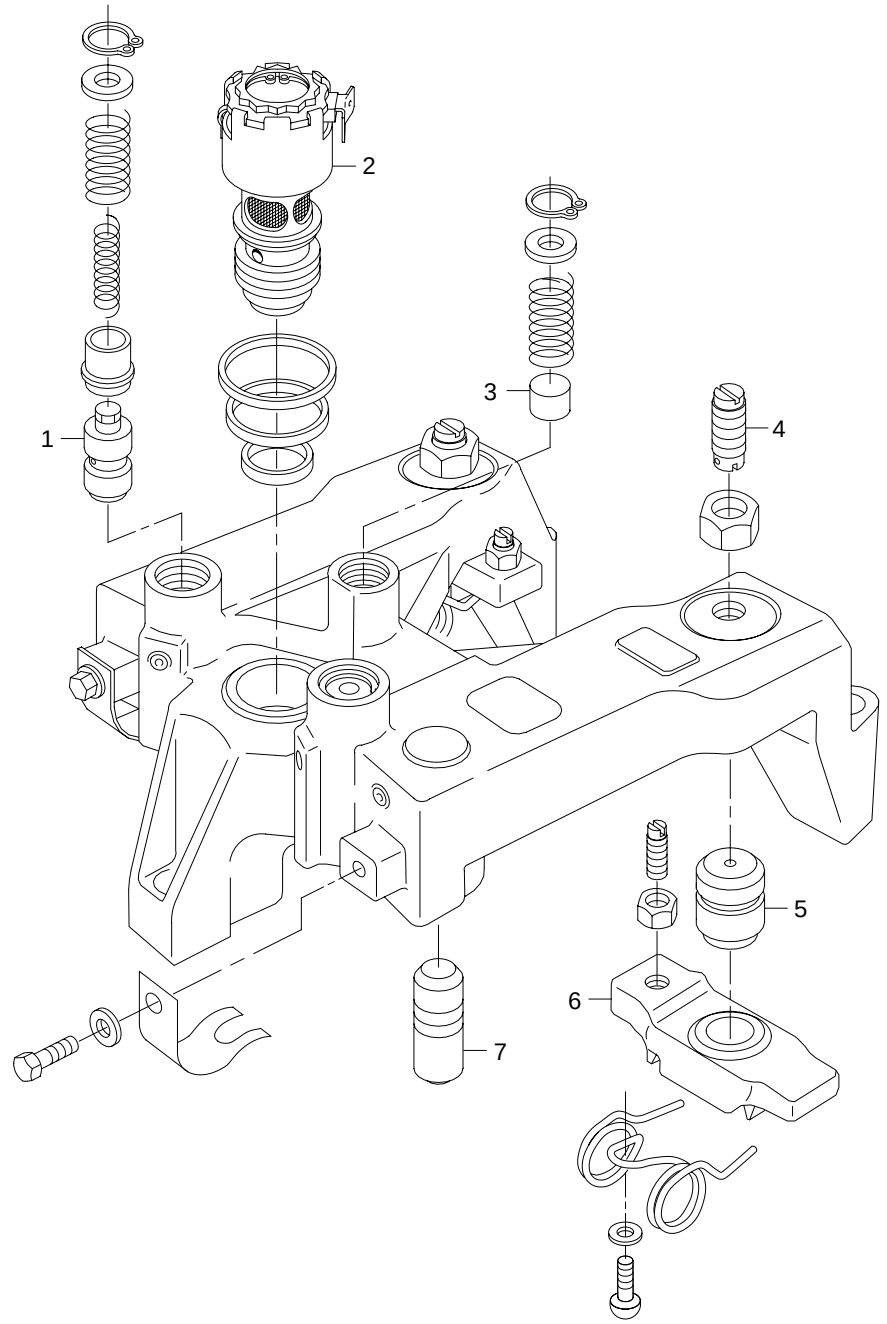
1. Solenoid Valve
2. Control Valve
3. Slave Piston Adjusting Screw (Reset®)
4. Master Piston
5. Slave Piston

Fig. 4, Model 411 Engine Brake Components

pressure through the control valve to both the master piston and the slave piston.

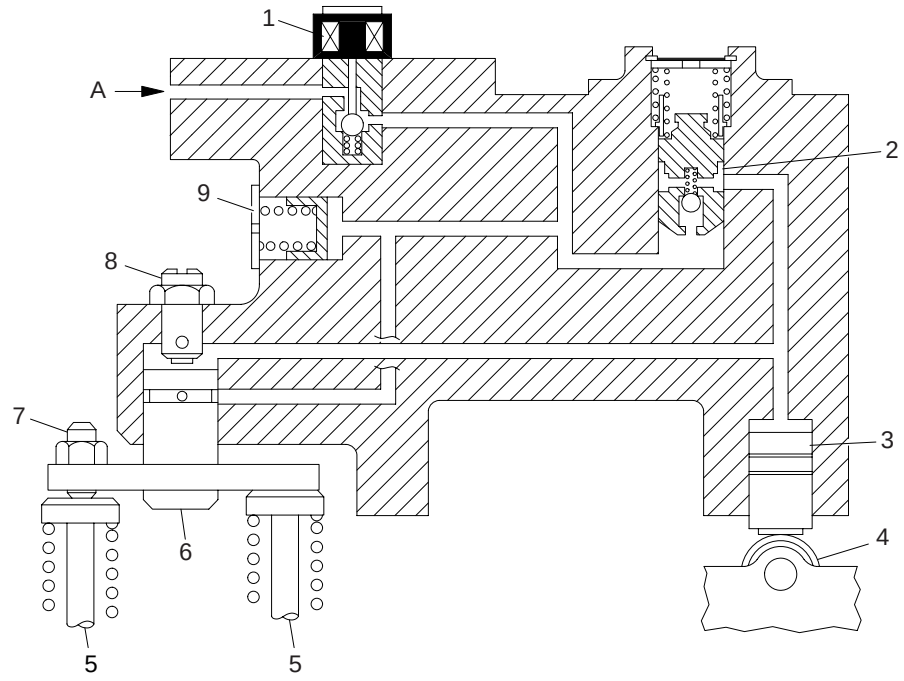
2. Oil pressure causes the master piston to move down, coming to rest on the injector rocker arm roller.
3. The injector rocker arm begins upward travel (as in the normal injection cycle) forcing the master piston upward and creating a high-pressure oil flow to the slave piston. The ball check valve in the control valve holds the high-pressure oil in the master-slave piston system.
4. When the engine piston is near top dead center, the slave piston moves down under the influence of the high-pressure oil flow. This momentarily

General Information



1. Control Valve
2. Solenoid Valve
3. Accumulator Piston
4. Slave Piston Adjusting Screw (Reset)
5. Slave Piston
6. Bridge
7. Master Piston

Fig. 5, Model 760A or 765 Housing Assembly



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A. Oil In
1. Solenoid Valve
2. Control Valve
3. Master Piston
4. Injector Pin and Roller
5. Exhaust Valve
6. Slave Piston Assembly
7. Leveling Screw
8. Slave Piston Adjusting Screw (Reset)
9. Accumulator

Fig. 6, Model 760A and 765

opens the exhaust valves, releasing compressed cylinder air to the exhaust manifold.

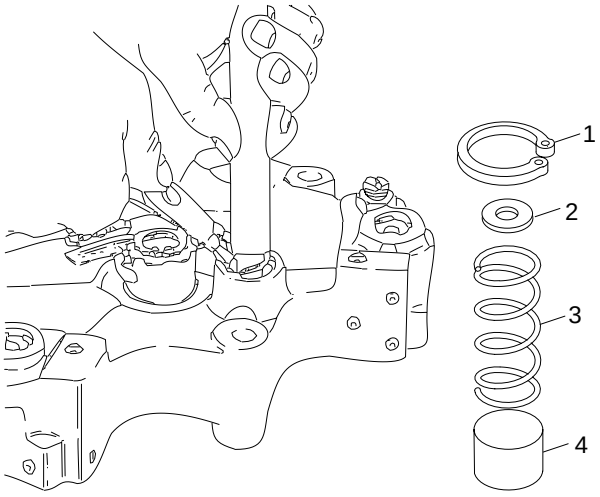
5. At the bottom of its stroke the slave piston separates from the valve in the slave piston reset adjusting screw, allowing high-pressure oil to flow into the accumulator. This reduces the pressure in the high-pressure circuit, permitting the slave piston to retract and the exhaust valves to close in preparation for the normal exhaust valve cycle. The oil pressure reserved in the accumulator ensures that the hydraulic circuit is fully charged for the next cycle.
6. Compressed air escapes to the atmosphere completing a compression braking cycle.

Accumulator Removal and Installation

WARNING

While performing any of the following procedures, never remove or install any engine brake component with the engine running. Serious personal injury could result.

Removal (See Fig. 1)



1. Retaining Ring
2. Accumulator Washer
3. Spring
4. Accumulator Piston

Fig. 1, Accumulator Assembly

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, see **Subject 180**.

WARNING

The accumulator spring is under strong compression. Use caution when removing the retaining ring and cover. Wear safety glasses. If the spring is accidentally discharged, personal injury may result.

4. Push down on the accumulator cover using the appropriate diameter rod and remove the retaining ring.
5. Relieve pressure on the accumulator cover; remove the cover and the spring.
6. Use a magnet to remove the piston from the accumulator bore.

Installation

IMPORTANT: Inspect the parts for wear or damage; replace them if needed.

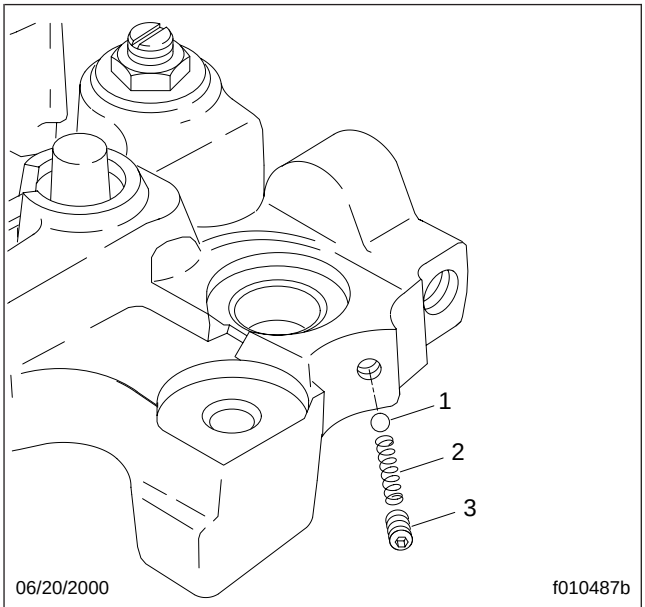
1. Install the piston, the spring, the cover, and the retaining ring.
2. Install the rocker cover. For instructions, see **Subject 180**.
3. Close and latch the hood.
4. Remove the chocks from the rear tires.

Ball Check Valve Removal and Installation

WARNING

While performing any of the following procedures, never remove or install any engine brake component with the engine running. Serious personal injury could result.

Removal (See Fig. 1)



1. Ball
2. Spring
3. Plug

Fig. 1, Ball Check Valve

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Remove the engine brake housing from the vehicle. For instructions, see **Subject 140**.
4. Remove the hex socket pipe plug. Be careful during the final turns to avoid loss of the spring and ball. Remove the spring and ball.

Installation

IMPORTANT: Inspect the parts for wear. Clean them in an approved cleaning solvent, or replace them if necessary.

1. Assemble the ball check valve by inserting the ball and the spring into the engine brake housing. Tighten the plug 106 lbf·in (1200 N·cm).

CAUTION

Make certain the parts are installed in the order shown in Fig. 1. Improper installation may result in engine damage.

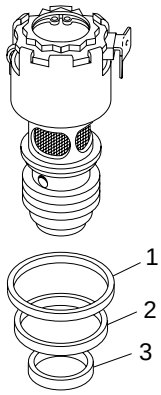
2. Install the engine brake housing using the instructions in **Subject 140**.
3. Close and latch the hood.
4. Remove the chocks from the rear tires.

Solenoid Valve Removal and Installation

⚠ WARNING

While performing any of the following procedures, never remove or install any engine brake component with the engine running. Serious personal injury could result.

Removal (See Fig. 1)



1. Upper Seal
2. Center Seal
3. Lower Seal

Fig. 1, Solenoid Seals

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, see **Subject 180**.

⚠ CAUTION

Do not disassemble or tamper with the solenoid valve. The solenoid valve is not field serviceable. Engine damage could result.

4. Disconnect the solenoid harness. Using a 7/8-inch socket and an extension, unscrew the solenoid valve.
5. Remove and discard the three rubber seal rings. If the lower ring stays in the bottom of the housing bore, remove it with a pick.

Installation

IMPORTANT: Wash out the solenoid valve with an approved solvent. Use a brush to clean the oil screen. When clean, dry the valve with compressed air.

IMPORTANT: Clean out the solenoid valve bore in the housing. Use clean paper towels. Never use rags as they may leave lint and residue that can plug the oil passageways.

1. Using new solenoid seal rings, coat them with clean lube oil. Install the upper and center seal rings on the solenoid body, and install the lower seal ring into the bottom of the solenoid bore in the housing.
2. Be sure the seals are seated properly and carefully screw the solenoid into the housing without unseating the seals. Tighten the valve 5 lbf·ft (7 N·m). Be careful not to twist the seals while installing the solenoid.
3. Install the rocker cover. For instructions, see **Subject 180**.
4. Close and latch the hood.
5. Remove the chocks from the rear tires.

Control Valve Removal and Installation

WARNING

While performing any of the following procedures, never remove or install any engine brake component with the engine running. Serious personal injury could result.

Removal

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, see **Subject 140**.

WARNING

Control valve covers are under load from the control valve springs. Remove with care to avoid personal injury.

4. Apply pressure on the control valve cover and remove the retaining ring, using retaining ring pliers. See **Fig. 1**.

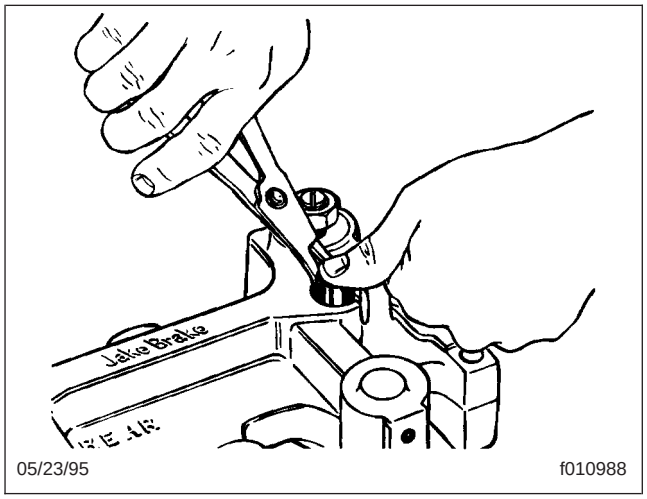


Fig. 1, Remove the Retaining Ring

5. Carefully remove the cover until the spring pressure ceases.
6. Carefully remove both control valve springs and the collar. See **Fig. 2**.

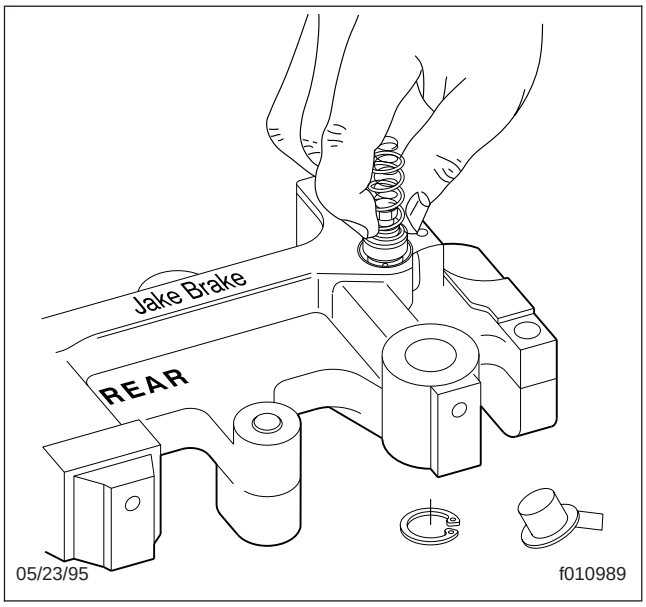


Fig. 2, Remove the Springs and Collar

7. Using needle nose pliers or your fingertips, carefully pull the control valve straight up and out of its bore. See **Fig. 3**.

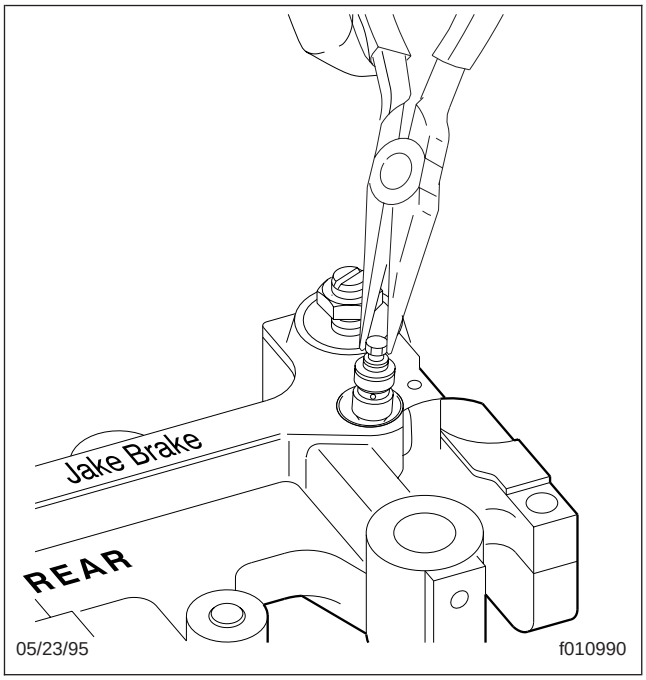


Fig. 3, Remove the Control Valve

Control Valve Removal and Installation

Installation

IMPORTANT: If binding occured during removal, inspect the control valve parts for damage or wear and replace them if necessary.

If there is no damage, clean the parts in an approved cleaning solvent.

⚠ CAUTION

Make sure the control valve collar is installed with the longer sleeve area up. See Fig. 4. If the collar is installed upside down, engine damage may result.

1. Install the control valve, collar, and springs. Make sure the retaining ring ears are positioned opposite the oil drain slot in the housing. See **Fig. 5**.

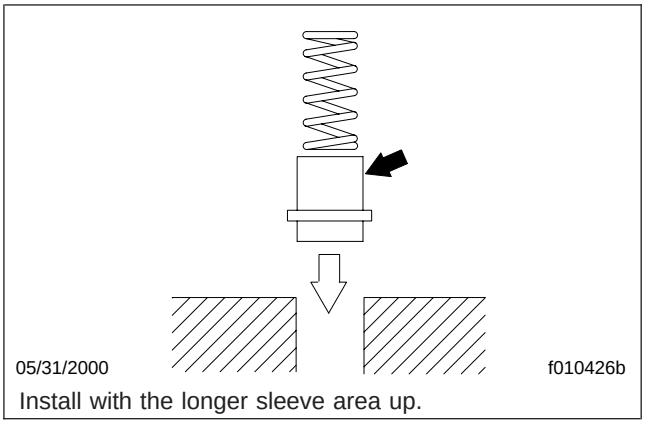


Fig. 4, Control Valve Collar Installation

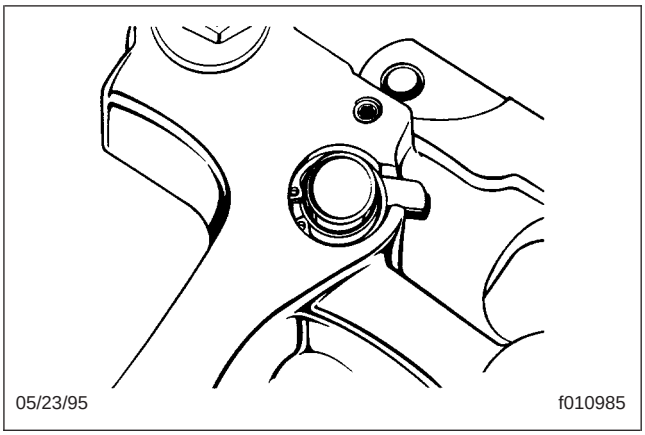


Fig. 5, Check the Retaining Ring Ears

2. Install the rocker cover. For instructions, see **Subject 140**.
3. Close and latch the hood.
4. Remove the chocks from the rear tires.

Engine Brake Housing Removal and Installation

WARNING

While performing any of the following procedures, never remove or install any engine brake component with the engine running. Serious personal injury could result.

Model 349A

REMOVAL

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Disconnect the batteries.
3. Open the hood.
4. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, see **Subject 180**.
5. Remove the brake housing.
   - 5.1 Remove the Jacobs washers and hexhead bolts that run through the housing and support tubes and into the support bases.
   - 5.2 Remove the two flanged screws and washers at the rocker shaft location.
   - 5.3 Remove the brake housing. Repeat this step to remove the second brake housing.

INSTALLATION

1. Install the brake housing.
   - 1.1 Make sure there is an O-ring on the oil supply adapter, and place a small amount of grease on the adapter.

   IMPORTANT: The housings are marked front and rear. The front housing must be installed on the front three cylinders and the rear housing must be installed on the rear three cylinders.

   - 1.2 Place the housing over the studs and install the two support tubes between the housing and support bases.
   - 1.3 Install the Jacobs washers and the hexhead bolts through the housing and support tubes and into the support bases. Hand-tighten the bolts.
   - 1.4 Install the two flanged screws and washers at the rocker shaft location.
   - 1.5 Tighten the flanged screws at the rocker shaft location 60 lbf·ft (82 N·m).
   - 1.6 Tighten the hexhead bolts at the support base locations 60 lbf·ft (82 N·m).
   - 1.7 Tighten the two flanged screws at the rocker shaft location 120 lbf·ft (163 N·m).
   - 1.8 Repeat this step to install the second brake housing.
2. Install the rocker cover. For instructions, see **Subject 180**.
3. Connect the batteries.
4. Close and latch the hood.
5. Remove the chocks from the tires.

Model 411

REMOVAL

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Disconnect the batteries.
3. Open the hood.
4. Wipe clean the engine brake housing area. Remove the rocker housing cover capscrews, and remove the cover and gasket from the spacer.
5. Disconnect the solenoid electrical harness from the terminal leadout in the spacer.
6. Remove the steel plates, O-ring, and gasket from the spacer. Disconnect the oil hose from the front brake housing and remove it through the hole in the spacer.
7. Remove the engine brake housing hold-down capscrews.
8. Remove the engine brake housing from the rocker-shaft supports.

Engine Brake Housing Removal and Installation

INSTALLATION

1. If the oil connector was previously removed from the front housing, install the connector and O-ring into the front housing as far as it will go.
2. Back out the slave-piston adjusting screws until the slave pistons are fully retracted (screws are loose).
3. Place the rear brake housing on the rockershaft supports over cylinders 4, 5, and 6. Loosely install four Jacobs hold-down capscrews. Lubricate the threads and underside of the capscrew heads. Lubricate both ends of the oil supply tube.

NOTE: No washers are used with the capscrews.

4. Place the front brake housing on the rocker-shaft supports over cylinders 1, 2, and 3. Carefully insert the oil connector into the rear housing.
5. Install the capscrews in the sixteen locations and hand-tighten them in the sequence shown in **Fig. 1**.

   Using the same sequence, tighten the capscrews 60 lbf·ft (81 N·m).

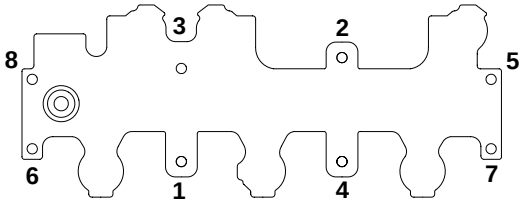


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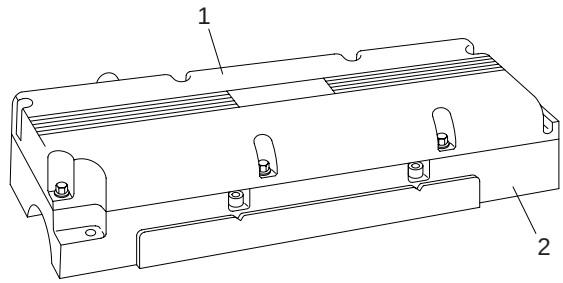
Fig. 1, Capscrew Tightening Sequence

6. Connect the batteries.
7. Close and latch the hood.
8. Remove the chocks from the tires.

Models 760A and 765

REMOVAL

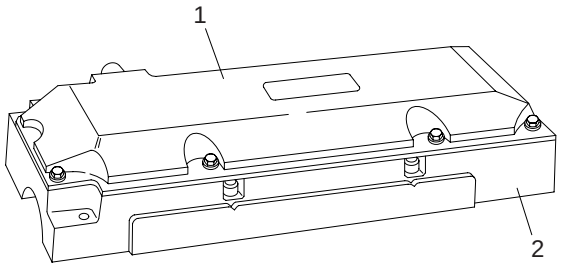
NOTE: The engine brake has been designed to fit on the Series 60 engine with no additional valve cover spacers. On engines equipped with aluminum valve cover caps (**Fig. 2** and **Fig. 3**), it is not necessary to remove the valve cover bases to remove and install the engine brake housings.



07/11/95 f010416

1. Valve Cover Cap, Aluminum Style 1
2. Valve Cover Base

Fig. 2, Valve Cover Cap and Base, Style 1



07/10/95 f010417

1. Valve Cover Cap, Aluminum Style 2
2. Valve Cover Base

Fig. 3, Valve Cover Cap and Base, Style 2

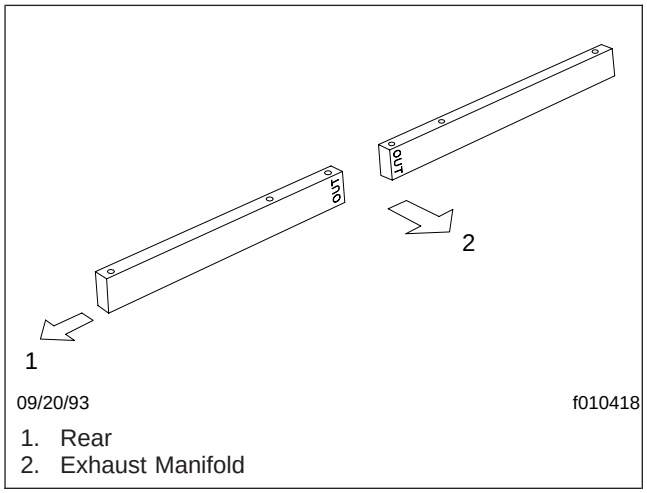
1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Disconnect the batteries.
3. Open the hood.
4. Remove each valve cover and gasket.
5. Remove the engine brake housing hold-down capscrews. There is one capscrew per housing on the camshaft side of the engine. There are two capscrews per housing on the exhaust manifold side of the engine.

Engine Brake Housing Removal and Installation

6. Remove the spacer bar between the exhaust side of each head and each engine brake housing mounting pad.
7. Lift each engine brake housing off the rocker shaft.

INSTALLATION

1. Place the spacer bars between the cylinder head and the engine brake mounting pads on the exhaust manifold side of the head. See **Fig. 4** and **Fig. 5**.



1. Rear
2. Exhaust Manifold

Fig. 4, Spacer Bar Positions

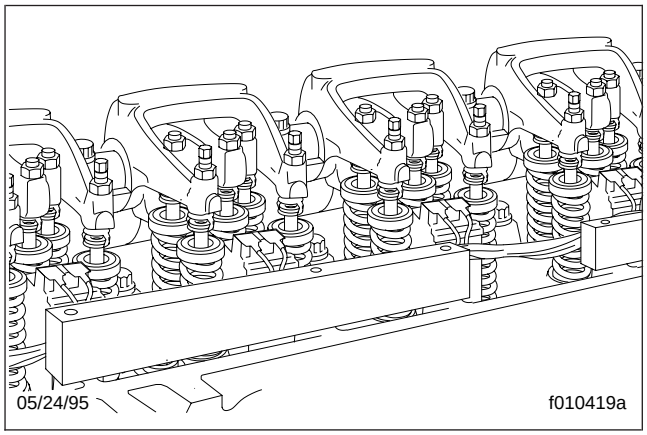


Fig. 5, Spacer Bar Placement

2. Place each engine brake housing over the rocker shaft with the solenoid valves toward the camshaft side of the engine. Make sure the housings do not interfere with the wiring harness.
3. Apply "Never Seize" to the threads and underside of the head of the housing hold-down capscrews.
4. Install a 4-3/8 inch (110 mm) long capscrew and its washer into each engine brake housing. See **Fig. 6** and **Fig. 7**. There are three capscrews per housing.

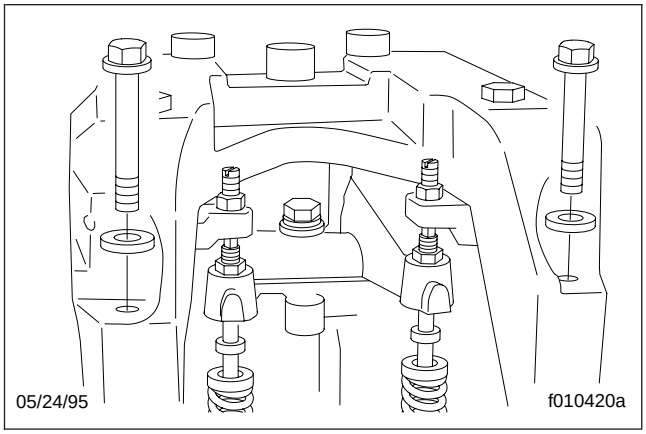


Fig. 6, Capscrews on the Exhaust Manifold Side

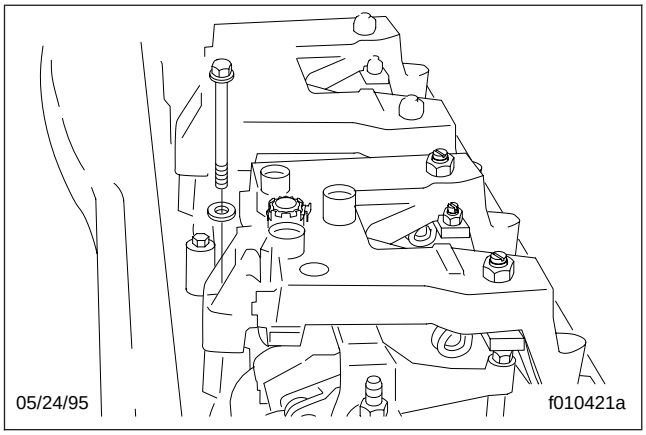


Fig. 7, Capscrew on the Camshaft Side

5. Before tightening the engine brake hold-down capscrew, move the housing from side to side and then locate the housing in the center of the range. See **Fig. 8**.
6. Tighten the engine brake housing hold-down capscrews.

   6.1 Tighten the three capscrews on the camshaft side of the engine 40 lbf·ft (55 N·m).

Engine Brake Housing Removal and Installation

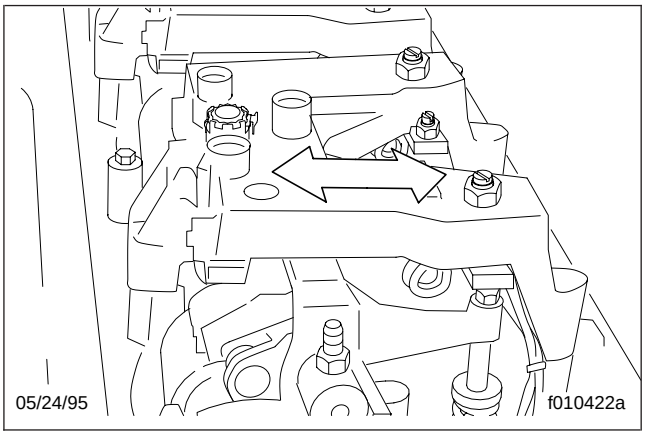


Fig. 8, Center the Housing

6.2 Tighten the six capscrews on the exhaust manifold side of the engine 40 lbf·ft (55 N·m).

6.3 In the same sequence, tighten all capscrews 100 lbf·ft (135 N·m).

7. Using plastic ties, secure the wiring harnesses to the spacer bars.
8. Adjust the slave piston lash. For instructions, see **Subject 170**.
9. Install the valve covers. For instructions, see the engine manufacturer's service manual.
10. Close and latch the hood.
11. Connect the batteries.
12. Remove the chocks from the tires.

Master Piston Removal and Installation

WARNING

While performing any of the following procedures, never remove or install any engine brake component with the engine running. Serious personal injury could result.

Model 310A

REMOVAL (See Fig. 1)

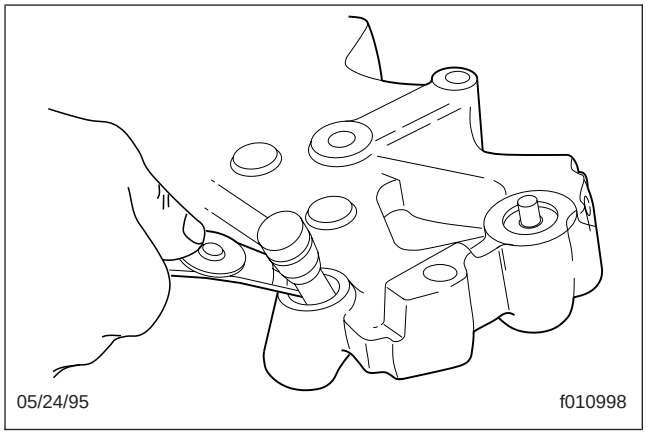


Fig. 1, Removing the Master Piston

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, see **Subject 180**.
4. Press down on the master piston retaining washer to relieve the spring force. While holding the washer, use a pair of snap ring pliers to remove the retaining ring from the groove. Carefully release the retainer and remove it along with the old spring.
5. Remove the master piston from the bore.

INSTALLATION

IMPORTANT: Clean the piston in a solvent and inspect it for wear. Inspect the piston bore for wear.

1. Install a new master piston return spring by inserting the small end into the bore. The large coil, marked with *white* paint, *should always be facing out*.
2. Place the retaining washer and snap ring over the foot of the master piston and compress them into the bore. Using snap ring pliers, replace the snap ring in the groove to retain the master piston.
3. Ensure the snap ring is properly engaged in the groove by gently grasping the master piston foot and pulling out until the master piston bottoms on the retaining washer. Release the master piston. If the assembly is correct, all parts should return to their original position.

NOTE: After the new spring is installed within the retaining washer and snap ring, it is normal to be able to see the spring in the bore around the retaining washer.

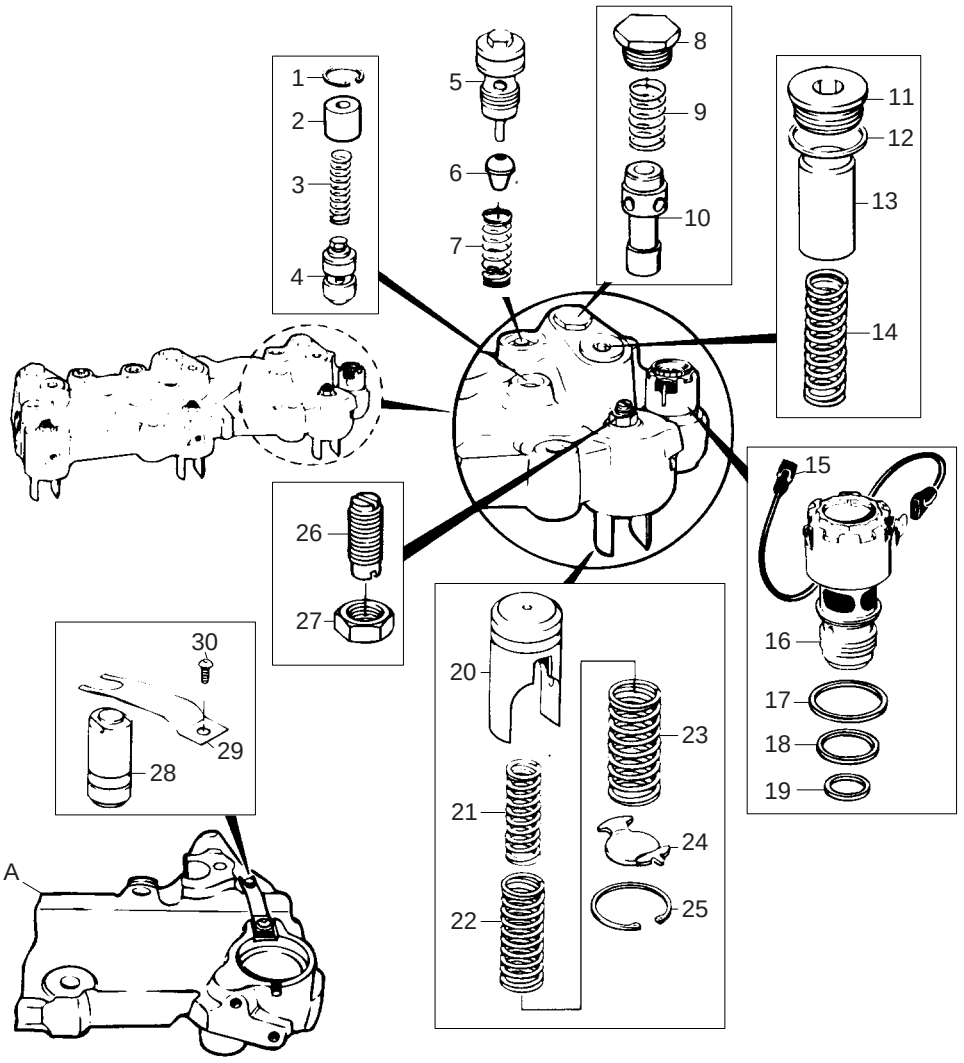
4. Repeat this procedure on the five other master pistons.
5. Install the rocker cover. For instructions, see **Subject 180**.
6. Close and latch the hood.
7. Remove the chocks from the tires.

Model 349A

REMOVAL (See Fig. 2)

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, see **Subject 180**.
4. Remove the engine brake housing. For instructions, see **Subject 140**.
5. Remove the buttonhead screw and the flat spring.
6. Remove the master piston.

Master Piston Removal and Installation



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A. Bottom of Brake Housing
1. Control Valve Retaining Ring
2. Control Valve Spacer/Cover
3. Control Valve Spring
4. Control Valve
5. Check Valve
6. Check Valve Seal
7. Check Valve Spring
8. Trigger Valve Cap
9. Trigger Valve Spring
10. Trigger Valve
11. Delay Piston Cap
12. Delay Piston Copper Seal (if used)
13. Delay Piston
14. Delay Piston Spring
15. Solenoid Valve Harness
16. Solenoid Valve
17. Upper Seal
18. Center Seal
19. Lower Seal
20. Slave Piston
21. Inner Slave Piston Spring
22. Center Slave Piston Spring
23. Outer Slave Piston Spring
24. Slave Piston Retainer
25. Slave Piston Retaining Ring
26. Slave Piston Adjusting Screw
27. Slave Piston Adjusting Screw Locknut
28. Master Piston
29. Master Piston Flat Spring
30. Master Piston Buttonhead Screw

Fig. 2, Brake Housing Assembly

INSTALLATION

IMPORTANT: Inspect all parts for damage and replace as needed.

IMPORTANT: If the master piston hard-face surface is scored or damaged, the corresponding rocker arm adjusting screw, master piston assembly, flat spring, and buttonhead screw must *all* be replaced.

NOTE: Do not change the adjustment of the master piston. Final adjustment is done on the engine.

1. Install the master piston.
2. Install a new flat spring and a new buttonhead screw.
3. Tighten the screw 60 lbf·in (680 N·cm).
4. Install the engine brake housing. For instructions, see **Subject 140**.
5. Install the rocker cover. For instructions, see **Subject 180**.
6. Close and latch the hood.
7. Remove the chocks from the tires.

Model 411

REMOVAL

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Remove the brake housing from the vehicle. For instructions, see **Subject 140**.
4. Remove the screw, washer and master piston spring from the bottom of the housing. See **Fig. 3**.
5. Remove the master piston from its bore. Needle-nose pliers are usually needed to initially pull the piston up. See **Fig. 4**.

INSTALLATION

IMPORTANT: If binding occured during removal, check for burrs or contaminants in the lube oil. If the piston is damaged, replace it. If the piston is not damaged, clean it in a cleaning solvent.

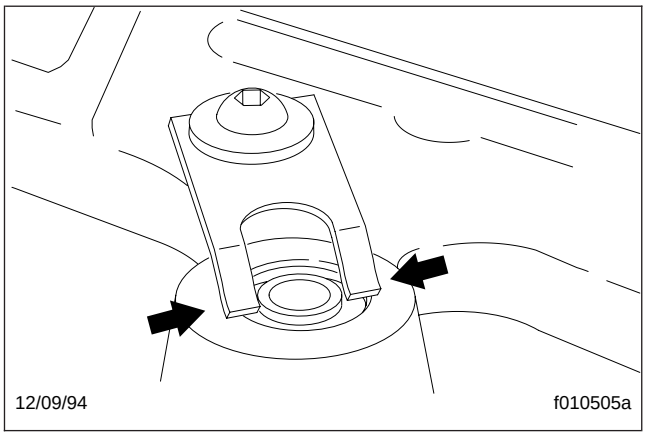


Fig. 3, Remove the Piston Spring

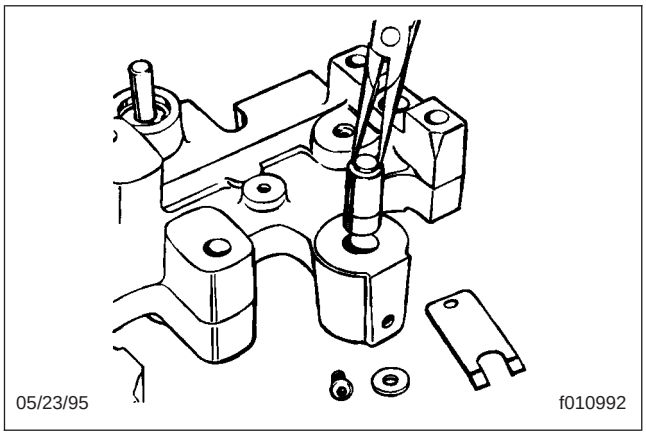


Fig. 4, Remove the Master Piston

1. Install the piston, spring, washer and screw. Make sure that when tightening the capscrew, the two tabs of the spring do not interfere with the sides of the center raised portion of the master piston. See **Fig. 3**.
2. Install the engine brake housing using the instructions in **Subject 140**.
3. Close and latch the hood.
4. Remove the chocks from the tires.

Master Piston Removal and Installation

Models 760A and 765

REMOVAL

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Remove the engine brake housing from the vehicle. For instructions, see **Subject 140**.
4. Remove the screw, washer and master piston spring from the housing. See **Fig. 5**.

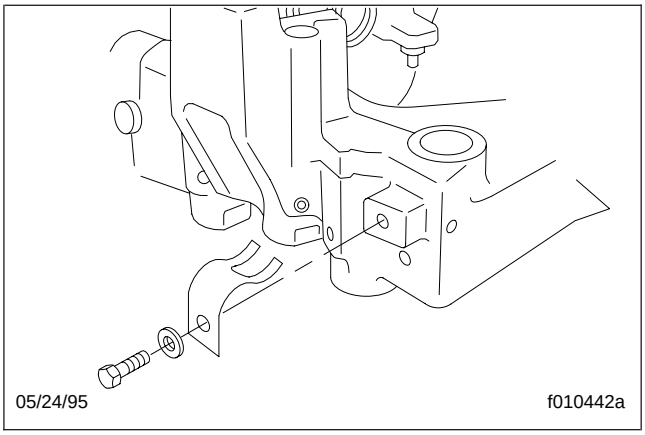


Fig. 5, Remove the Master Piston Spring

5. Using needle nose pliers if necessary, pull out the master piston. See **Fig. 6**.

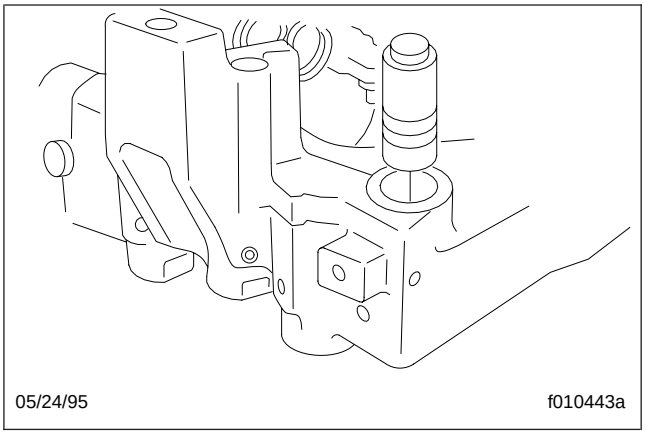


Fig. 6, Remove the Master Piston

INSTALLATION

IMPORTANT: Clean the piston in a cleaning solvent. Inspect the piston for excessive wear and for damage. Replace the piston if necessary.

1. Install the master piston, spring, washer and screw in the housing. See **Fig. 7**.

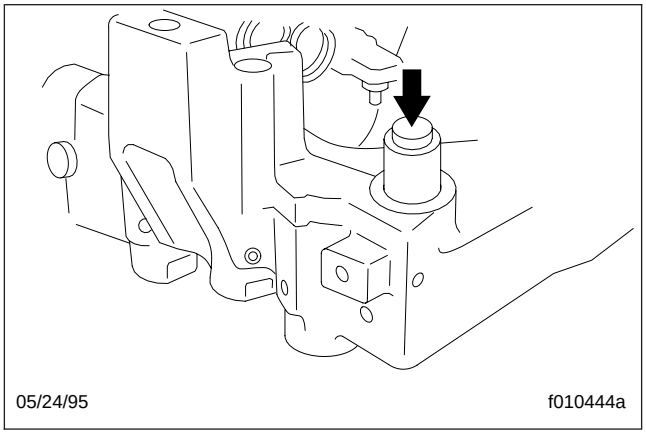


Fig. 7, Install the Master Piston

NOTE: Make sure the spring legs are centered around the master piston boss.

2. Tighten the screw 100 lbf·in (1120 N·cm).
3. Install the engine brake housing on the vehicle. For instructions, see **Subject 140**.
4. Reset the engine brake lash. For instructions, see **Subject 160**.
5. Close and latch the hood.
6. Remove the chocks from the tires.

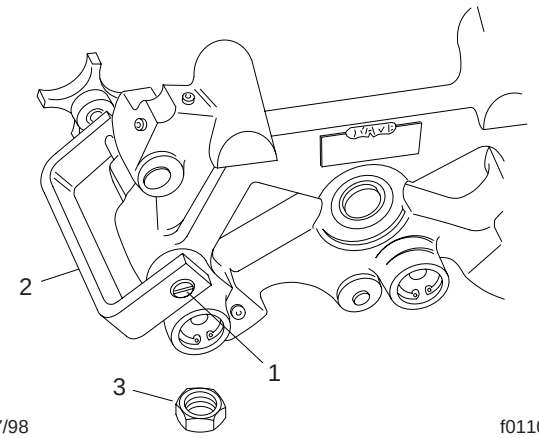
Slave Piston Removal and Installation

⚠ WARNING

While performing any of the following procedures, never remove or install any engine brake component with the engine running. Serious personal injury could result.

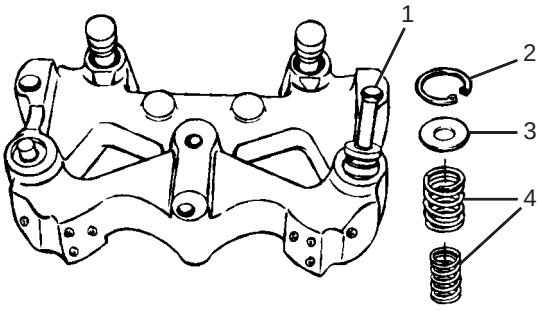
Model 310A

REMOVAL (See Fig. 1 and Fig. 2)



1. Clamp Fixture Hole
2. Clamp Fixture
3. Adjusting Screw Locknut

Fig. 1, Retract the Slave Piston with a Clamp



1. Slave Piston
2. Retaining Ring
3. Spring Retainer
4. Slave Piston Springs

Fig. 2, Slave Piston Components

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, see **Subject 180**.

Slave Piston Removal and Installation

WARNING

The slave piston is retained by springs that are under heavy compression. Use the following tools and instructions or the springs will be discharged with enough force to cause personal injury.

4. Remove the locknut on the slave piston adjusting screw. Back out the adjusting screw until the slave piston is fully retracted (the screw is loose).
5. Place the hole in the clamp fixture over the slave piston adjusting screw. See **Fig. 1**.
6. While holding the fixture in position, screw the holder down over the slave piston until the spring retainer is contacted.
7. Turn the handle slowly until the retainer is depressed to about 1/32 inch (1 mm), relieving pressure against the retaining ring.
8. Remove the retaining ring using retaining ring pliers. Back out the holder until the springs are loose. Remove the fixture.
9. Remove all the components, ensuring there is no binding or burrs.

INSTALLATION

IMPORTANT: Clean all the components in an approved cleaning solvent. Inspect parts and replace as needed.

1. Use the clamp fixture to install the piston and springs. Be sure the retaining ring is placed on the retainer before screwing the clamp-holder down over the slave piston.
2. Compress the slave piston springs down until the retainer is about 1/32 inch (1 mm) below the retaining ring groove. Install the retaining ring. Be sure the retaining ring is fully seated in the groove.
3. Remove the clamp fixture slowly to ensure correct seating of the retaining ring.
4. Install the rocker cover. For instructions, see **Subject 180**.
5. Close and latch the hood.
6. Remove the chocks from the tires.

Model 349A

REMOVAL **(See Fig. 3)**

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, see **Subject 180**.
4. Remove the engine brake housing. For instructions, see **Subject 140**.

WARNING

Remove the slave piston carefully. The slave piston is retained by springs that are under heavy compression. If the following instructions are not followed and proper tools are not used, the springs could be discharged with enough force to cause personal injury.

5. Remove the jam nut from the slave piston adjusting screw (Power-Lash®).
6. Back out the adjusting screw until the slave piston is fully retracted (the screw is loose).
7. Install the slave piston removal tool and turn the handle in to relieve the spring pressure.
8. Using retaining ring pliers, rotate the retaining ring to the slot in the housing and remove the retaining ring.
9. Turn the tool handle out to relieve the spring force, and remove the retainer, the springs and the slave piston.

INSTALLATION

1. Using the slave piston removal tool, install the slave piston, springs, retainer, adjusting screw, and jam nut.
2. Rotate the slave piston retaining ring 90 degrees from the slot in the housing to ensure that it is properly seated.
3. Adjust the slave piston.
   3.1 With the exhaust valve on the cylinder closed, insert a Jacobs 0.018-inch feeler

gauge between the slave piston feet and the exhaust bridge.

3.2 Turn the slave piston adjusting screw assembly in until you feel a slight drag on the feeler gauge.

3.3 Hold the slave piston adjusting screw in position and tighten the jam nut 25 lbf·ft (35 N·m).

3.4 Continue the slave piston adjustments following the sequence in **Table 1**.

Slave Piston Adjustment Sequence	
Engine Position	**Slave Piston Cylinder**
Cylinder 1 TDC	1, 3, 5
Cylinder 6 TDC	2, 4, 6

Table 1, Slave Piston Adjustment Sequence

4. Install the engine brake housing. For instructions, See **Subject 140**.
5. Install the rocker cover. For instructions, See **Subject 180**.
6. Close and latch the hood.
7. Remove the chocks from the tires.

Model 411

REMOVAL

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Remove the brake housing from the vehicle. For instructions, see **Subject 140**.

⚠ WARNING

Wear safety glasses and remove the slave piston carefully. The slave piston is retained by springs that are under heavy compression. If the following instructions are not used and the proper tools are not used, the spring could be discharged with enough force to cause personal injury.

4. Remove the locknut on the slave piston adjusting screw. Back out the adjusting screw until the slave piston is fully retracted (the screw is loose).
5. Use the slave piston clamp fixture to remove the slave piston. See **Fig. 4**. Place the hole in the clamp fixture over the slave piston adjusting screw.
6. While holding the fixture in position, screw the holder down over the slave piston stem until the retainer is contacted. Turn the handle slowly until the retainer is depressed about 1/32 inch (1 mm), relieving pressure against the retaining ring

   Using retaining ring pliers, remove the retaining ring. See **Fig. 5**.
7. Remove the retainer, spring, and slave piston. Check for nicks or burrs that could cause binding. See **Fig. 6**.

INSTALLATION

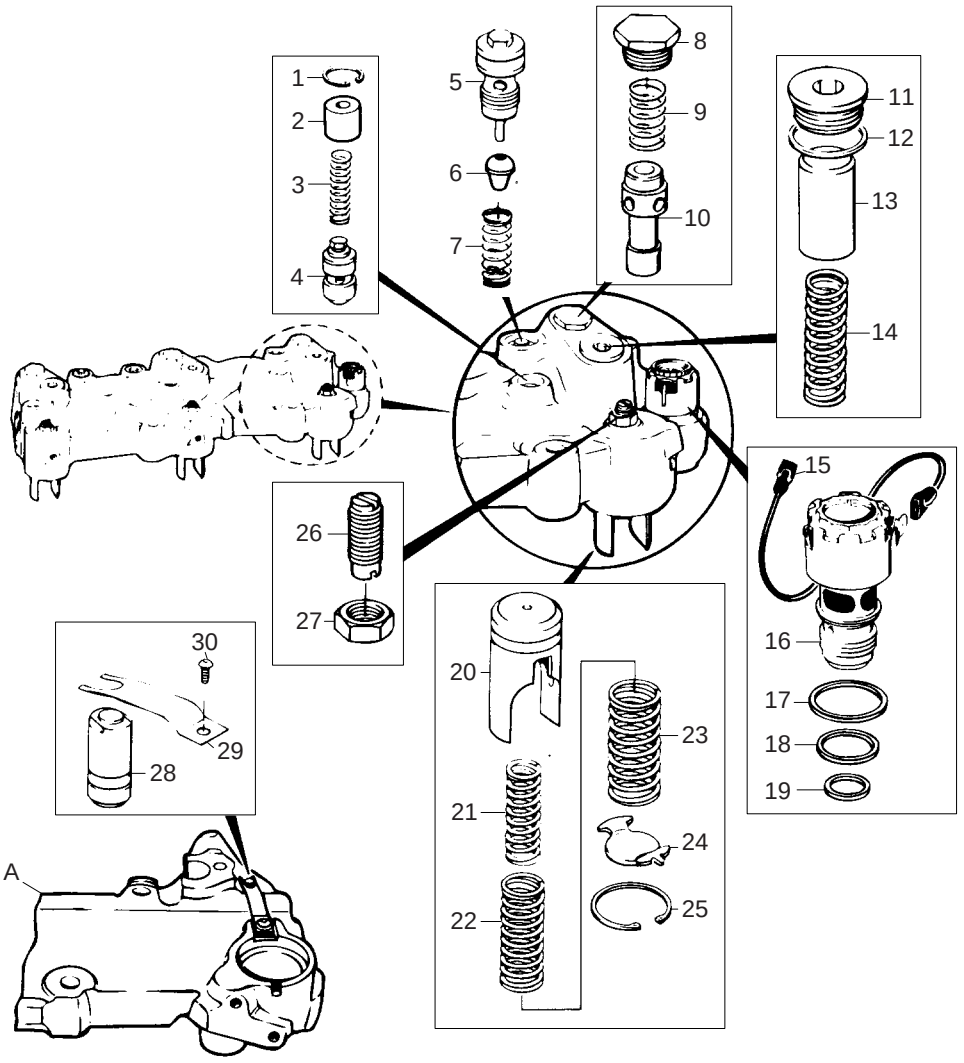
IMPORTANT: Clean the piston in an approved cleaning solvent. Run a small wire through any holes. Replace the piston if the ground surface on the outside diameter is scratched or scored.

IMPORTANT: Make sure all the components are assembled in the correct order.

1. Install the slave piston into the bore.
2. Install the springs and retainer over the slave piston foot.
3. Use the clamp fixture to compress the slave piston and springs until the retainer is about 1/32 in (1 mm) below the retaining ring groove.
4. Slide the retaining ring over the threaded rod of the clamp fixture, and install the retaining ring in its groove. Make sure the retaining ring is fully engaged in the groove.

   Remove the clamping fixture slowly to ensure proper seating of the retaining ring.
5. Install the engine brake housing using the instructions in **Subject 140**.
6. Close and latch the hood.
7. Remove the chocks from the tires.

Slave Piston Removal and Installation



06/06/2000 f011009

A. Bottom of Brake Housing

1. Control Valve Retaining Ring
2. Control Valve Spacer/Cover
3. Control Valve Spring
4. Control Valve
5. Check Valve
6. Check Valve Seal
7. Check Valve Spring
8. Trigger Valve Cap
9. Trigger Valve Spring
10. Trigger Valve
11. Delay Piston Cap
12. Delay Piston Copper Seal (if used)
13. Delay Piston
14. Delay Piston Spring
15. Solenoid Valve Harness
16. Solenoid Valve
17. Upper Seal
18. Center Seal
19. Lower Seal
20. Slave Piston
21. Inner Slave Piston Spring
22. Center Slave Piston Spring
23. Outer Slave Piston Spring
24. Slave Piston Retainer
25. Slave Piston Retaining Ring
26. Slave Piston Adjusting Screw
27. Slave Piston Adjusting Screw Locknut
28. Master Piston
29. Master Piston Flat Spring
30. Master Piston Buttonhead Screw

Fig. 3, Engine Brake Assembly

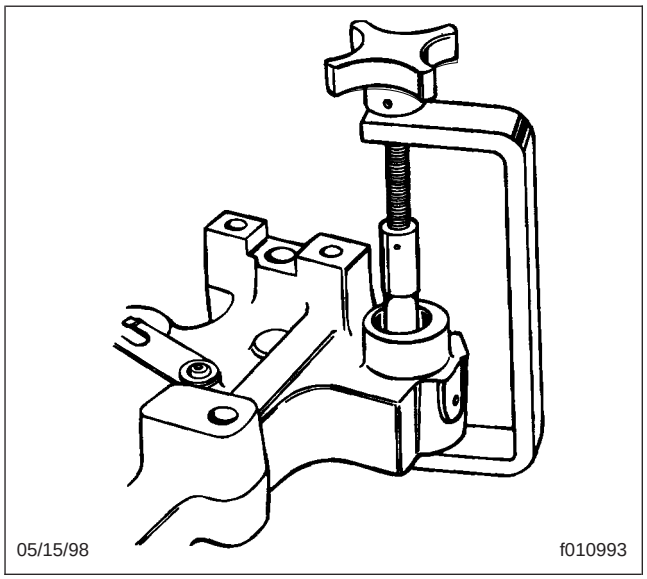


Fig. 4, Using the Clamp Fixture

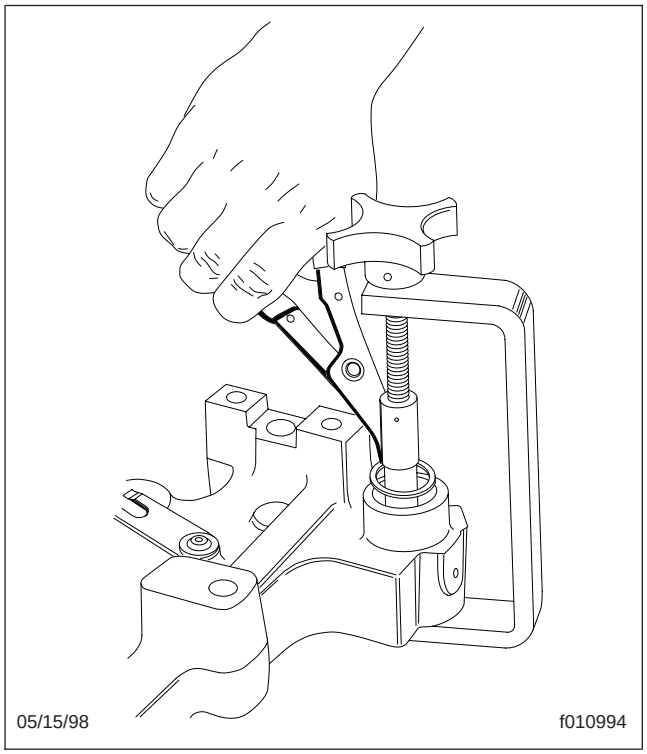


Fig. 5, Removing the Retaining Ring

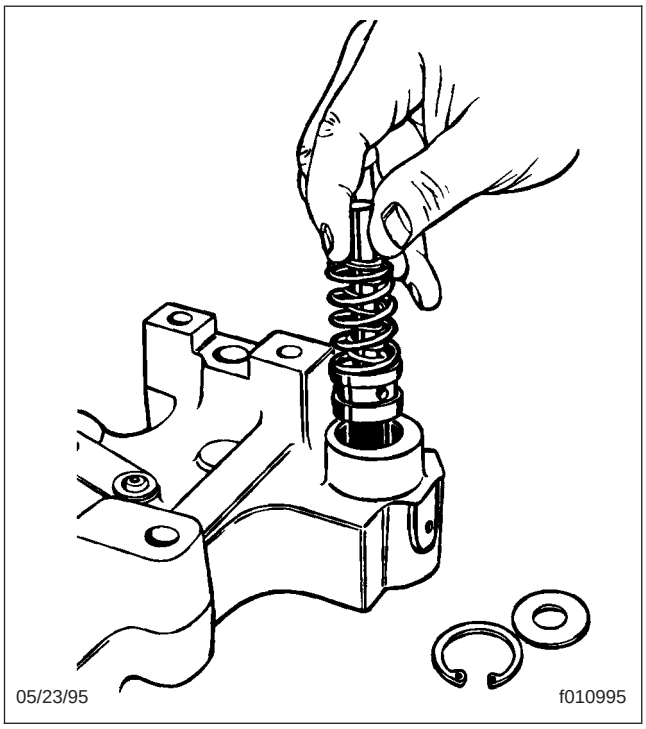


Fig. 6, Remove the Slave Piston

Models 760A and 765

REMOVAL

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Remove the engine brake housing from the vehicle using the instructions in **Subject 140**.
4. Remove the screw and spring that retain the slave piston assembly. See **Fig. 7**.
5. Remove the bridge and the slave piston. See **Fig. 8**.
6. Loosen the leveling screw locknut and remove the leveling screw from the bridge. See **Fig. 9**.

INSTALLATION

IMPORTANT: Inspect all components for excessive wear and for damage. Replace parts as needed.

Slave Piston Removal and Installation

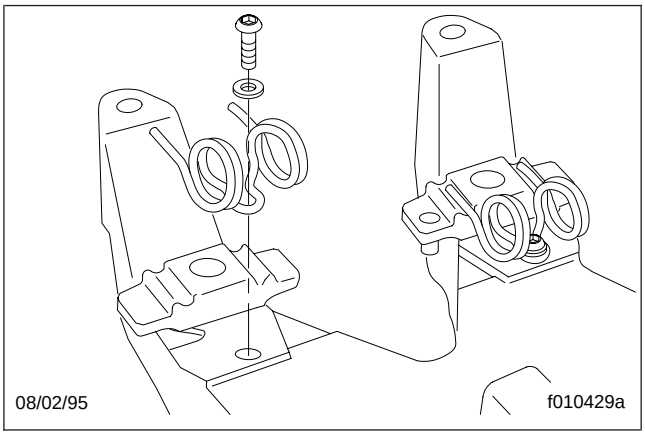


Fig. 7, Remove the Screw and Spring

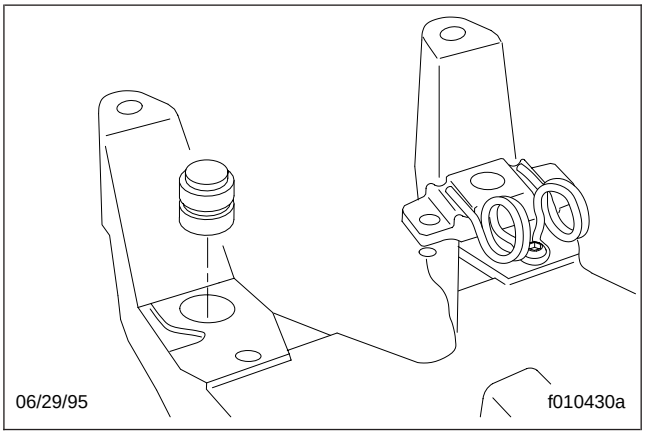


Fig. 8, Remove the Slave Piston

1. Install the leveling screw in the bridge. See **Fig. 9**. Tighten the locknut 25 lbf·ft (35 N·m).

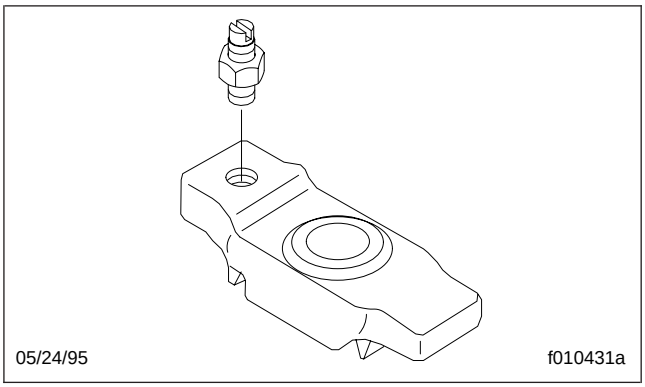


Fig. 9, Remove the Leveling Screw

2. Install the slave piston and the bridge with the leveling screw toward the center of the housing. See **Fig. 10**.

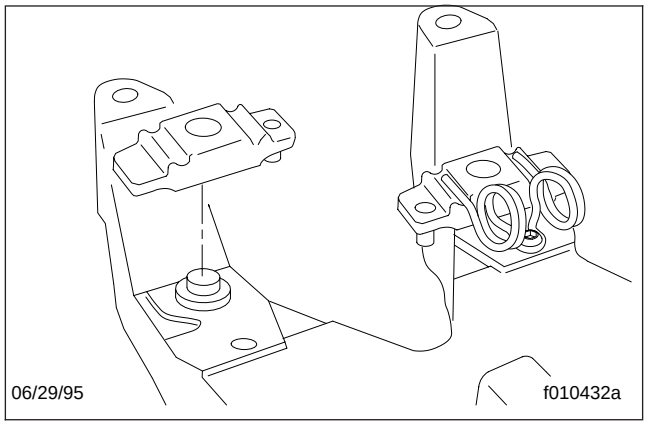


Fig. 10, Install the Slave Piston and Bridge

3. Install the slave piston assembly retaining spring with the ends over the bridge. See **Fig. 11**.

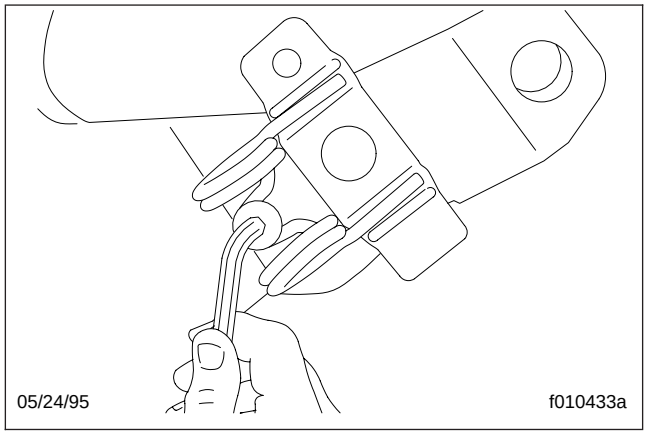


Fig. 11, Install the Retaining Spring

4. Install the screw over the center part of the spring. Tighten the screw 15 lbf·ft (20 N·m).
5. Install the engine brake housing on the engine using the instructions in **Subject 140**.

⚠ CAUTION

Follow the slave piston adjustment procedure exactly. Failure to use the correct adjustment procedure will result in poor engine brake performance and serious engine damage.

NOTE: Make the following adjustment with the engine stopped and the oil temperature 140°F (60°C) or lower. Rotate the engine until the exhaust valves on the cylinder to be adjusted are closed (rocker arm is loose).

6. Back out the *leveling screw* in the slave piston assembly until the end of the screw is beneath the surface of the bridge in the slave piston assembly. See **Fig. 12**.

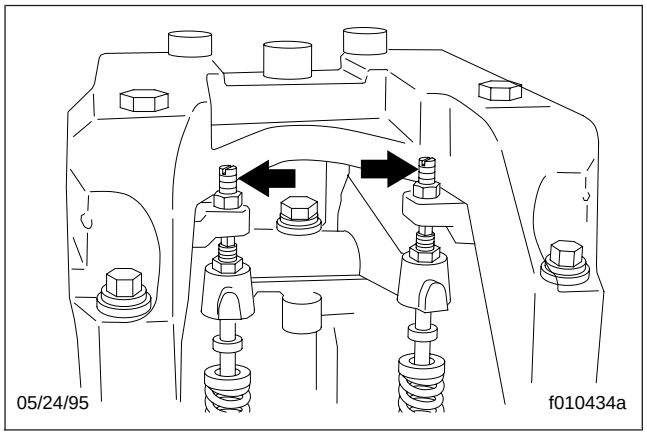


Fig. 12, Back Out the Leveling Screw

NOTE: The leveling screw is the screw located in the bridge member of the slave piston assembly.

7. Place the correct feeler gauge between the solid side of the *bridge* (the side without the leveling screw) and the exhaust rocker arm adjusting screw. See **Fig. 13**. See **Table 2** for the correct feeler gauge.

Feeler Gauges	
Engine Model (Displacement)	**Feeler Gauge inches (mm)**
12.7 liter	0.026 (0.6)
11.1 liter	

Table 2, Feeler Gauges

NOTE: A "G" in position 5 of the model number indicates a 12.7 liter engine; "W" indicates an 11.1 liter engine. Typical model numbers: 6067GU40 or 6067WU40. The model number is stamped on the engine block beneath the intake manifold. See **Fig. 14**.

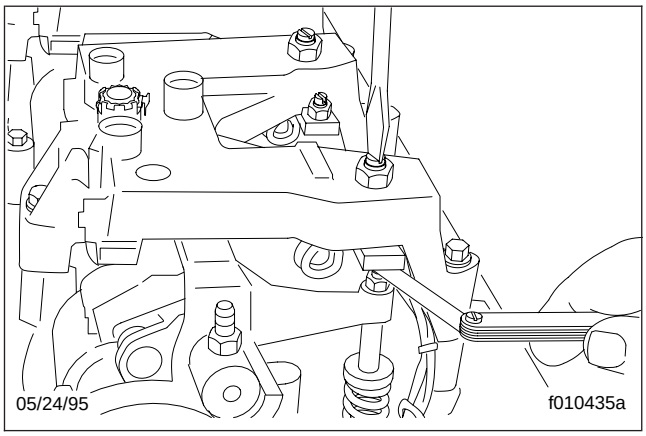
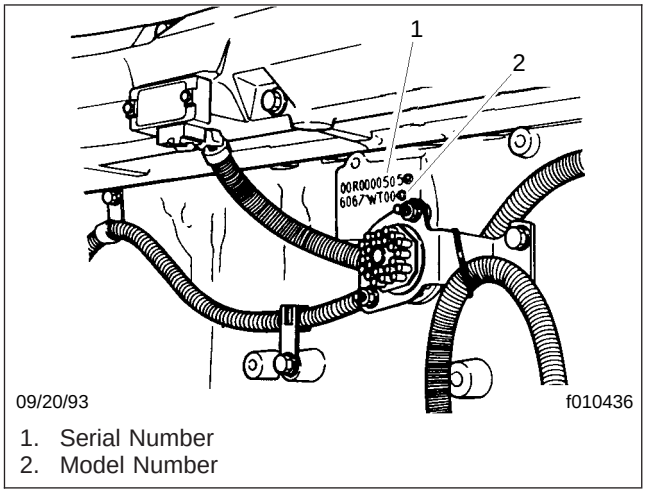


Fig. 13, Check with the Feeler Gauge

8. Turn the slave piston adjusting screw clockwise until a light drag is felt on the feeler gauge.



1. Serial Number
2. Model Number

Fig. 14, Engine Brake Identification

9. While holding the screw in this position, tighten the locknut 25 lbf·ft (35 N·m). See **Fig. 15**.

IMPORTANT: The slave piston adjusting screws used in the Model 760 engine brake are Reset® screws. Do not disassemble the Reset screws in the field.

10. Following the same procedure, set 0.020-inch (0.5-mm) clearance between the slave piston leveling screw and the rocker arm adjusting screw. See **Fig. 16**.

11. While holding the leveling screw in this position, tighten the locknut 35 lbf·ft (47 N·m).

Slave Piston Removal and Installation

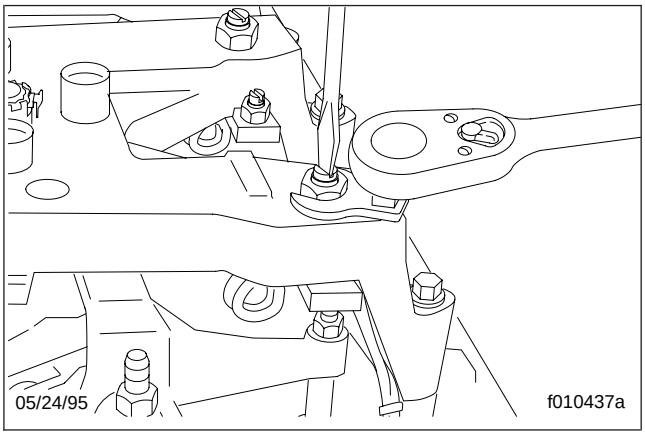


Fig. 15, Tighten the Adjusting Screw Locknut

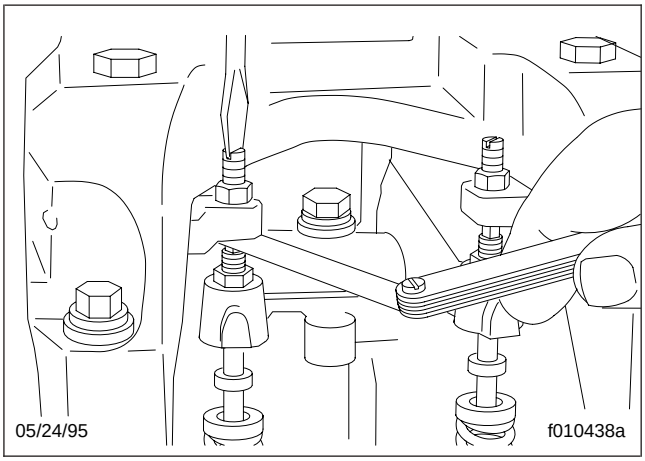


Fig. 16, Check the Clearance

12. Repeat the steps above for slave pistons of the remaining cylinders. Rotate the engine to close the exhaust valves for the cylinder being adjusted.
13. Close and latch the hood.
14. Remove the chocks from the tires.

Slave Piston Adjusting Screw Removal and Installation

WARNING

While performing any of the following procedures, never remove or install any engine brake component with the engine running. Serious personal injury could result.

Model 310A

REMOVAL

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, see **Subject 180**.
4. Loosen the slave piston adjusting screw locknut and remove the adjusting screw from the housing. See **Fig. 1**.

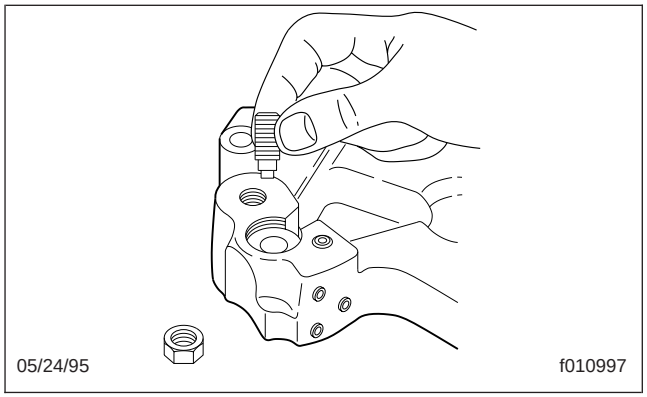


Fig. 1, Remove the Adjusting Screw

INSTALLATION

IMPORTANT: Clean the adjusting screw in an approved solvent.

CAUTION

Do not adjust or tamper with the adjusting screw. Engine damage could result.

NOTE: The part number for the screw is located at the top of the screw next to the screwdriver slot. See the manufacturer's parts manual for part number identification.

1. Inspect the slave piston adjusting screw. The plunger should protrude from the bottom of the screw. There should be light spring pressure when the plunger is depressed and the plunger should move freely. See **Fig. 2.** Replace the entire screw assembly if any problem is found.

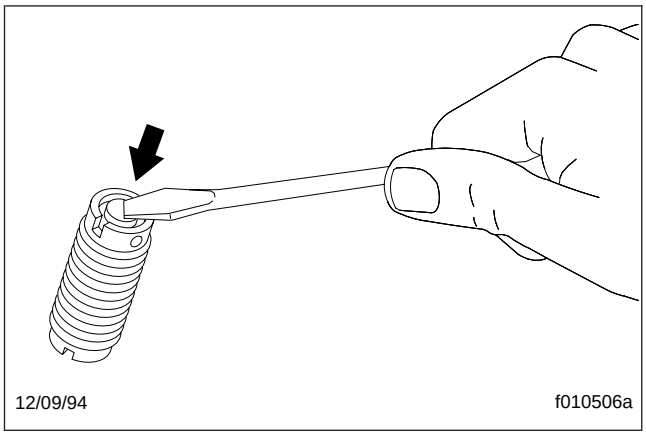


Fig. 2, Check the Adjusting Screw Plunger

2. Install the rocker cover. For instructions, see **Subject 180**.
3. Close and latch the hood.
4. Remove the chocks from the tires.

Model 411

REMOVAL

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Remove the rocker cover from the vehicle. For instructions, see **Subject 180**.
4. Remove the slave piston adjusting screw locknut and remove the adjusting screw from the housing. See **Fig. 3**.

INSTALLATION

IMPORTANT: Clean the adjusting screw in an approved solvent.

Slave Piston Adjusting Screw Removal and Installation

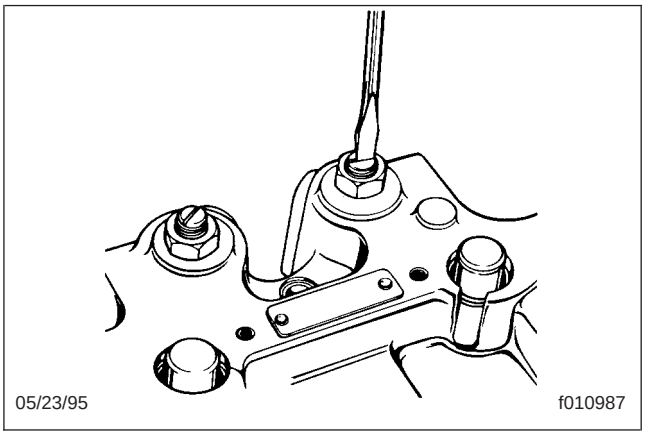


Fig. 3, Remove the Adjusting Screw

1. Inspect the slave piston adjusting screw. See **Fig. 2**. The plunger should protrude from the bottom of the screw. There should be light spring pressure when the plunger is depressed and the plunger should move freely. Be sure the retaining ring is fully engaged in its groove. Replace the entire screw assembly if any defect is found.

   Using retaining ring pliers, remove the retaining ring.

2. Install the slave piston adjusting screw and adjust the slave piston lash to 0.015 inch (0.03 mm).

NOTE: The slave piston lash must be set with the engine stopped and cold. The exhaust valves on the cylinder to be adjusted must be closed.

⚠ CAUTION

Do not over-tighten the adjusting screw locknut. Over-tightening the locknut will cause poor engine brake performance.

After tightening the slave piston adjusting screw locknut, check the clearance with a Jacobs feeler gauge. Readjust the piston lash if needed.

3. After the slave piston is adjusted, tighten the adjustment screw locknut 25 lbf·ft (34 N·m).
4. Install the rocker cover using the instructions in **Subject 140**.
5. Close and latch the hood.
6. Remove the chocks from the tires.

Model 760A and 765

REMOVAL

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Disconnect the batteries.
3. Open the hood.
4. Wipe the engine brake housing area clean and remove the valve cover. For instructions, see the engine manufacturer's service literature.
5. Loosen the slave piston adjusting screw locknut and remove the adjusting screw from the housing. See **Fig. 4**.

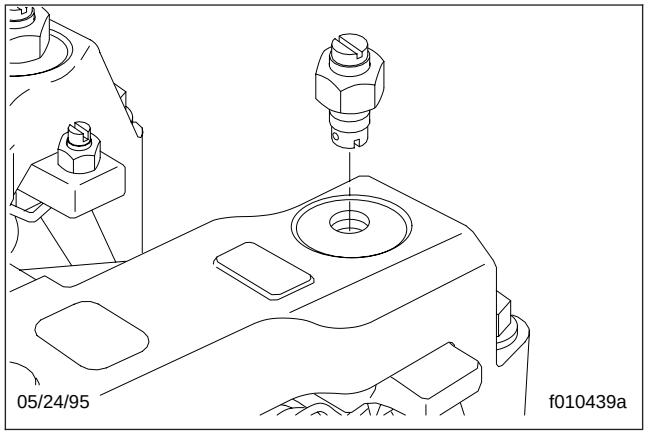


Fig. 4, Remove the Adjusting Screw

INSTALLATION

IMPORTANT: Clean the adjusting screw in cleaning solvent.

1. Inspect the slave piston adjusting screw. The plunger should protrude from the bottom of the screw. There should be light spring pressure when the plunger is depressed and the plunger should move freely. See **Fig. 2**. Be sure the retaining ring is fully engaged in its groove. If any defect is found, replace the entire screw assembly.

Slave Piston Adjusting Screw Removal and Installation

CAUTION

Do not disassemble or tamper with the slave piston adjusting screw assembly. Engine damage could result.

2. Screw the slave piston adjusting screw into the housing.
3. Reset the engine brake lash. For instructions, see **Subject 160**.
4. Close and latch the hood.
5. Connect the batteries.
6. Remove the chocks from the tires.

Rocker Cover Removal and Installation

⚠ WARNING

While performing any of the following procedures, never remove or install any engine brake component with the engine running. Serious personal injury could result.

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Remove the air piping between the air cleaner and the turbocharger.
4. Remove the engine cover inside the cab if more access is needed.
5. Drain the coolant and remove the upper radiator hose if it is in the way.
6. Wipe the engine brake housing area clean.
7. Remove the bolts that hold each rocker cover and remove the rocker covers. See **Fig. 1**.

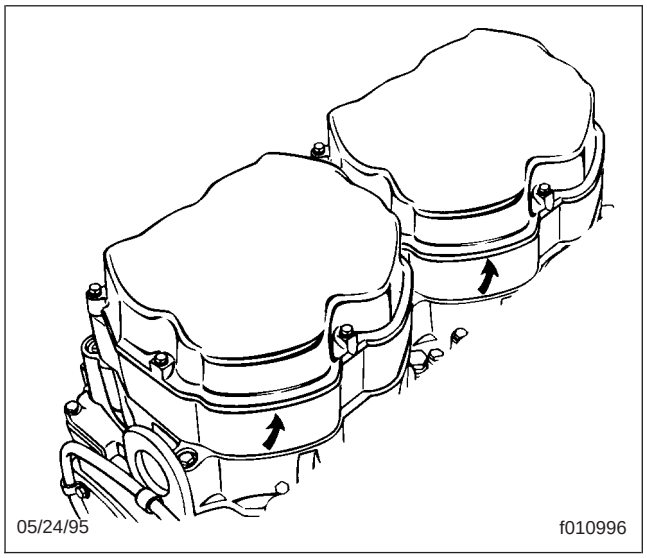


Fig. 1, Rocker Covers

8. Inspect the cover seals and replace them if they are damaged.
9. If needed, remove the fasteners that hold the engine brake spacer and remove the engine brake spacer.

Installation

1. If the engine brake spacer was removed, install it and tighten the fasteners 10 lbf·ft (14 N·m).
2. Make sure a rocker cover seal is located in the groove of each cover and install the cover on the spacer.

⚠ CAUTION

Be sure to tighten all the rocker cover bolts evenly. Excessive or uneven tightening may cause the rocker cover to crack.

3. For 310A models, install the six Jacobs' bolts per cover and tighten the bolts 5 lbf·ft (7 N·m).

   For 349A models, install the six Jacobs bolts per cover and tighten the bolts 10 lbf·ft (14 N·m).

   For 411 models, install a flatwasher, a new sleeve and a new noise isolator on each capscrew and install the capscrew assemblies in the cover. Tighten the bolts 130 lbf·in (1460 N·cm) in the sequence shown in **Fig. 2**.

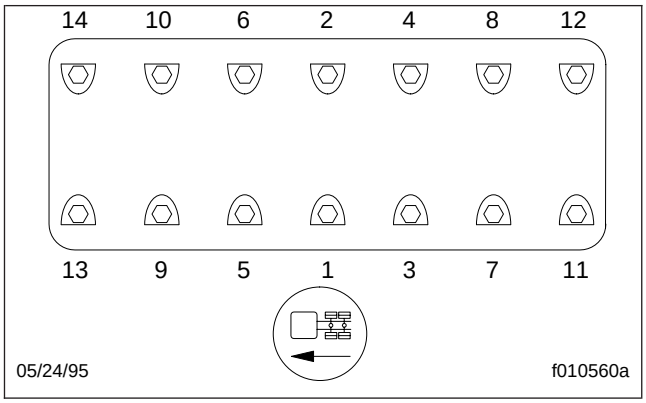


Fig. 2, Bolt Tightening Sequence

4. Install the upper radiator hose, if removed. Add coolant.
5. Install the engine cover inside the cab, if removed.
6. Install the air piping between the air cleaner and the turbocharger.

Rocker Cover Removal and Installation

7. Close and latch the hood.
8. Remove the chocks from the tires.

Engine Brake Bleeding and Operation Check

⚠ WARNING

While performing any of the following procedures, never remove or install any engine brake component with the engine running. Serious personal injury could result.

Model 310A

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, see **Subject 180**.

⚠ WARNING

Wear eye protection and do not expose your face to the engine area. Take precautions to prevent oil leakage onto the engine. Whenever the engine is running with the valve covers removed, oil splashing in the engine area could cause personal injury.

NOTE: Place a rag over the control valve and the accumulator covers to reduce oil spray.

4. Start the engine and allow it to run for a few minutes.
5. Press and release the engine brake solenoid disc several times to allow the housing to be filled with oil. See **Fig. 1**.

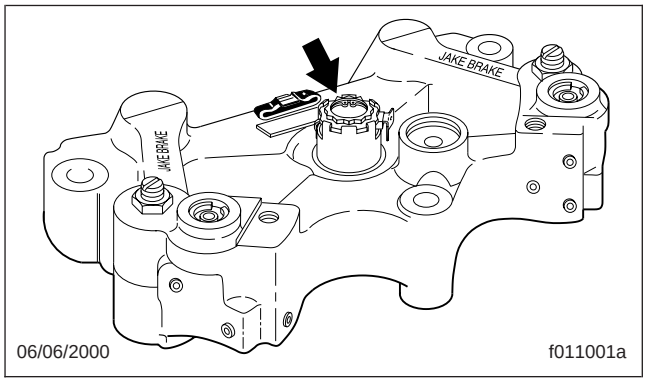


Fig. 1, Engine Brake Solenoid Disc

6. Watch the master piston to be sure it is moving down onto the injector rocker arm pad.
7. Watch the slave piston assembly. It should move down to contact the pin in the exhaust valve screw.
8. Check all the housings to be sure they are functioning.
9. Shut down the engine and clean the gasket surface for the rocker cover.
10. Install the rocker cover. For instructions, see **Subject 180**.
11. Close and latch the hood.
12. Remove the chocks from the tires.

Model 349A

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, see **Subject 180**.

⚠ WARNING

Wear eye protection and do not expose your face to the engine area. Take precautions to prevent oil leakage onto the engine. Whenever the engine is running with the valve covers removed, oil splashing in the engine area could cause personal injury.

4. Start the engine and allow it to run for 5 to 10 minutes.
5. With the engine at low idle, press and release the engine brake solenoid disc several times until the master pistons move out of the housing and the engine brake begins to operate.

   Oil leaving the control valve covers should be free of air bubbles before replacing the valve covers. This permits oil to fill the brake housing passages and prepares the brake for operation.
6. Inspect the engine brake for oil or fuel leakage or component interference. Correct any problems.

Engine Brake Bleeding and Operation Check

7. Shut down the engine and clean the gasket surface for the rocker cover.
8. Install the rocker cover. For instructions, see **Subject 180**.
9. Close and latch the hood.
10. Remove the chocks from the tires.

Check Valve Removal and Installation

WARNING

While performing any of the following procedures, never remove or install any engine brake component with the engine running. Serious personal injury could result.

Removal (See Fig. 1)

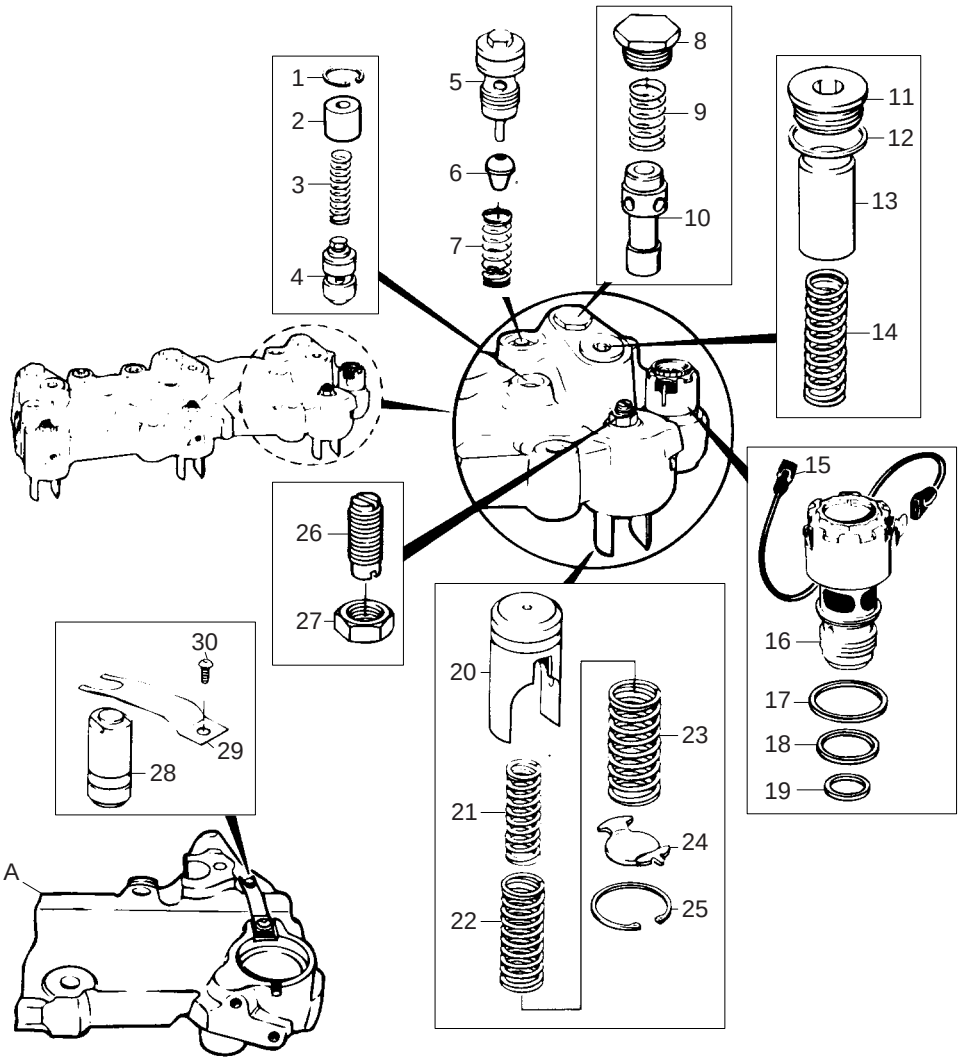
1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, see **Subject 180**.
4. Remove the check valve and the check valve spring.

Installation

NOTE: The check valve assembly contains a three-piece seal. Do not attempt to remove the seal. If the seal is damaged, replace the complete check valve assembly.

1. Install the check valve spring in the bore and install the check valve.
2. Tighten the check valve 35 lbf·ft (48 N·m).
3. Install the rocker cover. For instructions, see **Subject 180**.
4. Close and latch the hood.
5. Remove the chocks from the tires.

Check Valve Removal and Installation



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A. Bottom of Brake Housing
1. Control Valve Retaining Ring
2. Control Valve Spacer/Cover
3. Control Valve Spring
4. Control Valve
5. Check Valve
6. Check Valve Seal
7. Check Valve Spring
8. Trigger Valve Cap
9. Trigger Valve Spring
10. Trigger Valve
11. Delay Piston Cap
12. Delay Piston Copper Seal (if used)
13. Delay Piston
14. Delay Piston Spring
15. Solenoid Valve Harness
16. Solenoid Valve
17. Upper Seal
18. Center Seal
19. Lower Seal
20. Slave Piston
21. Inner Slave Piston Spring
22. Center Slave Piston Spring
23. Outer Slave Piston Spring
24. Slave Piston Retainer
25. Slave Piston Retaining Ring
26. Slave Piston Adjusting Screw
27. Slave Piston Adjusting Screw Locknut
28. Master Piston
29. Master Piston Flat Spring
30. Master Piston Buttonhead Screw

Fig. 1, Brake Housing Assembly

Delay Piston Removal and Installation

WARNING

While performing any of the following procedures, never remove or install any engine brake component with the engine running. Serious personal injury could result.

Removal (See Fig. 1)

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, see **Subject 180**.

WARNING

Remove the check valves before removing the delay piston caps. This relieves the pressure in the plenum chamber. Removing the delay piston caps with pressure in the plenum can result in personal injury.

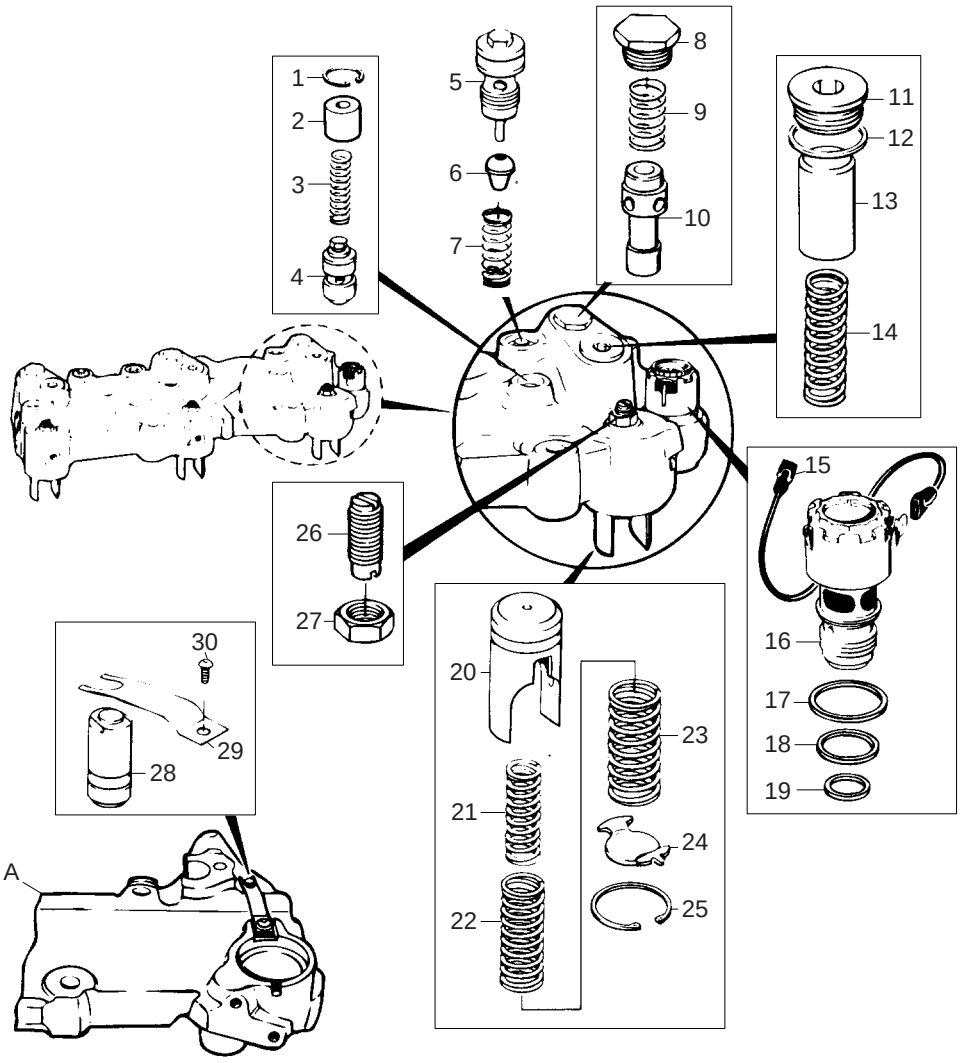
4. Remove the check valves. For instructions, see **Subject 200**.
5. Slowly remove the delay piston cap.
6. Use a magnet to remove the delay piston and the delay piston spring.

Installation

IMPORTANT: Inspect the piston. If the piston is scored or damaged in any way, replace it.

1. Install the spring and the delay piston.
2. Clean the oil from the delay piston cap and apply Loctite® 271 (or equivalent) before installing the cap. Tighten the cap 65 lbf·ft (88 N·m).
3. Install the rocker cover. For instructions, see **Subject 180**.
4. Close and latch the hood.
5. Remove the chocks from the tires.

Delay Piston Removal and Installation



06/06/2000 f011009

A. Bottom of Brake Housing

1. Control Valve Retaining Ring
2. Control Valve Spacer/Cover
3. Control Valve Spring
4. Control Valve
5. Check Valve
6. Check Valve Seal
7. Check Valve Spring
8. Trigger Valve Cap
9. Trigger Valve Spring
10. Trigger Valve
11. Delay Piston Cap
12. Delay Piston Copper Seal (if used)
13. Delay Piston
14. Delay Piston Spring
15. Solenoid Valve Harness
16. Solenoid Valve
17. Upper Seal
18. Center Seal
19. Lower Seal
20. Slave Piston
21. Inner Slave Piston Spring
22. Center Slave Piston Spring
23. Outer Slave Piston Spring
24. Slave Piston Retainer
25. Slave Piston Retaining Ring
26. Slave Piston Adjusting Screw
27. Slave Piston Adjusting Screw Locknut
28. Master Piston
29. Master Piston Flat Spring
30. Master Piston Buttonhead Screw

Fig. 1, Brake Housing Assembly

Trigger Valve Removal and Installation

WARNING

While performing any of the following procedures, never remove or install any engine brake component with the engine running. Serious personal injury could result.

Removal (See Fig. 1)

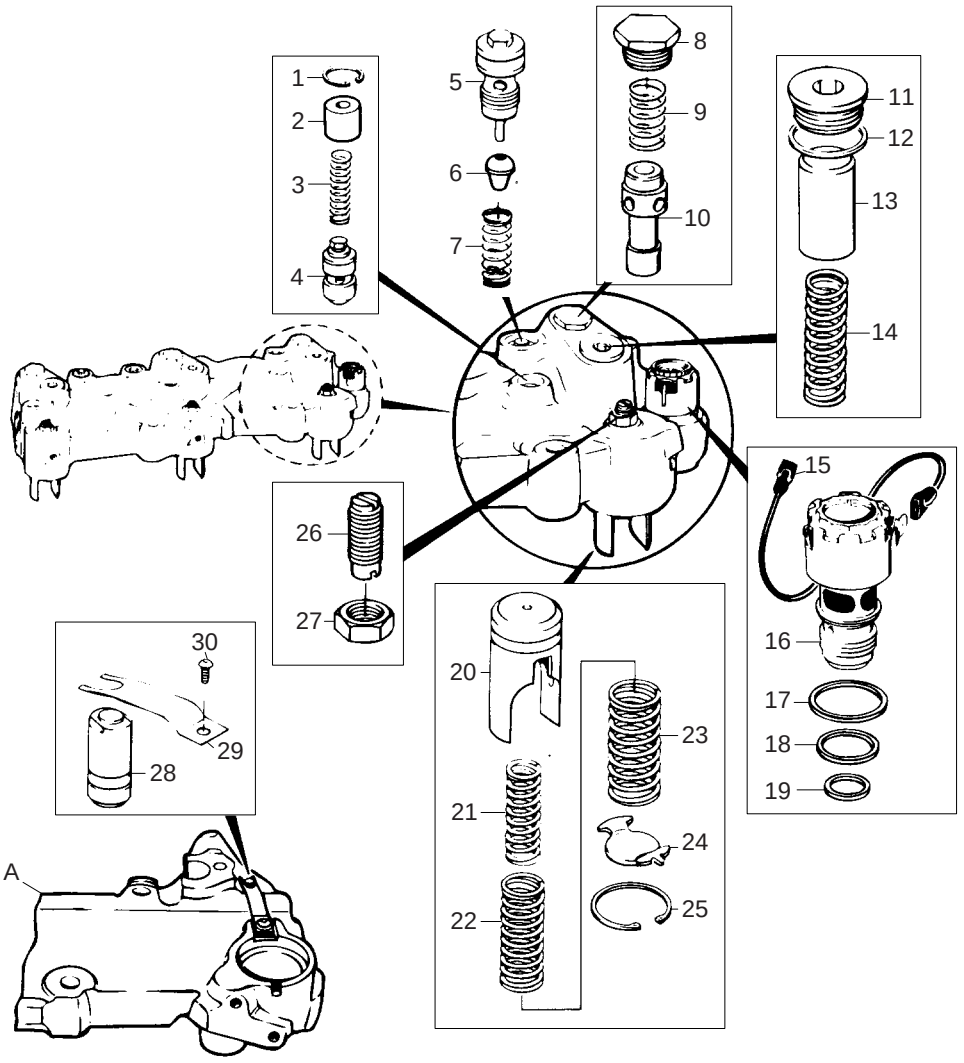
1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Wipe the engine brake housing area clean. Remove the rocker cover. For instructions, see **Subject 180**.
4. Remove the trigger valve cap and spring.
5. Remove the trigger valve.

Installation

IMPORTANT: Inspect the trigger valve parts for damage or wear and replace them as needed.

1. Install the trigger valve, using a new cap and spring.
2. Tighten the cap 35 lbf·ft (48 N·m).
3. Install the rocker cover. For instructions, see **Subject 180**.
4. Close and latch the hood.
5. Remove the chocks from the tires.

Trigger Valve Removal and Installation



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A. Bottom of Brake Housing

1. Control Valve Retaining Ring
2. Control Valve Spacer/Cover
3. Control Valve Spring
4. Control Valve
5. Check Valve
6. Check Valve Seal
7. Check Valve Spring
8. Trigger Valve Cap
9. Trigger Valve Spring
10. Trigger Valve
11. Delay Piston Cap
12. Delay Piston Copper Seal (if used)
13. Delay Piston
14. Delay Piston Spring
15. Solenoid Valve Harness
16. Solenoid Valve
17. Upper Seal
18. Center Seal
19. Lower Seal
20. Slave Piston
21. Inner Slave Piston Spring
22. Center Slave Piston Spring
23. Outer Slave Piston Spring
24. Slave Piston Retainer
25. Slave Piston Retaining Ring
26. Slave Piston Adjusting Screw
27. Slave Piston Adjusting Screw Locknut
28. Master Piston
29. Master Piston Flat Spring
30. Master Piston Buttonhead Screw

Fig. 1, Brake Housing Assembly

Troubleshooting Tables

Problem—Engine Will Not Start

Problem—Engine Will Not Start	
Possible Cause	**Remedy**
Solenoid valve stuck in "on" position	Make sure the electrical current to the engine brake is off. If the solenoid valve stays "on" (cap down) with the current off, replace the solenoid valve.

Problem—Engine Brake Will Not Function

Problem—Engine Brake Will Not Function	
Possible Cause	**Remedy**
Open electrical lead	Replace any broken wires.
Malfunctioning clutch switch	**WARNING: Do not touch the electrical connections when the engine brake system is energized. Touching the connections could possibly cause electrical shock.** Use a volt/ohmmeter to make sure there is electrical current at both terminals of the switch. If voltage will not pass through the switch, replace it.
Engine oil pressure too low	Determine the oil pressure at the engine brakes. If the oil pressure is below specifications, repair the engine following the manufacturer's procedures.
Malfunctioning throttle switch	Check for correct operation of the throttle.

Problem—Engine Brake Engages With the Switches Off

Problem—Engine Brake Engages With the Switches Off	
Possible Cause	**Remedy**
Damaged solenoid valve center seal ring	Remove the solenoid. Replace all the seal rings.
Incorrectly wired engine brake	Check the wiring against the Jacobs wiring diagram.

Problem—Engine Brake Weak or Slow to Engage

Problem—Engine Brake Weak or Slow to Engage	
Possible Cause	**Remedy**
Lubricating oil too cold and thick	Allow the engine to warm up before operating the Jake Brake.
Incorrectly adjusted slave piston or binding in its bore	**WARNING: Slave piston springs are under heavy compression. Remove the slave piston carefully when disassembly is necessary. Use either an arbor press or C-clamp. Failure to follow this procedure could result in personal injury.** Adjust the slave piston. Make sure it responds smoothly to the adjusting screw—loosen the jam nut and screw the adjusting screw through its full range for full slave piston travel. Make sure the piston travels the full range without binding or sticking.

Troubleshooting

Problem—Engine Brake Weak or Slow to Engage	
Possible Cause	**Remedy**
Damaged solenoid lower seal, allowing oil to escape housing	Remove the solenoid valve and replace all the seal rings.
Clogged solenoid screen, stopping supply of oil to engine brake	Remove the solenoid valve and clean or replace the screen.
Master piston not moving in its bore	Inspect the master piston and bore for scoring or burrs. If any are present, clean the surface with a crocus cloth. If the burrs cannot be removed, replace the piston or housing. Inspect the lubricating oil for signs of contaminants. If any are present, replace the oil and filters, and correct the cause of the contamination.
Control valves binding in housing bores	Remove each control valve. If the body is scored, replace the valve. Check for contaminants in the lubricating oil. Clean the housing and control valve. If it still binds, replace the housing.
Malfunctioning control valves	Remove each control valve. Make sure the check ball is seating in the bore and that it can be moved off the seat. Make sure there is spring pressure against the ball. Flush the valve in diesel fuel. Replace the control valve if needed.
Dash switches, clutch switch or throttle switch sluggish operation	Adjust or replace the switch. Check the throttle or clutch return springs for proper operation.
Solenoid valve electrical insulation breaking down	**WARNING: Do not touch the electrical connections when the engine brake system is energized. Touching the connections could possibly cause electrical shock.** Make sure the solenoid valve meets electrical specifications. If not, replace the solenoid valve.
Leaking engine brake housing plugs	Check the plugs for signs of leaks. If leaks are found, remove the plugs, clean the threads and install the plugs. Thread locking compound may help. Tighten the plugs 115 lbf·in (1300 N·cm).
Broken outer control valve spring or extremely high engine oil pressure	Replace the outer control valve spring. See the engine manufacturer's service manual for causes of high oil pressure.
Damaged upper solenoid seal ring, causing oil pressure to drop below minimum required for engine brake operation	Remove the solenoid. Inspect the seal rings and replace them if needed.
Damaged oil supply seals under or between housings, causing oil pressure to drop below minimum required for engine brake operation	Remove the housings and replace the seals. Check for cracked or broken oil connectors. Replace the seals.
Air in lubricating oil, causing oil pressure to drop below minimum required for engine brake operation	Check for aeration of the oil. Turn the engine brake on, then off. Watch the escape oil coming from under the control valve cover. If the oil has bubbles or is foamy, air is present in the system. Aeration can be caused by an over- or under-filled crankcase, by cracks in the oil pickup tube, or by leaks in the oil suction tube or hose. See the engine manufacturer's service manual for corrective measures.
Lubricating oil being diluted by diesel fuel, causing oil pressure to drop below minimum required for engine brake operation	Have the lubricating oil analyzed to determine if fuel is present. Refer to the engine manufacturer's service manual for corrective measures.
Low engine oil, causing oil pressure to drop below minimum required for engine brake operation	See the engine manufacturer's service manual for specifications. Add oil or recalibrate the dipstick as required.

Problem—Engine Brake Weak or Slow to Engage	
Possible Cause	**Remedy**
Worn engine rocker arm bushings, causing oil pressure to drop below minimum required for engine brake operation	Replace the bushings. See the engine manufacturer's service manual for instructions.
Oil leaking around cylinder heads, causing oil pressure to drop below the minimum required for engine brake operation	Repair the cause of the leaks. See the engine manufacturer's service manual for instructions.
Restrictions in oil passage leading to the engine brake causing oil pressure to drop below minimum required for engine brake operation	Inspect all the passageways; remove anything restricting the oil flow.

Problem—Engine Stalls or One or More Cylinders Continue Braking With the Dash Switches Off

Problem—Engine Stalls or One or More Cylinders Continue Braking With the Dash Switches Off	
Possible Cause	**Remedy**
Broken control valve inner spring	Replace the inner spring.
One or more control valves stuck in "on" (up) position	Check the control valves for binding. Remove and clean or replace them if necessary. Inspect the lubrication oil for contaminants.
Solenoid valve sticking in "on" position	If the solenoid valve cap remains down with no electric current being supplied, replace the solenoid valve.
Damaged center solenoid seal ring, allowing oil to enter engine brake with solenoid valve closed	Remove the solenoid and replace all the seal rings.
Plugged solenoid valve exhaust	Remove any restrictions at the exhaust (bottom) of the solenoid valve.
Dash switch stuck in the "on" position	Check for correct switch operation. Replace the switch as needed.

Problem—Engine Misses or Loses Power

Problem—Engine Misses or Loses Power	
Possible Cause	**Remedy**
Slave piston adjusted too tight	Adjust the slave piston. For instructions, see **Subject 160**.

Problem—Sudden Drop in Engine Lubrication Oil Pressure

Problem—Sudden Drop in Engine Lubrication Oil Pressure	
Possible Cause	**Remedy**
Missing or damaged oil inlet supply seal	Replace the seal.
Missing or damaged upper solenoid valve seal	Remove the solenoid and replace all the seal rings.
Cracked and leaking external oil supply hoses or fittings	Inspect all hoses and fittings for tightness, chafing or cuts.

General Information

A bypass oil filter is a remote-mounted oil filter plumbed to the engine. Not all of the engine oil runs through a bypass filter, the filter bleeds some of the oil from the engine, the rest of the oil "bypasses" the filter and stays within the engine.

Normal engine operation produces a variety of contaminants such as resins, gums, and acids. The bypass oil filter – sometimes used with a full-flow filter (an engine-mounted filter that *all* the oil must run through) – traps these contaminants and prevents excessive wear of engine parts. The filtered oil then returns to the engine crankcase or sump.

Sterling uses the following models of bypass oil filters:

- Fleetguard® Model LF3000™
- Fleetguard® Model LF9000™
- Fleetguard® Model LF9009™
- Spinner II®

FLEETGUARD

The Fleetguard filter provides both full-flow and bypass filtration functions. The full-flow section is constructed of synthetic media for fine filtration and high capacity. The bypass section is a stacked disc media that provides even finer filtration.

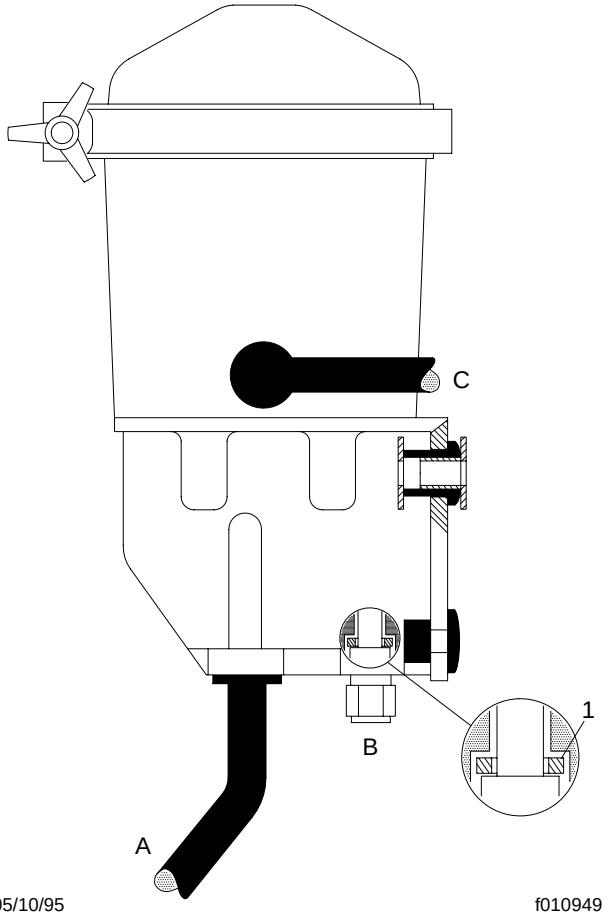
SPINNER II **(See Fig. 1 and Fig. 2)**

The Spinner II uses centrifugal force to separate contaminants from the oil, and uses air pressure to force the filtered oil back to the engine.

Engine oil enters the top half of the filter housing, and travels up through a spindle in the center of a cylindrical centrifuge turbine lined with an optional paper lining. At the same time, the pressure of the oil entering the filter housing makes the centrifuge spin. The oil sprays out of the top of the spindle, and the centrifugal force of the spinning centrifuge drives the oil contaminants against the inside of the centrifuge turbine. The contaminants cake inside the centrifuge turbine, and the clean oil runs into the bottom half of the filter housing.

The clean oil collects in the bottom half of the filter housing where it lifts a float. The float opens a valve that allows brake system air to enter the housing, and the air pressure forces the cleaned oil out of the housing and back to the engine.

Normal continuous operating oil pressure is about 60 psi (413.6 kPa). An engine equipped with the Spinner II does not need any extra oil. Flow rate through the cleaner is about 2 gallons (7.5 liters) per minute at normal operating pressure.



A. Oil Out
B. Air In
C. Oil In
1. Air Valve Cartridge Seal

Fig. 1, Spinner II Bypass Oil Filter

General Information

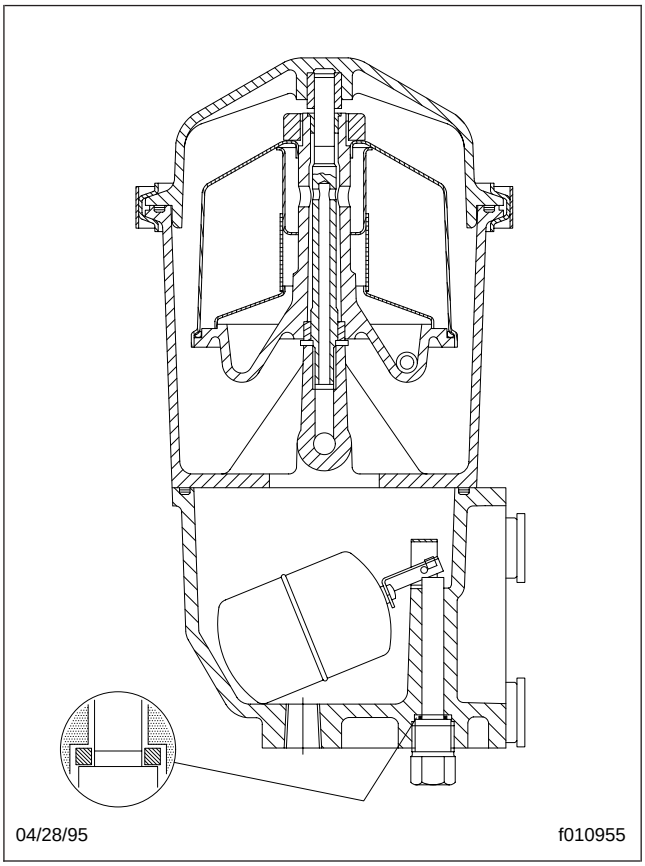


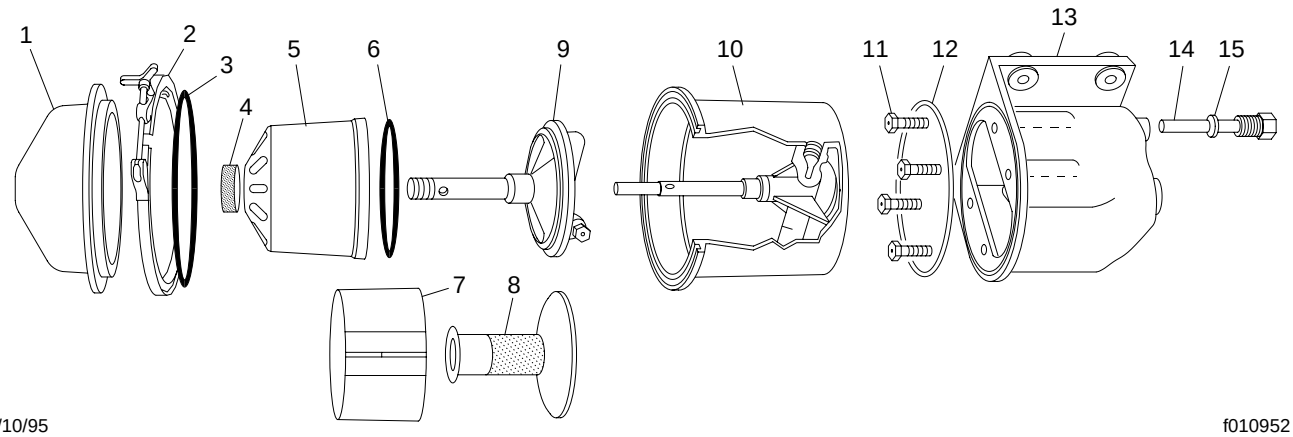
Fig. 2, Spinner II Bypass Oil Filter (sectional view)

Replacement

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

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the old oil filter.
3. Pre-fill the new oil filter with clean engine oil to prevent oil starvation to the lubricating system on initial start-up.
4. Place a thin film of clean oil on the gasket to ensure a positive seal.
5. Install the filter. Follow the filter tightening guidelines on the side of the filter.
6. Remove the chocks from the tires.

Cleaning (See Fig. 1)



1. Cover
2. Clamp
3. Cover Seal
4. Nut, Centrifuge Bowl
5. Centrifuge Bowl
6. Seal, Centrifuge Bowl
7. Paper Insert
8. Baffle/Screen
9. Centrifuge Turbine
10. Housing Assembly
11. Capscrew, M10 x 35 mm
12. Seal, Control Mechanism
13. Control Mechanism
14. Air Valve Cartridge Assembly
15. Seal, Air Valve Cartridge

Fig. 1, Spinner II Bypass Oil Filter

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

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Clean the centrifuge bowl.
   - 2.1 Make sure the centrifuge turbine assembly has come to a complete stop.
   - 2.2 Loosen the handle on the clamp. Disengage the T-bolt and remove the cover, using a coin in the gap to separate the cover from the housing.
   - 2.3 Partially withdraw the centrifuge turbine assembly from the housing and allow oil to drain from the nozzles before removing the assembly.
   - 2.4 Hold the centrifuge turbine assembly in one hand and loosen the knurled nut several turns until the face of the nut projects beyond the bronze bushing face.

⚠ CAUTION

Do not strike the nut or the bushing with or against a hard surface or you will damage them.

   - 2.5 Carefully separate the centrifuge bowl from the turbine base by striking the face of the nut with the palm of one hand while holding the bowl in the other. Remove the nut, the bowl and the baffle/screen.
   - 2.6 Replace the dirty centrifuge bowl with a new one, or carefully remove the cake of dirt from the bowl with a wooden spatula or other non-damaging tool. Wipe out the bowl with solvent.

   NOTE: To save time cleaning the bowl, an optional die-cut Bristol paper insert is available for lining the bowl so the compressed cake of dirt can be removed quickly.

   - 2.7 Wash the baffle/screen and turbine base, removing and discarding the black Nitrile bowl seal.
3. Inspect and assemble the centrifuge turbine assembly.

Centrifuge Bowl Cleaning, Spinner II®

3.1 Inspect the top and bottom bushings of the centrifuge turbine base and replace the turbine assembly, if the bushings show severe wear.

3.2 Place the baffle/screen over the stem of the turbine base and seat the baffle/screen evenly over the shoulder on the base.

3.3 Install the bowl seal in the recess in the outer edge of the turbine base.

3.4 Slide a new centrifuge bowl over the stem and seat it uniformly over the bowl seal.

3.5 Install and tighten the knurled bowl nut securely, *using finger pressure only.*

4. Clean and inspect the oil filter housing.

4.1 Inspect the housing assembly, paying special attention to the journal areas of the spindle.

4.2 Clean and inspect the cover.

4.3 Remove the old cover seal, and clean the groove in the housing and the mating surface of the cover.

4.4 Replace the cover seal with a new black Nitrile seal.

5. Check the air valve control mechanism. See **Fig. 2**.

5.1 Make a hook out of stiff wire, according to the measurements in **Fig. 2**.

5.2 Insert the hook at the spot shown in **Fig. 2**, and hook the float arm.

Lifting the float should release air into the filter housing.

Lowering the float should stop the flow of air into the filter housing.

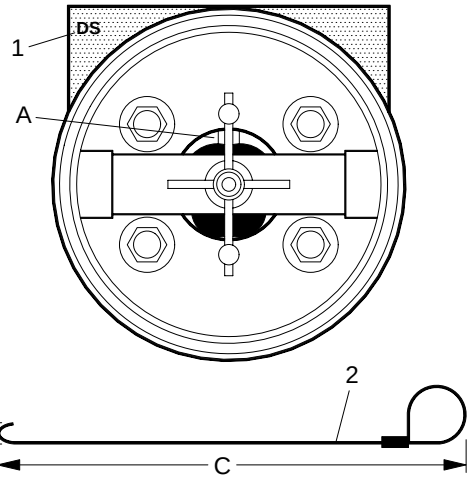
6. Install the centrifuge turbine assembly.

6.1 Install the centrifuge turbine assembly, and make sure it rotates freely.

6.2 Replace the cover, and position the clamp uniformly over the cover and housing flanges.

6.3 Tighten the clamp handle securely *by hand pressure only.*

7. With the engine running, check all the oil filter connections and joints for leaks.



NOTE: This is a view, downward into the housing assembly, with the centrifuge turbine assembly removed.

A. Use the hook at this point to hook the float arm.
B. 3/8 inch (10 mm)
C. 9 inches (229 mm)

1. Manufacturer Date Code
2. Hook

Fig. 2, Check the Air Valve

8. Remove the chocks from the tires.

General Information

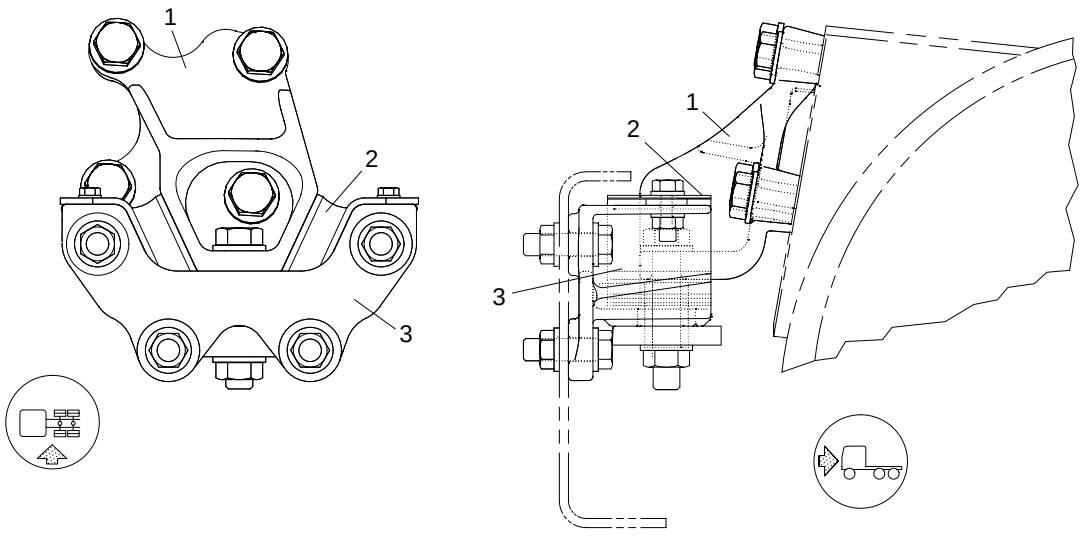
Three mounts support the engine and transmission in the chassis. Two of the engine mounts support the rear of the engine and transmission assembly, the third supports the front of the assembly.

The rear engine mounts on pre-EPA07 vehicles (**Fig. 1**) are bolted to the inside of the frame rails near the flywheel housing. These mounts support legs which are bolted to the flywheel housing. The V-shaped rear engine leg sets into a V-shaped rear engine mount. See **Fig. 2** and **Fig. 3**.

The rear engine mounts for EPA07 engines are designed for longer life and reduced engine vibration; they are one-piece, with the elastomer isolator bonded to the metal bracket. The engine leg fits into a flat recess in the mount. See **Fig. 4**.

The front engine mount is an underslung crossmember under the front of the engine. It supports a bracket (**Fig. 5** and **Fig. 6**) which is bolted to the engine at each side of the vibration damper pulley.

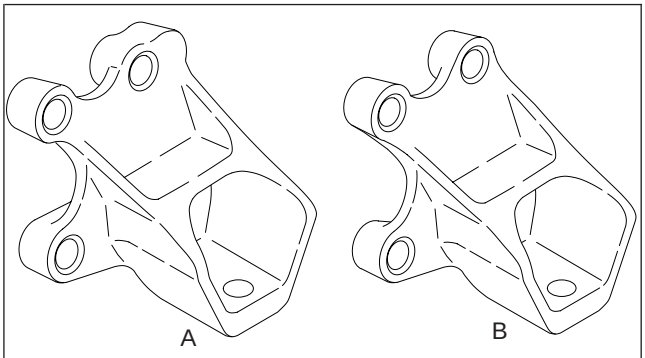
To isolate the engine and transmission from road shock, and to isolate the vehicle frame from engine vibration, the engine mounts are sandwiched between rubber isolator cushions, sometimes called restriction pads. Steel snubbers protect the cushions from wearing on the engine support brackets, and bolts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



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

Fig. 1, Rear Engine Mount, Cummins M11 Engine

General Information



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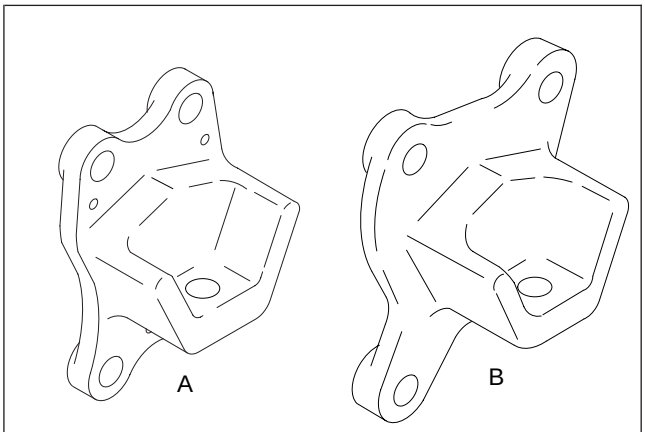
A. Caterpillar 3406 Engine Leg
B. Caterpillar 3176 Engine Leg

Fig. 2, Engine Legs, Caterpillar Engines



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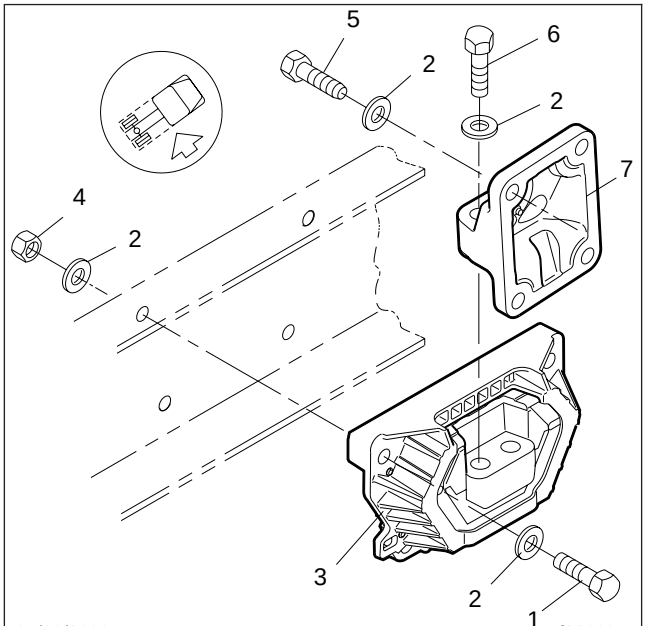
A. Detroit Diesel Series 55 Engine Leg
B. Detroit Diesel Series 50 and 60 Engine Leg

Fig. 3, Pre-EPA07 Engine Legs, Detroit Diesel Engines



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

Fig. 4, Rear Engine Mount and Engine Leg, EPA07 Engines

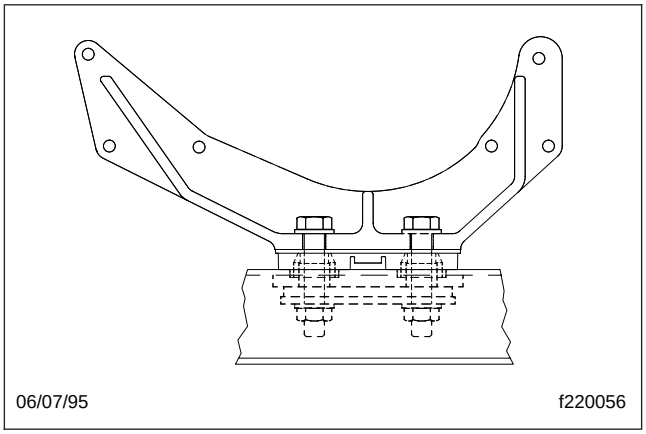

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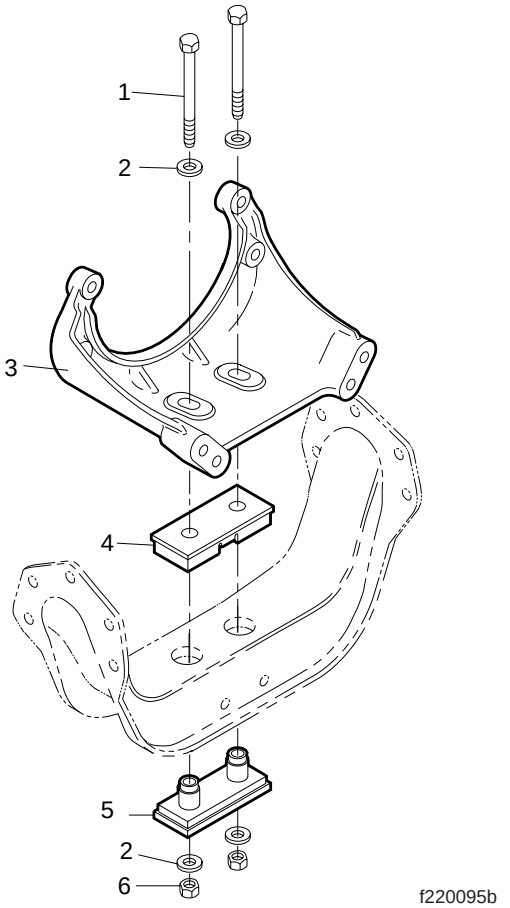
Fig. 5, Front Engine Support Bracket, Cummins M11 Engine



1. Hexbolt, 3/4–10
2. Hardened Washer
3. Front Engine Support Bracket
4. Upper Isolator
5. Lower Isolator
6. Hexnut, 3/4–10

Fig. 6, Front Engine Mount, EPA07 Engines

Replacement

NOTE: See **Fig. 1** for this procedure.

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

⚠ WARNING

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

2. 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.

   NOTE: To remove the bolt that connects the engine leg and the engine mount, you may have to disconnect and move the exhaust ducting. To do this, refer to the instructions in **Section 49.00**.

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

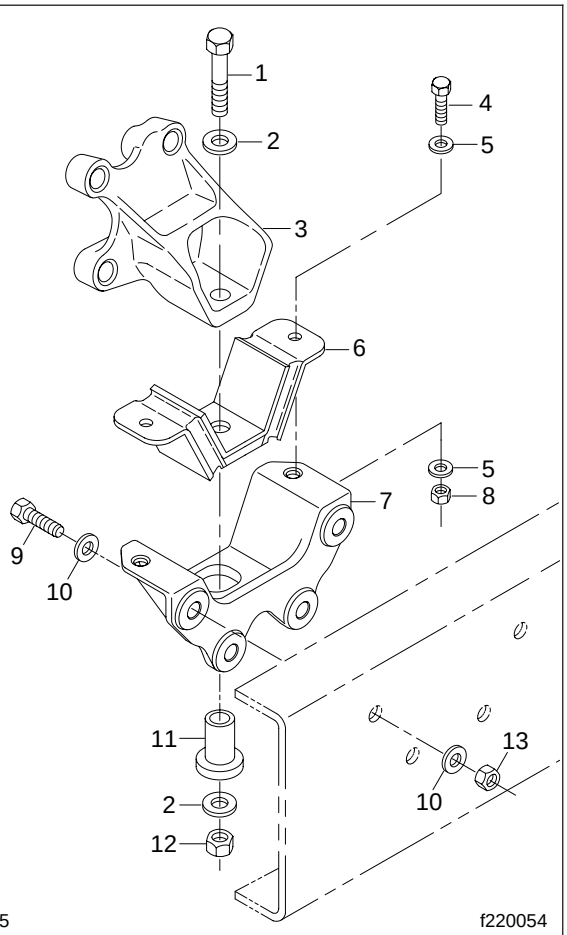
   2.3 Lift the engine slightly to take its weight off the right rear engine mount. Place engine stands under the engine to keep it off the engine mount.

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 120 to 152 lbf·ft (163 to 206 N·m).

5. If removed, install the engine leg on the right side of the flywheel housing. Apply thread-lock compound to the bracket mounting bolts, and tighten them to the torque values in **Table 1**.



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

Fig. 1, Rear Engine Mount Assembly for Cummins M11 Engines

Rear Engine Mount Replacement

Engine Leg-to-Flywheel Bolt Torques		
Engine Model	**Bolt Size**	**Torque lbf·ft (N·m)**
MBE4000	M16 x 1.5 x 50 mm (upper) M16 x 1.5 x 40 mm (lower)	195 (269)
Detroit Diesel Series 60	5/8–11 x 1-3/4 inches	136 (184)
Caterpillar C10/12/13/15/16	3/4–10 x 2 inches	190 (258)
Cummins ISM/ISX	3/4–10 x 2 inches	
Cummins N14	3/4–10 x 1-3/4 inches	

Table 1, Engine Leg-to-Flywheel Bolt Torques

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

NOTICE

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

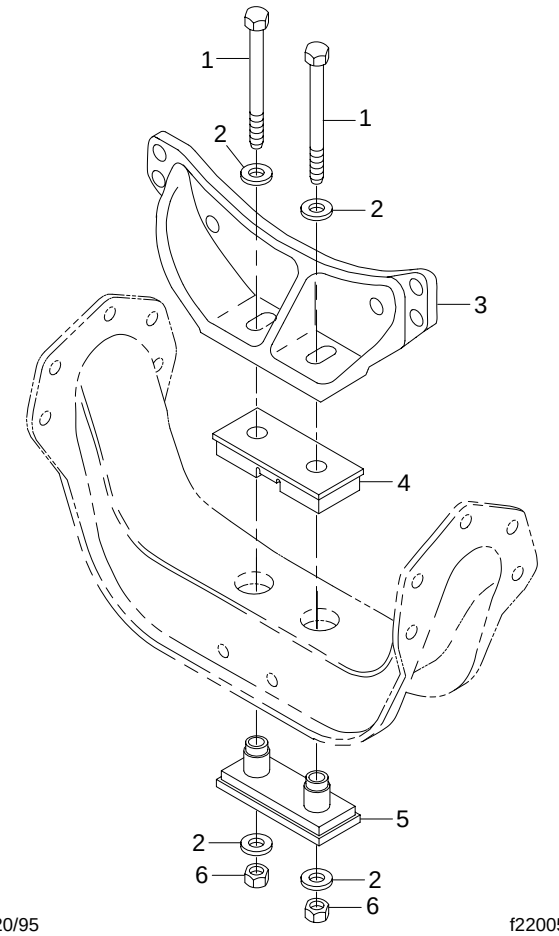
7. Install the upper isolator in the engine mount. In order for the isolator holes to align with the holes in the engine mount, the painted side of the isolator must be towards the engine. Fasten the isolator to the mount, and tighten the capscrews 14 to 18 lbf·ft (19 to 24 N·m).

⚠ WARNING

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

8. Secure the engine to the engine mounts.
   - 8.1 If not in place, set a jack under the rear of the engine and raise the jack until it is braced against the engine.
   - 8.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.
   - 8.3 Holding the lower isolator and snubber in place, install the bolt in the right rear engine mount, and secure it with the nut and hardened washer. Tighten the nut 213 to 269 lbf·ft (289 to 365 N·m).
9. Repeat this procedure for the other rear engine mount.
10. Remove the jack from under the engine.

Replacement



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

Fig. 1, Front Engine Mount Assembly, Cummins M11 Engine

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

⚠ WARNING

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

2. Disconnect the engine from the front engine mount; **see (Fig. 1)**.

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

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

   NOTE: In order to raise the front of the engine, without damaging the rear engine mounts, it may be necessary to loosen the bolts that run through the rear engine mounts.

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

3. If the front engine support bracket is to be replaced, refer to the engine manufacturer's service literature.
4. Inspect the engine mount rubber isolators for wear or damage, and replace them if necessary.

NOTICE

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

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

⚠ WARNING

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

Front Engine Mount Replacement

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 in place, install the bolts in the front engine mount and secure them with the nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

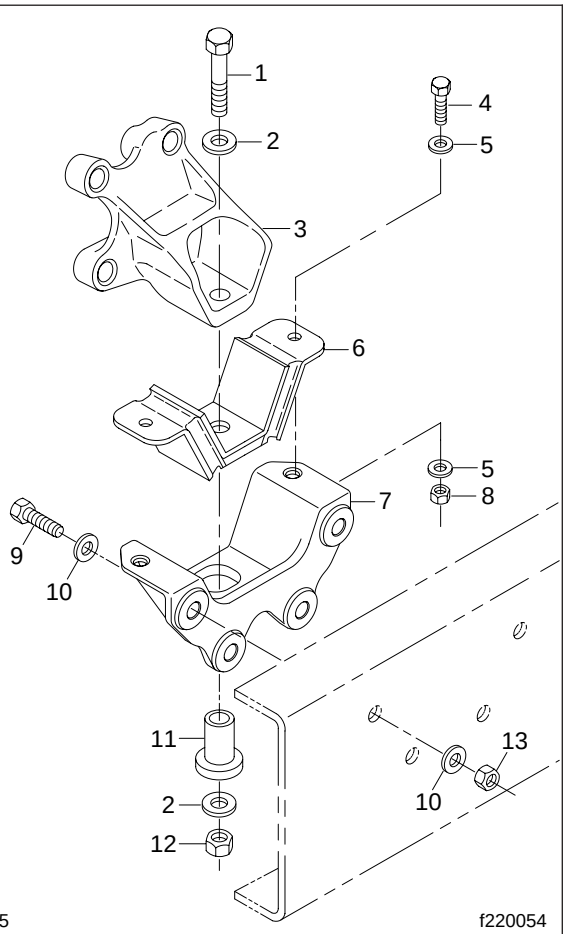
   NOTE: If you loosened the bolts that run through the rear engine mounts, tighten those bolts 213 to 269 lbf·ft (289 to 365 N·m).

   - 6.4 Remove the lifting chain from the engine lifting hooks.
7. Remove the chocks from the tires.

Rear Engine Mount Isolator Replacement

Replacement (See Fig. 1)

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



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

Fig. 1, Rear Engine Mount Assembly, Cummins M11 Engines

⚠ WARNING

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

   NOTE: To remove the bolt that connects the engine leg and the engine mount, you may have to disconnect and move the exhaust ducting. To do this, refer to the instructions in **Section 49.00**.

   2.2 Remove the bolt from the right rear engine mount. Save the fasteners.

   2.3 Use the jack to raise the engine slightly, and secure it with jack stands.

   2.4 Remove the two capscrews that hold the ends of the isolator to the engine mount.

   2.5 Remove the engine mount from the frame rail. For instructions, refer to **Subject 100**. Remove and discard the isolator.

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

NOTICE

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

4. Install the new isolator in the engine mount, and install the engine mount on the frame rail. In order for the isolator holes to align with the holes in the engine mount, the painted side of the isolator must be towards the engine. For instructions, refer to **Subject 100**.

   Secure the isolator to the mount with two capscrews and locknuts, tighten the locknuts 14 to 18 lbf·ft (19 to 24 N·m).

Rear Engine Mount Isolator Replacement

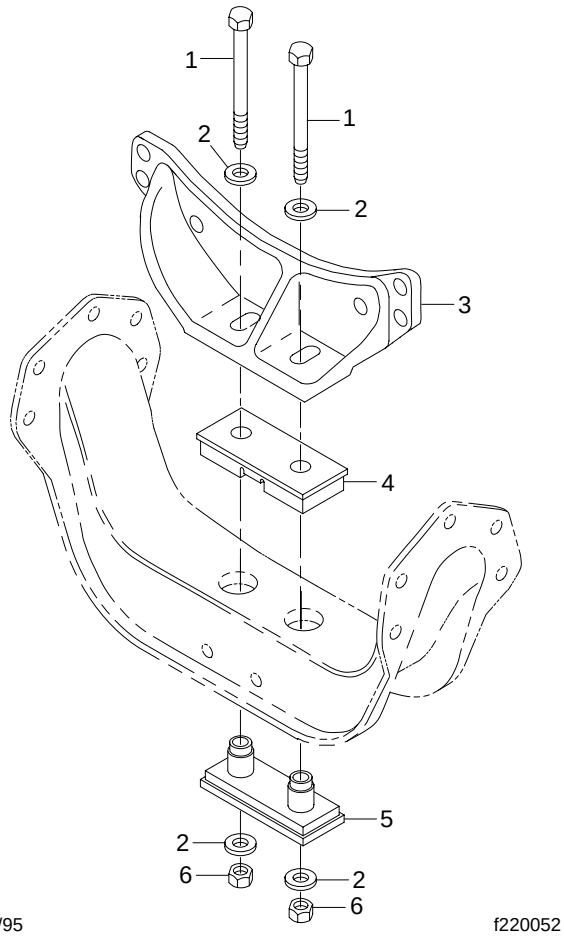
⚠ WARNING

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

5. Secure the engine to the engine mount.
   - 5.1 If not in place, set a jack under the rear of the engine and raise the jack until it is braced against the engine.
   - 5.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.
   - 5.3 Install the bolt in the right rear engine mount, and secure it with the nut and hardened washer. Tighten the nut 213 to 269 lbf·ft (289 to 365 N·m).
6. Repeat this procedure for the other rear engine mount.
7. Remove the jack from under the engine.

Front Engine Mount Isolator Replacement

Replacement (See Fig. 1)



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

Fig. 1, Front Engine Mount Assembly, Cummins M11 Engine

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

⚠ WARNING

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

2. Disconnect the engine from the front engine mount.

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

   2.2 Remove the bolt(s) from the front engine mount. Save the fasteners, 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.

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

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

NOTICE

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

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

5. Secure the engine to the front engine mount.

Front Engine Mount Isolator Replacement

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

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

5.3 Holding the lower isolator in place, install the bolts in the front engine mount and secure them with the nuts and washers. Tighten the nuts 213 to 269 lbf·ft (289 to 365 N·m).

NOTE: If you loosened the bolts that run through the rear engine mounts, tighten those bolts 213 to 269 lbf·ft (289 to 365 N·m).

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

Rear Engine Mount Replacement, EPA07 Engines

Removal

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

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

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

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

⚠ DANGER

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

To avoid potentially serious burns or material damage:

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

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

⚠ CAUTION

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

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

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

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

⚠ WARNING

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

Rear Engine Mount Replacement, EPA07 Engines

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

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

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

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

    For instructions on removing the fuel tank(s), refer to **Group 47** in this workshop manual.
17. Remove the fasteners that hold the driveline midship-bearing bracket to the frame crossmember.
18. Using suitable straps, secure the driveline and the midship bearing to the frame crossmember. Make sure the driveshaft is supported loosely enough so that the slip joint aft of the midship bearing will be able to extend when the engine is raised.
19. Remove the overslung crossmember from the transmission housing.

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

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

⚠ WARNING

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

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

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

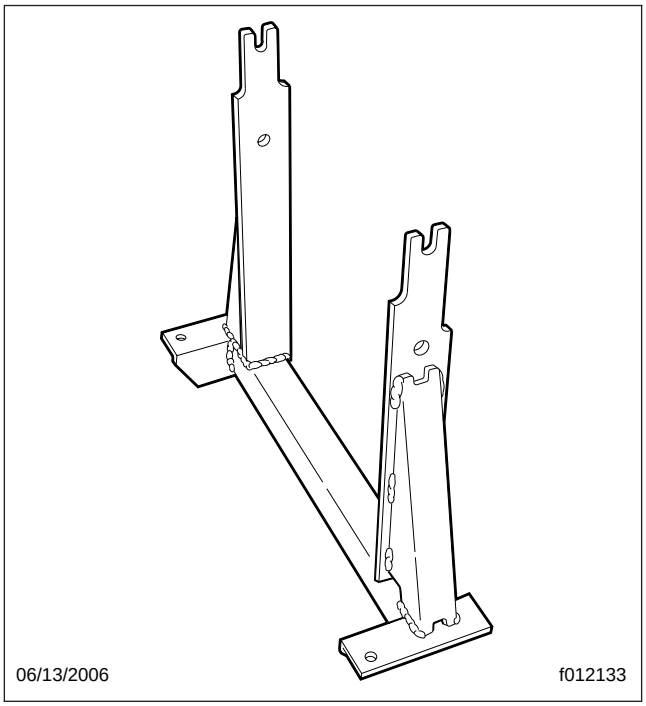
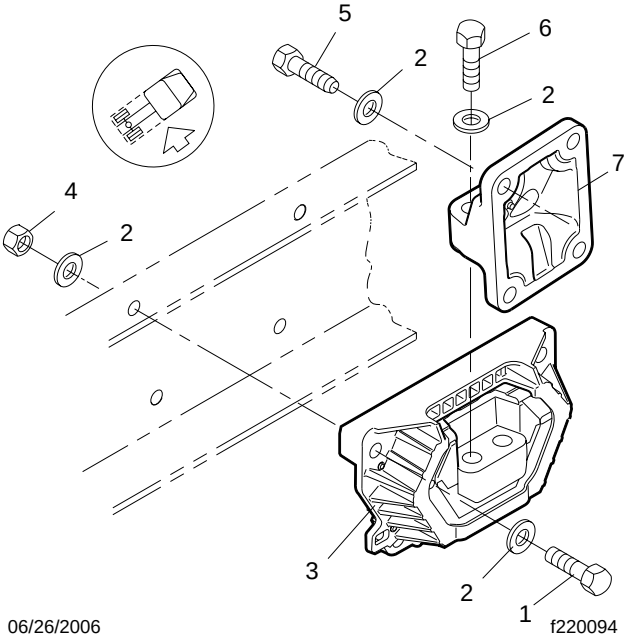


Fig. 1, Engine Shipping Stand, Detroit Diesel Series 60 Engine

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

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



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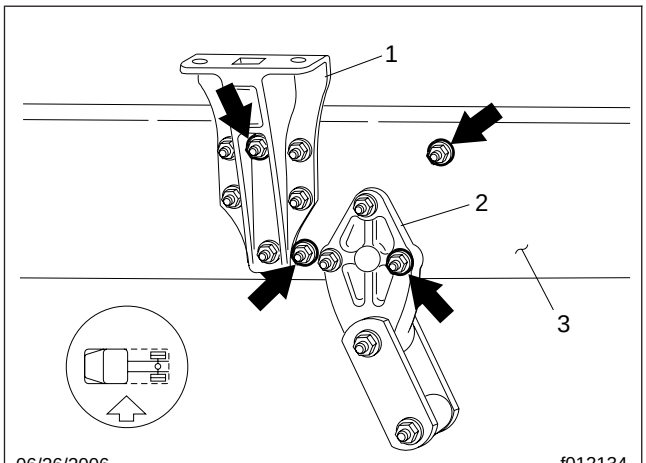
1. Hexbolt, 5/8–11
2. Hardened Washer
3. Rear Engine Mount Assembly
4. Hexnut, 5/8–11
5. Capscrew, 5/8–11
6. Capscrew, 3/4–10
7. Engine Leg

Fig. 2, Rear Engine Mount and Engine Leg

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



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

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

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

Installation

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

Rear Engine Mount Replacement, EPA07 Engines

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

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

Specifications

Engine Mount Torques, Pre-EPA07			
Description	**Capscrew Size**	**Grade**	**Torque: lbf·ft (N·m)**
Engine Mount-to-Frame Rail Capscrew	5/8–11 x 2.5 Inch	8	120 to 152 (163 to 206)
Engine Leg-to-Flywheel Housing Bolts:			
Cummins Engines	3/4–10 x 2 Inches	8	190 (258)
Detroit Diesel Series 60 Engines	5/8–11 x 1-3/4 Inches	8	136 (184)
MBE4000 Engines	M16 x 1.5 x 50 mm	10.9	175 (237)
Caterpillar Engines	3/4–10 x 2 Inches	8	170 to 210 (230 to 285)
Isolator-to-Rear Engine Mount Capscrew	5/16–18 x 1 Inch	8	14 to 18 (19 to 24)
Engine Leg-to-Engine Mount Capscrew	3/4–10 x 4.5 Inch	8	213 to 269 (289 to 365)
Front Engine Bracket-to-Front Engine Mount Capscrew	3/4–10 x 4 Inch	8	213 to 269 (289 to 365)

Table 1, Engine Mount Torques, Pre-EPA07

Engine Mount Torques, EPA07 Engines			
Description	**Capscrew Size**	**Grade**	**Torque: lbf·ft (N·m)**
Engine Mount-to-Frame Rail Capscrew	5/8–11	8	120 to 152 (163 to 206)
Engine Leg-to-Flywheel Housing Bolts:			
Detroit Diesel Series 60 Engines	5/8–11 x 2-1/4 Inches	8	136 (184)
MBE4000 Engines	M16 x 1.5 x 60 mm (upper) M16 x 1.5 x 50 mm (lower)	10.9	195 (269)
Caterpillar Engines (C13 & C15)	3/4–10 x 2-3/4 Inches	8	170 to 210 (230 to 285)
Engine Leg-to-Engine Mount Flange-Head Capscrew	3/4–10	8	320 (434)
Front Engine Bracket-to-Front Engine Mount Capscrew	3/4–10	8	213 to 269 (289 to 365)

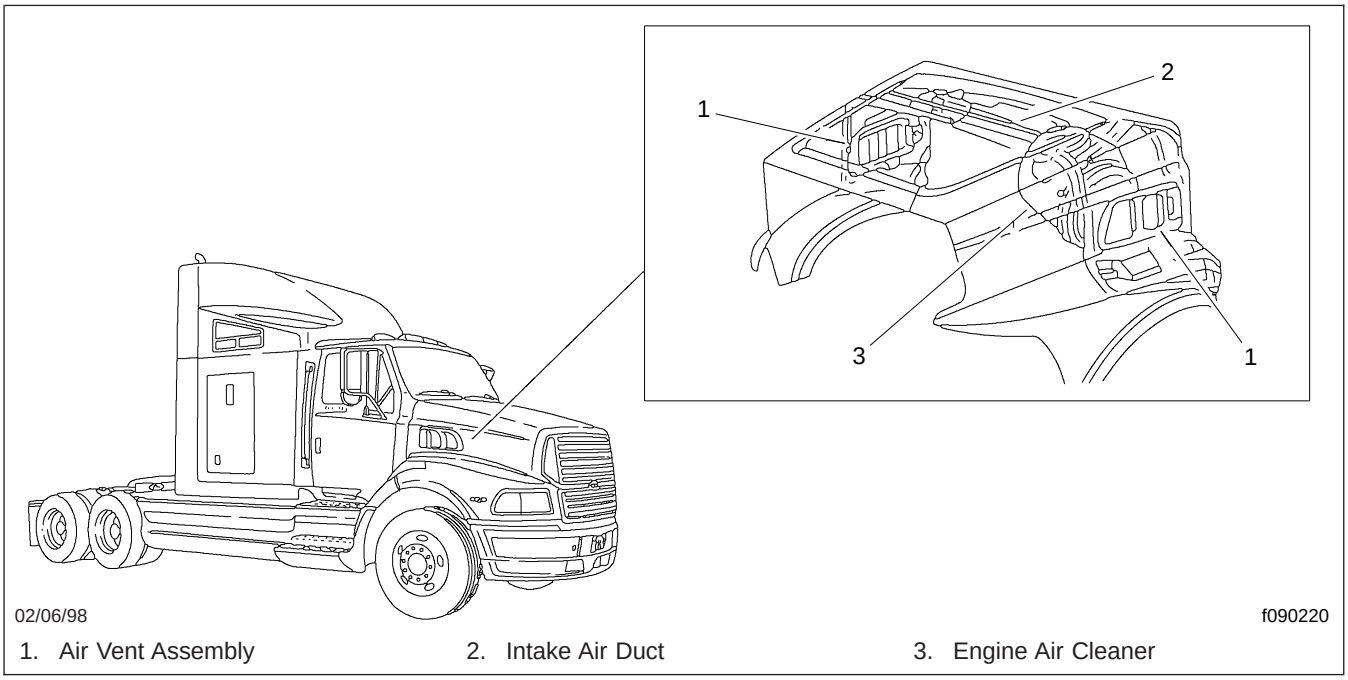
Table 2, Engine Mount Torques, EPA07 Engines

General Information

OUTSIDE AIR INTAKE SYSTEM

(See Fig. 1)

Air enters the air cleaner assembly through a duct molded into the underside of the hood. The ends of the duct are connected to air intake vents mounted on either side of the hood. At the outlet to the air filter assembly, a seal is installed on the air cleaner housing to prevent the entry of underhood air.



1. Air Vent Assembly
2. Intake Air Duct
3. Engine Air Cleaner

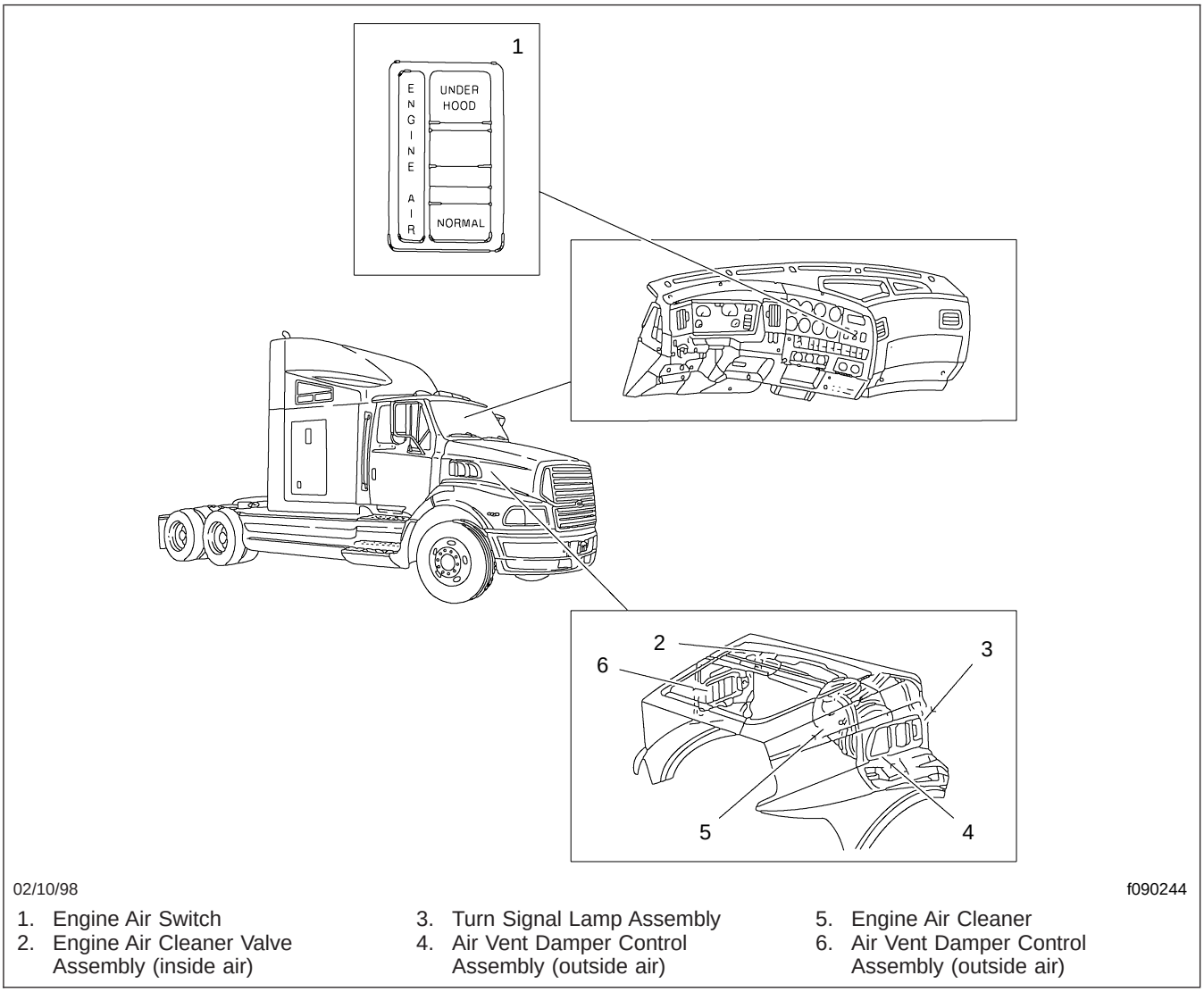
Fig. 1, Air Intake, Typical

INSIDE/OUTSIDE AIR INTAKE SYSTEM (See Fig. 2)

For snowplowing operations, the engine air intake can be switched from outside air to underhood (inside) air. The outside air intakes, mounted on either side of the hood, are sealed by pneumatic doors. At the same time, another pneumatic door, located under the hood in the air intake duct, opens to underhood (inside) air.

The inside/outside air intake system is controlled by the engine air switch on the instrument panel. When set in the underhood (inside) position, pressurized air activates the outside air doors and the inside air door. When the switch is set in the normal (outside) position, the air is vented and spring pressure returns the doors to the outside air intake system position.

General Information



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1. Engine Air Switch
2. Engine Air Cleaner Valve Assembly (inside air)
3. Turn Signal Lamp Assembly
4. Air Vent Damper Control Assembly (outside air)
5. Engine Air Cleaner
6. Air Vent Damper Control Assembly (outside air)

Fig. 2, Inside/Outside Air Intake System

Air Intake Ducting Replacement

Replacement

WARNING

Do not operate the engine with any component of the air intake system removed; serious personal injury can occur if the turbocharger impeller is touched when it is rotating and doing so could result in engine damage.

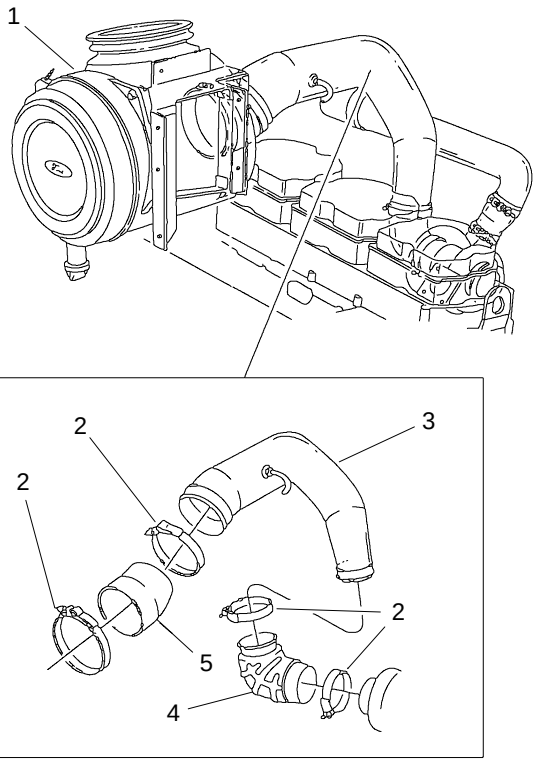
CAUTION

Do not operate the vehicle with the air filter element or any air intake component removed. All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners.

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Disconnect the air restriction gauge line, if equipped.
3. Loosen the screws on the hose clamps at the air cleaner outlet and the turbocharger inlet. See **Fig. 1** and **Fig. 2** (Cummins C10 and C12), **Fig. 3** and **Fig. 4** (Caterpillar 3306), **Fig. 5** and **Fig. 6** (Caterpillar 3406E), **Fig. 7** and **Fig. 8** (Cummins B5.9), **Fig. 9** and **Fig. 10** (Cummins C8.3), **Fig. 11** and **Fig. 12** (Cummins M11), **Fig. 13** and **Fig. 14** (Cummins N14), **Fig. 15** and **Fig. 16** (DDE Series 60).
4. Remove the air duct assembly from the air cleaner outlet and the turbocharger inlet.
5. Replace any damaged parts with new parts.

IMPORTANT: Rubber hoses that have been enlarged, extended, or modified by bonding after original molding, are not acceptable for installation between the air cleaner and the engine.

6. Install the air duct assembly on the air cleaner outlet and turbocharger inlet. Pull the hoses onto each connection until they overlap at least 1 inch (25 mm).
7. Tighten the hose clamp at the turbocharger 90 to 100 lbf·in (1015 to 1130 N·cm). Tighten the hose clamp at the air cleaner outlet 40 lbf·in (450 N·cm).
8. Connect the air restriction gauge line, if equipped.
9. Return the hood to the operating position and remove the chocks.



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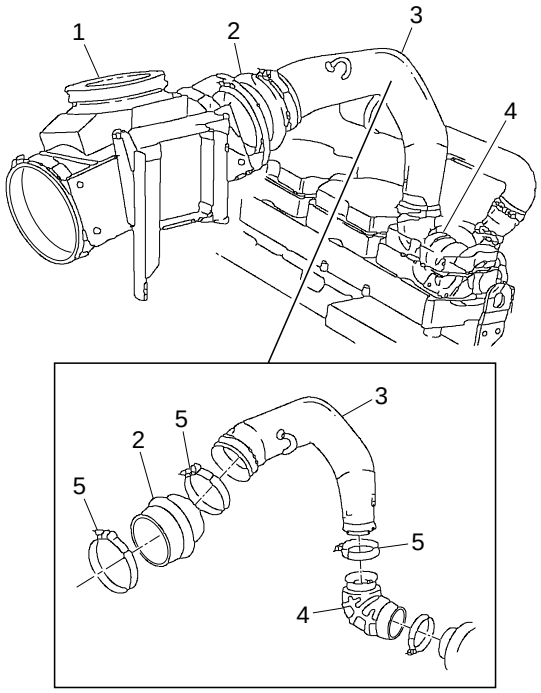
1. Air Cleaner Assembly
2. Clamp
3. Tube (air cleaner outlet hose to turbocharger inlet fitting)
4. Hose (air cleaner outlet hose to turbocharger inlet fitting)
5. Hose (air cleaner outlet)

Fig. 1, Caterpillar C10 and C12 Air Intake Ducting, Donaldson Filter Assemblies

Air Intake Ducting Replacement



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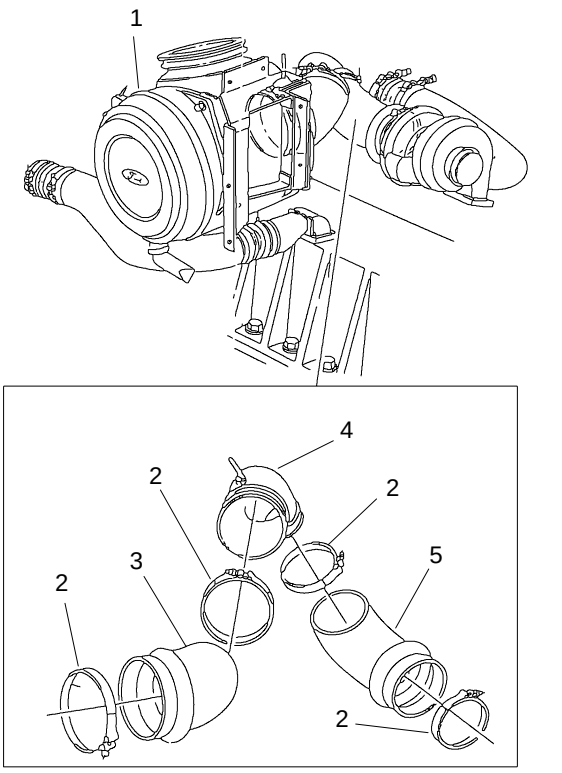
1. Air Cleaner Assembly
2. Hose (air cleaner outlet)
3. Tube (air cleaner outlet hose to turbocharger inlet fitting)
4. Fitting (turbocharger inlet)
5. Clamp

Fig. 2, Caterpillar C10 and C12 Air Intake Ducting, Farr Disposable Filter Assemblies



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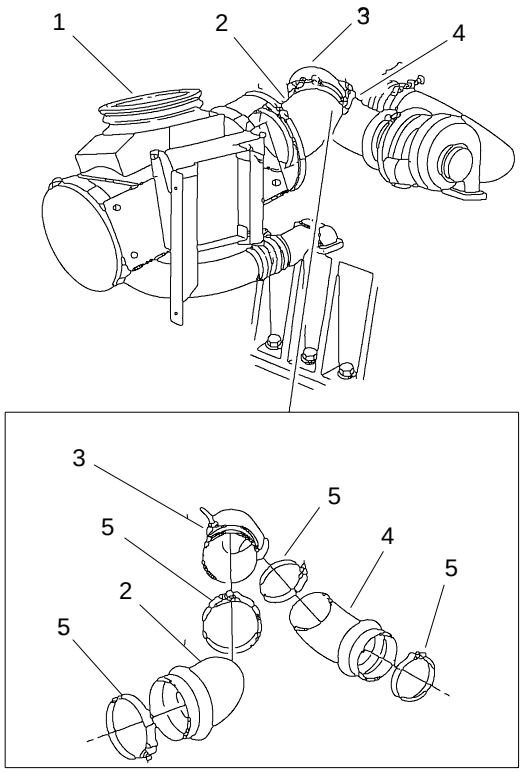
1. Air Cleaner Assembly
2. Clamp
3. Hose (air cleaner outlet)
4. Tube (air cleaner outlet hose to turbocharger inlet fitting)
5. Hose (air cleaner outlet tube to turbocharger inlet fitting)

Fig. 3, Caterpillar 3306 Air Intake Ducting, Donaldson Filter Assemblies

Air Intake Ducting Replacement



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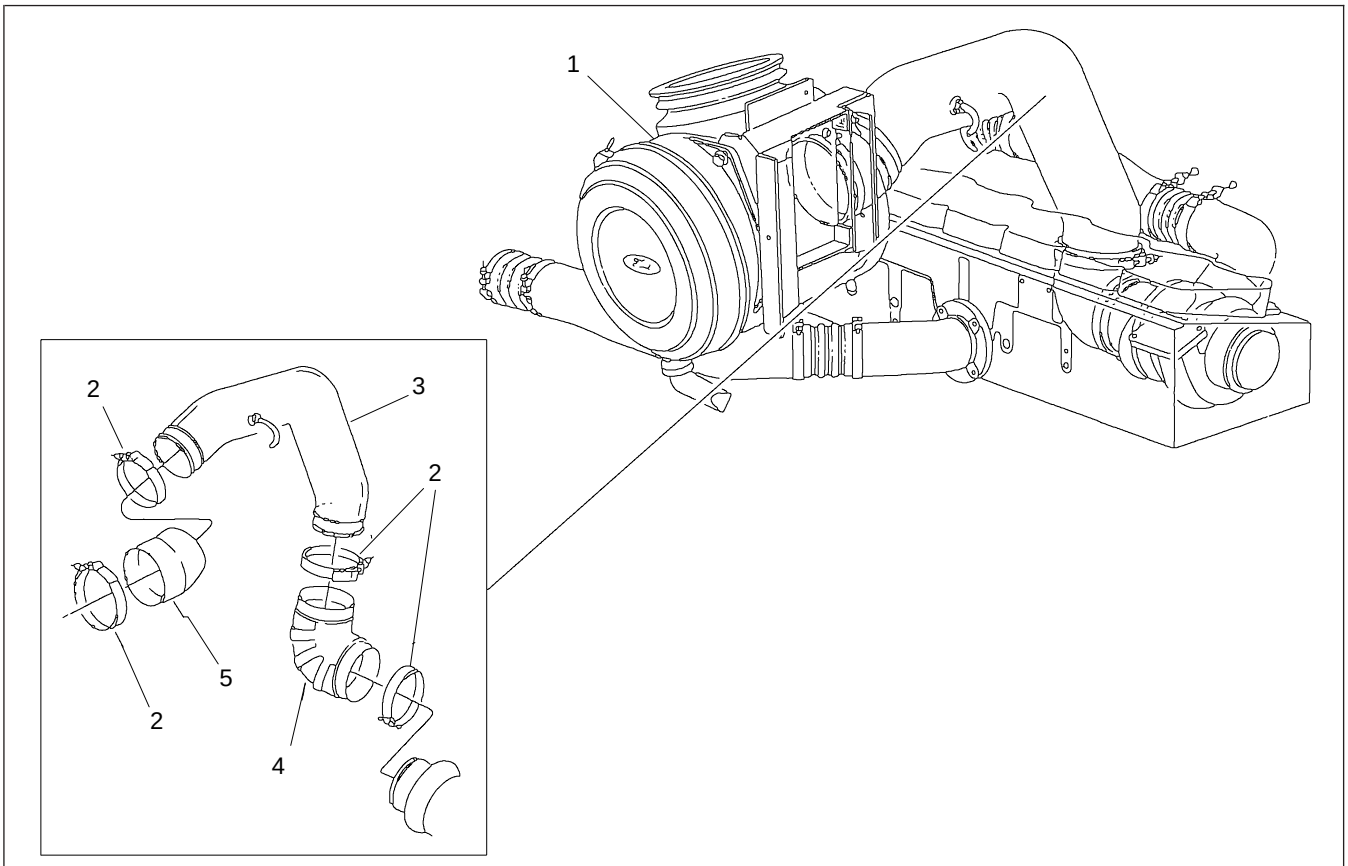
1. Air Cleaner Assembly
2. Hose (air cleaner outlet)
3. Tube (air cleaner outlet hose to turbocharger inlet fitting)
4. Hose (air cleaner outlet tube to turbocharger inlet fitting)
5. Clamp

Fig. 4, Caterpillar 3306 Air Intake Ducting, Farr Disposable Filter Assemblies

Air Intake Ducting Replacement

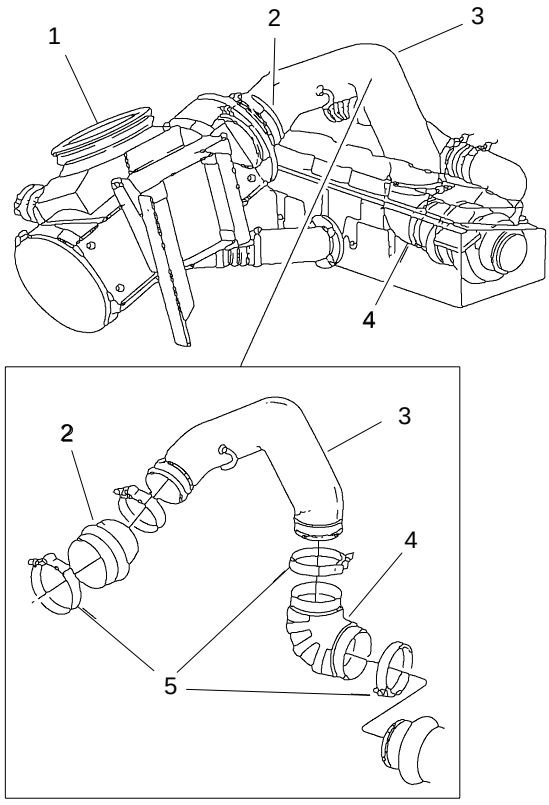


02/09/98 f090229

1. Air Cleaner Assembly
2. Clamp
3. Tube (air cleaner outlet hose to turbocharger inlet fitting)
4. Hose (air cleaner outlet tube to turbocharger inlet fitting)
5. Hose (air cleaner outlet)

Fig. 5, Caterpillar 3406E Air Intake Ducting, Donaldson Filter Assemblies

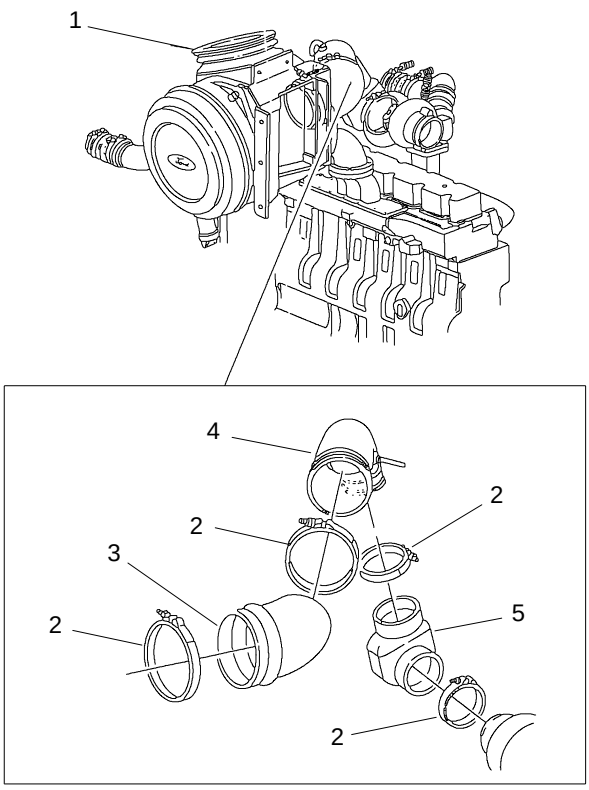
Air Intake Ducting Replacement



02/09/98 f090230

1. Air Cleaner Assembly
2. Hose (air cleaner outlet)
3. Tube (air cleaner outlet hose to turbocharger inlet fitting)
4. Hose (air cleaner outlet tube to turbocharger inlet fitting)
5. Clamp

Fig. 6, Caterpillar 3406E Air Intake Ducting, Farr Disposable Filter Assemblies

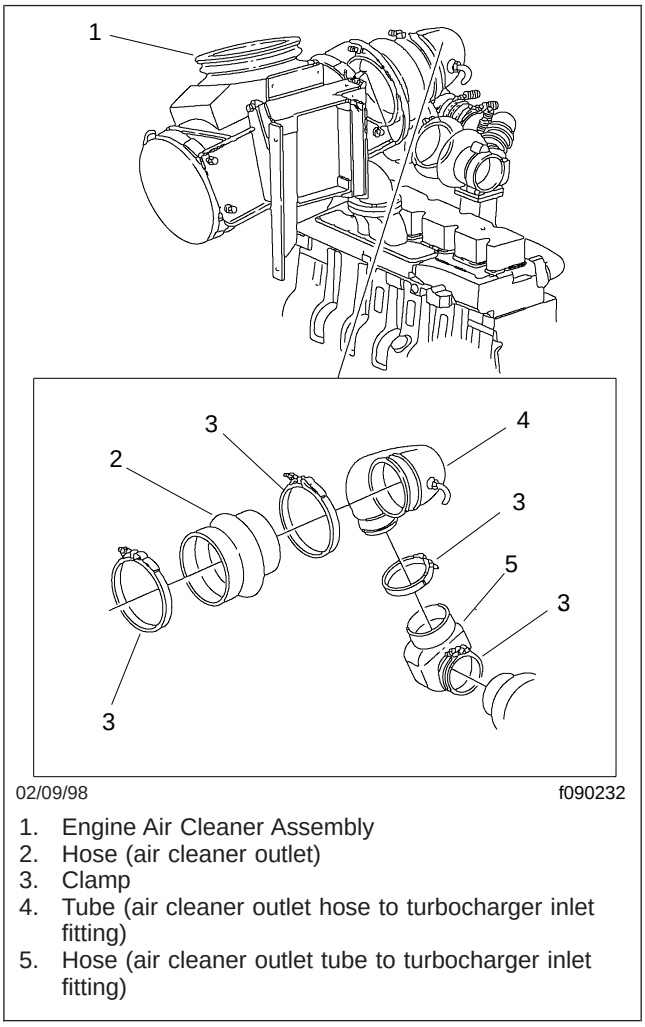


02/09/98 f090231

1. Engine Air Cleaner Assembly
2. Clamp
3. Hose (air cleaner outlet)
4. Tube (air cleaner outlet hose to turbocharger inlet fitting)
5. Hose (air cleaner outlet tube to turbocharger inlet fitting)

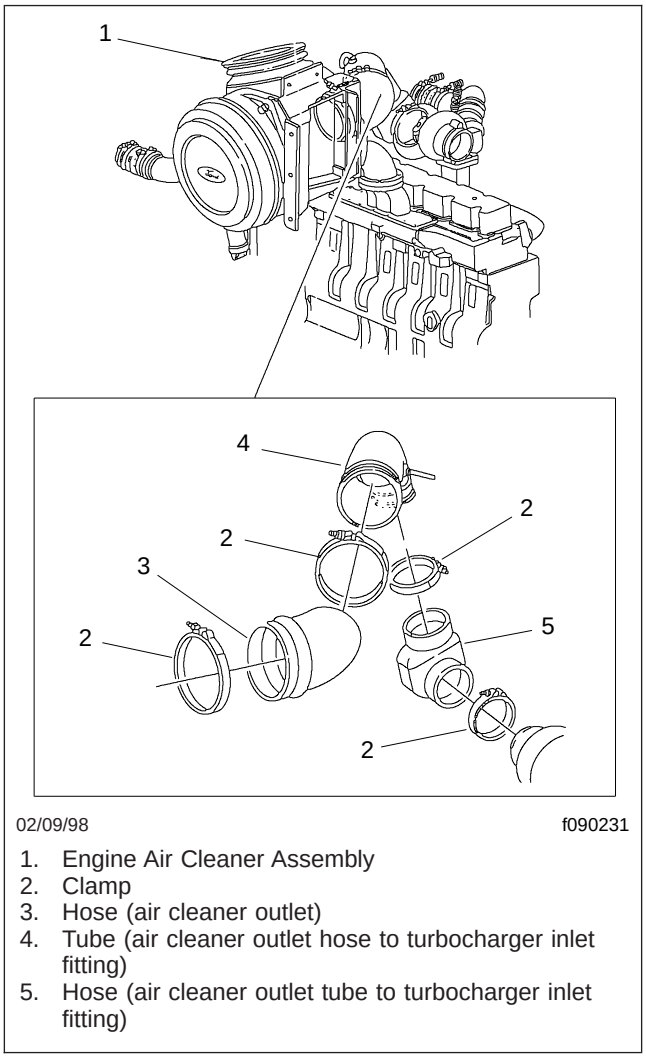
Fig. 7, Cummins ISB Air Intake Ducting, Donaldson Filter Assemblies

Air Intake Ducting Replacement



1. Engine Air Cleaner Assembly
2. Hose (air cleaner outlet)
3. Clamp
4. Tube (air cleaner outlet hose to turbocharger inlet fitting)
5. Hose (air cleaner outlet tube to turbocharger inlet fitting)

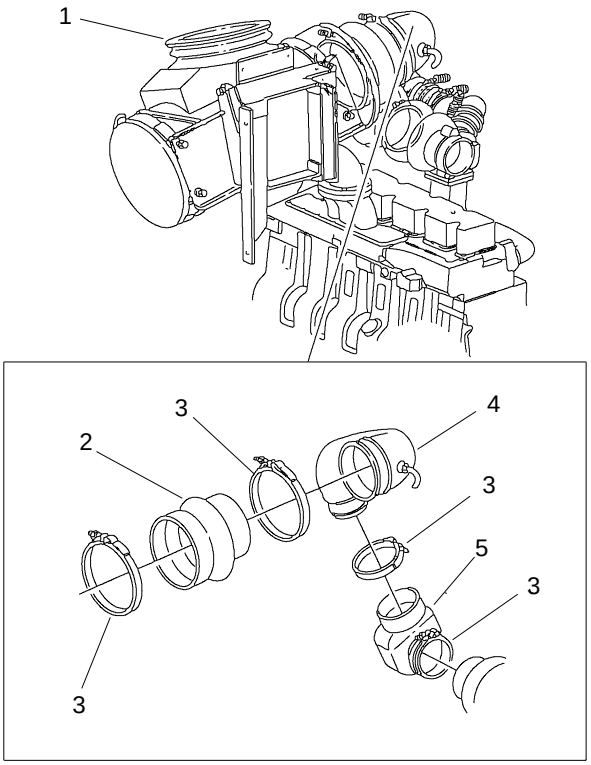
Fig. 8, Cummins ISB Air Intake Ducting, Farr Disposable Filter Assemblies



1. Engine Air Cleaner Assembly
2. Clamp
3. Hose (air cleaner outlet)
4. Tube (air cleaner outlet hose to turbocharger inlet fitting)
5. Hose (air cleaner outlet tube to turbocharger inlet fitting)

Fig. 9, Cummins ISC Air Intake Ducting, Donaldson Filter Assemblies

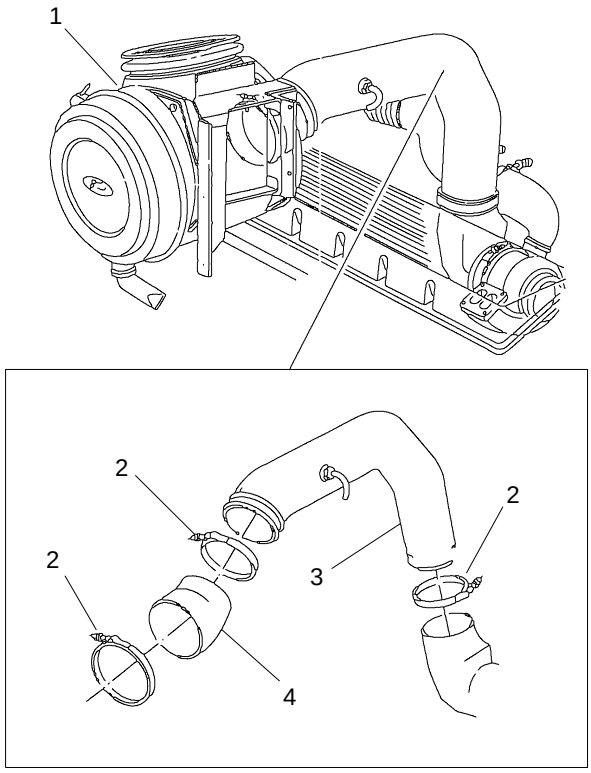
Air Intake Ducting Replacement



02/09/98 f090232

1. Engine Air Cleaner Assembly
2. Hose (air cleaner outlet)
3 Clamp
4. Tube (air cleaner outlet hose to turbocharger inlet fitting)
5. Hose (air cleaner outlet hose to turbocharger inlet fitting)

Fig. 10, Cummins ISC Air Intake Ducting, Farr Disposable Filter Assemblies

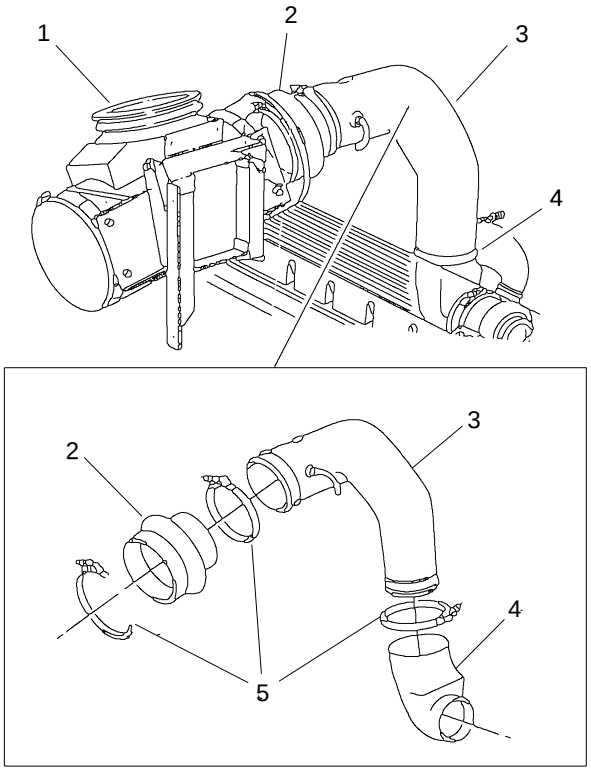


02/09/98 f090233

1. Air Cleaner Assembly
2. Clamp
3. Tube (air cleaner outlet hose to turbocharger inlet fitting)
4. Hose (air cleaner outlet)

Fig. 11, Cummins M11 Air Intake Ducting, Donaldson Filter Assemblies

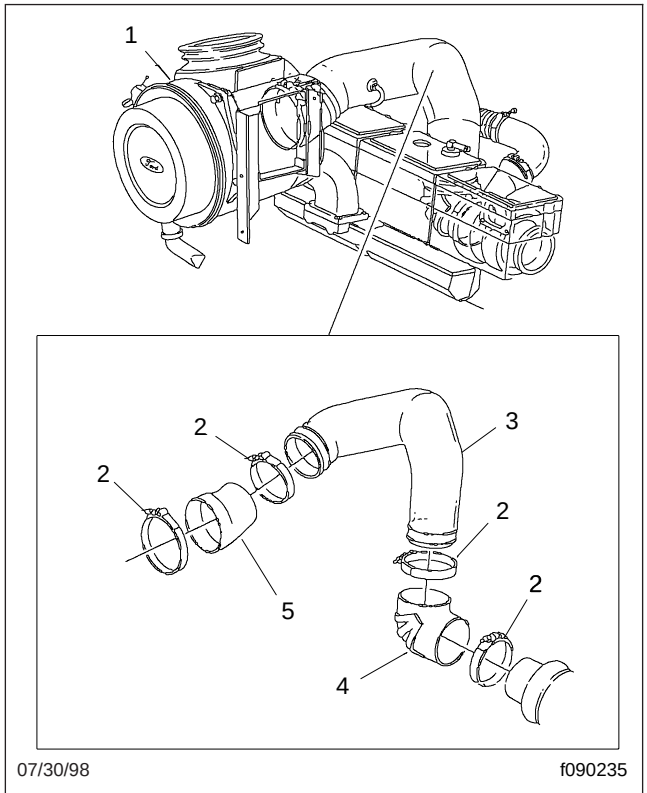
Air Intake Ducting Replacement



02/09/98 f090234

1. Air Cleaner Assembly
2. Hose (air cleaner outlet)
3. Tube (air cleaner outlet hose to turbocharger inlet fitting)
4. Hose (air cleaner outlet hose to turbocharger inlet fitting)
5. Clamp

Fig. 12, Cummins M11 Air Intake Ducting, Farr Disposable Filter Assemblies

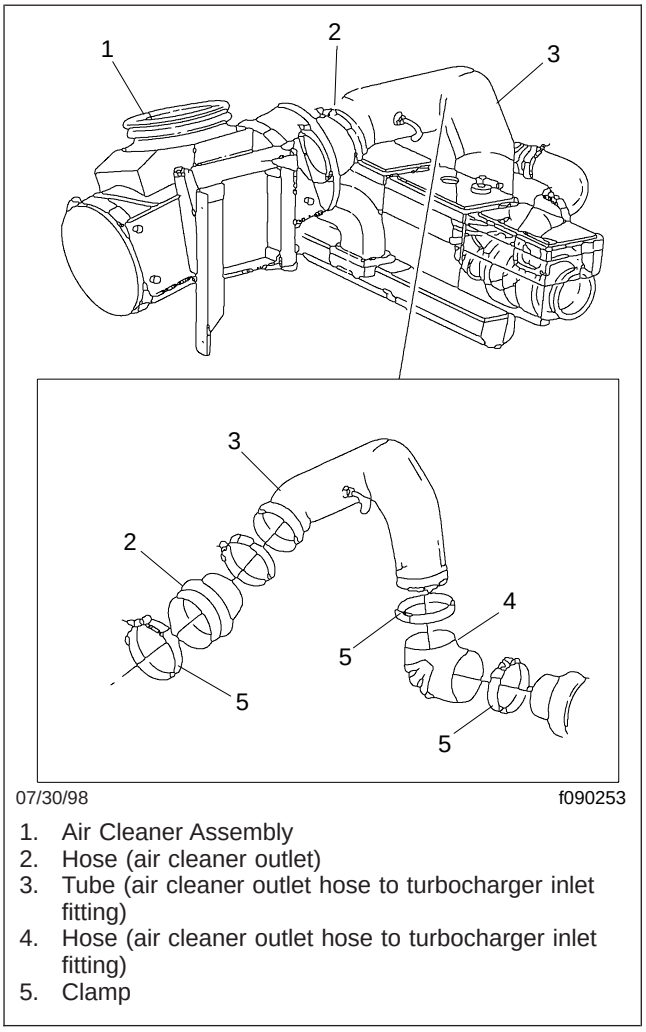


07/30/98 f090235

1. Air Cleaner Assembly
2. Clamp
3. Tube (air cleaner outlet hose to turbocharger inlet fitting)
4. Hose (air cleaner outlet hose to turbocharger inlet fitting)
5. Hose (air cleaner outlet)

Fig. 13, Cummins N14 Air Intake Ducting, Donaldson Filter Assemblies

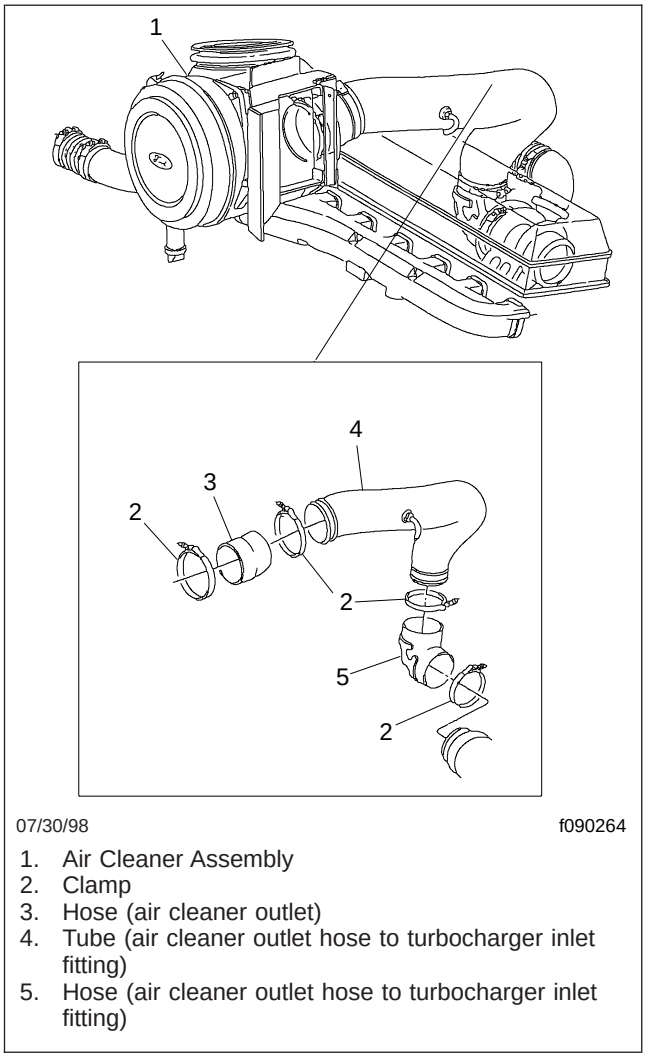
Air Intake Ducting Replacement



07/30/98 f090253

1. Air Cleaner Assembly
2. Hose (air cleaner outlet)
3. Tube (air cleaner outlet hose to turbocharger inlet fitting)
4. Hose (air cleaner outlet hose to turbocharger inlet fitting)
5. Clamp

Fig. 14, Cummins N14 Air Intake Ducting, Farr Disposable Filter Assemblies

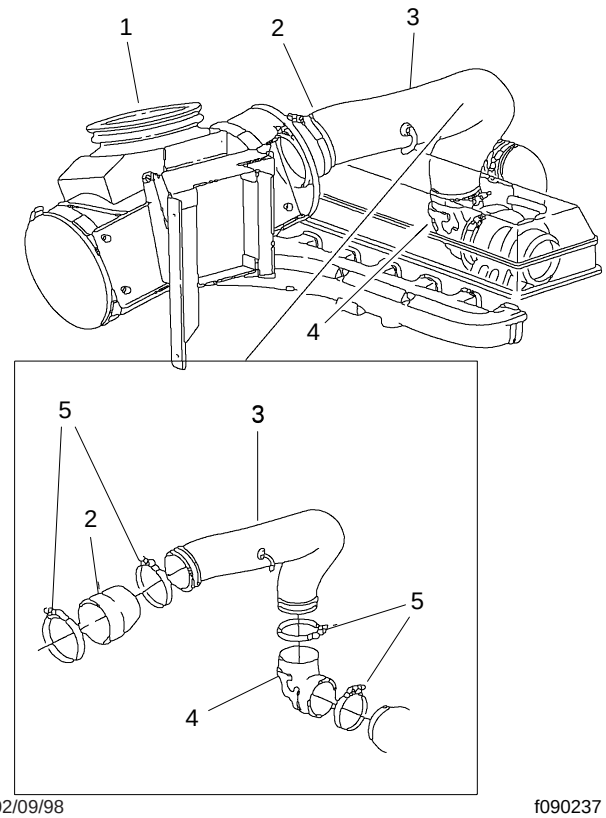


07/30/98 f090264

1. Air Cleaner Assembly
2. Clamp
3. Hose (air cleaner outlet)
4. Tube (air cleaner outlet hose to turbocharger inlet fitting)
5. Hose (air cleaner outlet hose to turbocharger inlet fitting)

Fig. 15, DDE Series 60 Air Intake Ducting, Donaldson Filter Assemblies

Air Intake Ducting Replacement



1. Air Cleaner Assembly
2. Hose (air cleaner outlet)
3. Tube (air cleaner outlet hose to turbocharger inlet fitting)
4. Hose (air cleaner outlet hose to turbocharger inlet fitting)
5. Clamp

Fig. 16, DDE Series 60 Air Intake Ducting, Farr Disposable Filter Assemblies

Troubleshooting

Problem—Excessive Black Smoke Under Load/Low Power

Problem—Excessive Black Smoke Under Load/Low Power	
Possible Cause	**Remedy**
Pressurized air leaking from loose connections or cracks in the charge air cooler, ducts or intake manifold.	Check the entire intake air system for leaks. Perform the charge air cooler leak test. Refer to "Leak Test—Charge Air Cooler" under "Charge Air Cooler Repairs" in this section. Repair the intake air system. Restore the vehicle. Test the system for proper operation.
Leaks or restrictions in the exhaust system will cause the turbine and impeller to operate at a lower speed and reduce the amount of air being forced into the cylinders.	Repair the exhaust system.
A restriction in the pressure side of the intake air system will change the air-to-fuel ratio.	Check for a restricted or leaking charge air cooler. Perform the charge air cooler leak test. Refer to "Leak Test—Charge Air Cooler" under "Charge Air Cooler Repairs" in this section. Repair the intake air system.
High restriction caused by the inside/outside air intake system valves frozen closed or air inlets iced over.	Check operation of the doors. If frozen, carefully free or thaw.
A malfunctioning, unserviceable or miscalibrated turbocharger wastegate can result in low boost pressures.	Check the turbocharger wastegate function and calibration. Refer to the engine manufacturer’s service manual. Replace or calibrate as necessary.
Failure of the turbocharger internal components. A bearing failure can produce friction, reducing the speed of the rotor assembly. Bearing failure can allow the compressor and impeller blades to rub the housing, reducing the rotor assembly speed.	Replace the turbocharger. Refer to the engine manufacturer’s service manual.
Restriction of airflow increases as the air cleaner element removes contaminants from the intake air. Restricted airflow changes the air-to-fuel mixture.	Replace the air cleaner element.

Problem—High Oil Consumption

Problem—High Oil Consumption	
Possible Cause	**Remedy**
A restricted or damaged oil return line will cause the turbocharger housing to become pressurized, causing engine oil to migrate past the turbocharger seals.	Clean or replace the oil return line as necessary. Restore the vehicle. Test the system for proper operation.
Suspect unserviceable seal rings only if there is an excessive amount of engine oil in the turbocharger housing and no other causes are found for the excessive oil consumption.	Replace the turbocharger. Refer to the engine manufacturer’s service manual.

Troubleshooting

Problem—High Oil Consumption	
Possible Cause	**Remedy**
Excessive crankcase pressure will not allow the oil to drain from the turbocharger. This will load the bearing housing and allow the engine oil to leak past the compressor seals and into the engine.	Refer to the engine manufacturer's service manual for causes of the excessive blow-by.

Problem—Boost Pressure High/Low

Problem—Boost Pressure High/Low	
Possible Cause	**Remedy**
Turbocharger wastegate failure or miscalibration can result in excessively high or low boost pressures. Low boost pressures can cause excessive smoke and low power. High boost pressures can cause major engine damage.	Check the turbocharger wastegate function and calibration. Refer to the engine manufacturer's service manual. Replace or calibrate as necessary. Restore the vehicle. Test the system for proper operation.
Pressurized air leaking from loose connections or cracks in the charge air cooler, ducts or intake manifold.	Refer to "Excessive Black Smoke Under Load/Low Power" in these problem charts.
	A restriction in the pressure side of the intake air system will change the air-to-fuel ratio.
	Leaks or restrictions in the exhaust system will cause the turbine and impeller to operate at a lower speed and reduce the amount of air being forced into the cylinders.

Problem—Noise/Vibration

Problem—Noise/Vibration	
Possible Cause	**Remedy**
Minor nicks or dents in the compressor or turbine wheel can result in vibrations.	Check the intake air and exhaust systems for leaks. Repair or replace system components or parts as necessary. Restore the vehicle. Test the system for proper operation.
Debris in the intake air or exhaust systems.	Check the intake air and exhaust systems for debris. Check the turbocharger housing for signs of damage due to rotor assembly contact. Clean, repair or replace system components or parts as necessary.
Leaks in the intake air or exhaust systems.	Check the compressor and turbine wheel for nicks and dents. Replace the turbocharger as necessary. Refer to the engine manufacturer's service manual.

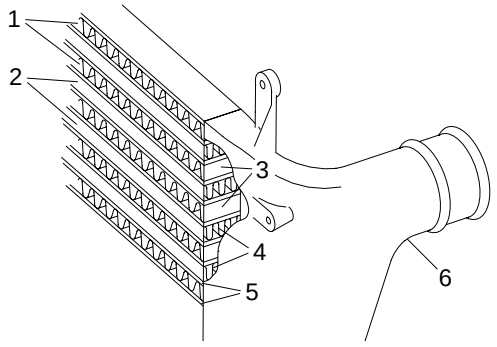
Specifications

Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Air Cleaner Clamps	—	18–26 (200–300)
Air Cleaner Assembly Bolts	—	48–96 (542–1085)
Charge Air Cooler Clamps	—	84–120 (949–1356)
Charge Air Cooler Duct Clamps	—	84–120 (949–1356)
DDC 60 Series Turbocharger Compressor Housing Clamp	15–19 (20–26)	—
Donaldson Air Cleaner Mounting Bolts	—	35–53 (400–600)
Intake Air Duct Clamps	—	10–30 (120–339)
Turbocharger Adapter Clamps	—	84–120 (949–1356)

Table 1, Torque Specifications

General Information

The charge air cooler (CAC) is attached to the front of the radiator, and is similar to a radiator. See **Fig. 1**. Outside ambient air passing through the CAC core cools the engine's intake air charge. The air charge leaving the turbocharger is hot compressed air, about 275 to 325°F (135 to 162°C), depending on the ambient temperature. The CAC reduces the air charge temperature to about 110°F (43°C) with a 77°F (25°C) ambient temperature, before the air charge enters the engine intake manifold. The temperature decrease lowers exhaust emissions, improves fuel economy, and increases horsepower.



08/28/95 f090149

1. Cold Fins
2. Hot Bars
3. Cold Bars
4. Hot Fins
5. Tube Plates
6. Header Tank

Fig. 1, CAC Construction

Vehicles Equipped With 900, 1050, and 1300-Square-Inch Radiators

Removal

1. Apply the parking brakes and chock the tires.
2. Remove the hood. For instructions, see **Group 88**.
3. Partially drain the cooling system. For instructions, see **Group 20**.
4. Recover the refrigerant. For instructions, see **Group 83**.
5. Remove the power steering oil cooler screws and position the oil cooler aside. See **Fig. 1**.

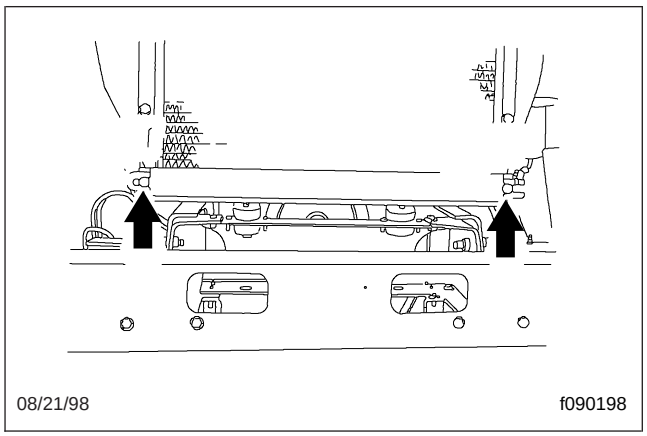


Fig. 1, Power Steering Oil Cooler Screws

6. Disconnect the condenser refrigerant lines. See **Fig. 2**. Immediately, plug the lines and condenser ports.
7. Remove the condenser line retaining screws and move the condenser lines out of the way. See **Fig. 3**.
8. Loosen the constant tension hose clamps at both ends of the hoses that attach the inlet and outlet air piping to the charge air cooler (CAC) connections. Disconnect the hoses from the CAC.
9. Remove the coolant supply tube from the coolant supply tank. See **Fig. 4**.
10. Disconnect the wiring connector from the low engine-coolant-level switch. See **Fig. 5**.

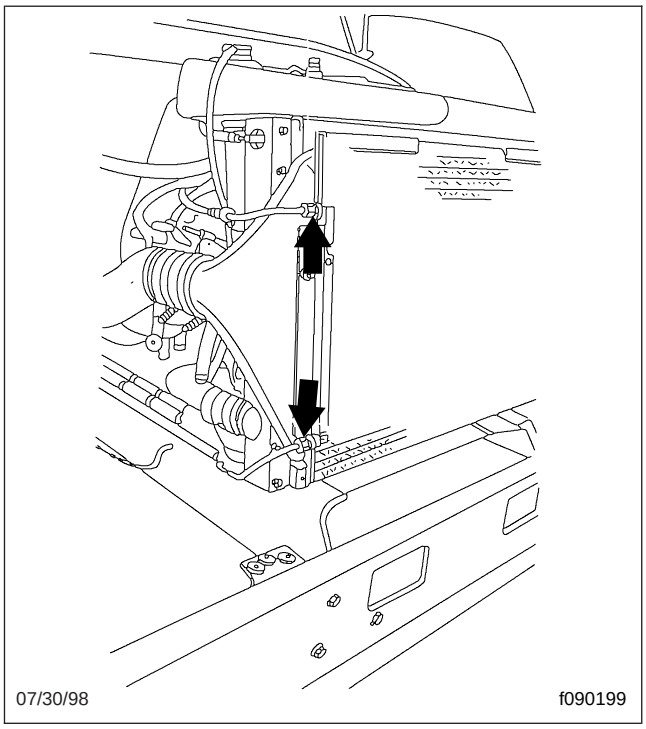


Fig. 2, Condenser Refrigerant Lines

11. Disconnect the wiring connector and the supply hose from the windshield washer pump.
12. Remove the two supply tanks from the radiator.
13. Remove the right-hand bracket that attaches the CAC to the radiator.
14. Remove the left-hand bracket that attaches the CAC to the radiator.
15. Remove the CAC and the condenser from the radiator.
16. Remove the condenser from the CAC.

Installation

1. Install the condenser on the CAC.
2. Position the CAC and the condenser on the radiator.
3. Install the left-hand retaining bracket that attaches the CAC to the radiator.
4. Install the right-hand retaining bracket that attaches the CAC to the radiator.
5. Install the four spacer blocks on the radiator. See **Fig. 6**.

Pre-EPA07 CAC Removal and Installation

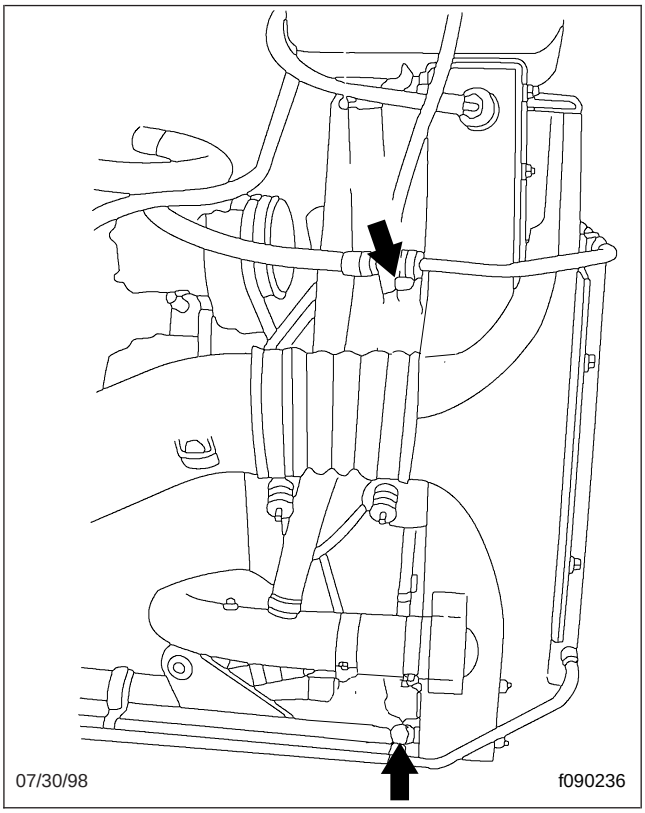


Fig. 3, Condenser Refrigerant Line Retaining Screws

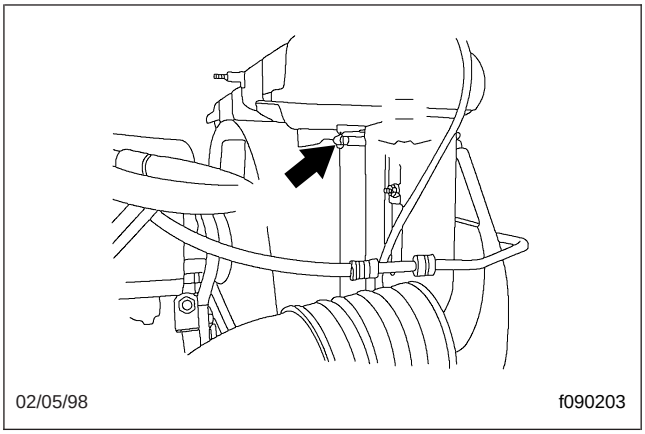


Fig. 4, Coolant Supply Tube

6. Install the two supply tanks onto the radiator. Tighten the retaining nuts 22 to 30 lbf·ft (30 to 41 N·m).
7. Connect the supply hose and the electrical connector to the washer pump.

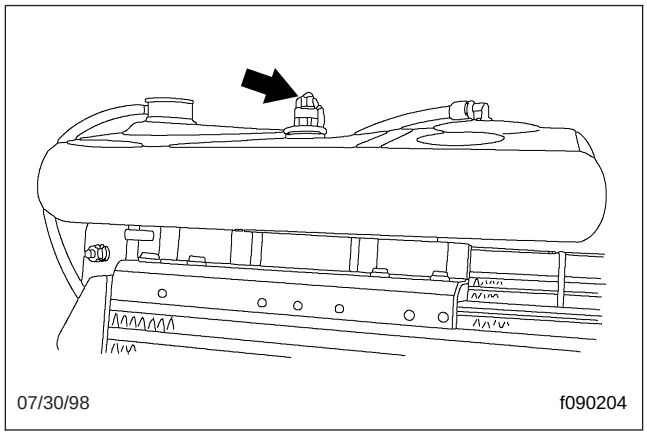


Fig. 5, Engine-Coolant-Level Switch Connector

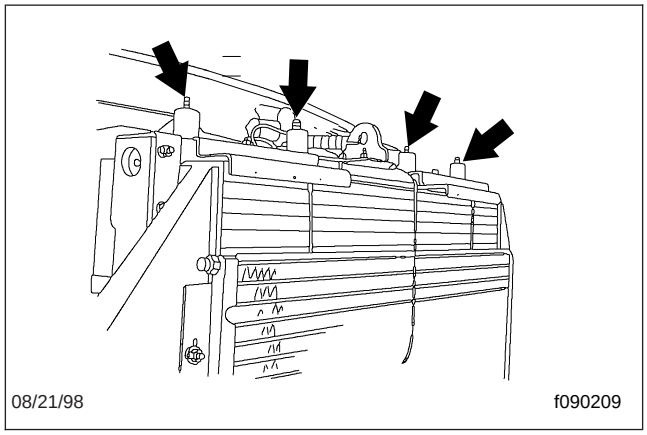


Fig. 6, Spacer Blocks

8. Connect the low engine-coolant-level switch electrical connector.
9. Connect the coolant supply tube to the coolant supply tank.
10. Pull the hoses and constant tension hose clamps forward until the hoses cover the CAC inlet and outlet connections up to the hose stops that are cast into the CAC connections.
11. Turn the constant tension hose clamps so their tightening screws are under the hoses or facing inboard. Tighten the clamp screws 45 lbf·in (500 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fas-

tener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

12. Position the condenser refrigerant lines and clamps. Install the screws.
13. Connect the condenser refrigerant lines and tighten the clamps 20 to 25 lbf·ft (27 to 34 N·m).
14. Position the power steering oil cooler and install the mounting bolts. Tighten the mounting bolts 50 to 70 lbf·ft (68 to 95 N·m).
15. Refill the cooling system. For instructions, see **Group 20**.
16. Install the hood. For instructions, see **Group 88**.
17. Evacuate, charge, and leak test the A/C system. For instructions, see **Group 83**.

Vehicles Equipped With 830-Square-Inch Radiators

Removal

1. Remove the hood. For instructions, see **Group 88**.
2. Partially drain the cooling system. For instructions, see **Group 20**.
3. Recover the refrigerant. For instructions, see **Group 83**.
4. Remove the power steering oil cooler screws and position the oil cooler aside. See **Fig. 1**.
5. Disconnect the condenser refrigerant lines. See **Fig. 7**. Immediately, plug the lines and the condenser ports.
6. Remove the condenser line screws and position the condenser lines out of the way.
7. Loosen the constant tension hose clamps at both ends of the hoses that attach the inlet and outlet air piping to the CAC connections. Disconnect the hoses from the CAC.

NOTE: Note the location and orientation of the mounting hardware for installation.

8. Remove the steel retaining nuts that attach the CAC to the radiator. See **Fig. 8**.

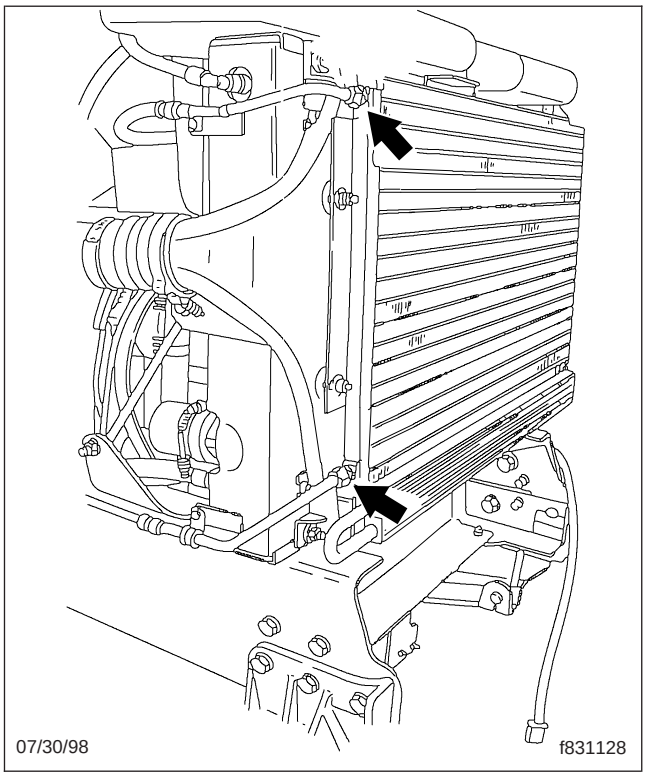


Fig. 7, Condenser Lines

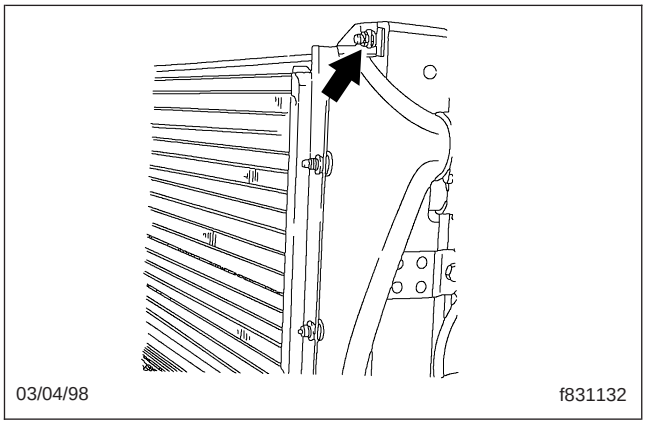


Fig. 8, CAC Retaining Nut

9. Remove the CAC, condenser insulator disk, and crush sleeve from the radiator.

Installation

1. Position the crush sleeve, insulator disk, CAC, and condenser on the radiator.

Pre-EPA07 CAC Removal and Installation

2. Install the steel retaining nuts that attach the CAC to the radiator.
3. Pull the convoluted hoses and constant tension hose clamps forward until the hoses cover the CAC inlet and outlet connections up to the hose stops that are cast into the CAC connections.
4. Turn the constant tension hose clamps so their tightening screws are under the hoses or facing inboard. Tighten the clamp screws 45 lbf·in (500 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

5. Position the condenser refrigerant lines and clamps. Install the screws.
6. Connect the condenser refrigerant lines and tighten the clamps 20 to 25 lbf·ft (27 to 34 N·m).
7. Position the power steering oil cooler and install the mounting bolts. Tighten the mounting bolts 50 to 70 lbf·ft (68 to 95 N·m).
8. Refill the cooling system. For instructions, see **Group 20**.
9. Install the hood. For instructions, see **Group 88**.
10. Evacuate, charge, and leak test the A/C system. For instructions, see **Group 83**.

EPA07 CAC Removal and Installation

Removal

1. Apply the parking brakes and chock the tires.
2. If the vehicle has a 37-tube charge air cooler (CAC), do the following:
   - 2.1 Remove the grille from the hood.
   - 2.2 Tilt and support the hood so that the hood straps can be be disconnected. The support system must be adjustable (while loaded with the weight of the hood) and very reliable to ensure the hood is protected from damage.
   - 2.3 Disconnect both hood straps from the top of the radiator.
3. If the vehicle has a 47-tube CAC, do the following:
   - 3.1 Remove the bumper. For instructions, see **Group 31**.
   - 3.2 Remove the hood. For instructions, see **Group 88**.
   - 3.3 Mark the position of the hood hinge with a paint marker and remove the hood hinge.
4. Loosen the hose clamps at both ends of the hoses that attach the inlet and outlet air ducts to the CAC, then push the clamps and hoses back onto the air piping.
5. Allow extra slack in the A/C condenser hoses by removing the hose support clamp that attaches the hoses near the right side of the radiator.
6. Place shop towels or rags on top of the right-side tire as padding for the condenser. Remove the fasteners that attach the condenser to the CAC, then, with the A/C hoses still connected, swing the condenser around, and carefully lay it on top of the padding on the right-side tire.
7. Remove the side air-recirculation baffles from the CAC.
8. Loosen the two upper bolts that hold the CAC to the cooling package side rails and completely remove the two lower bolts.
9. Support the CAC, then remove the two upper bolts.
10. While someone else supports the left side of the CAC, slightly raise the right side of the CAC. See **Fig. 1**. Then, with the left side held close to the radiator, pull the right side away from the cooling package frame. See **Fig. 2**.

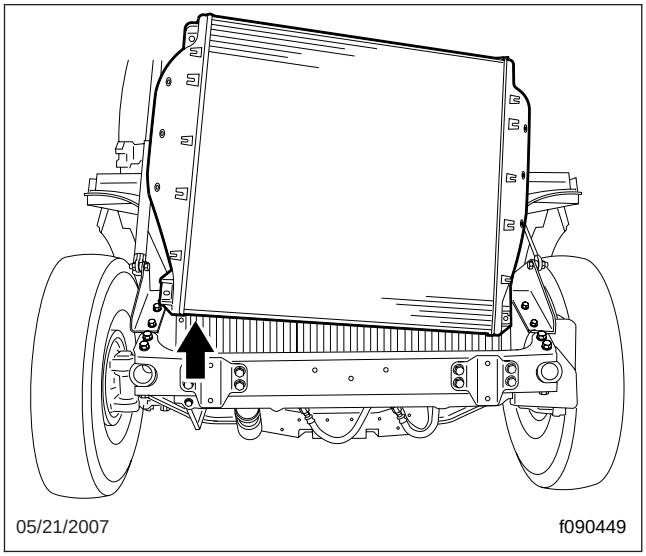


Fig. 1, CAC Tilted for Removal, Front View

Installation

1. With someone supporting the left side of the CAC, hook the left end tube on the cooling package, then adjust the angle of the CAC to allow the right end tube to slip past the cooling package frame.

NOTE: Installing the CAC may be more difficult than removing it, and the fit may be tight. Be sure nothing hinders the fit between the CAC and the cooling package frame.

2. Install the fasteners that attach the CAC to the radiator. Tighten all CAC mounting fasteners 28 lbf·ft (38 N·m).
3. Install the side air-recirculation baffles on the CAC, and tighten the fasteners 96 lbf·in (1080 N·cm).
4. Swing the A/C condenser around, and install it on the front of the CAC. Tighten all condenser fasteners 96 lbf·in (1080 N·cm). Install any A/C condenser hose support clamps that were removed.
5. Pull the convoluted hoses and constant tension hose clamps forward until the hoses cover the CAC tube ends up to the cast hose stops.

EPA07 CAC Removal and Installation

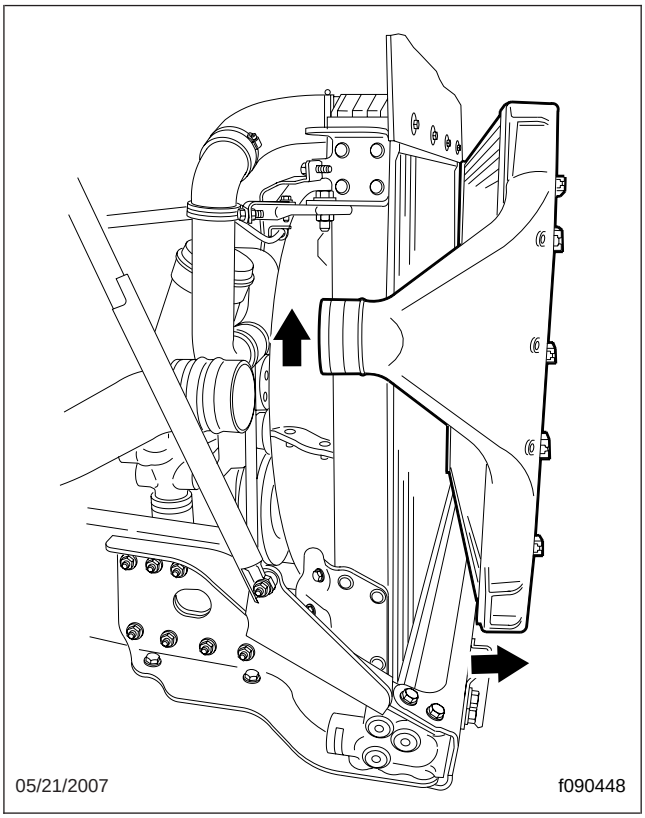


Fig. 2, CAC Tilted for Removal, Side View

6. Turn the constant tension hose clamps so their tightening screws are under the hoses or facing inboard. Tighten the clamp screws 45 lbf·in (500 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

7. If the vehicle has a 37-tube CAC, do the following:
   - 7.1 Tilt the hood to an angle that allows attachment of the hood straps to the top of the radiator. Attach the hood straps and remove the hood support.
   - 7.2 Return the hood to the operating position and install the grille.
8. If the vehicle has a 47-tube CAC, do the following:
   - 8.1 Install the hood hinge bracket.
   - 8.2 Install the hood. For instructions, see **Group 88**.
   - 8.3 Install the bumper. For instructions, see **Group 31**.
   - 8.4 Check the hood for proper alignment.

Inspection

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Check the charge air cooler (CAC) convoluted hoses and the inlet and outlet piping for holes or other damage. Also, check for loose or damaged constant tension 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).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

3. Check the CAC core fins. If the fins are bent, use a small pair of needlenose 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" in this subject.

CAC Core Leakage Test

Charge air coolers are designed in such a way that they may bleed 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.

The CAC core leakage test should be performed using a CAC test kit, part number 5039, which can be purchased from Kent-Moore/SPX at 1-800-328-6657.

Leakage Rate Specifications		
Engine	**Pressure Drop in 15 Seconds: psi (kPa)**	**Start Pressure: psi (kPa)**
Caterpillar	5 (34)	30 (207)
Cummins	7 (48)	30 (207)
Detroit Diesel	5 (34)	25 (172)

Table 1, Leakage Rate Specifications

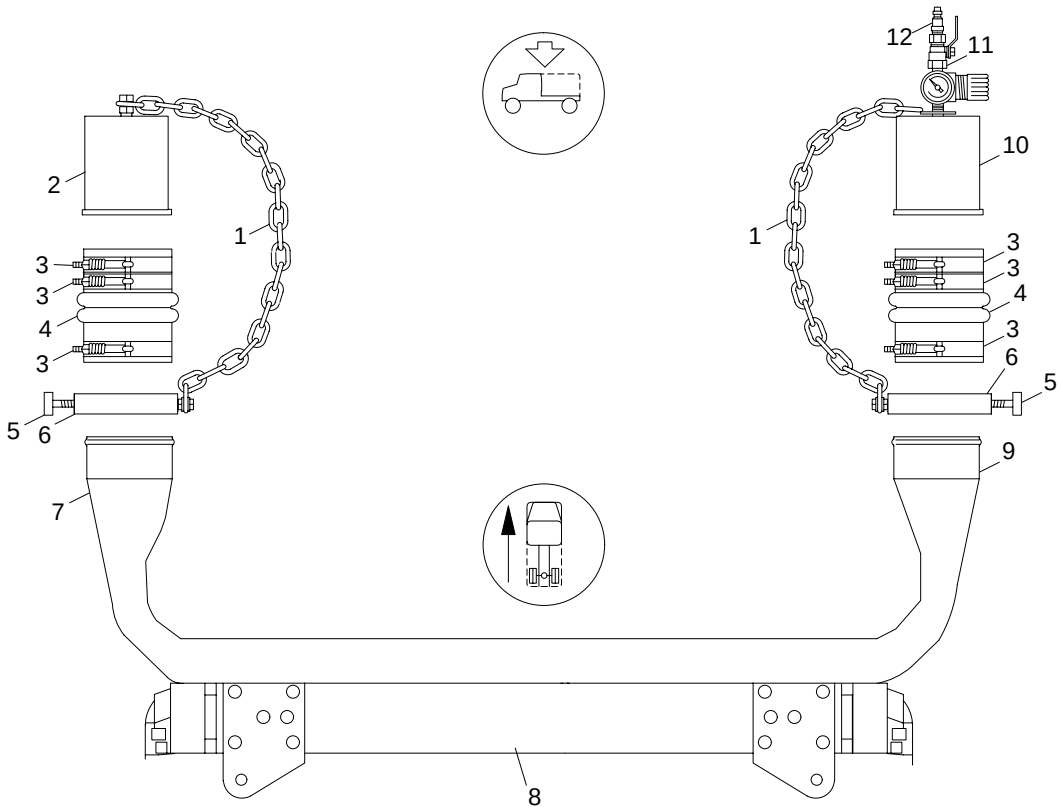
1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Connect the test equipment to the CAC core as follows. See **Fig. 1**.
   - 2.1 Remove the inlet and outlet air piping from the convoluted hoses that attach them to the CAC air inlet and air outlet.
   - 2.2 Slip a safety ring with thumbscrew 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 tension hose clamp on each convoluted hose.
   - 2.4 Install the test plug without an adapter in the CAC air inlet and turn the plug so the safety chain is inboard. Tighten each constant tension hose clamp 72 lbf·in (810 N·cm).
   - 2.5 Install the test plug with adapter in the CAC air outlet and turn the plug so the safety chain is inboard. Tighten each constant tension hose clamp 72 lbf·in (810 N·cm).

⚠ WARNING

Always secure the test plugs with the safety rings. Test pressures could blow an unsecured test plug out at high speed, possibly causing eye injury or other serious personal injury.

   - 2.6 If not already installed, install a test valve/gauge assembly and air chuck in the test plug with adapter.

CAC Inspection and Leakage Test



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

Fig. 1, CAC Core Components

2.7 Attach a pressurized air line to the air chuck on the pressure regulator valve.

3. Test the CAC core as follows.

⚠ 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 test valve, then slowly open the pressure regulator valve and allow the CAC to gradually fill with air to the start pressure. See **Table 1**.

3.2 Close the test valve and watch the gauge for 15 seconds. If there is more than the specified drop in the CAC pressure in 15 seconds, replace the CAC. See **Table 1**.

IMPORTANT: Do not attempt to repair the CAC core.

3.3 When testing is completed, reduce the pressure on the pressure regulator valve to bleed air from the CAC.

4. Remove the test equipment (and the additional constant tension hose clamps) from the convoluted hoses.

5. Pull the convoluted hoses and constant tension 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; then tighten the screws 45 lbf·in (500 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

Charge Air Cooler Flushing

If the charge air cooler (CAC) is suspected of being contaminated, flush the CAC.

1. Apply the parking brakes and chock the tires.
2. Remove the CAC. For instructions, see **Subject 100** for pre-EPA07 engines, or **Subject 110** for EPA07 engines.
3. Set the CAC in a horizontal position with the air inlet and outlet ports facing up.

IMPORTANT: Use only naphtha or mineral spirits to clean the CAC. 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 CAC tubes to the headers, which may result in leakage.

4. Pour a filtered naphtha or mineral spirits solution into the CAC until it is 40 percent full.
5. Cap the inlet and outlet ports on the CAC.
6. Rock the CAC 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 CAC for more than 10 minutes.

7. Remove the caps from the inlet and outlet ports.
8. Drain the CAC and properly dispose of the solvent.
9. Leave the caps off and allow the residual solvent to evaporate.
10. Install the CAC. For instructions, see **Subject 100** for pre-EPA07 engines, or **Subject 110** for EPA07 engines.

Restriction Test

After flushing the charge air cooler (CAC) because of turbocharger or engine damage, test the pressure drop across the CAC and air piping, as follows:

1. Remove the pipe plug (if equipped) from the tapped hole in the turbocharger air outlet elbow.

   Remove the pipe plug, or the nylon tube and atomizer for the ether start system (if equipped), or the air line to the turbocharger air-pressure gauge (if equipped), from the tapped hole in the left-hand rear of the intake manifold.

   Install an air pressure gauge in each tapped hole.

2. Operate the engine at rated speed and horsepower; there is no need to operate the engine at its peak torque rating. While operating the engine, read both air pressure gauges.

   Because of the turbulence of the air at the turbocharger outlet, subtract 0.3 inHg (1 kPa) from the pressure measurement taken at the turbocharger outlet, to make it a true reading.

   From that reading, subtract the reading taken at the intake manifold. This is the pressure drop of the CAC.

   If the pressure drop is more than 4 inHg (14 kPa), flush or replace the CAC as needed.

Replacement

⚠ WARNING

Do not operate the engine with any component of the air intake system removed; doing so could result in engine damage and serious personal injury can occur if the turbocharger impeller is touched when it is rotating.

IMPORTANT: All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners.

1. Apply the parking brakes and chock the tires.
2. Loosen the hose clamps at the charge air cooler (CAC), turbocharger outlet, and engine air intake inlet.
3. Remove the duct assembly.
4. Replace any damaged parts.
5. Install the duct assembly.
6. Tighten the hose clamp at the turbocharger 84 to 120 lbf·in (950 to 1360 N·cm).
7. Turn the constant tension hose clamps so their tightening screws are under the hoses or facing inboard. Tighten the clamp screws 45 lbf·in (500 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

Specifications

Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
A/C Condenser Core Refrigerant Line Fittings to Condenser Core	20–25 (27–34)	—
Charge Air Cooler Mounting Nuts, Cummins ISB and ISC, CAT 3126	25 (34)	—
Constant Tension Hose Clamps (vehicles built before February 26, 2007)	—	45 (500)
Constant Tension Hose Clamps (vehicles built on or after February 26, 2007)	—	98 (1100)
Coolant Supply and Return Hose Clamps	—	84–120 (950–1360)
Supply Tank Retaining Nuts	22–30 (30–41)	—
Power Steering Oil Cooler Mounting Bolts	50–70 (68–95)	—
Turbocharger Hose Clamp	—	84–120 (950–1360)
Windshield Washer Supply Tank Retaining Nut	22–30 (30–41)	—

Table 1, Torque Specifications

General Information

Visual inspection of an air cleaner element will not determine when an air cleaner element must be replaced. The air restriction gauge/indicator indicates when the air cleaner element needs to be changed. When the restriction gauge/indicator is red in full view, or the gauge/indicator reads 25 inH $_2$O (6 kPa) vacuum, the air cleaner element must be changed. The air restriction gauge/indicator must be reset each time a new engine air cleaner element is installed.

The standard air restriction indicator is located under the hood near the air cleaner assembly (**Fig. 1**). As an option, an air restriction gauge is located in the instrument panel. See **Fig. 2**.

A dry-type air cleaner element is standard equipment on all Sterling vehicles equipped with diesel engines. Air is filtered through a pleated, chemically treated paper air cleaner element to remove contaminants before entering the engine induction system. Vehicles are equipped with a standard single stage air cleaner assembly manufactured by Donaldson, with optional Donaldson and Farr air cleaner assemblies.

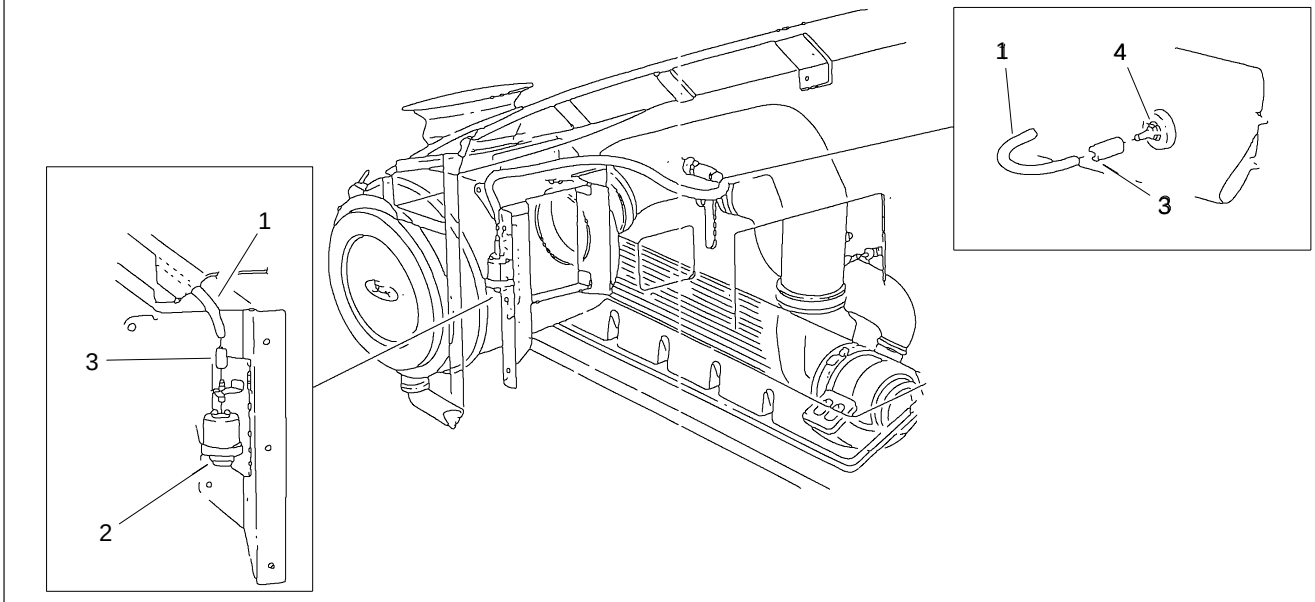
AIR CLEANER—DONALDSON

(See Fig. 3)

There are several types of Donaldson air cleaners available, ranging from the standard single stage to the optional high-capacity single stage and two-stage dual element air cleaners. All of these air cleaners have removable, disposable air cleaner elements.

AIR CLEANER—FARR **(See Fig. 4)**

The Farr disposable-type engine air cleaner element is integral to the air cleaner housing and is serviced as a complete unit.



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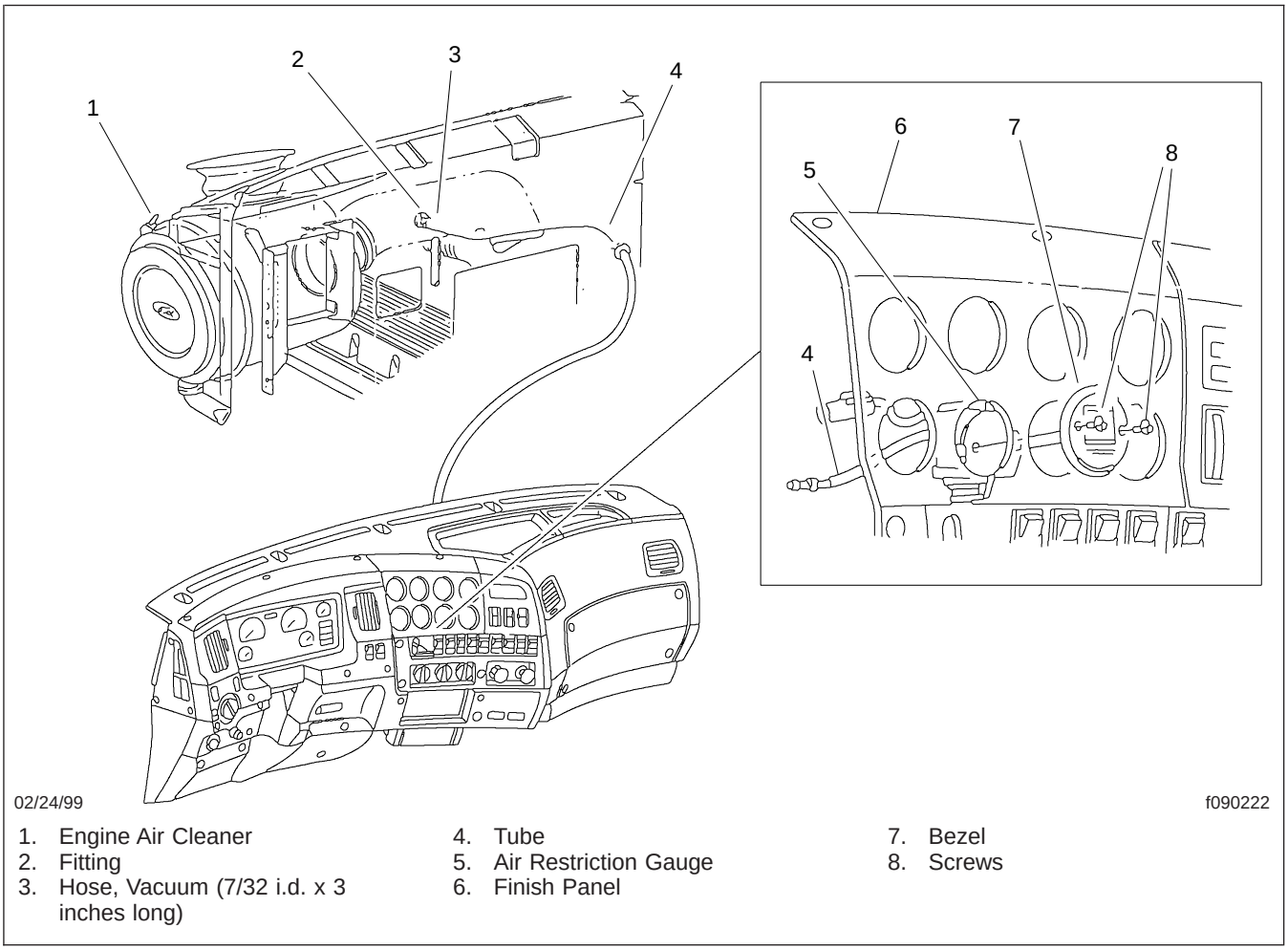
1. Tube
2. Engine Air Restriction Gauge
3. Hose, Vacuum (7/32 i.d. x 3 inches long)
4. Fitting

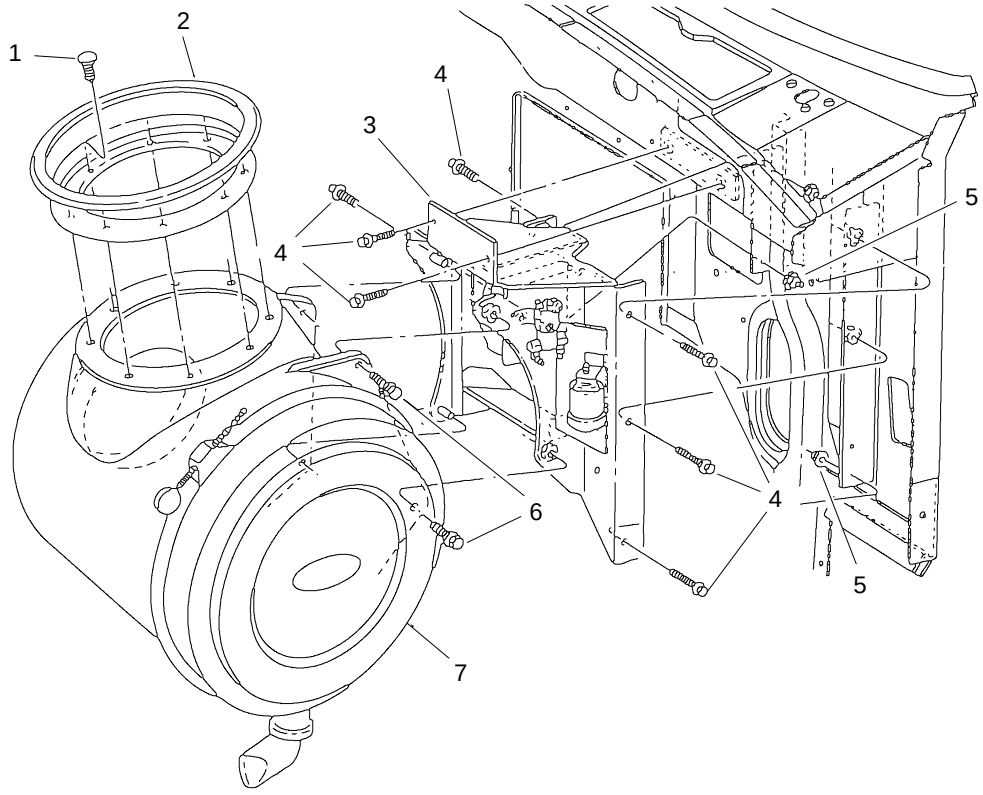
Fig. 1, Air Restriction Indicator-Underhood

General Information



1. Engine Air Cleaner
2. Fitting
3. Hose, Vacuum (7/32 i.d. x 3 inches long)
4. Tube
5. Air Restriction Gauge
6. Finish Panel
7. Bezel
8. Screws

Fig. 2, Air Restriction Gauge-Instrument Panel



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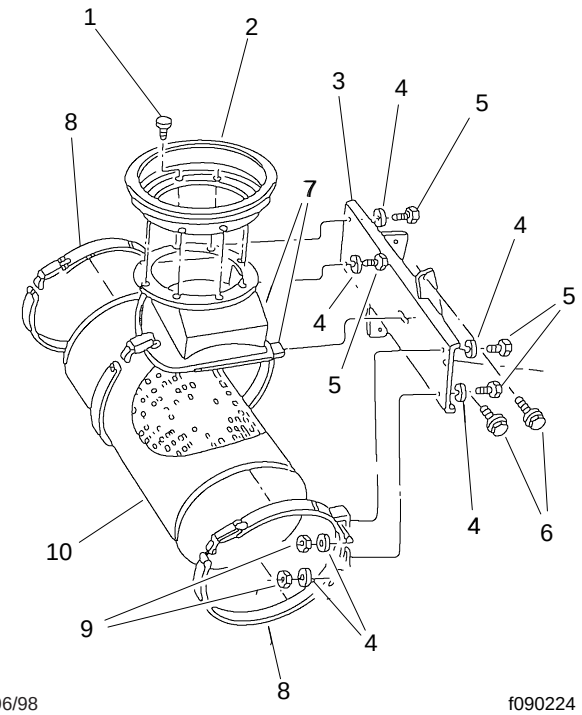
1. Nylon Push Pin
2. Air Cleaner Inlet Seal
3. Engine Air Cleaner Mounting Bracket
4. Bolt, M8 x 1.25 Hex Flange
5. Nut, M8 x 1.25 Hex Flange Lock
6. Bolt, 5/16-18 x 1.38 Hex Flange
7. Air Cleaner Assembly

Fig. 3, Air Cleaner-Donaldson, Typical

General Information



1. Nylon Pushpin
2. Air Cleaner Inlet Seal
3. Engine Air Cleaner Mounting Bracket
4. 3/8 Flat Washer
5. 3/8–16 Hex-Head Bolt
6. 5/16–18 Hex-Head Bolt
7. Air Cleaner Intake Adaptor
8. Air Cleaner Clamp Assembly
9. 3/8–16 Hex Locknut
10. Air Cleaner Assembly

Fig. 4, Air Cleaner-Farr, Typical

Donaldson Single-Stage Air Cleaner Element Replacement

Replacement

IMPORTANT: Use only Donaldson RadialSeal® air filter elements in Donaldson filter housings. Use of "will-fit" filters can result in engine damage, which will void the warranty on the engine.

1. Remove the cover; see **Fig. 1**.

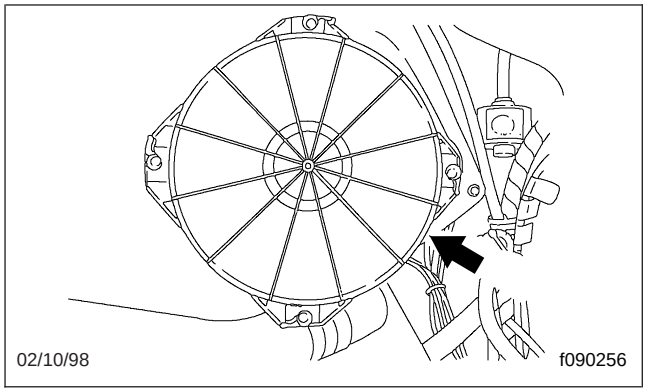


Fig. 1, Air Cleaner Cover

2. Remove the filter element. Move the end of the element vertically and horizontally, or twist to gently break the seal. Avoid dislodging any dust from the filter element during removal.

NOTICE

Do not clean or reuse air filter elements. Cleaning and reusing the elements increases the chances of dirt entering the engine. Always replace with a new one.

IMPORTANT: Do not damage the outlet tube during cleaning. This is a filter element sealing surface.

3. Inspect the filter housing for damage or signs of air leaks; see **Fig. 2**. Replace the filter housing if necessary.
4. Use a clean shop cloth to clean the filter housing, the outlet tube where it extends into the housing, and the inside of the outlet tube.
5. Inspect the old filter element for damage and signs of air leaks; see **Fig. 3**. Correct any problems before installing a new filter element.
6. Install the new element on the outlet tube. Apply firm, even pressure on the outer rim of the filter element to ensure a tight seal with the outlet tube; see **Fig. 4**.

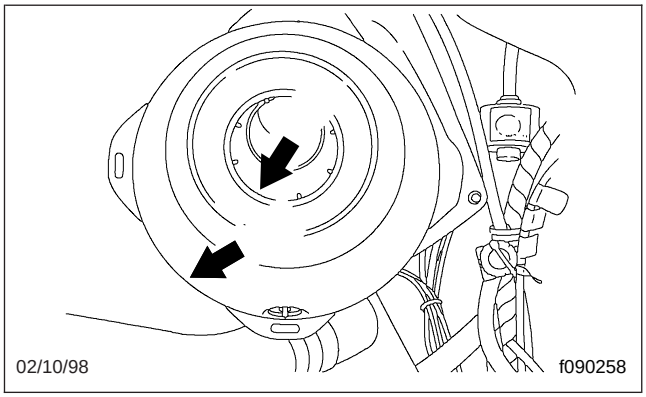


Fig. 2, Inspecting the Filter Housing

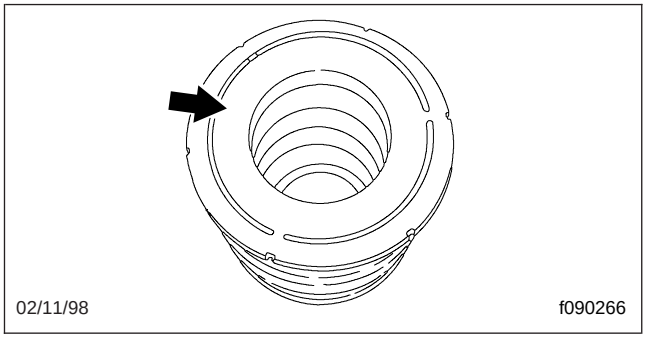


Fig. 3, Inspecting the Element

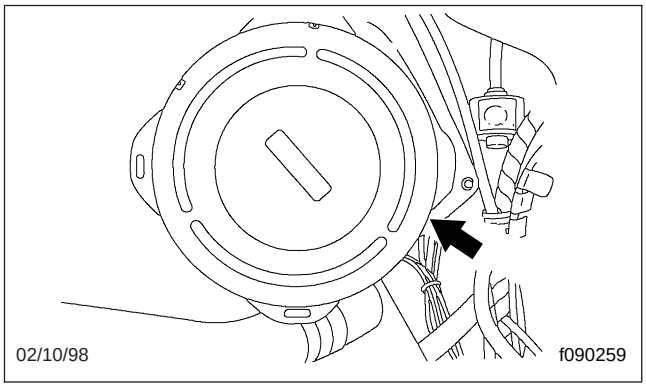


Fig. 4, Installing the Element

NOTE: Cover pressure is not necessary to compress the element seal.

7. Install the cover.

Donaldson Single-Stage Air Cleaner Element Replacement

8. Press the air restriction indicator/gauge reset button.

Donaldson Two-Stage Air Cleaner Dual Element Replacement

Replacement

IMPORTANT: Use only Donaldson RadialSeal® air filter elements in Donaldson filter housings. Use of "will-fit" filters can result in engine damage, which will void the warranty on the engine.

1. Remove the cover; see **Fig. 1**.

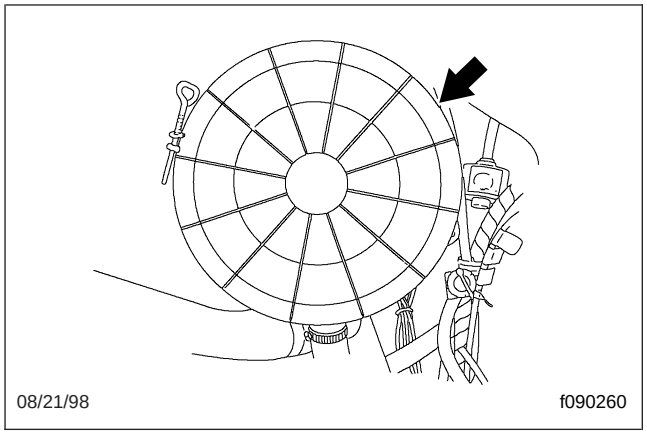


Fig. 1, Air Cleaner Cover

NOTICE

Do not clean or reuse air filter elements. Cleaning and reusing the elements increases the chances of dirt entering the engine. Always replace with a new one.

2. Remove the first-stage filter element; see **Fig. 2**. Move the end of the element vertically and horizontally, or twist to gently break the seal. Avoid dislodging any dust from the filter element during removal.
3. Inspect the old filter element for damage and signs of air leaks, see **Fig. 3**. Correct any problems before installing a new filter element.

NOTE: Perform the next two steps only after the first-stage filter element has been replaced several times.

4. Remove the inner filter element; see **Fig. 4**. Move the end of the element vertically and horizontally, or twist to gently break the seal. Avoid dislodging any dust from the filter element during removal.

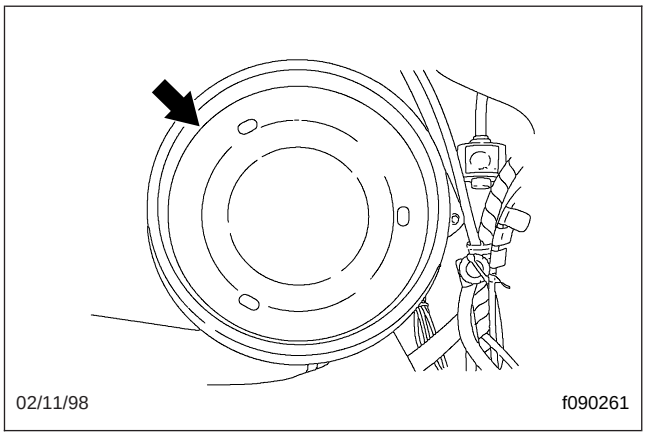


Fig. 2, First-Stage Element

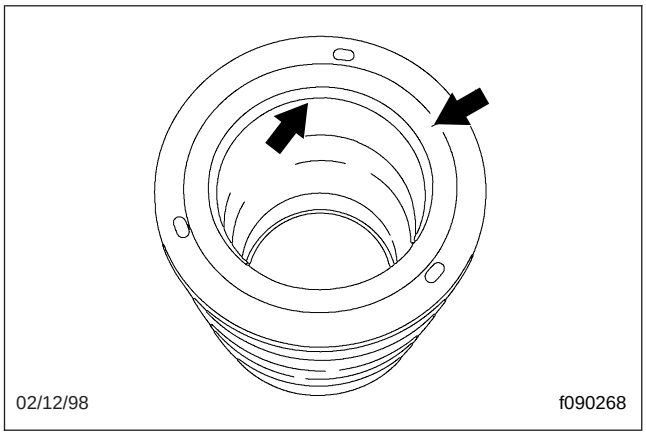


Fig. 3, Inspecting the First-Stage Element

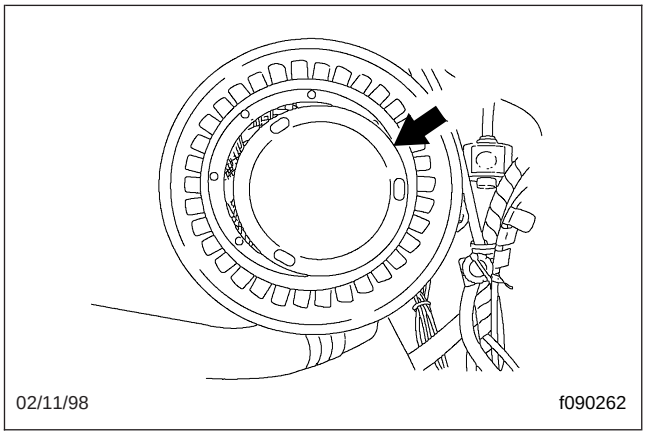


Fig. 4, Inner Element

Donaldson Two-Stage Air Cleaner Dual Element Replacement

5. Inspect the old filter element for damage or signs of air leaks; see **Fig. 5**. Correct any problems before installing a new filter element.

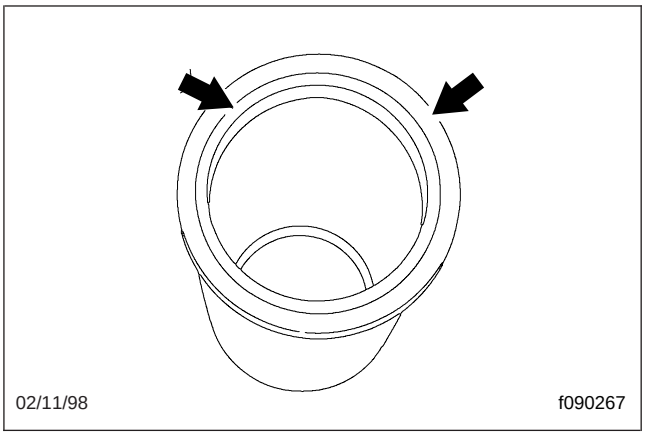


Fig. 5, Inspecting the Inner Element

6. Use a clean shop cloth to clean the housing; see **Fig. 6**.

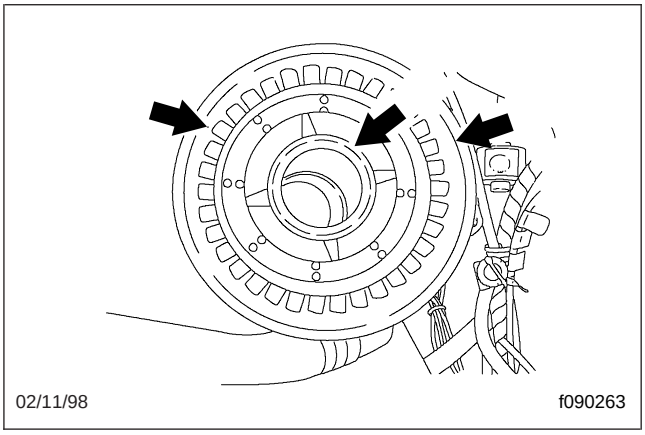


Fig. 6, Inspecting the Housing

7. Inspect the filter housing for damage and signs of air leaks. Correct any problems before installing a new filter element.
8. Install the inner filter element.
9. Install the first-stage filter element.
10. Install the cover with the drain valve at the bottom.
11. Press the air restriction indicator/gauge reset button.

Specifications

Torque Specifications	
Description	**lbf·in (N·cm)**
Air Cleaner Clamps	18–26 (200–300)
Air Cleaner Assembly Bolts	48–96 (45–124)
Donaldson Air Cleaner Mounting Bolts	35–53 (400–600)

Table 1, Torque Specifications

Air Compressor (See Fig. 1)

⚠ WARNING

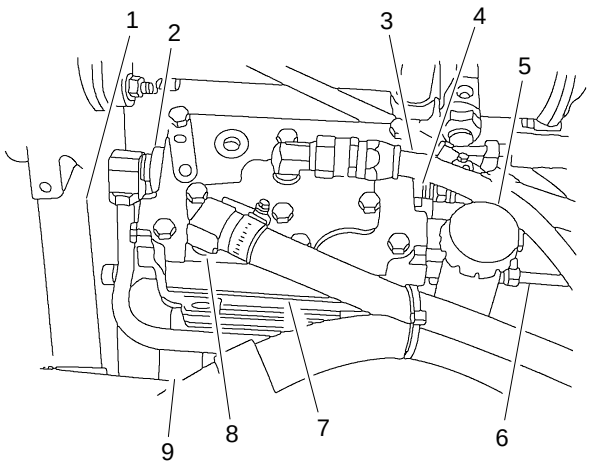
Avoid contact with the air compressor discharge line. Compressed air directly from the air compressor is hot enough to burn the skin.

The Tu-Flo 550 is a two cylinder, single-stage, reciprocating air compressor which supplies compressed air to the vehicle air system and has a rated displacement of 13.2 cfm (374 L/min) of air at 1250 rpm.

The compressor draws air from the air intake pipe, compresses the air, and delivers it to the air system supply reservoir. The compressor runs continuously but has "loaded" and "unloaded" modes, which are regulated by the air governor and the compressor loading assembly. When the governor sends an air signal to the unloader assembly, the unloader assembly 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 105 psi (724 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 130 psi (896 kPa), the air governor also sends an air signal to open the sludge ejector in the air dryer.

The air compressor is:

- Gear driven by the front end accessory drive;
- Lubricated by the engine lubrication system;
- Cooled by the engine coolant system.



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1. Engine Front Cover
2. Coolant Port
3. Discharge Line (to air dryer or reservoir)
4. Coolant Port
5. Governor
6. Unloader Line (to air dryer)
7. Air Compressor
8. Air Inlet Port
9. Oil Inlet Port

Fig. 1, Air Compressor

Removal

NOTE: Although the illustrations show the Cummins ISC engine, the Cummins ISB is similar.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Drain the engine coolant.
4. Disconnect the following lines (**Fig. 1**):

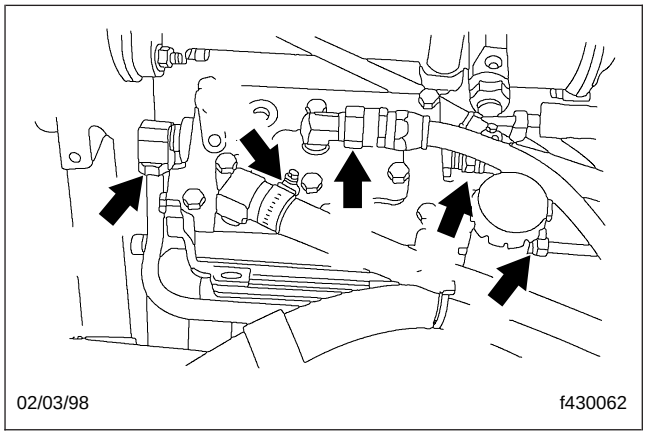


Fig. 1, Air Line Connections

- intake and discharge air lines
- two coolant lines
- governor air lines

5. If necessary, remove the starter to access the power steering pump. For instructions, see the appropriate section in **Group 15** in this manual.
6. Remove the bolts. See **Fig. 2**.
7. Remove the power steering pump and gasket from the engine. Hang it out of the way leaving the hoses attached.
8. If the air governor is attached to the compressor, remove it. For instructions, see **Section 13.01** in this manual.

IMPORTANT: An assistant is necessary to remove the air compressor from the engine compartment.

9. Remove the air compressor nuts from the studs on the mounting flange.

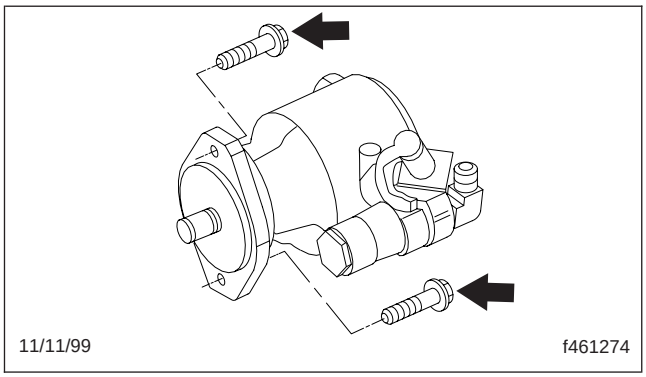


Fig. 2, Power Steering Pump Mounting Bolts

10. Slide the air compressor off the studs and lift it out of the engine compartment. See **Fig. 3**.

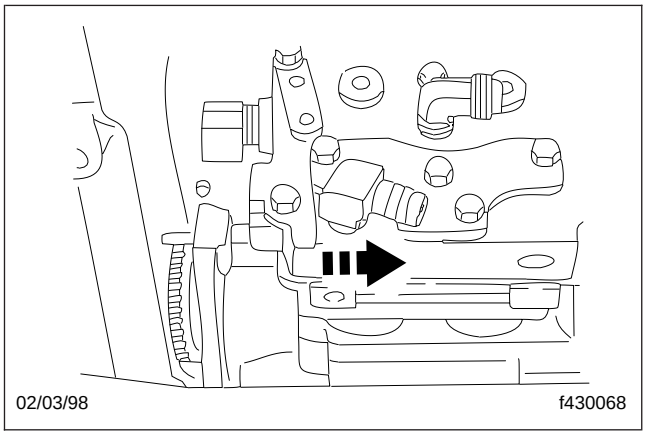


Fig. 3, Compressor and Studs

Installation

1. Remove the dirt and grease from the air compressor mounting surfaces and compressor lines.
2. Install a new gasket. Slide the air compressor onto the studs.
3. Tighten the retaining bolts and fittings 30 to 46 lbf·ft (41 to 62 N·m). See **Fig. 4**.
4. Position the power steering pump and install the bolts. Tighten the bolts 20 lbf·ft (27 N·m). See **Fig. 2**.
5. Connect the following lines to the air compressor (**Fig. 1**):

- intake and discharge air lines
- two coolant lines

Air Compressor Removal and Installation

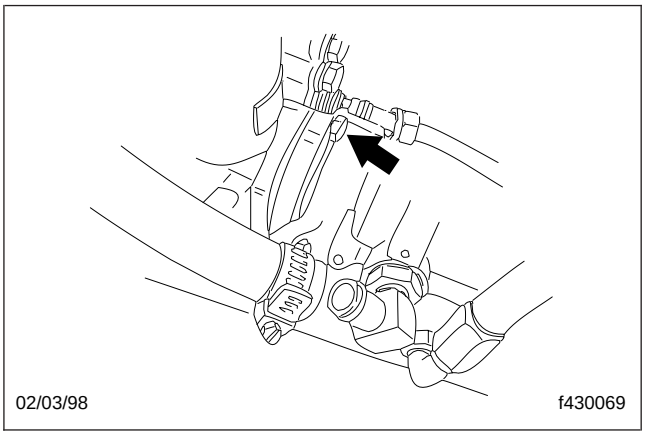


Fig. 4, Retaining Bolt

- governor air lines.

6. Fill the engine cooling system. For instructions, see **Group 20** in this manual.
7. Remove the chocks from the tires.

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Drain the air system.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

3. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
4. Drain the radiator coolant. For instructions, see **Group 20**.
5. Remove the cylinder head from the crankcase. See **Fig. 1**.

   5.1 Scribe an alignment mark across the cylinder head and the crankcase for assembly alignment.

   IMPORTANT: Do not use a marking method, such as chalk, that can be wiped off during assembling.

   5.2 Note positions of any attached components, then remove the cylinder head capscrews.

   5.3 Tap the cylinder head with a soft mallet to break the gasket seal. Remove the cylinder head.

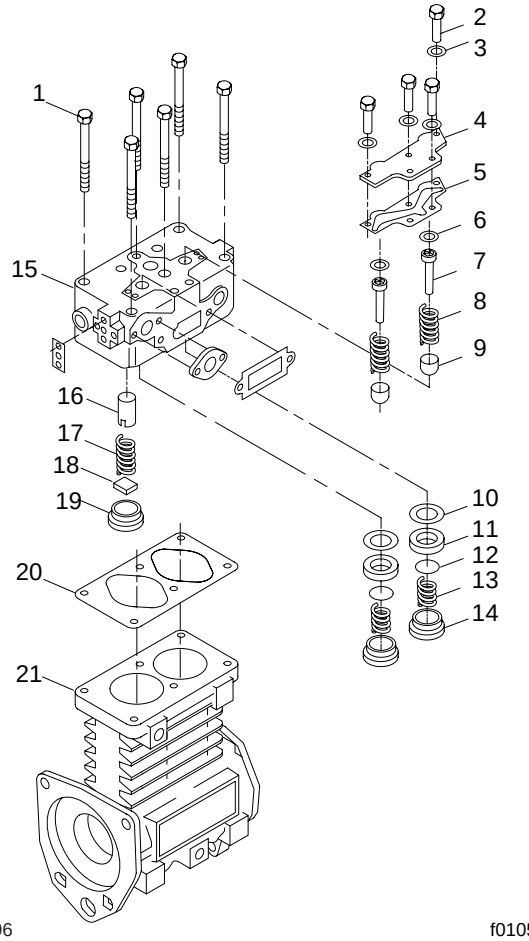
Installation

1. Scrape off any gasket material from the cylinder head and the crankcase.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

2. Using compressed air, blow dirt particles or gasket material from all cylinder cavities.



1. Capscrew
2. Capscrew
3. Lockwasher
4. Unloader Plate
5. Gasket
6. O-Ring
7. Piston
8. Spring
9. Bushing
10. Gasket
11. Seat
12. Inlet Valve
13. Spring
14. Stop
15. Cylinder Head
16. Stop
17. Spring
18. Discharge Valve
19. Seat
20. Gasket
21. Crankcase

Fig. 1, Cylinder Head, Exploded View

3. Install the cylinder head on the compressor crankcase.

   3.1 Place a new cylinder head gasket on the crankcase. If the cylinder head gasket has a bead on one side, install the gasket with the bead side up.

Cylinder Head Removal and Installation

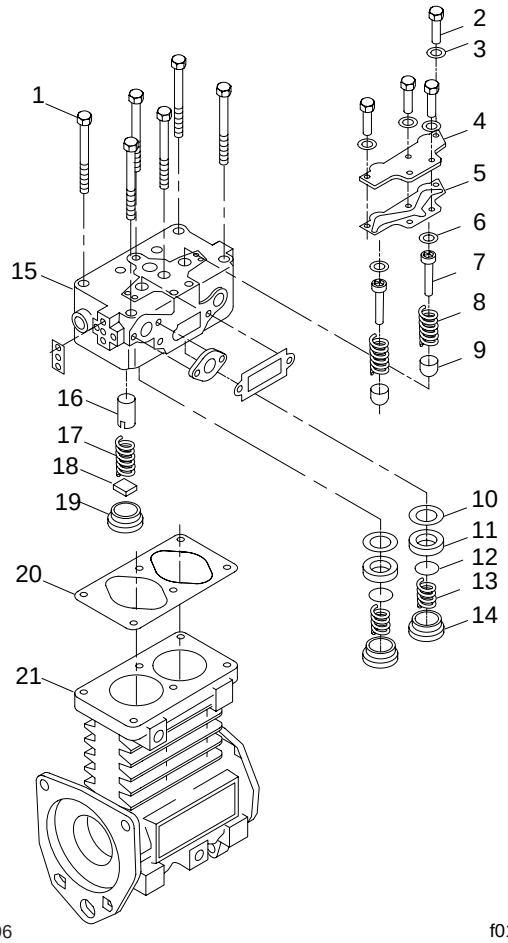
3.2 Using the previously marked alignment, position the cylinder head on the crankcase.

3.3 Position on the cylinder head any brackets, spacers, or clamps that were removed. Install the cylinder head capscrews and tighten them evenly, in a cross pattern, 37 to 42 lbf·ft (50 to 57 N·m).

4. Connect the air discharge line and the water lines to the cylinder head.
5. Fill the engine cooling system. For instructions, see **Group 20**.
6. Operate the engine and make sure there are no coolant leaks.
7. Remove the chocks from the tires.

Cylinder Head Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)



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1. Capscrew
2. Capscrew
3. Lockwasher
4. Unloader Plate
5. Gasket
6. O-Ring
7. Piston
8. Spring
9. Bushing
10. Gasket
11. Seat
12. Inlet Valve
13. Spring
14. Stop
15. Cylinder Head
16. Stop
17. Spring
18. Discharge Valve
19. Seat
20. Gasket
21. Crankcase

Fig. 1, Cylinder Head, Exploded View

1. Remove the compressor from the vehicle. For instructions, see **Subject 100**.
2. Place the compressor on a suitable work surface. Remove the cylinder head from the crankcase. For instructions, see **Subject 110**.
3. Remove the unloader mechanism.
   - 3.1 Remove the unloader plate capscrews, lockwashers, and the unloader plate. Scrape off any gasket material from the unloader plate and the cylinder head.
   - 3.2 Remove and discard the unloader pistons, O-rings, and springs.
4. Check the unloader piston bushings. If damaged or worn excessively, replace the compressor.

NOTE: Before disassembling the discharge valve mechanism, measure and record the discharge valve travel from closed to completely open. If the measurement exceeds 0.046 inch (1.17 mm), replace the compressor. If the measurement is within 0.046 inch, proceed to the next step.

5. Using a 9/16-inch Allen wrench, remove and discard the discharge valve seats, discharge valves, and discharge valve springs.
6. Remove and discard the inlet valve stops and springs, along with the inlet valves, inlet valve seats, and gaskets.

Cleaning and Inspection

1. Remove carbon deposits from the discharge cavity, rust and scale from the cooling cavities.
2. Clean carbon and dirt from the inlet and unloader passages.
3. Scrape all foreign material from the body surfaces.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

4. Using solvent, thoroughly clean all metal parts removed from the cylinder head. Using shop air, blow the dirt particles from the cavities and passages.

Cylinder Head Disassembly, Cleaning and Inspection, and Assembly

5. Check that all cavities and passages are clear, including the inlet and unloader.
6. Check that all mating surfaces are clean of old gasket material. Remove any old material.
7. Inspect the cylinder head for cracks or damage.
8. With the cylinder head and head gasket secured to a flat surface or to the crankcase, apply shop air pressure to one of the coolant ports with all other ports plugged.
9. Check for leaks by applying a soap solution to the exterior of the body. If leakage is detected, replace the compressor.

Assembly (See Fig. 1)

1. Install the unloader mechanism.
   - 1.1 With the unloader pistons being prelubricated from the manufacturer, install the new unloader springs, and the new unloader pistons. The unloader piston O-rings are pre-installed on the unloader pistons.
   - 1.2 Install the new unloader plate gasket and the unloader plate.
   - 1.3 Install the unloader plate lockwashers and capscrews. Tighten the capscrews 15 to 18 lbf·ft (20 to 25 N·m) in a cross pattern.
2. Install the inlet valve mechanism.
   - 2.1 Install the new inlet valve gaskets, new inlet valve seats, new inlet valves, and the new inlet valve springs into their bores.
   - 2.2 Install the new inlet valve stops and tighten 70 to 90 lbf·ft (95 to 122 N·m).
3. Install the new discharge valve springs, new discharge valves, and the new discharge valve seats into their bores. Tighten the seats 70 to 90 lbf·ft (95 to 122 N·m). The discharge valve travel should be 0.030 to 0.046 inch (0.762 to 1.17 mm).
4. Test for leakage at the discharge valves by applying 100 psi (690 kPa) through the cylinder head discharge port and apply soap solution to the discharge valve and seat. Leakage in the form of soap bubbles is permissible.

   If there is extreme leakage, leave the air pressure applied and with a hardwood dowel and a hammer, tap the discharge valves off of their seats several times. This will improve the seal between the discharge valve and the valve seat and should reduce leakage.

   If there is still extreme leakage, replace the discharge valve seats.

   With the air pressure still applied at the discharge port of the cylinder head, check for leakage around the discharge valve stop on top of the cylinder head. No leakage is permitted.
5. Install the compressor cylinder head. For instructions, see **Subject 110**.
6. Tighten the unloader plate capscrews 15 to 18 lbf·ft (20 to 25 N·m).
7. Install the compressor on the engine. For instructions, see **Subject 100**.

Crankcase Disassembly, Cleaning and Inspection, and Assembly

Disassembly

1. Remove the compressor from the vehicle and place it on a suitable work surface. For instructions, see **Subject 100**.
2. Remove the air compressor cylinder head. For instructions, see **Subject 110**.
3. Before disassembling the compressor, use a metal scribe to mark the parts with matching numbers or lines.

IMPORTANT: Do not use a marking method, such as chalk, that can be wiped off during assembly.

4. Remove the pistons and connecting rods. See **Fig. 1**.
   - 4.1 Remove the base plate capscrews.
   - 4.2 Tap the base plate with a soft mallet to break the gasket seal.
   - 4.3 Scrape off any gasket material from the crankcase and base plate.
   - 4.4 Remove the connecting rod bolts and connecting rod caps.
   - 4.5 Push the pistons and connecting rods out through the cylinder bore of the crankcase. Discard the pistons and connecting rod assemblies including the connecting rod caps and the connecting rod bolts.
5. Remove the crankshaft.
   - 5.1 Remove the key or keys from the crankshaft and any burrs from the crankshaft where the key or keys were removed.

     NOTE: Some compressors may have a crankshaft key at each end.
   - 5.2 Remove the end-cover capscrews, the end cover, end-cover seal, and the rear thrustwasher.
   - 5.3 If the compressor has sleeve bearings, remove and discard the sleeve bearings from the crankcase and the end cover.
   - 5.4 If the compressor has a ball-type main bearing, remove the rear snap ring (if so equipped). Press the crankshaft and ball bearing from the crankcase, then press the ball bearing from the crankshaft.
   - 5.5 Remove and discard the front and rear thrustwashers.

Cleaning and Inspection

1. Scrape off any gasket material from the top and bottom of the crankcase.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

2. Clean all parts with solvent, before inspecting them, and dry the parts with compressed air.
3. Clean all oil passages through the crankshaft, crankcase, end cover, and base plate. Inspect the passages with a wire to be sure they are clear.
4. Check the fit of the new pistons, piston rings, and connecting rods.
   - 4.1 To check the ring gap, place the ring in the top of the cylinder bore and, using a piston, push the ring to midpoint of the cylinder bore and check the ring gap. The gap for compression rings must be 0.002 to 0.013 inch (0.050 to 0.330 mm).

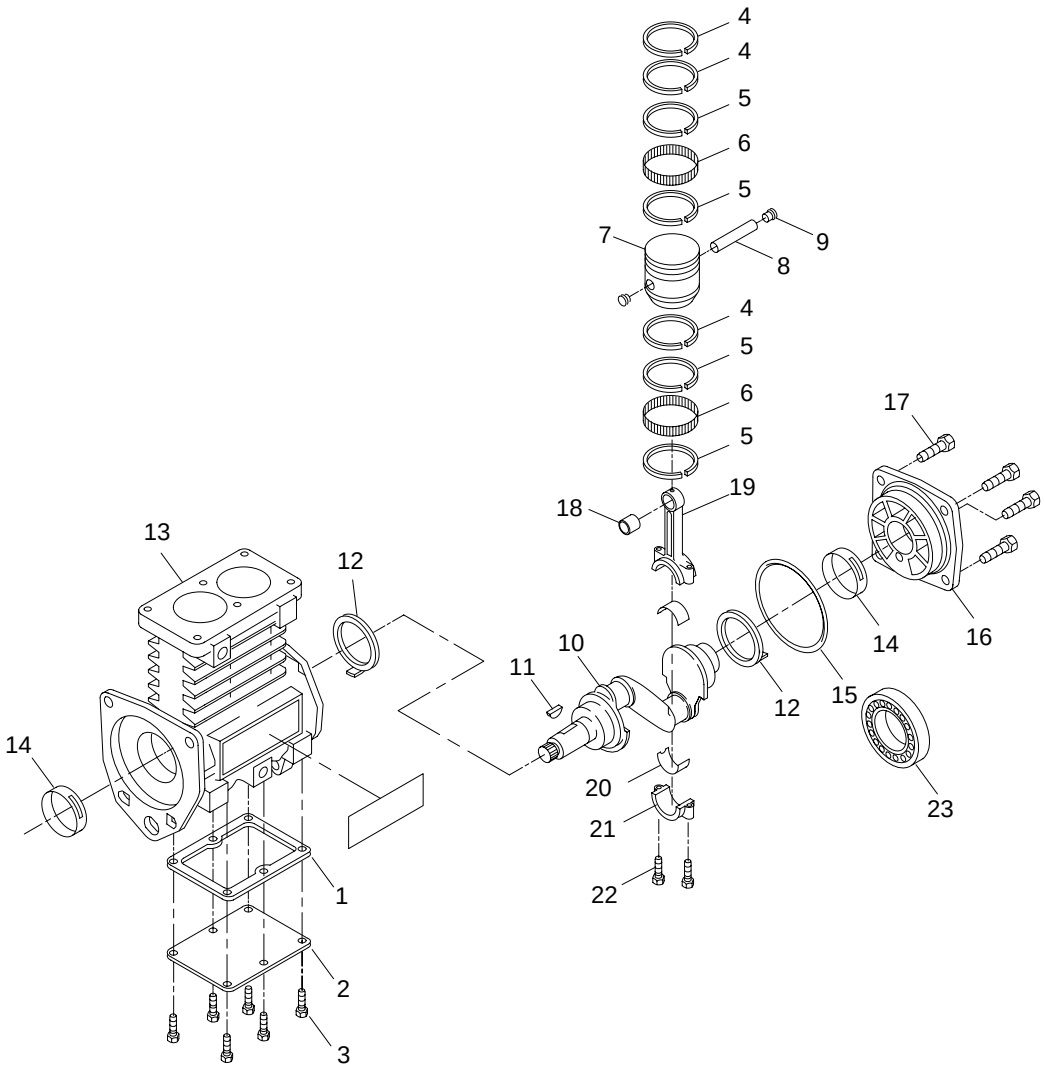
     The gap for oil ring and expander ring must be 0.010 to 0.040 inch (0.254 to 1.016 mm). See **Table 1** and **Fig. 2**.

Allowable End Gap	
Ring	**End Gap in inch (mm)**
Compression	0.002–0.013 (0.050–0.330)
Oil and Expander	0.010–0.040 (0.254–1.016)

Table 1, Allowable End Gap

   - 4.2 Check the fit of the piston rings in the piston ring grooves. Groove clearance for the compression ring is 0.002 to 0.004 inch (0.051 to 0.101 mm). Groove clearance for the expander and oil rings is 0.000 to 0.006 inch (0.000 to 0.152 mm).

Crankcase Disassembly, Cleaning and Inspection, and Assembly



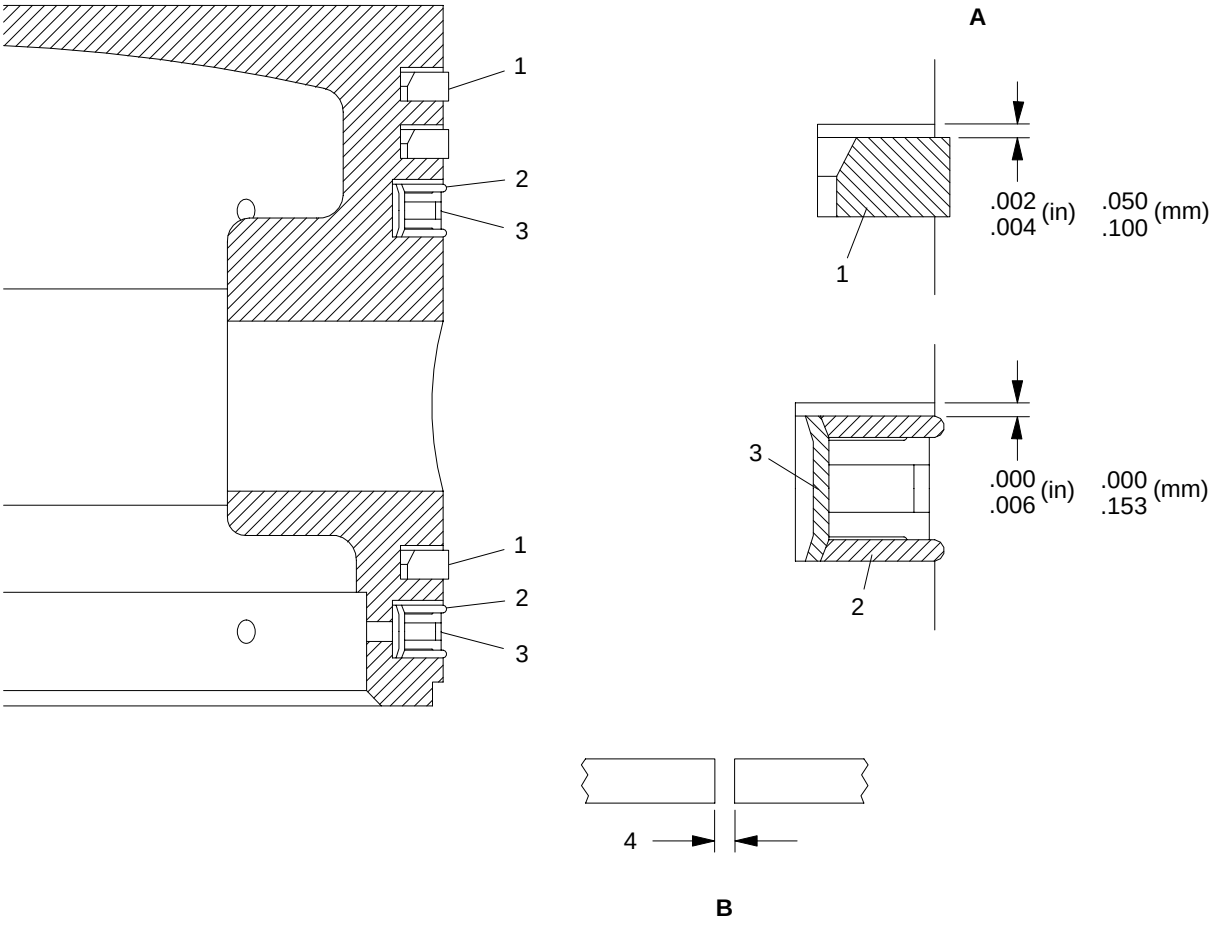
1. Base Gasket
2. Base Plate
3. Base Plate Capscrew
4. Compression Ring
5. Oil Ring
6. Expander Ring
7. Piston
8. Wrist Pin
9. Wrist Pin Button
10. Crankshaft
11. Crankshaft Key
12. Thrust Washer
13. Crankcase
14. Sleeve Bearing
15. End Cover Seal
16. End Cover
17. End Cover Capscrew
18. Wrist Pin Bushing
19. Connecting Rod
20. Connecting Rod Bearing (Sets)
21. Connecting Rod Cap
22. Connecting Rod Bolt
23. Ball Bearing

Fig. 1, Crankcase, Exploded View

5. Inspect the crankcase.

   5.1 Check the crankcase surfaces for cracks and damage.

   5.2 On compressors where main ball bearings are used, measure the difference between the outside diameter of the ball bearing outer race and the inside diam-



A. Side Clearance
B. Ring End Gap With Ring in the Cylinder Bore
1. Compression Ring
2. Oil Ring
3. Expander Ring
4. End Gap

Fig. 2, Piston Specifications

eter of the crankcase bore. It should be 0.0003 inch (0.008 mm) tight to 0.0023 inch (0.058 mm) loose to ensure proper fit. Replace the compressor if the fit exceeds the limit.

5.3 Check the end cover for cracks and damage. Replace them as necessary.

5.4 Check the cylinder bore with an inside micrometer or with calipers. Cylinder bores which are scored, out-of-round, or tapered more than 0.0005 inch (0.013 mm) should be rebored and honed oversize. Oversized pistons and piston rings are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm) oversize.

6. Inspect the crankshaft.

6.1 Check the crankshaft splines, gear teeth, tapered ends, and all machined and ground surfaces for wear, scoring, or damage. Repair the damage, or replace the crankshaft if needed.

Crankcase Disassembly, Cleaning and Inspection, and Assembly

6.2 Check the crankshaft connecting rod journals for extreme scoring, and measure them for out-of-round wear. Acceptable crankshaft journal diameter is 1.1242 to 1.1250 inch (28.555 to 28.575 mm). If the crankshaft is extremely scored or worn out-of-round, and cannot be reground, replace it.

NOTE: If the crankshaft needs to be reground or replaced, do so before proceeding to the next step. For compressors having reground crankshafts, connecting rod bearing inserts are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm) undersize.

Assembly (See Fig. 1)

1. For compressors with sleeve bearings, install the crankshaft and end cover.
   - 1.1 Press the new sleeve bearings into the end cover and crankcase. Make sure the slots in the bearings line up with the oil passages in the end cover and crankcase.

     If there is no oil passage present in the crankcase, press the sleeve bearing into the crankcase with the slot located 90 degrees from vertical.
   - 1.2 Install the new front thrustwasher with the tang inserted in the slot toward the flange.
   - 1.3 Insert the crankshaft and the rear thrustwasher with the tang toward the end cover of the compressor.
   - 1.4 Place the end-cover seal on the boss of the end cover.
   - 1.5 Install the end cover making sure not to pinch the end cover seal and the tang of the rear thrustwasher is inserted in the slot of the end cover. Install and tighten the capscrews 15 to 18 lbf·ft (20 to 25 N·m) in a cross pattern.
2. If one end of the compressor uses a ball-type main bearing, install the crankshaft and endcovers.
   - 2.1 Press the new sleeve bearings into the crankcase. Make sure the slots in the bearings line up with the oil passage in the end cover and crankcase.

     If there is no oil passage present in the crankcase, press the sleeve bearing into the crankcase with the slot located 90 degrees from vertical.
   - 2.2 Install the new front thrustwasher with the tang inserted in the slot toward the flange.
   - 2.3 Press the ball bearing onto the correct end of the crankshaft, so that the drive end of the crankshaft will be positioned in the crankcase as marked before disassembly. Using an arbor press, carefully press the ball bearing and the crankshaft into the crankcase. Install the retainer ring, if equipped.
3. Assemble the new piston rings on the new pistons.

   IMPORTANT: To properly test a compressor under operating conditions, a test rack is necessary for correct mounting, cooling, lubricating, and driving the compressor.

   NOTE: Install the piston rings on the pistons starting at the center of the piston and moving outward. Rotate the piston rings in their respective grooves so that the end gap is at least 90 degrees from the previous ring's end gap.
   - 3.1 Install the expander ring in the piston groove. The ends of the expander ring must butt and must not overlap.
   - 3.2 Install the bottom oil ring by inserting one end below the expander ring in the ring groove, and wind the ring into position. Install the top oil ring in the same manner above the expander ring making sure the gap is staggered from the bottom oil ring and the expander ring.
   - 3.3 Install the compression rings in the correct grooves, with the bevel or "pip" mark (if any) toward the top of the piston.
4. Assemble the new connecting rods on the new pistons.

4.1 Lubricate the wrist pins and the wrist pin bushings in the connecting rods with clean engine oil.

4.2 Position the connecting rods in the pistons and press in the wrist pins. Secure the wrist pins by installing the wrist pin buttons in the ends of the wrist pins.

5. Install the new pistons and new connecting rods.

5.1 Apply clean engine oil to both pistons, the piston rings, the wrist pins, the connecting rod caps and the new connecting rod bearings.

5.2 Turn the crankshaft so its number-one rod journal (the one nearer the drive end) is down and centered.

5.3 Using a piston ring compressor, insert the number-one connecting rod and piston through the top of the number-one cylinder bore.

NOTE: The connecting rods and connecting rod caps are matched sets, therefore the caps must not be switched or rotated end for end.

5.4 Install the connecting rod bearings on the connecting rod and connecting rod cap.

5.5 Tighten the new connecting rod bolts evenly in increments of 11 to 13 lbf·ft (15 to 17 N·m).

5.6 Turn the crankshaft so its number-two connecting rod journal is in the downward, center position.

5.7 Install the number-two connecting rod and piston in the same manner as described above.

6. Before replacing the cylinder head on the crankcase, ensure that the correct pistons have been used by turning the crankshaft one complete revolution such that each piston moves to its maximum upward stroke. At the upward stroke position, each piston should move to the top of the crankcase. If the piston does not approach the top of the crankcase, the piston is incorrect and if not replaced could result in compressor damage.

7. Install the base plate.

7.1 Position the gasket on the crankcase. Install the base plate on the crankcase as marked before disassembly.

7.2 Tighten the six capscrews 15 to 18 lbf·ft (20 to 25 N·m) in a cross pattern.

8. Install the cylinder head on the crankcase. For instructions, see **Subject 110**.

9. Install the compressor on the engine. For instructions, see **Subject 100**.

10. Operate the engine and check for leaks.

Problem—Excessive Oil Passage

Problem—Excessive Oil Passage	
Possible Cause	**Remedy**
Restricted air intake	Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed.
Restricted oil return line to engine	Check for excessive bends, kinks, and restrictions in oil return line. Return line must descend from compressor to engine crankcase. Repair as needed.
Damaged oil seal ring or loose end cover	Inspect oil seal ring for wear or damage. Repair as needed. Check the end cover capscrew torques and tighten as necessary.
Insufficient compressor cooling (compressor runs hot)	Remove grease, grime, or dirt from the cooling fins of the compressor. Check for damaged cooling fins. Replace damaged components. Check for correct coolant line sizes. Check the coolant flow through the compressor. Minimum allowable flow is 2.5 gallons per minute at maximum engine governed speed, and minimum allowable flow is 0.5 gallons per minute at engine idle. If low, inspect the coolant lines for rust scale, kinks, and restrictions. Repair or replace as necessary.
Compressor runs loaded an excessive amount of time	Check air lines and connections for leakage. Repair or replace lines and connections until leakage is eliminated.
Back pressure from the engine crankcase	Check for excessive engine crankcase pressure. Repair or replace ventilation components as necessary. NOTE: An indication of crankcase pressure is a loose or partially lifted dipstick.
Excessive engine oil pressure	Check the engine oil pressure with a test gauge, and compare the reading to the engine specification. Do not restrict the compressor oil supply line.
Malfunctioning compressor	Replace or repair the compressor after making certain none of the preceding conditions exist.

Problem—Noisy Compressor Operation

Problem—Noisy Compressor Operation	
Possible Cause	**Remedy**
Loose drive coupling or gear (as indicated)	Inspect the fit of the drive coupling and gear on the compressor crankshaft. Tighten or replace the components. If the crankshaft keyway is damaged, replace the compressor.
Compressor cylinder head or discharge line restrictions	Inspect the compressor discharge port and discharge line for carbon build-up. If carbon is detected, remove the carbon and check for proper coolant flow to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Air compressor bearing damaged or worn	Replace the bearings.
Malfunctioning compressor	Rebuild or replace the compressor after making certain none of the preceding conditions exist.

Troubleshooting

Problem—Excessive Build-Up and Recovery Time

Problem—Excessive Build-Up and Recovery Time	
Possible Cause	**Remedy**
Restricted air intake	Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed.
Restricted discharge or compressor discharge cavity	Inspect the compressor discharge port and line for restrictions and carbon build-up. If carbon is detected, remove the carbon. Check for proper cooling to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Slipping drive components	Check for faulty drive gears and coupling, and replace as necessary.
Excessive air system leakage (not including the air compressor)	Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated.
Unloader pistons seized	Check the operation of the unloading mechanism. Check for corrosion and contamination of unloader pistons. Check for correct operation of the compressor air governor. If the governor is operating properly, repair or replace the unloading mechanism.
Malfunctioning compressor	Rebuild or replace the compressor after making certain none of the preceding conditions exist.

Problem—Compressor Fails to Unload

Problem—Compressor Fails to Unload	
Possible Cause	**Remedy**
Faulty or worn unloader pistons or bores	Inspect for worn, dirty, or corroded unloader pistons and bores. Replace as necessary.
Malfunctioning governor	Check the setting with an accurate test gauge. Repair or replace the air governor.
Unloader air lines from governor damaged	Inspect the air lines to and from the governor for kinks or restrictions. Repair or replace the air lines.

Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Cylinder Head	37–42 (50–57)
Unloader Cover Plate	15–18 (20–25)
Discharge Valve Seat	70–90 (95–122)
Inlet Valve Stop	70–90 (95–122)
End Cover	15–18 (20–25)
Connecting Rod	11–13 (15–17)
Bottom Cover	15–18 (20–25)
Inlet Fitting	15–18 (20–25)
Discharge Fitting	15–18 (20–25)
Governor or Governor Adaptor	15–18 (20–25)

Table 1, Torque Specifications

Compressor Specifications	
Description	**in (mm)**
Discharge Valve Travel (minimum/maximum)	0.030/0.046 (0.762/1.168)
Fit Between Crankcase Bore and Ball-Type Main Bearing (minimum/maximum)	0.0003/0.0023 (0.008/0.058)
Clearance for Crankshaft Main Journals to i.d. of Sleeve-Type Main Bearing (maximum)	0.005 (0.13)
Crankshaft Main Journal Standard Diameter	1.1242–1.1250 (28.555–28.575)
Clearance Between Crankshaft Rod Journals and Connecting Rod Bearing (minimum/maximum)	0.0003/0.0021 (0.008/0.053)
Crankshaft Rod Journal Standard Diameter *	1.1242–1.1250 (28.555–28.575)
Cylinder Bore Out-of-Round (maximum)	0.0005 (0.013)
Cylinder Bore Taper (maximum)	0.0005 (0.013)
Clearance Between Cylinder Bore and Cast Iron Piston (minimum/maximum) †	0.002/0.004 (0.050/0.101)
Clearance Between Wrist Pins and Connecting Rod Bushings (maximum)	0.0007 (0.0178)
Compression Ring Groove Clearance	0.002–0.004 (0.050–0.101)
Oil and Expander Ring Groove Clearance	0.00–0.006 (0.00–0.152)
Compression Ring Gap (installed in cylinder)	0.002–0.013 (0.050–0.330)
Oil and Expander Ring Gap (installed in cylinder)	0.010–0.040 (0.254–1.016)

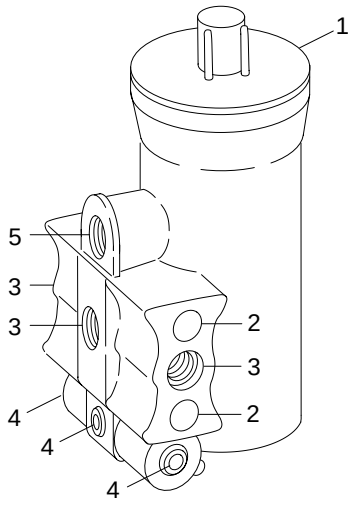
* For compressors having reground crankshafts, undersize connecting rod bearing inserts are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm).
† Oversized pistons and piston rings are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm).

Table 2, Compressor Specifications

General Information

The governor, operating in conjunction with the compressor unloading mechanism, automatically controls the air pressure in the air brake or air supply system between the desired, predetermined maximum and minimum pressures. Normal air pressure in all Sterling vehicles is 105 to 130 psi (724 to 896 kPa). The compressor runs continuously while the engine runs, but the actual compression of air is controlled by the governor actuating the compressor unloading mechanism, which stops or starts compression when the maximum or minimum reservoir pressures are reached. The D–2 governor has a piston upon which air pressure acts to overcome the pressure setting spring, and controls the inlet and exhaust valve to either admit or exhaust air to or from the compressor unloading mechanism.

D–2 governors have mounting holes, which allow for direct mounting to the compressor. Porting consists of 3 reservoir ports (1/8 NPT), 3 unloader ports (1/8 NPT), and 1 exhaust port (1/8 NPT). See **Fig. 1**.



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1. Top Cover
2. Mounting Hole
3. Unloader Port
4. Reservoir Port
5. Exhaust Port

Fig. 1, Governor

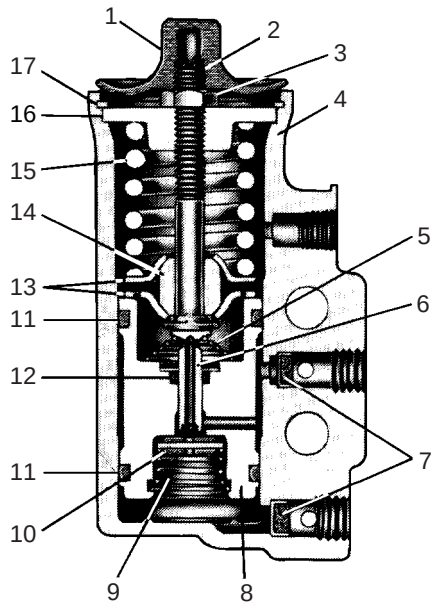
The governor receives a signal pressure from the supply reservoir or the air dryer (if equipped). When the signal pressure reaches the preset cutout pressure (130 psi [896 kPa] maximum), the governor will prevent the compressor inlet valve from closing. With the inlet valve unable to close, the compressor cannot compress the air drawn in and will exhaust it back through the inlet valve.

When the signal pressure from the reservoir drops to the cutin pressure (105 psi [724 kPa] minimum), the governor will allow the inlet valve to close. When the inlet valve can close, the air compressor will compress air and expel it through the discharge line to the reservoir or air dryer (if equipped).

Pressurized air enters the D–2 governor at one of its reservoir ports, and acts on the area of the piston and beneath the inlet and exhaust valve. As air pressure builds up, the piston moves against the resistance of the pressure-setting spring. The piston and inlet and exhaust valve move up when the reservoir air pressure reaches the cutout setting of the governor. The exhaust stem seats on the inlet and exhaust valve, and then the inlet passage opens. Reservoir air then flows by the open inlet valve, through the passage in the piston, and out the unloader port to the compressor unloading mechanism. Air also flows around the piston, and acts upon the additional area of the piston. This added force, which results from a larger area on the piston, ensures a positive action and fully opens the inlet valve.

As the system reservoir air pressure drops to the cutin setting of the governor, the force exerted by the air pressure on the piston will be reduced so that the pressure-setting spring will move the piston down. The inlet valve will close and the exhaust will open. With the exhaust open, the air in the unloader line will escape back through the piston, through the exhaust stem and out the exhaust port. See **Fig. 2**.

General Information



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1. Cover
2. Adjusting Screw
3. Adjusting Screw Locknut
4. Body
5. Exhaust Stem Spring
6. Exhaust Stem
7. Filters
8. Piston
9. Inlet and Exhaust Valve Spring
10. Inlet and Exhaust Valve
11. O-Rings
12. Exhaust Stem O-Ring
13. Lower Spring Seats
14. Spring Guide
15. Pressure-Setting Spring
16. Upper Spring Seat
17. Retaining Ring

Fig. 2, Governor, Cross Section View

Safety Precautions

⚠ WARNING

Before attempting to work on the air brake system, certain precautions must be observed. Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized. The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.

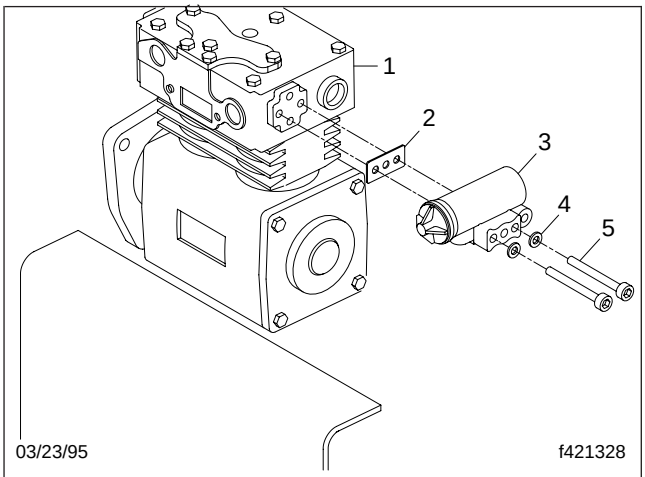
Observe the following precautions when working on or around air brake systems and components:

1. When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.
2. Hoses will whip dangerously if disconnected under pressure.
3. Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.
4. As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber pushrods and spring actuators which apply automatically with the loss of pressure. This also applies when checking the service brake system.
5. Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.
6. Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.
7. The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.
8. Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.
9. To avoid injury, keep clear of the air chamber pushrod when brakes are applied or when air is exhausted from the system.

Removal (See Fig. 1)

WARNING

Before working on or around air brake systems and components, read "Safety Precautions" in Subject 100. Failure to do so could result in personal injury.



1. Air Compressor
2. Gasket
3. Air Governor
4. Lockwasher
5. Capscrew

Fig. 1, Governor Mounting (typical)

NOTE: The governor may be mounted on the air compressor, on the air dryer, or remote mounted on the vehicle frame.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires. Drain the air reservoirs.
2. Disconnect the reservoir and unloader port air lines. If the air governor is remotely mounted, mark the lines for later reference. Cap the air lines tightly to keep out contaminants.
3. Remove the governor mounting capscrews and lockwashers, then remove the governor.

Installation

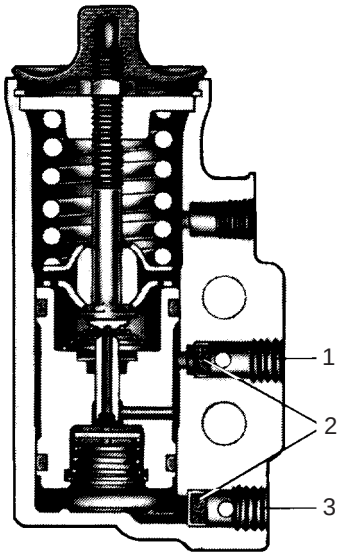
1. Clean the mounting pad on both the compressor and the governor block, and be sure the compressor unloading port is clear and clean.
2. Using a new governor mounting gasket, install the governor and its mounting capscrews and lockwashers. Tighten the bolts 11 to 15 lbf·ft (15 to 20 N·m).
3. Clean the reservoir and unloader fittings and apply Loctite® 242, or equivalent sealant, in small quantities to the threads.

CAUTION

Make sure excess sealant does not get inside the fittings. Loose material inside the plumbing may clog the governor or other components, causing damage.

4. Connect the reservoir and unloader port air lines as referenced earlier. Tighten the fittings 11 to 13 lbf·ft (15 to 18 N·m).
5. Perform the operating and leakage tests in Subject 130.
6. After the tests have been completed and the governor is operating properly, screw the top cover on tightly until it seals the body, preventing the entry of any foreign matter.
7. If necessary, install new filters in the reservoir and unloader ports. See Fig. 2. These cup-shaped filters can be installed with the head of a pencil.
8. Remove the chocks from the tires.

Removal and Installation



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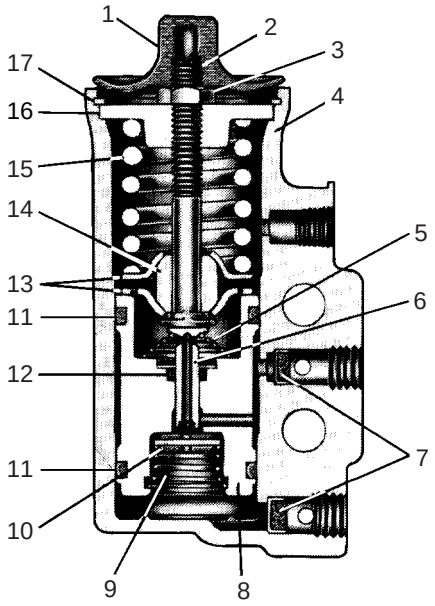
1. Unloader Port
2. Port Filters
3. Reservoir Port

Fig. 2, Filter Installation

Disassembly (See Fig. 1)



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1. Cover
2. Adjusting Screw
3. Adjusting Screw Locknut
4. Body
5. Exhaust Stem Spring
6. Exhaust Stem
7. Filters
8. Piston
9. Inlet and Exhaust Valve Spring
10. Inlet and Exhaust Valve
11. O-Rings
12. Exhaust Stem O-Ring
13. Lower Spring Seats
14. Spring Guide
15. Pressure-Setting Spring
16. Upper Spring Seat
17. Retaining Ring

Fig. 1, Governor, Cross Section View

1. Remove the governor from the vehicle using the instructions in **Subject 110**.
2. Clean the governor exterior of road dirt and grease.
3. Unscrew the top cover.
4. With a pair of retaining ring pliers, remove the spring assembly retaining ring.
5. Remove the adjusting screw and spring assembly.
6. Remove the locknut, then the hex-shaped upper spring seat from the adjusting screw.
7. Remove the pressure-setting spring, lower spring seat, spring guide, and the other lower spring seat from the adjusting screw.
8. Remove the exhaust stem and its spring from the top of the piston. With the body in the inverted position, tap lightly and remove the piston.
9. Remove the inlet and exhaust valve spring and the valve from the piston.
10. Remove the two piston O-rings and remove the exhaust stem O-ring.
11. Clean or remove the unloader and reservoir port filters.

Cleaning and Inspection

1. Clean all metal parts in mineral spirits.
2. Wipe all rubber parts dry, using a clean cloth.
3. Inspect the governor body for cracks or other damage. Be particularly careful that all air passages in the body, filters, exhaust stem, and piston are not obstructed.
4. Check the springs for cracks, distortion, or corrosion.
5. Replace all worn or damaged parts.

Assembly (See Fig. 1)

IMPORTANT: Prior to assembly, lubricate the lower body bore, the top of the piston, the piston grooves, piston O-rings, and the spring guide and adjusting screw with Dow Corning 55-M pneumatic grease, or equivalent.

1. Install the exhaust stem O-ring in its groove in the stem bore of the piston.
2. Install the upper and lower piston O-rings.
3. Drop the inlet and exhaust valve into place at the bottom of the piston.
4. Install the inlet and exhaust valve spring with the small end against the valve. Press the spring

Disassembly, Cleaning and Inspection, and Assembly

down until the larger coiled end snaps into the groove inside the piston.

5. Position the exhaust stem spring over the exhaust stem. Carefully press the stem into the stem bore of the piston.
6. Install the piston in the body.
7. Install one lower spring seat, spring guide, the other lower spring seat, pressure-setting spring, and the hex-shaped upper spring seat on the adjusting screw, in that order. Screw the upper spring seat down until the distance from the top of the seat to the bottom of the stem head is about 1-7/8 inches (48 mm).
8. Install the locknut.
9. Before placing the adjusting screw and stem assembly in the governor body, check that the exhaust stem and its spring are in place in the piston.
10. Install the adjusting screw and spring assembly, and the retaining ring.
11. Install the governor on the vehicle, using the instructions in **Subject 110**.

Tests

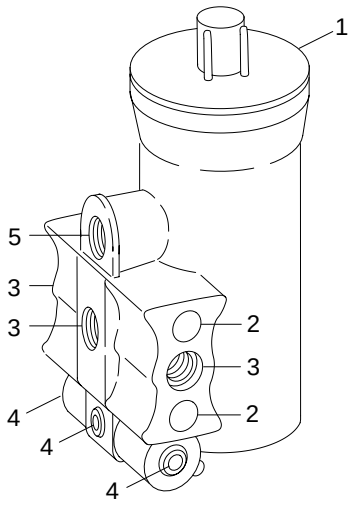
The following test should be performed whenever the vehicle air pressure is incorrect and the causes are unknown.

If the air governor does not function as described or if leakage is excessive, replace it with a new or remanufactured unit, or repair it using genuine Bendix parts and the instructions in this section.

1. Park the vehicle on a level surface and set the parking brake. Chock the tires.
2. Open the hood.
3. Run the engine to build up air pressure in the system.

IMPORTANT: Make sure the test gauge is registering accurately before using it to check or adjust the air governor.

4. Using a test gauge attached to the supply reservoir, check the pressure at the time the air governor cuts out. The cut-out pressure should be 120 to 130 psi (827 to 896 kPa).
5. With the engine still running, make a series of brake applications to reduce the air pressure and observe at what pressure the air governor cuts in the compressor. The minimum cut-in pressure should be 100 psi (689 kPa).
6. If either the cut-out or cut-in pressures are incorrect, proceed to **Subject 140**.
7. Test the leakage on the air governor in both the cut-in and cut-out positions.
   - 7.1 With the compressor in the cut-in position, apply a soap solution to the air governor exhaust port. See **Fig. 1**. A slight bubble leakage is permitted. Excessive leakage indicates that the inlet valve or lower piston O-ring is worn out.
   - 7.2 With the compressor in the cut-out position, apply a soap solution to the air governor exhaust port. See **Fig. 1**. A slight bubble leakage is permitted. Excessive leakage indicates that the exhaust valve seat, stem, O-ring, or upper piston O-ring is worn out.
8. Close the hood.



1. Top Cover
2. Mounting Hole
3. Unloader Port
4. Reservoir Port
5. Exhaust Port

Fig. 1, Air Governor

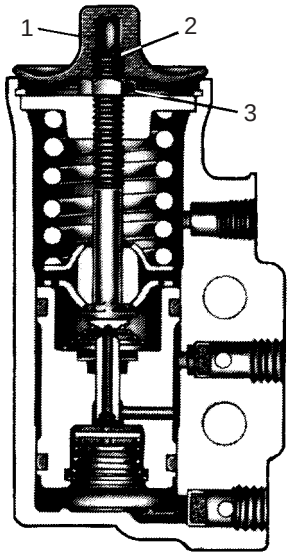
9. Remove the chocks from the tires.

Adjustment

NOTE: An air governor with a dryer reservoir module (DRM) is not adjustable.

If the pressure settings of the governor are inaccurate or if they need to be changed, proceed as follows.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the top cover from the governor and loosen the adjusting screw locknut. See **Fig. 1**.



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1. Top Cover
2. Adjusting Screw
3. Adjusting Screw Locknut

Fig. 1, Air Governor, Cross Section View

3. To raise the pressure settings, turn the adjusting screw counterclockwise. To lower the pressure setting, turn the adjusting screw clockwise.

NOTE: The pressure range between cut in and cut out is not adjustable.

If these adjustments do not correct the pressure settings, repair or replace the governor.

4. Tighten the adjusting screw locknut and install the top cover.
5. Remove the chocks from the tires.

General Information (See Fig. 1)

WARNING

Avoid contact with the air compressor discharge line. Compressed air directly from the air compressor is hot enough to burn the skin.

The air compressor is a one cylinder, single-stage, reciprocating air compressor, which supplies compressed air to the vehicle air system. It has a rated displacement of 15.2 cfm (430 L/min) or 18.7 cfm (530 L/min).

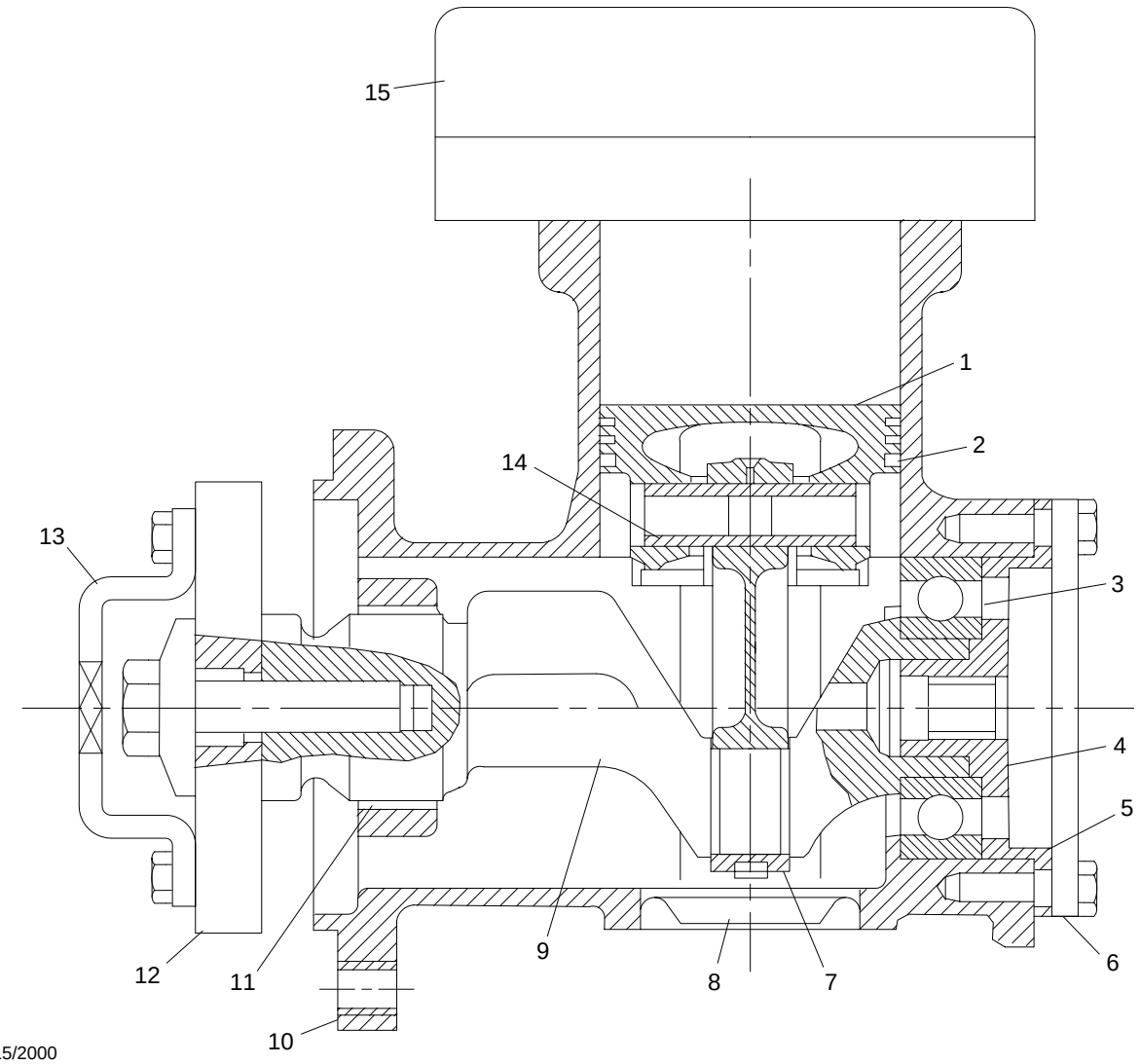
The air compressor is:

- Lubricated by the engine lubrication system;
- Cooled by the engine coolant system;
- Controlled by a governor that may be attached or remotely mounted.

All models of the Cummins air compressor are the same design except for the drive gear, mounting arrangement, rear drive through and porting on the heads.

The ISC engine was first available with the Cummins air compressor in July, 1998. The ISB, ISM and N14 engines offered it starting in January, 1999. The ISX and Signature engines are only available with the Cummins air compressor.

General Information



1. Piston
2. Rings
3. Bearing
4. Retainer
5. Adapter
6. Rear Cover
7. Connecting Rod
8. Sump Plug
9. Crankshaft
10. Crankcase
11. Bushing
12. Drive Gear
13. Barring Adapter
14. Wrist Pin
15. Head

Fig. 1, Air Compressor

Air Compressor Removal and Installation

Removal

NOTE: Depending on engine model, Cummins engines may have either a fuel pump or a power steering pump mounted to the back of the air compressor.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Release system air pressure.
3. Drain the engine coolant.
4. Disconnect the following lines:
   - intake and discharge air lines
   - two coolant lines
   - control line at or from the governor
5. If the power steering pump is mounted to the compressor:
   - 5.1 Remove the power steering pump mounting bolts. See **Fig. 1**.

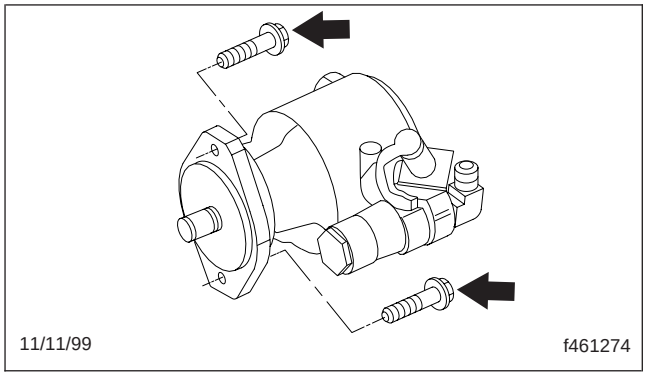


Fig. 1, Power Steering Pump Mounting Bolts

   - 5.2 Remove the power steering pump and gasket from the engine. Tie the pump and lines out of the way.
6. If the fuel pump is mounted to the compressor:
   - 6.1 Disconnect the fuel line from the fuel filter.
   - 6.2 Disconnect the fuel return line from the fuel pump.
   - 6.3 Disconnect the fuel outlet line from the fuel pump.
   - 6.4 Disconnect the electrical wire from the fuel pump solenoid.
   - 6.5 Remove the support bracket from the engine block to the fuel pump.
   - 6.6 Remove the fuel pump and filter assembly from the air compressor.

IMPORTANT: An assistant is necessary to remove the air compressor from the engine compartment.

7. Slide the air compressor off the studs and lift it out of the engine compartment. See **Fig. 2**.

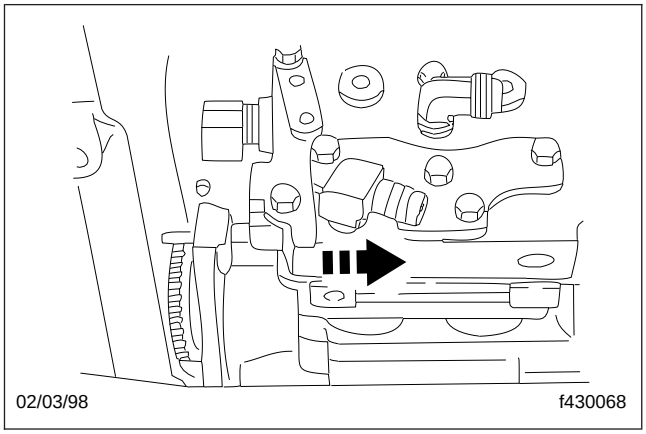


Fig. 2, Compressor and Studs

Installation

IMPORTANT: See the timing instructions in **Subject 140**.

1. Remove the dirt and grease from the air compressor mounting surfaces and compressor lines.
2. Install a new gasket and slide the air compressor onto the studs.
3. Tighten the retaining bolts and fittings 30 to 46 lbf·ft (41 to 62 N·m). See **Fig. 3**.
4. If the power steering pump is mounted to the compressor:
   - 4.1 Position the power steering pump.
   - 4.2 Install the mounting bolts. Tighten the bolts 30 to 46 lbf·ft (41 to 62 N·m). See **Fig. 1**.
5. If the fuel pump is mounted to the compressor:

Air Compressor Removal and Installation

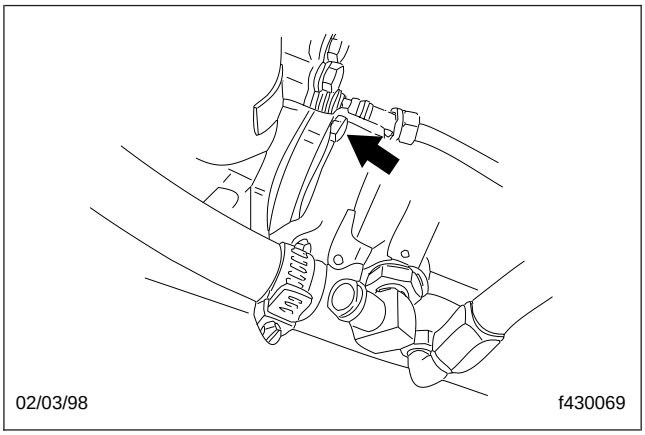


Fig. 3, Retaining Bolt

5.1 Install the fuel pump and filter assembly onto the air compressor.

5.2 Install the support bracket from the engine block to the fuel pump.

5.3 Connect the electrical wire to the fuel pump solenoid.

5.4 Connect the fuel outlet line to the fuel pump.

5.5 Connect the fuel return line to the fuel pump.

5.6 Connect the fuel line to the fuel filter.

6. Connect the following lines to the air compressor:
   - intake and discharge air lines
   - two coolant lines
   - control line at or from the governor
7. Fill the engine cooling system. For instructions, see **Group 20**.
8. Remove the chocks from the tires.

Air Compressor Disassembly and Assembly

Disassembly

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the air compressor. For instructions, see **Subject 100**.

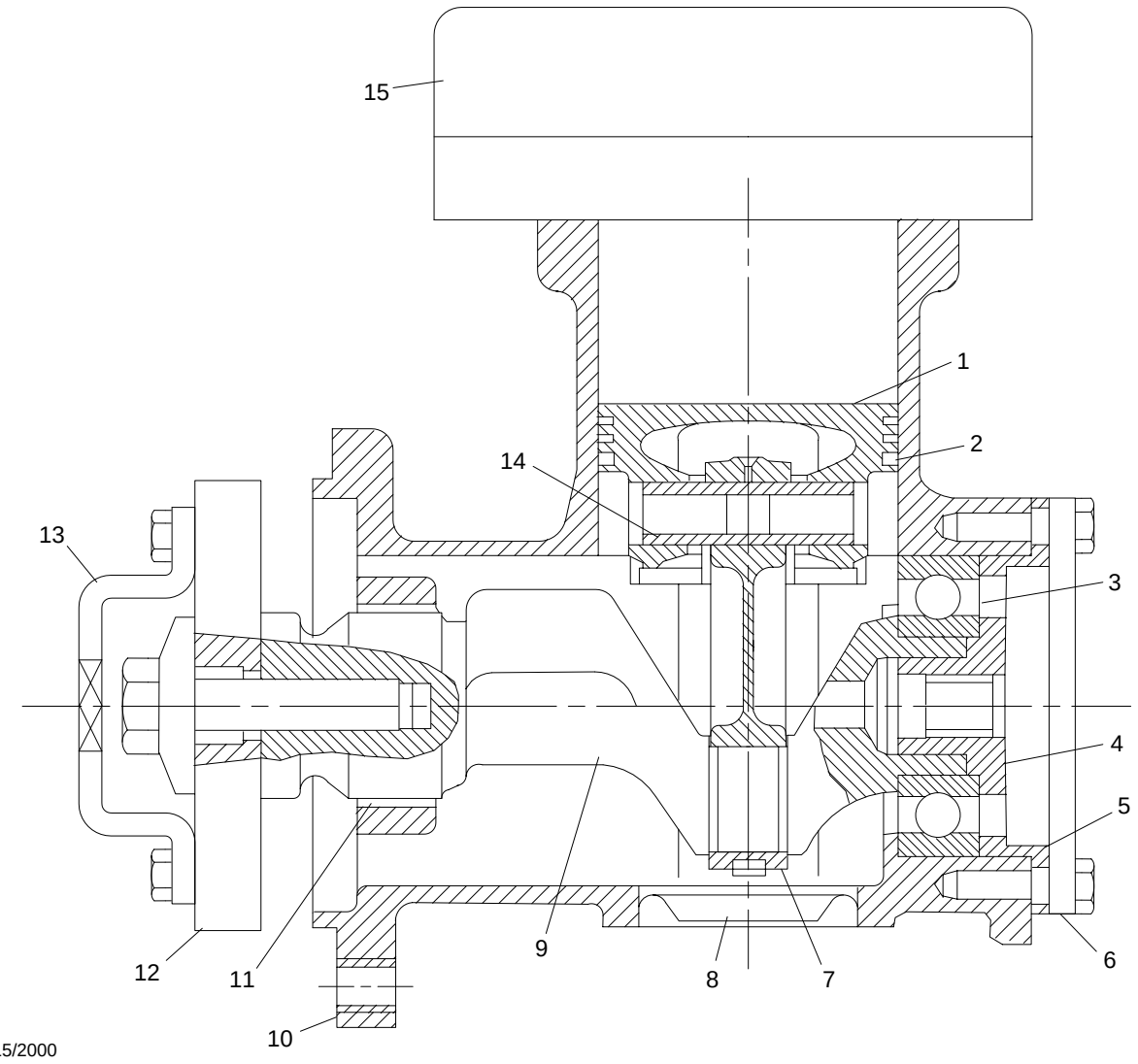
NOTE: All models of the air compressor are the same design except for the drive gear, mounting arrangement, rear drive through and porting on the heads. Follow the instructions for the appropriate engine model for removal of the drive gear and rear cover (if equipped).

3. For Signature and ISX engines:
   - 3.1 Remove the barring adapter. See **Fig. 1**.
   - 3.2 Remove the drive gear.
   - 3.3 Remove the rear cover, gasket and adapter ring.
4. For N14 and ISM engines: the drive gear does not need to be removed to service the compressor.
5. For ISB, ISC and ISL engines:
   - 5.1 Remove the drive gear. See **Fig. 1**.
   - 5.2 Remove the rear cover, gasket and adapter ring (if equipped).
6. Remove the four 13 mm head bolts. Discard the bolts.
7. Remove the head, valve and gasket. Note the position of these parts in respect to the crankcase for assembly. A paint marker can be used to mark the positions.
8. Using a large screwdriver or similar device, knock the sump plug out of the crankcase via the cast slot.
9. Align the crankshaft to position the rod cap in the access hole.
10. Remove the two torx head 30 rod bolts.
11. Pull the rod cap off of the rod and crankshaft.
12. Push the piston and rod assembly out of the top of the crankcase with a wooden dowel or hammer handle, pushing on the bottom of the rod.
13. Position the crankshaft in the top-dead-center position (the gear alignment pin will also be in the top-dead-center position) and press the crankshaft out of the rear of the crankcase. This requires approximately 3,000 lbs (1360 kg) of force.
14. If the front bearing bushing is in good condition, do not remove it. See **Subject 120** for the permissible maximum diameter.
15. Clamp the crankshaft by the counterweight and remove the bearing retaining nut. It will require a high removal torque in the counterclockwise direction. A section of splined shaft can be used as a tool.
16. Remove the bearing from the shaft. A press is required.

Assembly

1. Press the ball bearing on to the rear crankshaft journal and assemble the retainer.
   - 1.1 For ISB and ISC engines, the retainer has a spline in the center. Tighten 332 to 369 lbf·ft (450 to 500 N·m).
   - 1.2 For Signature, ISX, N14 and ISM engines, the retainer has a 3-jaw driver. Tighten 185 to 221 lbf·ft (250 to 300 N·m).
2. Press a front bushing into the crankcase to a depth of 0.7 inches (18 mm) below the machined flange.
3. Assemble the crankshaft into the crankcase making sure the rod throw is in the top-dead-center position and will enter through the cast clearance slot.
4. Press the assembly in until it securely bottoms on the shoulder.
5. Assembly the rings on the piston. Insure the rings are in the correct orientation. Stagger the end gaps.
6. Coat the wrist pin, rod bore and piston bores with light oil. Assembly the rod, wrist pin and retainers. Make sure the retainers are secure in the grooves. The rod should move freely.
7. Coat the piston bore with light oil. Using a ring compressor, install the piston into the crankcase.

Air Compressor Disassembly and Assembly



1. Piston
2. Rings
3. Bearing
4. Retainer
5. Adapter
6. Rear Cover
7. Connecting Rod
8. Sump Plug
9. Crankshaft
10. Crankcase
11. Bushing
12. Drive Gear
13. Barring Adapter
14. Wrist Pin
15. Head

Fig. 1, Air Compressor

Align the rod to match up to the crankshaft. The piston and rod have no fore or aft preference.

8. Apply light oil to the crankshaft rod journal and assemble the rod cap. Tighten the bolts 48 to 58 lbf·in (540 to 660 N·cm). Rotate the bolts an additional 65 to 85 degrees.
9. Check that the crankshaft rotates without binding or excessive torque. The maximum torque is 53 lbf·in (600 N·cm).

10. Apply red Loctite® sealant to the sealing surface of the sump plug and press it in the crankcase until the flange seats.
11. Assemble the gasket/valve assembly and head to the crankcase. Make sure the guide pins are in the correct direction to enter the larger diameters in the valve and crankcase. If orientation marks were applied during disassembly, simply align them and proceed. Assembly and tighten the four head bolts 13 to 16 lbf·ft (18 to 22 N·m). Rotate the bolts an additional 85 to 105 degrees. Complete the torque sequence by alternating corners.
12. For Signature, ISX or P/N 3680441:
    - 12.1 Assemble the O-ring seal, flange, cover gasket and cover. Tighten the bolts 13 to 16 lbf·ft (18 to 22 N·m). Make sure the alignment of the flange matches all holes.
    - 12.2 Assemble the drive gear on the crankshaft and tighten the remaining bolts 111 to 114 lbf·ft (150 to 155 N·m).
    - 12.3 Assemble the barring adapter using two bolts and tighten 33 to 37 lbf·ft (45 to 50 N·m).
13. For N14, ISM or P/N 3558163, no post assembly is required.
14. For ISB, ISC, ISL, P/N 3944525, or P/N 3944460:
    - 14.1 Press the gear on the crankshaft supporting the rear end of the crank.
    - 14.2 Assembly and tighten the bolt 111 to 114 lbf·ft (150 to 155 N·m). Rotate the bolt an additional 180 to 190 degrees.
15. Install the air compressor. For instructions, see **Subject 100**.
16. Remove the chocks from the tires.

Cleaning

Parts cleaning can be done by most commercial methods used for cleaning ferrous metals and aluminum parts.

⚠ WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles or a face shield and protective clothing. Failure to follow these precautions could result in serious personal injury.

Soak the parts in a kerosene emulsion-based cleaner designed to remove carbon. The cleaner must have a pH of 9.5 or less to avoid turning the aluminum parts black. The cleaner manufacturer or supplier can be contacted about solution concentration, temperature, and soak time. If using a hot caustic cleaning process, do not immerse aluminum parts.

NOTE: Do not use a scraper to remove carbon and scale. The sealing surfaces can be damaged. The parts can be scrubbed with a stiff non-metallic brush. Avoid the use of abrasive products similar to "Scotch Brite" because of damage and the abrasive grit left behind by these products.

Inspection

Any evidence of heavy wear or deformation on any component as if it was over stressed, disqualifies the part for reuse.

Head

Inspect the valve elements for breakage and cracks. Any signs of damage renders the parts unusable.

Inspect the sealing seats for wear and deformations due to debris. Anything more than a polishing of the set renders the part unusable.

Crankcase

Inspect the top surface and sump plug bore. They should be smooth and free of scratches to enable resealing on assembly, see **Fig. 1**.

The front bearing bushing may not have been removed during the disassembly procedure. If it was not removed, inspect it in-place for wear and galling. The maximum allowable diameter is 2 inches (55 mm). The surface should be smooth and free of galling or damage from debris.

The bearing bores should be free of heavy scratches and not show any deformation of material so that the assembly of the bearings will be smooth and tight.

The piston bore should not be scratched or show evidence of aggressive wear. Polished wear is acceptable in the ring areas. The bore should not exceed 3 inches (85 mm) in diameter. Evidence of galling or operation with debris disqualifies the crankcase for reuse.

Crankshaft

Inspect the machined diameters for damage and wear. The front bearing journal and rod journal can show polished wear. The wear limit on the front journal is 2 inches (55 mm) and the rod journal is 1.25 inches (32 mm). The rear bearing journal may show phantom contact from the bearing assembly and removal. Any galled material or deformation disqualifies it for reuse.

Inspect the thread in the front and rear to make sure they have not been stripped or deformed.

Piston

Inspect the ring grooves for wear and damage. Polished wear is normal, but a "step" at the base of the groove indicates excessive wear. Groove width limits are:

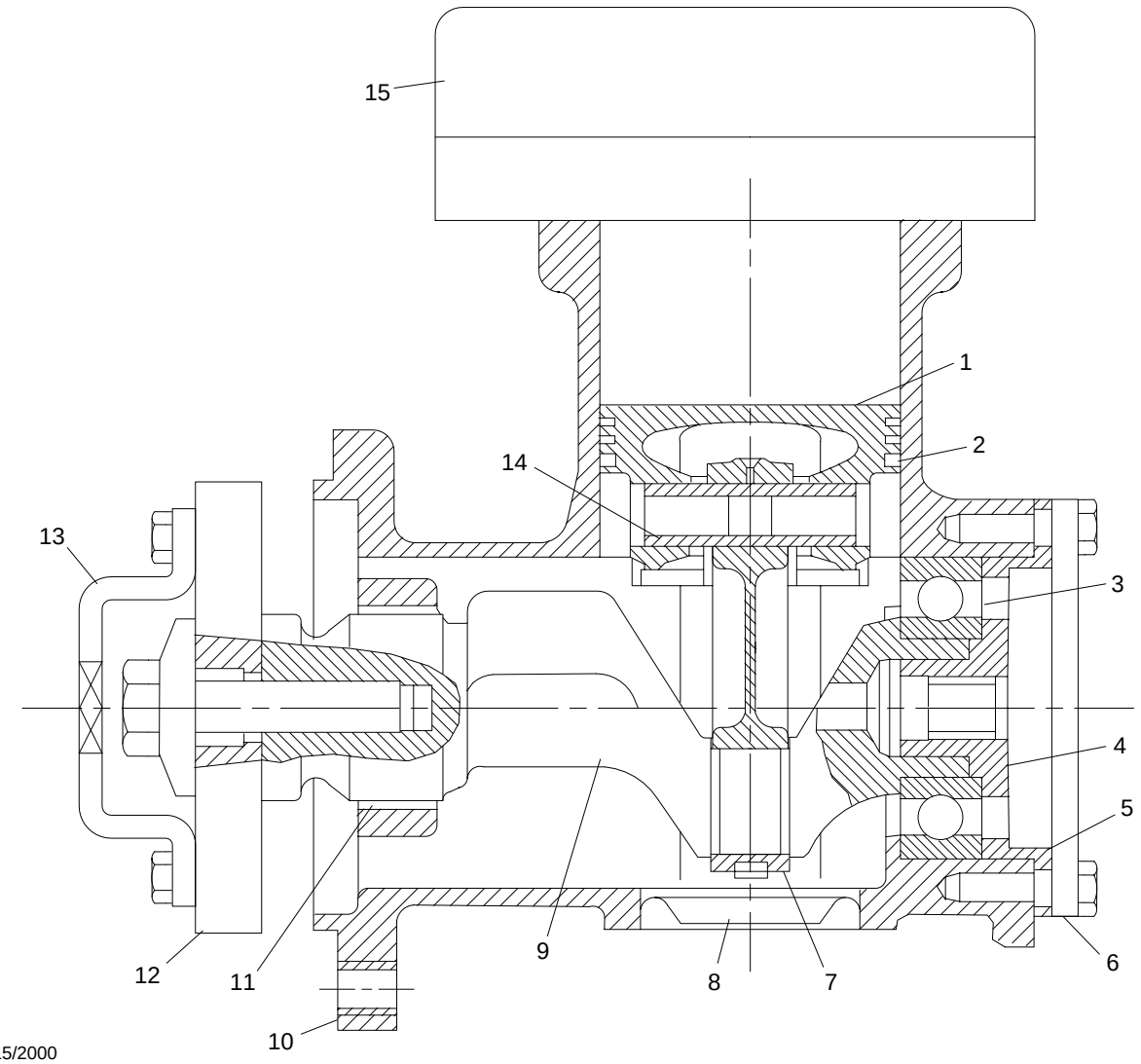
- Compression ring groove: 0.08 inches (2.025 mm)
- Oil ring groove: 0.16 inches (4.033 mm)

Inspect the outside diameter for excessive wear. The piston is not reusable if the machining marks are worn off the skirt.

Inspect the wrist pin bores. The maximum diameter is 0.75 inches (19.063 mm).

If the top appears that large debris or broken parts have been present during operation (dents), it is best to replace the piston.

Air Compressor Cleaning and Inspection



1. Piston
2. Rings
3. Bearing
4. Retainer
5. Adapter
6. Rear Cover
7. Connecting Rod
8. Sump Plug
9. Crankshaft
10. Crankcase
11. Bushing
12. Drive Gear
13. Barring Adapter
14. Wrist Pin
15. Head

Fig. 1, Air Compressor

Rod

Inspect the wrist pin bores. The maximum diameter is 0.75 inches (19.019 mm).

Inspect the lower bore with the rod cap assembled. The maximum diameter is 1.25 inches (32.06 mm).

The finish should appear smooth with no evidence of galling.

Wrist Pin

Inspect the surface and make sure it is smooth and free of damage. The maximum diameter is 0.75 inches (19.045 mm) for reuse.

There may be phantom areas of smoothness on the wrist pin that came in contact with the rod and piston bores. These should show no perceptible depth.

Rear Ball Bearing

This bearing should always be changed during rebuild.

Crankcase Preparation for Reuse

If the crankcase is being reused and new rings are being installed, the bore should be honed lightly with 220 grit honing stones and stroked up and down to produce a cross-hatch pattern in the bore that has an approximate included angle of 30 degrees. The honing process is used to produce a visual pattern on the bore and remove as little material as possible.

Bench Testing

On a bench, use a wrench to turn the compressor over. Check for the following:

- Moving parts are not binding.
- The intake port should draw some vacuum indicating the inlet valve is seating.
- The exhaust port should pass some air demonstrating the exhaust valve is seating.

Using shop air, pressurize the exhaust port to make sure there is good exhaust valve seating.

Using shop air, cycle the unloader piston.

Apply a tank with a vacuum of 20 to 30 inHg (68 to 101 kPa) to check inlet valve seating. A small drop in vacuum indicates good seating.

Using shop air, pressurize a water port (with other port plugged) to make sure gaskets and castings are leak proof.

Vehicle Testing

Install the compressor on a vehicle and check for the following:

- The system pressure should build from 85 to 100 psi (586 to 689 kPa) in 25 seconds or less.
- The compressor should unload as the system pressure comes up to 120 psi (827 kPa).
- Bleed the air down with the brakes. The compressor should load again at approximately 100 psi (689 kPa).
- Check for audible air leaks during the load cycle.
- Check for small leaks by applying a soap solution to the exterior of the compressor.
- Check for any coolant leaks.
- Check for any oil leaks.

Timing

ISB and ISC Engines

NOTE: On ISC engines, compressors with a build date of January 1, 1999 to April 1, 1999 do not have the gear timed to the compressor. To determine the build date of a compressor, locate the data tag on the rear of the compressor, just below the cylinder head. The build date code is a 4-digit number such as 0999. The first 2 digits represent the week it was built and the last 2 digits represent the year the compressor was built. A build date code of 0999 indicates the ninth week of 1999, or the week of February 22 through 26, 1999.

IMPORTANT: The engine must be at #1 top-dead-center when timing the air compressor to the engine.

1. Remove the air compressor. For instructions, see **Subject 100**.
2. Position the air compressor so it can be viewed from the gear end.
3. Rotate the gear as necessary to position the timing mark ("I") in the three o'clock position. The air compressor has a divot on the housing at the three o'clock position.
4. Install the air compressor. For instructions, see **Subject 100**.

ISM and N14 Engines

1. Remove the air compressor. For instructions, see **Subject 100**.
2. Position the timing mark (a small punch mark or drilling) on the end of the air compressor crankshaft at the 12 o'clock position.
3. Position the accessory drive shaft dowel pin at the 2 o'clock position as viewed from the front of the engine.
4. Install the splined coupling on the accessory drive shaft.
5. Install the air compressor. For instructions, see **Subject 100**.

ISX and Signature Engines

1. Remove the air compressor. For instructions, see **Subject 100**.
2. Pin the engine crankshaft.
3. Rotate the gear on the air compressor until the mark on the gear is lined-up with the V-notch on the air compressor housing, located at the 3 o'clock position as viewed from the front of the engine.
4. Install a new gasket, air compressor and four capscrews onto the front gear housing. For instructions, see **Subject 100**.

Troubleshooting Tables

Problem—Excessive Oil Passage

Problem—Excessive Oil Passage	
Possible Cause	**Remedy**
Restricted air intake	Check the engine air filter and replace if necessary. Check the compressor air inlet for kinks and excessive bends. Repair as needed.
Restricted oil return line to engine	Check for excessive bends, kinks, and restrictions in the oil return line. The return line must descend from the compressor to the engine crankcase. Repair as needed.
Damaged oil seal ring or loose end cover	Inspect the oil seal ring for wear or damage. Repair as needed. Check the end cover capscrew torques and tighten as necessary.
Compressor runs loaded an excessive amount of time	Check air lines and connections for leakage. Repair or replace lines and connections until leakage is eliminated.
Back pressure from the engine crankcase	Check for excessive engine crankcase pressure. Repair or replace ventilation components as necessary. NOTE: An indication of crankcase pressure is a loose or partially lifted dipstick.
Excessive engine oil pressure	Check the engine oil pressure with a test gauge, and compare the reading to the engine specification. Do not restrict the compressor oil supply line.
Malfunctioning compressor	Replace the compressor after making certain none of the preceding conditions exist.

Problem—Noisy Compressor Operation

Problem—Noisy Compressor Operation	
Possible Cause	**Remedy**
Loose drive coupling or gear (as indicated)	Inspect the fit of the drive coupling and gear on the compressor crankshaft. Tighten or replace the components. If the crankshaft keyway is damaged, replace the compressor.
Compressor cylinder head or discharge line restrictions	Inspect the compressor discharge port and discharge line for carbon build-up. If carbon is detected, remove the carbon and check for proper coolant flow to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Air compressor bearing damaged or worn	Replace the bearings.
Malfunctioning compressor	Replace the compressor after making certain none of the preceding conditions exist.

Problem—Excessive Build-Up and Recovery Time

Problem—Excessive Build-Up and Recovery Time	
Possible Cause	**Remedy**
Restricted air intake	Check the engine air filter and replace if necessary. Check the compressor air inlet for kinks and excessive bends. Repair as needed.

Troubleshooting

Problem—Excessive Build-Up and Recovery Time	
Possible Cause	**Remedy**
Restricted discharge or compressor discharge cavity	Inspect the compressor discharge port and line for restrictions and carbon build-up. If carbon is detected, remove the carbon. Check for proper cooling to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Slipping drive components	Check for faulty drive gears and coupling, and replace as necessary.
Excessive air system leakage (not including the air compressor)	Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated.
Unloader pistons seized	Check the operation of the unloading mechanism. Check for corrosion and contamination of unloader pistons. Check for correct operation of the compressor air governor. If the governor is operating properly, repair or replace the unloading mechanism.
Malfunctioning compressor	Replace the compressor after making certain none of the preceding conditions exist.

Problem—Compressor Fails to Unload

Problem—Compressor Fails to Unload	
Possible Cause	**Remedy**
Faulty or worn unloader pistons or bores	Inspect for worn, dirty, or corroded unloader pistons and bores. Replace as necessary.
Malfunctioning governor	Check the setting with an accurate test gauge. Repair or replace the air governor.
Damaged unloader air lines from governor	Inspect the air lines to and from the governor for kinks or restrictions. Repair or replace the air lines.

Specifications

Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Compressor Retaining Bolts and Fittings	30–46 (41–62)	—
Power Steering Pump Mounting Bolts	30–46 (41–62)	—
Ball Bearing Retainer: ISM, ISX, N14 and Signature	185–221 (250–300)	—
Ball Bearing Retainer: ISB and ISC	332–369 (450–500)	—
Rod Cap Bolts	—	48–58 (540–660)
Head Bolts	13–16 (18–22)	—
Drive Gear Retaining Bolt	111–114 (150–155)	—
Cover Bolts; ISX and Signature	13–16 (18–22)	—
Barring Adapter	33–37 (45–50)	—

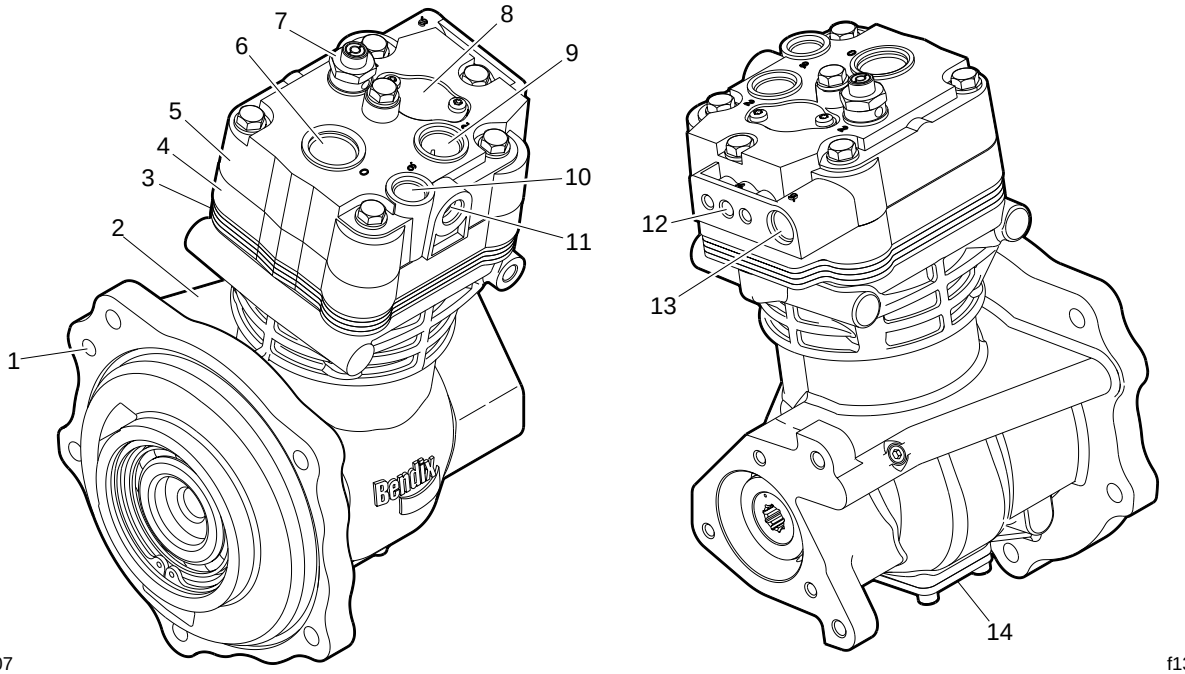
Table 1, Torque Specifications

General Description

The function of the Bendix air compressors is to provide and maintain air under pressure to operate devices in the air brake system. See **Fig. 1** and **Fig. 2**. The Bendix BA-921 and 360cc air compressors are both single-cylinder reciprocating compressors with a rated displacement of 15.8 cubic feet per minute (cfm) at 1250 rpm. The Bendix BA-922 compressor is very similar to the BA-921 compressor, but has two cylinders and a rated displacement of 31.6 cfm at 1250 rpm.

stops or starts based on the cut-in and cut-out pressure settings of the governor.

The cylinder head assembly is made up of the cylinder head, cooling plate, and a valve plate assembly. The cylinder head contains the air and coolant ports as well as an unloader piston. The cooling plate is located between the cylinder head and valve plate assemblies, and assists in cooling the cylinder head assembly. The valve plate assembly, consisting of brazed steel plates, has several valve openings and channels for conducting air and engine coolant into and out of the cylinder head. The compressor is



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1. Oil Supply Bore
2. Crankcase
3. Valve Plate Assembly
4. Cooling Plate
5. Cylinder Head
6. Air Supply Port
7. Discharge Safety Valve
8. Unloader Valve Cover
9. Discharge Port
10. Coolant Supply Port
11. Freeze Plug
12. Governor Connection Port
13. Coolant Return Port
14. Crankcase Cover

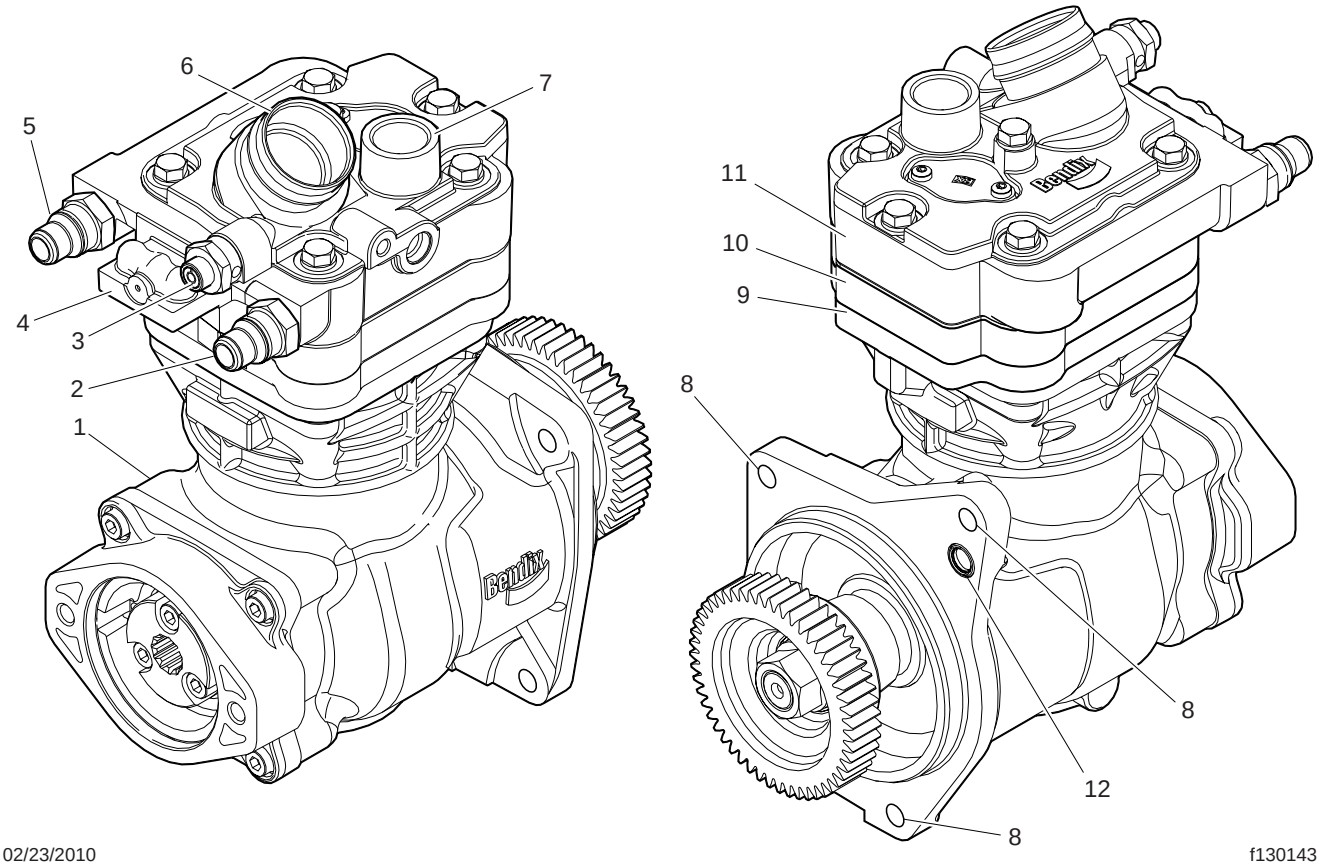
Fig. 1, Bendix BA-921 Air Compressor

The air governor operates in conjunction with the air compressor to maintain the air pressure in the air system between a maximum (cut-out) and minimum (cut-in) pressure. The air compressor turns continuously while the engine is on, but actual compression of air is controlled by the governor, which actuates the air compressor unloading mechanism. Unloading

cooled by air flowing through the engine compartment as it passes the compressor's cooling fins, and by the flow of engine coolant through the cylinder head. The vehicle's engine provides a continuous supply of oil to lubricate the compressor.

Bendix air compressors are typically equipped with a safety valve in the cylinder head safety valve port,

General Information



1. Crankcase
2. Coolant Return Port
3. Pressure Relief Valve
4. Governor Connection Port
5. Coolant Supply Port
6. Air Supply Port
7. Discharge Port
8. Mounting Fastener Holes
9. Valve Plate Assembly
10. Cooling Plate
11. Cylinder Head
12. Oil Bore

Fig. 2, Bendix 360cc Air Compressor

directly connected to the discharge port. The safety valve protects the cylinder head assembly in the event of excessively high discharge line pressure. Excessive air pressure causes the safety valve to unseat, releases air pressure, and gives an audible alert to the operator.

Replacement

1. Shut down the engine, apply the parking brakes, chock the tires, and open the hood.
2. Drain the air system.
3. Disconnect the batteries.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent eye injury could result from flying debris.

4. Using a cleaning solvent, remove road dirt and grease from the outside of the air compressor, then dry the compressor with compressed air.
5. Depending on the vehicle's engine and chassis specifications, the air compressor may be difficult to access behind the frame rail. It may be necessary to reposition or remove components above and below the frame rail that interfere with access to the compressor, such as battery cables and transmission oil cooler lines.

   Clear any wiring harnesses out of the way, removing P-clamps as necessary.
6. Remove any components attached to the air compressor, such as the fuel pump (Series 60 engines) or power steering pump (DD13/15/16 engines).
7. Drain the coolant from the radiator and cylinder block. For instructions, see **Group 20**.
8. Remove the coolant supply and return lines from the compressor. For a Bendix BA-921/922 compressor, see **Fig. 1**. For a Bendix 360cc compressor and line connections, see **Fig. 2** and **Fig. 3**.
9. Identify and disconnect all air and oil lines attached to the air compressor.
10. Remove the air governor and the air governor mounting gasket, if equipped, or remove the air governor remote line.

NOTICE

Do not allow the air compressor drive gear to make contact with the gear train during removal. Damage to the seal surface could cause oil leakage.

11. Support the air compressor and remove the mounting fasteners that attach the compressor to the engine. Remove the air compressor.
12. Discard all gaskets.

IMPORTANT: Ensure new gaskets are clean and not damaged.

13. Install a new air compressor gasket on the compressor.

NOTICE

Ensure the correct mounting capscrews are used to install the air compressor. If the wrong length is used, the cup plugs installed in the cylinder block can be pushed out into the gear train, causing damage to the gear train.

14. Using capscrews, attach the air compressor to the gear case. See **Table 1** for torque specifications.

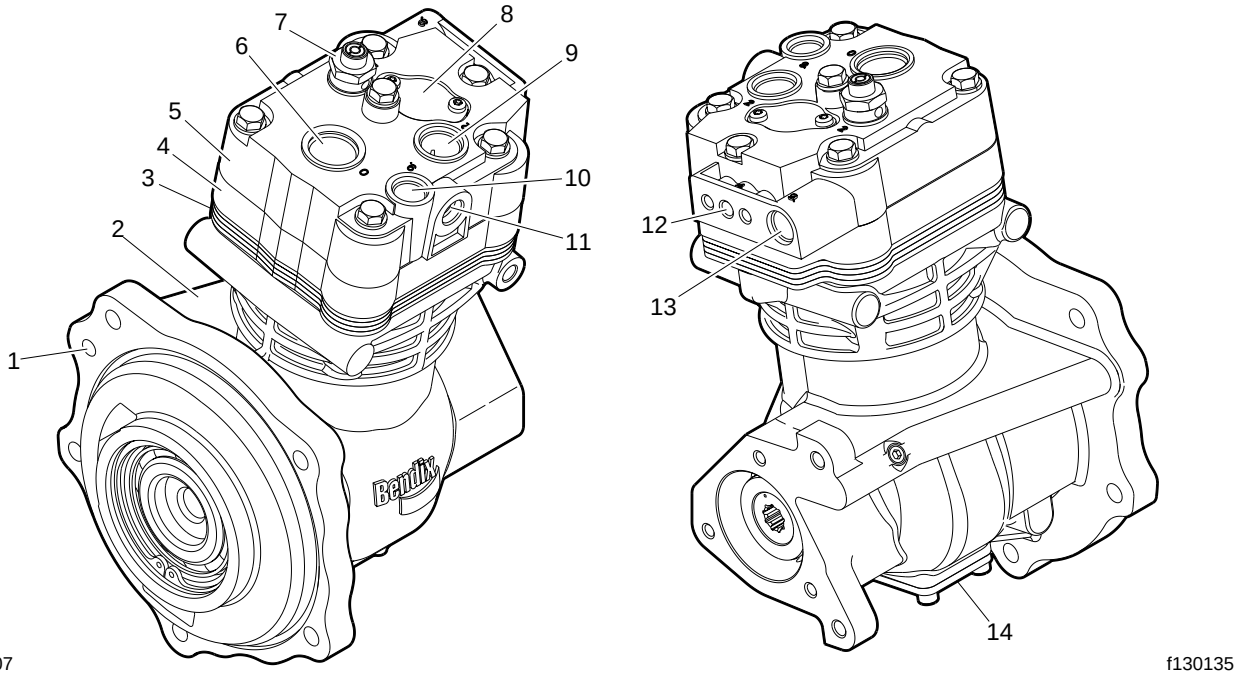
Mounting Fastener Torque Values	
Description	**Torque: lbf·ft (N·cm)**
BA-921 Mounting Capscrews M10 1.50 x 85 (4 qty) M10 1.50 x 35 (1 qty)	43–54 (58–73)
360cc Mounting Capcrews 1.37 in (35 mm) (4 qty)	44 (60)
Power Steering Pump Mounting Fasteners	27–32 (37–43)
Fuel Pump Mounting Fasteners	22–28 (30–38)
Air Governor Mounting Fasteners	11–15 (15–20)

Table 1, Mounting Fastener Torque Values

15. If equipped with a compressor-mounted air governor, install a new gasket on the air governor and install the air governor on the compressor. If the vehicle has a remote-mounted air governor, connect the air governor remote line to the compressor.

IMPORTANT: Ensure that coolant lines connected to a Bendix 360cc compressor are equipped with an O-ring and O-ring retainer on both ends. After installing the lines, ensure that

Air Compressor Replacement

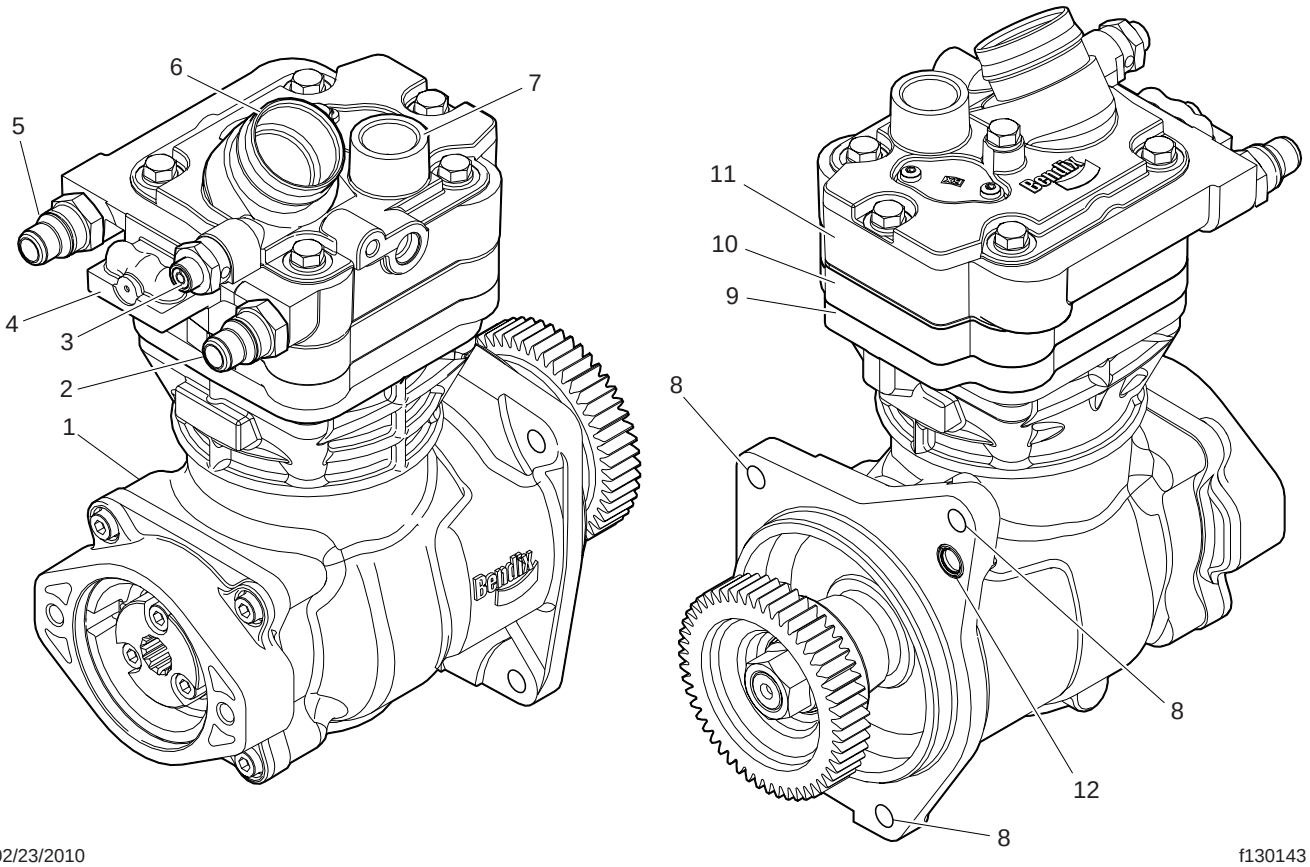


1. Oil Supply Bore
2. Crankcase
3. Valve Plate Assembly
4. Cooling Plate
5. Cylinder Head
6. Air Supply Port
7. Pressure Relief Valve
8. Unloader Valve Cover
9. Discharge Port
10. Coolant Supply Port
11. Freeze Plug
12. Governor Connection Port
13. Coolant Return Port
14. Crankcase Cover

Fig. 1, BA-921 Air Compressor

each coolant line retainer is engaged in the locked position.

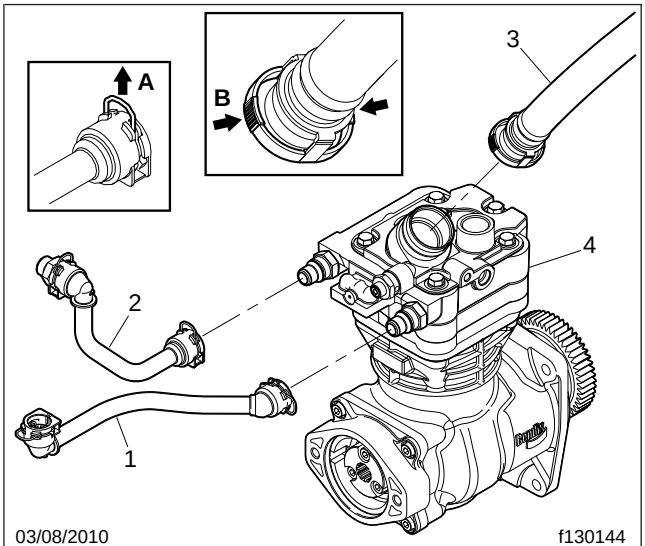
16. Connect the air and coolant lines to the air compressor. Connect the oil line, if equipped, to the compressor.
17. Install any components that were removed from the air compressor, such as the fuel pump (Series 60 engines) or power steering pump (DD13/15/16 engines). See **Table 1** for torque specifications.
18. Move all wiring harnesses back into place and install any wiring harness P-clamps that were previously removed.
19. Fill the engine cooling system. For instructions, see **Group 20**.
20. Connect the batteries.
21. Start the engine and check for leaks.



1. Crankcase
2. Coolant Return Port
3. Pressure Relief Valve
4. Governor Connection Port
5. Coolant Supply Port
6. Air Supply Port
7. Discharge Port
8. Mounting Fastener Holes (4 qty)
9. Valve Plate Assembly
10. Cooling Plate
11. Cylinder Head
12. Oil Bore

Fig. 2, Bendix 360cc Air Compressor

Air Compressor Replacement



A. Pull securing clip up in order to disconnect coolant lines.
B. Squeeze the two tabs on the air supply line to disconnect it from the compressor.

1. Coolant Return Line
2. Coolant Supply Line
3. Air Supply Line
4. Air Compressor

Fig. 3, Bendix 360cc Air Compressor Line Connections

General Information (See Fig. 1)

The starting system consists of:

- A starter motor;
- A flywheel ring gear;
- A starter relay;
- An ignition switch and push-button switch;
- A battery and the interconnecting wiring;
- A start interlock switch (for manual transmissions) and neutral position switch (for automatic transmissions).

STARTER MOTOR

The starter motor:

- Is a permanent magnet, 12V DC motor;
- Has an integral starter solenoid;
- Has an overrunning clutch in the starter drive;
- Has an optional temperature override switch.

The model 28-MT starter is used in vehicles equipped with the Cummins ISB diesel engine. See **Fig. 2**.

The model 37-MT starter is used in vehicles equipped with the Cummins ISC diesel engine. See **Fig. 3**.

The model 42-MT is used in vehicles equipped with any of the Cummins, Caterpillar and Detroit Diesel premium diesel engines. See **Fig. 4**.

STARTER SOLENOID

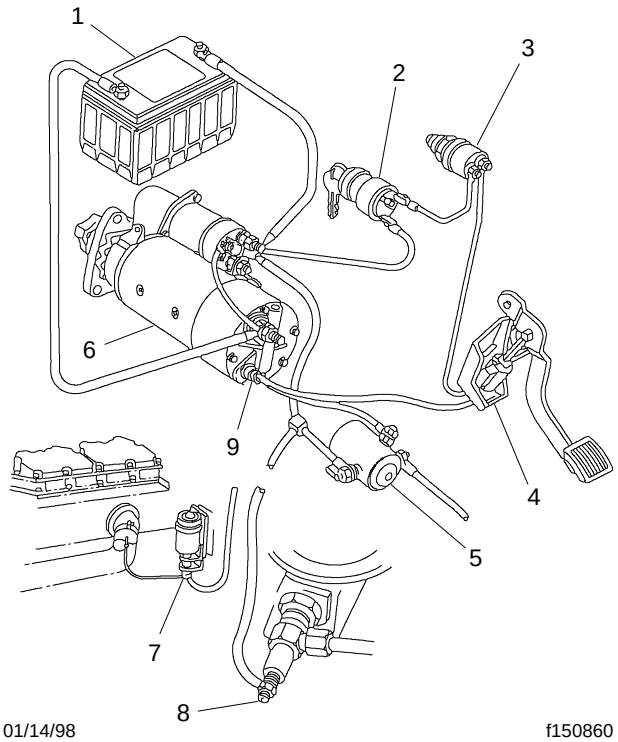
The starter solenoid (see **Fig. 5**):

- Is an electromagnet;
- When energized, causes the contacts to close, connecting the battery to the starter motor and causing the starter motor to turn the starter drive;
- Is kept in the energized condition by a hold-in winding until the starter switch is released.

STARTER DRIVE

The starter drive (see **Fig. 6**):

- Is operated by the starter solenoid;
- Engages the flywheel to turn the engine;



1. Battery
2. Ignition Switch
3. Push-Button Switch (optional)
4. Interlock Switch
5. Starter Relay
6. Starter
7. Ether Start System
8. Intake Heater System
9. Overcrank Protection

Fig. 1, Starting System

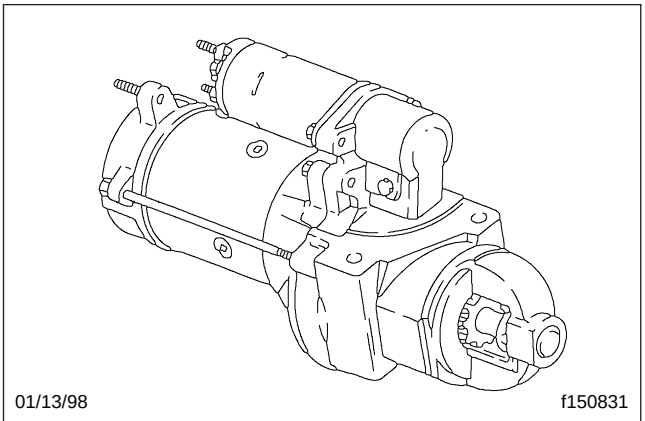


Fig. 2, 28-MT Starter

General Information

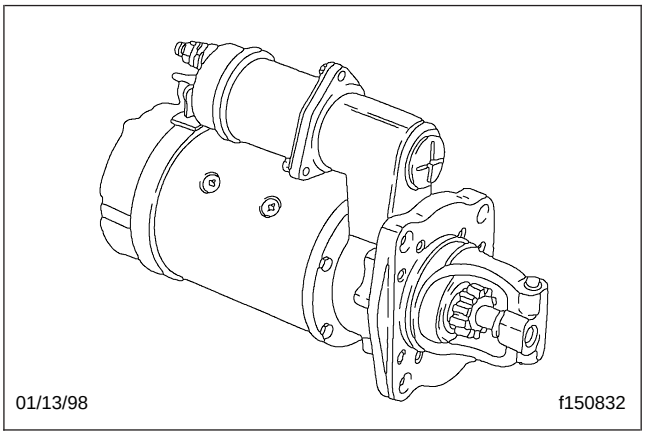


Fig. 3, Model 37-MT Starter

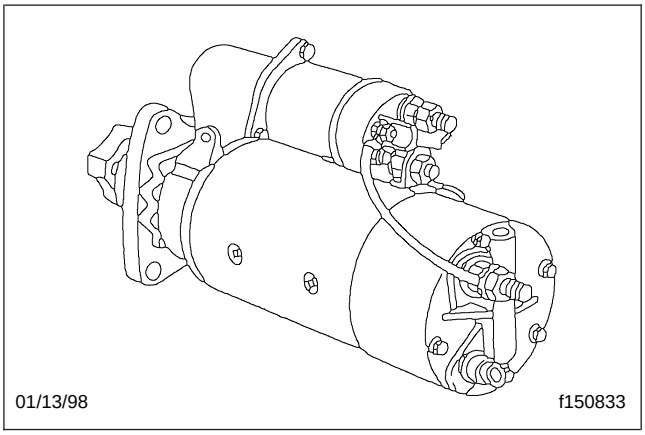


Fig. 4, Model 42-MT Starter

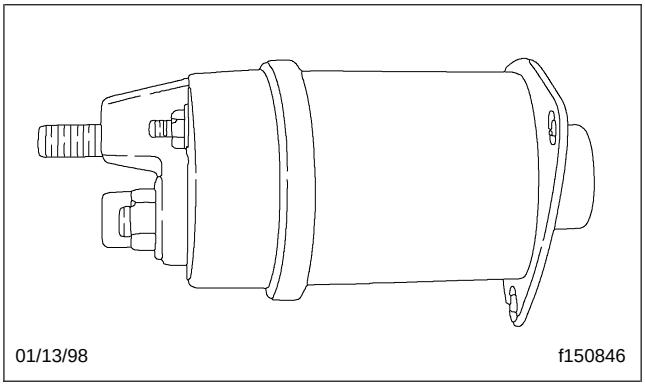


Fig. 5, Starter Solenoid

- Has an internal overrunning clutch which allows the starter drive to spin freely when the engine starts and picks up speed. This prevents starter motor damage caused by the engine driving the starter motor.

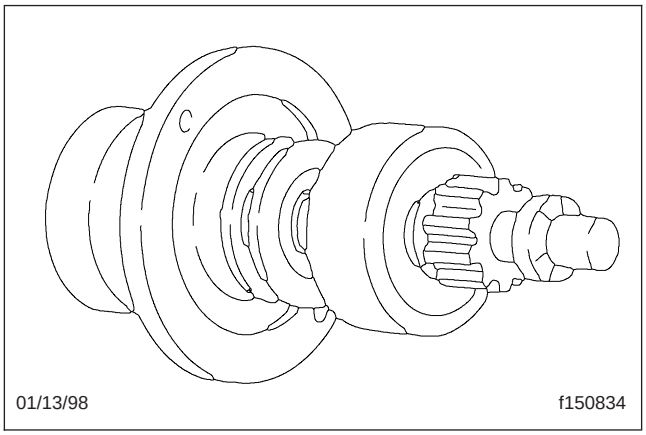


Fig. 6, Starter Drive

STARTER RELAY

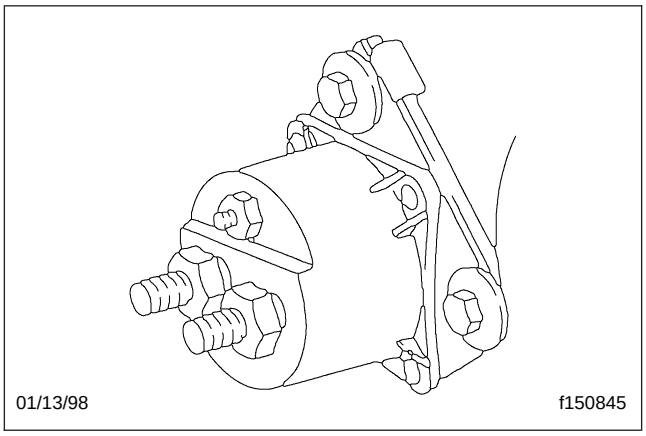


Fig. 7, Starter Relay

The starter relay (see **Fig. 7**):

- Controls the current to the starter solenoid;
- Is engaged by the ignition switch;
- Connects the battery to the starter motor.

SAFETY PRECAUTIONS

⚠ CAUTION

Do not ground the positive starter cable as the heavy gauge battery input lead at the starter so-

lenoid is always "electrically hot". Failure to follow this precaution can cause electrical system damage.

Start Interlock Switch Replacement

Replacement

1. Remove the lower left-hand finish panel of the instrument panel. Remove the retaining screws and the finish panel. See **Fig. 1**.

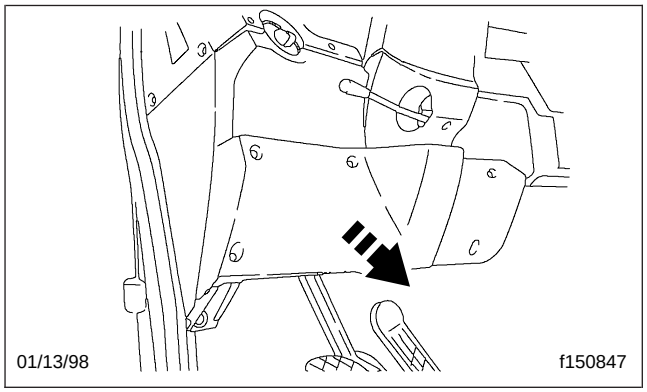


Fig. 1, Lower Left-Hand Finish Panel

2. Remove the windshield wiper control module. Disconnect the wiring and remove the module from the mounting bracket. See **Fig. 2**.

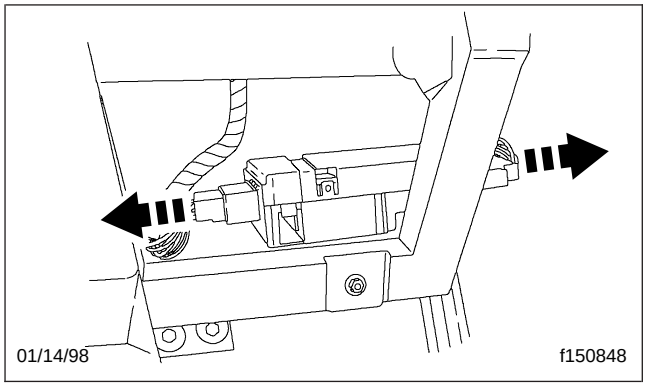


Fig. 2, Disconnect the Wiper Control Module Connectors

3. Remove the retaining bolts and lower the steering column onto the driver seat. See **Fig. 3**.
4. Remove the retaining nut and bolt. Remove the interlock switch. See **Fig. 4**.
5. Place the replacement start interlock switch into position.
6. Install the retaining nut and bolt.

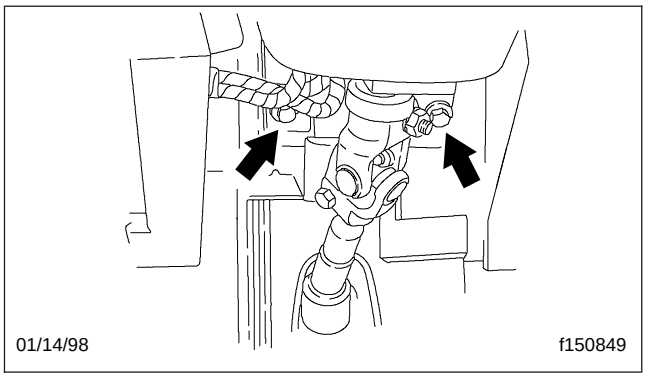


Fig. 3, Steering Column Retaining Bolts

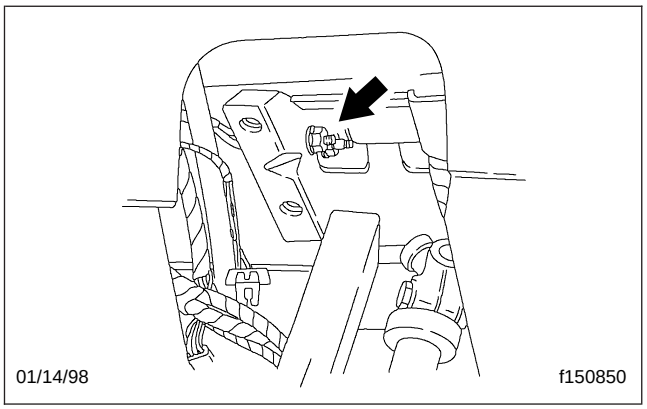
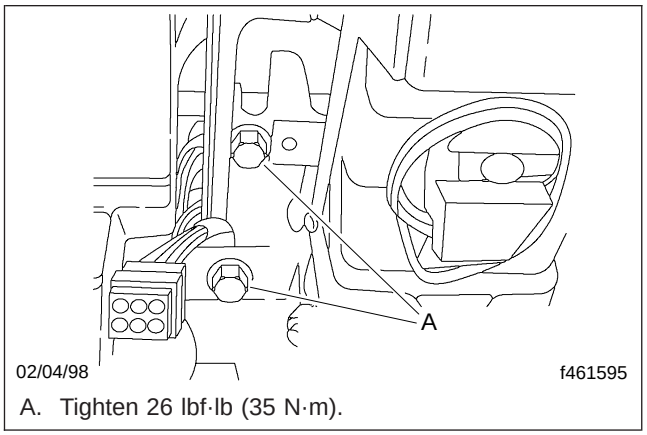


Fig. 4, Interlock Switch Retaining Bolt

7. Position the steering column on the steering column mounting bracket. Tighten the bolts to 26 lbf·lb (35 N·m). See **Fig. 5**.



A. Tighten 26 lbf·lb (35 N·m).

Fig. 5, Steering Column Mounting

Start Interlock Switch Replacement

8. Install the windshield wiper control module and connect the wiring.
9. Install the lower left-hand finish panel of the instrument panel and install the retaining screws.

Cleaning and Inspection

STARTER MOTOR

CAUTION

Do not clean the field coils, armature, or starter drive with any degreasing solvents. This will dissolve the lubricant in the starter drive and brush end cover. It will damage the armature and field coil insulation.

1. Wipe the field coils, armature, commutator, armature shaft, and brush end cover with a clean cloth.
2. Clean all of the remaining starter motor parts with mineral spirits.
3. Examine the contacts on the starter solenoid assembly and clean them with very fine sandpaper or crocus cloth.
4. Test the starter solenoid windings for shorts and opens. See **Subject 300**.

ARMATURE

CAUTION

Do not clean the armature with any degreasing solvents. This will damage the armature insulation.

1. Wipe the armature with a clean cloth.

CAUTION

Do not use emery cloth to clean the commutator; doing so will create grooves.

2. Clean the commutator by lightly sanding with 00-grade sandpaper.

NOTE: Loose connections can cause arcing and burning of the commutator bars.

3. Inspect the points where the conductors are joined to the commutator bars for loose connections.
4. Inspect the armature for opens.

NOTE: Repair the connections if the commutator bars are not badly burned,

5. To repair the riser bars, weld the leads in the riser bars using a rosin flux.

CAUTION

Use care not to undercut the mica to prevent excessive cummutator runout.

6. Turn down the commutator in a lathe.

CAUTION

Do not use emery cloth to clean the commutator; doing so will create grooves.

7. Lightly sand the commutator with 00-grade sandpaper.
8. Use a growler to inspect the armature for short circuits.
9. Use a 110-volt test lamp to inspect the armature grounds.
10. Inspect the commutator surface for grooves, and check for runout exceeding 0.002 inch (0.051 mm) out of round.

CAUTION

Use care not to undercut the mica to prevent excessive cummutator runout.

11. Lightly sand the commutator with 00-grade sandpaper.

CAUTION

Do not use emery cloth to clean the commutator; doing so will create grooves.

NOTE: If the commutator is worn, dirty, out of round, or has high insulation, turn the armature on a lathe.

BUSHINGS

CAUTION

Do not drill, ream, or machine the sintered bushings in any way. These bushings are supplied to size. If the bushings are drilled or reamed the inside diameter (i.d.) will be too large, and the

Cleaning and Inspection

bushing pores will be sealed over, causing premature failure of the starter motor.

1. Remove the bushing from the housing.
2. Use a suitable puller or driver of the correct size.
3. Remove the tangent wick from the oil reservoir.
4. Saturate the bushing, wick, and oil reservoir with SAE 20 weight oil.
5. Install the tangent wick into the oil reservoir.

NOTE: It is not necessary to cross-drill a sintered bushing when used with a tangent wick.

6. Install the bushing in the housing. Use an arbor press.

FIELD COIL INSPECTION

NOTE: The field coil cannot be checked for grounds if the ground connection cannot be disconnected.

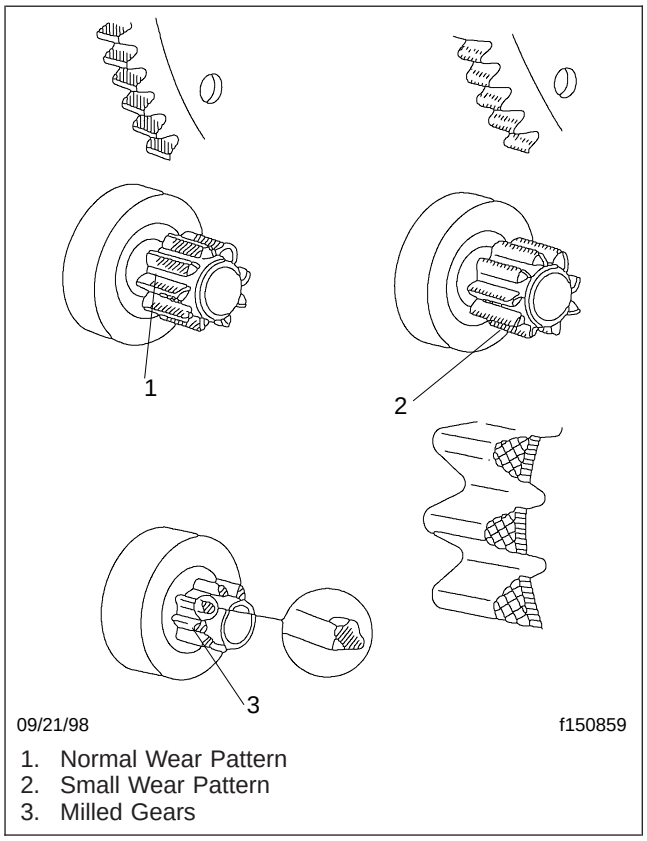
1. Check the field coil for grounds.
   - 1.1 Disconnect the field coil ground connections.
   - 1.2 Connect one lead to the field frame and the other lead to the field connector.
   - 1.3 If resistance is greater than 5 ohms, then at least one field is grounded. Repair or replace the damaged field coil(s) as necessary.
2. Check the field coil for open circuits with a test lamp.
3. Connect the test lamp leads to the ends of the field coil. If the test lamp does not light, then repair or replace the damaged field coil(s) as necessary.

BRUSH AND BRUSH HOLDER

1. Check the brushes for free movement in the brush holders. Inspect the brushes for excessive wear. Where brush leads are insulated, make sure the insulation is not burned or worn.
2. Check the tension of each brush spring at the point of contact with the brush. Use a spring scale hooked under the brush spring lip. Brush spring tension must be within specifications.
3. The brushes must be well seated to the commutator; that is, contacting the commutator over at least 60 percent of brush contact area. If not, fit the brushes to the commutator with fine sandpaper until desired seating area is obtained. Do only one brush at a time. Clean the brushes and commutator with compressed air. Make sure no abrasive particles from sandpaper are embedded in the contact area of brushes.
4. New brushes are not ground to fit the commutator; therefore, they must be seated as described.
5. Mark each brush and brush holder with which it was seated to permit assembly in the same position.

STARTER DRIVE/FLYWHEEL RING GEAR INSPECTION

1. Inspect the drive assembly and flywheel ring gear for the following (see **Fig. 1**):
   - pinion gear turns roughly or turns in both directions
   - pinion gear and ring gear teeth broken or showing evidence of step wear
   - deep scoring or other damage to the shift lever collar
2. Replace the drive assembly or ring gear if damaged. If a new drive assembly is to be installed, be sure it has the same number of teeth as the replaced component.



1. Normal Wear Pattern
2. Small Wear Pattern
3. Milled Gears

Fig. 1, Starter Drive/Flywheel Ring Gear Wear Patterns

Troubleshooting

Inspection and Verification

CAUTION

Do not ground the positive starter cable as the heavy gauge battery input lead at the starter solenoid is always "electrically hot". Failure to follow this precaution can cause electrical system damage.

1. Verify the vehicle owner's original concern by operating the system to duplicate the condition.
2. Inspect the system to determine if any of the following mechanical or electrical concerns apply.

Visual Inspection Chart	
Mechanical	**Electrical**
Starter motor mounting	Battery condition
Starter relay mounting	Electrical connections at the switches, relay and solenoid

Table 1, Visual Inspection Chart

3. If the concern(s) remains after the inspection and verification, determine the symptoms and go to the problem charts.

Troubleshooting

Problem—Engine Does Not Crank or the Relay Clicks

Problem—Engine Does Not Crank or the Relay Clicks (See Fig. 1, Fig. 2, Fig. 3, Fig. 4 and Fig. 5)	
Possible Cause	**Remedy**
Loose or corroded battery cable connections	Check the function of the starter relay. Connect a remote starter switch between the battery positive terminal at the starter relay and the starter relay S-terminal. Press the remote starter switch button. If the starter cranks the engine, and the vehicle is equipped with push button start, check for continuity at the start push-button switch. Measure the resistance between the start push-button terminals while holding the button in. If the resistance is greater than 5 ohms, replace the start push-button. Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 703 (W/O) for an open.
Undercharged battery	Measure the voltage between the start push-button battery feed Circuit 703 (W/O) and a clean chassis ground. If the voltage is greater than 10 volts and the vehicle is equipped with a manual transmission, check for continuity at the start interlock switch; if the vehicle is equipped with an AT, MT, or HT automatic transmission, check the transmission shift linkage adjustment; if the vehicle is equipped with an MD or HD automatic transmission check Circuit 32 (R/BL) for an open between the battery feed to the vehicle interface module. If the voltage is less than 10 volts, repair the open in Circuit 703 (W/O). Reconnect the start push-button switch. Test the system for normal operation.
Worn or damaged starter relay	Measure the resistance across the interlock switch terminals with the switch push button in the out position (clutch pedal pressed). To access the switch, refer to the procedure in **Subject 100**. If the resistance is greater than 5 ohms, replace the interlock switch. Test the system for normal operation. If the resistance is less than 5 ohms, check for an open between Circuit 32 (R/BL) and the start switch to the start interlock switch.
Faulty starter motor ground circuit	Measure the voltage between the starter interlock switch battery feed terminal, Circuit 32 (R/BL), and a clean chassis ground. If the voltage is greater than 10 volts, repair the open in Circuit 32 (R/BL) between the starter interlock switch and the starter relay. Test the system for normal operation. If the voltage is less than 10 volts, repair the open in Circuit 32 (R/BL) between the starter interlock switch and the starter push button/fuse panel. Test the system for normal operation.
Worn or damaged starter motor	Check the transmission shift linkage adjustment. See **Group 26** in this manual. If the linkage adjustment is incorrect, adjust the linkage. Test the system for normal operation. If the linkage adjustment is OK, check for continuity at the neutral position switch. Measure the resistance between the neutral position switch terminals. If the resistance is greater than 5 ohms, replace the neutral position switch. Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 32 (R/BL) for an open between the battery feed and the neutral position switch. Measure the voltage between the neutral position switch battery feed terminal, Circuit 32 (R/BL), and a clean chassis ground. If the voltage is greater than 10 volts, repair the open in Circuit 32 (R/BL) between the start interlock switch and the starter relay. Test the system for normal operation. If the voltage is less than 10 volts, repair the open in Circuit 32 (R/BL) between the starter interlock switch and the starter push-button/fuse panel. Test the system for normal operation.
Worn or damaged ignition/push-button switch	Measure the voltage between the vehicle interface module connector Pin F1, Circuit 32 (R/BL) and a clean chassis ground. If the voltage is less than 10 volts, repair the open in Circuit 32 (R/BL) between the vehicle interface module and the starter relay. If voltage is greater than 10 volts, replace the vehicle interface module. Test the system for normal operation.

Problem—Engine Does Not Crank and the Relay Does Not Click

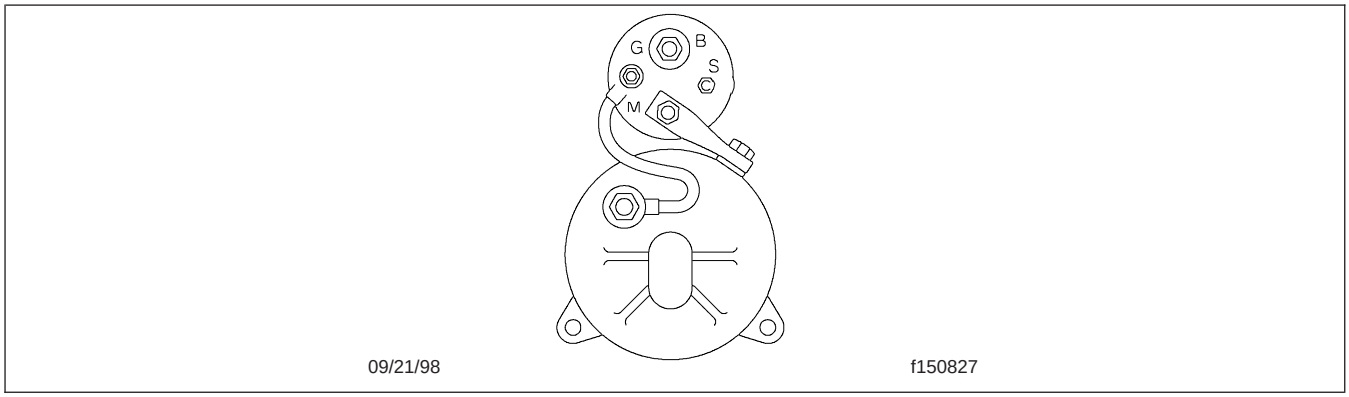


Fig. 1, Starter Solenoid Terminals

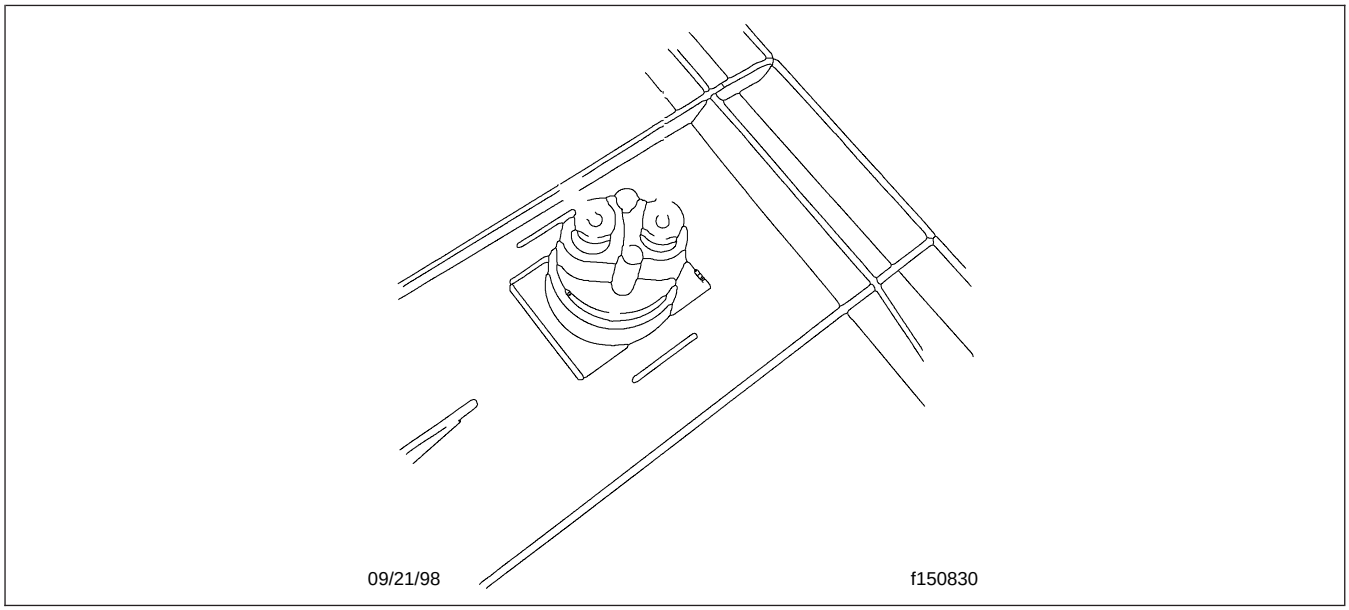


Fig. 2, Push-Button Terminals

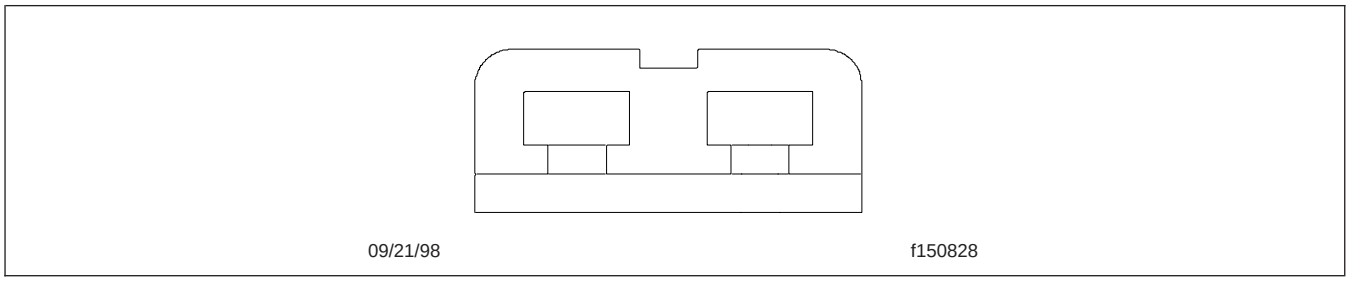


Fig. 3, Starter Push-Button Switch Connector

Troubleshooting

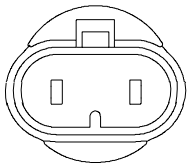


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Fig. 4, Starter Interlock Switch Battery Feed Terminal

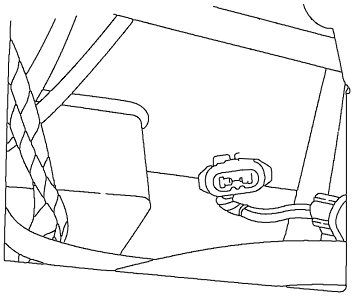

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Fig. 5, Starter Solenoid Terminals

Problem—Engine Does Not Crank and the Relay Does Not Click	
Possible Cause	**Remedy**
Loose or corroded battery cable connections	Check the starter relay ground. Measure the resistance between the starter relay case and a clean chassis ground. If the resistance is less than 5 ohms, replace the starter relay. Test the system for normal operation. If the resistance is greater than 5 ohms, clean the ground connection between the starter relay case and the body ground. Test the system for normal operation. Check the starter solenoid function. The parking brake must be set and the transmission must be in neutral. Connect a remote starter switch between the battery positive terminal at the starter motor and the starter motor S-terminal. Press the remote starter switch button. If the starter cranks the engine and the vehicle is not equipped with overcrank protection, repair open in Circuit 669 (R/BL) between the starter relay and starter solenoid. Test the system for normal operation. If the vehicle is equipped with overcrank protection, check for continuity at the overcrank protection thermostat. Disconnect the overcrank protection thermostat harness connector. Measure the resistance between the overcrank protection thermostat terminals. If the resistance is greater than 5 ohms, replace the overcrank protection thermostat. Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 669 (R/BL) for an open between the starter relay and the overcrank protection thermostat. Measure the voltage between the overcrank thermostat connector battery feed terminal, Circuit 669 (R/BL), and a clean chassis ground. If the voltage is less than 10 volts, repair the open in Circuit 669 (R/BL). Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 669 (R/BL) for an open between the overcrank protection thermostat and the starter solenoid. Measure the voltage between the starter solenoid S-terminal and a clean chassis ground. If the voltage is less than 10 volts, repair the open in Circuit 669 (R/BL). Test the system for normal operation. If the voltage is greater than 10 volts, check the starter solenoid. Disconnect the batteries. Label and disconnect the wiring at the starter solenoid. Test the starter solenoid. Refer to "Component Tests" in this subject. If the solenoid passes the test, repair or replace the starter motor. If the solenoid fails the test, replace the starter solenoid. Test the system for normal operation.
Undercharged battery	
Worn or damaged starter relay	
Faulty starter motor ground circuit	
Worn or damaged starter motor	
Worn or damaged ignition/push-button switch	

Troubleshooting

Problem—Engine Cranks Slowly

Problem—Engine Cranks Slowly	
Possible Cause	**Remedy**
Loose or corroded battery cable connections	Perform the "Starter Motor, Load Test". Refer to "Component Tests" in this subject. If the starter does not pass previous test, test the batteries. Refer to **Group 54**. If the starter passes the load test, check the starter circuit for excessive resistance. Perform the "Starter Motor, Motor Feed Circuit Voltage Drop Test" and the "Starter Motor, Motor Ground Circuit Voltage Drop Test". Refer to "Component Tests" in this subject. If the starter circuit does not pass the two previous tests, clean the circuit connections as necessary. Test the system for normal operation. If the starter circuit passes the "Voltage Drop Tests", perform the "Starter Motor, No Load" test. Refer to "Component Tests". If the starter passes the "Starter Motor, No Load" test. The slow cranking is caused by excessive engine drag. Refer to the engine manufacturer's service literature for additional diagnostic procedures. If the starter does not pass the "Starter Motor, No Load" test, repair or replace the starter. Refer to the appropriate starter section in this manual. Test the system for normal operation.
Undercharged battery	
Loose or corroded starter motor connections	
Worn or damaged starter motor	

Problem—Unusual Starter Noise

Problem—Unusual Starter Noise	
Possible Cause	**Remedy**
Starter improperly mounted	Check the starter motor mounting. Check for loose starter motor mounting bolts. If the starter motor mounting bolts are loose, tighten the mounting bolts to the specified torque. Refer to the appropriate section in this manual for torque specifications. Test the system for normal operation. If the starter motor mounting bolts are tight, check for proper engagement of the starter drive. Remove the starter motor. Refer to the appropriate section in this section. Inspect the starter drive and flywheel for damage. If the starter drive and flywheel are OK, disassemble, inspect and repair the starter motor if necessary. Refer to the starter manufacturer's manual for overhaul procedures. If the starter drive or flywheel are damaged, replace the flywheel and the drive pinion. Refer to the engine manufacturer's service literature for the flywheel replacement procedure. Refer to the appropriate section in this manual for the drive pinion replacement procedure. Test the system for normal operation.
Worn or damaged starter motor	
Improper starter drive engagement to flywheel	

Problem—The Starter Spins but the Engine Does Not Crank

Problem—The Starter Spins but the Engine Does Not Crank	
Possible Cause	**Remedy**
Starter improperly mounted	Check the flywheel. Remove the starter motor. Refer to the appropriate section in this manual. Inspect the flywheel and the drive pinion for damage or excessive wear. See **Subject 110**. If the flywheel or the drive pinion is worn or damaged, replace the flywheel and the drive pinion. Refer to the engine manufacturer's service literature for the flywheel replacement procedure. Refer to the appropriate section in this manual for the drive pinion replacement procedure. Test the system for normal operation. If no damage is present, check the overrunning clutch.
Worn or damaged starter motor	
Improper starter drive engagement to flywheel	Check the operation of the overrunning clutch. Refer to "Component Tests" in this subject. If the overrunning clutch does not operate properly, replace the overrunning clutch. Refer to the appropriate section in this manual. Test the system for normal operation. If the overrunning clutch operates properly, disassemble and inspect the starter motor for internal damage.

Component Tests

Starter Motor, Load Test (See Fig. 6)

NOTE: The batteries must be fully charged before performing a starter load test.

1. Set the parking brake and shift the transmission into the NEUTRAL position.
2. Disconnect the wiring from the fuel shutoff solenoid.
3. Connect the Rotunda Alternator, Regulator, Battery and Starter Tester (ARBST). Follow the manufacturer's supplied instructions.
4. Connect a remote starter switch across the starter relay S-terminal and the battery positive terminal post.
5. Turn the ignition switch to the RUN position.
6. Crank the engine and record the voltmeter reading.
7. Turn the carbon pile control knob until the voltmeter indicates the same reading recorded during cranking the engine. Record the ammeter reading.
8. Compare the ammeter reading with the specifications listed in the appropriate starter section.

Starter Motor, Drive Pinion Test

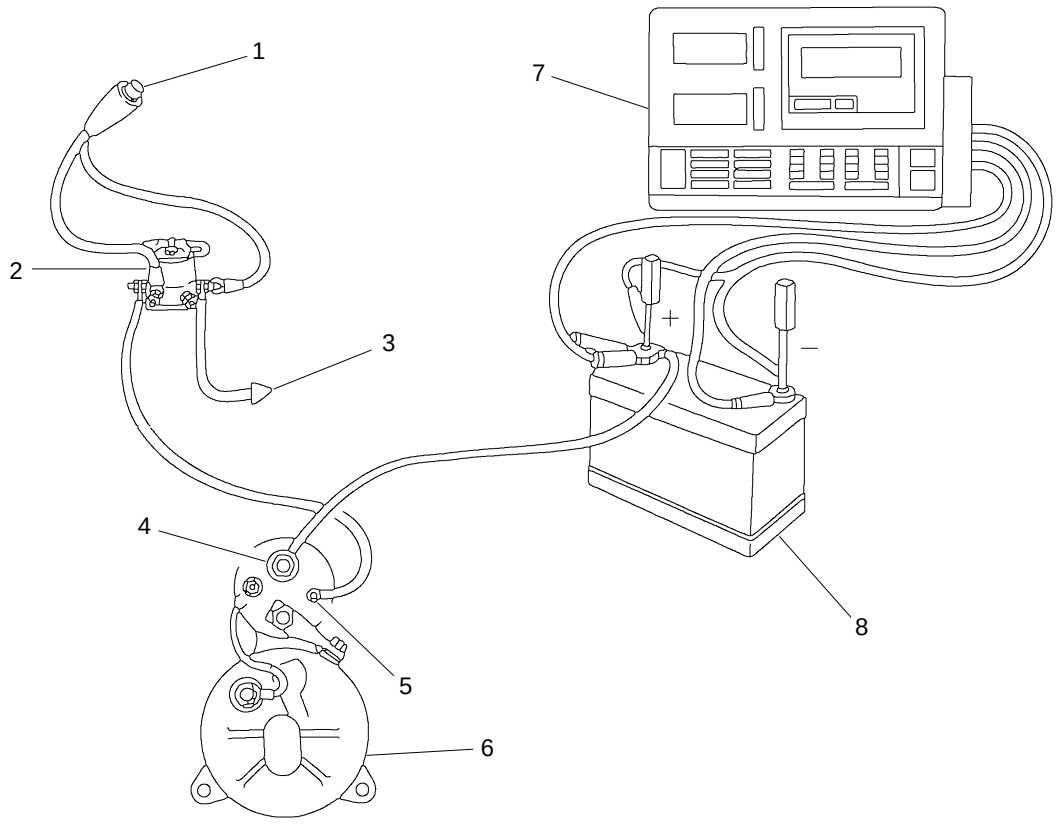
1. Rotate the pinion drive clockwise and counterclockwise.
2. The pinion drive should free-wheel in one direction and lock to the armature shaft in the other.
3. If the pinion drive free-wheels in both directions, replace the starter drive.

Starter Motor, No-Load Test (See Fig. 7)

1. Connect a fully charged battery to the starter.
2. Connect the Rotunda Alternator, Regulator, Battery and Starter Tester (ARBST) as illustrated.
3. Connect a remote starter switch between the starter solenoid S-Terminal and the positive battery terminal post.
4. Press the remote starter switch. The pinion should shift to the crank position and the motor should run smoothly.
5. While the starter motor is running, record the voltmeter and ammeter readings.
6. The voltage reading should be greater than 11.0 volts and the amperage should be no more than 70 amps.
7. If voltage is lower than specified or amperage is higher than specified, refer to the results table below to determine possible cause and corrective action.

STARTER MOTOR NO-LOAD TEST RESULTS

Troubleshooting



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1. Remote Starter Switch
2. Starter Relay
3. To Ignition/Push-Button Switch
4. Starter Solenoid B+ Terminal
5. Starter Solenoid S-Terminal
6. Starter Motor
7. Rotunda Alternator, Regulator, Battery and Starter Tester (ARBST)
8. Battery

Fig. 6, Starter Motor Load Test Setup

Starter Motor No-Load Test Results		
Test Result	**Probable Source**	**Action to Take**
Normal Current and Speed	Cranking motor OK.	Recheck the battery, switches and wiring, including voltage drop tests, if cranking motor operation on the engine is slow or sluggish.
Current Flow With Test Circuit Switch Open	Solenoid contacts stuck closed.	Test and, if necessary, replace the solenoid assembly.

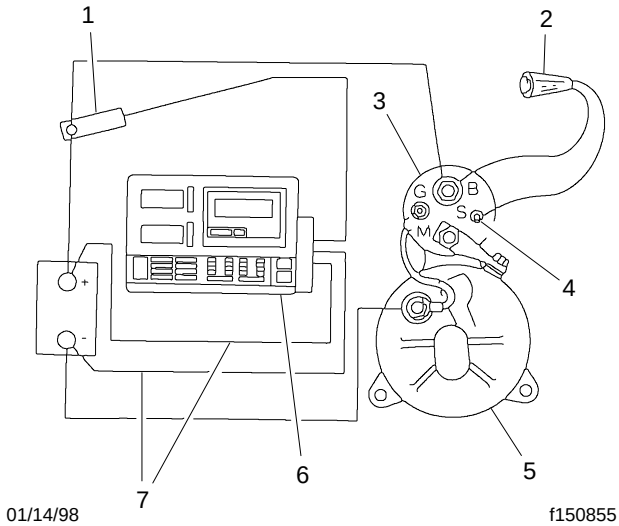
Starter Motor No-Load Test Results		
Test Result	**Probable Source**	**Action to Take**
Failure to Operate With Very Low or No Current	Open solenoid winding.	Inspect and test the solenoid assembly.
	Open field circuit.	Inspect and test the frame and field assembly.
	Open armature coil(s) or high insulation between commutator bars.	Inspect the armature.
	Broken brush spring(s) or worn brushes.	Inspect the brushes and brush springs.
Failure to Operate With High Current	Frozen bearing, or other damage to drivetrain.	Inspect the bearings, armature, driveshaft and related drive parts.
	Direct ground in terminals or fields.	Inspect and Test the frame and field assembly, solenoid assembly, armature and brush installations for shorts.
Low Speed With High Current	Excessive friction in bushings or gear reduction unit, bent armature shaft or loose pole shoe, bent driveshaft.	Inspect the bearings, armature, driveshaft, and gear reduction gears.
	Shorted armature.	Inspect and test the armature.
	Grounded armature or fields.	Inspect and test the frame and field coil assembly and armature.
Low Speed With Normal (or Low) Current	High internal electrical resistance caused by poor connections, defective leads or dirty commutator.	Inspect the internal wiring, electrical connections and armature commutator.
	Open solenoid winding.	Inspect and test the solenoid assembly.
	Open field circuit.	Inspect and test the frame and field assembly.
	Open armature coil(s) or high insulation between commutator bars.	Inspect the armature.
	Broken brush spring(s) or worn brushes.	Inspect the brushes and brush springs.
High Speed with High Current	Shorted fields.	Inspect and test the frame and field assembly.

Table 2, Starter Motor No-Load Test Results

Starter Motor, Motor Feed Circuit Voltage Drop Test (See Fig. 8)

1. This test is performed to determine if slow cranking is caused by high resistance in the starter motor circuit wiring.
2. The voltage drop test can only be performed with the starter motor on the vehicle.
3. Disconnect the wiring from the fuel shutoff solenoid.
4. Connect the positive lead of the 73 Digital Multimeter to the battery positive (+) post, and the negative lead to the starter solenoid M-terminal.
5. Connect a remote starter switch between the starter solenoid S-terminal and the positive battery terminal post.
6. Press the remote starter switch and record the voltage reading.
7. The voltage reading should be 0.5 volt or less. A reading higher than 0.5 volt indicates high resistance.

Troubleshooting



1. Inductive Pickup
2. Remote Starter Switch
3. B+ Terminal
4. S-Terminal
5. Starter Motor
6. Rotunda Alternator, Regulator, Battery and Starter Tester (ARBST)
7. Voltmeter Leads

Fig. 7, Starter Motor No-Load Test Setup

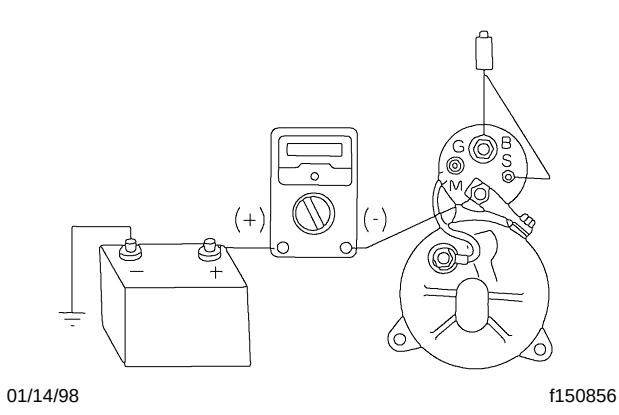


Fig. 8, Motor Feed Circuit Voltage Drop Test Setup

8. Repeat the test on the starter solenoid B+ terminal.
9. If the readings are higher than 0.5 volt, remove the wiring from the starter solenoid.
10. Clean and inspect each wire connector and the starter solenoid terminals.
11. Install the wires onto the starter solenoid and retest.
12. If the reading at the starter solenoid M-terminal is still higher than 0.5 volt or the reading at the B+ terminal is lower, perform the starter solenoid test. If no change is noted, replace the positive battery cable lead.

Starter Motor, Motor Ground Circuit Voltage Drop Test (See Fig. 9)

NOTE: A slow cranking condition can also be caused by high resistance in the ground circuit.

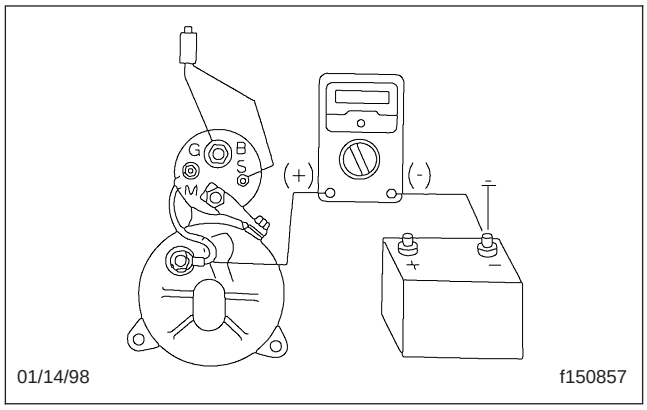
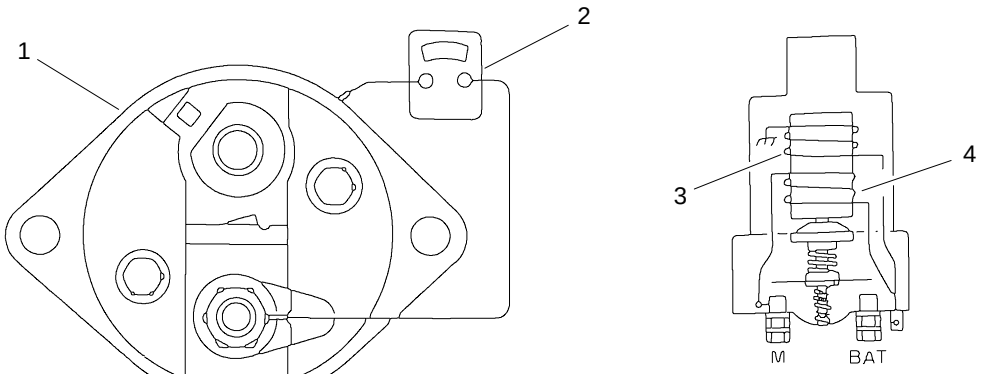


Fig. 9, Motor Ground Circuit Voltage Drop Test Setup

1. Disconnect the wiring from the fuel shutoff solenoid.
2. Connect the digital volt-ohmmeter positive lead to the starter motor housing.
3. Connect the digital volt-ohmmeter negative lead to the battery negative (-) terminal.
4. Connect a remote starter switch between the starter solenoid S-terminal and the positive battery terminal post.
5. Press the remote starter switch and record the voltage reading.
6. The voltage reading should be 0.2 volt or less. If the voltage reading is higher, remove and clean the negative cable connections at the battery, starter motor and the body.
7. Retest the system. If readings are still higher than 0.2 volt, test each individual negative cable.

Starter Solenoid (See Fig. 10 and Fig. 11)



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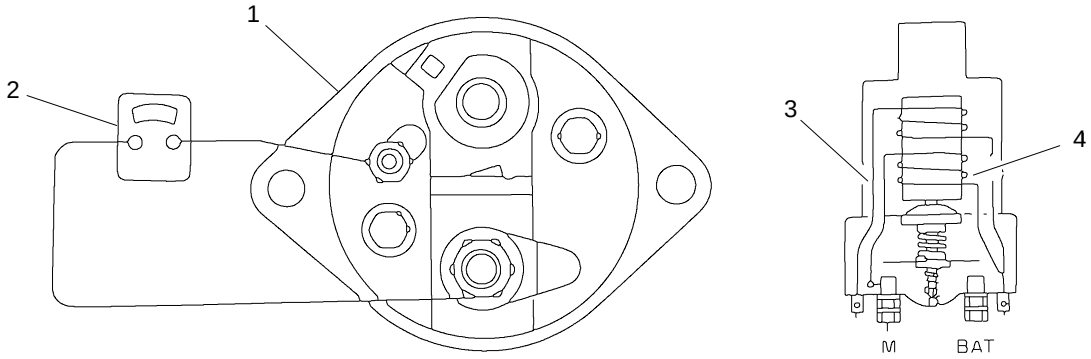
1. Delco Remy 28–MT Starter Motor Solenoid
2. Ohmmeter
3. Solenoid Hold-In Winding
4. Solenoid Pull-In Winding

Fig. 10, Delco Remy 28-MT Solenoid Windings Test Setup



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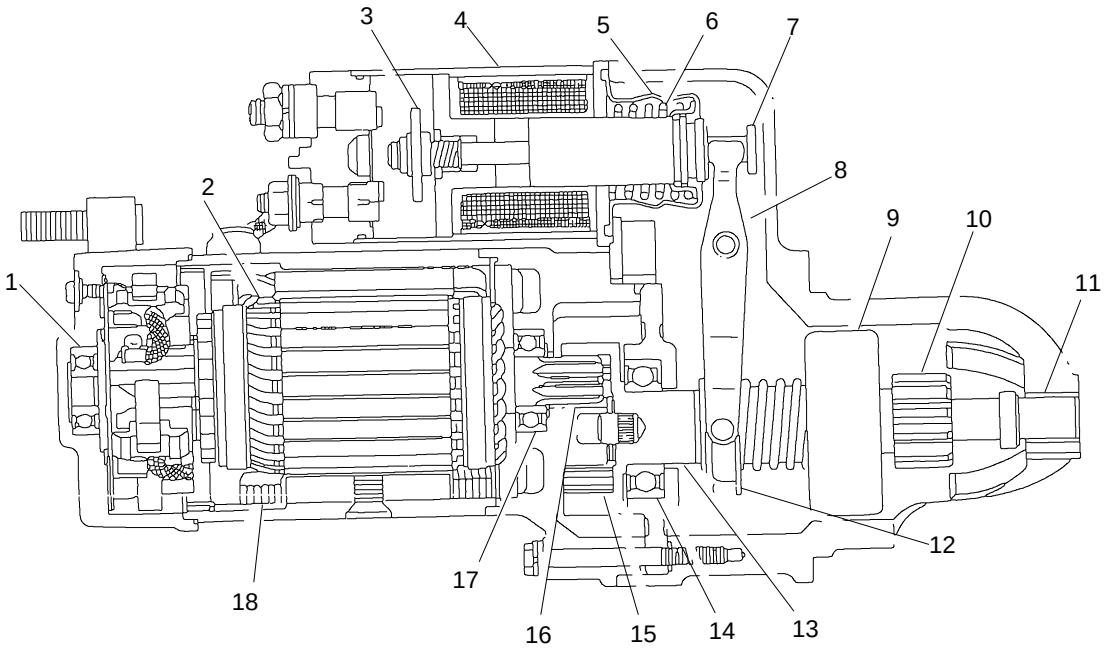
1. Delco Remy 37–MT Starter Motor Solenoid
2. Ohmmeter
3. Solenoid Hold-In Winding
4. Solenoid Pull-In Winding

Fig. 11, Delco Remy 37-MT Solenoid Windings Test Setup

1. Disconnect the battery negative cable.
2. Using Rotunda digital multimeter or equivalent, check the windings of the solenoid by measuring the resistance between the starter motor ground terminal and the solenoid case. The resistance reading should be approximately 0.95 ohms.

General Information

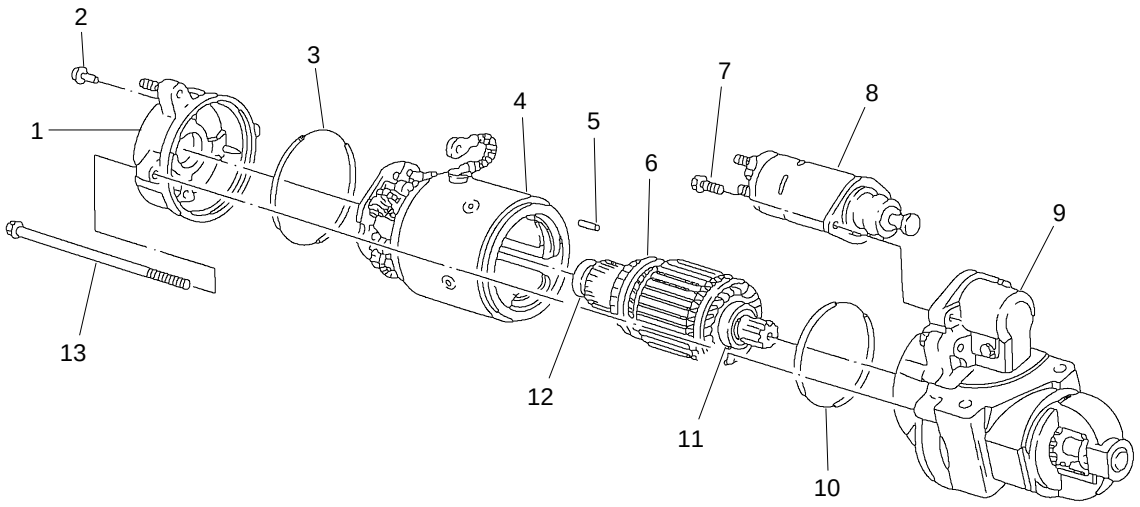
A typical starter is shown in **Fig. 1**, **Fig. 2**, **Fig. 3** and **Fig. 4**.



1. Ball Bearing
2. Armature
3. Solenoid Contact Disk
4. Solenoid
5. Sealing Boot
6. Plunger Spring
7. Solenoid Plunger
8. Shift Lever
9. Clutch Drive Assembly
10. Pinion
11. Bushing
12. Drive Collar
13. Driveshaft
14. Ball Bearing
15. Internal Gear
16. Armature Gear
17. Ball Bearing
18. Field Coil

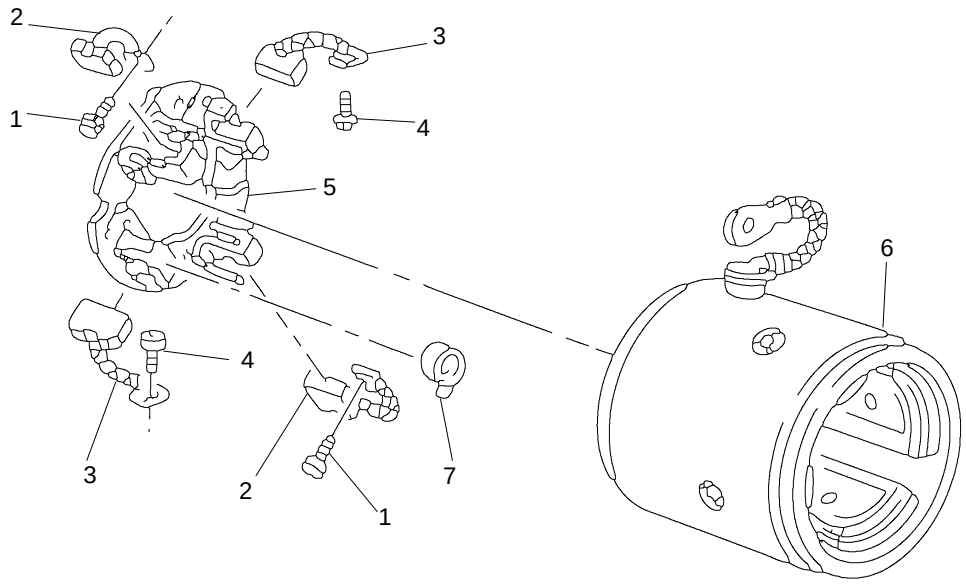
Fig. 1, Model 28-MT Starter, Cross Section

General Information



1. Brush End Plate and Bushing
2. Brush Plate Screw
3. O-Ring
4. Frame, Field and Brush Holder Assembly
5. Dowel Pin
6. Starter Motor Armature
7. Solenoid Screw
8. Starter Solenoid
9. Gear Reduction and Drive Assembly
10. Frame Seal
11. Ball Bearing
12. Ball Bearing
13. Through-Bolts

Fig. 2, Model 28-MT Starter, Disassembled View



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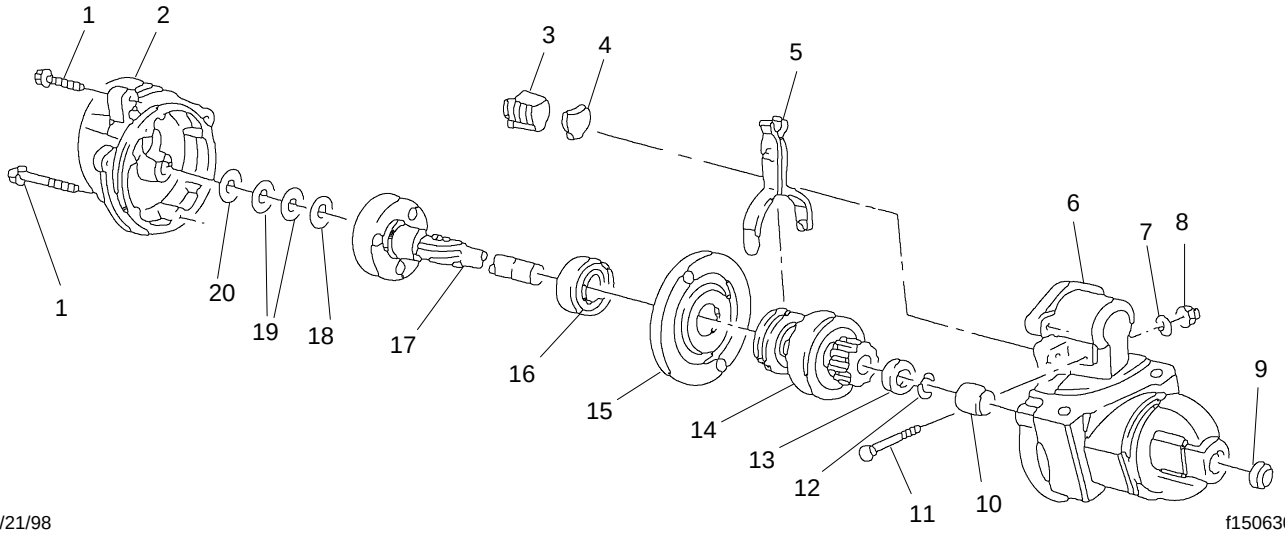
1. Screw
2. Brush
3. Brush
4. Screw
5. Brush Holder
6. Starter Frame
7. Spring

Fig. 3, Brushes

General Information



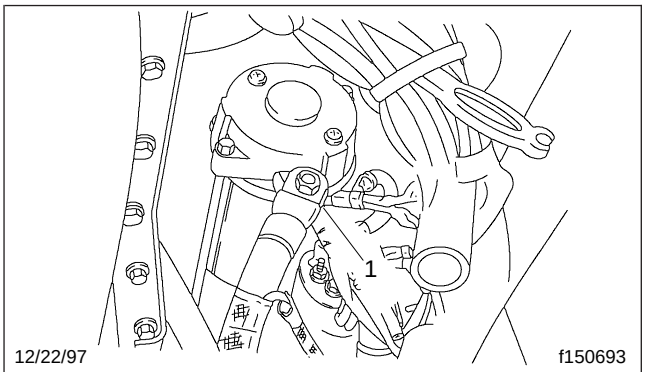
1. Screw
2. Armature Support Bracket
3. Drive Housing Plug
4. Plate (if used)
5. Shift Lever
6. Drive End Housing
7. Washer
8. Nut
9. Bushing Plug (if used)
10. Bushing
11. Screw
12. Stop Rings
13. Pinion Stop
14. Clutch Drive Assembly
15. Driveshaft Support
16. Bearing
17. Driveshaft
18. Washer (thick)
19. Washer (thin)
20. Washer (fiber)

Fig. 4, Starter Drive Gear Assembly

Replacement

Before replacing the starter, perform the checks in the troubleshooting subject in **Section 15.00** in this manual.

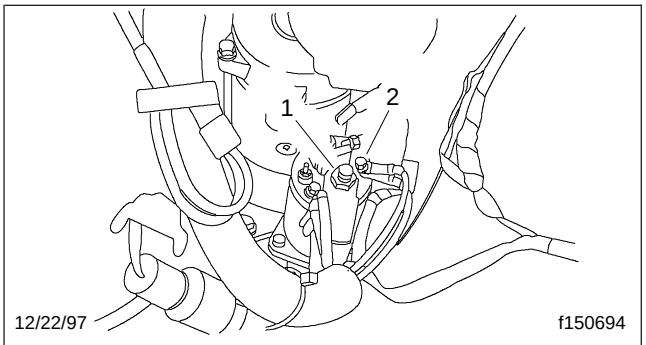
1. Disconnect the battery ground cable(s).
2. Disconnect the starter motor electrical leads. See **Fig. 1**.



1. Starter Motor Electrical Lead

Fig. 1, Starter Motor Electrical Lead

3. Disconnect the starter solenoid electrical leads. See **Fig. 2**.



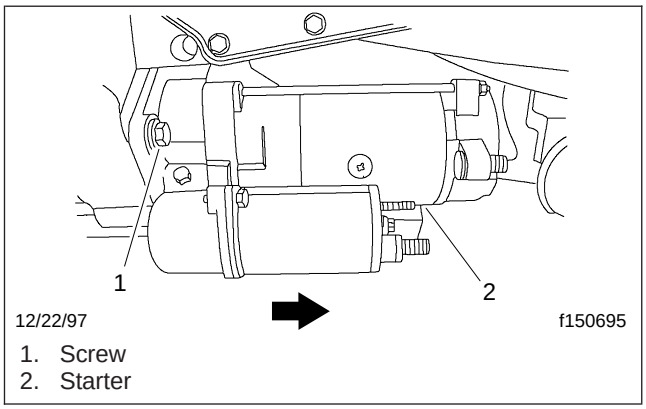
1. Solenoid B+ Lead
2. Solenoid S-Lead

Fig. 2, Starter Solenoid Electrical Leads

NOTE: This step applies to vehicles equipped with overcrank protection.

4. Disconnect the electrical connector.
5. Remove the starter motor. See **Fig. 3**.

   5.1 Remove the three screws.

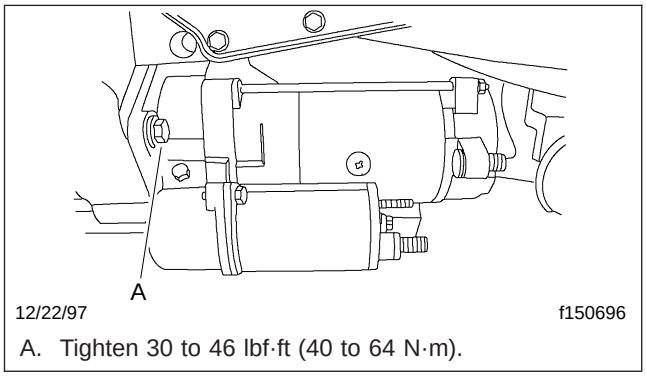


1. Screw
2. Starter

Fig. 3, Starter Motor Removal

   5.2 Remove the starter motor.

6. Insert the starter nose housing through the mounting hole into the flywheel housing.
7. Install the three starter mounting bolts and lockwashers. Tighten the starter mounting bolts 30 to 46 lbf·ft (40 to 64 N·m). See **Fig. 4**.
8. Apply Silicone Dielectric Compound D7AZ–19A331–A or equivalent meeting specification ESE–M1C171–A to all of the starter motor electrical connections.



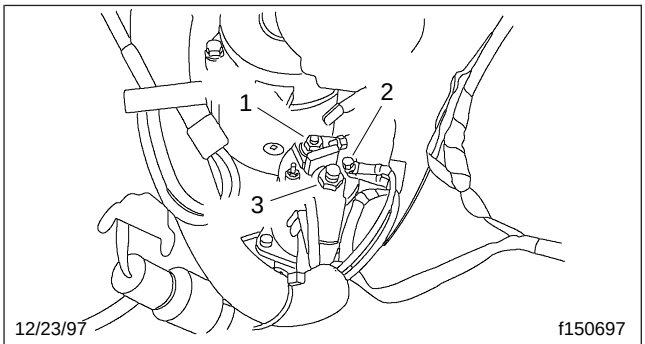
A. Tighten 30 to 46 lbf·ft (40 to 64 N·m).

Fig. 4, Starter Motor Bolts

9. Make sure that all electrical loads such as lights, ignition switches and accessories are turned off, then connect the battery ground cable(s).

Replacement

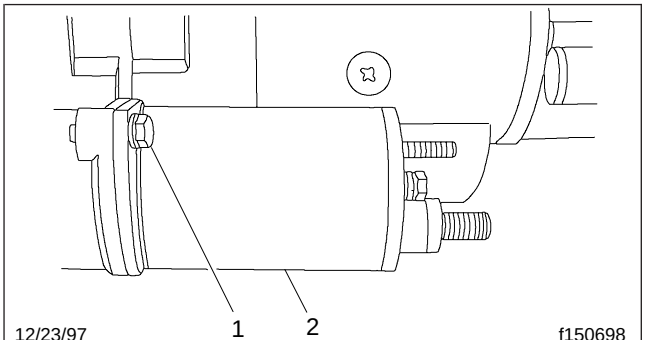
1. Disconnect the battery ground cable(s).
2. Disconnect the solenoid electrical leads. See **Fig. 1**.



1. Solenoid S-Terminal
2. Solenoid B+ Terminal
3. Solenoid M-Terminal

Fig. 1, Solenoid Electrical Leads

3. Remove the starter solenoid. See **Fig. 2**.



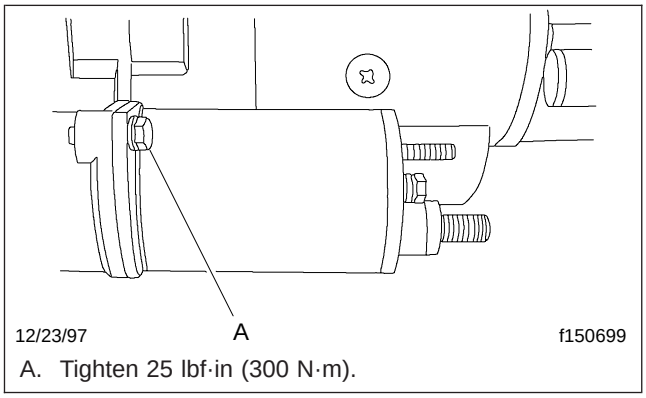
1. Screw
2. Starter Solenoid

Fig. 2, Starter Solenoid Screws

3.1 Remove the three screws.

3.2 Remove the starter solenoid.

4. Position the solenoid into the starter housing.
5. Install the three screws.
6. Connect the three solenoid electrical leads.
7. Apply Silicone Dielectric Compound D7AZ–19A331–A or equivalent meeting specification ESE–M1C171–A to all of the solenoid electrical connections. See **Fig. 3**.



A. Tighten 25 lbf·in (300 N·m).

Fig. 3, Solenoid Screws

Disassembly

1. Scribe the brush end cover, starter frame, drive lever housing, and drive end housing. See **Fig. 1**.

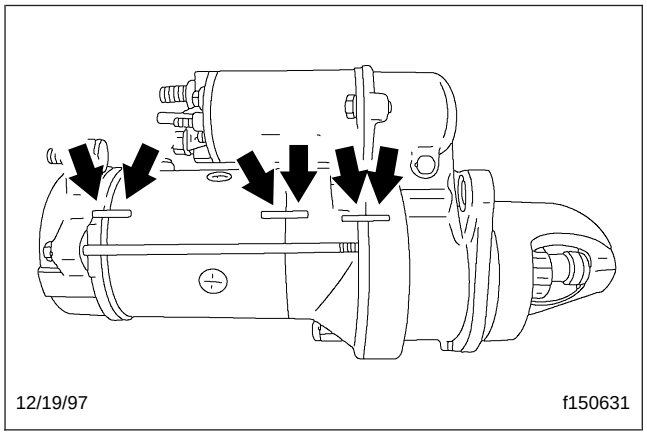


Fig. 1, Scribe Marks on the Starter Motor

2. Disconnect the starter motor strap. See **Fig. 2**.

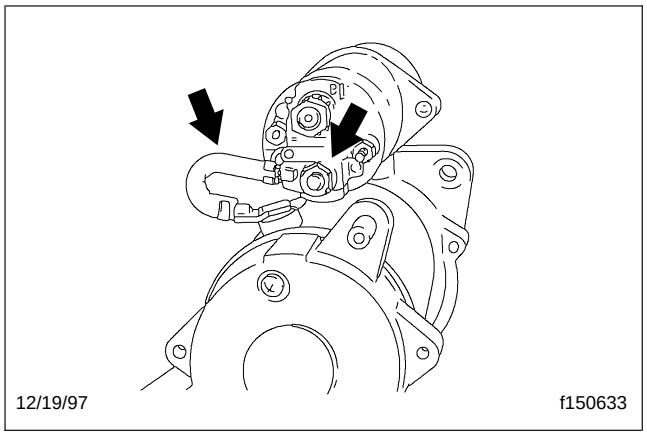


Fig. 2, Starter Motor Strap

3. Remove the bush cover bolts. See **Fig. 3**.
4. Remove the brush cover-to-bush end cover screws. See **Fig. 4**.
5. Separate the brush cover from the starter frame. Use a plastic-tipped hammer, if necessary. See **Fig. 5**.
6. Remove and inspect the starter frame to bush cover seal. See **Fig. 6**.

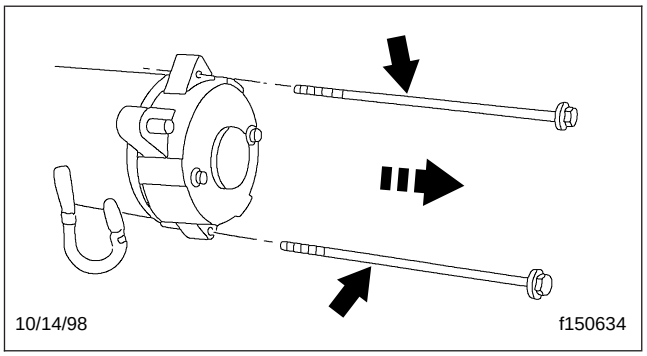


Fig. 3, Removing the Bush End Cover Bolts

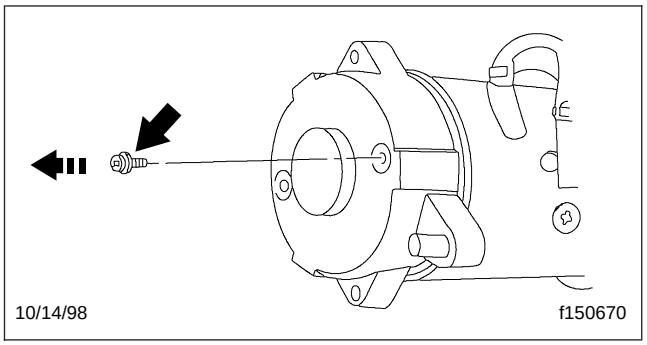


Fig. 4, Removing the Brush Assembly-to-Bush End Cover Screws

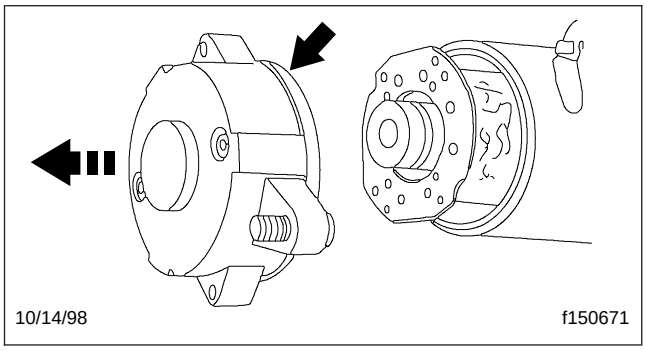


Fig. 5, Separating the Brush Cover

7. Scribe the brush holder and starter motor. See **Fig. 7**.

NOTE: During removal of the starter frame, the locating pin installed between the starter frame and the starter drive gear assembly may become loose. Use care not to lose the locating pin installed between the starter frame and the starter drive gear assembly.

Starter Motor Disassembly and Assembly

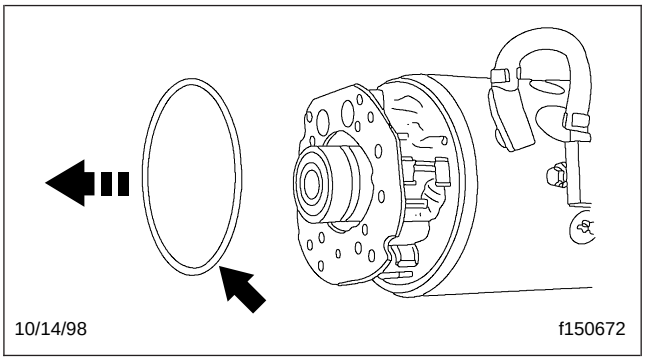


Fig. 6, Starter Frame-to-Bush End Cover Seal

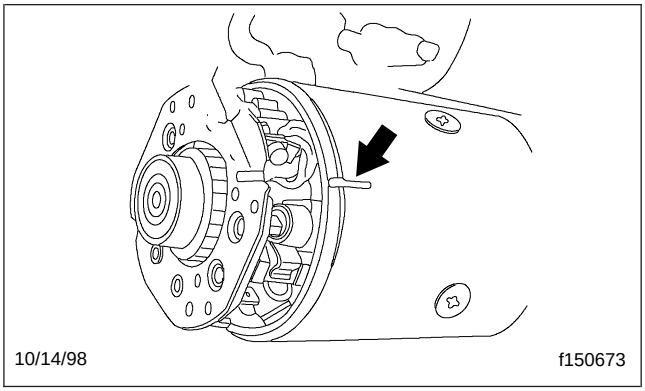


Fig. 7, Scribed Brush Holder and Starter Motor

8. Remove the starter frame and brush holder assembly from the armature. See **Fig. 8**.

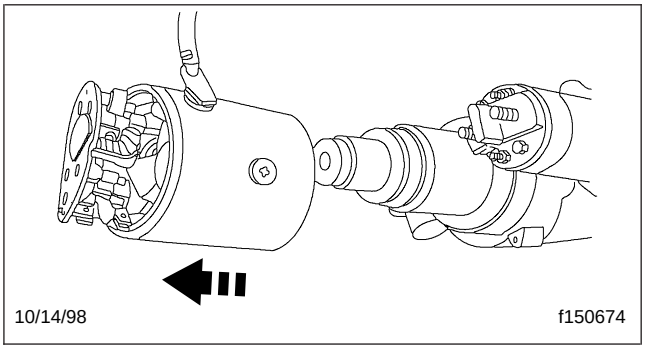
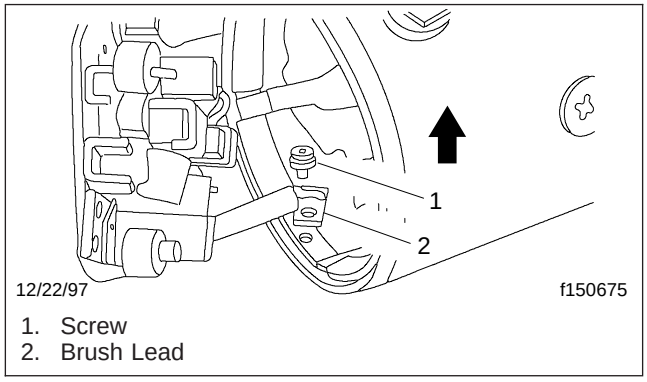


Fig. 8, Removing the Starter Frame and Brush Holder from the Armature

9. Disconnect the two insulated brush electrical leads. See **Fig. 9**.
10. Remove the brush holder assembly. See **Fig. 10**.



1. Screw
2. Brush Lead

Fig. 9, Insulated Brush Leads

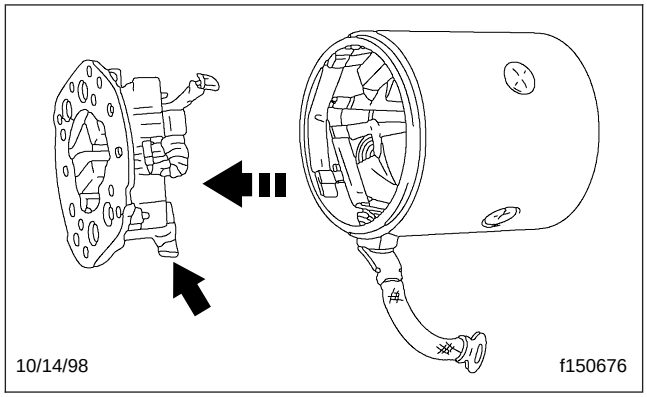
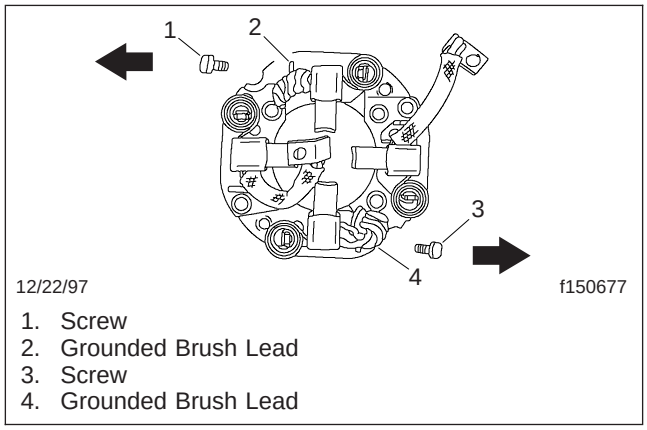


Fig. 10, Removing the Brush Holder Assembly

11. Disconnect the two grounded brush electrical leads. See **Fig. 11**.



1. Screw
2. Grounded Brush Lead
3. Screw
4. Grounded Brush Lead

Fig. 11, Grounded Brush Electrical Leads

12. Remove the four brushes from the brush holder. See **Fig. 12**.

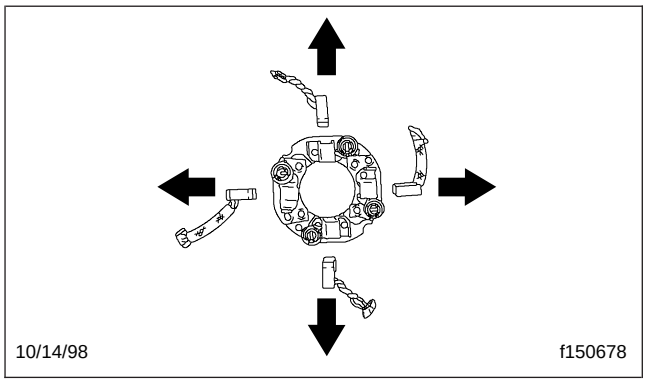
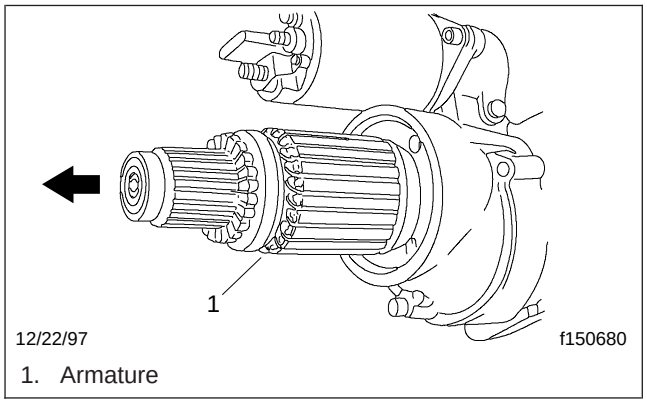


Fig. 12, Removing the Starter Motor Brushes

13. Remove the armature. See **Fig. 13**.



1. Armature

Fig. 13, Starter Armature

14. Remove and inspect the armature support bracket seal. See **Fig. 14**.

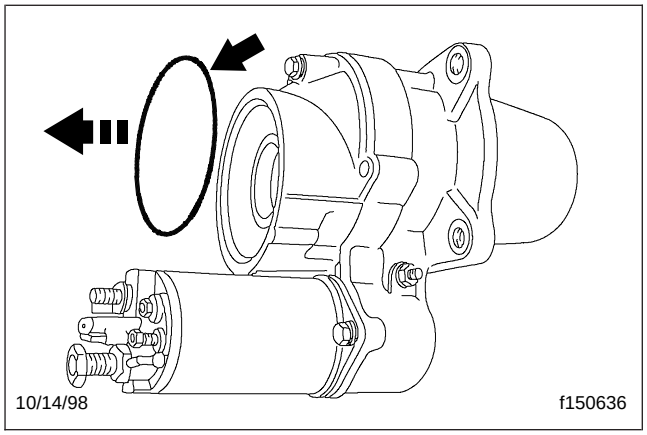


Fig. 14, Armature Support Bracket Seal

15. Remove the bolts. See **Fig. 15**.

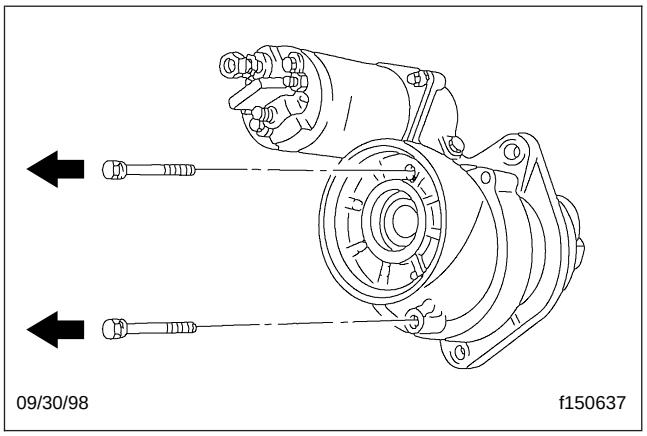


Fig. 15, Armature Support Bracket Screws

16. Remove the armature support bracket, fiber washer, thin washer(s), and thick washer. Note the position of the washers during removal. See **Fig. 16**.

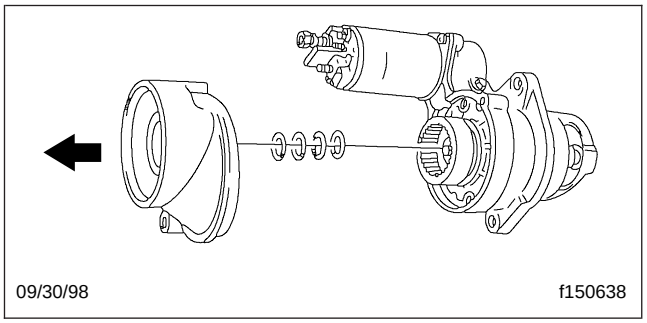


Fig. 16, Removing the Armature Support Bracket

17. Remove the starter solenoid. See **Fig. 17**.

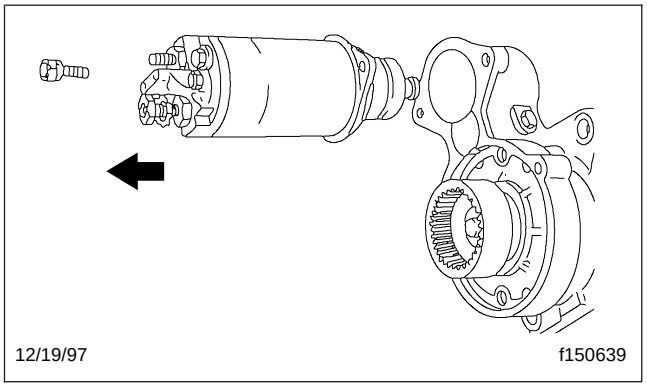


Fig. 17, Starter Solenoid

18. Remove the plug. See **Fig. 18**.

Starter Motor Disassembly and Assembly

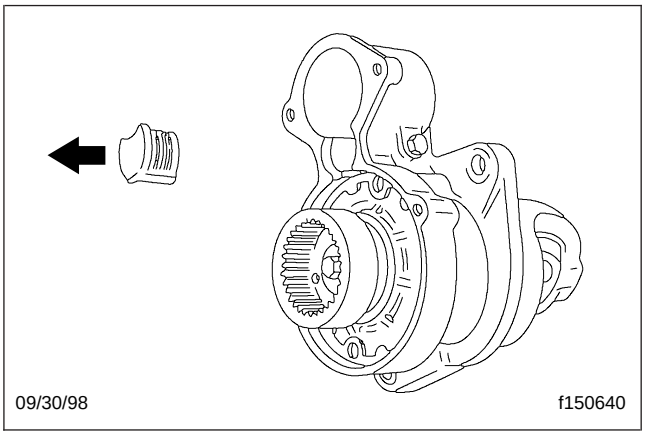
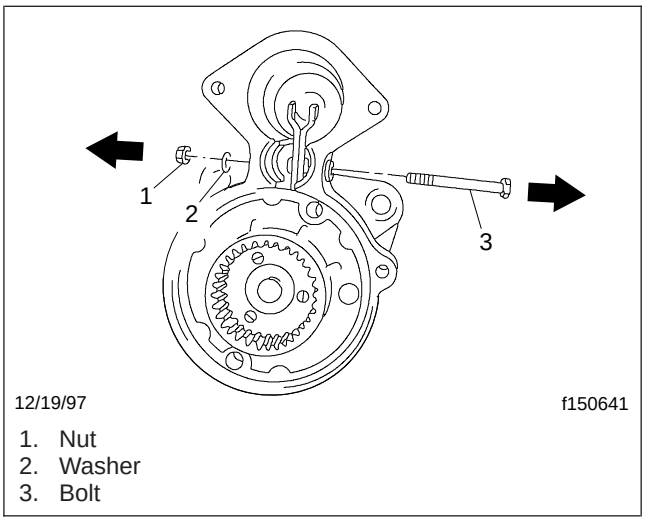


Fig. 18, Driveshaft and Clutch Assembly Screw

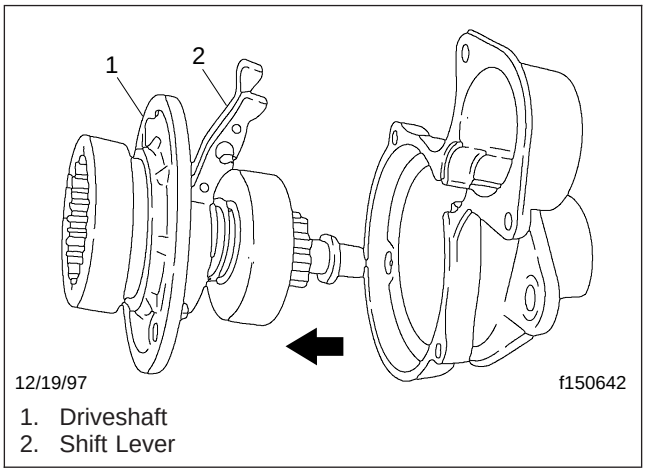
19. Remove the shift lever bolt, nut and washer. See **Fig. 19**.



1. Nut
2. Washer
3. Bolt

Fig. 19, Shift Lever Mounting

20. Remove the driveshaft and clutch assembly and the shift lever. See **Fig. 20**.
21. Remove the shift lever from the clutch assembly. See **Fig. 21**.
22. Drive the pinion stop to the rear. See **Fig. 22**.
23. Remove and discard the stop rings and pinion stop. See **Fig. 23**.
24. Remove the clutch drive assembly. See **Fig. 24**.
25. Remove the driveshaft support. See **Fig. 25**.



1. Driveshaft
2. Shift Lever

Fig. 20, Removing the Driveshaft and Shift Lever

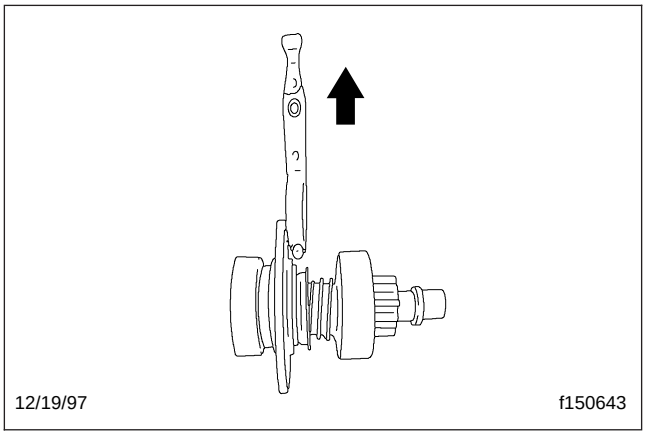


Fig. 21, Removing the Shift Lever from the Clutch Assembly

26. Inspect the bearing for damage, binding, or the feel of flat spots. See **Fig. 26**.

CAUTION

The center support bearing must be replaced with a new bearing whenever removed. Removal of the center support bearing causes internal damage to the bearing. See Fig. 27.

NOTE: If the center support bearing is damaged or unserviceable, perform the following step.

NOTE: For fabrication of the center support bearing removal tool, see **Fig. 28**. Use 3/16 inch (6 mm) bolts.

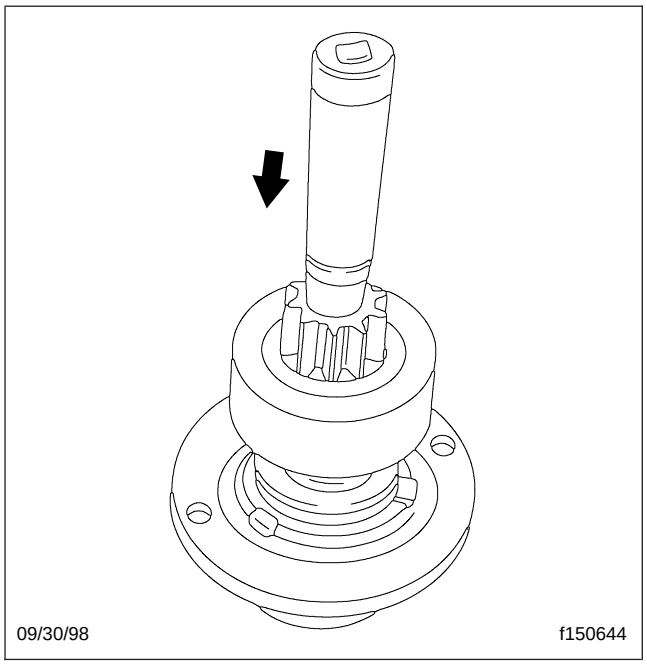


Fig. 22, Driving the Pinion Stop to the Rear

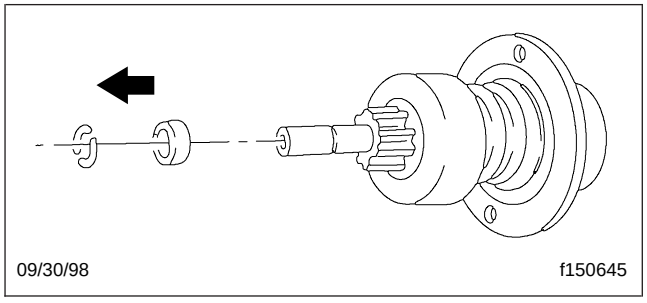


Fig. 23, Pinion Stop Rings

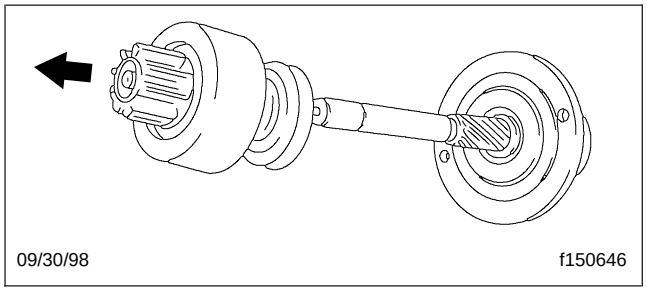


Fig. 24, Removing the Clutch Drive Assembly

27. Remove and discard the bearing. Use the center support bearing removal tool, or equivalent, a suitable arbor press and support fixture.

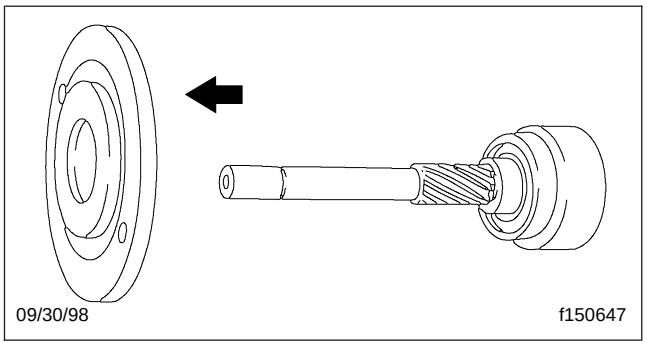


Fig. 25, Removing the Driveshaft Support

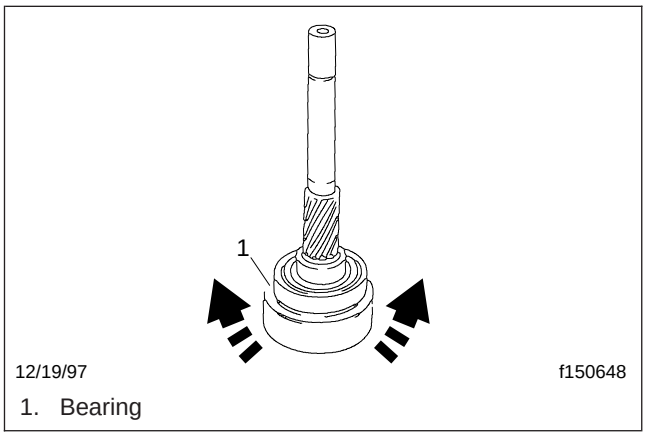


Fig. 26, Spinning the Bearing for Inspection

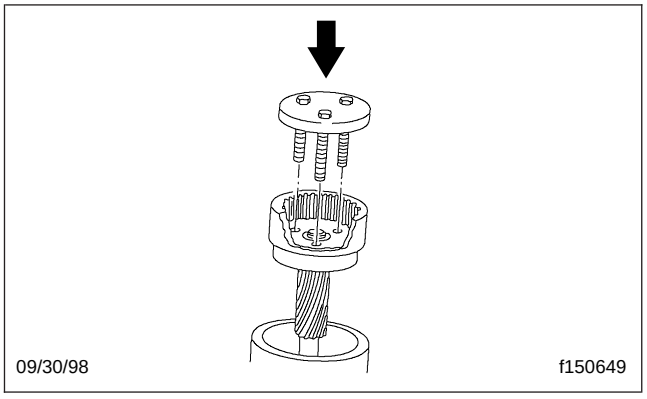
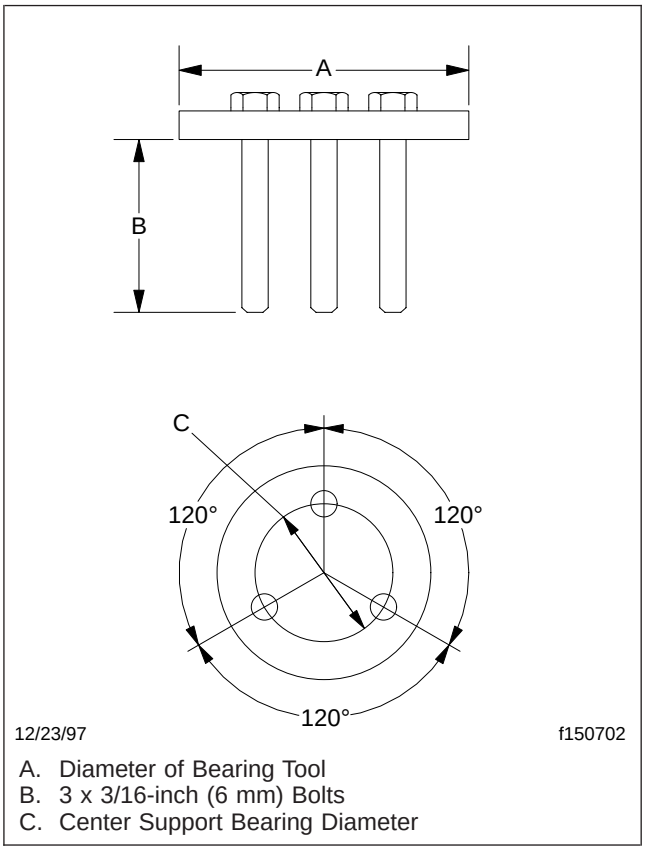


Fig. 27, Removing the Center Support Bearing

28. Inspect the bearing for damage, binding, or the feel of flat spots. See **Fig. 29**.

Starter Motor Disassembly and Assembly



A. Diameter of Bearing Tool
B. 3 x 3/16-inch (6 mm) Bolts
C. Center Support Bearing Diameter

Fig. 28, Center Support Bearing Removal Tool Dimensions

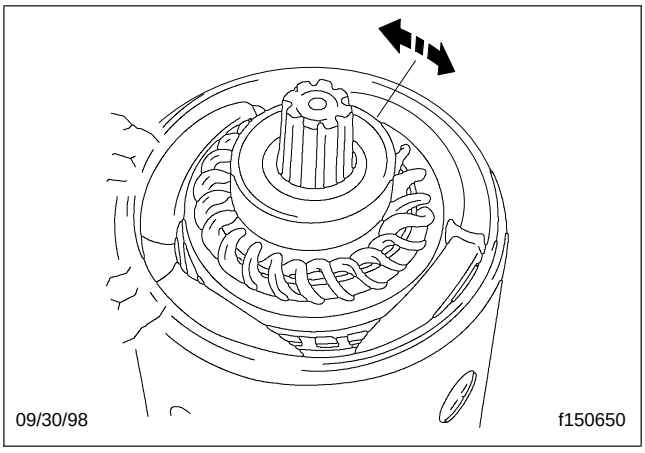


Fig. 29, Bearing Inspection Points

CAUTION

The armature drive end bearing must be replaced with a new bearing whenever removed. Removal of the armature drive end bearing causes internal damage to the bearing.

NOTE: If the armature drive end bearing is damaged or unserviceable, perform the following step.

29. Remove and discard the bearing. Use a suitable bearing puller. See **Fig. 30**.

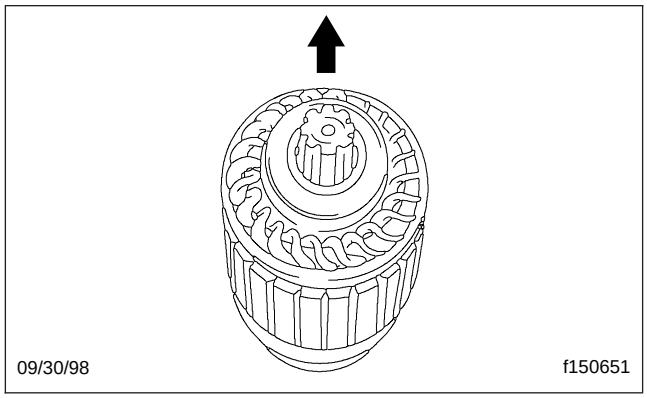


Fig. 30, Removing the Bearing

30. Inspect the armature commutator end bearing for damage, binding, or the feel of flat spots. See **Fig. 31**.

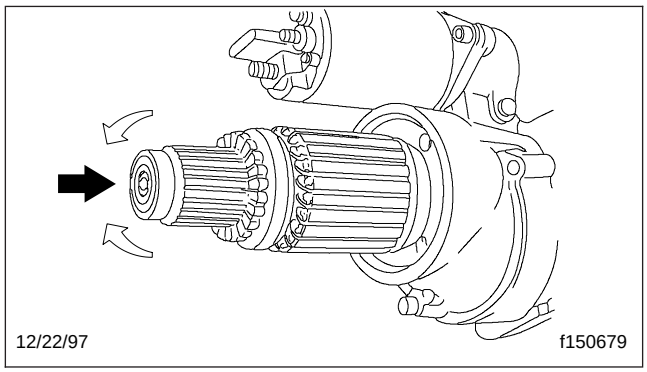


Fig. 31, Inspect the Armature Commutator End Bearing

CAUTION

The armature commutator end bearing must be replaced with a new bearing whenever removed.

Removal of the armature commutator end bearing causes internal damage to the bearing.

NOTE: Perform this step if the bearing is unserviceable.

31. Remove and discard the bearing. Use as suitable bearing puller. See **Fig. 32**.

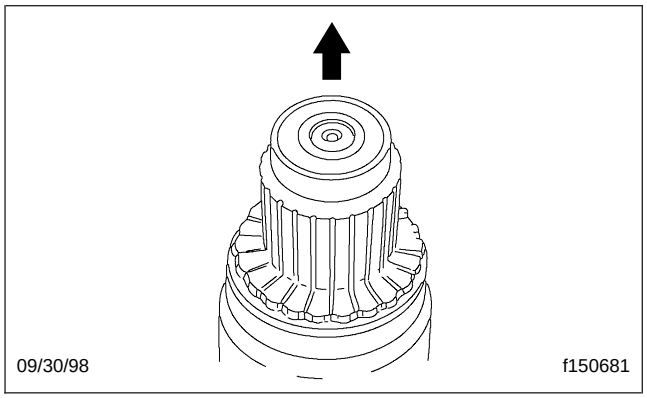


Fig. 32, Removing the Armature Commutator End Bearing

32. Clean and inspect the starter motor and its components refer to **Group 15**:
    - starter motor
    - armature
    - bushings
    - field coil
    - brush and brush holder
    - starter drive/flywheel ring gear inspection
    - starter frame and magnet

Assembly

1. If the armature commutator end bearing was removed, install the new bearing. See **Fig. 33**.
    1.1 Use a tube that bears on the bearing inner race and a suitable arbor press.
    1.2 Press on the bearing until the inner race bottoms out against the shoulder on the armature shaft.
    1.3 Check the bearing for binding and damage.

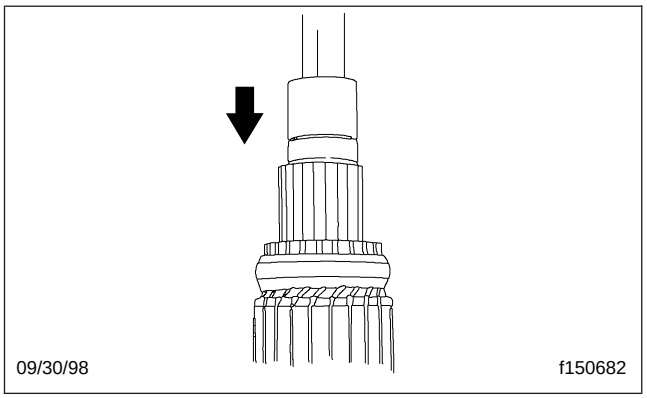


Fig. 33, Installing a New Armature Commutator End Bearing

2. If the armature drive end bearing was removed, install the new bearing. See **Fig. 34**.

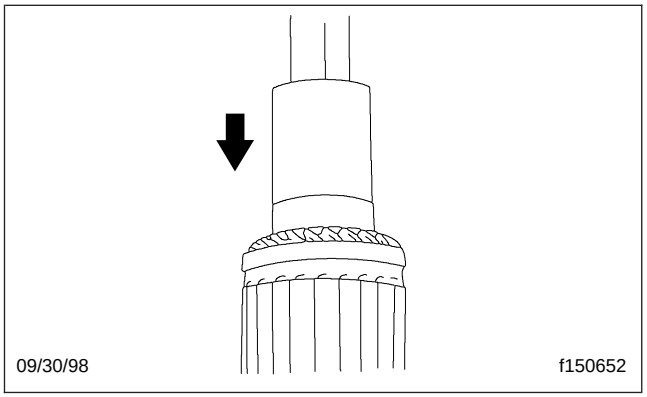


Fig. 34, Installing a New Armature Drive End Bearing

    2.1 Use a tube that bears on the bearing inner race and a suitable arbor press.
    2.2 Press on the bearing until the inner race bottoms out against the shoulder on the armature shaft.
    2.3 Check the bearing for binding and damage.
3. If the center support bearing was removed, install the new bearing. See **Fig. 35**.
    3.1 Use a tube that bears on the bearing inner race and a suitable arbor press.

    Press on the bearing until the inner race bottoms out against the shoulder on the driveshaft.

Starter Motor Disassembly and Assembly

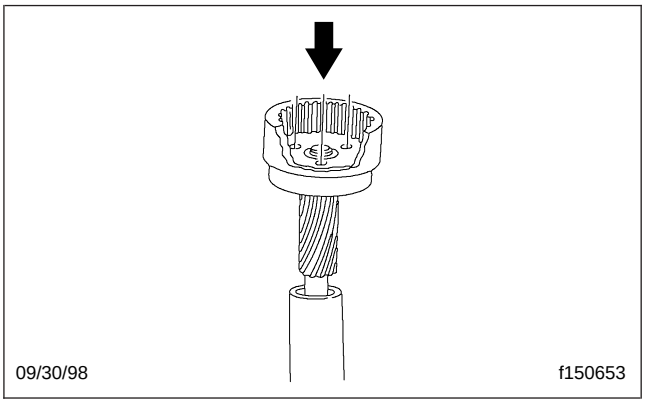


Fig. 35, Installing a New Center Support Bearing

3.2 Check the bearing for binding and damage.

4. Install the driveshaft support. See **Fig. 36**.

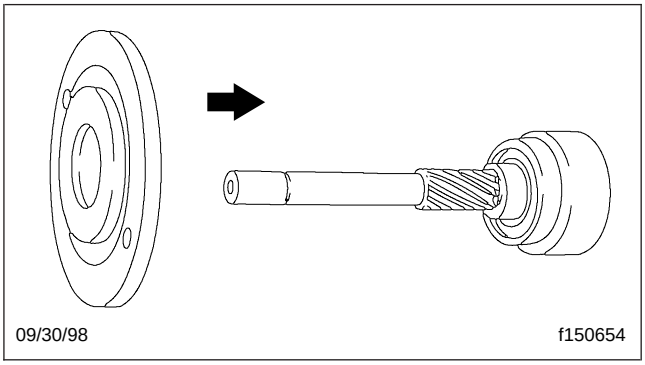


Fig. 36, Installing the Driveshaft Support

5. Install the clutch drive assembly. See **Fig. 37**.

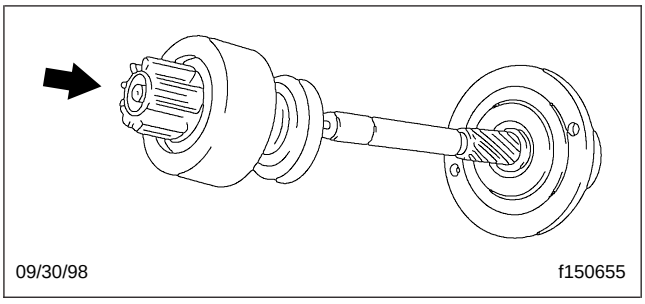


Fig. 37, Installing the Clutch Drive Assembly

6. Position the new pinion stop and stop rings on the driveshaft. See **Fig. 38** and **Fig. 39**.

7. Drive the pinion stop forward onto the stop rings. Use either a 9/16 inch or 14 mm open end wrench or the fabricated tool installed in a suitable vise. See **Fig. 40**.

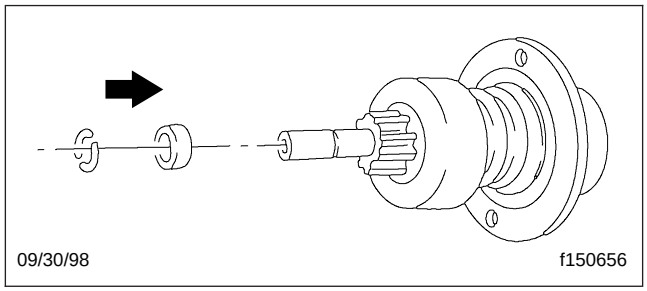


Fig. 38, Position the Pinion Stop and Stop Rings

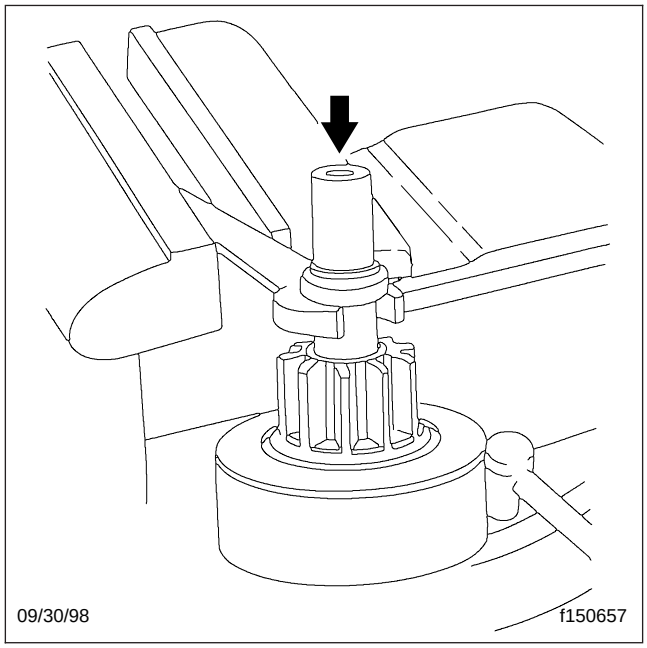


Fig. 39, Using a Wrench to Position the Pinion Stop

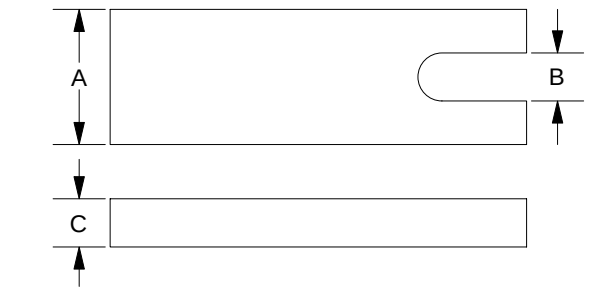
8. Stake the upper edge of the pinion stop in four equally spaced places. See **Fig. 41**.

9. Position the shift lever. See **Fig. 42**.

10. Align the holes in the driveshaft support with the holes in the drive end housing and install the driveshaft and clutch assembly and the shift lever. See **Fig. 43**.

10.1 Make sure the center support bearing is fully seated in the driveshaft support.

10.2 Make sure the driveshaft support is fully seated in the drive end housing.



A. 1 inch (25.4 mm)
B. 0.56 inch (14 mm)
C. 0.35 inch (9 mm)

Fig. 40, Pinion Stop Installation Tool Dimensions

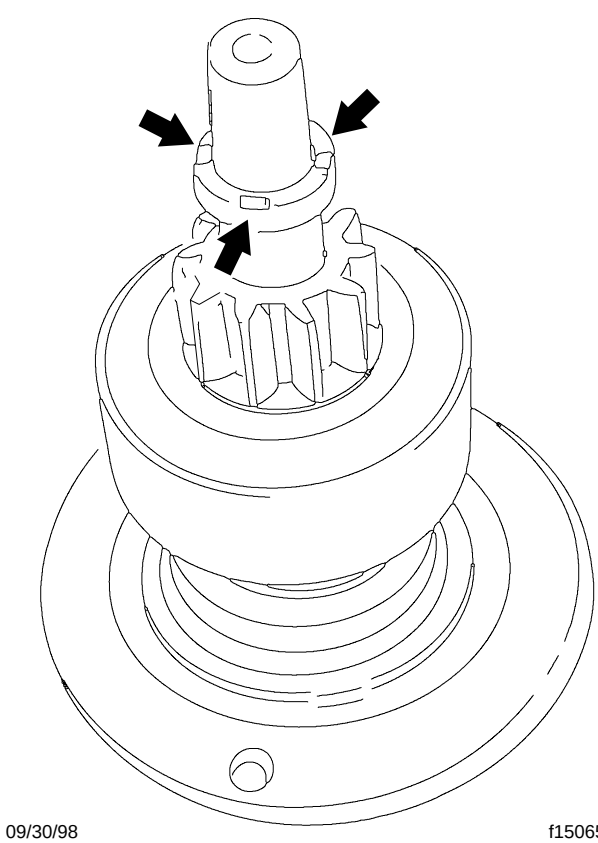


Fig. 41, Installing the Pinion Evenly

11. Install the bolt, washer and nut. Tighten the bolt to 40 lbf·in (500 N·cm). See **Fig. 44**.
12. Install the plug. See **Fig. 45**.

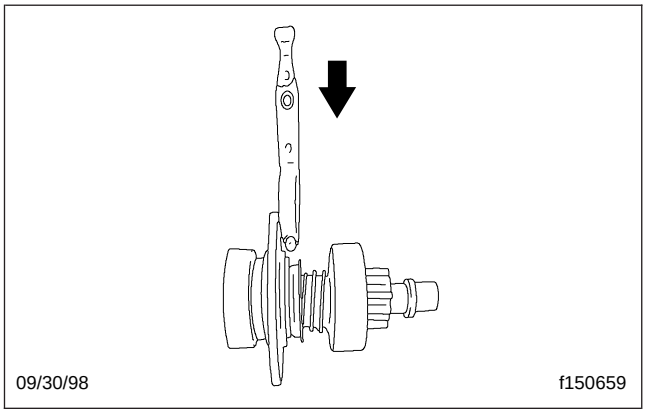
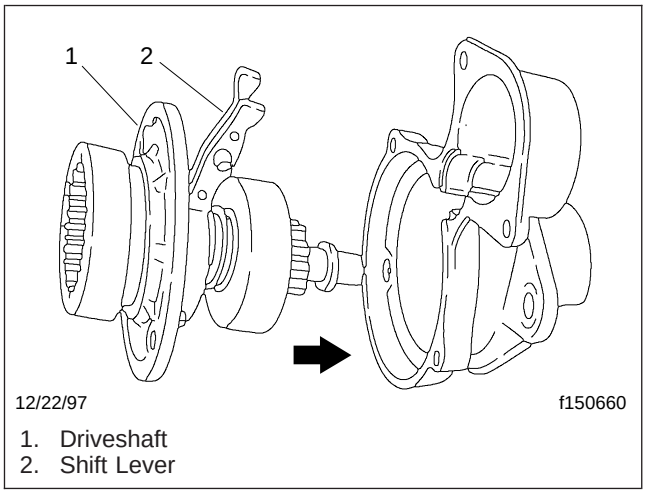
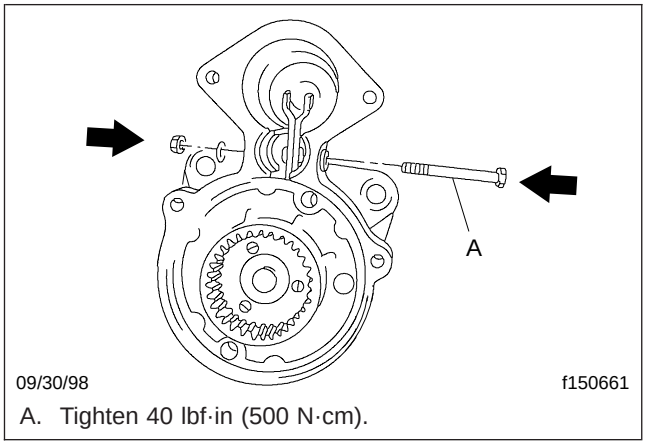


Fig. 42, Shift Lever Position



1. Driveshaft
2. Shift Lever

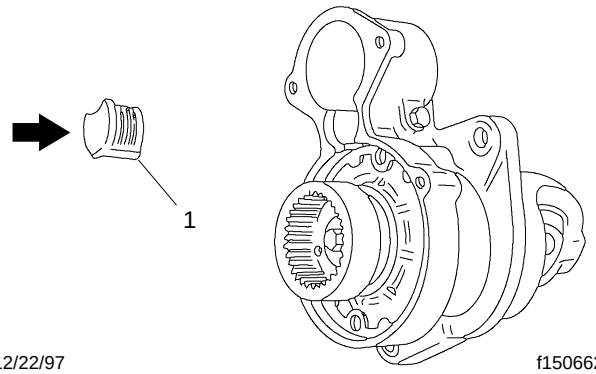
Fig. 43, Installing the Shift Lever and Clutch Assembly



A. Tighten 40 lbf·in (500 N·cm).

Fig. 44, Shift Lever Bolt

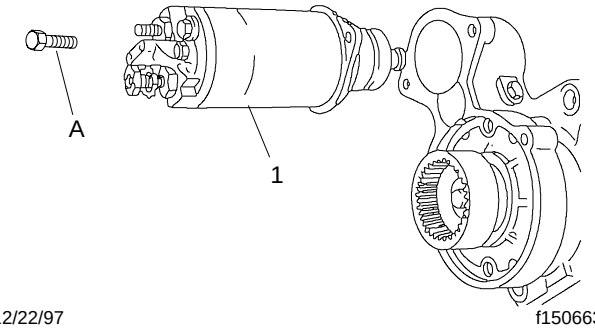
Starter Motor Disassembly and Assembly



1. Plug

Fig. 45, Install the Plug

13. Install the starter solenoid. See **Fig. 46**.



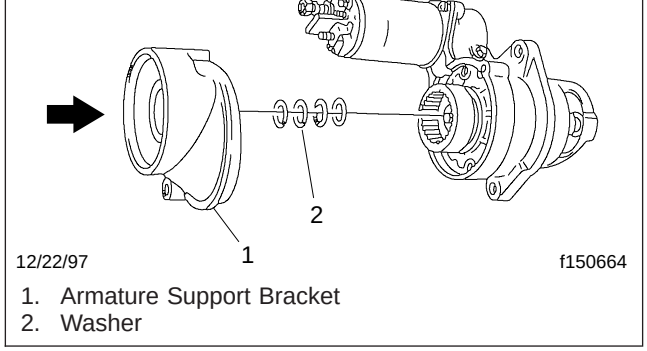
A. Tighten 25 lbf·in (300 N·cm).
1. Starter Solenoid

Fig. 46, Solenoid Bolt

14. Position the thick washer, thin washer(s) and fiber washer. Align and install the armature support bracket. See **Fig. 47**.
15. Install the armature support bracket bolts. Tighten the bolts to 75 lbf·in (850 N·cm). See **Fig. 48**.
16. Install the seal. See **Fig. 49**.
17. Install the armature. See **Fig. 50**.

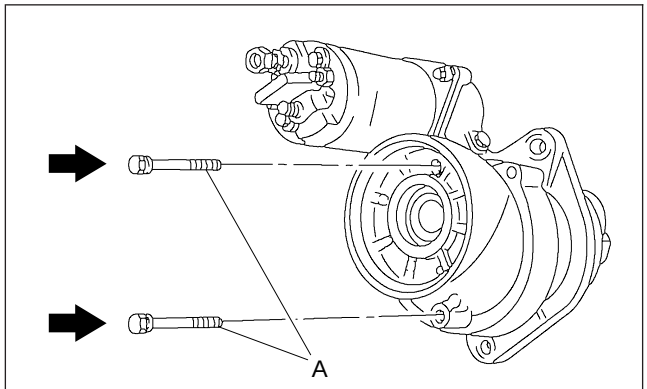
NOTE: Make sure the insulated and ground brushes are installed in proper holders.

18. Install and cage the four brushes. See **Fig. 51**.



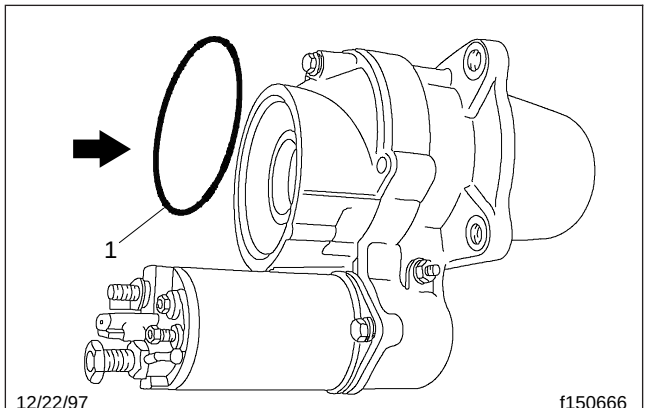
1. Armature Support Bracket
2. Washer

Fig. 47, Align and Install the Armature Support Bracket and Components



A. Tighten 75 lbf·in (850 N·cm).

Fig. 48, Armature Support Bracket Bolts



1. Seal

Fig. 49, Install the Seal

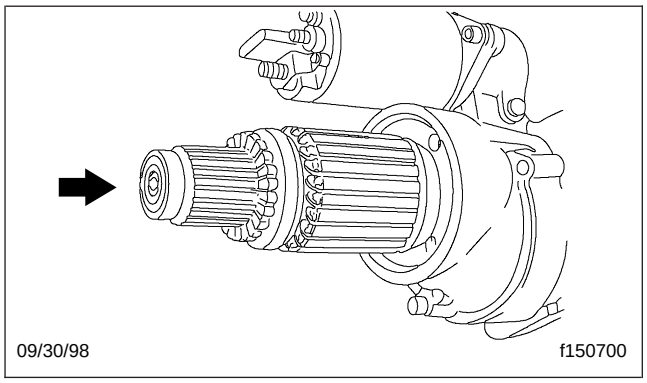


Fig. 50, Install the Armature

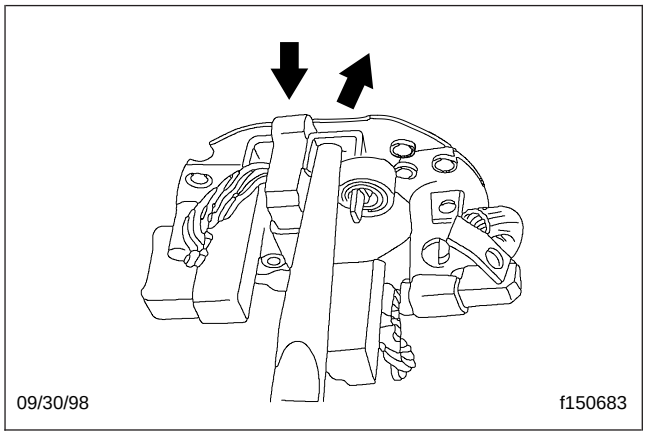


Fig. 51, Install and Cage the Four Brushes

19. Connect the two grounded brush electrical leads. See **Fig. 52**.

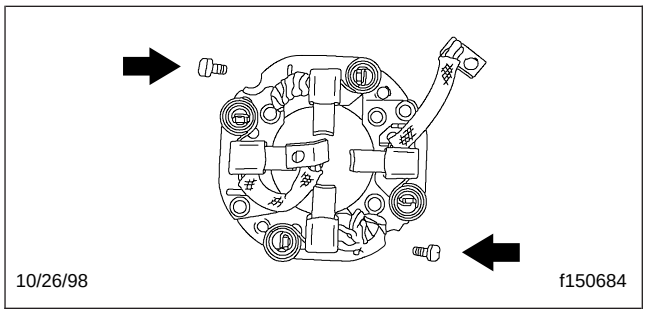


Fig. 52, Connect the Brush Electrical Leads

20. Align and position the brush holder assembly. See **Fig. 53**.
21. Connect the two insulated brush electrical leads. Tighten the Leads to 13 lbf·in (200 N·cm). See **Fig. 54**.

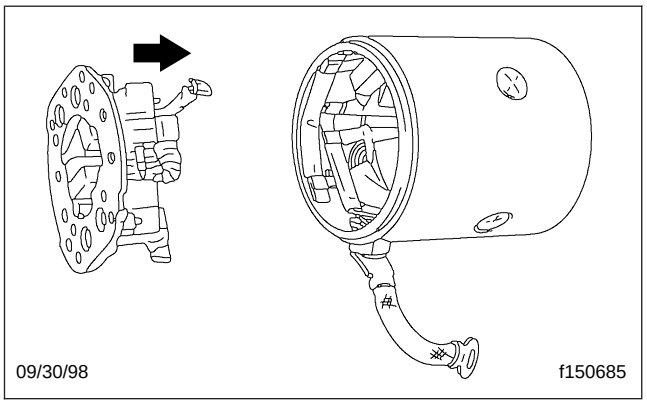
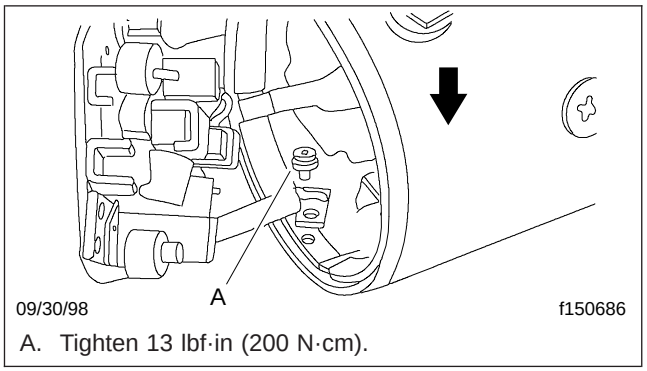


Fig. 53, Position the Brush Holder Assembly



A. Tighten 13 lbf·in (200 N·cm).

Fig. 54, Connect the Brush Electrical Leads

NOTE: If the locating pin installed between the starter frame and the starter drive gear assembly has been lost, it must be replaced with a 0.079 inch x 0.394 inch (2 mm x 10 mm) pin.

22. Align and install the starter frame and brush holder assembly on the armature shaft. See **Fig. 55**.

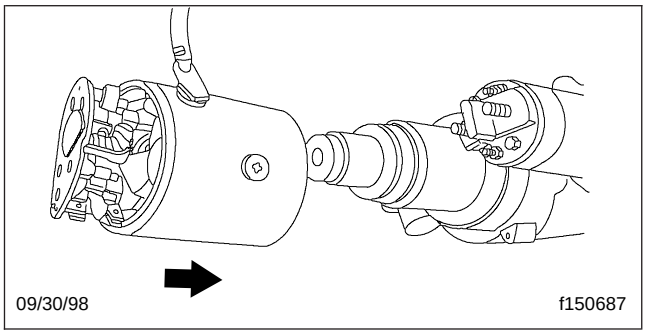


Fig. 55, Align and Install the Starter Frame Onto the Armature

Starter Motor Disassembly and Assembly

23. Release the four brushes. See **Fig. 56**.

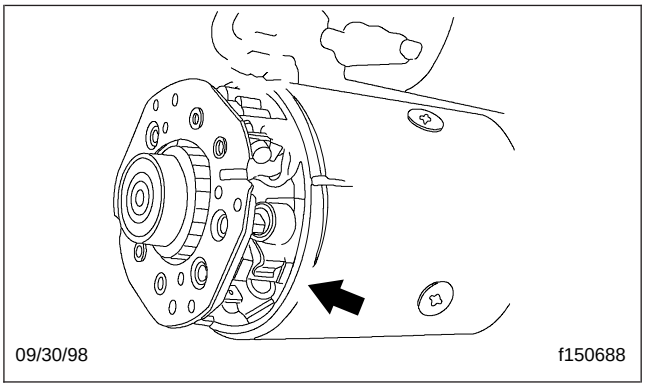


Fig. 56, Release the Brushes

24. Install the brush cover-to-starter frame seal. See **Fig. 57**.

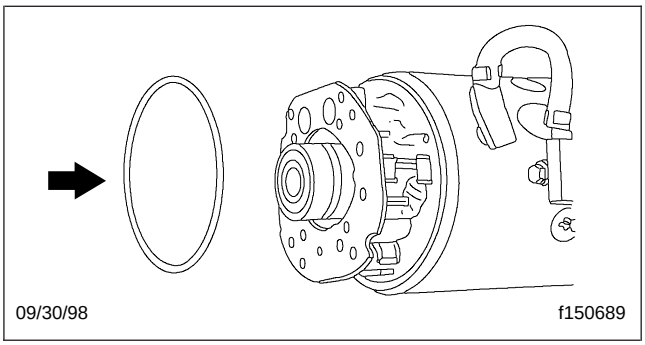


Fig. 57, Brush Cover-to-Starter Frame Seal

⚠ CAUTION

Use care not to damage the starter frame seal during the installation of the brush end cover.

25. Align and position the brush cover. See **Fig. 58**.
26. Install the two bolts. Use a scribe to align the tapped holes in the brush holder assembly and the bolt holes in the brush cover. Tighten the bolts to 25 lbf·in (300 N·cm). See **Fig. 59**.
27. Align the timing spots on the brush cover and the starter frame. See **Fig. 60**.
28. Install the two bolts and tighten them to 75 lbf·in (900 N·cm). See **Fig. 61**.
29. Connect the starter motor strap. See **Fig. 62**.

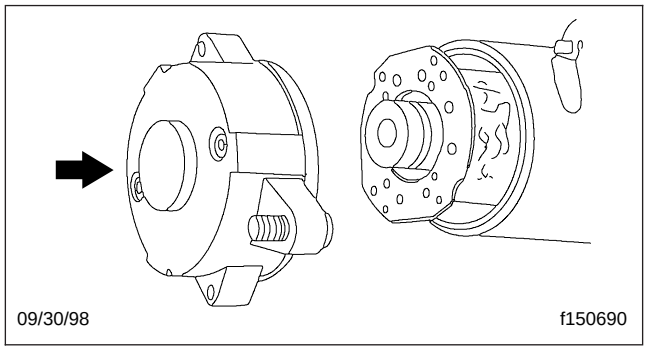
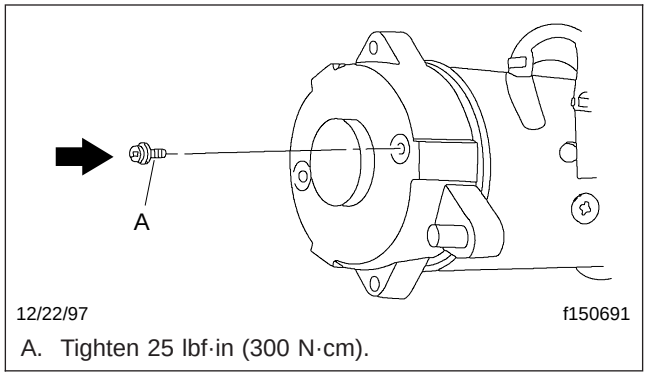


Fig. 58, Installing the Brush Cover



A. Tighten 25 lbf·in (300 N·cm).

Fig. 59, Brush Holder Bolts

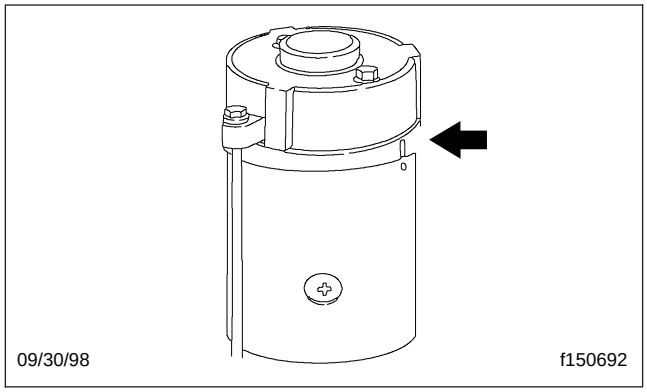
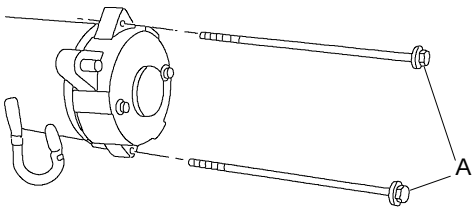


Fig. 60, Scribe Marks



12/22/97 f150668

A. Tighten 75 lbf·in (900 N·cm).

Fig. 61, Brush Cover Bolts

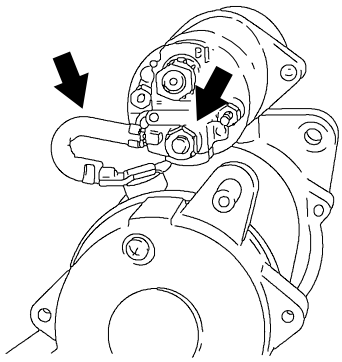


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Fig. 62, Starter Motor Strap

Disassembly

1. Scribe the starter frame, armature support bracket, and drive housing. See **Fig. 1**.

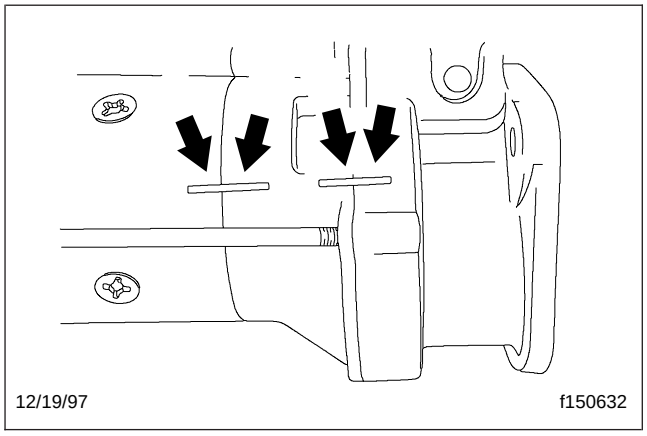


Fig. 1, Scribe Marks on the Starter Motor

2. Disconnect the starter motor strap. See **Fig. 2**.

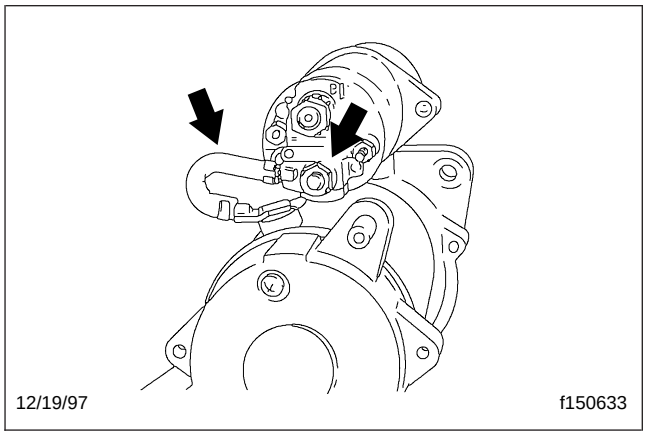


Fig. 2, Starter Motor Strap

3. Remove the brush cover bolts. See **Fig. 3**.

NOTE: Use care not to pull the armature shaft out of the brush holder assembly during drive end housing removal.

4. Remove the drive end housing. Use a plastic-tipped hammer, if necessary. See **Fig. 4**.
5. Remove and inspect the seal. See **Fig. 5**.
6. Remove the armature support bracket bolts. See **Fig. 6**.

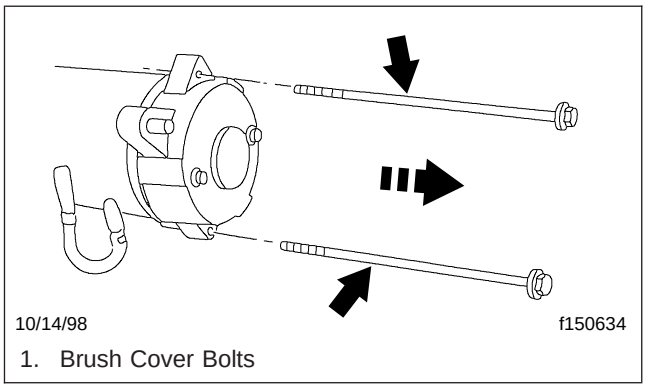


Fig. 3, Brush Cover Bolts

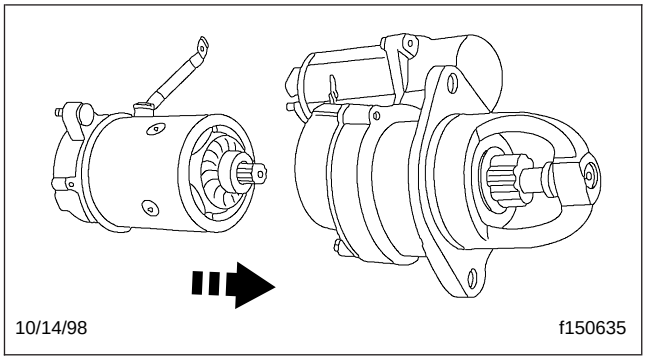


Fig. 4, Removing the Drive End Housing

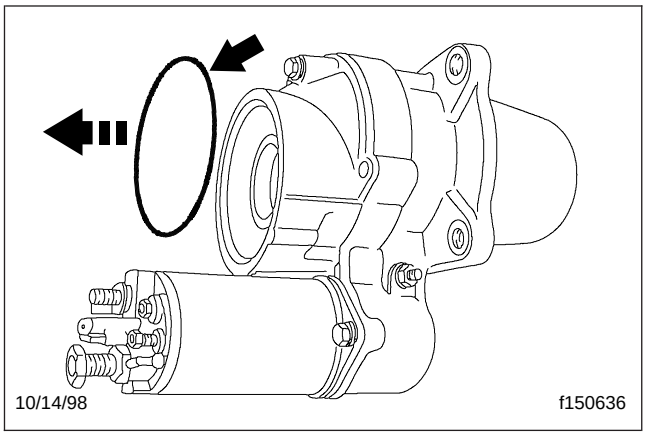


Fig. 5, Removing the Drive End Housing Seal

7. Remove the armature support bracket, fiber washer, thin washer(s), and thick washer. Note the position of the washers during removal. See **Fig. 7**.
8. Remove the starter solenoid. See **Fig. 8**.

Starter Drive Assembly, Disassembly and Assembly

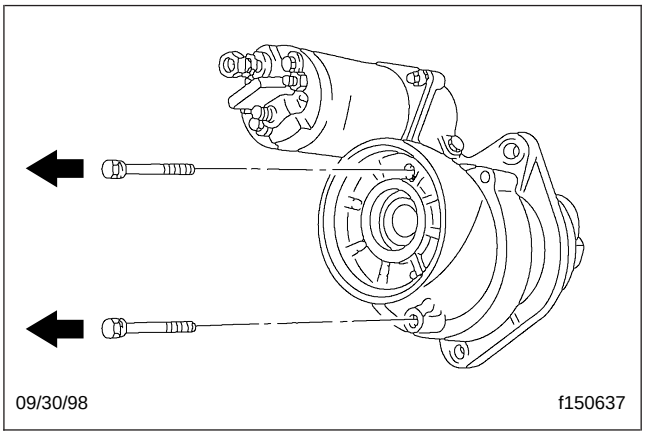


Fig. 6, Armature Support Bracket Bolts

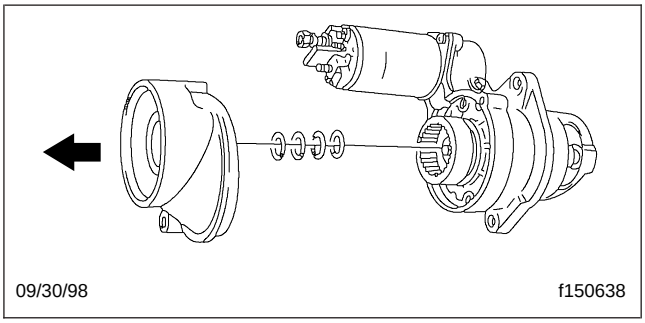


Fig. 7, Removing the Armature Support Bracket and Components

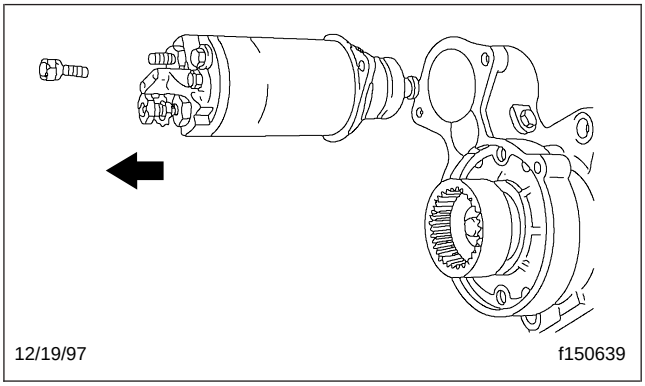


Fig. 8, Remove the Starter Solenoid

9. Remove the plug. See **Fig. 9**.
10. Remove the shift lever bolt, nut and washer. See **Fig. 10**.
11. Remove the driveshaft and clutch assembly and the shift lever. See **Fig. 11**.

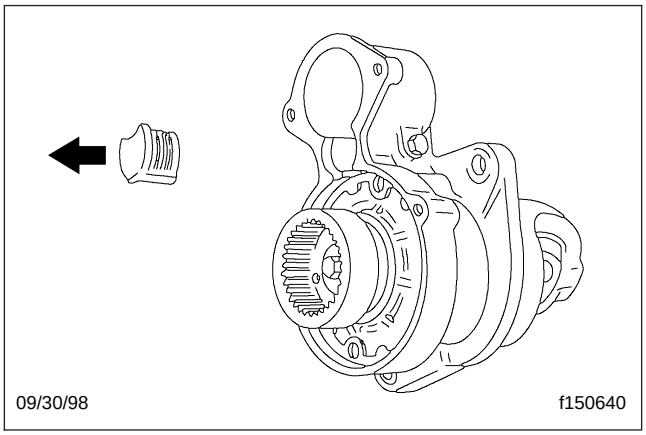
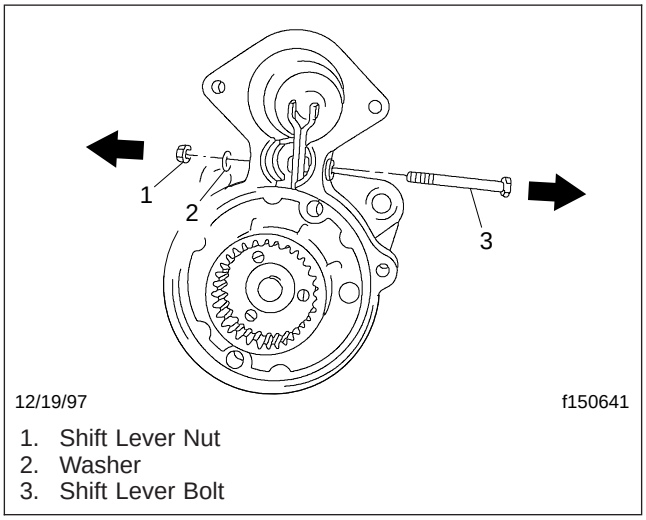


Fig. 9, Remove the Plug



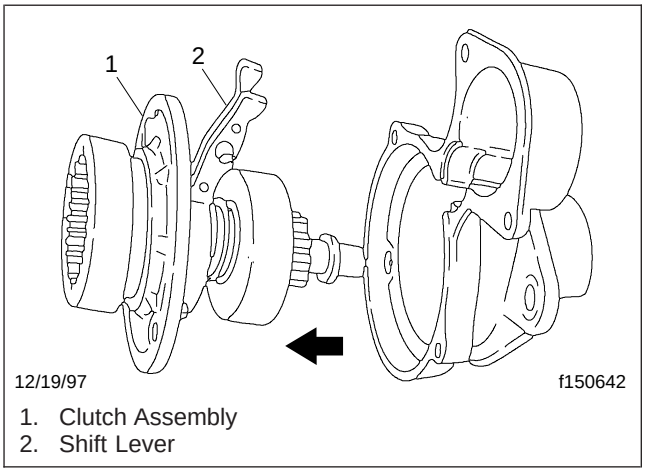
1. Shift Lever Nut
2. Washer
3. Shift Lever Bolt

Fig. 10, Shift Lever Screw, Nut and Washer

12. Remove the shift lever. See **Fig. 12**.
13. Drive the pinion stop to the rear. See **Fig. 13**.
14. Remove and discard the stop rings and pinion stop. See **Fig. 14**.
15. Remove the clutch drive assembly. See **Fig. 15**.
16. Remove the driveshaft support. See **Fig. 16**.
17. Inspect the bearing for damage, binding, or the feel of flat spots. See **Fig. 17** and **Fig. 18**.

⚠ CAUTION

The center support bearing must be replaced with a new bearing whenever it is removed. Re-



1. Clutch Assembly
2. Shift Lever

Fig. 11, Driveshaft and Clutch Assembly

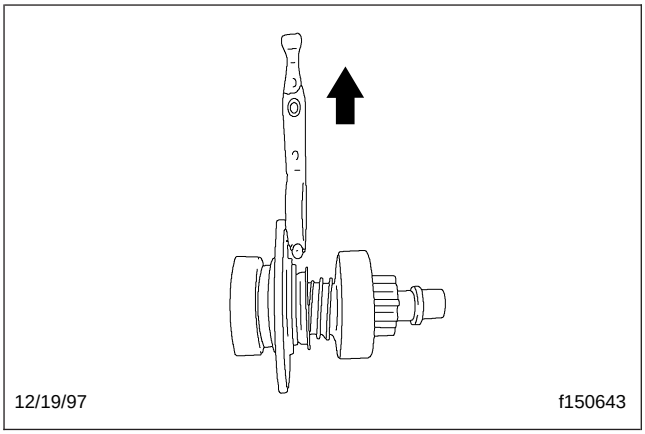


Fig. 12, Removing the Shift Lever

moval of the center support bearing causes internal damage to the bearing.

NOTE: For fabrication of the center support bearing removal tool, refer to the illustration. Use 3/16-inch (6-mm) bolt. See **Fig. 19**.

18. If the center support bearing is damaged or unserviceable, remove and discard the bearing. Use the center support bearing removal tool, or equivalent, a suitable arbor press and support fixture.
19. Spin the bearing to inspect the bearing for damage, binding, or the feel of flat spots. See **Fig. 20**.

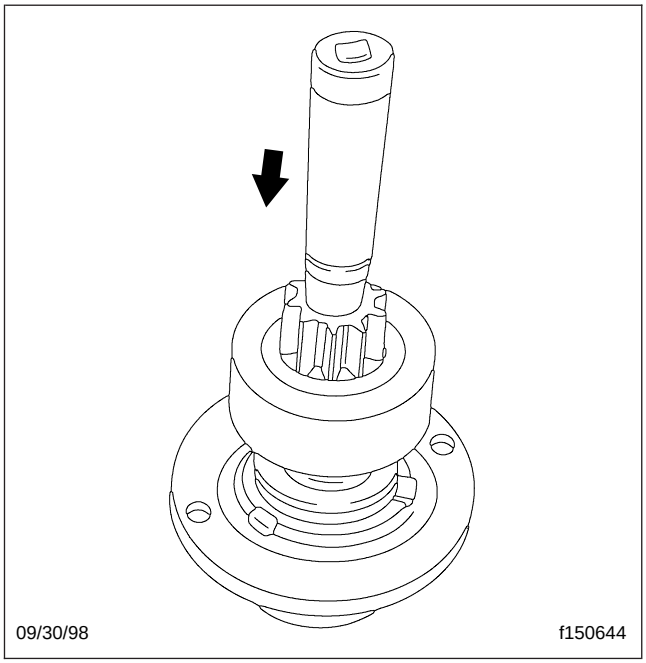


Fig. 13, Pinion Stop

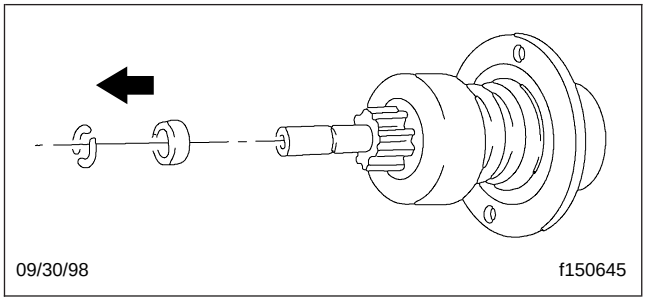


Fig. 14, Removing the Stop Ring and Pinion Stop

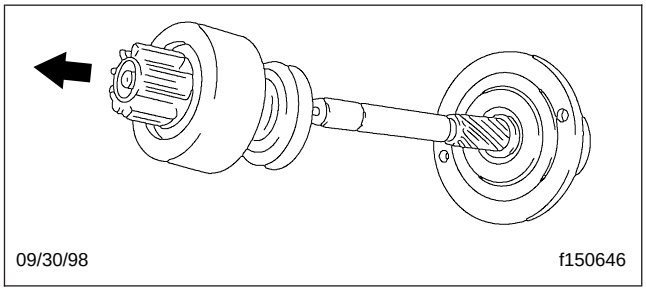


Fig. 15, Clutch Drive Assembly

NOTE: If the armature drive end bearing is damaged or unserviceable, perform the next two steps.

Starter Drive Assembly, Disassembly and Assembly

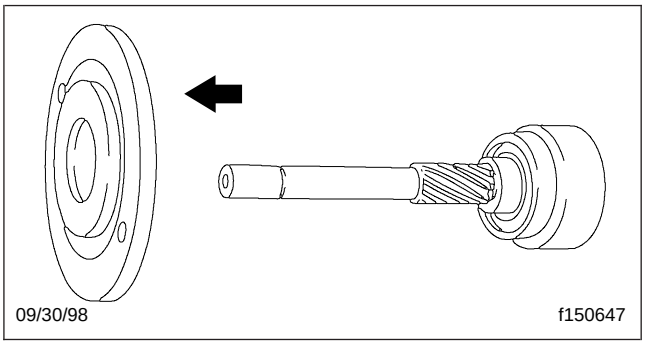
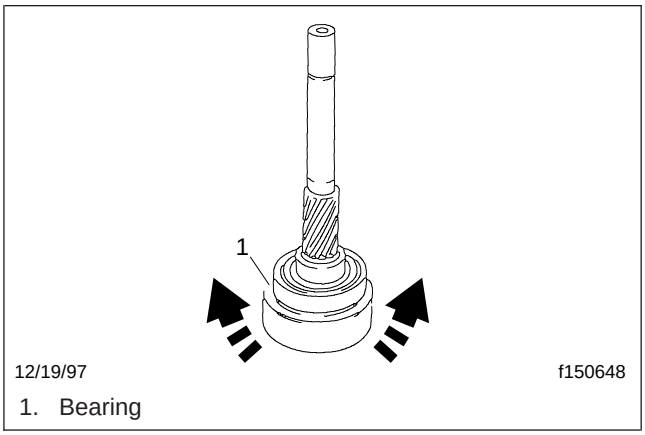


Fig. 16, Driveshaft Support



1. Bearing

Fig. 17, Inspect the Bearing

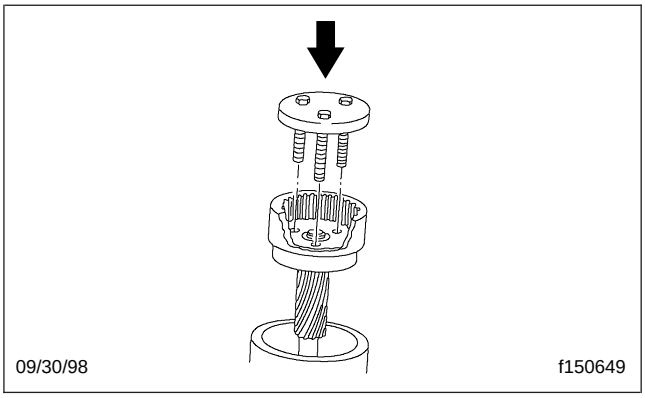
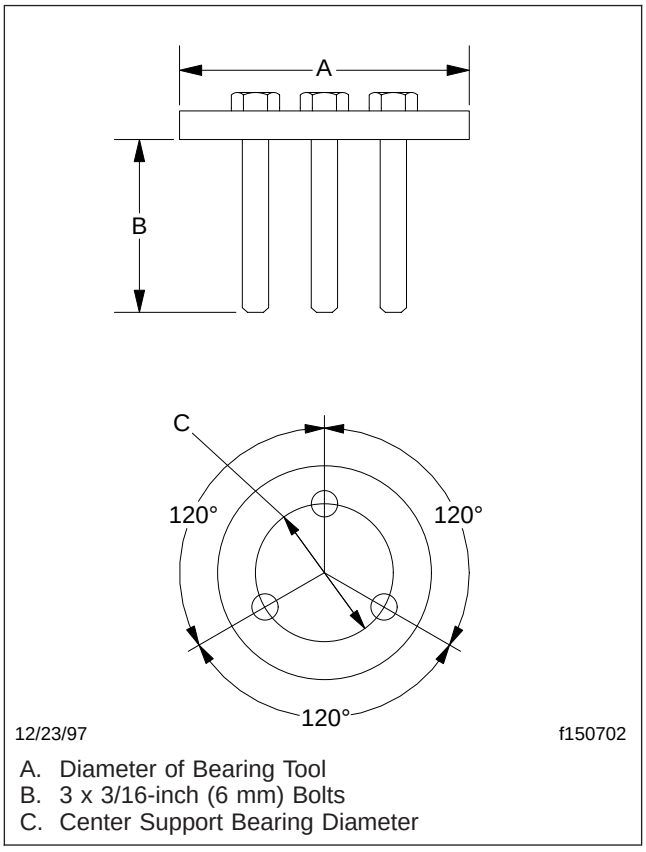


Fig. 18, Inspect the Bearing

20. Disassemble the commutator end of the starter motor. Refer to **Subject 140**.



A. Diameter of Bearing Tool
B. 3 x 3/16-inch (6 mm) Bolts
C. Center Support Bearing Diameter

Fig. 19, Center Support Bearing Removal Tool Dimensions

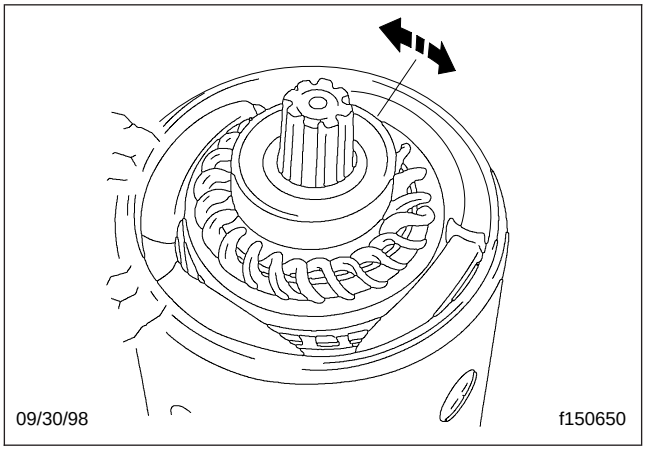


Fig. 20, Inspect the Bearing

CAUTION

The armature drive end bearing must be replaced with a new bearing whenever removed. Removal of the armature drive end bearing causes internal damage to the bearing.

21. Remove and discard the bearing. Use a suitable bearing puller. See **Fig. 21**.

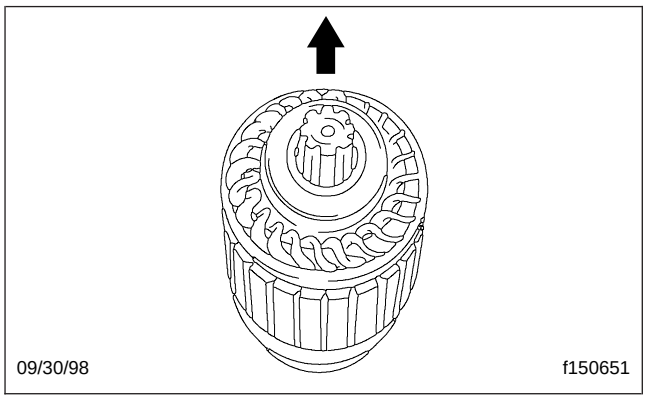


Fig. 21, Bearing Removal

22. Inspect the armature. Refer to **Group 15**.
23. Inspect the drive end housing bushing. Refer to **Group 15**.
24. Inspect the starter drive/flywheel ring gear. Refer to **Group 15**.

Assembly

NOTE: Perform the next two steps if the armature drive end bearing was removed.

1. Install the new bearing. See **Fig. 22**.
   - 1.1 Use a tube that bears on the bearing inner race and a suitable arbor press.
   - 1.2 Press on the bearing until the inner race bottoms out against the shoulder on the armature shaft.
   - 1.3 Check the bearing for binding and damage.
2. Assemble the commutator end of the starter motor. Refer to **Subject 140**.
3. If the center support bearing was removed, install a new bearing. See **Fig. 23**.

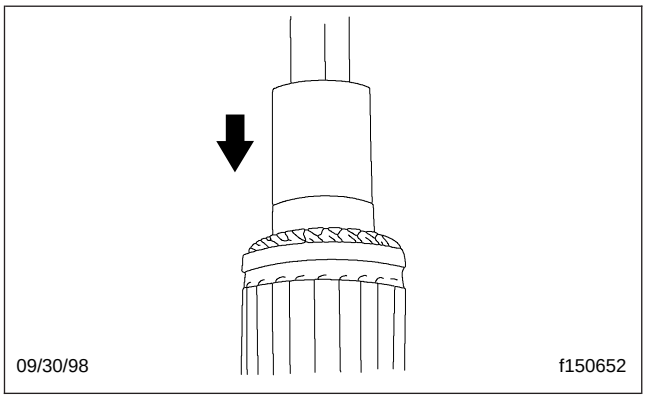


Fig. 22, Install a New Bearing

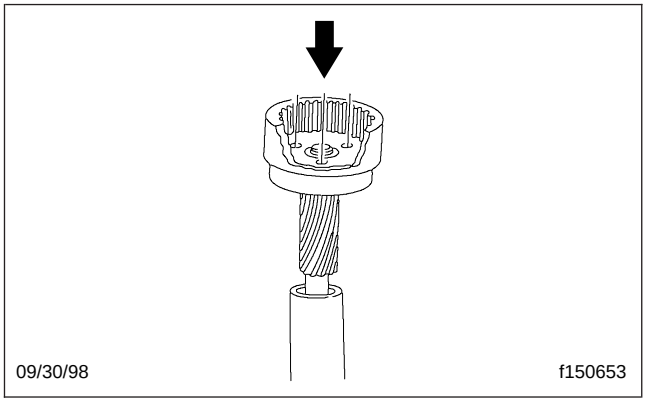


Fig. 23, Install a New Center Support Bearing

   - 3.1 Use a tube that bears on the bearing inner race and a suitable arbor press.
   - 3.2 Press on the bearing until the inner race bottoms out against the shoulder on the driveshaft.
   - 3.3 Check the bearing for binding and damage.
4. Install the driveshaft support. See **Fig. 24**.
5. Install the clutch drive assembly. See **Fig. 25**.
6. Position the new pinion stop and stop rings on the drive shaft. See **Fig. 26**.
7. Drive the pinion stop forward onto the stop rings.

   Use either a 9/16-inch or 14-mm open end wrench or the fabricated tool installed in a suitable vise. See **Fig. 27** and **Fig. 28**.
8. Stake the upper edge of the pinion stop in four equally spaced places. See **Fig. 29**.

Starter Drive Assembly, Disassembly and Assembly

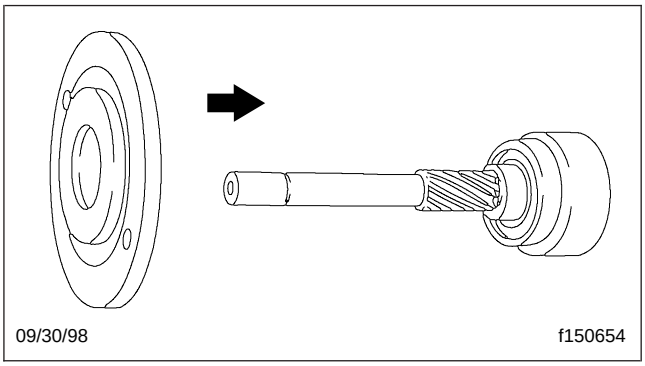


Fig. 24, Installing the Driveshaft Support

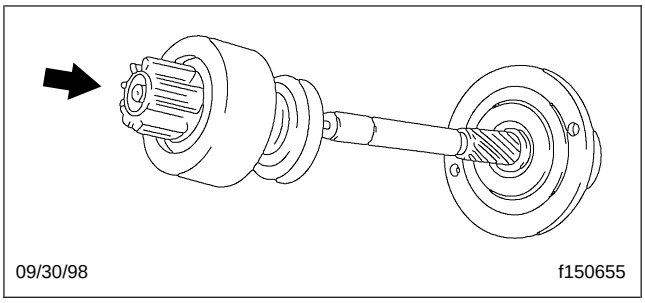


Fig. 25, Installing the Clutch Drive Assembly

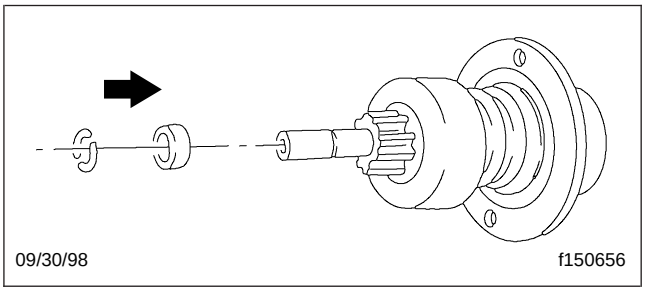


Fig. 26, Positioning a New Pinion Stop and Stop Ring

9. Position the shift lever. See **Fig. 30**.
10. Align the holes in the driveshaft support with the holes in the drive end housing and install the driveshaft and clutch assembly and the shift lever. See **Fig. 31**.
    - 10.1 Make sure the center support bearing is fully seated in the driveshaft support.
    - 10.2 Make sure the driveshaft support is fully seated in the drive end housing.
11. Install the bolt, washer and nut. Tighten the bolt to 40 lbf·in (500 N·cm). See **Fig. 32**.

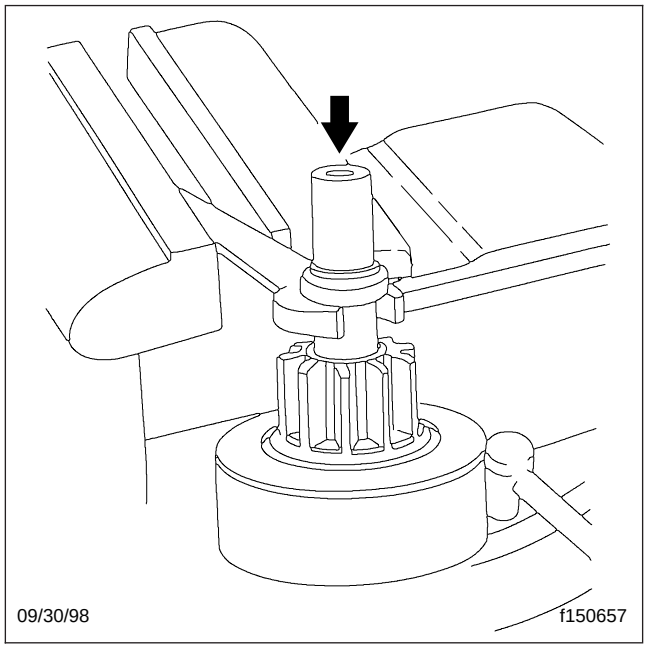
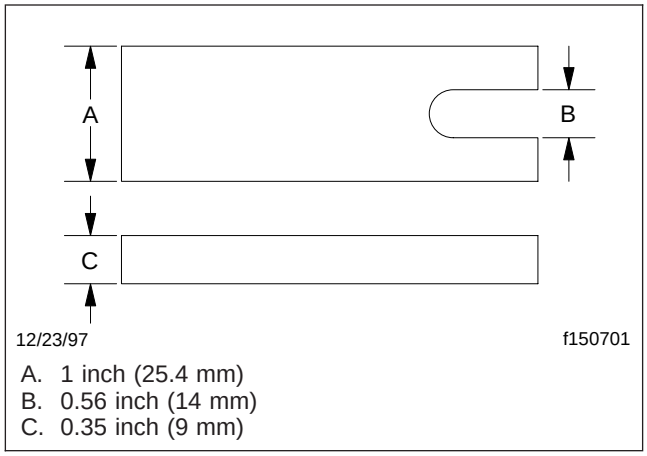


Fig. 27, Installing the Pinion Stop



A. 1 inch (25.4 mm)
B. 0.56 inch (14 mm)
C. 0.35 inch (9 mm)

Fig. 28, Fabricated Pinion Stop Installation Tool Dimensions

12. Install the plug. See **Fig. 33**.
13. Install the starter solenoid. See **Fig. 34**.
14. Position the thick washer, thin washer(s) and fiber washer. Align and install the armature support bracket. See **Fig. 35**.
15. Install the armature support bracket bolts. Tighten the bolts to 75 lbf·in (850 N·cm). See **Fig. 36**.

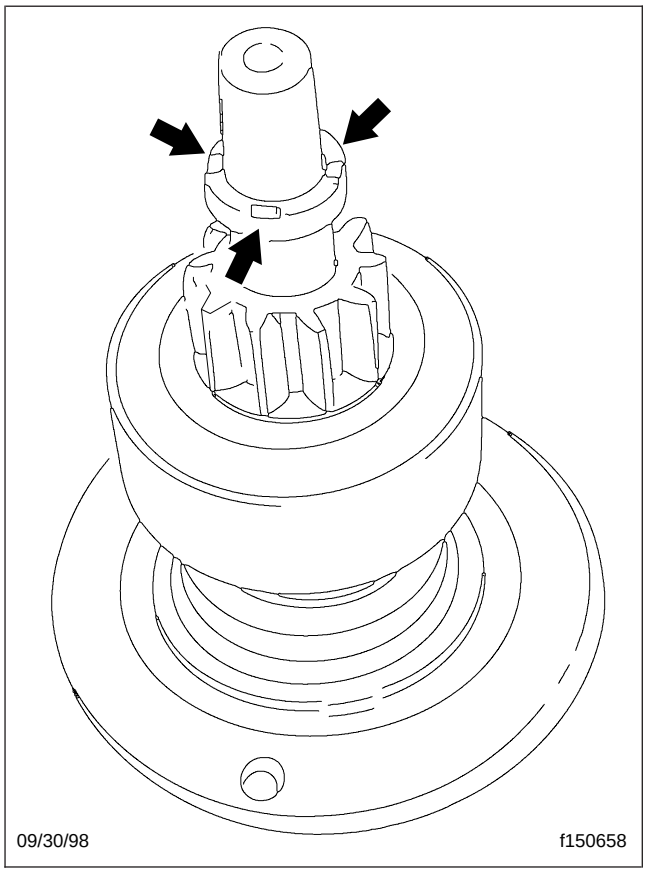


Fig. 29, Stake the Pinion Stop Equally

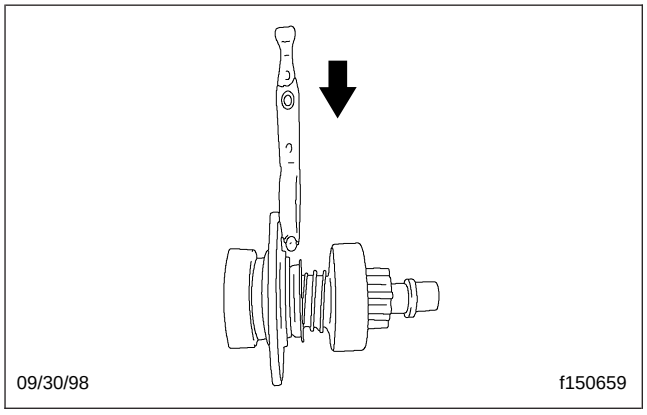


Fig. 30, Shift Lever in Position

16. Install the seal. See **Fig. 37**.
17. Align and install the drive end housing. See **Fig. 38**.

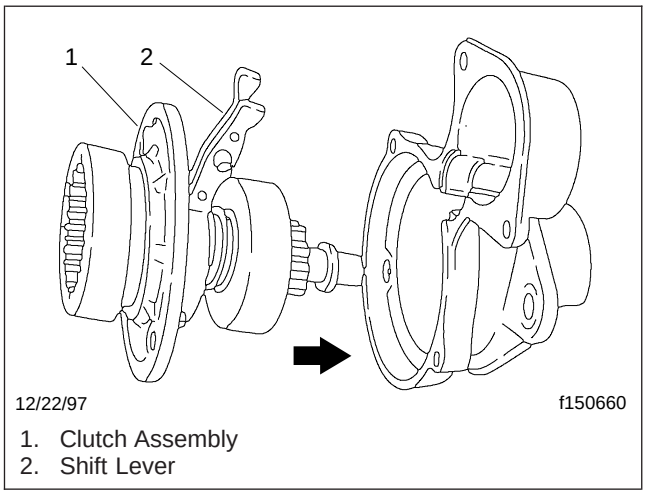


Fig. 31, Installing the Shift Lever and Clutch Assembly

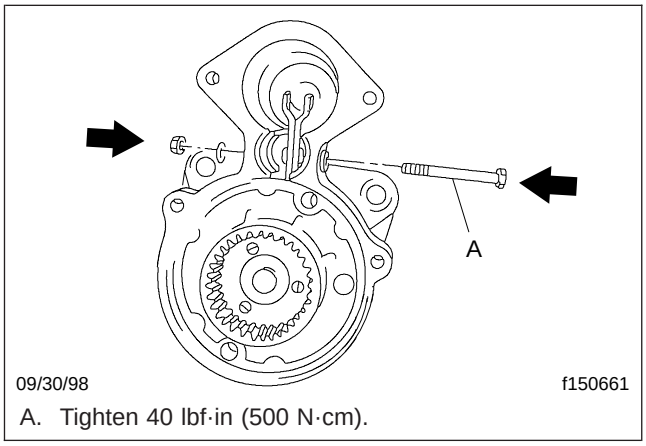
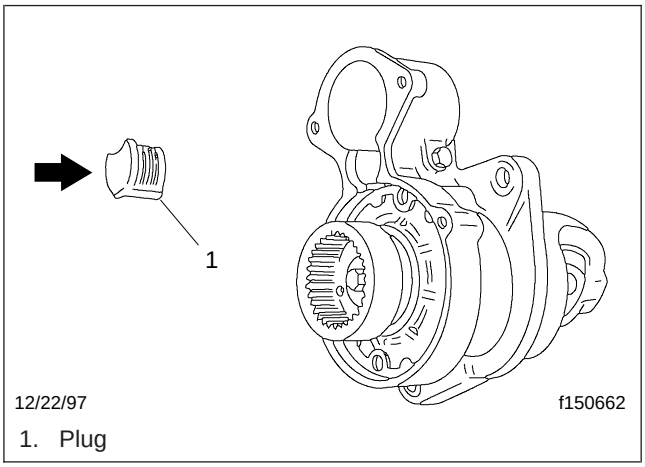


Fig. 32, Shift Lever Bolt

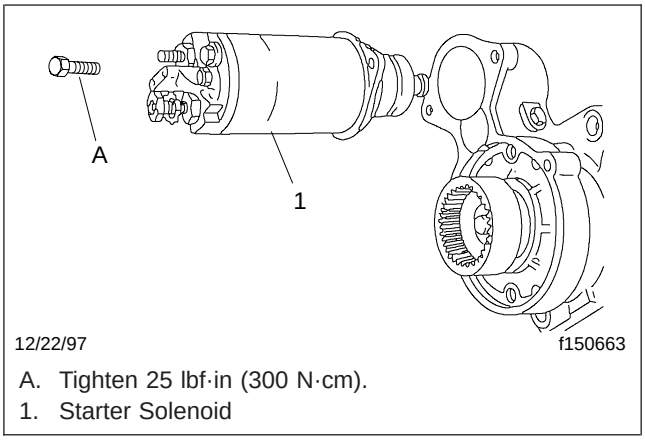
18. Install the bush cover bolts. Tighten the bolts to 25 lbf·in (300 N·cm). See **Fig. 39**.
19. Reconnect the starter motor strap. See **Fig. 40**.

Starter Drive Assembly, Disassembly and Assembly



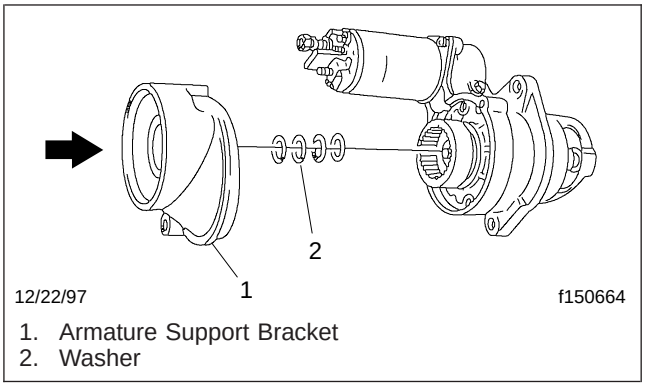
1. Plug

Fig. 33, Install the Plug



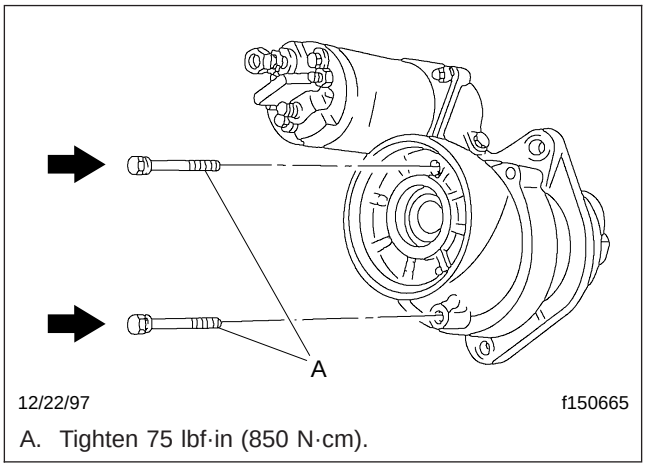
A. Tighten 25 lbf·in (300 N·cm).
1. Starter Solenoid

Fig. 34, Tighten the Solenoid Bolt



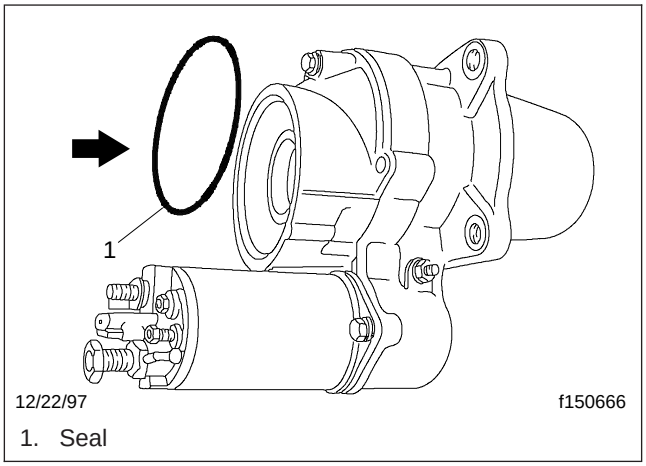
1. Armature Support Bracket
2. Washer

Fig. 35, Align and Install the Armature Support Bracket and Components



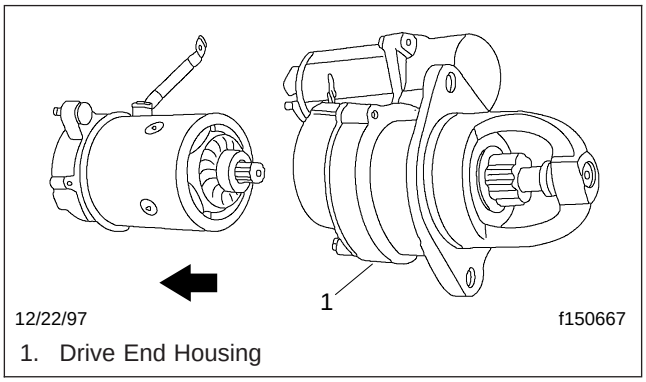
A. Tighten 75 lbf·in (850 N·cm).

Fig. 36, Armature Support Bracket Bolts



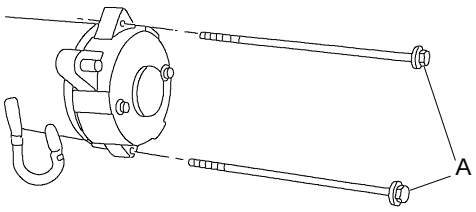
1. Seal

Fig. 37, Install the Seal



1. Drive End Housing

Fig. 38, Installing the Drive End Housing



12/22/97 f150668

A. Tighten the bolts to 25 lbf·in (300 N·cm).

Fig. 39, Install the Bush Cover Bolts

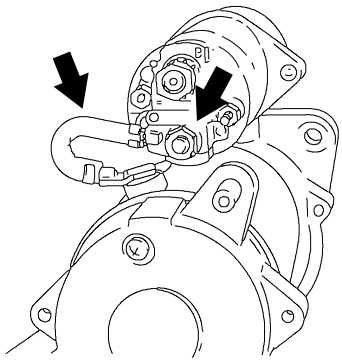


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Fig. 40, Connect the Starter Motor Strap

Disassembly

1. Scribe the brush cover and field frame. See **Fig. 1**.

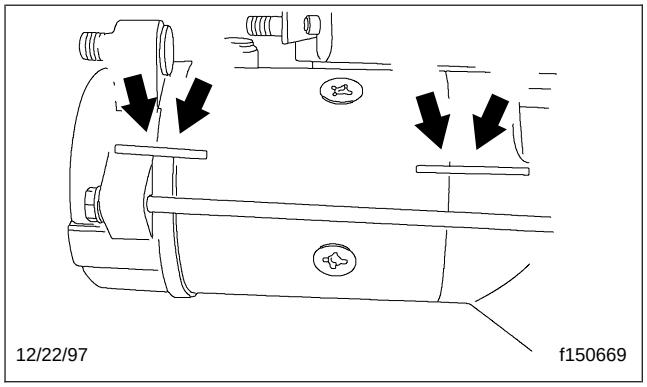


Fig. 1, Scribed Brush Cover and Field Frame

2. Disconnect the starter motor strap. See **Fig. 2**.

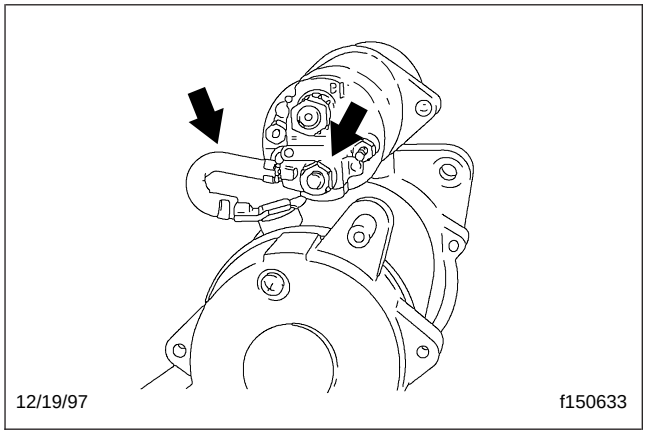


Fig. 2, Starter Motor Strap

3. Remove the brush cover bolts. See **Fig. 3**.
4. Remove the brush cover bolts. See **Fig. 4**.
5. Remove the brush cover.

   Use a plastic-tipped hammer, if necessary. See **Fig. 5**.
6. Remove and inspect the seal. See **Fig. 6**.
7. Scribe the brush holder and starter motor. See **Fig. 7**.

NOTE: During removal of the field frame, the locating pin installed between the field frame and the starter drive gear assembly may become loose. Use care not to lose the locating pin installed between the field frame and the starter drive gear assembly.

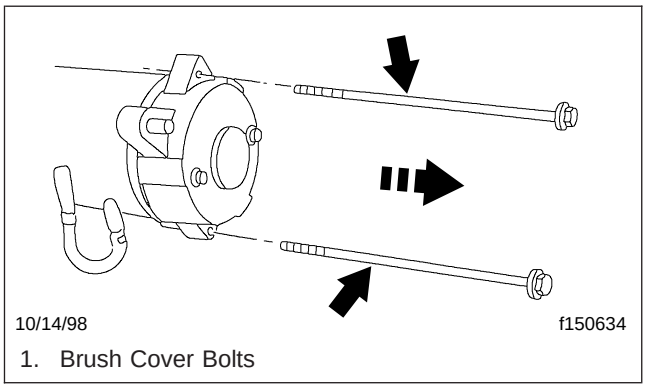


Fig. 3, Brush Cover Bolts

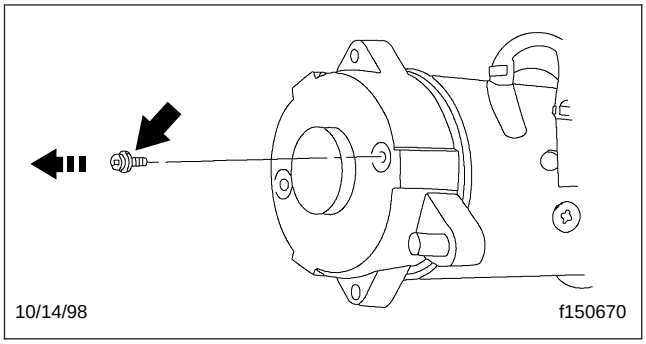


Fig. 4, Brush Cover Bolts

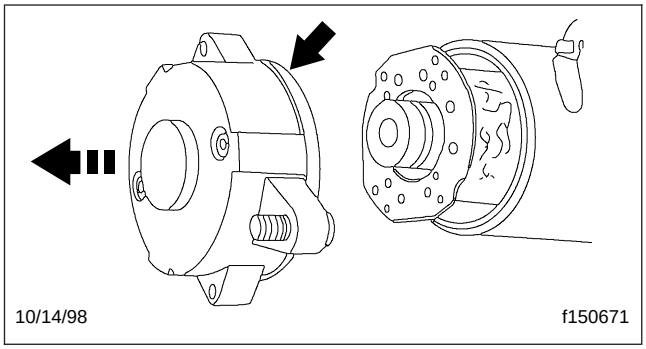


Fig. 5, Brush Cover Removal

8. Remove the field frame and brush holder assembly from the armature. See **Fig. 8**.
9. Disconnect the two insulated brush electrical leads. See **Fig. 9**.

Brushes Disassembly and Assembly

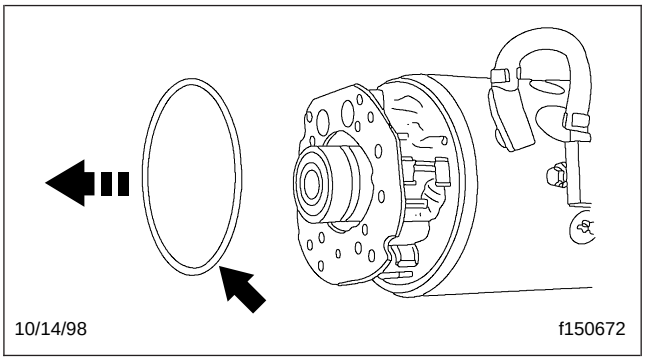


Fig. 6, Remove and Inspect the Seal

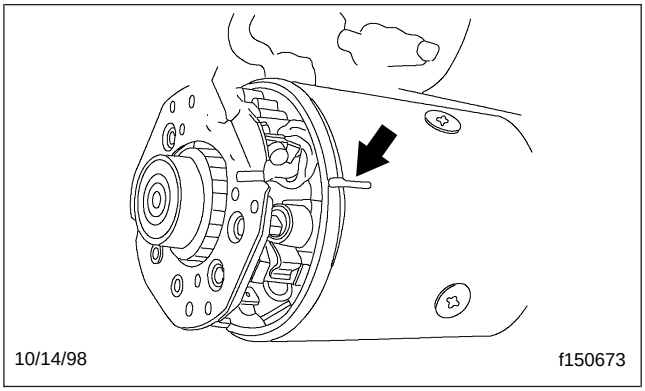


Fig. 7, Scribe the Brush Holder and the Starter Motor

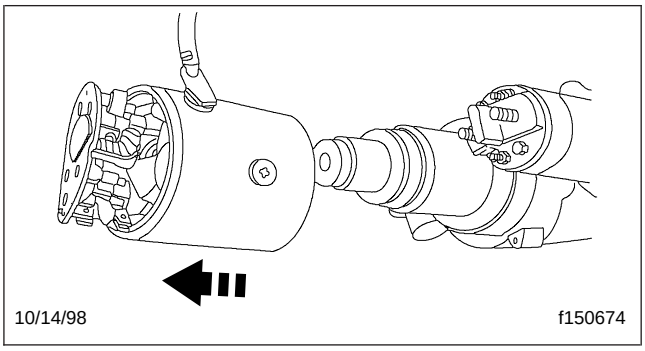
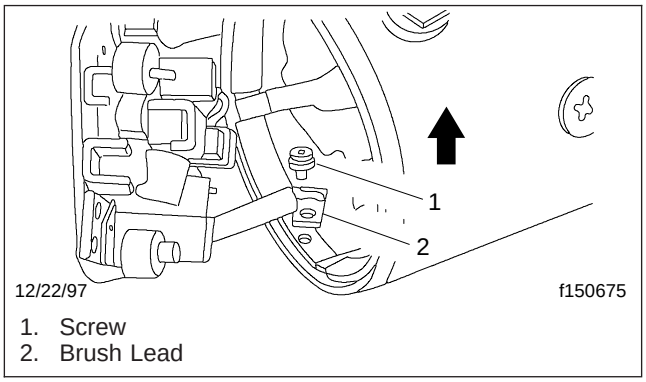


Fig. 8, Remove the Field Frame and Brush Holder from the Armature

10. Remove the brush holder assembly. See **Fig. 10**.
11. Disconnect the two grounded brush electrical leads. See **Fig. 11**.
12. Remove the four brushes from the brush holder. See **Fig. 12**.



1. Screw
2. Brush Lead

Fig. 9, Disconnect the Electrical Leads

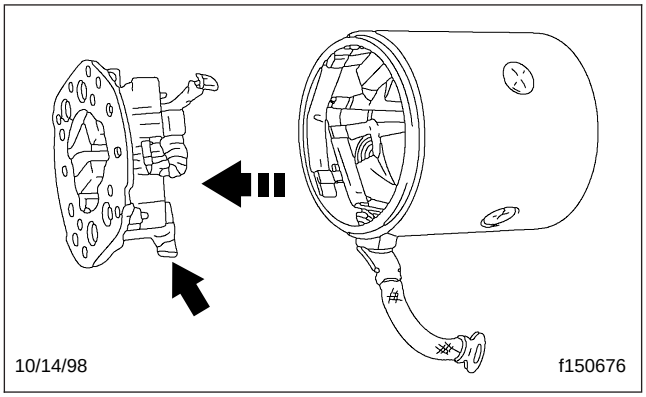
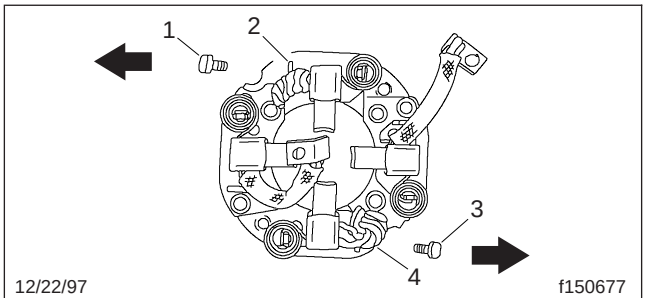


Fig. 10, Remove the Brush Holder Assembly



1. Screw
2. Grounded Brush Lead
3. Screw
4. Grounded Brush Lead

Fig. 11, Disconnect the Two Grounded Brush Leads

13. Inspect the bearing for damage, binding, or the feel of flat spots. See **Fig. 13**.

NOTE: Perform the next two steps if the bearing is unserviceable.

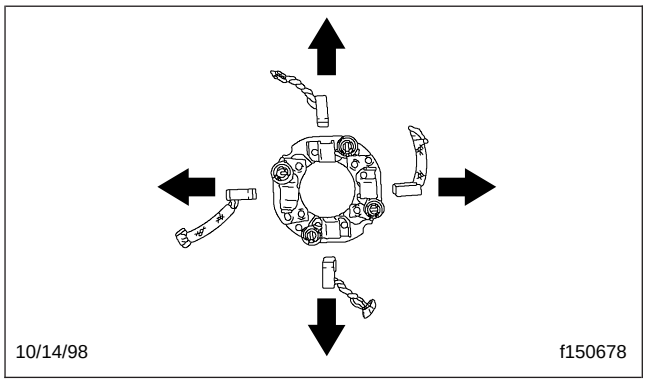


Fig. 12, Remove the Brushes from the Brush Holder

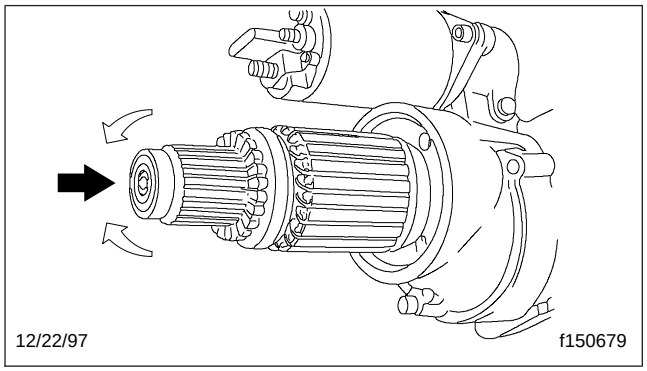
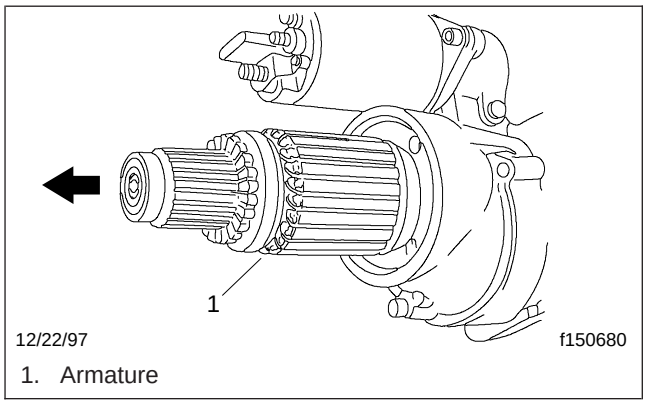


Fig. 13, Inspect the Bearing

14. Remove the armature. See **Fig. 14**.



1. Armature

Fig. 14, Remove the Armature

CAUTION

The armature commutator end bearing must be replaced with a new bearing whenever removed.

Removal of the armature commutator end bearing causes internal damage to the bearing.

15. Remove and discard the bearing.

    Use a suitable bearing puller. See **Fig. 15**.

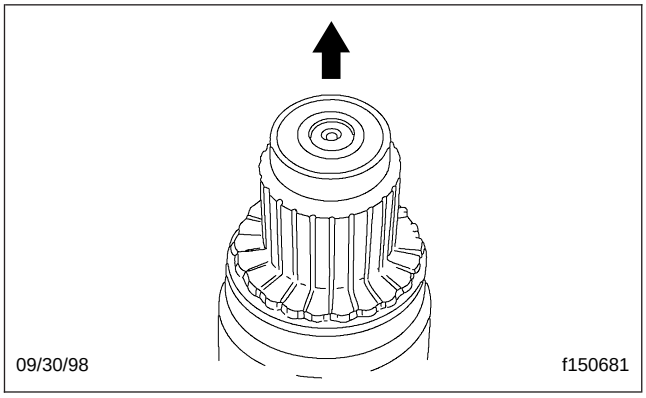


Fig. 15, Remove the Bearing

Assembly

1. Inspect the armature. Refer to **Group 15**.
2. Inspect the brush and brush holder. Refer to **Group 15**.
3. If the armature commutator end bearing was removed, install the new bearing. See **Fig. 16**.

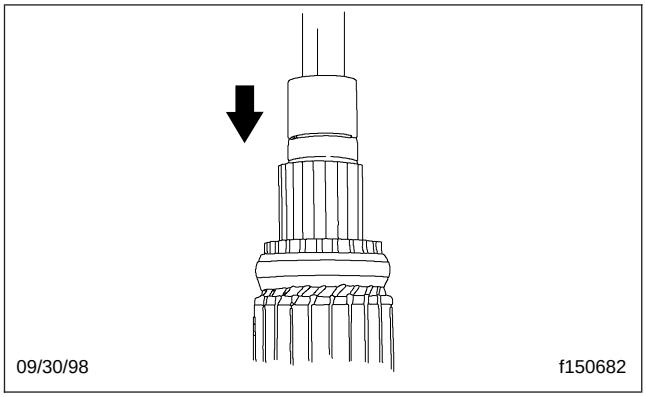


Fig. 16, Install a New Bearing

3.1 Use a tube that bears on the bearing inner race and a suitable arbor press.

3.2 Press on the bearing until the inner race bottoms out against the shoulder on the armature shaft.

Brushes Disassembly and Assembly

3.3 Check the bearing for binding and damage.

4. Install the armature. See **Fig. 17**.

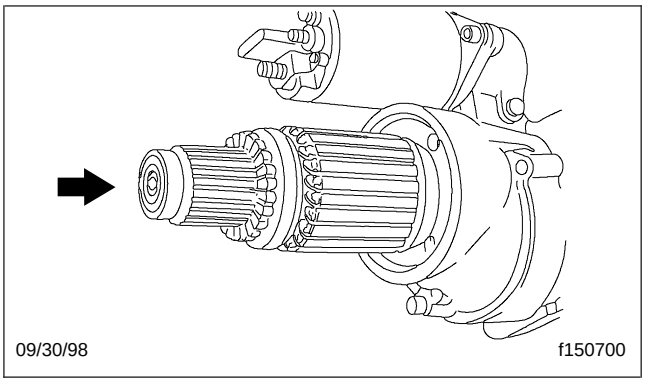


Fig. 17, Install the Armature

NOTE: Make sure the insulated and ground brushes are installed in proper holders.

5. Install and cage the four brushes. See **Fig. 18**.

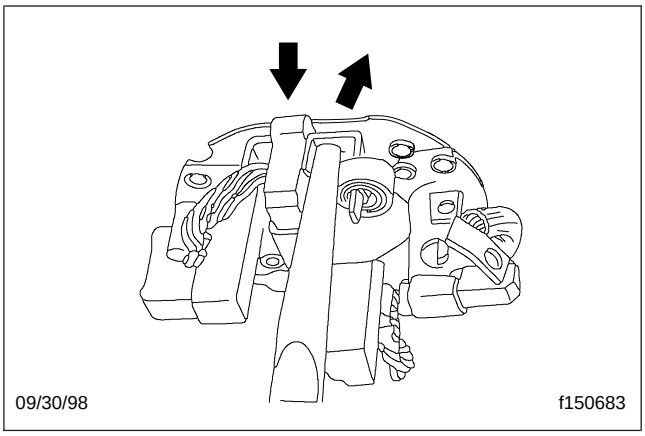


Fig. 18, Install and Cage the Four Brushes

6. Connect the two grounded brush electrical leads. See **Fig. 19**.
7. Align and position the brush holder assembly. See **Fig. 20**.
8. Connect the two insulated brush electrical leads. Tighten the leads to 13 lbf·in (200 N·cm). See **Fig. 21**.

NOTE: If the locating pin installed between the field frame and the starter drive gear assembly has been lost, it must be replaced with a 0.079-inch x 0.394-inch (2-mm x 10-mm) pin.

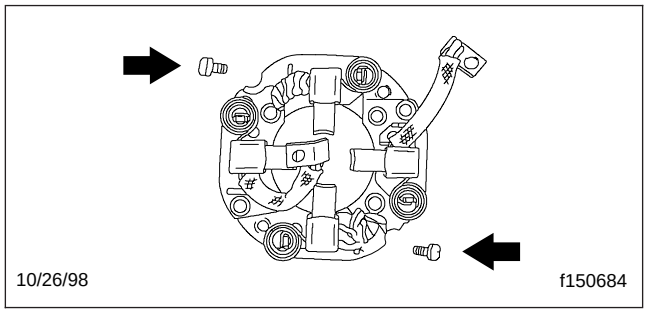


Fig. 19, Connect the Two Brush Leads

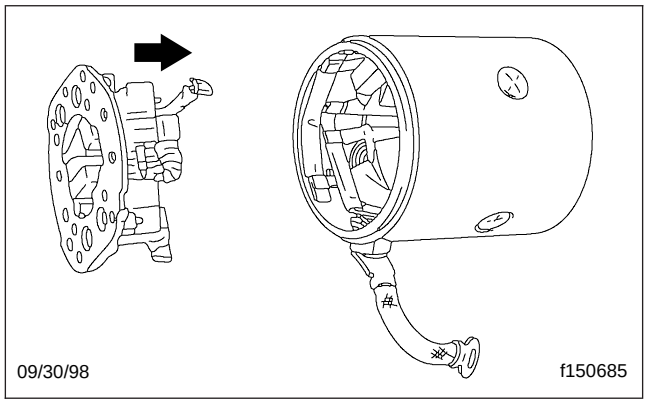
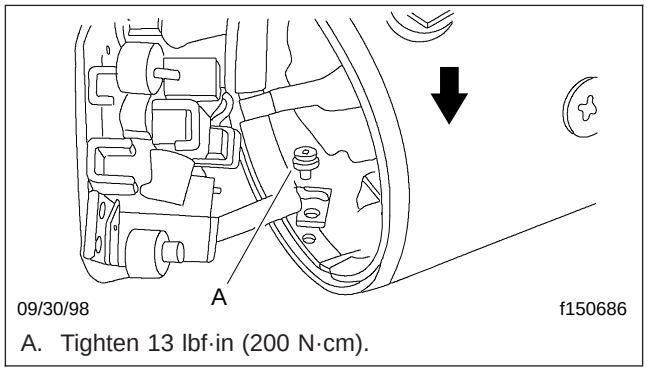


Fig. 20, Align and Position the Brush holder Assembly



A. Tighten 13 lbf·in (200 N·cm).

Fig. 21, Connect the Two Electrical Leads

9. Align and install the field frame and brush holder assembly on the armature shaft. See **Fig. 22**.
10. Release the four brushes. See **Fig. 23**.
11. Install the seal. See **Fig. 24**.

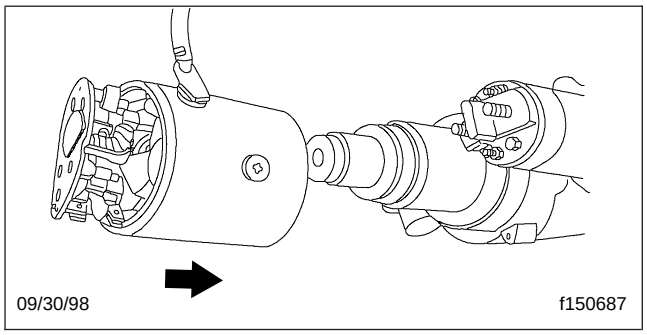


Fig. 22, Align and Install the Field Frame and Brush Holder

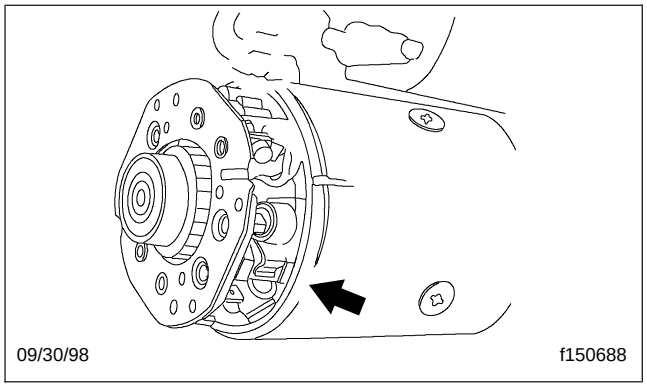


Fig. 23, Release the Four Brushes

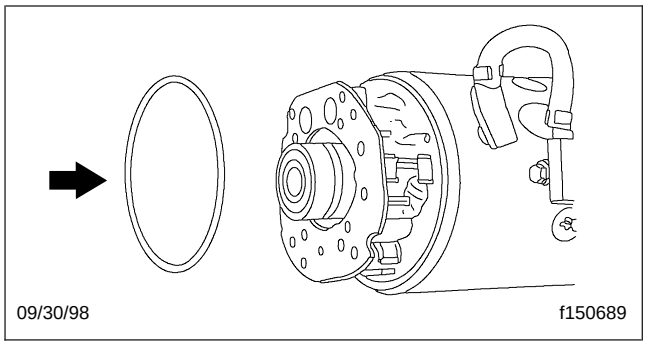


Fig. 24, Install the Seal

CAUTION

Use care not to damage the field frame seal during the installation of the brush end cover.

12. Align and position the brush end cover on the field frame. See **Fig. 25**.
13. Install the two bolts. Use a scribe to align the tapped holes in the brush holder assembly and the bolt holes in the brush cover. Tighten the bolts to 25 lbf·in (300 N·cm). See **Fig. 26**.

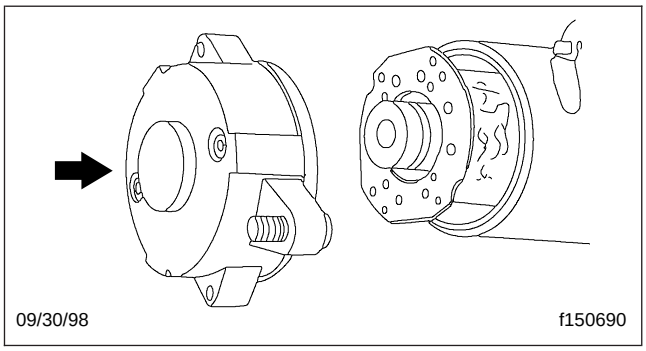
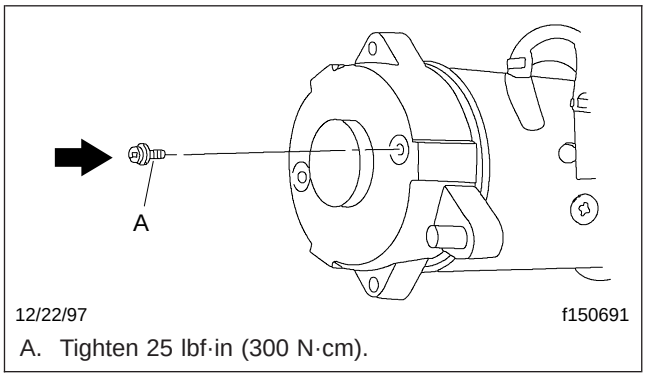


Fig. 25, Align and Install the Brush End Cover



A. Tighten 25 lbf·in (300 N·cm).

Fig. 26, Brush Holder Bolts

14. Align the timing spots on the brush cover and the field frame. See **Fig. 27**.

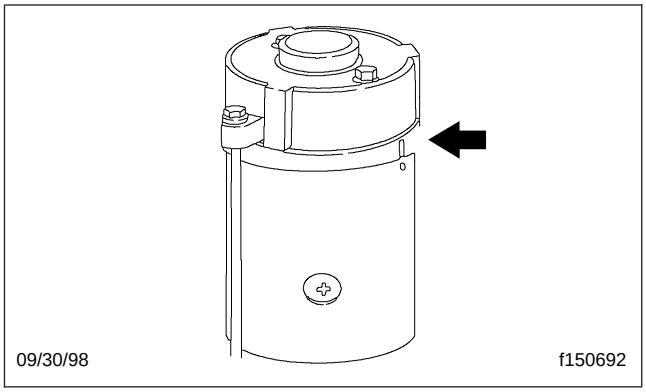
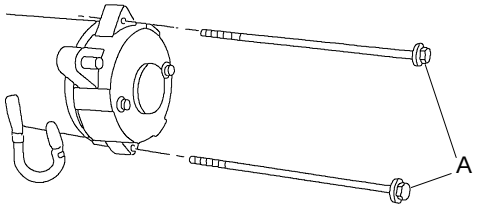


Fig. 27, Install the Brush Cover to the Field Frame

15. Install the two bolts and tighten them to 75 lbf·in (900 N·cm). See **Fig. 28**.

Brushes Disassembly and Assembly



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A. Tighten 75 lbf·in (900 N·cm).

Fig. 28, Tighten the Brush Cover Bolts

16. Connect the starter motor strap. See **Fig. 29**.

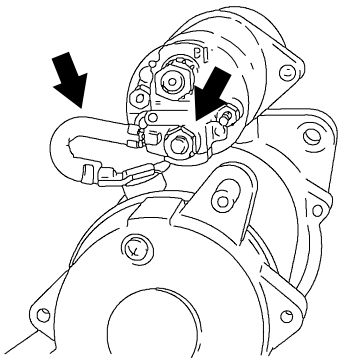

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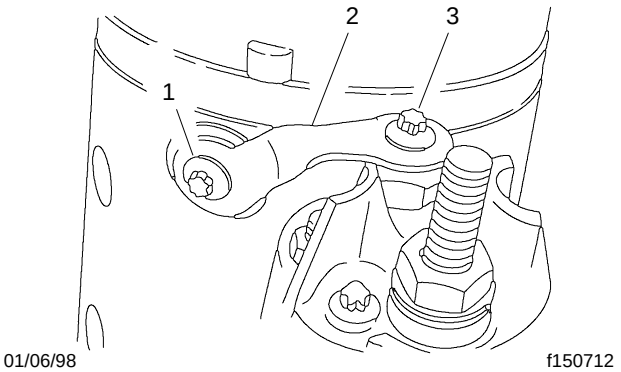
Fig. 29, Connect the Starter Motor Strap

Starter Drive Pinion Depth Adjustment

1. Remove the starter motor, if necessary. See **Fig. 1**.



1. Starter Connector
2. Starter Motor Strap
3. Solenoid Connector

Fig. 1, Starter Motor Strap

2. Remove the starter motor strap, if necessary.

NOTE: In order to properly perform this test, the M-terminal cannot touch the solenoid

3. Remove the M-terminal nut.
4. Carefully bend the M-terminal away from the back nut, to clear the nut and stud.
5. Place an insulating material between the M-terminal and the solenoid.
6. Connect a jumper lead between the battery positive terminal and starter solenoid S-terminal. See **Fig. 2**.
7. Connect a jumper lead between the battery negative terminal and a clean metal ground on the starter solenoid case. See **Fig. 3**.

NOTE: The starter drive will shift into the cranking position and remain there until the battery is disconnected.

8. Momentarily flash a jumper lead from the grounding point to the M-terminal. See **Fig. 4**.
9. Press on the overrunning clutch just enough to remove any starter drive assembly free travel.

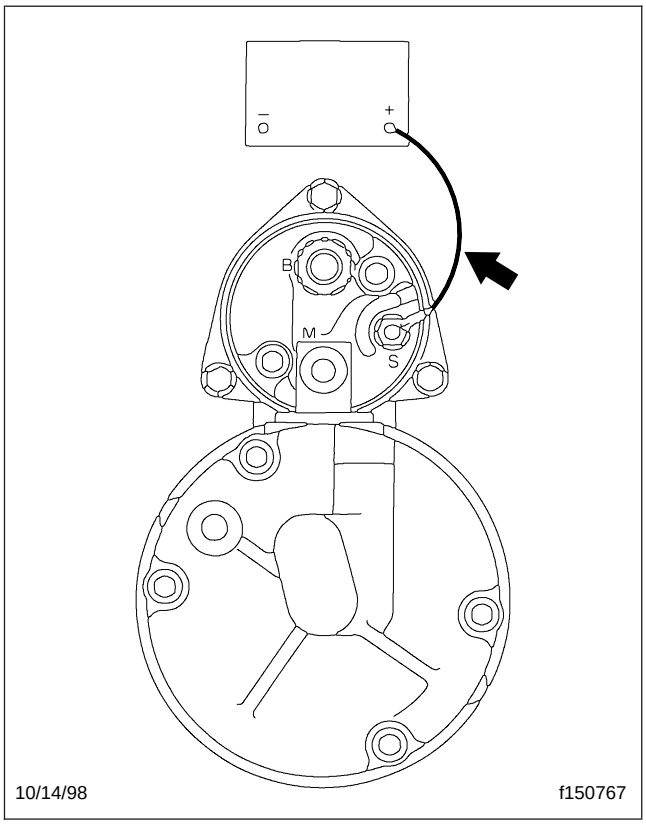


Fig. 2, S-Terminal Jumper Lead to Battery

10. Measure the distance between the starter drive pinion and the end housing. The clearance must be within the specifications shown. See **Fig. 5**.

NOTE: If the solenoid plunger shaft turns, the starter solenoid must be removed so the solenoid plunger shaft can be held.

11. If the clearance is not within the specifications, then adjust it by removing the access plug and turning the solenoid plunger shaft nut. See **Fig. 6**.

Starter Drive Pinion Depth Adjustment

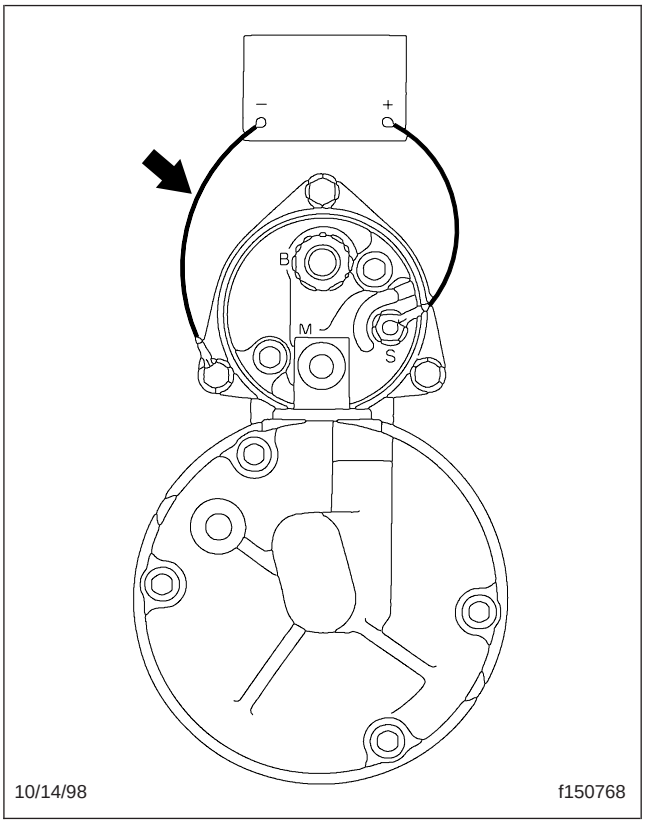


Fig. 3, Battery Negative Terminal Lead

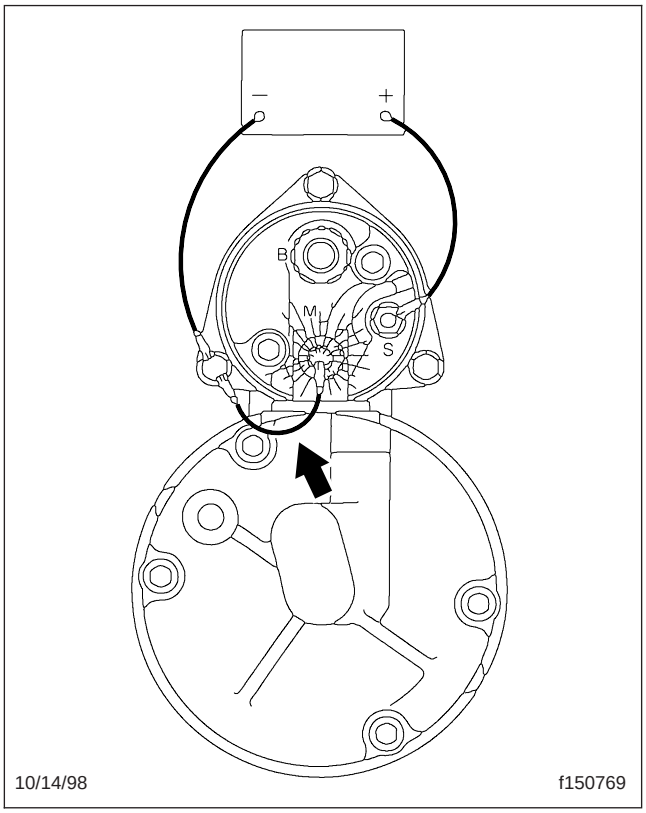


Fig. 4, M-Terminal Lead

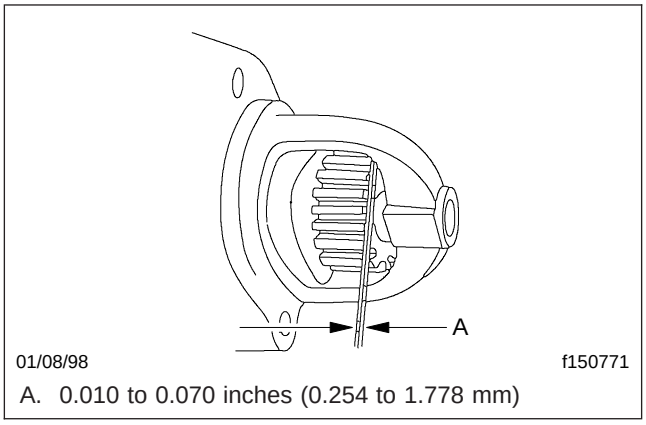
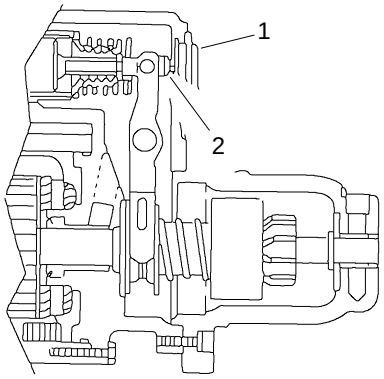


Fig. 5, Starter Drive Pinion/End Housing Clearance

Starter Drive Pinion Depth Adjustment



1. Access Plug
2. Solenoid Plunger Shaft Nut

Fig. 6, Pinion Depth Adjustment

General Specifications	
Item	**Specification**
Lubricants	
Silicone Dielectric Compound D7AZ–19A331–A	ESE–M1C171–A
Multipurpose Lubricant	—
SAE 20W Motor Oil	—

Table 1, General Specifications

General Specifications	
Starter Motor	
Type	**Delco Remy Model 28–MT 12-Volt Starter**
Current Draw Under Normal Load	300—600A
Minimum Stall Torque	41 lbf·ft (55 N·m) @ 4.5V
Maximum Load	750A
No-Load Current Draw	170A
No-Load Speed	5600 rpm
Brush Length Wear Limit	0.472 in (12 mm)
Commutator Wear Limit	1.378 in (35 mm)
Commutator Undercut Depth Wear Limit	0.008 in (0.2 mm)
Maximum Commutator Runout	0.005 in (0.127 mm)
Maximum Starting Circuit Voltage Drop (Battery Positive Terminal-to-Starter Terminal at Normal Engine Operating Temperature	0.5V
Pull-In Winding Current Consumption	52–59A 10V 0.17–0.19 ohms
Hold-In Winding Current Consumption	12–14A 10V 0.76–0.81 ohms

Table 2, General Specifications

General Specifications	
Starter Motor	
Type	**Delco Remy Model 37–MT 12-Volt Starter**
Current Draw Under Normal Load	400–500A
Minimum Stall Torque	15 lbf·ft (21 N·m) 1.6V 600A
Maximum Load	1400A
No-Load Current Draw	130–175A @ 11V
No-Load Speed	6100–6700 rpm @ 1V
Brush Length—New	0.98 inch (24.89 mm)
Brush Length—Wear Limit	0.65 inch (16.51 mm)
Brush Spring Tension—New	3.8 lb (1.75 kg)
Brush Spring Tension—Wear Limit	2.4 lb (1.09 kg)
Maximum Commutator Runout	0.005 inch (0.127 mm)
Maximum Starting Circuit Voltage Drop (Battery Positive Terminal-to-Starter Terminal at Normal Engine Operating Temperature)	0.5V
Starter Drive Pinion Depth Adjustment	0.010–0.070 inch (0.254–1.778 mm)

Table 3, General Specifications

General Specifications	
Starter Motor	
Type	**Delco Remy Model 42–MT 12-Volt Starter**
Current Draw Under Normal Load	400–500A
Minimum Stall Torque	15 lbf·ft (21 N·m) 1.6V 600A
Maximum Load	1400A
No-Load Current Draw	100–170A @ 11V
No-Load Speed	5500–7800 rpm @ 11V
Brush Length—New	0.98 inch (24.89 mm)
Brush Length—Wear Limit	0.65 inch (16.51 mm)
Brush Spring Tension—New	3.8 lb (1.75 kg)
Brush Spring Tension—Wear Limit	2.4 lb (1.09 kg)
Maximum Commutator Runout	0.005 inch (0.127 mm)

Specifications

General Specifications	
Maximum Starting Circuit Voltage Drop (Battery Positive Terminal-to-Starter Terminal at Normal Engine Operating Temperature)	0.5V
Starter Drive Pinion Depth Adjustment	0.330–0.392 inch (8.3–9.9 mm)

Table 4, General Specifications

Torque Specifications (Delco Remy Model 28–MT 12-Volt Starter)		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Brush Plate Screws	—	25 (30)
Brush Electrical Lead Screws	—	13 (20)
Drive End Housing Bolts	—	75 (90)
Shift Lever Bolt and Nut	—	40 (50)
Solenoid Mounting Bolts	—	25 (30)
Starter Mounting Bolts	30–46 (40–64)	—
Through-Bolts	—	75 (90)

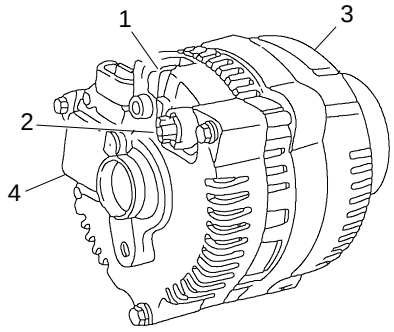
Table 5, Torque Specifications (Delco Remy Model 28-MT 12-Volt Starter)

Torque Specifications (Delco Remy Model 37–MT and 42–MT 12-Volt Starters)		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Brush End Cover Mounting Bolts	—	44–53 (500–600)
Drive End Housing Mounting Bolts	13–21 (18–29)	—
Shift Lever Housing Mounting Bolts	13–16 (17–22)	—
Starter Motor Mounting Bolts	40–70 (54–94)	—
Starter Solenoid Mounting Bolts	11–15 (15–21)	—

Table 6, Torque Specifications (Delco Remy Model 37-MT 12-Volt Starter)

General Information (See Fig. 1)

The Motorcraft 95 ampere alternator is belt-driven from the engine. Field current is supplied from the voltage regulator, mounted on the rear of the alternator, to the rotating field of the alternator through two alternator brushes and two rotor slip rings.



1. S-Terminal
2. B+ Terminal
3. Alternator
4. Voltage Regulator

Fig. 1, Motorcraft 95 Ampere Alternator

The alternator produces power in the form of alternating current. The alternating current is rectified to direct current by six diodes. The voltage regulator automatically adjusts the alternator field current to maintain the alternator output voltage within prescribed limits to correctly charge the battery. The alternator is self-current limiting.

Alternator Removal and Installation

Removal

NOTE: The alternator removal and installation procedure is typical.

1. Disconnect the negative battery cable from the battery. See **Group 54** in this manual.
2. Remove the drive belt. See **Group 01** in this manual.
3. Disconnect the wire harness attachments from the rear of the alternator assembly. See **Fig. 1**.

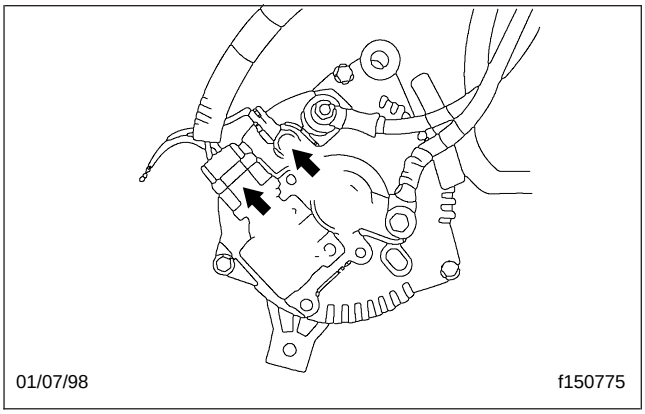


Fig. 1, Alternator Wiring Harnesses

4. Disconnect the positive and negative alternator cables. See **Fig. 2**.

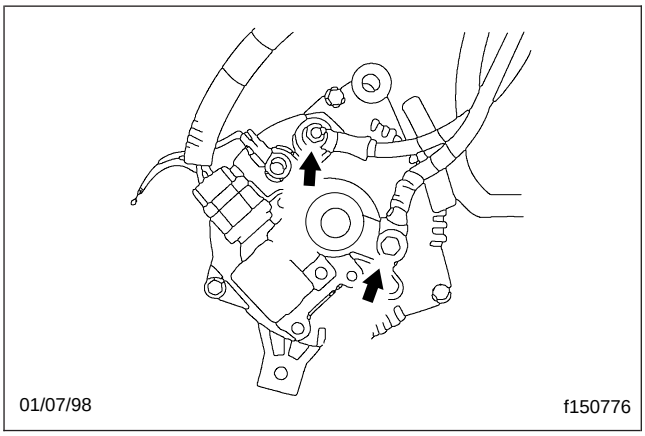
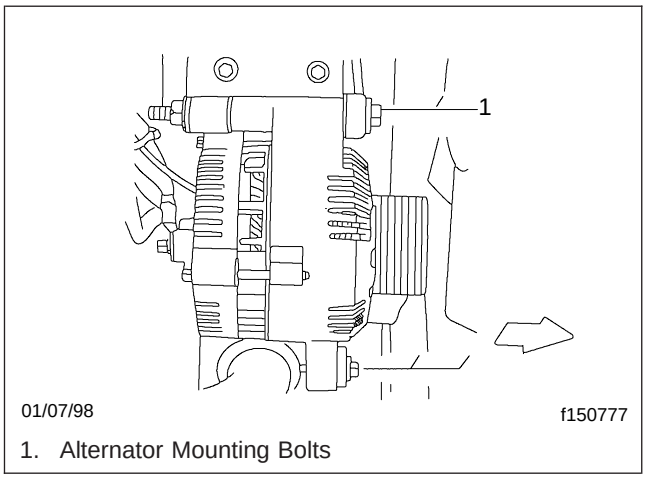


Fig. 2, Positive and Negative Alternator Cables

5. Remove the mounting bolts from the alternator, and remove the alternator. See **Fig. 3**.

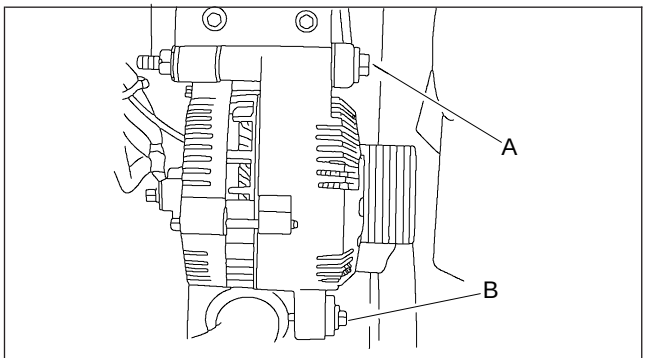


1. Alternator Mounting Bolts

Fig. 3, Alternator Mounting Bolts

Installation

1. Position the alternator and install the mounting bolts finger tight. If an automatic serpentine belt tensioner is used, tighten the upper bolt to 50 to 70 lbf·ft (68 to 95 N·m) and tighten the lower bolt to 22 to 32 lbf·ft (30 to 43 N·m). See **Fig. 4**.



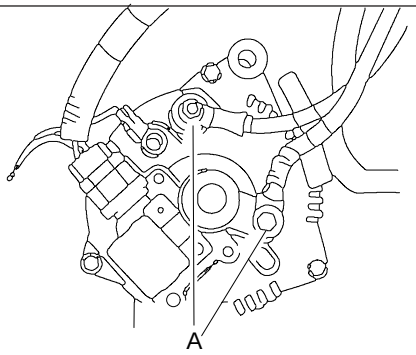
A. Tighten 50 to 70 lbf·ft (68 to 95 N·m).
B. Tighten 22 to 32 lbf·ft (30 to 43 N·m).

Fig. 4, Alternator Bolt Tightening

2. Install the drive belt.
3. Tension the drive belt, then tighten the alternator mounting bolts to the proper torque noted in the previous step.
4. Connect the two wiring harnesses on the rear of the alternator.

Alternator Removal and Installation

5. Connect the positive and negative cables and tighten the nuts to 15 to 30 lbf·in (170 to 340 N·cm). See **Fig. 5**.



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A. Tighten 15 to 30 lbf·in (170 to 340 N·cm).

Fig. 5, Tightening Alternator Cables

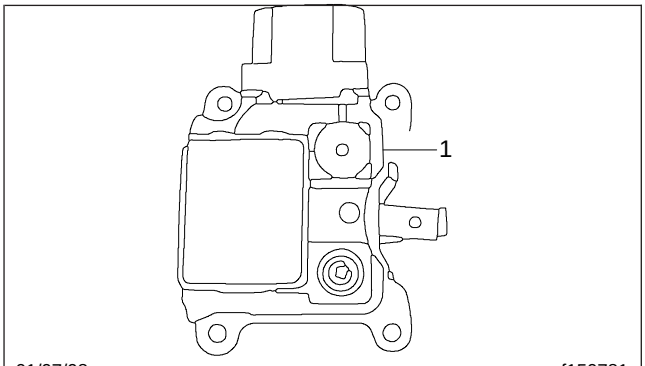
6. Connect the negative battery battery cable.

Replacement

1. Disconnect the negative battery terminal from the battery.
2. Disconnect voltage regulator electrical connector.

NOTE: Only the regulator, brush holder and generator pulley are serviceable. If the generator needs further service, it must be replaced as an assembly.

3. Remove the screws retaining the voltage regulator to the generator rear housing, and remove the voltage regulator.
4. Remove the tab covering the screw head with a screwdriver. See **Fig. 1**.



1. Tab Covering

Fig. 1, Screw Tab

5. Remove the screws retaining the voltage regulator to the brush holder.
6. Separate the brush holder from the voltage regulator. See **Fig. 2**.
7. Put the new voltage regulator into the brush holder.
8. Install the retaining screws.
9. Install the tab covering the screw head. See **Fig. 1**.
10. Put the voltage regulator on the rear of the generator and install the retaining screws.
11. Connect the electrical connector.
12. Connect the battery ground cable to the battery.

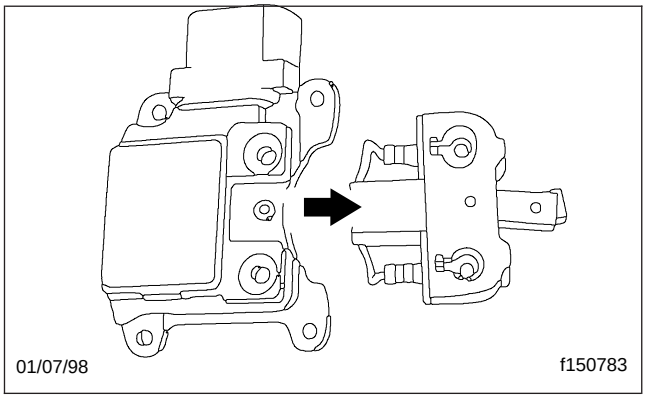


Fig. 2, Separating the Voltage Regulator from the Brush Holder

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

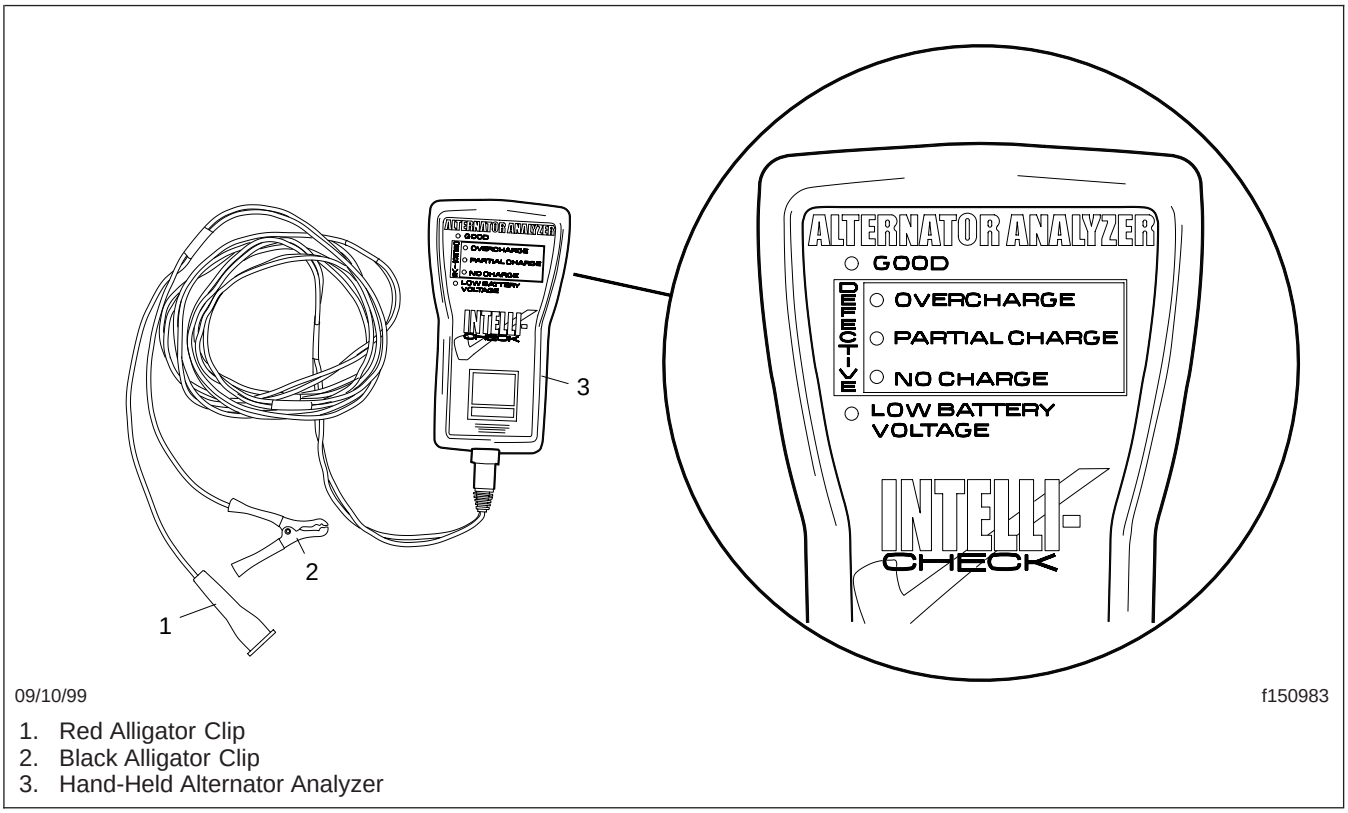
Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
    - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
        A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
        B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
        C. Repeat the applicable steps of the Pre-Test Procedure.
    - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
    - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
    - If the **GOOD** (green) LED illuminates, proceed to the next step.
    - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
    - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging

Troubleshooting



1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

system using the instructions in "Alternator/Charging System Testing."

4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/ Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing".

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

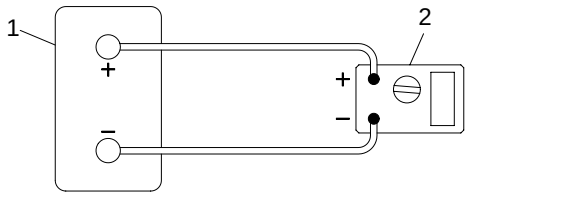
1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

2. Check the alternator output without a load. See **Fig. 3**.



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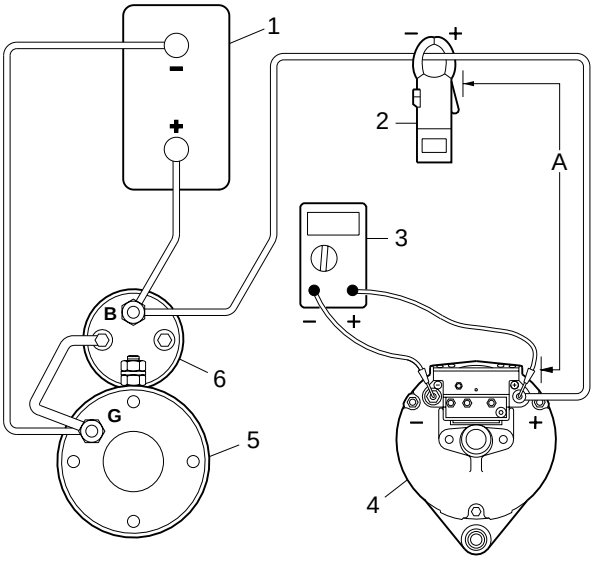
1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)



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A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Test

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3**.

3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

- Both front and rear heater blowers (on HIGH)
- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

Troubleshooting

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

Specifications

Alternator Specifications							
Supplier	Rating		Slip Ring Turning		Brush Length		Pulley Nut
	Amperes @ 15V	Watts @ 15V	Minimum Diameter	Maximum Runout	New	Wear Limit	
Sterling	95 A	1425 W	1.04 in (26.4 mm)	0.0005 in (0.013 mm)	0.709 in (18 mm)	0.118 in (3 mm)	60–100 lbf·ft (82–135 N·m)

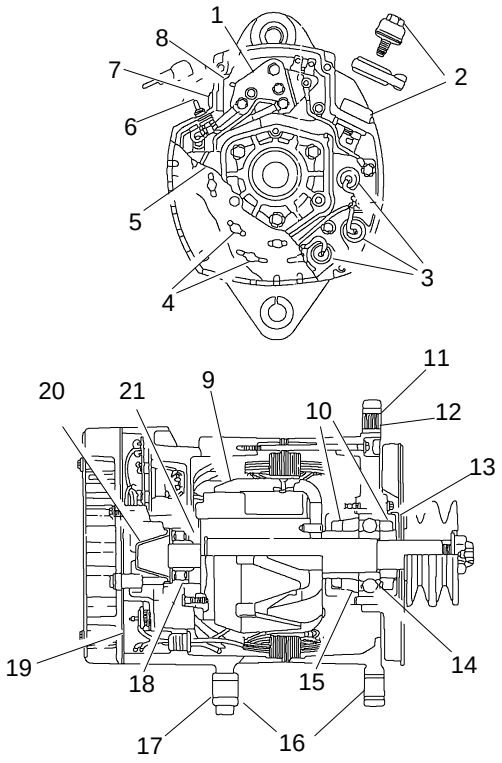
Table 1, Alternator Specifications

Torque Specifications		
Description	lbf·ft (N·m)	lbf·in (N·cm)
Front Housing Bearing Retainer Screws	—	25–42 (280–480)
Rectifier Assembly Retaining Screw	—	25–35 (280–480)
Brush Holder Retaining Screw	—	20–30 (230–340)
Voltage Regulator Retaining Screw	—	25–35 (280–480)
Engine Gauge Feed Wire to Alternator Bolt	—	15–30 (170–340)
Engine Gauge Feed Wire to Alternator Nut	—	15–30 (170–340)
Alternator Pivot Bolt	50–70 (68–95)	—
Alternator Mounting Bolt	22–32 (30–43)	—

Table 2, Torque Specifications

General Information

Delco Remy SI-series alternators (**Fig. 1**) feature a built-in diode rectifier and voltage regulator.



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1. Voltage Regulator
2. Output Terminal
3. Rectifiers
4. Air Inlet Baffles
5. Diode Trio/Capacitor Assembly
6. Relay Terminal
7. Access Plug
8. External Voltage Adjustment
9. Stationary Field Coil (Brushless)
10. Lip Seals
11. Steel Bushing
12. Locking Thread Insert
13. Labyrinth Seal
14. Heavy-Duty Ball Bearing
15. Grease Reservoir
16. Steel Mounting Bushings
17. Adjustable Bushing
18. Heavy-Duty Roller Bearing
19. Sealed Regulator and Rectifier Compartment
20. Grease Reservoir
21. Lip Seal

Fig. 1, Typical Delco Remy SI Series Alternator Components (30-SI shown)

The integrated-circuit voltage regulator is designed for low parasitic draw, and features a low turn-on speed. A special diode-trio/capacitor assembly provides superior radio frequency interference (RFI) suppression.

In SI series alternators, standard load dump protection guards the alternator against voltage spikes caused by loose connections or interruptions in the charging line, and environmental sealing protects against dirt, road salt, and other damaging materials.

Some SI series alternators can be operated in either a clockwise or counterclockwise direction, though the external fan may require changing for reverse rotation. They will work at continuous speeds of up to 10,000 alternator rpm, and can survive intermittent speeds up to 12,000 alternator rpm.

NOTE: Because of different pulley diameters, alternators usually spin much faster than actual engine rpm.

The ambient temperature range for proper operation of older models is -40 to 185°F (-40 to 85°C), but alternators designed for EPA07 and later engines are designed to withstand temperatures up to 221°F (105°C).

NOTE: Most alternators get their cooling air through ducts at the rear, exhausting out the pulley-end as the cooling fan sucks air through. Exhaust leaks near the alternator must be fixed immediately; they can severely damage the alternator.

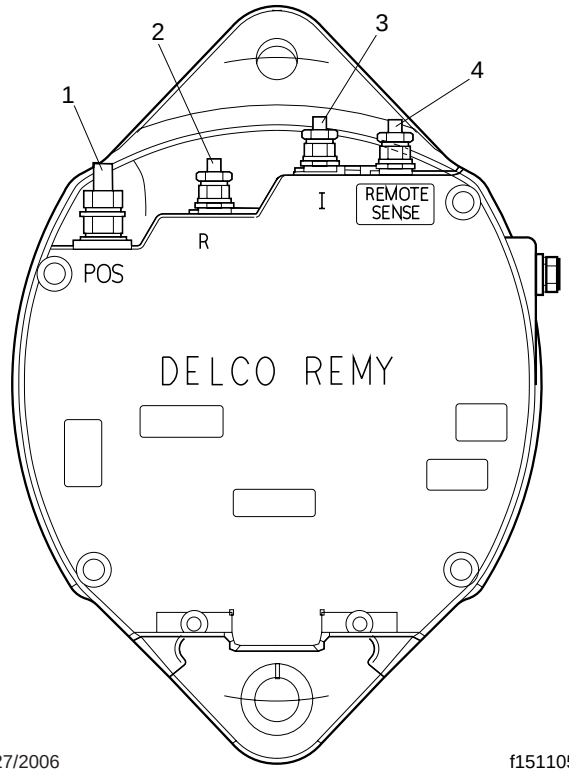
All alternators should be kept clean, to aid heat dispersal. Follow manufacturers' directions for cleaning; do not use high pressure spray or powerful solvents which can damage internal components.

The solid state, integrated circuit voltage regulator built into SI series alternators limits system voltage by switching the ground circuit for the alternator rotor field on and off. When the ground circuit is on, field current passes from a diode trio through the stationary field coil. Nominal regulated voltages of 13.8, 14.0, and 14.2 volts are available for 12-volt systems, and 27.8 volts for 24-volt systems.

An "R" or relay terminal may be present (see **Fig. 2**). This terminal can be used to operate some types of charge indicators, an ADLO system, a tachometer, or a similar device, by providing voltage pulses at about half of system voltage and at a frequency of 1 pulse for each 7.5 revolutions of the alternator. The current

General Information

draw of the accessories being powered through this terminal must not exceed 4 amperes. The R terminal is normally of the unthreaded pin type.



1. Output (BAT) Terminal
2. Relay (R) Terminal
3. Indicator Light (I) Terminal
4. Optional Remote Sense Terminal

Fig. 2, 35-SI and 36-SI Wiring Connectors

When an "I" terminal is present, it is connected internally to the field circuit, and is often used to power a dashboard alternator indicator light. That light shows when there is a voltage difference between the positive side of the field circuit and the system voltage at the other side of the indicator light.

During normal alternator operation, the light will be off since the diode trio output voltage equals the system voltage. A side benefit of this circuit is that current is passed through the field winding during engine start-up, resulting in a lower alternator turn-on speed. If an indicator light is not required, a diode or resistor can be used in place of a light bulb. Up to 1 ampere of current may be passed through this circuit to aid in alternator turn-on.

Some SI series alternators feature Remote Sense (see **Fig. 2**), where a fourth terminal on the alternator connects to the batteries to sense battery voltage and adjust alternator output, keeping the batteries at optimum charge.

Alternators for EPA07 and Later Engines

EPA07 engines require alternators that are resistant to higher temperatures. The 35-SI and 36-SI, brushless designs, are direct replacements for earlier alternators, such as the 33-SI and 34-SI. The 36-SI features 100-amp output at idle engine speeds, to run auxiliary equipment with minimum exhaust emissions and maximum fuel efficiency.

The 24-SI (see **Fig. 3**) is a brush-type EPA07 alternator available for some engines and applications. Its design features twin fans in the center of the housing, sucking air in from each end and exhausting it through openings around the middle of the alternator housing for optimal cooling. This is different from most alternators, where a fan at the drive end sucks air through the alternator from the rear.

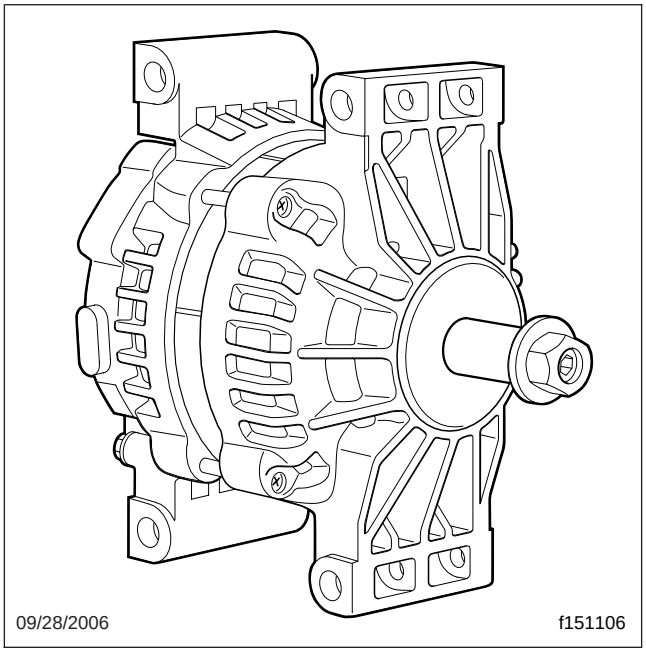


Fig. 3, Delco Remy 24-SI Pad Mount Alternator

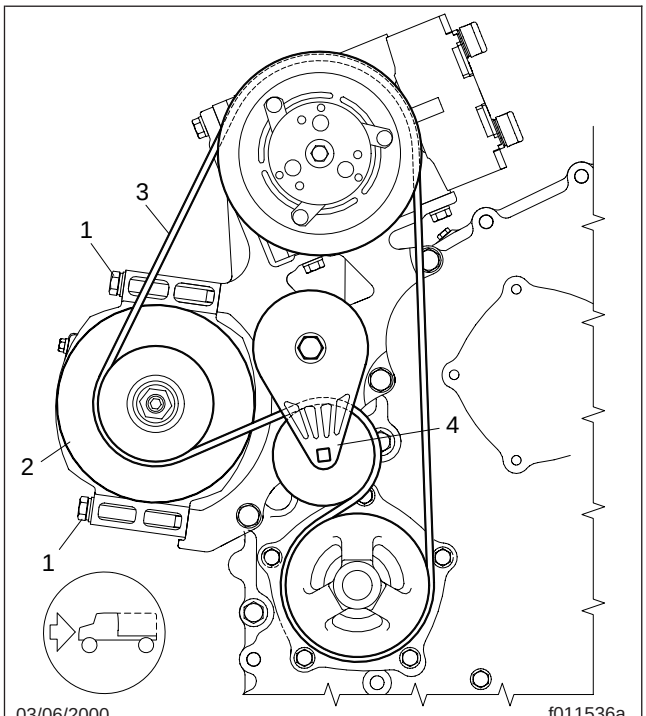
Pad-Mount Alternator Removal

NOTE: There are three common alternator mount configurations, as shown in **Fig. 1**, but most vehicles now use the pad mount.

1. Park the vehicle on a level surface, turn off all electrical loads such as lights, ignition, and accessories, set the parking brake, and chock the tires.

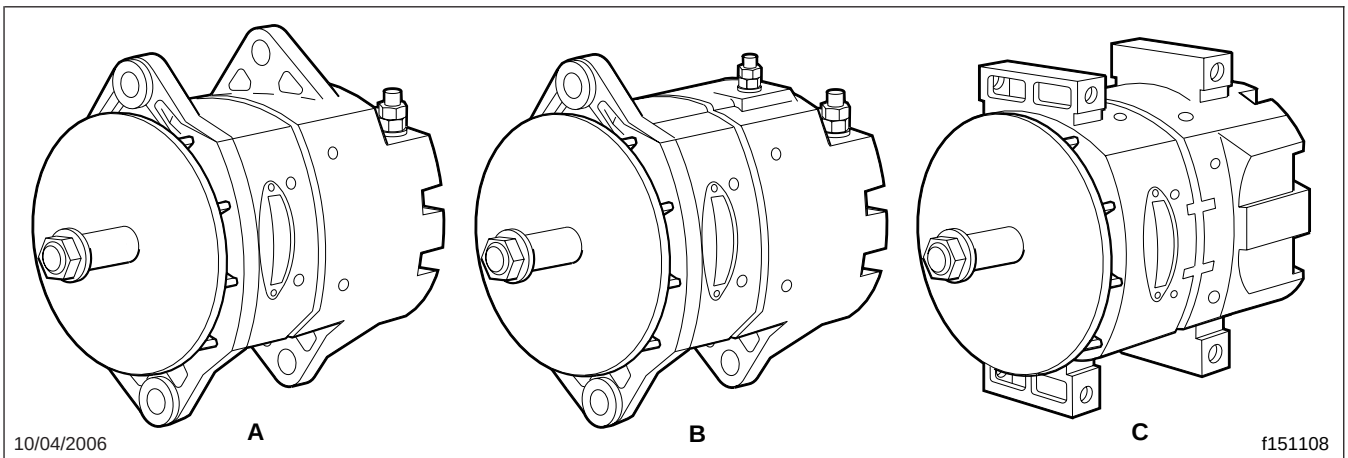
IMPORTANT: To be sure it is necessary to remove the alternator, perform the checks in **Troubleshooting 300**. Problems elsewhere in the electrical system are often misdiagnosed as alternator problems.

2. Turn the battery switch to the OFF position, or disconnect the batteries.
3. Tilt the hood.
4. Disconnect the electrical leads attached to the alternator. Mark the leads for correct installation.
5. Use a 1/2-inch-drive wrench in the square hole of the belt tensioner to relieve belt tension, and remove the belt from around the alternator pulley. See **Fig. 2**.
6. Support the alternator, and remove the four mounting capscrews and lockwashers that attach the alternator to the engine. Remove the alternator.



1. Mounting Capscrew
2. Alternator
3. Belt
4. Tensioner

Fig. 2, Typical Pad-Mount Alternator Installation



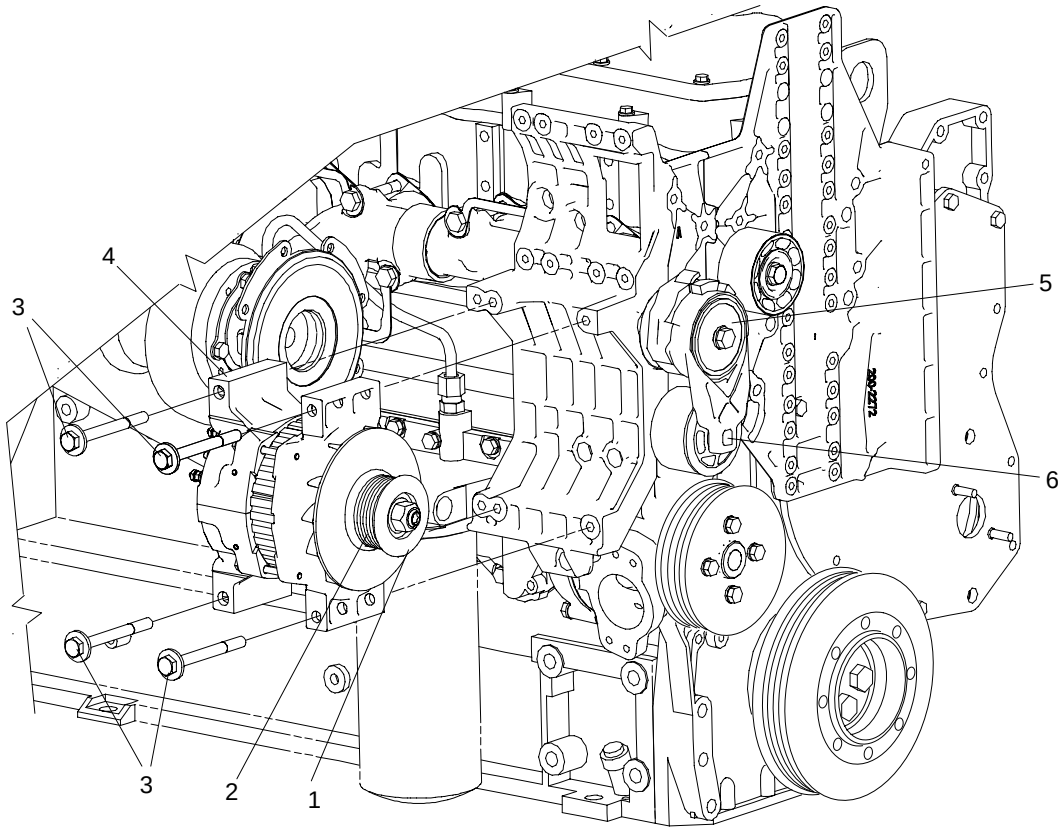
A. Quad Mount
B. Hinge Mount
C. Pad Mount

Fig. 1, Delco Remy Alternator Mount Configurations (35-SI shown)

Removal and Installation

Pad-Mount Alternator Installation

1. Place the alternator in position on its mount, and support it. See **Fig. 3**
2. Install the four alternator mounting capscrews and lockwashers. Tighten the capscrews to the torque value specified by the engine manufacturer.
3. Using a 1/2-inch-drive wrench in the square hole of the belt tensioner, relieve tension and install the belt around the alternator pulley. See **Fig. 2**.
4. Connect the wires to the alternator as previously marked.
   - Torque the nut for the battery cable 80 to 120 lbf·in (900 to 1350 N·cm).
   - Torque the nut for the ground cable 50 to 60 lbf·in (560 to 680 N·cm).
5. Spray any exposed terminal connectors with dielectric red enamel.
6. Rotate the battery switch to the ON position, or connect the batteries.
7. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see *Alternator Voltage Output Test* in **Troubleshooting 300**.
8. Return the hood to the operating position.



1. Alternator drive pulley
2. Serpentine belt grooves
3. Mounting capscrews
4. Pad mount alternator
5. Belt tensioner 1/2-inch square hole
6. Belt tensioner pulley

Fig. 3, Typical Pad-Mount Alternator Installation (Caterpillar shown)

Hinge-Mount Alternator Removal

1. Disconnect the negative battery cable from the battery. See **Group 54** for instructions.
2. Remove the drive belt. See **Group 01** for instructions.
3. Disconnect all alternator cables. Tag them by terminal for proper installation.
4. Remove the upper mounting capscrew from the alternator.
5. Remove the lower mounting capscrew from the alternator, and remove the alternator.

Installation

1. Position the alternator and install the lower mounting capscrew. Tighten the capscrew 50 to 70 lbf·ft (86 to 95 N·m).
2. Install the upper mounting capscrew. Tighten the capscrew 32 to 41 lbf·ft (43 to 56 N·m).
3. Connect the alternator cables. Tighten the nuts 44 to 71 lbf·in (500 to 800 N·cm).
4. Install the drive belt.
5. Connect the negative battery cable to the battery.

Troubleshooting

Incorrect problem diagnosis has caused many alternators to be replaced that later investigation reveals were working properly. The following procedures should provide accurate diagnoses, preventing unneeded replacements.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened
- The wiring and terminals are clean and in good condition
- All terminal nuts are torqued and properly protected

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test, and Alternator Amperage Output Test

1. Use a digital volt-ohmmeter (VOM) set on the 2–20 Vdc (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 1**, check that voltage is 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

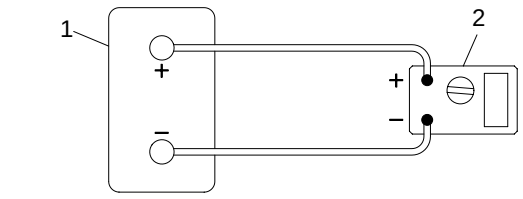
   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

IMPORTANT: Be sure to disconnect the batteries, or remove them from the vehicle before charging.

2. Check the alternator output without a load. See **Fig. 2**.

   2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

   2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 2**.



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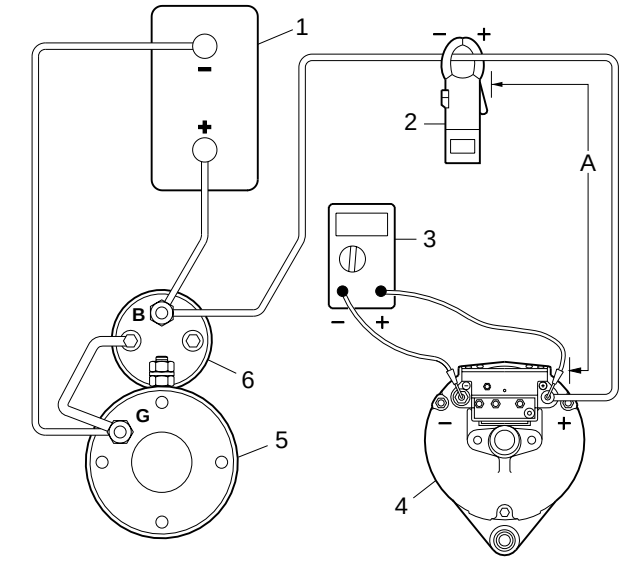
1. Battery
2. Digital Voltmeter

Fig. 1, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)



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A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 2, Setup 2: Alternator Output Test

   2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 2**.

   3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 2**.

Troubleshooting

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

- Both front and rear heater blowers (on HIGH)
- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 1**.

NOTE: **Figure 1** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 2**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at speed, so that the alternator is producing maximum output. Adjust the tester to the alternator's maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpm and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 The rated amperage output should be stamped on the alternator. If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed, and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 1** and **Fig. 2**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables, and terminals.

6.1 Check all connections between the battery, starter, and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

Intelli-Check Alternator Analyzer

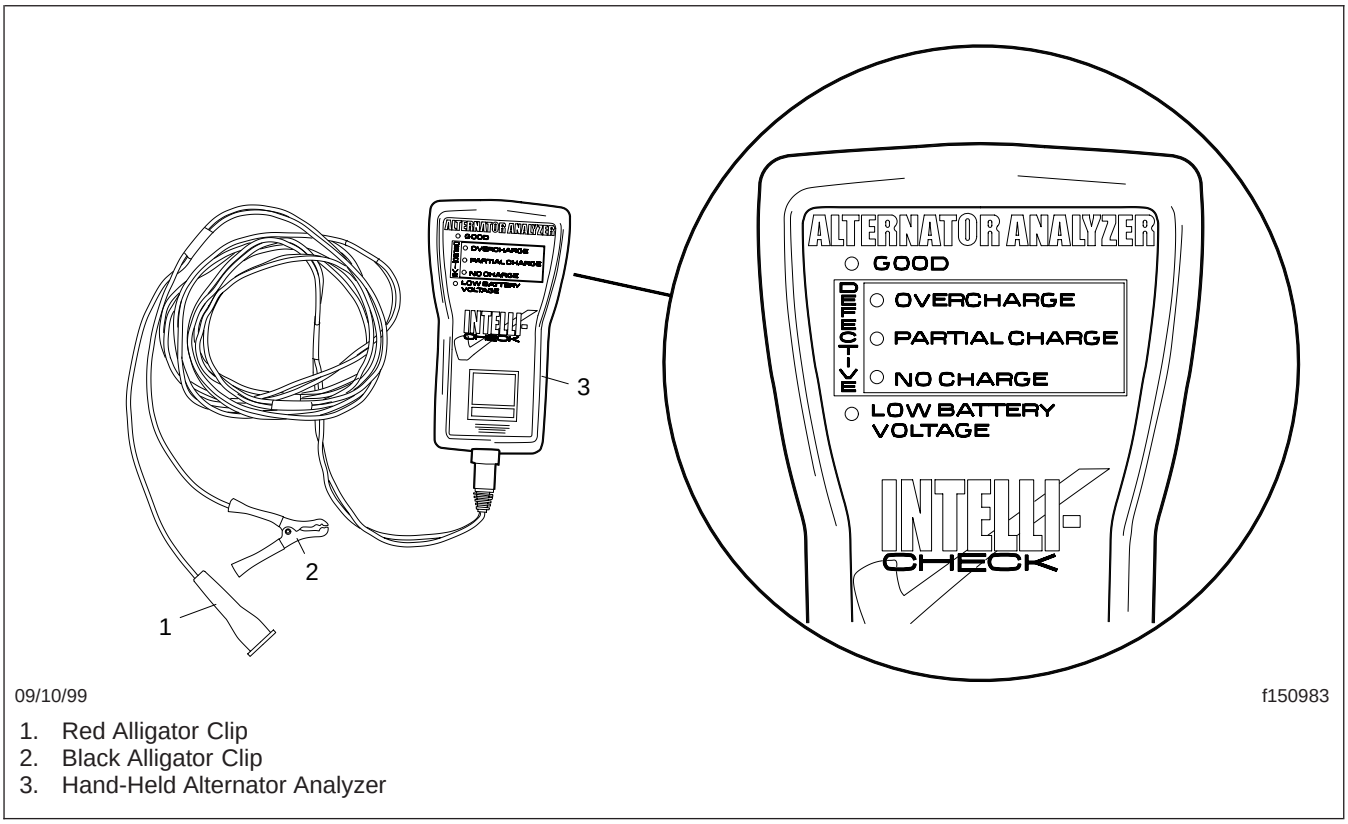
To perform a quick test of alternators, Delco Remy has a tool called the Intelli-Check Alternator Analyzer

(DR 10457848, a single tester, or DR 10457865, a four-pack of testers). See **Fig. 3**.

NOTE: These instructions apply specifically to the original Delco Remy Intelli-Check.

Pre-Test Procedure (engine off)

1. Inspect the alternator connections to verify that all terminals are tightly secured. Verify that the sense wire is connected to the sense terminal, on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off, as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate, depending on the condition of the batteries:
   - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
     A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
     B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
     C. Repeat the applicable steps of the Pre-Test Procedure.
   - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.



1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 3, Delco Remy Intelli-Check Alternator Analyzer

- **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Tester Operating Instructions (engine running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify that the engine is at idle and that all electrical loads are off.
3. Accelerate the engine to its governed speed, hold for 10 seconds, then return to idle.
    - If the **GOOD** (green) LED illuminates, proceed to the next step.
    - If any LEDs illuminate indicating overcharge, partial charge, or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
    - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing."
4. With the engine running, turn on all electrical loads.
5. Accelerate the engine to its governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/Charging System Testing" to analyze the charging system completely.

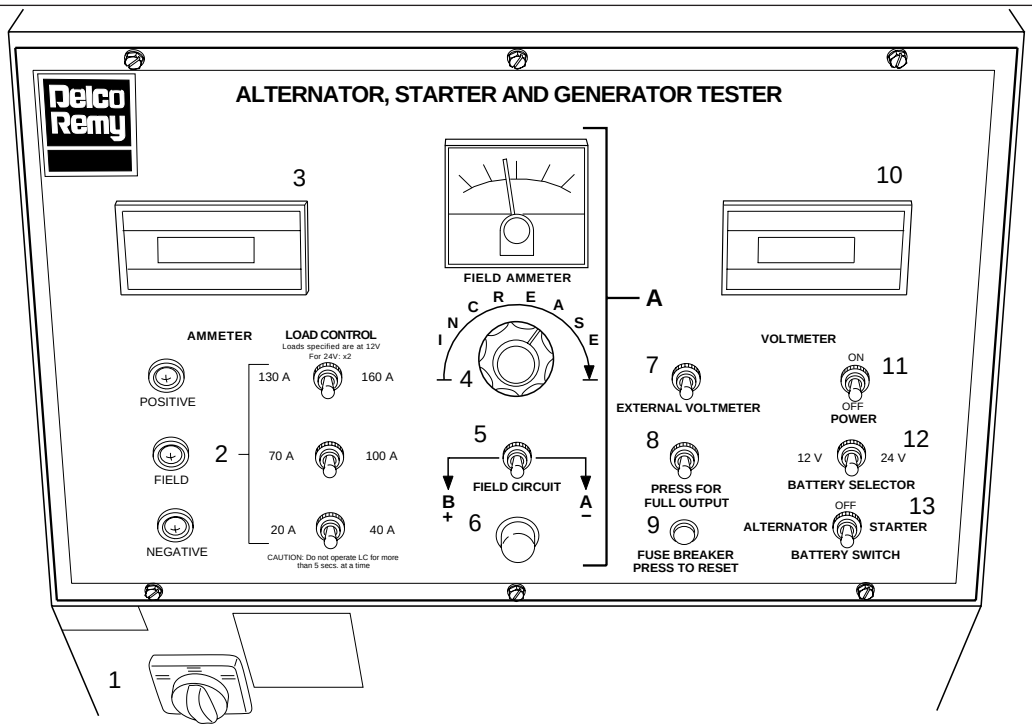
7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing".

Required Equipment

See **Fig. 1** for a standard Delco Remy Tester.

NOTE: This equipment and the following tests may also be used to test Leece Neville alternators.

- Delco Remy alternators require a 2-1/2 inch V-belt pulley, p/n DR 10503932 (supplied with the Delco Remy tester).
- Leece-Neville alternators require a 3-1/2 inch V-belt pulley, p/n LN 107 22, and a 5/8-inch washer, p/n LN 120 129.



A. These controls are not used when testing alternators with internal voltage regulators.

1. Motor Switch: Forward–Off–Reverse
2. Load Control Switches
3. Ammeter
4. Variable Field Control
5. Field Selector Switch
6. DTL Lamp
7. External Voltmeter Switch
8. Full Field Switch
9. Circuit Breaker (Press to Reset)
10. Voltmeter
11. Power Switch
12. 12–24-Volt Selector
13. Alternator/Battery Test Switch

Fig. 1, Alternator Tester Control Panel (typical)

The tests in this subject require the following equipment:

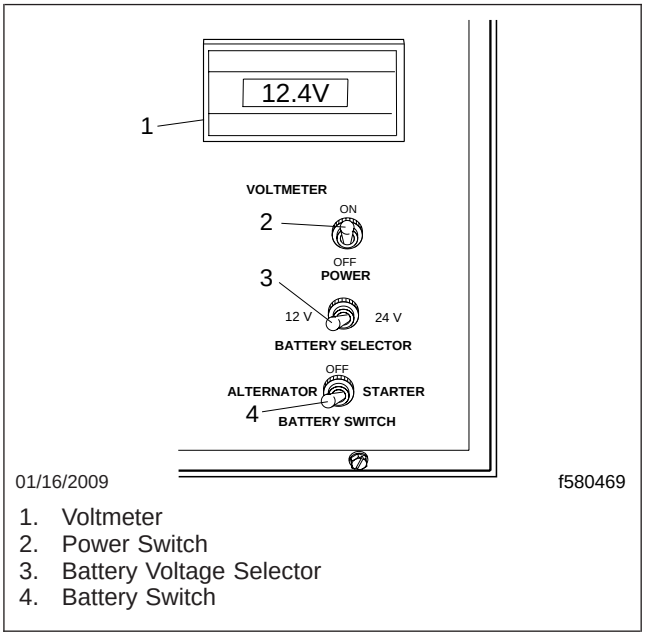
- Alternator tester with the battery charged to at least 12.4 V (Delco Remy shown).
- Alternator to be tested.
- V-belt.
- Jumper lead to connect the BAT (+) alternator terminal to the remote sense terminal.
- Standard 5/8–18 hexnut, for mounting the pulley on the alternator. Use a standard hexnut, not the self-locking nut that is supplied with the alternator.

NOTICE

Repeatedly using self-locking nuts may damage the threads on the pulley shaft.

Test Preparation

1. Set the battery voltage selector switch to 12V. See **Fig. 2**.



1. Voltmeter
2. Power Switch
3. Battery Voltage Selector
4. Battery Switch

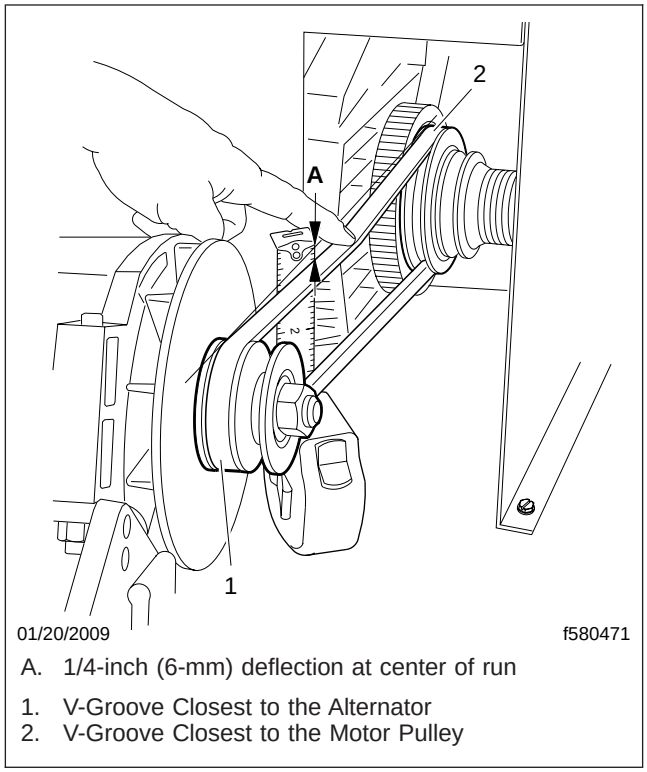
Fig. 2, Alternator Tester Power Switches

2. Set the battery switch to "Alternator." See **Fig. 2**.

NOTICE

The next step supplies battery voltage to the alternator tester power and ground cables. Ensure that they are separated and insulated from each other, and that they are not touching conductive materials. Failure to observe this precaution could cause component damage.

3. Turn the tester power switch ON. See **Fig. 2**. Check the battery voltage in the voltmeter on the tester. The tester battery voltage must be at least 12.4V; if it is below 12.4V, charge or replace the tester battery as necessary. Turn the power switch OFF.
4. Mount the appropriate manufacturer's pulley on the alternator.
5. Mount the alternator on the tester.
   - 5.1 Run the belt from the largest V-groove of the bench motor drive pulley to the V-groove closest to the alternator on the alternator pulley. See **Fig. 3**. Do not use the serpentine belt groove.



A. 1/4-inch (6-mm) deflection at center of run

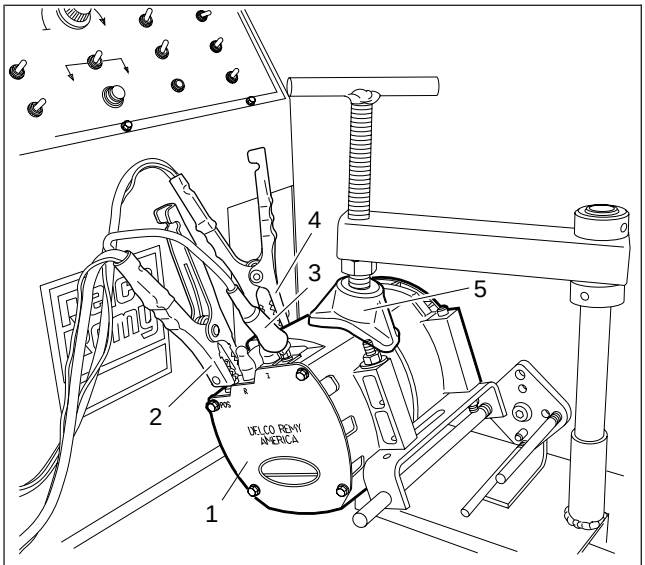
1. V-Groove Closest to the Alternator
2. V-Groove Closest to the Motor Pulley

Fig. 3, Belt Deflection with Alternator Mounted on Tester

   - 5.2 Move the vise to align the pulleys, so that the belt runs straight between the V-groove on the motor pulley and the V-groove closest to the alternator.
   - 5.3 Tension the V-belt with the hand wheel, so that it deflects 1/4-inch (6 mm) under hand pressure at the center of the run, then clamp the alternator in position.
6. Connect the electrical leads from the tester to the alternator. See **Fig. 4**. Take care that the tester power and ground cables are separated and insulated from each other, and that they are not touching conductive materials.
   - 6.1 Connect the red positive lead from the tester to the output terminal (BAT or +) on the alternator.

6.2 Connect the black negative lead from the tester to the output ground terminal (-) or to a mounting ear of the alternator.

7. Attach a jumper lead from the output terminal (BAT or +) to the remote sense terminal. Some testers have this jumper built-in on the positive lead, as shown in **Fig. 4**, Item 3; others may require a separate jumper as shown in **Fig. 5**.



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1. Alternator
2. Positive Lead
3. Remote Sense Jumper
4. Negative Lead
5. Clamp

Fig. 4, Alternator Clamped on Tester with Leads Connected

Voltage Test

NOTICE

Ensure that the alternator tester power and ground cables are separated and insulated from each other, and that they are not touching conductive materials. Failure to do so could cause damage to the tester.

1. Turn the tester power switch ON. See **Fig. 2**, Item 2.

WARNING

The following steps involve spinning the alternator with the open V-belt; be careful that all loose objects, garments, hair, and hands are well clear of the alternator and belt, and use safety shields properly, or serious personal injury may occur.

2. Turn the motor switch (located on the lower left-hand portion of the tester) to the FORWARD position, to start the alternator free-spinning. See **Fig. 1**, Item 1.

NOTE: The voltage output limit applies only to a non-loaded alternator. The purpose of this test is to ensure that the alternator produces the proper voltage with no load (free-spin).

3. Record the alternator voltage output during free-spin. See **Fig. 2**, Item 1.
   - If the alternator output is between 13.5V and 14.7V, the alternator is functioning properly; proceed to the *Load Test*.
   - If the alternator output is not between 13.5V and 14.7V, the alternator is faulty and must be replaced.

Load Test

1. Calculate the test load for the alternator being tested. The test load is 80 percent of the alternator-output rating.

   Multiply the alternator-output rating by **0.8**, to calculate the test load.

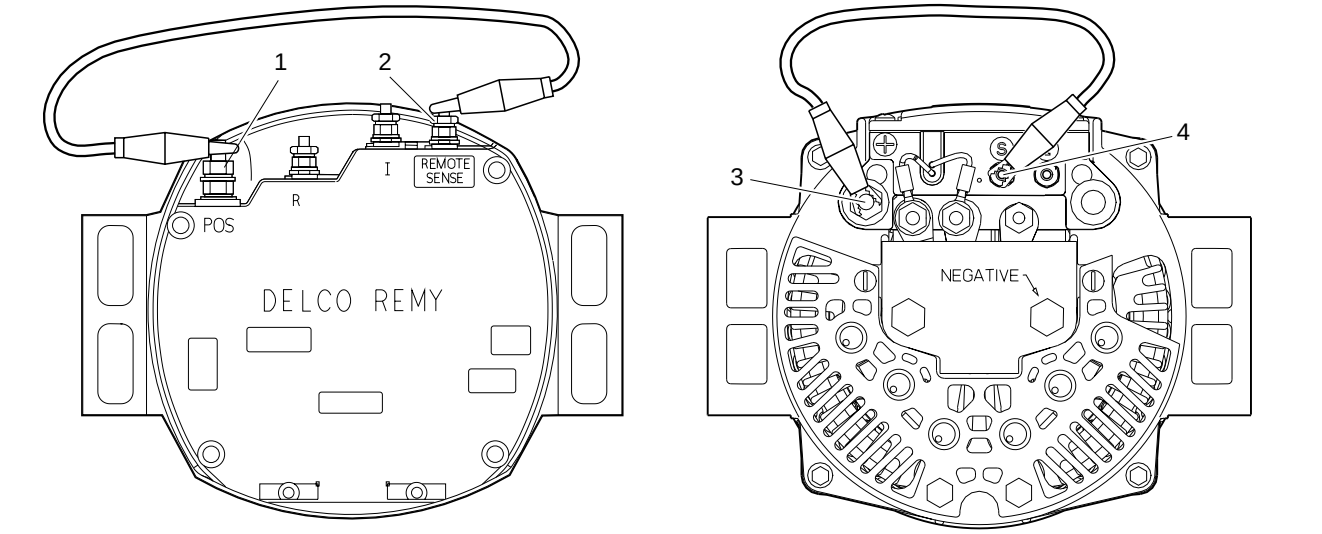
   For example, an alternator with 100-amp output rating has an 80-amp test load (100 x 0.8 = 80).

NOTE: Contact a Delco Remy or Leece-Neville representative if you are unsure of the calculation.

2. Determine the appropriate load-control-switch setting to use for the alternator being tested. See **Fig. 1**, Item 2.

   Use the load-control-switch setting **equal to, or the next level below** the test load calculation.

   For example, on this tester the available settings are 20/40, 70/100, and 130/160 amp. The load-control-switch setting for the 100-amp alternator



1. Delco Remy Positive Terminal
2. Delco Remy Remote Sense Terminal
3. Leece-Neville Positive Terminal
4. Leece-Neville Remote Sense Terminal

Fig. 5, Installed Jumper Leads (Typical)

would be 70 amp, because it is the available setting just below 80 amp.

NOTICE

Do not operate the alternator under load for more than 5 continuous seconds or damage to the alternator may occur.

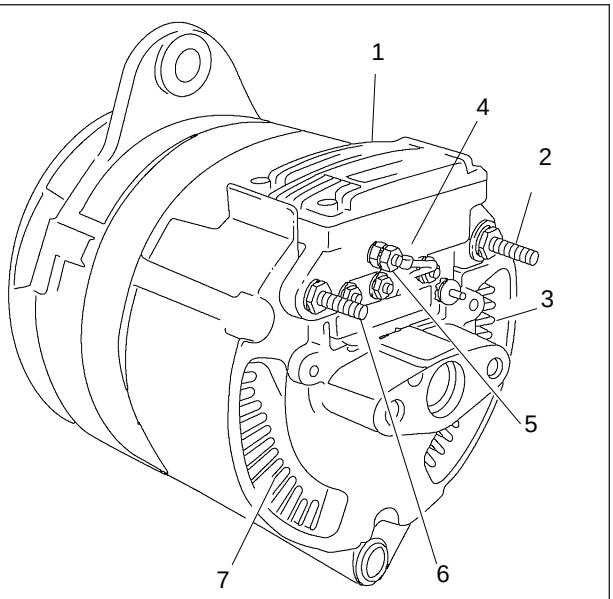
3. Apply the appropriate load switch for 5 seconds then release.
4. Record the **difference** in voltage output between when the alternator is free-spinning, and under load.
    - For all alternators except Delco Remy 22SI, if the voltage difference between free-spin and loaded is more than 0.5V, the alternator is faulty and must be replaced. If the voltage difference between free-spin and loaded is less than 0.5V, the alternator is functioning properly.
    - For Delco Remy 22SI, if the voltage difference between free-spin and loaded is more than 1.0V, the alternator is faulty and must be replaced. If the voltage difference between free-spin and loaded is less than 1.0V, the alternator is functioning properly.
5. Turn the tester power switch OFF, then disconnect the electrical leads and jumper from the alternator.

Specifications

Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Terminal Nut	—	44–71 (500–800)
Pivot Bolt (DDE Series 60 engine)	50–70 (68–95)	—
Alternator-Mounting Fasteners (DDE Series 60 engine)	32–41 (43–56)	—

Table 1, Torque Specifications

General Information (See Fig. 1)



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1. Voltage Regulator
2. Alternator Positive Terminal
3. Positive Rectifier Assembly
4. Full Field Access Hole
5. Diode Trio Connection
6. Alternator Negative Terminal
7. Negative Rectifier Assembly

Fig. 1, Alternator, Rear View

The 2500JB series Prestolite alternator is a high output air-cooled unit with an integral voltage regulator with extra large heat sinks, fully enclosed brushes, heavy-duty bearings, a dynamically balanced rotor and a heavy-duty stator.

While the rotor is turning, an alternating current is induced in the stator windings. The alternating current produced in the stator is converted to direct current by the positive and negative rectifier assemblies. The alternator output current increases with the speed of the rotor. The voltage regulator monitors the output voltage through sensing leads which are connected to the positive and negative rectifier assemblies. When the output voltage deviates from the set voltage, the regulator interrupts the rotor field coil ground.

The alternator can be full fielded by inserting a small round piece of stiff wire as far as it will go into the full field access hole in the back of the voltage regulator and connecting the wire to the negative output terminal on the alternator.

Removal and Installation (except with Cummins N14 with 1050 sq. in. Radiator)

Removal

NOTE: The alternator removal and installation procedure is typical.

1. Disconnect the battery negative cable(s).
2. Remove the air inlet duct.
3. Disconnect the positive and negative alternator cable. See **Fig. 1**.

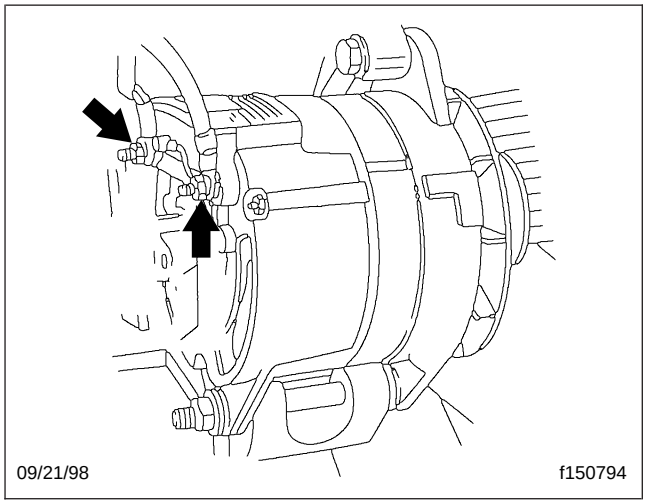


Fig. 1, Positive and Negative Alternator Cables

4. Loosen the adjusting rod nuts and remove the drive belt(s). See **Fig. 2**.
5. Remove the upper and lower alternator mounting bolts and remove the alternator. See **Fig. 3**.

Installation

1. Position the alternator and install, but do not tighten the mounting bolts. See **Fig. 3**.
2. Install the drive belts and set the drive belt tension with the adjusting rod nuts. See **Fig. 2**.
3. Tighten the lower mounting bolt to 65 lbf·ft (88 N·m). Tighten the upper mounting bolt 32 to 41 lbf·ft (43 to 56 N·m). See **Fig. 3**.
4. Install the positive and negative alternator cables. Tighten nuts to 48 to 60 lbf·in (550 to 650 N·cm). See **Fig. 1**.
5. Install the air inlet duct.

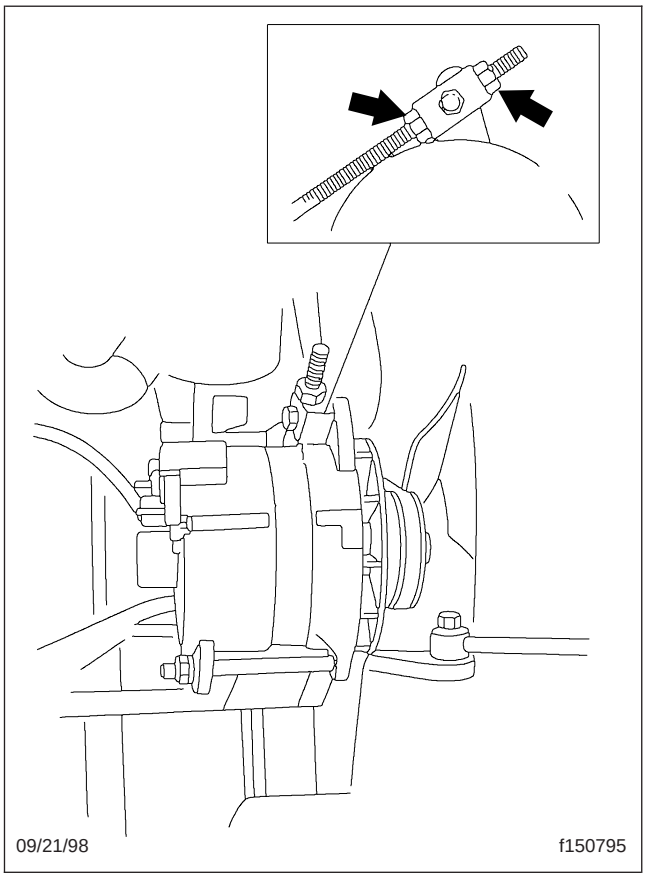


Fig. 2, Adjusting Rod Nuts

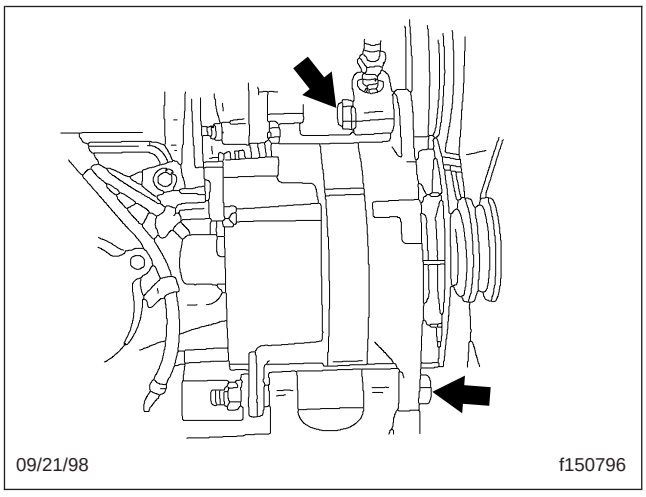


Fig. 3, Alternator Mounting Bolts

6. Connect the battery negative cable.

Removal and Installation (with Cummins N14 with 1050 sq. in. Radiator)

Removal

1. Disconnect the battery negative cable.
2. Drain the coolant. See **Group 20**.
3. Loosen the three hose clamps, then disconnect the coolant fill tube and remove the lower radiator hose. See **Fig. 1**.

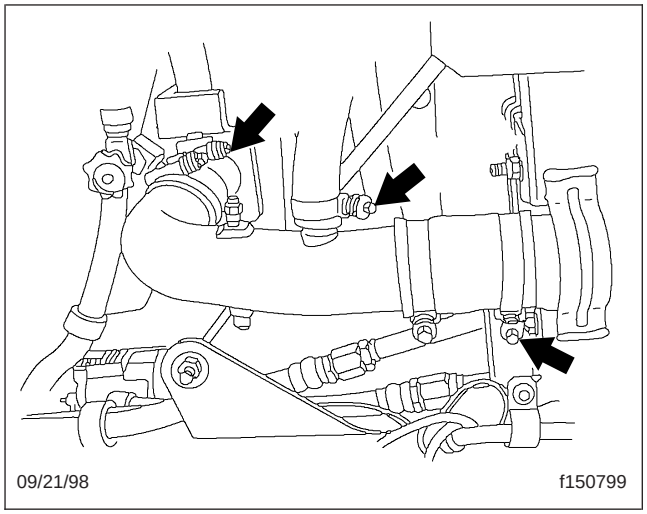


Fig. 1, Hose Clamps

4. Remove the radiator cross support lower nut and bolt and loosen the upper nut. Position the radiator cross support out of the way. See **Fig. 2**.

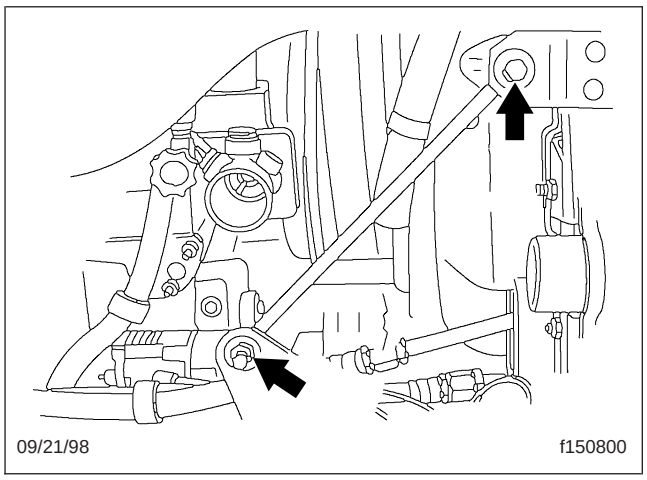


Fig. 2, Radiator Cross Support

5. Remove the alternator positive and negative cables. See **Fig. 3**.

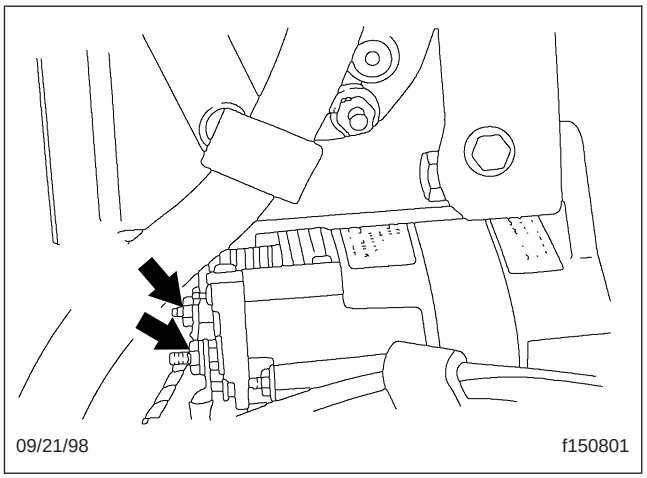


Fig. 3, Alternator Positive Cable Connections

6. Loosen the belt tension adjustment nut and the bolt, then remove the drive belt(s). See **Fig. 4**.

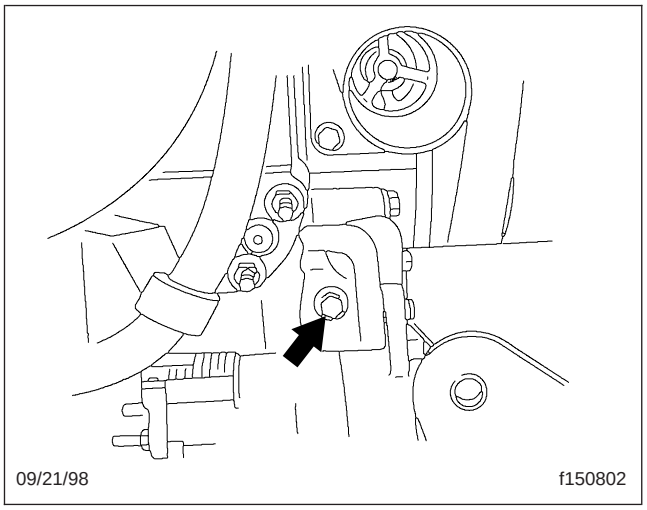


Fig. 4, Belt Tension Adjustment Nut

7. Remove the alternator upper mounting bolt. See **Fig. 5**.
8. Remove the alternator bracket bolt and the bracket. See **Fig. 6**.
9. Remove the alternator lower mounting bolts, then remove the alternator. See **Fig. 7**.

Removal and Installation (with Cummins N14 with 1050 sq. in. Radiator)

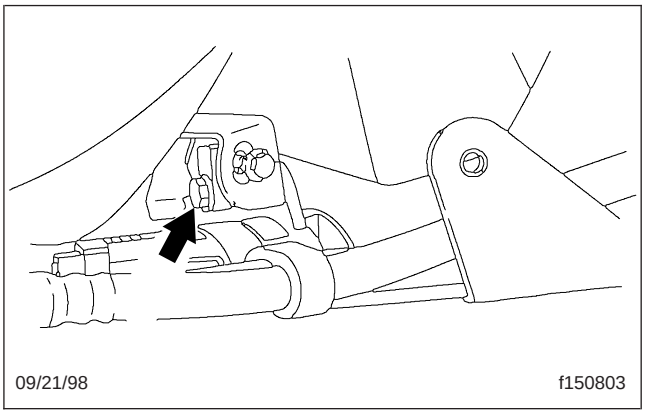


Fig. 5, Alternator Upper Mounting Bolt

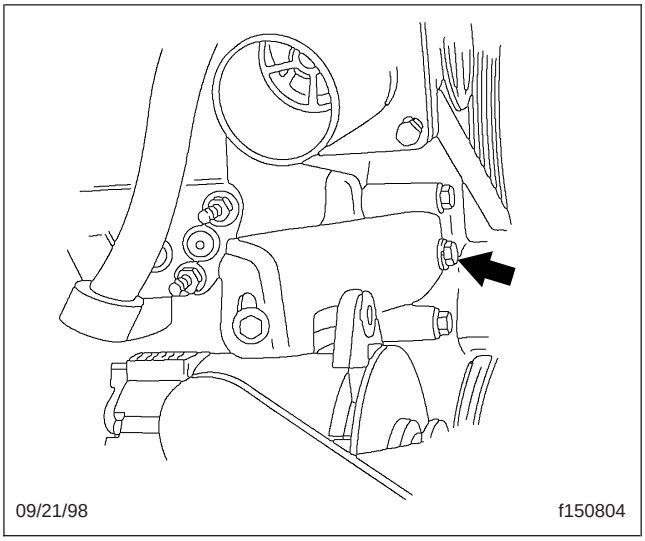


Fig. 6, Alternator Bracket Bolt

Installation

1. Set the alternator in position in the engine compartment.
2. Install the alternator lower mounting bolts, but do not tighten. See **Fig. 7**.
3. Install the alternator bracket bolt and the bracket. See **Fig. 6**.
4. Install the alternator upper mounting bolt, but do not tighten. See **Fig. 5**.
5. Install the drive belt(s) and set the drive belt tension. See **Fig. 4**.

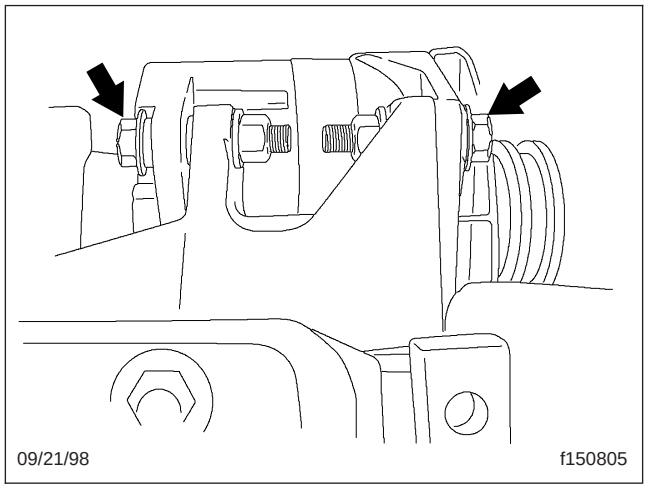


Fig. 7, Lower Alternator Mounting Bolts

6. Tighten the lower alternator mounting bolts to 65 lbf·ft (88 N·m). See **Fig. 7**.
7. Tighten the alternator upper mounting bolt to 32 to 41 lbf·ft (43 to 56 N·m). See **Fig. 5**.
8. Install the alternator positive and negative cables. Tighten nuts to 48 to 60 lbf·in (550 to 650 N·cm). See **Fig. 3**.
9. Install the radiator cross support lower nut and bolt and tighten the top nut. See **Fig. 2**.
10. Install the lower radiator hose and the coolant fill tube. See **Fig. 1**.
11. Add coolant. See **Group 20**.
12. Connect the battery negative cable(s).

Alternator Voltage Regulator Replacement

Replacement

1. Disconnect the battery negative cable.

NOTE: Alternator removal is necessary for the Cummins N14 only.

2. Remove the alternator (Cummins N14 only) or remove the air inlet duct (except Cummins N14).
3. Remove the alternator voltage regulator screws. See **Fig. 1**.

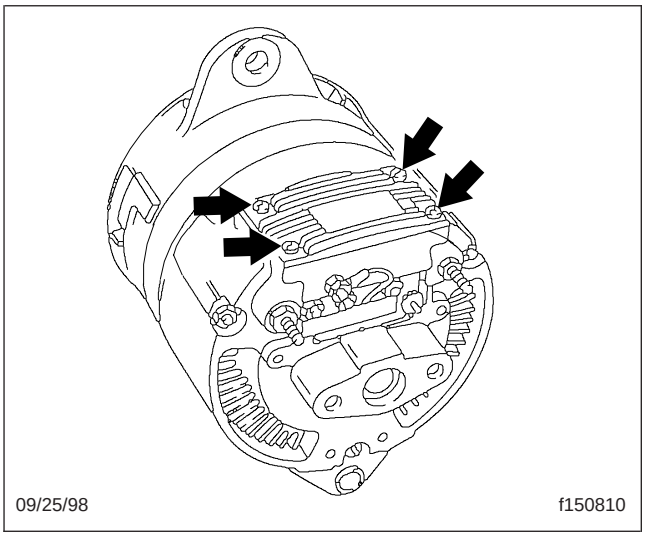


Fig. 1, Voltage Regulator Retaining Screws

4. Remove the alternator voltage regulator positive and negative terminal screws. See **Fig. 2**.
5. Remove the diode trio nut and wire. See **Fig. 3**.
6. Remove the blue or blue/white voltage regulator solderless eye connector retaining nut. See **Fig. 4**.
7. Pull the brushes straight out to determine if replacement is necessary. See **Fig. 5**.
8. Install the brushes. See **Fig. 6**.
9. Compress the brushes and lock them down with a round stiff wire. See **Fig. 7**.
10. Install the blue or blue/white voltage regulator solderless eye connector retaining nut. Tighten nut to 18 to 20 lbf·in (200 to 230 N·cm). See **Fig. 8**.

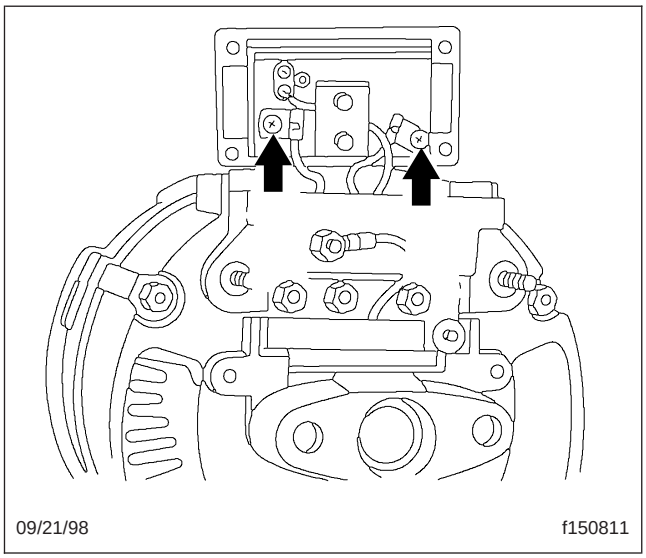


Fig. 2, Voltage Regulator Positive and Negative Connections

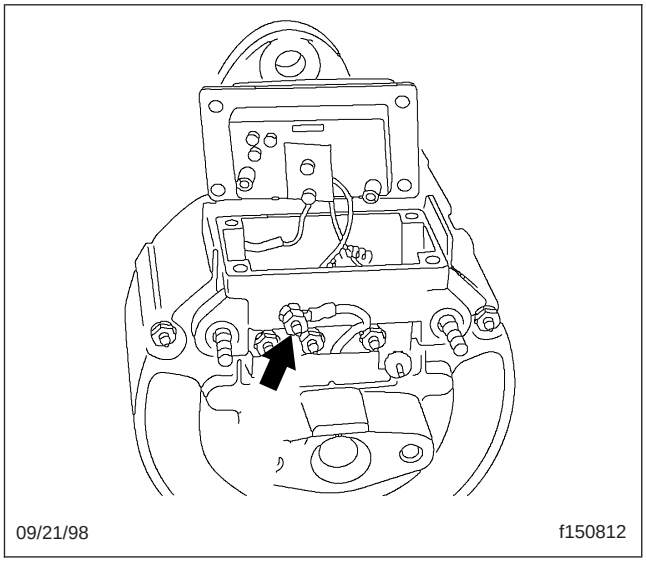


Fig. 3, Diode Trio Nut

11. Install the diode trio wire and nut. Tighten nut to 18 to 20 lbf·in (200 to 230 N·cm). See **Fig. 9**.
12. Install the alternator voltage regulator positive and negative terminal screws. See **Fig. 10**.
13. Position the voltage regulator cover using the alignment points shown in **Fig. 11**.
    13.1 Position the voltage regulator cover and apply downward pressure.

Alternator Voltage Regulator Replacement

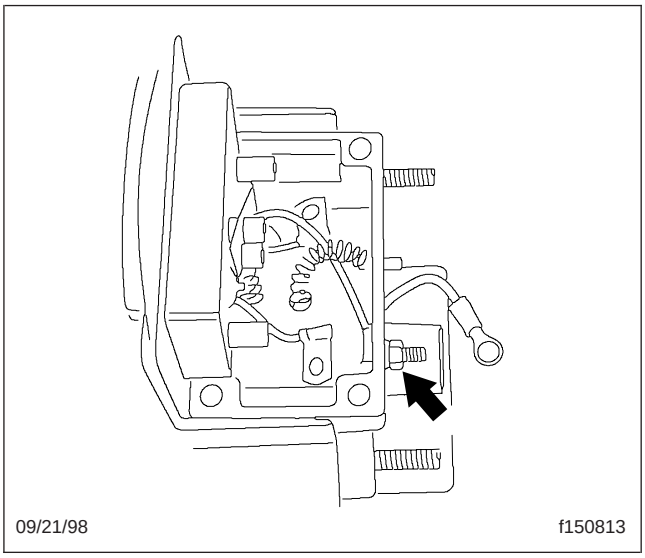


Fig. 4, Solderless Eye Connector Retaining Nut

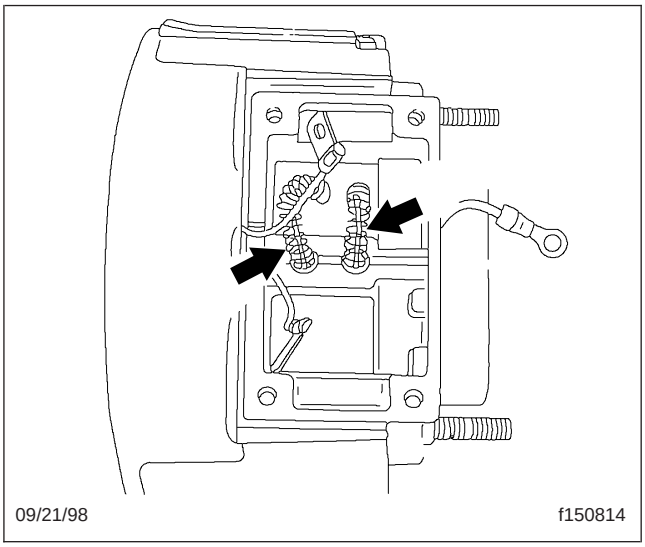


Fig. 5, Removing the Brushes

13.2 Make sure that the alternator voltage regulator positive and negative wires are seated correctly in the grooves.

13.3 Pull the wire from the side of the alternator voltage regulator while continuing to apply downward pressure.

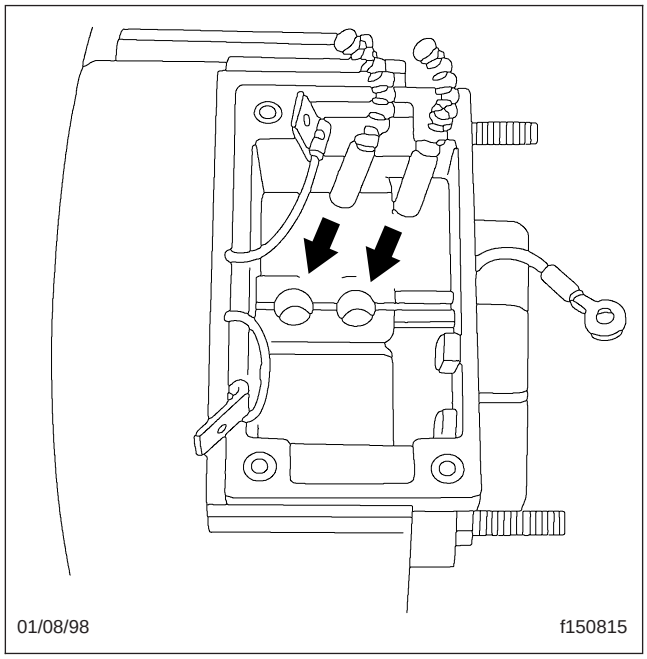


Fig. 6, Installing the Brushes

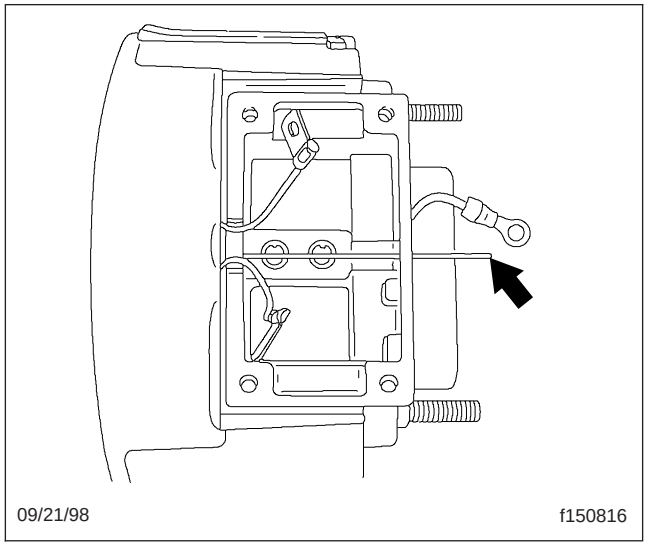


Fig. 7, Locking Down the Brushes

⚠ CAUTION

Do not overtighten the alternator voltage regulator screws or damage will occur.

Alternator Voltage Regulator Replacement

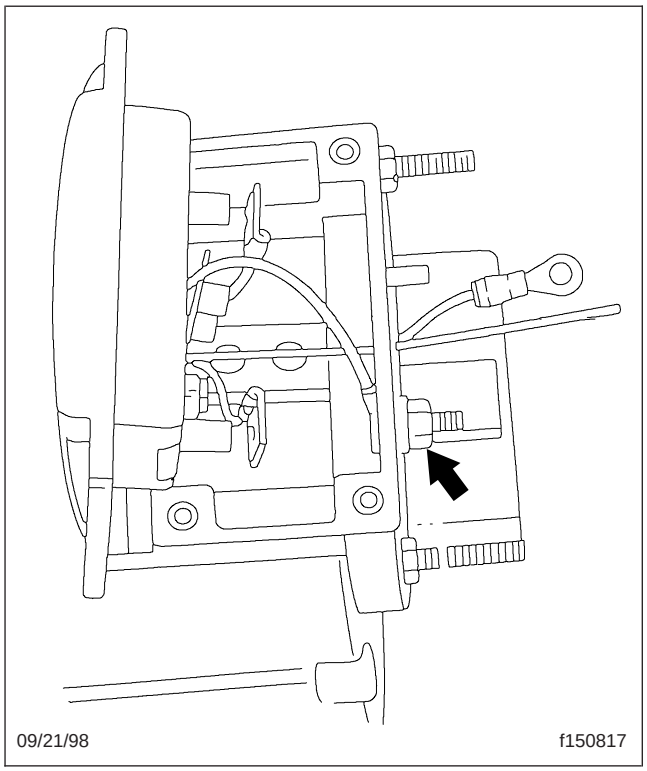


Fig. 8, Solderless Eye Connector Retaining Nut

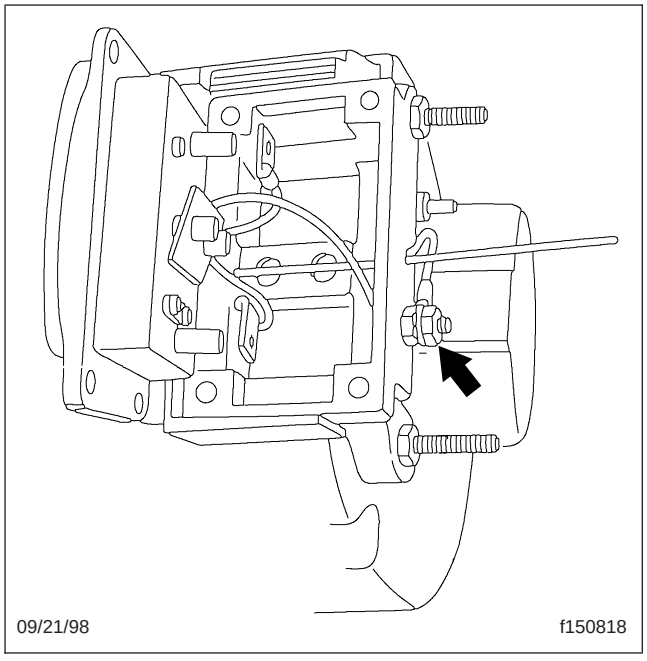


Fig. 9, Diode Trio Wire

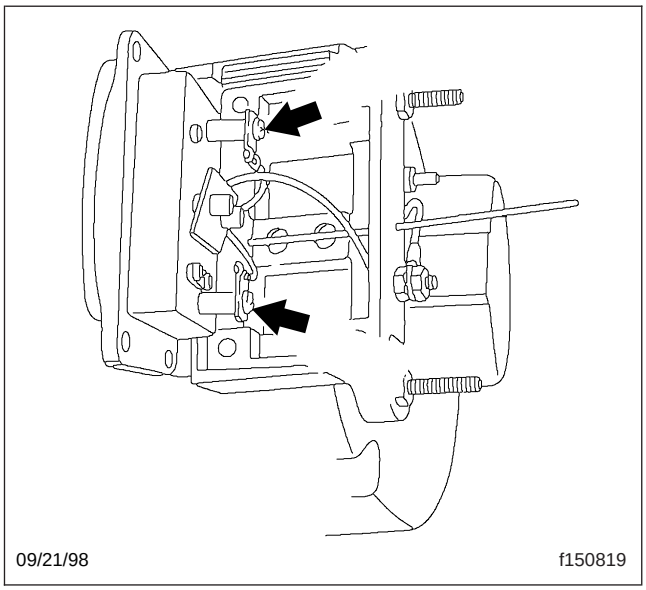
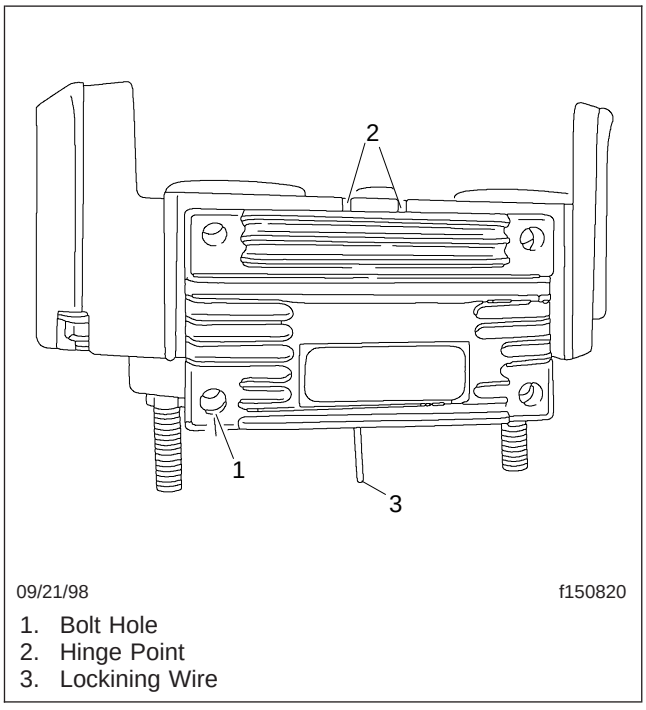


Fig. 10, Alternator Terminal Screws



1. Bolt Hole
2. Hinge Point
3. Lockining Wire

Fig. 11, Voltage Regulator Cover Alignment Points

14. Install the alternator voltage regulator screws. Tighten the screws 9 to 11 lbf·in (100 to 120 N·cm). See **Fig. 1**.

Alternator Voltage Regulator Replacement

15. Install the alternator (Cummins N14 only) or install the air inlet duct (except Cummins N14).

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

To troubleshoot the SmartChek™ diagnostic alternator perform 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 several 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.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/ Charging System Testing."

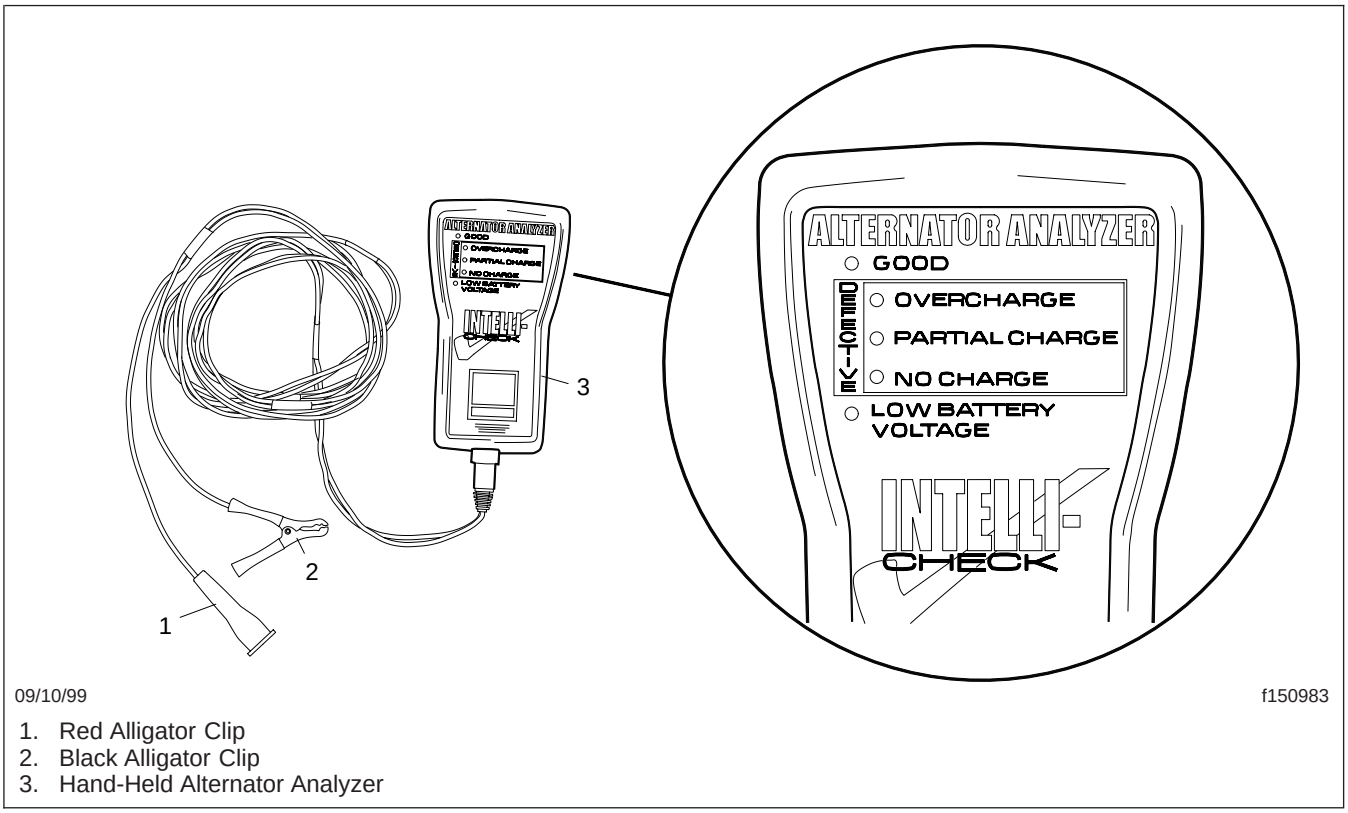
Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
   - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
     A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
     B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
     C. Repeat the applicable steps of the Pre-Test Procedure.
   - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
   - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Troubleshooting



1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
   - If the **GOOD** (green) LED illuminates, proceed to the next step.
   - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
   - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing."
4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/ Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.

8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing."

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

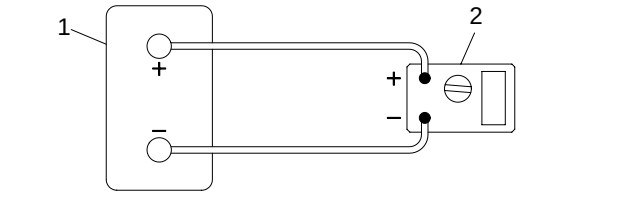
1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

2. Check the alternator output without a load. See **Fig. 3**.



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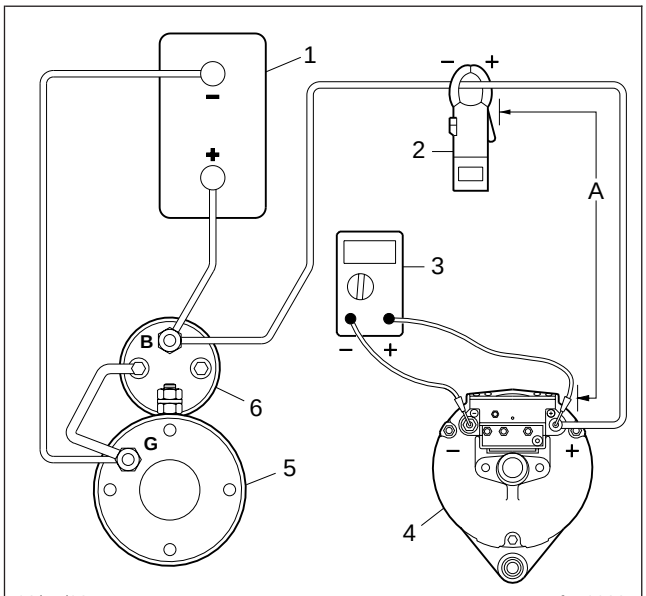
1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.



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A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Voltage

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3**.

   3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

   NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

   3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

   - Both front and rear heater blowers (on HIGH)

Troubleshooting

- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

Specifications

Alternator Specifications								
Supplier	**Amperes @ 14 V**	**Watts @ 14 V**	**Alternator RPM**	**Maximum Speed Rating**	**Temperature Range**	**Min. Brush Length**	**Rotor Coil Resistance Measured at the Slip Rings**	**Min. Slip Ring Dia.**
Prestolite	85 A	1190 W	3200	8000 rpm	-40°–200°F (-40°–93°C)	0.18 in (4.76 mm)	2.3–2.7 ohms	1.057 in (26.850 mm)
	100 A	1400 W	5000					
	115 A	1610 W	3000					
	130 A	1820 W	5000					
	145 A	2030 W	5000					

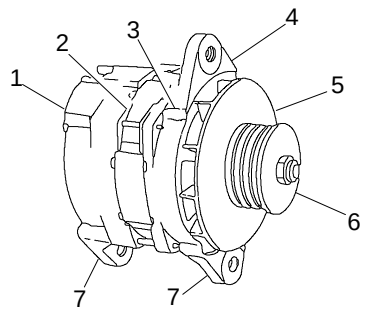
Table 1, Alternator Specifications

Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Pulley Nut	70–80 (95–108)	—
Voltage Regulator Screws	—	9–11 (100–120)
Positive and Negative Terminal Nuts	—	48–60 (550–650)
Diode Trio Wire (Black) Nuts	—	18–20 (200–230)
Alternator Lower Mounting Bolt	65 (88)	—
Alternator Upper Mounting Bolt	32–41 (43–56)	—

Table 2, Torque Specifications

General Information (See Fig. 1)

The 21-SI series Delcotron alternator is a high-output IAR-type charging system with a built-in rectifier and voltage regulator which produces DC current. The 21-SI alternator can be operated in either clockwise or counterclockwise direction at continuous speeds of up to 10,000 rpm (intermittent speeds of up to 12,000 rpm are also acceptable). The ambient temperature range for proper operation is -30° to 200°F (-34° to 93°C).



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1. Slip Ring End (SRE) Housing
2. Stator
3. Drive End (DE) Housing
4. Adjustment Lug
5. Alternator Fan
6. Alternator Pulley
7. Mounting Lugs

Fig. 1, Alternator, 100, 115, 130 and 145 Ampere

The voltage regulator is a solid-state integrated circuit type with a nominal regulated voltage setting of 14.0 volts. In addition, the voltage regulator features flat temperature compensation, low parasitic draw and low turn-on speed with improved RFI suppression capability and load dump protection from voltage spikes. The voltage regulator limits system voltage by switching the ground circuit for the alternator rotor field on and off.

Alternator Removal and Installation

Removal

NOTE: The alternator removal and installation procedure is typical.

1. Disconnect the battery negative cable. See **Group 54** in this manual.
2. Remove the drive belt. See **Group 01** in this manual.
3. Disconnect the positive and negative alternator cables. See **Fig. 1**.

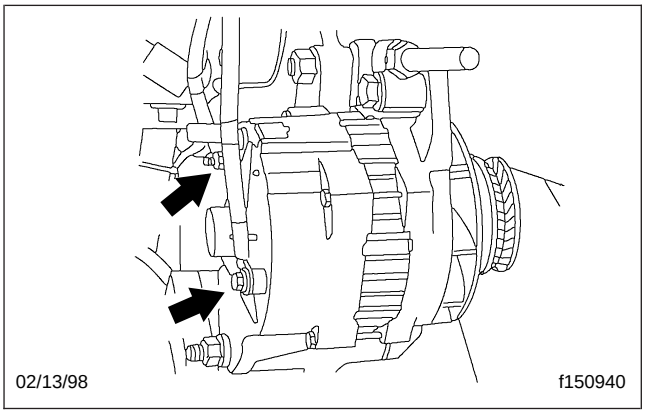


Fig. 1, Positive and Negative Alternator Cables

4. Remove the alternator belt.
5. Remove the mounting bolts from the alternator, then remove the alternator. See **Fig. 2**.

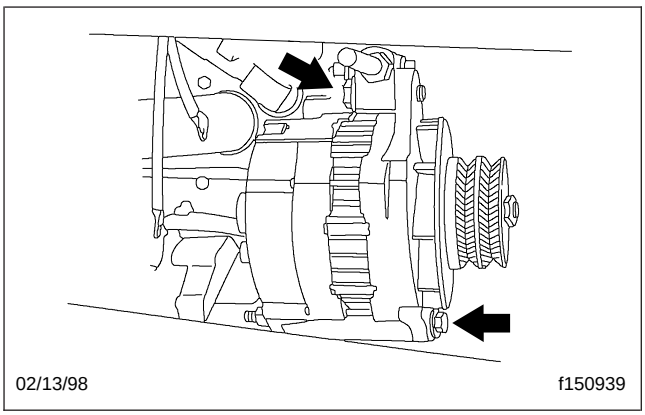
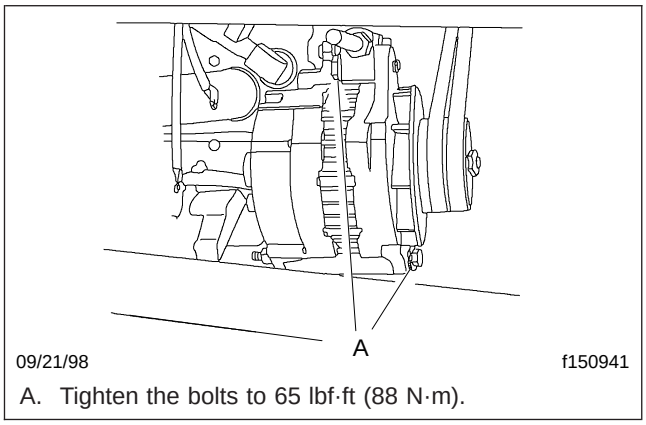


Fig. 2, Alternator Mounting Bolts

Installation

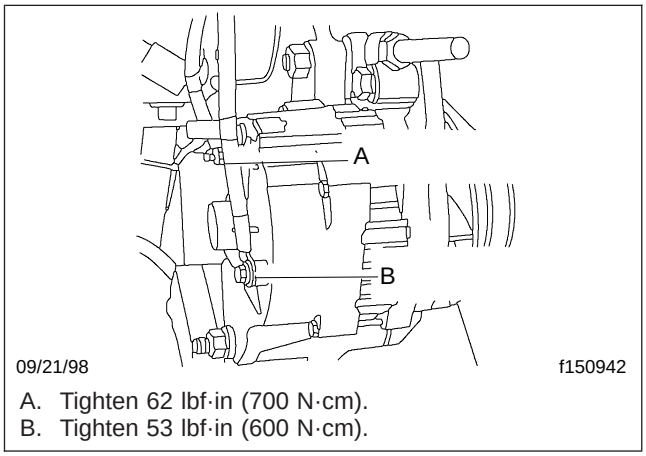
1. Position the alternator within the engine compartment.
2. Install the alternator mounting bolts. Tighten the bolts to 65 lbf·ft (88 N·m). See **Fig. 3**



A. Tighten the bolts to 65 lbf·ft (88 N·m).

Fig. 3, Tighten the Alternator Cable Nuts

3. Connect the alternator positive and negative cables. Tighten the positive cable retaining nut to 62 lbf·in (700 N·cm); tighten the negative cable retaining nut to 53 lbf·in (600 N·cm). See **Fig. 4**.



A. Tighten 62 lbf·in (700 N·cm).
B. Tighten 53 lbf·in (600 N·cm).

Fig. 4, Tighten the Alternator Cable Nuts

4. Install and tension the alternator belt.
5. Connect the battery negative cable.

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

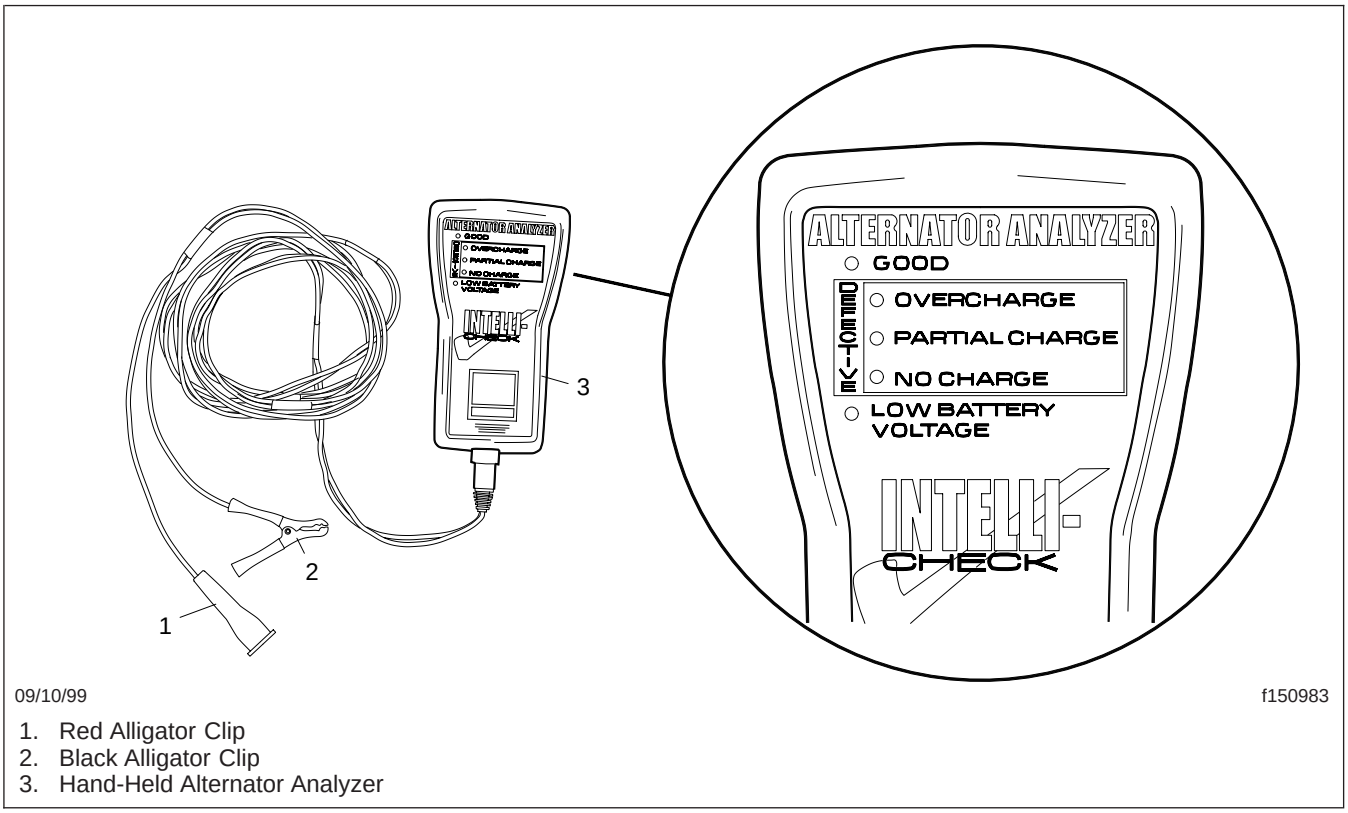
Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
    - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
        A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
        B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
        C. Repeat the applicable steps of the Pre-Test Procedure.
    - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
    - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
    - If the **GOOD** (green) LED illuminates, proceed to the next step.
    - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
    - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging

Troubleshooting



1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

system using the instructions in "Alternator/Charging System Testing."

4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/ Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing".

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

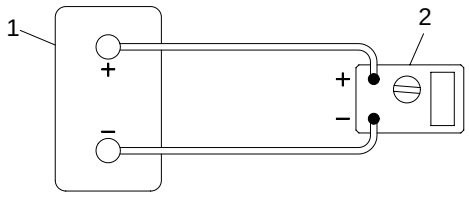
1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

2. Check the alternator output without a load. See **Fig. 3**.



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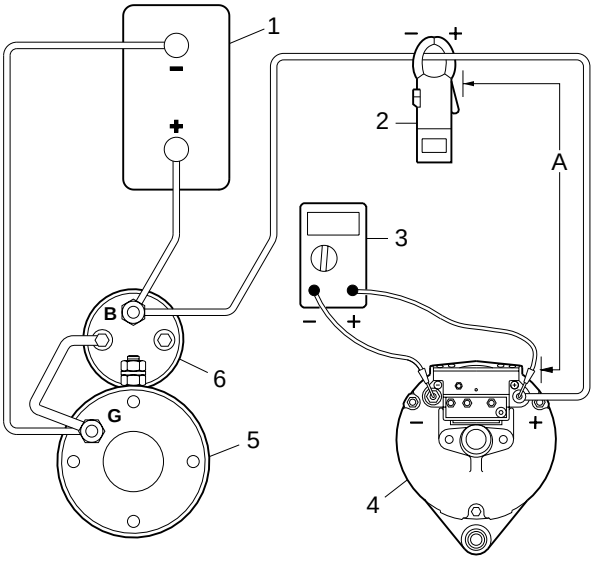
1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)



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A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Test

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3**.

3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

- Both front and rear heater blowers (on HIGH)
- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

Troubleshooting

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

Specifications

Alternator Specifications				
Ambient Temperature Operating Range	**Ampere Rating @500 rpm 12V**	**Wattage @500 rpm 12V**	**Continuous Speed Rating**	**Intermittent Speed Rating**
-30°–200°F (-34°–93°C)	100 A	1400 W	10,000 rpm	12,000 rpm
	115 A	1610 W		
	130 A	1820 W		
	145 A	2030 W		

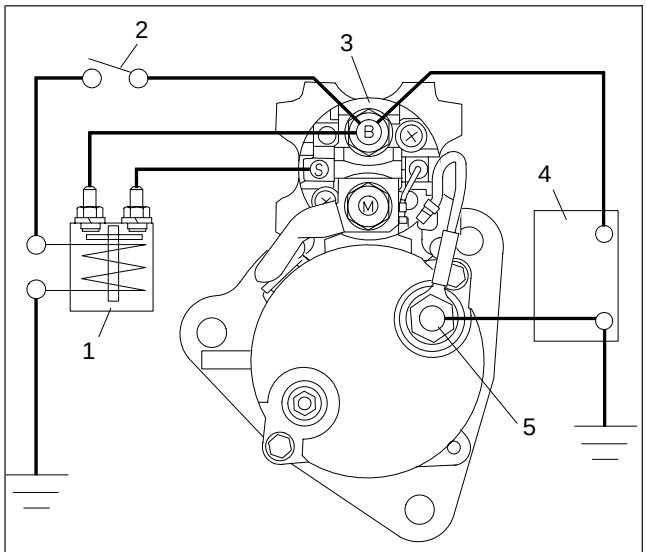
Table 1, Alternator Specifications

Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Pulley Nut	74 (100)	—
Adjusting Bolt	65 (88)	—
Mounting Nut	65 (88)	—
Ground Screw	—	53 (600)
B+ Terminal Nut	—	62 (700)

Table 2, Torque Specifications

General Information

The Mitsubishi starter (MIB 970379FL), which weighs approximately 28 pounds (12.7 kg), uses a planetary gear reduction system. The starter attaches to the flywheel housing. In the area of the output shaft, the starter provides protection from dust, water, or oil splash for the inner starter parts. See **Fig. 1**, for a circuit diagram of the Mitsubishi isolated-ground type starter.



1. Magnetic Switch
2. Start Switch
3. Starter Solenoid
4. Battery
5. Starter Motor

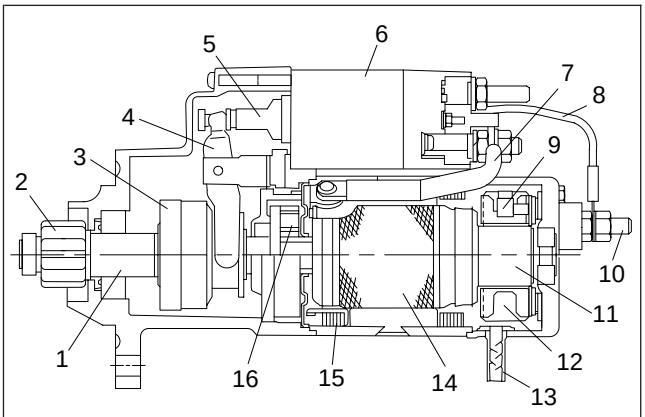
Fig. 1, Basic Starting Circuit (isolated-ground type)

Principles of Operation

When the start switch is closed (the switch is in the start position) current flows through the magnetic switch windings. The magnetic switch contacts close and current flows through the starter solenoid windings.

The starter clutch is thrust forward by movement of the plunger and the lever. See **Fig. 2**. Current flowing in the starter solenoid windings causes the pinion gear to slowly rotate. The pinion engages the ring gear and, when the pinion is securely engaged, the main solenoid contacts close and the starter cranks.

When the engine starts, the starter clutch prevents excessive overrun of the armature.



1. Output Shaft
2. Pinion
3. Clutch
4. Lever
5. Plunger
6. Solenoid
7. M-Lead
8. Ground Wire
9. Brush Spring
10. Ground Terminal
11. Commutator
12. Brush
13. Drain Tube
14. Armature
15. Field Coil
16. Planetary Gear

Fig. 2, Starter Cross-Section (isolated-ground stud type)

⚠ CAUTION

Release the start switch immediately when the engine starts to prevent damage to the starter. Do not crank the starter for more than 30 seconds at one time or the starter may overheat. If you do crank the starter continuously for 30 seconds, wait 10 minutes to allow the starter to cool before attempting starting again.

Removal

Before removing the starter from the vehicle for repair, perform the checks in **Troubleshooting 300**.

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Turn off all electrical loads such as lights, ignition, and accessories.
3. Disconnect the batteries.
4. Open the hood.
5. Disconnect the electrical leads attached to the starter, making note of the number of each and where they attach. Mark the terminals and wires for installation.

NOTE: It may be difficult to access the starter mounting bolts. Straddle the front axle with arms extended around the leaf springs and use a long socket extender or breaker bar.

6. Remove the three mounting bolts and lockwashers that attach the starter to the engine. Remove the starter.

Installation

1. Insert the starter nose housing through the mounting hole in the flywheel housing.
2. Install the three starter mounting bolts and lockwashers and tighten them securely.
3. Connect the wires to the starter as previously marked, making sure that all are accounted for. Make sure that all battery cables are routed so as to avoid contact with sharp edges and other chafe sites. Tighten the nuts 16 to 30 lbf·in (180 to 340 N·cm).
4. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.
5. Connect the batteries.
6. Lower the hood to the operating position.
7. Remove the chocks from the tires.

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

Specifications

See **Table 1** for starter fastener torque values.

Fastener Torque Values			
Description	**Size**	**Torque Value**	
		lbf·ft (N·m)	**lbf·in (N·cm)**
Starter to Flywheel Housing	M12 x 1.5	53-63 (72-85)	—
Nut, Copper Stud	M12	15-22 (20-30)	—

Table 1, Fastener Torque Values

General Information

RADIATOR

The radiator is made of either copper/brass or aluminum with a tube and serpentine fin-type design. The coolant flows through the radiator in the horizontal direction. Two header tanks provide uniformed coolant supply to the radiator tubes. The two header tanks are repairable.

COOLANT RECOVERY SYSTEM

The coolant recovery system has been designed to perform two functions. The first function is to supply and recover coolant for the radiator. The second function is to allow trapped air and other gasses to escape from the cooling system. This reduces the need to bleed the cooling system when refilling or topping-off the fluid level.

COOLANT HOSES

See **Fig. 1** for Cummins ISB, **Fig. 2** for Cummins ISC, **Fig. 3** for Cummins M11, **Fig. 4** for Cummins N14, **Fig. 5** for Caterpillar 3126, **Fig. 6** for Caterpillar 3306, **Fig. 7** for Caterpillar 3406, **Fig. 8** for Caterpillar C10/C12, and **Fig. 9** for DDC 60 Series.

COOLANT SPECIFICATION

Whenever you add engine coolant to the radiator, for diesel engines, use equal parts of water and Heavy Duty Diesel Engine Cooling System Fluid E6HZ–19549–A or equivalent meeting specification ESE–M97B18–C. Also, add Motorcraft Heavy-Duty Cooling System Additive FW–15 or equivalent meeting specification ESN–M99B169–A, at a strength of 4 ounces per gallon of engine coolant being added. If you have to add coolant more than once a month, or if you have to add more than one quart at a time, check the cooling system for leaks.

Do not use alcohol or methanol antifreeze, or mix them with the specified coolant.

Plain water may be used in an emergency, but replace it with the specified engine coolant and conditioner additive as quickly as possible to avoid damage to the system. With only water in the system, do not let the engine run hot.

Some engine coolant recycling manufacturers have claimed to have the ability to recycle engine coolant. Sterling has not authorized the use of recycled engine coolant nor the use of any machines or devices that recycle engine coolant. Recycled coolant is not equivalent to Heavy-Duty Diesel Engine Cooling System Fluid E6HZ–19549–A or equivalent meeting specification ESE–M97B18–C.

Further, the disposal of all used engine coolant must always be done in accordance with all applicable federal, state and local laws and regulations.

Ordinary tap water may be used in an emergency except in areas where the water is known to be exceptionally hard or to have a high alkali content. The cooling system should be drained and flushed and the proper mixture of coolant added as soon as possible.

To avoid possible overheating in very hot weather, do not use mixtures with more than 50 percent antifreeze except in areas where antifreeze protection below –35°F (–37°C) is required. In this case, refer to the coolant mixture chart on the cooling system fluid container.

Refer to the "Diesel Engine Manufacturer Operator's Manual" for cooling system maintenance procedures.

Do not add any radiator sealers containing water soluble oil to the cooling system of diesel engines, as this will make the corrosion resistor inoperative.

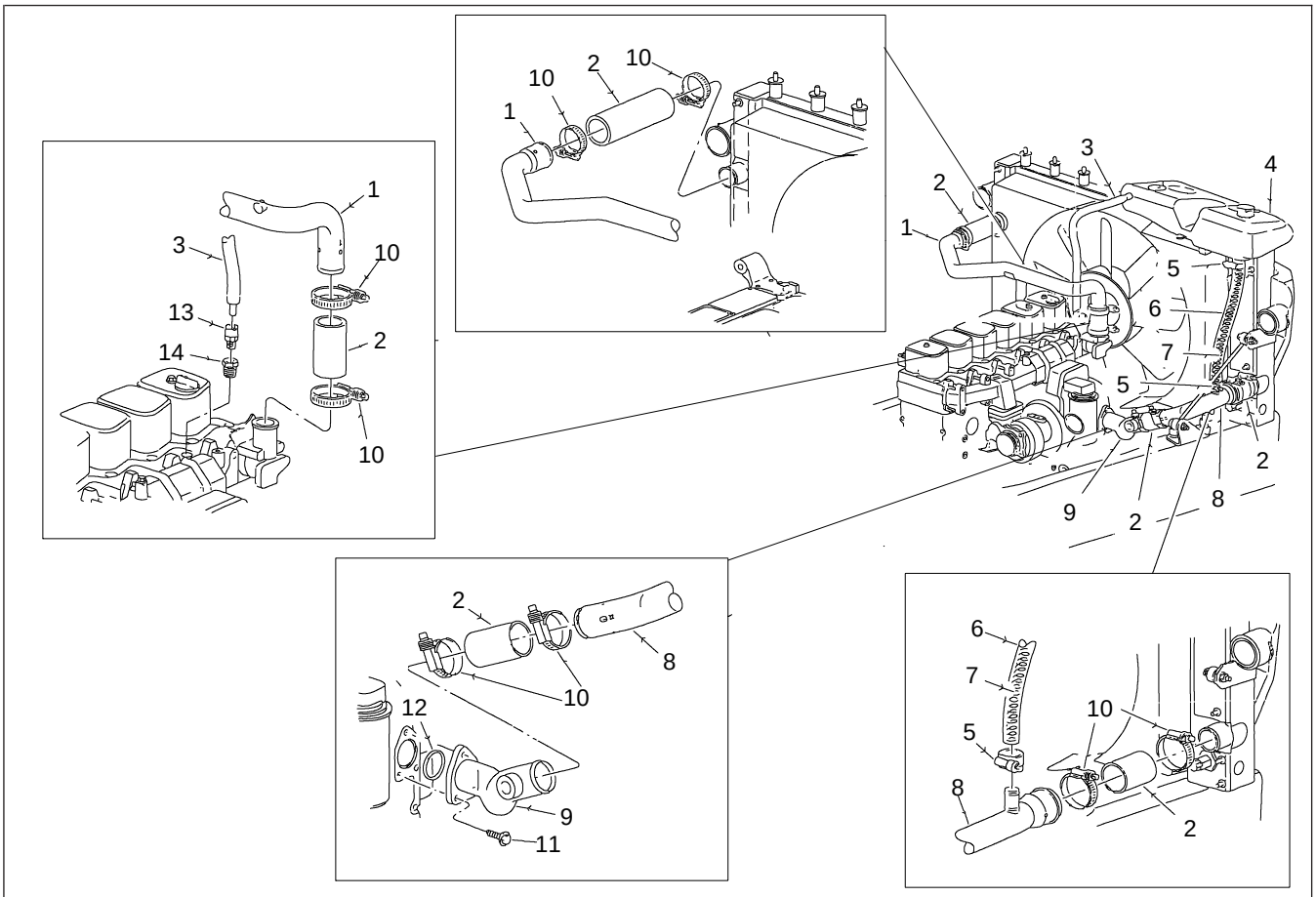
A standard ethylene glycol hydrometer can be used to check the protection level of the long-life coolant.

When water or coolant is added to the supply tank, operate the engine at fast idle for 30 minutes before letting the vehicle stand with the engine off for prolonged periods to prevent damage to the cooling system during periods of below freezing temperatures. This will allow a uniform mixture throughout the cooling system and prevent damage by freezing, when sufficient antifreeze is used.

The viscous fan clutch is a temperature-sensitive and torque-limiting fluid drive which provides the engine cooling and fuel savings by operating the engine cooling fan in a controlled manner. The viscous fan clutch is a self-contained unit that requires no additional connections of air, oil, or coolant lines.

If it has been determined that the viscous fan clutch is worn or damaged because it failed to engage or disengage at the correct temperature, or failed to operate the fan at the specified speed, then replacement of the viscous clutch assembly is required.

General Information



03/11/98 f200457

1. Radiator Upper Pipe
2. Connector Hose
3. Engine Vent Hose
4. Engine Coolant Supply Tank
5. Clamp
6. Hose (supply)
7. Spring Insert
8. Radiator Lower Pipe
9. Radiator Lower Pipe Elbow
10. Clamp
11. Bolt
12. Gasket, Water Outlet
13. Adapter
14. Bushing

Fig. 1, Coolant Hoses, Cummins ISB

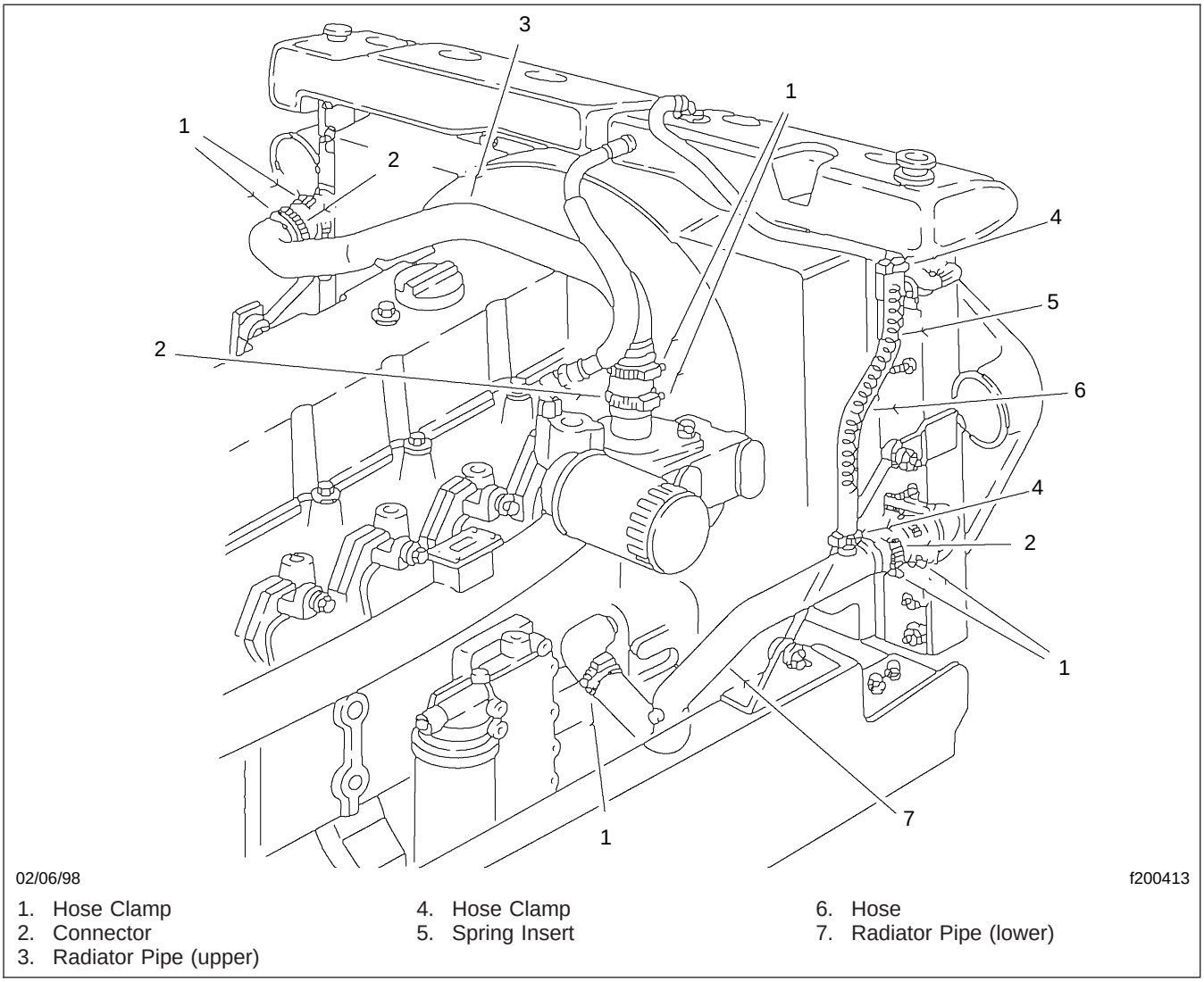
The viscous clutch components cannot be serviced in the field.

If the fan drive belt(s) is noisy, check the tension of the belt(s) to make certain it is within specifications. Also, check for misaligned pulleys. If the drive belt(s) is worn or frayed, replace it.

COOLANT CONDITIONER

⚠ CAUTION

Inadequate concentration of the coolant conditioner can result in major corrosive damage to engine cooling system components. Over-concentration can cause formation of gels that can cause coolant flow restriction, plugging of passages and overheating.



1. Hose Clamp
2. Connector
3. Radiator Pipe (upper)
4. Hose Clamp
5. Spring Insert
6. Hose
7. Radiator Pipe (lower)

Fig. 2, Coolant Hoses, Cummins ISC

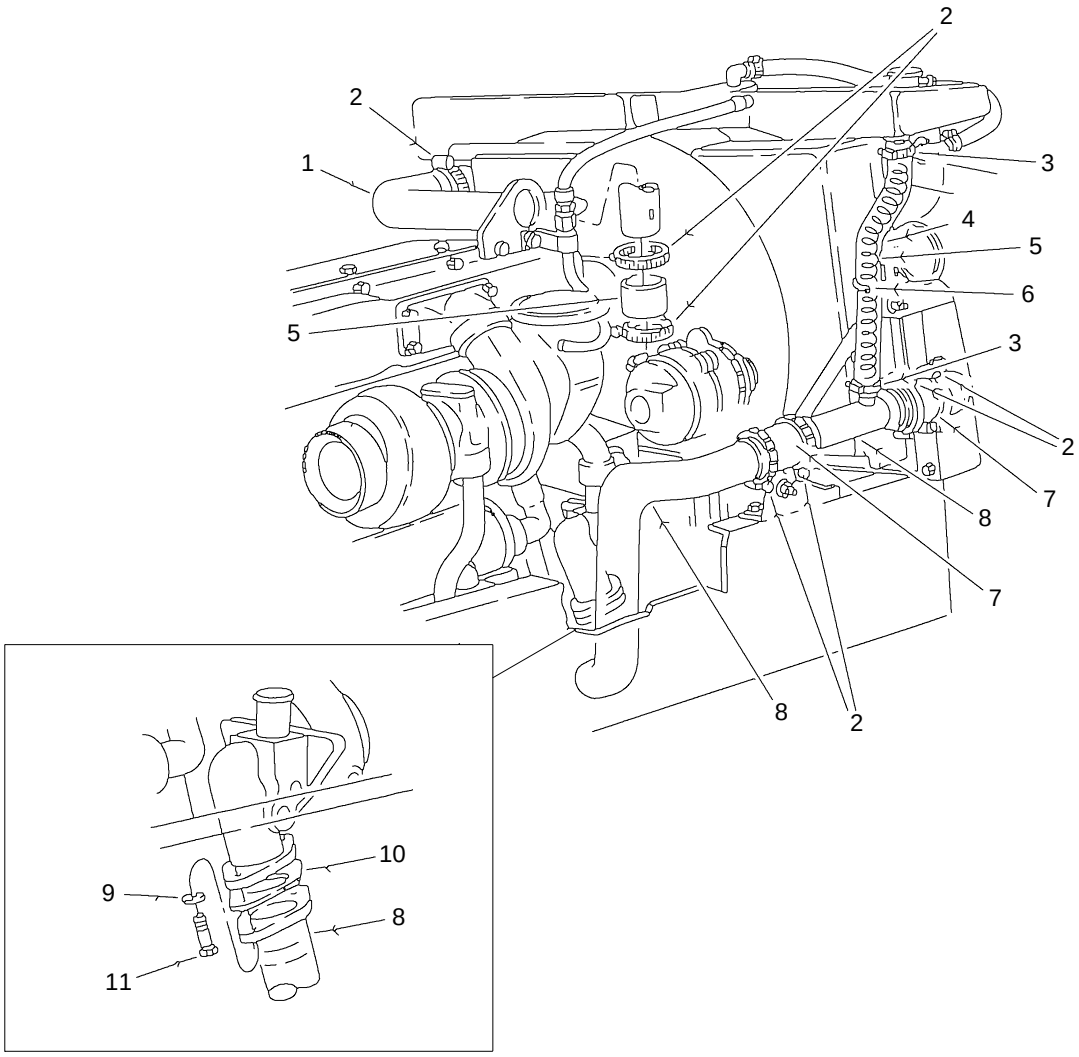
With Sterling diesel engines, always use engine cooling system conditioner as specified.

Changing engine coolant filter/conditioner as specified will help keep engine coolant properly conditioned.

Engine coolant conditioner provides additional long-term protection against cavitation erosion and corrosion beyond that provided by the engine coolant solution.

Do not add any radiator sealers containing water-soluble oil to the cooling system of diesel engines, as this will make the corrosion resistor inoperative.

General Information



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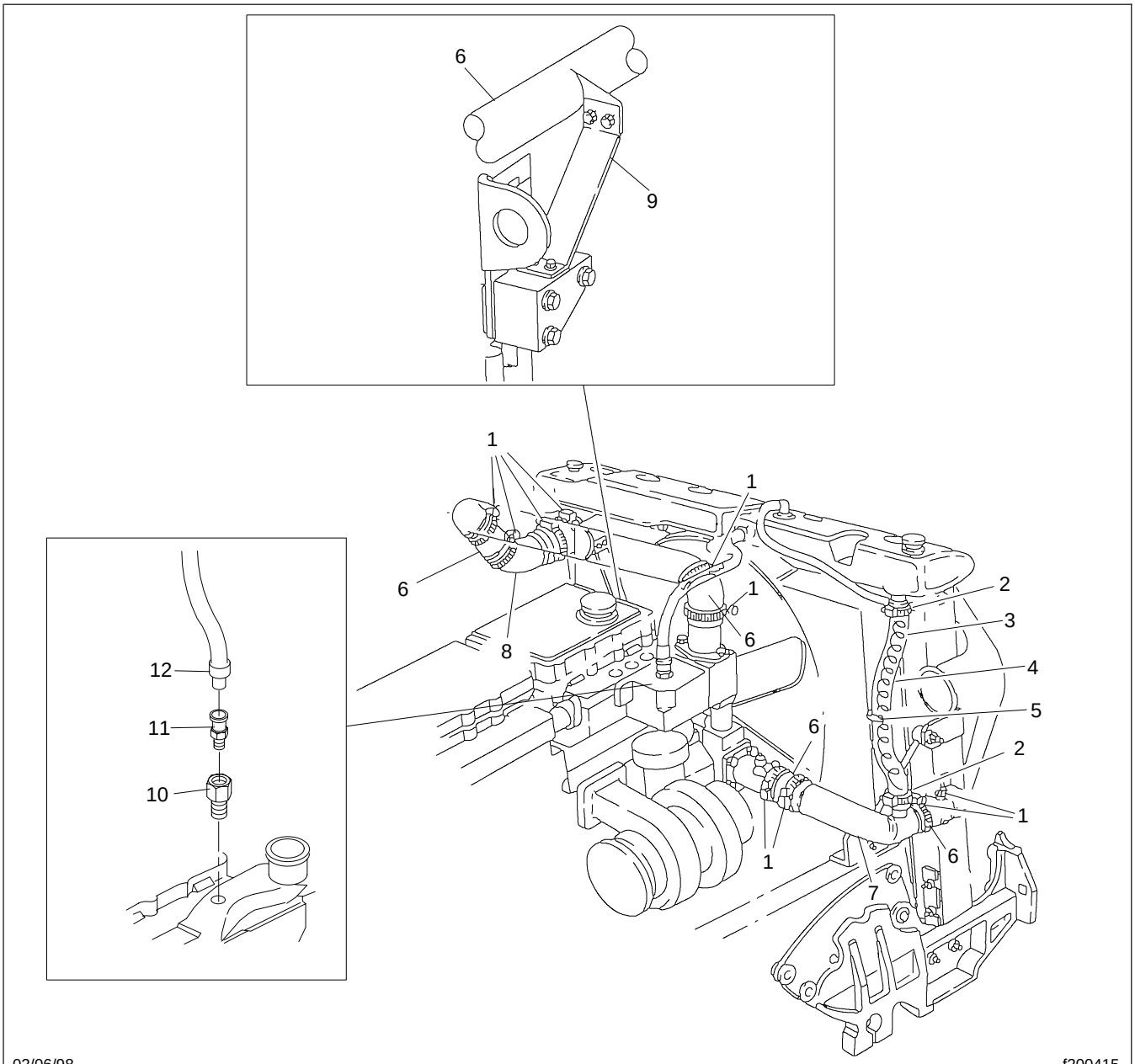
1. Radiator Pipe (upper)
2. Hose Clamp
3. Hose Clamp
4. Hose
5. Spring Insert
6. Clip
7. Connector
8. Radiator Pipe (lower)
9. Washer
10. Gasket
11. Bolt

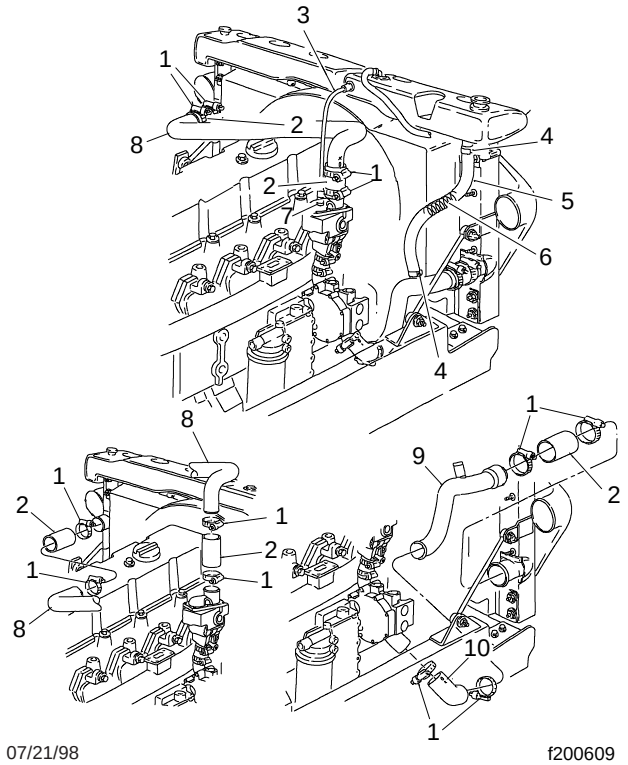
Fig. 3, Coolant Hoses, Cummins M11



1. Hose Clamp
2. Hose Clamp
3. Spring Insert
4. Hose
5. Clip
6. Connector
7. Radiator Pipe (lower)
8. Radiator Pipe (upper)
9. Bracket
10. Bushing
11. Adapter
12. Engine Vent Hose

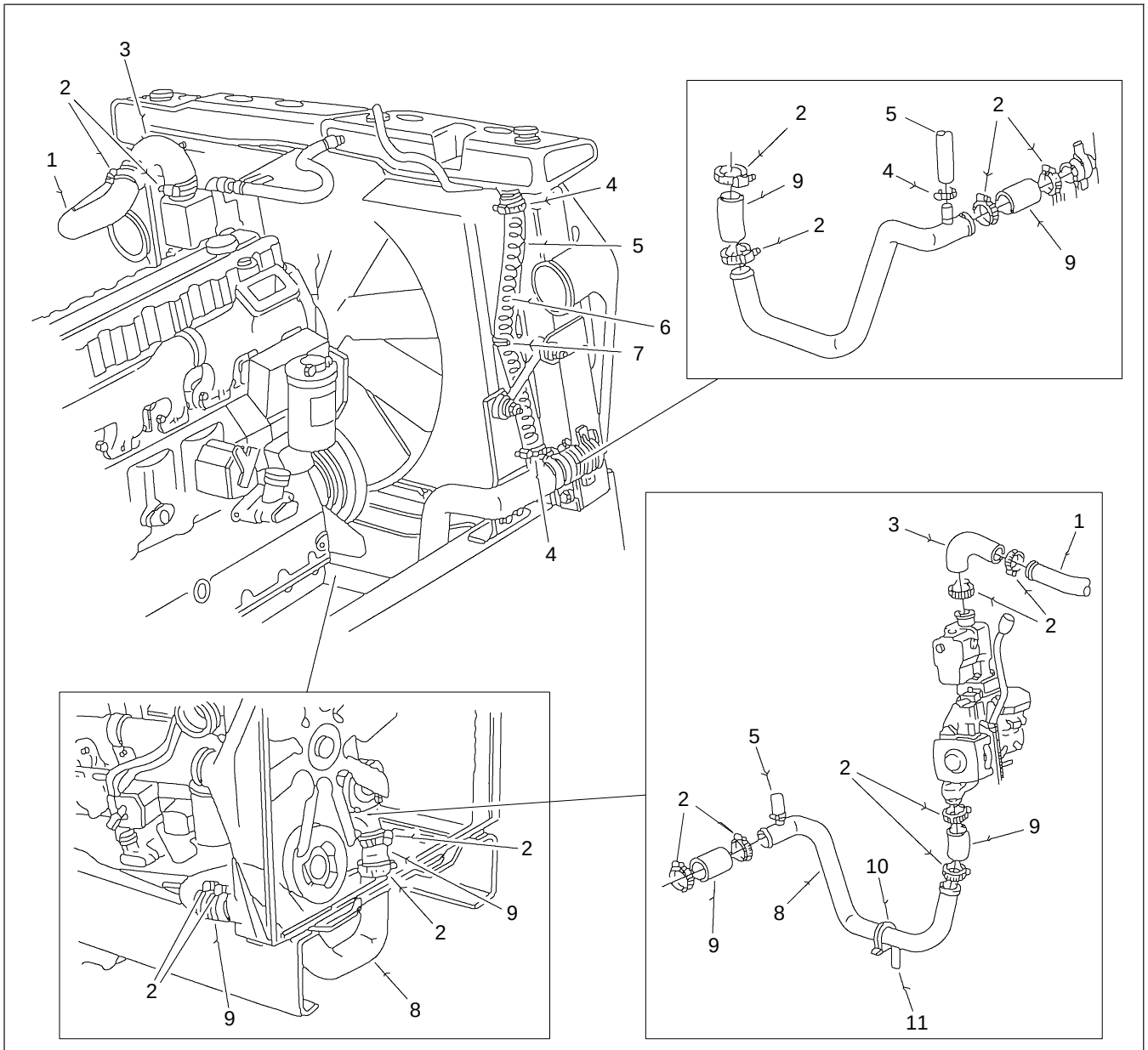
Fig. 4, Coolant Hoses, Cummins N14

General Information



1. Clamp
2. Hose (connector)
3. Engine Vent Hose
4. Clamp
5. Hose
6. Spring Insert
7. Adapter
8. Radiator Pipe (upper)
9. Radiator Pipe (lower)
10. Radiator Hose (lower)

Fig. 5, Coolant Hoses, Caterpillar 3126



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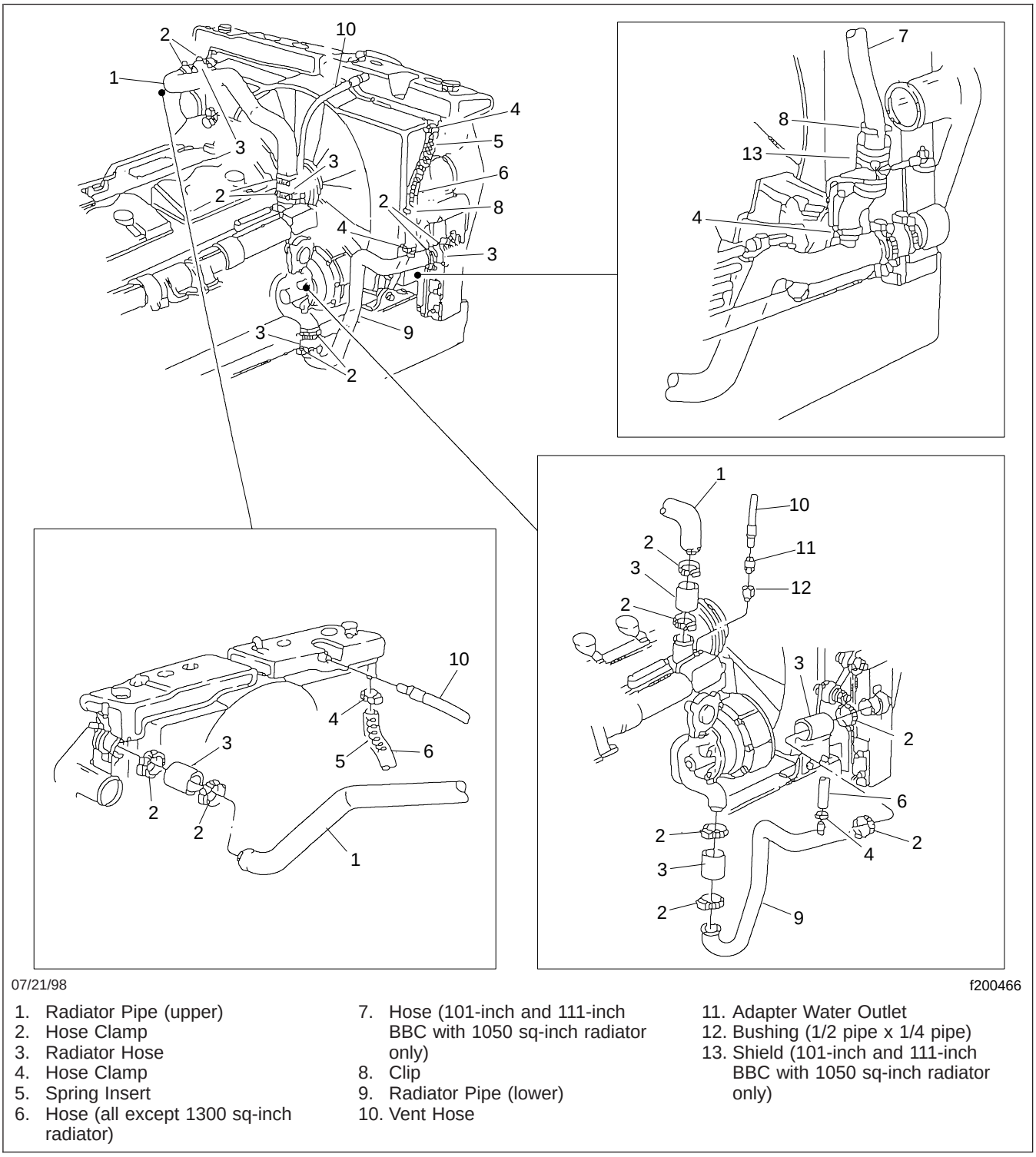
1. Radiator Pipe (upper)
2. Hose Clamp
3. Radiator Hose (upper)
4. Hose Clamp
5. Hose
6. Spring Insert
7. Clip
8. Radiator Pipe (lower)
9. Radiator Hose (lower)
10. Clip
11. Bracket

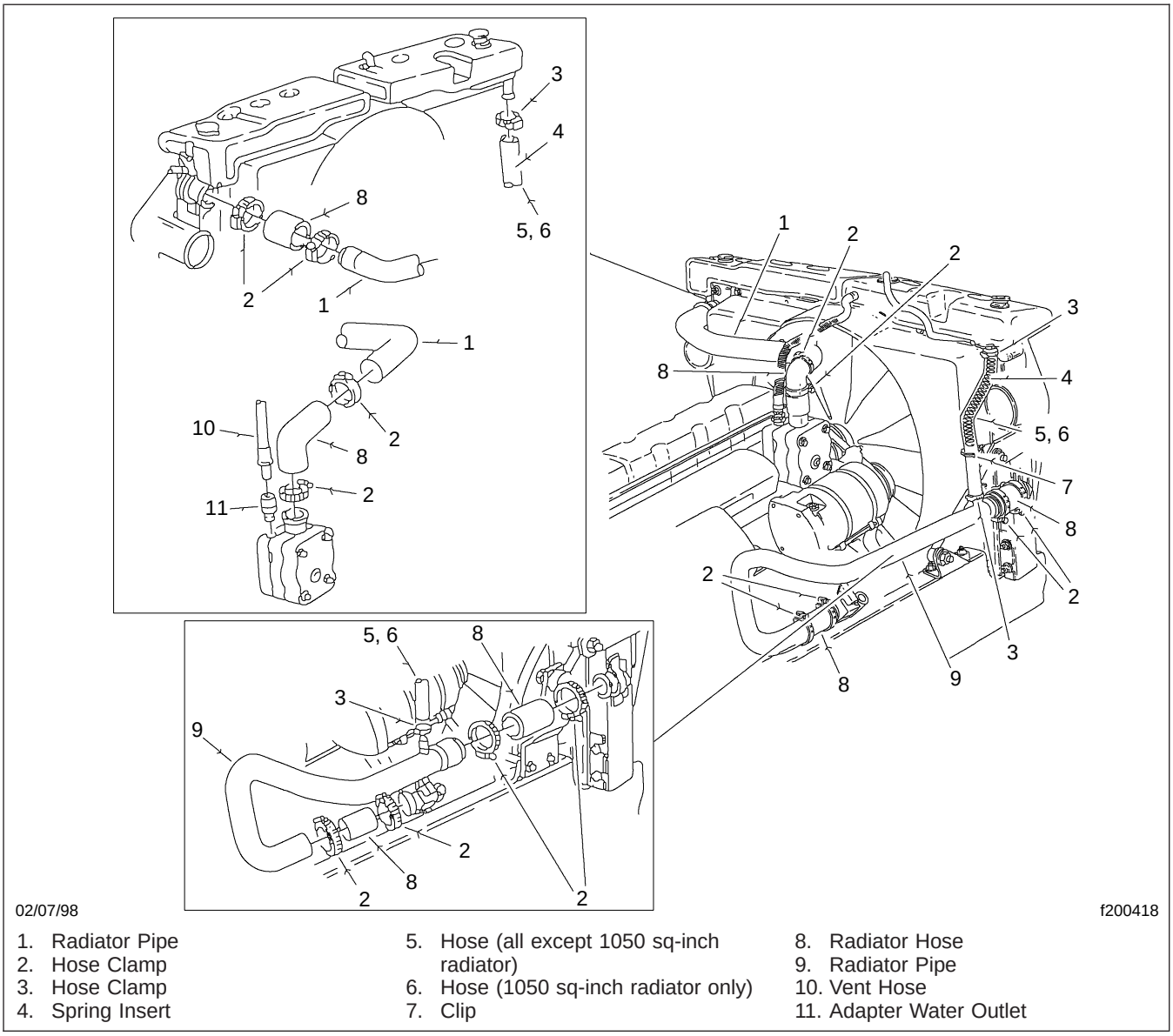
Fig. 6, Coolant Hoses, Caterpillar 3306

General Information



1. Radiator Pipe (upper)
2. Hose Clamp
3. Radiator Hose
4. Hose Clamp
5. Spring Insert
6. Hose (all except 1300 sq-inch radiator)
7. Hose (101-inch and 111-inch BBC with 1050 sq-inch radiator only)
8. Clip
9. Radiator Pipe (lower)
10. Vent Hose
11. Adapter Water Outlet
12. Bushing (1/2 pipe x 1/4 pipe)
13. Shield (101-inch and 111-inch BBC with 1050 sq-inch radiator only)

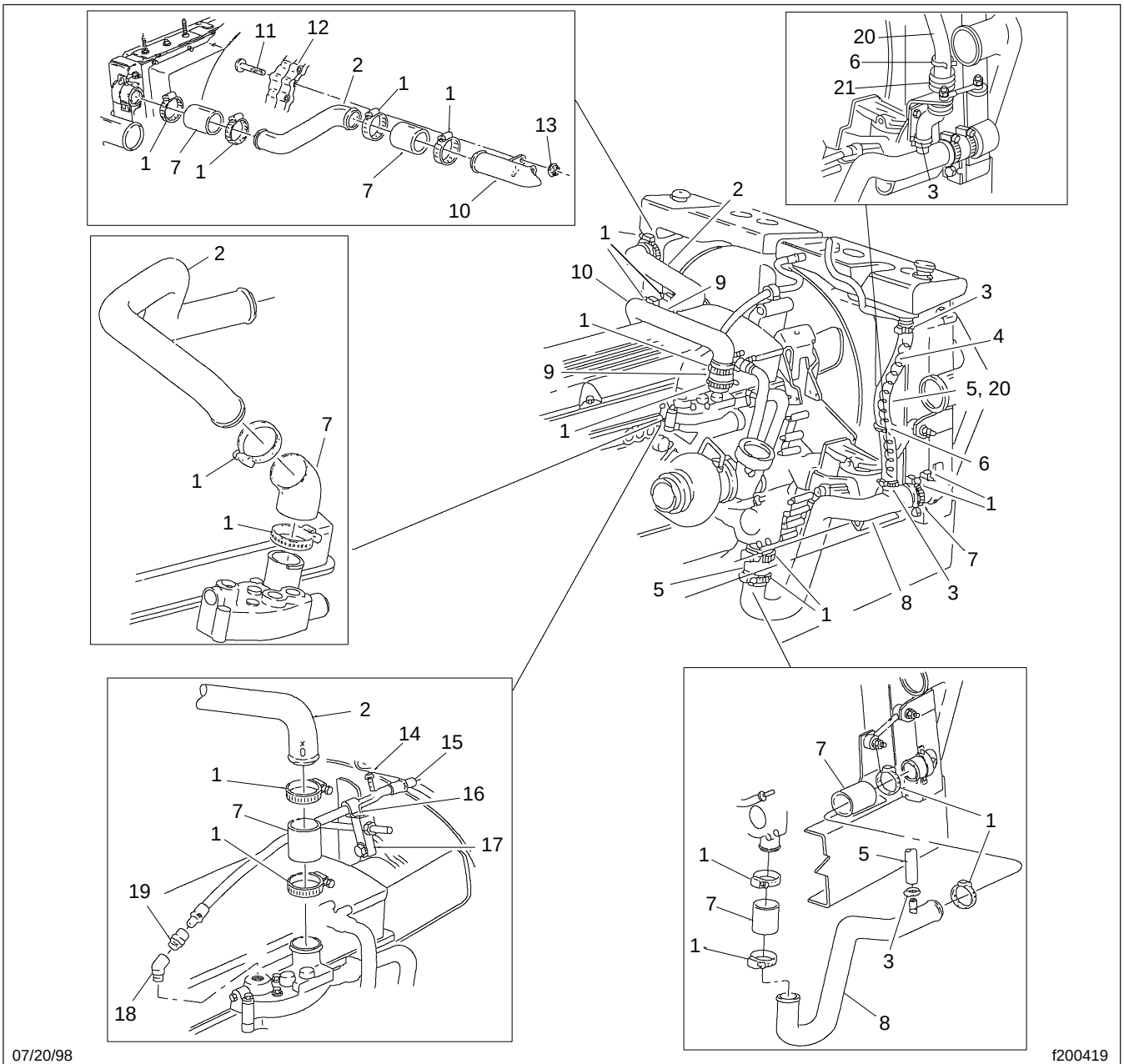
Fig. 7, Coolant Hoses, Caterpillar 3406



1. Radiator Pipe
2. Hose Clamp
3. Hose Clamp
4. Spring Insert
5. Hose (all except 1050 sq-inch radiator)
6. Hose (1050 sq-inch radiator only)
7. Clip
8. Radiator Hose
9. Radiator Pipe
10. Vent Hose
11. Adapter Water Outlet

Fig. 8, Coolant Hoses, Caterpillar C10 and C12

General Information



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1. Hose Clamp
2. Radiator Pipe
3. Hose Clamp
4. Spring Insert
5. Hose (all except 1050 sq-inch radiator)
6. Clip
7. Radiator Hose
8. Radiator Pipe
9. Radiator Hose
10. Radiator Pipe
11. Bolt
12. Engine Front Cover (part of engine)
13. Locknut
14. Bolt
15. Vent Hose
16. Clip (5/8 wraparound)
17. Generator Adjustment Block
18. Elbow (1/4 pipe x 1/4 pipe 45°)
19. Adapter Water Outlet
20. Hose (1050 sq-inch radiator only)

Fig. 9, Coolant Hoses, DDC 60 Series

Cooling System Draining, Filling and Bleeding

DRAINING

1. Open the drain cock, located on the lower left-hand side of the radiator.
2. Remove the radiator cap from the surge tank.
3. Close the drain cock.
4. Install the radiator cap.

FILLING

⚠ CAUTION

Never operate an engine with the cooling system filled only with water. Severe engine corrosion can occur. Do not operate an engine without the proper additives. Refer to Group 20 in the vehicle maintenance manual for proper cooling system additives.

1. Fill the cooling system with a 50/50 mix of the engine coolant and clean water.
2. Add the cooling system additives.

BLEEDING

1. Remove the radiator cap from the surge tank.
2. Place the heater temperature control in the maximum heat position.

⚠ WARNING

Do not stand in line with or near the cooling fan when revving the engine.

3. Start the engine and vary the rpm between idle and 1500 rpm for three minutes.
4. Increase the rpm to the maximum (governed speed).
5. Run the engine until the thermostat opens (the upper radiator hose becomes hot).
6. Allow the engine to run at the maximum an additional ten minutes to allow air to escape from the cooling system.
7. Allow the engine to return to idle.
8. Top off the surge tank. The coolant level should be between the "Full" mark and the "Add" mark.
9. Install the radiator cap onto the surge tank.

Charge Air Cooler Removal and Installation

NOTE: This procedure is for in-vehicle removal and installation of the charge air cooler (CAC).

Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.
2. Open the hood and disconnect the left headlight wiring from the connector on the hood.
3. Disconnect the hood from the tilt-assist assembly and rest the hood on a padded table.

NOTE: Do not disconnect the refrigerant lines from the A/C condenser.

4. Remove the fasteners from the A/C condenser and any stand-off brackets for the refrigerant hoses as needed.
5. Remove the A/C condenser from the front of the CAC. Cover the condenser with cardboard and secure it to the side and out of the way.
6. Remove the nuts, washers, and the two supply tanks from the radiator. See **Fig. 1**.

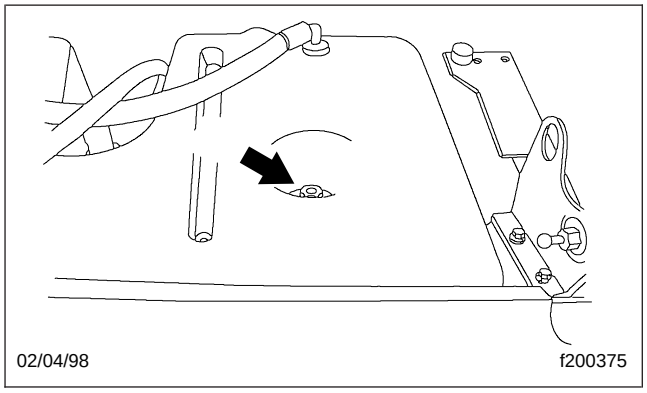


Fig. 1, Supply Tank fasteners

7. Remove the four spacer blocks from the radiator. See **Fig. 2**.
8. Remove the three nuts and the right-hand bracket retaining the charge air cooler to the radiator. See **Fig. 3**.
9. Remove the three nuts and the left-hand bracket retaining the charge air cooler to the radiator. See **Fig. 4**.

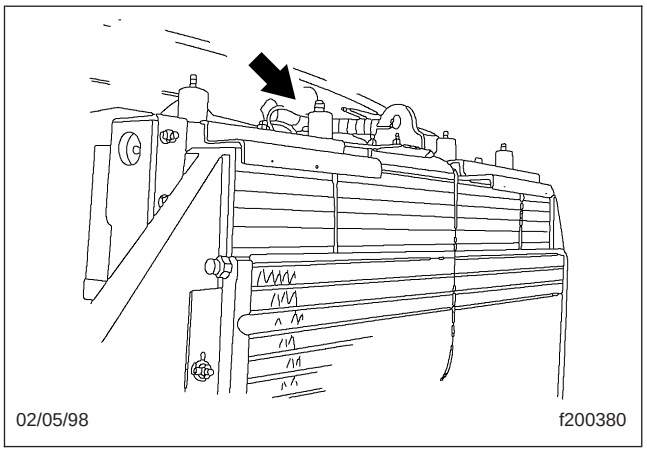


Fig. 2, Spacer Blocks

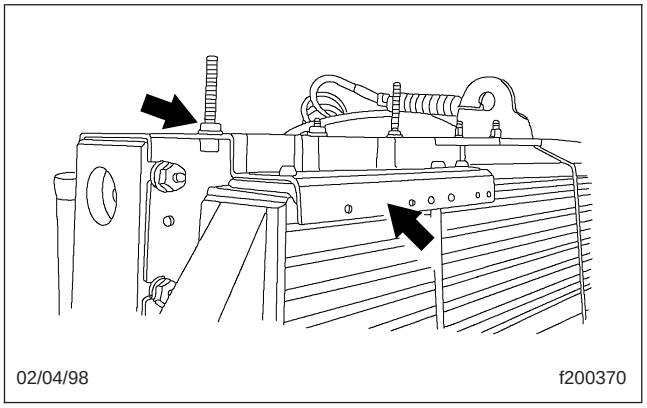


Fig. 3, Right-Hand Bracket and Fasteners

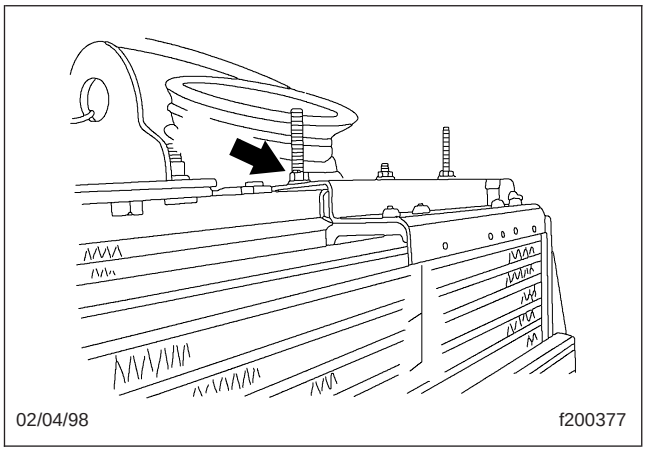


Fig. 4, Left-Hand Bracket Fasteners

Charge Air Cooler Removal and Installation

10. For the Cummins 8.3L engine only, remove the four locknuts retaining the charge air cooler to the radiator. See **Fig. 5**.

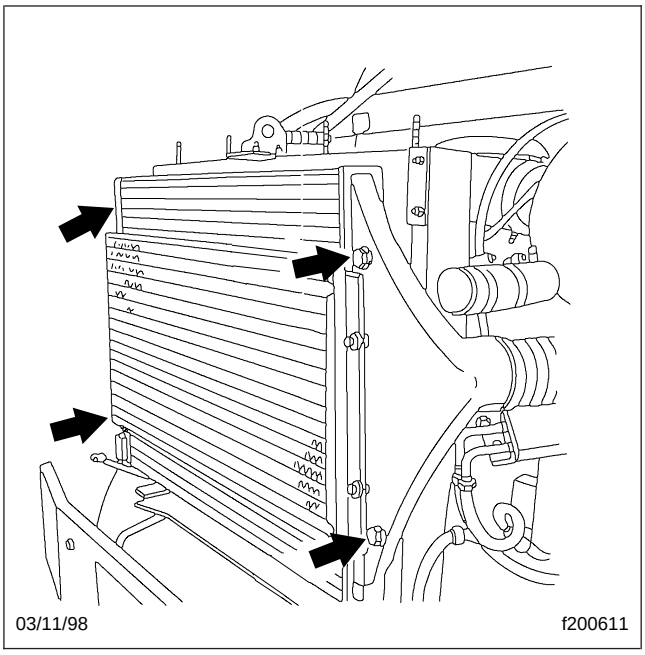


Fig. 5, Charge Air Cooler Locknuts

11. Remove the charge air cooler from the radiator. See **Fig. 6**.

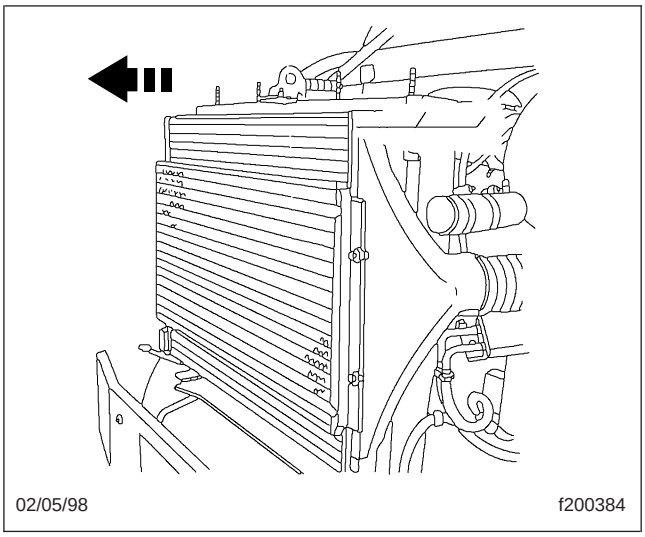


Fig. 6, Remove the Charge Air Cooler

Installation

1. Position the charge air cooler onto the radiator. See **Fig. 7**.

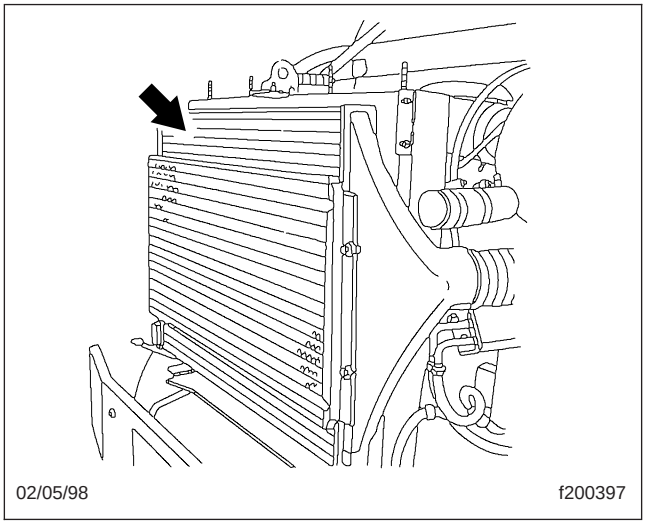


Fig. 7, Positioning Air Charge Cooler onto Radiator

2. For the Cummins 8.3L engine only, install the four locknuts retaining the charge air cooler to the radiator. Tighten locknuts to 30 to 37 lbf·ft (40 to 50 N·m). See **Fig. 5**.
3. Install the three nuts and the left-hand bracket retaining the charge air cooler to the radiator. See **Fig. 4**.
4. Install the three nuts and the right-hand bracket retaining the charge air cooler to the radiator. See **Fig. 3**.
5. Install the four spacer blocks onto the radiator. See **Fig. 2**.
6. Install the nuts, washers and the two supply tanks onto the radiator. Tighten to 22 to 30 lbf·ft (30 to 41 N·m). See **Fig. 1**.
7. Install the A/C condenser. Attach any stand-off brackets for the refrigerant hoses that were removed.
8. Tilt the hood and connect the hood to the tilt-assist assembly.
9. Connect the wiring to the left-side headlight.
10. Return the hood to the operating position.

11. Remove the chocks.

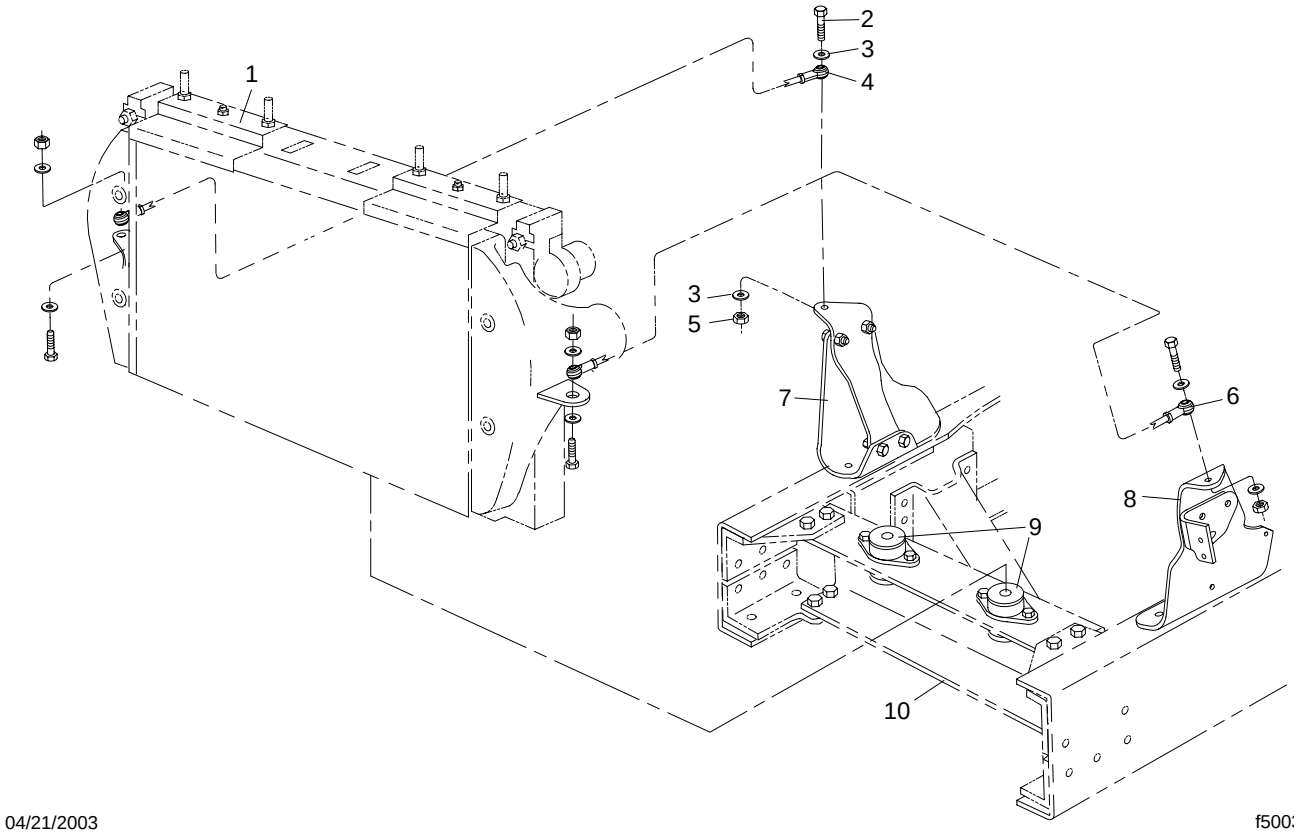
Radiator Removal and Installation

This procedure covers 900, 1050, and 1300-square-inch radiators.

See **Fig. 1** for a view of the 900-square-inch radiator installation.

Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.
2. Open the hood and disconnect the left headlight wiring from the connector on the hood.
3. Disconnect the hood from the tilt-assist assembly and rest the hood on a padded table.
4. Disconnect the wiring for the surge tank and windshield washer reservoir sensors and loosen it from the top and side of the radiator assembly.



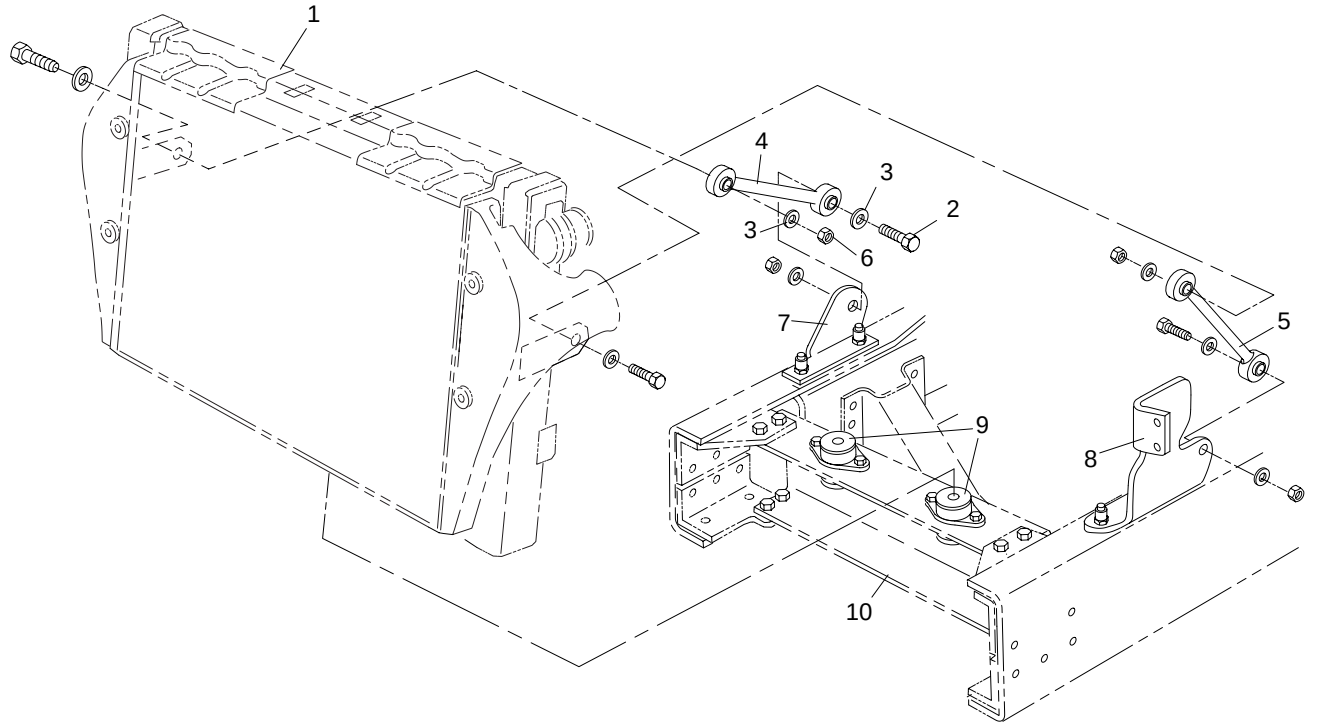
1. Cooling Module
2. Hexbolt (qty. 4)
3. Washer (qty. 8)
4. Right Strut Rod
5. Hexnut (qty. 4)
6. Left Strut Rod
7. Right Strut Rod Bracket
8. Left Strut Rod Bracket
9. Isolator (qty. 2)
10. Front Closing Crossmember

Fig. 1, 900-Square-Inch Radiator

See **Fig. 2** for a view of the 1050-square-inch radiator installation.

See **Fig. 3** for a view of the 1300-square-inch radiator installation.

Radiator Removal and Installation



1. Cooling Module
2. Hexbolt (qty. 4)
3. Washer (qty. 8)
4. Right Strut Rod
5. Left Strut Rod
6. Hexnut (qty. 4)
7. Right Strut Rod Bracket
8. Left Strut Rod Bracket
9. Isolator (qty. 2)
10. Front Closing Crossmember

Fig. 2, 1050-Square-Inch Radiator

5. Remove the windshield washer reservoir from the left side of the radiator.
6. Disconnect the charge air cooler (CAC) hoses from the CAC.
7. Disconnect the power steering oil cooler from the radiator and swing it out of the way.

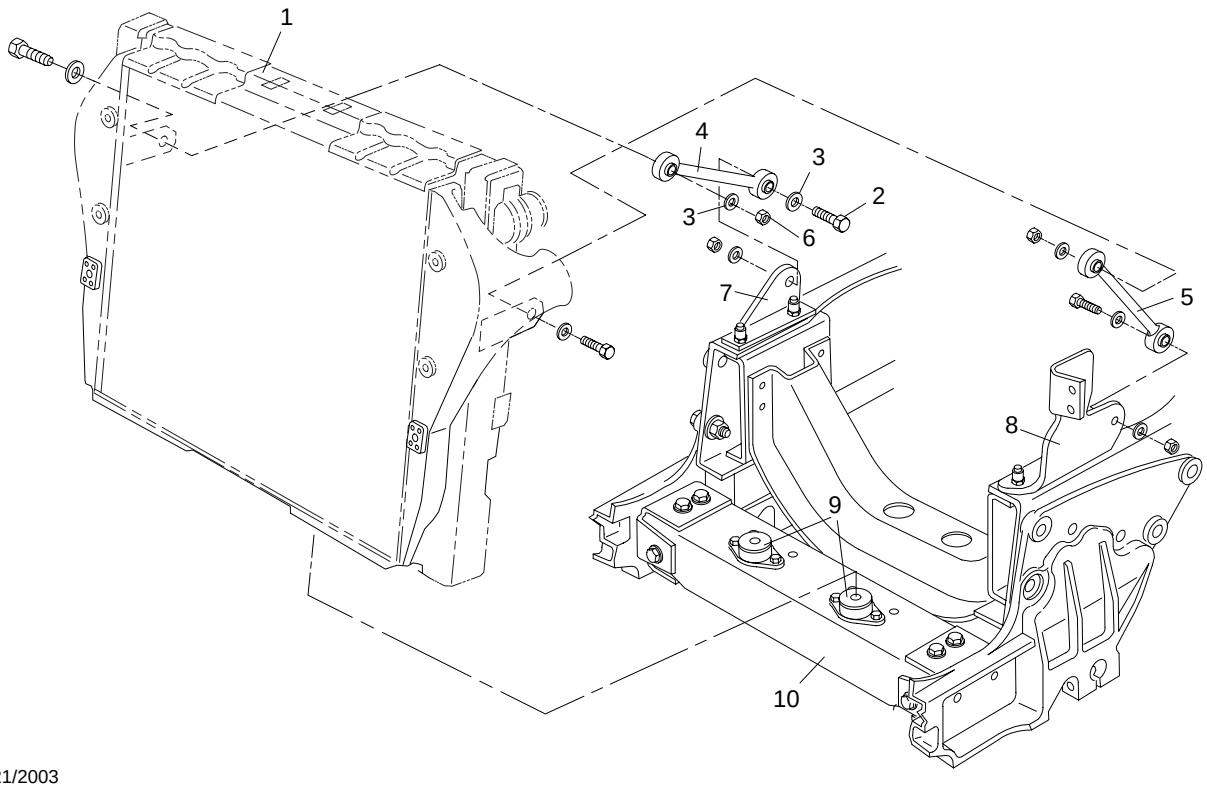
NOTE: Do not disconnect the refrigerant lines.

8. Remove the A/C condenser from the front of the CAC. Cover the condenser with cardboard and secure it to the side and out of the way. Remove any stand-off brackets for the refrigerant hoses as needed.

⚠ 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.

9. Drain the radiator.
10. Disconnect the radiator upper and lower hoses. Cap or plug the hoses to prevent dirt from entering the system.
11. Disconnect the hoses from the surge tank. Cap or plug the hoses to prevent dirt from entering the system.
12. Remove the surge tank.
13. Support the radiator with a lifting device.



1. Cooling Module
2. Hexbolt (qty. 4)
3. Washer (qty. 8)
4. Right Strut Rod
5. Left Strut Rod
6. Hexnut (qty. 4)
7. Right Strut Rod Bracket
8. Left Strut Rod Bracket
9. Isolator (qty. 2)
10. Front Closing Crossmember

Fig. 3, 1300-Square-Inch Radiator

14. Disconnect the radiator strut rods and swing them out of the way.
15. Remove the nuts from the studs on the bottom of the radiator.
16. Using the lifting device, remove the radiator from the vehicle.
17. Remove the fan shroud, CAC, and hood spring brackets as necessary.

Installation

1. Install the fan shroud, CAC, and hood spring brackets if they were removed.
2. Using the lifting device, position the radiator over the front crossmember. Align the lower radiator mount studs with the holes in the isolators and lower support bracket.
3. Lower the radiator into position.
4. Install the 1/2–13 hexnuts and washers on the studs on the bottom of the radiator. Tighten to 95 lbf·ft (129 N·m).
5. Position the radiator supports and install the retaining bolts, washers and nuts. Tighten 75 to 105 lbf·ft (102 to 142 N·m).
6. Install the A/C condenser on the front of the CAC. Install any clamps or standoff brackets that were removed.
7. Install the power steering oil cooler.
8. Install the CAC hoses.

Radiator Removal and Installation

9. Remove the plugs, connect the coolant hoses to the radiator, and connect the hose clamps. Your hose clamps can be T-bolt clamps (see **Fig. 4**), Breeze Constant-Torque clamps (see **Fig. 5**), or ABA Radial worm-drive hose clamps (see **Fig. 6**).

   When working with T-bolt type hose clamps, tighten the clamps 55 lbf·in (620 N·cm). These clamps are now standard on hoses with an inside diameter greater than 2 inches (51 mm).

   When installing the Breeze Constant-Torque hose clamps, the clamps must be tightened to the correct torque. The screw tip of the clamp should extend about 1/4 inch (6 mm) from the clamp housing, and the Belleville washer stacks should be collapsed almost flat. Use a torque wrench to install these hose clamps correctly. The correct installation torque for Breeze Constant-Torque hose clamps is as follows:

   For Breeze Constant-Torque hose clamps with a 5/16-inch tightening screw hex: 55 lbf·in (620 N·cm).

   For Breeze Constant-Torque hose clamps with a 3/8-inch tightening screw hex: 90 lbf·in (1020 N·cm).

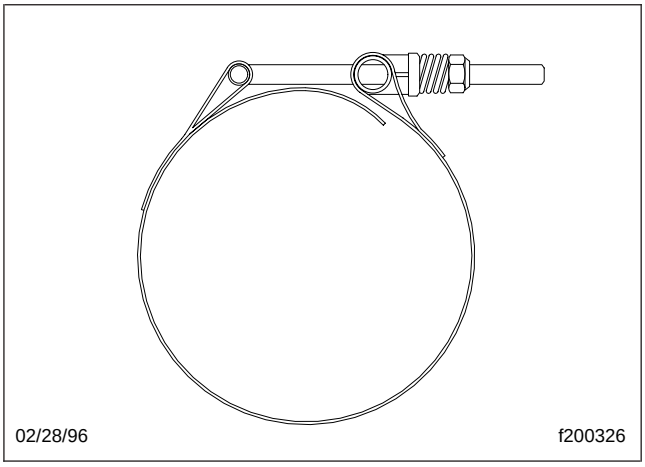
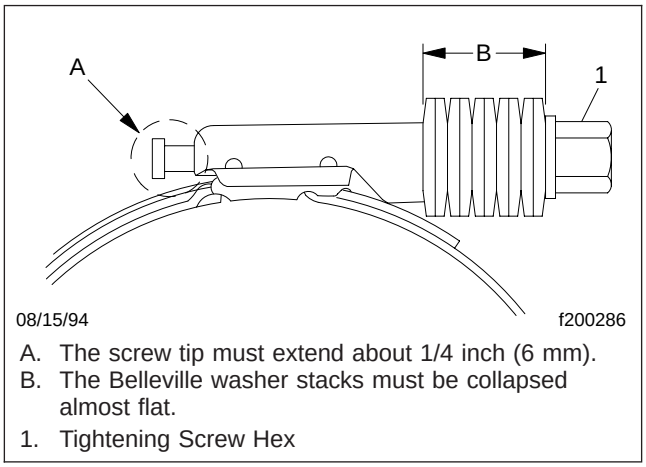


Fig. 4, T-bolt Type Hose Clamp

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



A. The screw tip must extend about 1/4 inch (6 mm).
B. The Belleville washer stacks must be collapsed almost flat.
1. Tightening Screw Hex

Fig. 5, Breeze Constant-Torque Hose Clamp Installation

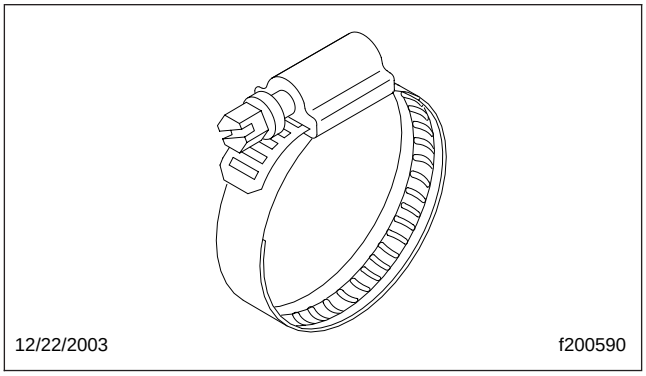


Fig. 6, ABA Radial Worm-Drive Hose Clamp (typical)

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.

10. Install the surge tank.
11. Remove the plugs, then connect the hoses to the surge tank.
12. Install the windshield washer reservoir and connect the hoses.
13. Attach the electrical wires to the surge tank and windshield washer reservoir.
14. Tilt the hood and connect the hood to the tilt-assist assembly.
15. Connect the wiring to the left-side headlight.
16. Fill the radiator.
17. Return the hood to the operating position.
18. Remove the chocks.

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

Surge Tank Removal and Installation

Removal

1. Drain the radiator until the surge tank is empty.
2. Disconnect the radiator vent hose.
3. Disconnect the engine vent hose.
4. Loosen the clamp and remove the hose.
5. Disconnect the harness routing clamp. See **Fig. 1**.

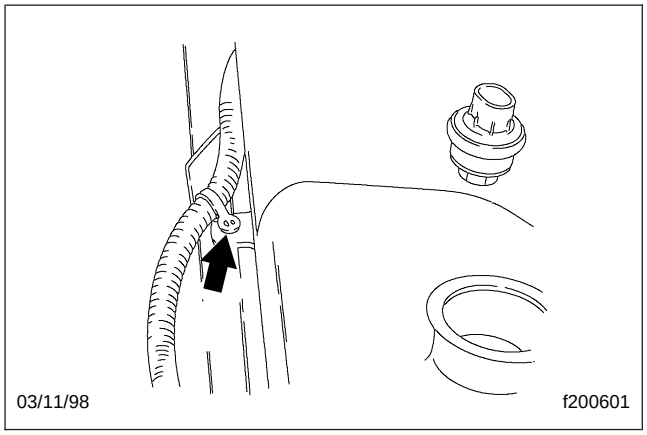


Fig. 1, Harness Routing Clamp

6. Disconnect the coolant level sensor electrical connector.
7. Remove the two nuts, washers and the surge tank from the radiator.

Installation

1. Install the two nuts, washers and the surge tank onto the radiator.
2. Connect the coolant level sensor electrical connector.
3. Connect the harness routing clamp. See **Fig. 1**.
4. Install the hose and tighten the clamp.
5. Connect the engine vent hose.
6. Connect the radiator vent hose.
7. Fill the cooling system.

Radiator Cleaning and Inspection

CAUTION

Be careful not to damage the radiator and charge air cooler fins and louvers. Damaged fins or louvers will degrade cooling performance.

1. Clean the radiator using a soft bristle brush, warm water and a mild liquid detergent.
2. Rinse the radiator with clean water.
3. Inspect the radiator for excessive corrosion and damaged cooling fins and tubes.

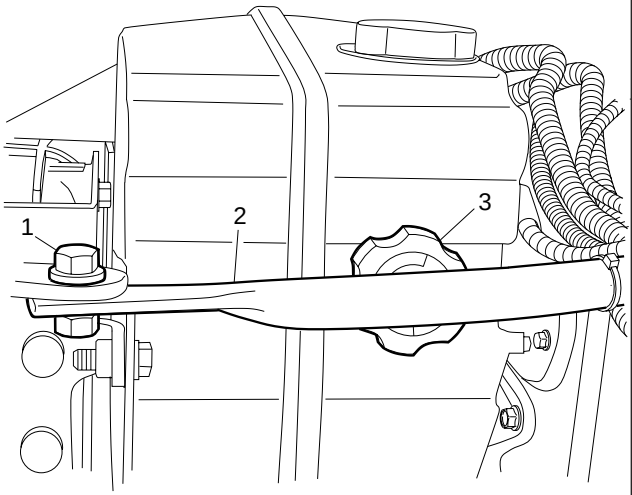
NOTE: Do not use caustic cleaning solutions to clean the radiator. A radiator boil-out tank can be used only after the radiator side tanks have been removed.

4. Add a mild liquid detergent to the inside of the radiator.
5. Fill the radiator with water and allow it to soak.
6. Rinse the radiator using only clean water.
7. Inspect the radiator for excessive corrosion and damage.

Engine Mounted Radiator, Cooling System Pressure Testing

NOTE: If the engine-mounted radiator strut rod blocks access to the surge tank pressure cap, remove the strut as follows.

1. Unbolt the driver's side radiator strut rod from the radiator and the engine. Set the strut rod on the engine, and do not disconnect anything that might be attached to it. See **Fig. 1**.



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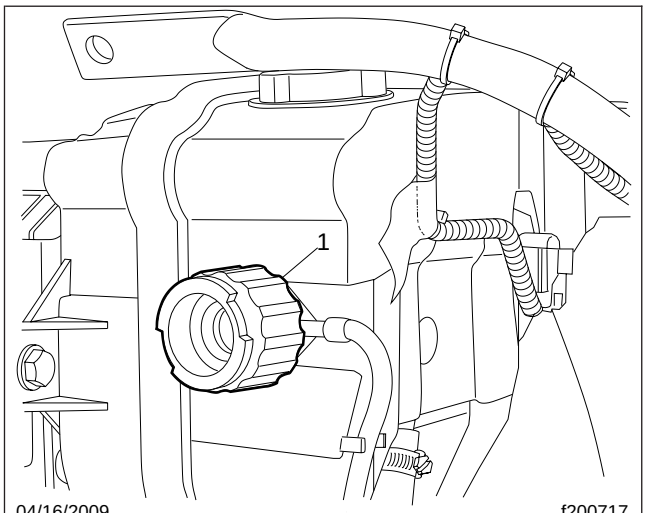
1. Strut Rod Mounting Capscrew and Nut
2. Strut Rod
3. Pressure Cap

Fig. 1, Radiator Strut Rod Installation

2. Remove the pressure cap and attach the appropriate adaptor tool (J-42401-3 or J-42401-1A) to the surge tank. See **Fig. 2**.

NOTE: These are Kent-Moore/SPX part numbers. Other companies sell these adaptors, Snap-On, Mac, Cornwell, etc. These are the same adaptors that are used on cars.

3. Attach a radiator-pressure hand pump, and apply no more than 20 psi (138 kPa) of pressure to the cooling system. See **Fig. 3**.
4. Check for leaks. Repair as needed.



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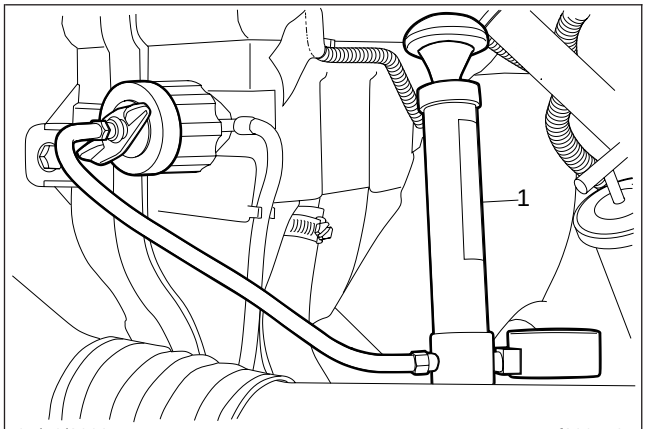
1. Adaptor

Fig. 2, Adaptor Installation



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1. Hand Pump

Fig. 3, Hand Pump Installation

5. Remove the pump and adaptor tool, and install the radiator cap.
6. Install the strut rod, and tighten the fasteners 68 lbf·ft (92 N·m).

Radiator Pressure Testing

Out of Vehicle Pressure Testing

1. Remove the radiator from the vehicle. For instructions, refer to **Subject 120** in this manual section.
2. Pressure-test the radiator.
   - 2.1 Plug the inlet, outlet, and all other ports on the radiator assembly.

NOTICE

Do not apply a higher amount of air pressure than specified below; too much pressure will damage the radiator core.

   - 2.2 Remove the radiator cap, and install a pressure regulator and gauge. Using a hand pump, apply 20 psi (138 kPa) air pressure through the filler neck.
   - 2.3 Submerge the radiator in a tank of water and check it for leaks. Remove the radiator from the water.
   - 2.4 Remove the plugs and the testing gauge, and install the radiator cap. Repair the radiator, if necessary.
3. Install the radiator in the vehicle. For instructions, refer to **Subject 120** in this manual section.

Specifications

General Specifications	
Item	**Specification**
Sterling Heavy Duty Diesel Engine Cooling System Fluid	ESE–M97B18–C
Coolant Conditioner	—
Coolant Freeze Protection	–34°F (–37°C) when mixed 50/50 with water
Coolant Boil Protection	265°F (129°C) when mixed 50/50 with water

Table 1, General Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Radiator Side Support Mounting Bolts and Nuts	75–105 (102–142)
Radiator-to-Crossmember Mounting Bolts	110–150 (149–203)
Coolant Supply Bottle Mounting Nuts	22–30 (30–41)

Table 2, Torque Specifications

General Information

The cooling system components are:

- coolant
- fan and fan clutch, fan shroud
- radiator
- water pump
- coolant recovery/supply bottle
- thermostat
- coolant hoses
- coolant filter
- block heater

Coolant is drawn from the radiator by the integrally mounted water pump. The output from the water pump empties into the bottom of the oil cooler cavity in the cylinder block.

From the cooler cavity, the coolant flows into the upper water manifold. A portion of the coolant flows through the coolant filter and returns to the lower water manifold. The remainder flows through six cast openings up to the cylinder head.

A portion of the coolant flowing into the cylinder head is directed to the liner cavity and, by means of a diffuser plate cast into the cavity, is circulated around the top portion of the liners.

The remainder of the coolant flows across the valve bridges, around the injector bores and down into the liner cavities through two orificed holes per cylinder. The orificed holes control the coolant flow around the liners.

From the liner cavities, the coolant flows through cast openings into the lower water manifold and into the thermostat cavity.

⚠ CAUTION

The use of a winter front or other airflow restriction devices mounted in front of the radiator is not recommended on vehicles equipped with chassis mounted air-to-air after cooling. Airflow restriction causes high exhaust temperatures, power loss, excessive fan usage, reduction in fuel economy, and a risk of the engine overheating. If a winter front or other airflow restriction device is used, it must have a permanent opening directly in line with the center of the fan drive.

The minimum opening size must be at least 120 sq-inch (775 sq-cm).

Troubleshooting

INSPECTION AND VERIFICATION

⚠ CAUTION

Allow the engine to cool before checking engine coolant level to prevent burn injuries.

1. Verify the original concern by operating the engine cooling system to duplicate the condition.
2. Check for leaks at the following locations:
   - hoses and hose connections
   - radiator seams, radiator core, and radiator drain petcock
   - all core plugs and drain plugs
   - heater core
   - water pump
3. Check the compressed air storage tanks for coolant. If coolant is found, check the air compressor for internal leaks.
4. Check the oil dipstick for evidence of coolant in the engine oil.

Problem—Loss of Coolant

Problem—Loss of Coolant	
Possible Cause	**Remedy**
Damaged radiator	Check the engine coolant level at the coolant supply bottle. If the coolant level is not within specifications, add coolant to the coolant supply bottle until fluid is between the cold fill level marks. Check the coolant recovery system. Allow the engine to cool, then remove the cap. Visually inspect the radiator cap for foreign material between the sealing gasket and diaphragm. If the radiator cap is not OK, clean the radiator cap. Perform a radiator cap pressure test. If the radiator cap is OK, add coolant to the coolant supply bottle until fluid is between the cold fill level marks. If the coolant supply bottle leaks, replace the coolant supply bottle. Test the system for normal operation. If the coolant supply bottle does not leak, perform the "Radiator Pressure Test" in this subject. Repair as necessary. Test the system for normal operation. If the coolant level is within specifications, check the radiator cap. Perform a radiator cap pressure test. If the radiator cap is not OK, replace the radiator cap. Test the system for normal operation. If the radiator cap is OK, check for an internal coolant leak. Inspect the coolant in the coolant supply bottle for signs of transmission fluid or engine oil. If oil is evident, refer to the original equipment manufacturer's engine manual. Test the system for normal operation. If oil is not evident in the coolant, check the engine and transmission for coolant. If coolant is evident, refer to the original equipment manufacturer's engine manual. Test the system for normal operation. If coolant is not evident, pressure test the radiator. Refer to "Component Tests" in this subject. If the cooling system leaks, repair or replace the leaking components. Test the system for normal operation. If no leaks are detected, the cooling system is operational.
Loose or damaged radiator hoses	
Loose or damaged heater hoses	
Damaged heater core	
Damaged engine gaskets	
Damaged coolant supply bottle	

Troubleshooting

Problem—Engine Overheats

Problem—Engine Overheats	
Possible Cause	**Remedy**
Defective thermostat	Check the engine coolant level at the coolant supply bottle. NOTE: If the engine is hot, allow the engine to cool before proceeding. If the coolant level is not OK, refill the engine coolant at the coolant supply bottle. Refer to "Problem—Loss of Coolant" chart for further tests. If the coolant level is OK, check the engine coolant for contaminants such as rust, corrosion, or discoloration. If the coolant condition is not OK, flush the engine cooling system. Test the system for normal operation. If the coolant condition is OK, check for an airflow obstruction.
Defective water pump	Inspect the A/C condenser core and radiator for obstructions, such as leaves or bugs. If there is an obstruction, clean the A/C condenser core and radiator. Test the system for normal operation. If no obstructions are present, check the heater core operation.
Plugged radiator (A/C condenser) or defective heater core	Install the radiator cap. Start the engine and allow it to run. As the engine starts to heat up, feel the heater core inlet and outlet hoses. They should be the same temperature after three or four minutes. If the inlet hose is not the same temperature as the outlet hose, turn the engine off. Repair or replace the heater core. Refer to **Group 83** in this manual. Test the system for normal operation. If the inlet hose is the same temperature as the outlet hose, leave the engine running and check the thermostat operation.
Defective fan clutch	Feel the inlet and outlet hoses and the underside of the radiator upper hose. If the radiator upper hose and the inlet and outlet hoses are cold, replace the thermostat. Test the system for normal operation. If the hoses are as warm as the rest of the cooling system, stop the engine, check the cooling fan clutch. Perform the "Fan Clutch Component Tests" in **Section 20.02**. If the fan clutch is defective follow fan clutch replacement procedures in **Section 20.02**. Test the system for normal operation. If the fan clutch is OK, refer to the original equipment manufacturer's engine manual for engine repairs.

Problem—Engine Does Not Reach Normal Operating Temperature

Problem—Engine Does Not Reach Normal Operating Temperature	
Possible Cause	**Remedy**
Defective thermostat	Check the engine temperature. Start the engine and allow it to run for 15 minutes. Feel the inlet and outlet hoses and the underside of the radiator upper hose. If the upper radiator hose and the heater water hoses are cold, replace the water thermostat. Test the system for normal operation. If the hoses are at the proper temperature, refer to **Group 54** for troubleshooting of the temperature gauge.

COMPONENT TESTS

Radiator Pressure Test

1. Remove the radiator cap.
2. Install the pressure tester onto the coolant supply bottle.
3. Slowly pump up the pressure in the radiator until the rated pressure (located on the radiator cap) is obtained.
4. Observe the radiator cores, hoses, and the coolant tanks for leaks. Repair as necessary.

General Information

The fan clutch is used to maintain engine temperature by engaging or disengaging the cooling fan by sensing of the coolant temperature or air temperature at the fan. The purpose of the fan clutch is to operate the fan only when it is needed. These vehicles use four types of fan clutches:

- Eaton Viscous
- Horton "On/Off" (automatic cycling)
- Kysor "On/Off" (automatic cycling)
- Kysor "On/Off" (electrically controlled)

EATON VISCOUS CLUTCH

The Eaton Viscous Clutch fan drive (see **Fig. 1**), senses the air temperature behind the radiator core, and engages or disengages the fan depending on that temperature. A coiled metal heat sensor on the fan drive detects changes in the temperature and engages the fan when more cooling is needed, or disengages the fan when the engine is sufficiently cooled.

The fan clutch uses a fluid shearing action to supply the force needed to turn the fan blade. A one-piece input shaft and disc assembly is bolted to a fan hub; the disc is lined with ring-shaped grooves that face matching grooves on the inside of the drive chamber. Two bearing assemblies allow the drive chamber to be free-wheeling in relation to the input disc.

To engage the fan, the heat sensor on the front of the clutch opens a valve in the clutch's drive chamber. The centrifugal force of the spinning input disc causes silicone fluid to flow from the drive chamber to the outer edges of the disc. This fluid shearing action causes the drive chamber and fan blade to spin, increasing in speed as all of the grooves are filled with the silicone.

To disengage the fan, the heat sensor closes the valve in the clutch's drive chamber, which stops the flow of silicone fluid. The centrifugal force of the spinning input disc causes silicone fluid to flow outward to the outer edge of the clutch where it returns to the drive chamber through a passage in the input plate. Without the silicone fluid to create the shearing action between the two plates, the fan begins to free-wheel.

HORTON "ON/OFF" CLUTCH

The Horton "On/Off" Clutch fan drive (see **Fig. 2**), is a temperature-controlled, air-operated clutch that controls engine temperature by engaging or disengaging the fan. Internal spring pressure disengages the fan clutch when the coolant temperature is below the specified temperature range; internal air pressure engages the fan clutch when the coolant temperature rises above the specified range.

Air pressure to the fan clutch (see **Fig. 3**), is controlled by a solenoid valve; the solenoid valve is controlled by a temperature switch that is installed in the thermostat housing. See **Fig. 4**.

When the engine is cold, the solenoid valve restricts air pressure to the cylinder, and the fan clutch remains disengaged. When the coolant temperature rises to the temperature switch setting, the switch provides power to the solenoid valve, and the valve releases compressed air to engage the fan clutch. When the coolant temperature drops to the temperature switch cutoff setting, the solenoid stops the compressed air, and the clutch disengages.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-drier. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve, and the valve releases compressed air to engage the fan clutch.

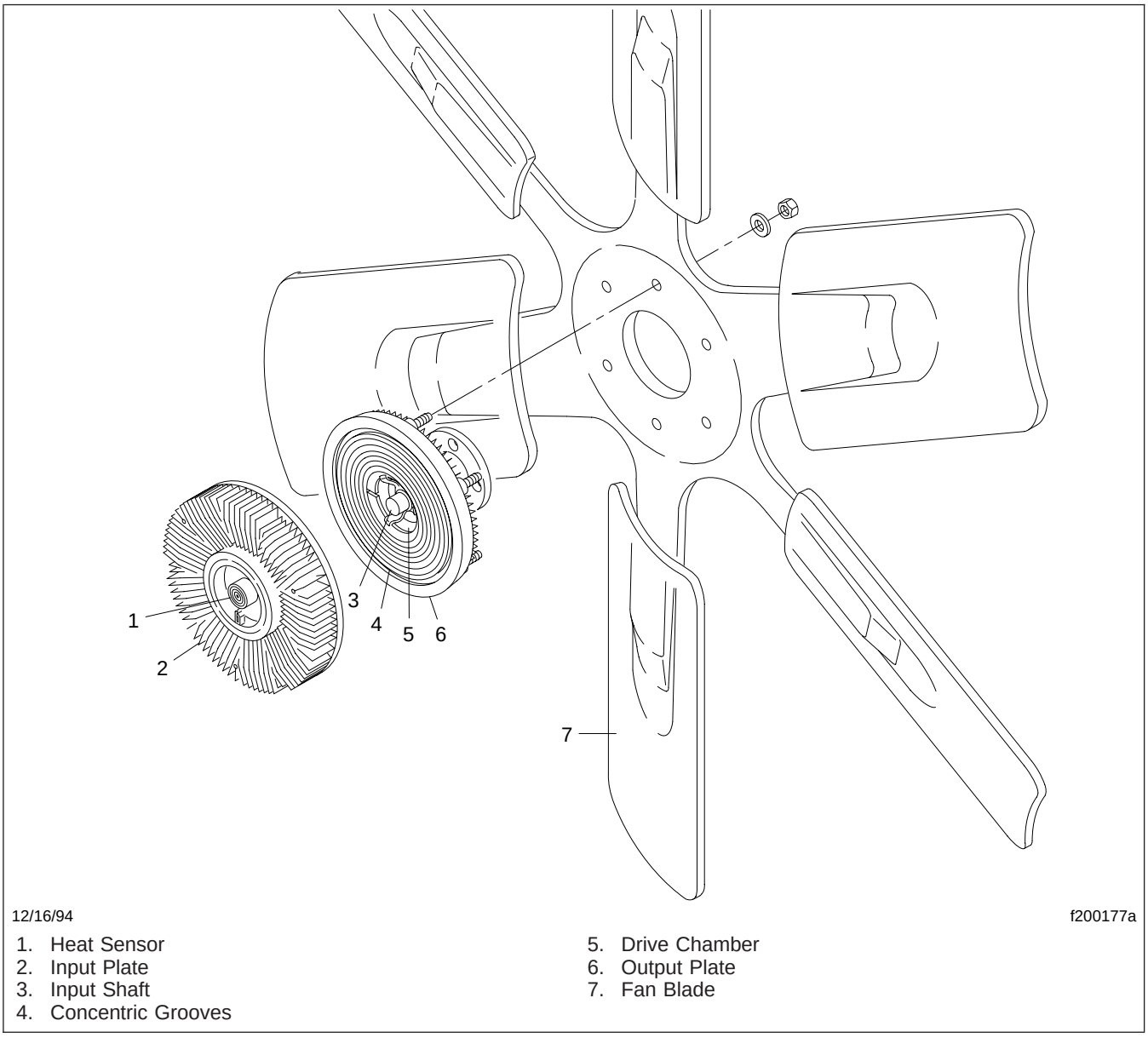
KYSOR "ON/OFF" CLUTCH

The Kysor "On/Off" Clutch fan drive (see **Fig. 5**), is an air-operated, temperature-controlled clutch that controls engine temperature by engaging or disengaging the fan. Internal spring pressure engages the fan clutch when the coolant temperature rises above the specified temperature range; internal air pressure disengages the fan clutch when the coolant temperature is below the specified range.

Air pressure to the fan clutch (see **Fig. 6**), is controlled by a solenoid valve; the solenoid valve is controlled by a temperature switch that is installed in the thermostat housing. See **Fig. 7**.

When the engine is cold, the solenoid valve allows air pressure to enter the cylinder, and the fan clutch remains disengaged. When the coolant temperature rises to the temperature switch setting, the switch provides power to the solenoid valve, and the valve releases compressed air from the cyclinder and the

General Information



1. Heat Sensor
2. Input Plate
3. Input Shaft
4. Concentric Grooves
5. Drive Chamber
6. Output Plate
7. Fan Blade

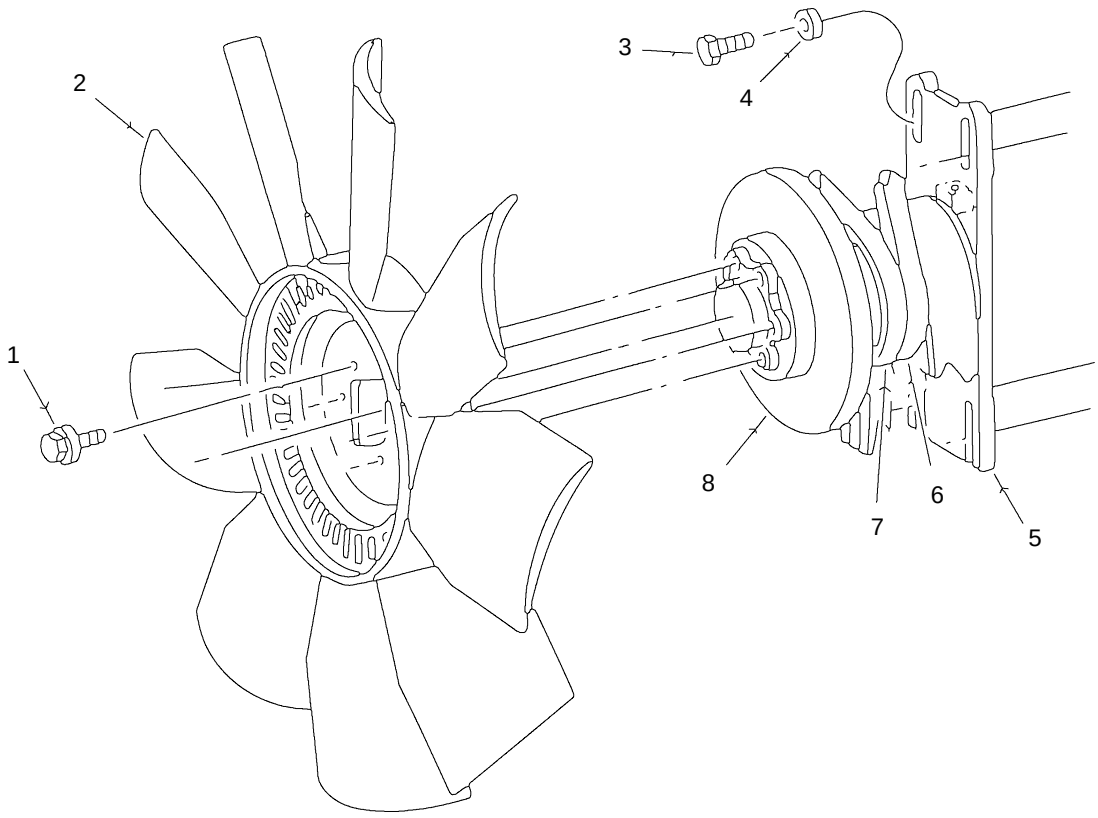
Fig. 1, Eaton Viscous Clutch, Typical

fan clutch spring engages the fan clutch. When the coolant temperature drops to the temperature switch cutoff setting, the solenoid valve allows air pressure to enter the cylinder, and the clutch disengages.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-drier. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve, and the valve releases compressed air to engage the fan clutch.

FAN CLUTCH CONTROL METHODS

The method of controlling the fan clutch will vary with the clutch manufacturer and engine manufacturer. See **Fig. 8**. The air operated fan clutches are optional on some midrange engines and standard on all



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1. Bolt (6 qty.)
2. Fan Assembly
3. Bolt (10 qty.)
4. Flatwasher (10 qty.)
5. Fan Clutch Bracket
6. Air Conditioner Compressor Drive Belt
7. Alternator Drive Belt
8. Fan Clutch Assembly

Fig. 2, Horton "On/Off" Fan Clutch, Typical

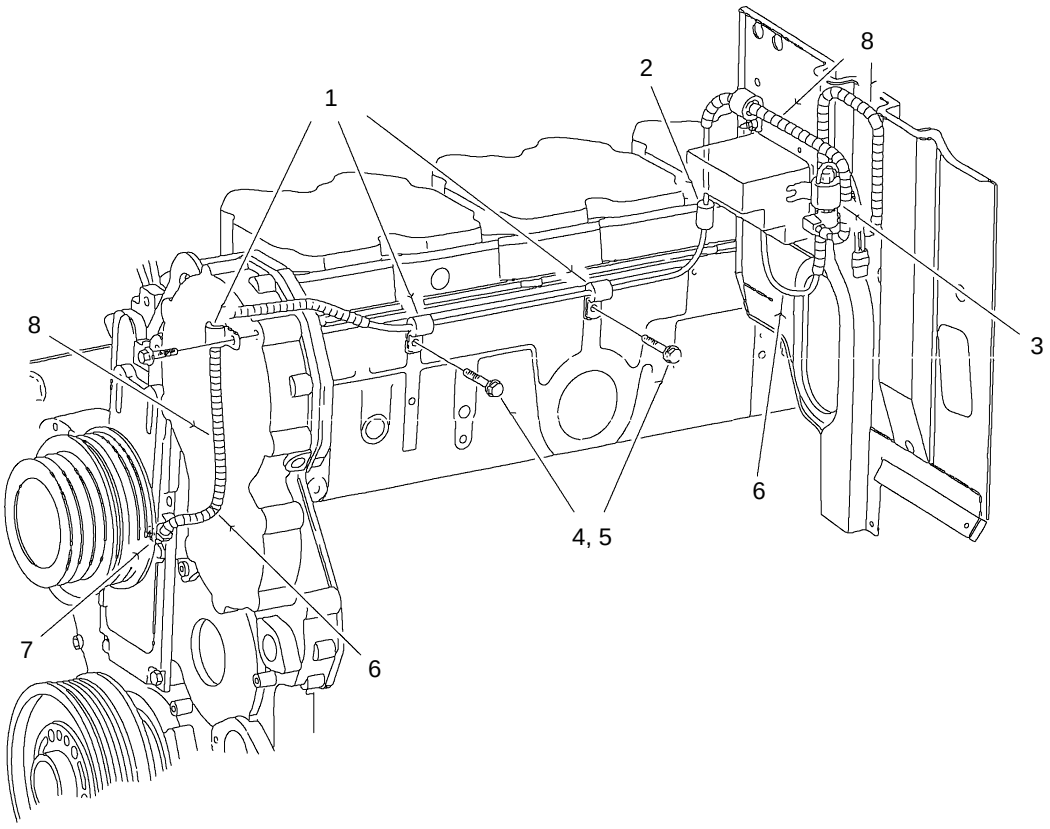
premium engines. This type of fan requires a system for turning the fan on and off. In all cases, an air control solenoid is opened and closed to control airflow to the fan clutch. Different methods are used to control the action of the solenoid. On the Cummins, Caterpillar and DDC electronic engines the solenoid is controlled by the Engine Control Module (ECM). On the Cummins C8.3 and the Caterpillar 3306 engines, a separate fan control module is used to control the opening and closing of the air control solenoid.

On all electronically controlled engines, a relay is used to complete the circuit to the air control solenoid. On a Detroit Diesel Corporation (DDC) engine, the relay coil is energized when the ECM provides a ground. On all other electronic engines, the relay coil is energized when the ECM supplies the coil with battery voltage. The separate module used to control the fan on the Cummins C8.3 and the Caterpillar 3306 engines does not require a relay. The module is wired directly to the air control solenoid.

FAN CLUTCH OVERRIDE (OPTIONAL)

With the air operated fan clutches, the operator is provided with a fan clutch override function. A switch in the instrument panel completes a circuit that bypasses the ECM or module control functions. To prevent system override with the vehicle in motion, the

General Information



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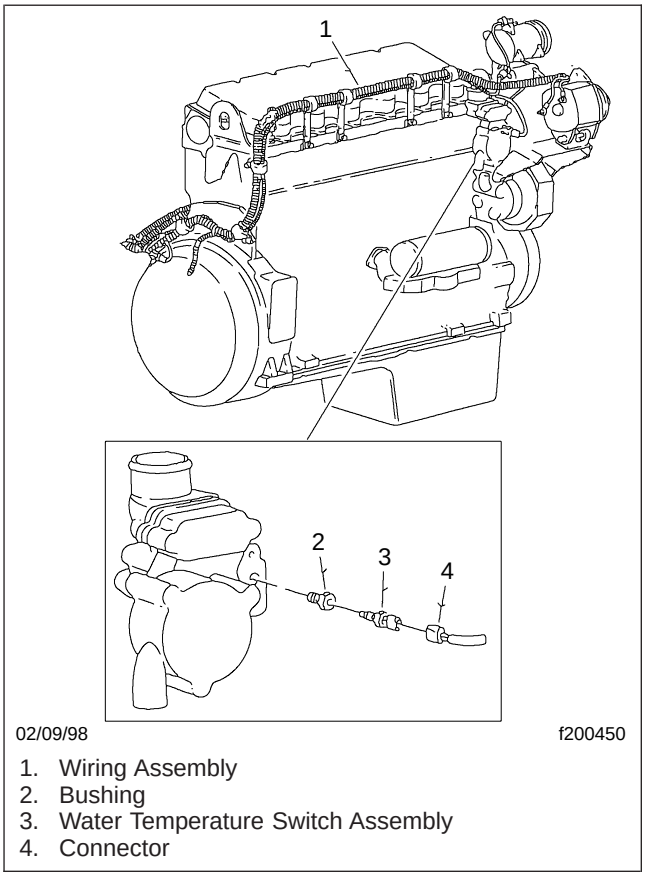
1. Clip
2. Air Line Fitting
3. "On/Off" Fan Clutch Solenoid
4. Washer
5. Bolt
6. Air Tube
7. Connector
8. Shield

Fig. 3, Horton "On/Off" Fan Clutch Air Line Routing, Typical

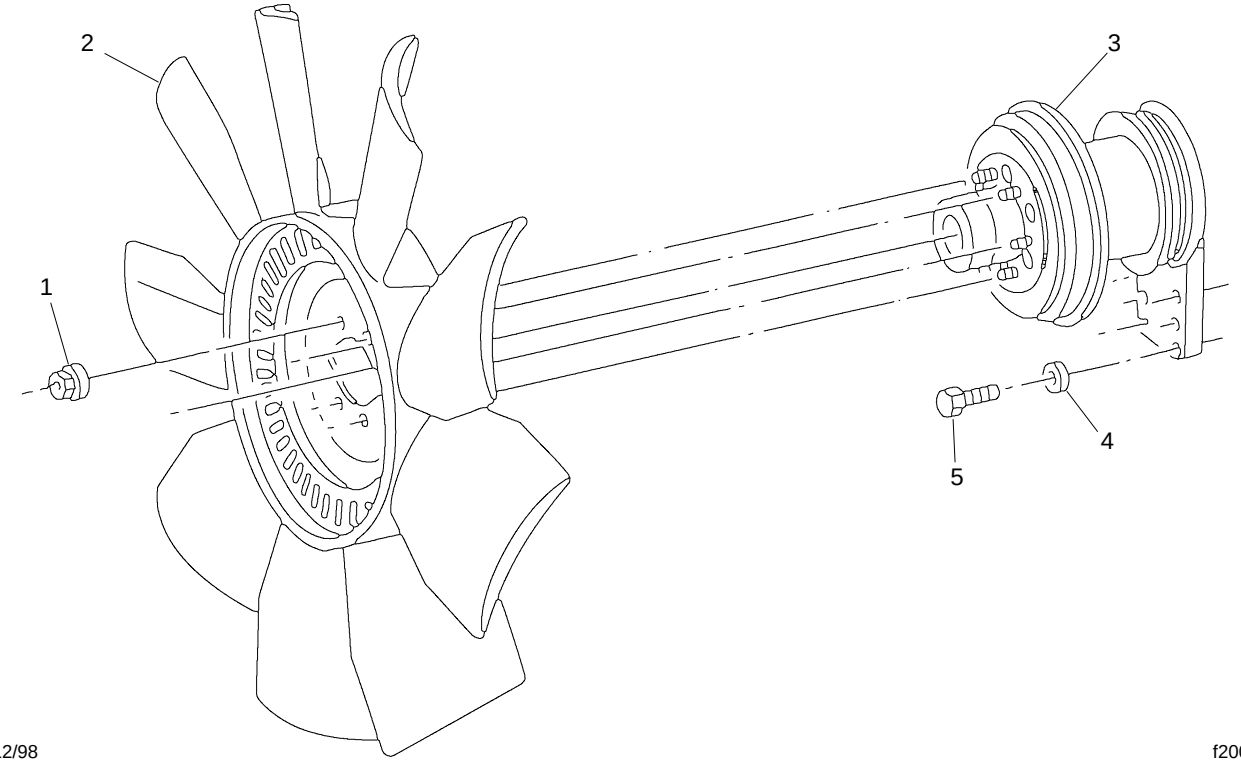
clutch override circuit will not function unless the parking brake is set.



1. Wiring Assembly
2. Bushing
3. Water Temperature Switch Assembly
4. Connector

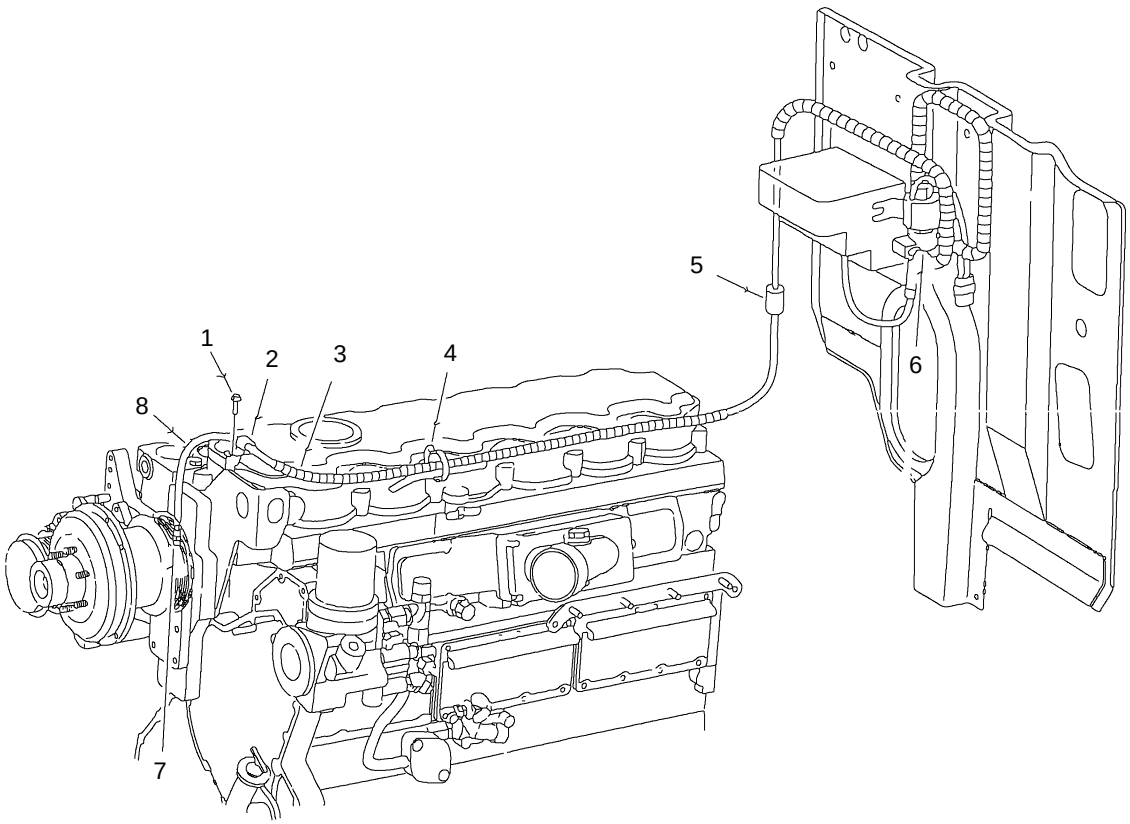
Fig. 4, Horton "On/Off" Fan Clutch Water Temperature Switch, Typical

General Information



1. Locknut (6 qty.)
2. Fan Blade Assembly
3. Fan Clutch Assembly
4. Flatwasher (6 qty.)
5. Bolt (6 qty.)

Fig. 5, Kysor "On/Off" Fan Clutch, Typical



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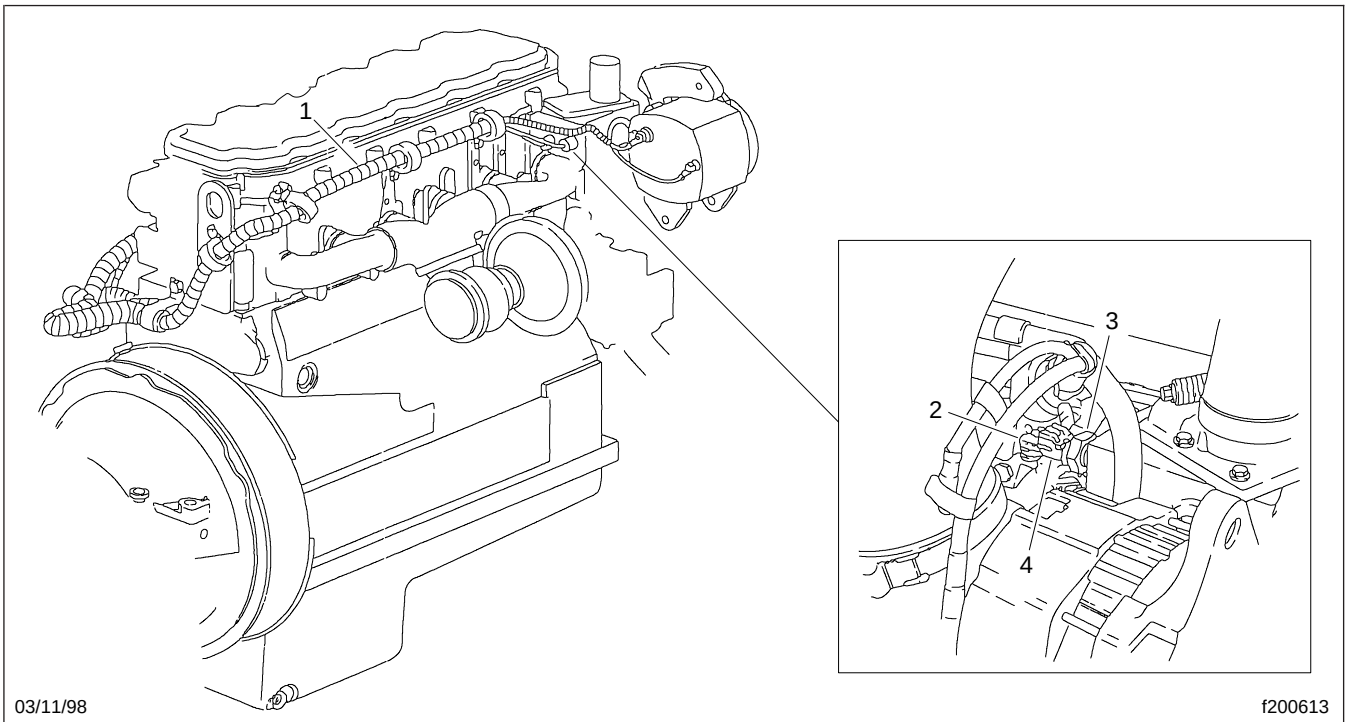
1. Bolt
2. Clip
3. Shield
4. Strap
5. Air Line Fitting
6. "On/Off" Fan Clutch Solenoid
7. Connector
8. Air Tube

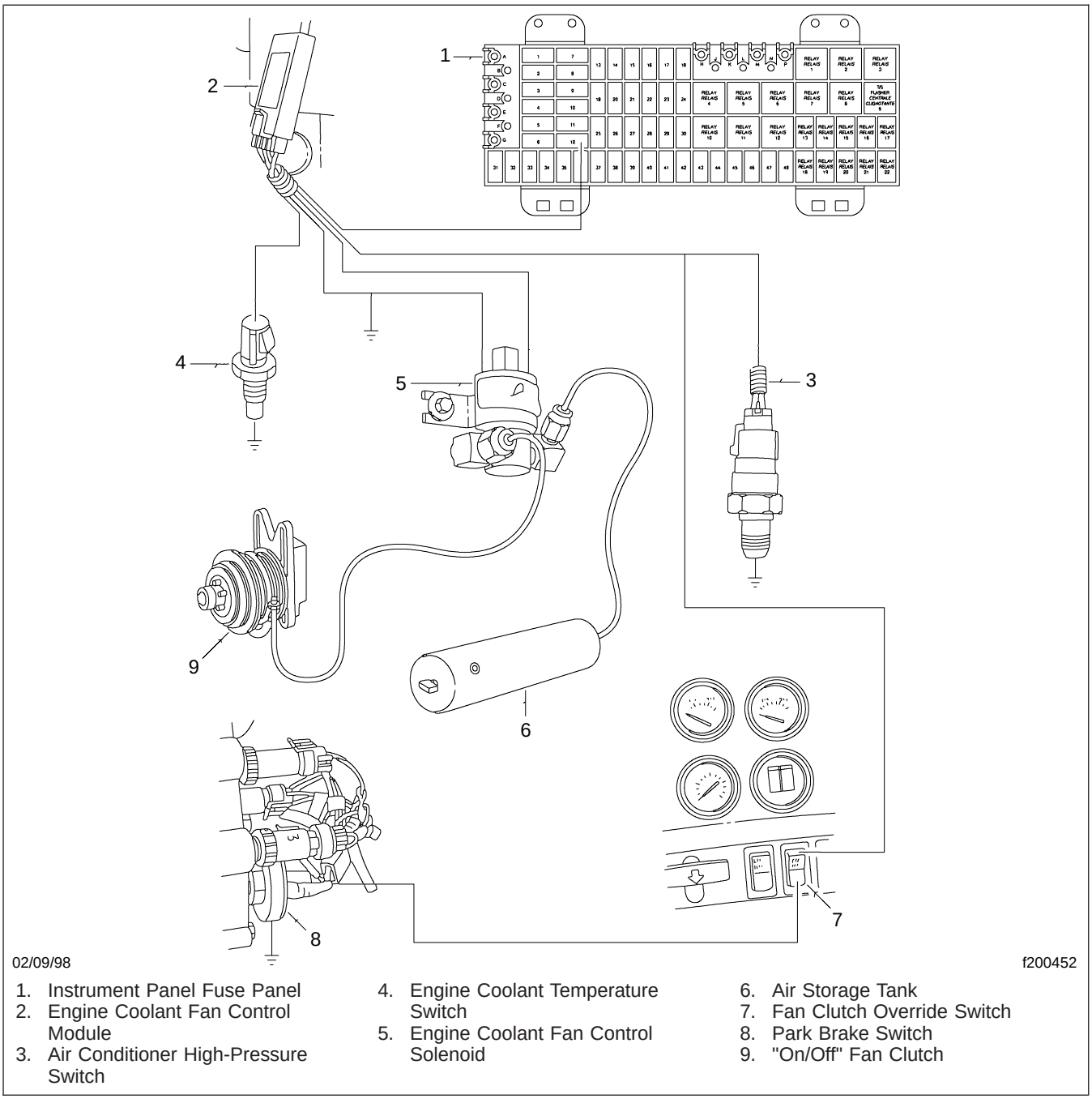
Fig. 6, Kysor "On/Off" Fan Clutch Air Line Routing, Typical

General Information



1. Wiring Assembly
2. Connector
3. Bushing
4. Water Temperature Switch Assembly

Fig. 7, Kysor "On/Off" Fan Clutch Water Temperature Switch, Typical



1. Instrument Panel Fuse Panel
2. Engine Coolant Fan Control Module
3. Air Conditioner High-Pressure Switch
4. Engine Coolant Temperature Switch
5. Engine Coolant Fan Control Solenoid
6. Air Storage Tank
7. Fan Clutch Override Switch
8. Park Brake Switch
9. "On/Off" Fan Clutch

Fig. 8, "On/Off" Fan Clutch System, Module Type

Fan Clutch Override Park Brake Switch Replacement

Replacement

1. Remove the four screws and the cover from the air block. See **Fig. 1**.

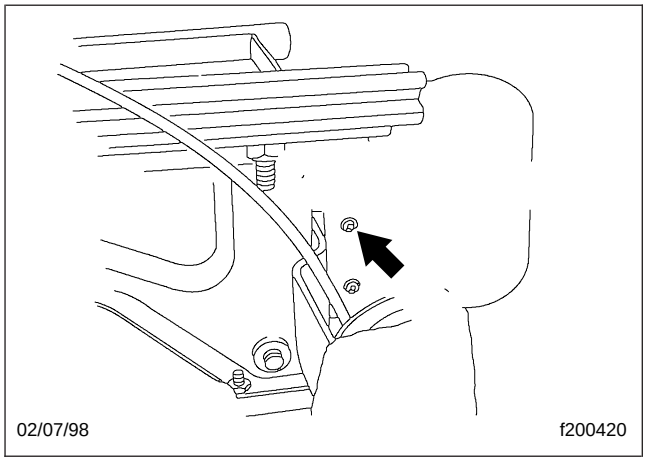


Fig. 1, Fan Clutch Override Park Brake Switch Cover

2. Disconnect the two electrical leads from the fan clutch override park brake switch. See **Fig. 2**.

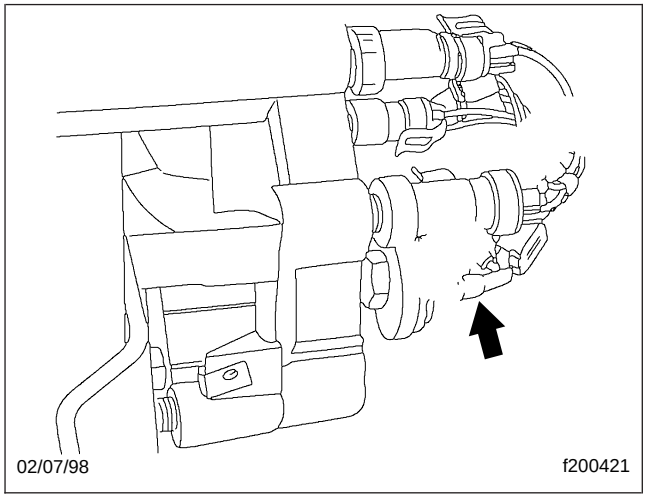


Fig. 2, Fan Clutch Override Park Brake Switch Electrical Leads

3. Remove the fan clutch override park brake switch from the air block. See **Fig. 3**.
4. Install the fan clutch override park brake switch. See **Fig. 3**.
5. Connect the two electrical leads to the fan clutch override park brake switch. See **Fig. 2**.

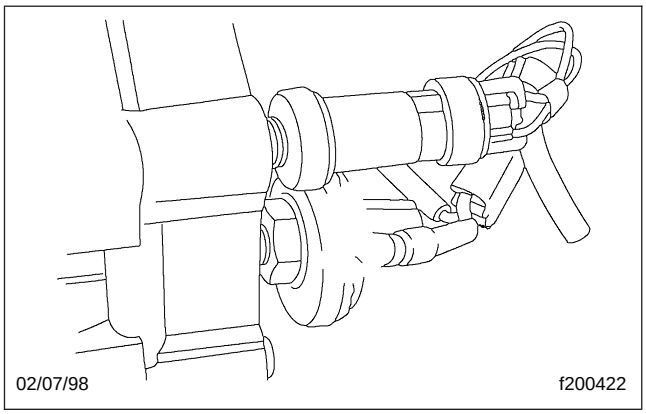


Fig. 3, Fan Clutch Override Park Brake Switch

6. Install the four screws and the cover on the air block. See **Fig. 1**.

Engine Coolant Fan Control Solenoid Replacement

Replacement

1. Disconnect the electrical connector. See **Fig. 1**.

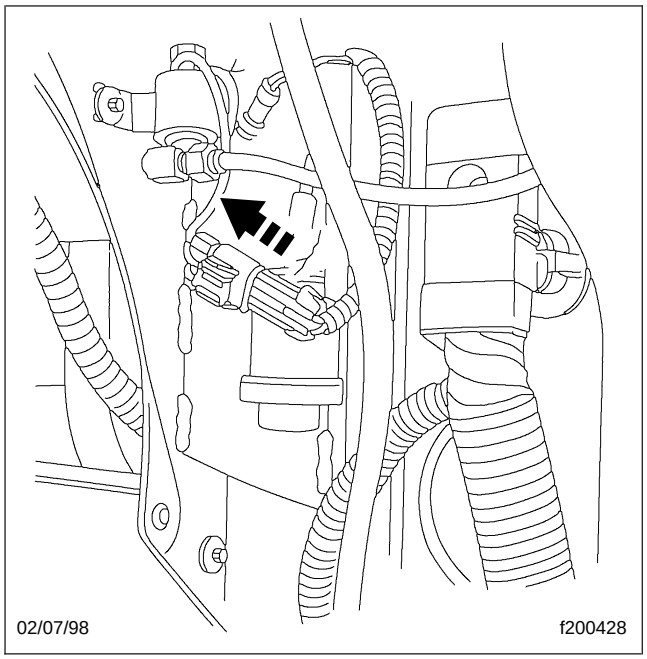


Fig. 1, Fan Control Solenoid Electrical Connector

2. Press in on the barrel connector and remove the two air lines from the fan control solenoid. See **Fig. 2**.
3. Remove the two mounting bolts and the fan control solenoid. See **Fig. 3**.
4. Install the two mounting bolts and the fan control solenoid. See **Fig. 3**.
5. Connect the two air lines to the fan control solenoid. See **Fig. 2**.
6. Connect the electrical connector. See **Fig. 1**.

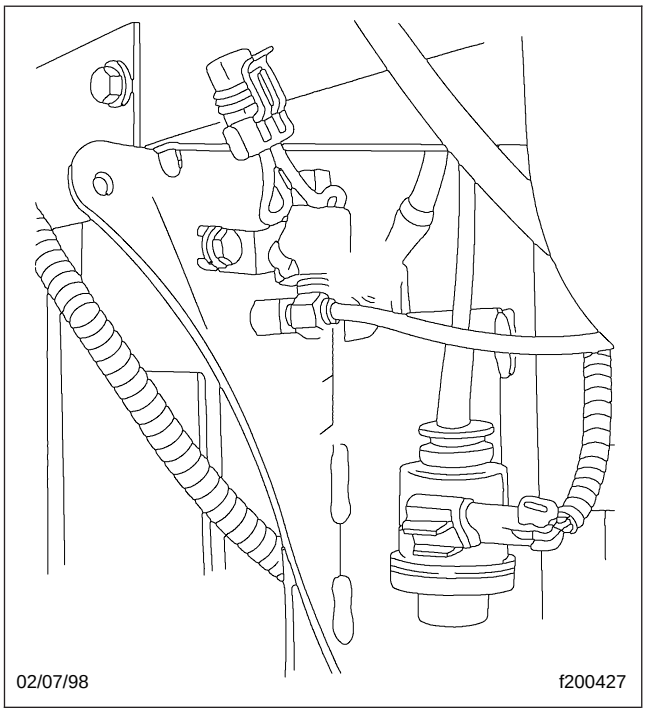


Fig. 2, Fan Control Solenoid Air Lines

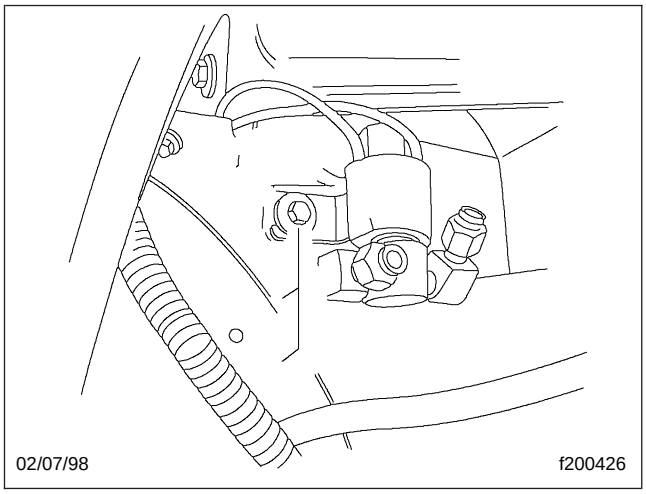


Fig. 3, Fan Control Solenoid Mounting Bolts

Fan Override Switch Replacement

Replacement

1. Remove the eight retaining screws from the center instrument panel. See **Fig. 1**.

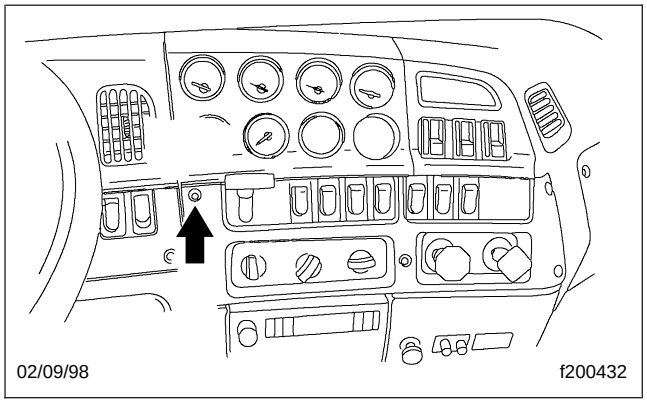


Fig. 1, Center Instrument Panel Retaining Screws

2. Remove the trailer brake lever handle, if so equipped. See **Fig. 2**.

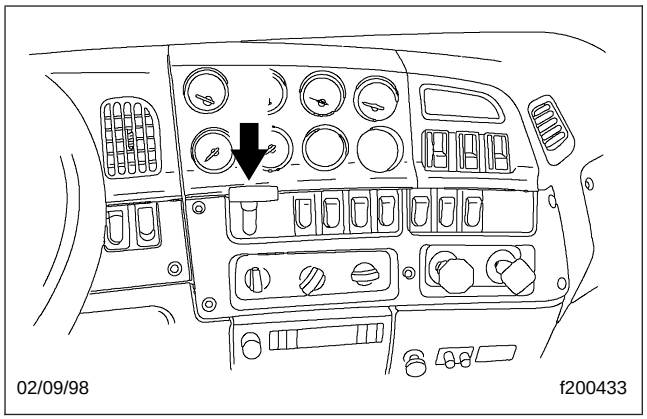


Fig. 2, Trailer Brake Lever Handle

3. Lift the center instrument panel away from the dash panel. See **Fig. 3**.
4. Disconnect the electrical connector from the fan override switch. See **Fig. 4**.
5. Depress the four retaining clips and press the fan override switch out of the center instrument panel. See **Fig. 5**.
6. Install the fan override switch into the center instrument panel. See **Fig. 5**.

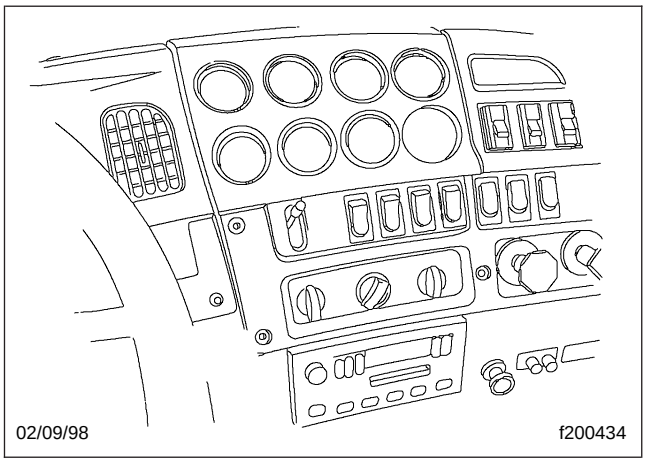


Fig. 3, Center Instrument Panel

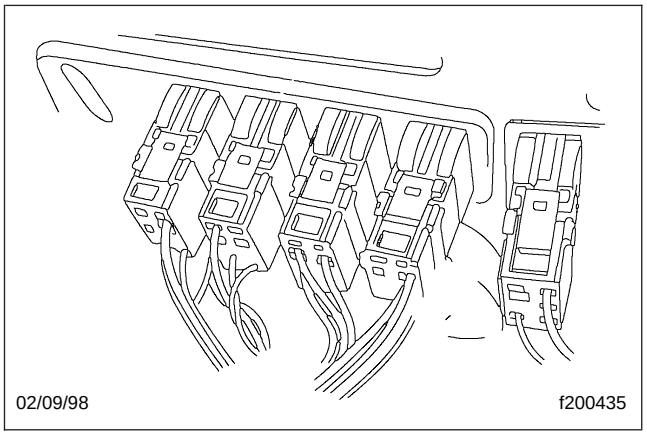


Fig. 4, Fan Override Switch Electrical Connector

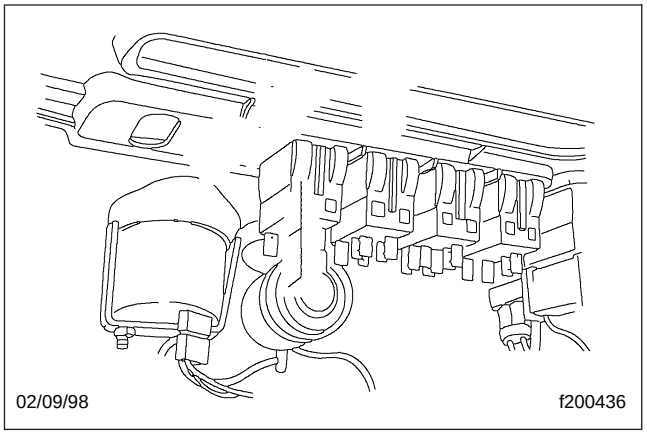


Fig. 5, Fan Override Switch Retaining Clips

Fan Override Switch Replacement

7. Connect the electrical connector to the fan override switch. See **Fig. 4**.
8. Position the center instrument panel on the dash panel. See **Fig. 3**.
9. Install the trailer brake lever handle, if so equipped. See **Fig. 2**.
10. Install the eight retaining screws for the center instrument panel. See **Fig. 1**.

Engine Coolant Fan Timer Control Module Replacement

Replacement

1. Remove the air cleaner assembly. For instructions, refer to **Group 09** in this manual.
2. Disconnect the electrical connector from the coolant fan timer control module. See **Fig. 1**.

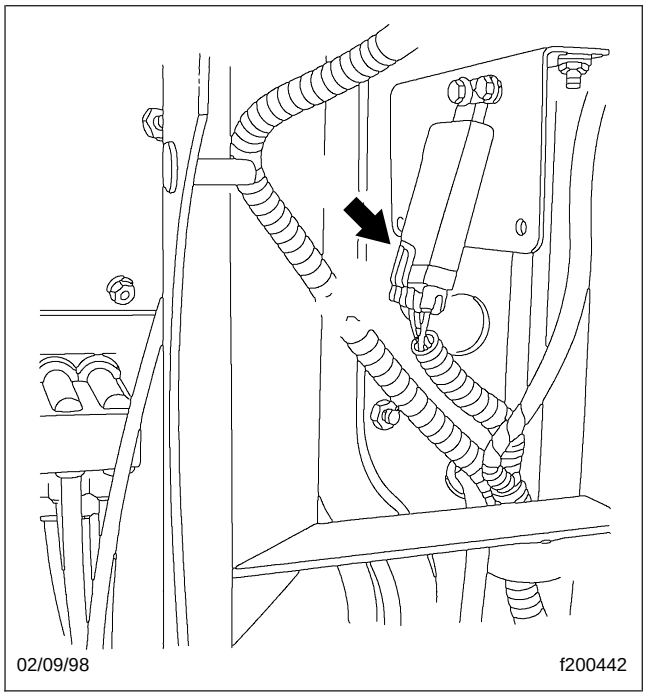


Fig. 1, Coolant Fan Timer Control Module Electrical Connector

3. Remove the two retaining bolts and the coolant fan timer control module. See **Fig. 2**.
4. Install the two retaining bolts and the coolant fan timer control module. See **Fig. 2**.
5. Connect the electrical connector to the coolant fan timer control module. See **Fig. 1**.

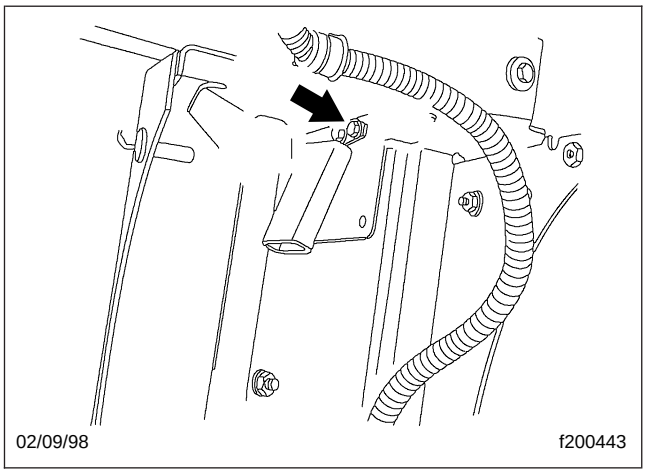
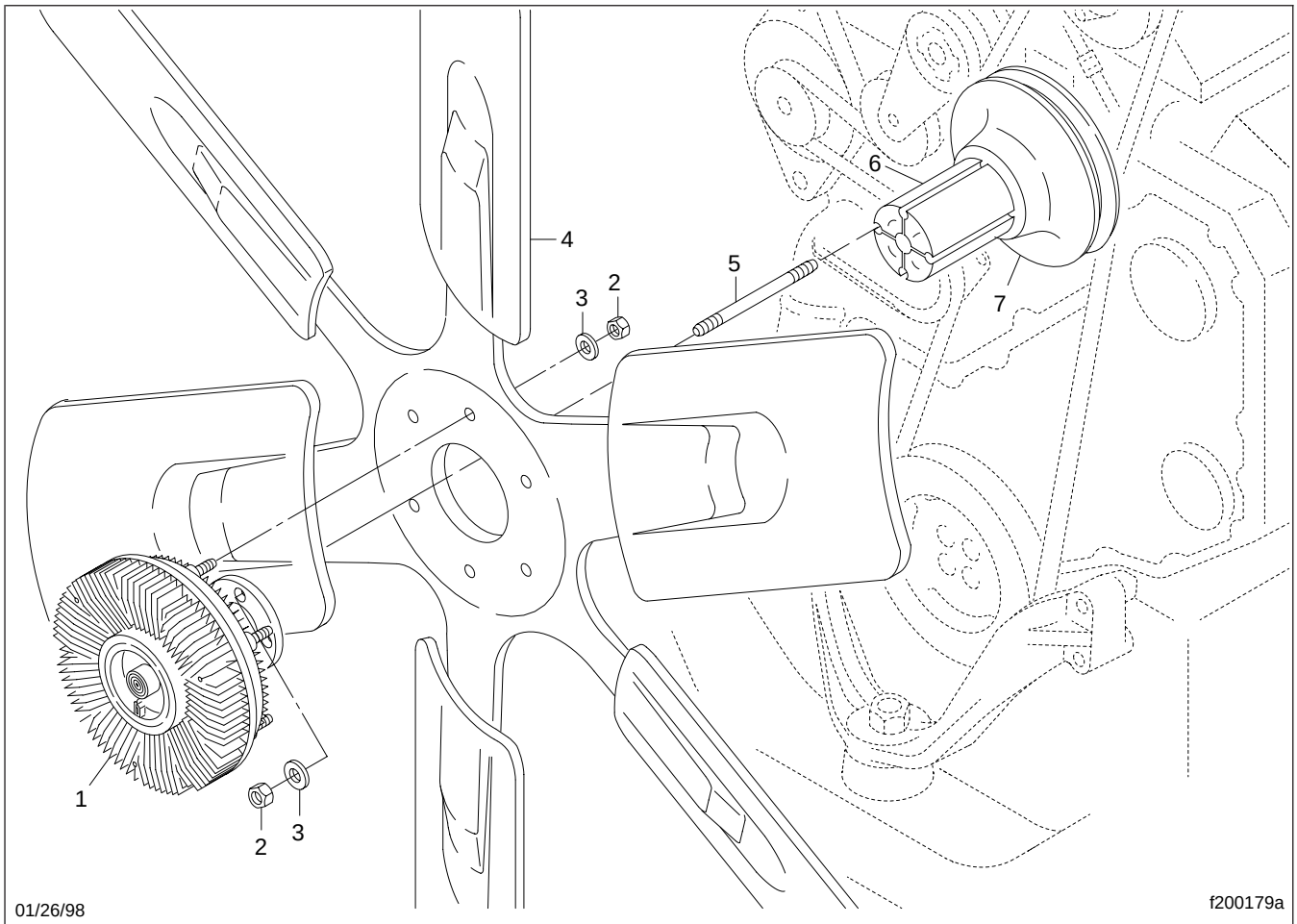


Fig. 2, Coolant Fan Timer Control Module Retaining Bolts

Eaton Viscous Fan Clutch Removal and Installation

Removal (See Fig. 1)



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

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Open the hood.
3. Drain the coolant, and remove the upper radiator hose.
4. Remove the coolant recovery line.
5. Remove the locknuts and lockwashers that hold the clutch to the fan hub. Remove the clutch from the engine.
6. Remove the six mounting bolts that hold the fan blade to the clutch. Remove the blade.

Eaton Viscous Fan Clutch Removal and Installation

Installation (See Fig. 1)

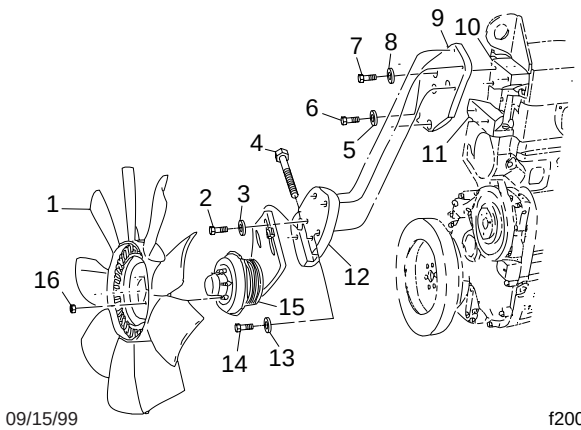
1. Install the fan blade on the fan clutch. Tighten the fan mounting locknuts as follows:
    - Model 575: 15 to 20 lbf·ft (20 to 27 N·m)
    - Model 610: 40 lbf·ft (54 N·m)
    - Model 660: 22 lbf·ft (30 N·m)

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 45 lbf·ft (61 N·m).
3. Install the upper radiator hose.
4. Install the coolant recovery hose.
5. Refill the coolant.
6. Close the hood.
7. Remove the chocks from the tires.

Horton Advantage Fan Clutch Removal and Installation

Removal (See Fig. 1)



1. Fan
2. Hexhead Bolt (1/2–13 x 1.75)
3. Washer
4. Drive Belt Tension Adjustment Bolt
5. Washer
6. Hexhead Bolt (1/2–13 x 2.50)
7. Hexhead Bolt (1/2–13 x 4.25)
8. Washer
9. Support Bracket
10. Spacer
11. Fan Adjustment Support Block
12. Fan Position Adjustment Plate
13. Washer
14. Hexhead Flange Bolt (3/8–13 x 2.50)
15. Fan Clutch Assembly
16. Locknut (3/8–24)

Fig. 1, Horton Advantage Fan Clutch Assembly (Cummins N14 Engine)

NOTE: This procedure is general and covers all Sterling vehicles equipped with Horton Advantage fan clutches.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Open the hood.

⚠ WARNING

Use care when loosening the air line. The line could be under pressure and may have dirt or sludge in the air stream. If quickly disconnected, the line may whip, possibly causing eye or other bodily injury.

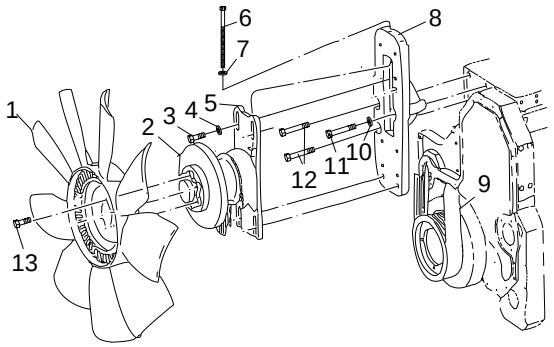
3. Disconnect the air line from the fan clutch.
4. If necessary, disconnect the charge-air-cooler hoses, radiator hoses and power steering cooling line brackets to gain clearance during fan clutch removal. For instructions, see the appropriate section in **Group 20**.
5. Loosen the radiator support brackets and tilt the top of the radiator forward.
6. Remove the fan blade from the fan clutch.
7. Loosen the fan clutch retaining fasteners.
8. Remove the alternator V-belt and the A/C compressor V-belt. For accessory drive belt configurations, see **Section 01.03**.
9. Remove the bolts (or nuts) and washers that attach the fan clutch and hub assembly to the engine. Remove the fan clutch and hub assembly.

Installation (See Fig. 1)

1. Position the fan clutch and hub assembly on the engine and install the bolts (or nuts) and washers. Tighten the mounting fasteners just enough to hold the assembly in place, and allow enough play for fan belt adjustment.
2. Connect the air line to the fan clutch.
3. Install the accessory drive belts. For instructions, see the applicable engine subject in **Section 01.03**.
4. Tighten the clutch and hub assembly mounting fasteners 85 lbf·ft (115 N·m).
5. Position the fan blade on the fan clutch hub and install the fasteners.
6. Secure the radiator in the original position.
7. If removed, connect the charge-air-cooler hoses, radiator hoses and power steering cooling line brackets. For instructions, see the appropriate section in **Group 20**.
8. Close the hood.
9. Remove the chocks from the tires.

Kysor K22RA Fan Clutch Removal and Installation

Removal (See Fig. 1)



09/15/99 f200494

1. Fan
2. Fan Clutch
3. Hexhead Bolt (1/2–13 x 1.50) (4 Qty.)
4. Washer
5. Support Bracket
6. Drive Belt Tension Adjustment Bolt
7. Washer
8. Fan Clutch Assembly Mounting Plate
9. Serpentine Belt
10. Washer
11. Hexhead Bolt, M12 x 1.75 X 100
12. Hexhead Bolt, M12 x 1.75 X 120
13. Hexhead Flange Bolt (3/8–16 x 0.62) (6 Qty.)

Fig. 1, Kysor K22RA Fan Clutch Assembly (Cummins ISM Engine)

NOTE: This procedure is general and covers all Sterling vehicles equipped with Kysor K22RA fan clutches.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Open the hood.

⚠ WARNING

Use care when disconnecting the air line. The line could be under pressure and may have dirt or sludge in the air stream. If quickly disconnected, it may whip, possibly causing eye or other bodily injury.

3. Disconnect the air line from the fan clutch.
4. If necessary, disconnect the charge-air-cooler hoses, radiator hoses, power steering cooling line brackets and radiator support brackets to gain clearance during fan clutch removal. For instructions, see the appropriate section in **Group 20**.
5. Remove the six fan-to-hub retaining bolts and move the fan away from the fan clutch hub.

NOTE: It may be necessary to remove the fan to gain clearance for the removal of the fan clutch.

6. Remove the accessory drive belts. For instructions, see the applicable engine subject in **Section 01.03**.
7. Remove the bolts (or nuts) and washers that attach the fan clutch and hub assembly to the engine. Remove the fan clutch and hub assembly.

IMPORTANT: Because the fan clutch assembly is heavy, an assistant may be necessary to help remove the fan clutch from the engine compartment.

Installation (See Fig. 1)

1. Position the fan clutch and hub assembly on the engine and install the bolts (or nuts) and washers. Tighten the mounting fasteners just enough to hold the assembly in place, and allow enough play for belt adjustment.

IMPORTANT: Because the fan clutch assembly is heavy, an assistant may be necessary to help install the fan clutch.

2. Install the accessory drive belts. For instructions, see the applicable engine subject in **Section 01.03**.
3. Tighten the clutch and hub assembly mounting fasteners 85 lbf·ft (115 N·m).
4. Position the fan on the clutch and install the fasteners that hold the fan to the fan clutch.
5. Connect the air line to the fan clutch.
6. If removed, connect the charge-air-cooler hoses, radiator hoses, power steering cooling line brackets and radiator support brackets. For instructions, see the appropriate section in **Group 20**.

Kysor K22RA Fan Clutch Removal and Installation

7. Close the hood.
8. Remove the chocks from the tires.

Troubleshooting

INSPECTION AND VERIFICATION

1. Verify the vehicle owner's original concern by operating the starting system to duplicate the condition.
2. Inspect to determine if any of the following mechanical or electrical concerns apply:
    - leaking or damaged air lines
    - worn or damaged clutch
    - corroded, loose or damaged electrical connections
    - blown fuse
    - damaged wiring
3. If the concerns remain after the inspection, determine the possible causes and go to the problem charts.

Problem—Fan Clutch Does Not Engage (Mechanical Fault)

Problem—Fan Clutch Does Not Engage (Mechanical Fault)	
Possible Cause	**Remedy**
Clutch leaking air (Horton)	Overhaul or replace the clutch.
Air supply restricted	Repair as necessary.

Troubleshooting

Problem—Fan Clutch Does Not Engage (Module Control System)

Problem—Fan Clutch Does Not Engage (Module Control System)	
Possible Cause	**Remedy**
Electrical system	Isolate the control circuits. Set the parking brake. Press the fan override switch to the "On" position. If the fan clutch engages, check Circuit 39 (R/W) for an open. Measure the resistance between connector 192, Terminal D, Circuit 39 (R/W) and the coolant temperature sensor connector terminal. If the resistance is greater than 5 ohms, repair the open in Circuit 39 (R/W). Test the system for normal operation. If the resistance is less than 5 ohms, check the coolant temperature sensor ground circuit 57 (BK) for an open. Measure the resistance between the coolant temperature connector terminal, Circuit 57 (BK) and a clean chassis ground. If the resistance is greater than 5 ohms, repair the open in Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check the temperature sensor function. Install a known good temperature sensor. If the fan clutch does not engage, replace the control module. Test the system for normal operation. If the replacement temperature sensor has corrected the condition, test the system for normal operation. If the fan clutch does not engage, check the control module battery feed Circuit 517 (BK/W). Measure the voltage at connector 192, Terminal A, Circuit 517 (BK/W). If the voltage is less than 10 volts, repair the open in Circuit 517 (BK/W). Test the system for normal operation. If the voltage is greater than 10 volts, check the control module ground Circuit 57 (BK). Measure the resistance between connector 192, Terminal B, Circuit 57 (BK) and a clean chassis ground. If the resistance is greater than 5 ohms, repair the open in Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check the control solenoid function. Connect a jumper to a 12-volt source and touch the opposite end to the control solenoid battery feed terminal, Circuit 936 (BK). If the solenoid does not click, check the control solenoid ground circuit for an open. Measure resistance between connector 192, terminal D, Circuit 39 (R/W) and the temperature sensor connector. If the resistance is less than 5 ohms, replace the control solenoid. Test the system for normal operation. If the resistance is greater than 5 ohms, repair the open in Circuit 57 (BK). Test the system for normal operation. If the solenoid clicks, check Circuit 39 (R/W) for an open. Measure the resistance between connector 192, Terminal C, Circuit 936 (BK) and the control solenoid connector. If the resistance is greater than 5 ohms, repair the open in Circuit 936 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 39 (R/W) for an open. Measure the resistance between connector 192, Terminal D, Circuit 39 (R/W) and the temperature sensor connector. If the resistance greater than 5 ohms, repair the open in Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, measure the resistance between the temperature sensor connector terminal, Circuit 57 (BK) and a clean chassis ground. If the resistance is less than 5 ohms, check the temperature sensor function. Install a known good temperature sensor. If the clutch fan engages, the replacement sensor has corrected the condition. Test the system for normal operation. If the fan clutch does not engage, replace the control module. Test the system for normal operation.

Problem—Fan Clutch Does Not Engage (ECM Control System)

Problem—Fan Clutch Does Not Engage (ECM Control System)	
Possible Cause	**Remedy**
Electrical system	Isolate the ECM control circuits. Set the parking brake. Press the fan override switch to the "On" position. If the fan clutch engages, refer to the engine manufacturer's service literature for testing procedures related to the ECM. If the fan clutch does not engage, check for continuity at the fan clutch relay coil. Remove the fan clutch relay coil. Measure the resistance between relay Terminals 1 and 2. If the resistance is greater than 5 ohms, replace the fan clutch relay. Test the system for normal operation. If the resistance is less than 5 ohms, check for continuity at the fan clutch relay contacts. If equipped with a Horton fan, measure the resistance between relay Terminals 4 and 3. For all other fans, check the resistance between terminals 5 and 3 with the relay coil energized. If the resistance is greater than 5 ohms, replace the fan clutch relay. Test the system for normal operation. If the resistance is less than 5 ohms, check for battery feed to the relay coil. Measure the voltage at relay socket 2, Circuit 517 (BK/W). If the voltage is less than 10 volts, repair the open in Circuit 517 (BK/W). If the voltage is greater than 10 volts, check for battery feed to relay contacts. Measure the voltage at relay socket 5, or socket 4 if a Horton fan, Circuit 517 (BK/W). If the voltage is less than 10 volts, repair the open in Circuit 517 (BK/W). If the voltage is greater than 10 volts, check the control solenoid function. Connect a jumper to a 12-volt source and touch the opposite end to the control solenoid battery feed terminal, Circuit 936 (BK). If the solenoid does not click, check the control solenoid ground circuit for an open. Measure resistance between the control solenoid connector terminal, Circuit 57 (BK) and a clean chassis ground. If the resistance is less than 5 ohms, replace the control solenoid. Test the system for normal operation. If the resistance is greater than 5 ohms, repair the open in Circuit 57 (BK). Test the system for normal operation. If the solenoid clicks, check Circuit 936 (BK) for an open. Measure the resistance between fan clutch relay socket 3, Circuit 936 (BK) and the control solenoid connector. If the resistance is greater than 5 ohms, repair the open in Circuit 936 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check circuit 721 (BL/GN) for an open. Measure the resistance between relay socket Terminal 1, Circuit 721 (BL/GN) and one of the following ECM connector terminals: • Cummins connector C170 Terminal C. • Caterpillar connector C110 Terminal 28. • DDC connector C135 Terminal Y3. If the resistance is greater than 5 ohms, repair the open in Circuit 721 (BL/GN). Test the system for normal operation. If the resistance is less than 5 ohms, refer to the engine manufacturer's service literature for testing procedures related to the ECM.

Troubleshooting

Problem—Fan Clutch Does Not Disengage (Mechanical)

Problem—Fan Clutch Does Not Disengage (Mechanical)	
Possible Cause	**Remedy**
Air line restricted	Repair as necessary.
Air line leaking (Kysor)	Repair or replace as necessary.

Problem—Fan Clutch Does Not Disengage (Module Control System)

Problem—Fan Clutch Does Not Disengage (Module Control System)	
Possible Cause	**Remedy**
Electrical system	Isolate the fan control solenoid. Disconnect the wiring at the fan control solenoid. If the solenoid does not click, replace the fan control solenoid. Test the system for normal operation. If the solenoid does click, isolate the coolant temperature sensor. Disconnect the wiring at the coolant temperature sensor. If the fan clutch disengages, replace the coolant temperature sensor. Test the system for normal operation. If the fan clutch does not disengage, isolate the A/C clutch high-pressure switch. Disconnect the wiring at the A/C clutch high-pressure switch. If the fan clutch disengages, replace the A/C clutch high-pressure switch. Test the system for normal operation. If the fan clutch does not disengage, replace the fan control module. Test the system for normal operation.

Problem—Fan Clutch Does Not Disengage (ECM Control System)

Problem—Fan Clutch Does Not Disengage (ECM Control System)	
Possible Cause	**Remedy**
Electrical system	Isolate the fan control solenoid. Disconnect the wiring at the fan control solenoid. If the solenoid does not click, replace the fan control solenoid. Test the system for normal operation. If the solenoid clicks, isolate the fan clutch relay. Remove the fan clutch relay. If the fan clutch disengages, replace the fan clutch relay. Test the system for normal operation. If the fan clutch does not disengage, isolate the A/C clutch high-pressure switch. Disconnect the wiring at the A/C clutch high-pressure switch. If the fan clutch disengages, replace the A/C clutch high-pressure switch. Test the system for normal operation. If the fan clutch does not disengage, refer to the engine manufacturer's service literature for testing procedures related to the ECM.

Problem—Fan Override Does Not Operate

Problem—Fan Override Does Not Operate	
Possible Cause	**Remedy**
Electrical system	Isolate the control module (for ECM controlled system, refer to the fan override switch continuity). Press the fan override switch to the "On" position. Set the parking brake. Measure the resistance between connector 192, Terminal E, Circuit 90 (GN/W) and a clean chassis ground. If the resistance is less than 5 ohms, replace the control module. Test the system for normal operation. If the resistance is more than 5 ohms, check fan override switch continuity (all systems). Make sure the switch is in the "On" position. Measure the resistance between switch Terminals 2 and 3. If the resistance is greater than 5 ohms, replace the switch. Test the system for normal operation. If the resistance is less than 5 ohms and the system is module controlled, check the control module Circuit 90 (GN/W) for an open. Measure the resistance between connector 192, Terminal E, Circuit 90 (GN/W) and connector 2015, Terminal 2, Circuit 90 (GN/W). If the resistance is greater than 5 ohms, repair the open in Circuit 90 (GN/W). Test the system for normal operation. If the resistance is greater than 5 ohms, repair the open in Circuit 90 (GN/W). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 162 (GN/R) for an open. Measure the resistance between connector 2015, Terminal 3, Circuit 162 (GN/R) and the parking brake switch terminal. If the resistance is greater than 5 ohms, repair the open in Circuit 162 (GN/R). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 57 (BK) for an open. Measure the resistance between the parking brake switch terminal, Circuit 57 (BK) and a clean chassis ground. If the resistance is less than 5 ohms, replace the parking brake switch. Test the system for normal operation. If the resistance is greater than 5 ohms, repair the open in Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms and the system is ECM controlled, check the A/C relay Circuit 90 (GN/W) for an open. Remove the A/C compressor clutch relay. Measure the resistance between relay socket 2, Circuit 90 (GN/W) and connector 2015, Terminal 2, Circuit 90 (GN/W). If the resistance is greater than 5 ohms, repair the open in Circuit 90 (GN/W). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 162 (GN/R) for an open. Measure the resistance between connector 2015, Terminal 3, Circuit 162 (GN/R) and the parking brake switch terminal. If the resistance is greater than 5 ohms, repair the open in Circuit 162 (GN/R). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 57 (BK) for an open. Measure the resistance between the parking brake switch terminal, Circuit 57 (BK) and a clean chassis ground. If the resistance is less than 5 ohms, replace the parking brake switch. Test the system for normal operation. If the resistance is greater than 5 ohms, repair the open in Circuit 57 (BK). Test the system for normal operation.

Troubleshooting

Problem—Fan Clutch Does Not Engage With High A/C System Pressure (Module Control System)

Problem—Fan Clutch Does Not Engage With High A/C System Pressure (Module Control System)	
Possible Cause	**Remedy**
Electrical system	Isolate the A/C clutch high-pressure switch. Install a jumper across the switch connector terminals. If the fan clutch engages, replace the A/C clutch high-pressure switch. Test the system for normal operation. If the fan clutch does not engage, check Circuit 57 (BK) for an open. Measure the resistance between the A/C clutch high-pressure switch terminal, Circuit 57 (BK) and a clean chassis ground. If the resistance is less than 5 ohms, repair the open in Circuit 57 (BK). Test the system for normal operation. If the resistance is greater than 5 ohms, check Circuit 90 (GN/W) for an open. Measure the resistance between connector 192, Terminal E, Circuit 90 (GN/W) and A/C clutch high-pressure switch connector terminal. If the resistance is less than 5 ohms, replace the fan control module. Test the system for normal operation. If the resistance is greater than 5 ohms, repair the open in Circuit 90 (GN/W). Test the system for normal operation.

Problem—Fan Clutch Does Not Engage With High A/C System Pressure (ECM Control System)

Problem—Fan Clutch Does Not Engage With High A/C System Pressure (ECM Control System)	
Possible Cause	**Remedy**
Electrical system	Isolate the A/C clutch high-pressure switch. Install a jumper across the switch connector terminals. If the fan clutch engages, replace the A/C clutch high-pressure switch. Test the system for normal operation. If the fan clutch does not engage, isolate the A/C compressor clutch relay. Place a finger on the A/C compressor clutch relay. Cycle the ignition key from the "On" to the "Off" position. If the relay does not click, check Circuit 57 (BK) for an open. Remove the jumper from the A/C clutch high-pressure switch connector. Measure the resistance between the A/C clutch high-pressure switch terminal, Circuit 57 (BK) and a clean chassis ground. If the resistance is greater than 5 ohms, repair the open in Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 90 (GN/W) for an open. Remove the A/C compressor clutch relay. Measure the resistance between the relay socket, Terminal 2, Circuit 90 (GN/W) and the A/C clutch high-pressure switch connector. If the resistance is greater than 5 ohms, repair the open in Circuit 90 (GN/W). Test the system for normal operation. If the resistance is less than 5 ohms, check for battery feed to the A/C compressor clutch relay coil. Measure the voltage at the A/C relay socket, Terminal 1, Circuit 517 (BK/W). If the voltage is greater than 10 volts, replace the A/C compressor clutch relay. Test the system for normal operation. If the voltage is less than 10 volts, repair the open in Circuit 517 (BK/W). Test the system for normal operation. If the relay does click, isolate the A/C compressor clutch relay contacts. Remove the A/C compressor clutch relay. Install a jumper across relay socket Terminals 4 and 3, Circuits 350 (Y) and 937 (BK). If the fan clutch engages, replace the relay. Test the system for normal operation. If the fan clutch does not engage and the vehicle is equipped with a DDC Series 60 engine, check Circuit 937 (BK) for an open at the relay socket to ground. Measure the resistance between relay socket Terminal 3, Circuit 937 (BK) and a clean chassis ground. If the resistance is greater than 5 ohms, repair the open in Circuit 937 (BK). Test the system for normal operation. If the resistance is less than 5 ohms (all engines), check Circuit 937 (BK) for an open at the relay socket and the ECM connector. Measure the resistance between the relay socket Terminal 3, Circuit 937 (BK) and one of the following ECM connector terminals: Caterpillar connector C110, Terminal 29 or Cummins connector C170, Terminal 10. If the resistance is greater than 5 ohms, repair the open in Circuit 937 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 350 (Y) for an open. Measure the resistance between the relay socket Terminal 4, Circuit 350 (Y) and one of the following ECM connector terminals: Caterpillar connector C110, Terminal 38, Cummins connector C171, Terminal T or DDC connector C135, Terminal H1. If the resistance is less than 5 ohms, refer to the engine manufacturer's service literature for testing procedures related to the ECM. If the resistance is greater than 5 ohms, repair the open in Circuit 350 (Y). Test the system for normal operation.

Troubleshooting

Component Tests

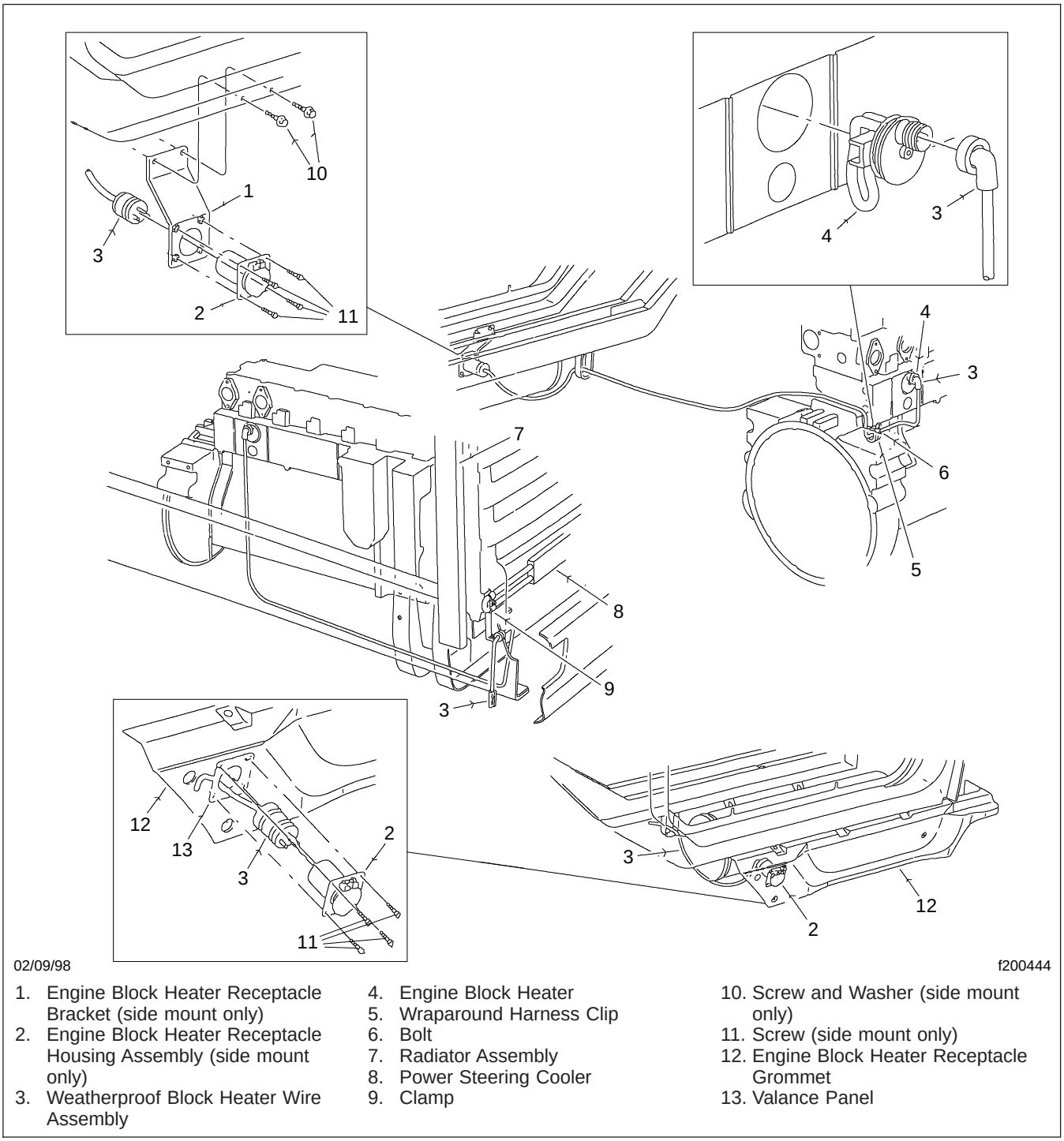
FAN CLUTCH TEST

1. Check the fan clutch for the following wear indications:
   - 1.1 Smoke from the clutch as it engages.
   - 1.2 Blistered paint or discolored metal (blueing).
   - 1.3 Air leak (Horton and Kysor "On/Off" fan clutches only).
   - 1.4 Excessive wobble or free play at the mounting shaft.
2. If any of the above conditions exist, replace the fan clutch.
3. On the viscous-type clutches, spin the fan. A light resistance should be felt. If no resistance or very high resistance is felt, replace the fan clutch.

Engine Block Heater

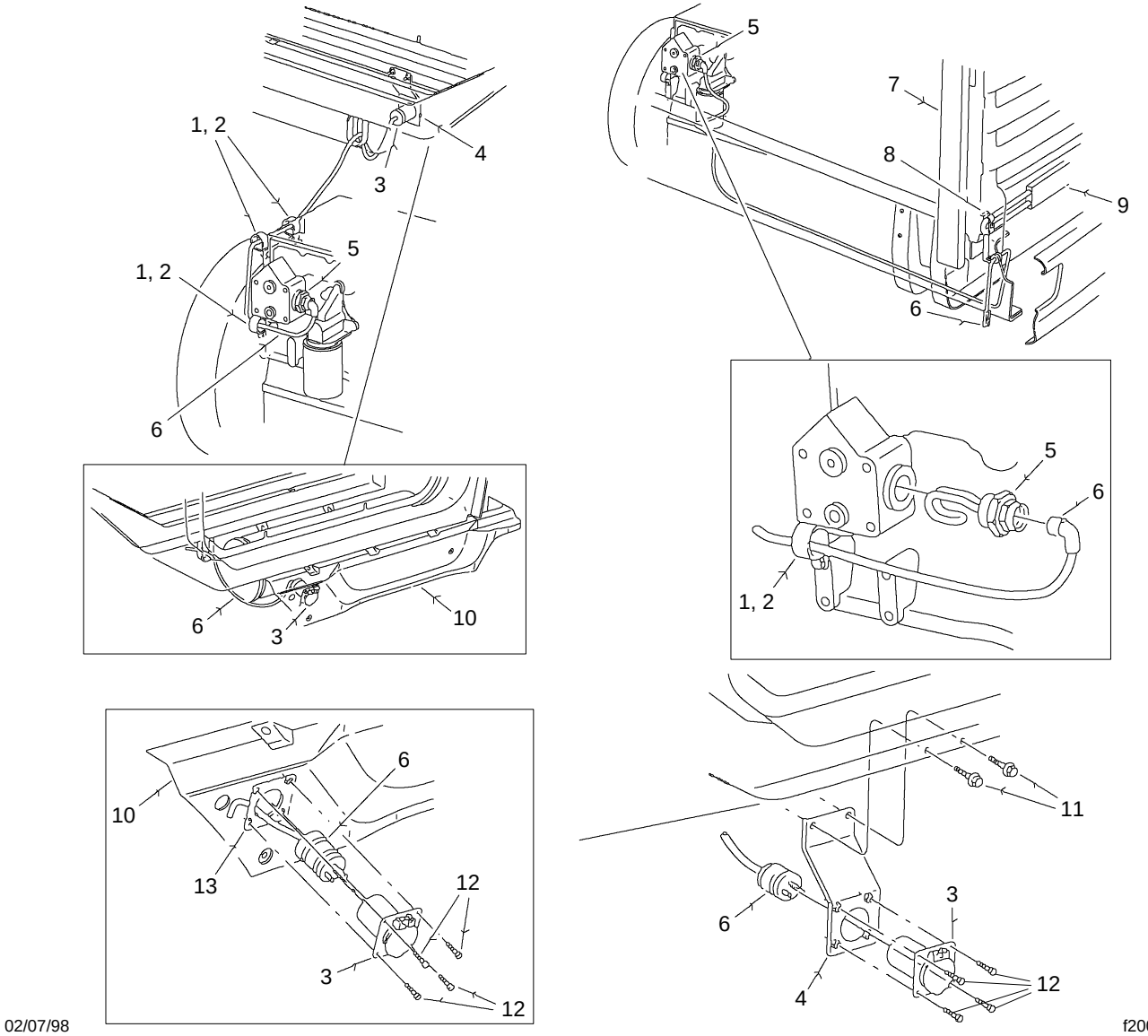
The engine block heater consists of an electrical heating element installed in one or more of the core plug openings in the engine block, and an electrical cable that plugs into a standard 110-volt AC electrical outlet. See **Fig. 1**, **Fig. 2**, **Fig. 3**, **Fig. 4**, **Fig. 5**, **Fig. 6** and **Fig. 7**. The engine block heater is designed to keep the engine coolant warm during cold weather to aid in cold-weather starting.

General Information



1. Engine Block Heater Receptacle Bracket (side mount only)
2. Engine Block Heater Receptacle Housing Assembly (side mount only)
3. Weatherproof Block Heater Wire Assembly
4. Engine Block Heater
5. Wraparound Harness Clip
6. Bolt
7. Radiator Assembly
8. Power Steering Cooler
9. Clamp
10. Screw and Washer (side mount only)
11. Screw (side mount only)
12. Engine Block Heater Receptacle Grommet
13. Valance Panel

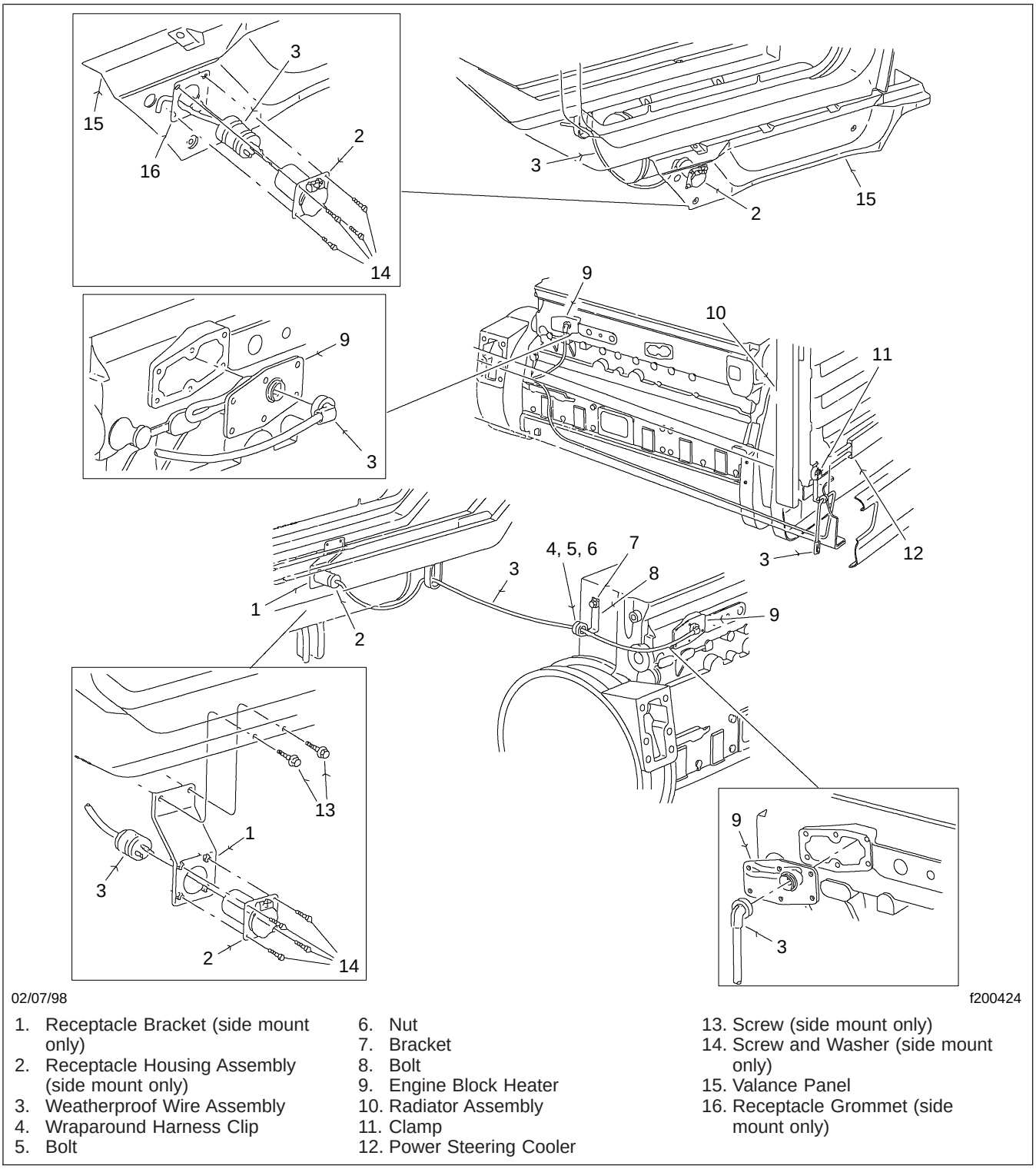
Fig. 1, Block Heater, Cummins ISB and ISC



1. Wraparound Harness Clip
2. Bolt
3. Engine Block Heater Receptacle Housing Assembly (side mount only)
4. Engine Block Heater Receptacle Bracket (side mount only)
5. Engine Block Heater
6. Weatherproof Block Heater Wire Assembly
7. Radiator Assembly
8. Clamp
9. Power Steering Cooler
10. Valance Panel
11. Screw and Washer (side mount only)
12. Screw (side mount only)
13. Engine Block Heater Receptacle Grommet

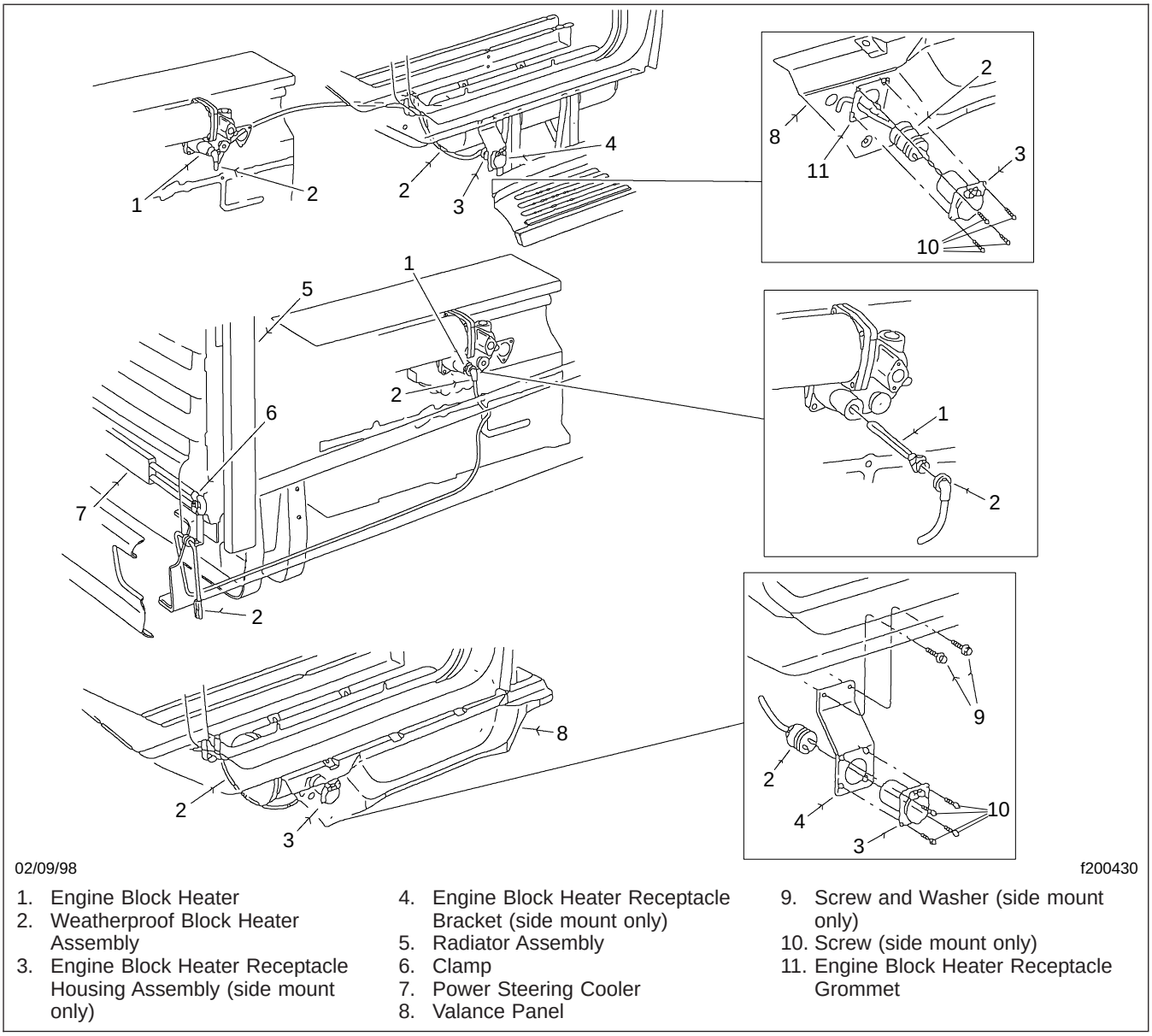
Fig. 2, Block Heater, Cummins M11

General Information



1. Receptacle Bracket (side mount only)
2. Receptacle Housing Assembly (side mount only)
3. Weatherproof Wire Assembly
4. Wraparound Harness Clip
5. Bolt
6. Nut
7. Bracket
8. Bolt
9. Engine Block Heater
10. Radiator Assembly
11. Clamp
12. Power Steering Cooler
13. Screw (side mount only)
14. Screw and Washer (side mount only)
15. Valance Panel
16. Receptacle Grommet (side mount only)

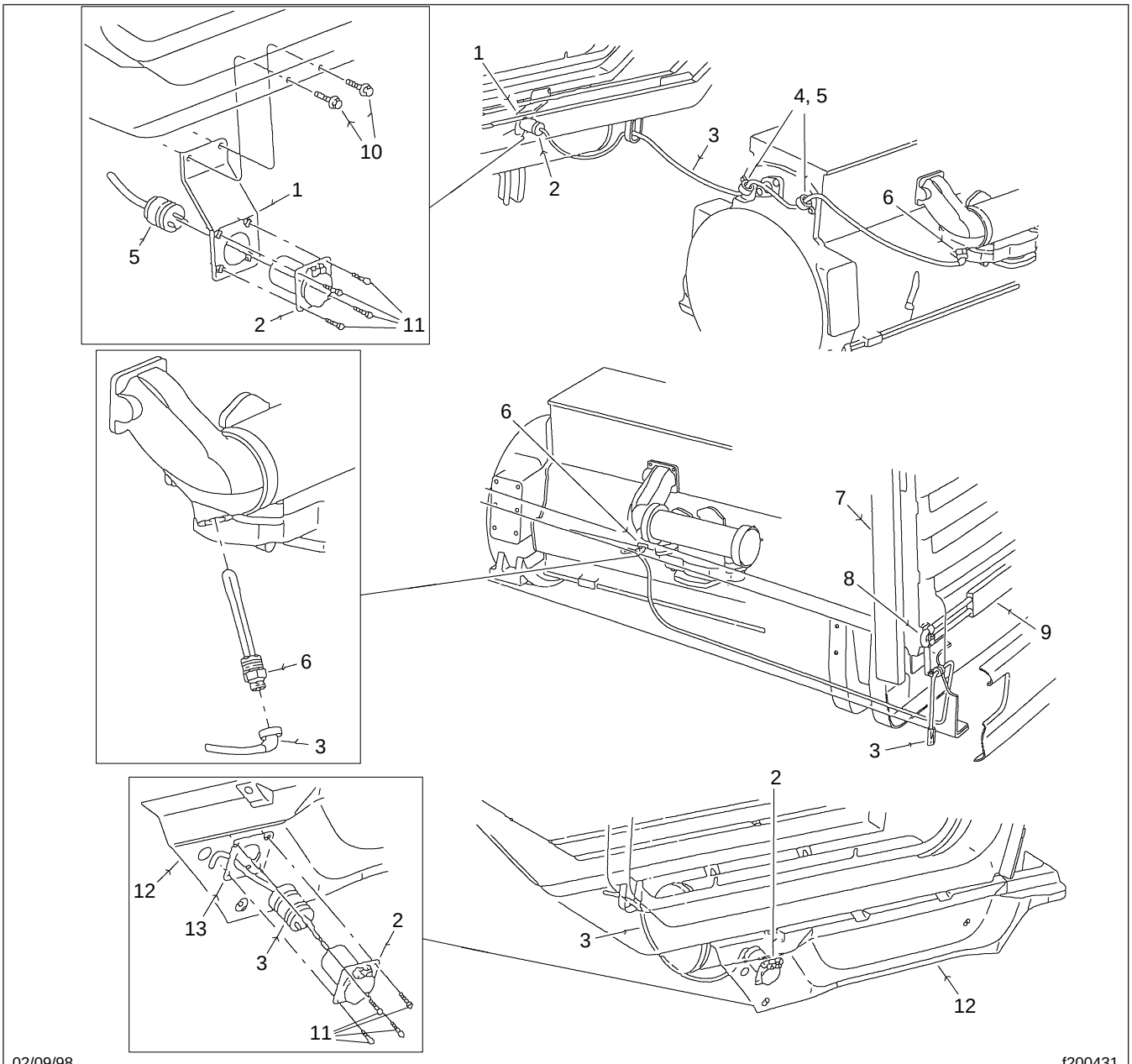
Fig. 3, Block Heater, Cummins N14



1. Engine Block Heater
2. Weatherproof Block Heater Assembly
3. Engine Block Heater Receptacle Housing Assembly (side mount only)
4. Engine Block Heater Receptacle Bracket (side mount only)
5. Radiator Assembly
6. Clamp
7. Power Steering Cooler
8. Valance Panel
9. Screw and Washer (side mount only)
10. Screw (side mount only)
11. Engine Block Heater Receptacle Grommet

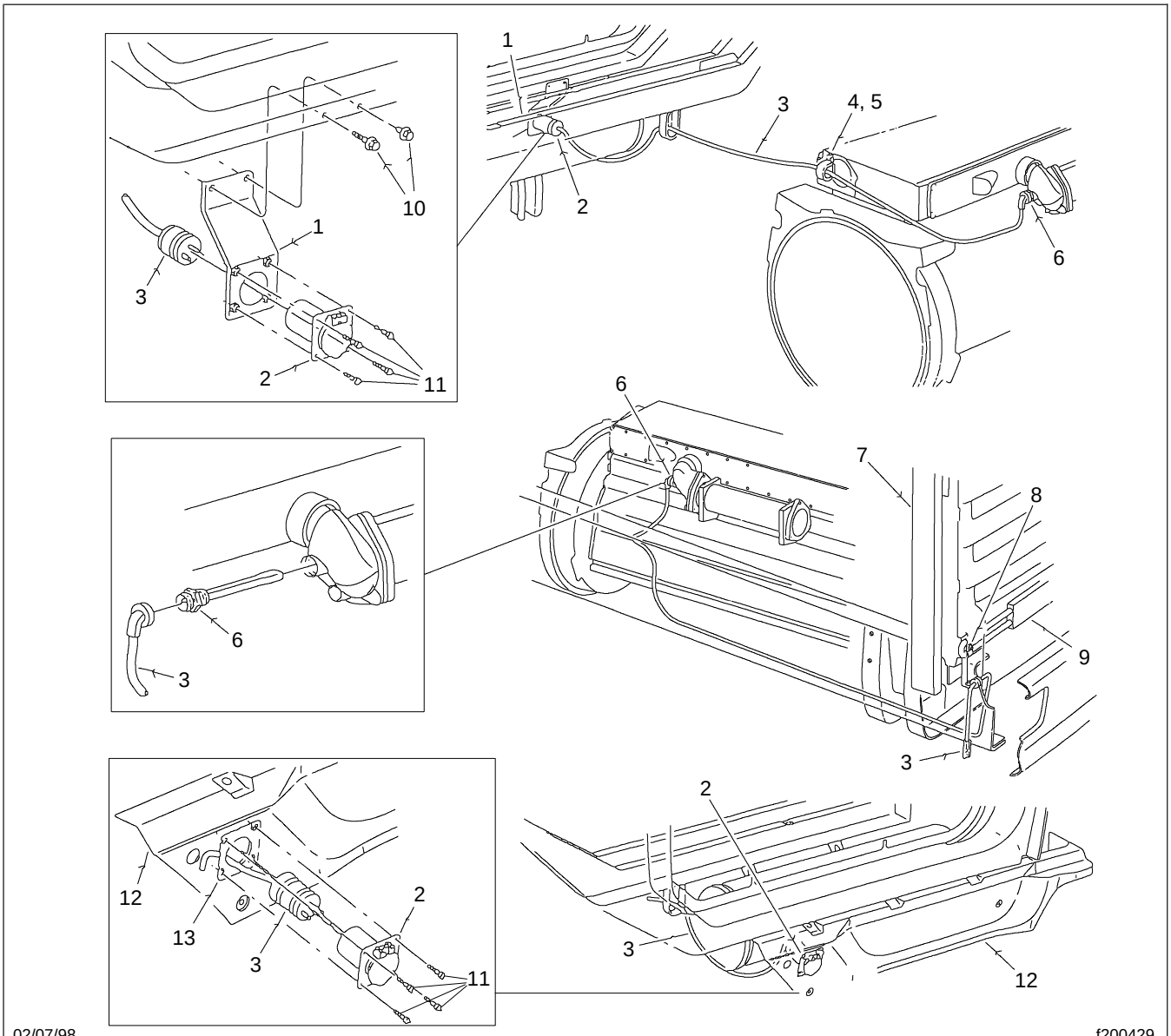
Fig. 4, Block Heater, Caterpillar 3306

General Information



1. Engine Block Heater Receptacle Bracket (side mount only)
2. Engine Block Heater Receptacle Housing Assembly (side mount only)
3. Weatherproof Block Heater Wire Assembly
4. Wraparound Harness Clip
5. Screw and Washer
6. Engine Block Heater
7. Radiator Assembly
8. Clamp
9. Power Steering Cooler
10. Screw and Washer (side mount only)
11. Screw (side mount only)
12. Engine Block Heater Receptacle Grommet (side mount only)
13. Valance Panel

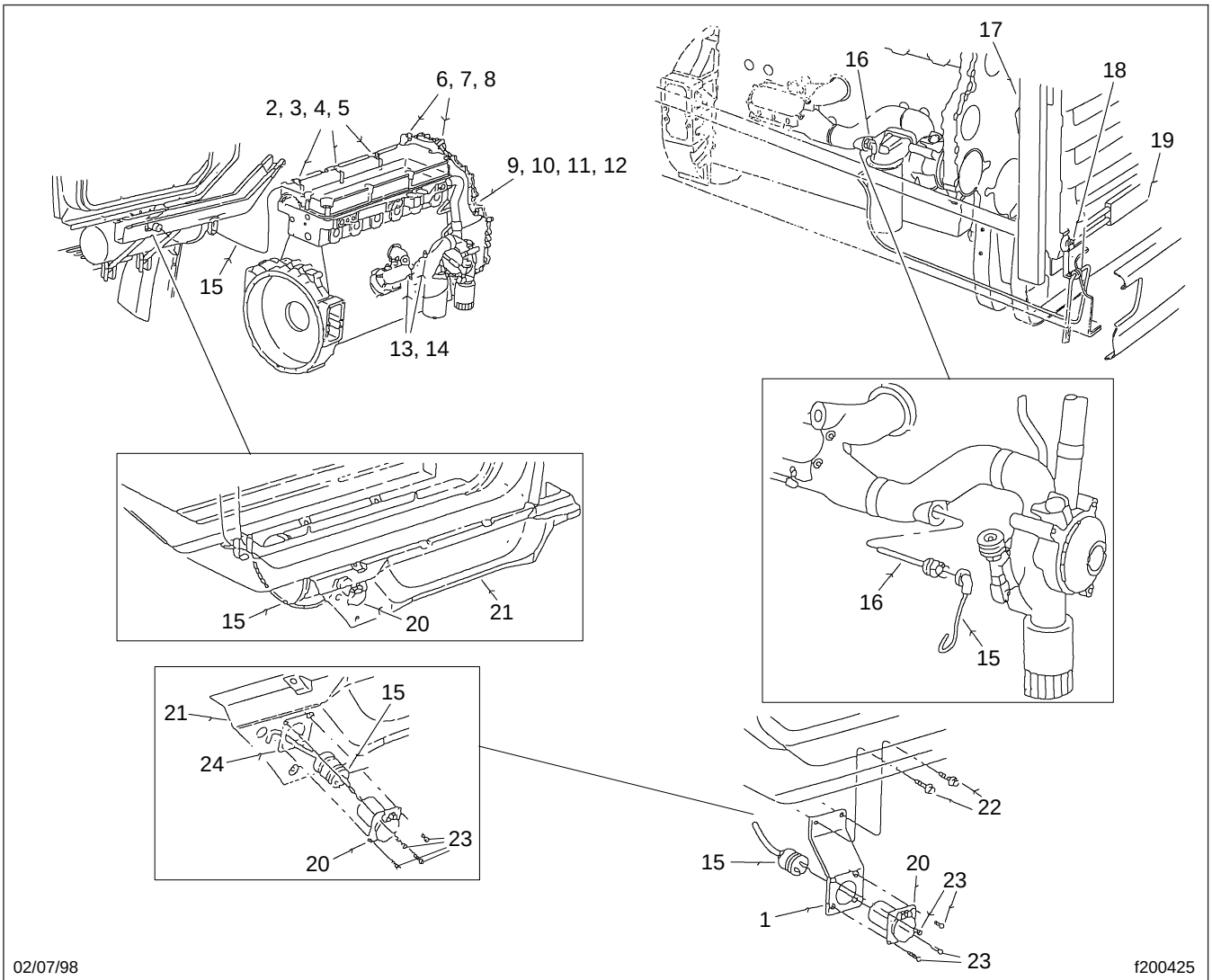
Fig. 5, Block Heater, Caterpillar 3406



1. Engine Block Heater Receptacle Bracket (side mount only)
2. Engine Block Heater Receptacle Housing Assembly (side mount only)
3. Weatherproof Block Heater Wire Assembly
4. Wraparound Harness Clip
5. Bolt
6. Engine Block Heater
7. Radiator Assembly
8. Clamp
9. Power Steering Cooler
10. Screw and Washer (side mount only)
11. Screw (side mount only)
12. Valance Panel
13. Engine Block Heater Receptacle Grommet (side mount only)

Fig. 6, Block Heater, Caterpillar C10 and C12

General Information



1. Engine Block Heater Receptacle Bracket (side mount only)
2. Wraparound Harness Clip
3. Bracket
4. Bolt
5. Nut
6. Wraparound Harness Clip
7. Bolt
8. Nut
9. Wraparound Harness Clip
10. Bolt
11. Washer
12. Nut
13. Wraparound Harness Clip
14. Bolt
15. Weatherproof Block Heater Wire Assembly
16. Engine Block Heater
17. Radiator Assembly
18. Clamp
19. Power Steering Cooler
20. Engine Block Heater Receptacle Housing Assembly (side mount only)
21. Valance Panel
22. Screw (side mount only)
23. Screw and Washer (side mount only)
24. Engine Block Heater Receptacle Grommet (side mount only)

Fig. 7, Block Heater, DDC Series 60

Troubleshooting

INSPECTION AND VERIFICATION

1. Verify the original concern by operating the engine block heater to duplicate the condition.
2. Check for leaks at the core plugs.

Problem—Engine Block Heater Does Not Operate Properly

Problem—Engine Block Heater Does Not Operate Properly	
Possible Cause	**Remedy**
Block heater power cable	Check the power cable. Check the resistance in Circuits 1, 2 and 3 of the block heater. If the resistance is 5 ohms or less in Circuits 1, 2 and 3, replace the block heater. Test the system for normal operation. If the resistance is not 5 ohms or less in Circuits 1, 2 and 3, replace the power cable. Test the system for normal operation.
Block heater	

General Information

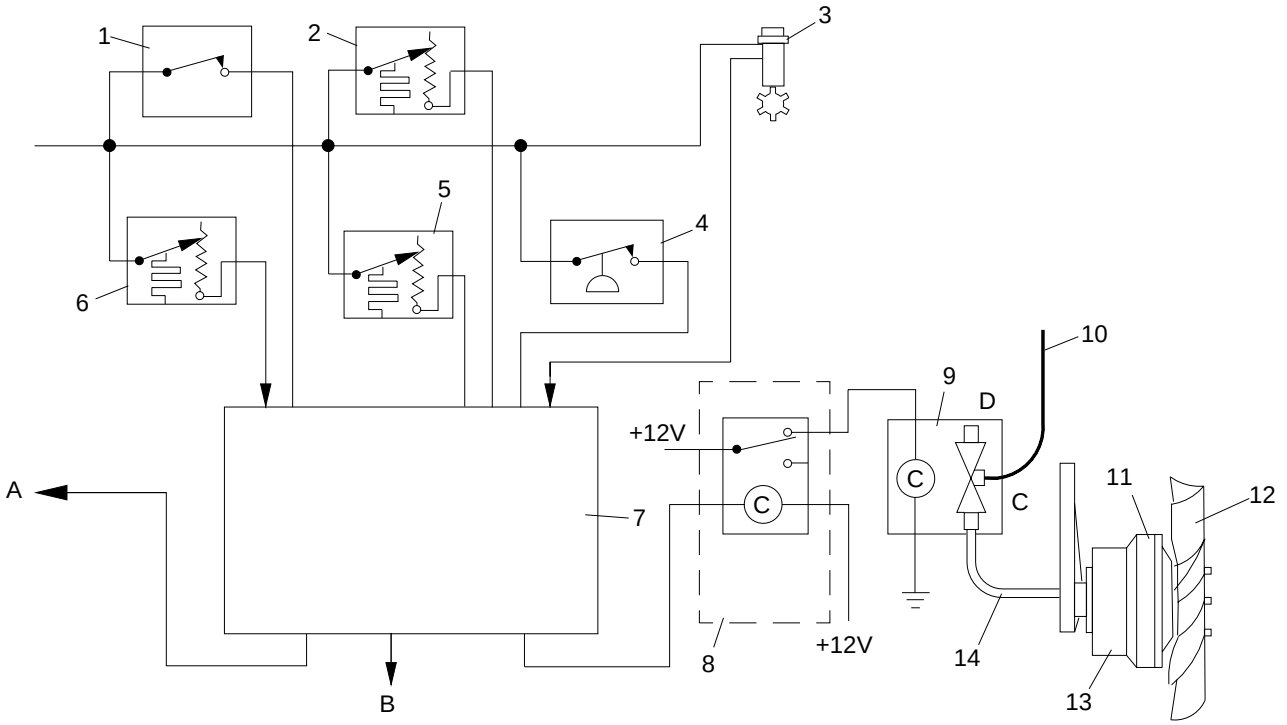
The Horton DriveMaster® fan clutch is a temperature-controlled, air-operated clutch for the engine cooling fan. It is spring engaged, and controls the engine temperature by engaging or disengaging the fan.

When the coolant temperature is below a specified range, air pressure keeps the fan disengaged to save engine power. When the coolant temperature rises above the specified range, air pressure to the fan clutch is cut off and internal spring pressure engages the fan.

Air pressure to the fan clutch is controlled by a solenoid valve; the solenoid valve is controlled by a temperature switch installed in the thermostat housing. The temperature switch is connected to the engine ECM, which controls the solenoid valve. See **Fig. 1**. When you start a cold engine, the solenoid valve allows air pressure to the fan clutch and the clutch remains disengaged. When the coolant temperature rises to the temperature switch setting, the switch provides power to the solenoid valve and the valve cuts off compressed air to engage the fan.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-dryer. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve, which cuts off air to the fan clutch, engaging the fan.

General Information



A. To Indicators and Gauges
B. To Electronic Injectors and Other Actuators
C. Normally Closed
D. Normally Open

1. Fan Override Switch
2. Air Temperature Sensor
3. Engine Speed Sensor
4. A/C Pressure Switch
5. Coolant Temperature Sensor
6. Foot Throttle
7. Engine ECM
8. Fan Relay (not present in all systems)
9. Solenoid Valve
10. Air Supply from Reservoir
11. Fan Clutch
12. Air Supply to Fan Clutch

Fig. 1, Fan Clutch Schematic (engine ECM controlled)

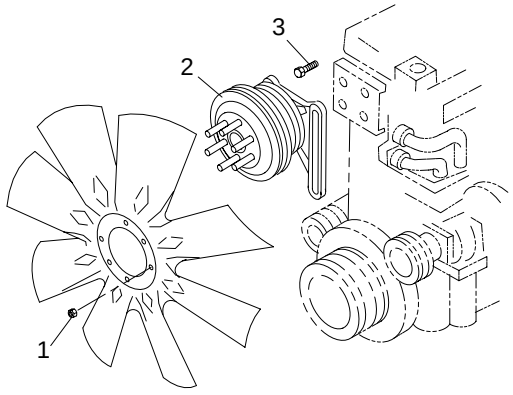
Removal

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

⚠ WARNING

Wear safety goggles when draining the air system or disconnecting an air line because dirt and sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnected pressurized air lines, as they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

2. Drain the air tanks.
3. Tilt the hood.
4. Disconnect the left-side hose from the charge air cooler.
5. Remove the drive belts from the engine.
6. Disconnect the air line from the fan hub.
7. Remove the fan.
8. Remove the fan clutch assembly from the engine. See **Fig. 1**.



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1. Hexnut
2. Fan Clutch Assembly
3. Hexbolt

Fig. 1, Fan Clutch Removal (typical)

8.1 If equipped with a metal fan ring, remove the two top fasteners holding the upper mounting bracket for the fan ring.

8.2 Remove the fasteners holding the fan clutch mounting bracket to the front of the engine.

⚠ WARNING

The fan clutch assembly may weigh up to 55 lbs. (25 kg). Be careful when lifting it. Use a helper or a hoist, if necessary. Failure to use care when lifting the fan clutch could cause the assembly to fall, which could result in injury or component damage.

8.3 Remove the fan clutch assembly from the vehicle. If equipped with a metal fan ring, carefully push the ring forward to allow removal of the fan clutch assembly.

Installation

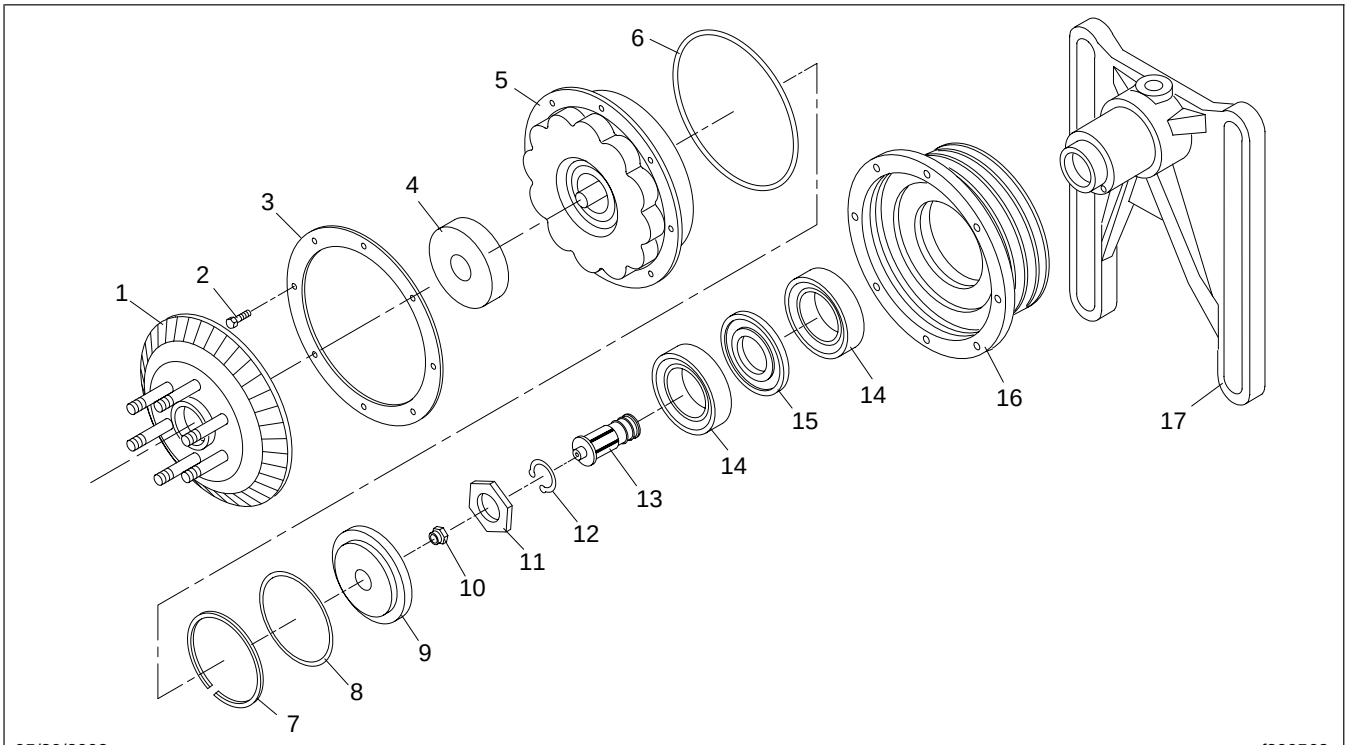
1. Using either a helper or a hoist, position the fan clutch assembly in place on the front of the engine, aligning the holes in the mounting bracket with those in the front of the engine.
2. Install the fasteners.

   If equipped with a metal fan ring, don't tighten the upper fan clutch fasteners completely.
3. Install the drive belts.
4. Connect the air line to the fan clutch.
5. Install the fan. Tighten the fan mounting nuts firmly.
6. Tighten the M8 fan-clutch mounting fasteners 15 lbf·ft (20 N·m).
7. Connect the left-side hose to the charge air cooler.
8. Lower the hood, and remove the chocks from the tires.

Disassembly

NOTE: This procedure involves a major rebuild of the Horton DriveMaster® fan clutch, using parts from the manufacturer's Super Kit. If you are replacing just the seals or the air cartridge, see **Subject 120** for the minor rebuild procedure.

Refer to **Fig. 1** for this procedure.



1. Fan Mounting Disc
2. Torx®-Head Screw (8 qty.)
3. Friction Lining
4. Cage Nut (supplied with repair kit)
5. Spring Housing/Piston Assembly
6. Air Chamber Seal
7. Air Chamber Cap Retaining Ring
8. O-Ring
9. Air Chamber Cap
10. Face Seal
11. Bearing Nut
12. Air Cartridge Retaining Ring
13. Air Cartridge Assembly
14. Sheave Bearings
15. Bearing Spacer
16. Sheave
17. Journal Bracket

Fig. 1, Horton DriveMaster Fan Clutch

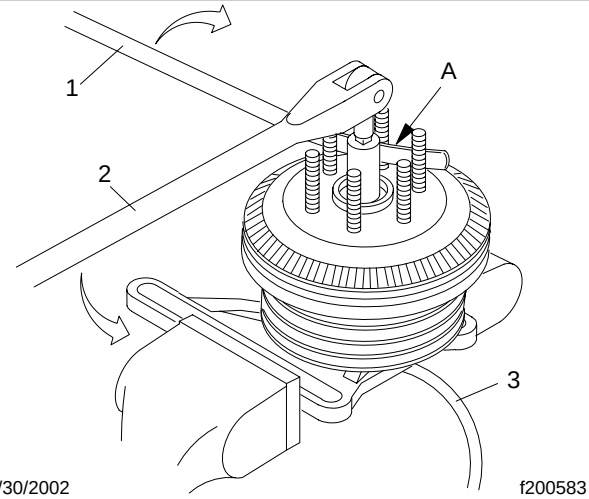
1. Remove the fan clutch assembly from the vehicle. For instructions, see **Subject 100**.
2. Put the fan clutch assembly in a vise.
3. Connect a shop air hose to the fan clutch air inlet.
4. Apply 80 to 120 psi (552 to 827 kPa) to the fan clutch to lift the fan mounting disc off the spring housing/piston assembly.

⚠ CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

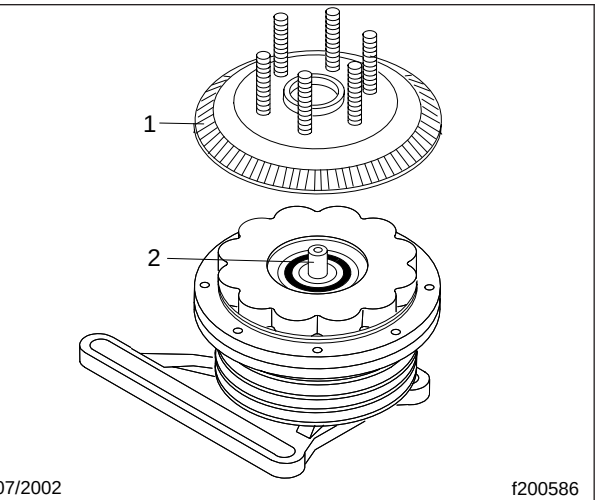
5. Using a pry bar, wrench, and a T55 Torx® bit, loosen the jack bolt (left-hand thread) by turning it counterclockwise. See **Fig. 2**.
6. Unscrew the fan mounting disc from the jack bolt. See **Fig. 3**

Fan Clutch Major Rebuild



A. Place the pry bar here.
1. Pry Bar (push clockwise)
2. Torx Bit and Wrench (turn counterclockwise)
3. Shop Air Hose (connected to the inlet port)

Fig. 2, Loosening the Jack Bolt



1. Fan Mounting Disc
2. Jack Bolt (left-hand thread)

Fig. 3, Fan Mounting Disc Removal and Installation

7. Inspect the fan mounting disc for wear or damage.

⚠ WARNING

Do not disassemble the spring housing from the piston. The interior springs are very strong, and if released could eject the housing with considerable force, possibly resulting in serious injury. Always use the cage nut to hold the spring housing and the piston together.

8. Using a wrench and a T55 Torx bit to hold the jack bolt, install the cage nut from the kit onto the jack bolt (left-hand thread). Hand tighten it onto the spring housing.

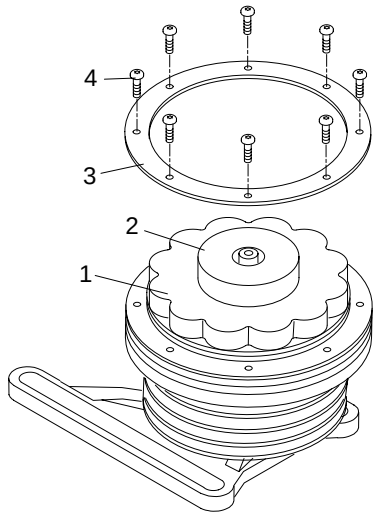
   The cage nut will keep the spring housing and piston together as an assembly. It will also maintain pressure on the internal springs after the Torx-head screws holding the friction lining in place are removed.

9. Release the air pressure from the fan clutch.

⚠ WARNING

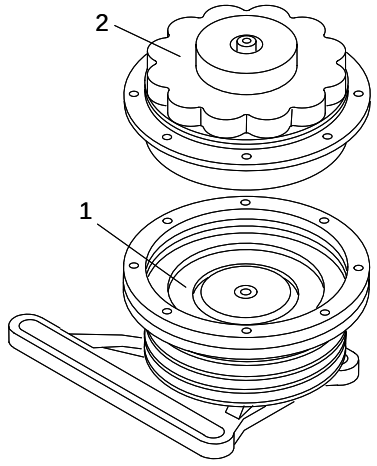
Release the air pressure from the fan clutch before removing the friction lining Torx-head screws. Failure to release the air pressure could result in the spring housing/piston assembly being ejected with force, which could result in personal injury.

10. Using a T27 Torx bit, remove the eight Torx-head screws holding the friction lining in place.
11. Remove the friction lining. See **Fig. 4**.
12. *Keeping the cage nut installed and tightened,* remove the spring housing/piston assembly. See **Fig. 5** .
13. Remove the air chamber seal. See **Fig. 6** .
14. Examine the inside of the air chamber for signs of moisture and/or contaminants.
15. Remove the air chamber cap retaining ring. See **Fig. 6** .
16. Using two small screwdrivers placed 180 degrees apart, gently and evenly pry the air chamber cap out of the sheave.
17. Remove the O-ring seal from the air chamber cap. See **Fig. 6** .
18. Remove the face seal. See **Fig. 6** .



1. Spring Housing/Piston Assembly
2. Cage Nut
3. Friction Lining
4. Torx-Head Screws

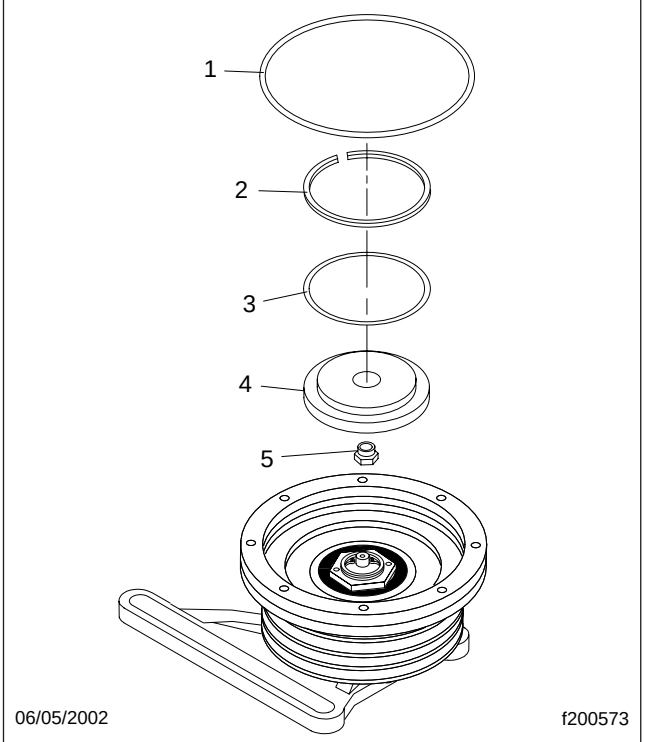
Fig. 4, Friction Lining Removal and Installation



1. Air Chamber
2. Spring Housing/Piston Assembly (with cage nut installed)

Fig. 5, Spring Housing/Piston Assembly Removal and Installation

19. Inspect the face seal for signs of wear. Wear indicates that dirt may exist in the air system



1. Air Chamber Seal
2. Retaining Ring
3. O-Ring Seal
4. Air Chamber Cap
5. Face Seal

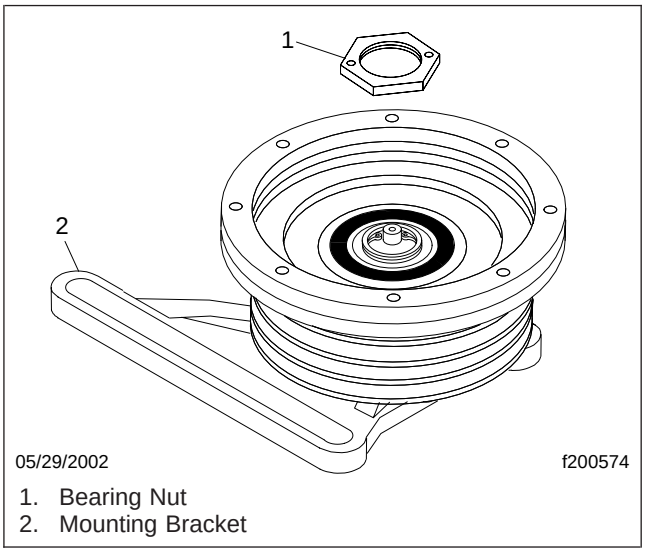
Fig. 6, Air Chamber Seal Removal and Installation

20. Remove the bearing nut from the mounting bracket. See **Fig. 7** .
21. Remove the sheave from the mounting bracket. See **Fig. 8** .
22. If replacing the bearings, support the sheave and press them out.
23. Clean and remove any dirt, debris, or corrosion that may be present.
24. Remove the air cartridge.
    - 24.1 Remove the retaining ring. See **Fig. 9**.
    - 24.2 Remove the air cartridge assembly. See **Fig. 10** .

Assembly

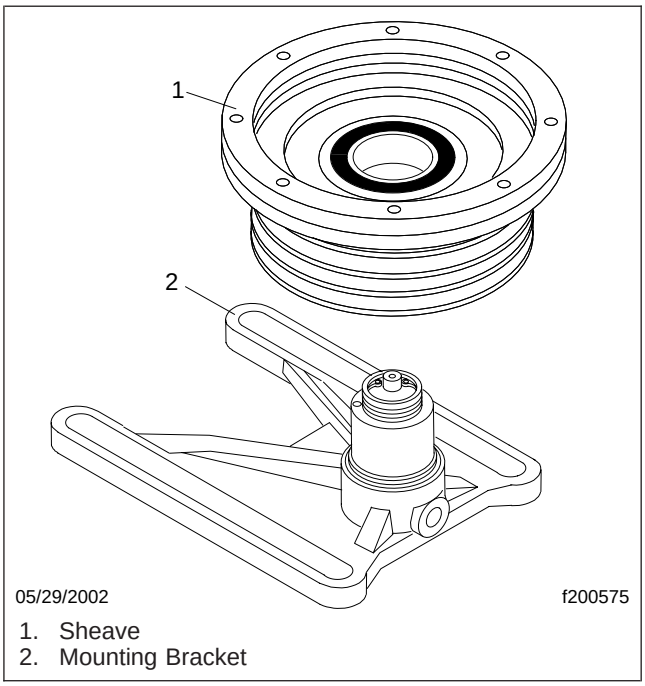
1. If necessary, clean the air cartridge bore in the mounting bracket.

Fan Clutch Major Rebuild



1. Bearing Nut
2. Mounting Bracket

Fig. 7, Bearing Nut Removal and Installation



1. Sheave
2. Mounting Bracket

Fig. 8, Removing the Sheave

NOTE: The sheave bearings do not require lubrication.

2. If replacing the sheave bearings, do the following:

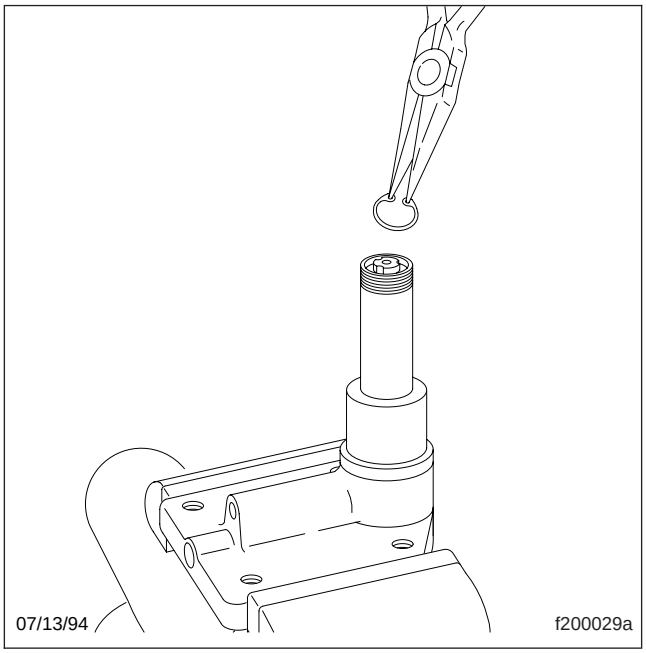
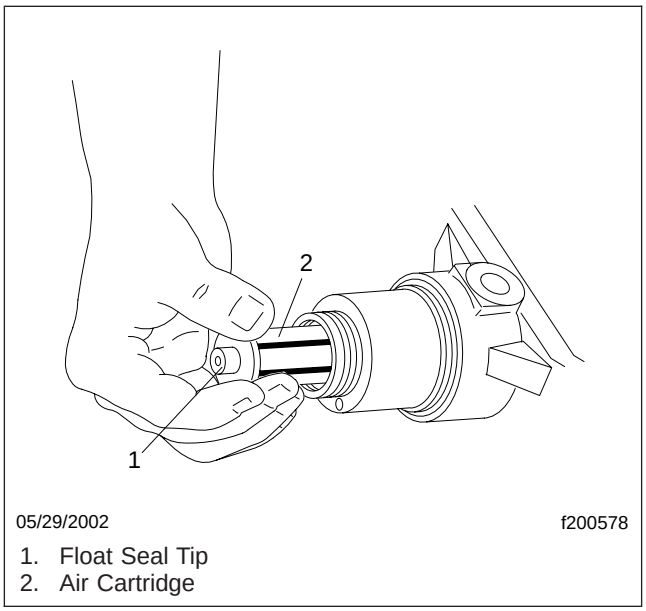


Fig. 9, Retaining Ring Removal and Installation

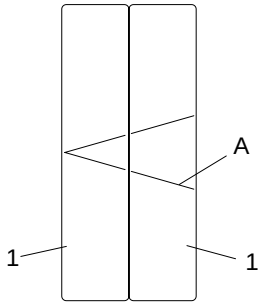


1. Float Seal Tip
2. Air Cartridge

Fig. 10, Removing the Air Cartridge

2.1 If equipped with two bearings, assemble the bearings so the markings on their edges line up to form an arrow. See

Fig. 11 . It doesn't matter which way the arrow faces when the bearings are installed.



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A. Align the markings to form an arrow.
1. Sheave Bearing

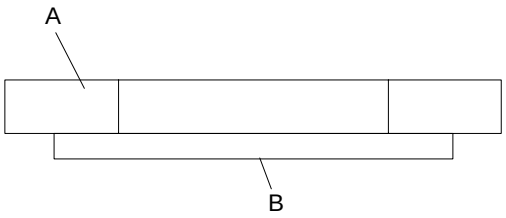
Fig. 11, Aligning the Bearings

IMPORTANT: If the fan clutch uses spacers, be sure to install them between the bearings.

2.2 Supporting the sheave, press the new sheave bearings — and spacers, if applicable — into place. Note the position of the lip inside the sheave.

2.3 Slide the sheave onto the mounting bracket. See **Fig. 8** .

2.4 Making sure that the bearing nut hex is facing up, install the bearing nut. See **Fig. 12** . Tighten 130 lbf·ft (176 N·m). See **Fig. 7** .



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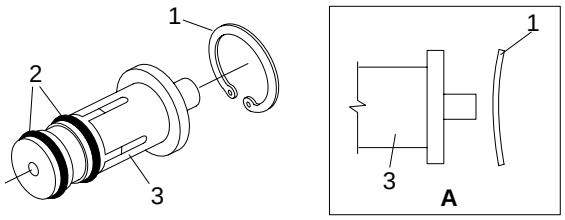
A. Hex faces up.
B Relief faces toward mounting bracket and bearings.

Fig. 12, Correct Bearing Nut Orientation

3. Apply O-ring lubricant from the kit to the outside O-rings of the new air cartridge assembly. See **Fig. 13** .



03/27/2000 f200515

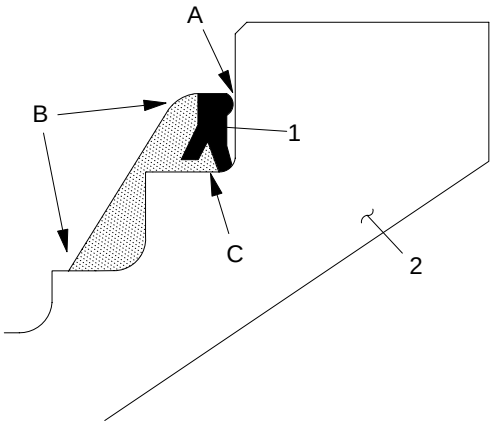
A. Convex surface of the retaining ring goes toward the air cartridge.
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 13, Installing the Air Cartridge Retaining Ring

4. Install the new air cartridge assembly into the mounting bracket.
5. Install the retaining ring, making sure the convex surface of the ring is toward the air cartridge. See **Fig. 13** .
6. Using a clean, dry cloth, clean both the float seal tip of the air cartridge and the face seal of the air chamber cap.
7. Assemble the air chamber cap and face seal. See **Fig. 6** .

   Tighten the face seal 75 to 100 lbf·in (850 to 1130 N·cm).
8. Lubricate the O-ring seal with the fresh lubricant from the kit.
9. Install the O-ring seal on the air chamber cap. See **Fig. 6** .
10. Carefully set the air chamber cap into the sheave. See **Fig. 6** .
11. Install the retaining ring. See **Fig. 6** .
12. Install the air chamber seal into the sheave. Be sure the seal is evenly seated against the side and bottom of the groove surfaces, and the "V" of the seal is facing down. See **Fig. 14** .
13. Lubricate contact surfaces with the fresh lubricant from the kit.

Fan Clutch Major Rebuild



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A. Seal is seated evenly against side and bottom of groove.
B. Apply grease only between these areas.
C. "V" of Seal Facing Down
1. Air Chamber Seal
2. Sheave

Fig. 14, Correct Installation of Air Chamber Seal (cross-section view)

WARNING

The new spring housing/piston assembly from the kit has a cage nut installed on it. Do not remove the cage nut. This will cause the spring housing to be forcibly ejected from the piston assembly, which could result in serious injury.

14. Carefully set the new spring housing/piston assembly into position. See **Fig. 6** . Note that the new assembly has a cage nut installed on it.
15. Rotate the new spring housing/piston assembly to align the mounting holes with those of the sheave.

IMPORTANT: Handle the new friction liner by the edges to avoid contamination.

16. Set the new friction liner from the kit into place, being careful to touch only the edges.
17. Using a T27 Torx bit, install the eight Torx-head screws. See **Fig. 4** . Tighten alternately 80 lbf·in (900 N·cm).
18. Apply a minimum of 80 psi (552 kPa) of clean air to the air inlet.
19. Remove the cage nut from the spring housing/piston assembly.
20. Install the new fan mounting disc from kit.

CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

21. Using a suitable wrench, a T55 Torx bit, and a pry bar, tighten the jack bolt (left-hand thread) 100 lbf·ft (136 N·m). Turn the wrench clockwise and push the pry bar counterclockwise.
22. Using shop air, actuate the fan clutch and check for correct engagement and disengagement of the fan mounting disc. If there is a problem, it must be corrected before installing the fan clutch onto the engine.
23. Check for air leaks at the bleed hole and around the spring housing/piston assembly.
24. Install the fan clutch assembly onto the engine. See **Subject 100** for instructions.

Disassembly

NOTE: This procedure involves a minor rebuild of the Horton DriveMaster® fan clutch, using parts from the manufacturer's Seal Kit. If a major rebuild of the fan clutch is needed, see **Subject 110**.

1. Remove the fan clutch assembly from the vehicle. For instructions, see **Subject 100**.
2. Put the fan clutch assembly in a vise.
3. Connect a shop air hose to the fan clutch air inlet.
4. Apply 80 to 120 psi (552 to 827 kPa) to the fan clutch to lift the fan mounting disc off the spring housing/piston assembly.

⚠ CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

5. Using a pry bar, wrench, and a T55 Torx® bit, loosen the jack bolt (left-hand thread) by turning it counterclockwise. See **Fig. 1**.
6. Unscrew the fan mounting disc from the jack bolt. See **Fig. 2**.
7. Inspect the fan mounting disc for wear or damage.

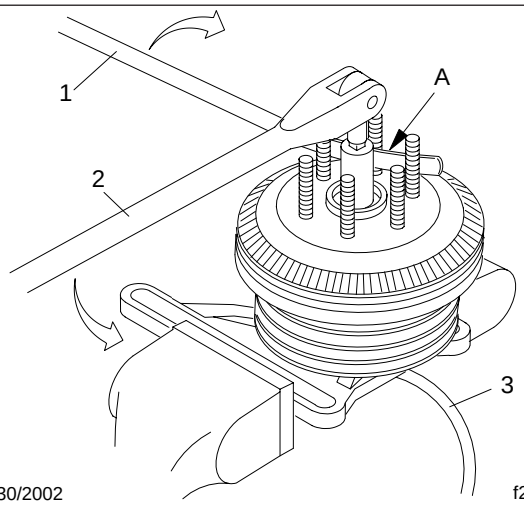
⚠ WARNING

Do not disassemble the spring housing from the piston. The interior springs are very strong, and if released could eject the housing with considerable force, possibly resulting in serious injury. Always use the cage nut to hold the spring housing and the piston together.

8. Using a wrench and T55 Torx bit to hold the jack bolt, install the cage nut from the kit onto the jack bolt (left-hand thread). Hand tighten it onto the spring housing.

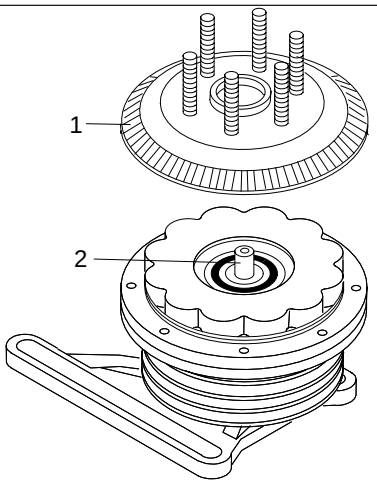
   The cage nut will keep the spring housing and piston together as an assembly. It will also maintain pressure on the internal springs after the Torx-head screws holding the friction lining in place are removed.

9. Release the air pressure from the fan clutch.



A. Place the pry bar here.
1. Pry Bar (push clockwise)
2. Torx Bit and Wrench (turn counterclockwise)
3. Shop Air Hose (connected to the inlet port)

Fig. 1, Loosening the Jack Bolt



1. Fan Mounting Disc
2. Jack Bolt (left-hand thread)

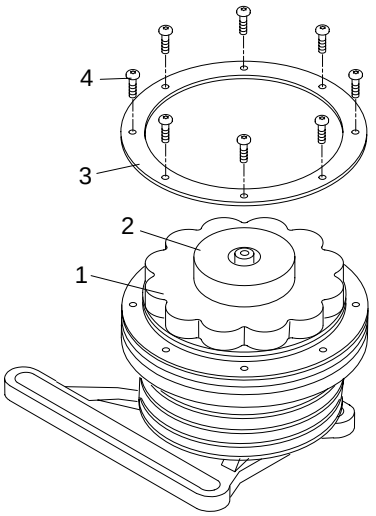
Fig. 2, Fan Mounting Disc Removal and Installation

Fan Clutch Minor Rebuild

⚠ WARNING

Release the air pressure from the fan clutch before removing the friction lining Torx-head screws. Failure to release the air pressure could result in the spring housing/piston assembly being ejected with force, which could result in personal injury.

10. Using a T27 Torx bit, remove the eight Torx-head screws holding the friction lining in place.
11. Remove the friction lining. See **Fig. 3**.



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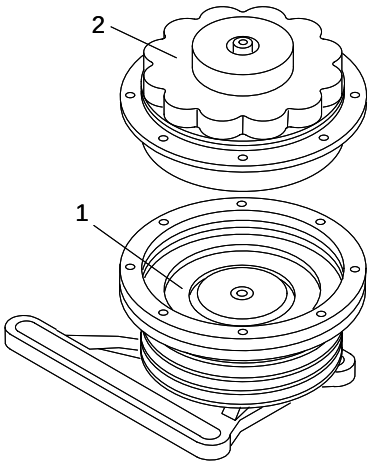
1. Spring Housing/Piston Assembly
2. Cage Nut
3. Friction Lining
4. Torx-Head Screws

Fig. 3, Friction Lining Removal and Installation

12. *Keeping the cage nut installed and tightened,* remove the spring housing/piston assembly. See **Fig. 4** .
13. Remove the air chamber seal. See **Fig. 5** .
14. Examine the inside of the air chamber for signs of moisture and/or contaminants.
15. Remove the air chamber cap retaining ring. See **Fig. 5** .
16. Using two small screwdrivers placed 180 degrees apart, gently and evenly pry the air chamber cap out of the sheave.



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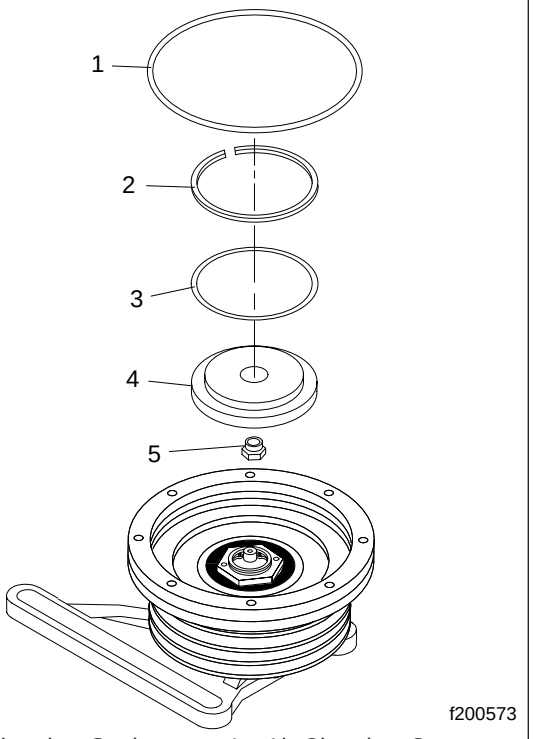
1. Air Chamber
2. Spring Housing/Piston Assembly (with cage nut installed)

Fig. 4, Spring Housing/Piston Assembly Removal and Installation

17. Remove the O-ring seal from the air chamber cap. See **Fig. 5** .
18. Remove the face seal. See **Fig. 5** .
19. Inspect the face seal for signs of wear. Wear indicates that dirt may exist in the air system.
20. Remove the air cartridge.
    - 20.1 Remove the retaining ring. See **Fig. 6**.
    - 20.2 Remove the air cartridge assembly. See **Fig. 7** .

Assembly

1. Clean the mounting bracket bore if necessary.
2. Apply O-ring lubricant from the kit to the outside O-rings of the new air cartridge assembly. See **Fig. 8** .
3. Install the new air cartridge assembly into the mounting bracket.
4. Install the retaining ring, making sure the convex surface of the ring is toward the air cartridge. See **Fig. 8** .



1. Air Chamber Seal
2. Retaining Ring
3. O-Ring Seal
4. Air Chamber Cap
5. Face Seal

Fig. 5, Air Chamber Seal Removal and Installation

5. Using a clean, dry cloth, clean both the float seal tip of the air cartridge and the face seal of the air chamber cap.
6. Assemble the air chamber cap and face seal. See **Fig. 5** .

   Tighten the face seal 75 to 100 lbf·in (850 to 1130 N·cm).
7. Lubricate the O-ring seal with the fresh lubricant from the kit.
8. Install the O-ring seal on the air chamber cap. See **Fig. 5** .
9. Carefully set the air chamber cap into the sheave. See **Fig. 5** .
10. Install the retaining ring. See **Fig. 5** .
11. Install the air chamber seal into the sheave. Be sure the seal is evenly seated against the side

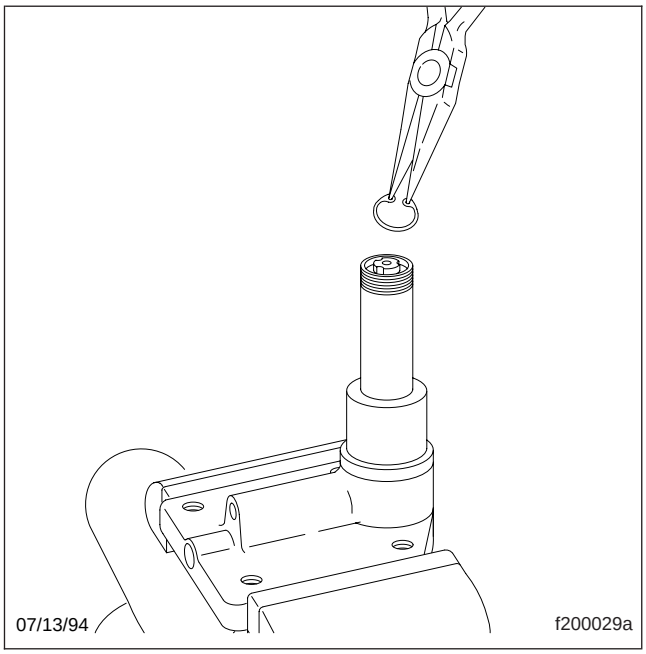
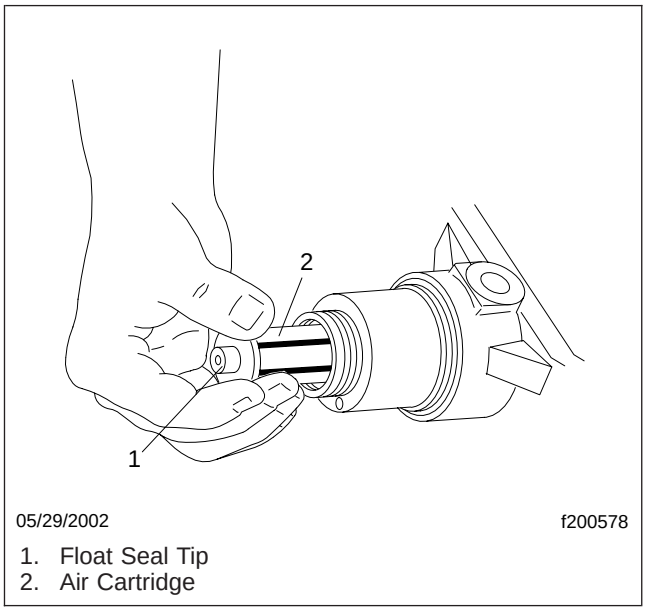


Fig. 6, Retaining Ring Removal and Installation (sheave not shown)



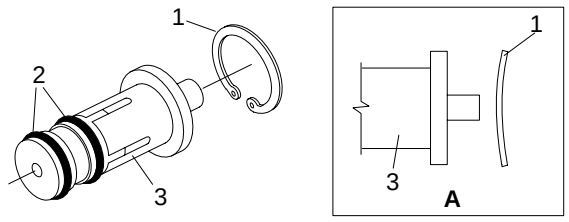
1. Float Seal Tip
2. Air Cartridge

Fig. 7, Removing the Air Cartridge (sheave not shown)

and bottom of the groove surfaces, and the "V" of the seal is facing down. See **Fig. 9** .

12. Lubricate contact surfaces with the fresh lubricant from the kit.

Fan Clutch Minor Rebuild



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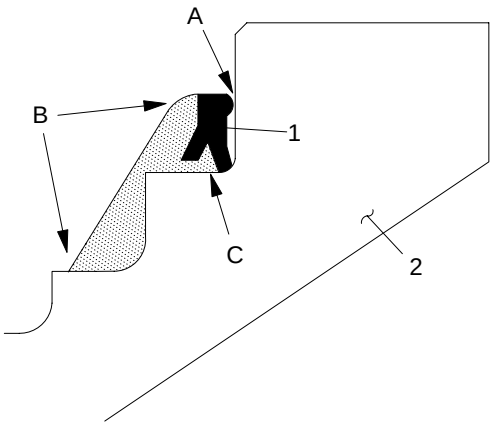
A. Convex surface of the retaining ring goes toward the air cartridge.
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 8, Installing the Air Cartridge Retaining Ring



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A. Seal is seated evenly against side and bottom of groove.
B. Apply grease only between these areas.
C. "V" of Seal Facing Down
1. Air Chamber Seal
2. Sheave

Fig. 9, Correct Installation of Air Chamber Seal (cross-section view)

⚠ WARNING

The new spring housing/piston assembly from the kit has a cage nut installed on it. Do not remove the cage nut. This will cause the spring housing to be forcibly ejected from the piston assembly, which could result in serious injury.

13. Carefully set the new spring housing/piston assembly into position. See **Fig. 4** . Note that the new assembly has a cage nut installed on it.
14. Rotate the new spring housing/piston assembly to align the mounting holes with those of the sheave.
15. Set the friction liner from the kit into place, being careful to touch only the edges.
16. Using a T27 Torx bit, install the eight Torx-head screws. See **Fig. 3** . Tighten alternately 80 lbf·in (900 N·cm).
17. Apply a minimum of 80 psi (552 kPa) of clean air to the air inlet.
18. Remove the cage nut from the spring housing/piston assembly.

⚠ CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

19. Using a suitable wrench, a T55 Torx bit, and a pry bar, tighten the jack bolt (left-hand thread) 100 lbf·ft (136 N·m). Turn the wrench clockwise and the pry bar counterclockwise.
20. Using shop air, actuate the fan clutch and check for correct engagement and disengagement of the fan mounting disc. If there is a problem, it must be corrected before installing the fan clutch onto the engine.
21. Check for air leaks at the bleed hole and around the spring housing/piston assembly.
22. Install the fan clutch assembly onto the engine. See **Subject 100** for instructions.

Troubleshooting Tables

Problem—Air Is Leaking from the Fan Clutch

Problem—Air Is Leaking from the Fan Clutch	
Possible Cause	**Remedy**
The face seal or air cartridge is damaged or worn.	Install a new seal kit.
The O-ring seals are damaged or worn.	Install a new seal kit.

Problem—The Fan Clutch Fails to Engage

Problem—The Fan Clutch Fails to Engage	
Possible Cause	**Remedy**
There's no power to the fan clutch control circuit.	Check all electrical connections, and repair or replace wiring as needed. Check the circuit breaker for the engine fan and repair or replace as needed.
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally open, not normally closed. Replace the switch if it is damaged or if the switch is the wrong type.
The solenoid valve is malfunctioning.	Replace the solenoid valve.
The solenoid is not exhausting.	Make sure the solenoid exhaust port is not plugged.

Problem—The Fan Clutch Does Not Disengage

Problem—The Fan Clutch Does Not Disengage	
Possible Cause	**Remedy**
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally open, not normally closed. Replace the switch if it is damaged or if the switch is the wrong type.
A restricted air line doesn't allow air supply to the clutch.	Make sure the air lines are not pinched or plugged. Repair the air lines as needed.
The fan clutch is leaking.	Install a new seal kit.
The air supply to the fan clutch is restricted.	Make sure the fan clutch air lines are not leaking or pinched. Repair the lines as needed.
The piston is seized due to contamination or dry seals.	Clean the air supply. Do a major rebuild.

Problem—The Fan Clutch Cycles Frequently

Problem—The Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
The fan clutch control circuit has a loose connection or is poorly grounded.	Check all wiring connections, and repair the circuit as needed. Check the circuit breaker for the engine fan and repair or replace as needed.
The temperature control settings are incorrect.	Check the fan clutch control setting of the temperature switch, according to the engine installed in the vehicle. Repair or replace the temperature switch as needed.

Troubleshooting

Problem—The Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
The fan cycling switch at the receiver-dryer is set too low.	Check the switch at the receiver-dryer, and if needed, replace the switch with a switch with a higher setting. Check the ACPU switch and unit.
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
The engine temperature is too high.	Check the programmable engine control parameters, and reprogram as needed.
The temperature switch is malfunctioning.	Replace the temperature switch.

Problem—The Fan Clutch Engages, But the Engine Still Overheats

Problem—The Fan Clutch Engages, But the Engine Still Overheats	
Possible Cause	**Remedy**
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
There is a problem somewhere else in the cooling system.	Refer to cooling system troubleshooting, **Section 20.00**.

Specifications

Horton DriveMaster® Repair Kits		
Kit Description *	**Part Number**	**When Used**
Super Kit	HOR994347	Fan Clutch Major Rebuild
Seal Kit	HOR994346	Replacing Seals and Air Cartridge
Friction Disc Kit	HOR994348	Replacing Fan Mounting Disc and Friction Lining
Friction Liner Kit	HOR994349	Replacing Friction Lining Only

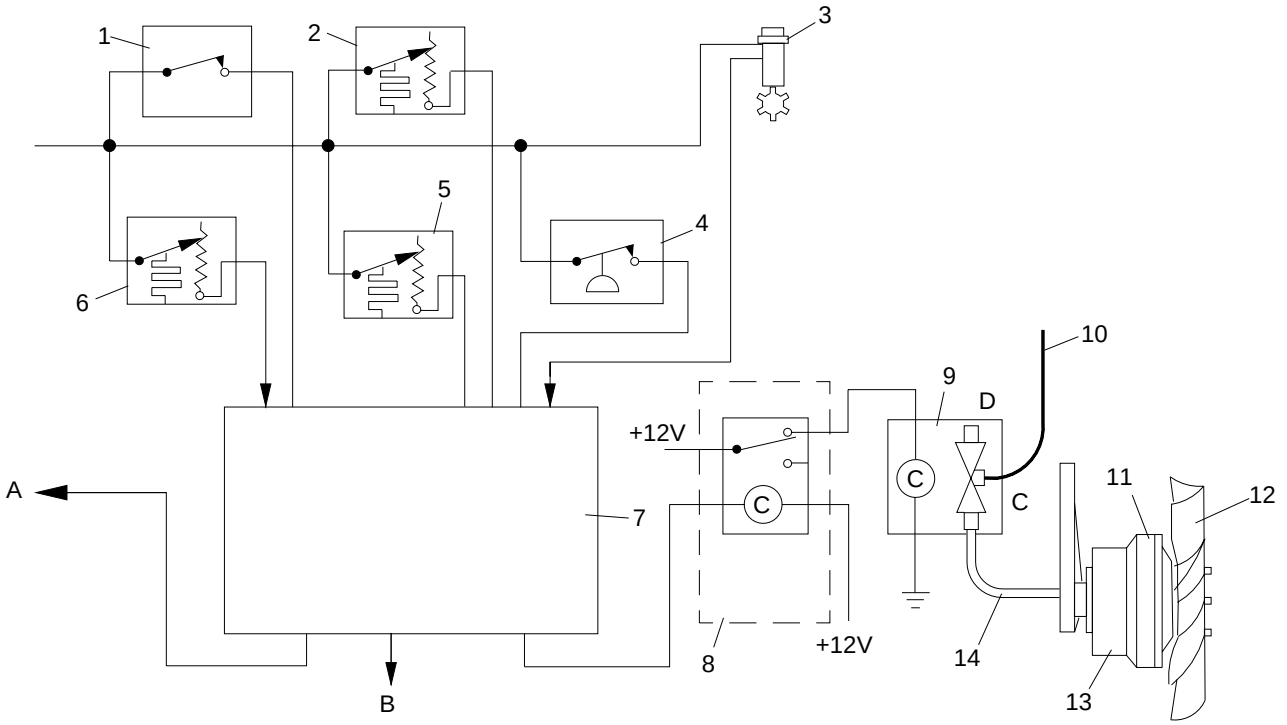
* All kits are available from the PDCs.

Table 1, Horton DriveMaster Repair Kits

Description	Torque	
	lbf·in (N·cm)	**lbf·ft (N·m)**
Friction Lining Screws	80 (900)	—
Face Seal	75 to 100 (850 to 1130)	—
Bearing Nut	—	130 (176)
Jack Bolt	—	100 (136)

Table 2, Torque Values

Specifications



A. To Indicators and Gauges
B. To Electronic Injectors and Other Actuators
C. Normally Closed
D. Normally Open

1. Fan Override Switch
2. Air Temperature Sensor
3. Engine Speed Sensor
4. A/C Pressure Switch
5. Coolant Temperature Sensor
6. Foot Throttle
7. Engine ECM
8. Fan Relay (not present in all systems)
9. Solenoid Valve
10. Air Supply from Reservoir
11. Fan Clutch
12. Air Supply to Fan Clutch

Fig. 1, Fan Clutch Schematic (engine ECM controlled)

General Information

The purpose of the clutch is to connect and disconnect a manually operated transmission and the remainder of the drivetrain system from the engine. This permits starting and stopping the vehicle, shifting and changing speeds that correspond to the engine speed through gear reductions for both forward and reverse directions.

The driven discs are either a 14-inch (356-mm) single plate, see **Fig. 1** and **Fig. 2**, a 14-inch (356-mm) dual plate, see **Fig. 3**, **Fig. 4** and **Fig. 5**, or a 15.5-inch (394-mm) dual plate, see **Fig. 6** and **Fig. 7**. The cover assembly consists of a cover, pressure plate, pressure springs and a release bearing assembly.

The flywheel housing is engine specific; refer to the appropriate engine manufacturer's service manual for procedures.

All model clutches are the pull-type and function by pulling on the release bearing, which is engaged to the release lever.

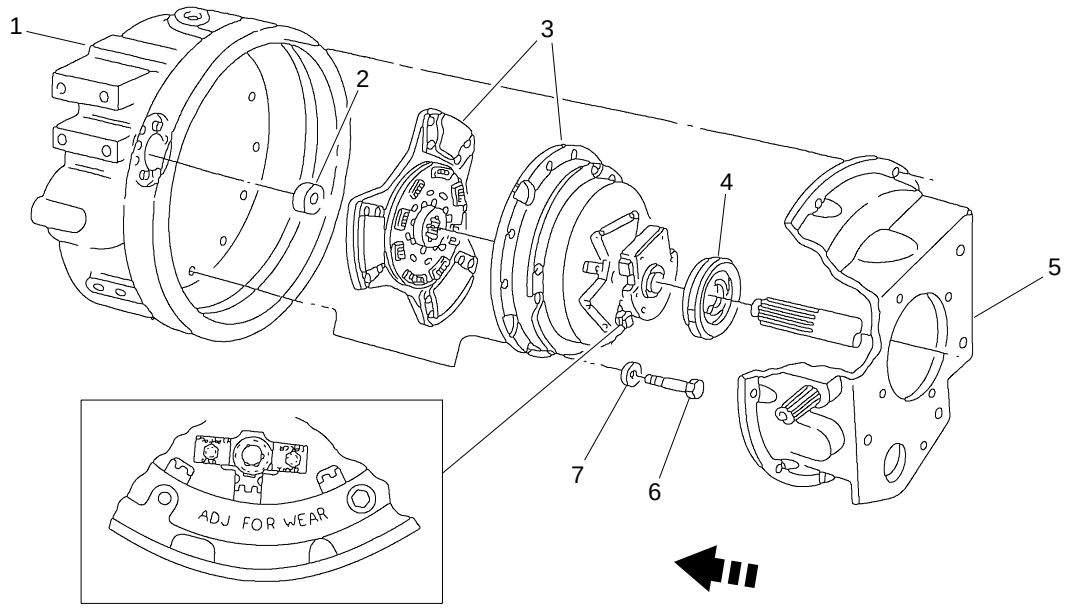
When the clutch is engaged, the pressure springs load the pressure plate, holding the clutch disc clamped firmly between the flywheel and the pressure plate.

When the clutch pedal is pressed, movement is transmitted to the clutch mechanical linkage, which turns the release shaft and actuates the clutch release lever.

As the release shaft turns, the clutch release lever pulls back on the release bearing, levers and pressure springs, permitting the pressure plate to move away from the clutch disc. The clutch disc is disengaged from the flywheel and the transmission can be shifted to another gear.

Another internal part is a pilot ball bearing mounted in the flywheel, which supports the end of the input shaft. The bearings are designed for long life and require no periodic maintenance.

The Spicer clutch discs are available with either organic or primarily ceramic facings, which provide long life. Damper-style hubs and Spicer Solo adjustment-free clutches are also available.



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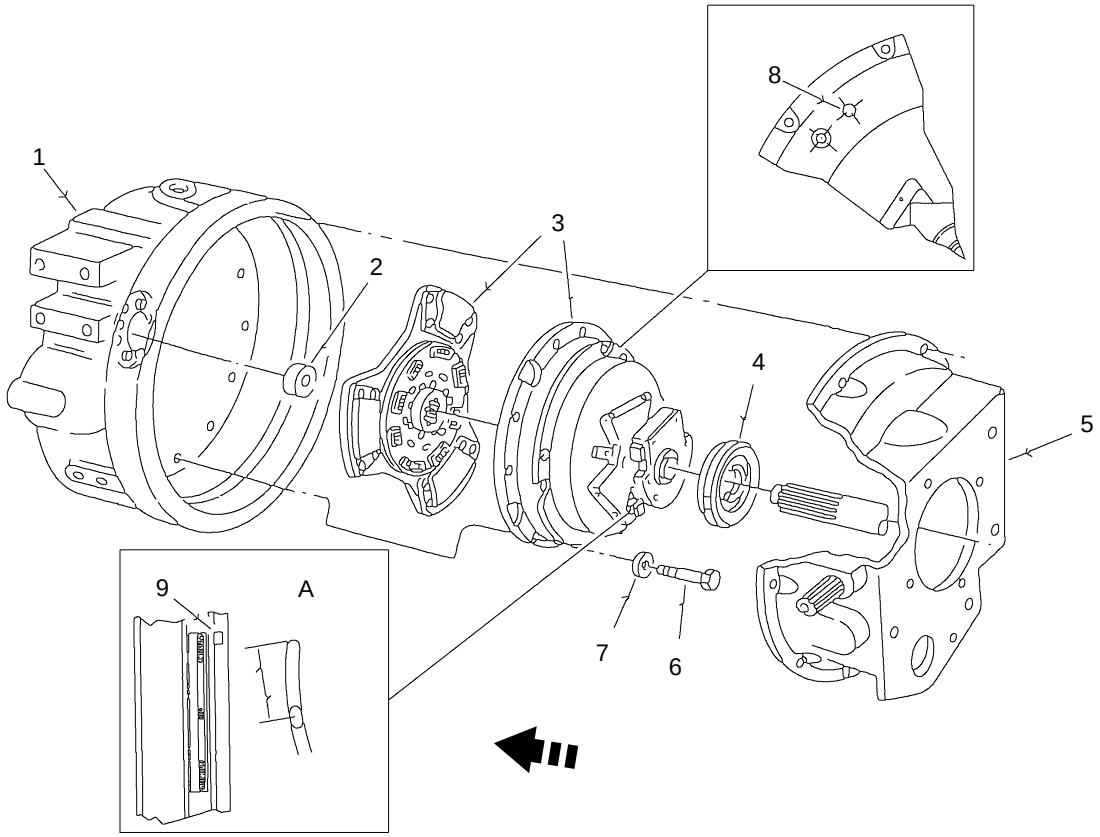
1. Engine/Flywheel Housing Assembly
2. Pilot Bearing
3. Clutch Assembly
4. Torque-Limiting Clutch Brake
5. Transmission Clutch Housing
6. Bolt
7. Washer

Fig. 1, Spicer Stamped Angle-Spring® (SAS) 14-Inch (356-mm) Single-Plate Kwik-Adjust™ Clutch

General Information



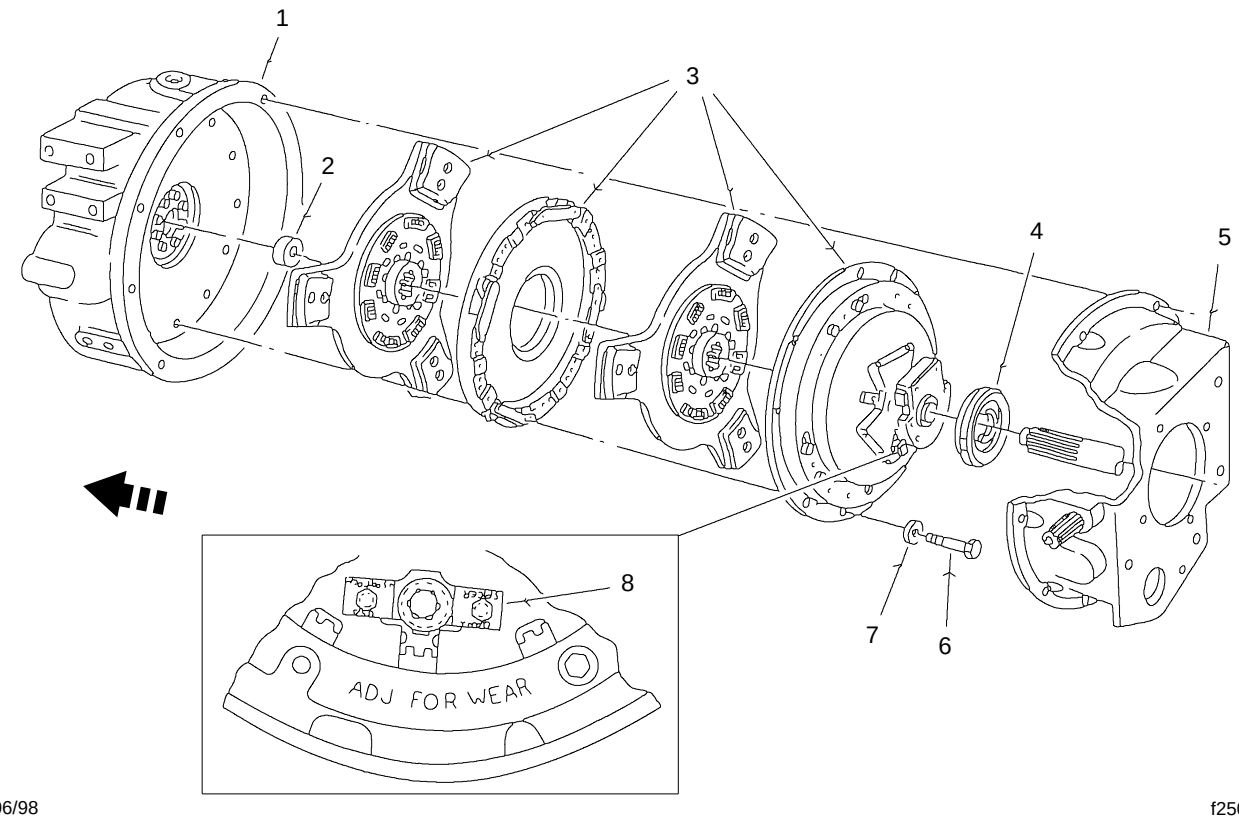
1. Engine/Flywheel Housing Assembly
2. Pilot Bearing
3. Clutch Assembly
4. Torque-Limiting Clutch Brake
5. Transmission Clutch Housing
6. Bolt
7. Washer
8. Shipping Bolt, 3/8-16 x 1.25-inch
9. Clutch Wear Indicator

Fig. 2, Spicer 14-Inch (356-mm) Single-Plate Solo Adjustment Free Clutch

Spicer clutches utilize angle springs and an adjustable pressure plate. This pull-type design uses centrally located pressure springs isolated from the heat of the pressure plate. The 14-inch (356-mm) and 15.5-inch (394-mm) CAS clutches use drive straps to hold the pressure plate in position. The clutch release bearing rotates continuously and only carries a thrust load when the clutch is released. The release bearing can be lubricated through the transmission lower inspection opening in the clutch housing. Anti-friction bushings are used in the release lever system to help provide low release load at the pedal.

The purpose of the clutch brake, see **Fig. 8**, is to slow down or stop the transmission input shaft from rotating on non-synchronized transmissions. This permits a clean engagement of either first or reverse gears when starting the vehicle from a standstill.

Non-synchronized transmissions use a torque limiting clutch brake. The brake is a steel hub with two tangs, encased in a cover that has a facing material bonded to both sides. The torque limiting feature is provided by an internal slip washer, loaded by a wave spring washer that is then driven by the hub. The spring washer reacts against the clutch brake cover on the one side and the internal slip washer on the other, providing a clamping force and creating a breakaway torque within the brake. The hub and spring washer combination slips with respect to the covers after approximately 18 lbf·ft (24 N·m) load has been exceeded. This protects the outer facings.



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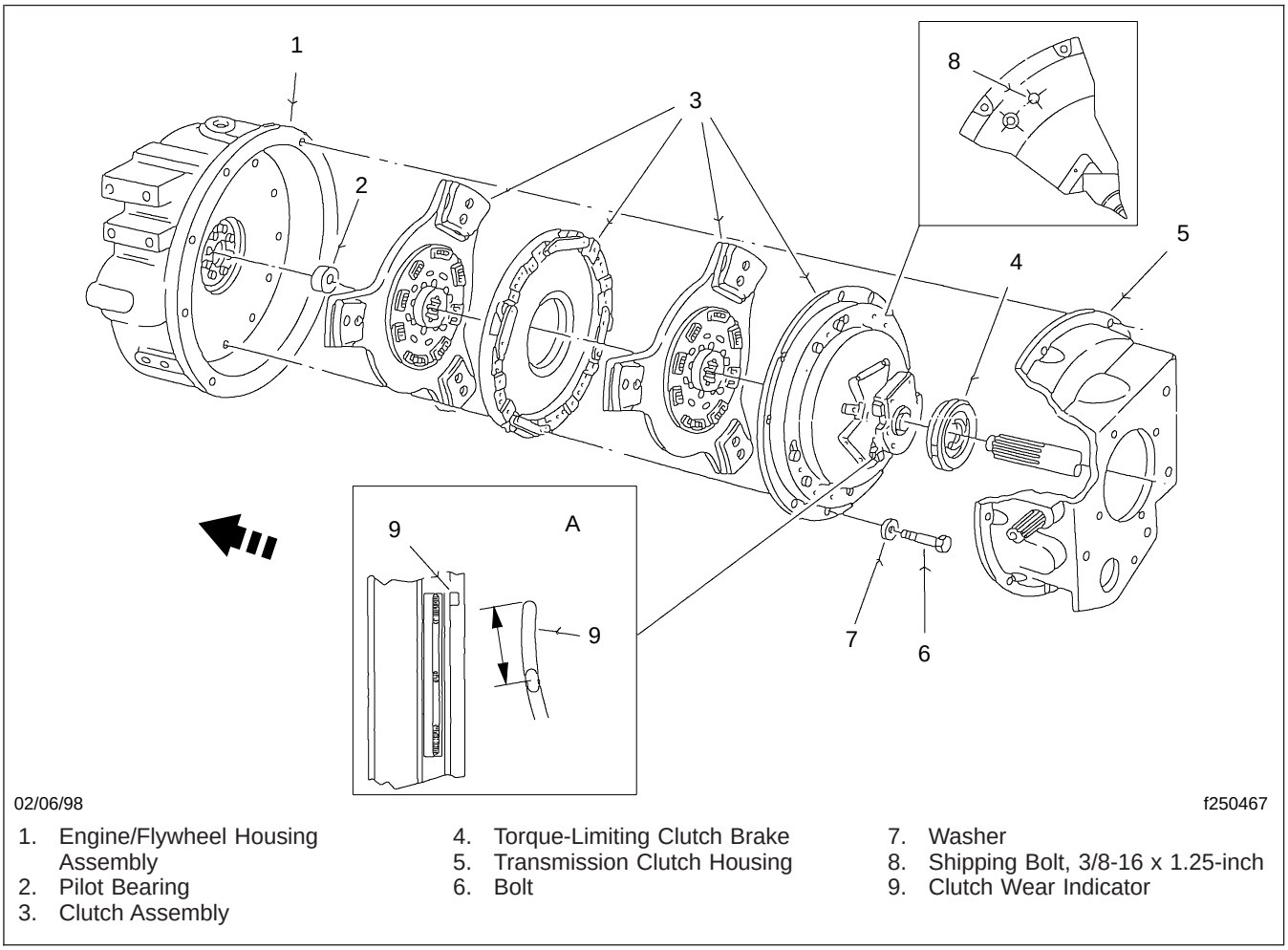
1. Engine/Flywheel Housing Assembly
2. Pilot Bearing
3. Clutch Assembly
4. Torque-Limiting Clutch Brake
5. Transmission Clutch Housing
6. Bolt
7. Washer
8. Kwik-Adjust Bolt

Fig. 3, Spicer Stamped Angle-Spring® (SAS) 14-Inch (356-mm) Dual-Plate Kwik-Adjust™ Clutch

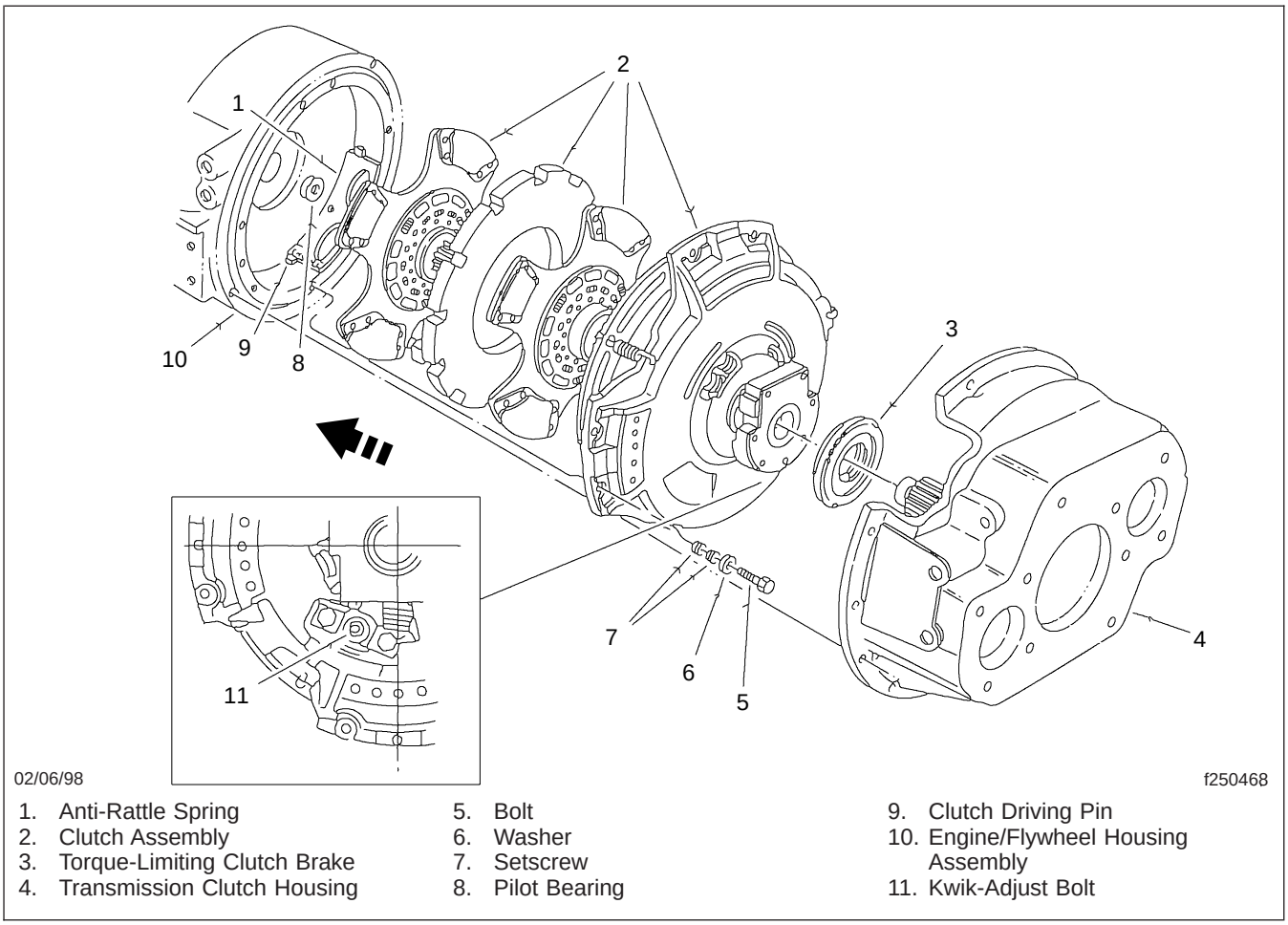
When the operator depresses the clutch pedal beyond the normal clutch disengage position, the clutch release bearing comes in contact with the clutch brake and the transmission input shaft bearing cover. Because the tangs on the brake hub are engaged in the transmission input shaft splines, the transmission is slowed down or stopped. The driver can then shift from first to reverse or from reverse to first without clashing or putting undue strain on the gears.

General Information



1. Engine/Flywheel Housing Assembly
2. Pilot Bearing
3. Clutch Assembly
4. Torque-Limiting Clutch Brake
5. Transmission Clutch Housing
6. Bolt
7. Washer
8. Shipping Bolt, 3/8-16 x 1.25-inch
9. Clutch Wear Indicator

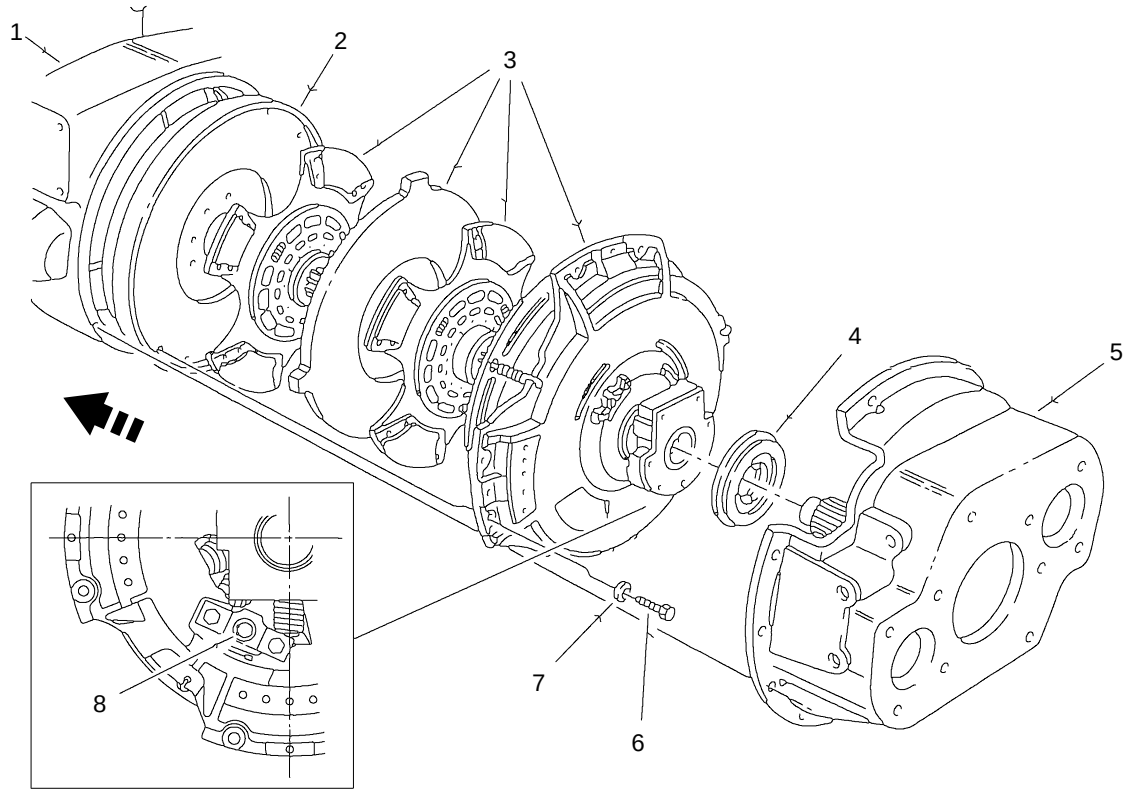
Fig. 4, Spicer 14-Inch (356-mm) Dual-Plate Solo Adjustment Free Clutch



1. Anti-Rattle Spring
2. Clutch Assembly
3. Torque-Limiting Clutch Brake
4. Transmission Clutch Housing
5. Bolt
6. Washer
7. Setscrew
8. Pilot Bearing
9. Clutch Driving Pin
10. Engine/Flywheel Housing Assembly
11. Kwik-Adjust Bolt

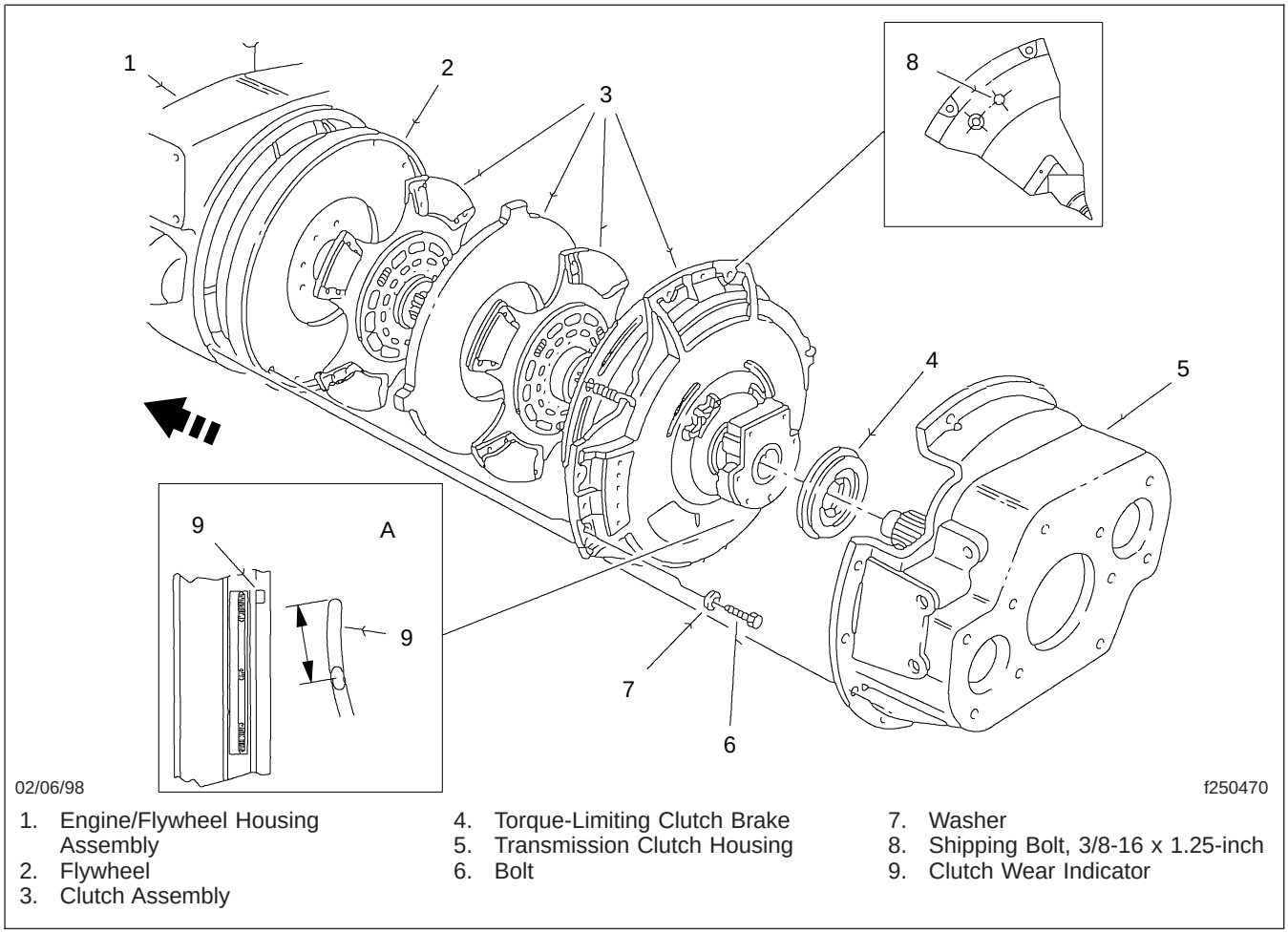
Fig. 5, Spicer Angle-Spring® (AS) 14-Inch (356-mm) Dual-Plate Kwik-Adjust™ Clutch With Easy-Pedal™ Mechanism

General Information



1. Engine/Flywheel Housing Assembly
2. Flywheel
3. Clutch Assembly
4. Torque-Limiting Clutch Brake
5. Transmission Clutch Housing
6. Bolt
7. Washer
8. Kwik-Adjust Bolt

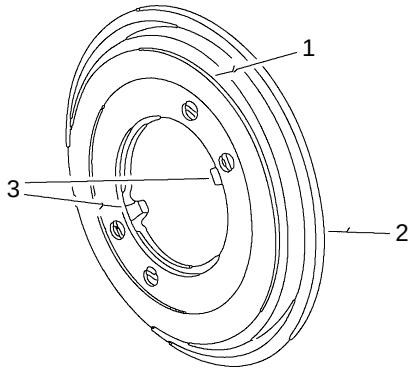
Fig. 6, Spicer Angle-Spring® (AS) 15.5-Inch (394-mm) Dual-Plate Kwik-Adjust™ Clutch With Easy-Pedal™ Mechanism



1. Engine/Flywheel Housing Assembly
2. Flywheel
3. Clutch Assembly
4. Torque-Limiting Clutch Brake
5. Transmission Clutch Housing
6. Bolt
7. Washer
8. Shipping Bolt, 3/8-16 x 1.25-inch
9. Clutch Wear Indicator

Fig. 7, Spicer Angle-Spring® (AS) 15.5-Inch (394-mm) Dual-Plate Solo Adjustment Free Clutch

General Information



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1. Facing Material
2. Metal Casing
3. Tangs

Fig. 8, Clutch Brake

Clutch Assembly Pre-Installation Checks

⚠ WARNING

Do not inhale the dust from brakes, clutches or associated components. Inhalation of dust from these components could be injurious to your health and could cause cancer or asbestosis. Compressed air or brushes must not be used to clean brakes, brake drums, clutches and associated components. A vacuum cleaner such as Rotunda Brake and Clutch Service Vacuum 164-R3600 or equivalent equipped for this purpose must be carefully used to remove any dust. Adherent dust must be removed with a damp rag. Any dust must be contained in a sealed and labeled bag for disposal. Wear an approved high-efficiency cartridge or airline respirator and use extra caution to avoid breathing the dust. Use non-asbestos replacement parts whenever possible.

1. Clean and inspect the flywheel housing face and bore, clutch housing face, transmission input shaft and front face for wear/damage and repair as necessary.

NOTE: If the clutch release lever is worn excessively, replace as required.

2. Inspect the clutch release fingers and locating faces. If necessary, smooth with a carborundum stone.
3. Clean the clutch release fingers and locating faces with a suitable solvent.
4. Apply a light coating of grease to the clutch release lever finger tips and locating faces. Use premium long-life grease.
5. Apply grease to the cross-shaft bushings until clean grease appears from all four bushings. Use premium long-life grease.
6. If the shift/fork assembly has not been dismantled, check that the shafts do not protrude into the fork locating space and make sure the non-operating shaft end is flush with the outside of the clutch housing. Make sure the assembly turns freely.

Spicer Stamped Angle-Spring® (SAS) 14-Inch (356-mm) Single-Plate Kwik-Adjust™ Clutch

REMOVAL

⚠ CAUTION

Make sure the clutch release lever clears the release bearing and is rotated over the wear pads as the clutch housing is moved rearward, or the release bearing and release lever can be damaged.

Do not let the rear of the transmission hang or drop while the input shaft is engaged in the clutch disc splines, or the clutch disc can be damaged.

1. Remove the transmission; refer to **Group 26** in this manual.
2. Install the truck clutch alignment shaft into the release bearing, disc and pilot bearing. See **Fig. 1**.

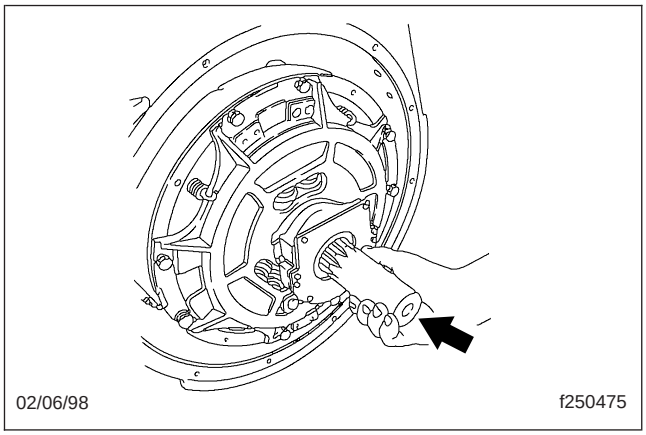


Fig. 1, Truck Clutch Alignment Shaft

⚠ CAUTION

Before the clutch assembly is removed, the spacer blocks must be installed to prevent the release bearing from moving forward and bottoming. If the release bearing is allowed to move too far forward, the internal levers in the clutch cover can partially come out of the groove in the retainer. If the cover is reinstalled, internal binding

Clutch Removal and Installation

of the clutch or loss of levers will occur. Both are detrimental to the clutch assembly.

3. Install two 1/2 x 1-3/4 x 3-inch wooden blocks between the clutch cover and the release bearing assembly to relieve the heavy internal spring load in the clutch assembly. See **Fig. 2**. If there is inadequate clearance to install the spacers, use the release fork tool provided in the Spicer clutch service kit (CSK1) to pull back the release bearing assembly evenly and then install the spacer blocks.

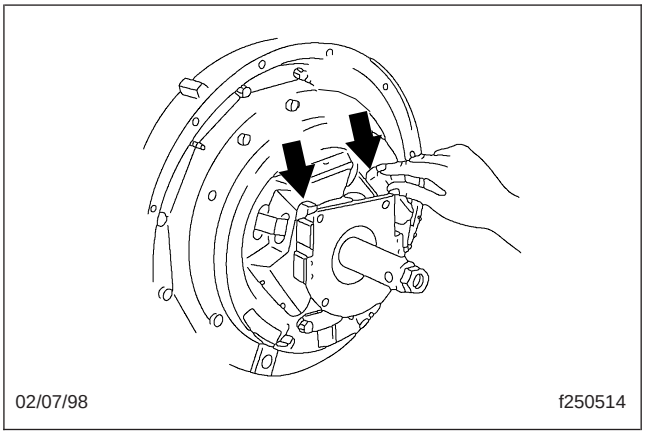
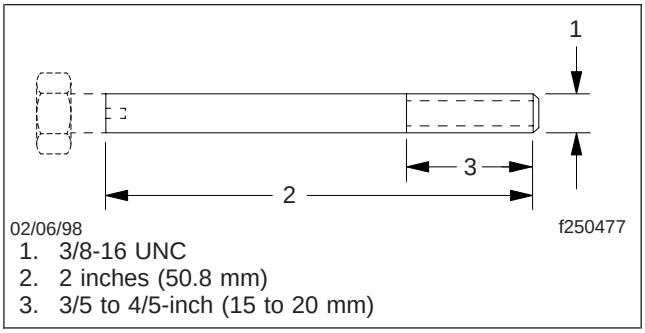


Fig. 2, Wooden Block Location

4. Remove the two top mounting bolts retaining the cover assembly to the flywheel and install two 3/8-16 x 2-inch guide studs made from a standard bolt to help support the weight of the clutch. See **Fig. 3** and **Fig. 4**.



1. 3/8-16 UNC
2. 2 inches (50.8 mm)
3. 3/5 to 4/5-inch (15 to 20 mm)

Fig. 3, Guide Stud Dimensions

NOTE: Loosen the remaining clutch cover bolts in a crisscross pattern to prevent cocking and bending of the clutch mounting bolts.

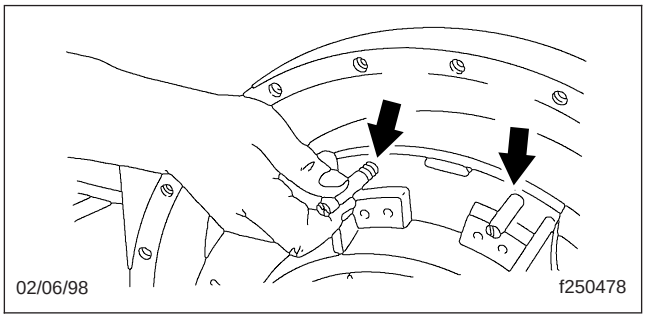


Fig. 4, Guide Stud Location

5. Remove the six remaining mounting bolts. See **Fig. 5**.

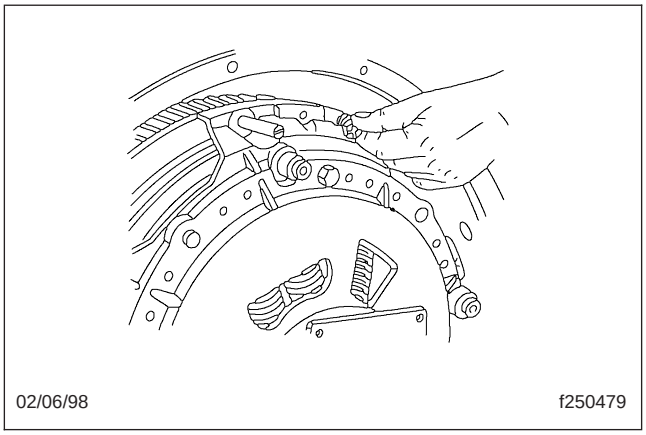


Fig. 5, Clutch Cover Mounting Bolts

6. Remove the alignment tool, the clutch cover assembly and the clutch disc from the flywheel. See **Fig. 6**.
7. Inspect the flywheel housing and flywheel. If the flywheel is heat-checked or warped, refer to the appropriate engine manufacturer's recommendations regarding machining or replacement. See **Fig. 7**.

NOTE: If splines are worn excessively or notched, the clutch disc will not slide on the shaft.

8. Check the condition of the transmission input shaft. See **Fig. 8**.
   - 8.1 Use a crocus cloth or file to dull sharp edges of the splines.
   - 8.2 Replace the input shaft as required.

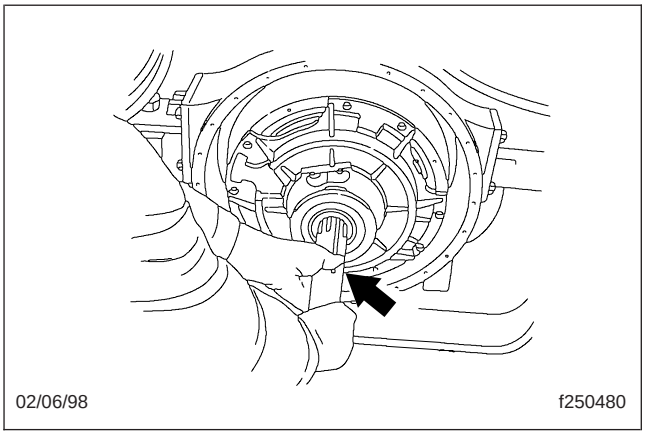


Fig. 6, Alignment Tool, Clutch Cover Assembly and Clutch Disc

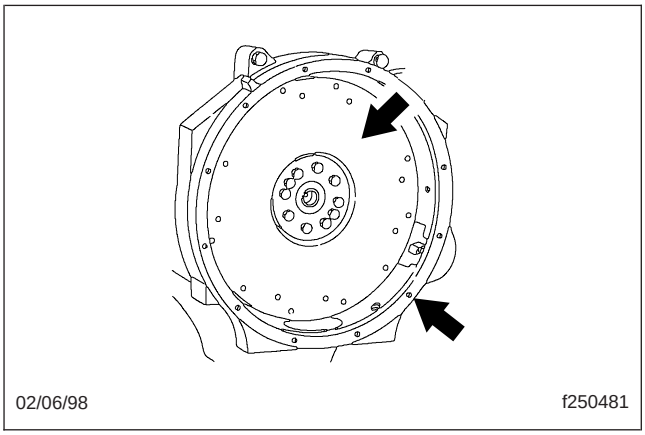


Fig. 7, Flywheel Housing and Flywheel Inspection

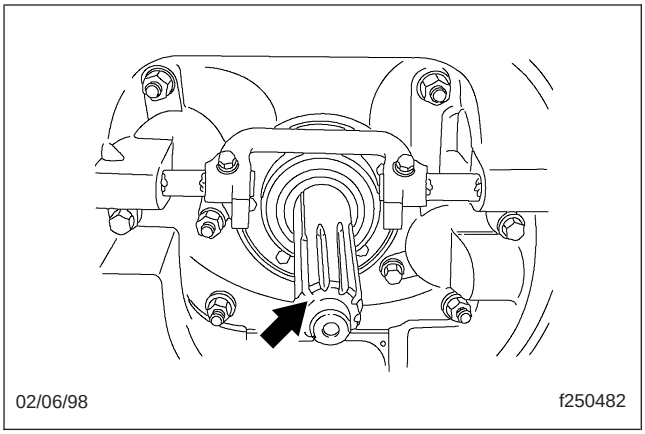


Fig. 8, Transmission Input Shaft Inspection

9. Check for wear on the fingers of the clutch release lever, cross-shaft and cross-shaft bushings. See **Fig. 9**. Replace any of the components if excessive wear is noted.

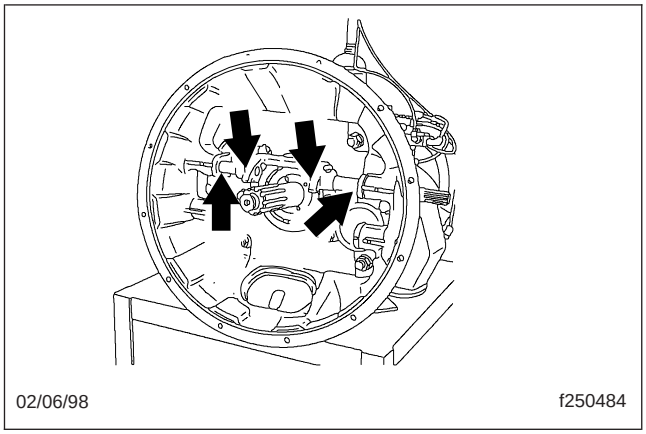


Fig. 9, Clutch Release Lever, Cross-Shaft and Cross-Shaft Bushings Inspection

NOTE: If a new clutch is to be installed, a new pilot bearing must also be used.

10. Inspect the pilot bearing. See **Fig. 10**. If required, remove the pilot bearing in the rear of the flywheel; refer to the appropriate engine manufacturer's service manual.

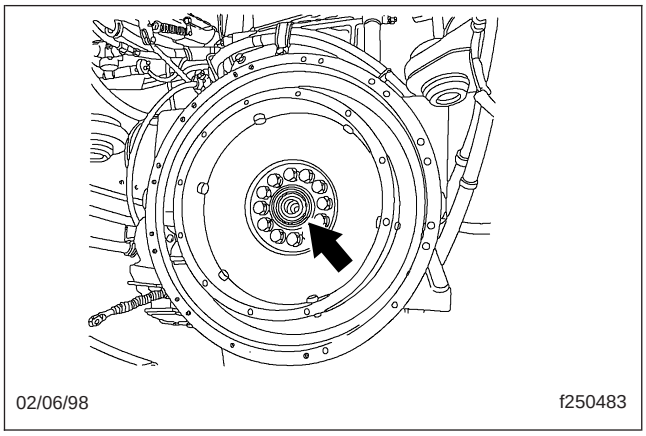


Fig. 10, Pilot Bearing Inspection

INSTALLATION

1. Install the two guide studs at the 11 o'clock and 1 o'clock positions on the flywheel. See **Fig. 4**.

Clutch Removal and Installation

IMPORTANT: The clutch will not function correctly if the disc is installed backwards. Make sure the side marked "Pressure Plate Side" faces the pressure plate.

NOTE: If a new clutch is to be installed, a new pilot bearing must also be installed.

2. Insert the truck clutch alignment shaft through the splines and into the pilot bearing. See **Fig. 11**.

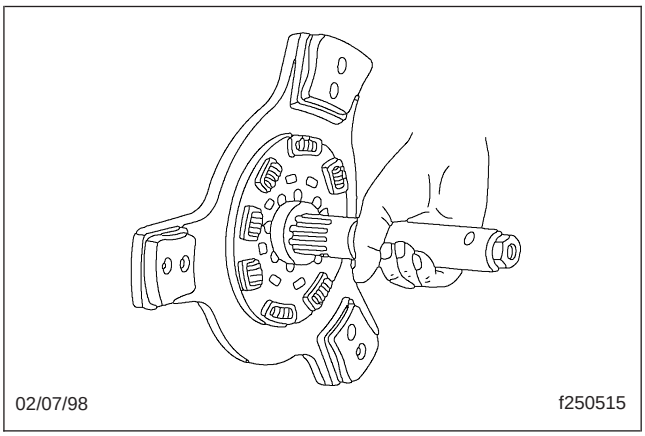


Fig. 11, Truck Clutch Alignment Shaft Installation

3. With the alignment tool still in place, carefully slide the clutch cover assembly over the alignment tool and onto the guide studs. See **Fig. 12**. Align the adjustment bolt with the opening in the clutch housing.

4. Install and hand-tighten the clutch cover mounting bolts. See **Fig. 5**.

IMPORTANT: Use approved mounting bolts only.

5. Replace the guide studs with the two mounting bolts.

6. Tighten the clutch cover mounting bolts 35 to 45 lbf·ft (48 to 61 N·m) in the sequence shown. See **Fig. 13**.

7. Remove the wood blocks from between the release bearing housing and the clutch cover assembly. See **Fig. 2**.

8. Remove the truck clutch alignment shaft. Reinsert the tool completely. Slowly move the tool in and out to check for binding. If binding exists, reinstall the clutch assembly.

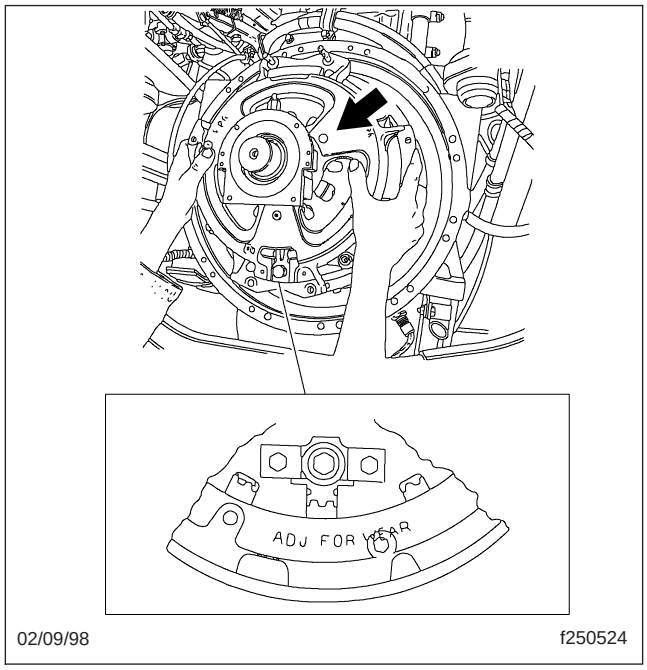


Fig. 12, Clutch Cover Assembly Installation

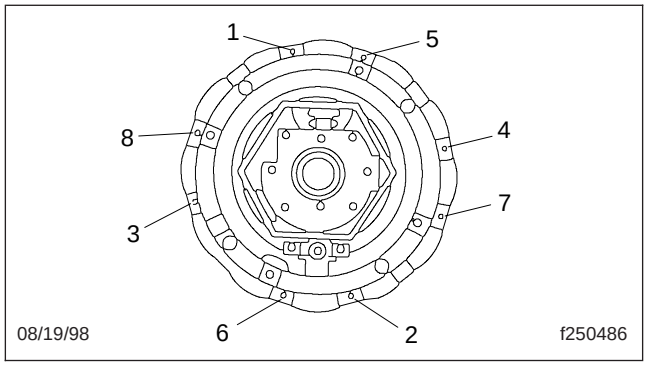


Fig. 13, Clutch Cover Tightening Sequence

9. Shift the transmission into gear.

10. Position the clutch release bearing housing so that the flat section is on top. See **Fig. 14**.

NOTE: Clutch release bearings must be lubricated after adjustment and at regular maintenance intervals.

NOTE: Clutches with a permanently sealed release bearing require no lubrication.

11. Apply a small daub of grease to each of the clutch release lever fingers and the release bear-

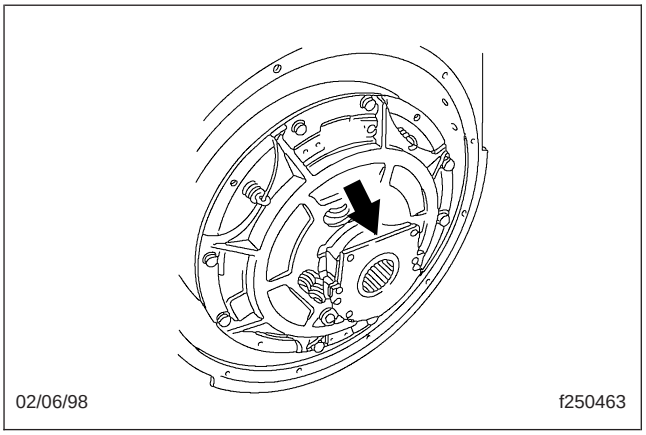


Fig. 14, Clutch Release Bearing Positioning

ing wear pads (both sides). See **Fig. 15**. Use premium long-life grease.

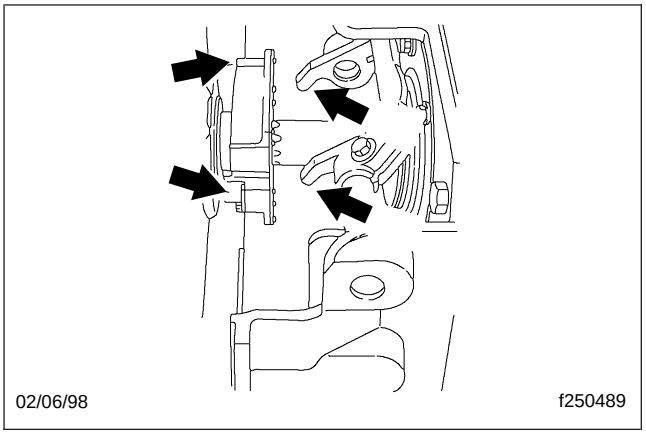
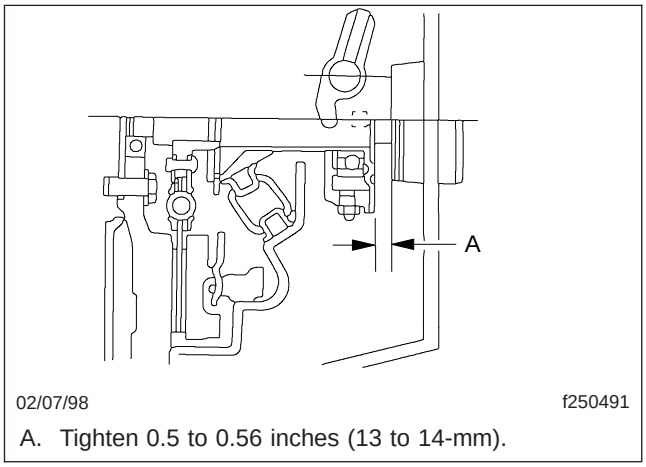


Fig. 15, Grease Application Locations

12. Install the transmission; refer to **Group 26** in this manual.
13. Release the clutch by holding down the clutch pedal.

NOTE: Apply an inward pressure on the pressure plate adjustment bolt. A clockwise adjustment will move the release bearing toward the transmission. A counterclockwise adjustment will move the release bearing toward the flywheel.

14. Using the pressure plate adjustment bolt, adjust the clutch release bearing travel dimension from 0.5 to 0.56 inches (13 to 14 mm). Measure between the rear face of the release bearing and the front face of the transmission bearing retainer or clutch brake. See **Fig. 16**.



A. Tighten 0.5 to 0.56 inches (13 to 14-mm).

Fig. 16, Clutch Release Bearing Travel

15. After the final adjustment is made, align the adjustment bolt to the nearest square edge and allow the adjustment bolt to disengage by moving outward. Recheck the clutch release bearing travel.
16. Check clutch pedal free play. If it is not within 1-1/2 to 2 inches (38.1 to 50.8 mm), then a linkage adjustment must be made.
17. Install the clutch housing inspection cover.

Spicer 14-Inch (356-mm) Single-Plate Solo Adjustment Free Clutch

REMOVAL

CAUTION

Make sure the clutch release lever clears the release bearing and is rotated over the wear pads as the clutch housing is moved rearward, or the release bearing and release lever can be damaged.

Do not let the rear of the transmission hang or drop while the input shaft is engaged in the clutch disc splines, or the clutch disc can be damaged.

Clutch Removal and Installation

1. Remove the transmission; refer to **Group 26** in this manual.
2. Install the truck clutch alignment shaft into the release bearing, disc and pilot bearing. See **Fig. 1**.

CAUTION

Before the clutch assembly is removed on the Spicer Solo adjustment-free clutch, four shipping bolts must be installed in the clutch cover to prevent the pressure plate from moving forward.

3. Install the four shipping bolts. See **Fig. 17**.

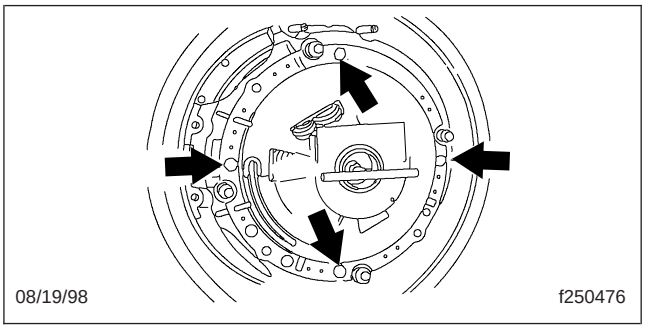


Fig. 17, Solo Adjustment-Free Clutch Shipping Bolts

CAUTION

Before the clutch assembly is removed, the spacer blocks must be installed to prevent the release bearing from moving forward and bottoming. If the release bearing is allowed to move too far forward, the internal levers in the clutch cover can partially come out of the groove in the retainer. If the cover is reinstalled, internal binding of the clutch or loss of levers will occur. Both are detrimental to the clutch assembly.

4. Install two 1/2 x 1-3/4 x 3-inch wooden blocks between the clutch cover and the release bearing assembly to relieve the heavy internal spring load in the clutch assembly. See **Fig. 2**. If there is inadequate clearance to install the spacers, use the release fork tool provided in the Spicer clutch service kit (CSK1) to pull back the release bearing assembly evenly and then install the spacer blocks.
5. Remove two top mounting bolts retaining the cover assembly to the flywheel and install two 3/8-16 x 2-inch guide studs made from a standard bolt to help support the weight of the clutch. See **Fig. 3** and **Fig. 4**.

NOTE: Loosen the remaining clutch cover bolts in a crisscross pattern to prevent cocking and bending of the clutch mounting bolts.

6. Remove the six remaining mounting bolts. See **Fig. 5**.
7. Remove the alignment tool, the clutch cover assembly and the clutch disc from the flywheel. See **Fig. 6**.
8. Inspect the flywheel housing and flywheel. See **Fig. 7**. If the flywheel is heat-checked or warped, refer to the appropriate engine manufacturer's recommendations regarding machining or replacement.

NOTE: If splines are worn excessively or notched, the clutch disc will not slide on the shaft.

9. Check the condition of the transmission input shaft. See **Fig. 8**.
   - 9.1 Use a crocus cloth or file to dull sharp edges of the splines.
   - 9.2 Replace the input shaft as required.
10. Check for wear on the fingers of the clutch release lever, cross-shaft and cross-shaft bushings. See **Fig. 9**. Replace any of the components if excessive wear is noted.

NOTE: If a new clutch is to be installed, a new pilot bearing must also be used.

11. Inspect the pilot bearing. See **Fig. 10**. If required, remove the pilot bearing in the rear of the flywheel; refer to the appropriate engine manufacturer's service manual.

INSTALLATION

1. Install the two guide studs at the 11 o'clock and 1 o'clock positions on the flywheel. See **Fig. 4**.

IMPORTANT: The clutch will not function correctly if the disc is installed backwards. Make sure the side marked "Pressure Plate Side" faces the pressure plate.

NOTE: If a new clutch is to be installed, a new pilot bearing must also be installed.

2. Insert the truck clutch alignment shaft through the splines and into the pilot bearing. See **Fig. 11**.
3. Install and hand-tighten the clutch cover mounting bolts. See **Fig. 5**.

IMPORTANT: Use approved mounting bolts only.

4. Replace the guide studs with the two mounting bolts.
5. Tighten the clutch cover mounting bolts 35 to 45 lbf·ft (48 to 61 N·m) in the sequence shown. See **Fig. 13**.

NOTE: Leave the truck clutch alignment shaft in place until the shipping bolts are removed.

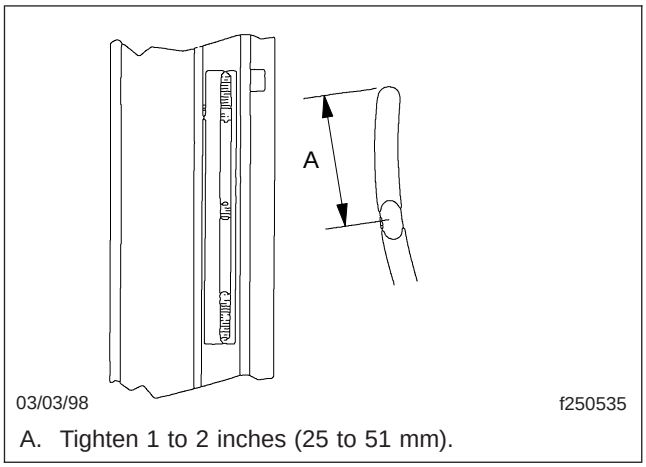
NOTE: Save the four shipping bolts installed during removal.

6. Remove the four shipping bolts from the clutch cover. See **Fig. 17**.
7. Check to make sure there is no visible gap between the spacer sleeve and the bolt head.
8. Remove the wood blocks from between the release bearing housing and the clutch cover assembly. See **Fig. 2**.
9. Remove the truck clutch alignment shaft. Reinsert the tool completely. Slowly move the tool in and out to check for binding. If binding exists, reinstall the clutch assembly.
10. Rotate the clutch release bearing housing so that the flat section is on top. See **Fig. 14**.

NOTE: Clutch release bearings must be lubricated after adjustment and at regular maintenance intervals.

NOTE: Clutches with a permanently sealed release bearing require no lubrication.

11. Apply a small daub of grease to each of the clutch release lever fingers and the release bearing wear pads (both sides). See **Fig. 15**. Use premium long-life grease.
12. Install the transmission; refer to **Group 26** in this manual.
13. Actuate the clutch assembly by depressing the clutch pedal five times, releasing the clutch.
14. Check release bearing travel. See **Fig. 16**. Release travel should be within specification.
15. Check clutch pedal free play. If it is not within 1-1/2 to 2 inches (38.1 to 50.8 mm), then a linkage adjustment must be made.
16. After actuating the clutch, the wear indicator will be between 1 to 2 inches (25 to 51 mm) from its initial start position. See **Fig. 18**.



A. Tighten 1 to 2 inches (25 to 51 mm).

Fig. 18, Wear Indicator Specification

17. Install the clutch housing inspection cover.

Spicer 14-Inch (356-mm) Dual-Plate and Spicer Angle-Spring® (AS) 15-1/2-Inch (394-mm) Dual-Plate Solo Adjustment Free Clutches

REMOVAL

CAUTION

Do not let the rear of the transmission hang or drop while the input shaft is engaged in the clutch disc splines. The clutch discs can be damaged.

Make sure the clutch release lever clears the release bearing and is rotated over the wear pads as the clutch housing is moved rearward, or the release bearing and release lever can be damaged.

Clutch Removal and Installation

1. Remove the transmission; refer to **Group 26** in this manual.
2. Install the truck clutch alignment shaft into the release bearing, discs and pilot bearing. See **Fig. 1**.

CAUTION

Before removing the clutch cover assembly on a Spicer Solo adjustment-free clutch, four shipping bolts must be installed in the clutch cover to prevent the pressure plate from moving forward.

3. Install the four shipping bolts. See **Fig. 17**.

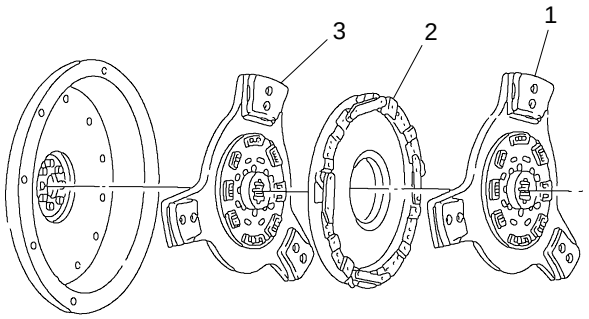
CAUTION

Whenever the clutch is removed, spacer blocks must be installed to prevent the release bearing from moving forward and bottoming. If the release bearing is allowed to move too far forward, the internal levers in the clutch cover can partially come out of the groove in the retainer. If the cover is reinstalled, internal binding of the clutch or loss of levers can occur. Both are detrimental to the clutch assembly.

4. Install two 1/2 x 1/2 x 3-inch wooden blocks between the clutch cover and the release bearing assembly to relieve the heavy internal spring load in the clutch assembly. See **Fig. 2**. If there is inadequate clearance to install the spacers, use the release fork tool provided in the Spicer clutch service kit (CSK1) to evenly pull back the release bearing assembly and then install the spacer blocks.
5. For vehicles with a 14-inch (356-mm) clutch, remove the two top mounting bolts retaining the cover assembly to the flywheel and install the two 3/8-16 x 2-inch guide studs made from a standard bolt to help support the weight of the clutch. See **Fig. 4**.
6. For vehicles with a 15-1/2-inch (394-mm) clutch, remove the top two mounting bolts retaining the cover assembly to the flywheel and install two guide studs (7/16-14 x 5-inch) to help support the weight of the clutch. See **Fig. 4**.

NOTE: Loosen the remaining clutch cover bolts in a crisscross pattern to prevent cocking and bending of the clutch mounting bolts.

7. Remove all of the mounting bolts. See **Fig. 5**.
8. Remove the clutch cover and the alignment tool. See **Fig. 6**.
9. Remove the clutch assembly. See **Fig. 19** and **Fig. 20**.



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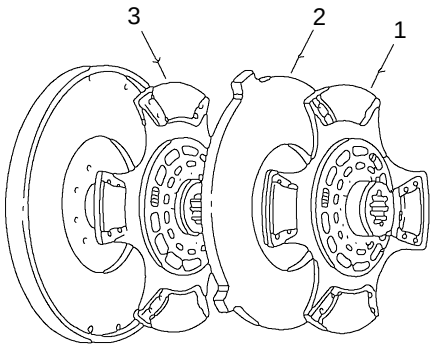
1. Clutch Rear Driven Disc
2. Intermediate Drive Plate
3. Front Driven Disc

Fig. 19, 14-Inch (356-mm) Clutch



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1. Clutch Rear Driven Disc
2. Intermediate Drive Plate
3. Front Driven Disc

Fig. 20, 15-Inch (381-mm) Clutch

10. Inspect the flywheel housing and flywheel. See **Fig. 7**. If the flywheel is heat-checked or warped, refer to the appropriate engine manufacturer's recommendations regarding machining or replacement.

11. Inspect the pilot bearing. See **Fig. 10**. If required, remove the pilot bearing in the rear of the flywheel; refer to the appropriate engine manufacturer's service manual.

NOTE: If the splines are worn excessively or notched, the clutch discs will not slide on the shaft.

12. Check the condition of the transmission input shaft. See **Fig. 8**.
    - 12.1 Use a crocus cloth or file to dull the sharp edges of the splines.
    - 12.2 Replace the input shaft as required.
13. Check for wear on the fingers of the clutch release lever, cross-shaft and cross-shaft bushings. See **Fig. 9**. Replace as required.

INSTALLATION

IMPORTANT: If a new clutch is to be installed, a new pilot bearing must also be installed.

1. If removed, install the pilot bearing; refer to the appropriate engine manufacturer's service manual.
2. Install the two guide studs at the 11 o'clock and 1 o'clock positions on the flywheel. See **Fig. 4**.

IMPORTANT: The clutch will not function correctly if the disc is installed backwards. Make sure the side marked "Flywheel Side" faces the flywheel and the side marked "Pressure Plate Side" faces the pressure plate. The drive straps must face the pressure plate.

3. Using the truck clutch alignment shaft, assemble the clutch assembly. See **Fig. 19** and **Fig. 20**.
4. Install and hand-tighten the clutch cover mounting bolts.

IMPORTANT: Use only approved mounting bolts.

5. Replace the guide studs with the two mounting bolts. See **Fig. 5**.
6. Tighten the clutch cover mounting bolts 35 to 45 lbf·ft (48 to 61 N·m) for 14-inch (356-mm) clutches or 50 to 70 lbf·ft (68 to 95 N·m) for 15-inch (381-mm) clutches in the sequence shown. See **Fig. 21**.

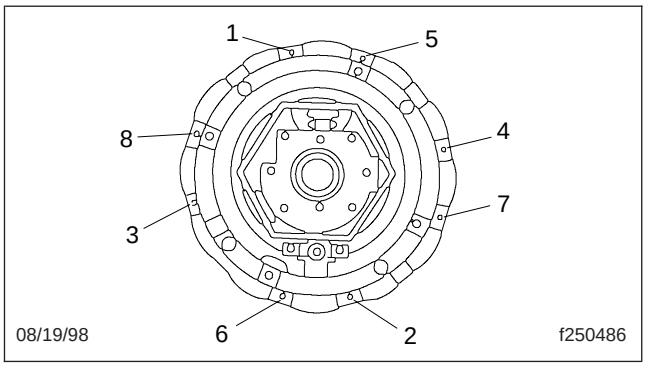


Fig. 21, Clutch Cover Tightening Sequence

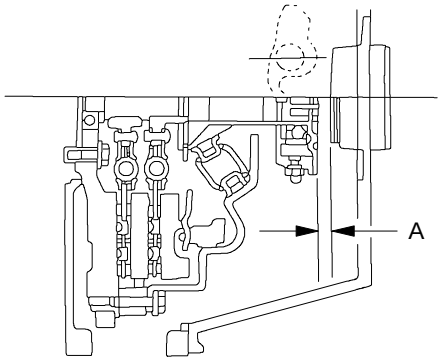
NOTE: Save the shipping bolts installed during removal.

7. Remove the four shipping bolts from the clutch cover. See **Fig. 17**.
8. Check to make sure there is no visible gap between the spacer sleeve and the bolt head.
9. Remove the wood blocks from between the release bearing housing and the clutch cover assembly. See **Fig. 2**.
10. Remove the truck clutch alignment shaft. Reinsert the tool completely. Slowly move the tool in and out to check for binding. If binding exists, reinstall the clutch assembly.
11. Rotate the clutch release bearing housing so that the flat section is on top. See **Fig. 14**. If the cross-shaft is below center, rotate the bearing housing 180 degrees.

NOTE: Clutch release bearing must be lubricated after adjustment and at regular maintenance intervals.

12. Apply a small amount of grease to each of the clutch release lever fingers and the release bearing wear pads (both sides). See **Fig. 15**. Use premium long-life grease.
13. Install the transmission; refer to **Group 26** in this manual.
14. Actuate the clutch assembly by depressing the clutch pedal five times, releasing the clutch.
15. Check release bearing travel. See **Fig. 22**. Release travel should be within specification.

Clutch Removal and Installation



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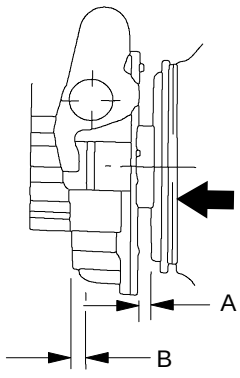
A. Tighten 0.50 to 0.56 inches (12.7 to 14.2 mm).

Fig. 22, Clutch Release Bearing Travel

16. Check clutch pedal free play. If it is not within 1-1/2 to 2 inches (38.1 to 50.8 mm), then a linkage adjustment must be made.
17. After actuating the clutch, the wear indicator will be between 1 to 2 inches (25 to 51 mm) from its initial start position. See **Fig. 18**.
18. Check release bearing travel, clutch brake squeeze (non-synchronized transmission) and proper clutch pedal free play adjustment. See **Fig. 23**.

    Adjust as required.



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A. Clutch Brake Squeeze 0.126 inches (3.2 mm)
B. Release Bearing Travel 0.50 to 0.56 inches (12.7 to 14.2 mm)

Fig. 23, Clutch Brake Squeeze and Release Bearing Travel

19. Install the clutch housing inspection cover.

Spicer Stamped Angle-Spring® (SAS) 14-Inch (356-mm) Dual-Plate Kwik-Adjust™ Clutch

REMOVAL

⚠ CAUTION

Do not let the rear of the transmission hang or drop while the input shaft is engaged in the clutch disc splines, or the clutch discs can be damaged.

Make sure the clutch release lever clears the release bearing and is rotated over the wear pads as the clutch housing is moved rearward, or the release bearing and release lever can be damaged.

1. Remove the transmission; refer to **Group 26** in this manual.
2. Install the truck clutch alignment shaft into the release bearing, discs and pilot bearing. See **Fig. 1**.

⚠ CAUTION

Whenever the clutch is removed, spacer blocks must be installed to prevent the release bearing from moving forward and bottoming. If the release bearing is allowed to move too far forward, the internal levers in the clutch cover can partially come out of the groove in the retainer. If the cover is reinstalled, internal binding of the clutch or loss of levers can occur. Both are detrimental to the clutch.

NOTE: If there is inadequate clearance to install the spacers, use the release fork tool provided in the Spicer clutch service kit (CSK1) to pull back the release bearing assembly evenly and then install the wood blocks.

3. Install two wood blocks (5/8-inch x 3-inch) between the clutch cover and the release bearing assembly to relieve the heavy internal spring load in the clutch assembly. See **Fig. 2**.
4. Loosen the clutch cover bolts in a crisscross pattern to prevent cocking and bending of the clutch mounting bolts. See **Fig. 24**.

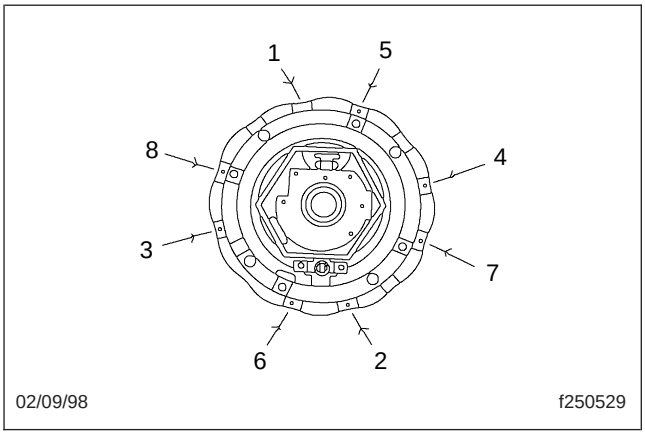


Fig. 24, Clutch Cover Bolt Removal Sequence

5. Remove the top two mounting bolts retaining the cover assembly to the flywheel and install two guide studs to help support the weight of the clutch. See **Fig. 3** and **Fig. 4**.
6. Remove the remaining mounting bolts and remove the clutch cover. See **Fig. 25**.

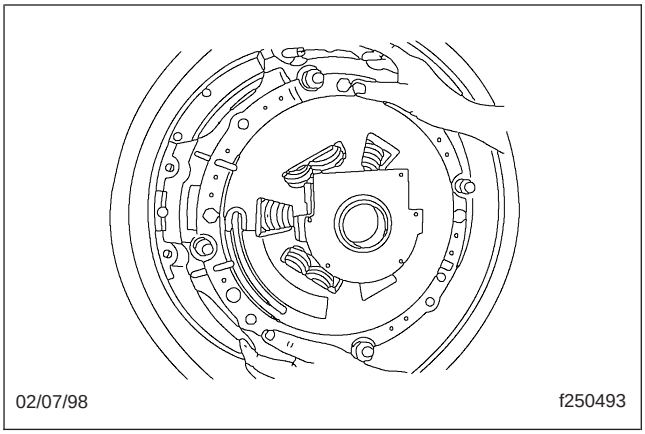


Fig. 25, Clutch Cover Removal

7. Remove the clutch assembly. See **Fig. 19**.

IMPORTANT: If a new clutch is to be installed, a new pilot bearing must also be installed.

8. Inspect and replace the pilot bearing as required. Refer to the appropriate engine manufacturer's service manual. See **Fig. 10**.

NOTE: If the splines are worn excessively or notched, the clutch discs will not slide on the shaft.

9. Check the condition of the transmission input shaft. See **Fig. 8**.
   - 9.1 Use a crocus cloth or file to dull the sharp edges of the splines.
   - 9.2 Replace the input shaft as required.
10. Check for wear on fingers of the clutch release lever, cross-shaft and cross-shaft bushings. Replace as required. See **Fig. 9**.
11. Inspect the flywheel housing and flywheel. If the flywheel is heat-checked or warped, refer to the appropriate engine manufacturer's recommendations regarding machining or replacement. See **Fig. 7**.
12. For vehicles with the 14-2 flywheel, refer to the following steps for drive pin replacement. The 14-2 flywheel contains drive pins. The flywheel must first be removed from the engine to service the intermediate plate drive pins. Remove the two set screws from each of the drive pin set screw holes. See **Fig. 26**.

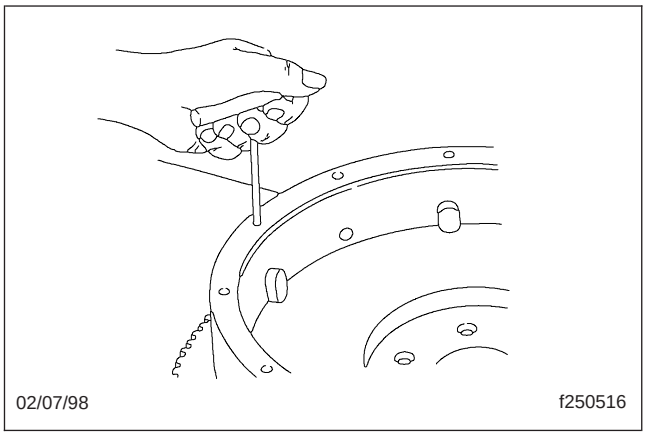


Fig. 26, Removing Drive Pin Set Screws

13. Remove the drive pins. See **Fig. 27**.

⚠ WARNING

To avoid serious injury to the eyes and face, always use a brass hammer and a drive pin alignment tool (if available) to install the drive pins. Safety glasses must be worn at all times.

14. Install six new drive pins in the flywheel, equally spaced. See **Fig. 28**.

Clutch Removal and Installation

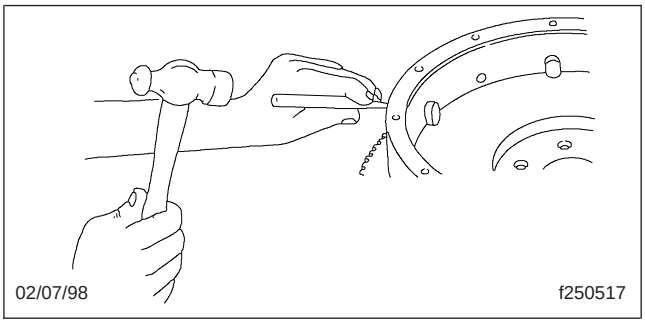


Fig. 27, Removing Drive Pins

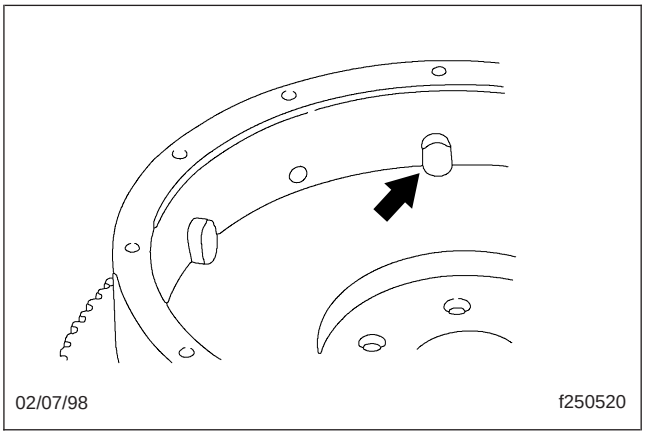
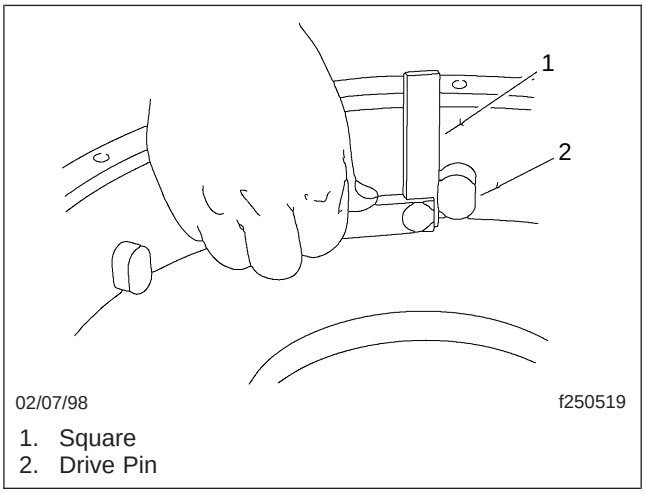


Fig. 28, Installing Drive Pins

15. Make sure the shanks of the drive pins are a press-fit in the flywheel rim, and that the heads are square with the friction face. See **Fig. 29**.



1. Square
2. Drive Pin

Fig. 29, Checking Drive Pin Installation

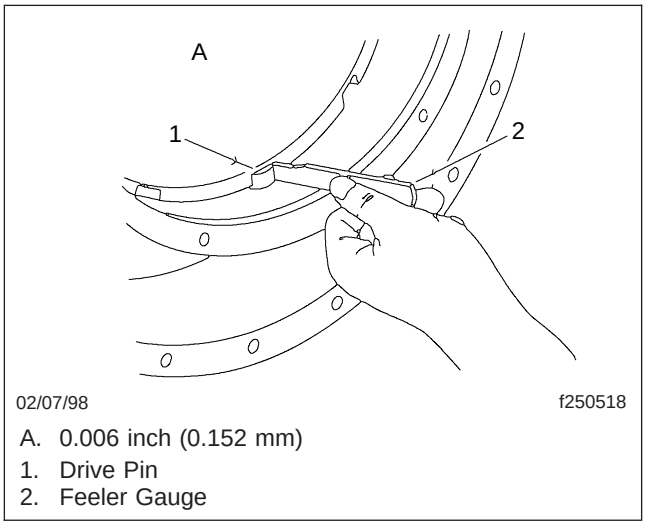
16. Position the intermediate drive plate over the drive pins.

CAUTION

Do not file or grind the drive pins to provide adequate clearance as this can cause uneven loading on the drive pins, which will result in clutch sticking, and possibly broken drive pins.

NOTE: The minimum clearance between the drive pins and the drive slots should be within specification.

17. Apply pressure to the intermediate drive plate in one direction and measure the clearance between the drive pins and the drive slots in the plate. See **Fig. 30**.



A. 0.006 inch (0.152 mm)
1. Drive Pin
2. Feeler Gauge

Fig. 30, Measuring Drive Pin Clearance

18. If the alignment and the clearance are correct, remove the intermediate plate and install new set screws. The set screws are 3/8-inch by 3/8-inch, and two must be used to lock each drive pin. See **Fig. 26**.

19. Install the flywheel to the crankshaft. Refer to the appropriate engine manufacturer's service manual. See **Fig. 31**.

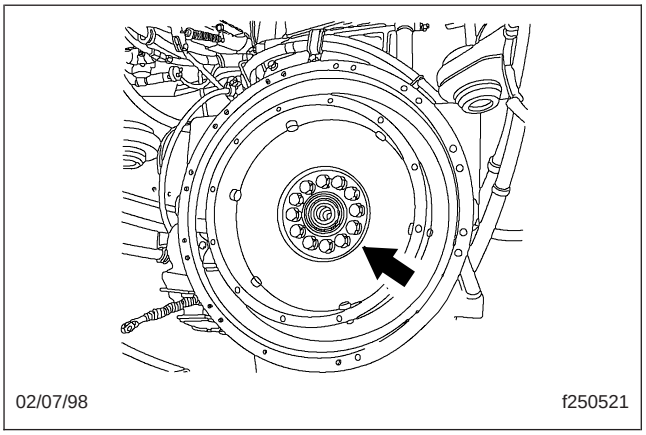


Fig. 31, Flywheel Installation

INSTALLATION

IMPORTANT: The clutch will not function correctly if the disc is installed backwards. Make sure the side marked "Flywheel Side" faces the flywheel.

1. Install the front disc in the flywheel housing. See **Fig. 32**.

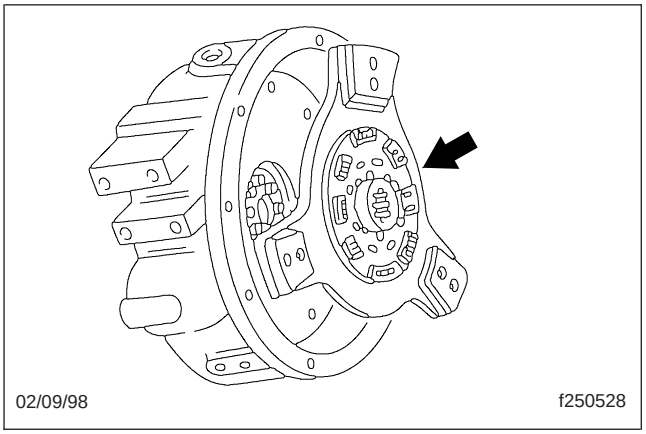


Fig. 32, Installing Front Clutch Disc

2. Install the intermediate plate into the flywheel housing, positioning the drive slots over the drive pins. See **Fig. 31** and **Fig. 33**.

NOTE: On the 14-2 super duty clutch, make sure to use three anti-rattle springs equally spaced between the drive pins.

3. Install the three anti-rattle springs with rounded sections toward the flywheel face. See **Fig. 34**.

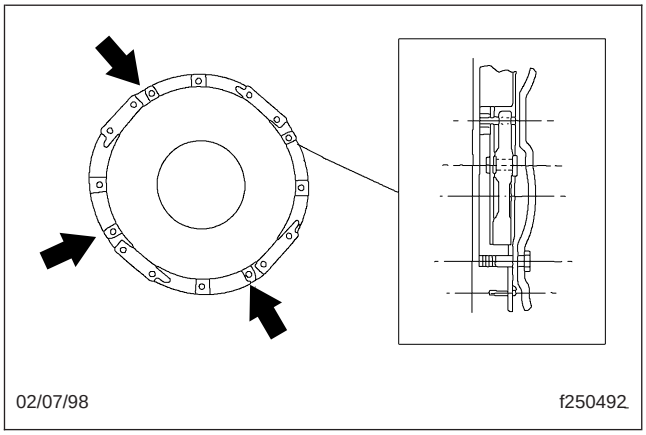


Fig. 33, Installing Intermediate Plate

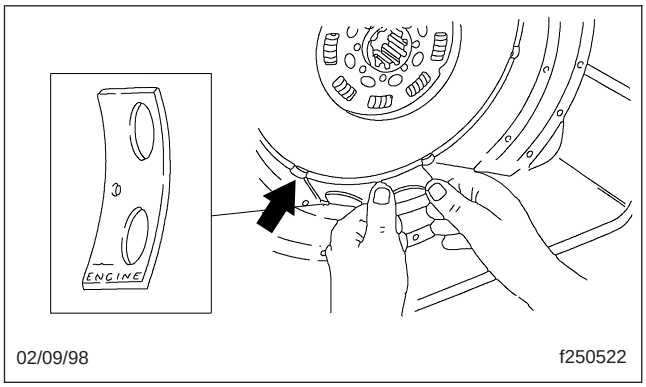


Fig. 34, Installing Anti-Rattle Springs

IMPORTANT: The clutch will not function correctly if the disc is installed backward. Make sure the side marked "Pressure Plate Side" faces the pressure plate.

4. Insert the truck clutch alignment shaft into the hub of the rear clutch disc. Position the rear disc in place and push the alignment tool through the front disc and into the pilot bearing. See **Fig. 11**.
5. With the alignment tool still in place, carefully slide the clutch cover assembly over the aligning tool and onto the guide studs. Align the Kwik-Adjust bolt with the opening in the clutch housing (6 o'clock). See **Fig. 12**.
6. Install and hand-tighten the clutch cover mounting bolts. See **Fig. 5**.
7. Replace the guide studs with the two remaining clutch cover mounting bolts.

Clutch Removal and Installation

8. Tighten the clutch cover mounting bolts in the sequence shown. See **Fig. 13**.
9. Remove the wood blocks from between the release bearing housing and the clutch cover assembly if they have not fallen out. See **Fig. 2**.
10. Remove the truck clutch alignment shaft. Reinsert the tool completely. Slowly move the tool in and out to check for binding. If binding exists, reinstall the clutch assembly.
11. Rotate the clutch release bearing housing so that the flat section is on top. See **Fig. 14**. If the cross-shaft is below center, rotate the bearing housing 180 degrees.
12. Apply a small amount of grease to each of the clutch release lever fingers and the release bearing wear pads (both sides). See **Fig. 15**.
13. Install the transmission; refer to **Group 26** in this manual.
14. Release the clutch by holding down the clutch pedal.

NOTE: Apply an inward pressure on the adjustment bolt. A clockwise adjustment will move the release bearing toward the transmission. A counterclockwise adjustment will move the release toward the flywheel.

15. Adjust the clutch release bearing travel dimension to specification. Measure between the rear face of the release bearing and the front face of the transmission bearing retainer or clutch brake. See **Fig. 16**.
16. After the final adjustment is made, align the adjustment bolt to the nearest square edge and allow the adjustment bolt to disengage by moving outward. Recheck the clutch release bearing travel.
17. Check clutch pedal freeplay. If it is not within specifications, a linkage adjustment must be made.
18. Install the clutch housing inspection cover.

Spicer Angle-Spring® (AS) 14-Inch (356-mm) and 15-1/2-Inch (394-mm) Dual-Plate Kwik-Adjust™ Clutches with Easy-Pedal™ Mechanism

REMOVAL

⚠ CAUTION

Do not let the rear of the transmission hang or drop while the input shaft is engaged in the clutch disc splines, or the clutch discs can be damaged.

Make sure the clutch release lever clears the release bearing and is rotated over the wear pads as the clutch housing is moved rearward, or the release bearing and release lever can be damaged.

1. Remove the transmission; refer to **Group 26** in this manual.
2. Install the truck clutch alignment shaft into the release bearing, discs and pilot bearing. See **Fig. 1**.

⚠ CAUTION

Whenever the clutch is removed, spacer blocks must be installed to prevent the release bearing from moving forward and bottoming. If the release bearing is allowed to move too far forward, the internal levers in the clutch cover can partially come out of the groove in the retainer. If the cover is reinstalled, internal binding of the clutch or loss of levers can occur. Both are detrimental to the clutch.

NOTE: If there is inadequate clearance to install the spacers, use the release fork tool provided in the Spicer cutch service kit (CSK1) to pull back the release bearing assembly evenly and then install the wood blocks.

3. Install two wood blocks (5/8-inch x 3-inch) between the clutch cover and the release bearing assembly to relieve the heavy internal spring load in the clutch assembly. See **Fig. 2**.

4. Loosen the clutch cover bolts in a crisscross pattern to prevent cocking and bending of the clutch mounting bolts. See **Fig. 24**.
5. Remove the top two mounting bolts retaining the cover assembly to the flywheel and install two guide studs to help support the weight of the clutch. See **Fig. 4**.
6. Remove the remaining mounting bolts and remove the clutch cover. See **Fig. 12**.
7. Remove the clutch assembly. See **Fig. 20**.
8. Inspect the flywheel housing and flywheel. If the flywheel is heat-checked or warped, refer to the appropriate engine manufacturer's recommendations regarding machining or replacement. See **Fig. 7**.

IMPORTANT: If a new clutch is to be installed, a new pilot bearing must also be installed.

9. Inspect and replace the pilot bearing as required. Refer to the appropriate engine manufacturer's service manual. See **Fig. 10**.
10. Check the intermediate drive plate tabs. If the tabs are worn or damaged, replace.

IMPORTANT: Do not grind the tabs of the intermediate drive plate.

11. Check the clearance between the slot of the clutch housing and the tab of the intermediate drive plate. If the clearance is less than specified, replace the intermediate drive plate. See **Fig. 35**.

NOTE: If the splines are worn excessively or notched, the clutch discs will not slide on the shaft.

12. Check the condition of the transmission input shaft. See **Fig. 8**.
    - 12.1 Use a crocus cloth or file to dull the sharp edges of the splines.
    - 12.2 Replace the input shaft as required.
13. Check for wear on fingers of the clutch release lever, cross-shaft and cross-shaft bushings. Replace as required. See **Fig. 9**.

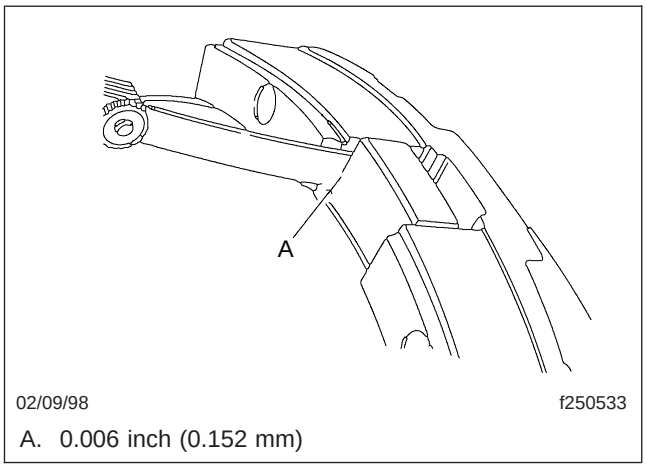


Fig. 35, Checking Intermediate Drive Plate Tab Clearance

INSTALLATION

NOTE: For the 15-1/2-inch (394-mm) clutch assembly, it is recommended that the clutch discs, intermediate plate and cover be assembled on the bench and then fitted to the flywheel as an assembly with a suitable clutch lift assist jack.

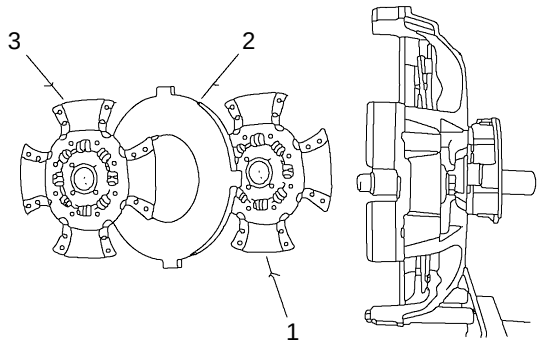
NOTE: The seven-spring damper disc assembly with a 15-1/2-inch (394-mm) cast clutch is used only with a flywheel that has a 10.125 inch (258-mm) or greater damper pocket.

1. Insert two 7/16-14 x 5 inch guide studs in the two upper mounting holes of the flywheel. Rotate the flywheel to level the studs. See **Fig. 4**.

IMPORTANT: The clutch will not function correctly if the disc is installed backwards. Make sure the side marked "Pressure Plate Side" faces the pressure plate.

2. Using the truck clutch alignment shaft, assemble the clutch assembly. See **Fig. 36**.
3. Position the clutch assembly over the guide studs and slide the assembly forward until the alignment tool fits into the pilot bearing. See **Fig. 37**.
4. Install and hand-tighten the clutch cover bolts. See **Fig. 5**.
5. Replace the guide studs with the two remaining clutch cover bolts.

Clutch Removal and Installation



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1. Clutch Rear Driven Disc
2. Intermediate Drive Plate
3. Front Driven Disc

Fig. 36, Assembling Clutch Assembly

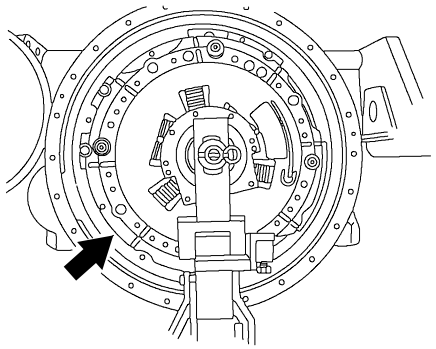

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Fig. 37, Installing Clutch Assembly

6. Tighten the clutch cover bolts 50 to 70 lbf·ft (68 to 95 N·m) in the sequence shown. See **Fig. 21**.
7. Remove the wood blocks from between the release bearing housing and the clutch cover assembly if they have not fallen out. See **Fig. 2**.
8. Remove the truck clutch alignment shaft. See **Fig. 6**.
9. Using a 1/4-inch diameter flat nose drift, gently tap each of the four separator pins toward the flywheel. After tapping, the pins must be flush against the flywheel. See **Fig. 38**.
10. Rotate the clutch release bearing housing so that the flat section is on top. See **Fig. 14**. If the cross-shaft is below center, rotate the bearing housing 180 degrees.

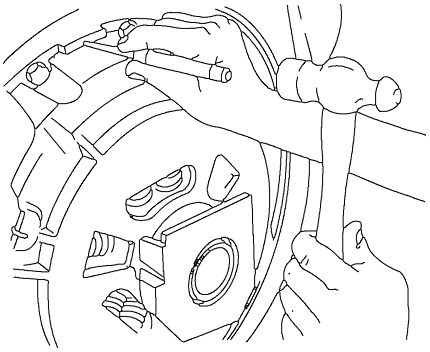

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Fig. 38, Installing Separator Pins

NOTE: Clutch release bearings must be lubricated after adjustment and at regular maintenance intervals. Clutches with a permanently sealed release bearing require no lubrication.

11. Apply a small amount of grease to each of the clutch release lever fingers and the release bearing wear pads (both sides). See **Fig. 15**.
12. Install the transmission; refer to **Group 26** in this manual.
13. Release the clutch by holding down the clutch pedal.

NOTE: Apply an inward pressure on the adjustment bolt. A clockwise adjustment will move the release bearing toward the transmission. A counterclockwise adjustment will move the release toward the flywheel.

14. Adjust the clutch release bearing travel dimension to specification. Measure between the rear face of the release bearing and the front face of the transmission bearing retainer or clutch brake. See **Fig. 22**.
15. After the final adjustment is made, align the adjustment bolt to the nearest square edge and allow the adjustment bolt to disengage by moving outward. Recheck the clutch release bearing travel.

Disc Check

NOTE: Skip the first step for an adjustment-free clutch assembly disc check.

1. Block the release bearing with wood blocks (1/2 x 1/2 x 3 inches [13 mm x 76 mm] for two-plate and 1/2 x 1-3/4 x 3 inches [13 mm x 44 mm x 76 mm] for single-plate) using the tool. See **Fig. 1**.

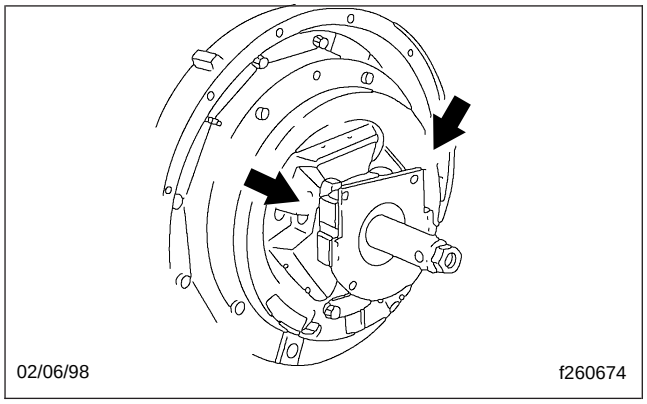


Fig. 1, Block the Release Bearing

2. Remove the clutch from the flywheel.

NOTE: The front disc can have different thickness facings than the rear disc on some dual disc clutch assemblies.

3. Measure the facing thickness in three or four areas around each clutch disc using a vernier caliper. See **Fig. 2**. Replace the clutch disc if the measurements are less than specified. Refer to **Specifications, 400**.

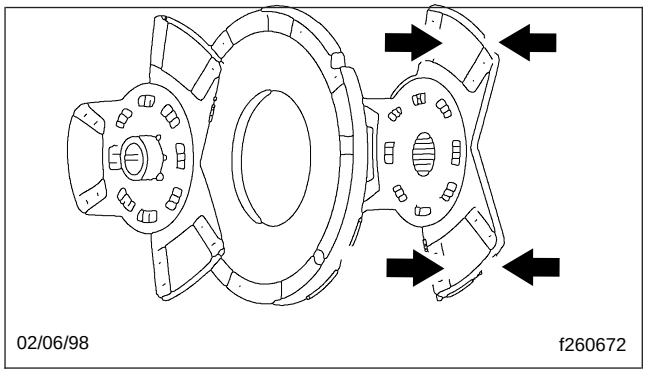


Fig. 2, Measure the Facing Thickness

4. Check the driven disc hub spline for burrs or uneven wear. If either is evident, replace the disc.
5. Measure the clearance between the clutch disc spline and the transmission input shaft spline using a feeler gauge. Clearance should be: 0.002 to 0.006 inch (0.05 to 0.15 mm). See **Fig. 3**. Replace the clutch disc if the clearance is greater than specified.

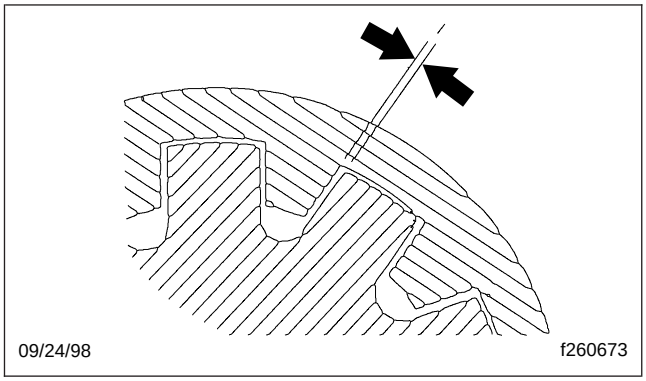


Fig. 3, Spline Clearance

6. Check the pilot bearing. Refer to the engine manufacturer's literature.

NOTE: When installing a new disc, be careful not to drop it or to contaminate it with oil or grease.

7. Perform the following checks and replace the clutch assembly if any of these conditions are present.
   - 7.1 Check the clutch disc facing for oil or grease contamination and eliminate the source of any contamination.
   - 7.2 Check the clutch disc for worn or loose facings.
   - 7.3 Check the clutch disc for loose rivets in the hub.
   - 7.4 Check the clutch disc for distortion.
   - 7.5 Check for broken springs (springs loose enough to rattle will not cause noise when the vehicle is operating).

Clutch Inspection

Clutch Pedal Inspection

Inspect the clutch pedal for the following (see **Fig. 4**):

- worn pivot
- twisted or bent pedal
- damaged pedal pad

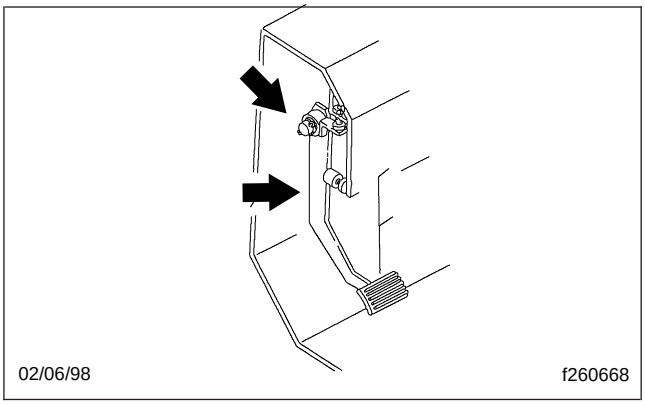


Fig. 4, Clutch Pedal Inspection

Clutch Pedal Free Play Check

1. Check the clutch free play at the top of the pedal stroke (1-1/2 to 2 inch [38.1 to 50.8 mm]). See **Fig. 5**.

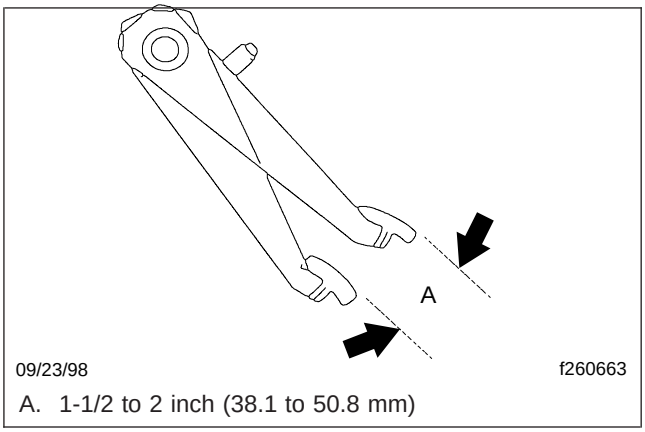


Fig. 5, Clutch Free Play

2. Check that the free travel and the release travel are as specified with the clutch pedal up. See **Fig. 6**.

NOTE: Proceed to the following steps if an adjustment is necessary.

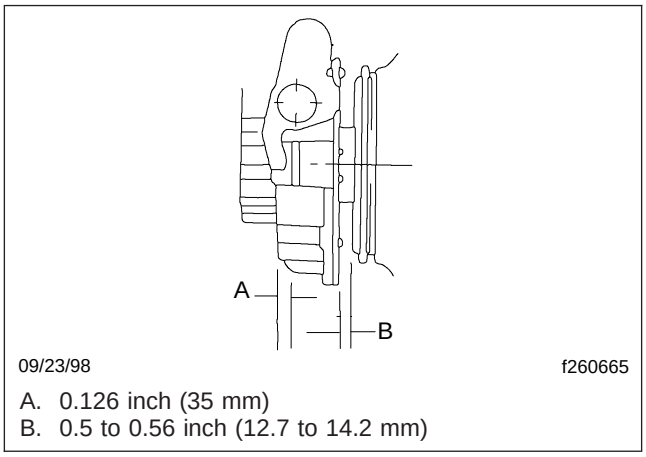


Fig. 6, Clutch Travel

3. Block or hold the clutch pedal in the released position. See **Fig. 7**.

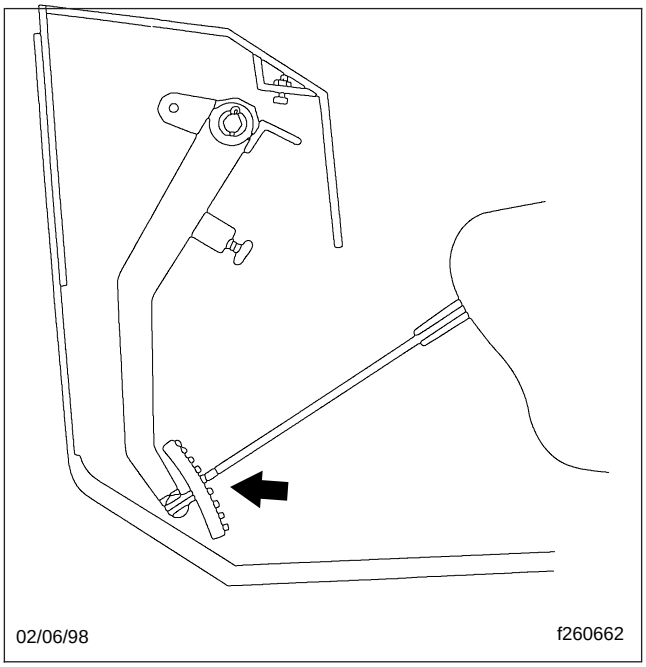


Fig. 7, Clutch Pedal Held in Released Position

4. Rotate the engine flywheel until the Kwik-Adjust adjustment bolt is exposed. See **Fig. 8**.
5. Adjust the bearing release travel to 0.50 to 0.56 inch (12.7 to 14.2 mm).
   5.1 Apply inward pressure and rotate the adjusting bolt.

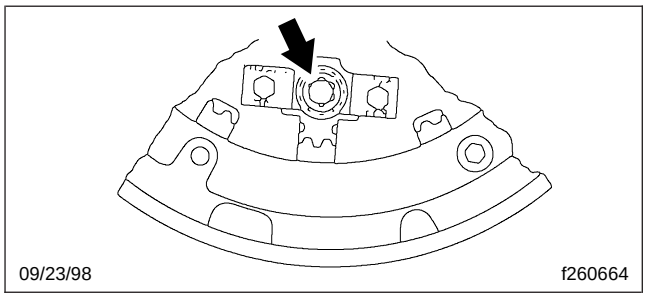


Fig. 8, Kwik-Adjust Adjustment Bolt

Rotation or movement of one lug position will move the release bearing approximately 1/5 inch (5.1 mm).

5.2 A clockwise adjustment will move the release bearing housing toward the transmission.

5.3 A counterclockwise adjustment will move the release bearing housing toward the flywheel.

6. Release the clutch pedal.
7. Verify the clutch pedal free play is within specification.

Clutch Pedal Clutch and Driven Disc Check

1. Adjust the clutch by turning the adjusting bolt until there is no free travel between the clutch fork and the release bearing. See **Fig. 8**.
2. Test drive the vehicle to determine if the release of the clutch has been affected. Replace only the driven discs if the release has improved.
3. Adjust the clutch after replacing the discs.

Pressure Plate Check

CAUTION

Do not use cleaners with a petroleum base, and do not immerse the pressure plate in the solvent.

NOTE: A heavily worn lever indicates the lever is binding. Replace the pressure plate if there is a substantial difference in lever wear.

NOTE: Always check the condition of the engine flywheel for cracks, heat checks or other damage whenever the clutch is inspected, removed or replaced.

NOTE: Smooth and flat pressure plate surfaces must be used for satisfactory clutch life.

1. Inspect the pressure plate friction surface for scoring, burring, heat checking or distortion. See **Fig. 9**. If the friction surface is badly scored, heat checked, warped, or dished in, replace it with a new cover assembly.

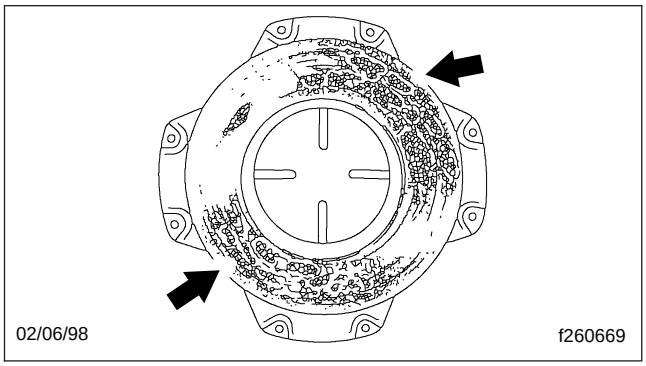


Fig. 9, Pressure Plate Friction Surface

2. Clean the pressure plate and flywheel surfaces with a suitable commercial solvent to make sure surfaces are free from any oil film.
3. Check the face runout of the pressure plate using a straightedge and a feeler gauge. See **Fig. 10**. Replace the clutch cover assembly if the runout is greater than 0.02 inch (0.5 mm).

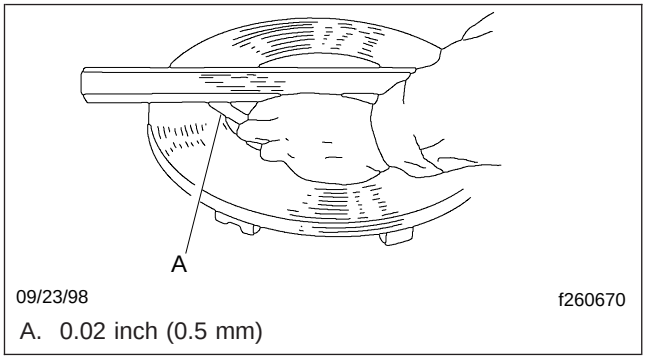


Fig. 10, Pressure Plate Face Runout

Clutch Inspection

Flywheel Check

Refer to the engine manufacturer's literature.

Flywheel Runout Check

Refer to the engine manufacturer's literature.

Release Hub and Bearing Check

CAUTION

The bearing is prelubricated and must not be cleaned with solvent.

1. Wipe all oil and dirt from the release bearing.
2. Hold the hub and the back plate and apply pressure while rotating the bearing. Replace the bearing if the bearing rotation is rough.
3. Check for surface scoring or burrs that will affect the sliding motion of the release bearing on the transmission input shaft.

   Polish away any scoring or burrs with a fine grade emery paper or crocus cloth.
4. Check the release bearing hub groove for nicks and burrs or lever wear.

   Replace the bearing if there is excessive wear on the lever, the groove or the yoke contact surface.

Flywheel Housing Check

Refer to the engine manufacturer's literature.

Pilot Bearing Check, Ball Type

1. Check the fit and rotation of the clutch pilot bearing in the bore of the crankshaft.

   Replace the bearing if worn or damaged. Refer to the engine manufacturer's literature.
2. Check the pilot bearing for roughness, evidence of overheating or loss of lubricant. Replace the bearing if any of these conditions are found.

CAUTION

Avoid using too much lubricant. It will contaminate the clutch disc when the clutch revolves.

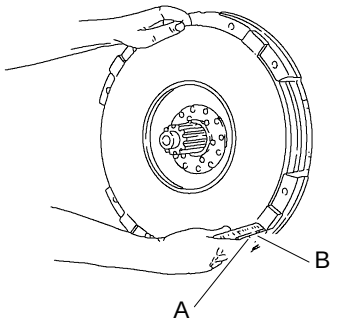
3. Coat the pilot bearing bore in the crankshaft with a small quantity of lithium-based grease.

Flywheel Housing Alignment

Refer to the engine manufacturer's literature.

Intermediate Plate Check

1. Check the friction surfaces of the intermediate plate for heat checks, scoring or distortion as described for the pressure plate.
2. Check the driving slots of the intermediate plate for wear using a feeler gauge. See **Fig. 11**. Replace the plate if wear exceeds specifications.



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A. 14-inch (356-mm): 0.020 inch (0.508 mm)
B. 15-1/2 inch (394-mm): 0.016 to 0.021 inch (0.406 to 0.533 mm)

Fig. 11, Intermediate Plate Driving Slots

3. Check the drive lugs for wear.

Release Lever

1. Make sure the cross-shaft and lever assembly rotates freely and has no play in the clutch housing bushings. See **Fig. 12**. If play exists, replace the bushings and the shaft as required.

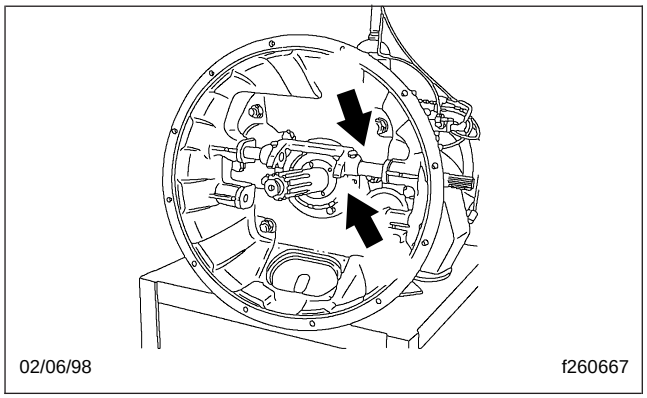


Fig. 12, Cross-Shaft and Lever Assembly

2. Check that the release lever fork tips are not worn excessively and that the curved portion of the lever is curved with no flat spots. See **Fig. 13**.

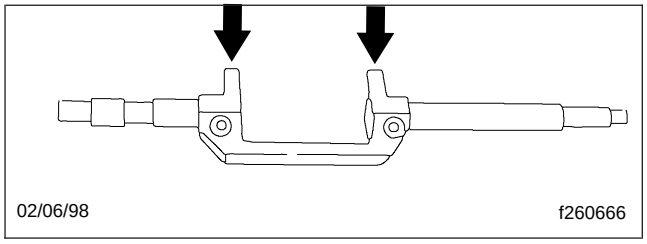


Fig. 13, Release Lever Fork Tips

3. Check that the locating flats show no sign of excessive wear or grooving. Replace as necessary.

Input Shaft Spline Check

NOTE: Any wear or damage on the input shaft prevents the clutch from operating correctly.

1. Check the splines on the input shaft for wear and damage. See **Fig. 14**.
2. Use an emery cloth to remove small scratches from the input shaft.
3. Replace the input shaft if worn or damaged.

Clutch Brake Check

1. Clamp the clutch brake in a vise. See **Fig. 15**.
2. Slide a modified input shaft through the clutch brake. See **Fig. 16**. You can fabricate a tool, to accommodate a torque wrench, by welding a nut onto a cut input shaft.

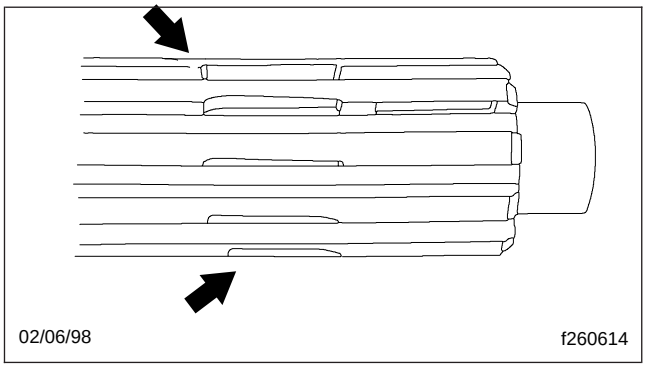


Fig. 14, Input Shaft Splines

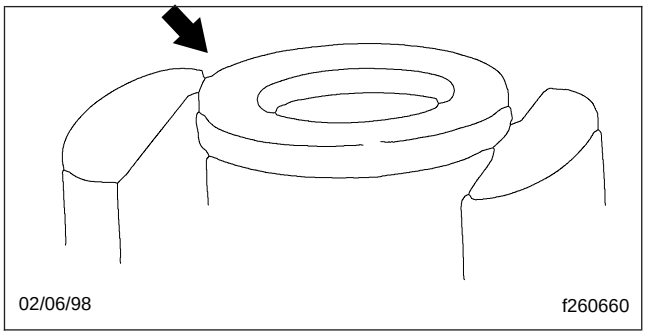


Fig. 15, Clutch Brake

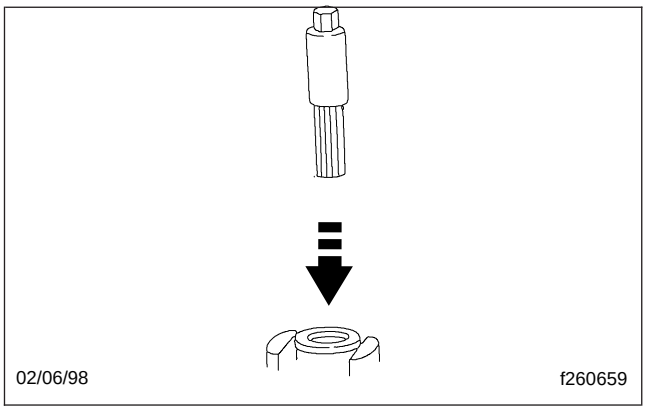


Fig. 16, Modified Input Shaft

3. Rotate the nut two half turns with a torque wrench. Tighten 12 lbf·ft (16.3 N·m). Replace the clutch brake if the torque reading is less than specified.

Clutch Inspection

Replace the clutch brake if the torque reading is greater than 35 lbf·ft (48 N·m) to eliminate the possibility of tang breakage.

Clutch Brake Check, On Vehicle

1. Adjust the external linkage rod to obtain the specified clutch pedal free play. See **Fig. 6**.
2. Check the adjustment results by placing a business card (or a similar item) behind the clutch release bearing and depress the clutch pedal. The card should be held tight.
3. Release the clutch pedal. The clutch brake is correctly adjusted if the card slips out when the pedal is approximately 1/2 inch (12.7 mm) from the end of the pedal stroke.

Clutch System Adjustment (Except Spicer Solo Adjustment-Free)

NOTE: The linkage must not be adjusted to compensate for clutch face wear. The linkage must only be reset to provide proper clutch pedal free play at the installation of a new clutch and not every time you adjust the clutch internally. Set the bearing release travel to specification before adjusting the linkage for proper pedal free play.

1. Remove the clutch housing inspection cover. See **Fig. 17**.

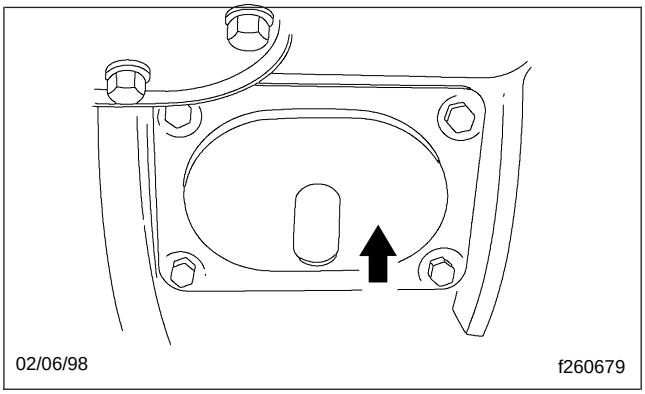


Fig. 17, Clutch Housing Inspection Cover

2. Remove the clutch pedal free play by placing the clutch release lever against the release bearing.
3. Measure the distance between the rear of the release bearing and the clutch brake or input shaft cover, depending on whether it has a synchronized or non-synchronized transmission. Bearing release travel must be within the specified dimension. See **Fig. 6**.
4. Rotate the flywheel until the Kwik-Adjust bolt is exposed. See **Fig. 8**.
5. Hold or block the clutch pedal in the released position. See **Fig. 7**.
6. Adjust the bearing release travel to 0.50 to 0.56 inch (12.7 to 14.2 mm).
   - 6.1 Apply inward pressure on the adjusting bolt. Rotation or movement of one lug position will move the release bearing approximately 1/5 inch (0.51 mm).
   - 6.2 A clockwise adjustment will move the release bearing housing toward the transmission.
   - 6.3 A counterclockwise adjustment will move the release bearing housing toward the flywheel. After the final adjustment is made, align the adjustment to the nearest square edge allowing the adjustment bolt to disengage by an outward movement.
7. On vehicles equipped with 15-1/2 (394-mm) or 14-inch (356-mm) two-plate clutches, set the four separate pins against the flywheel friction surface. See **Fig. 18**. Place a 1/4-inch (6.35-mm) punch in the pin holes and tap until firmly seated.
8. Using Premium Long-Life Grease XG–1–C or equivalent meeting specification ESA–M1C75–B, lubricate the release bearing wear pads. See **Fig. 19**.
9. Release the clutch pedal to engage the clutch.
10. Verify the clutch pedal free play is within specification. If it is not within specification, then a linkage adjustment must be made.
11. Install the clutch housing inspection cover. See **Fig. 17**.

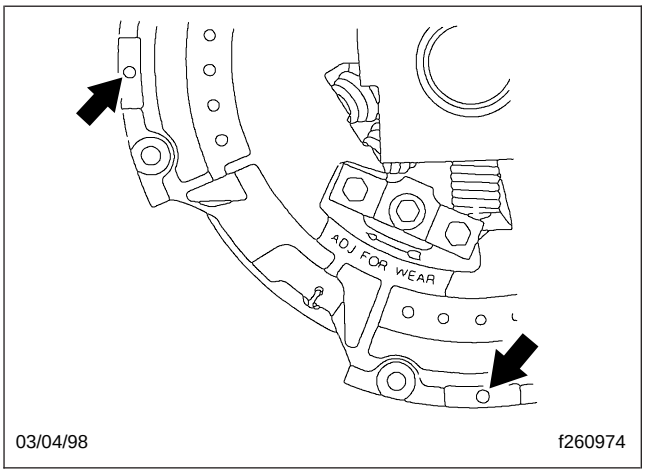


Fig. 18, Pin Holes

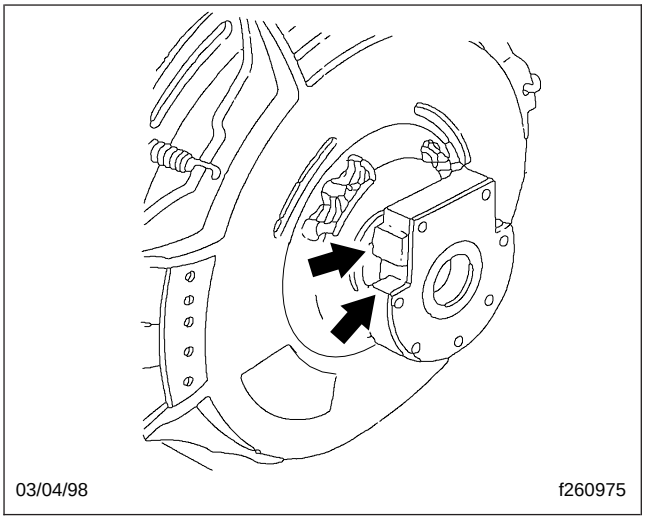


Fig. 19, Release Bearing Wear Pads

Spicer Solo Adjustment-Free Clutch System Adjustment

NOTE: The linkage must not be adjusted to compensate for clutch face wear. The linkage must only be reset to provide proper pedal free play at the installation of a new clutch. Set the bearing release travel to specification before adjusting the linkage for proper pedal free play.

NOTE: The internal adjustment is only set at the installation of a new clutch. After installation, perform the following procedure.

NOTE: The shipping bolts must be removed before adjusting the clutch. Perform the first two steps only if the shipping bolts were not removed during clutch installation.

1. Remove the clutch housing inspection cover to access the four hex-head shipping bolts. See **Fig. 17**.
2. Remove the four shipping bolts. See **Fig. 20**.

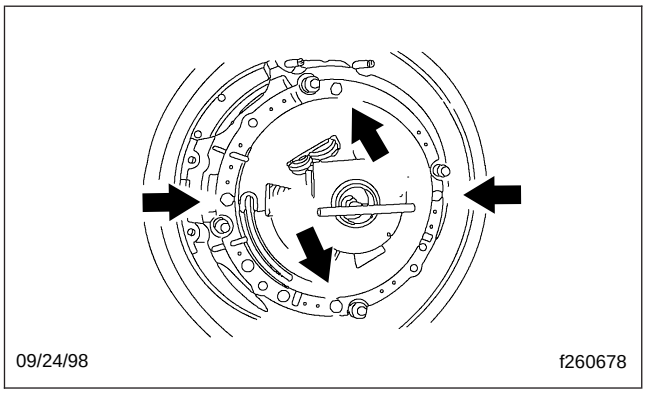


Fig. 20, Shipping Bolts

3. Depress the clutch pedal five times in order to obtain the specified bearing release travel.
4. Verify the clutch pedal free travel is within 1-1/2 to 2 inches (38.1 to 50.8 mm). If it is not within specification, adjust the linkage and check the pedal free travel again.
5. Install the clutch housing inspection cover.

Specifications

General Specifications	
Item	**Specification**
Premium Long-Life Grease XG–1–C or –K	ESA–M1C75–B

Table 1, General Specifications

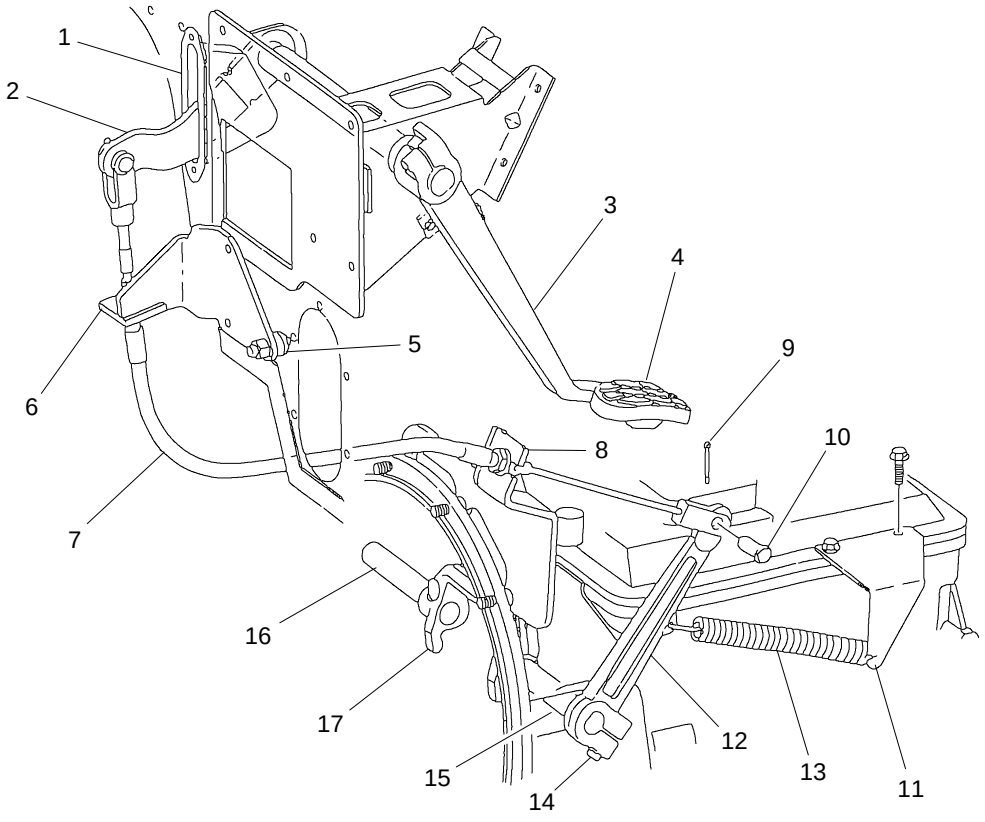
Torque Specifications	
Description	**lbf·ft (N·m)**
Clutch Release Lever to Clutch Release Shaft Bolts	31–42 (42–57)
Clutch Cover Bolts, 3/8-16 x 1.25-Inch, 14-Inch (356-mm) Clutch Disc	35–45 (48–61)
Clutch Cover Bolts, 7/16-14 x 2.50-Inch, 15.5-Inch (394-mm) Clutch Disc	50–70 (68–95)

Table 2, Torque Specifications

General Information

The mechanical clutch linkage is a system of leverage necessary to multiply the relatively small force at the clutch pedal to a larger force at the clutch pressure plate fingers.

There are two separate clutch linkage systems: the cable-actuated linkage available on vehicles with 101-inch BBC, and the clutch rod-actuated linkage available on vehicles with 113- and 122-inch BBC. See **Fig. 1**, **Fig. 2** and **Fig. 3**.



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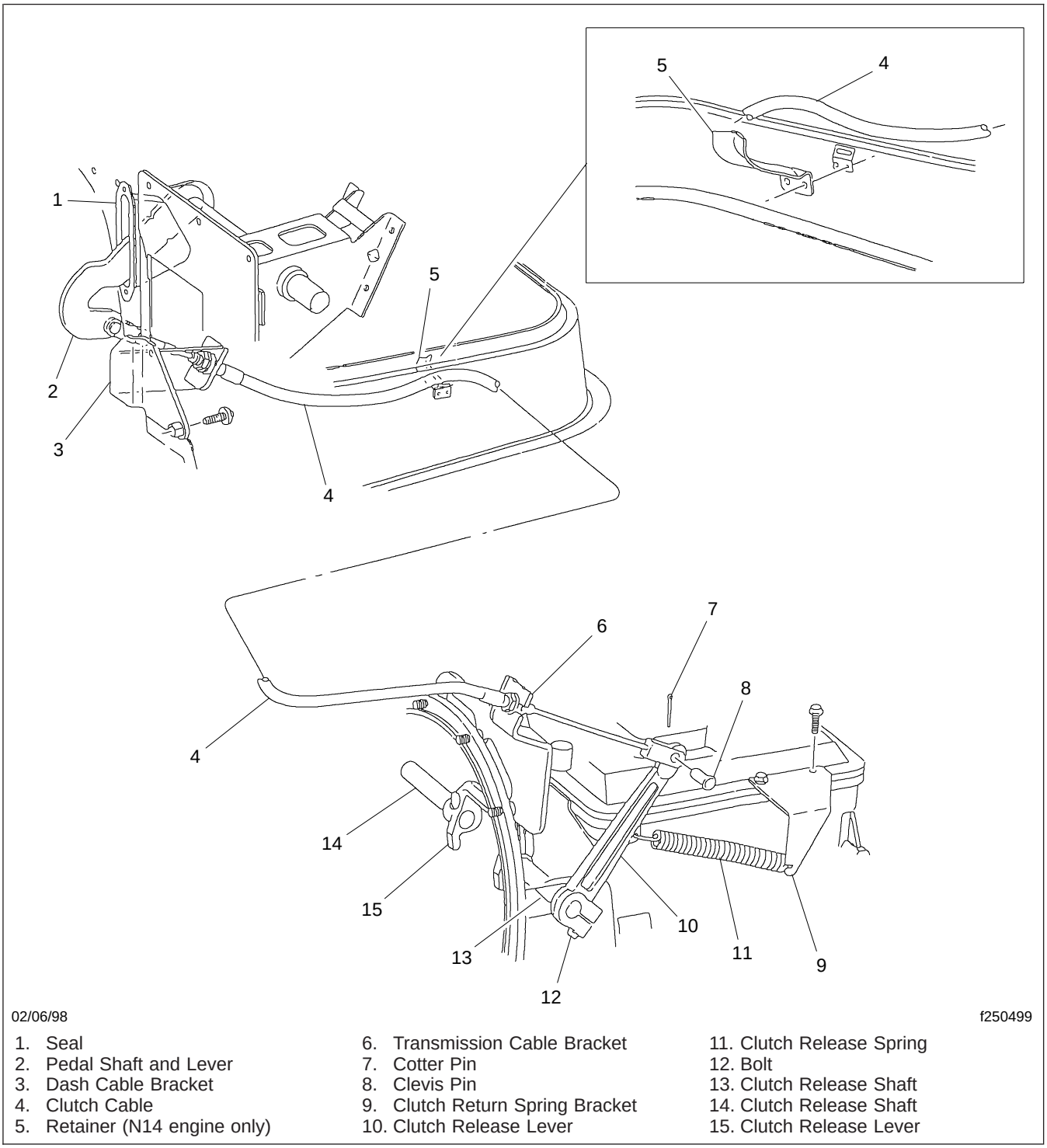
1. Seal
2. Pedal Shaft and Lever
3. Clutch Pedal
4. Clutch Pedal Pad
5. Bolt
6. Dash Cable Bracket
7. Clutch Cable
8. Transmission Cable Bracket
9. Cotter Pin
10. Clevis Pin
11. Clutch Return Spring Bracket
12. Clutch Release Lever
13. Clutch Release Spring
14. Bolt
15. Clutch Release Shaft
16. Clutch Release Shaft
17. Clutch Release Lever

Fig. 1, Clutch Cable System, 101-Inch BBC With Mid-Range Diesel Engine

General Information



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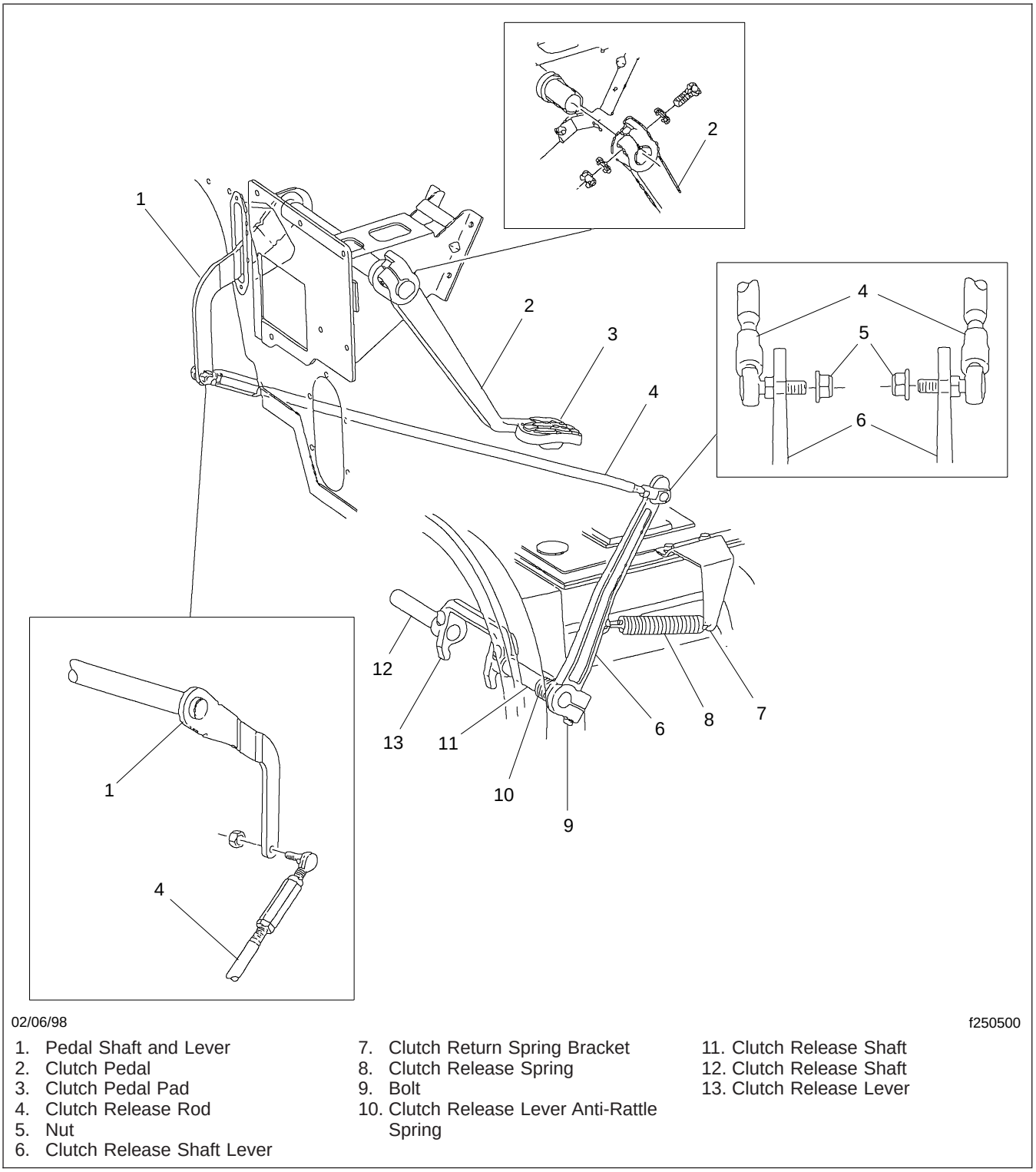
1. Seal
2. Pedal Shaft and Lever
3. Dash Cable Bracket
4. Clutch Cable
5. Retainer (N14 engine only)
6. Transmission Cable Bracket
7. Cotter Pin
8. Clevis Pin
9. Clutch Return Spring Bracket
10. Clutch Release Lever
11. Clutch Release Spring
12. Bolt
13. Clutch Release Shaft
14. Clutch Release Shaft
15. Clutch Release Lever

Fig. 2, Clutch Cable System, 101-Inch BBC With Premium Diesel Engine



1. Pedal Shaft and Lever
2. Clutch Pedal
3. Clutch Pedal Pad
4. Clutch Release Rod
5. Nut
6. Clutch Release Shaft Lever
7. Clutch Return Spring Bracket
8. Clutch Release Spring
9. Bolt
10. Clutch Release Lever Anti-Rattle Spring
11. Clutch Release Shaft
12. Clutch Release Shaft
13. Clutch Release Lever

Fig. 3, Clutch Linkage System, 113- and 122-Inch BBC

Left-Hand-Drive Clutch Pedal Removal and Installation

REMOVAL

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the bolt, the nut and the washer(s) from the clutch pedal. See **Fig. 1**.

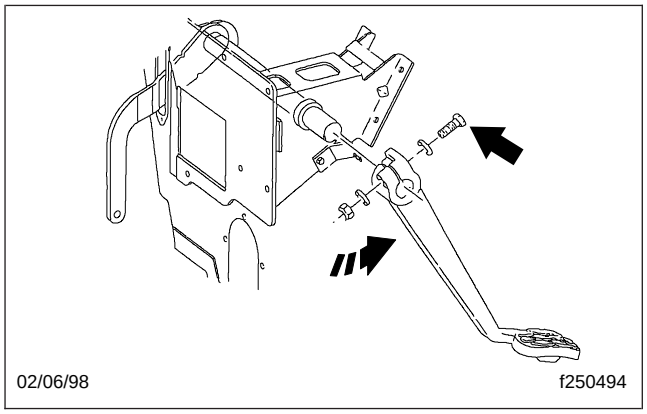
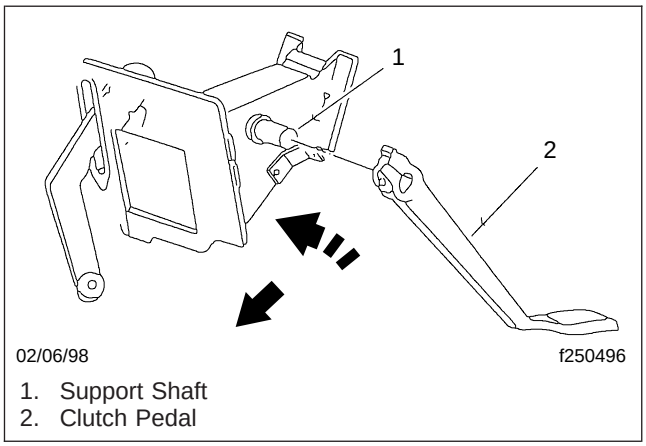


Fig. 1, Remove the Clutch Pedal Retaining Bolt and Pedal

3. Remove the clutch pedal from the support shaft by pulling and sliding the pedal from the shaft. See **Fig. 1**.
4. Check the clutch pedal for a worn pivot, a twisted or bent pedal, or a worn clutch pedal. Repair or replace as needed.

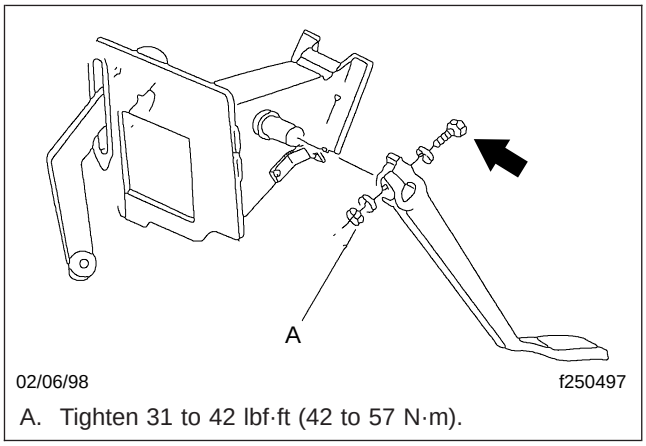
INSTALLATION

1. Install the clutch pedal. See **Fig. 2**.
   - 1.1 Align the clutch pedal with the support shaft.
   - 1.2 Push the pedal toward the brake pedal until the clutch pedal contacts the shoulder of the shaft.
2. Install the bolt, washer(s) and nut, and tighten the nut 31 to 42 lbf·ft (42 to 57 N·m). See **Fig. 3**.
3. Remove the chocks from the tires.



1. Support Shaft
2. Clutch Pedal

Fig. 2, Install the Clutch Pedal



A. Tighten 31 to 42 lbf·ft (42 to 57 N·m).

Fig. 3, Install the Clutch Pedal Retaining Bolt

Right-Hand-Drive Clutch Pedal Removal and Installation

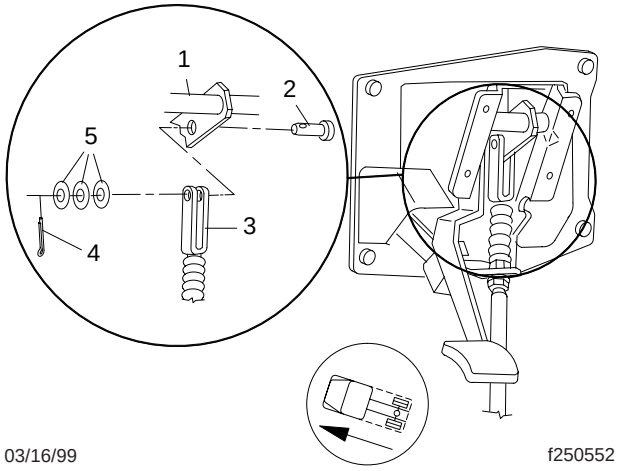
REMOVAL

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the under steering panel by removing the five screws.
3. Remove the two retaining clips from the clutch pedal shaft.

NOTE: After removing the clutch pedal shaft, the clutch pedal will become loose; attached only to the clutch cable.

Clutch Pedal Removal and Installation

4. Remove the clutch pedal shaft.
5. Disconnect the clutch cable assembly from the pedal. See **Fig. 4**.



1. Clutch Pedal Assembly Shaft
2. Clevis Pin
3. Clevis
4. Cotter Pin
5. Flatwasher

Fig. 4, Clutch Cable-to-Pedal Shaft Components

5.1 Loosen the clutch cable jam nuts and pull the unit forward.

5.2 Remove the cotter pin and disconnect the clevis from the rod connecting the clutch pedal to the flex cable.

NOTE: Be careful not to damage the speed control inhibitor switch or assembly when removing the clutch pedal assembly.

6. Remove the clutch pedal assembly.
7. Check the clutch pedal for a worn pivot, a twisted or bent pedal, or a worn clutch pedal. Repair or replace as needed.

INSTALLATION

NOTE: Bushings are fragile.

1. Open the hood.
2. Remove the five fasteners from the splash shield under the hood. Remove the splash shield.
3. Loosen the lower clutch cable jam nut (located under the hood).
4. Remove the cotter pin from the lower end of the flex cable. Disconnect the cable from the pivot arm (clutch release lever).
5. Connect the clevis to the rod connecting the clutch pedal to the flex cable. Insert the cotter pin. See **Fig. 4**.
6. Install the clutch pedal shaft and the four bushings, and attach the retaining clips to each end of the shaft.
7. Install the clutch cable into the upper clutch cable bracket (located under the dash). Tighten the jam nut to 15 to 30 lbf·ft (21 to 40 N·m).
8. Insert the cable into the lower clutch cable bracket (located under the hood). Tighten the jam nut to 15 to 30 lbf·ft (21 to 40 N·m).
9. Connect the flex cable to the pivot arm.
10. Adjust free play, if necessary.
11. Install the splash shield. Tighten the five fasteners.
12. Install the under steering panel and tighten the five screws.
13. Close the hood.
14. Remove the chocks from the tires.

Clutch Release Rod Removal and Installation

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the nut and separate the release rod from the clutch pedal shaft and lever. See **Fig. 1**.

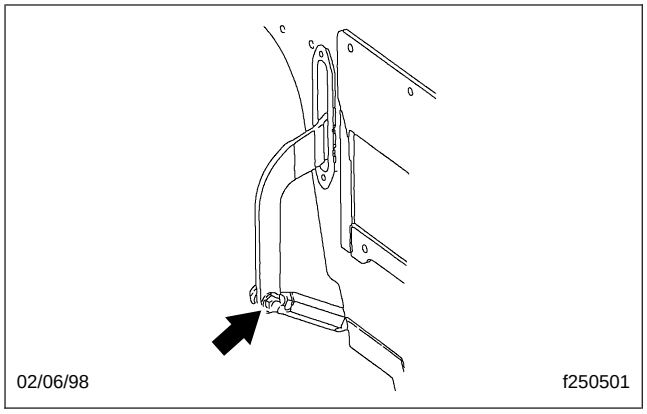


Fig. 1, Separate the Clutch Release Rod from the Clutch Pedal Shaft

3. Remove the nut and separate the release rod from the clutch release lever. See **Fig. 2**.

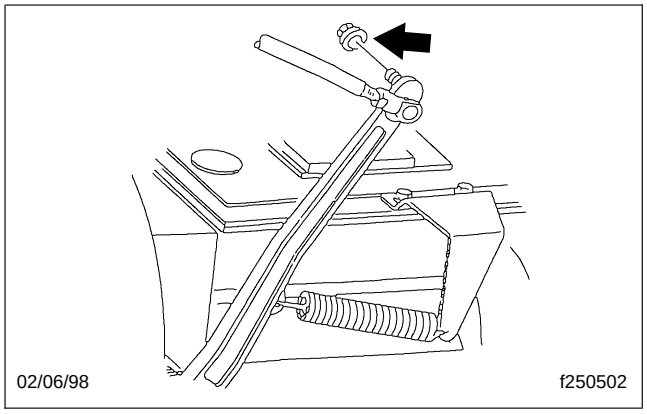
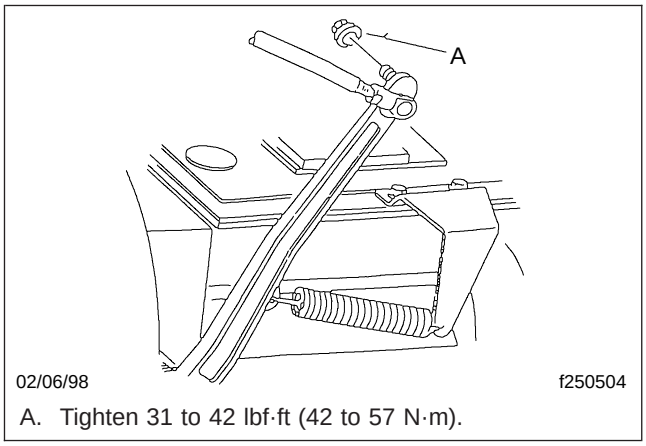


Fig. 2, Separate the Clutch Release Rod from the Clutch Release Lever

4. Remove the release rod.

Installation

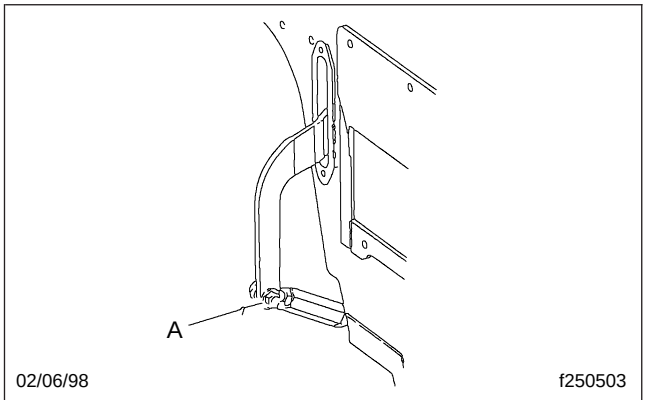
1. Install the clutch release rod and nut to the clutch release lever. Tighten 31 to 42 lbf·ft (42 to 57 N·m). See **Fig. 3**.



A. Tighten 31 to 42 lbf·ft (42 to 57 N·m).

Fig. 3, Install the Clutch Release Rod to the Clutch Release Lever Nut

2. Install the clutch release rod and nut to the clutch pedal shaft and lever. Tighten 31 to 42 lbf·ft (42 to 57 N·m). See **Fig. 4**.



A. Tighten 31 to 42 lbf·ft (42 to 57 N·m).

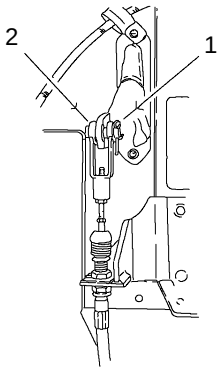
Fig. 4, Install the Clutch Release Rod to the Clutch Pedal Shaft and the Lever Nut

3. Adjust as necessary. See **Subject 150** for instructions.
4. Remove the chocks from the tires.

Left-Hand-Drive Clutch Release Cable Removal and Installation

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Open the hood.
3. Remove the five fasteners from the splash shield and remove the splash shield.
4. Remove the under steering panel by removing the five screws.
5. Disconnect the electrical to the clutch.
6. Disconnect the clutch cable from the clutch pedal shaft and lever. See **Fig. 1**.



1. Cotter Pin
2. Clevis Pin

Fig. 1, Disconnect the Clutch Cable from the Clutch Pedal Shaft

   6.1 Remove and discard the cotter pin.

   6.2 Remove the clevis pin.

7. Loosen the clutch cable jam nut and remove the clutch cable from the dash cable bracket. See **Fig. 2**.
8. Disconnect the clutch cable from the clutch release lever. See **Fig. 3**.

   8.1 Remove and discard the cotter pin.

   8.2 Remove the clevis pin.

9. Loosen the clutch cable jam nut and remove the clutch cable from the transmission cable bracket. See **Fig. 4**.
10. Remove the clutch cable.

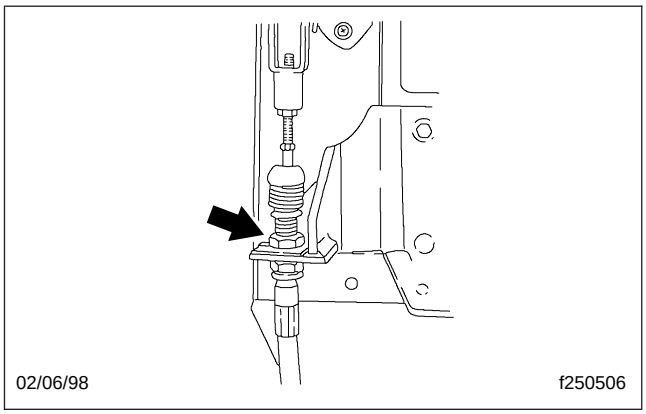
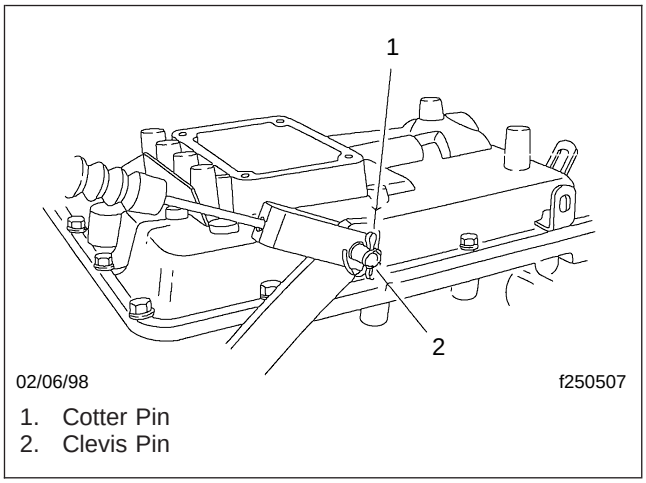


Fig. 2, Clutch Cable Jam Nut



1. Cotter Pin
2. Clevis Pin

Fig. 3, Disconnect the Clutch Cable from the Clutch Release Lever

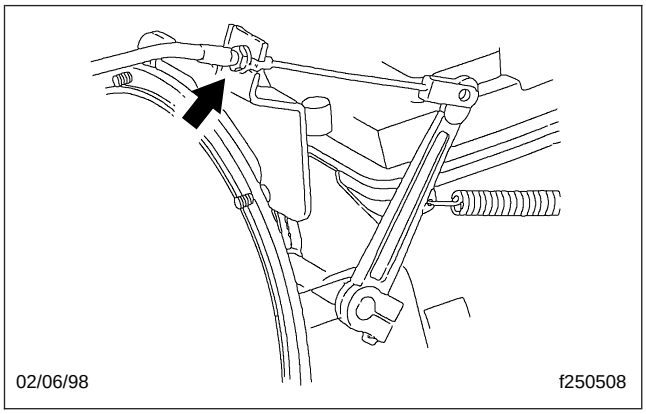
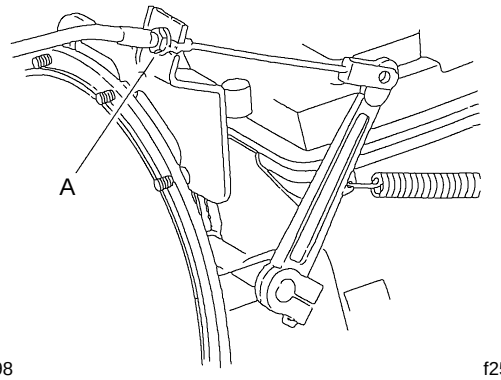


Fig. 4, Remove the Clutch Cable from the Transmission Cable Bracket

Left-Hand-Drive Clutch Release Cable Removal and Installation

Installation

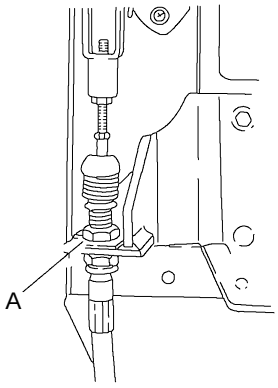
1. Install the clutch cable.
2. Install the clutch cable in the transmission cable bracket and tighten the clutch cable jam nut. See **Fig. 5**.



A. Tighten 15 to 30 lbf·ft (21 to 40 N·m).

Fig. 5, Install the Clutch Cable in the Transmission Cable Bracket

3. Connect the clutch cable to the clutch release lever. Install new cotter pin.
4. Connect the clutch cable to the dash cable bracket. See **Fig. 6**.



A. Tighten 15 to 30 lbf·ft (21 to 40 N·m).

Fig. 6, Tighten the Clutch Cable Jam Nut

5. Connect the clutch cable to the clutch pedal shaft and lever. Install a new cotter pin.
6. Install the under steering panel. Tighten the five screws.
7. Install the splash shield. Tighten the five fasteners.
8. Close and latch the hood.
9. Adjust as necessary. For instructions, see **Subject 150**.
10. Remove the chocks from the tires.

Right-Hand-Drive Clutch Flex Cable Removal and Installation

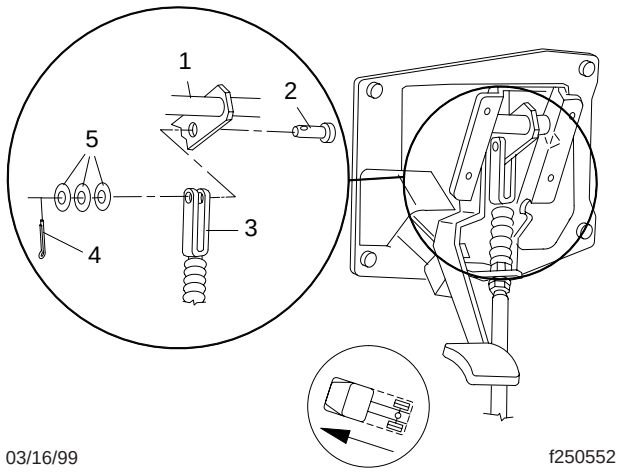
Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Tilt the hood.
3. Remove the five fasteners from the splash shield and remove the splash shield.
4. Remove the under steering panel by removing the five screws.
5. Remove the two retaining clips from the clutch pedal shaft.

NOTE: After removing the clutch pedal shaft, the clutch pedal will become loose; attached only to the clutch cable.

6. Remove the clutch pedal shaft.
7. Disconnect the clutch cable assembly from the pedal.

   7.1 Loosen the clutch cable jam nuts and pull the unit forward.



1. Clutch Pedal Assembly Shaft
2. Clevis Pin
3. Clevis
4. Cotter Pin
5. Flatwashers

Fig. 1, Clutch Cable-to-Pedal Shaft Components

   7.2 Remove the cotter pin and disconnect the clevis from the rod connecting the clutch pedal to the flex cable. See **Fig. 1**.

NOTE: Be careful not to damage the speed control inhibitor switch or assembly when removing the clutch pedal assembly.

8. Remove the clutch pedal assembly.
9. Loosen the clutch cable jam nut (under the hood). **Fig. 2**.

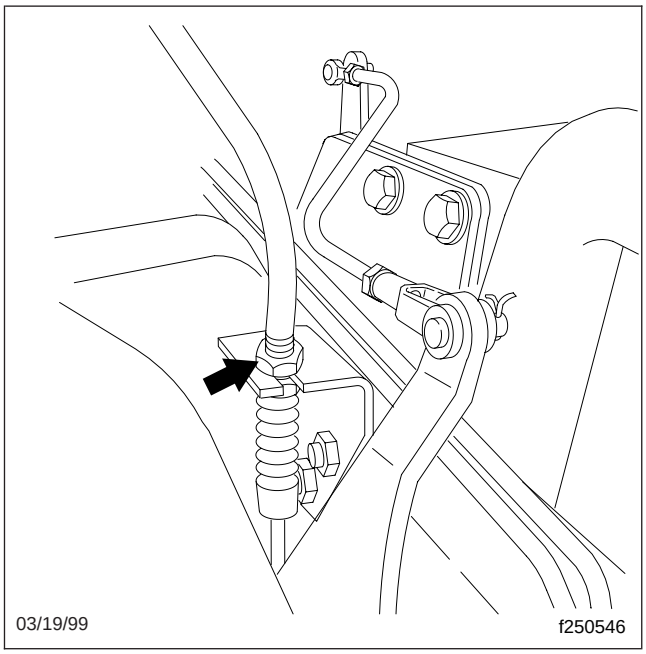


Fig. 2, Clutch Cable Jam Nut

10. Remove the cotter pin from the lower end of the flex cable and disconnect the cable from the pivot arm (clutch release lever). See **Fig. 3**.
11. Pull the carpet back and remove the cable by pulling it through the floor panel.

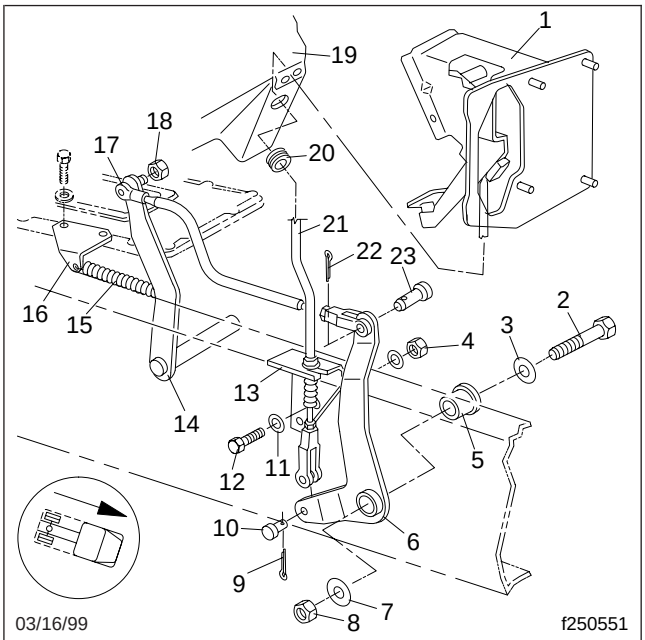
Installation

NOTE: The following step is a two-person operation.

1. Install the clutch flex cable.

   1.1 Attach a 30-inch (76.2-cm) piece of wire to the narrow end of the flex cable.

Right-Hand-Drive Clutch Flex Cable Removal and Installation



1. Clutch Pedal Assembly (cab interior)
2. Actuating Lever Through-Bolt
3. Flatwasher
4. Cotter Pin
5. Bushing
6. Clutch Lever (pivot arm)
7. Flatwasher
8. Locknut
9. Cotter Pin
10. Clevis Pin
11. Flatwasher
12. Retaining Bolt
13. Clutch Cable Retaining Bracket
14. Clutch Lever (pivot arm)
15. Clutch Lever Return Spring
16. Spring Return Bracket
17. Clutch Rod
18. Locknut
19. Cab Wall
20. Grommet
21. Clutch Cable
22. Cotter Pin
23. Clevis Pin

Fig. 3, Clutch Linkage Components

1.2 Have one person pull the wire from inside the cab while the other guides the flex cable through the floor panel.

2. Install the clutch pedal.

2.1 Align the clutch pedal with the flex cable and insert the rod.

2.2 Connect the clevis to the rod connecting the clutch pedal to the flex cable. Insert the cotter pin. See **Fig. 3**.

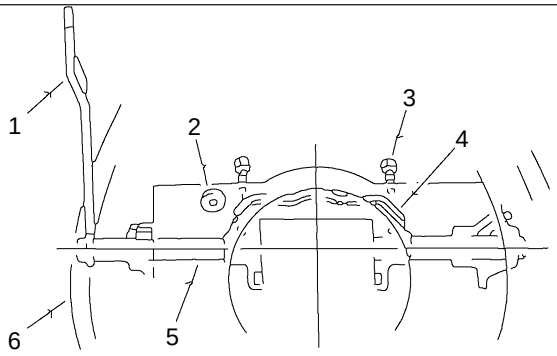
NOTE: Bushings are fragile.

3. Install the clutch pedal shaft, the four bushings and attach the retaining clips to each end of the shaft.
4. Install the clutch cable into the upper clutch cable bracket (under the dash).
5. Insert the cable into the lower clutch cable bracket (under the hood) and tighten the jam nut 15 to 30 lbf·ft (21 to 40 N·m). See **Fig. 2**.
6. Connect the flex cable to the pivot arm.
7. Adjust clutch free play, if necessary.
8. Install the splash shield. Tighten the five fasteners until snug.
9. Install the under steering panel and tighten the five screws until snug.
10. Close the hood.
11. Remove the chocks from the tires.

Clutch Release Fork/Lever/Shaft Removal and Installation

Removal

1. Remove the transmission; see **Group 26** of this manual.
2. Remove the two bolts and the clutch release lever. See **Fig. 1**.



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1. Clutch Release Arm
2. Washer
3. Bolt
4. Clutch Release Lever
5. Clutch Release Stud Shaft
6. Transmission Clutch Housing

Fig. 1, Clutch Release Lever

3. Slide the clutch release stud shaft out from the clutch housing. See **Fig. 2**.

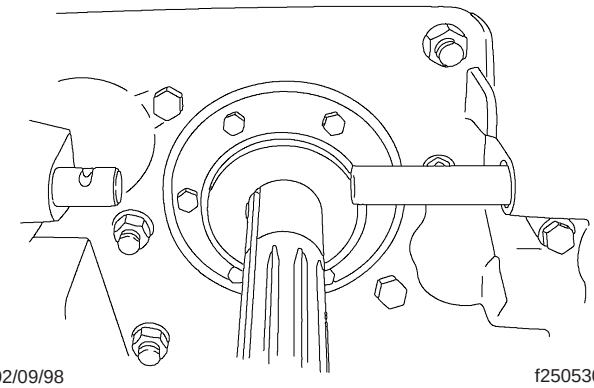

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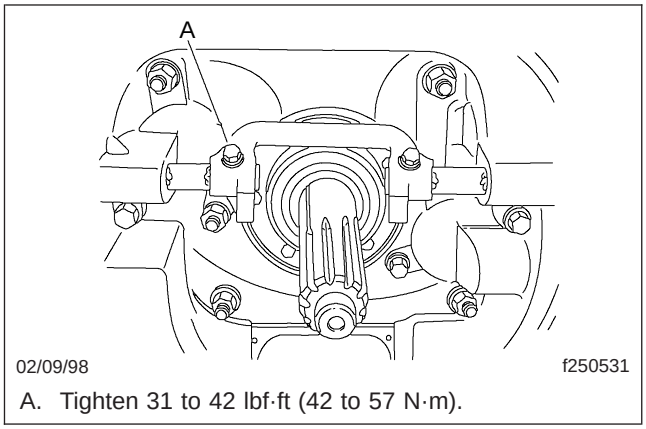
Fig. 2, Clutch Release Stud Shaft

Installation

1. Slide the clutch release stud shaft into the clutch housing.
2. Install the clutch release lever and bolts. Tighten the bolts 31 to 42 lbf·ft (42 to 57 N·m). See **Fig. 3**.



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A. Tighten 31 to 42 lbf·ft (42 to 57 N·m).

Fig. 3, Clutch Release Lever Bolts

Adjustment

IMPORTANT: Observe the following points before performing the clutch linkage adjustment:

- Be sure internal clutch adjustments are correct before making adjustments to the clutch linkage. See the appropriate section in this manual.
- Adjust clutch linkage only after repair or replacement of the clutch or clutch linkage components.
- Do not attempt to adjust the linkage to compensate for component wear.
- If equipped with cab air suspension, be sure the air bags are properly inflated. If the air bags are not inflated, the clutch linkage cannot be adjusted correctly.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Remove the clutch inspection cover from the bottom of the bell housing.
4. Measure the distance between the release yoke and the release bearing. If this measurement is 1/8-inch (3.2-mm), no further work is needed. If the measurement is incorrect, do all the remaining steps.
5. Be sure the clutch pedal is all the way up against the upper stop.
6. For solid linkage, loosen the jam nuts on both sides of the adjusting rod at the upper end of the clutch release rod. See **Fig. 1**.

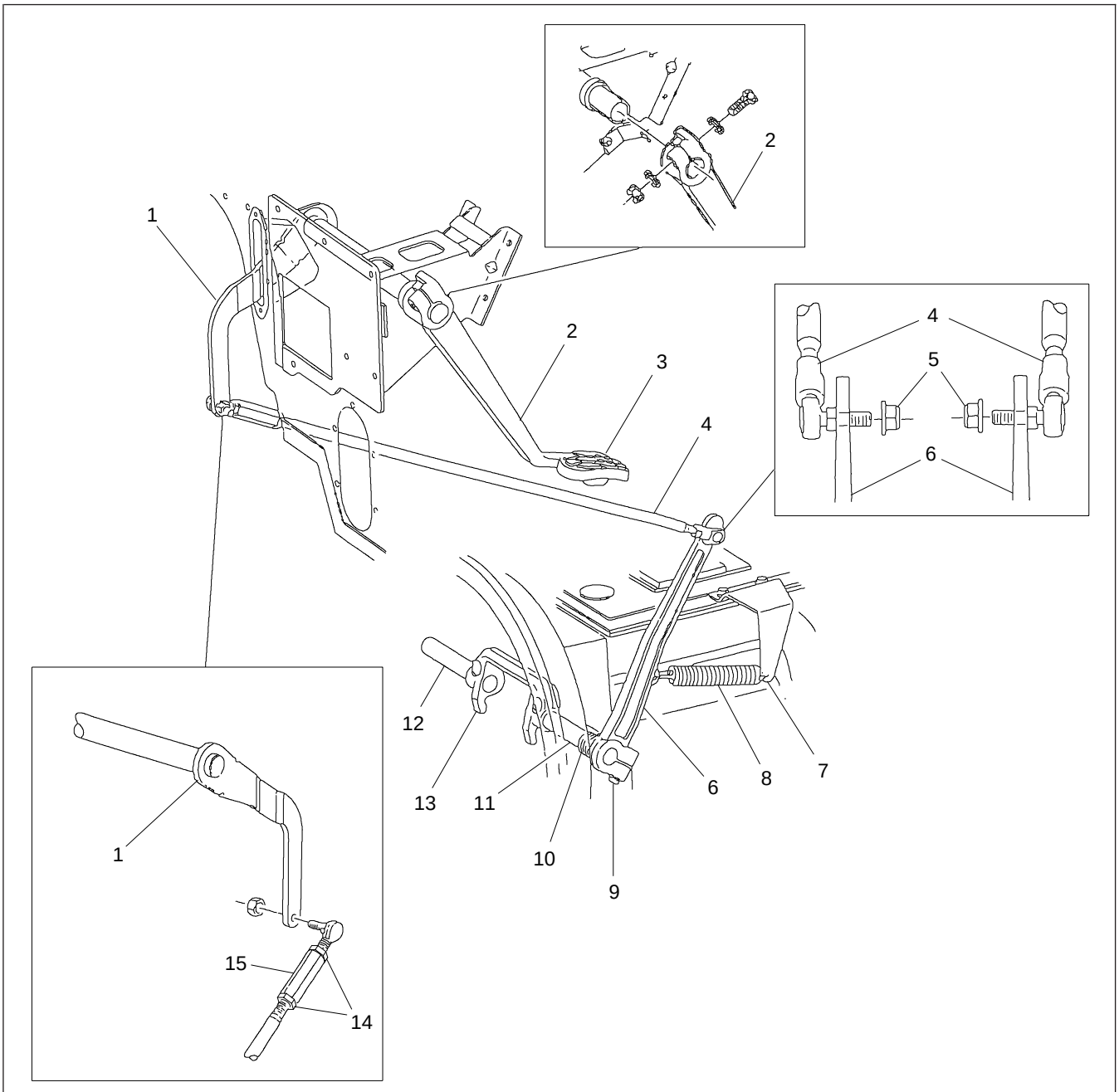
   For cable linkage, loosen the jam nut under the clevis at the upper end of the clutch release cable. See **Fig. 2**.
7. For solid linkage, disconnect the clutch rod from the pedal shaft assembly. See **Fig. 1**.

   For cable linkage, disconnect the release cable from the pedal shaft assembly. See **Fig. 2**.
8. Set the distance between the release yoke and the release bearing to 1/8-inch (3.2-mm) and hold.
9. For solid linkage, turn the adjusting nut on the upper end of the release rod until the center of the rod-end hole is aligned with the center of the hole in the pedal shaft lever. Tighten the jam nuts on both sides of the adjusting nut 15 to 30 lbf·ft (21 to 40 N·m). After adjusting the linkage, at least 3/8-inch (9.5-mm) of thread must remain engaged in each end of the adjusting nut.

   For cable linkage, turn the clevis at the upper end of the release cable until the center of the clevis hole is aligned with the center of the hole in the pedal shaft lever. Tighten the jam nut under the clevis 15 to 30 lbf·ft (21 to 40 N·m). After adjusting the cable, at least 3/8-inch (9.5-mm) of thread must remain engaged in the bottom of the clevis.
10. For solid linkage, connect the clutch rod to the pedal shaft assembly and tighten the nut 31 to 42 lbf·ft (42 to 57 N·m).

    For cable linkage, connect the release cable to the pedal shaft assembly and tighten the nut 31 to 42 lbf·ft (42 to 57 N·m).
11. Release the yoke and clutch bearing.
12. Install the inspection cover on the bottom of the bell housing.
13. Close and latch the hood.
14. Remove the chocks from the rear tires.

Clutch Pedal Adjustment



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1. Pedal Shaft and Lever Assembly
2. Clutch Pedal
3. Clutch Pedal Pad
4. Clutch Release Rod
5. Nut
6. Clutch Release Shaft Lever
7. Clutch Return Spring Bracket
8. Clutch Release Spring
9. Bolt
10. Clutch Release Lever Anti-Rattle Spring
11. Left Clutch Release Shaft
12. Right Clutch Release Shaft
13. Clutch Release Yoke
14. Jam Nuts
15. Adjusting Nut

Fig. 1, Clutch Linkage System

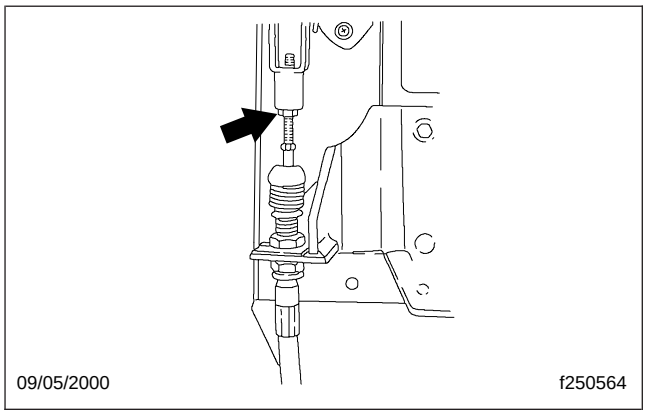


Fig. 2, Clutch Cable Jam Nut

Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Clutch Pedal Nut	31–42 (42–57)
Rod-to-Clutch Release Lever Nut	31–42 (42–57)
Clutch Release Lever Nut	31–42 (42–57)
Clutch Cable/Rod Jam Nuts	15–30 (21–40)

Table 1, Torque Specifications

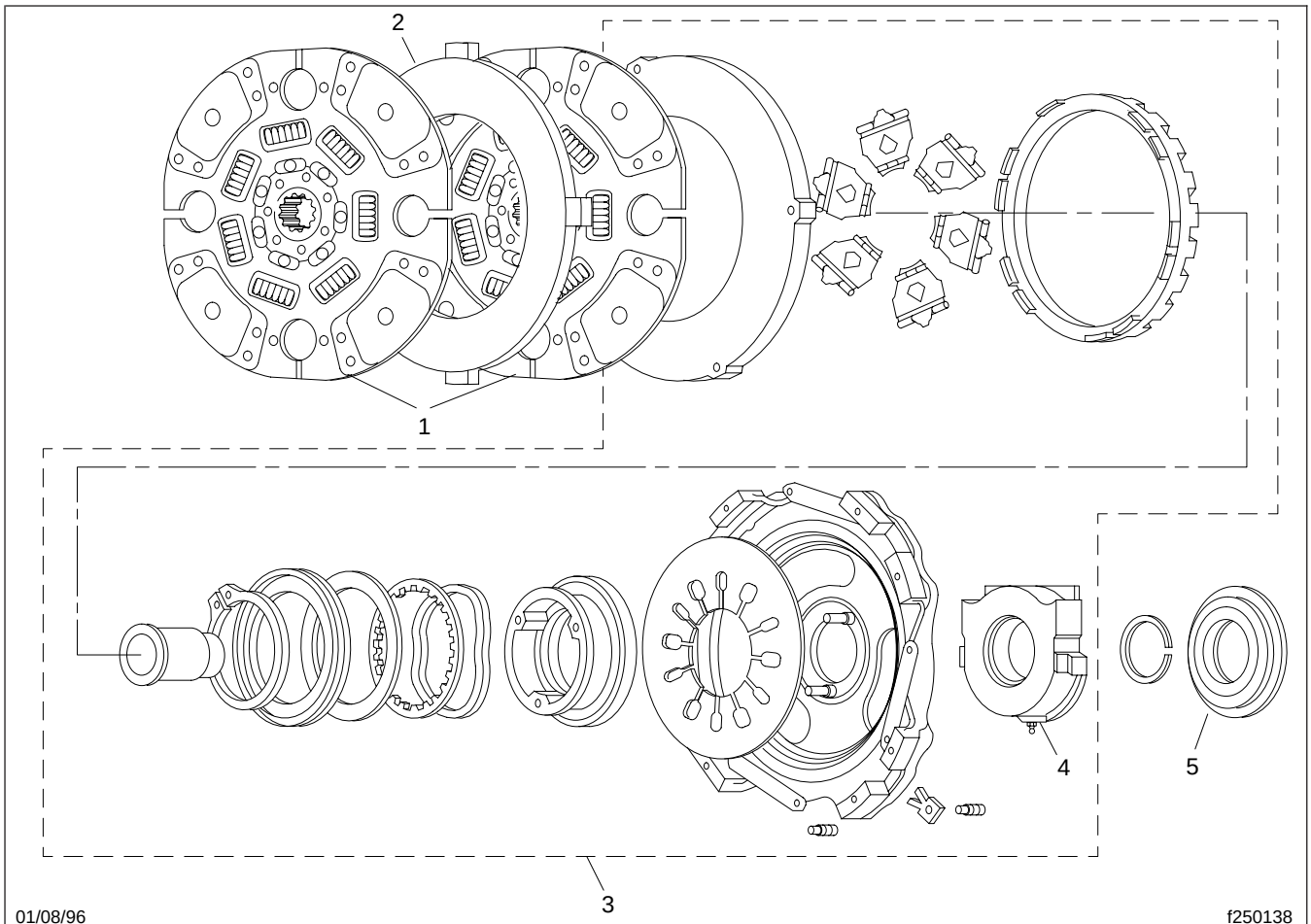
General Information

Sterling trucks offer 15-1/2 inch Meritor clutch models (**Fig. 1**). An identification plate is located on the front cover. Meritor clutches feature the following design characteristics:

- dual-plate
- diaphragm spring
- pull-type
- dry-disc

Mounted directly on the flywheel, the clutch cover assembly houses most of the components, including the pressure plate. A diaphragm spring provides the force necessary to push the pressure plate forward and engage the clutch. The center plate, which separates the driven discs, has tabs that fit into slots on the clutch cover assembly.

A splined 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 hubs of the driven discs mesh with the



1. Ceramic Discs
2. Center Plate
3. Pressure Plate and Cover Assembly
4. Release Bearing
5. Clutch Brake

Fig. 1, Meritor Dual-Plate Clutch

splined input shaft to transmit power from the engine

General Information

to the transmission. The rest of the clutch assembly can spin freely around the input shaft when the clutch pedal is depressed.

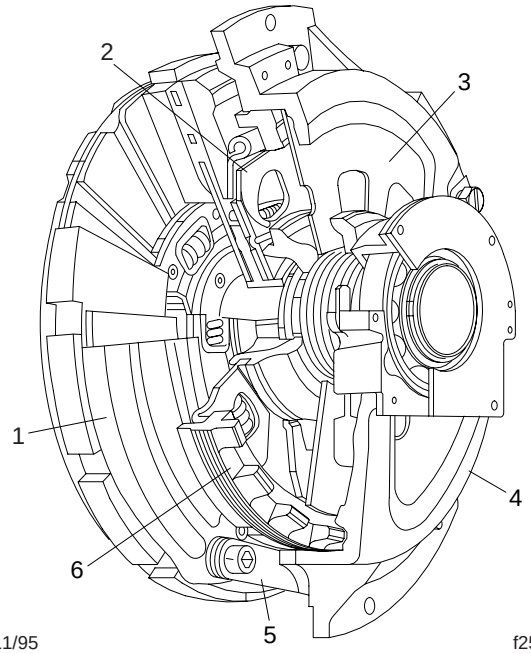
A clutch brake stops the transmission gears from rotating when the truck is stopped and when shifting into first or reverse gears. This lets the gears engage quickly without gear clash.

The release bearing assembly transfers the movement of the clutch linkage to engage or disengage the clutch. The release bearing assembly is available with a grease fitting or as an "extended lube" assembly. Ball bearings permit the release bearing to rotate freely. A coil spring is installed on the sleeve between the release bearing and the hub. The coil spring holds the sleeve on the retainer in a "ball joint" arrangement. This prevents vibration and allows for minor misalignment that may occur between the transmission and the engine due to tolerances between the mounting surface dimensions.

The pressure plate and cover assembly apply the force necessary to engage the clutch. The following parts are in the pressure plate and cover assembly (see **Fig. 2**):

- The *cover* is the housing for the diaphragm spring, adjusting ring, levers, retainer, and the release bearing sleeve. Three holes in the cover provide air flow to remove heat from the clutch.
- The *diaphragm spring* is a one-piece unit that produces the pressure to lock the discs between the pressure plate, the center plate, and the flywheel. The spring is located and held in the cover by the retainer.
- Six *levers* connect the cover assembly to the release bearing sleeve. The levers multiply and transfer the force of the diaphragm spring from the retainer to the pressure plate.
- The *adjusting ring*, located inside the cover and in front of the pressure plate, controls the release bearing clearance. The clearance must be adjusted periodically to compensate for clutch lining wear.
- The *pressure plate* applies the force from the diaphragm spring and locks the clutch discs between the center plate and the flywheel.

The clutch discs are splined to allow movement along the transmission input shaft. Power is transmitted from the flywheel, pressure plate, and center



1. Pressure Plate
2. Lever
3. Diaphragm Spring
4. Cover
5. Strap
6. Adjusting Ring

Fig. 2, Clutch Components

plate through the discs to the transmission. Soft-rate damper springs absorb the damaging engine torsional vibrations. Ceramic disc linings (**Fig. 3**), are made from ceramic and bronze material. Rivets fasten the ceramic lining to the disc. The ceramic lining provides positive clutch engagement. The co-axial torsion springs also absorb torque shock during engagement.

The center plate increases the service life of the clutch by increasing the surface area for power transfer. The 15-1/2 inch clutch center plate is driven by tabs on the plate which fit into slots on the clutch cover.

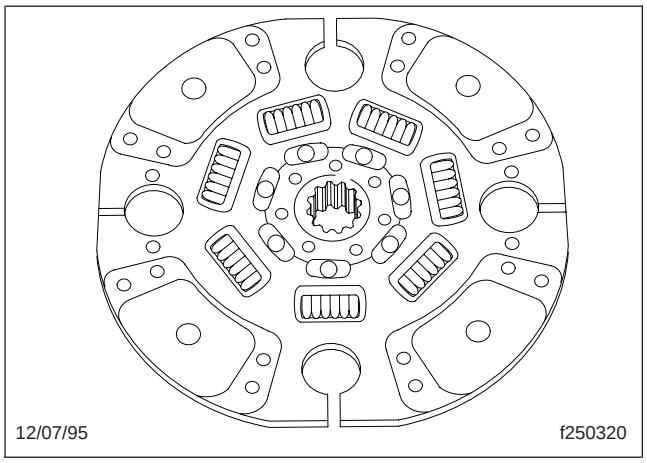


Fig. 3, Ceramic Disc

Clutch Adjustments

NOTE: Clutch linkage adjustment is required only after repair or replacement of the clutch or clutch linkage components. See **Section 25.01** for procedures.

Internal clutch adjustments should be done whenever:

- The clutch is removed or installed;
- Any component of the clutch linkage is serviced;
- The clutch free pedal is less than 1.50 in (38.1 mm).

Before adjusting the clutch make sure:

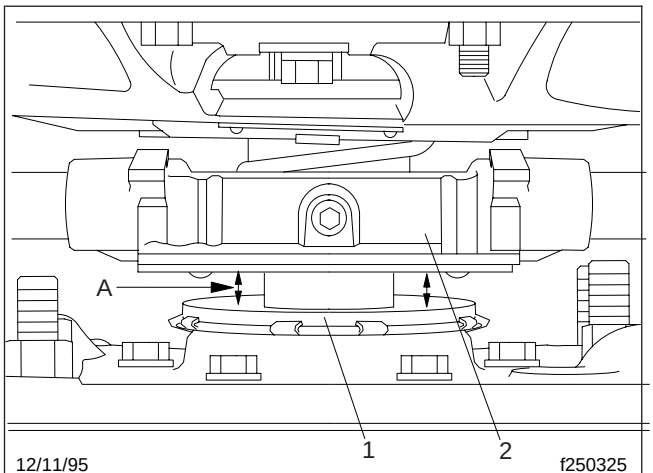
- The clutch system is in good condition;
- The linkage is tight but moves freely during operation;
- The release fork moves when the clutch pedal moves;
- There is no "false" free pedal. Keep the clutch lever from moving and depress the clutch pedal. If the pedal moves more than 2.0 in (50.8 mm), "false free pedal" is in the linkage. Inspect the linkage and all pivot points for wear or damage. Repair or replace worn or damaged parts.

RELEASE-BEARING CLEARANCE CHECK

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the inspection hole cover on the clutch housing.
3. Measure the distance between the end of the release bearing and the clutch brake. See **Fig. 1**. This distance must be 0.50 to 0.56 inch (12.7 to 14.2 mm).

NOTE: While checking this dimension, pull the release bearing toward the transmission using your hand or a screwdriver.

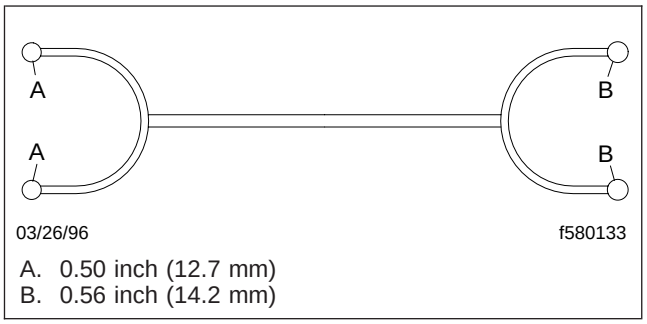
IMPORTANT: An inspection tool A02-12419 (available through the PDCs) can be used to check the distance between the release bearing and the clutch brake. See **Fig. 2**. One end of the tool has green tape on it and is 0.50 inch (12.7 mm) in diameter; the other end has blue tape on it and is 0.56 inch (14.2 mm) in diameter.



A. 0.50 to 0.56 inch (12.7 to 14.2 mm) clearance
1. Clutch Brake
2. Release Bearing

Fig. 1, Measuring the Release Bearing Clearance

4. 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 (14.2 mm)

Fig. 2, Inspection Tool A02-12419

4.1 Insert the blue 0.56-inch (14.2-mm) end. If it fits loosely the gap is too wide and adjustment is needed. Go to the next step.

Clutch Adjustments

4.2 If the blue 0.56-inch (14.2-mm) end cannot 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, no adjustment is needed.

4.3 If the green end of the tool cannot be inserted in the gap, adjustment is needed. Go to the next step.

5. If the release bearing clearance is not correct, adjust the clutch.

5.1 Turn the flywheel so that the lock plate is seen through the inspection cover. See **Fig. 3**.

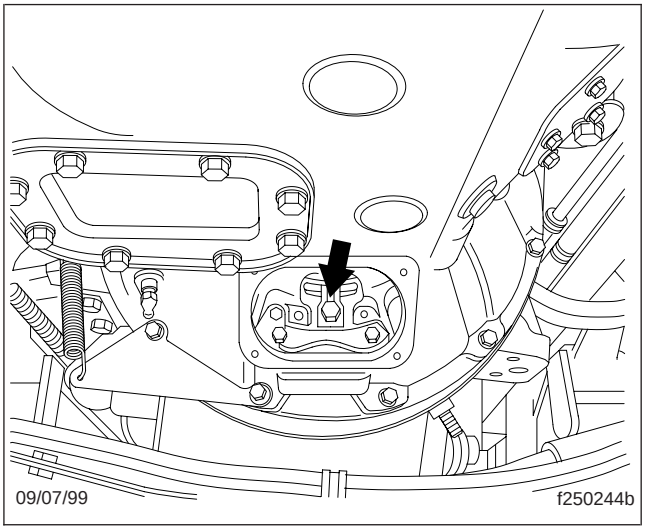


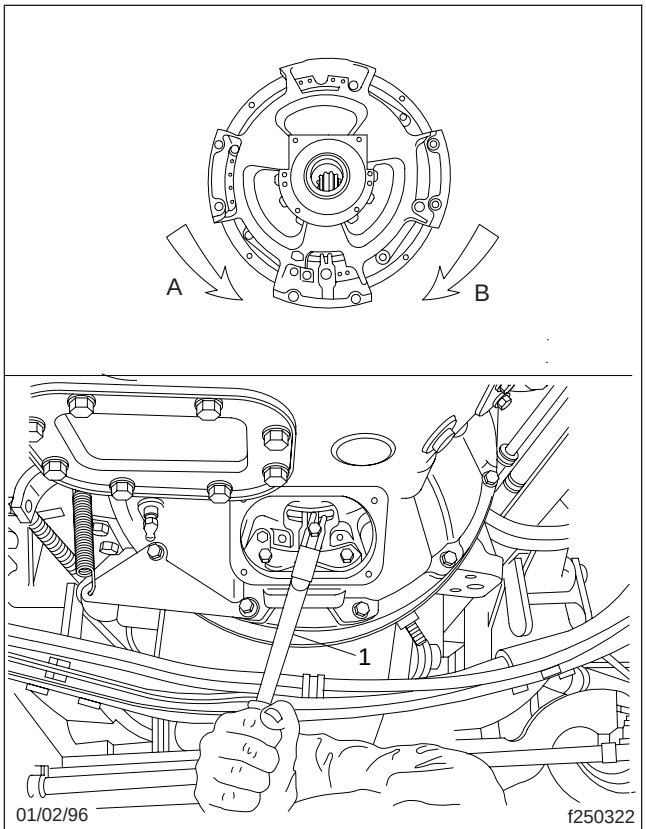
Fig. 3, Lock Plate Capscrew

NOTE: Do not use the starter to move the flywheel. Turn the crankshaft with a socket wrench on the front pulley. If the front pulley is difficult to turn, use a spanner wrench on the teeth of the flywheel. See the engine manufacturer's manual for further information.

5.2 Push the clutch pedal to the bottom of its travel. Have another person hold the pedal at the bottom of its travel (or use a block of wood to hold the pedal).

5.3 Remove the capscrew and lockwasher that fasten the lock plate to the clutch cover. See **Fig. 3**.

5.4 Turn the adjusting ring to obtain the specified release bearing clearance. Using a screwdriver or an adjusting tool as a lever against the notches in the ring, move the adjusting ring. See **Fig. 4**. When the adjusting ring is moved one notch, the release bearing will move 0.03 inch (about 0.8 mm).



A. Turn the adjusting ring in this direction to move the release bearing *toward* the clutch.
B. Turn the adjusting ring in this direction to move the release bearing *away from* the clutch.
1. Adjusting Ring Tool

Fig. 4, Turning the Adjusting Ring

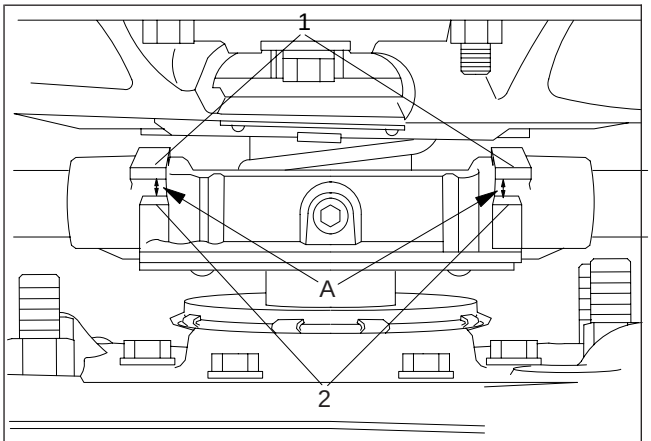
NOTE: The adjusting tool is available from: Kent-Moore Tools, part number J-36216; Owatonna Tools, part number 7028; or, Snap-On Tools®, part number GA454.

5.5 Install the lock plate. Install the capscrew that fastens the lock plate to the clutch

cover. Tighten the capscrew 25 to 30 lbf·ft (34 to 40 N·m).

5.6 Release the clutch pedal.

6. Check the clearance between the tips of the release fork and the bosses on the release bearing. The distance must be 0.105 to 0.145 inch (2.7 to 3.7 mm). See **Fig. 5**. If necessary, adjust the clutch linkage. For instructions, see **Section 25.01**.



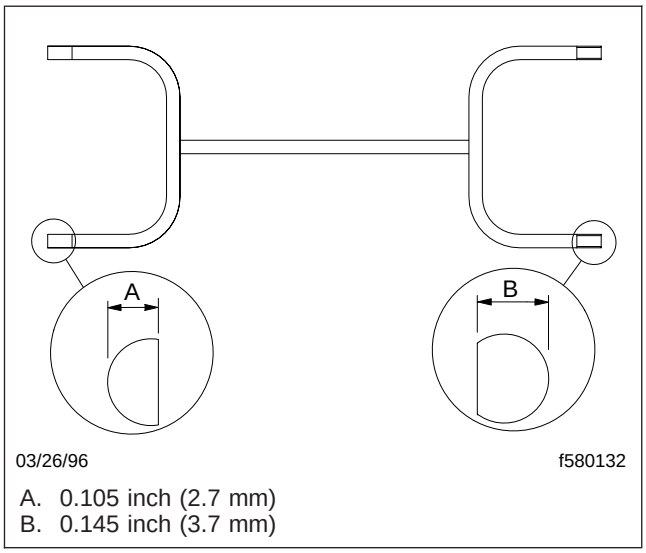
A. 0.105 to 0.145 inch (2.7 to 3.7 mm) clearance
1. Release Fork
2. Boss on Release Bearing

Fig. 5, Checking Clearance

NOTE: The pedal must be released to check the release bearing clearance.

IMPORTANT: An inspection tool A02-12254 (available through the PDCs) can be used to check the distance between the bosses on the release bearing and the tips of the release fork (free travel). See **Fig. 6**. The legs on one end of the tool have green tape on them and are 0.105 inch (2.7 mm) thick; the legs on the other end have blue tape on them and are 0.145 inch (3.7 mm) thick.

7. If using tool A02-12254 to check the distance between the release bearing and the release fork, position the tool so it straddles the fork to ensure that there will not 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. 6, Inspection Tool A02-12254

7.1 Insert the blue 0.145-inch (3.7-mm) end. If it fits loosely the gap is too wide and adjustment is needed. For instructions, see **Section 25.01**.

7.2 If the blue 0.145-inch (3.7-mm) end cannot 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, no adjustment is needed.

7.3 If the green end of the tool cannot be inserted in the gap, adjustment is needed. For instructions, see **Section 25.01**.

8. Remove the chocks from the tires.

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the transmission. Follow the procedures in **Group 26** of this manual.

CAUTION

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported by the input shaft in the pilot bearing bore in the flywheel. Taking these precautions will prevent damage to the clutch assembly and the pilot bearing.

3. Remove the clutch brake assembly from the transmission input shaft. See **Fig. 1**.

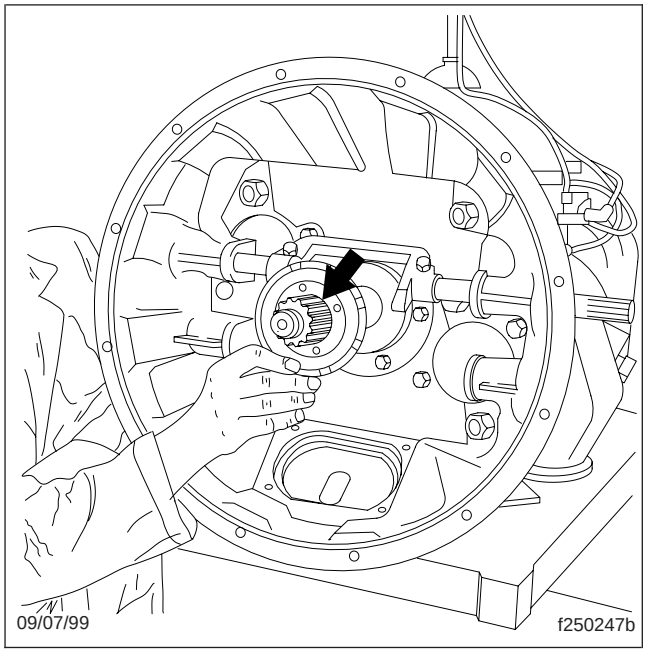


Fig. 1, Clutch Brake

4. Install a clutch alignment tool through the clutch and into the flywheel pilot bearing to support the clutch assembly during removal. Use the correct tool so that the splines of the tool match the splines in the clutch. See **Fig. 2**.

NOTE: If an alignment tool is not available, use an input shaft from a manual transmission. Remove the gear from the end of the input shaft. See **Fig. 3**.

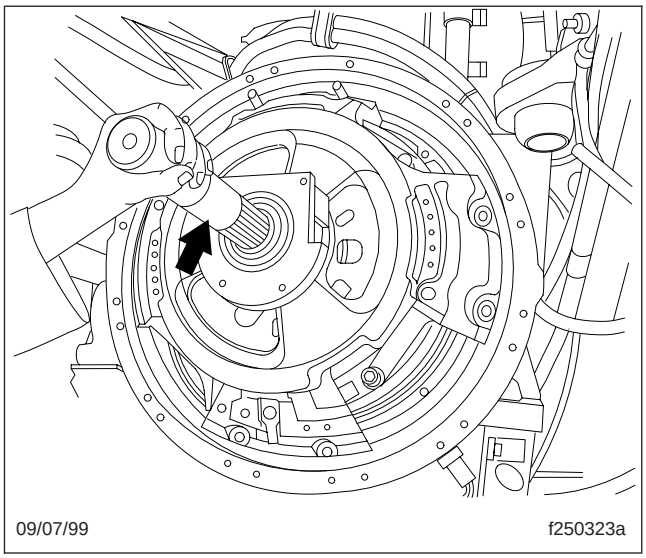
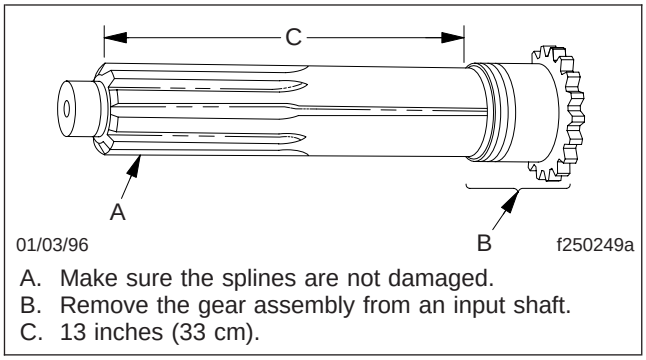


Fig. 2, Clutch Alignment Tool

5. Remove the top two bolts that fasten the pressure plate and cover assembly to the flywheel. Install two guide studs in the holes. See **Fig. 4**. The studs can be made by removing the head from two 7/16-inch capscrews.



A. Make sure the splines are not damaged.
B. Remove the gear assembly from an input shaft.
C. 13 inches (33 cm).

Fig. 3, Manual Transmission Input Shaft

6. Make two wooden spacer blocks 1/2 to 5/8 inch (13 to 16 mm) thick. Insert them between the release bearing assembly and the clutch cover. The wooden spacer blocks ease removal and installation of the clutch. See **Fig. 5**.

Clutch Removal

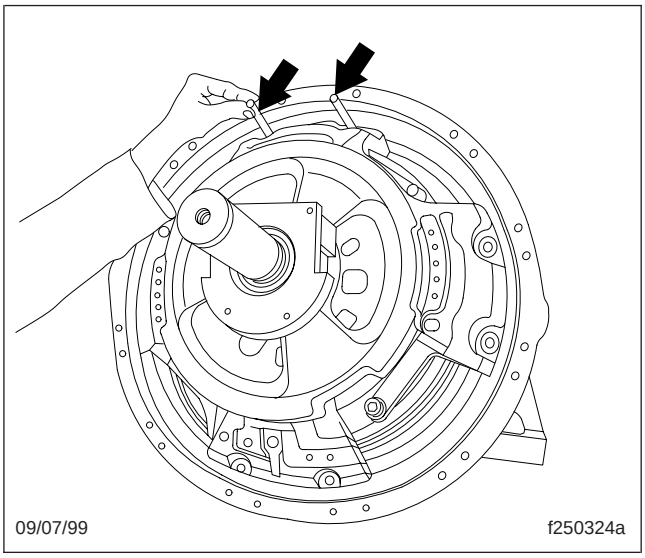


Fig. 4, Guide Studs

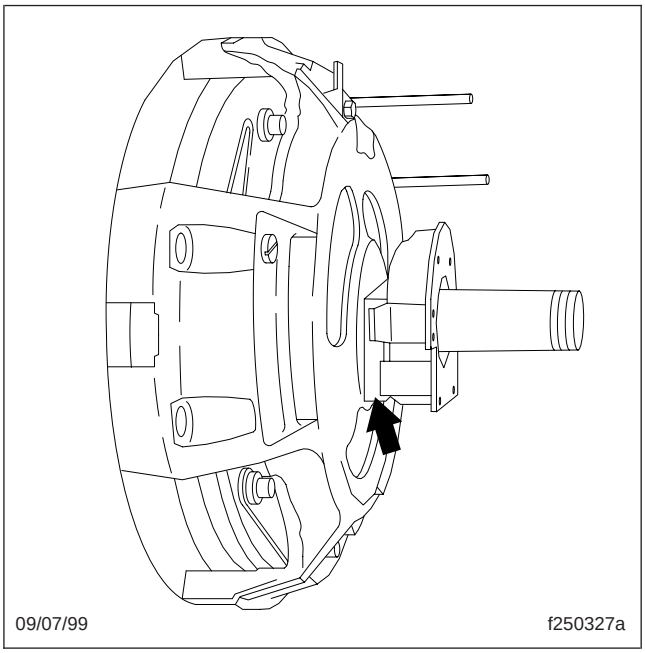
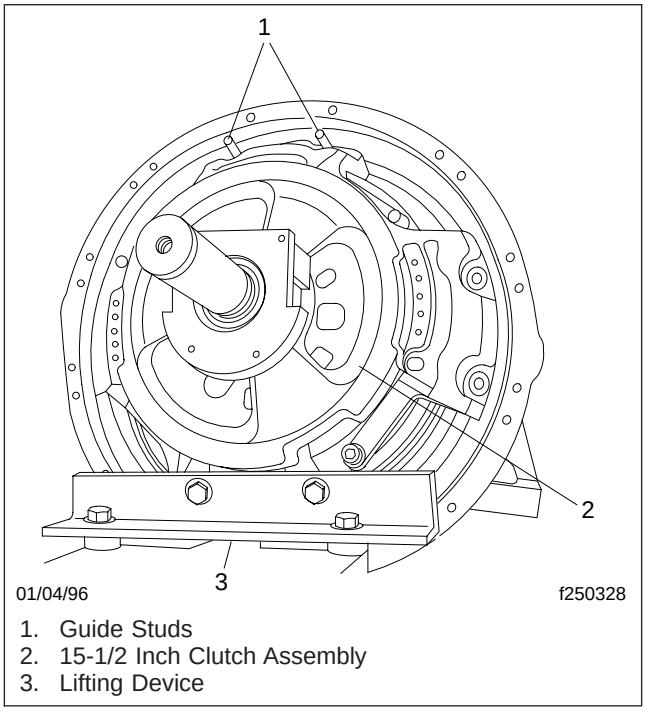


Fig. 5, 1/2- to 5/8-inch (13- to 16-mm) Spacers

⚠ WARNING

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

7. Connect a lifting device to the pressure plate and cover assembly. See **Fig. 6**.



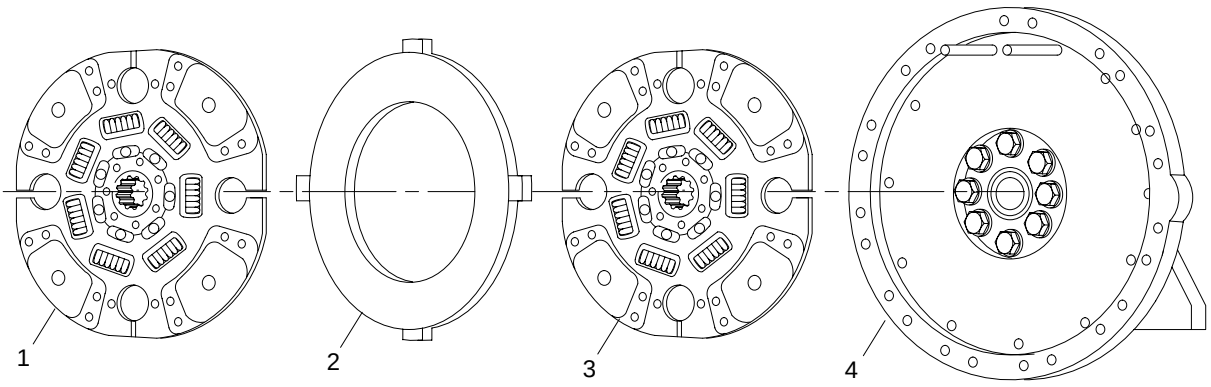
1. Guide Studs
2. 15-1/2 Inch Clutch Assembly
3. Lifting Device

Fig. 6, Connecting a Lifting Device

8. Remove the remaining bolts that fasten the pressure plate and cover assembly to the flywheel.

NOTE: When removing the clutch, the discs and the pressure plate can stay in the cover.

9. Remove the pressure plate and cover assembly over the alignment tool and off the flywheel.
10. Remove the alignment tool, the rear disc, the center plate, and the front disc. See **Fig. 7**.
11. Whenever the clutch assembly is serviced or the engine is removed, the pilot bearing in the flywheel should be removed and replaced. Use an appropriate internal puller to remove the pilot bearing. Discard the pilot bearing.



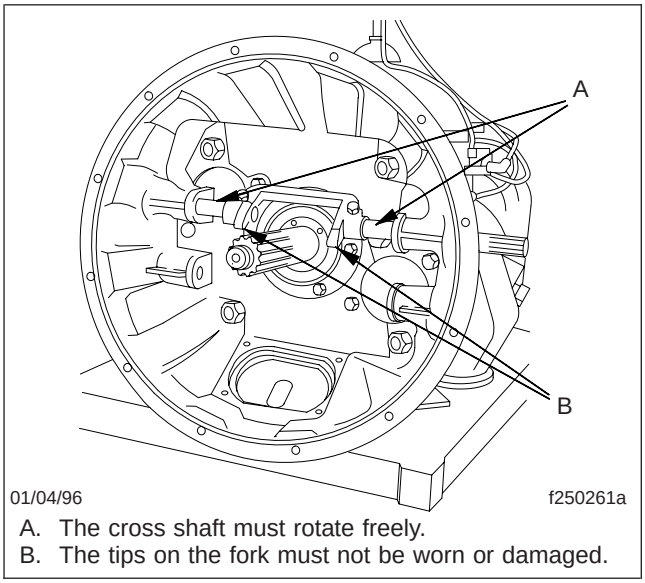
1. Front Clutch Disc
2. Center Plate
3. Rear Clutch Disc
4. Flywheel Housing

Fig. 7, Front Disc, Rear Disc, and Center Plate Removal

Inspection

1. Remove the clutch from the vehicle. See **Subject 110** for instructions.
2. Inspect the release fork and the cross shaft. See **Fig. 1**. Make sure the release fork is straight and the tips of the fork are not worn or damaged. Replace forks that are worn or damaged.

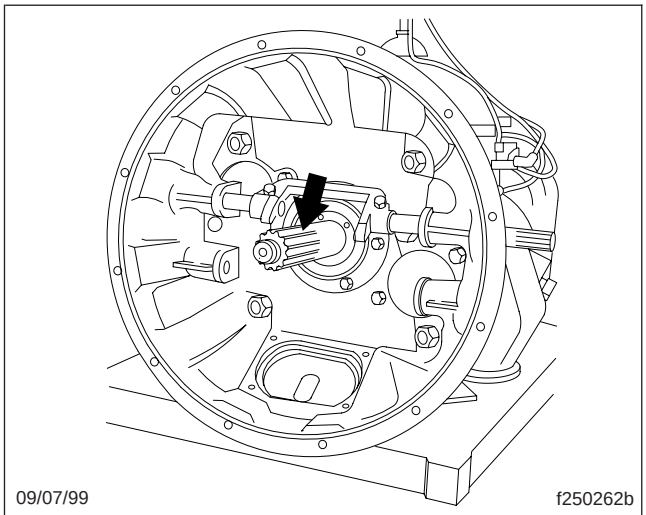
   Make sure the cross shaft rotates freely and doesn't have any side-to-side movement in the transmission housing. If used, inspect the bushings for the shaft in the housing. Replace any parts that are worn or damaged. For instructions, refer to **Section 25.01**.



A. The cross shaft must rotate freely.
B. The tips on the fork must not be worn or damaged.

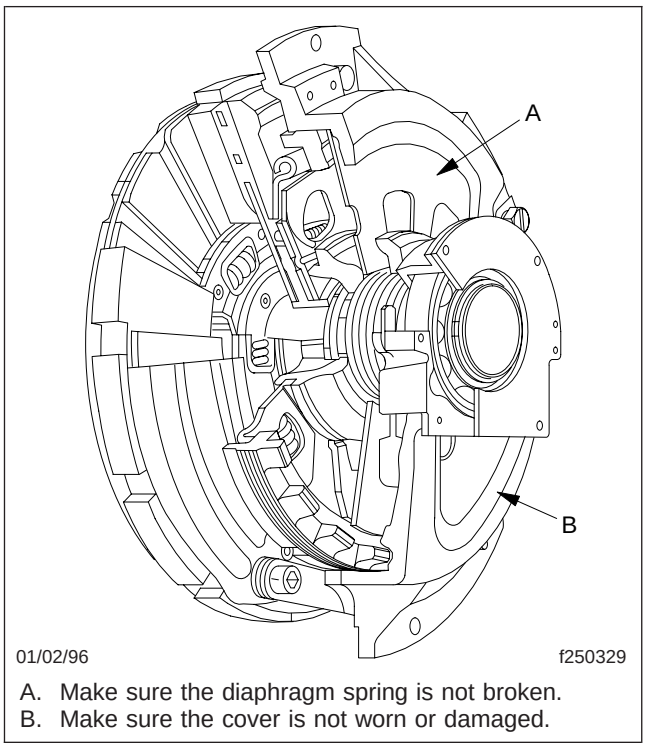
Fig. 1, Release Fork and Cross Shaft Inspection

3. Inspect the splines on the input shaft. See **Fig. 2**. Make sure the splines are not worn or damaged. Inspect the release bearing area of travel for damage. Using an emery cloth, remove small scratches from the input shaft. If the input shaft is worn or damaged, replace it. Any wear or damage on the input shaft causes the clutch to work incorrectly.
4. Remove dirt and contamination from the pressure plate and cover assembly with non-petroleum based cleaning solvents.
5. Inspect the cover for wear and damage. Make sure the diaphragm spring inside the cover is not broken. See **Fig. 3**. If the diaphragm spring is broken, the clutch cover must be disassembled to replace the spring.



NOTE: The splines must not be worn or damaged.

Fig. 2, Input Shaft Splines



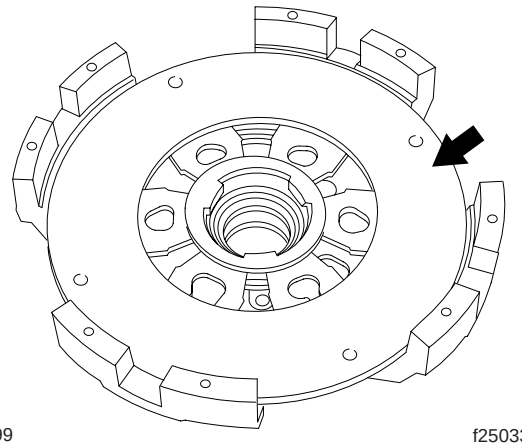
A. Make sure the diaphragm spring is not broken.
B. Make sure the cover is not worn or damaged.

Fig. 3, Diaphragm Spring and Cover Inspection

Clutch Inspection

6. Inspect the pressure plate.

   6.1 Visually check the pressure plate for wear or damage. See **Fig. 4**. If the plate is cracked, replace it. Heat marks are normal, and can usually be removed with an emery cloth. If the heat marks can't be removed, replace the pressure plate.



NOTE: Inspect the pressure plate surface for wear, cracks, or heat damage.

Fig. 4, Pressure Plate

   6.2 Put the pressure plate and cover assembly on a bench with the plate facing up.

   6.3 Using a caliper, measure any scratches or scoring on the pressure plate. See **Fig. 5**. If the damage to the surface of the plate is more than 0.015 inch (0.38 mm), replace the pressure plate.

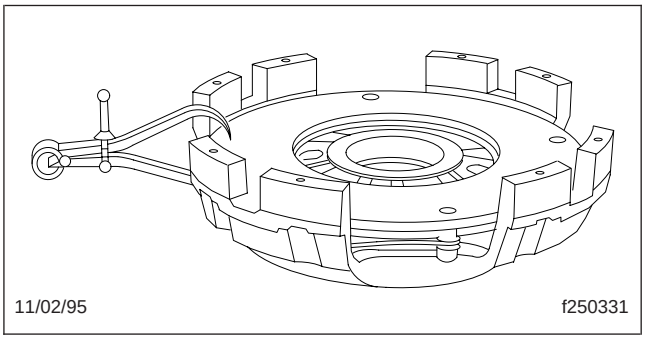
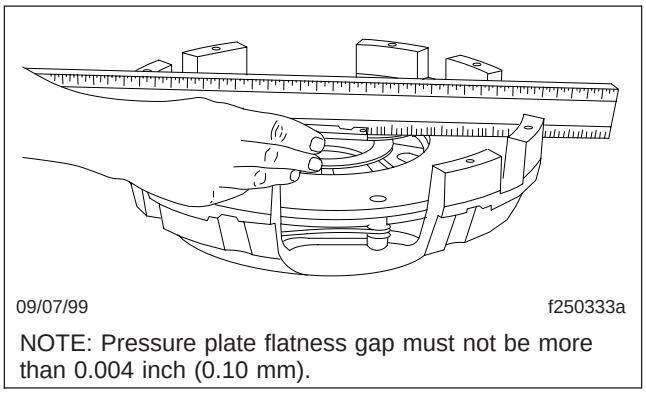


Fig. 5, Measuring Scratches or Scoring on the Pressure Plate

   6.4 Make sure the surface of the pressure plate is flat. Put a straightedge on the surface of the center plate, making sure it crosses the center of the plate. See **Fig. 6**. Using a feeler gauge, measure each gap that appears between the straightedge and the pressure plate. Rotate the straightedge through at least four positions. If any gap is more than 0.004 inch (0.10 mm), replace the pressure plate.



NOTE: Pressure plate flatness gap must not be more than 0.004 inch (0.10 mm).

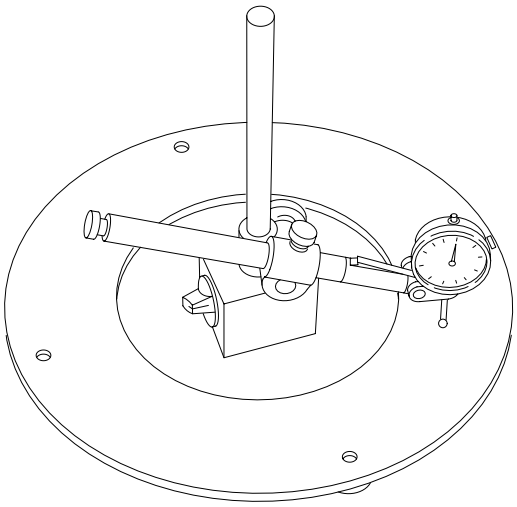
Fig. 6, Checking the Pressure Plate Surface

   6.5 Measure the runout of the pressure plate to make sure the surfaces are parallel to each other. Put marks on a capscrew, strap, and pressure plate location to ensure that the pressure plate is installed in the original position on the cover. Remove the capscrews that fasten the pressure plate to the strap. Put the pressure plate on a bench so that the smooth surface is up. Put the base of a dial indicator inside the center of the plate. See **Fig. 7**. Put the tip of the dial indicator on the surface of the plate. Set the dial indicator to zero. Rotate the dial indicator one complete turn around the surface of the pressure plate. If the reading on the indicator is more than 0.002 inch (0.05 mm), replace the pressure plate.

7. Inspect the clutch discs.

   7.1 Visually check for wear or damage. If any disc is worn, replace it.

   7.2 Make sure the co-axial springs are not loose in the hub. See **Fig. 8**. Springs that rattle are not necessarily loose; springs



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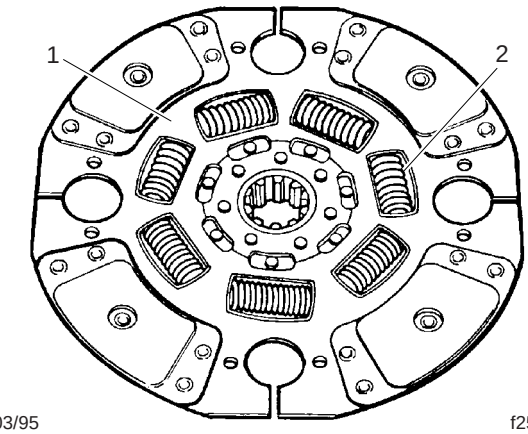
NOTE: Pressure plate runout must not be more than 0.002 inch (0.05 mm).

Fig. 7, Dial Indicator Mounting

that have any movement are. If any disc has loose springs, replace it.



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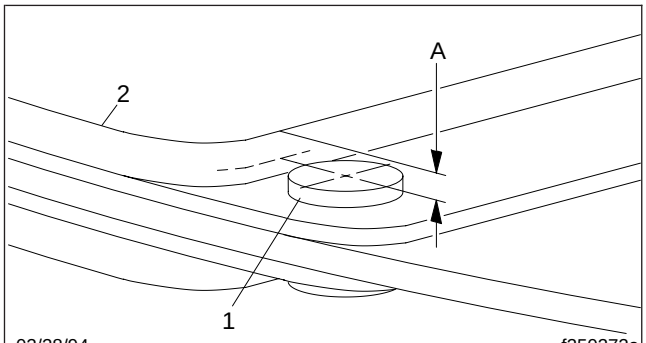
1. Hub
2. Co-Axial Spring

Fig. 8, Checking the Co-Axial Springs

7.3 Make sure the splines in the hub are not damaged. Make sure the hub is fastened to the disc. Replace any disc that is damaged.

7.4 Using a cleaning solvent with a non-petroleum base, remove grease and oil from the discs. If the grease and oil cannot be removed, replace the disc.

7.5 Ceramic linings are fastened to the disc with rivets. Replace the disc if the lining is loose, damaged, or worn to the top of the rivets. See **Fig. 9**.



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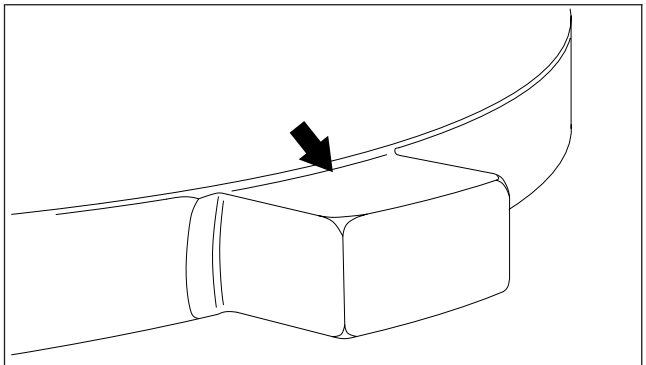
A. Replace the ceramic disc if the lining is even with or below the top of the rivet.
1. Rivet
2. Lining

Fig. 9, Checking the Ceramic Lining

8. Inspect the center plate.

8.1 Inspect the tabs on the outer edge of the center plate. See **Fig. 10**. If the tabs are worn or damaged, replace the center plate. If not, go to the next step and inspect the center plate.



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NOTE: Make sure the tabs are not worn or damaged.

Fig. 10, Tab

Clutch Inspection

8.2 Inspect the center plate for wear or damage. If the plate is cracked, replace it. Heat marks are normal, and can usually be removed with an emery cloth. If the heat marks cannot be removed, replace the center plate.

8.3 Using a micrometer or a caliper, measure the thickness of the center plate. The minimum thickness should be 0.742 inch (18.84 mm). If the center plate measures less than the minimum thickness, replace it. See **Fig. 11**.

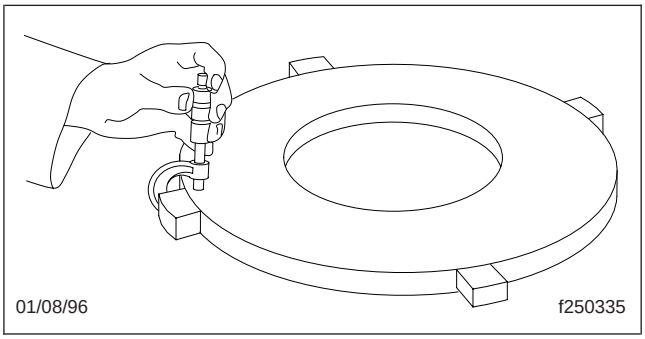


Fig. 11, Measuring Center Plate Thickness

8.4 Make sure the surface of the center plate is flat. Put a straightedge on the surface of the center plate, making sure it crosses the center of the plate. See **Fig. 12**. Using a feeler gauge, measure each gap that appears between the straightedge and the pressure plate. Rotate the straightedge through at least four positions. If any gap is more than 0.002 inch (0.05 mm), grind a new surface on the center plate; if not, go to the next step.

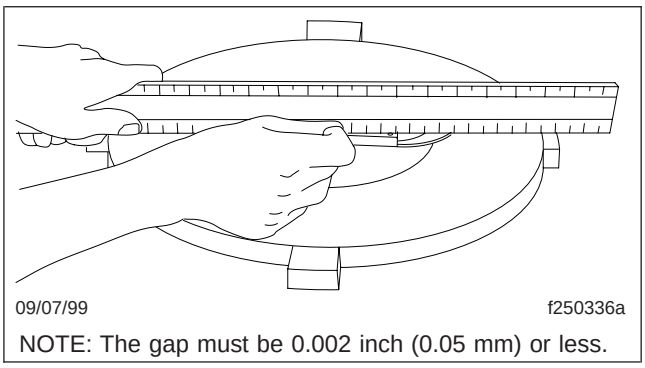


Fig. 12, Checking the Center Plate Surface

8.5 Measure the runout of the center plate to make sure the surfaces are parallel to each other. See **Fig. 13**. Put the base of the dial indicator inside the center of the plate. Put the tip of the dial indicator on the surface of the plate. Set the dial indicator to zero. Rotate the dial indicator one complete turn around the surface of the center plate. If the reading on the indicator is more than 0.002 inch (0.05 mm), grind a new surface on the center plate; if not, go to the next step.

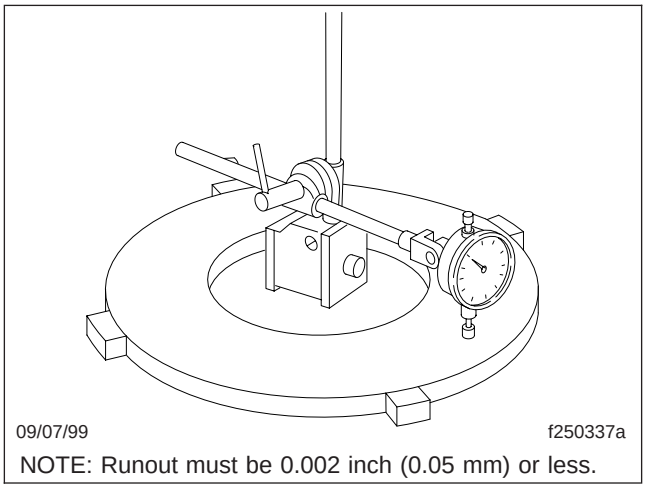
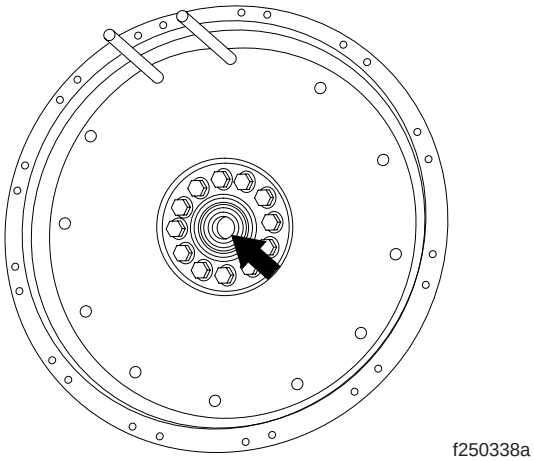


Fig. 13, Measuring Center Plate Runout

8.6 If either the runout or the flatness of the center plate is more than 0.002 inch (0.05 mm), grind enough material so that the plate is flat, but do not go below the minimum thickness. Refer to the table in **Specifications, 400** for center plate minimum thickness. Re-check the flatness and runout of the center plate.

9. Although the pilot bearing must be replaced whenever the clutch is removed, inspect the old pilot bearing for wear or damage. See **Fig. 14**. If worn or damaged, correct the cause.

10. Inspect the surface of the flywheel for wear or damage. If the flywheel is cracked, replace it. Heat marks are normal, and can usually be removed with an emery cloth. Some wear or damage can be removed by grinding a new surface on the flywheel. If wear or damage on the surface of the flywheel cannot be removed, replace the flywheel.



NOTE: Make sure the pilot bearing is not worn or damaged.

Fig. 14, Pilot Bearing

Refer to the engine manufacturer's service manual for flywheel service procedures.

IMPORTANT: If the flywheel surface is reground, make sure there is still adequate thickness for the capscrews to hold the clutch to the flywheel. The threads for these capscrews are below the surface of some flywheels, requiring the use of capscrews with a shoulder. If some of the flywheel surface is removed, the capscrews may not hold. Use new capscrews that are the correct length.

11. Inspect the ring gear teeth on the outer surface of the flywheel. If the teeth are worn or damaged, replace the ring gear or the flywheel. Refer to the engine manufacturer's service manual for instructions.

    Check the tabs on the outer edge of the flywheel. Replace the flywheel if the tabs are worn or damaged.

12. The flywheel surface must be flat for correct clutch operation. Check the runout of the outer surface of the flywheel. Refer to the engine manufacturer's service manual for instructions.

NOTE: In general, maximum runout is 0.0005 inch times the flywheel diameter in inches.

13. Refer to the engine manufacturer's service manual for instructions and check the following:
    - pilot bearing bore runout
    - crankshaft end play
    - runout of the outer surface of the flywheel housing
    - runout of the inside of the flywheel housing

⚠ CAUTION

Do not clean ground or polished parts in a hot solution tank or with water, steam, or alkaline solutions. These solutions will cause the parts to corrode.

14. Clean the disassembled parts.

    14.1 Using a cleaning solvent or kerosene, clean all ground or polished parts or surfaces.

    14.2 Rough parts can be cleaned with the ground or polished parts. The rough parts can also be cleaned in hot solution tanks with a weak alkaline solution. The parts must remain in the tank until they are completely cleaned and heated.

    14.3 Dry the parts with clean paper, shop towels, or compressed air immediately after cleaning.

15. Apply lubricant to the cleaned and dried parts that are not damaged and are to be immediately assembled. *Do not* apply lubricant to the linings.

    If parts are to be stored, apply a special material that prevents corrosion and rust to all surfaces. *Do not* apply the material to the linings. Store the parts inside special paper or other material that prevents corrosion and rust.

Installation

NOTE: During clutch removal, spacers or wooden blocks are installed between the release bearing and the clutch cover to facilitate removal. Do not remove the spacers or wooden blocks until after the clutch is installed. The spacers or blocks make installation of the clutch easier by holding the clutch components in position.

1. Make sure the vehicle is parked on a level surface, the parking brake is set and the tires are chocked.
2. Lubricate the bore in the crankshaft for the pilot bearing with the specified lubricant. Do not use too much lubricant. Excess lubricant can contaminate the discs and cause the clutch to slip.
3. Use the correct size of driver to install the pilot bearing in the crankshaft bore. See **Fig. 1**. Refer to the engine manufacturer's service manual for instructions.

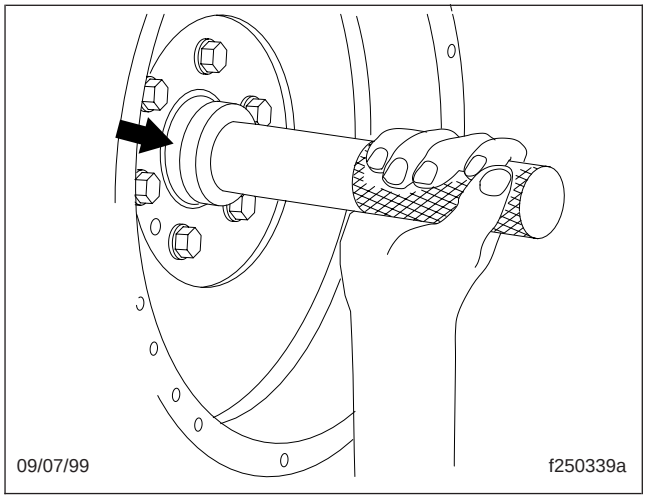


Fig. 1, Driver

4. Install 3/8-inch guide studs in two of the upper mounting holes for the cover and pressure plate assembly. See **Fig. 2**.

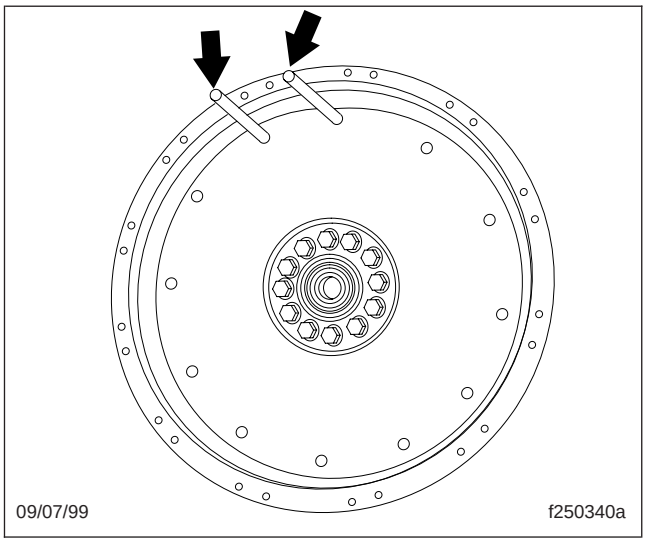


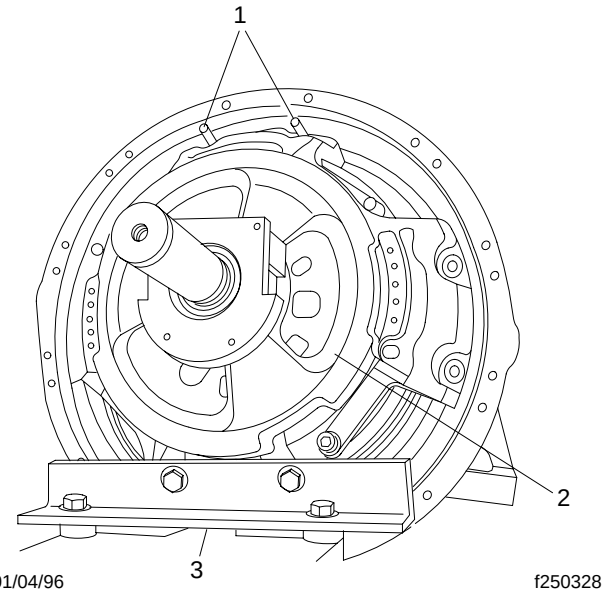
Fig. 2, Guide Studs

WARNING

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

5. Connect a lifting device to the pressure plate and clutch cover assembly. See **Fig. 3**.
6. Install the rear disc in the pressure plate and cover assembly. Make sure the words *PRESSURE PLATE SIDE* on the disc are toward the pressure plate. See **Fig. 4**.
7. Install the center plate over the disc in the pressure plate and clutch cover assembly. Make sure the tabs on the plate are in the slots on the cover.
8. Install the front disc against the center plate. Make sure the words *FLYWHEEL SIDE* on the disc are toward the flywheel. See **Fig. 4**. Make sure the facings of ceramic clutches are aligned.
9. Install the alignment tool through the assembly. Rotate the discs so that the splines in the hub are aligned with the splines on the tool. See **Fig. 4**.

Clutch Installation



1. Guide Studs
2. 15-1/2 Inch Clutch Assembly
3. Lifting Device

Fig. 3, Lifting the Clutch Assembly

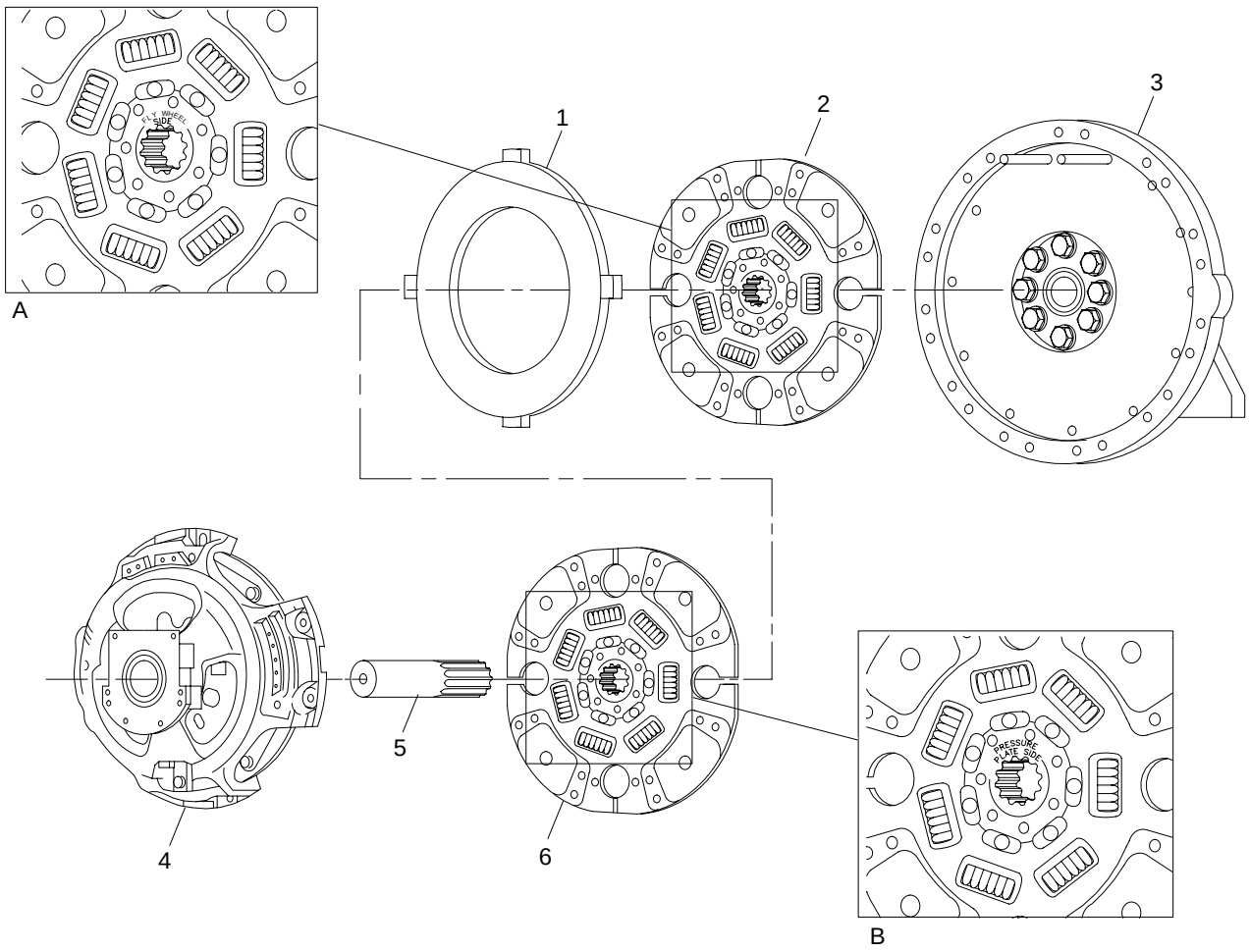
⚠ WARNING

Tilt the front of the alignment tool up when the clutch assembly is installed. If the tool is not tilted up, components will fall off the tool, causing personal injury and component damage.

10. Using a lifting device, lift the clutch assembly onto the guide studs. See **Fig. 3**. Make sure the alignment tool is installed in the flywheel pilot bearing.
11. Install the clutch assembly against the flywheel. Remove the lifting device.
12. Install and hand-tighten the capscrews that fasten the clutch to the flywheel.
13. Remove the guide studs. Install and hand-tighten the remaining capscrews.

NOTE: When the capscrews are tightened, the wooden blocks or spacers will fall from between the release bearing and the cover.

14. Tighten the capscrews to the torque values in **Specifications, 400.**
15. Remove the alignment tool (or the input shaft used as an alignment tool).
16. If used, install the clutch brake on the transmission input shaft. Make sure the tabs on the clutch brake engage the slots on the input shaft. See **Fig. 5**.
17. Install the transmission. Follow the procedures in **Group 26** of this manual.
18. Remove the chocks from the tires.



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A. Markings must be toward the flywheel.
B. Markings must be toward the pressure plate.

1. Center Plate
2. Rear Clutch Disc
3. Flywheel Housing
4. Cover
5. Alignment Tool
6. Front Clutch Disc

Fig. 4, Alignment Tool Installation

Clutch Installation

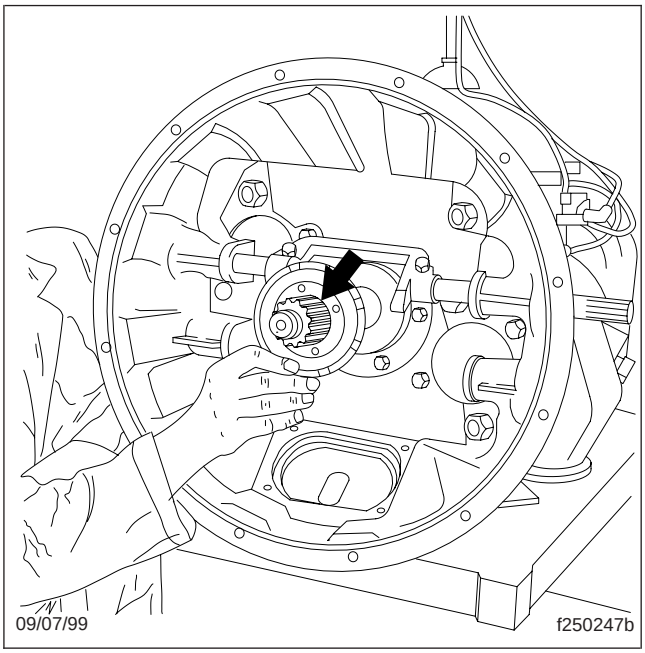


Fig. 5, Clutch Brake

Troubleshooting Tables

TROUBLESHOOTING—FUNCTIONAL PROBLEMS

NOTE: Before troubleshooting the clutch, make sure that:

- The engine is operating correctly;
- The engine mounts are in good condition;
- The driveline angles of the engine, transmission, driveshaft, and rear axle are correct.

Problem—The Clutch Does Not Disengage Completely

Problem—The Clutch Does Not Disengage Completely	
Possible Cause	**Remedy**
Clutch linkage and release bearing need adjustment	Adjust the clutch linkage and release bearing.
Worn or damaged linkage	Lubricate the linkage. Make sure the linkage is not loose. If the condition persists, replace the linkage.
Worn or damaged release bearing	Lubricate (if applicable) the release bearing. If the condition persists, replace the release bearing.
Worn or damaged input shaft splines	Replace the input shaft.
Loose clutch housing	Tighten the fasteners to the specified torque. If necessary, replace the fasteners.
Worn or damaged pressure plate	Replace the pressure plate and cover assembly.
Worn or damaged center plate	Replace the center plate.
Center plate binds	Inspect the tabs on the center plate and the slots in the cover. Service as needed.
Damaged clutch disc hub(s)	Replace the clutch discs.
Worn linings beyond specification	Replace the clutch discs.
Damaged linings	Replace the clutch.
Oil or grease on the linings	Clean the linings. If the oil or grease cannot be removed, replace the clutch discs.
Clutch installed with incorrect lining for the vehicle application	Install a clutch with the correct type of lining.
Damaged pilot bearing	Replace the pilot bearing.

Problem—Clutch Pedal Hard to Operate

Problem—Clutch Pedal Hard to Operate	
Possible Cause	**Remedy**
Damaged bosses on the release bearing assembly	Replace the bearing assembly. Make sure the clutch is adjusted correctly.
Worn or damaged clutch linkage	Lubricate the linkage. If the condition still exists, replace the linkage.
Worn or damaged pressure plate and cover assembly components	Replace the pressure plate and cover assembly.
Clutch cross shaft binds	Lubricate the cross shaft. If the condition persists, replace the cross shaft and bushings as required.

Troubleshooting

Problem—The Clutch Slips

Problem—The Clutch Slips	
Possible Cause	**Remedy**
Driver keeps his foot on the clutch pedal	Use correct driving procedures.
Clutch linkage or release bearing needs adjustment	Adjust the clutch linkage or release bearing.
Worn or damaged pressure plate and cover assembly components	Replace the pressure plate and cover assembly.
Worn or damaged linings	Replace the clutch discs.
Oil or grease on the linings	Clean the linings. If the oil or grease cannot be removed, replace the clutch discs.
Clutch installed with incorrect lining for the vehicle application	Install a clutch with the correct type of lining.
Worn or damaged flywheel	Service the flywheel as needed. For instructions, refer to the engine manufacturer's service manual.

Problem—The Clutch is Noisy

Problem—The Clutch is Noisy	
Possible Cause	**Remedy**
Clutch linkage or release bearing needs adjustment	Adjust the clutch linkage or release bearing.
Worn or damaged linkage	Lubricate the linkage. If the condition persists, replace the linkage.
Worn or damaged release bearing	Lubricate (if applicable) the release bearing. If the condition persists, replace the release bearing.
Worn or damaged clutch housing	Replace the clutch housing.
Loose clutch housing	Tighten the fasteners to the specified torque. If necessary, replace the fasteners.
Damaged hub, or broken co-axial spring(s) in clutch disc	Replace the clutch discs.
Linings worn below specified dimensions	Replace the clutch discs.
Damaged linings	Replace the clutch discs.
Oil or grease on the linings	Clean the linings. If the oil or grease cannot be removed, replace the clutch discs.
Damaged pilot bearing	Replace the pilot bearing.

Problem—The Clutch Vibrates

Problem—The Clutch Vibrates	
Possible Cause	**Remedy**
Damaged input shaft splines	Replace the input shaft.
Out of balance pressure plate and cover assembly	Remove the pressure plate and cover assembly. Check their balance and install them. If the problem persists, replace the pressure plate and cover assembly.

Problem—The Clutch Vibrates	
Possible Cause	**Remedy**
Damaged splines in clutch disc hub(s)	Replace the clutch discs.
Loose flywheel	Tighten the fasteners to the specified torque. If necessary, replace the fasteners. Check the flywheel mounting surface for damage. If necessary, replace the flywheel.

TROUBLESHOOTING—COMPONENT PROBLEMS

Problem—Broken Tabs on the Clutch Brake

Problem—Broken Tabs on the Clutch Brake	
Possible Cause	**Remedy**
Vibration	Inspect the clutch disc hubs; check the installation of the clutch. Make sure dampened discs are used.
Incorrectly adjusted clutch linkage	Adjust the clutch linkage. Also, check the installation of the clutch.
Driver used clutch brake while vehicle was moving	Use correct driving procedures.

Problem—Worn or Damaged Release Bearing Housing

Problem—Worn or Damaged Release Bearing Housing	
Possible Cause	**Remedy**
Driver keeps his foot on the pedal	Use correct driving procedures.
Incorrectly adjusted clutch linkage	Adjust the clutch linkage. Also, check the installation of the clutch.

Problem—Worn Bosses on the Release Bearing Housing

Problem—Worn Bosses on the Release Bearing Housing	
Possible Cause	**Remedy**
Damaged linkage or out of adjustment linkage	Lubricate and adjust the linkage. Inspect the linkage for wear or damage.
Binding release yoke	Lubricate the release yoke shaft. If the yoke does not move freely, replace the shaft and yoke assembly.
Out of adjustment free pedal	Adjust the free pedal to specification.

Problem—Worn or Damaged Input Shaft Splines

Problem—Worn or Damaged Input Shaft Splines	
Possible Cause	**Remedy**
Transmission not aligned	Make sure the flywheel housing and the clutch housing are aligned to specification.
Transmission not installed correctly	Install the transmission correctly.
Damaged clutch disc hubs	Replace the clutch discs.

Troubleshooting

Problem—Worn or Damaged Input Shaft Splines	
Possible Cause	**Remedy**
Worn or damaged pilot bearing	Replace the pilot bearing.
Engine vibration	Make sure dampened discs are used.

Problem—Pressure Plate Cracked or Damaged by Heat

Problem—Pressure Plate Cracked or Damaged by Heat	
Possible Cause	**Remedy**
Driver engages clutch while coasting	Use correct driving procedures.
Driver uses clutch as a brake	Use correct driving procedures.
Clutch free pedal not adjusted correctly	Adjust the free pedal to specifications.
Oil or grease on clutch linings	Clean the clutch discs. If the oil or grease cannot be removed, replace the clutch discs. Repair the cause of the grease or oil.
Worn or damaged diaphragm spring	Replace the pressure plate and the cover assembly.
Driver slips clutch excessively during engagement	Use correct driving procedures.

Problem—Grooves Worn in the Pressure Plate

Problem—Grooves Worn in the Pressure Plate	
Possible Cause	**Remedy**
Worn or damaged clutch discs	Replace the clutch discs. If damaged, replace the center plate and flywheel.

Problem—The Clutch Disc Hub is Warped

Problem—The Clutch Disc Hub is Warped	
Possible Cause	**Remedy**
Transmission not installed correctly	Replace the clutch discs. Install the transmission correctly.

Problem—The Hub Separates from the Clutch Disc

Problem—The Hub Separates from the Clutch Disc	
Possible Cause	**Remedy**
Excessive engine vibration	Repair the engine.
Transmission not installed correctly	Install the transmission correctly.
Loose clutch housing	Tighten the clutch housing to the specified torque.
Driver engages clutch while vehicle is coasting	Use correct driving procedures.
Shock loading	Use correct driving procedures.

Problem—Heat Damage to the Clutch Disc

Problem—Heat Damage to the Clutch Disc	
Possible Cause	**Remedy**
Driver keeps his foot on clutch pedal or slips clutch	Use correct driving procedures.
Clutch does not engage or disengage completely	See "Clutch Does Not Disengage Completely" under "TROUBLESHOOTING—FUNCTIONAL PROBLEMS."
Free pedal not adjusted correctly	Adjust the free pedal.
Worn or damaged diaphragm spring	Replace the pressure plate and cover assembly.
Oil or grease on the clutch linings	Clean the clutch discs. If the oil or grease cannot be removed, replace the clutch discs. Repair the cause of the grease or oil.

Problem—The Linings Separate from the Disc

Problem—The Linings Separate from the Disc	
Possible Cause	**Remedy**
Linings worn below the specified dimension	Replace the clutch discs.
Driver allows vehicle to coast downhill with transmission in gear and clutch engaged	Use correct driving procedures.

Problem—Heat Damage to the Clutch Disc

Problem—Heat Damage to the Clutch Disc	
Possible Cause	**Remedy**
Driver does not start vehicle in correct gear	Use correct driving procedures.
Driver engages clutch while vehicle is coasting	Use correct driving procedures.
Center plate tabs binding in the clutch cover	Replace the pressure plate and cover assembly.
Clutch does not release	See "Clutch Does Not Disengage Completely" under "TROUBLESHOOTING—FUNCTIONAL PROBLEMS."

Specifications

General Specifications	
Description	**Specifications**
Actuation Type	Pull
Minimum Clutch Housing Size for Mounting	SAE Number 2
Pressure Plate Actuation	Single Diaphragm Spring
Clamp Load	3600 lbf (16 013 N) 4000 lbf (17 793 N)
Adjustment	Manual
Facing Size	15.35 x 8.66 inch (390 x 220 mm)
Lining Availability	Ceramic
Lining-to-Disc Fastener	Rivet

Table 1, General Specifications

Pressure Plate Specifications	
Description	**Clutch Diameter**
Pressure Plate Runout	0.000 to 0.002 inch (0.00 to 0.05 mm)
Pressure Plate Flatness	0.002 to 0.004 inch (0.05 to 0.10 mm)
Maximum Allowable Wear	0.015 inch (0.38 mm)

Table 2, Pressure Plate Specifications

Center Plate Specifications	
Description	**Specifications**
Center Plate Runout	0.000–0.002 inch (0.00–0.05 mm)
Center Plate Flatness	0.000–0.002 inch (0.00–0.05 mm)
Center Plate Minimum Thickness	0.742 inch (18.84 mm)
Center Plate Drive	Tabs on Center Plate in Clutch Cover

Table 3, Center Plate Specifications

Clutch Disc Specifications	
Description	**Specifications**
Number of Splines on Disc	10
Spline Diameter	2.00 inch (51.0 mm)
Minimum Disc Thickness	To Top of Rivet

Table 4, Clutch Disc Specifications

Torque Values	
Description	**Torque: lbf·ft (N·m)**
Adjusting Ring Lock Capscrew	25–30 (34–40)

Specifications

Torque Values	
Description	**Torque: lbf·ft (N·m)**
Capscrew Between Cover Assembly and Flywheel	45–50 (62–67)

Table 5, Torque Values

Removal

See **Fig. 1** for a complete exploded view of the clutch- and brake-pedal assembly.

1. Park the vehicle on a level surface, shut down the engine, apply the parking brakes, and chock the tires.
2. Inside the cab, remove the five screws from the under steering panel and remove the panel. See **Fig. 2**.
3. Remove the ABS check-switch bracket by removing the screw from the lower left dash panel. Move the bracket out of the way to allow better access to the clutch pedal.
4. Remove the clutch pedal. See **Fig. 3**.
   - 4.1 Remove the capscrews and belleville washers from the wedge at the end of the clutch cross-shaft.
   - 4.2 Pry the wedge out from the end of the pedal.
   - 4.3 Remove the pedal. Discard the wedge, washers, and capscrew.

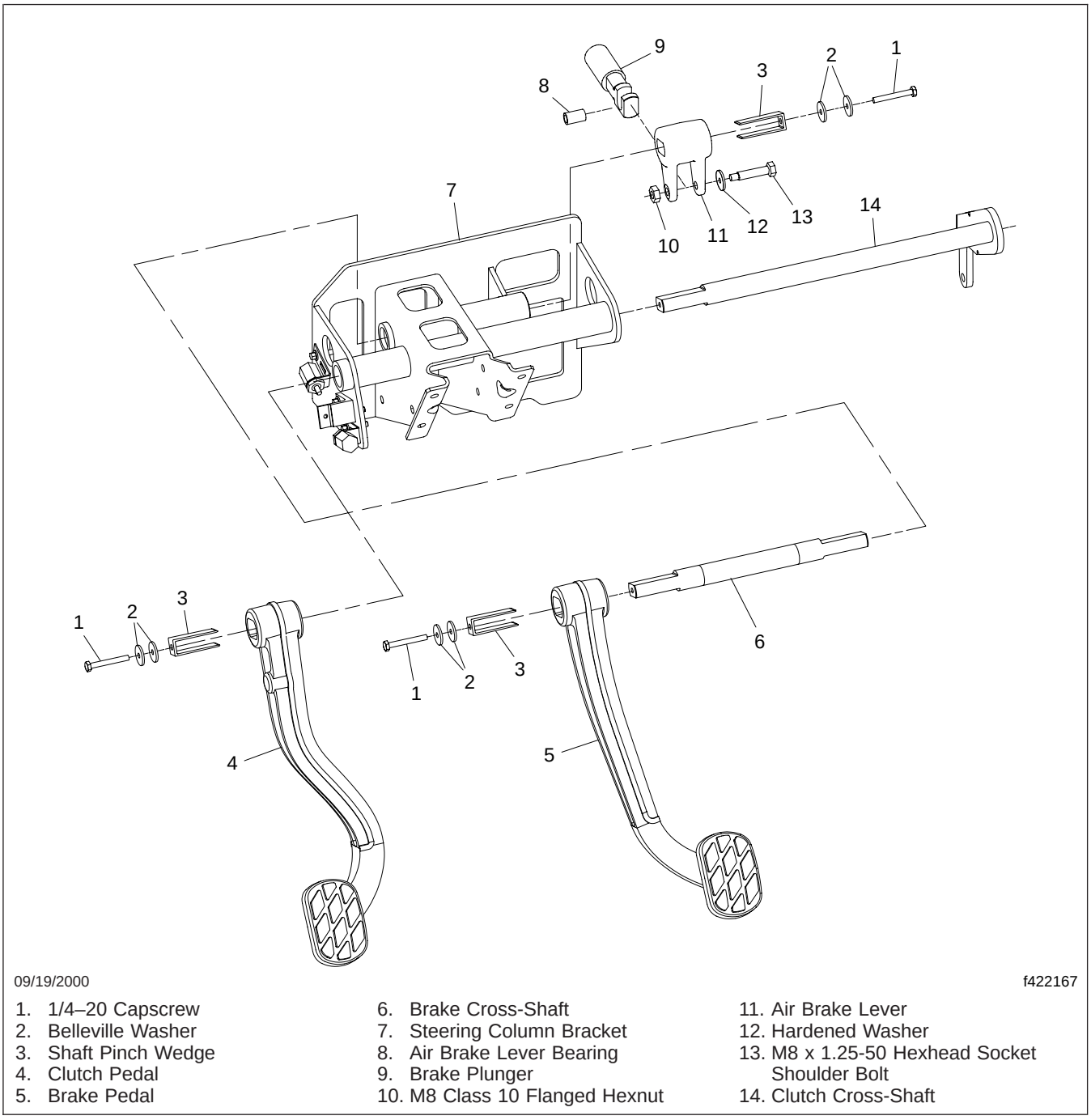
Installation

1. Slide the pedal on to the end of the clutch cross-shaft.

IMPORTANT: The wedge, belleville washers and capscrews must be replaced after they are removed for any reason. For part numbers, see **Specifications 400**.

2. Install a new wedge, belleville washers and capscrew as shown in **Fig. 3**. The belleville washers are concave and must be installed facing each other as shown.
3. Tighten the capscrew 8 lbf·ft (10.8 N·m).
4. Install the ABS check-switch bracket.
5. Install the under steering panel.
   - 5.1 Position the under steering panel.
   - 5.2 Install the spacer.
   - 5.3 Tighten the five screws. See **Fig. 2**.
6. Remove the chocks from the tires.
7. Test the drive the vehicle at a slow speed to test clutch pedal operation.

Clutch Pedal Removal and Installation



1. 1/4–20 Capscrew
2. Belleville Washer
3. Shaft Pinch Wedge
4. Clutch Pedal
5. Brake Pedal
6. Brake Cross-Shaft
7. Steering Column Bracket
8. Air Brake Lever Bearing
9. Brake Plunger
10. M8 Class 10 Flanged Hexnut
11. Air Brake Lever
12. Hardened Washer
13. M8 x 1.25-50 Hexhead Socket Shoulder Bolt
14. Clutch Cross-Shaft

Fig. 1, Brake- and Clutch-Pedal Assembly

Clutch Pedal Removal and Installation

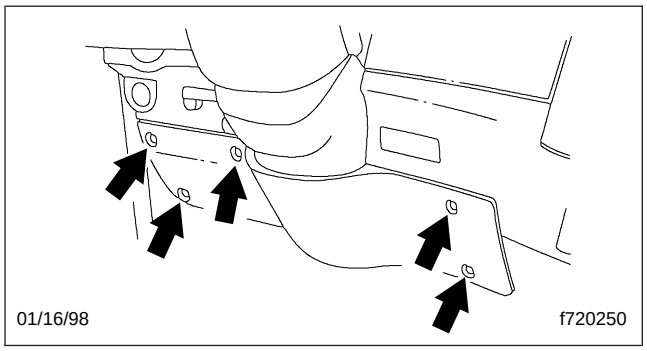
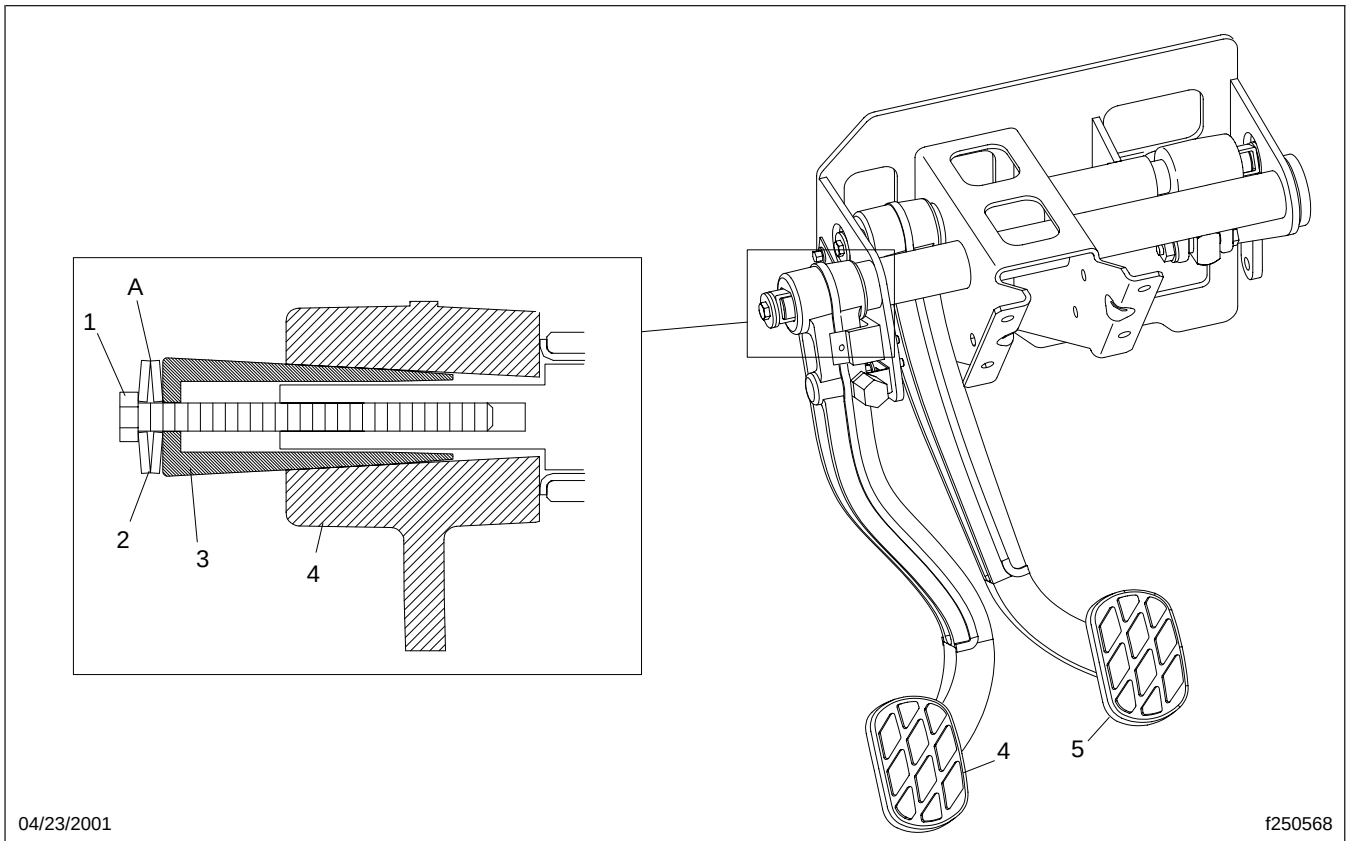


Fig. 2, Under Steering Panel Screw Location



A. **IMPORTANT: Belleville washers must be installed as shown here.**
1. 1/4–20 Capscrew
2. Belleville Washer
3. Shaft Pinch Wedge
4. Clutch Pedal
5. Brake Pedal

Fig. 3, Clutch Pedal Removal and Installation

Removal

See **Fig. 1** for a complete exploded view of the clutch- and brake-pedal assembly.

1. Park the vehicle on a level surface, shut down the engine, apply the parking brakes, and chock the tires.
2. Inside the cab, remove the five screws from the under steering panel and remove the panel. See **Fig. 2**.
3. Remove the ABS check-switch bracket by removing the screw from the lower left dash panel. Move the bracket out of the way to allow better access to the clutch pedal.
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   - 4.2 Pry the wedge out from the end of the pedal.
   - 4.3 Remove the pedal. Discard the wedge, washers, and capscrew.

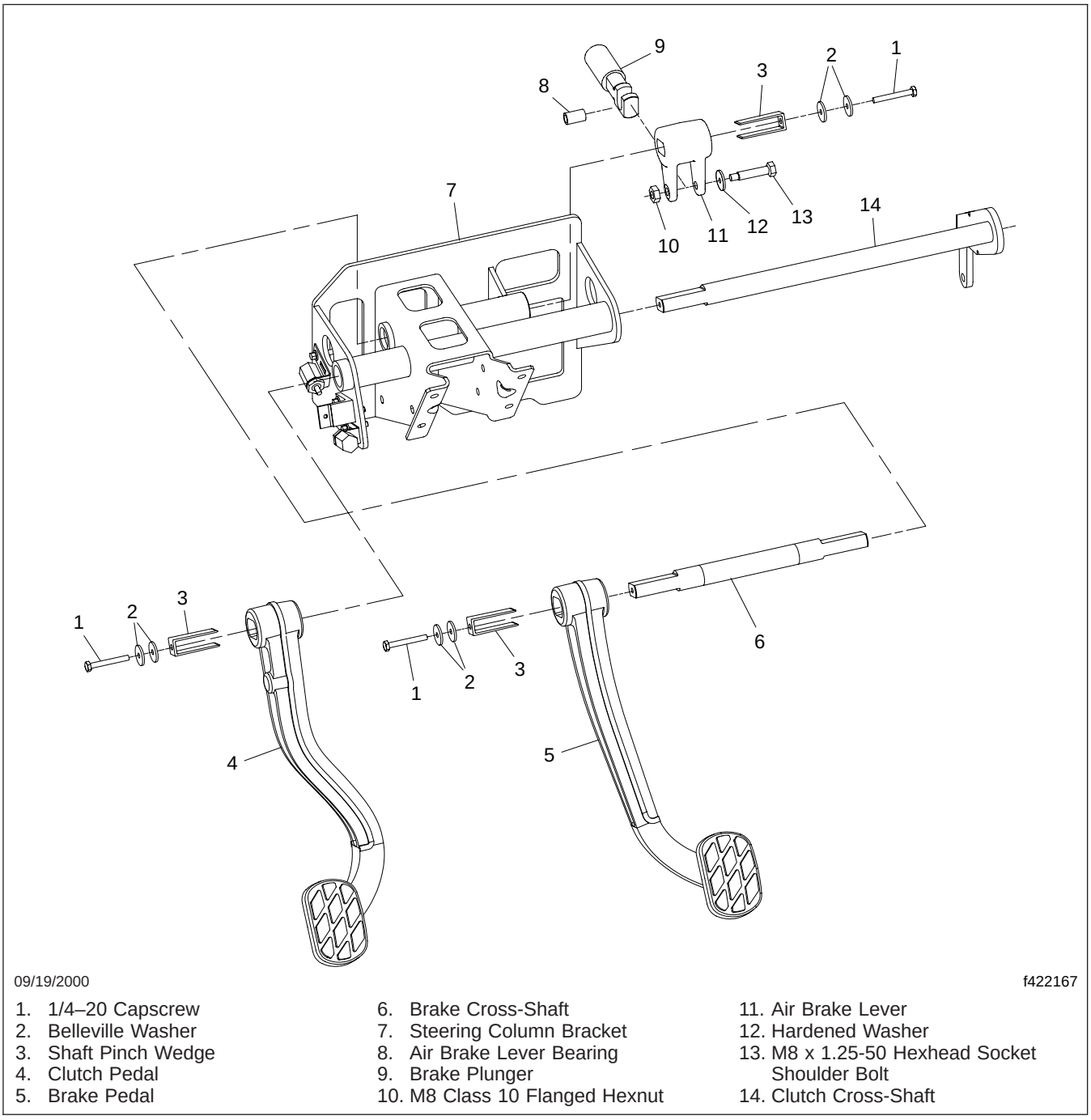
Installation

1. Slide the pedal on to the end of the clutch cross-shaft.

IMPORTANT: The wedge, belleville washers and capscrews must be replaced after they are removed for any reason. For part numbers, see **Specifications 400**.

2. Install a new wedge, belleville washers and capscrew as shown in **Fig. 3**. The belleville washers are concave and must be installed facing each other as shown.
3. Tighten the capscrew 8 lbf·ft (10.8 N·m).
4. Install the ABS check-switch bracket.
5. Install the under steering panel.
   - 5.1 Position the under steering panel.
   - 5.2 Install the spacer.
   - 5.3 Tighten the five screws. See **Fig. 2**.
6. Remove the chocks from the tires.
7. Test the drive the vehicle at a slow speed to test clutch pedal operation.

Clutch Pedal Removal and Installation



1. 1/4–20 Capscrew
2. Belleville Washer
3. Shaft Pinch Wedge
4. Clutch Pedal
5. Brake Pedal
6. Brake Cross-Shaft
7. Steering Column Bracket
8. Air Brake Lever Bearing
9. Brake Plunger
10. M8 Class 10 Flanged Hexnut
11. Air Brake Lever
12. Hardened Washer
13. M8 x 1.25-50 Hexhead Socket Shoulder Bolt
14. Clutch Cross-Shaft

Fig. 1, Brake- and Clutch-Pedal Assembly

Clutch Pedal Removal and Installation

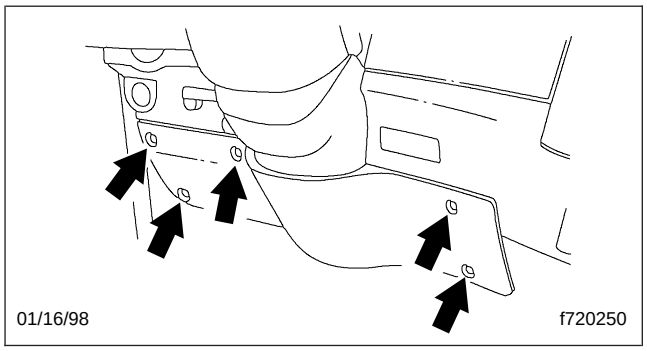
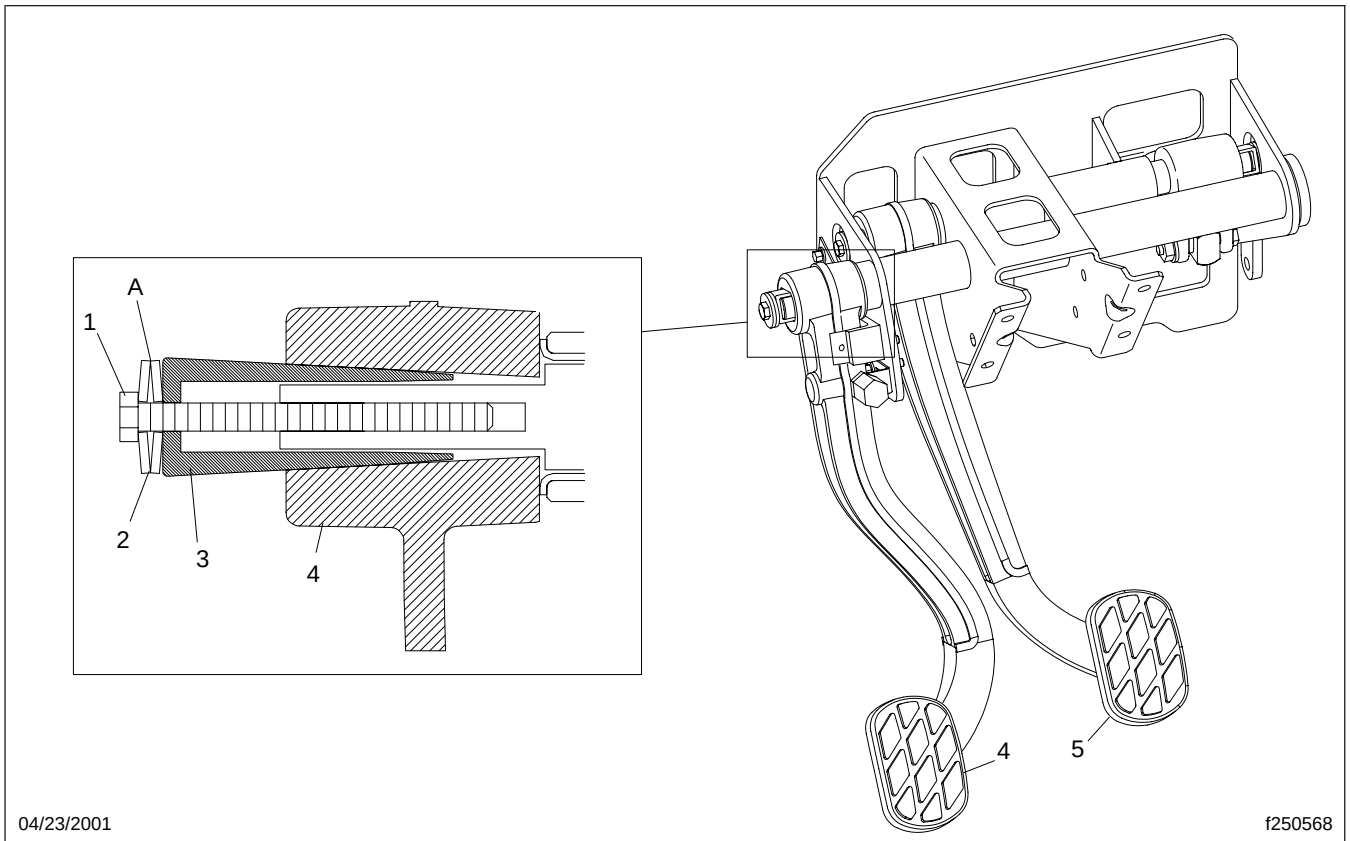


Fig. 2, Under Steering Panel Screw Location



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1. 1/4–20 Capscrew
2. Belleville Washer
3. Shaft Pinch Wedge
4. Clutch Pedal
5. Brake Pedal

Fig. 3, Clutch Pedal Removal and Installation

General Information

EATON FULLER RT–6609A SERIES MANUAL TRANSMISSION

The Eaton Fuller RT–6609A series transmission features a twin countershaft.

The twin-countershaft design, which splits torque evenly between the two countershafts, provides a high torque capacity-to-weight ratio. Because the torque is split, each gear set carries only half of the load, greatly reducing the face width of each gear.

The design employs a floating gear. The mainshaft gears, when not engaged, float between the countershaft gears, eliminating the need for gear sleeves and bushings. All gears are constant mesh with spur-type teeth.

The RT–6609A transmission has five low range speeds, four high range speeds and two reverse speeds.

EATON FULLER RT–8608–L, RT–11609–A, RTX–11609–B/R, RT–12609–A, RTX–12609–B/R, RT–13609-A, RTX–13609–B/R, RT–14609–A AND RTX–14609–B/R MANUAL TRANSMISSIONS

The Eaton Fuller RT–8608–L, RT–11609–A, RTX–11609–B/R, RT–12609–A, RTX–12609–B/R,RT–13609-A, RTX–13609–B/R, RT–14609–A and RTX–14609–B/R manual transmissions feature a twin countershaft. The twin countershaft design, which splits torque equally between the two shafts, provides a high torque capacity-to-weight ratio.

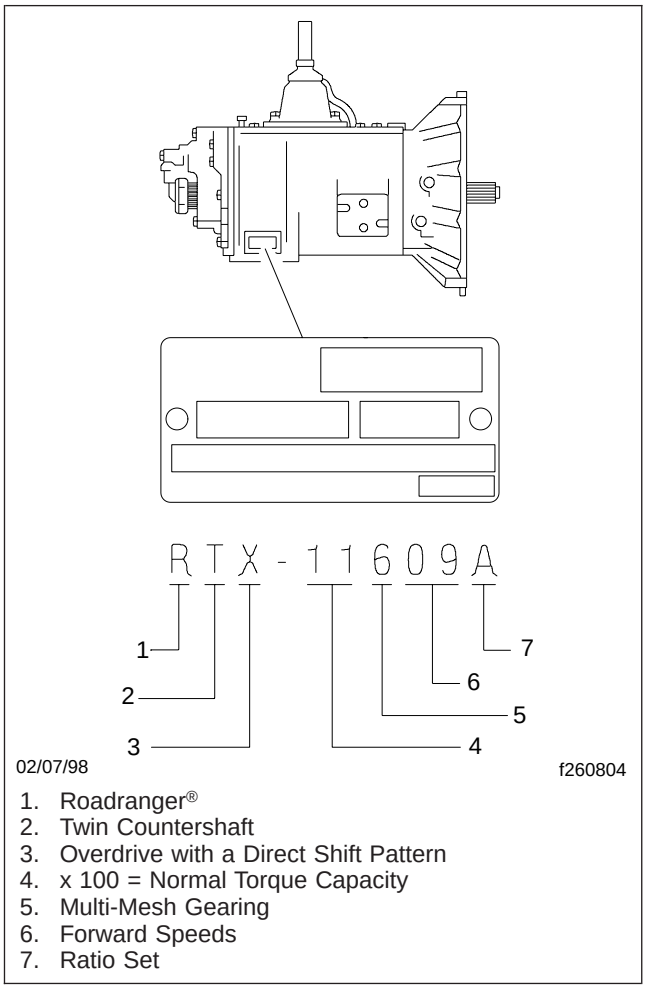
Because of torque splitting, each gearset carries only half the load, greatly reducing the face width of each gear. The mainshaft gears, when not engaged, float between the countershaft gears, eliminating the need for gear sleeves and bushings. All gears are in constant mesh and have spur-type teeth.

The RT–8608–L, RTX–11609–B/R, RTX–12609–B/R, RTX–13609–B/R, RT–13609–A and RTX–14609–B/R series transmissions have nine forward speeds and two reverse speeds consisting of a 5-speed front section and a 2-speed auxiliary section.

IDENTIFICATION

IMPORTANT: Do not remove or destroy the transmission identification tag.

All Eaton Fuller transmissions are identified by the model and serial number. This information is stamped on the transmission identification tag and affixed to the case. See **Fig. 1**.



1. Roadranger®
2. Twin Countershaft
3. Overdrive with a Direct Shift Pattern
4. x 100 = Normal Torque Capacity
5. Multi-Mesh Gearing
6. Forward Speeds
7. Ratio Set

Fig. 1, Transmission Identification Tag

Specifications

Lubricant Refill Capacity			
Transmission	Approximate Capacity		
	U.S. Pints	Imperial Pints	Liters
All	15	12.5	7.0

Table 1, Lubricant Fill Capacity

Torque Specifications	
Description	lbf·ft (N·m)
Air Filter/Regulator Mounting Capscrews	8–12 (10–16)
Air Filter Plug (1 1/2–18 Threads)	17–21 (23–28)
Auxiliary Drive Gear Bearing Retainer Capscrews (3/8–16 Threads)	35–45 (47–61)
Auxiliary Housing Capscrews (3/8–16 Threads)	35–45 (47–61)
Clutch Housing Capscrews (Use Lockwasher)	80–100 (108–136)
Clutch Housing Nuts (Use Lockwasher) (5/8–18 Threads)	180–200 (244–271)
Clutch Housing-to-Engine Bolts	50–70 (68–95)
Clutch Release Arm-to-Shaft Nut	15–30 (20–40)
Detent Spring Cover Capscrews	35–45 (47–61)
Front Bearing Cover Capscrews (3/8–16 Threads)	35–45 (47–61)
Hand Hole Cover Capscrew	20–25 (27–34)
Large PTO Cover Capscrew	50–65 (68–88)
Main Countershaft Cover Capscrew	90–120 (122–163)
Oil Drain Plug (3/4 Pipe Threads)	45–55 (61–75)
Oil Fill Plug (1 1/4 Pipe Threads)	60–75 (81–102)
Output Shaft Nut (Oiled at Vehicle Installation)	450–500 (610–678)
Range Cylinder Cover Capscrews (3/8–16 Threads)	35–45 (47–61)
Range Cylinder Shift Bar Nut (1/2–20 Threads)	60–70 (81–95)
Range Shift Yoke Capscrews (3/8–24 Threads) (Secure with Lockwire)	65–85 (88–115)
Range Piston Nut (Secure with Lockwire)	50–65 (68–88)
Rear Bearing Cover Capscrew	35–45 (47–61)

Torque Specifications	
Description	lbf·ft (N·m)
Reverse Idler Gear Nut	50–60 (68–81)
Reverse Signal Switch Plug (9/16–18 Threads)	35–50 (47–67
Shift Control Housing Capscrews (3/8–16 Threads)	35–45 (47–61
Shift Lever Housing Capscrews (3/8–16 Threads)	35–45 (47–61)
Small PTO Cover Capscrew	18–23 (24–31)
Slave Valve Capscrews	8–12 (11–16)
Studs (Driven Until Bottomed, 5/8–11 Threads)	60 (81)
Thermocouple Plug (1/2 Pipe Threads)	40–50 (54–67
Yoke Lock Screws (Secure with Lockwire)	35–45 (47–61)

Table 2, Torque Specifications

General Information

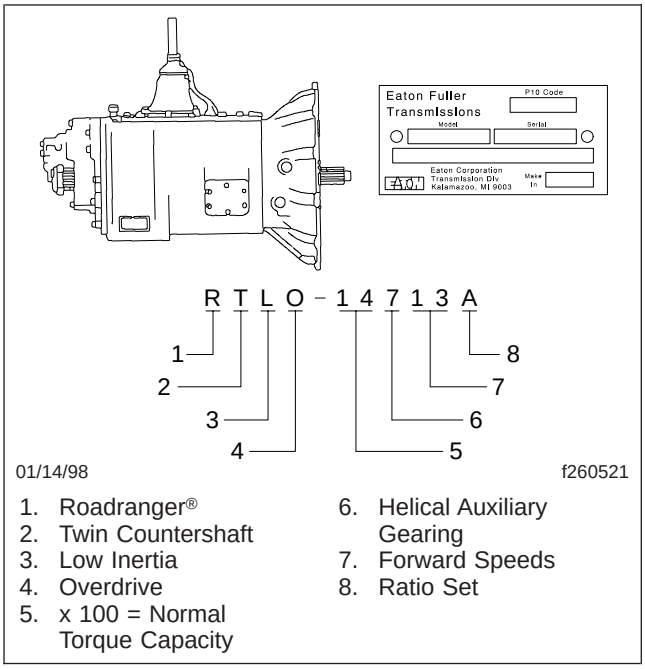
FULLER RTLO–12713, RTLO–14713, RTLO–16713 and RTLO–18718B

The FULLER RTLO–12713, RTLO–14713, RTLO–16713 and RTLO–18718B are low inertia models with twin countershafts and helical auxiliary gears. A sliding clutch connects the transmission's front section to the auxiliary section. This enables the front section to slow down quickly during a gearshift, a range shift or a split shift to make shifting easier. Preselection during a split shift is possible with the low inertia models.

IDENTIFICATION

IMPORTANT: Do not remove or destroy the transmission identification tag.

All Eaton Fuller transmissions are identified by the model and serial number. This information is stamped on the transmission identification tag and affixed to the case. See **Fig. 1**.



1. Roadranger®
2. Twin Countershaft
3. Low Inertia
4. Overdrive
5. x 100 = Normal Torque Capacity
6. Helical Auxiliary Gearing
7. Forward Speeds
8. Ratio Set

Fig. 1, Transmission Identification Tag

Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Clutch Housing-to-Engine Bolts (M10 x 1.50 x 40)	40–60 (54–81)
Clutch Housing-to-Engine Bolts (7/16-14 x 1.50)	50–70 (68–95)
Clutch Release Arm-to-Shaft Nut	15–30 (20–40)
Hand Hole Cover Capscrew	20–25 (27–34)
Oil Drain Plug	45–55 (61–75)
Oil Fill Plug	60–70 (81–95)
Oil Trough Capscrews	8–12 (11–16)
Output Shaft Nut	450–500 (610–678)
Shift Control Housing Capscrews	35–45 (47–61)

Table 1, Torque Specifications

General Information

EATON RT–8908LL, RTO–11908LL, RTO–14908LL, RT–14915, RTO–14915, and RTO–16915 SERIES MANUAL TRANSMISSIONS

The Eaton RT–8908LL, RTO–11908LL, RTO–14908LL, RT–14915, RTO–14915, and RTO–16915 series transmissions are designed for heavy-duty vehicles, for both on-highway and off-highway use.

The twin countershaft design splits torque evenly between the two countershafts and provides a high torque capacity-to-weight ratio. Because of torque splitting, each gearset carries only half of the load, greatly reducing the face width of each gear.

This design incorporates mainshaft gears, (see **Fig. 1**), that when not engaged, float between the countershaft gears, (see **Fig. 2**), eliminating the need for gear sleeves and bushings.

The RT–8908LL, RTO–11908LL and RTO–14908LL transmissions have a low and a low-low gear ratio in addition to 8 or 15 highway ratios depending on model. See **Table 1** and **Table 2** for 8-speed and 15-speed gear ratios.

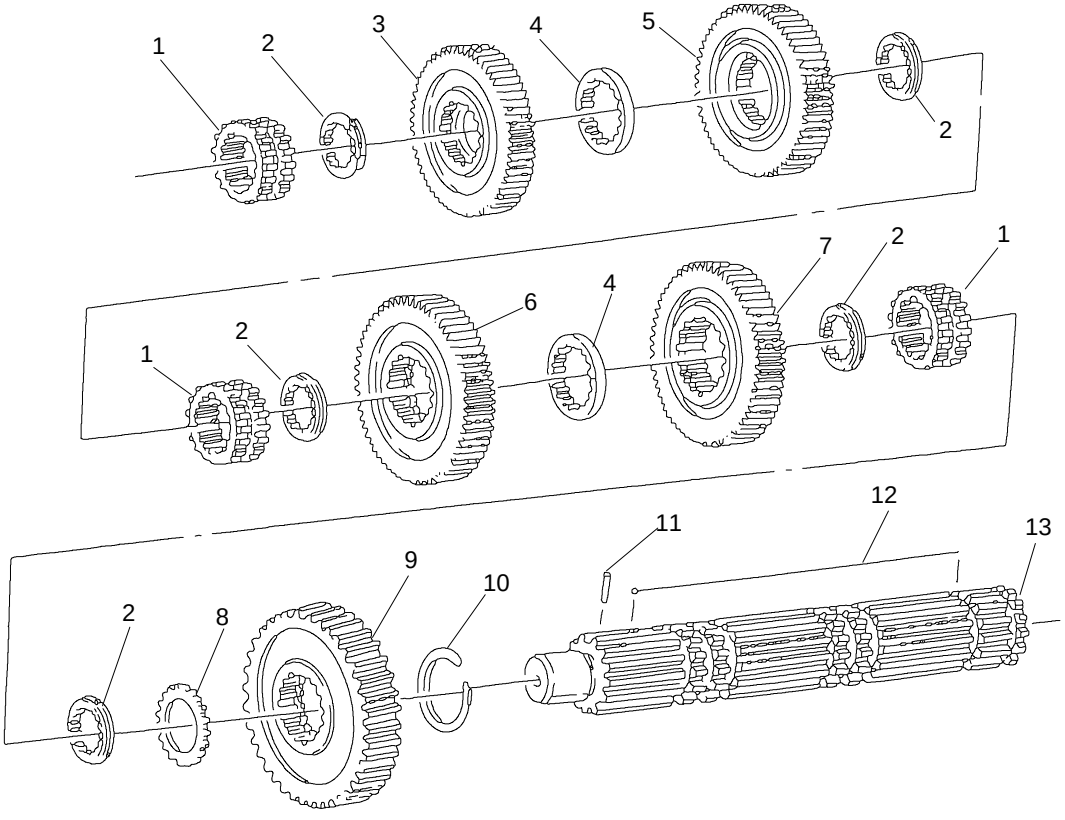
8-Speed Gear Ratios															
		LOW Range					HI Range				Reverse			Relative Speed PTO Gear to Input RPM	
Model	Deep Red. LOW-LOW	LOW	1st	2nd	3rd	4th	5th	6th	7th	O.D.	LOW-LOW	LOW	HI	Right	Bottom
RTO–8908LL	19.58	12.67	8.39	6.23	4.58	3.41	2.46	1.83	1.35	1.00	20.47	13.24	3.89	—	—
RTO–11908LL	14.56	9.42	6.24	4.63	3.40	2.53	1.83	1.36	1.00	.74	15.22	9.85	2.89	.935	.935
RTO–14908LL	14.56	9.42	6.24	4.63	3.40	2.53	1.83	1.36	1.00	.74	15.22	9.85	2.89	.935	.935

Table 1, 8-Speed Gear Ratios

15-Speed Gear Ratios													
												Relative Speed PTO Gear to Input RPM	
Model	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Reverse	Right	Bottom
RT–14915	9.96 16.94	7.63 12.98	5.90 10.03	4.54 7.73	3.57 6.07	2.79	2.14	1.65	1.27	1.00	2.76 9.84 15.21	.696	.696
RTO–14915	7.83 13.31	6.00 10.20	4.63 7.88	3.57 6.07	2.81 4.77	2.19	1.68	1.30	1.00	.79	2.17 7.73 11.95	.885	.885
RTO-16915	7.83 13.31	6.00 10.20	4.63 7.88	3.57 6.07	2.81 4.77	2.19	1.68	1.30	1.00	.79	2.17 7.73 11.95	.885	.885

Table 2, 15-Speed Gear Ratios

General Information



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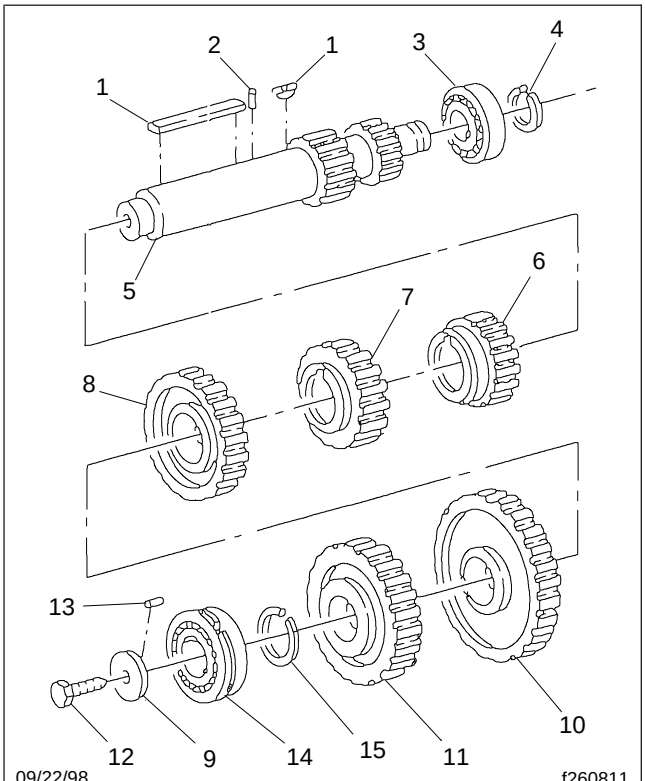
1. Sliding Clutch
2. Tolerance Washer
3. Mainshaft Overdrive (Fourth) Gear
4. Spacer Washer
5. Mainshaft Third Gear
6. Mainshaft Second Gear
7. Mainshaft First Gear
8. Spacer Washer
9. Mainshaft Reverse Gear
10. Snap Ring
11. Roll Pin
12. Key
13. Mainshaft

Fig. 1, Mainshaft Assembly, Disassembled View



1. Key
2. Roll Pin
3. Bearing
4. Snap Ring
5. Countershaft
6. Countershaft Second Gear
7. Countershaft Third Gear
8. Countershaft Overdrive Gear
9. Retainer
10. PTO Gear
11. Countershaft Drive Gear
12. Capscrew
13. Roll Pin
14. Bearing
15. Snap Ring

Fig. 2, Countershaft Assembly, Disassembled View

Fuller RTO–11909MLL and RTO–14909MLL Manual Transmissions

The Fuller RTO–1909MLL and RTO–14909MLL are 11-speed transmissions. In addition to nine forward speeds, there are two additional speeds for low and low-low reduction. These transmissions use the Roadranger® air system, have twin countershafts, helical auxiliary gearing and overdrive with a direct shift pattern.

Eaton RTLO Manual Transmissions

DESCRIPTION

The Eaton RTLO transmissions are low inertia transmissions. A low inertia transmission uses a sliding clutch that disengages the front box of the transmission from the back box during split-shifts, range shifts and regular gear shifts. This allows the front box to slow down faster than the back box, thus making shifting much easier since the gears to be shifted are no longer being spun by the inertia of the back box. This also allows pre-selection of gears during split-shifts. This feature is not found on the other transmissions. The RTLO transmissions also use Roadranger® valves and twin countershafts and have multi-mesh (spur-type) auxiliary gears.

These transmissions have the low inertia design:

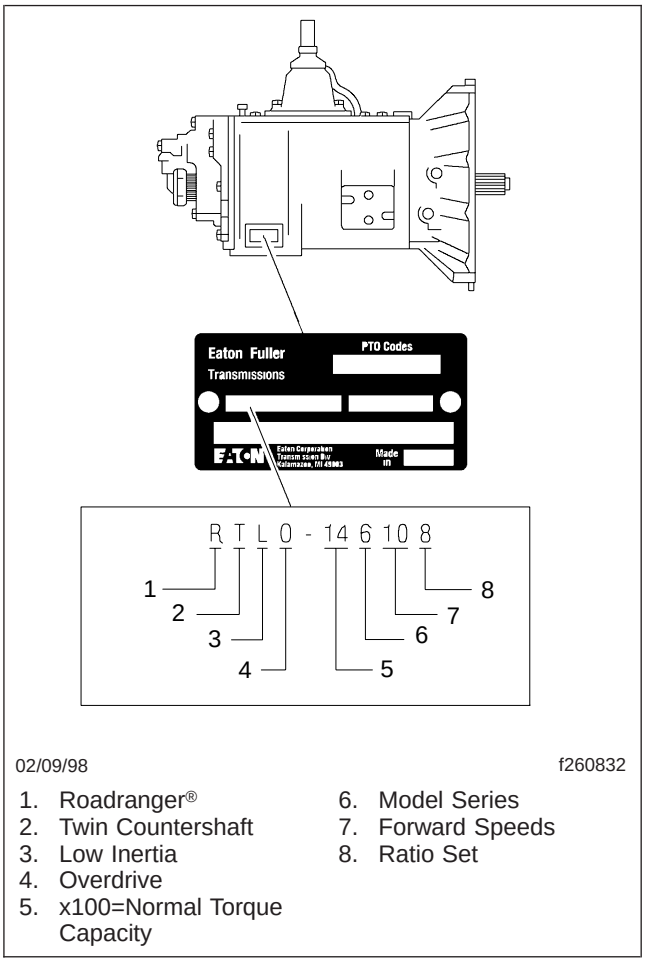
- RTLO–11610B
- RTLO–12610B
- RTLO–13610B
- RTLO–14610B
- RTLO–15610B
- RTLO–16610B

IDENTIFICATION

IMPORTANT: Do not remove or destroy the transmission identification tag.

All Eaton Fuller transmissions are identified by the model and serial number. This information is stamped on the transmission identification tag and affixed to the case. See **Fig. 3**.

General Information



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1. Roadranger®
2. Twin Countershaft
3. Low Inertia
4. Overdrive
5. x100=Normal Torque Capacity
6. Model Series
7. Forward Speeds
8. Ratio Set

Fig. 3, Transmission Identification Plate

Specifications

General Specifications	
Item	**Specification**
Threadlock® and Sealer EOAZ–19554–AA	WSK–M2G315–A5
Gasket and Trim Adhesive D7AZ–19B508–B	ESR–M11P17–A and ESE–M2G52–A
Eaton Approved Synthetic Transmission Oil	SAE 50
Heavy-Duty Engine Oil	MIL–L–2104–D, API–CD, CAT TO–4
Mineral Gear Oil with Rust and Oxidation Inhibitor	API–MT–1
Multi-Purpose Grease DOAZ–19584–AA	ESR–M1C159–A or ESB–M1C93–B
Silicone Lubricant COAZ–19553–AA	ESR–M13P4–A
Threadlock® and Sealer EOAZ–19554–AA	WSK–M2G315–A5

General Specifications	
Item	**Specification**
Gasket and Trim Adhesive D7AZ–19B508–B	ESR–M11P17–A and ESE–M2G52–A
Rust Penetrant and Inhibitor F2AZ–19A501–A	ESR–M99C56–A

Table 1, General Specifications

Lubricant Refill Capacity			
Transmission	**Approximate Capacity**		
	U.S. Pints	**Imperial Pints**	**Liters**
All	28	23.2	13.2

Table 2, Lubricant Refill Capacity

Torque Specifications	
Description	**lbf·ft (N·m)**
Eaton RT–8908LL, RTO–11908LL, RTO–14908LL, RT–14915, RTO–14915, and RTO–16915 Series Manual Transmission	
Clutch Housing Capscrews	90–100 (122–136)
Clutch Housing Stud Nuts	180–190 (244–256)
Clutch Housing-to-Engine Bolts (M10 x 1.50 x 40)	40–60 (54–81)
Clutch Housing-to-Engine Bolts 7/16–14 x 1.50)	50–70 (68–95)
Clutch Release Arm-to-Shaft Nut	15–30 (20–40)
Oil Drain Plug	45–55 (61–75)
Oil Fill Plug	60–75 (81–101)
Oil Trough Capscrews	8–12 (11–16)
Shift Control Housing Capscrews	35–45 (47–61)
Shift Lever Housing Capscrews	35–45 (47–61)
Fuller RTO-11909MLL and RTO-14909MLL Manual Transmissions	
Clutch Housing Capscrews	122–136 (90–100)
Oil Trough Capscrews	11–16 (8–12)
Transmission Rear Mount Jam Nut	203–278 (150–205)
Top Rear Engine Support Bracket Retaining Nut	203–278 (150–205)
Gearshift Lever Capscrews	47–61 (35–45)
Shift Bar Housing Capscrews	47–61 (35–45)
Transmission to Engine Capscrews	68–95 (50–70)

Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Clutch Release Arm Nut	20–40 (15–30)
Eaton RT–LO Manual Transmissions	
Clutch Housing Capscrews	122–136 (90–100)
Clutch Housing Stud Nuts	244–256 (180–190)
Clutch Housing-to-Engine Bolts (M10 x 1.50 x 40)	54–81 (40–60)
Clutch Housing-to-Engine Bolts (7/16–14 x 1.50)	68–95 (50–70)
Clutch Release Arm-to-Shaft Nut	20–40 (15–30)
Oil Drain Plug	61–75 (45–55)
Oil Fill Plug	81–101 (60–75)
Oil Trough Capscrews	11–16 (8–12)
Shift Control Housing Capscrews	47–61 (35–45)
Shift Lever Housing Capscrews	47–61 (35–45)

Table 3, Torque Specifications

General Information

EATON FULLER L9000-SERIES 9- and 10-SPEED DIRECT AND OVERDRIVE TRANSMISSIONS

The Eaton Fuller L9000-Series 9- and 10-Speed direct and overdrive transmissions feature the Roadranger® air shift system, twin countershafts and helical auxiliary gears. The series includes the following models: RT/X–11709H, RT/X–12709H, RT/X–13709H, RT/X–14709H, RTX–16709H, RT/X–11710B, RTX–11710C, RT/X–12710B, RTX–12710C, RT/X–13710B, RTX–13710C, RT/X–14710B, RTX–14710C, RTX–15710 B/C, and RTX–16710 B/C.

NOTE: The 9-speed transmission gear ratios are shown in **Table 1** and the 10-speed transmission gear ratios are shown in **Table 2**.

9-Speed Gear Ratio												
											Relative Speed PTO Gear to Input rpm	
Model	LO	1st	2nd	3rd	4th	5th	6th	7th	8th	Reverse	Right	Bottom
RT–11709H	13.29	9.16	6.53	4.80	3.57	2.56	1.83	1.34	1.00	3.89/ 13.89	.696	.696
RT–12709H	13.29	9.16	6.53	4.80	3.57	2.56	1.83	1.34	1.00	3.89/ 13.89	.696	.696
RT–13709H	13.29	9.16	6.53	4.80	3.57	2.56	1.83	1.34	1.00	3.89/ 13.89	.696	.696
RT–14709H	13.29	9.16	6.53	4.80	3.57	2.56	1.83	1.34	1.00	3.89/ 13.89	.696	.696
RTX–11709H	10.55	7.41	5.23	3.79	2.77	1.95	1.38	1.00	0.73	2.99/ 11.33	.788	.788
RTX–12709H	10.55	7.41	5.23	3.79	2.77	1.95	1.38	1.00	0.73	2.99/ 11.33	.788	.788
RTX–13709H	10.55	7.41	5.23	3.79	2.77	1.95	1.38	1.00	0.73	2.99/ 11.33	.788	.788
RTX–14709H	10.55	7.41	5.23	3.79	2.77	1.95	1.38	1.00	0.73	2.99/ 11.33	.788	.788
RTX–16709H	10.55	7.41	5.23	3.79	2.77	1.95	1.38	1.00	0.73	2.99/ 11.33	.788	.788
RTX–16709B	12.46	7.41	5.23	3.79	2.77	1.95	1.38	1.00	0.73	3.43/ 13.03	.788	.788

Table 1, 9-Speed Gear Ratio

10-Speed Gear Ratio												
											Relative Speed PTO Gear to Input rpm	
Model	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Reverse	Right	Bottom
RT–11710B	14.78	11.00	8.17	6.00	4.46	3.31	2.46	1.83	1.34	1.00	3.38/ 14.78	.788	.788

General Information

10-Speed Gear Ratio													
												Relative Speed PTO Gear to Input rpm	
Model	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Reverse	Right	Bottom
RT–12710B	14.78	11.00	8.17	6.00	4.46	3.31	2.46	1.83	1.34	1.00	3.38/ 14.78	.788	.788
RT–13710B	14.78	11.00	8.17	6.00	4.46	3.31	2.46	1.83	1.34	1.00	3.38/ 14.78	.788	.788
RT–14710B	14.78	11.00	8.17	6.00	4.46	3.31	2.46	1.83	1.34	1.00	3.38/ 14.78	.788	.788
RTX–11710B	10.99	8.18	6.07	4.46	3.32	2.46	1.83	1.36	1.00	.74	2.52/ 11.23	.788	.788
RTX–12710B	10.99	8.18	6.07	4.46	3.32	2.46	1.83	1.36	1.00	.74	2.52/ 11.23	.788	.788
RTX–13710B	10.99	8.18	6.07	4.46	3.32	2.46	1.83	1.36	1.00	.74	2.52/ 11.23	.788	.788
RTX–14710B	10.99	8.18	6.07	4.46	3.32	2.46	1.83	1.36	1.00	.74	2.52/ 11.23	.788	.788
RTX–15710B	10.99	8.18	6.07	4.46	3.32	2.46	1.83	1.36	1.00	.74	2.52/ 11.23	.788	.788
RTX–15710C	12.80	9.25	6.76	4.90	3.58	2.61	1.89	1.38	1.00	.73	2.78/ 13.62	.788	.788
RTX–16710B	10.99	8.18	6.07	4.46	3.32	2.46	1.83	1.36	1.00	.74	2.52/ 11.23	.788	.788
RTX–16710C	12.80	9.25	6.76	4.90	3.58	2.61	1.89	1.38	1.00	.73	2.78/ 13.62	.788	.788

Table 2, 10-Speed Gear Ratio

IDENTIFICATION

IMPORTANT: Do not remove or destroy the transmission identification tag.

All Eaton Fuller transmissions are identified by the model and serial number. This information is stamped on the transmission identification tag and affixed to the case. See **Fig. 1**.

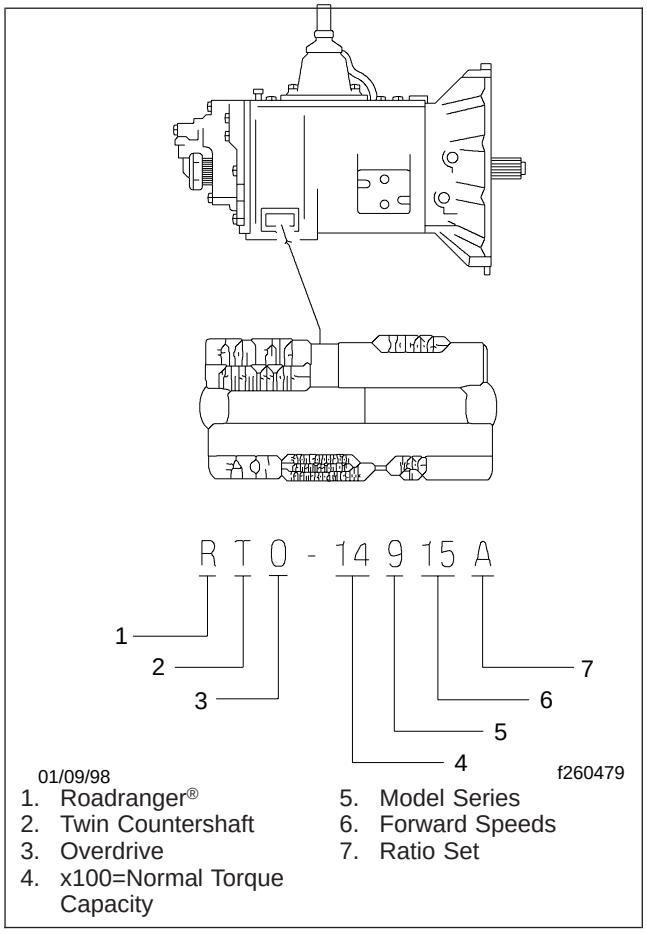


Fig. 1, Transmission Identification Plate

Torque Specifications	
Description	**lbf·ft (N·m)**
Clutch Housing Capscrews, Aluminum Clutch Housing	70–75 (95–102)
Clutch Housing Capscrews, Cast Clutch Housing	90–100 (122–136)
Clutch Housing Stud Nuts, Aluminum Clutch Housing	170–175 (230–237)
Clutch Housing Stud Nuts, Cast Clutch Housing	180–190 (244–256)
Clutch Housing-to-Engine Bolts (M10 x 1.50 x 40)	40–60 (54–81)
Clutch Housing-to-Engine Bolts (7/16–14 x 1.50)	50–70 (68–95)
Clutch Release Arm-to-Shaft Nut	15–30 (20–40)
Oil Drain Plug	45–55 (61–75)
Oil Fill Plug	60–75 (81–101)
Oil Trough Capscrews	8–12 (11–16)
Shift Control Housing Capscrews	35–45 (47–61)
Shift Lever Housing Capscrews	35–45 (47–61)

Table 1, Torque Specifications

Removal

⚠ WARNING

Set the parking brake and chock the wheels prior to performing this procedure to prevent unexpected and possible sudden vehicle movement.

1. Remove the interior trim as required and remove the transmission floor cover plate.

NOTE: The removal and installation procedures apply to all vehicles except where noted.

2. Remove the drain plug and allow the fluid to drain. See **Fig. 1**.

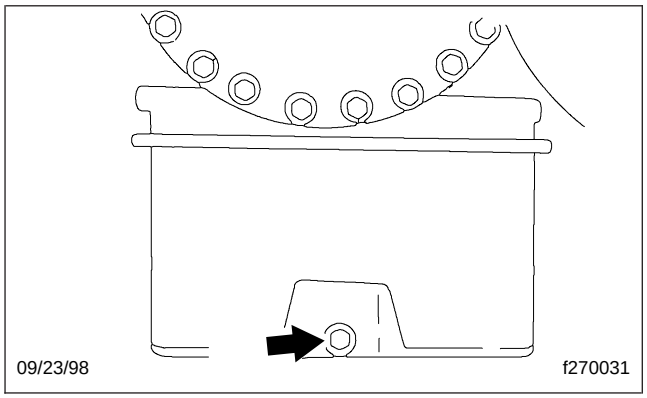
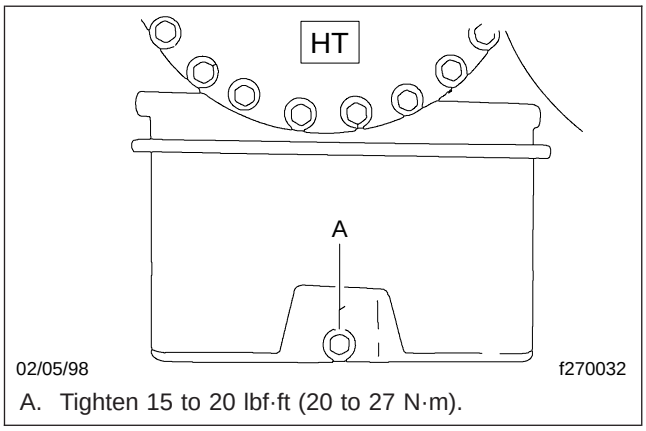


Fig. 1, Drain Plug

NOTE: Drain the fluid when the transmission is at normal operating temperature: 160 to 200°F (71 to 93°C).

3. Clean and install the drain plug when the fluid is drained. See **Fig. 2**.
4. Disconnect the fluid filler tube and plug the opening. See **Fig. 3**.
5. Disconnect the selector lever cable at the transmission control lever, and remove the cable clamp and bracket from the housing. See **Fig. 4**.
6. Disconnect all electrical connectors at the transmission.

IMPORTANT: Mark the driveshaft before removal in order to prevent an out-of-phase condition upon installation.



A. Tighten 15 to 20 lbf·ft (20 to 27 N·m).

Fig. 2, Tightening the Drain Plug

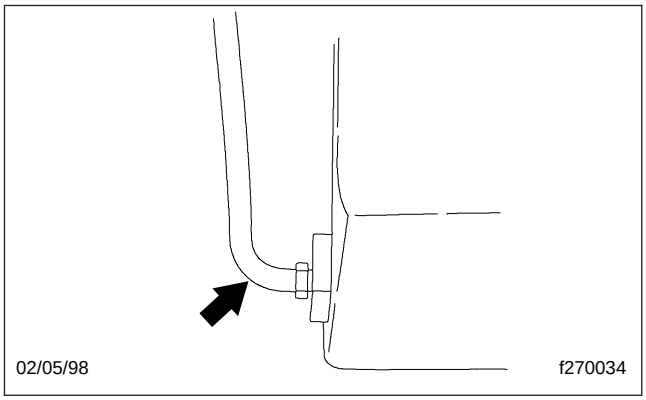
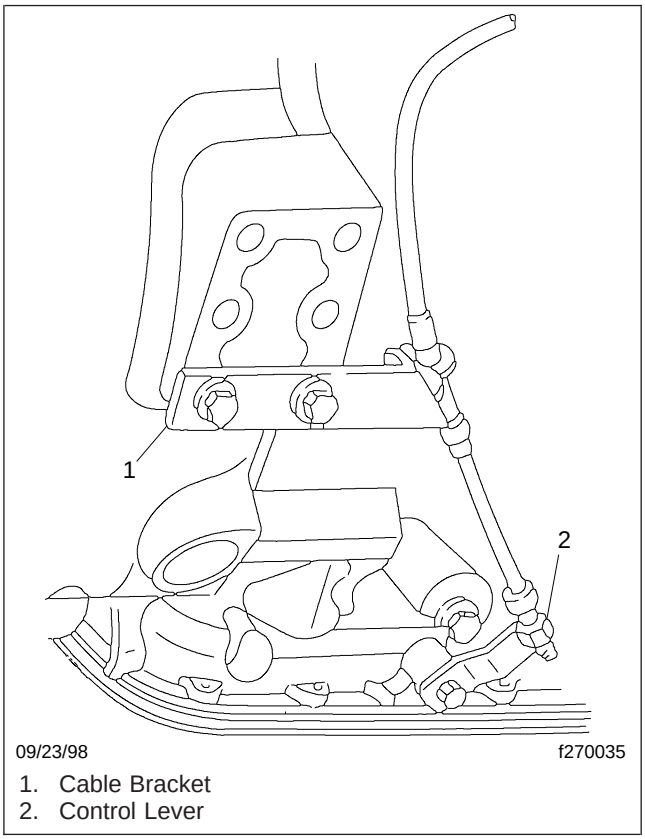


Fig. 3, Fluid Filler Tube

7. Remove the four output shaft yoke U-joint bolts. See **Fig. 5**.
8. Disconnect the driveshaft at the transmission output shaft yoke. Position the driveshaft aside.
9. On HT Series transmissions, disconnect the modulator cable assembly and linkage.
10. Disconnect the fluid cooler tubes at the fittings on the transmission. Drain the lines if desired. Plug the line and transmission fittings.
11. Disconnect or remove the exhaust manifold-to-exhaust pipe and bracket, if necessary.
12. Remove the access cover from the flywheel housing.

NOTE: The transmission cannot be removed from or installed onto the torque converter while it is in the vehicle. Remove the converter and the transmission from the vehicle as a unit.

Removal and Installation



1. Cable Bracket
2. Control Lever

Fig. 4, Selector Lever and Cable Clamp

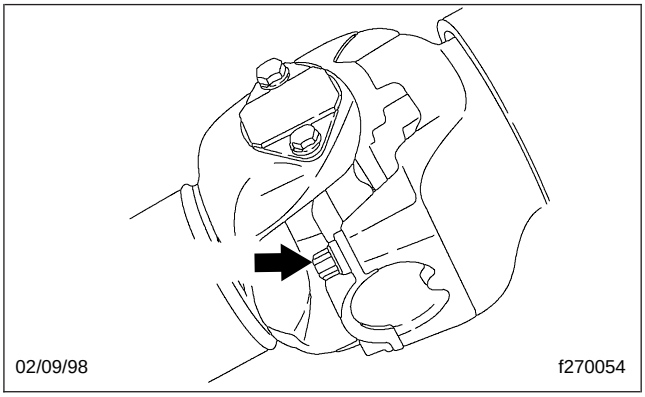


Fig. 5, Output Shaft U-joint Bolt

13. Remove the bolts retaining the flywheel to the converter (adapter plate for AT and MT).
14. Place a support under the rear end of the engine, then raise the engine to take the weight off the transmission support, if so equipped.
15. Support the transmission with a suitable transmission jack.
    - 15.1 Place the jack so the fluid pan does not support the entire weight of the transmission.
    - 15.2 Fasten a safety chain over the top of the transmission and to both sides of the jack.
16. Remove the 12 transmission-to-flywheel housing bolts. See **Fig. 6**.

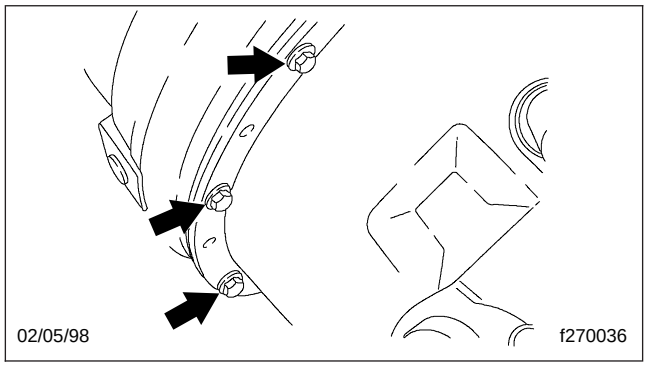


Fig. 6, Transmission-to-Flywheel Housing Bolts

17. Remove the transmission support, if so equipped. Note the positioning of the shims for installation. See **Fig. 7**.

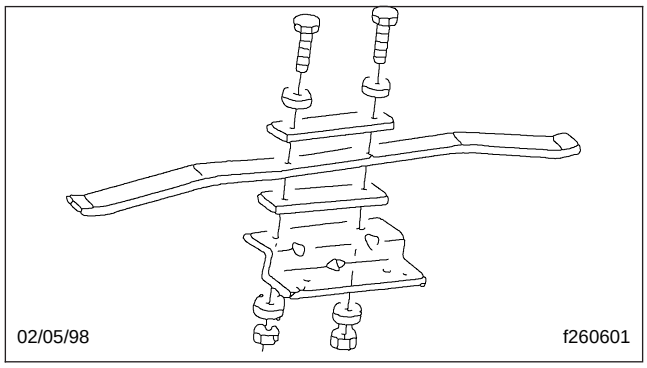


Fig. 7, Transmission Support Bracket

NOTE: Transmission supports are both engine and transmission model dependent.

18. Move the converter and transmission away from the engine until the converter housing clears the crossmember, then lower the unit.

⚠ WARNING

A retaining strap must be used to secure the torque converter to the transmission to prevent personal injury or damage to the torque converter.

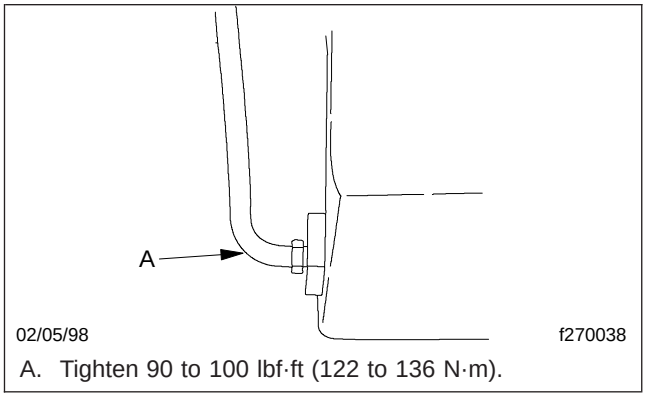
19. Raise the floorpan slightly to permit the converter housing to clear the crossmember, if necessary.

Installation

1. Check the flexplate runout. The maximum total indicated runout (TIR) is 0.030 inch (0.762 mm) for B5.9 and C8.3 engines. Refer to the engine manufacturer's repair manual for all other engines.
2. Check the flywheel housing face alignment. Refer to the engine manufacturer's repair manual.
3. Position the transmission to the engine. Then raise the transmission with the converter on the jack, then move the unit into position over the crossmember. Align the holes in the converter with the holes in the flywheel, then push the unit forward.
4. Install and tighten the bolts retaining the flywheel to the converter (adapter plate for AT and MT). Refer to **Specifications, 400** for the proper torque.
5. Install the access cover on the flywheel housing.
6. Install the bolts retaining the transmission to the flywheel housing. Tighten the retaining bolts: AT/MT: 38 to 45 lbf·ft (52 to 61 N·m), HT: 54 to 65 lbf·ft (73 to 88 N·m).
7. Install the transmission support, if so equipped.
8. Lower the transmission jack and remove it from underneath the vehicle.
9. Remove the engine support from under the rear end of the engine.
10. On HT Series transmissions, install the modulator control actuating cable assembly

IMPORTANT: Do not connect the kickdown control linkage at this time.

11. Install the selector lever cable clamp and bracket and connect the selector lever cable to the transmission control lever.
12. Remove the protective plug and connect the fluid filler tube. Tighten the retaining bolts: MT/HT: 90 to 100 lbf·ft (122 to 136 N·m), AT: 70 to 80 lbf·ft (95 to 108 N·m). See **Fig. 8**.



A. Tighten 90 to 100 lbf·ft (122 to 136 N·m).

Fig. 8, Tightening the Fluid Filler Tube

13. Install or connect the exhaust manifold-to-exhaust pipe and bracket if it was removed or disconnected.
14. Install the U-joint into its original position and install the driveshaft U-joint bolts.
15. Connect the electrical connectors.
16. Replace the fluid filter. Remove the protective plugs and install the fluid cooler tubes.
17. Adjust both the selector lever linkage and if applicable, the modulator control actuating cable.
18. Fill the transmission.
19. Install the transmission floor cover plate and any interior trim removed.

Specifications

Torque Specifications		
Description	**lbf·ft (N·m)**	**lb·in (N·cm)**
Adjuster Lock-Nut	—	44–62 (500–700)
Universal Joint Flange Retaining Bolt (AT and MT)	103–121 (139–164)	—
Universal Joint Flange Retaining Bolt (AT and MT)	103–121 (139–164)	—
Flange Retaining Nut (HT)	600–800 (813–1085)	—
Transmission-to-Flywheel Housing Bolts (AT and MT)	38–45 (52–61)	—
Neutral Start Switch	—	44-62 (500–700)
Backup Lamp Switch	—	44–62 (500–700)
Fluid Filler Tube to Filler Pan (MT and AT)	90–100 (122–136)	—
Fluid Filler Tube (AT)	70–80 (95–108)	—
Selector Cable Bracket to Transmission Housing	8–10 (11–13)	—
Transmission-to-Flywheel Housing Bolts (HT)	54–65 (73–88)	—
Control Lever Retaining Nuts	15–20 (20–27)	—
Modulator Unit Retaining Bolt	12–17 (16–23)	—

Torque Specifications		
Description	**lbf·ft (N·m)**	**lb·in (N·cm)**
Drain Plug	15–20 (20–27)	—
Flexplate-to-Converter Bolts (HT)	96–116 (130–157)	—
Flexplate-to-Adapter Plate Bolts (AT)	42–50 (57–68)	—
Flexplate-to-Adapter Plate Bolts (MT)	38–45 (52–61)	—
Transmission Kickdown Control Stud Nut	12–17 (16–23)	—

Table 1, Torque Specifications

General Specifications	
Item	**Specification**
Premium Power Steering Fluid	WSA–M2C195–A
Exxon Transmission Fluid EC–29488	WSA–M2C195–A
Multi-Purpose Grease DOAZ–19584–AA	ESR–M1C159–A and ESB–M1C93–A

Table 2, General Specifications

Approximate Lubricant Refill Capacity					
			Approximate Capacity		
Transmission	**Filler Location**	**Drain Location**	**U.S. Pints**	**Liters**	**Imp. Pints**
AT–542, AT–545 *	Right Side	Right Side	30, 40	14.2,18.9	25, 33.2
MT Series	Right Side	Left Side	36	17.3	29.9
HT Series	Right Side	Left Side	60 (6" or 7" Fluid Pan)	28.4 (6" or 7" Fluid Pan)	50 (6" or 7" Fluid Pan)

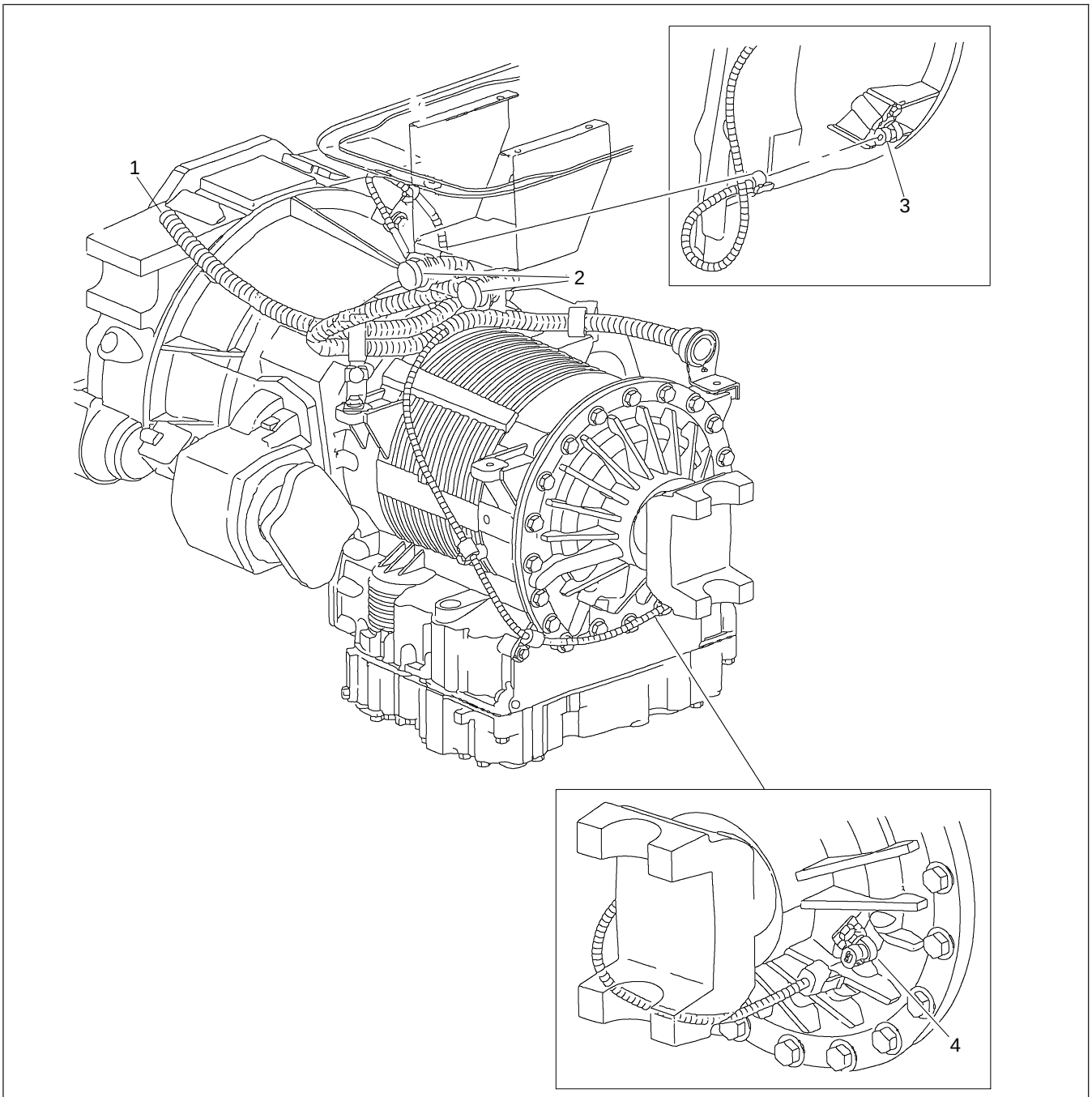
* Approximate U.S. and Imperial fluid capacities do not include cooler circuit capacities.

Table 3, Approximate Lubricant Refill Capacity

General Information

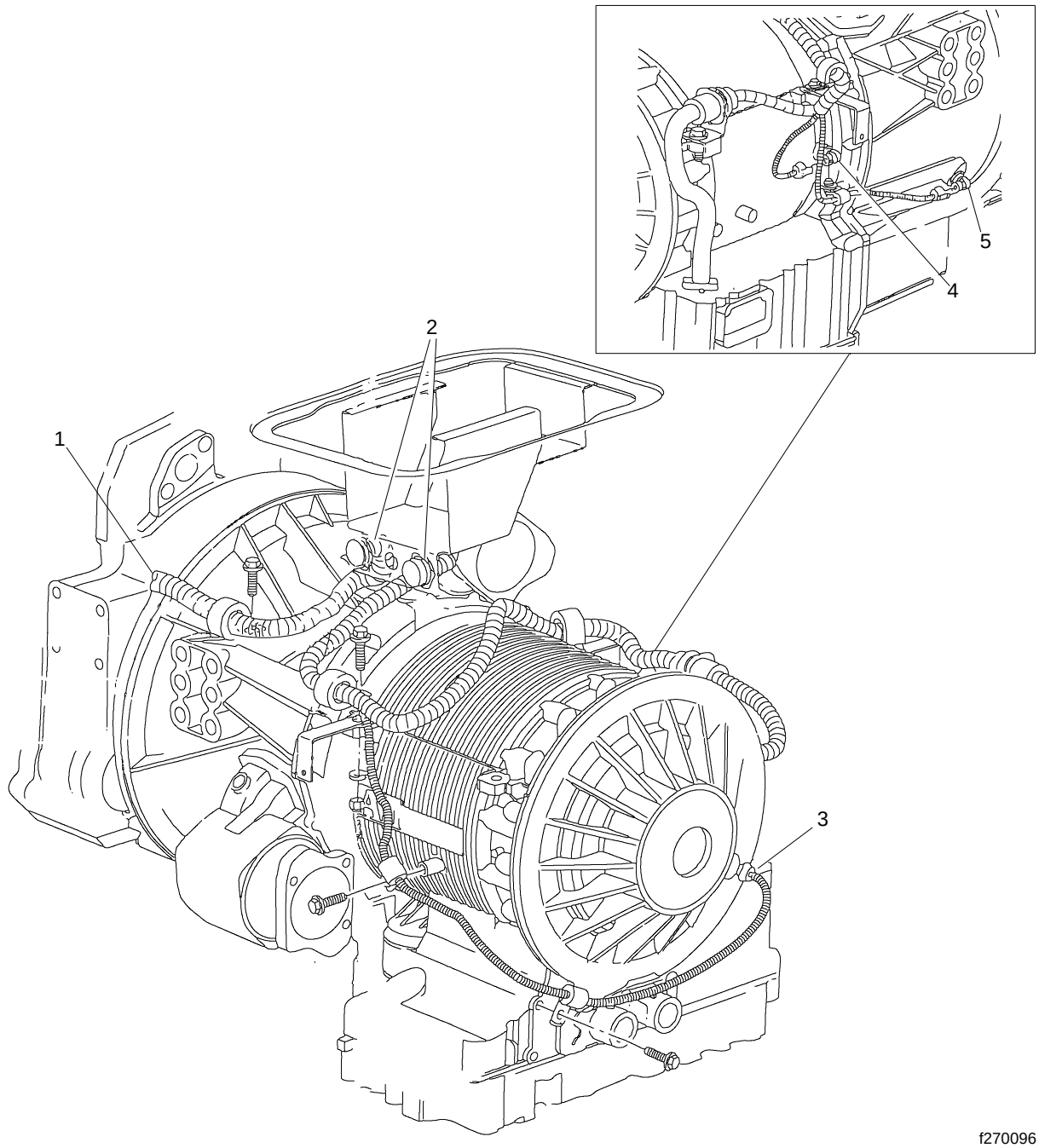
The Allison MD and HD Series automatic transmissions are shown in **Fig. 1**, **Fig. 2**, and **Fig. 3**.

General Information



1. To Engine Wiring (pedestal mounted shifter)
2. To Engine Wiring (instrument panel mounted shifter)
3. To Transmission Control Module and Vehicle Interface Module (pedestal mounted shifter)
4. To Transmission Control Module and Vehicle Interface Module (instrument panel mounted shifter)

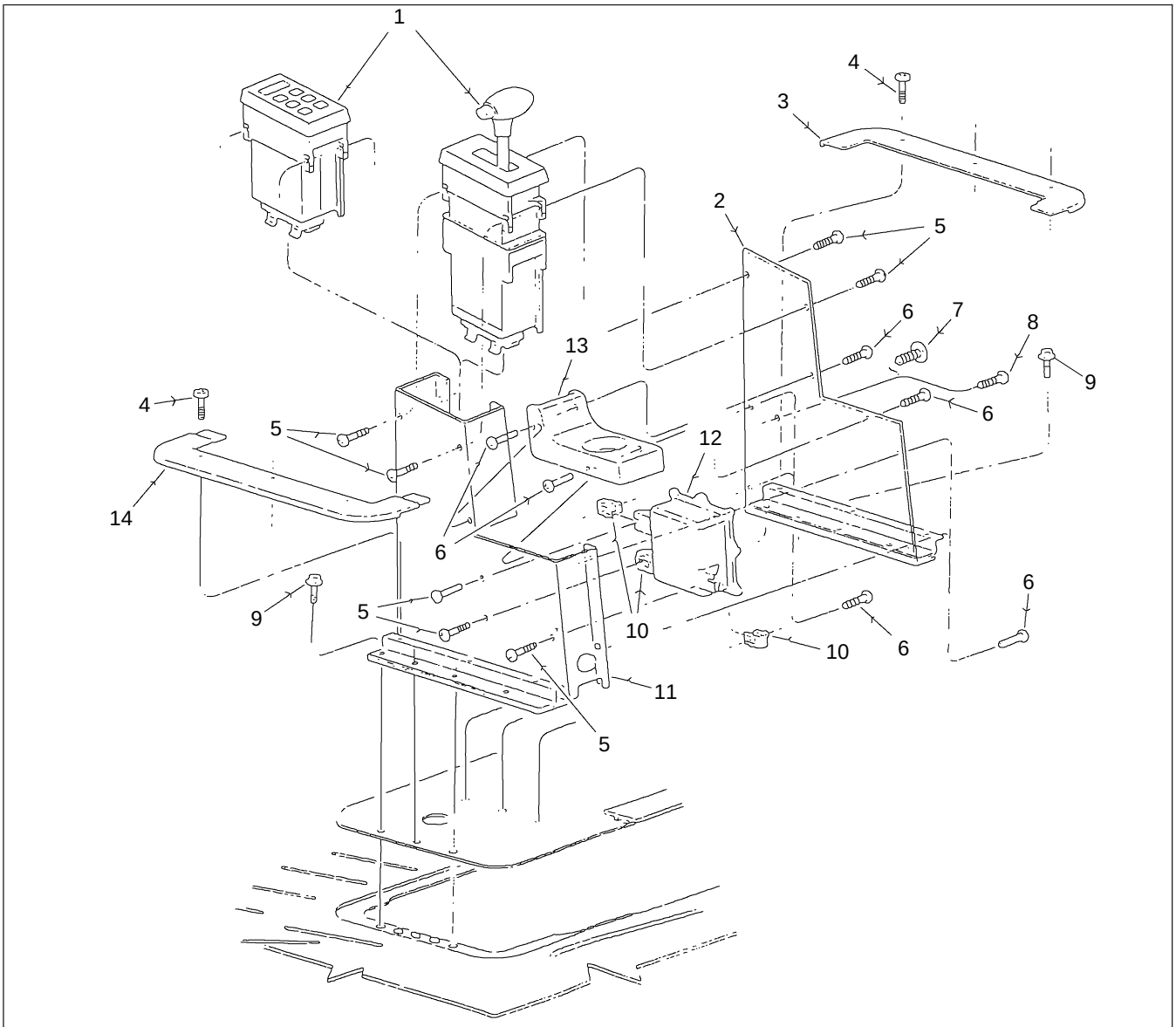
Fig. 1, MD Series Transmission Harness Routing



1. To Engine Wiring (pedestal mounted shifter)
2. To Engine Wiring (instrument panel mounted shifter)
3. To Transmission Control Module and Vehicle Interface Module (pedestal mounted shifter)
4. To Transmission Control Module and Vehicle Interface Module (instrument panel mounted shifter)
5. Output Speed Sensor

Fig. 2, HD Series Transmission Harness Routing

General Information



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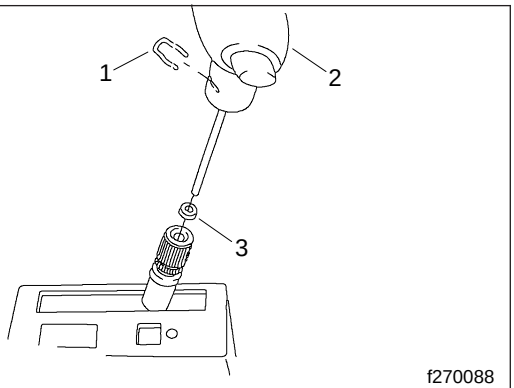
1. Control Assembly
2. Cover Panel (RH)
3. Cover Side Trim
4. Screw
5. Bolt
6. Screw
7. Pin
8. Bolt (use with lever style shifter)
9. Bolt
10. Nut
11. Control
12. Vehicle Interface Module
13. Cupholder
14. Cover, Side Trim

Fig. 3, Electronic Gear Selection Assembly

Pedestal-Mounted Keypad and Lever Style Shifters, TCM and VIM

REMOVAL

1. Set the parking brake and chock the wheels.
2. Disconnect the battery ground cable.
3. Remove the clip at the base of the shift knob with a small screwdriver or similar tool. See **Fig. 1**.



1. Clip
2. Shift Knob
3. Bushing

Fig. 1, Shift Selector Knob and Components

4. Remove the shift knob and the shaft from the selector housing.
5. Remove the bushing from the shaft.
6. Refer to illustrations in **Subject 050** for shift selector and module components.

INSTALLATION

1. Refer to illustrations in **Subject 050** for shift selector and module components.
2. Install the bushing onto the shift shaft.
3. Install the shift knob and the shaft onto the selector housing.
4. Install the clip at the base of the shift knob with a small screwdriver or similar tool.
5. Tighten all of the bolts and screws securely.

Connect the battery ground cable.

Instrument Panel-Mounted Keypad Shifter, TCM and VIM

REMOVAL

1. Remove the Torx® screws from the right-hand trim panel.
2. Remove the right-hand trim panel cover.
3. Disconnect the electrical connector from behind the keypad mounting bracket.
4. Remove the two mounting nuts from behind the keypad shifter and remove the keypad shifter.
5. Refer to illustration in **Subject 050** if module removal is required.

INSTALLATION

1. Refer to illustration in **Subject 050** if module installation is required.
2. Connect the electrical connector from behind the keypad mounting bracket.
3. Install the two mounting nuts behind the keypad shifter and install the keypad shifter.
4. Install the right-hand trim panel cover.
5. Install the Torx® screws into the right-hand trim panel.

Specifications

Approximate Lubricant Refill Capacity					
			Approximate Capacity		
Transmission	Filler Location	Drain Location	U.S. Pints	Liters	Imp. Pint
Allison HD Series	Right Side	Left Side	94.5	44.5	78
Allison MD Series	Right Side	Left Side	58	27.5	48

Table 1, Approximate Lubricant Refill Capacity

Torque Specifications	
Description	lbf·ft (N·m)
MD 3000 Series, with C10 Engine: Flexplate-to-Ring Gear Bolts	17–21 (24–29)
HD 4000 Series: Transmission-to-Flywheel Housing Bolts	54–65 (73–88)
HD 4000 Series with DDC60, 3406E, C10, C12 and M11 Engines: Flexplate-to-Ring Gear	96–116 (130–157)
HD 4000 Series, with N14 Engine:Ring Gear-to-Adapter Ring	96–116 (130–157)

Table 2, Torque Specifications

General Information

FLUID COOLER, INTEGRAL, ISC, 210-, 225- AND 250-HP LOW TORQUE ENGINES AND ISB ENGINE

The automatic transmission fluid cooler (heat exchanger) mounts in the right radiator tank. The heated transmission fluid circulates through the fluid cooler. The engine coolant circulates over the fluid cooler to absorb the heat from the transmission fluid. The cooled transmission fluid passes through a filter either in the return line to the transmission, or for MD series transmissions, an integral fluid filter.

FLUID COOLER, AUXILIARY, EXCEPT ISC, 210-, 225- AND 250-HP LOW TORQUE ENGINES AND ISB ENGINE

The auxiliary automatic transmission fluid cooler mounts behind the radiator assembly. Two hoses connect it to the transmission. The heated transmission fluid circulates through the cooler tubes. Air passing over the cooler element absorbs the heat from the transmission fluid. The cooled transmission fluid passes through a filter in either the return line to the transmission, or for MD series transmissions, an integral fluid filter.

OPERATING TEMPERATURES

Do not operate the transmission at temperatures that are consistently above 250°F (120°C). Intermittent operating temperatures to 300°F (149°C), however, will not harm the transmission. Operating temperatures above 250°F (120°C) increase the lubricant's rate of oxidation and shortens its effective life. When the average operating temperature is above 250°F (120°C), the transmission will either require more frequent fluid changes or external cooling.

The following conditions in any combination can cause operating temperatures of over 250°F (120°C):

- operating consistently at slow speeds
- high ambient temperatures
- restricted airflow around the transmission

TRANSMISSION TEMPERATURE INDICATOR LIGHT

The instrument panel-mounted TRANS TEMP warning light indicates when the transmission fluid temperature is at 300°F (149°C). If the light illuminates, stop the vehicle and shift the transmission to NEUTRAL. Then, accelerate the engine to 1200 to 1500 rpm to allow the transmission fluid to return to a normal temperature of 160 to 220°F (71 to 104°C). Check the transmission fluid level before resuming operation.

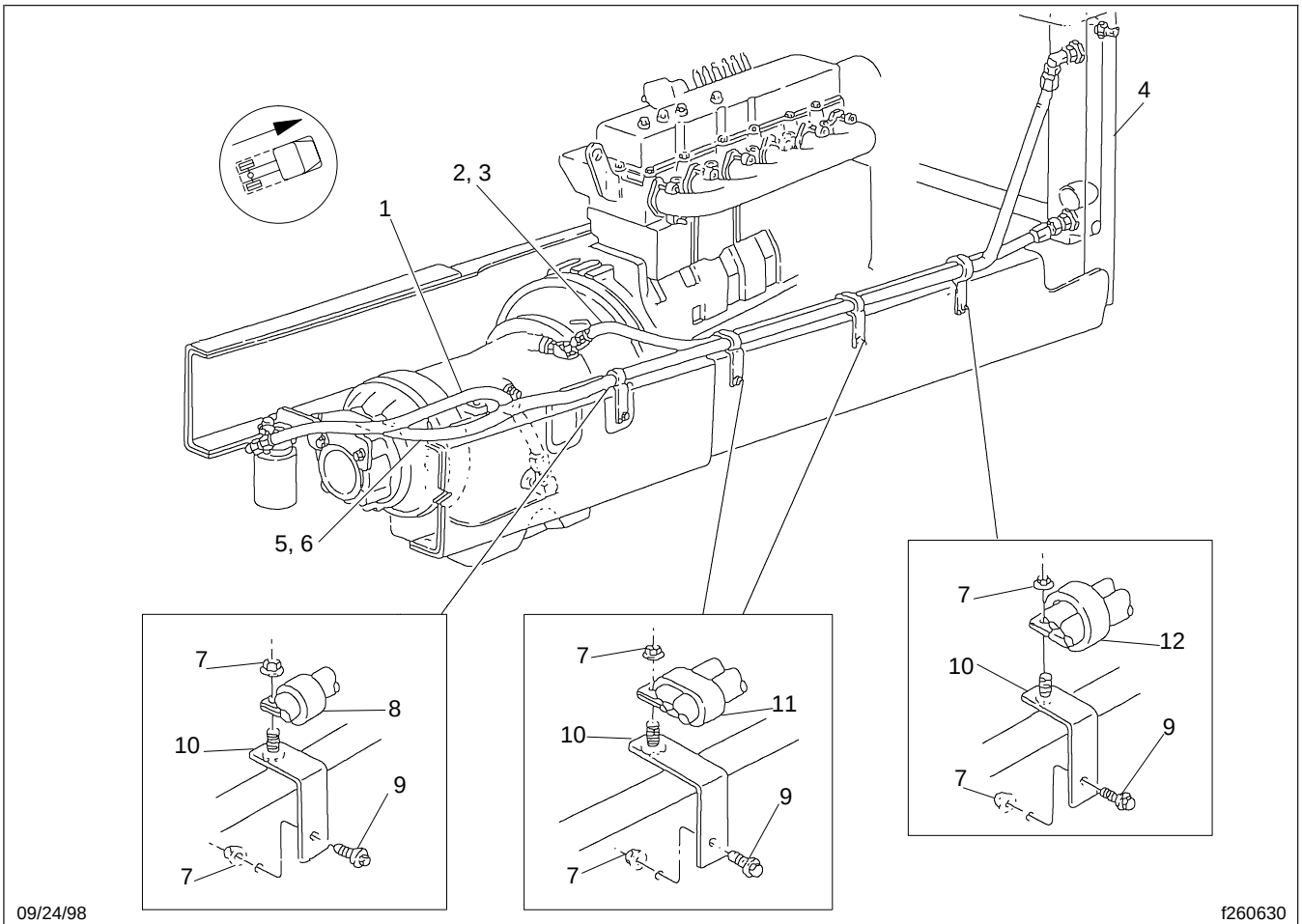
TRANSMISSION COOLER LINE FILTER

Normal transmission component wear creates debris that circulates in the transmission fluid cooling system. The debris eventually lodges in the transmission fluid cooler, preventing efficient cooling. In most cases, there is no effective method to completely remove the debris from the transmission fluid, yet as much as possible must be eliminated. Transmission fluid cooling systems use either an external filter in the fluid return circuit, or for MD series transmissions an integral fluid filter, to remove any debris present in the fluid, providing protection against excessive transmission wear, overheating, or damage due to contamination.

FLUID COOLER TUBES AND TRANSMISSION FLUID FILTER

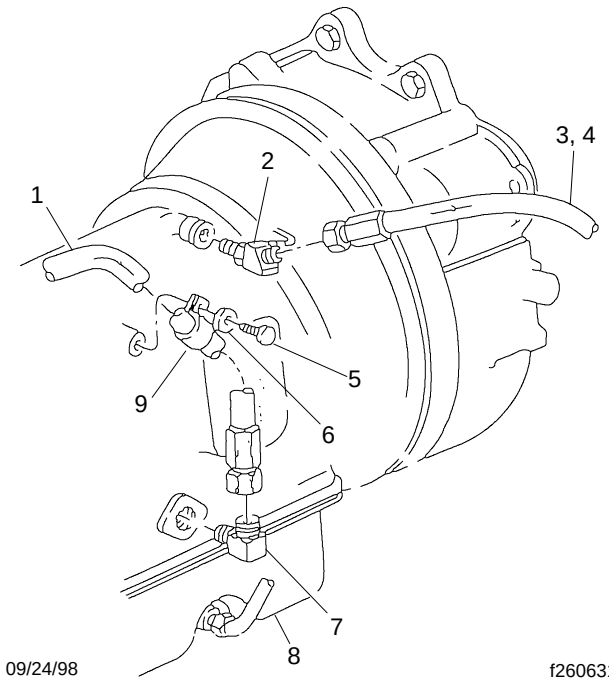
Refer to **Fig. 1**, **Fig. 2**, **Fig. 3**, **Fig. 4**, **Fig. 5**, **Fig. 6**, **Fig. 7**, **Fig. 8**, **Fig. 9**, **Fig. 10**, **Fig. 11**, **Fig. 12**, **Fig. 13**, **Fig. 14**, **Fig. 15**, **Fig. 16** and **Fig. 17** when removing and installing the fluid cooler tubes and the filter.

General Information



1. Transmission Fluid Cooler Return Tube
2. Transmission Fluid Cooler Supply Tube (ISC, 3126)
3. Transmission Fluid Cooler Supply Tube (ISB)
4. Cooling Module
5. Transmission Fluid Cooler Return Tube (ISC, 31126)
6. Transmission Fluid Cooler Return Tube (ISB)
7. Hex Nut, 5/16–18 x 1.13
8. Clip
9. Hex Bolt, 5/16–18 x 1.13
10. Bracket
11. Clip
12. Clip

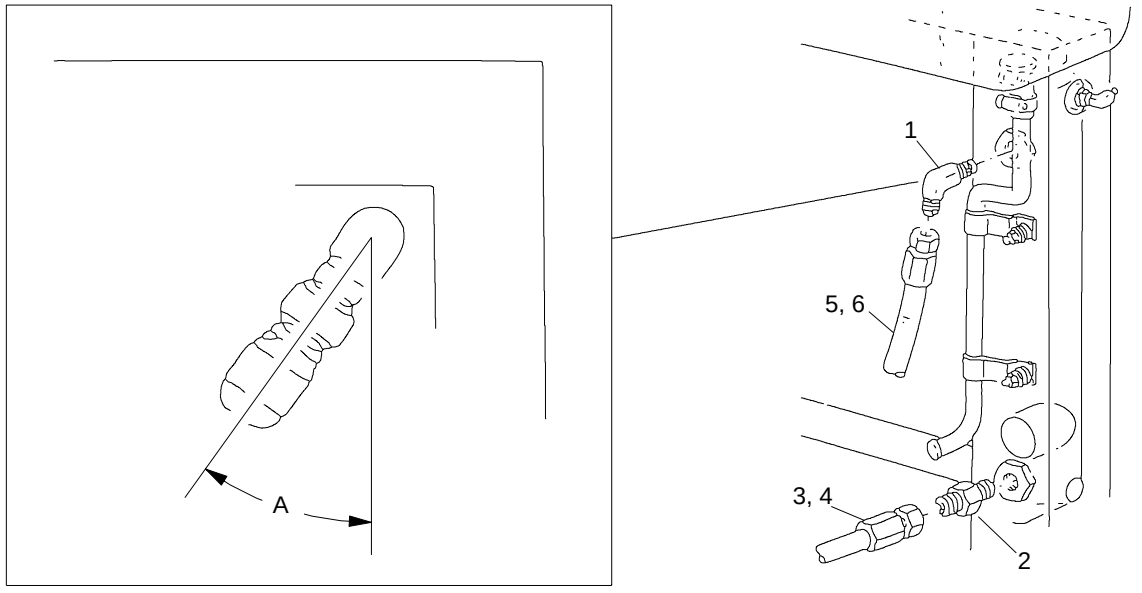
Fig. 1, Fluid Cooler Tubes, MT-643 and MT-653



1. Transmission Fluid Cooler Return Tube
2. Tee, 3/4 45 FL x 11/16 Standard Thread
3. Transmission Fluid Cooler Supply Tube (ISC, 3126)
4. Transmission Fluid Cooler Supply Tube (ISB)
5. Bolt, 7/16–14 x 1.00 Hex
6. Washer, 7/16 x.95 x.10 Flat
7. Elbow, 3/4 45 FL x 1–1/16 Standard Thread
8. Transmission Assembly
9. Clip

Fig. 2, Fluid Cooler Tube and Tube Connections, MT-643 and MT-653

General Information



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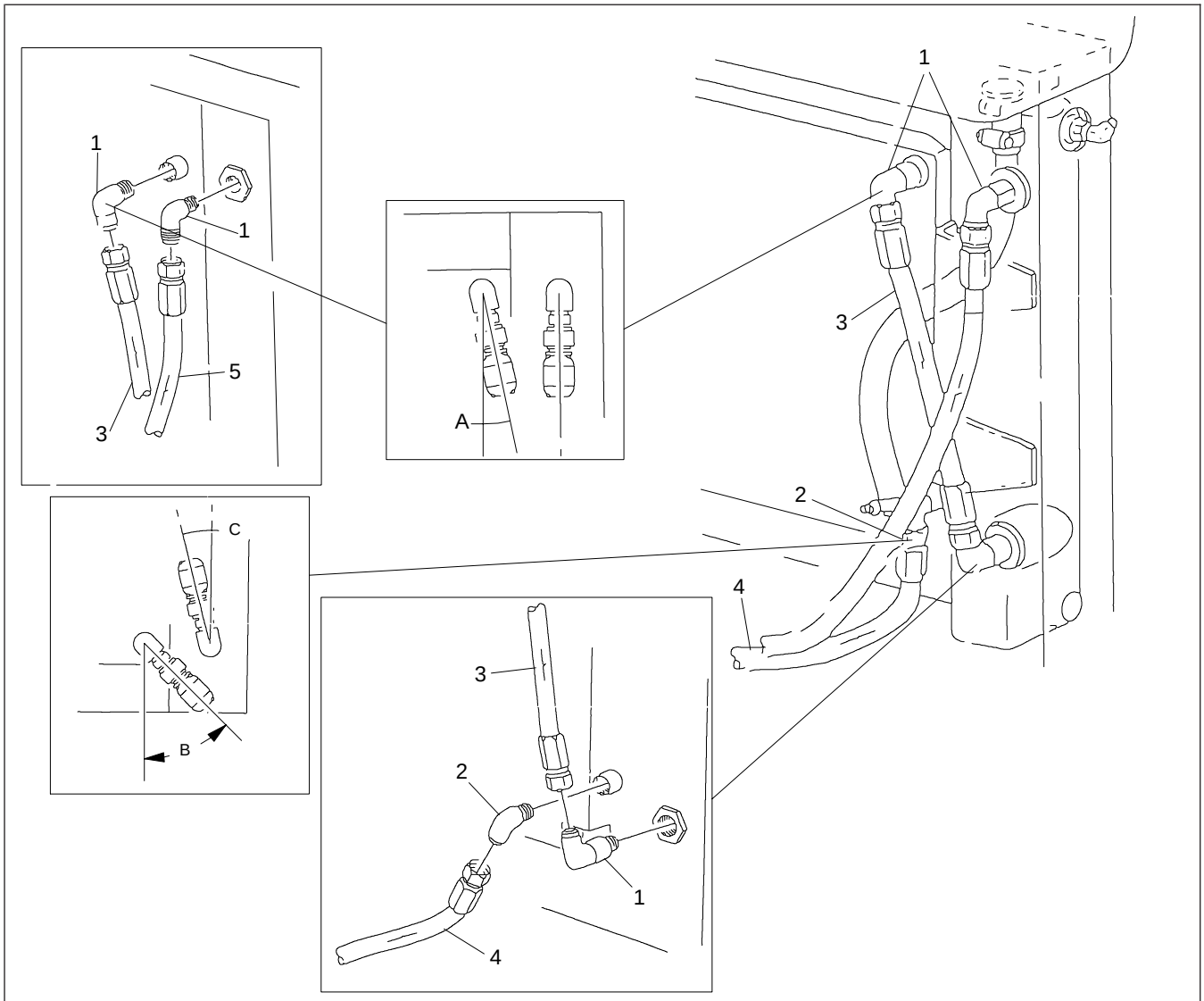
A. 15 Degrees
1. 90-Degree Elbow
2. Connector
3. Transmission Fluid Cooler Supply Tube (ISC, 3126)
4. Transmission Fluid Cooler Supply Tube (ISB)
5. Transmission Fluid Cooler Return Tube (ISC, 3126)
6. Transmission Fluid Cooler Return Tube (ISB)

Fig. 3, Fluid Cooler Tube and Tube Connections, MT-643 and MT-653 With ISC and 3126 Low Torque Engines and ISB Engine



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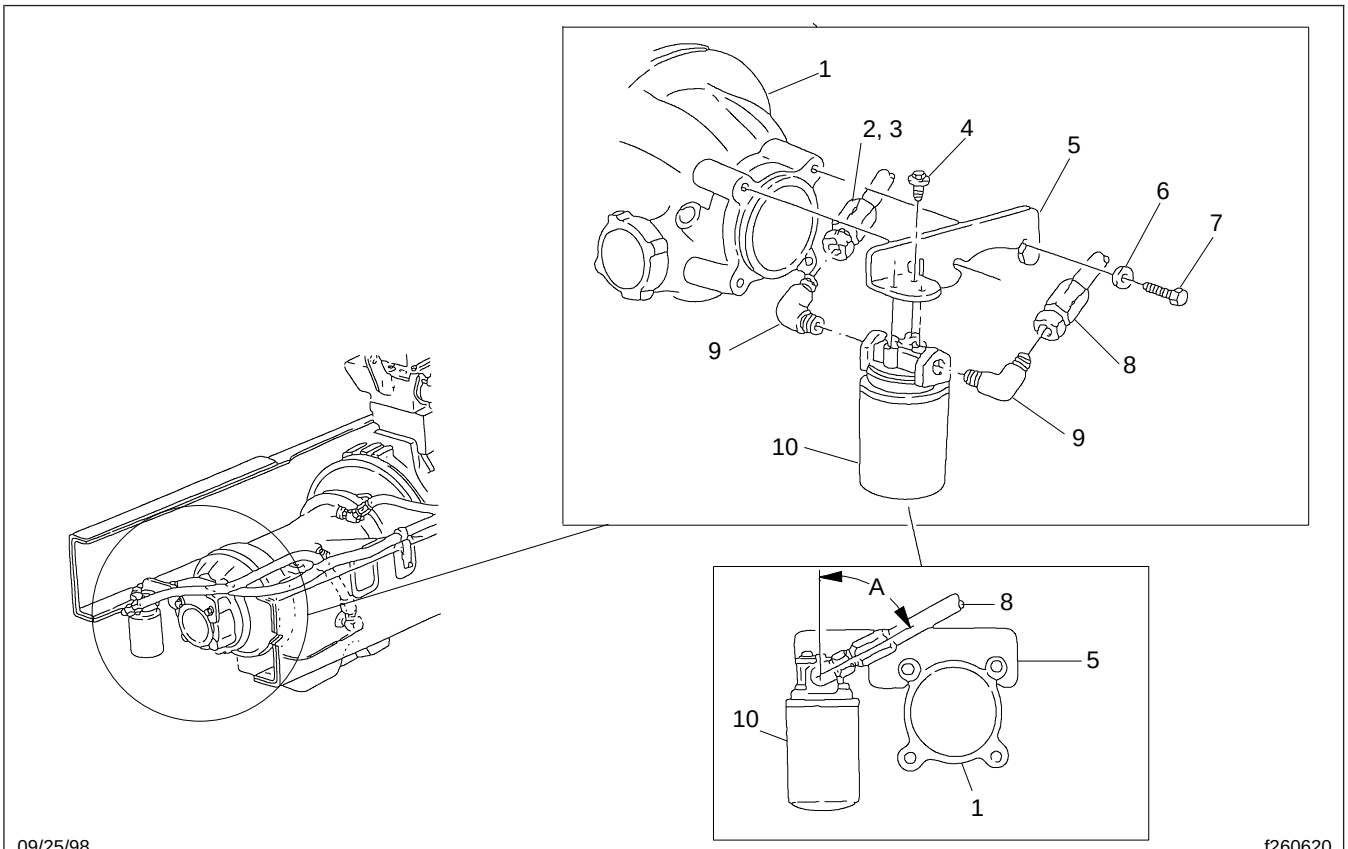
A. 12 Degrees
1. 90-Degree Elbow
2. 45-Degree Elbow
3. Transmission Fluid External Cooler to Integral Cooler Tube
B. 45 Degrees
4. Transmission Fluid Cooler Supply Tube
5. Transmission Fluid Cooler Tube Return Tube

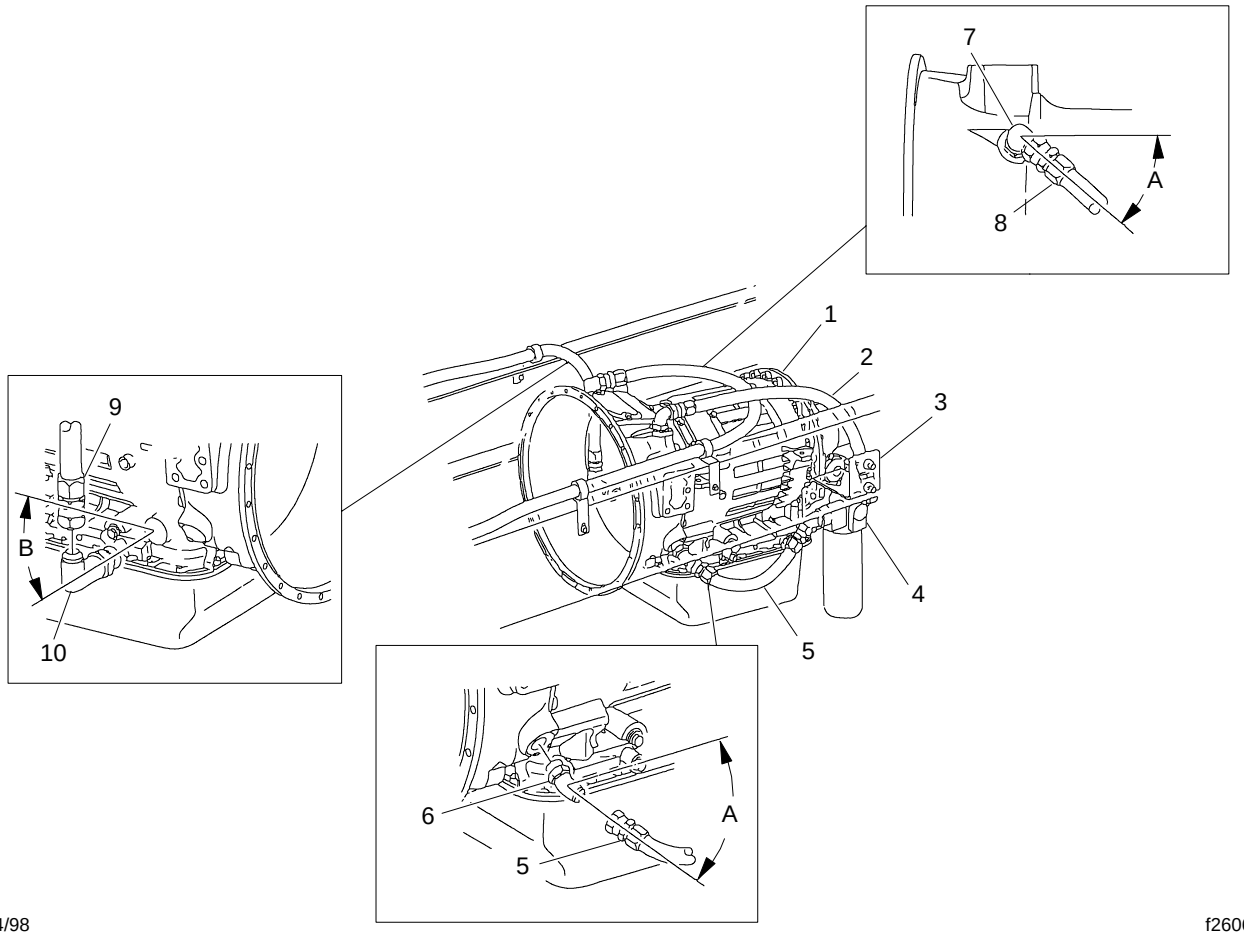
Fig. 4, Fluid Cooler Tube and Tube Connections, MD-3000 With 3126 High Torque Engines

General Information



A. 60 Degrees
1. Transmission Assembly
2. Transmission Fluid Cooler Return Tube (ISC)
3. Transmission Fluid Cooler Return Tube (ISB)
4. Hex Bolt, 5/16–18 x.75
5. Bracket
6. Flatwasher, 5/8 x 1.18 x 13
7. Hex Bolt, 5/8–11 x 1.50
8. Transmission Fluid Cooler Return Tube
9. 90-Degree Elbow
10. Filter Assembly

Fig. 5, Transmission Fluid Filter, MT-643, MT-653



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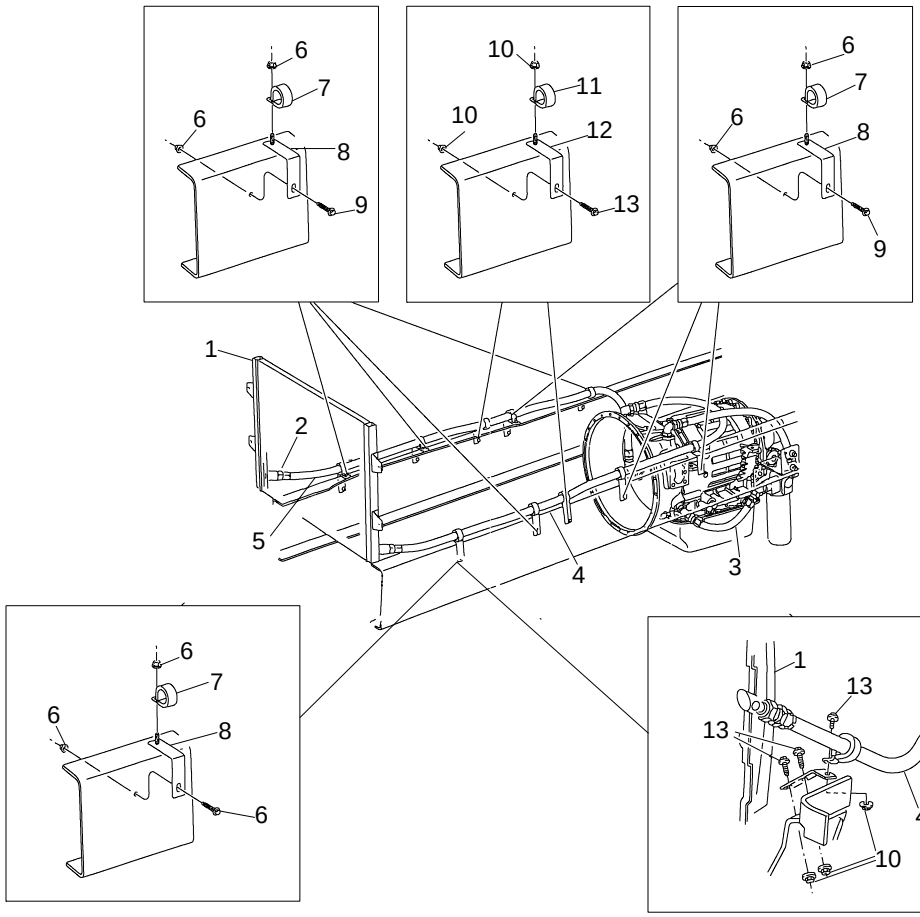
A. 45 Degrees
B. 90 Degrees
1. Transmission Assembly
2. Transmission Fluid Filter Supply Tube (101 and 113 BBC with DDC 60, N14, 3406)
3. Transmission Fluid Filter Bracket (101 and 113 BBC with C10, C12, 3306, M11, 122 BBC with DDC 60, N14, 3406)
4. Transmission Fluid Filter Assembly (122 BBC with C10, C12, 3306, M11)
5. Transmission Fluid Filter Return Tube
6. Transmission Fluid Filter Return Tube Elbow, 45-Degree
7. Transmission Fluid Filter Return Tube (101 and 113 BBC with C10, C12, 3306 and M11, 122 BBC with DDC 60, N14, 3406)
8. Transmission Fluid Filter Return Tube (101 and 113 BBC with DDC 60, N14, 3406, M11)
9. Transmission Fluid Cooler Return Tube (122 BBC with C10, C12, 3306, M11)
10. 90-Degree Elbow, Straight Thread

Fig. 6, Fluid Cooler Tubes and Tube Connections, HT-740 and HT-750 With Premium Diesel

General Information



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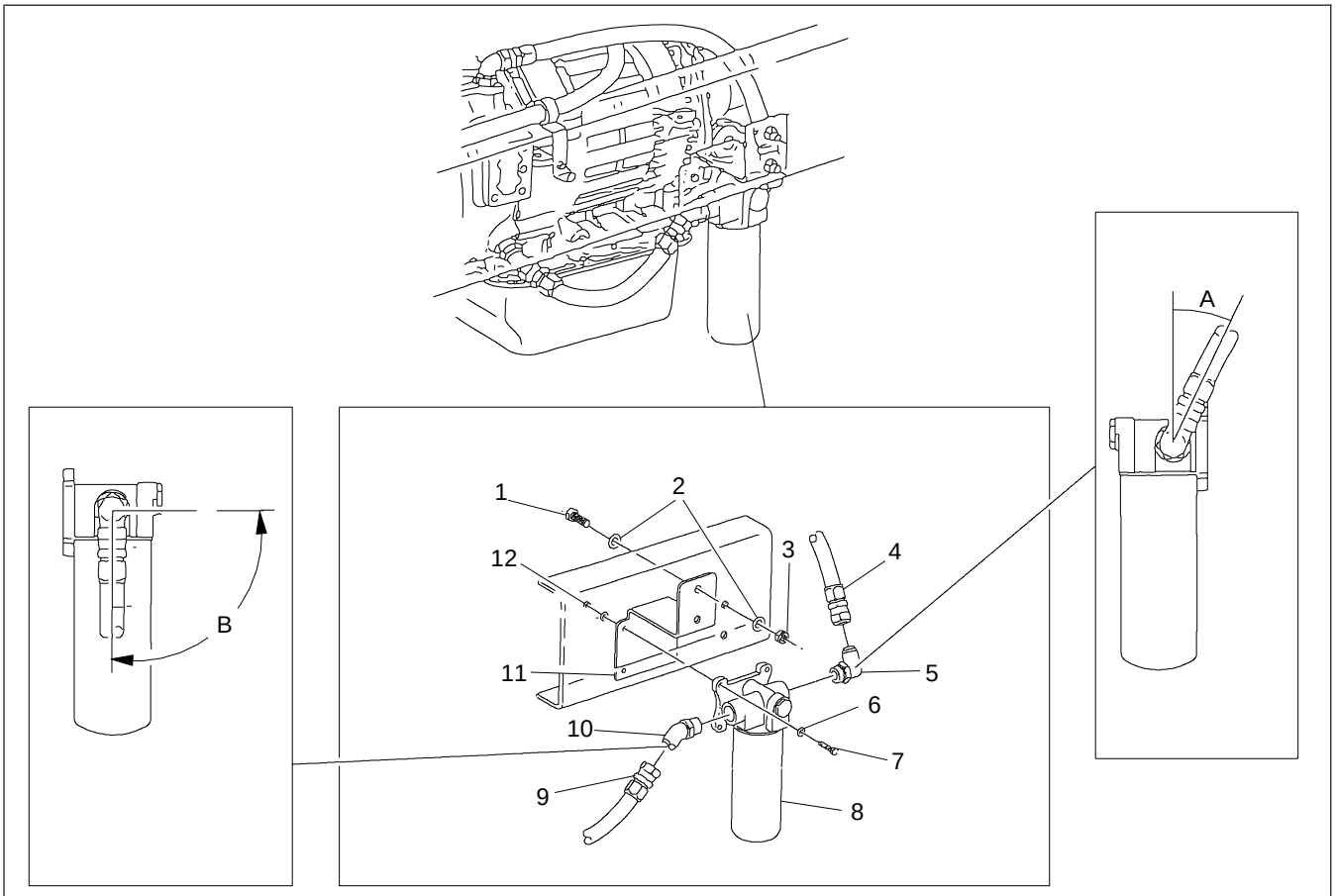
1. Transmission Fluid Cooler
2. Straight Connector
3. Transmission Fluid Filter Return Tube
4. Transmission Fluid Cooler Supply Tube
5. Transmission Fluid Cooler Return Tube
6. Nut
7. Clip
8. Bracket
9. Bolt
10. Nut (101 and 111 BBC)
11. Clip (101 and 111 BBC)
12. Bracket (101 and 111 BBC)
13. Bolt (101 and 111 BBC)
14. Retainer (101 and 111 BBC)

Fig. 7, Fluid Cooler Tubes and Frame Connections, HT-740 and HT-750 With Premium Diesel



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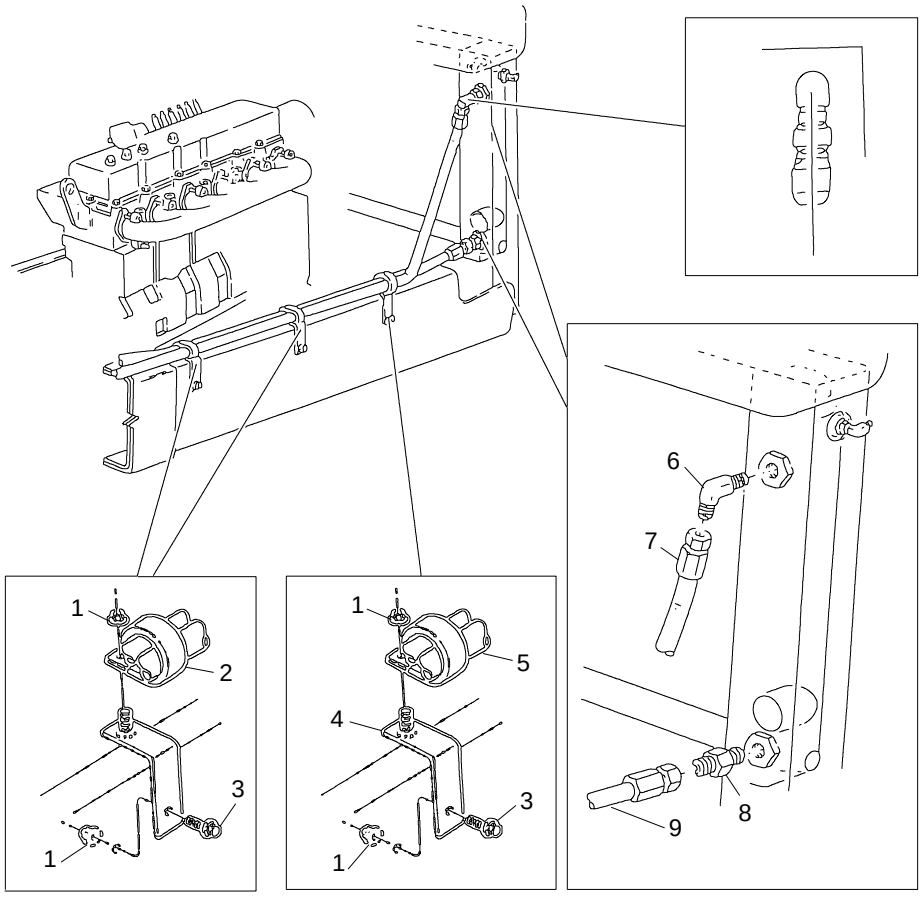
A. 25 Degrees
1. Hex Bolt, 5/8–11 x 1.75
2. Washer, 5/8 x 1.18 x 0.13
3. Hex Nut, 5/8–11
4. Transmission Fluid Filter Supply Tube
5. 90-Degree Elbow
6. Washer, 3/8 x 75 x 0.10

B. 90 Degrees
7. Bolt, 3/8–16 x 1.75 Hex
8. Transmission Fluid Filter Assembly
9. Transmission Fluid Filter Return Tube
10. 45-Degree Elbow
11. Transmission Fluid Filter Bracket
12. Hex Nut, 3/8–16

Fig. 8, Transmission Fluid Filter, HT-740 and HT-750 With Premium Diesel

General Information



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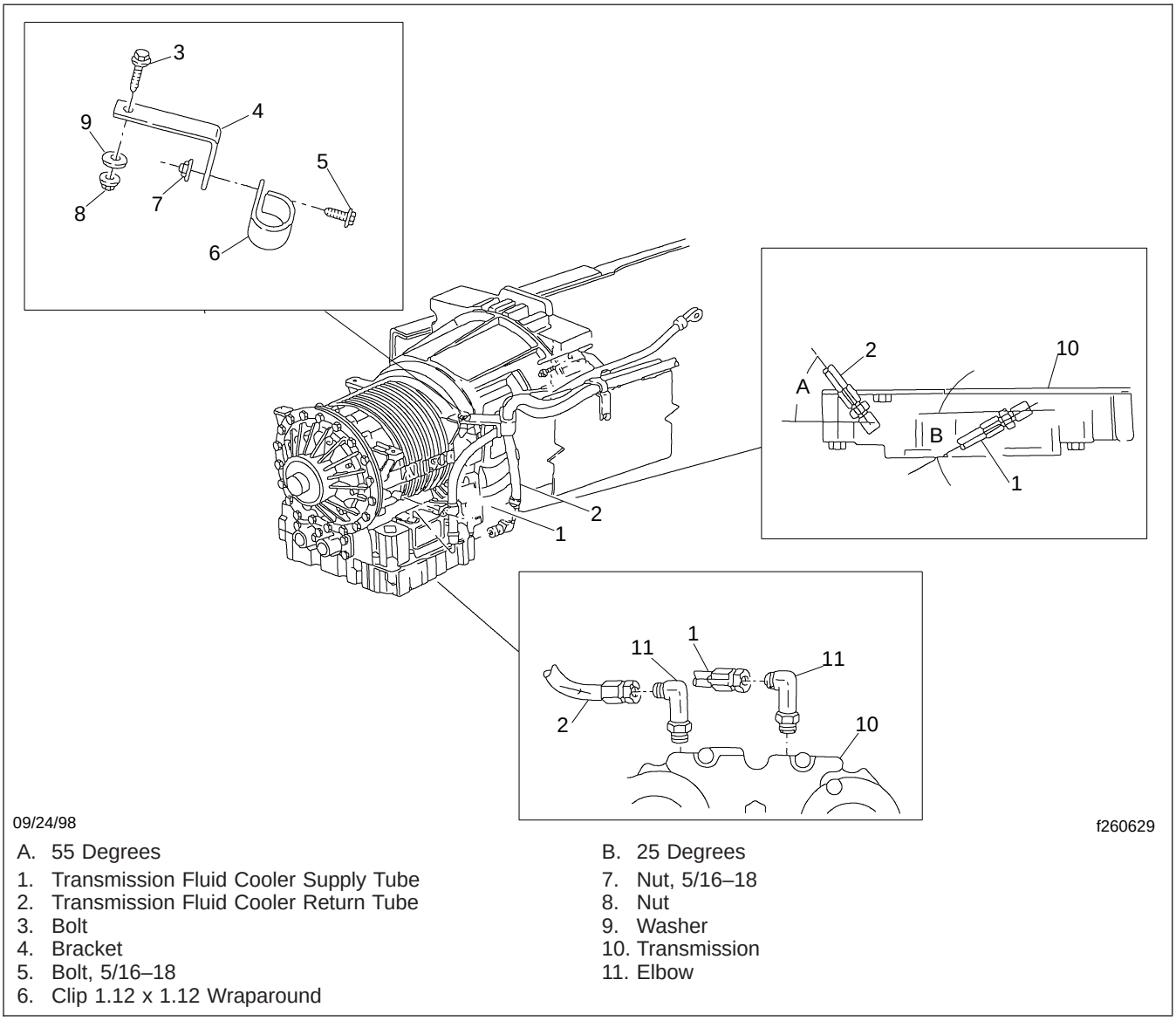
1. Nut
2. Clip, Wraparound
3. Bolt
4. Bracket
5. Clip
6. 90-Degree Elbow
7. Transmission Fluid Cooler Return Tube
8. Straight Connector, Pipe
9. Transmission Fluid Cooler Supply Tube

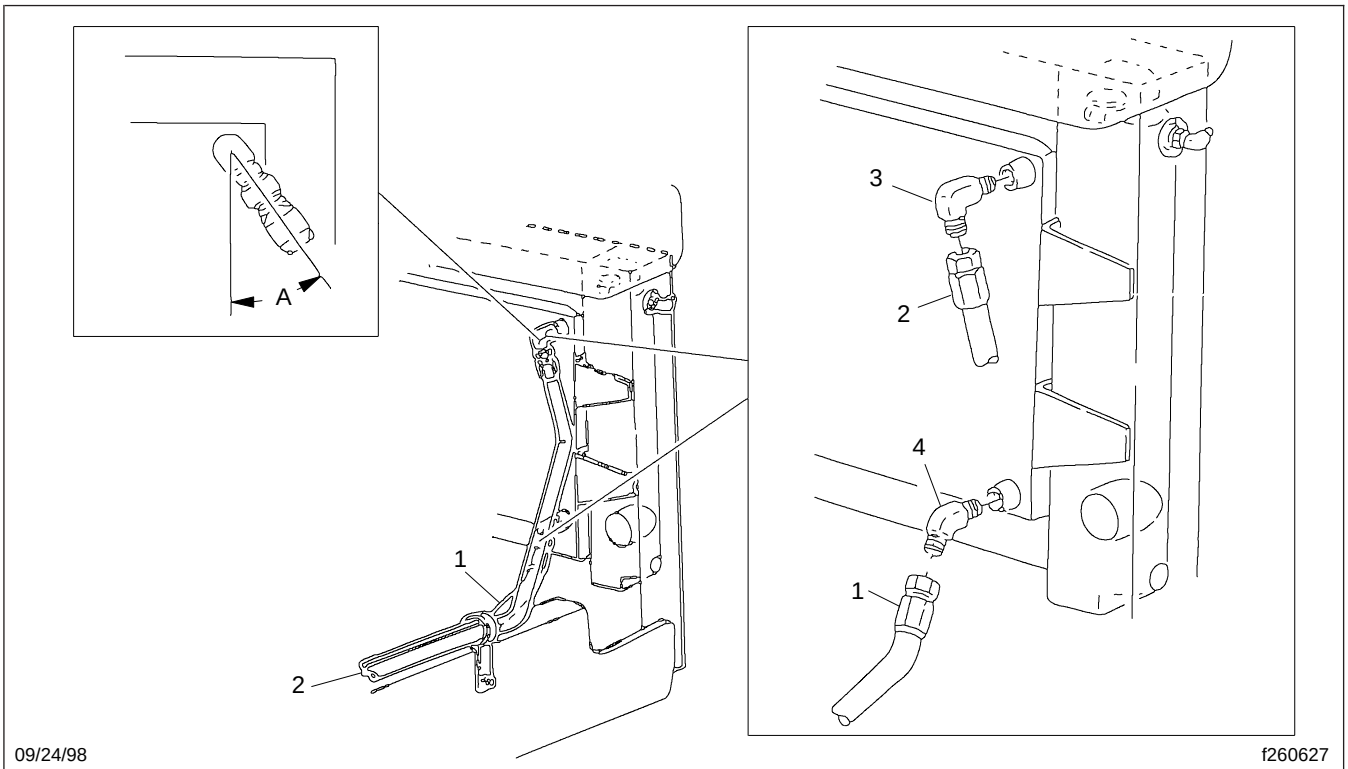
Fig. 9, Fluid Cooler Tubes, Tube and Frame Connections, MD-3000, With Radiator Integral Cooler, With ISC, 210-, 225- and 250-HP Low Torque Engines and ISB Engine



A. 55 Degrees
B. 25 Degrees
1. Transmission Fluid Cooler Supply Tube
2. Transmission Fluid Cooler Return Tube
3. Bolt
4. Bracket
5. Bolt, 5/16–18
6. Clip 1.12 x 1.12 Wraparound
7. Nut, 5/16–18
8. Nut
9. Washer
10. Transmission
11. Elbow

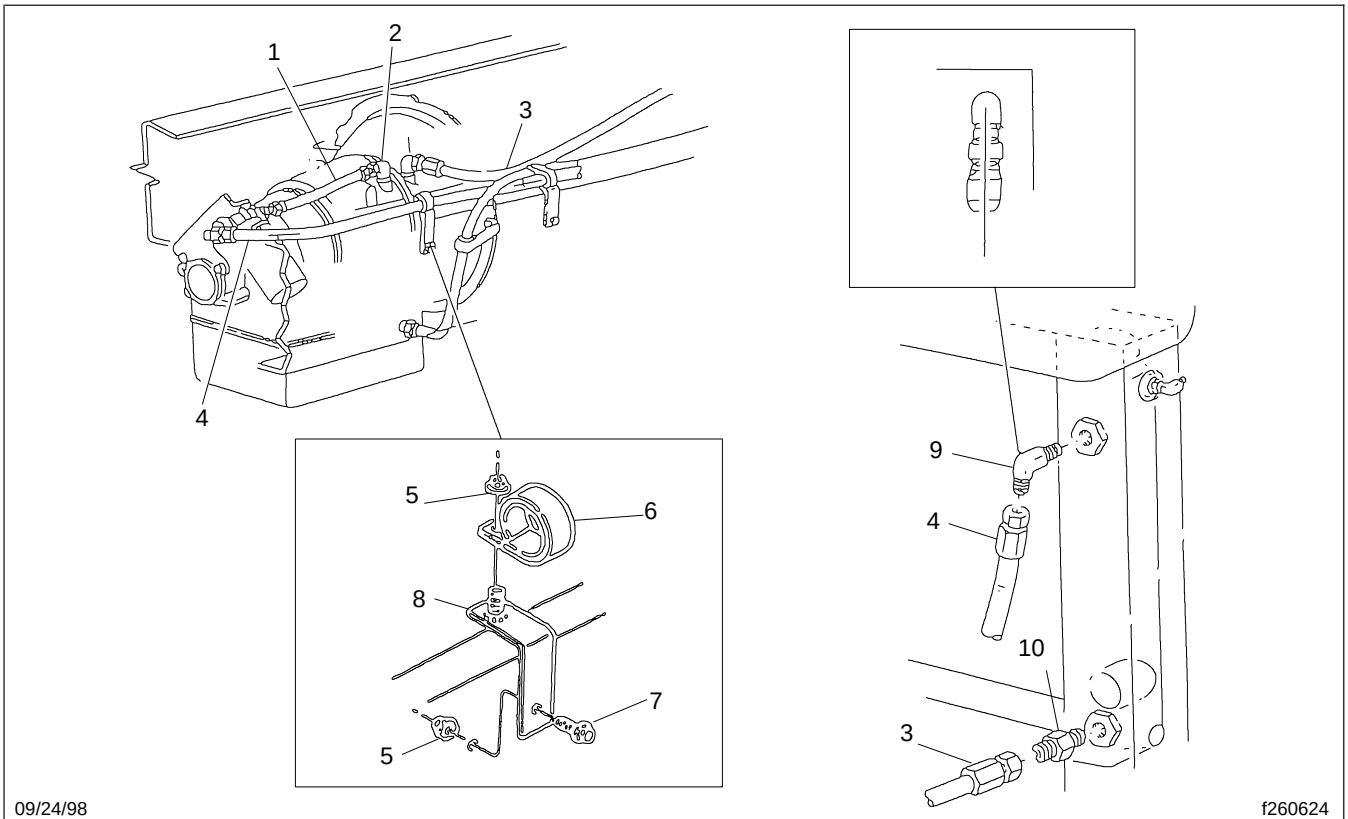
Fig. 10, Fluid Cooler Tubes and Tube Connections, MD-3000

General Information



A. 30 Degrees
1. Transmission Fluid Cooler Supply Tube (101 and 113 BBC with ISC)
2. Transmission Fluid Cooler Return Tube (101 and 113 BBC with ISC)
3. 90-Degree Elbow, Pipe
4. 45-Degree Elbow, Pipe

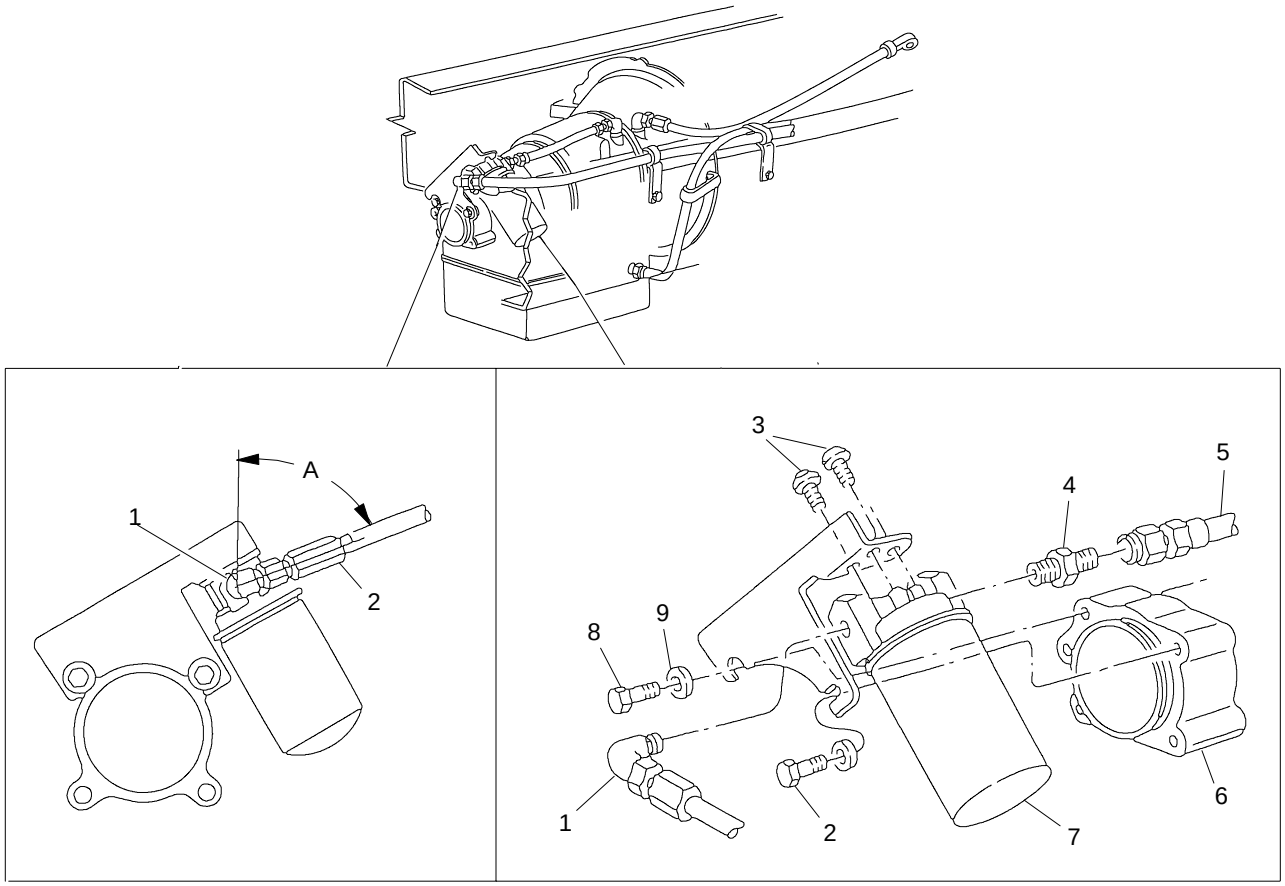
Fig. 11, Fluid Cooler Tubes and Tube Connections, MD-3000, With External Cooler, With ISC, 300-, 275- and 250-HP High Torque Engines



1. Fluid Filter to Transmission Tube
2. Elbow
3. Transmission Fluid Cooler Supply Tube
4. Transmission Fluid Cooler Return Tube
5. Nut, 5/16–18
6. Clip, 1.88 Wraparound
7. Bolt, 5/15–18
8. Bracket
9. 90-Degree Elbow, 3/4–45 FL x 3/4 Ex Pipe
10. 45-Degree Connector, 3/4–45 FLG x 3/4 Ex Pipe, Straight

Fig. 12, Fluid Cooler Tubes and Tube and Frame Connections, AT-542, AT-545, With Radiator Integral Cooler

General Information



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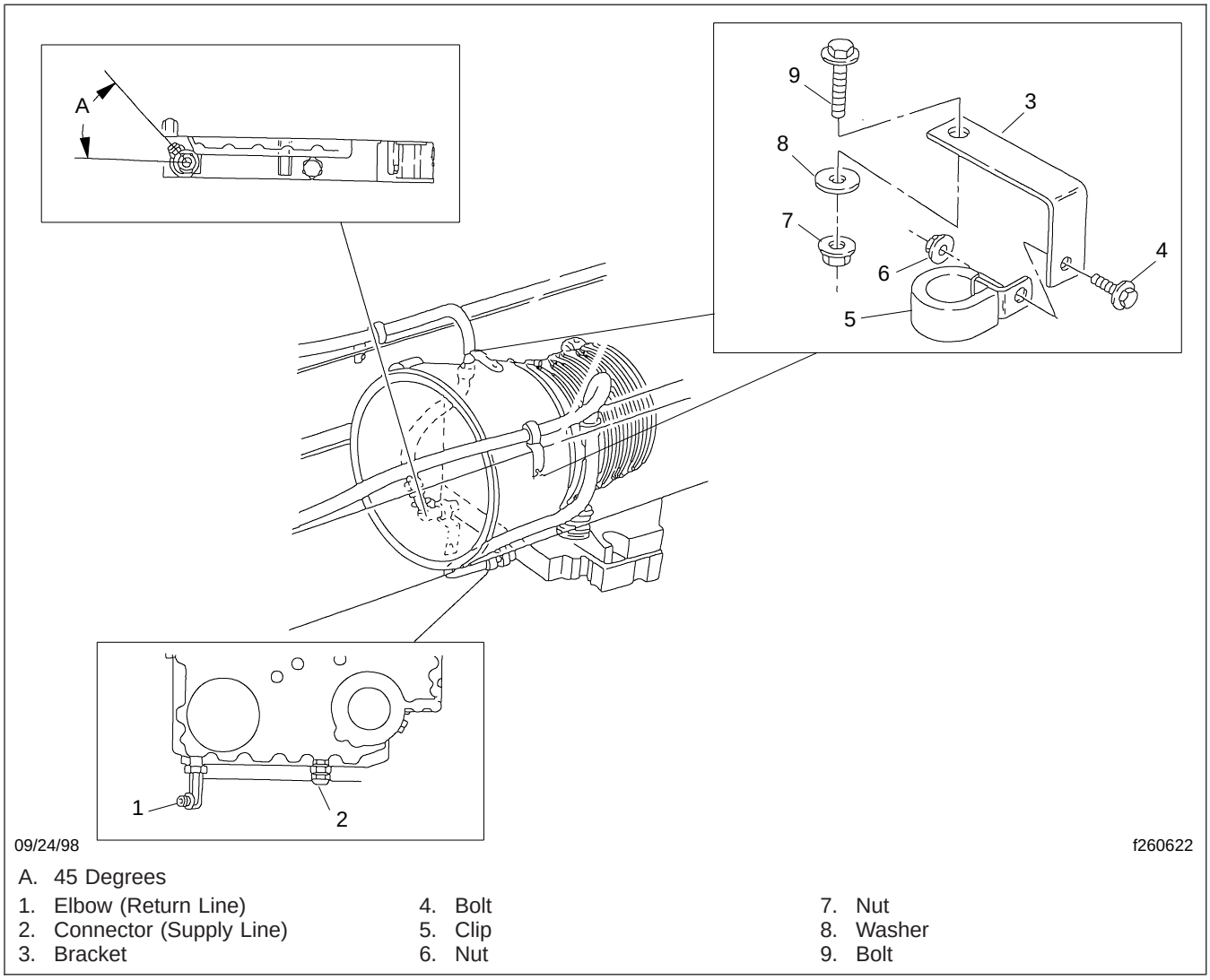
A. 60 Degrees
1. 90-Degree Elbow, 3/4-45 FL x 3/4 Ex Pipe
2. Transmission Fluid Cooler Return Tube
3. Bolt, 5/16–18
4. Connector, 3/4–45 FL x 3/4 Pipe
5. Fluid Filter to Transmission Tube
6. Transmission
7. Filter Assembly
8. Bolt, 5/16–11
9. Washer

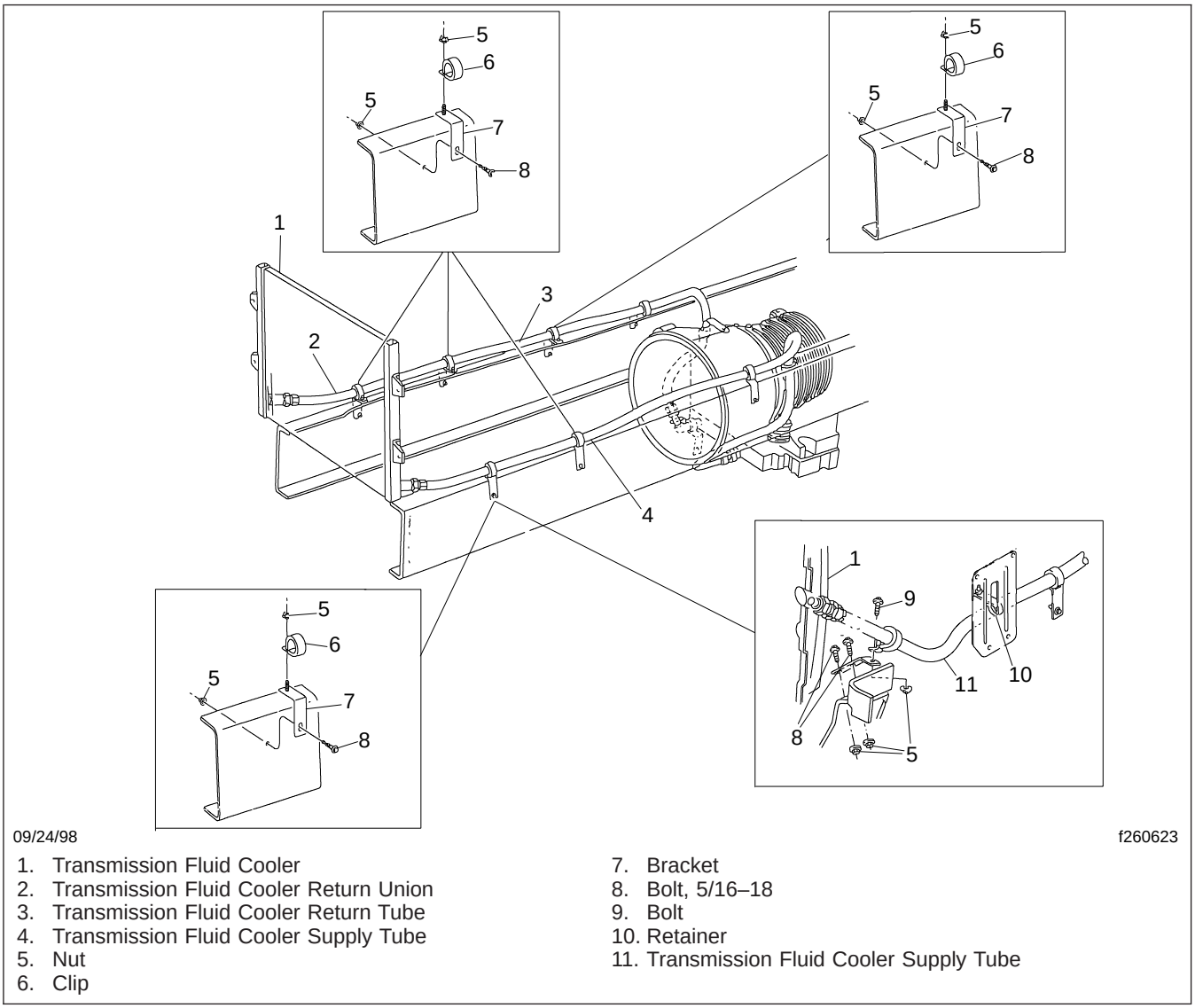
Fig. 13, Transmission Fluid Filter, AT-542, AT-545



A. 45 Degrees
1. Elbow (Return Line)
2. Connector (Supply Line)
3. Bracket
4. Bolt
5. Clip
6. Nut
7. Nut
8. Washer
9. Bolt

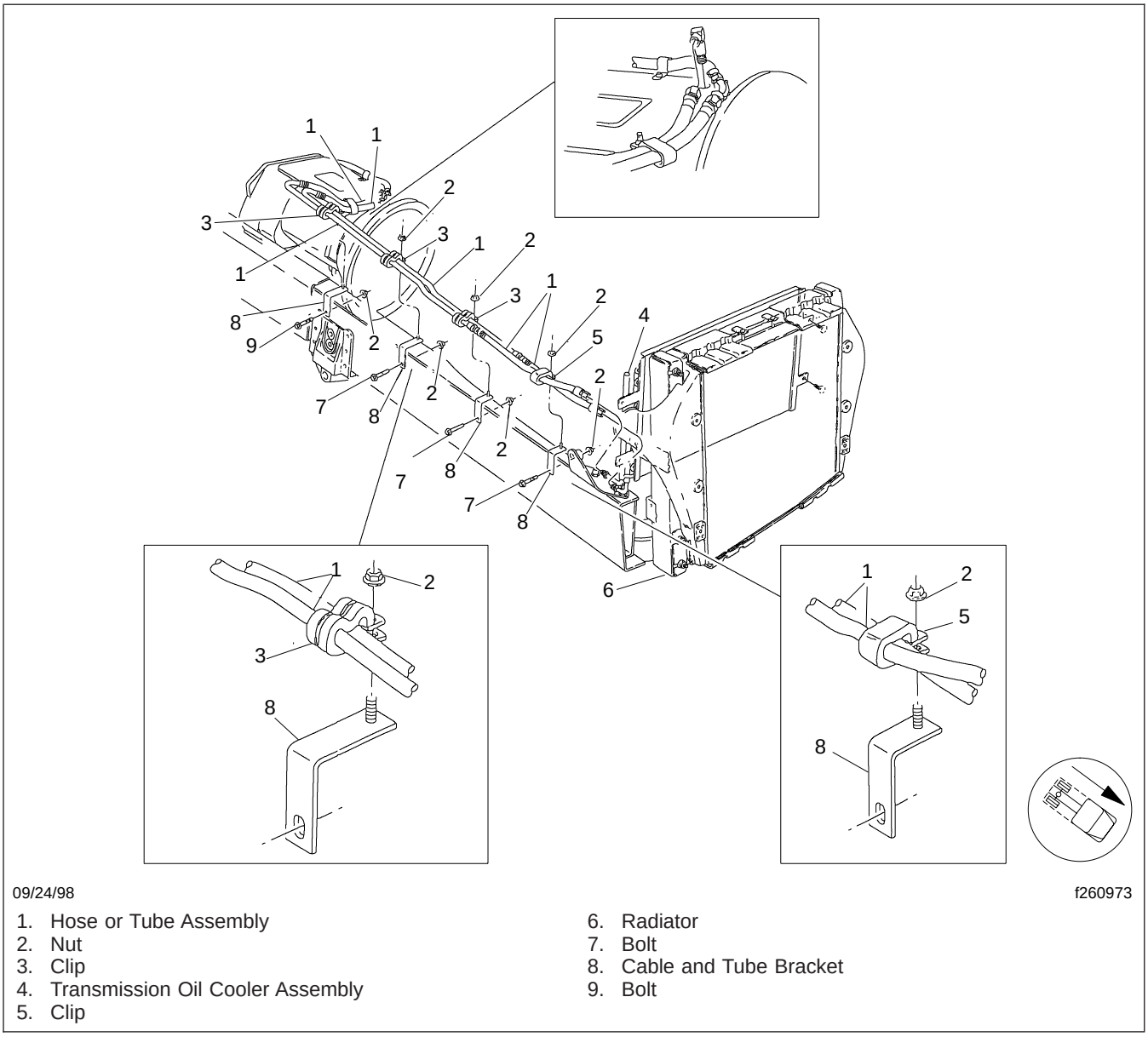
Fig. 14, Fluid Cooler Tubes and Tube and Frame Connections, HD-4000

General Information



1. Transmission Fluid Cooler
2. Transmission Fluid Cooler Return Union
3. Transmission Fluid Cooler Return Tube
4. Transmission Fluid Cooler Supply Tube
5. Nut
6. Clip
7. Bracket
8. Bolt, 5/16–18
9. Bolt
10. Retainer
11. Transmission Fluid Cooler Supply Tube

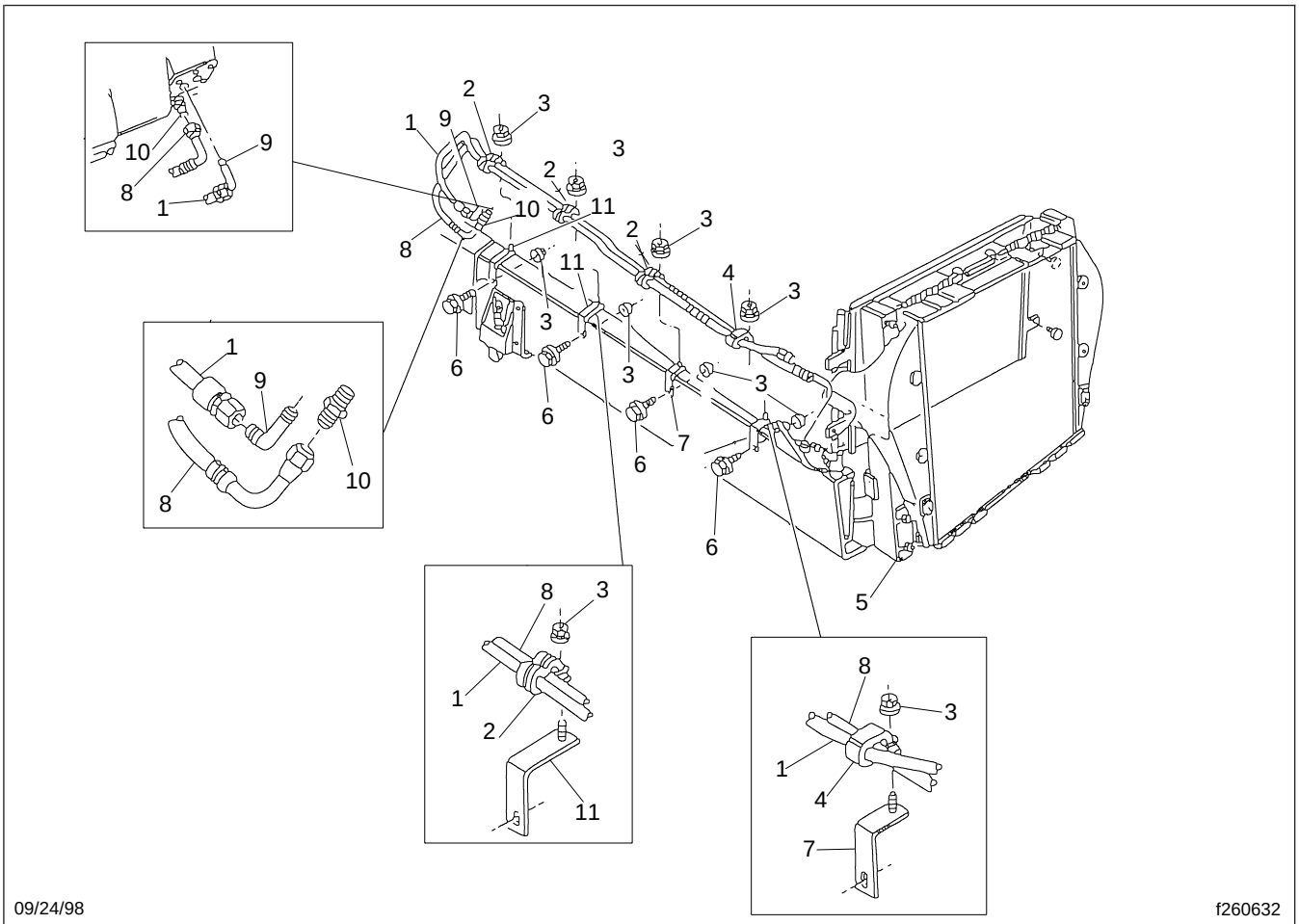
Fig. 15, Fluid Cooler Tubes and Frame Connections, HD-4000 With Premium Diesel



1. Hose or Tube Assembly
2. Nut
3. Clip
4. Transmission Oil Cooler Assembly
5. Clip
6. Radiator
7. Bolt
8. Cable and Tube Bracket
9. Bolt

Fig. 16, Fluid Cooler Tubes and Frame Connections, Manual Transmission, All FR Series

General Information



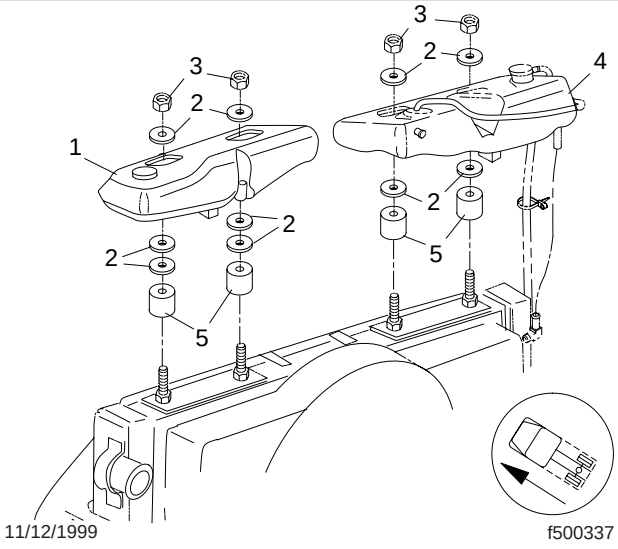
1. Transmission Oil Cooler Return Line
2. Clip
3. Nut
4. Clip
5. Radiator
6. Bolt
7. Bracket
8. Transmission Oil Cooler Outlet Line
9. 90-Degree Elbow, Pipe
10. Connector
11. Bracket

Fig. 17, Fluid Cooler Tubes and Frame Connections, Manual Transmission, All RT Series

Air-to-Oil Transmission Oil Cooler Removal and Installation

Removal

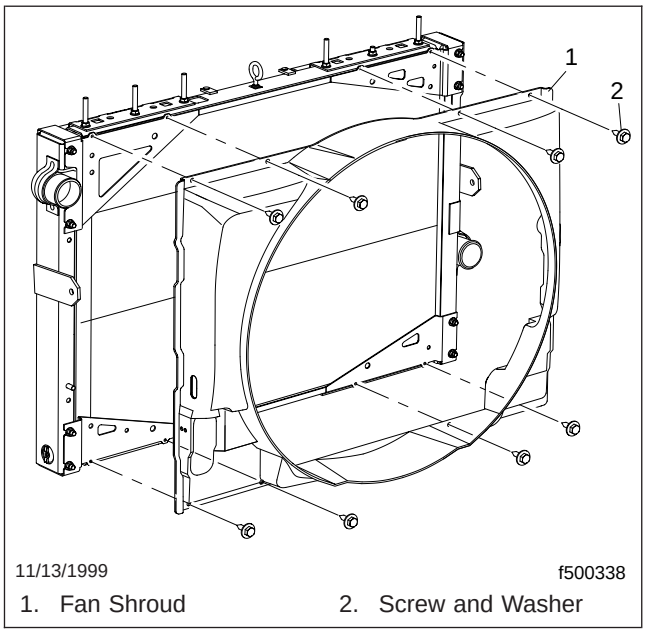
1. Park the vehicle on a level surface, turn the front tires to the right, and set the parking brake. Shut down the engine. Chock the tires.
2. Open the hood.
3. Remove the windshield washer fluid reservoir. For instructions, see **Group 82** in this manual. See **Fig. 1**.



1. Washer Reservoir
2. Flatwasher
3. Nut
4. Surge Tank
5. Spacer

Fig. 1, Surge Tank and Washer Reservoir

4. Remove the mounting bolts, disconnect the surge tank sensor electrical connector, and move the surge tank out of the way. For instructions, see **Group 20** in this manual. See **Fig. 1**.
5. Disconnect the fan shroud from the cooling module by removing the eight screws. See **Fig. 2**.
6. Remove the fan. For instructions, see **Group 20** in this manual.
7. If necessary, disconnect the charge-air-cooler duct to provide access to the oil cooler. For instructions, see **Group 09** in this manual.
8. Loosen the air conditioner compressor belt and pulley. For instructions, see **Group 83** in this manual.



1. Fan Shroud
2. Screw and Washer

Fig. 2, Fan Shroud

9. Using a special belt tool, remove the serpentine belt. For instructions, see **Group 01** in this manual.
10. Disconnect the two fluid lines from the oil cooler and either drain them into a drain pan or plug them. Remove the right-side pipe fitting.
11. Remove the fan shroud.
12. Remove the four nuts and the washers retaining the transmission fluid cooler to the radiator and separate the cooler from the radiator support retaining studs. See **Fig. 3**.

Installation

1. Position the cooler onto the radiator support retaining studs. Install the four retaining nuts and washers. Tighten the nuts 22 to 30 lbf·ft (30 to 41 N·m). See **Fig. 4**.
2. Position the fan shroud.
3. Install the fan. For instructions, see **Group 20** in this manual.
4. Using a special belt tool, install the serpentine belt. For instructions, see **Group 01** in this manual.

Air-to-Oil Transmission Oil Cooler Removal and Installation

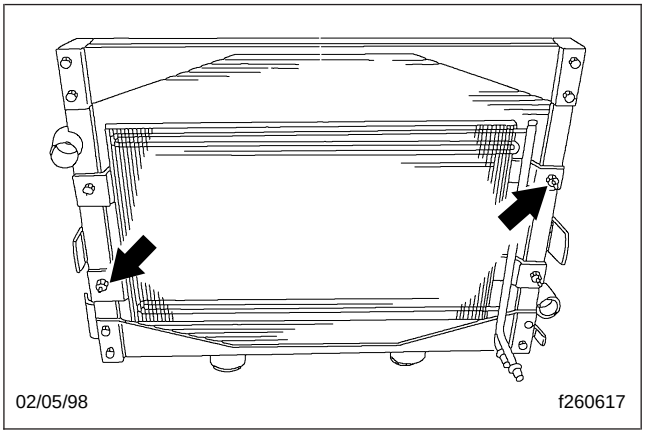


Fig. 3, Radiator Support Retaining Studs

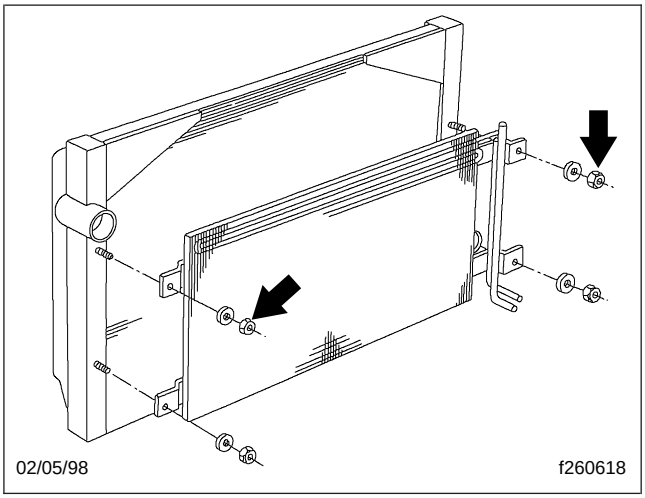


Fig. 4, Cooler Installation

5. Attach the air conditioner compressor belt and pulley. For instructions, see **Group 83** in this manual.
6. Connect the fan shroud to the cooling module by installing the eight screws.
7. If thread sealant is not already present, apply a light coating of Loctite®, or equivalent, to the threads of all fittings. Install the right-side pipe fitting. Connect the two fluid lines to the oil cooler.
8. Connect the charge-air-cooler duct, if removed. For instructions, see **Group 09** in this manual.
9. Position the surge tank. Install and tighten the mounting bolts. Connect the surge tank sensor electrical connector. For instructions, see **Group 20** in this manual.
10. Install the windshield washer fluid reservoir. For instructions, see **Group 82** in this manual.
11. Add transmission fluid as necessary.
12. Close the hood.
13. Start the engine and check for leaks.
14. Remove the chocks from the tires.

Transmission Cooling Tubes Replacement

Replacement

1. Remove the tube end connector and the mounting brackets.
2. Install the tube end connector and the mounting brackets. Refer to the illustrations shown in **Subject 050** for installation views.

Replacement

⚠ WARNING

Always dispose of used automotive fluids in a responsible manner. Follow your community's standards for disposing of these types of fluids. Consult your local recycling center.

1. Drain the transmission fluid into a suitable container. Refer to the appropriate transmission section for the transmission fluid drain and refill procedure.
2. Carefully loosen the transmission fluid filter by hand or with an oil filter wrench and remove it from the transmission filter mounting adapter. Refer to the illustrations shown under "General Information" for installation views of the fluid filter bracketry and connections.
3. Lightly coat the filter O-ring with a thin coat of the automatic transmission fluid.

⚠ CAUTION

Do not overtighten the filter; the gasket can be crushed, resulting in fluid leakage.

4. Install the new filter carefully onto the transmission fluid filter mounting adapter. Hand-tighten the filter until snug, then using an oil filter wrench, carefully rotate it an additional 1/3 to 1/2 revolution.
5. Refill the transmission. Refer to the appropriate transmission section for transmission fluid drain and refill procedure.

Troubleshooting

INSPECTION AND VERIFICATION

Clean and inspect all transmission cooling system components suspected of leaking fluid. Replace the component(s) as required; refer to the appropriate removal and installation procedure in this section.

Problem—Transmission Overheating

Problem—Transmission Overheating	
Possible Cause	**Remedy**
Clogged fluid cooler	Check the fluid cooler for clogging. Repair as required.
System leaks	Inspect the fluid cooler for leaks. Repair as required.

Problem—Fluid Leakage at the Cooler

Problem—Fluid Leakage at the Cooler	
Possible Cause	**Remedy**
Damaged or loose connections or fittings	Replace the cooler/fittings or reseal/retighten the fittings as required.

Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Fluid Filter Assembly-to-Bracket Retaining Bolt	54–70 (73–95)
Fluid Filter Assembly Bracket-to-Transmission Retaining Bolt	54–70 (73–95)
Auxiliary Fluid Cooler to Radiator	22–30 (30–41)
Tighten Fluid Filter 1/3 to 1/2 Revolution Past Hand-Tight	—
Tighten Fluid Tube Fittings Hand-Tight. Back Off One Turn for Proper Orientation Then Tighten	54–70 (73–95)
Tighten Pipe Thread Fittings a Minimum of Two Turns Past Hand-Tight. Directional Fittings to be Oriented by Positive Tightening Only	—
Lower Fluid Return Elbow to Transmission, MT–643 and MT–653	25–35 (34–47)

Table 1, Torque Specifications

General Information

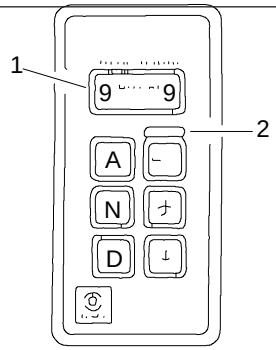
Several Allison electronic transmissions are used in the L-Line and A-Line vehicles:

- MD–3050 (close ratio)
- MD–3550 (wide ratio)
- MD–3060 (close ratio)
- MD–3560 (wide ratio)
- MD–3066 (close ratio)
- HD–4050
- HD–4550
- HD–4060
- HD–4560

SHIFT SELECTORS

Vehicle manufacturers can choose different types of shift selectors for their equipment. The shift selector in an Allison-equipped vehicle will be similar to one of those illustrated.

Push-Button Shifter (See Fig. 1)



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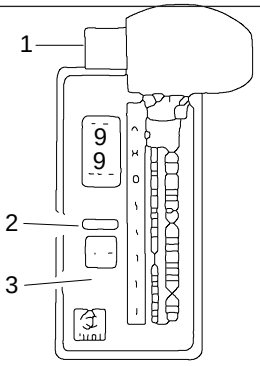
1. Select Monitor Display
2. Mode ID

Fig. 1, Push-Button Shifter

The push-button shift selector has reverse, neutral, drive, up and down arrows, a mode button, and a digital display. When a range button has been pressed, a tone will sound, the SELECT indicator will display the chosen operation (if the transmission control module (TCM) determines the shift is acceptable), and the transmission will shift to the starting range as indicated on the MONITOR display. In DRIVE, selection of a specific gear can be accomplished by pressing the up or down arrow buttons. Conditions resulting in the CHECK TRANS light located on the instrument panel will disable the pad and no tones will be heard.

Shift Lever Selector (See Fig. 2)



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1. Hold Override Button
2. Mode ID
3. Diagnostic Mode Button

Fig. 2, Shift Lever Selector

The lever selector is an electromechanical control. The pattern of positions can vary according to the shift selector installed. Positions R, N, and D are selected by pressing a hold override button and choosing the desired gear. It is possible to move between forward drive positions without pressing the hold override button.

SHIFT SELECTOR FEATURES

Mode Button

A mode button (a dash-mounted switch can be used) is located on both lever type and push-button type shift selectors. It is used to activate a second shift schedule or specialized function when desirable. The mode being utilized is identified above the mode button. The display will indicate MODE ON for most programmed functions. This is typically programmed for "economy," which will enable the transmission to shift at a lower engine rpm to conserve fuel.

Display Mode

This button is featured on the shift lever type selector. It is used to access diagnostic code information. On the push-button type selector, diagnostic code

information can be accessed by pressing the up and down arrow buttons at the same time.

Check Transmission Light

If this light illuminates (accompanied by eight seconds of short beeps from the shift selector) while the vehicle is in operation, it indicates the TCM has detected the transmission operating parameters have been exceeded and the shifts are being restricted (such as upshifts and downshifts). Also, the SELECT digit on the shifter display will be blank. A diagnostic code will be recorded in the TCM if this should happen. The transmission will continue to operate in order to seek service assistance. If the vehicle is equipped with a push-button shifter, it will not operate. If equipped with a shift lever and the lever is moved, a continuous alarm will sound until the original shift lever position is restored.

DRIVING RANGES, ALLISON MD AND HD SERIES

⚠ WARNING

In the event the operator leaves the vehicle even momentarily while the engine is running, be sure that the transmission is in NEUTRAL, parking brake or emergency brakes are set and properly engaged, and the wheels are chocked. Unexpected and possibly sudden vehicle movement can occur if these precautions are not taken.

⚠ WARNING

These transmissions have no PARK position. Before leaving the driver's seat, always shift into N (NEUTRAL) and set the parking brake. Shut the engine off and remove the ignition key. Always use wheel chocks for hilly or off-road parking. Unexpected and possibly sudden vehicle movement can occur if these precautions are not taken.

With an Allison MD or HD equipped vehicle, selecting the right moment to upshift or downshift during changing road and traffic conditions is not necessary. The Allison MD or HD does it for you. However, knowledge of the gear ranges and when to select them will make vehicle control and your job even easier.

The MD–3060, MD–3560, MD–3066, HD–4060 and HD–4560 automatics are six-speed transmissions which have five forward driving ranges. The MD–3050, MD–3550, MD–3056, HD–4050 and HD–4550 are five-speed transmissions with four forward driving ranges. All of these transmissions are electronically controlled and are available with a push-button or shift lever shifter. The driving ranges are as follows:

Reverse

The vehicle must be completely stopped before shifting from forward to reverse or from reverse to forward. The select indicator will display R and the monitor will display R when reverse is attained.

Neutral

⚠ WARNING

Do not allow the vehicle to coast in neutral. Transmission braking is not available in NEUTRAL. This practice can also result in transmission damage.

Place the transmission in NEUTRAL before starting the engine. The engine will not start in any other gear (if it does, the neutral start circuit should be serviced immediately). NEUTRAL is also used during stationary operation of the power takeoff (if so equipped).

Drive

NOTE: In case of engine shutdown (such as running out of fuel) while the transmission is in gear, the transmission will remain in gear until the ignition key is turned to the OFF position. After the ignition key has been turned to the OFF position the transmission will automatically shift to neutral and the monitor on the shift pad will display NEUTRAL when the ignition key is in the ON position. If the vehicle is equipped with a shift lever shifter, the transmission will return to neutral (when the ignition key is turned to OFF) but the engine cannot be restarted until the shift lever is moved to the NEUTRAL position.

The vehicle will attain first gear when DRIVE is selected, and as the speed increases, the transmission will automatically upshift through each gear. As the

vehicle slows down, the transmission will automatically downshift.

Fifth Through Second Gears

CAUTION

The MD and HD transmissions incorporate a hold feature to prohibit upshifting above the gear selected during normal driving. However, for downhill operation, the transmission may upshift above the highest gear selected when the engine governed speed is exceeded and damaging the engine is a possibility.

Occasionally, the road conditions, load, or traffic conditions will make it desirable to restrict the automatic shifting to a lower gear. These positions also provide progressively greater engine braking for going down grades (the lower the gear, the greater the braking effect).

First Gear

Use the first gear when pulling through mud and deep snow, when maneuvering in tight spaces, or while driving up or down grades. The low gear provides the vehicle with its maximum driving power and maximum engine braking power.

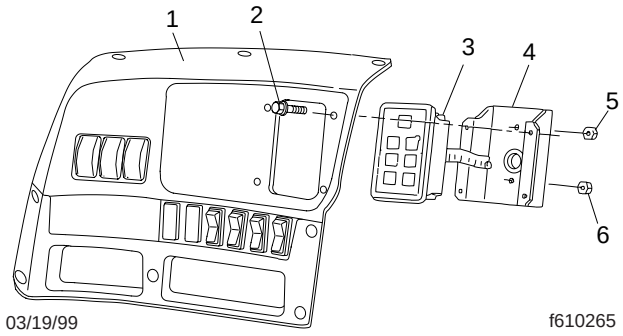
Power Take Off Operation (PTO)

The PTO drive gear on these transmissions is engine-driven and provides direct engine power. The power takeoff can be operated when the vehicle is either moving or stopped.

The PTO gear is in constant mesh with the drive gear in the converter housing. A friction clutch or constant drive is used to transmit power to the PTO output.

Automatic Transmission Push Button Shift Selector Removal and Installation

Removal (See Fig. 1)



1. Auxiliary Finish Panel
2. Retaining Bolt (4 Qty.)
3. Shift Selector
4. Shift Selector Bracket
5. Shift Selector Retaining Nut (4 Qty.)
6. Shift Selector Bracket Retaining Nut (2 Qty.)

Fig. 1, Push Button Shift Selector and Components

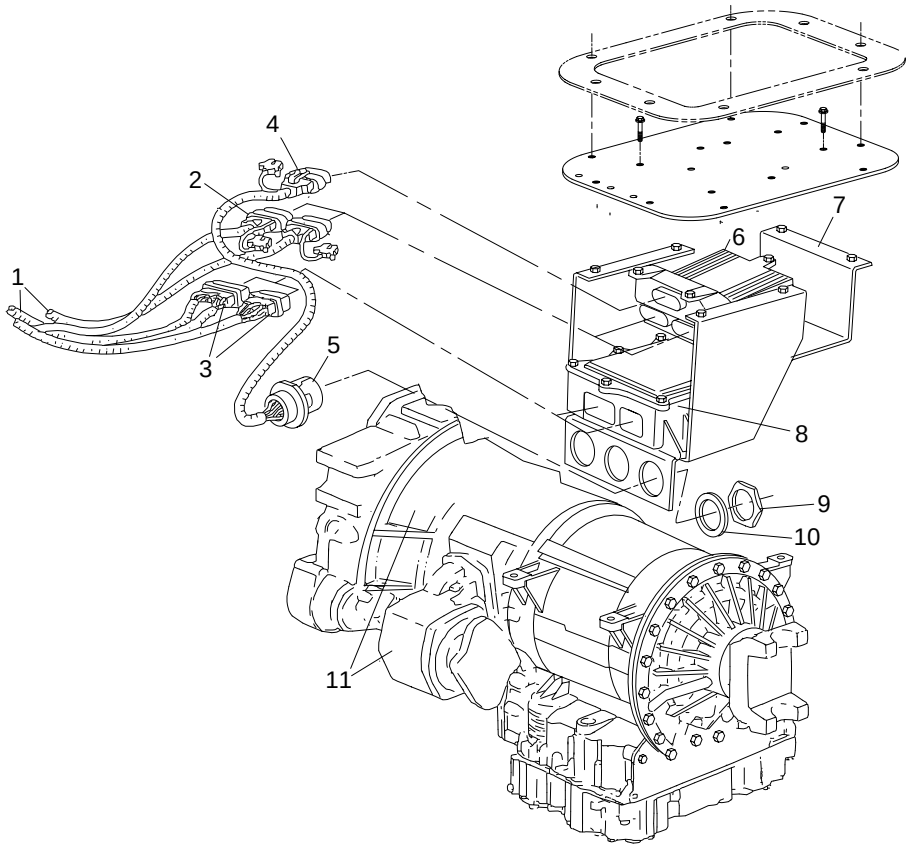
1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Unscrew and remove the parking brake knob.
4. Remove the eight fasteners securing the auxiliary finish panel to the instrument panel.
5. Remove the four screws securing the push button shift selector to the auxiliary finish panel.
6. Pull the auxiliary finish panel forward.
7. Disconnect the electrical wires.
8. Remove the push button shift selector.

Installation (See Fig. 1)

1. Install and tighten the four screws to secure the push button shift selector to the auxiliary finish panel.
2. Connect the electrical wires.
3. Install the auxiliary finish panel and tighten the eight fasteners.
4. Screw in the parking brake knob.
5. Connect the battery.
6. Remove the chocks from the tires.

Automatic Transmission Vehicle Interface Module Removal and Installation

Removal (See Fig. 1)



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1. Wiring Harness (from shift selector in cab)
2. Shift Selector-to-Electronic Control Unit Connector
3. Vehicle Interface Module Connectors
4. Automatic Transmission Control Unit Connector
5. Allison Transmission Connector
6. Electronic Control Unit (ECU)
7. Module Bracket
8. Vehicle Interface Module
9. Harness Connector Nut
10. Washer
11. Transmission and PTO

Fig. 1, Vehicle Interface Module Location

NOTE: The vehicle interface module is located on a bracket above the transmission.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Remove any trim or floor covering from the transmission access plate.
4. Remove the eight screws from the access plate.
5. Remove the access plate.
6. Disconnect the transmission module connectors from the transmission control module bracket.
7. Loosen the bolts holding the connectors to the vehicle interface module. Remove the connectors.

Automatic Transmission Vehicle Interface Module Removal and Installation

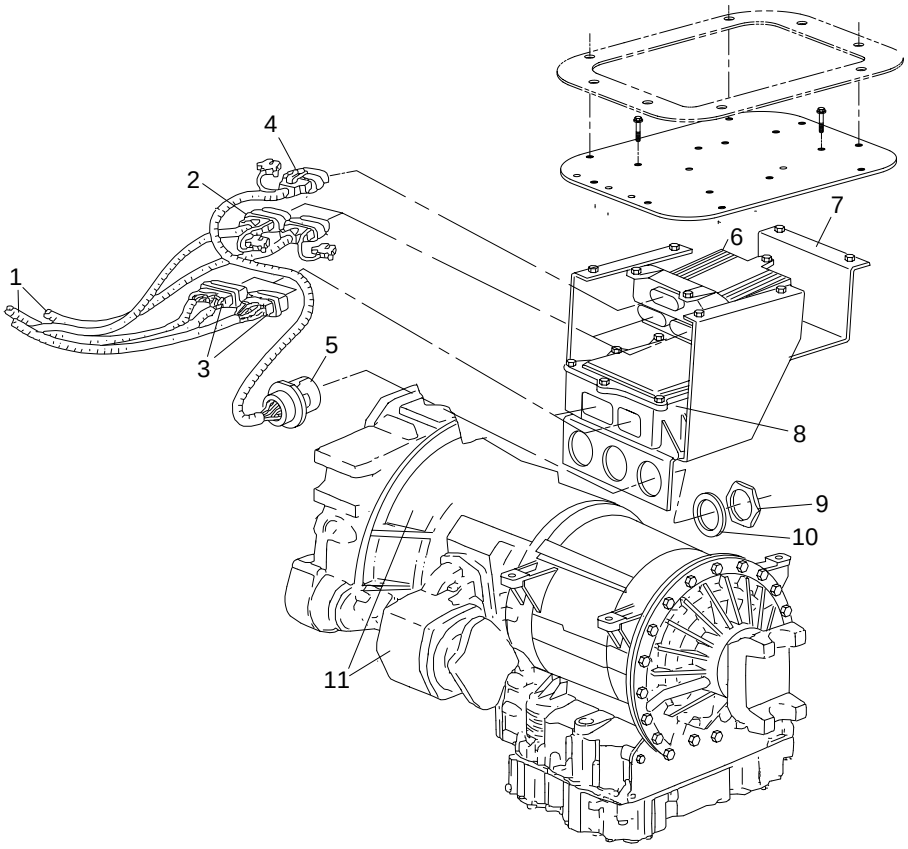
8. Remove the three retaining bolts from the mounting brackets.
9. Disconnect the ECU connectors.
10. Remove the vehicle interface module.

Installation (See Fig. 1)

1. Align the vehicle interface module with the three mounting holes on the bracket.
2. Insert and tighten the three retaining bolts.
3. Connect the vehicle interface module connectors and tighten the bolts.
4. Connect the ECU connector.
5. Connect the transmission module connectors to the transmission control module bracket.
6. Position the access plate.
7. Install the eight screws in the access plate.
8. Install any trim or floor covering on the transmission access plate.
9. Connect the batteries.
10. Remove the chocks from the tires.

Automatic Transmission ECU Removal and Installation

Removal (See Fig. 1)



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1. Wiring Harness (from shift selector in cab)
2. Shift Selector-to-Electronic Control Unit Connector
3. Vehicle Interface Module Connectors
4. Automatic Transmission Control Unit Connector
5. Allison Transmission Connector
6. Electronic Control Unit (ECU)
7. Module Bracket
8. Vehicle Interface Module
9. Harness Connector Nut
10. Washer
11. Transmission and PTO

Fig. 1, Transmission Control Unit (ECU) Location

NOTE: The electronic control unit (ECU) is located on a bracket above the transmission.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Remove any trim or floor covering from the transmission access plate.
4. Remove the eight screws from the access plate.
5. Remove the access plate.
6. Disconnect the transmission module connectors from the transmission control module bracket.
7. Disconnect the ECU connector.
8. Remove the three retaining bolts from the mounting brackets.

Automatic Transmission ECU Removal and Installation

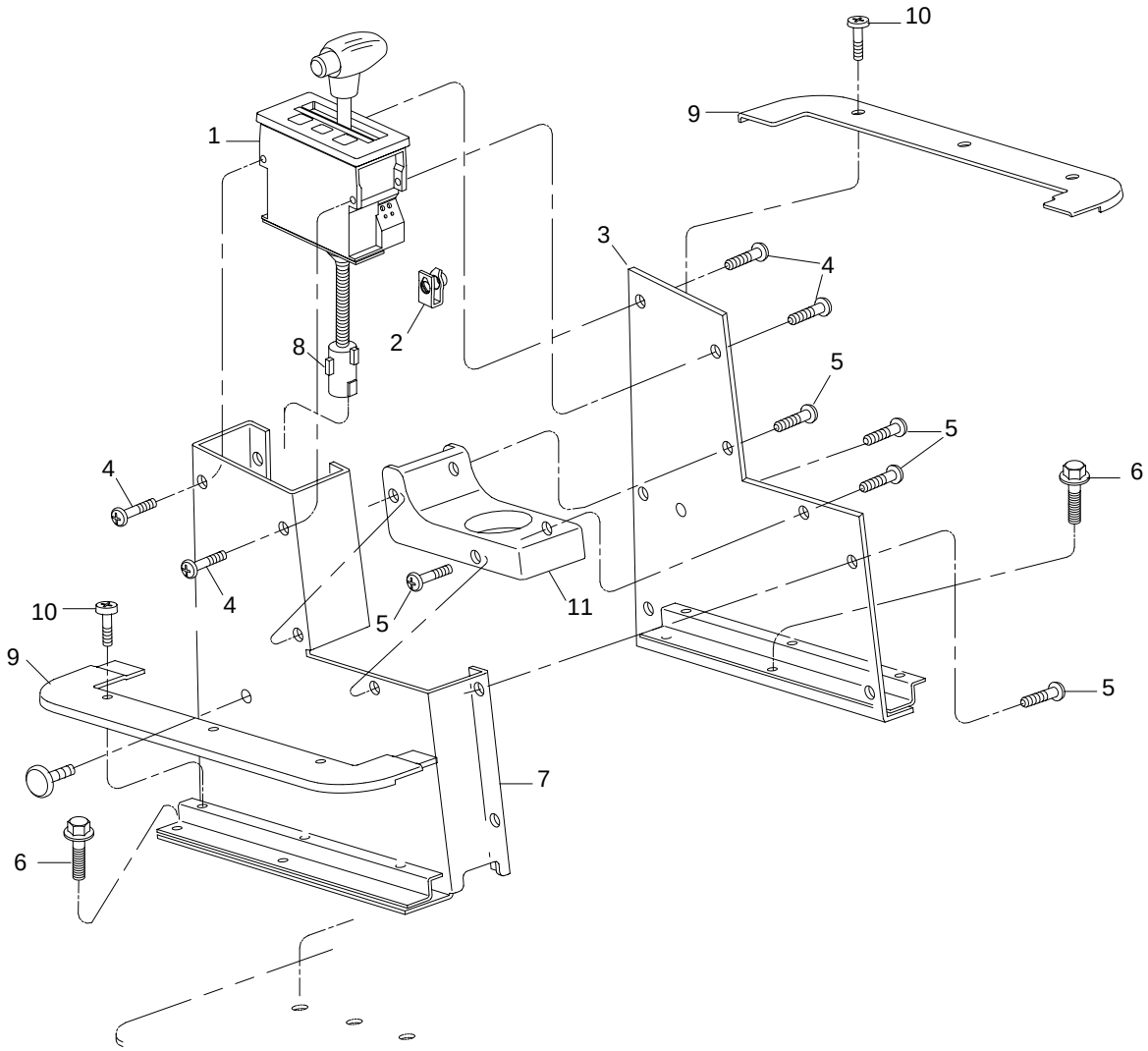
9. Remove the ECU.

Installation (See Fig. 1)

1. Align the ECU with the three mounting holes on the bracket.
2. Insert and tighten the three retaining bolts.
3. Connect the ECU connector.
4. Connect the transmission module connectors to the transmission control module bracket.
5. Position the access plate.
6. Install the eight screws in the access plate.
7. Install any trim or floor covering on the transmission access plate.
8. Connect the batteries.
9. Remove the chocks from the tires.

Electronic Automatic Transmission Shifter/Pedestal Removal and Installation

Removal (See Fig. 1)



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1. Shifter
2. Nut, M6
3. Right Cover Panel
4. Bolt
5. Screw
6. Hexbolt, M6
7. Left Cover Panel
8. Connector
9. Trim Cover
10. Screw
11. Transmission Control Cover/Cup Holder

Fig. 1, Electronic Shifter and Pedestal Assembly

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.

Electronic Automatic Transmission Shifter/Pedestal Removal and Installation

3. Remove the fasteners from the right trim cover. Remove the trim cover.
4. Remove the fasteners from the right cover panel. Remove the right cover panel.
5. Disconnect the electronic shifter connector.
6. Remove the transmission control cover/cup holder.
7. Remove the fasteners from the left trim cover. Remove the trim cover.
8. Remove the fasteners from the left cover panel. Remove the left cover panel.
9. Remove the fasteners holding the shifter to the left cover panel. Remove the shifter.

Installation (See Fig. 1)

1. Position the shifter in the left cover panel. Install the fasteners.
2. Position the left cover panel in the vehicle and install the fasteners.
3. Position the left trim cover and install the fasteners.
4. Install the transmission control cover/cup holder.
5. Connect the electronic shifter connector.
6. Position the right cover panel and install the fasteners.
7. Position the right trim cover and install the fasteners.
8. Connect the batteries.
9. Remove the chocks from the tires.

Allison MT–643 Automatic Transmission Pedestal and Shift Cable Removal and Installation

Removal (See Fig. 1)

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Remove the shift pedestal boot.
4. Disassemble the shift pedestal.
   - 4.1 Remove the left and right panels.
   - 4.2 Remove the front and back panels.
   - 4.3 Remove the base plate.
5. Disconnect the electrical connector from the shift assembly.
6. Disconnect the shift cable from the shift assembly. See **Fig. 2**.
7. Push the shift cable out from inside the vehicle.
8. Disconnect the shift cable from the transmission and the transmission bracket.

NOTE: If the cable bolt (upper or lower) is removed, count the number of turns or threads. The bolt must be installed in the same position from which it was removed.

9. Remove the shift cable.

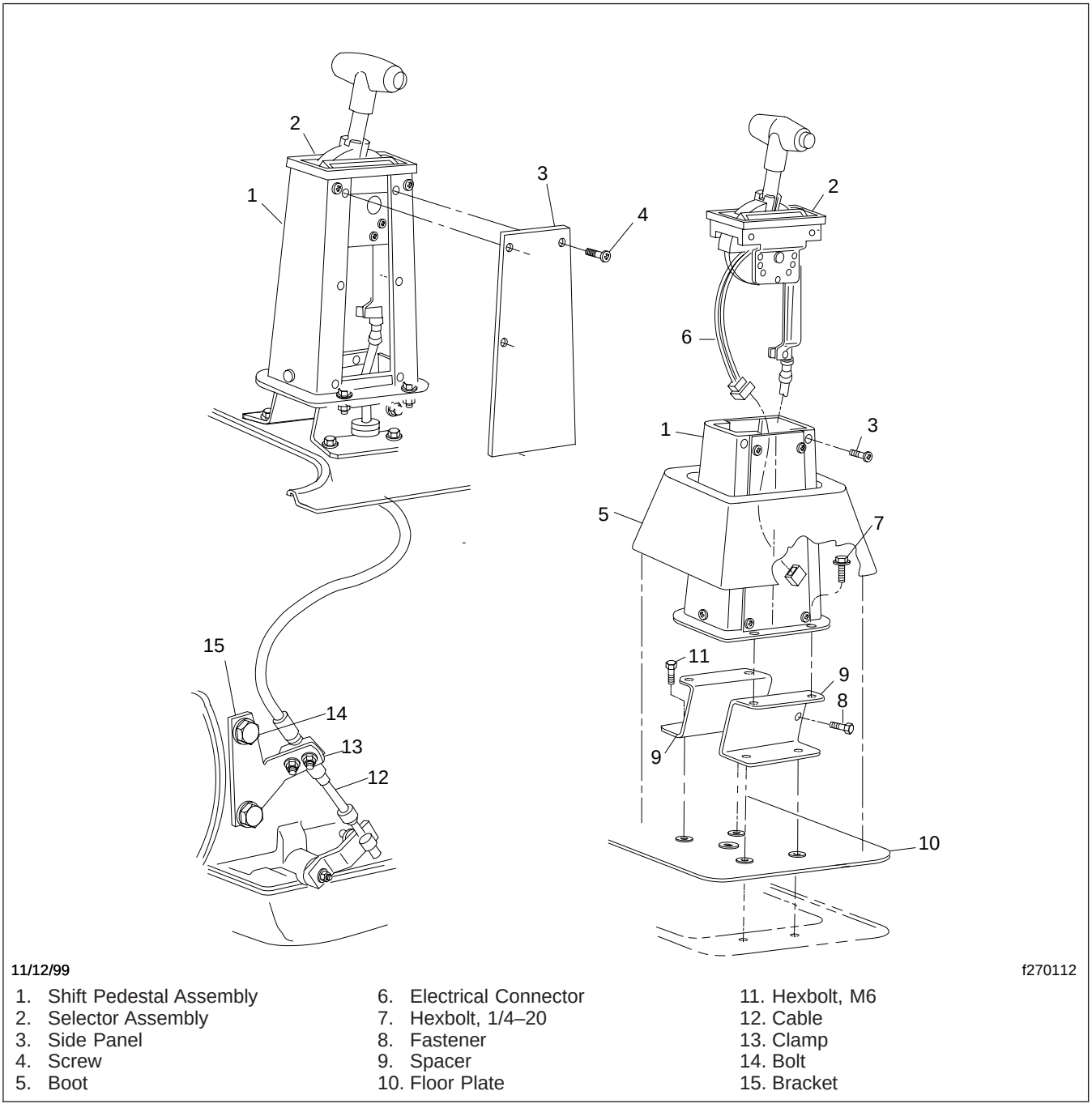
Installation (See Fig. 1)

1. Position the shift cable and the grommet. Use a soap-and-water solution to ease installation.
2. Connect the shift cable to the shift assembly. See **Fig. 2**.
   - 2.1 Attach the cable to the shifter pivot and tighten the rod nut.
   - 2.2 Anchor the cable with the U-bolt, spacer and bracket using 1/4-inch lockwashers and nuts.
   - 2.3 Place the shift lever in reverse and move the transmission selector arm into reverse (counterclockwise). Thread the pivot onto the cable rod until the pivot lines up with the outer hole in the arm. Insert the pivot in the hole and secure with a cotter pin.
   - 2.4 Move the shifter through all positions to make sure that it matches the transmission detents. Adjust again if necessary and tighten the rod nut against the pivot.
3. Connect the electrical connector to the shift assembly.
4. Assemble the shift pedestal.
   - 4.1 Install the base plate.
   - 4.2 Install the front and rear panels.
   - 4.3 Install the left and right panels.
5. Install the shift pedestal boot.

NOTE: Make sure the shifter is in the neutral position.

6. Connect the shift cable to the transmission and the transmission bracket.
7. Connect the batteries.
8. Remove the chocks from the tires.

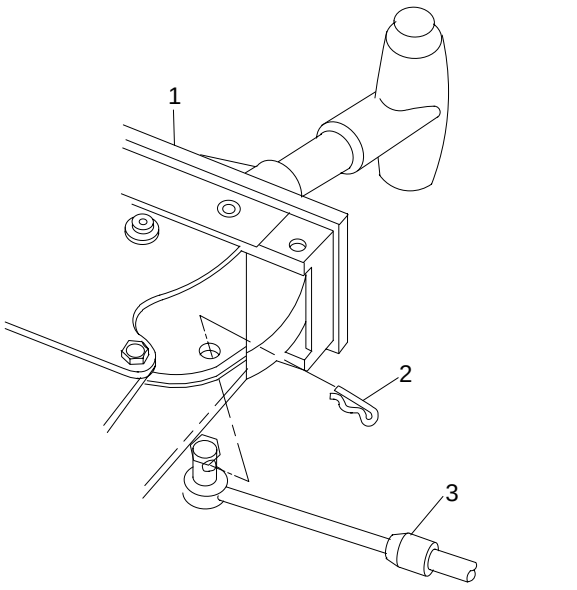
Allison MT–643 Automatic Transmission Pedestal and Shift Cable Removal and Installation



1. Shift Pedestal Assembly
2. Selector Assembly
3. Side Panel
4. Screw
5. Boot
6. Electrical Connector
7. Hexbolt, 1/4–20
8. Fastener
9. Spacer
10. Floor Plate
11. Hexbolt, M6
12. Cable
13. Clamp
14. Bolt
15. Bracket

Fig. 1, Pedestal and Shift Cable Assembly

Allison MT–643 Automatic Transmission Pedestal and Shift Cable Removal and Installation



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1. Shift Assembly
2. Clevis Pin
3. Cable Assembly

Fig. 2, Shift Cable Assembly

Troubleshooting

DIAGNOSTIC TROUBLE CODES (DTC)

The following is a list of some of the most common Allison diagnostic codes. For a complete listing accompanied with service information, see the *Allison MD Series and HD Series Troubleshooting Manuals*.

The Allison diagnostic codes are broken down into a two-digit main code, and a two-digit sub-code.

If the code (**Table 1**) is intermittent, closely inspect the vehicle wiring for transmission system power and grounds. Check for loose, dirty or painted connections. Check the vehicle interface module (VIM) for loose, incorrect or overheating relays or fuses. Check for wires that are chafed and touching other components.

Allison Codes 13/12 and 13/23		
13	12	Battery voltage to electronic control until (TCM) is too low
13	23	Battery voltage to the TCM is too high

Table 1, Allison Codes 13/12 and 13/23

This code (**Table 2**) indicates the TCM has detected a high or low temperature in the transmission sump. All shifts are inhibited when code 24/12 is set. No upshifts are allowed above a calibration range when code 24/23 is set. All restrictions are cleared when the temperature conditions are normal.

Allison Codes 24/12 and 24/23		
24	12	Oil temperature cold
24	23	Oil temperature hot

Table 2, Allison Codes 24/12 and 24/23

Should the hot oil code appear (24/23), shift the transmission to neutral and accelerate the engine to 1200-1500 rpm to allow the transmission to return to normal temperature 160 to 220°F (71 to 104°C) before operation takes place. Check the transmission oil level.

This code (**Table 3**) indicates the TCM has diagnosed a fault with the sump temperature sensor or associated circuitry. This indicates the sensor failed showing abnormally high or low temperature readings.

Allison Codes 33/12 and 33/23		
33	12	Oil temperature sensor low
33	23	Oil temperature high

Table 3, Allison Codes 33/12 and 33/23

Power interruption (**Table 4**) would occur only after the power has been restored. During power interruption, the DO NOT SHIFT light will illuminate, but the transmission will shift.

Allison Codes 35/0 and 35/16		
35	00	Power interruption (this would occur only after the power has been restored). During power interruption, the DO NOT SHIFT light will illuminate but the transmission will shift.
35	16	Power interruption at the same time the TCM is recording a critical code

Table 4, Allison Codes 35/0 and 35/16

A 35/16 power interruption at the same time the TCM is recording a critical code indicates the TCM has detected a complete power loss before the ignition was turned off.

General Information

The manual transmissions have tags to identify assemblies for repair purposes. See **Fig. 1**. Refer to the appropriate transmission section for transmission identification tag information.

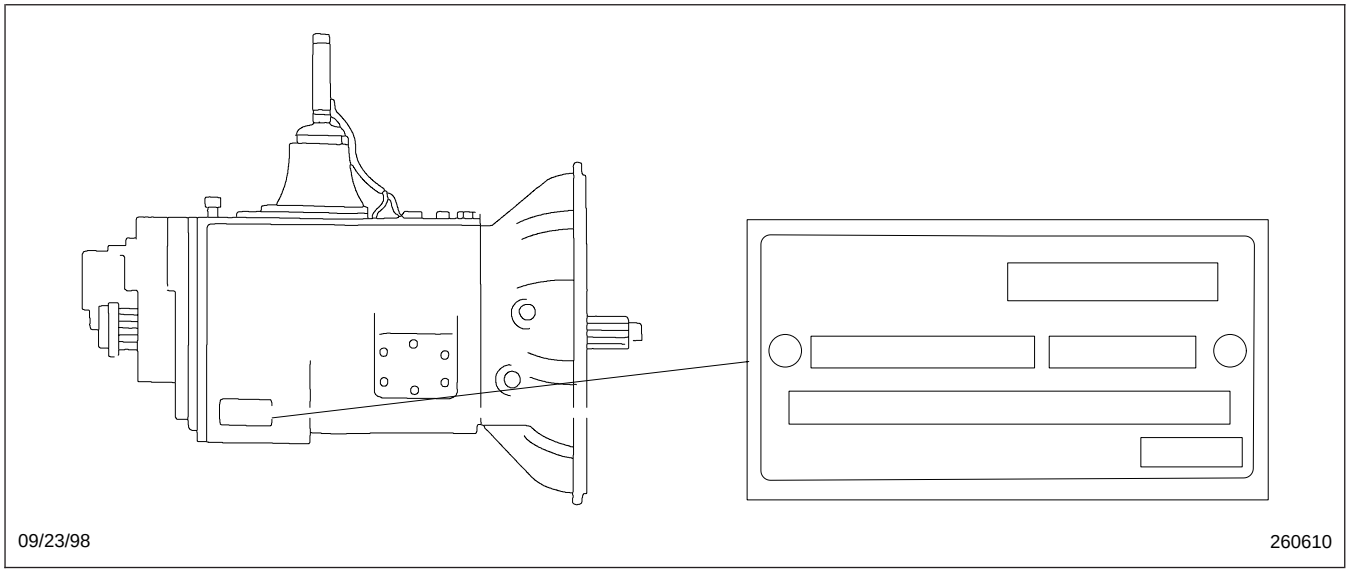

Fig. 1, Identification Tag

Removal

1. Park the vehicle on a level surface. Shut down the engine and place the transmission in high gear. Set the parking brakes, raise the hood, and chock all the tires.
2. Disconnect the battery ground cable.
3. Drain the air system.
4. Disconnect the driveline from the transmission output yoke and move it out of the way.
5. Remove the passenger seat. For instructions, see the applicable section in **Group 91**.
6. Remove the shift lever, boot, and air lines from the cab.

   6.1 Remove the shift lever boot screws from the floor cover plate. See **Fig. 1**. Lift off the shift lever boot.

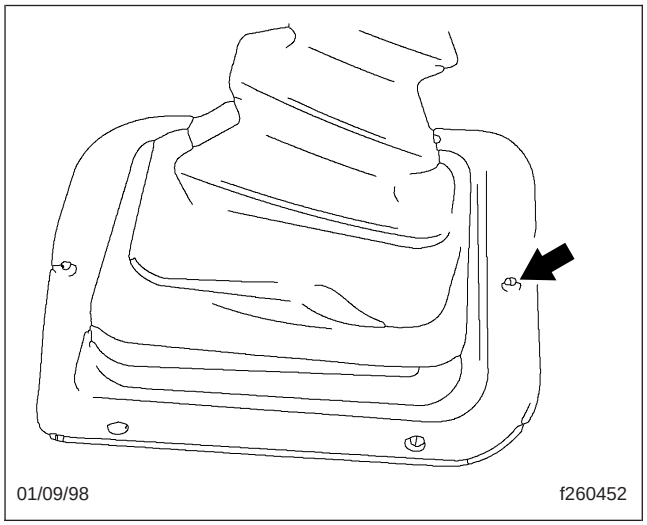

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Fig. 1, Shift Lever Boot Screws

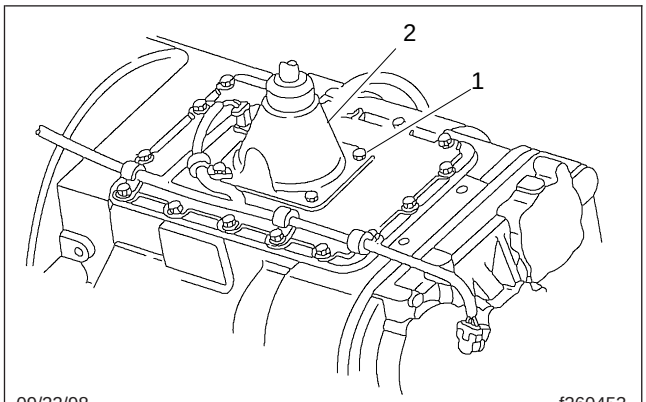
   6.2 Lift up and remove the floor covering as needed.

   6.3 Remove the cover plate retaining screws and the cover plate from the floor.

   6.4 Disconnect the air lines and electrical connectors from the shift lever, if installed.

   6.5 Disconnect the shift lever from the shift tower.

7. Disconnect the vehicle air lines at the transmission.
8. Remove the shift tower from the transmission. See **Fig. 2**.



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1. Mounting Capscrews
2. Shift Tower

Fig. 2, Shift Tower Assembly

   8.1 Remove the shift tower mounting capscrews.

   8.2 Remove the shift tower assembly from the shift bar housing.

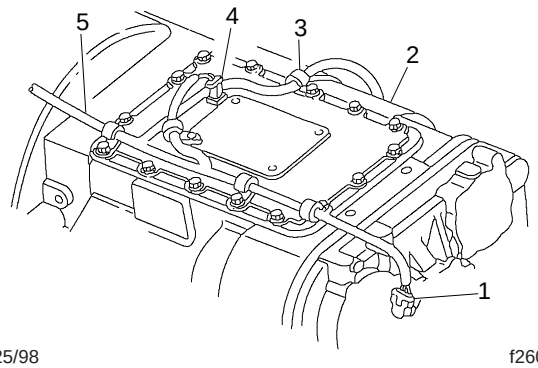
   8.3 Cover the hole in the shift bar housing to prevent dirt from entering the transmission.

9. Unfasten the clip retainers and sensor connectors on the transmission wiring harness and move it out of the way. See **Fig. 3**.
10. Disconnect the fuel lines and brackets from the top of the transmission as needed.
11. Disconnect the clutch linkage. Remove the nut that attaches the clutch rod to the lever arm and separate the two pieces. See **Fig. 4**.
12. Remove the exhaust system as required.
13. Drain the transmission fluid, if necessary.

NOTE: It is not necessary to drain the transmission if the transmission is being removed to service the clutch.

14. Disconnect the transmission cooler lines, if equipped. See **Fig. 5**.

Removal and Installation



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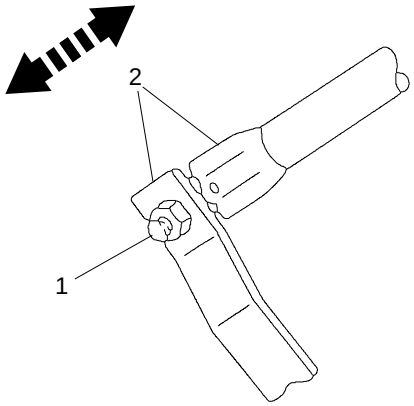
1. Harness Connector
2. Wiring Harness
3. Clip Retainer
4. Sensor Connector
5. To Engine Harness

Fig. 3, Wiring Harness and Components



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1. Nut
2. Clutch Rod and Lever Arm

Fig. 4, Clutch Linkage

⚠ WARNING

Secure the transmission to the jack according to the manufacturer's instructions to prevent it from falling. Failure to do so can cause transmission damage and/or bodily harm.

15. Position a suitable jack under the transmission and fasten it with chains. See **Fig. 6**.

NOTE: The type of transmission support bracket installed depends on the model of engine and transmission. See the transmission manufacturer's manual for more information.

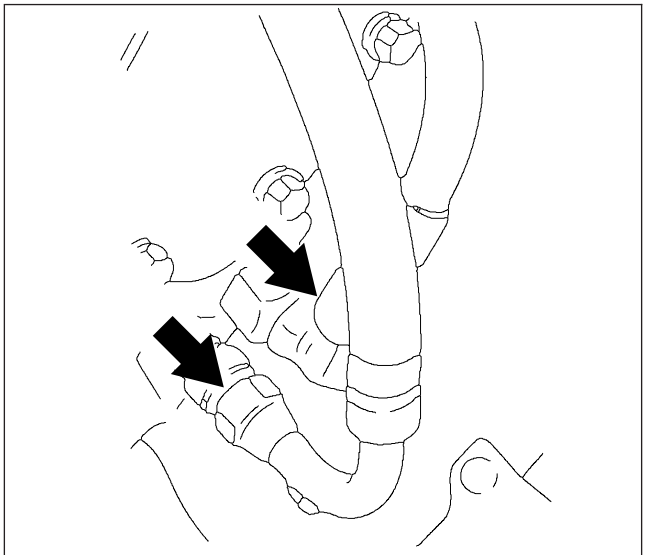

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Fig. 5, Transmission Cooler Lines

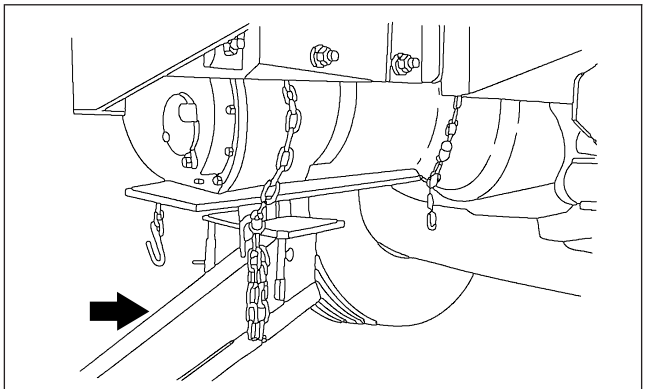

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Fig. 6, Transmission Jack

16. Remove the rear transmission support bracket, if so equipped.

    Note the positioning of the shims for installation.

17. Remove the transmission mounting bolts from the bell housing. See **Fig. 7**.

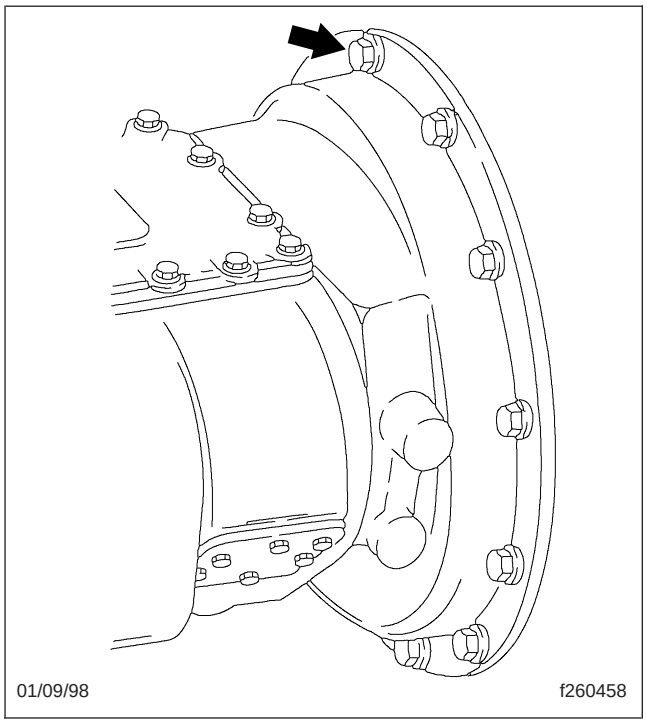


Fig. 7, Housing Bolts

CAUTION

To make sure the release lever fingers clear the release bearing, check that the release arm clears the case-mounted components as it is rotated.

18. Separate the transmission from the engine flywheel housing.

    Make sure the clutch release lever is rotated over the wear pads and clears the release bearing as the transmission is moved rearward. See **Fig. 8**.

19. Remove the transmission from the vehicle.

Installation

1. Move the shift mechanism to shift the transmission into gear. See **Fig. 9**.
2. Make sure the flat side of the release bearing housing is facing upward. See **Fig. 10**.
3. Apply a small quantity of grease to the fingers of the clutch release fork. See **Fig. 11**.

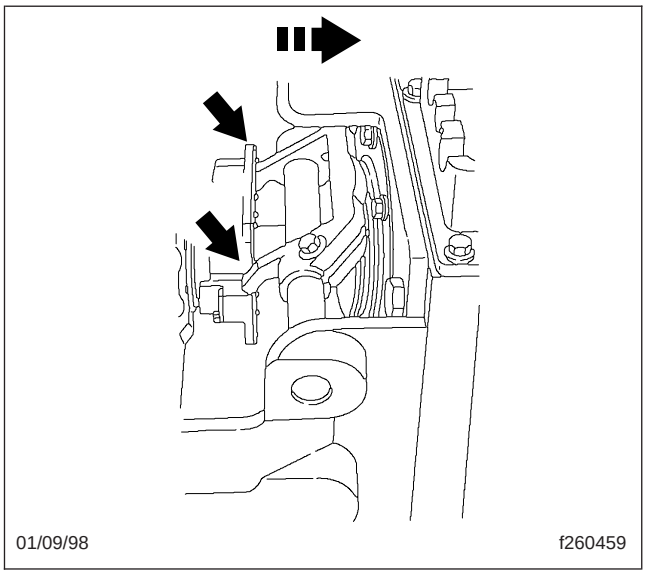


Fig. 8, Clutch Release Lever Clearing the Release Bearing

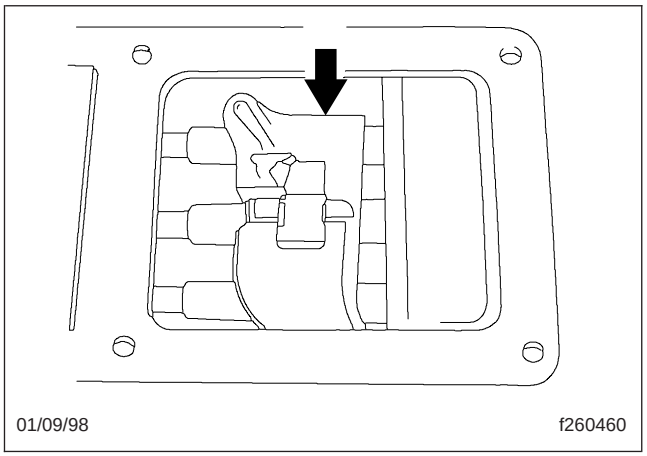


Fig. 9, Shift Mechanism

4. Apply a small quantity of grease to the clutch wear pads. See **Fig. 12**.
5. Align the transmission with the flywheel housing and clutch. See **Fig. 13**.

    5.1 Make sure the transmission is square to and lined up with the flywheel housing.

    5.2 Align the input shaft and clutch hub splines by turning the output shaft.

IMPORTANT: Do not force the transmission onto the flywheel housing or clutch. If the transmis-

Removal and Installation

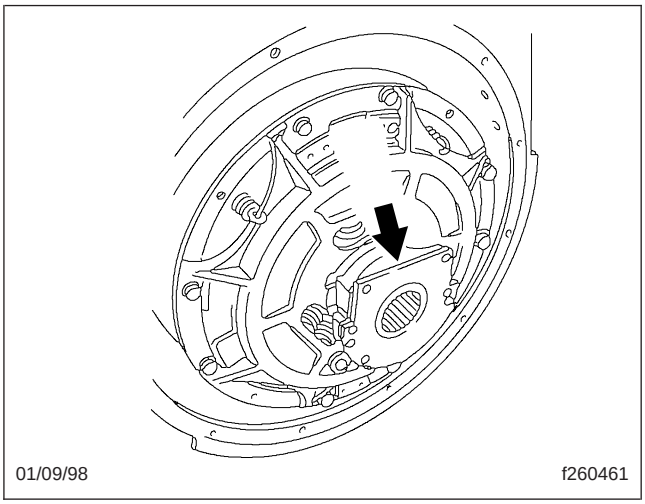


Fig. 10, Check the Release Bearing Housing

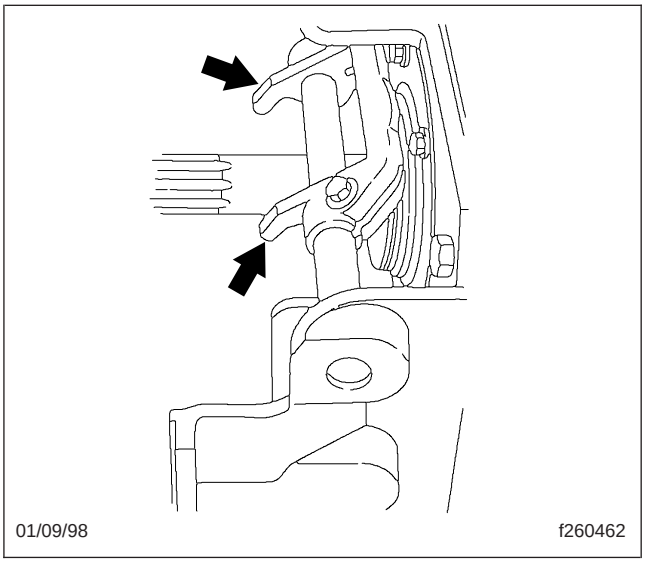


Fig. 11, Clutch Release Fork Fingers

sion does not move freely into position, stop and find out the cause.

6. Move the transmission into place, checking all around for adequate clearance. See **Fig. 14**.
   - 6.1 Make sure the clutch release arm clears the case-mounted components as it is rotated.
   - 6.2 Make sure the release fork clears the bearing and is rotated over the wear pads as the transmission is moved forward.

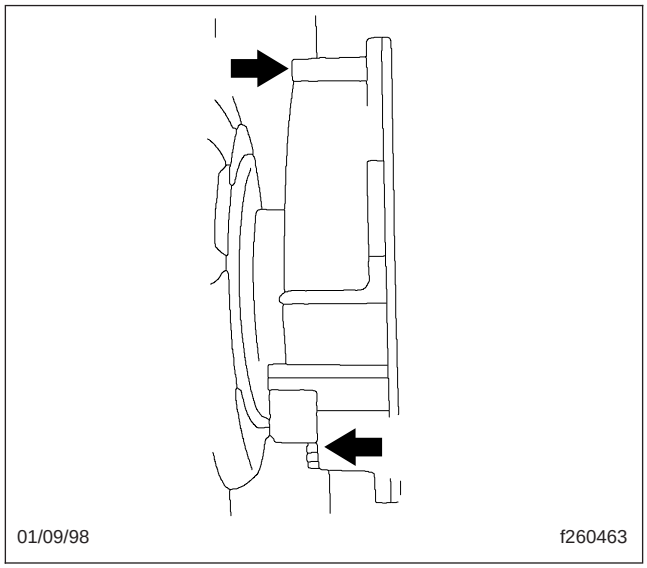


Fig. 12, Clutch Wear Pads

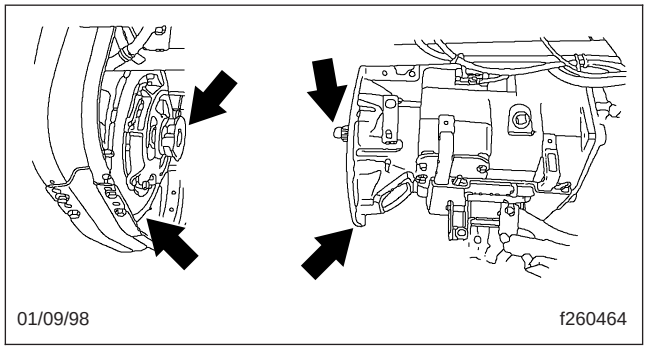


Fig. 13, Aligning the Transmission

7. Install the transmission mounting bolts. Tighten each bolt 40 to 60 lbf·ft (54 to 81 N·m). See **Fig. 15**.
8. Connect the clutch release arm to the clutch rod. Tighten the nut at the clutch release arm 15 to 30 lbf·ft (20 to 40 N·m).
9. Install the transmission support bracket, if removed. See **Fig. 16**.
10. Remove the chains from the transmission and lower the jack.
11. Connect the transmission cooler lines, if removed.
12. Attach the fuel lines and brackets, as removed.

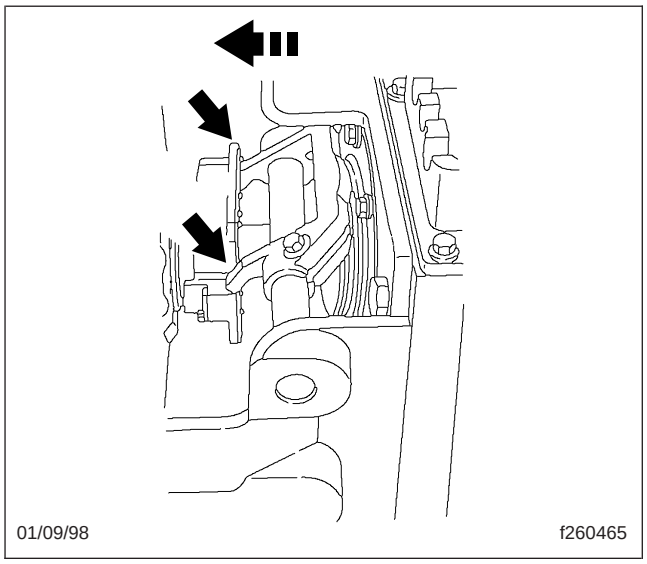
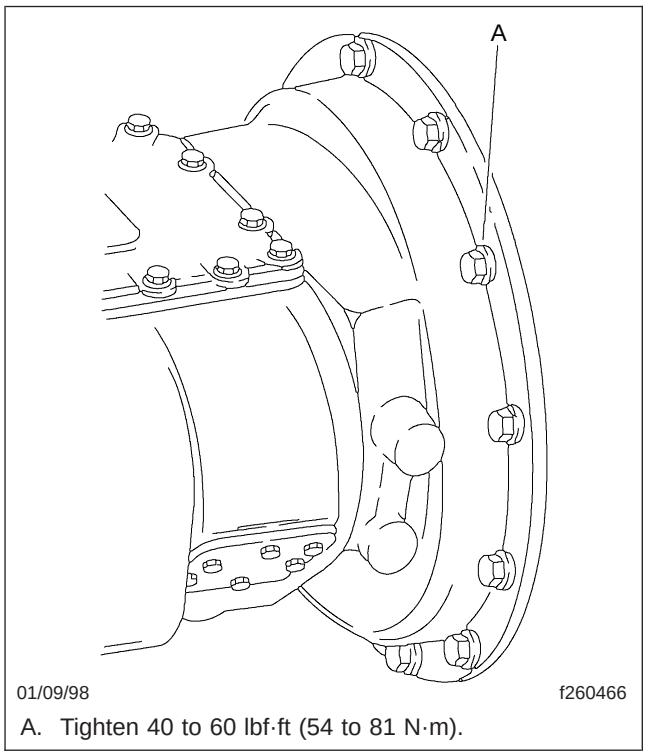


Fig. 14, Check Release Lever Clearance



A. Tighten 40 to 60 lbf·ft (54 to 81 N·m).

Fig. 15, Tighten the Housing Bolts

13. Connect the clutch linkage, as removed. See **Fig. 17**.

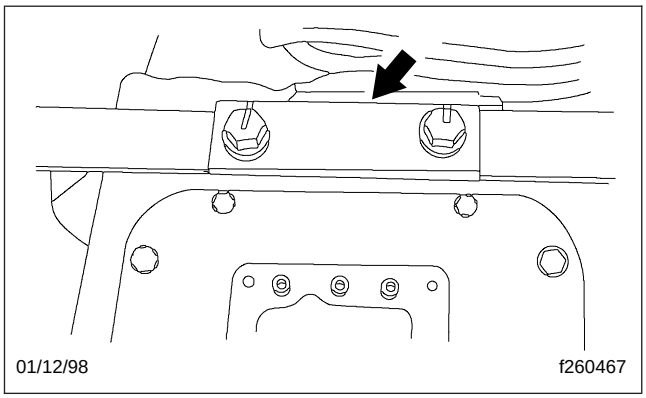


Fig. 16, Transmission Support Bracket

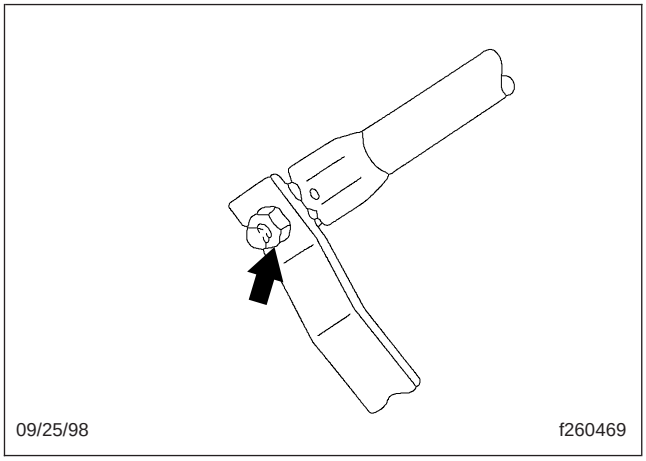


Fig. 17, Connect the Clutch Linkage

14. Position the shift tower gasket on the transmission top cover. See **Fig. 18**.

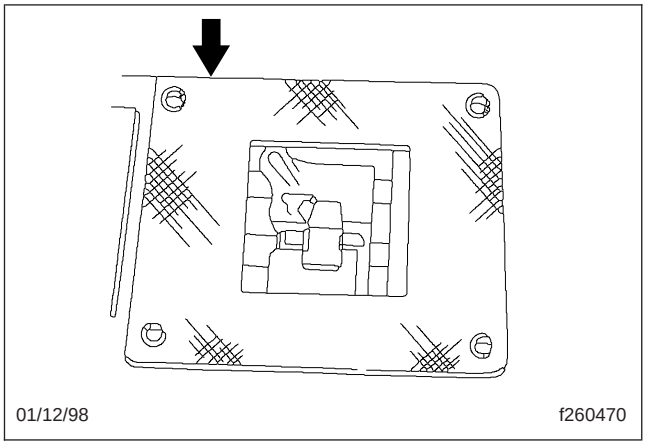


Fig. 18, Position the Gasket

Removal and Installation

15. Make sure the shift block and yoke notches are aligned in the neutral position. See **Fig. 19**.

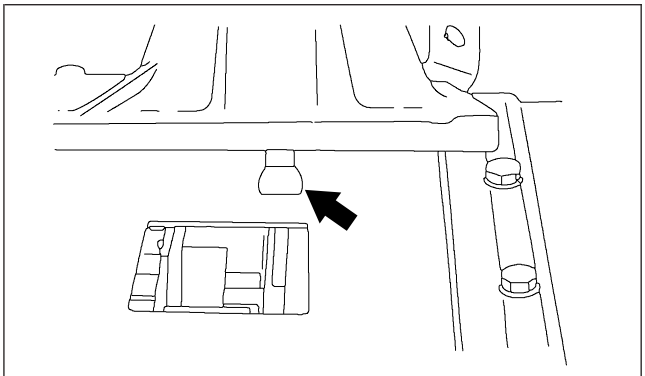
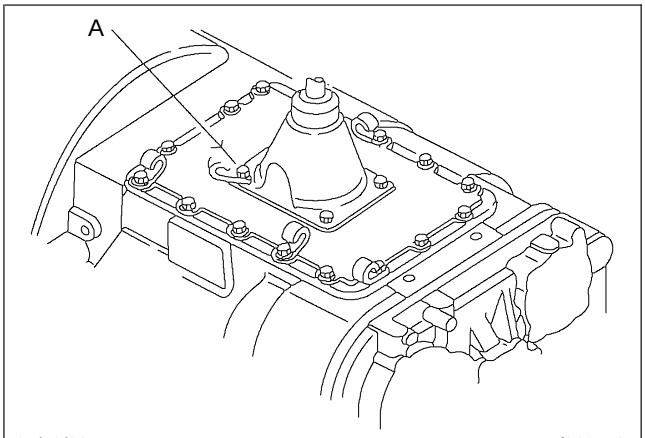


Fig. 19, Align the Shift Block and Yoke Notches

16. Install the shift tower on the shift bar housing. Tighten the shift tower mounting capscrews 35 to 45 lbf·ft (48 to 61 N·m). See **Fig. 20**.



A. Tighten 35 to 45 lbf·ft (48 to 61 N·m).

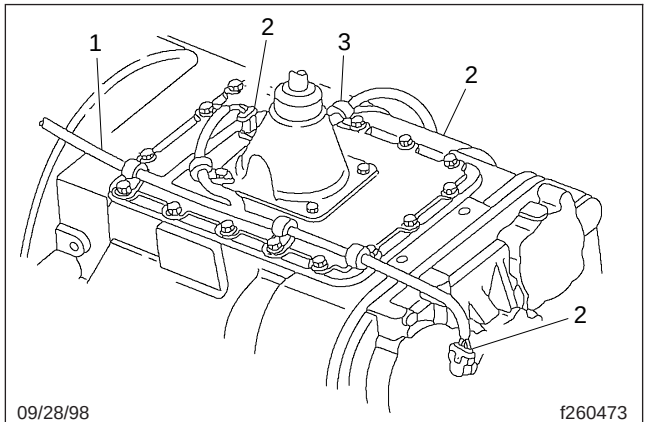
Fig. 20, Install the Shift Tower

17. Install the transmission wiring harness. See **Fig. 21**.

    17.1 Position the harness on the transmission, as removed.

    17.2 Connect the applicable harness and sensor connectors.

    17.3 Fasten the clip retainers as needed.



1. Transmission Harness
2. Electrical Connector
3. Clip Retainer

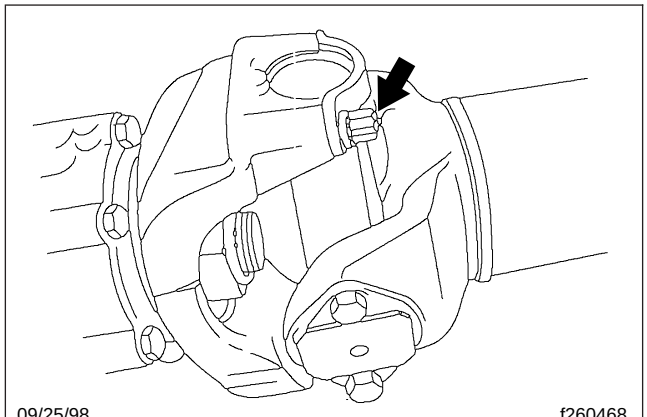
Fig. 21, Wiring Harness Installation

18. Connect the vehicle air system to the transmission.

19. Connect the driveshaft to the transmission output yoke. See **Fig. 22**.

    Tighten the U-joint end cap or strap capscrews. Use the following values depending on the size of the capscrew:

    - 3/8–16: 40 lbf·ft (54 N·m)
    - 3/8–24: 50 lbf·ft (68 N·m)
    - 1/2–20: 110 lbf·ft (149 N·m)



Tighten the strap capscrew.

Fig. 22, Connect the Driveshaft U-Joint

20. Install the exhaust system, as removed.

21. Install the shift lever on the shift tower. Install the transmission floor cover plate and install the retaining screws. Install the floor covering and shift lever boot, as removed.
22. Install the passenger seat, as removed. For instructions, see the applicable section in **Group 91**.
23. Connect the battery ground cable.
24. Add transmission fluid. Fill the transmission until the lubricant is level with the bottom of the fill hole, with the vehicle in the usual operating position. For approximate lubricant capacities of various models, see **Specifications, 400**.

    Tighten the fill plug as follows:

    - 25 to 35 lbf·ft (34 to 48 N·m) for Eaton Fuller transmissions with 0.75-inch pipe threads
    - 60 to 75 lbf·ft (81 to 102 N·m) for Eaton Fuller transmissions with 1.25-inch pipe threads
    - 35 to 50 lbf·ft (48 to 68 N·m) for Meritor transmissions
25. Start the engine and run it long enough to pressurize the air system to at least 80 psi (550 kPa). Check the transmission for fluid leaks and repair as necessary.
26. Lower the hood and remove the chocks from all the tires.

Troubleshooting

EXCESSIVE NOISE

Checking for Excessive Noise With the Engine Off

Check for a binding condition and listen for noise while pressing and releasing the clutch pedal.

- If a binding condition/noise is evident, check and adjust the clutch and linkage as required. After making all necessary adjustments/ repairs, test for normal operation.
- If a binding condition/noise is not evident, proceed to "Checking for Excessive Noise with the Engine Running" verification procedure.

Checking for Excessive Noise With the Engine Running

1. Start the engine.

NOTE: Some noise will not adversely affect clutch function and does not necessarily indicate a failed release bearing/out-of-plane pressure plate release levers. Therefore, inspection of these components is not required unless the noise is excessive. For example: a light, intermittent clicking noise will be audible during some instances of clutch pedal actuation due to the limit of the pedal free-travel. While in some instances, a normal bearing noise will be audible upon further pedal actuation.

2. Check for a binding condition and listen for noise while pressing the clutch pedal from the free play zone to the non-free play zone.
3. Check for a squealing noise when engaging the clutch.
    - If a binding condition or noise is not evident, verify other concerns accordingly.
    - If a squealing noise is evident, inspect the pilot bearing for proper installation, wear and loss of lubrication. Replace as required.
    - If a binding condition/noise is evident, inspect the release bearing and the pressure plate levers for wear. Also, check the flywheel housing bore and face alignment. Replace/correct as required.

Knocking or Thudding Gears

NOTE: Improper handling of the gears, before or during assembly, will cause bumps or swells on the gear teeth. The bumps or the swells will cause a knocking or a thudding noise to occur during transmission operation. Generally, the noise is more prominent when loading the gear. To help in locating the gear damage, verify in which gear position the noise occurs.

1. Check for bumps and swells on the gear teeth by looking for highly polished spots on the tooth face. See **Fig. 1**.

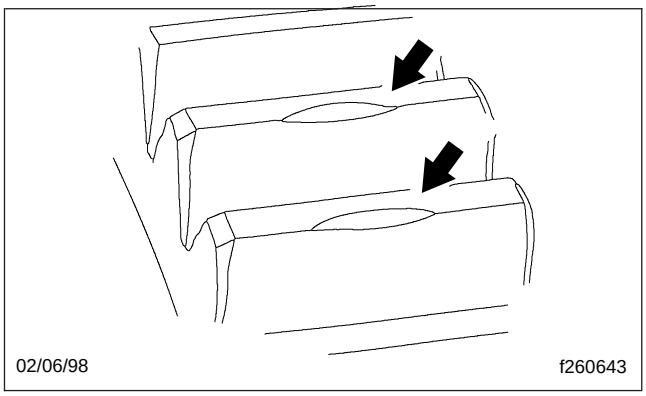


Fig. 1, Gear Teeth Inspection

2. Remove the bumps/swells with a hone or a small grinder.

Cracked Gear

NOTE: A gear cracked or broken by shock loading or by pressing on a shaft during installation will produce a knocking or thudding noise at low speeds. At high speeds, a howl will be present. See **Fig. 2**.

Check for cracked or broken gears.

High-Pitched Whine or Squeal

NOTE: A howling noise will result from advanced gear deterioration.

Check for normal gear wear, including gear tooth pitting from excessive use.

Troubleshooting

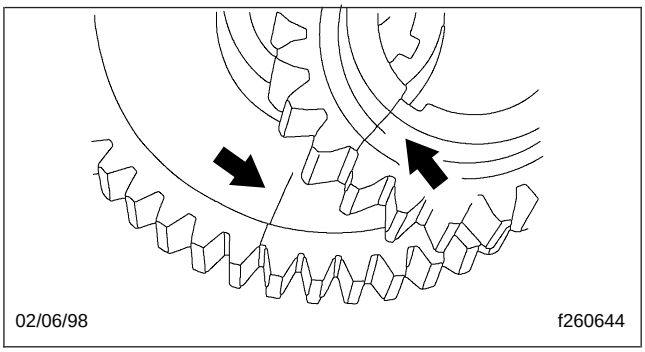


Fig. 2, Cracked Gears

Mismatched Gearsets

Check for mismatched gear sets by looking for an uneven wear pattern on the face of the gear teeth.

Bearings

NOTE: Bearing noise begins at low shaft speeds in any gear. Pinched bearings having insufficient axial or radial clearance can cause a whining or squealing noise.

Check for bearings with damaged balls or rollers, or with pitted and spalled raceways.

Growling

Check for improper gear timing that occurred while reassembling the transmission, or due to a gear turning on the countershaft. Both of these conditions will produce an error in tooth spacing.

Causes or Types of Noise Other Than the Transmission

Check for noises coming from sources other than the transmission:

- rough idling engine
- engine operating noise
- clutch driven plates in which the dampening action of springs or rubber blocks has been eliminated by the wear set or fracture
- driveline out of balance
- unequal joint working angles
- worn crosses in universal joints
- loose or worn center bearings
- worn or pitted teeth on the ring gear and pinion of the driving axle
- rear axle bearing failure
- wheels out of balance
- worn spring pivot bearing
- loose U-bolts
- brake drums warped or out of balance

Clashing

NOTE: Snubbing and clashing of gears while shifting are frequent abuses to which non-synchronized transmissions are subjected. Light snubbing will do little damage. Most damage is done by the hard clash shift caused by engaging gears that are far out of synchronization. This can break pieces of metal from the ends of the clutching teeth. See **Fig. 3**.

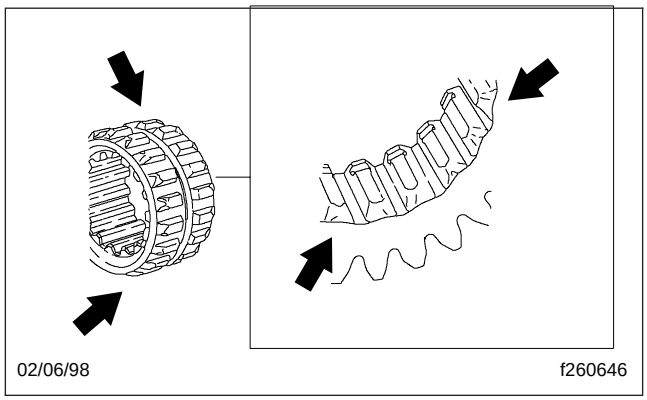


Fig. 3, Broken Clutching Teeth

Check the gears for snubbing. Clashing gears can be traced to one of the following causes:

- Improper shifting—This applies to drivers who are not familiar with the shift pattern or have not learned the rpm spread between shifts.
- Clutch—Clashing when starting up in first or reverse gear can be caused by insufficient clutch clearance or a dragging clutch not releasing properly. This makes the transmission countershafts and mainshaft gears continue rotating while the clutch pedal is depressed. Clashing results when the nonrotating sliding clutch is forced to mesh with a rotating mainshaft gear. Double clutching during lever shifts will reduce snubbing and clashing.

- Inertial force—Countershafts and mainshaft gears usually take from three to five seconds to stop rotating after the clutch has been disengaged. Attempting to mesh a clutch gear with a mainshaft gear before the mainshaft gear stops will result in clashing. If the transmission is not equipped with a clutch brake or countershaft brake, pause a few seconds after depressing the clutch pedal before attempting initial engagement of the transmission.

Gear Rattle at Idle

NOTE: Mainshaft gears are designed to have a specified amount of axial clearance which allows them to rotate freely on the mainshaft. The amount of clearance is governed by the use of washers. A rough idling engine can set up vibrations, causing the mainshaft gears to rattle as they strike mating gears. This condition can usually be cured by improving the idling characteristics of the engine. In some instances, such as high mileage units, tolerance washers will have to be changed to bring the axial gear clearance within specification.

Check the mainshaft gear axial clearance.

VIBRATION

NOTE: Although the effects of vibration will show up in the transmission, vibration usually originates somewhere else in the drivetrain. Vibration can usually be felt and can be accompanied by noise.

1. Check the gear and shaft splines for fretting. See **Fig. 4**.

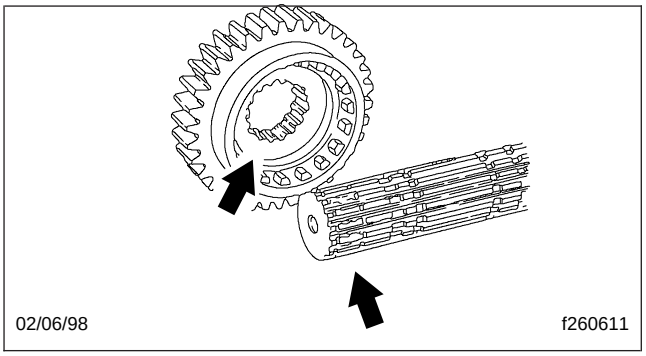


Fig. 4, Gear and Shaft Splines

2. Check the bearing for fretting. See **Fig. 5**.

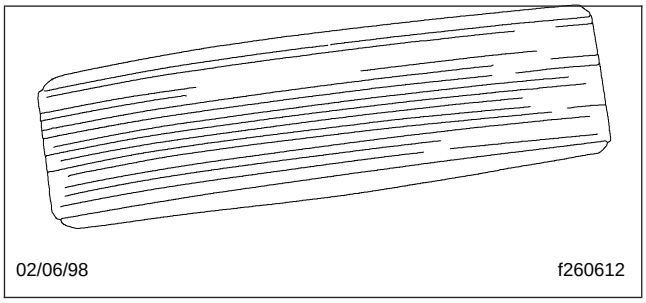


Fig. 5, Bearing Surface Check

3. Check for broken/loose synchronizer pins, and continuous loosening of capscrews, brackets and mountings. See **Fig. 6**.

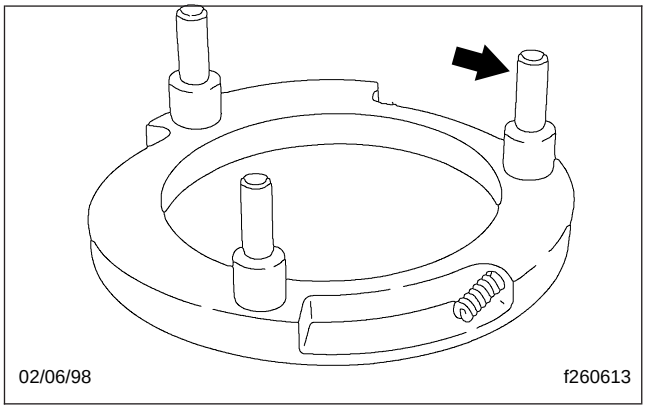


Fig. 6, Synchronizer Pin Check

4. Check for input shaft spline wear. See **Fig. 7**.

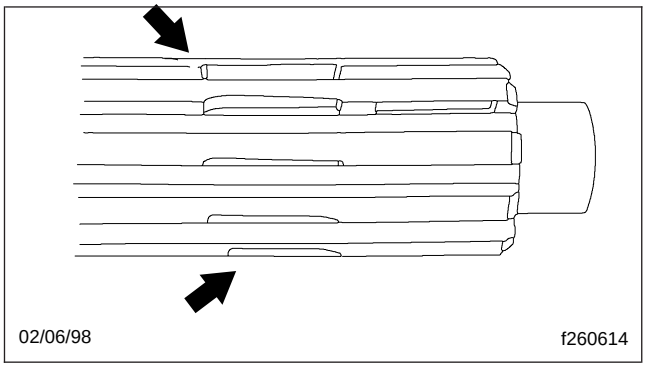


Fig. 7, Input Shaft Spline Wear

Troubleshooting

GEAR SLIPOUT AND JUMPOUT, FRONT SECTION

NOTE: When a sliding clutch is moved to engage with a mainshaft gear, the mating teeth must be parallel or under the right conditions, slipout will result.

1. Check for tapered or worn clutching teeth that will try to walk apart as the gears rotate.
2. Check to make sure the transmission is mounted eccentrically to the engine flywheel pilot. See **Fig. 8**.

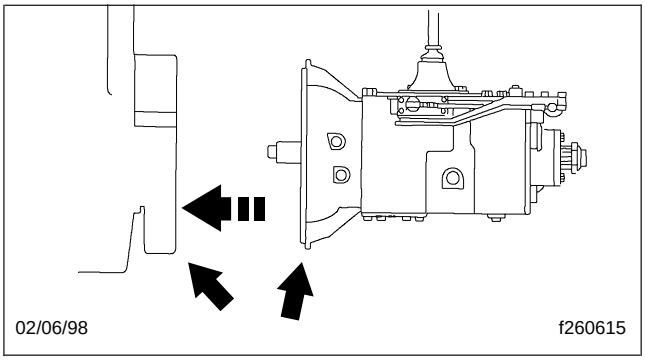


Fig. 8, Transmission Mounting Check

3. Check the gear clutching teeth for taper. See **Fig. 9**.

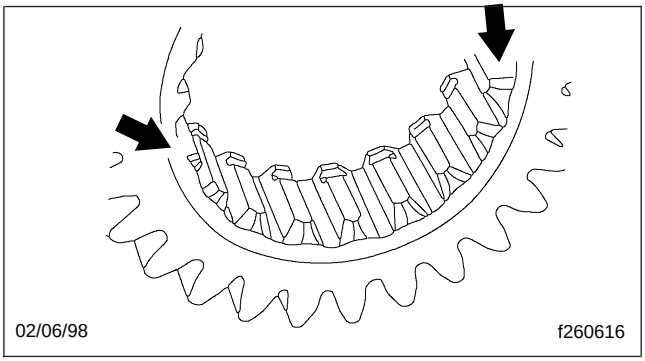


Fig. 9, Gear Clutching Teeth Check

4. Check the detent spring(s). See **Fig. 10**.
5. Check the yoke bar detent notch for wear. See **Fig. 11**.
6. Check the shift lever for excessive play. See **Fig. 12**.

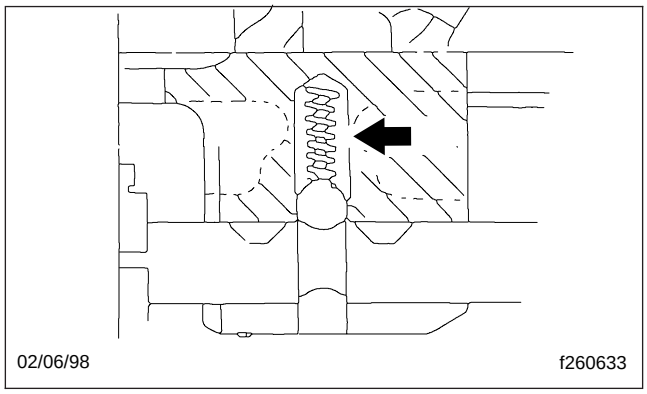


Fig. 10, Detent Spring Check

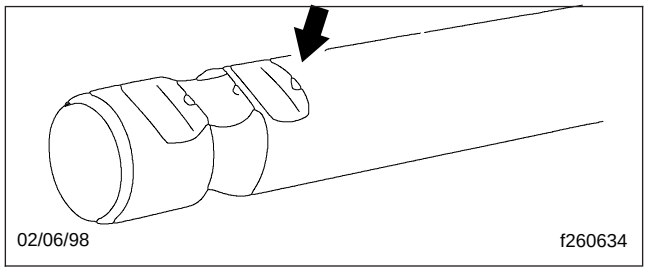


Fig. 11, Yoke Bar Detent Notch Check

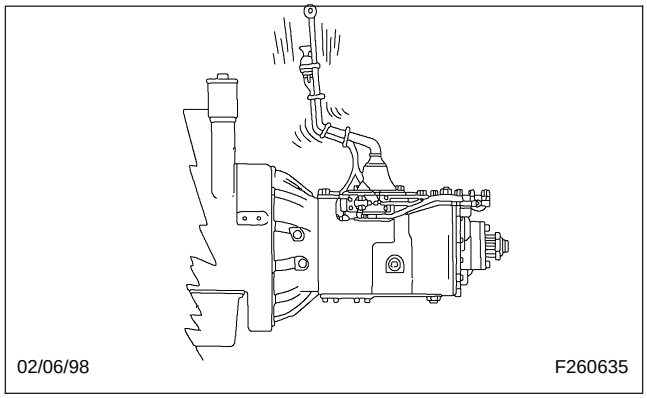


Fig. 12, Excess Play Check

GEAR SLIPOUT AND JUMPOUT, AUXILIARY SECTION

NOTE: Slipout in the auxiliary section can be caused by the clutching teeth being worn, tapered or not fully engaged. These conditions cause the clutch gear to walk out of engagement as the gears turn. Some causes of these clutching conditions are gear clashing or normal wear after a long life. Vibrations set up by an

improperly aligned driveline and low air pressure add to the slipout condition.

1. Check for clutching teeth wear and taper.
2. Jumpout in the auxiliary section usually occurs with the splitter gearset. If torque is not sufficiently broken during splitter shifts, the sliding clutch gear will not have enough time to complete the shift before torque is reapplied to the gears. As torque is reapplied, the partially engaged clutch gear jumps out of the splitter gear. Since the gears have torque applied to them, damage will be done to the clutching teeth of the mating gears. See **Fig. 13**.

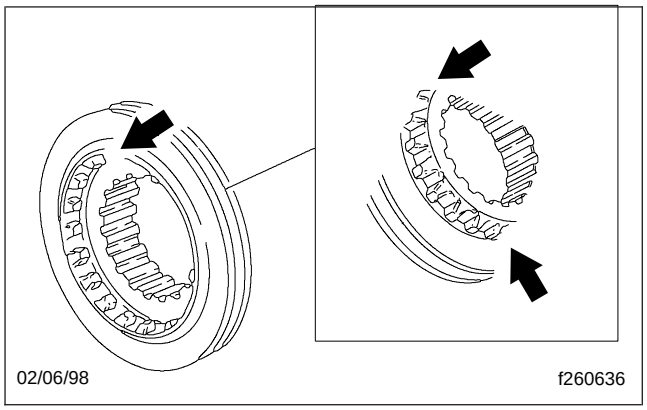


Fig. 13, Clutching Teeth

HARD SHIFTING

1. Remove the shift lever from the top of the transmission. See **Fig. 14**.

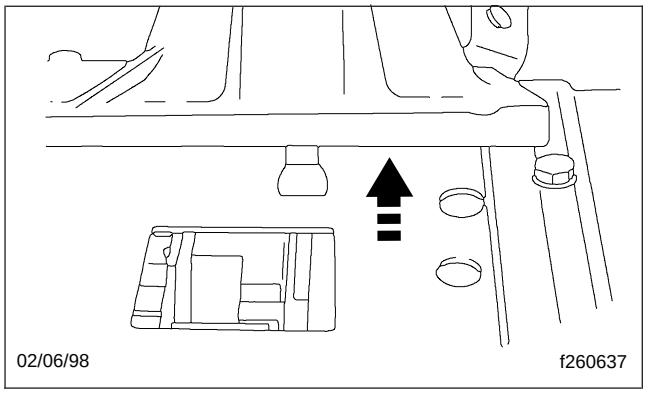


Fig. 14, Shift Lever Removal

2. Using a suitable prybar, move the shift blocks into each gear position. See **Fig. 15**. If the trouble is in the transmission, the shift blocks will be difficult to move.

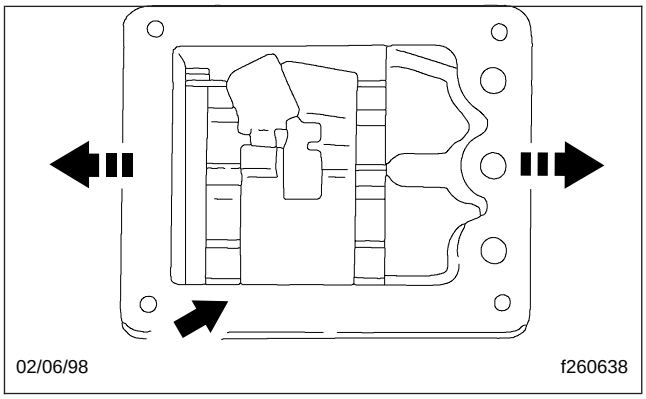


Fig. 15, Check Shift Blocks

3. Check for twisted splines on the mainshaft. See **Fig. 16**.

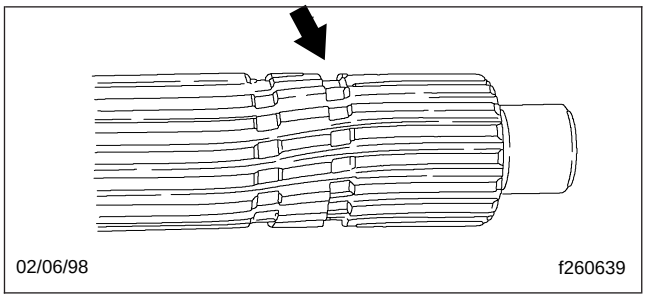


Fig. 16, Check for Twisted Splines

4. Check the yoke bars for binding in the bar housing. See **Fig. 17**.

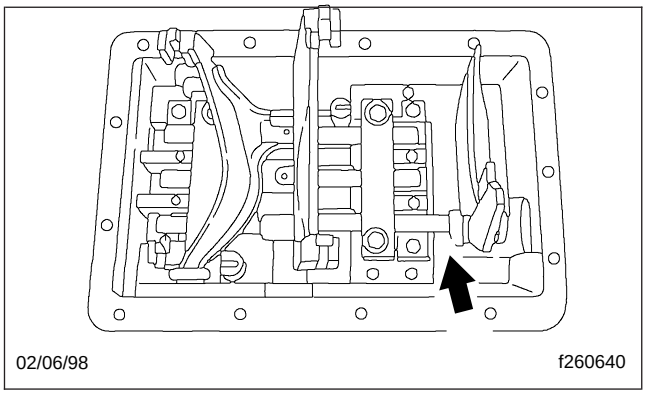


Fig. 17, Check for Binding Yoke Bars

Troubleshooting

NOTE: Gear clashing must not be confused with hard shifting. Gear clashing occurs when an attempt is made to engage the clutch before it has reached synchronization with the mainshaft gear. If hard shifting occurs, only in first and reverse, then restricted movement of the shift block detent plunger must be considered as a possible cause of the condition.

5. Check for restricted plunger movement from burrs on the plunger or from overtightening the plunger spring plug. Refer to the appropriate transmission section in **Group 26** for the proper adjustment. See **Fig. 18**.

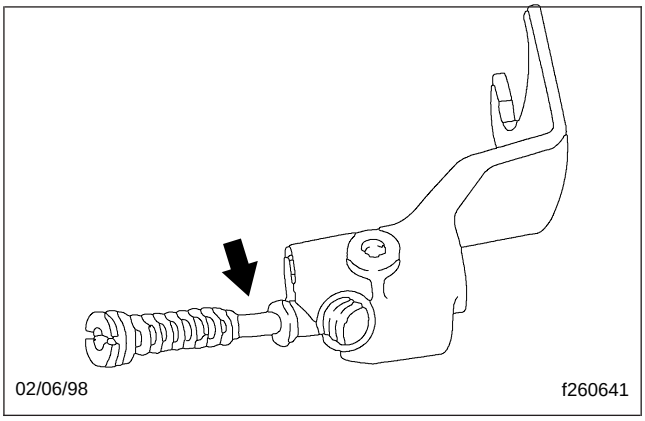


Fig. 18, Check Plunger Movement

HEAT

1. Check for proper level of lubricating oil. See **Fig. 19**.
2. The following conditions can also contribute to overheating:
   - operating consistently under 20 mph (32 km/h)
   - high engine rpm
   - restricted airflow around the transmission, due to the transmission being boxed in by frame rails, deck lids, fuel tanks and mounting brackets, or by a large bumper assembly
   - an exhaust system too close to the transmission
   - high ambient temperature
   - high horsepower, overdrive operation
   - coasting downhill with the clutch depressed

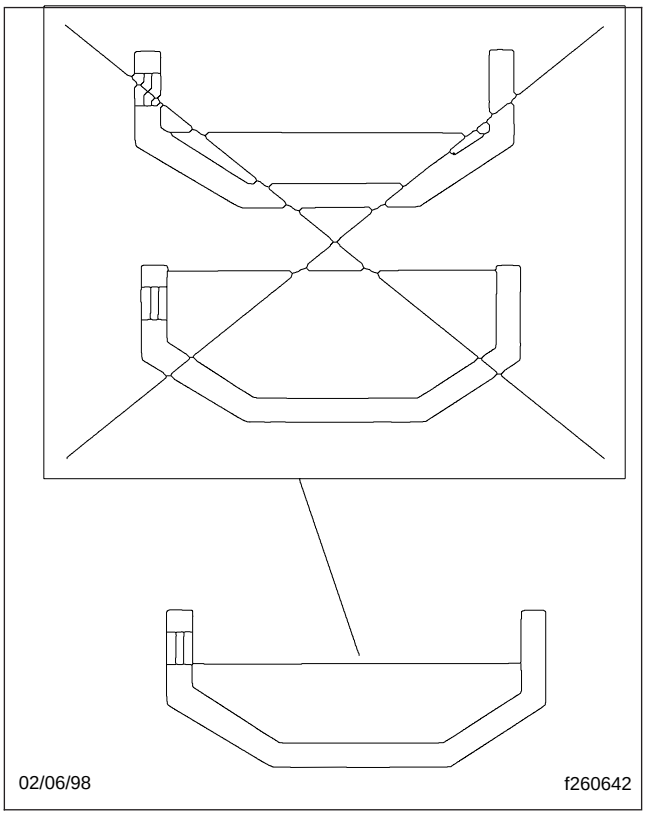


Fig. 19, Oil Level Check

Problem—Gear Jumpout (Auxiliary Section)

Problem—Gear Jumpout (Auxiliary Section)	
Possible Cause	**Remedy**
Worn yoke pad(s)	Check for resultant damage and replace the damaged/worn part(s).
Worn yoke slot in the clutch gear	Tighten the part(s) and correct the restriction(s).
Damaged insert valve	
Damaged regulator	
Clutching teeth tapered, worn or not fully engaged	
Bearing failure	
Gear twisted out of time on the shaft	
Inner race left off the front of the auxiliary countershaft	
Loose or pinched air line, loose fitting or connector	

Problem—Slipout or Jumpout (Front Section)

Problem—Slipout or Jumpout (Front Section)	
Possible Cause	**Remedy**
Worn yoke pad(s)	Check for resultant damage and replace the damaged/worn part(s).
Worn yoke slot in the clutch gear	Check and repair the resultant damage. Correct the engine and transmission alignment.
Weak or missing detent spring	
Gear twisted out of time on the shaft	
Clutching teeth tapered, worn or not fully engaged	
Broken key	
Broken engine mount	
Engine and transmission misaligned	

Problem—Slow Shift (Splitter Gear)

Problem—Slow Shift (Splitter Gear)	
Possible Cause	**Remedy**
Damaged insert valve	Check for resultant damage and replace the damaged part(s).
Damaged O-ring	
Damaged regulator	
Loose or pinched air line, loose fitting or connector	Tighten the part(s) and correct the restriction(s).
Improperly mounted gasket	Reset to specification.
Excessive amount of silicone or no silicone on the O-rings	Clean the parts and apply a thin coating of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A.

Troubleshooting

Problem—Slow Shift or Will Not Shift (Range)

Problem—Slow Shift or Will Not Shift (Range)	
Possible Cause	**Remedy**
Worn or damaged regulator (auxiliary)	Check for resultant damage and replace the damaged/worn part(s).
Worn or damaged synchronizer (auxiliary)	
Broken key (auxiliary)	
Broken synchronizer spring	
Loose or pinched air line, loose fitting or connector	Tighten the part(s) and correct the restriction(s).
Sticking slave valve piston, excessive amount of silicone or no silicone on the O-rings	Clean the parts and apply a thin coating of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A.
Damaged O-ring or cracked air cylinder piston	Replace the parts applying a thin coating of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A during installation.
Loose air cylinder piston nut	Clean and tighten the nut.

Problem—Hard Shift or Will Not Shift (Front Section)

Problem—Hard Shift or Will Not Shift (Front Section)	
Possible Cause	**Remedy**
Incorrect detent spring (too strong) installed	Check for resultant damage and replace the damaged/incorrect part(s).
Bent yoke bar	
Cracked shift bar housing	
Twisted mainshaft	
Gear twisted out of time on the shaft	
Broken engine mount	
Burr on the yoke bar	Smooth the yoke bar with emery paper.
Obstructed linkage	Correct the obstruction.
Improper clutch adjustment	Adjust to specification.

Problem—Hard Shifting into First and Reverse Gears Only

Problem—Hard Shifting into First and Reverse Gears Only	
Possible Cause	**Remedy**
Restricted movement of shift block detent plunger	Check for resultant damage and replace the damaged part(s). Adjust to specification.

Problem—Able to Shift Front Section into Two Gears at Once

Problem—Able to Shift Front Section into Two Gears at Once	
Possible Cause	**Remedy**
Missing interlock ball/pin	Install the missing parts.
Broken key (front section)	Check for resultant damage and replace the damaged part(s).

Problem—Grinding on Initial Lever Engagement

Problem—Grinding on Initial Lever Engagement	
Possible Cause	**Remedy**
Worn yoke pads	Check for resultant damage and replace the damaged/worn part(s).
Worn bushings in the control housing	
Gear twisted out of time on the shaft	
Clutch brake tangs broken (pull)	
Countershaft brake not working (push)	Check the air lines or hoses and replace the damaged part(s).
Clutch brake not adjusted	Adjust to specification.
Improper linkage/clutch adjustment	
Not equipped with countershaft or clutch brake	Install the missing parts.
Obstructed linkage	Correct the obstruction.

Problem—Lever Locks Up or Sticks in Gear

Problem—Lever Locks Up or Sticks in Gear	
Possible Cause	**Remedy**
Twisted mainshaft	Check for resultant damage and replace the damaged part(s).
Obstruction	Correct the obstruction.
Improper installation	Correct the installation.

Problem—Noise

Problem—Noise	
Possible Cause	**Remedy**
Rough running engine	Repair as required.
Driveline out of balance	
Unequal joint working angles	

Troubleshooting

Problem—Noise	
Possible Cause	**Remedy**
Worn universal joints	Check for resultant damage and replace the damaged/worn part(s).
Loose or worn center bearings	
Worn drive axle	
Wheel(s)/brake drum(s) out of balance	
Loose U-bolts	
Inner race left off the front of the auxiliary countershaft	
Gear is twisted out of time on the shaft	
Cracked gear	
Bearing failure	
Improper oil level (too low or too high), oil quality, additives or infrequent oil changes	Check for resultant damage and replace the damaged part(s). Follow the manufacturer's specified maintenance requirements.
Burr on the gear tooth	Smooth the gear with emery paper or replace as required.

Problem—Gear Rattle at Idle

Problem—Gear Rattle at Idle	
Possible Cause	**Remedy**
Excessive mainshaft gear tolerance	Adjust to specification.
Rough running engine	Repair as required.

Problem—Vibration

Problem—Vibration	
Possible Cause	**Remedy**
Fretted gear and shaft splines	Check for resultant damage and replace the damaged/worn part(s).
Fretted or fatigued bearing(s)	
Input shaft spline wear	
Worn universal joints	
Broken synchronizer	
Broken engine mount	
Worn suspension	
Rough running engine	Repair as required.
Loose brackets and mountings	Check for resultant damage and replace the damaged part(s). Tighten nuts to specification.
Output shaft nut improperly tightened	
Loose lug nuts	

Problem—Vibration	
Possible Cause	**Remedy**
Improper driveline setup	Check for resultant damage and replace the damaged part(s). Correct the balance/ driveline setup.
Wheel(s)/brake drum(s) out of balance	

Problem—Burned Mainshaft Washer

Problem—Burned Mainshaft Washer	
Possible Cause	**Remedy**
Low oil level	Check for resultant damage and replace the damaged part(s). Follow the manufacturer's specified requirements for maintenance/driving/towing.
Improper coasting	
Improper towing of the vehicle	

Problem—Input Shaft Splines Worn or Input Shaft Broken

Problem—Input Shaft Splines Worn or Input Shaft Broken	
Possible Cause	**Remedy**
Starting in too high of a gear	Check for resultant damage and replace the damaged/worn part(s).
Shocking the gear	
Clutch failure	
Improper clutch adjustment	Check for resultant damage and replace the damaged part(s). Adjust the clutch to specification.
Engine and transmission misaligned	Check for resultant damage and replace the damaged part(s). Correct the engine and transmission alignment/driveline setup.
Improper driveline setup	

Problem—Cracked Clutch Housing

Problem—Cracked Clutch Housing	
Possible Cause	**Remedy**
Broken engine mount	Check for resultant damage and replace the damaged part(s). Correct the engine and transmission alignment.
Engine and transmission misaligned	

Problem—Broken Auxiliary Housing

Problem—Broken Auxiliary Housing	
Possible Cause	**Remedy**
Improper driveline setup	Check for resultant damage and replace the damaged part(s). Correct the driveline setup.

Troubleshooting

Problem—Burned Synchronizer

Problem—Burned Synchronizer	
Possible Cause	**Remedy**
Worn or damaged regulator	Check for resultant damage and replace the damaged/worn part(s).
Broken synchronizer spring	
Yoke installed backwards	Check for resultant damage and reinstall or replace the part(s) as required.
Improper oil quality or additives	Check for resultant damage and replace the damaged part(s). Follow the manufacturer's specified maintenance requirements.

Problem—Shaft Twist or Failure

Problem—Shaft Twist or Failure	
Possible Cause	**Remedy**
Starting in too high of a gear or shock load	Check for resultant damage and replace the damaged part(s).
Lugging	
Attempting to start with brakes locked	
Improper clutching techniques	
Transmission application improper for intended use	
Bumping into a dock when moving in reverse	
Improper mounting of adjustable fifth wheel	
Fatigue or impact	

Problem—Excessive Heat

Problem—Excessive Heat	
Possible Cause	**Remedy**
Inner race left off the front of the auxiliary countershaft	Check for resultant damage and replace the damaged part(s).
Gear twisted out of time on the shaft	
Bearing failure	
Improper oil level (too low or too high), oil quality, additives or infrequent oil changes	Check for resultant damage and replace the damaged part(s). Follow the manufacturer's specified maintenance requirements.
Restricted airflow around transmission	
High ambient temperature	
Operating consistently at low speeds	

Problem—Excessive Heat	
Possible Cause	**Remedy**
Too great of an operating angle	Check for resultant damage and replace the damaged part(s). Follow the manufacturer's specified operating requirements.
High engine rpm	
High horsepower, overdrive operation	
Coasting downhill with the clutch depressed	

Problem—Drive Set Damage

Problem—Drive Set Damage	
Possible Cause	**Remedy**
Bearing failure	Check for resultant damage and replace the damaged part(s).
Too great of an operating angle	
Low oil level	Check for resultant damage and replace the damaged part(s). Follow the manufacturer's specified maintenance requirements.

Problem—Burned Bearing

Problem—Burned Bearing	
Possible Cause	**Remedy**
Inner race left off the front of the auxiliary countershaft	Check for resultant damage and replace the damaged part(s).
Improper oil level (too low or too high), oil quality, additives or infrequent oil changes	Check for resultant damage and replace the damaged part(s). Follow the manufacturer's specified maintenance requirements.

Problem—Oil Leakage

Problem—Oil Leakage	
Possible Cause	**Remedy**
Blocked breather hole	Remove the blockage.
High oil level	Adjust oil level to specification.
Pin hole in the case	Check for resultant damage and replace the damaged part(s).
Damaged rear seal	
Loose or missing capscrews	Install the missing parts. Apply the appropriate sealant. Tighten to specifications.

Problem—Overlapping Gear Ratios

Problem—Overlapping Gear Ratios	
Possible Cause	**Remedy**
Air hose attached to the wrong port	Check air line/hose routing and correct as required.

Specifications

Torque Values, Manual Transmissions			
Description	**Size**	**Class**	**Torque: lbf·ft (N·m)**
Clutch Release Arm Nut	3/8–16	—	15–30 (20–40)
Shift Tower Mounting Capscrews	M10	10.9	35–45 (48–61)
Transmission Fluid Fill Plug, Eaton Transmissions	0.75"	—	25–35 (34–48)
	1.25"	—	60–75 (81–102)
Transmission Fluid Fill Plug, Meritor Transmissions	—	—	35–50 (48–68)
Transmission Mounting Bolts	M10 x 1.5	8.8	40–60 (54–81)
U-Joint End Cap or Strap Capscrews	3/8–16	—	40 (54)
	3/8–24	—	50 (68)
	1/2–20	—	110 (149)

Table 1, Torque Values, Manual Transmissions

Transmission Lubricant Capacities	
Transmission Model	**Capacity in Quarts (liters)***
Eaton 5-Speed	
FS–4205/5205 Series	6.25 (5.9)
FS–6305 Series	9.75 (9.2)
Eaton 6-Speed	
FS–5306/6306 Series	9.0 (8.5)
FS–5406/6306/8406 Series	9.75 (9.2)
Eaton 9-Speed	
Fuller RT–6609	6.0 (5.7)
All Other 9-Speed Models	13.5 (12.8)
Eaton 10-Speed	
Fuller FR/FRO Series (all models)	11.75 (11.1)
Fuller RT/RTX Series (all models)	13.0 (12.3)
All Other 10-Speed Models	14.0 (13.2)
Eaton 11-Speed	
All Models	14.0 (13.2)
All Eaton 13-Speed Series	
All Models	14.0 (13.2)
All Eaton 15-Speed Series	
All Models	14.0 (13.2)
All Eaton 18-Speed Series	
All Models	14.0 (13.2)

* Quantities listed are approximate. Fill the transmission until the lubricant is level with the bottom of the fill hole, with the vehicle in the usual operating position.

Table 2, Transmission Lubricant Capacities

Eaton FS–4205 Five-Speed Manual Transmission

The FS–4205 series transmission is a five-speed synchronized unit that features a constant mesh low and reverse, and offers an efficient ratio of torque capacity to weight. There are two FS–4205 Series models: the FS–4205A and the FS–4205B. Transmission features include split-pin synchronizers in second, third, fourth and fifth gears, tapered roller bearings, and needle roller bearings at main support locations.

The shift forks have steel-backed bronze wear pads that can be replaced, if necessary. The shift pattern is the standard progression type with all shifts having the same throw at the shift lever. Transmissions are available with either standard ratio or the soft ratio, which splits the step in a two-speed axle. The FS–4205A has a standard ratio and the FS–4205B has a soft-fourth ratio.

The FS–4205 series transmissions have five forward speeds and one reverse speed with gear ratios as shown in **Table 1**.

FS–4205 Series Gear Ratios						
Model	**First**	**Second**	**Third**	**Fourth**	**Fifth**	**Reverse**
FS–4205A	8.05:1	4.35:1	2.45:1	1.48:1	1.00:1	8.05:1
FS–4205B	6.99:1	3.78:1	2.13:1	1.28:1	1.00:1	6.99:1

Table 1, FS-4205 Series Gear Ratios

FS–5205 Series Five Speed Manual Transmission

The FS–5205 Series transmission is a five-speed, synchronized unit that features a constant mesh low and reverse and offers an efficient ratio of torque capacity to weight. There are two FS–5205 Series models: the FS–5205A and the FS–5205B. Transmission features include split-pin synchronizers in second, third, fourth and fifth gears, two tapered roller bearings on the mainshaft and two tapered roller bearings on the countershaft.

The shift forks have replaceable steel-backed bronze wear pads, (see the transmission manufacturer's manual for replacement procedures). The shift pattern is the standard progression type, with all shifts having the same throw at the shift lever. Transmissions are available with either the standard ratio or the soft-fourth ratio, which splits the step in a two-speed axle. The FS–5205A has a standard ratio and the FS–5205B has a soft-fourth ratio.

The FS–5205 Series transmissions have five forward speeds and one reverse speed, with gear ratios as follows, see **Table 2**.

FS–5205 Gear Ratios												
Model	**Gear Ratios**						**Relative Speed PTO Gear to Input RPM**		**Length**		**Weight**	
	1st	**2nd**	**3rd**	**4th**	**5th**	**Rev**	**Right**	**Left**	**mm**	**In.**	**kg**	**Lb**
FS–5205A	7.52	4.35	2.54	1.52	1.00	6.27	0.460	0.435	589.3	23.2	104.3	230
FS–5205B	6.82	3.68	2.15	1.28	1.00	5.30	0.543	0.515	589.3	23.2	104.3	230

Table 2, FS-5205 Gear Ratios

General Information

FS–6205 Series Five Speed Manual Transmission

The FS–6205 Series transmission is a five-speed synchronized unit that features a constant mesh low and reverse, and offers an efficient ratio of torque capacity to weight. Transmission features include split-pin synchronizers in second, third, fourth and fifth gears, two tapered roller bearings on the mainshaft and two tapered roller bearings on the countershaft.

Countershaft end play is controlled by shims located in the countershaft rear bearing cap. Mainshaft end play is controlled by shims located in the mainshaft rear bearing cover.

The shift forks are single-piece forged and have bronze wear pads that can be replaced, if necessary.

The FS–6205 Series transmissions have five forward speeds and one reverse speed with gear ratios as follows:

- First 7.22:1
- Second 3.89:1
- Third 2.22:1
- Fourth 1.39:1
- Fifth 1.00:1
- Reverse 7.22:1

FS–5306A and FS–6306A Six Speed Manual Transmissions

The FS–5306A and the FS–6306A Series transmissions are six-speed synchronized units that feature a constant mesh LOW and REVERSE, and offer an efficient ratio of torque capacity to weight. Transmission features include split-pin synchronizers in second, third, fourth, fifth and sixth gears; two tapered roller bearings on the mainshaft and two tapered roller bearings on the countershaft; all gears are helical cut.

Countershaft end play is controlled by shims located in the countershaft rear bearing cap. Mainshaft end play is controlled by shims located in the mainshaft rear bearing cover.

The shift forks are single-piece forged and have bronze wear pads that can be replaced.

The FS–5306A and the FS–6306A Series transmissions have six forward speeds and one reverse speed with gear ratios as follows:

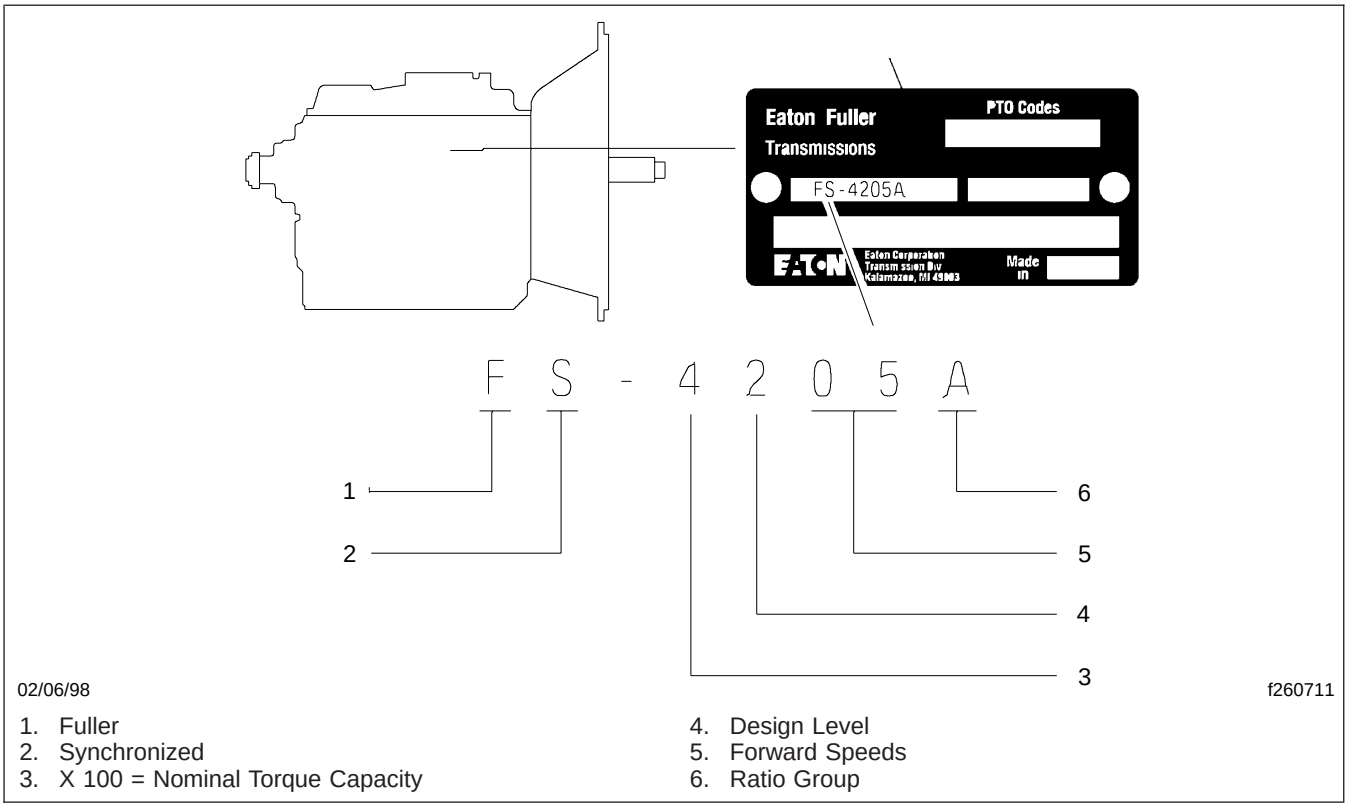
- First 9.01:1
- Second 5.27:1
- Third 3.22:1
- Fourth 2.04:1
- Fifth 1.36:1
- Sixth 1.00:1
- Reverse 8.63:1

IDENTIFICATION

IMPORTANT: Do not remove or destroy the transmission identification tag.

All Eaton Fuller transmissions are identified by the model and serial number. This information is stamped on the transmission identification tag and affixed to the case. See **Fig. 1**.

NOTE: The design level of 2 indicates that this transmission uses a one-piece air module system rather than a separate slave valve and regulator system connected by hoses.



1. Fuller
2. Synchronized
3. X 100 = Nominal Torque Capacity
4. Design Level
5. Forward Speeds
6. Ratio Group

Fig. 1, Transmission Identification Tag

General Specifications	
Item	**Specification**
Lubricant Capacity	5.7 Liters (12 Pints)
Lubricant Specification	
Eaton Roadranger® CD50 Transmission Fluid	—
Heavy Duty Engine Oil Grade 80W90	SAE 50 or MIL–L–2104–E or F, or API–SG or SH
Mineral Gear Oil With Rust and Oxidation Inhibitor	API–GL–1
Premium Long-Life Grease XG–1–C or K	ESA–M1C75–B
Sealant Specification	
Threadlock® and Sealer EOAZ–19554–AA	WSK–M2G315–A5
Gasket and Trim Adhesive D7AZ–19B508–B	ESR–M11P17–A and ESE–M2G52–A
Pipe Sealant with Teflon® D8AZ–19554–A	WSK–M2G350–A2 and ESR–M18P7–A
End Play Limits	
Mainshaft (FS–4205 and FS–5205)	0.008–0.012 in. (0.203–0.305 mm)
Mainshaft (FS–5306A, FS–6306A and FS–6205)	0.006–0.010 in. (0.15–0.25 mm)
Countershaft (FS–4205 and FS–5205)	0.002–0.008 in. (0.05–0.20 mm)
Countershaft (FS–5306A, FS–6306A and FS–6205)	0.006–0.010 in. (0.15–0.25 mm)

Table 1, General Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Transmission-to-Clutch Housing Bolts	90–100 (122–136)
Shift Bar Housing Capscrews	35–40 (47–54)
Drain and Fill Plugs	45–55 (61–75)

Table 2, Torque Specifications

General Information

THE FR–11210B, FR–12210B, FR–13210B, FR–14210B, FRO–11210B, FRO–12210B, FRO–13210B, FRO–14210B/C, FRO–15210B/C and FRO–16210B/C SERIES MANUAL TRANSMISSIONS

The FR–11210B, FR–12210B, FR–13210B, FR–14210B, FRO–11210B, FRO–12210B, FRO–13210B, FRO–14210B/C, FRO–15210B/C and FRO–16210B/C Series transmissions have ten forward speeds and two reverse speeds. The gear shift lever mechanically engages and disengages five forward gears and one reverse gear in the transmission front section. The range lever on the shift knob allows the operator to control an air-shifted auxiliary section to provide a low and a high range. The five forward gears selected in low range are used again in high range to provide the remaining five progressive forward gear ratios.

Once the highest shift lever position (fifth gear) is obtained in low range, the operator preselects the range shift lever for high range. The range shift occurs in neutral as the shift lever is moved from the fifth gear position to the sixth gear position.

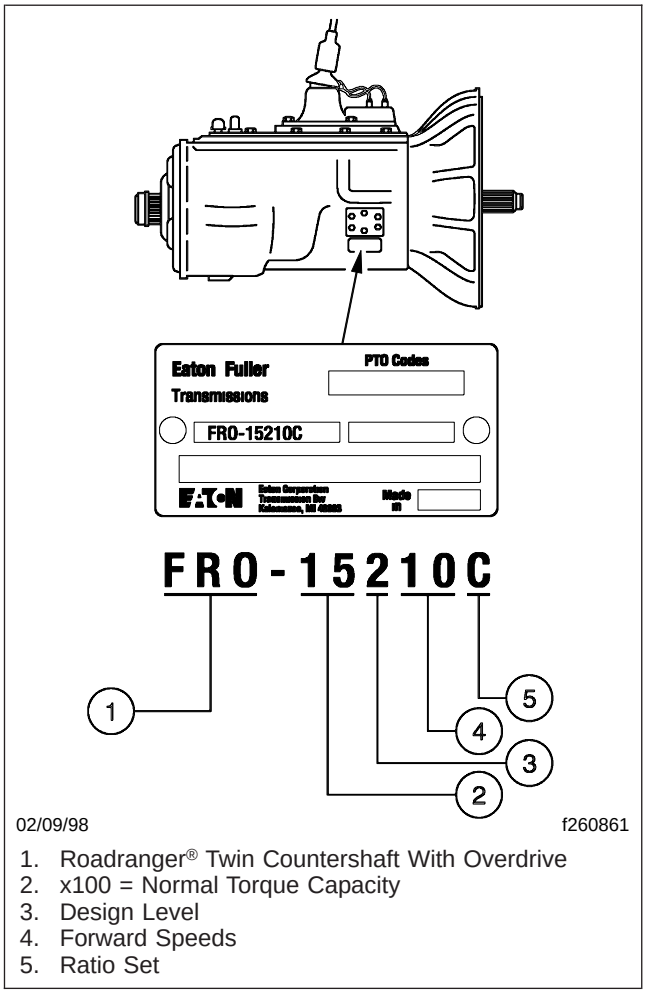
When downshifting, the operator preselects the range lever for low range and the range shift occurs automatically as the shift lever is moved to the next gear position.

IDENTIFICATION

IMPORTANT: Do not remove or destroy the transmission identification tag.

All Eaton Fuller transmissions are identified by the model and serial number. This information is stamped on the transmission identification tag and affixed to the case. See **Fig. 1**.

NOTE: The design level of 2 indicates that this transmission uses a one-piece air module system rather than a separate slave valve and regulator system connected by hoses.



1. Roadranger® Twin Countershaft With Overdrive
2. x100 = Normal Torque Capacity
3. Design Level
4. Forward Speeds
5. Ratio Set

Fig. 1, Transmission Identification Tag

General Specifications	
Item	**Specification**
Lubricant Capacity	11.1 Liters (23.5 Pints)
Lubricant Specification	
Eaton Approved Synthetic Transmission Oil	SAE 50
Heavy Duty Engine Oil	SAE 50 or MIL–L–2104–D, or API–CD or CAT TO–4
Mineral Gear Oil 80W90, 75W	API MT–1
Sealant Specification	
Threadlock® and Sealer EOAZ–19554–AA	WSK–M2G315–A5
Gasket and Trim Adhesive D7AZ–19B508–B	ESR–M11P17–A and ESE–M2G52–A

Table 1, General Specifications

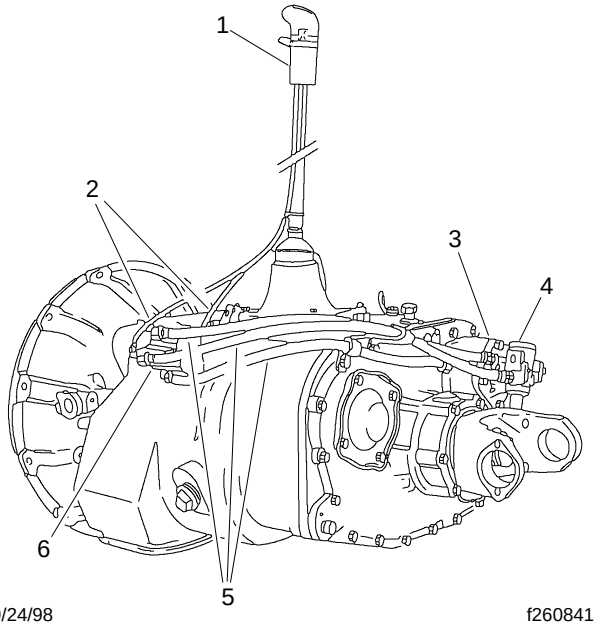
Torque Specifications	
Description	**lbf·ft (N·m)**
Clutch Housing Capscrews (M12 x 1.7)	97–108 (72–80)
Clutch Housing Nuts (M16 x 1.5)	244–271 (180–200)
Clutch Housing-to-Engine Bolts	54–81 (40–60)
Clutch Release Arm-to-Shaft Nut	20–40 (15–30)
Oil Drain Plug (3/4 Pipe Threads)	61–74 (45–55)
Oil Fill Plug (1-1/4 Pipe Threads)	34–47 (25–35)
Shift Control Housing Capscrews (M10 x 1.5)	40–45 (54–61)
Shift Lever Housing Capscrews (M10 x 1.5)	47–61 (35–45)
Shift Block Capscrew (M10 x 1.5)	54–61 (40–45)
Air Module Capscrews (M8 x 1.25)	27–31 (20–23)
Studs (Driven Until Bottomed, M16 x 2)	81 (60)
Shift Bar Housing Capscrews	54–61 (40–45)

Table 2, Torque Specifications

General Information (See Fig. 1, Fig. 2, Fig. 3, and Fig. 4)

RANGE SHIFT AIR SYSTEM

Fuller air shift transmissions are equipped with a range shift air system. Deep reduction components are added to the range shift air system for 15-speed and LL, (Low-Low), deep reduction transmissions. A splitter air system is used with 13-speed transmissions. See **Fig. 5**.



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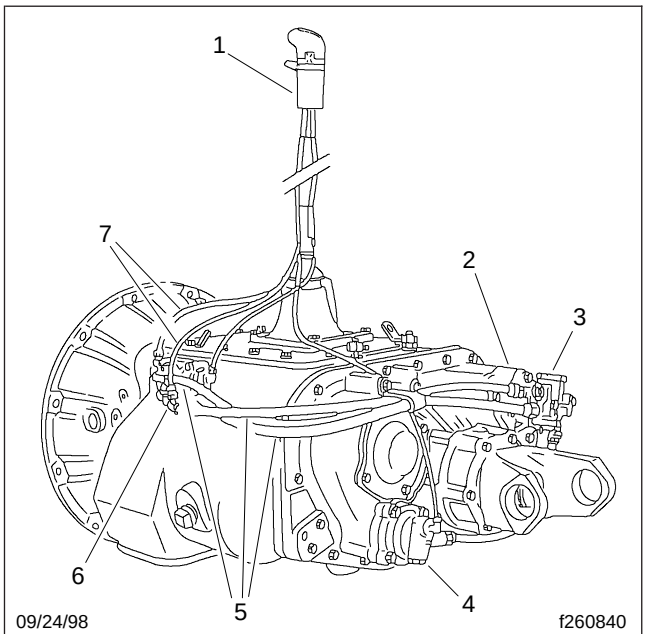
1. Roadranger® Valve
2. 5/32-inch Outside Diameter Air Lines
3. Range Cylinder
4. Air Filter/Regulator
5. 1/4-inch Inside Diameter Air Hoses
6. Slave Valve

Fig. 1, Two-Speed Auxiliary

AIR FILTER

The air filter contains a replaceable filter element that can be removed by turning out the end cap. This element must be cleaned or replaced at each oil change, or more often under high humidity conditions.



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1. Roadranger® Valve
2. Range Cylinder
3. Air Filter/Regulator
4. Deep Reduction or Splitter Cylinder
5. 1/4-inch Inside Diameter Air Hoses
6. Slave Valve
7. 5/32-inch Outside Diameter Air Lines

Fig. 2, Three-Speed Auxiliary

AIR REGULATOR

The air regulator adjusts the system air pressure to 58 to 63 psi (396 to 431 kPa). See **Fig. 6.** The regulator is non serviceable and is replaced as an assembly.

The filter element is serviceable and must be cleaned or replaced during maintenance procedures.

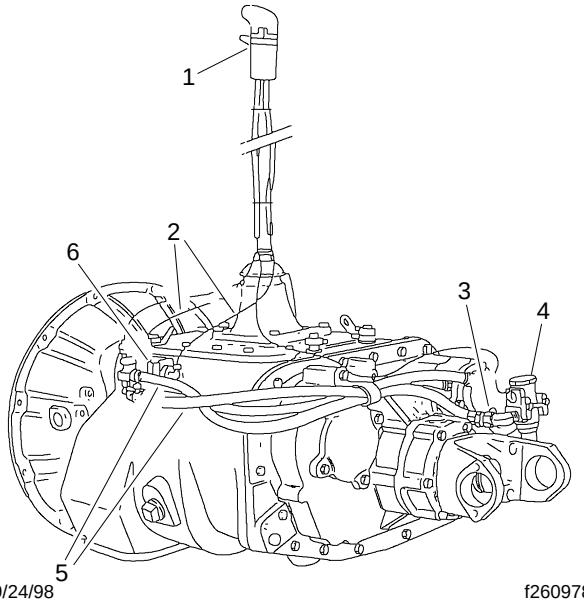
SLAVE VALVE, POPPET-TYPE (19470)

The poppet-type slave valve (19470) is a non serviceable valve. If this valve is damaged, the complete assembly must be replaced. See **Fig. 7.**

SLAVE VALVE, PISTON-TYPE (A–5000)

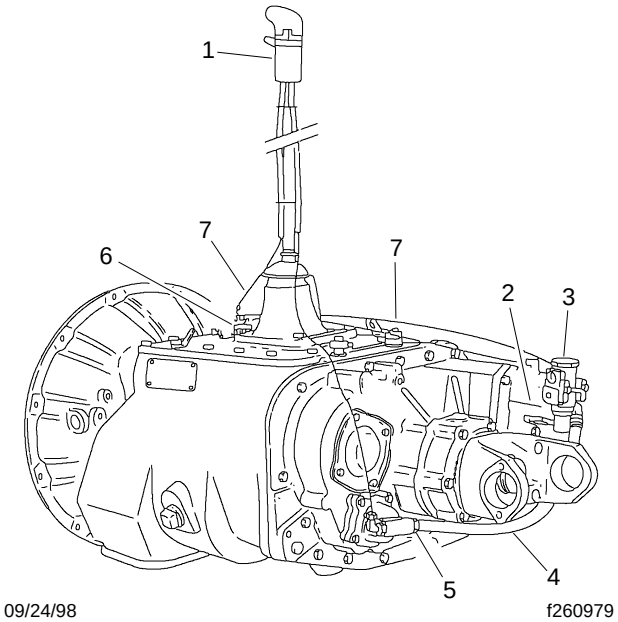
The piston-type slave valve (A–5000) is a serviceable valve. It can be disassembled and parts replaced as necessary. See **Fig. 8.**

General Information



1. Roadranger® Valve
2. 5/32-inch Outside Diameter Air Lines
3. Combination Cylinder
4. Air Filter/Regulator
5. 1/4-inch Inside Diameter Air Hoses
6. Slave Valve

Fig. 3, Combination Cylinder



1. Roadranger® Valve
2. Range Cylinder
3. Air Filter/Regulator
4. 1/4-inch Inside Diameter Air Hose
5. Deep Reduction or Splitter Cylinder
6. Range Actuator Valve
7. 5/32-inch Outside Diameter Air Lines

Fig. 4, RTLO-10 Speeds

SLAVE VALVE, PRESELECTION

An air valve shaft protruding from the shift bar housing prevents the actuating piston in the slave valve from moving while the shift lever is in a gear position and releases the piston when the lever is moved to or through Neutral. See **Fig. 9.**

RANGE CYLINDER

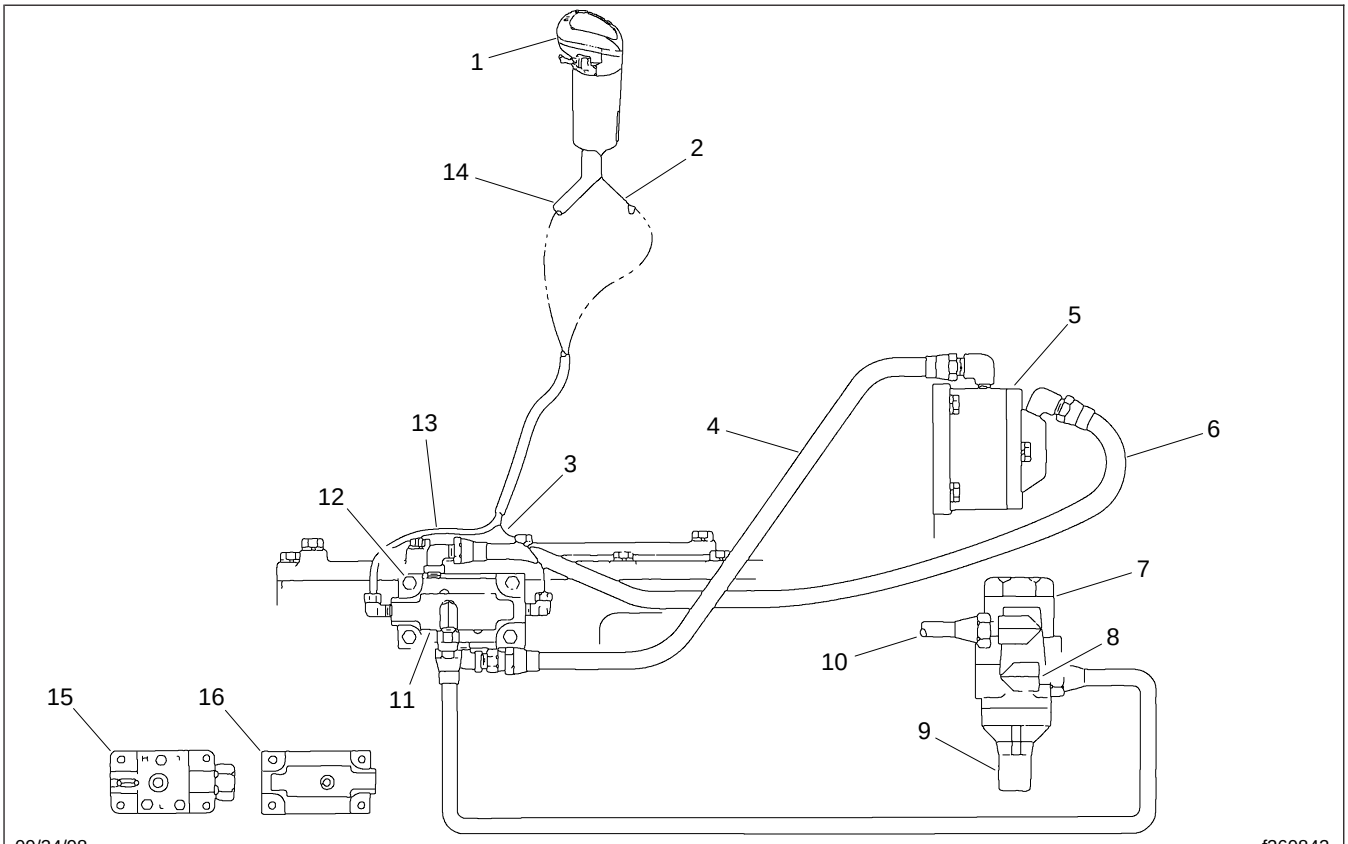
NOTE: The numbers in parentheses correspond to the numbers in the following illustration.

In low range, the air pressure is supplied from the slave valve to the (1) low range port in the range cylinder. This air pressure forces the (2) range cylinder piston to the rear, engaging the low range gearing. Air pressure on the back of the piston and in the (3) high range air line is exhausted out the slave valve.

In high range, the air pressure is supplied from the slave valve to the high range port of the range cylinder cover. This air pressure forces the range cylinder piston forward, engaging the high range gearing. The air pressure that was on the front side of the piston and in the low range airline during low range operation is exhausted out the slave valve. See **Fig. 10.**

ROADRANGER® VALVE (A–6909)

Constant air pressure is supplied from the slave valve to the S-port of the valve. In low range (ranger lever down), air passes through the lever and out the P-port of the Roadranger valve. This air returns to the slave valve through the end port or P-port, depending on the type of slave valve used. In high range (control lever up) the lever prevents the air from passing through the Roadranger valve. Air pressure that was in the outlet line is exhausted out the bottom of the Roadranger valve. See **Fig. 11.**



1. Roadranger® Valve (A–6909)
2. Black Air Line to Port Marked P
3. Signal Air Line
4. Low Range Air Line
5. Range Shift Cylinder
6. High Range Air Line
7. Air Filter
8. Constant Air Supply Line
9. Regulator
10. Air Supply Port
11. Slave Valve
12. Slave Valve
13. Supply Air Line
14. Red Air Line to Port Marked S
15. Slave Valve
16. Slave Valve

Fig. 5, Range Shift Air System

INTERMEDIATE SHIFT CYLINDER

Constant, regulated air is channeled through the cover to the front side of the shift piston. Air is always on the side of the piston.

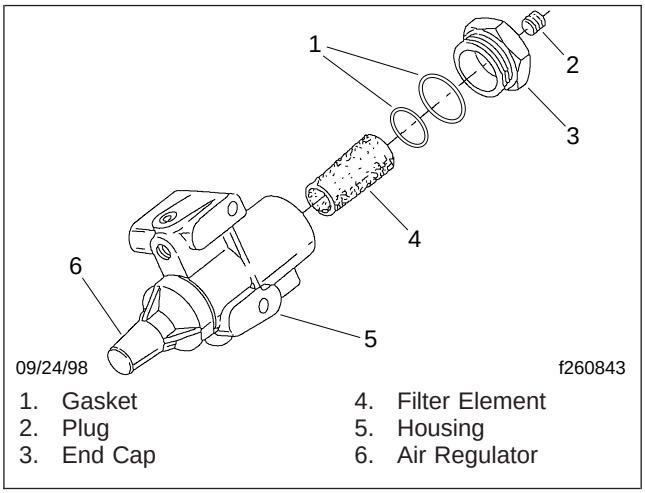
The shift piston is moved by removing or applying air (from constant supply) to the back side of the piston. This piston area is larger and can overcome the area of the front side of the piston. The removal or application of air on the back side of the piston is controlled by the insert valve in the cylinder cover; this valve in turn is controlled by the Roadranger® valve.

DEEP REDUCTION AIR SYSTEM

Roadranger® Valve (A–6915)

In addition to the various components of the range shift air system, the deep reduction air system utilizes a reduction cylinder and a Roadranger valve A–6915.

General Information



1. Gasket
2. Plug
3. End Cap
4. Filter Element
5. Housing
6. Air Regulator

Fig. 6, Air Regulator Assembly

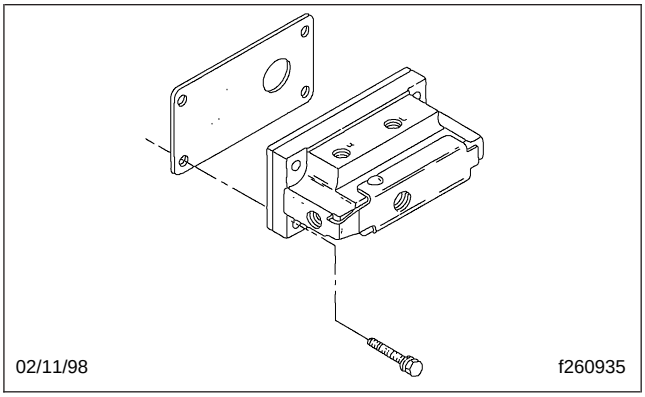


Fig. 7, Slave Valve, Poppet Type (19470)

Constant air from the air filter/regulator assembly is supplied to the Roadranger valve A–6915. Air is supplied to the built-in deep reduction valve only while in low range, from the tee fitting at the low range or L-port of the slave valve. The insert valve is installed in the cylinder cover to provide the proper airflow needed to move the reduction piston in the cylinder.

With the deep reduction button in the rearward position, the SP-port of the Roadranger valve is closed and no air is supplied to the center port of the cylinder cover.

While in low range, the button can be moved forward to operate in deep reduction. The SP-port of the valve is opened when deep reduction selection is made, supplying air to the center port of the cylinder cover.

While in high range, the mechanical interlock of the Roadranger valve prevents movement of the deep reduction button to the forward position. See **Fig. 13.**

Travel of the small insert valve piston is only 0.031 inch (0.794 mm). As shown in the illustrations, when no air is applied to the top side of the valve piston, constant air supplied from the air filter/regulator passes freely through the insert valve and to the back side of the cylinder piston, moving the yoke bar forward to disengage the deep reduction gearing (low range and high range). When air is applied to the top side of the valve piston through the signal line, the piston moves down to cut off air supplied to the backside of the cylinder piston. This air is exhausted out the bottom port of the cover when constant air supplied from the regulator is directed to the front side of the cylinder piston, moving the yoke bar rearward to engage the deep reduction gearing (deep reduction). See **Fig. 14** and **Fig. 15**.

Insert Valve

The insert valve located in the shift cylinder cover is a small, 1.19 inch (30.163 mm) valve. It is installed with the flat surface to the inside toward the center port, and it is secured with a special nut in the bottom bore of the cover. See **Fig. 16**.

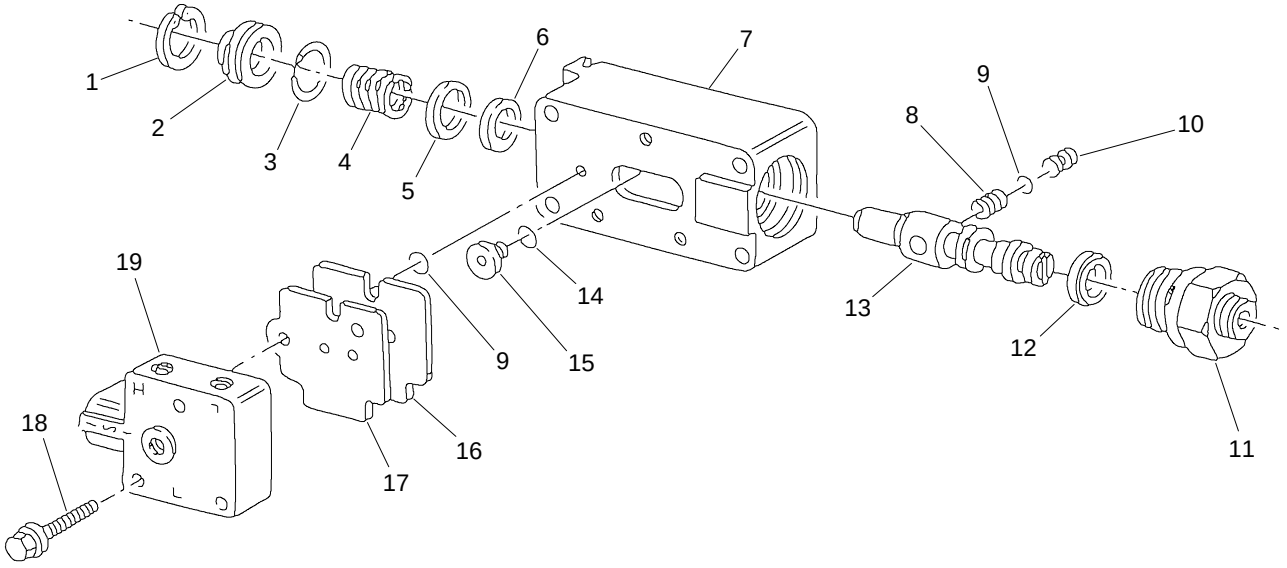
The insert valve is self-contained and cannot be disassembled except for the three O-rings on the outer diameter. These three O-rings are a stationary seal and do not move in the cylinder.

Travel of the small piston in the insert valve is approximately 0.03 inch (0.794 mm). The insert valve is a normally open valve.

When there is no signal or delivery of air to the top side of the insert piston, the constant air from the regulator passes through the insert valve and to the back of the piston and moves the yoke bar forward (direct).

When the insert valve piston is activated by a signal or delivery of air, the insert valve is closed and shuts off the constant air to the back of the shift piston. Air in the shift cylinder is exhausted out through the insert valve and the bottom bore of the cover.

When air is removed from the back of the shift piston, constant air on the front side of the shift piston moves the shift bar to the rear. See **Fig. 17** and **Fig. 18**.



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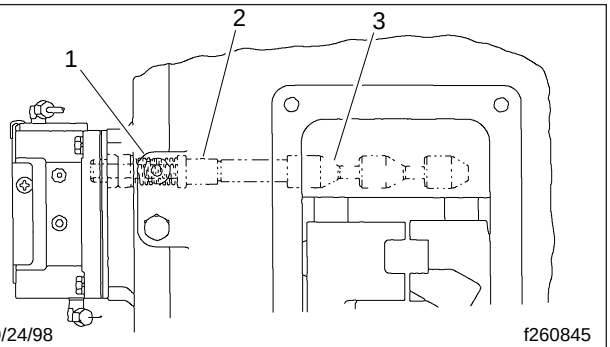
1. Snap Ring
2. Plug
3. O-Ring
4. Spring
5. Washer
6. U-Seal
7. Body
8. Spring
9. O-Ring
10. Seal
11. End Cap
12. U-Seal
13. Piston
14. O-Ring
15. Seal
16. Plate
17. Gasket
18. Capscrew
19. Sidecap

Fig. 8, Piston-Type Slave Valve



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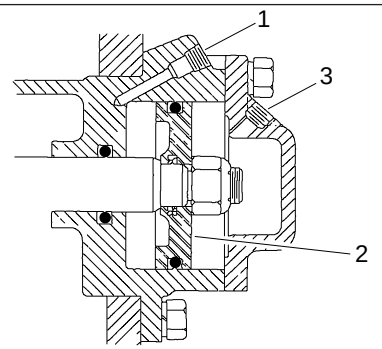
1. Actuating Spring
2. Actuating Pin
3. Air Valve Shaft

Fig. 9, Slave Valve Air Valve Shaft



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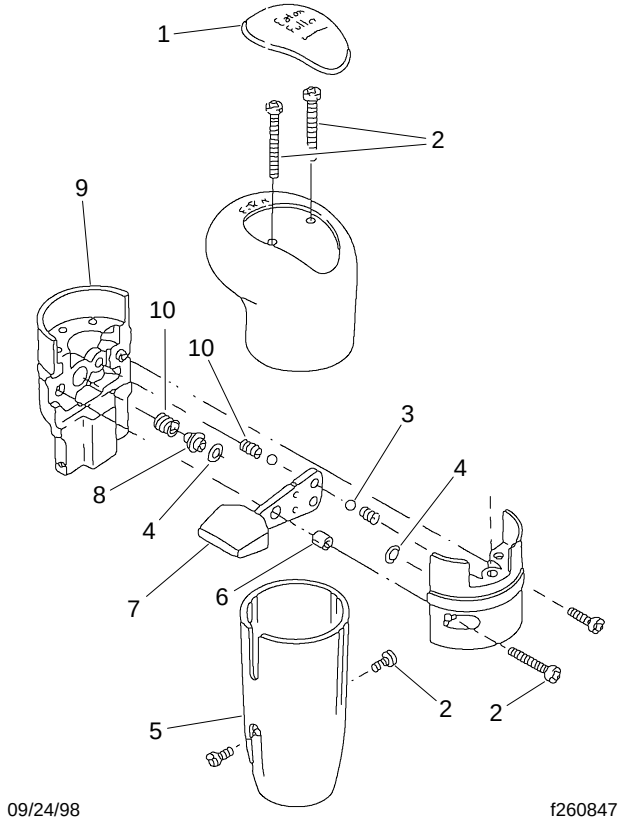
1. High Range Port
2. Range Cylinder Piston
3. Slave Valve

Fig. 10, Range Cylinder

SPLITTER AIR SYSTEM

This air system is used with the 12713-, 14713- and 16713-Series Roadranger® transmissions. The splitter gear system is used only while in high range and splits the high range gearing into either overdrive or underdrive ratios depending upon the transmission model. This system consists of an A–6913

General Information



1. Medallion
2. Screw
3. Ball
4. O-Ring
5. Cover
6. Pin
7. Lever
8. Retainer
9. Housing
10. Spring

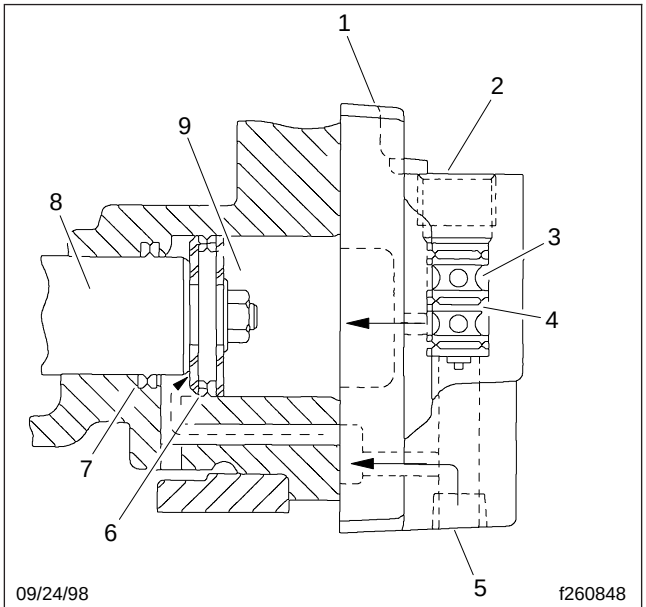
Fig. 11, Roadranger® Valve

Roadranger valve and a splitter shift cylinder and gearing located in the auxiliary section of the transmission. See **Fig. 19** and **Fig. 20**.

Splitter Cylinder Assembly

Constant, regulated air is channeled through the cover to the front side of the shift piston. Air is always on this side of the piston. See **Fig. 21**.

The shift piston is moved by removing or applying air (from constant supply) to the back side of the piston. This piston area is larger and can overcome the area of the front side of the piston. The removal or application of air on the back side of the piston is controlled by the insert valve in the cylinder cover; this valve in turn is controlled by the Roadranger valve.



1. Cover Assembly
2. Left Side Port (Signal Line from Roadranger Valve)
3. Exhaust Port
4. Insert Valve
5. Right Side Port (Constant Air)
6. Seal B
7. Seal A
8. Yoke Bar
9. Piston

Fig. 12, Intermediate Shift Cylinder Assembly

Insert Valve

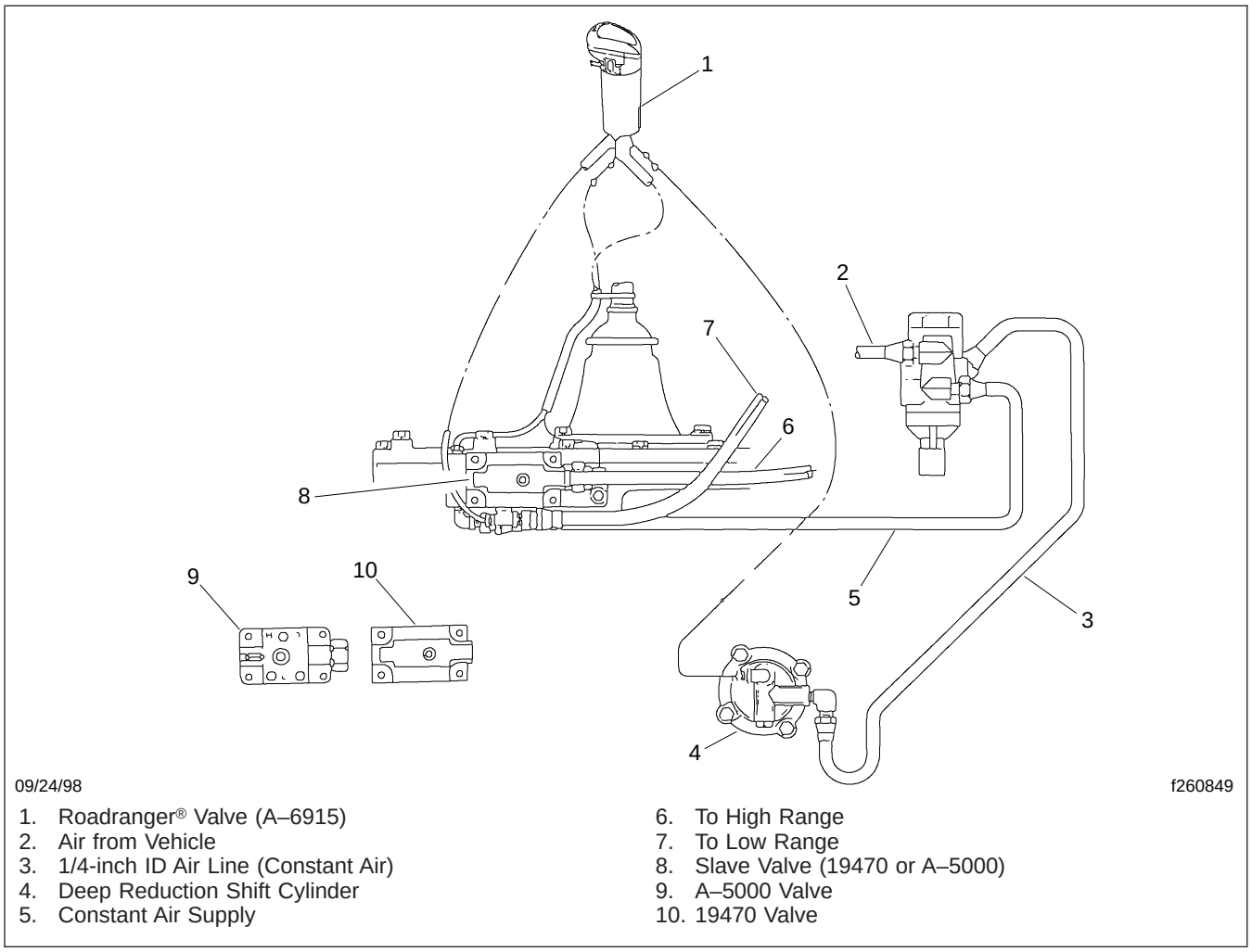
The insert valve located in the shift cylinder cover is a small, 1.19 inch (30.163 mm) valve. It is installed with the flat surface to the inside toward the center port, and it is secured with a special nut in the bottom bore of the cover.

The insert valve is self-contained and cannot be disassembled except for the three O-rings on the outer diameter. These three O-rings are a stationary seal and do not move in the cylinder.

Travel of the small piston in the insert valve is approximately 0.794 mm (0.03 inch). The insert valve is a normally open valve.

When there is no signal or delivery of air to the top side of the insert piston, the constant air from the regulator passes through the insert valve and to the back side of the piston and moves the yoke bar forward (direct). See **Fig. 22**.

When the insert valve piston is activated by a signal or delivery of air, the insert valve is closed and shuts



1. Roadranger® Valve (A–6915)
2. Air from Vehicle
3. 1/4-inch ID Air Line (Constant Air)
4. Deep Reduction Shift Cylinder
5. Constant Air Supply
6. To High Range
7. To Low Range
8. Slave Valve (19470 or A–5000)
9. A–5000 Valve
10. 19470 Valve

Fig. 13, Roadranger® Valve

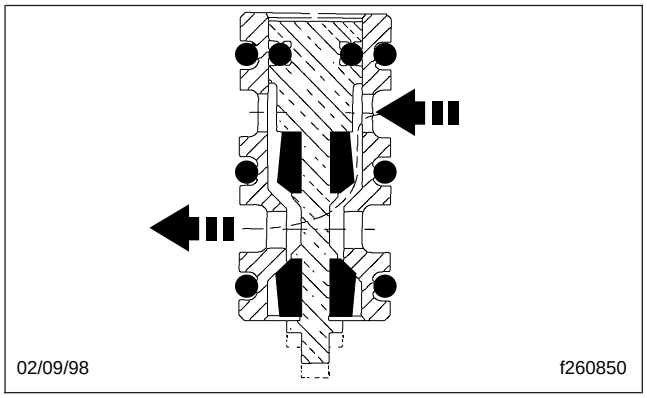


Fig. 14, Low Range and High Range

off the constant air to the backside of the shift piston. Air in the shift cylinder is exhausted out through the insert valve and the bottom bore of the cover. See **Fig. 23**.

When air is removed from the back side of the shift piston, constant air on the front side of the shift piston moves the shift bar to the rear.

AIR SYSTEM, FR SERIES

Air System Operation

The range shift air system uses pressurized air to allow the operator to shift the auxiliary section be-

General Information

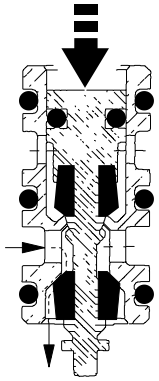


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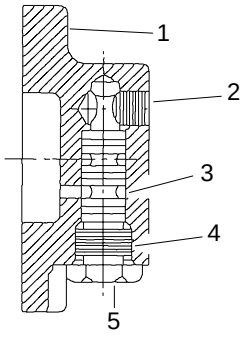
Fig. 15, Deep Reduction



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1. Deep Reduction Cylinder Cover
2. Center Port, Signal Line from Roadranger® Valve SP-Port
3. Insert Valve
4. Retaining Nut
5. Bottom Exhaust Port

Fig. 16, Insert Valve

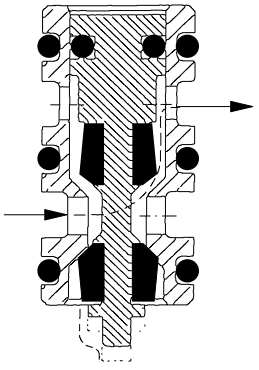

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Fig. 17, Low Range and High Range

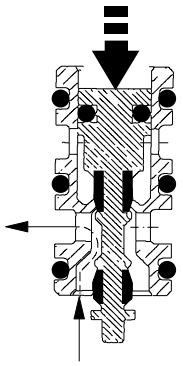

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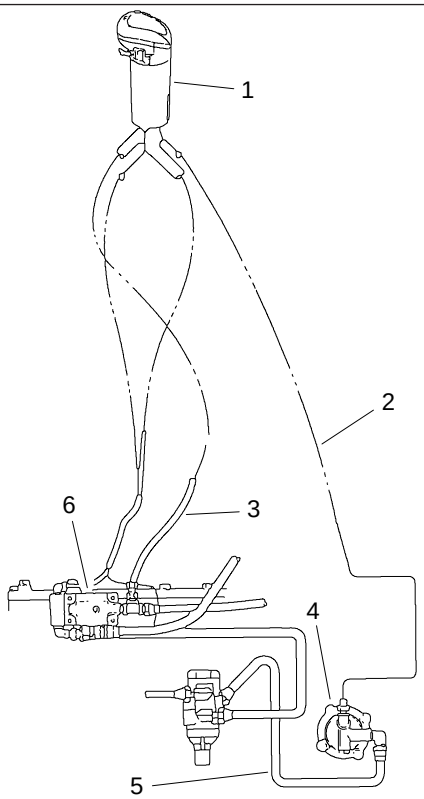
Fig. 18, Deep Reduction



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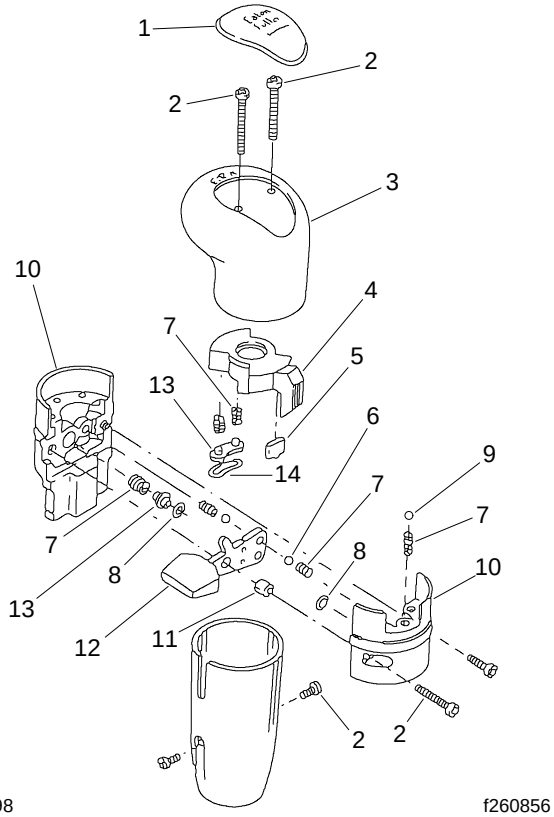
1. Roadranger® Valve (A–6913)
2. 5/32-inch OD Line to Port D
3. 5/32-inch OD Line to S-Port
4. Splitter Cylinder Cover
5. 1/4-inch ID Splitter Supply Air Line
6. Slave Valve

Fig. 19, Splitter Air System



1. Medallion
2. Screw
3. Top Cover
4. Actuator
5. Detent
6. Ball
7. Spring
8. O-Ring
9. 5/32-inch Ball
10. Housing
11. Pin
12. Lever
13. Retainer
14. Seal

Fig. 20, Roadranger® Valve A-6915

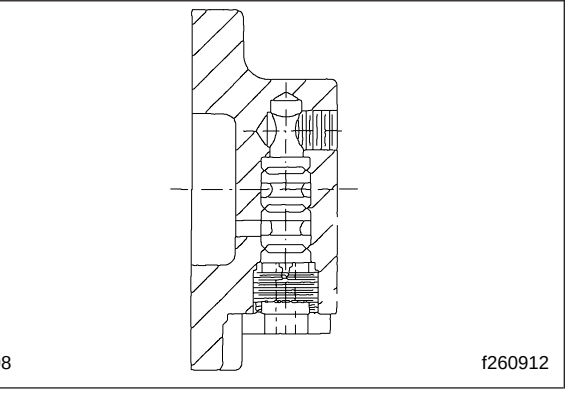


Fig. 21, Splitter Shift Cylinder in Direct Position

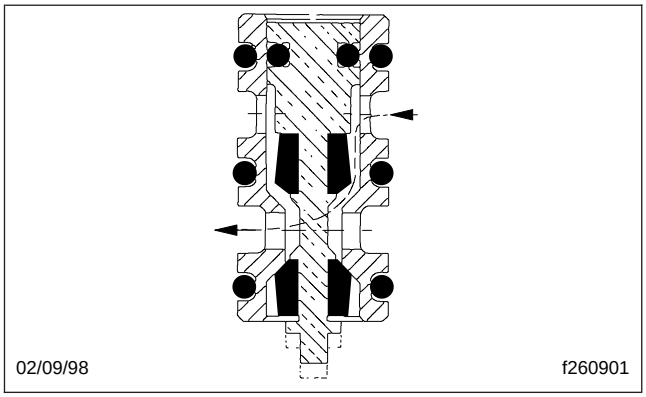


Fig. 22, High Range

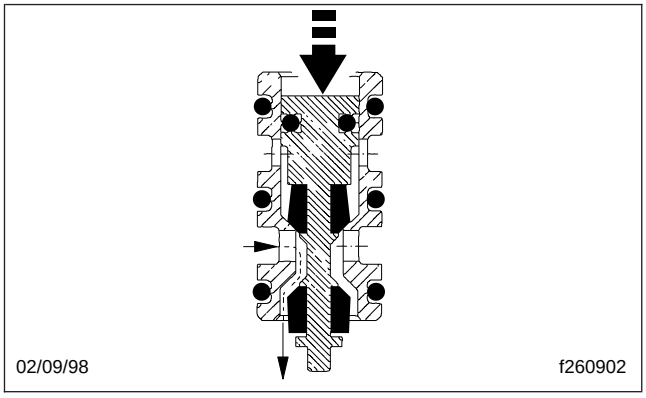


Fig. 23, Splitter Gear Engagement

tween low range and high range. The operator controls this shift with a switch on the shift knob.

Shift Knob (Master Control Valve)

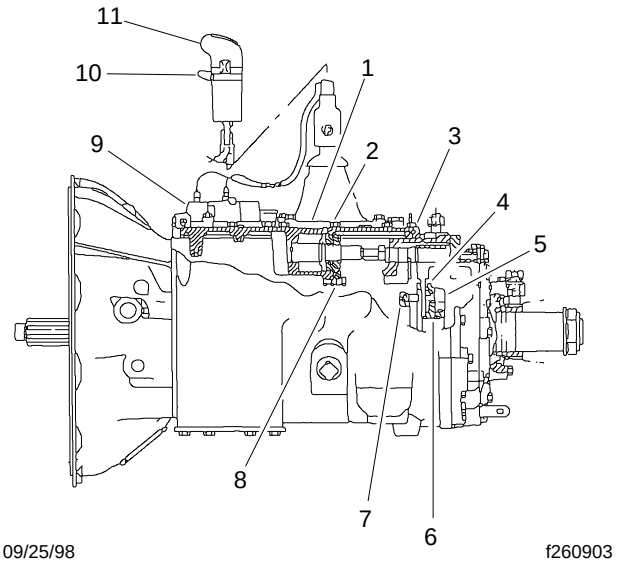
The master control valve, located in the shift knob, is an operator-controlled switch. When the range selector is in the DOWN position, low range is selected. When the range selector is in the UP position, high range is selected.

Air Module

Unlike other transmissions, which have separate air valves, filters and regulators, the FR Series transmission has all of these in one air module housing located on top of the transmission. This module contains an air filter, an air pressure regulator, a spool valve and an interlock mechanism. Depending on the position of the range selector, the air module directs airflow to the low range or high range side of the range piston to complete a range shift. See **Fig. 24**.

General Information

The range shift interlock feature of the air module allows the driver to preselect range shifts (place the range selector in the UP or DOWN position) while the transmission is still in gear. The system interlock will prevent the range shift until the shift lever and transmission are in neutral. The range shift will complete as the shift lever passes through Neutral. This feature prevents transmission damage and smooths shifting. The air module interlock operation is described in greater detail later in this section.



1. Range Shift Cylinder
2. Range Piston
3. Range Yoke Bar
4. Range Yoke
5. Low Range Synchronizer
6. Range Sliding Clutch
7. High Range Synchronizer
8. Piston Range Bar
9. Air Module
10. Range Selector
11. Shift Knob (A–6909)

Fig. 24, Transmission Air System Components

Range Cylinder and Piston

The range cylinder is located on the underside of the shift bar housing. It contains the range piston and bar assembly. The range piston and bar assembly is connected with the range yoke bar to move the range sliding clutch back and forth. Depending on the position of the range selector, pressurized air is supplied to the front or back of the range piston to shift the auxiliary section into low or high range.

Range Bar and Yoke

Located in the transmission auxiliary section, the range yoke bar and yoke move the range sliding clutch to low or high range. The range yoke bar extends into the main case, where it is connected with the range piston bar. The range yoke is positioned in the slot of the range sliding clutch. When the range cylinder moves the range bar and yoke, the yoke moves the sliding clutch into the high or low range position.

Range Sliding Clutch and Synchronizer

The range sliding clutch and synchronizer are located on the auxiliary mainshaft (output shaft). The range sliding clutch connects the auxiliary mainshaft to either the auxiliary drive gear (in high range) or the auxiliary reduction gear (in low range). The synchronizer allows the sliding clutch to move into gear without grinding.

Air Module Interlock

PURPOSE

The air module interlock allows the range to shift only when the transmission is in Neutral. The interlock prevents a range shift when a front section gear is engaged.

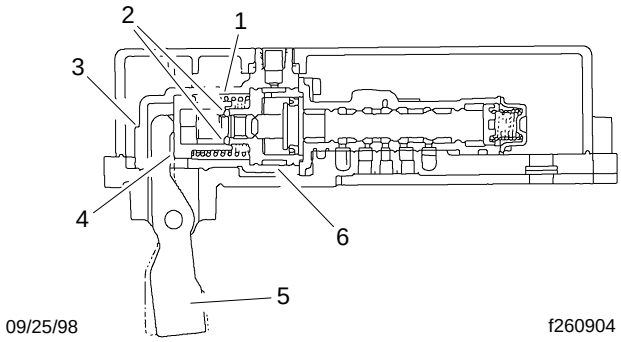
This feature allows the driver to preselect the range shift (move the range selector on the shift knob) while a front section gear is still engaged. The range shift will start and finish as the shift lever is moved through Neutral. The range shift must occur with the front section in neutral to prevent damage to the range synchronizers.

INTERLOCK CONSTRUCTION

The air module interlock finger extends out of the bottom of the air module and through a hole in the shift bar housing where it contacts the shift shaft. The interlock return spring continuously forces the interlock finger against the shift shaft. See **Fig. 25**.

The shift shaft contains a groove that corresponds with the neutral shift position. The groove provides clearance so that the interlock finger and interlock end cap can move to the relaxed position when the transmission front section is in neutral.

Four interlock balls are contained in four separate holes in the slave piston guide. The slave piston end of the interlock end cap contains a relief that provides clearance for the interlock balls.



1. Interlock Return Spring
2. Interlock Balls
3. Interlock/Slave Piston Housing
4. Interlock End Cap
5. Interlock Finger
6. Slave Piston Guide

Fig. 25, Air Module Interlock Components

INTERLOCK OPERATION

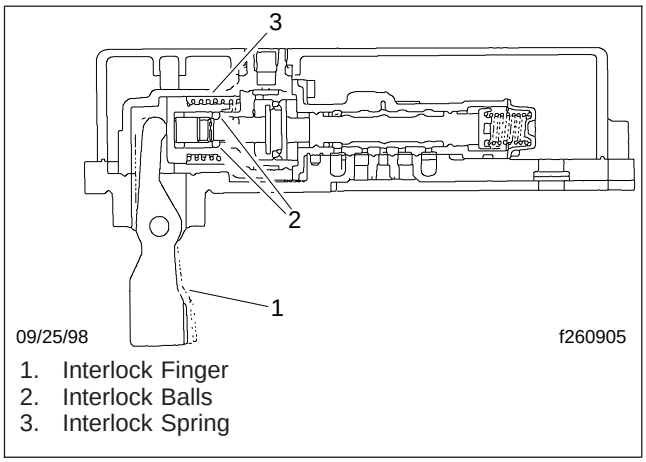
When the transmission front section is shifted into gear, the shift shaft is moved either forward or rearward. When the shift shaft moves, the interlock finger rides up a ramp and out of the shift shaft neutral notch. The interlock finger pivots into the air module and forces the interlock endcap to the right, compressing the interlock return spring. The four interlock balls are forced down into their respective holes. In this position, the interlock balls drop into a groove on the slave piston and prevent fore-and-aft movement of the slave piston. This effectively locks the slave piston and spool valve in position. See **Fig. 26**.

When the transmission is shifted to Neutral, the interlock return spring forces the interlock end cap to the left as the interlock finger pivots into the neutral notch on the shift shaft. The interlock balls can now move up out of the groove on the slave piston and the slave piston can move freely. See **Fig. 27**.

Air System Airflow

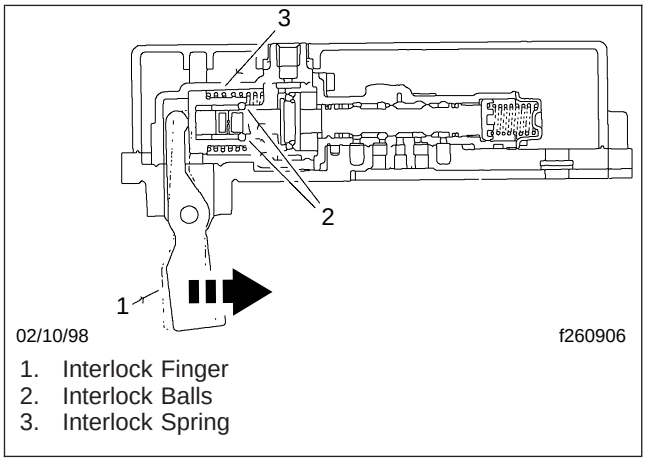
SUPPLY AIRFLOW

Vehicle air is supplied to the air module inlet at the vehicle air pressure of 90 to 130 psi (620 to 896 kPa). The air passes through the inlet filter inside the



1. Interlock Finger
2. Interlock Balls
3. Interlock Spring

Fig. 26, Interlock With Shift Lever in Gear



1. Interlock Finger
2. Interlock Balls
3. Interlock Spring

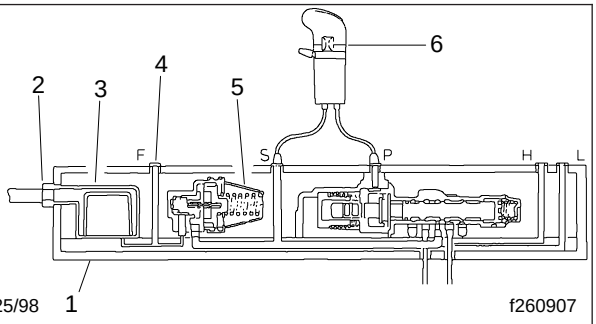
Fig. 27, Interlock With Shift Lever in Neutral

air module and goes to a pressure regulator, which regulates the air pressure to 80 psi (551 kPa). Through internal passages of the air module, the regulated air is available at the S-supply port on the air module cover and the supply port at the spool valve. From the S-supply port on the air module cover, air is supplied to the master valve S-supply port on the shift knob master valve through a 1/8 inch or 5/32-inch plastic air line. See **Fig. 28**.

LOW RANGE AIRFLOW

When low range is selected, supply air will flow through the air module spool valve to the low range port. Air flows through the low range passages in the air module and exits the module near the rear retaining capscrew. After exiting the air module, the air flows into a passage in the shift bar housing and is

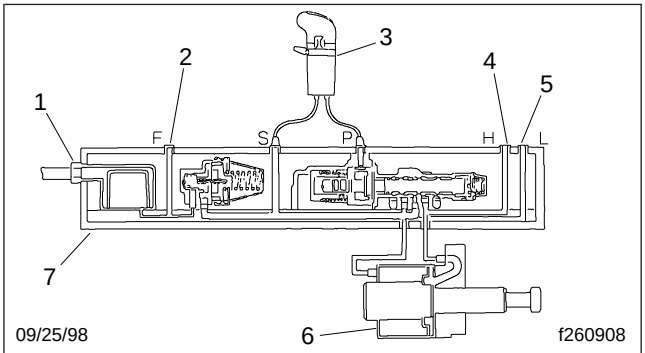
General Information



1. Air Module
2. Vehicle Supply Air Inlet
3. Filter
4. Filtered AirTest Part
5. Pressure Regulator
6. Shift Knob (A–6909)

Fig. 28, Supply Airflow Diagram

supplied to the front side of the range cylinder piston. The range piston, yoke and sliding clutch move rearward to shift the auxiliary into low range. See **Fig. 29**.

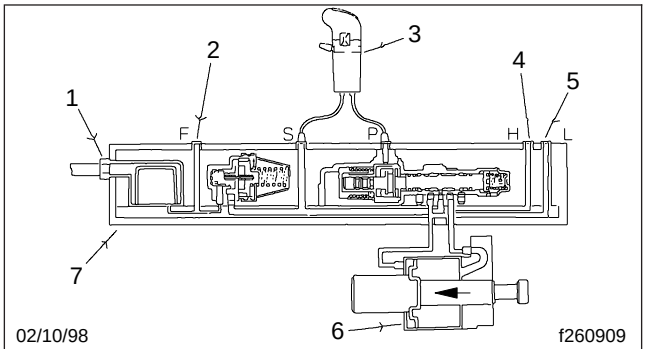


1. Vehicle Supply Air Inlet
2. Filtered Air Test Port
3. Shift Knob (A–6909)
4. High Range Test Port
5. Low Range Test Port
6. Range Cylinder
7. Air Module

Fig. 29, Low Range Airflow

HIGH RANGE AIRFLOW

When high range is selected, supply air will flow through the air module spool valve to the high range port. Air flows through the high range passages in the air module and exits the module near the rear retaining capscrew. After exiting the air module, the air flows into a passage in the shift bar housing and is supplied to the back side of the range cylinder piston. The range piston, yoke and sliding clutch move forward to shift the auxiliary into high range. See **Fig. 30**.



1. Vehicle Supply Air Inlet
2. Filtered Air Test Port
3. Shift Knob (A–6909)
4. High Range Test Port
5. Low Range Test Port
6. Range Cylinder
7. Air Module

Fig. 30, High Range Airflow Diagram

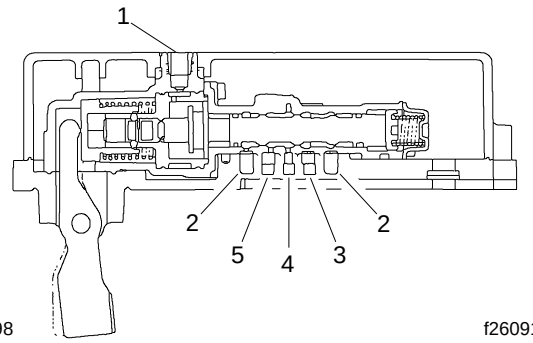
Air Module Operation

LOW RANGE, SHIFT LEVER IN NEUTRAL

When the range lever on the shift knob is placed in the down (low range) position, air flows through the master control valve and back to the air module through the 5/32-inch air line. This signal air will enter the air module at the P-port, where it will enter the slave piston chamber. With the shiftlever in Neutral, the air pressure will move the slave piston and spool valve to the full right position, and the spool return spring will be compressed. At this point, the supply port will be connected with the low range port, and the high range port will be exhausted. Pressurized air will move the range piston, bars, range yoke and range sliding clutch to the low range position. See **Fig. 31**.

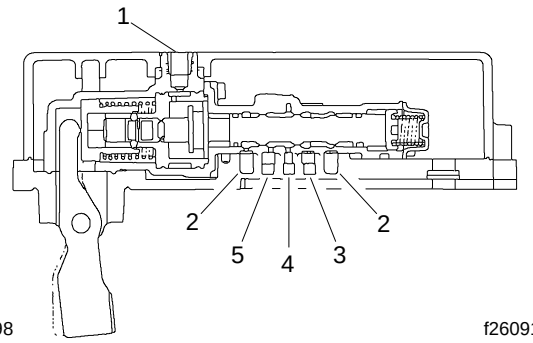
LOW RANGE, SHIFT LEVER IN GEAR

When the transmission is shifted into gear, the interlock mechanism will shift to the right, locking the slave piston and spool valve into position. Airflow through the air module is not affected. See **Fig. 32**.



1. P Pilot Signal
2. Exhaust
3. High Range
4. Supply
5. Low Range

Fig. 31, Airflow for Low Range With Shift Lever in Neutral

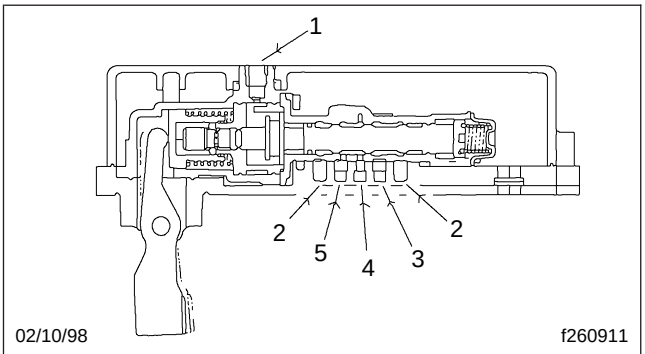


1. P Pilot Signal
2. Exhaust
3. High Range
4. Supply
5. Low Range

Fig. 32, Airflow With Shift Lever in Gear

LOW RANGE, SHIFT LEVER IN GEAR, HIGH RANGE PRESELECTED

With the shift lever still in gear, the driver preselects high range by switching the range lever on the shift knob to the up position. When the range lever is in the up position, the air supply is shut off to the P-port. The P-air line will be exhausted at the shift knob. The spool valve and slave piston will not move due to the interlock mechanism and the transmission being in gear. See **Fig. 33**.

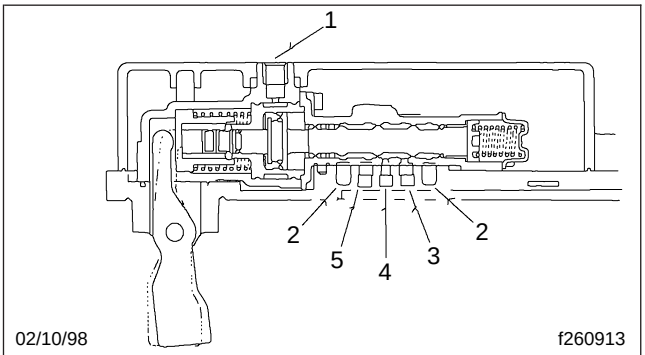


1. P Pilot Signal
2. Exhaust
3. High Range
4. Supply
5. Low Range

Fig. 33, Airflow for Low Range With High Range Preselected

HIGH RANGE, SHIFT LEVER IN NEUTRAL

With high range preselected, the interlock mechanism will release as soon as the shift lever is moved to Neutral. The spool return spring will move the spool valve and the slave piston to the full left position. Supply air will be provided to the high range port. The low range port will be exhausted. Pressurized air will move the range piston, bars, range yoke and range sliding clutch to the high range position. See **Fig. 34**.



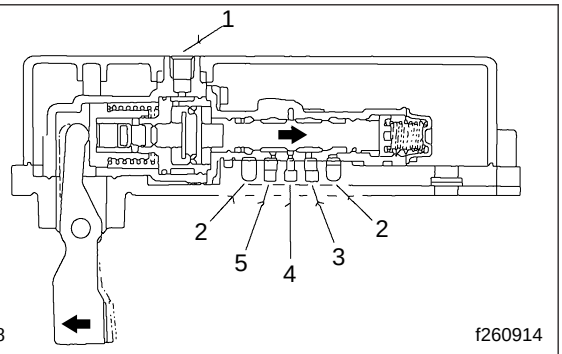
1. P Pilot Signal
2. Exhaust
3. High Range
4. Supply
5. Low Range

Fig. 34, Airflow for High Range With Shift Lever in Neutral

General Information

HIGH RANGE, SHIFT LEVER IN GEAR

When the shift lever is moved into gear, the interlock finger moves the interlock end cap to the right, which activates the interlock mechanism. It also moves the slave piston and spool valve partially to the right. The partial travel of the spool valve exposes the low range port to pressurized air from the supply port. Supply air is available to both the low and high range ports, and both exhaust ports are sealed. Equal air pressure is available on both sides of the range cylinder piston. Because the high range side of the piston has more available surface area than the low range side, the range remains in high range. See **Fig. 35**.



1. P Pilot Signal
2. Exhaust
3. High Range
4. Supply
5. Low Range

Fig. 35, Airflow for High Range With Shift Lever in Gear

SYNCHROSAVER OPERATION

For the range synchronizer to perform a range shift properly, the front section of the transmission must be in neutral. The range shift occurs after being properly preselected and while the driver moves the shift lever through Neutral to the next gear.

Because the range synchronizer can be damaged if the driver engages the front section while the range synchronizer attempts to synchronize for high range, a range synchronizer protection feature (SynchroSaver) is incorporated in this design.

The SynchroSaver feature protects the synchronizer by decreasing the force the synchronizer applies to the auxiliary drive gear when the front section is engaged in a gear.

When high range is selected and the transmission is in neutral, air pressure is available on the high range side of the piston and no air pressure is available on the low range side of the piston. The air pressure creates maximum force on the range piston, range yoke and high range synchronizer to provide a fast and efficient shift into high range.

When the transmission is in gear, air pressure is supplied to both the high range and low range sides of the range piston to equalize the air pressure on both sides. However, the high range side of the piston has a slightly larger surface area than the low range side; therefore, some force (greatly reduced from in Neutral) is still trying to shift the transmission to high range. The reduced force will prevent extensive damage to the high range synchronizer.

FR Series Air Module Removal and Installation

Removal

WARNING

A sudden release of air pressure can cause personal injury or damage to equipment. To prevent injury or equipment damage, exhaust the vehicle air system or shut off the air supply to the transmission before removing the air module.

1. Disconnect the supply air line from the IN port of the air module.
2. Tag the two air lines connected to the ports on the top of the air module with location information, and remove them. See **Fig. 1**.

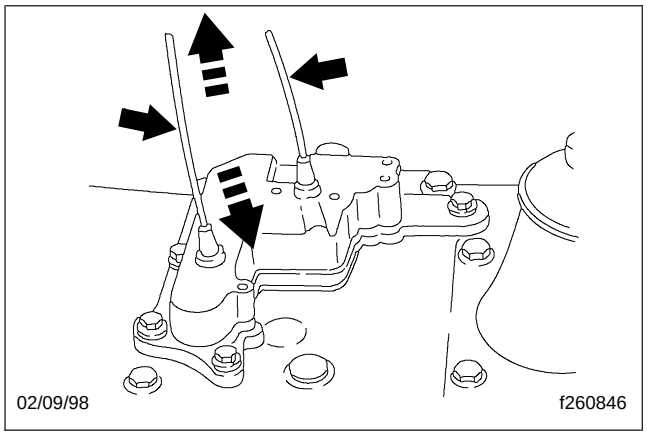


Fig. 1, Tag and Remove Air Lines

3. From the air module, remove the four capscrews, and lift the module from the shift bar housing and remove the two small O-rings. Inspect the O-rings and replace as necessary. See **Fig. 2**.

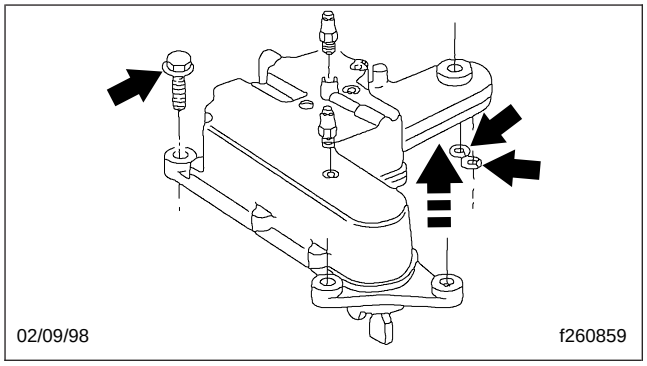


Fig. 2, Capscrews and O-Rings

4. From the air module interlock finger, remove the O-ring, and inspect for damage or wear. Replace if worn or damaged. See **Fig. 3**.

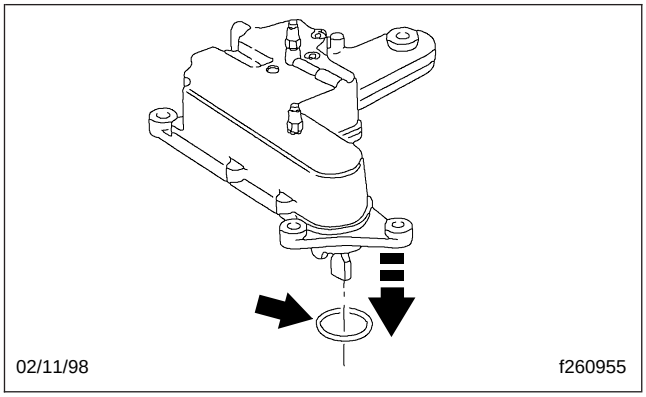


Fig. 3, Inspect O-Ring

Installation

1. Clean all rust, paint or other debris from the air module mounting surfaces of the shift bar housing.
2. To help prevent corrosion between the aluminum air module and the cast iron shift bar housing, apply a light film of high-temperature grease to the air module mounting surfaces of the shift bar housing.
3. Lightly apply suitable Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A to all O-rings.
4. Install the large O-ring on the air module interlock finger boss, and position the two small O-rings in the recesses in the shift bar housing. See **Fig. 4**.

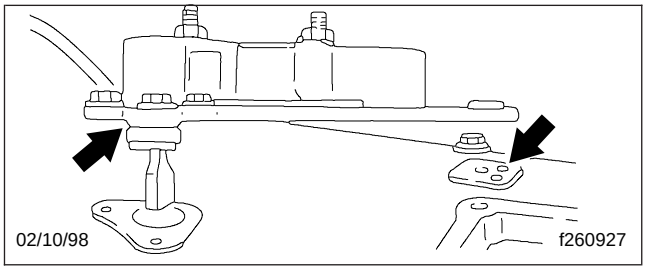


Fig. 4, Position of O-Rings

5. Position the air module on the shift bar housing.

FR Series Air Module Removal and Installation

6. Apply Threadlock® and Sealer EOAZ–19554–AA or equivalent meeting specification WSK–M2G315–A5 to the four retaining capscrews.
7. Install the four retaining capscrews. Tighten 20 to 23 lbf·ft (27 to 31 N·m). See **Fig. 5**.

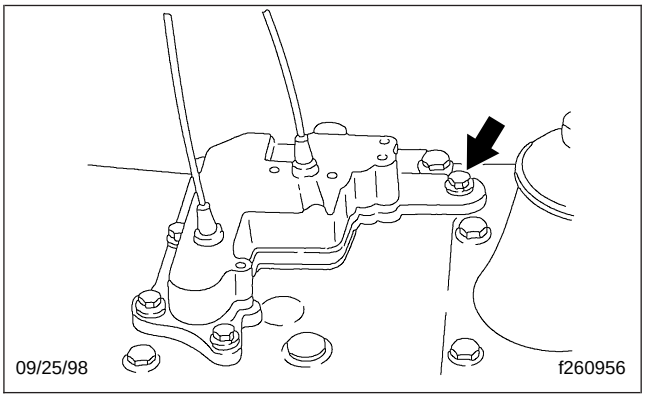


Fig. 5, Retaining Capscrews

8. Reconnect the air lines to the IN port and the ports on the top of the air module. See **Fig. 6**.

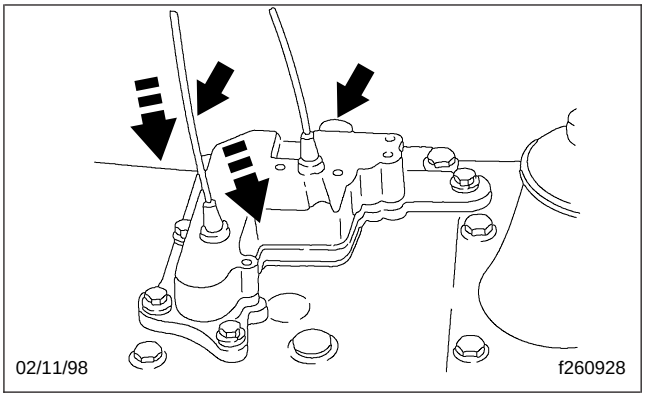


Fig. 6, Air Line Installation

9. Return air to the system, and check for leaks.

Roadranger® Valve Removal and Installation

Removal

1. Drain the air from the system.
2. Remove the screw in the side of the shift handle skirt, and slide the skirt down onto the shifter shaft. See **Fig. 1**.

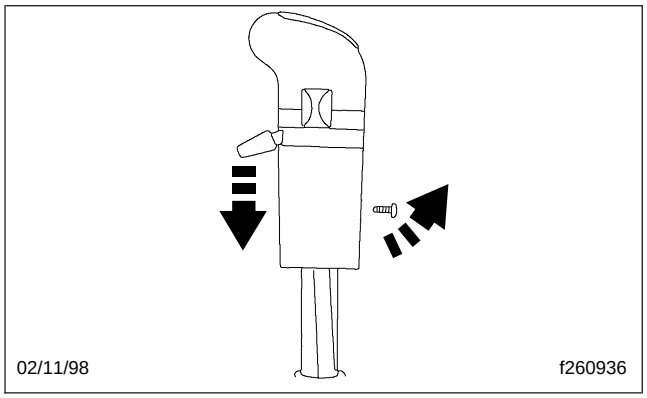


Fig. 1, Shifter Shaft Skirt and Screw

NOTE: If you experience difficulty removing the air line from the fitting, a slight impact to the tool used on the release sleeve helps remove the secured line.

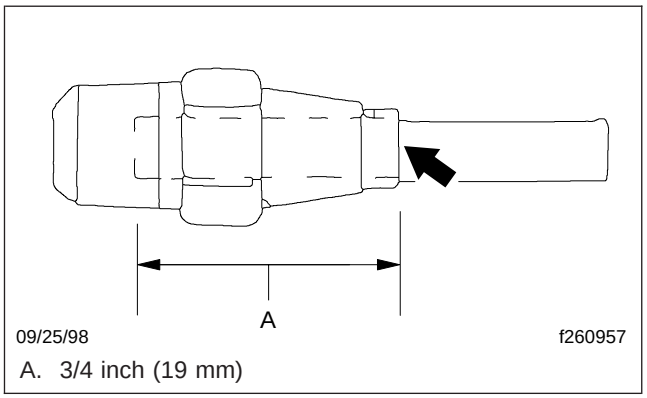
3. Remove the air line fittings from under the valve.

NOTE: The release sleeve must be depressed to remove the air line. A plastic tube cutter, a 5/32-inch open-end wrench or the equivalent can be used to depress the sleeve.

4. Apply pressure evenly to both sides of the release sleeve, and pull the tubing from the fitting. See **Specifications, 400**. See **Fig. 2**.
5. Loosen the lock nut and unscrew the valve from the shifter shaft. See **Fig. 3**.

Installation

1. Install the valve on the shifter shaft and tighten the lock nut. See **Fig. 3**.
2. Coat the threads, and install the screws. Use Threadlock® and Sealer EOAZ–19554–AA or equivalent meeting specification WSK–M2G315–A5.



A. 3/4 inch (19 mm)

Fig. 2, Tubing and Fitting Release Sleeve

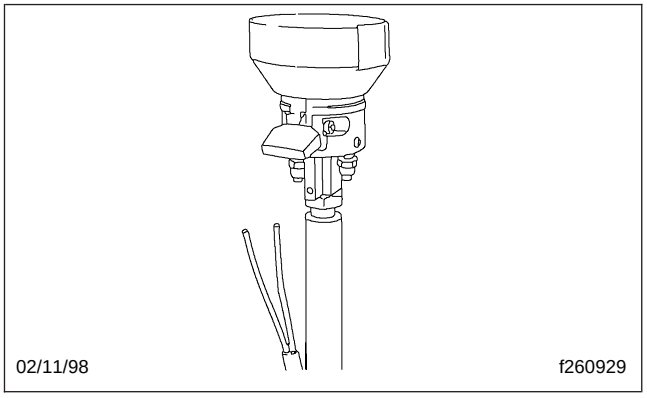


Fig. 3, Valve and Shifter Shaft

NOTE: The release sleeve must be depressed to install the air line. A plastic tube cutter, a 5/32-inch open-end wrench or the equivalent can be used to depress the sleeve.

3. Apply pressure evenly to both sides of the release sleeve, and push the tubing into the fitting. See **Specifications, 400**. See **Fig. 2**.
4. Install the air line fittings under the valve.
5. Install the screw in the side of the shift handle skirt, and slide the skirt up on the shifter shaft. See **Fig. 1**.
6. Return air to the system and check for leaks.

Slave Valve Removal and Installation

Removal

1. Remove the air lines to the slave valve at the range cylinder. See **Fig. 1**.

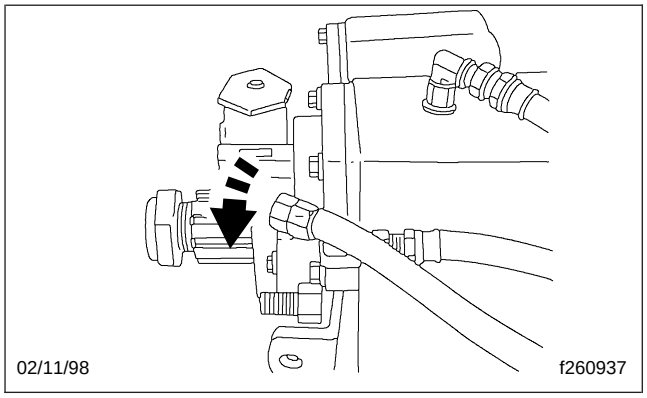


Fig. 1, Air Line Removal

2. Remove the four capscrews and remove the slave valve from the transmission. See **Fig. 2**.

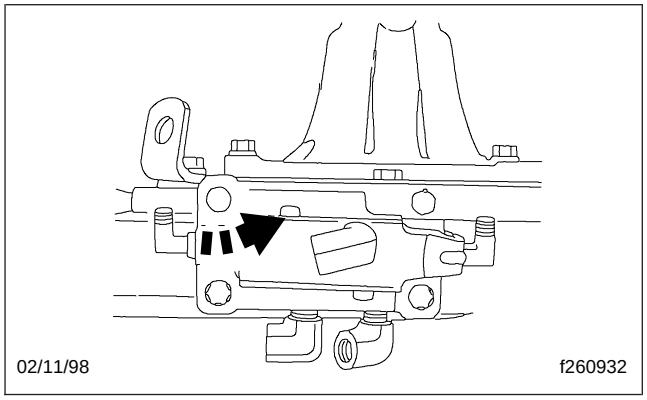


Fig. 2, Capscrew on Slave Valve

3. Remove the hat-type alignment sleeve from the bore in the slave valve. See **Fig. 3**.
4. Remove the spring and plunger pin from the bore in the transmission case. See **Fig. 4**.
5. Remove the slave valve gasket.

Installation

1. Install the slave valve gasket.
2. Install the spring and plunger pin in the bore of the transmission case. See **Fig. 4**.

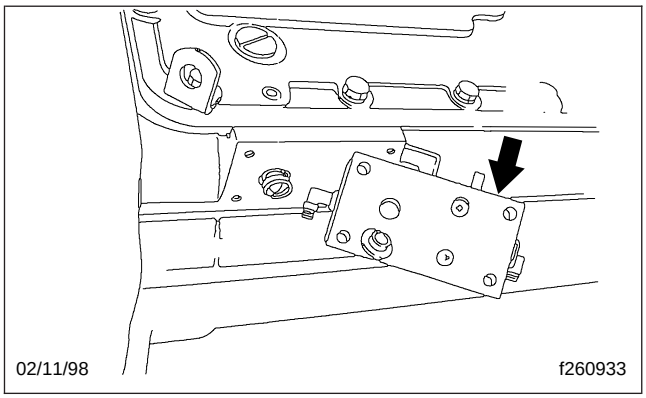


Fig. 3, Alignment Sleeve

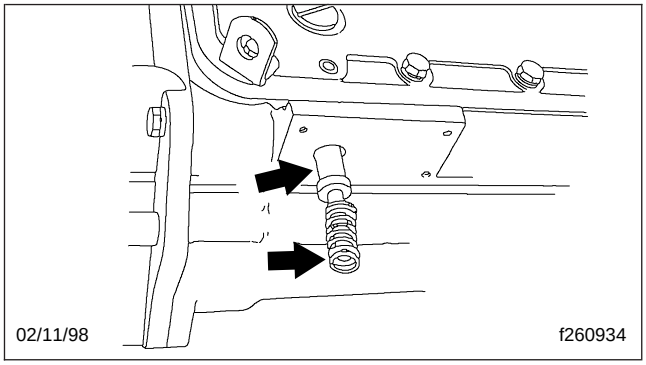


Fig. 4, Spring and Plunger Pin

3. Install the hat-type alignment sleeve in the bore of the slave valve. See **Fig. 3**.
4. Install the slave valve on the transmission.
5. Coat the capscrews threads, and install the capscrews. Use Threadlock® and Sealer EOAZ–19554–AA or equivalent meeting specification WSK–M2G315–A5. See **Specifications, 400**. See **Fig. 5**. Tighten 15 to 20 lbf·ft (20 to 27 N·m).
6. Install the air lines to the slave valve at the range cylinder. See **Fig. 1**.

Slave Valve Removal and Installation

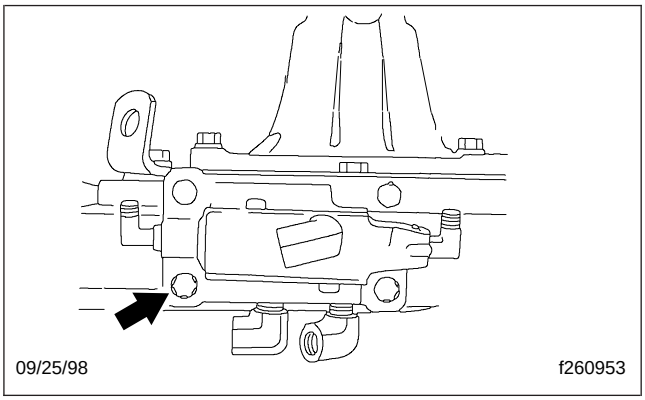


Fig. 5, Slave Valve Capscrew

Replacement

1. Disconnect and remove the air line between the slave valve and air regulator. See **Fig. 1**.

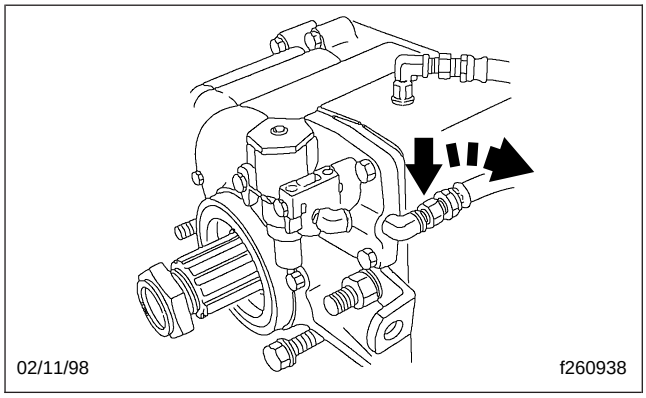


Fig. 1, Air Line Disconnection

2. Remove the capscrews and remove the air regulator and filter assembly from the transmission. See **Fig. 2**.

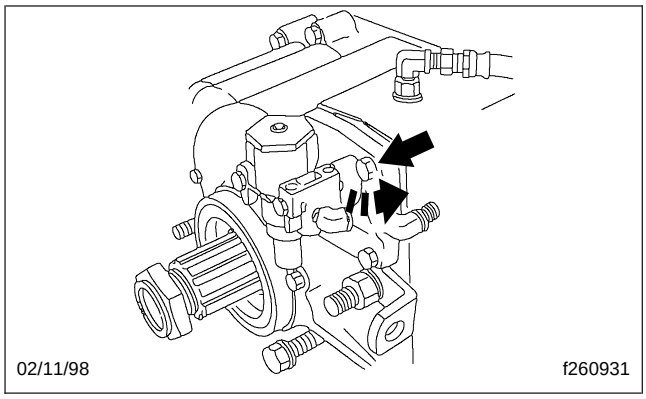


Fig. 2, Air Regulator, Filter Assembly and Capscrew

3. Replace the air regulator and filter assembly.
4. Coat the threads of the capscrews, and install the capscrews. See **Fig. 3**. Use Threadlock® and Sealer EOAZ–19554–AA or equivalent meeting specification WSK–M2G315–A5. See **Specifications, 400**. Tighten 8 to 12 lbf·ft (11 to 16 N·m).
5. Connect the air line between the slave valve and air regulator. See **Fig. 1**.

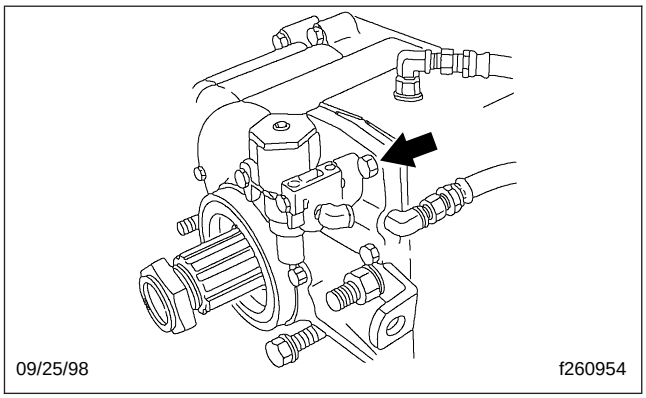
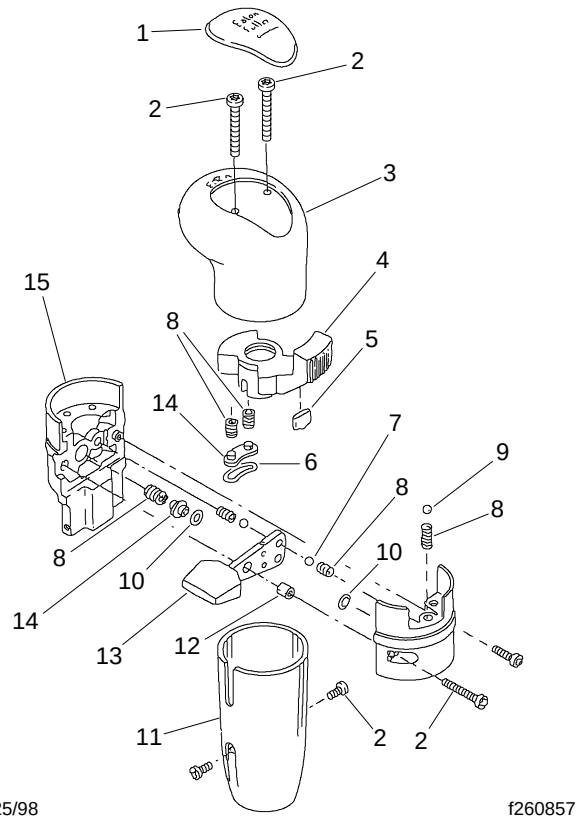


Fig. 3, Capscrew Installation

Roadranger® Valve A–6913 Dissassembly and Assembly

Disassembly

1. Pry the medallion from the recess in the top cover. See **Fig. 1**.



1. Medallion
2. Screw
3. Top Cover
4. Actuator
5. Detent
6. Seal
7. Ball
8. Spring
9. 5/32-inch Ball
10. O-Ring
11. Cover
12. Pin
13. Lever
14. Retainer
15. Housing

Fig. 1, Roadranger® Valve (A-6913)

2. Turn out the two screws to remove the top cover from the valve housing.
3. Remove the actuator button from the valve housing, and the spring retainer, springs, seal and detent parts from the actuator or valve housing.
4. Turn out the two screws in the side of the valve housing to separate the housing.
5. Remove the range preselection lever from the left housing, and the position balls and guide from the lever.
6. If necessary, remove the springs, O-ring and retainer from the bores in the right housing.

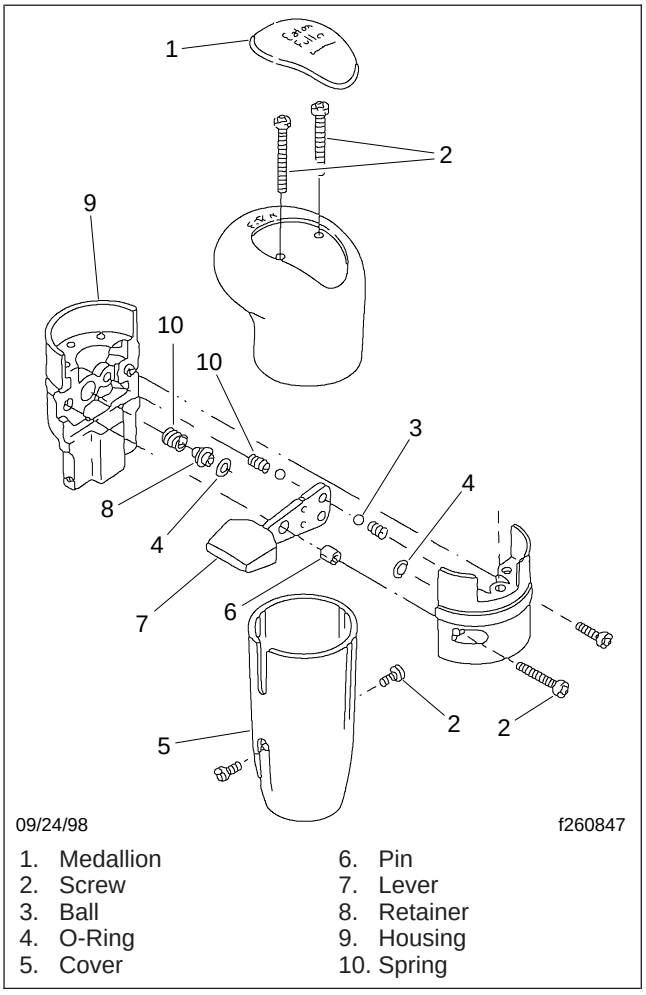
Assembly

1. Use a very small amount of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A on the O-rings to avoid clogging the ports. A small amount of grease on the position springs and balls will help to hold them in place during reassembly.
2. If necessary, replace the springs, O-ring and retainer in the bores in the right housing.
3. Install the range preselection lever in the left housing, and the position balls and guide in the lever.
4. Turn the two screws in the side of the valve housing to attach the housing.
5. Install the actuator button in the valve housing, and the spring retainer, springs, seal and detent parts in the actuator or valve housing.
6. Turn the two screws to attach the top cover to the valve housing.
7. Install the medallion in the recess on the top cover. See **Fig. 1**.

Roadranger® Valve A–6909 Disassembly and Assembly

Disassembly

1. Pry the medallion from the recess in the top cover. See **Fig. 1**.



1. Medallion
2. Screw
3. Ball
4. O-Ring
5. Cover
6. Pin
7. Lever
8. Retainer
9. Housing
10. Spring

Fig. 1, Roadranger® Valve (A-6909)

2. Turn out the two screws to remove the top cover from the valve housing.
3. Turn out the two screws in the side of the valve housing to separate the housing.
4. Remove the range preselection lever from the left housing, and the position balls and guide from the lever.
5. If necessary, remove the spring and O-ring from the bores in the left housing.
6. If necessary, remove the springs, O-ring and sleeve from the bores in the right housing.

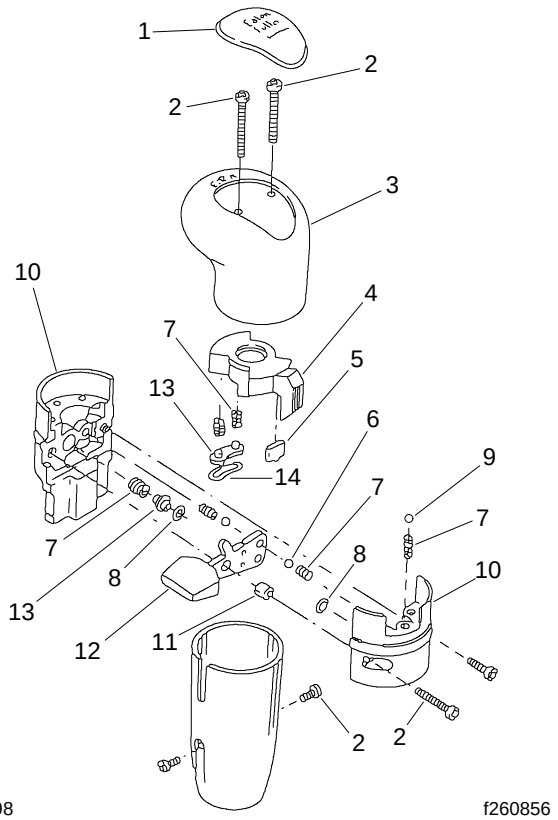
Assembly

1. Use a very small amount of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A on the O-rings to avoid clogging the ports. A small amount of grease on the position springs and balls will help to hold them in place during reassembly.
2. If necessary, install the springs, O-ring and sleeve in the bores of the right housing.
3. If necessary, install the spring and O-ring in the bores of the left housing.
4. Replace the range preselection lever on the left housing, and the position balls and guide on the lever.
5. Turn the two screws in the side of the valve housing to attach the housing.
6. Turn the two screws to attach the top cover to the valve housing.
7. Install the medallion in the recess of the top cover. See **Fig. 1**.

Roadranger® Valve A–6915 Disassembly and Assembly

Disassembly

1. Pry the medallion from the recess in the top cover. See **Fig. 1**.



1. Medallion
2. Screw
3. Top Cover
4. Actuator
5. Detent
6. Ball
7. Spring
8. O-Ring
9. 5/32-inch Ball
10. Housing
11. Pin
12. Lever
13. Retainer
14. Seal

Fig. 1, Roadranger® Valve (A-6915)

2. Turn out the two screws to remove the top cover from the valve housing.
3. Remove the actuator button from the valve housing, and the spring retainer, springs, seal and detent parts from the actuator or valve housing.
4. Turn out the two screws in the side of the valve housing to separate the housing.
5. Remove the range preselection lever from the left housing, and the position balls and guide from the lever.
6. If necessary, remove the springs, O-ring and retainer from the bores in the right housing.

Assembly

1. Use a very small amount of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A on the O-rings to avoid clogging the ports. A small amount of grease on the position springs and balls will help to hold them in place during reassembly.
2. If necessary, install the springs, O-ring and sleeve in the bores of the right housing.
3. Install the range preselection lever on the left housing, and the position balls and guide on the lever.
4. Turn the two screws in the side of the valve housing to attach the housing.
5. Install the actuator button on the valve housing, and the spring retainer, springs, seal and detent parts on the actuator or valve housing.
6. Turn the two screws to attach the top cover to the valve housing.
7. Install the medallion in the recess of the top cover. See **Fig. 1**.

Piston-Type Valve A–5000 Disassembly and Assembly

Disassembly

1. Refer to the "General Information" portion of this section for a disassembled view of the slave valve.
2. Disconnect all air lines.
3. Turn out the four capscrews and remove the slave valve from the transmission.
4. Turn out the three capscrews and remove the side cap.
5. Remove the seal from the piston, and remove the O-ring from the seal.
6. Remove the spring from the piston.
7. Turn out the end cap from the valve body, and remove the piston from the bore.
8. Remove the U-seal from the piston.
9. Remove the nylon plug from the piston, and remove the O-ring from the plug.
10. Remove the snap ring from the bore in the front of the valve body.
11. Remove the plug, spring, washer and U-seal from the valve body bore. Remove the O-ring from the plug.

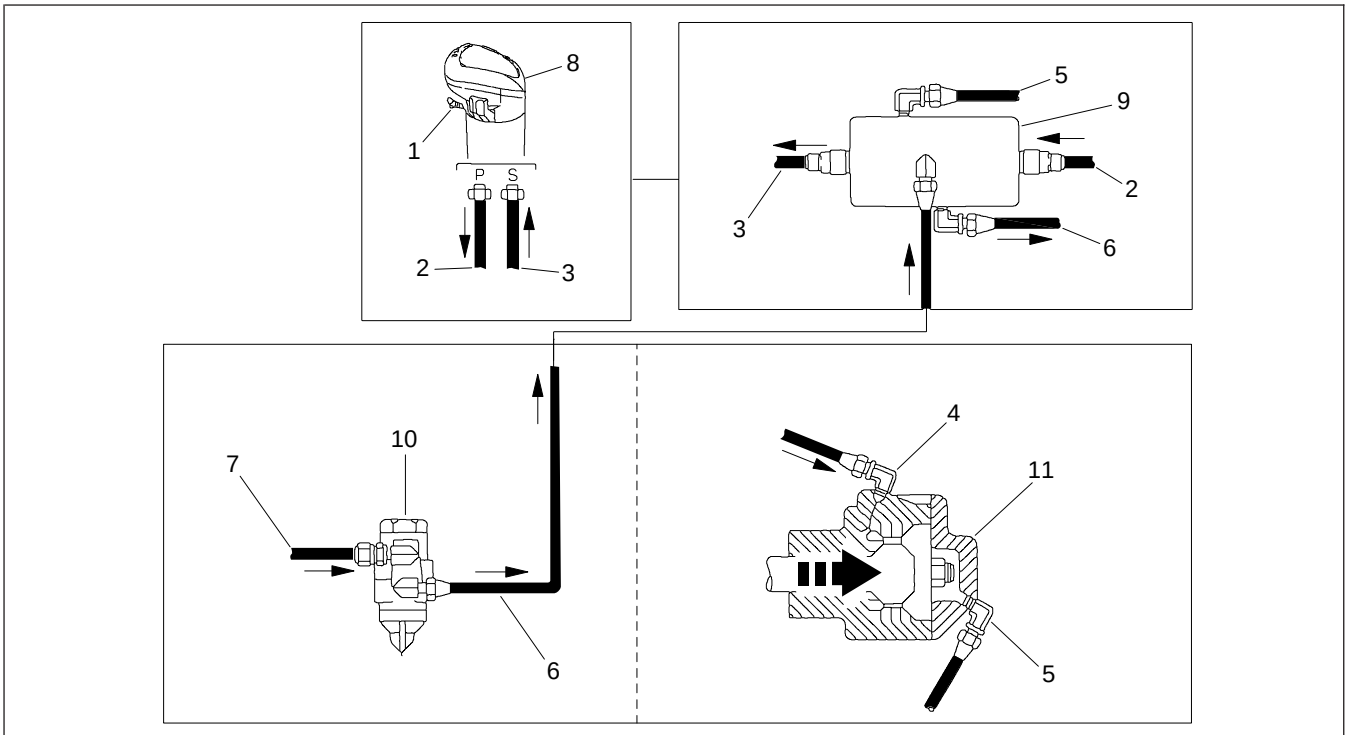
Assembly

1. Install the plug, spring, washer and U-seal in the valve body bore. Install the O-ring in the plug.
2. Install the snap ring in the bore on the front of the valve body.
3. Install the nylon plug from the piston, and remove the O-ring from the plug. When reinstalling the end cap, do not use more than 40 lbf·ft (54 N·m) of torque. Overtightening can result in binding the piston in the valve bore.
4. Install the U-seal from the piston.
5. Turn the end cap in the valve body, and install the piston in the bore.
6. Install the spring on the piston.
7. Install the O-ring on the seal, and install the seal on the piston.
8. Install the side cap, and turn the three capscrews.
9. Install the slave valve to the transmission, and turn the four capscrews.
10. Connect all air lines.

Troubleshooting

AIR SYSTEM SCHEMATICS

NOTE: In the following illustrations, the arrows indicate the direction of airflow. Shaded areas indicate charged lines. Bold letters indicate the same routing between components. See **Fig. 1** and **Fig. 2**, "10-Speed Transmissions With A–6909 Roadranger® Valve." See **Fig. 3**, **Fig. 4** and **Fig. 5**, "LL and 15-Speed Transmissions With A–6915 Roadranger Valve." See **Fig. 6** and **Fig. 7**, "9-Speed Transmissions With A–6909 Roadranger Valve." See **Fig. 8** and **Fig. 9**, "13-Speed Underdrive and Overdrive Transmissions With A–6913 Roadranger Valve."

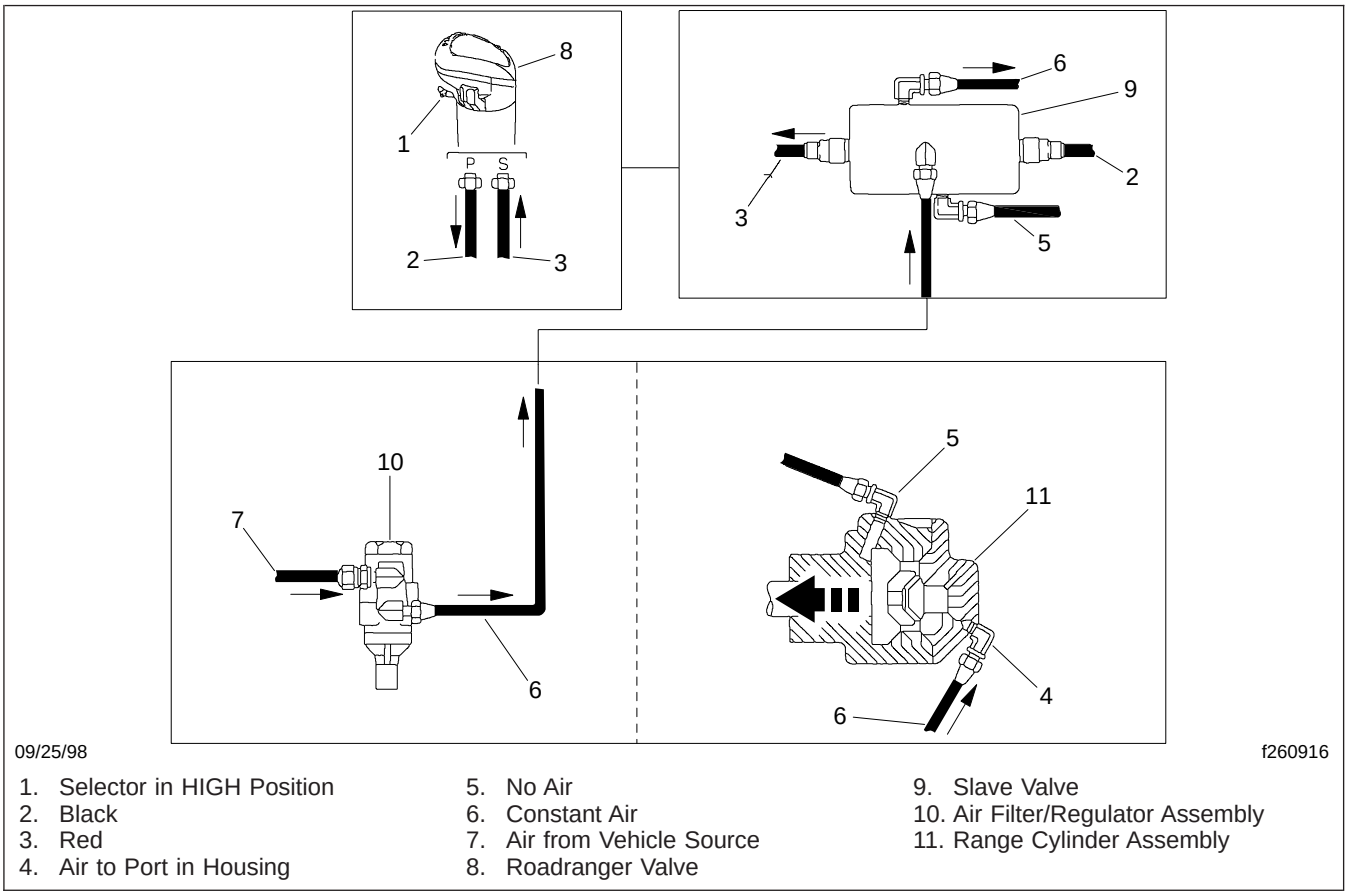


09/25/98 f260915

1. Selector in LOW Position
2. Black
3. Red
4. Air to Port in Housing
5. No Air
6. Constant Air
7. Air from Vehicle Source
8. Roadranger Valve
9. Slave Valve
10. Air Filter/Regulator Assembly
11. Range Cylinder Assembly

Fig. 1, 10-Speed Transmissions With A-6909 Roadranger® Valve

Troubleshooting

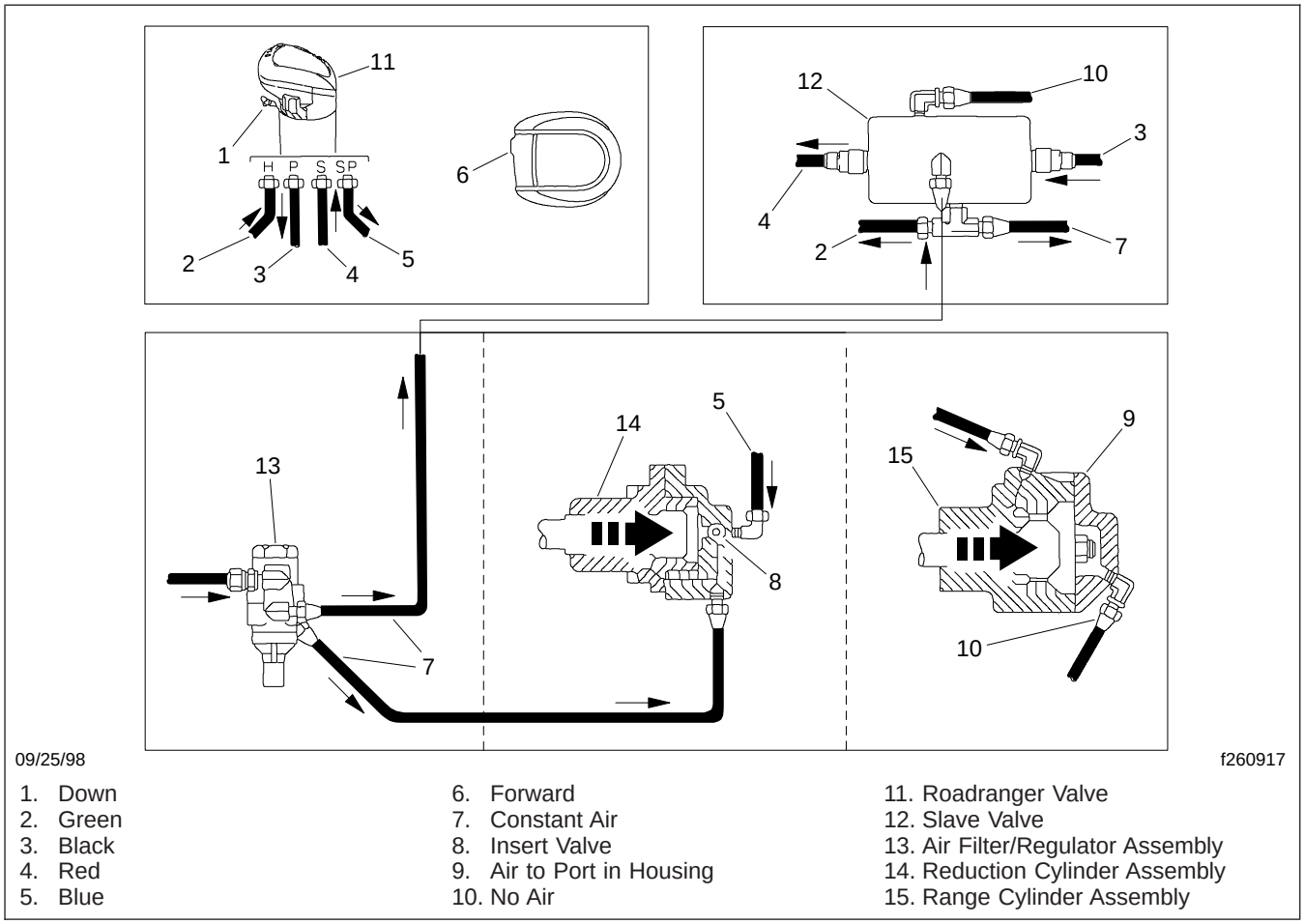


1. Selector in HIGH Position
2. Black
3. Red
4. Air to Port in Housing
5. No Air
6. Constant Air
7. Air from Vehicle Source
8. Roadranger Valve
9. Slave Valve
10. Air Filter/Regulator Assembly
11. Range Cylinder Assembly

Fig. 2, 10-Speed Transmissions With A-6909 Roadranger® Valve (Continued)

Problem—Slip-Out (Splitter)

Problem—Slip-Out (Splitter)	
Possible Cause	**Remedy**
Worn yoke pads, worn or damaged regulator, tapered clutching teeth, worn yoke slot in clutch gear or bearing failure	Replace damaged parts.
Damaged insert valve	Replace insert valve. Apply a thin coat of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A when reassembling.
Loose hose or fitting	Tighten the lose part.
Pinched air line or connector	Correct the restriction.
Gear twisted out of time on countershaft	Replace damaged parts and check for resultant damage.
Inner race left off front of auxiliary countershaft	Replace or install missing parts.
Improper preselection of splitter or not using clutch	Instruct the driver on proper driving techniques and check for resultant damage.



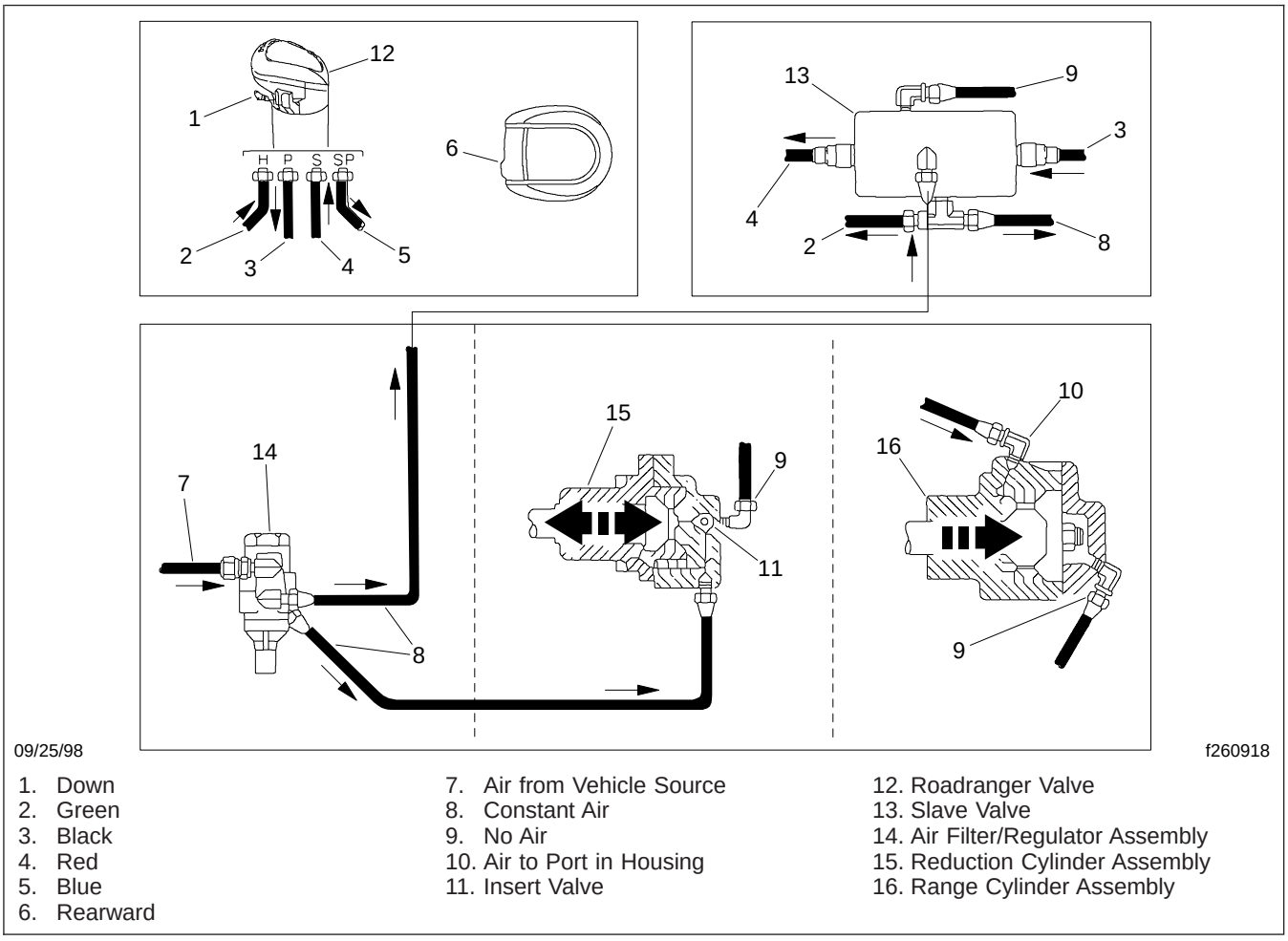
1. Down
2. Green
3. Black
4. Red
5. Blue
6. Forward
7. Constant Air
8. Insert Valve
9. Air to Port in Housing
10. No Air
11. Roadranger Valve
12. Slave Valve
13. Air Filter/Regulator Assembly
14. Reduction Cylinder Assembly
15. Range Cylinder Assembly

Fig. 3, LL and 15-Speed Transmissions With A-6915 Roadranger® Valve

Problem—Slip-Out (Range)

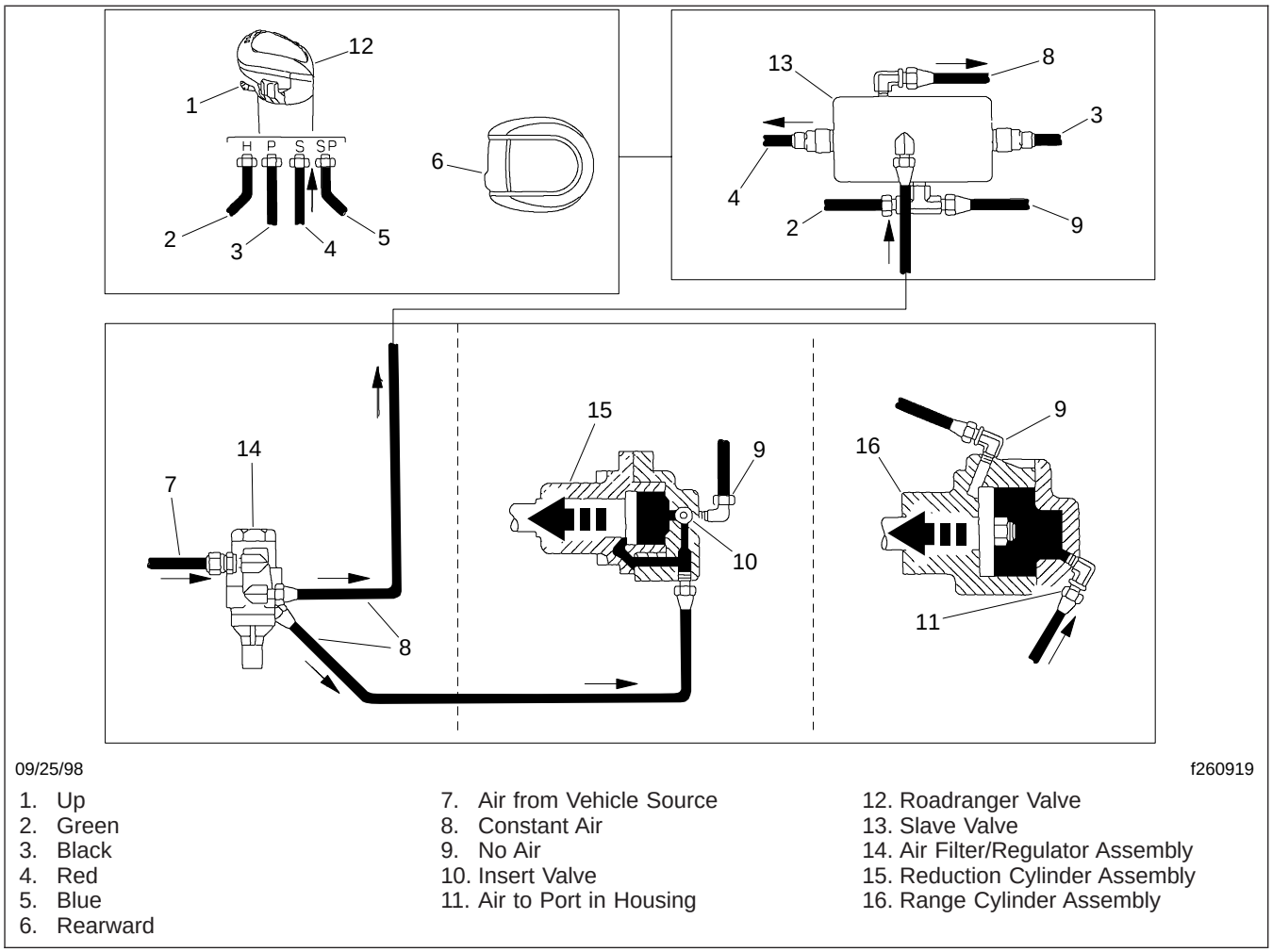
Problem—Slip-Out (Range)	
Possible Cause	**Remedy**
Worn or damaged regulator or tapered clutch teeth	Replace damaged parts.
Loose hose or fitting	Tighten the loose part.
Pinched air line or connector	Correct the restriction.
Gear twisted out of time on countershaft	Replace damaged parts and check for resultant damage.
Improper range shifting	Instruct the driver on proper driving techniques.

Troubleshooting



1. Down
2. Green
3. Black
4. Red
5. Blue
6. Rearward
7. Air from Vehicle Source
8. Constant Air
9. No Air
10. Air to Port in Housing
11. Insert Valve
12. Roadranger Valve
13. Slave Valve
14. Air Filter/Regulator Assembly
15. Reduction Cylinder Assembly
16. Range Cylinder Assembly

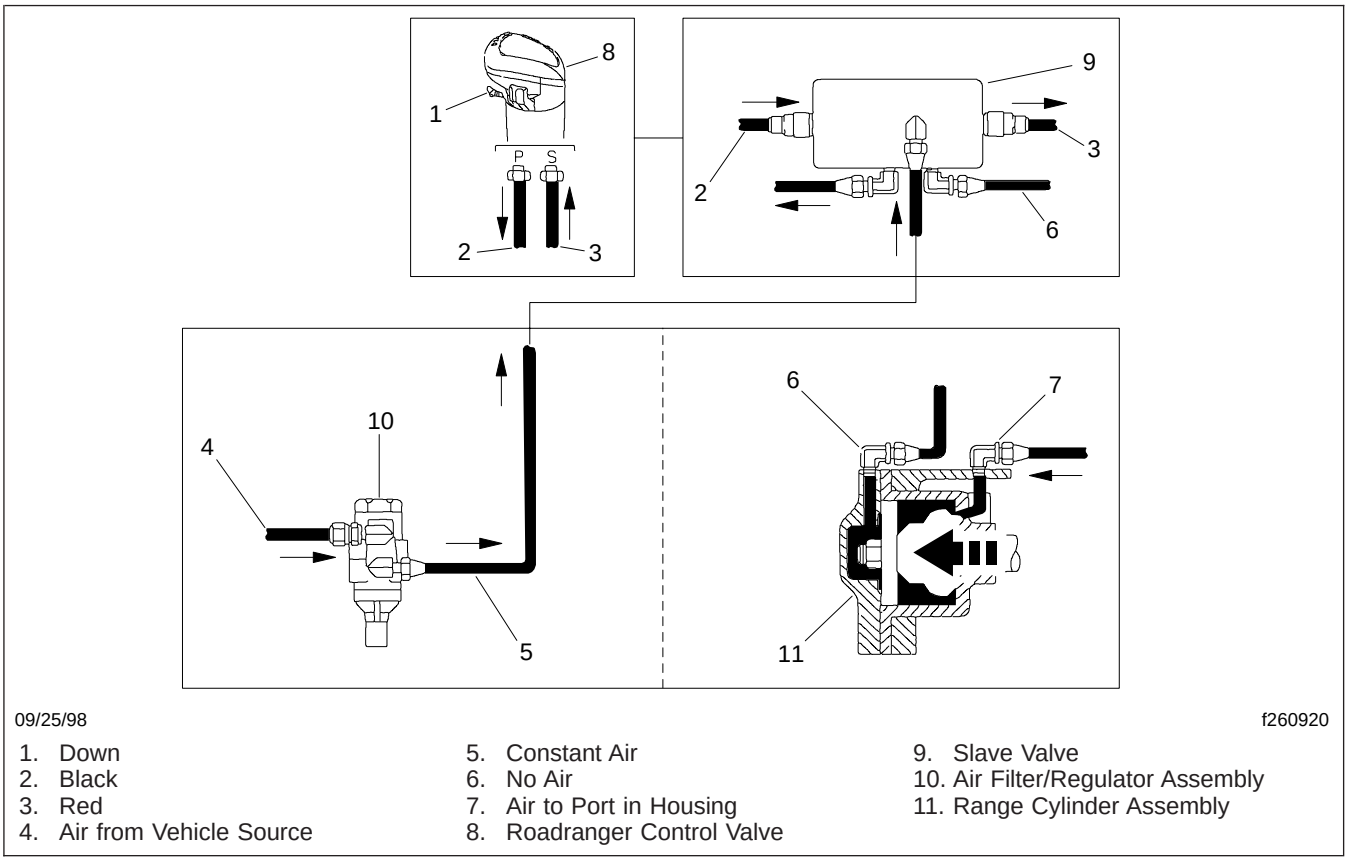
Fig. 4, LL and 15-Speed Transmissions With A-6915 Roadranger® Valve (Continued)



1. Up
2. Green
3. Black
4. Red
5. Blue
6. Rearward
7. Air from Vehicle Source
8. Constant Air
9. No Air
10. Insert Valve
11. Air to Port in Housing
12. Roadranger Valve
13. Slave Valve
14. Air Filter/Regulator Assembly
15. Reduction Cylinder Assembly
16. Range Cylinder Assembly

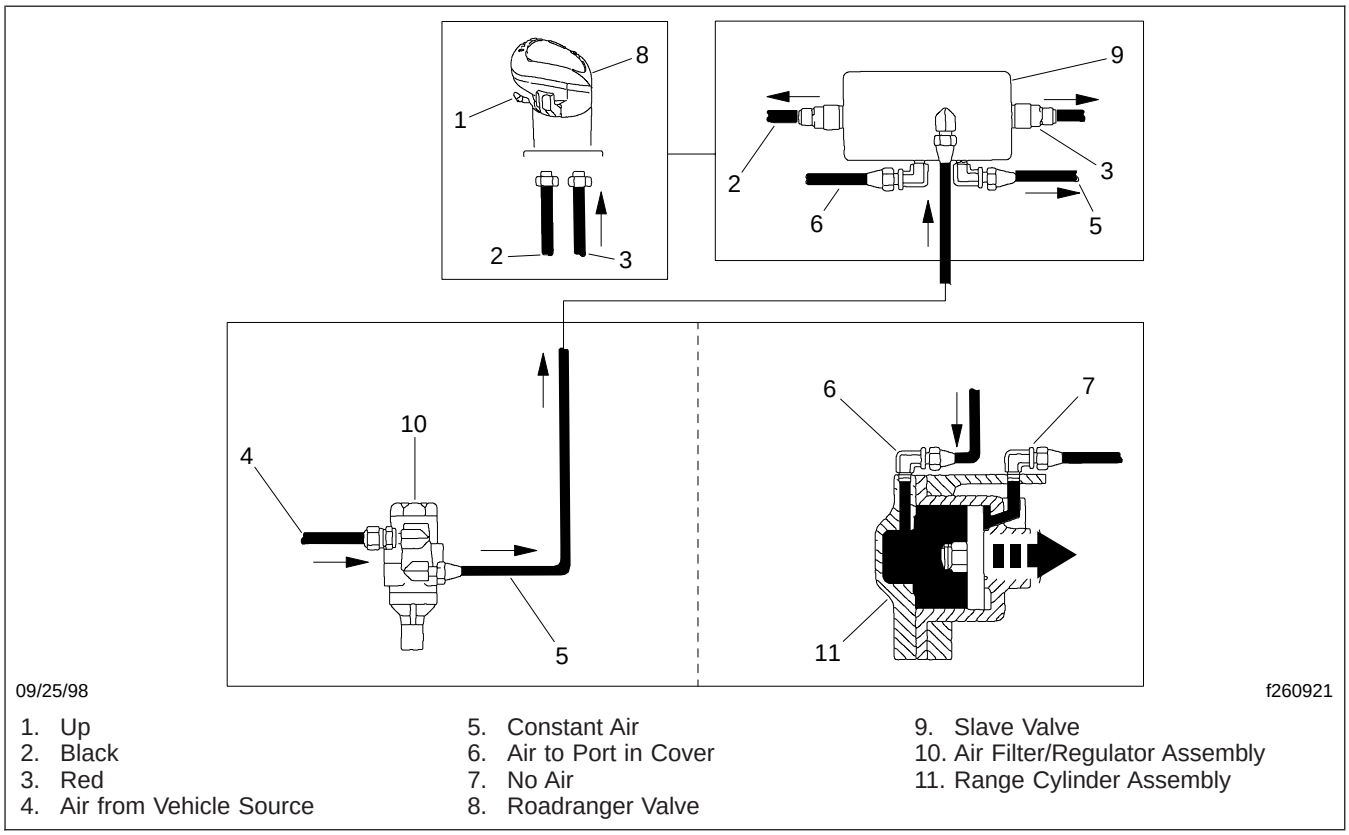
Fig. 5, LL and 15-Speed Transmissions With A-6915 Roadranger® Valve (Continued)

Troubleshooting



1. Down
2. Black
3. Red
4. Air from Vehicle Source
5. Constant Air
6. No Air
7. Air to Port in Housing
8. Roadranger Control Valve
9. Slave Valve
10. Air Filter/Regulator Assembly
11. Range Cylinder Assembly

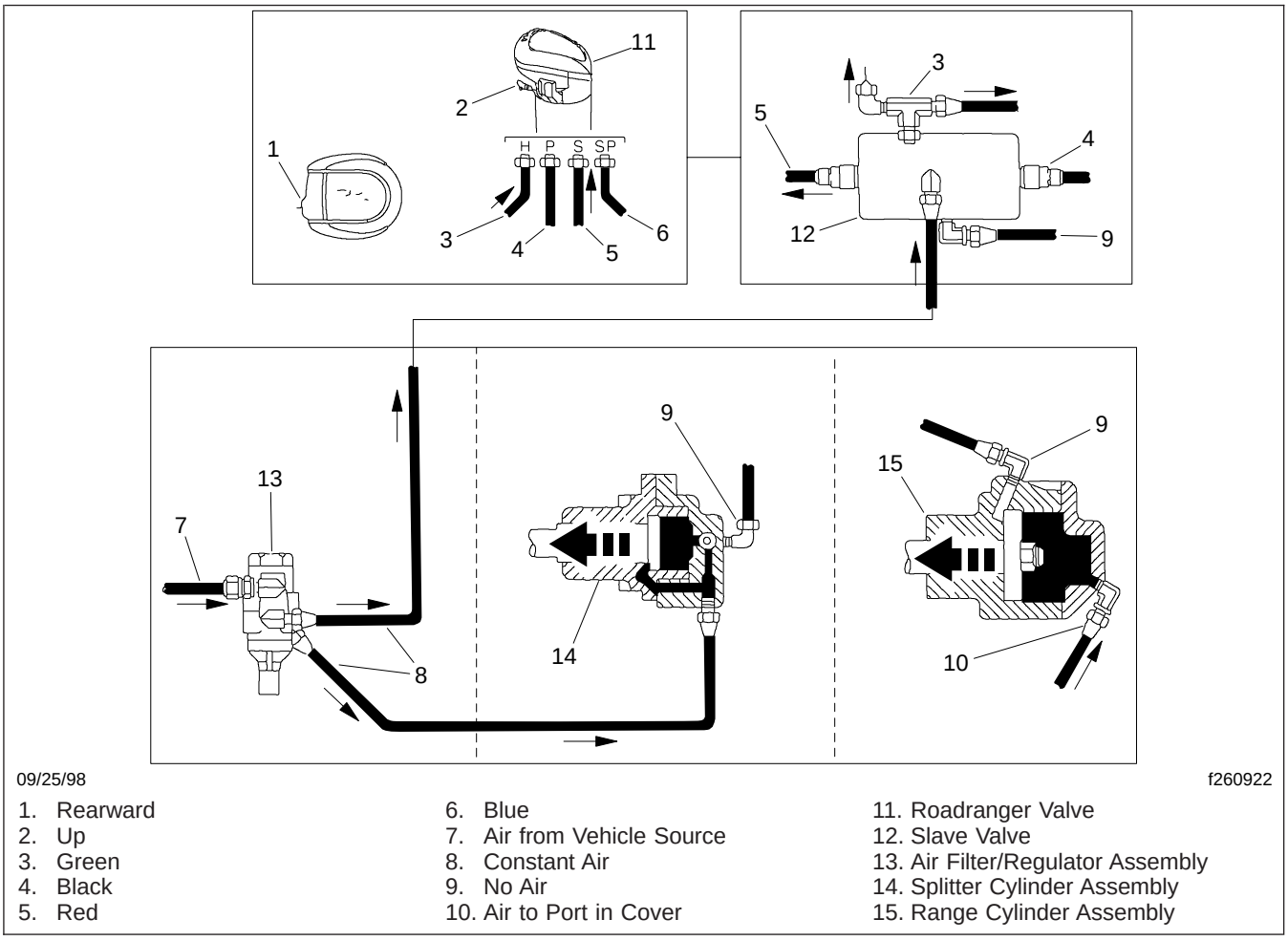
Fig. 6, 9-Speed Transmissions With A-6909 Roadranger® Valve



1. Up
2. Black
3. Red
4. Air from Vehicle Source
5. Constant Air
6. Air to Port in Cover
7. No Air
8. Roadranger Valve
9. Slave Valve
10. Air Filter/Regulator Assembly
11. Range Cylinder Assembly

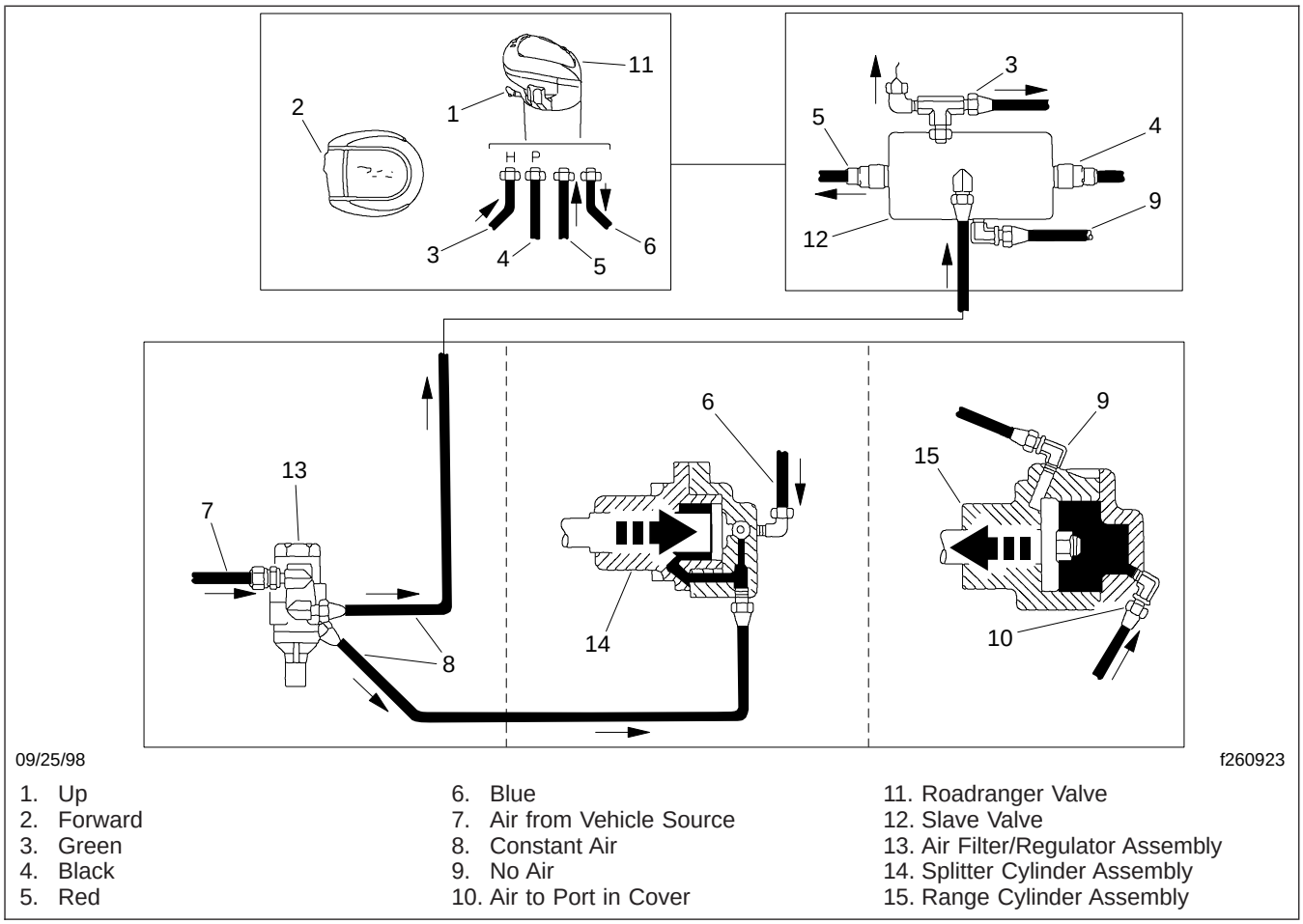
Fig. 7, 9-Speed Transmissions With A-6909 Roadranger® Valve (Continued)

Troubleshooting



1. Rearward
2. Up
3. Green
4. Black
5. Red
6. Blue
7. Air from Vehicle Source
8. Constant Air
9. No Air
10. Air to Port in Cover
11. Roadranger Valve
12. Slave Valve
13. Air Filter/Regulator Assembly
14. Splitter Cylinder Assembly
15. Range Cylinder Assembly

Fig. 8, 13-Speed Underdrive and Overdrive Transmissions With A-6913 Roadranger® Valve



1. Up
2. Forward
3. Green
4. Black
5. Red
6. Blue
7. Air from Vehicle Source
8. Constant Air
9. No Air
10. Air to Port in Cover
11. Roadranger Valve
12. Slave Valve
13. Air Filter/Regulator Assembly
14. Splitter Cylinder Assembly
15. Range Cylinder Assembly

Fig. 9, 13-Speed Underdrive and Overdrive Transmissions With A-6913 Roadranger® Valve (Continued)

Problem—Slow Shift (Splitter)

Problem—Slow Shift (Splitter)	
Possible Cause	**Remedy**
Damaged insert valve or O-ring	Replace the O-ring. Apply a thin coat of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A when reassembling.
Worn or damaged regulator	Replace damaged parts.
Loose hose or fitting	Tighten the loose part.
Pinched air hose, line or connector	Correct the restriction.
Improperly mounted gasket	Replace the part and set to proper specifications.
Improper preselection of splitter or not using clutch	Instruct the driver on proper driving techniques. Look for resultant damage.
Excessive silicone on O-rings	Clean parts and apply a thin coat of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A when reassembling.
Mixing oils or using additives	Look for resultant damage and set oil to specifications.

Troubleshooting

Problem—Slow Shift or Will Not Shift (Range)

Problem—Slow Shift or Will Not Shift (Range)	
Possible Cause	**Remedy**
Worn or damaged regulator or failed synchronizer	Replace damaged parts.
Loose hose or fitting or range cylinder piston nut loose	Tighten loose parts.
Pinched air hose, line or connector	Correct the restriction.
Sticking slave valve piston or excessive silicone on O-rings	Clean parts and apply a thin coat of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A.
Damaged O-ring or range cylinder piston cracked	Replace the part and apply a thin coat of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A.
Improperly mounted gasket	Replace the part and set to proper specifications.
Improper air line hookup	Check air lines and hoses.
Synchronizer spring broken	Replace (install) damaged (missing) parts.
No silicone or excessive silicone on O-rings	Clean parts and apply a thin coat of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A.
Restricted slave valve breather	Clean or replace parts.

Problem—Burned Synchronizer

Problem—Burned Synchronizer	
Possible Cause	**Remedy**
Worn or damaged regulator	Replace damaged parts.

Problem—Yoke Installed Backwards

Problem—Yoke Installed Backwards	
Possible Cause	**Remedy**
—	Replace parts and set to proper specifications.

Problem—Synchronizer Spring Broken

Problem—Synchronizer Spring Broken	
Possible Cause	**Remedy**
—	Replace (install) damaged (missing) parts.

Problem—Mixing Oils or Using Additives

Problem—Mixing Oils or Using Additives	
Possible Cause	**Remedy**
—	Look for resultant damage and set oil to specifications.

Problem—Overlapping Gear Ratios or Air Leak Out Range Valve (In High Range Only)

Problem—Overlapping Gear Ratios or Air Leak Out Range Valve (In High Range Only)	
Possible Cause	**Remedy**
Improper air line hookup	Check air lines and hoses and set to proper specifications.

Problem—Air Leak Out Range Valve (Constant Leak Only)

Problem—Air Leak Out Range Valve (Constant Leak Only)	
Possible Cause	**Remedy**
Damaged O-ring	Replace parts and apply a thin coat of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A.

Problem—Air Leak Out Slave Valve Breather

Problem—Air Leak Out Slave Valve Breather	
Possible Cause	**Remedy**
Damaged O-ring or range cylinder piston cracked	Replace parts and apply a thin coat of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A.

Problem—Pinched Air Line or Connector

Problem—Pinched Air Line or Connector	
Possible Cause	**Remedy**
—	Correct the restriction.

Problem—Range Cylinder Piston Nut Loose

Problem—Range Cylinder Piston Nut Loose	
Possible Cause	**Remedy**
—	Tighten the loose part.

Problem—Transmission Case Pressurized (All Range Positions)

Problem—Transmission Case Pressurized (All Range Positions)	
Possible Cause	**Remedy**
Damaged O-ring	Replace parts and apply a thin coat of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A.

Problem—Constant Air Leak Out Insert Valve Exhaust Port or Constant Air Leak Out Selector Valve Exhaust Port in "Direct" Position

Problem—Constant Air Leak Out Insert Valve Exhaust Port or Constant Air Leak Out Selector Valve Exhaust Port in "Direct" Position	
Possible Cause	**Remedy**
Damaged insert valve	Clean or replace parts and apply a thin coat of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A.

Troubleshooting

Problem—Constant Air Leak Out Insert Valve Exhaust Port or Constant Air Leak Out Selector Valve Exhaust Port in "Direct" Position	
Possible Cause	**Remedy**
Damaged O-ring	Replace parts and apply a thin coat of Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A.

COMPONENT TESTS

Air Filter/Regulator and Range System Test

1. Place the transmission shift lever in neutral.
2. Start the engine and wait for the air system pressure to reach governor cut off, 90 to 125 psi (621 to 862 kPa).

NOTE: If at any time during testing the truck's air pressure falls below 90 psi (621 kPa) restart the truck, wait for the air pressure to reach governor pressure, turn off the engine, and continue testing.

3. Turn off the engine.
4. Move the range control lever up to HI range.
5. Remove the two screws on the Roadranger® valve cover and pull the cover down. See **Fig. 10.**

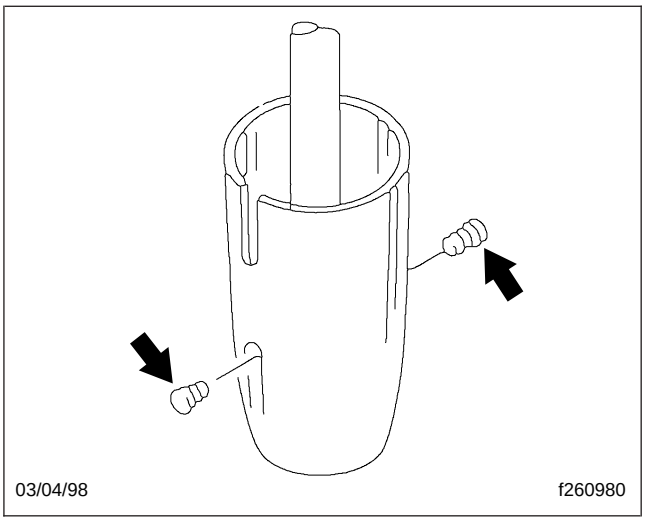


Fig. 10, Valve Cover Screws

6. Disconnect the black air line from "P" port. See **Fig. 11.**

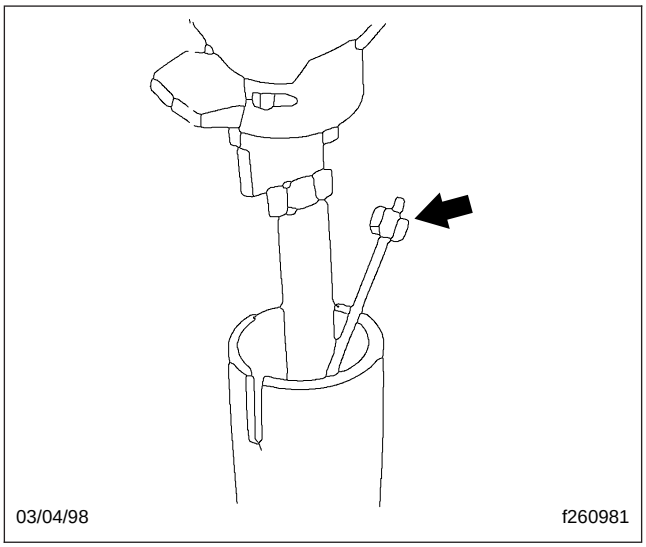


Fig. 11, Black Air Line from "P" Port

7. Check for air flow from the Roadranger valve "P" port.
   - 7.1 If there is no air flow, go to the following step.
   - 7.2 If there is air flow, replace the Roadranger valve.
8. Check for air flow from the "P" line.
   - 8.1 If there is no air flow, go to the following step.
   - 8.2 If there is air flow, replace the slave valve.
9. Install a suitable gauge in the "P" line. See **Fig. 12**.

   If the air pressure is outside the 58 to 63 psi (400 to 434 kPa) range and the vehicle's air system pressure is 90 to 125 psi (621 to 862 kPa), replace the air filter/regulator.
10. Move the range control lever down to LO range. The air pressure gauge should read between 58 to 63 psi (400 to 434 kPa).

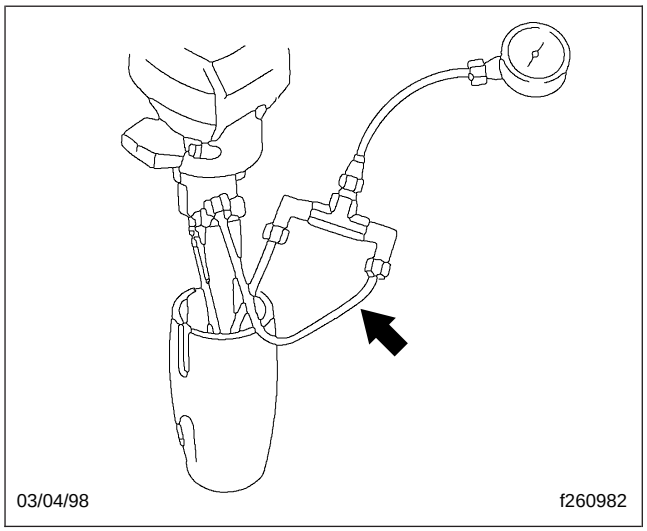


Fig. 12, Gauge Connected to "P" Line

11. Move the shift lever into any gear position.
    - 11.1 If there is no drop in air pressure, go to the following step.
    - 11.2 If the air pressure drops, replace the slave valve.
12. With the shift lever in gear, move the range control lever up to HI range.
    - 12.1 If the air pressure rapidly drops to 0 psi (0 kpa), go to the following step.
    - 12.2 If the air pressure remains between 58 to 63 psi (400 to 434 kPa), replace the Roadranger valve.
    - 12.3 If the air pressure drops slowly, check the Roadranger valve fittings, slave valve fittings, and the "P" line for restrictions.
    - 12.4 If the range shifts, remove the slave valve and check the neutral interlock pin. It should protrude with the shift lever in gear and retract with the shift lever in neutral. If it does protrude, replace the slave valve. If it does not protrude, inspect the interlock pin and the actuating plunger.
13. Move the shift lever into neutral.
    - 13.1 If the air pressure remains at 0 psi (0 kPa), go to the following step.
    - 13.2 If the air pressure does not remain at 0 psi (0 kPa), replace the slave valve.
14. Remove the test fixture. Assemble the Roadranger valve.
15. Move the range control lever down to LO range.
16. From the range cylinder cover, disconnect the HI range hose. See **Fig. 13**.

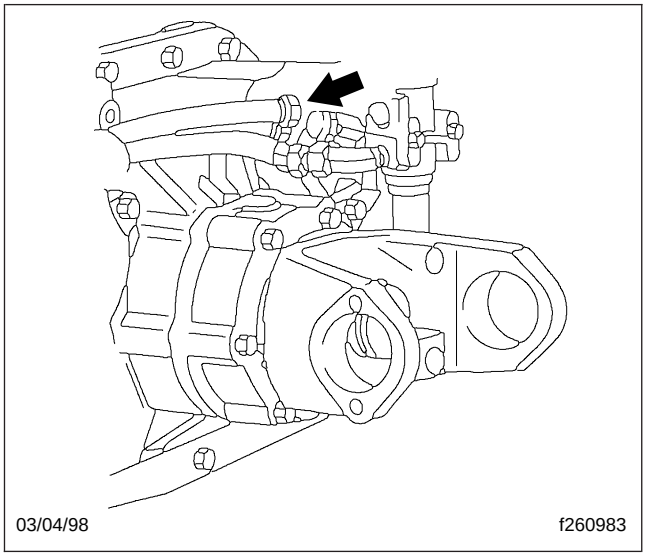


Fig. 13, HI Range Hose Location

17. Check for air flow out of the cylinder fitting.
    - 17.1 If there is no air flow, go to the following step.
    - 17.2 If there is air flow, disassemble the range cylinder and replace the range piston O-rings. Check the piston for cracks.
18. Check for air flow out of the HI range hose.
    - 18.1 If there is no air flow, go to the following step.
    - 18.2 If there is no air flow out of the hose, replace the slave valve.
19. Install the gauge between the range cylinder cover and the HI range hose.
20. Move the range control lever up into HI range.
    - 20.1 If the air pressure changes rapidly to between 58 to 63 psi (400 to 434 kPa), and an audible range shift occurs, go to the following step.

Troubleshooting

20.2 If the air pressure does not rapidly change to between 58 to 63 psi (400 to 434 kPa) and the vehicle air system pressure is 90 to 125 psi (621 to 862 kPa), replace the slave valve.

20.3 If there was not an audible range shift, disassemble and inspect the range cylinder and internal transmission components.

21. Move the range control lever down to LO range.

21.1 If the air pressure rapidly drops to 0 psi (0 kPa) and an audible range shift occurs, go to the following step.

21.2 If the air pressure does not rapidly drop to 0 psi (0 kPa) and the vehicle air system pressure is 90 to 125 psi (621 to 862 kPa), replace the slave valve.

21.3 If there is not an audible range shift, disassemble and inspect the range cylinder and internal transmission components.

22. Remove the breather or breather hole plug on the shift bar housing. Check for air flow from the hole.

22.1 If there is no air flow, go to the following step in test sequence.

22.2 If there is air flow, move the control valve lever up to HI range.

22.3 If air flow stops, replace the range cylinder to shaft O-ring.

22.4 If air flow does not stop, replace the splitter/reduction cylinder to piston O-ring.

23. Remove the test fixture. Connect the HI range hose.

Poppet-Type Slave Valve (19470)

The poppet-type slave valve is a non-serviceable valve. If the valve is damaged, the complete assembly must be replaced.

A restriction in the line between the outlet port of the range valve and the P-port of the slave valve can cause a constant air leak out the exhaust port of the slave valve.

1. Check air fittings and air lines between the slave valve and range valve for restrictions.

NOTE: If the capscrews are not tightened correctly, an air leak between the slave valve and the transmission case can result.

2. Check the torque of the four 1/4-inch slave valve mounting capscrews.

   Tighten to 97 lbf·in (11 N·m) and determine if the valve functions properly.

3. If retightening the four slave valve capscrews eliminates the air leaks, remove the valve from the transmission and tighten the three No. 10 Phillips-head baseplate screws on the back of the valve to 45 lbf·ft (61 N·m).

   If the four slave valve retaining capscrews are equipped with star washers, install flatwashers under the star washers to prevent them from fretting into the valve.

4. Reinstall the valve and tighten the capscrews to 97 lbf·in (11 N·m).

5. If the valve continues to leak after the above checks have been made, the valve must be replaced.

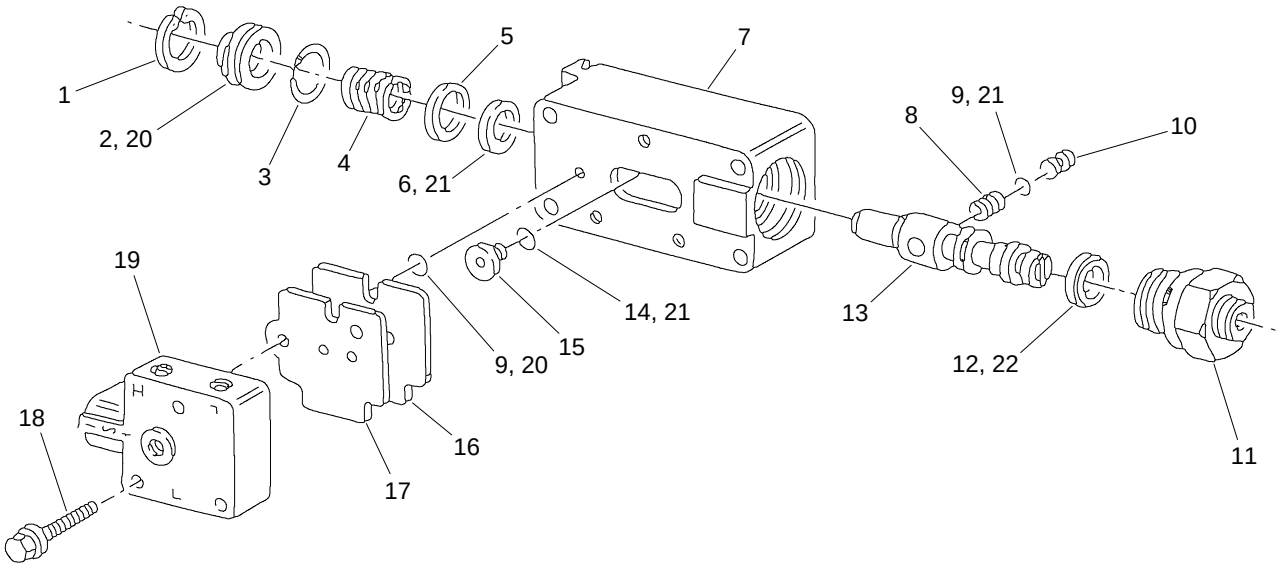
SLAVE VALVE TROUBLESHOOTING

(See Fig. 14)

Check the four O-rings and two U-seals for damage. If any of these are worn or damaged, there will be a constant air leak out the exhaust or to the atmosphere.

Roadranger® Valve

1. Place the shift lever in NEUTRAL.
2. Disconnect the 5/32-inch outside diameter air line at the center port of the reduction cylinder cover. Make sure this line leads from the SP-port of the Roadranger valve.
3. While in low range, move the deep reduction button forward.
4. There should be air flowing from the disconnected line.
5. Move the button rearward to shut off airflow and reconnect the air line.
6. If the preceding conditions did not exist, the Roadranger valve is damaged, or there is a restriction in the air lines.



1. Snap Ring
2. Plug
3. O-Ring
4. Spring
5. Washer
6. U-Seal
7. Body
8. Spring
9. O-Ring
10. Seal
11. End Cap
12. U-Seal
13. Piston
14. O-Ring
15. Seal
16. Plate
17. Gasket
18. Capscrew
19. Sidecap
20. Worn or Damaged O-Ring or U-Seal (Constant Leak to Atmosphere)
21. Worn or Damaged O-Ring or U-Seal (Constant Leak Through Exhaust in Both Ranges)
22. Worn or Damaged U-Sea (Constant Leak Through Exhaust in Low Range Only)

Fig. 14, Piston-Type Slave Valve

Insert Valve

NOTE: Any constant flow of air from the exhaust port of the cylinder cover usually indicates a faulty insert valve. Exhaust should occur only briefly when the deep reduction button is moved forward while in low range.

NOTE: A faulty insert valve, leaking at the O-rings of the valve outside diameter or leaking from inner seals will result in shift failure.

1. Check for constant air flowing from the exhaust port of the cylinder cover.
2. Check for constant air flowing from exhaust port F of the Roadranger valve while the deep reduction button is rearward.

NOTE: The three O-rings in position on the insert valve outside diameter can be replaced. However, if an inner seal is damaged, the complete assembly must be replaced.

3. Replace the O-rings if airflow is detected during the previous two steps.

Deep Reduction Air System

NOTE: Prior to performing the following checks, the correct psi readings must be obtained from the air filter/regulator and all air lines must be checked for leaks.

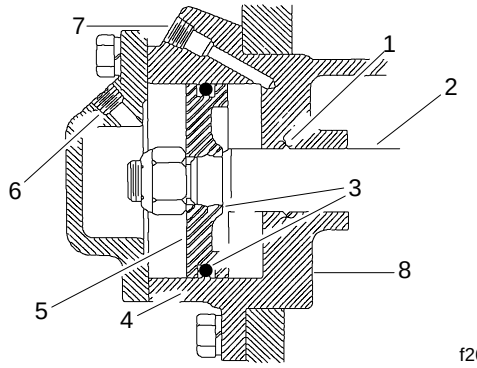
If the transmission fails to shift or shifts too slowly to or from deep reduction, the cause may be in the deep reduction air system or related components of the range shift air system.

To locate the cause, make the following checks with normal vehicle air pressure supplied to the system, but with the engine off.

Troubleshooting

1. With the shift lever in NEUTRAL, select low range and loosen the connection at the H-port of the Roadranger valve until it can be determined that air is supplied to the valve.
2. Reconnect the air line.
3. If there is no air, check for a restriction in the 5/32-inch outside diameter air line between the Roadranger valve and slave valve. Make sure this line is connected to the fitting at the low range, or L-port, of the slave valve.

Range Cylinder (See Fig. 15)



1. O-Ring Leak Results in Failure to Shift into Low Range: Pressurizing of Transmission
2. Shift Bar
3. O-Ring Leak Results in Failure to Shift in Either Low or Direct Range (Will Also Cause Steady Leak Out Breather in Air Valve)
4. Gasket Leak Results in Slow Shift to Direct Range
5. Shift Piston
6. Direct Range Air Port
7. Low Range Air Port
8. Range Cylinder

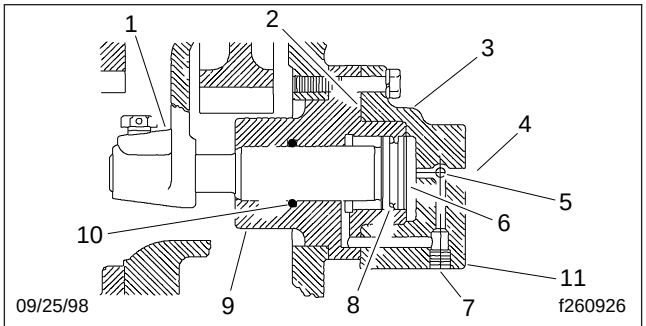
Fig. 15, Range Cylinder

NOTE: If any of the O-rings in the range shift cylinder are worn, the range shift will be affected. The degree of lost air will govern the degree of failure, from slow shift to complete failure to shift.

1. Remove the stop nut from the yoke bar.
2. Apply air to the low range air line to pop the piston from the cylinder housing.
3. Remove the O-rings from the outside diameter and inside diameter of the piston.
4. Install new O-rings.

   Lubricate with Silicone Lubricant COAZ–19553–AA or equivalent meeting specification ESR–M13P4–A.
5. Reassemble the cylinder assembly.

Reduction Cylinder (See Fig. 16)



1. Shift Yoke
2. Gasket C
3. Cover
4. Air Only When Splitter Control Button is Forward
5. Insert Valve
6. Yoke Bar and Piston
7. Constant Air from Air Filter/Regulator
8. O-Ring B
9. Housing
10. O-Ring A
11. Reduction Cylinder

Fig. 16, Reduction Cylinder

NOTE: If any of the seals in the reduction cylinder assembly are damaged, the deep reduction shift will be affected. The degree of air lost will govern the degree of failure, from slow shifting to complete shift failure.

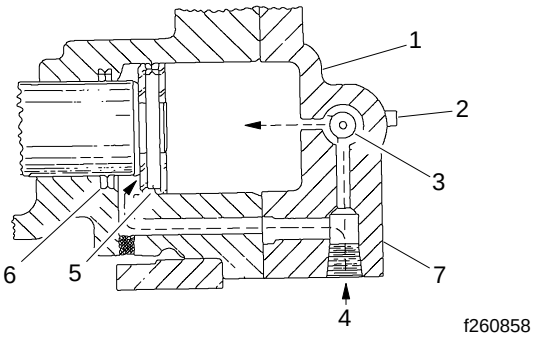
Inspect the O-rings and gasket for wear or damage.

Splitter Air System (See Fig. 17)

NOTE: There are two O-rings in the splitter cylinder.

1. Check for a failure to shift or slow shifting to overdrive or underdrive.

   Pressure inside the transmission may also be observed.
2. Check for leaks out of the cover exhaust when in overdrive or underdrive.



1. Cover Assembly
2. Center Port for Signal Line from Control Valve to Operate Insert Valve
3. Insert Valve
4. Side Port Constant Air
5. Seal B
6. Seal A
7. Splitter Cylinder

Fig. 17, Splitter Cylinder

3. Replace the O-rings if the conditions in the previous two steps exist.

Cover Assembly

NOTE: Any constant flow of air out the cover exhaust port usually indicates a faulty insert valve. Exhaust should occur briefly only when the splitter control is moved from direct to overdrive or underdrive.

1. Check for a constant leak out of the cover exhaust.
2. Check for a constant leak out of the splitter control exhaust with the splitter control in direct.

NOTE: If an inner seal is damaged, the entire insert valve must be replaced.

3. If leaks are detected, replace the three O-rings on the outer diameter of the insert valve.

Specifications

General Specifications	
Item	**Specification**
Lubricant	
Silicone Lubricant COAZ–19553–AA	ESR–M13P4–A
Adhesive	
Threadlock® and Sealer EOAZ–19554–AA	WSK–M2G315–A5

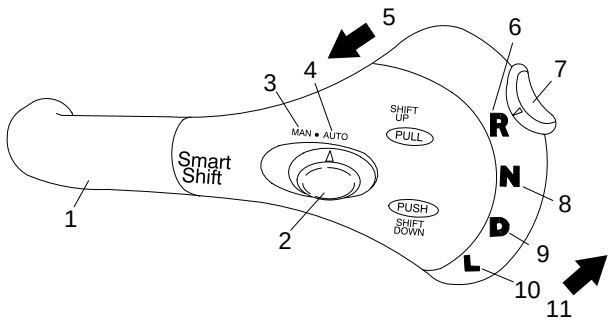
Table 1, General Specifications

Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Slave Valve, Poppet-Type, 1/4-Inch Capscrews	—	97 (1100)
Slave Valve, No. 10 Phillips-Head Baseplate Screws	45 (61)	—
Air Filter and Regulator	8–12 (11–16)	—
Slave Valve, Piston-Type	15–20 (20–27)	—
Range Cylinder	35–45 (48–61)	—
Splitter Cylinder	21–24 (28–33)	—
Reduction Cylinder	21–24 (28–33)	—
Slave Valve End Cap	40 (54)	—
Air Module Mounting Capscrews	20–23 (27–31)	—

Table 2, Torque Specifications

General Description

The SmartShift automated mechanical transmission shift lever subsystem is an electronic transmission control device. It is applicable to both automated mechanical and automatic transmissions but must be mated to an Eaton AutoShift, Meritor SureShift transmission. It replaces either the typical floor-mounted shift lever or dash-mounted pushbutton control. The SmartShift control mounts to the right-hand side of the steering column and is operated by the driver's right hand. See **Fig. 1** and **Fig. 2**. SmartShift accepts driver requests for transmission functions and transmits them through hard wiring to the transmission control unit (TCU).



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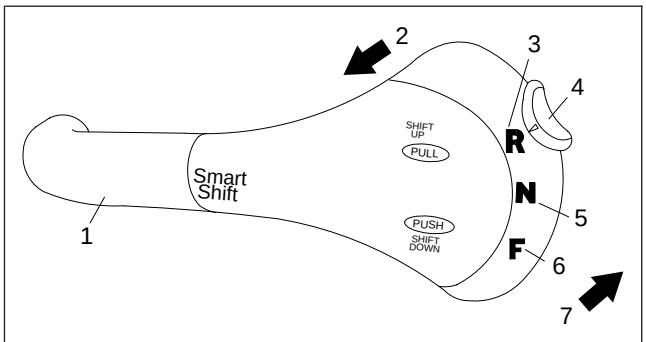
1. SmartShift Control
2. Forward Driving Mode Switch (slide switch)
3. "AUTO" Switch Position
4. "MAN" Switch Position
5. Upshift Direction (pull upward)
6. Reverse (R) Selector Position
7. Mode Selector Switch
8. Neutral (N) Selector Position
9. Drive (D) Selector Position
10. Low (L) Selector Position
11. Downshift Direction (push downward)

Fig. 1, SmartShift Control (Eaton)

SmartShift offers two main advantages over conventional transmission control devices. Usable cab space is increased and access to the sleeper is improved by removing the shift lever from the floor. Because of the steering-column mounting, the transmission control is within fingertip reach of the steering wheel, which enhances safety.

SmartShift is a true shift-by-wire system. Gearshifts are accomplished by a momentary pull or push on the control in the plane perpendicular to the steering wheel. See **Fig. 3**. Pull upward (toward yourself) on the control to upshift and push downward (away from yourself) to downshift. For the Eaton AutoShift transmission, a four-position (R, N, D, L) linear mode selector switch (**Fig. 1**) is located at the end of the control. For the Meritor SureShift transmission, a three-position (R, N, F) linear mode selector switch (**Fig. 2**) is located at the end of the control. The control is spring-loaded and returns to mid-position when released after an upshift or downshift.



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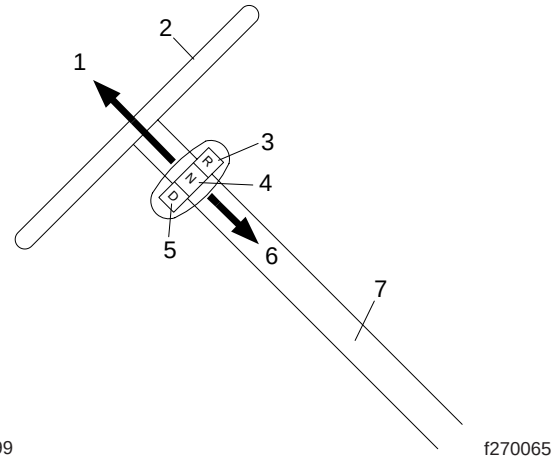
1. SmartShift Control
2. Upshift Direction (pull upward)
3. Reverse (R) Selector Position
4. Mode Selector Switch
5. Neutral (N) Selector Position
6. Forward (F) Selector Position
7. Downshift Direction (push downward)

Fig. 2, SmartShift Control (Meritor)

General Information

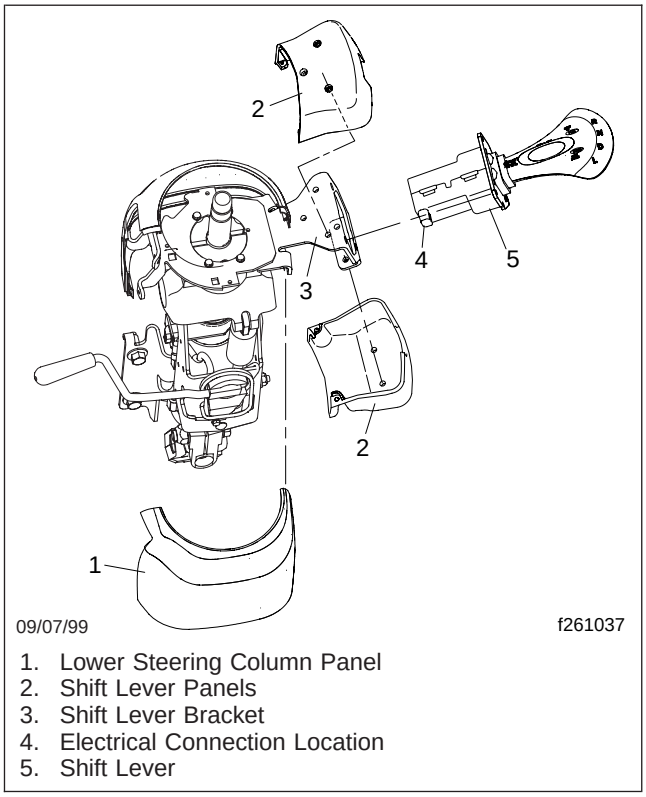


1. Upshift (pull upward)
2. Steering Wheel
3. Reverse (R) Position
4. Neutral (N) Position
5. Drive (D) Position
6. Downshift (push downward)
7. Steering Column

Fig. 3, SmartShift Control Operation (Eaton AutoShift control shown)

Replacement (See Fig. 1)

1. Shut down the engine, apply the parking brakes and chock the tires.
2. Remove the upper and lower shift lever panels.
   - 2.1 Remove the seven screws securing the panels.
   - 2.2 Separate the upper and lower panels, accessing the shift lever.
3. Remove the lower steering column panel.
4. Disconnect the electrical connector from the lever.
5. Remove the three bolts securing the shift lever to the bracket on the column.
6. Remove the shift lever.
7. Place the new lever into position and secure it using the bolts previously removed.
8. Connect the electrical connector to the shift lever.
9. Install the lower steering column panel.
10. Using the screws previously removed, install the upper and lower shift lever panels.
11. Remove the chocks from the tires.



1. Lower Steering Column Panel
2. Shift Lever Panels
3. Shift Lever Bracket
4. Electrical Connection Location
5. Shift Lever

Fig. 1, SmartShift Lever Replacement

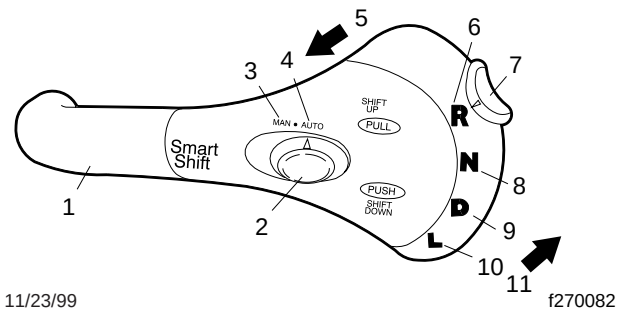
General Information

The following information is provided to help determine whether a potential transmission problem is actually the transmission or possibly the Freightliner SmartShift® Transmission Shift Control.

Resistance checks at the SmartShift connector can help determine connection problems.

DataLink Software can be used to test the SmartShift control. The tests require a ServiceLink computer connected to the vehicle. If the tests confirm the shift control is defective, this subject also includes connector resistance checks to rule out wiring issues.

For Eaton Fuller AutoShift, the four-position selector switch is marked "R-N-D-L". A slide switch is present. See **Fig. 1**.



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1. SmartShift Control
2. Slide Switch (forward driving mode switch)
3. MAN Position (on slide switch)
4. AUTO Position (on slide switch)
5. Upshift Direction
6. Reverse Position (on selector switch)
7. Selector Switch
8. Neutral Position (on selector switch)
9. Drive Position (on selector switch)
10. Low Position (on selector switch)
11. Downshift Direction

Fig. 1, SmartShift Control (with Eaton Fuller AutoShift)

Shift Control Resistance Checking

Parts

See **Table 1** for parts.

Parts for Wire Extension*		
Part Number	**Description**	**Qty.**
PAC12110847	Metri-Pack Terminal	3
PAC12047767	Connector Terminal	3
48-02493-184	18GA GTX Wire, Yellow	3 ft x 3
PAC12047781	3-Pin Connector	1
PAC12047783	Connector Lock	1

* Parts are available through the PDCs.

Table 1, Parts for Wire Extension

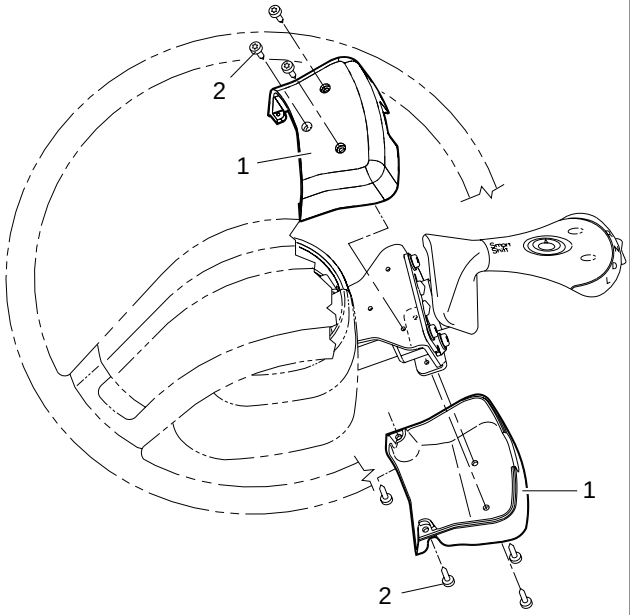
Procedure

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Remove the screws that secure the SmartShift control covers, and separate the forward and rear panels to access the shift control. See **Fig. 2**.
3. Disconnect the electrical connector from the plug on the shift control unit. See **Fig. 3**.
4. Assemble the wire extension from the parts in **Table 1** to allow for easy resistance testing, as follows.
   - 4.1 Crimp the connector terminals at the end of each 3-foot (1-meter) wire.
   - 4.2 Assemble the 3-pin connector with the connector terminals and connector lock.
   - 4.3 Crimp the Metri-Pack terminals on the other end of the wires.
5. Plug the wire extension into the plug on the shift control unit. See **Fig. 4** for SmartShift terminal positions.

NOTE: Using this new wire extension prevents the need to remove the shift control.

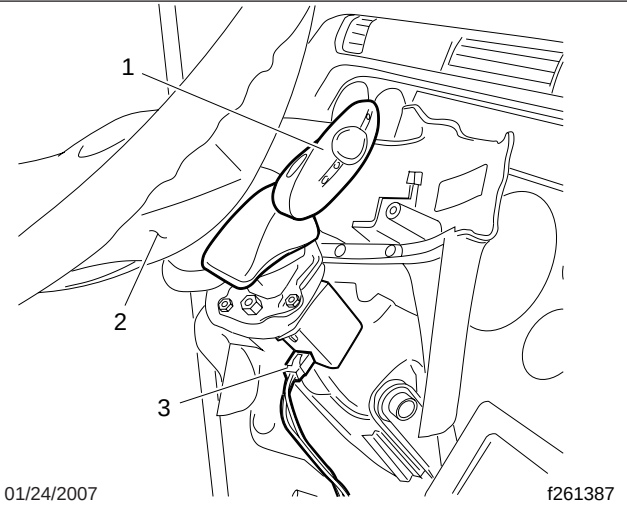
6. Check the resistance at the other end of the wires. See **Fig. 5**. Use **Table 2** and **Table 3**.

Troubleshooting



1. SmartShift Control Cover
2. Screw

Fig. 2, Steering Column Panel



1. Shift Control
2. Steering Wheel
3. Electrical Connector

Fig. 3, SmartShift Components

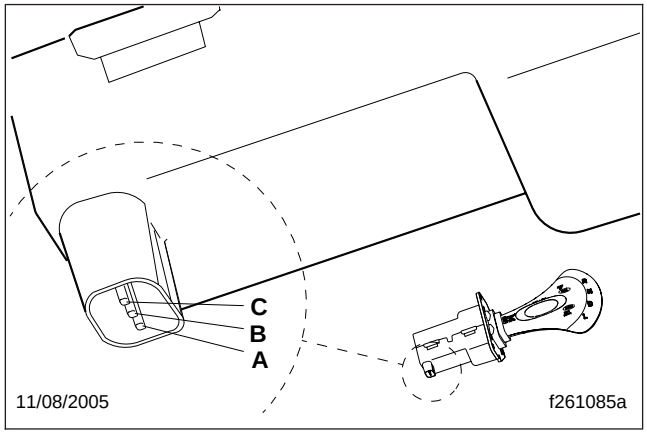
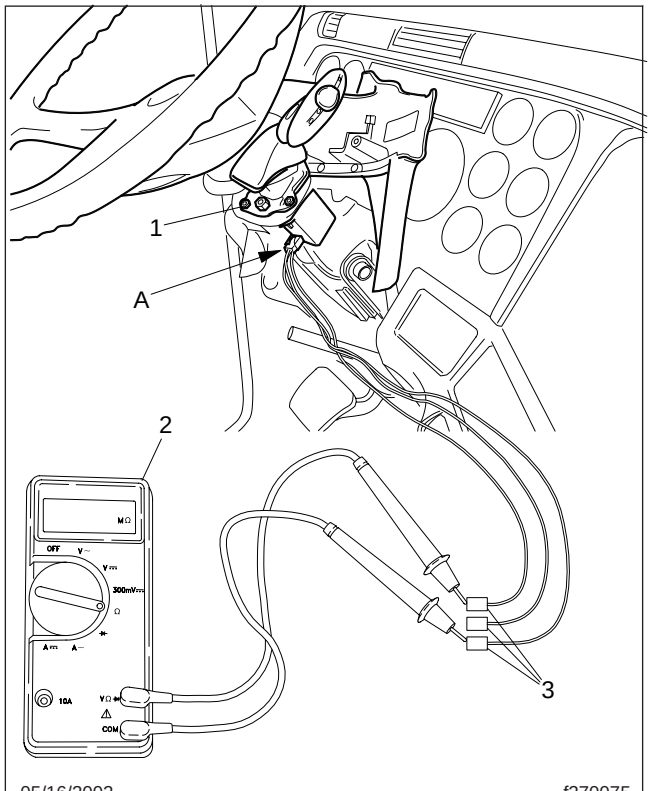


Fig. 4, SmartShift Terminal Positions



A. Plug the newly assembled wire extension into the plug on the shift control unit.

1. Shift Control Unit
2. Digital Multimeter (set to ohms)
3. Metri-Pack Terminals (at wire ends)

Fig. 5, Resistance Checking at Shift Control

Resistance at Positions B and C	
Selector Switch Position	**Reading: kOhm**
R	2.947–3.067
N	0.347–0.361
D	0.606–0.630
L	1.65–1.72

Table 2, Resistance at Positions B and C

Resistance at Positions A and C	
Slide Switch + Lever Position	**Reading: kOhm**
Manual	2.865–2.981
Manual + Up	0.531–0.553
Manual + Down	1.150–1.197
Auto	11.27–11.73

Table 3, Resistance at Positions A and C

7. After checking the resistance, unplug the wire extension, and reconnect the electrical connector.
8. Install the steering column trim panels.
9. Remove the chocks from the tires.

SmartShift Control Checking Using DataLink Monitor (DLM)

The AutoShift DataLink Monitor template (see **Fig. 6**) will display the current vehicle status and will reflect change in status. Vehicle information is retrieved from the transmission ECU on the datalink. The monitor can also be used to verify readings on the instrument panel.

1. With the wheels chocked, start the engine.
2. Connect the service computer to the engine and start ServiceLink.
3. Click on the **Transmission** icon on the left screen.
4. Click on the **Templates** tab. An overview of available templates will be shown.
5. Click on **SmartShift with Eaton AutoShift**.

NOTE: To test the shift control using the datalink, the vehicle can be placed into a mode that allows the gears to be shifted without the engine running. The following step explains how to enter that mode.

6. Turn the ignition OFF, then turn the ignition back ON, but don't start the engine. The transmission controller will still be in the Engine ON mode, thereby allowing the gears to be shifted.
7. Test the operation of the shift control for Reverse (R) and Neutral (N), as follows.
   - 7.1 Select R on the selector switch. In the *Range Selected* field of the template an R should be displayed.
   - 7.2 Select N on the selector switch. In the *Range Selected* field of the template an N should be displayed.
8. Test the operation of the shift control for Drive (D), as follows.
   - 8.1 Select D on the selector switch and turn the slide switch (reading "Automatic/Manual") to Automatic. In the *Range Selected* field of the template, a D should be displayed.
   - 8.2 With the selector switch still on D, toggle the slide switch from Automatic to Manual and back. Confirm that the *Range Selected* field shows a D while in Automatic and an H (High) while in Manual.
   - 8.3 While in Manual mode, change the selector switch to L (Low) and confirm that the *Range Selected* field changes from H to L.
9. Test upshifting and downshifting, as follows.
   - 9.1 With the selector switch on D, pull and hold the shift control lever. The *Up-Shift Req.* field will turn green and read ON for 3 seconds.
   - 9.2 Push and hold the shift control lever. The *Down-Shift Req.* field will turn green and read ON for 3 seconds.

NOTE: A blinking display indicates that the transmission is attempting to shift into the gear position. A solid display shows the current gear position attained.

10. When the selector switch is in any position but N (Neutral), the *Ign. Interrupted* field on the Monitor template will read YES.

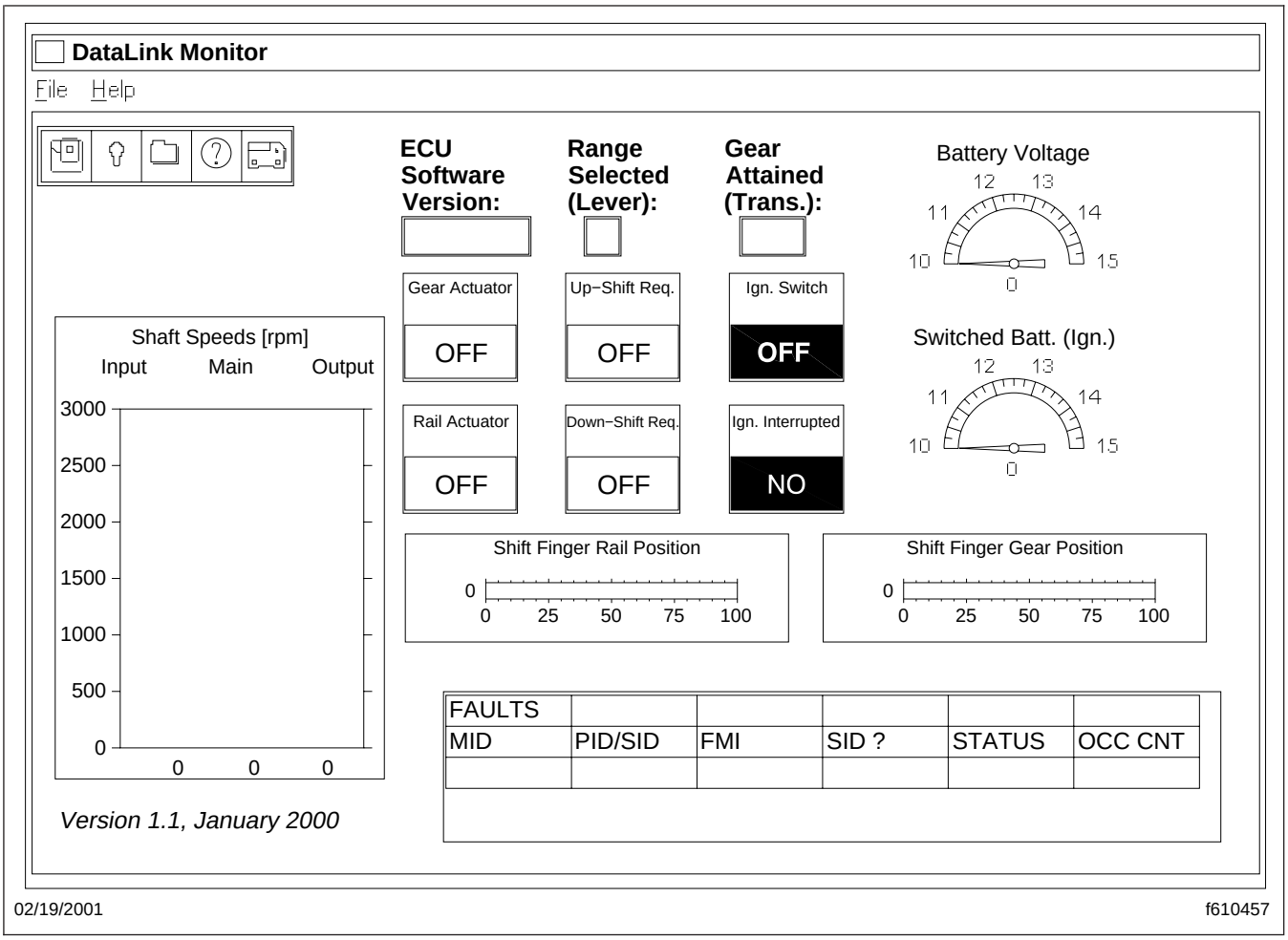
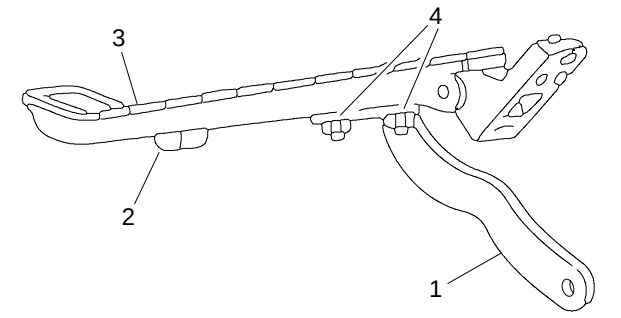


Fig. 6, DataLink Monitor Template for Eaton Fuller AutoShift

General Information

Throttle Pedal

The mechanical-linkage type throttle pedal (see **Fig. 1**) uses an adjustable rod to actuate the fuel injection pump lever.



1. Pedal Arm
2. Pedal Stop
3. Throttle Pedal
4. Locknuts

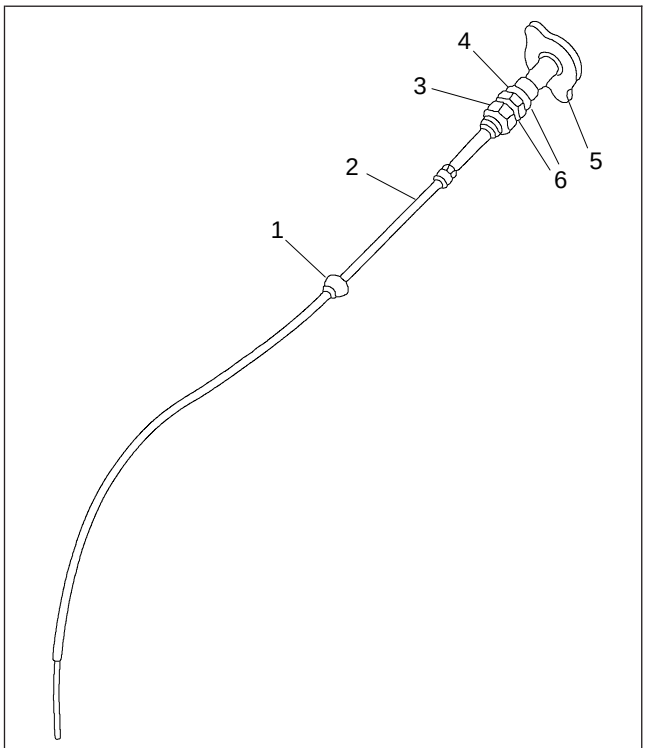
Fig. 1, Mechanical Throttle Pedal

Locking T-Handle Throttle

On some vehicles, a locking T-handle throttle control cable is used to control engine high idle (see **Fig. 2**). The locking T-handle type consists of a cable attached to the fuel injection pump control lever. When the T-handle is pulled out, the engine idle increases. When the desired idle speed is obtained, the T-handle is twisted to the right locking it at the chosen idle speed. Turning the T-handle to the left unlocks the handle. Pushing the T-handle back in allows the idle speed to decrease so that the engine idle reverts back to the base engine idle settings.

Vernier Hand Control Throttle

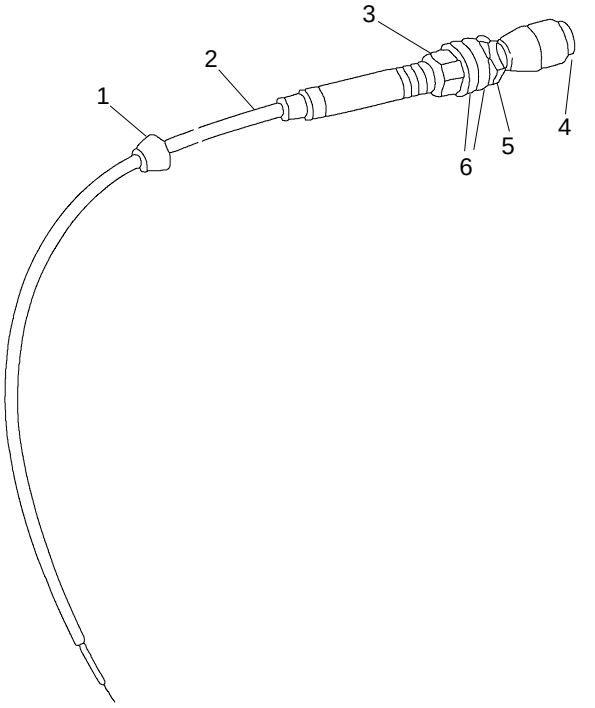
The Vernier hand control throttle works the same way as the locking T-handle throttle except that the Vernier hand control throttle uses a push button locking system (see **Fig. 3**). When the button is depressed, the hand throttle can be pulled out and pushed in to adjust the engine idle speed. When the button is released, the control cable locks in place.



1. Grommet
2. Hand-Throttle Cable Assembly
3. Nut
4. Bezel
5. T-Handle
6. Washer

Fig. 2, Locking T-Handle Hand Control Throttle

General Information



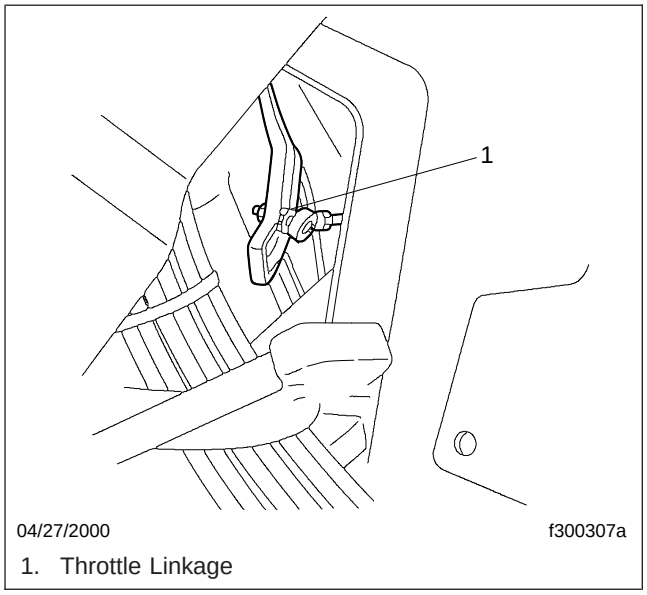
1. Grommet
2. Hand-Throttle Cable Assembly
3. Nut
4. Vernier Handle
5. Bezel
6. Washer

Fig. 3, Vernier Hand Control Throttle

Throttle Pedal Replacement, Engines with Electronic Automatic Transmissions

Replacement

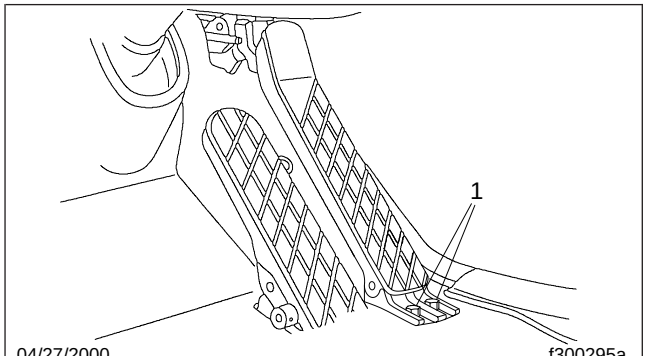
1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Remove the nut and the throttle linkage from the throttle pedal arm. See **Fig. 1**.



1. Throttle Linkage

Fig. 1, Throttle Linkage

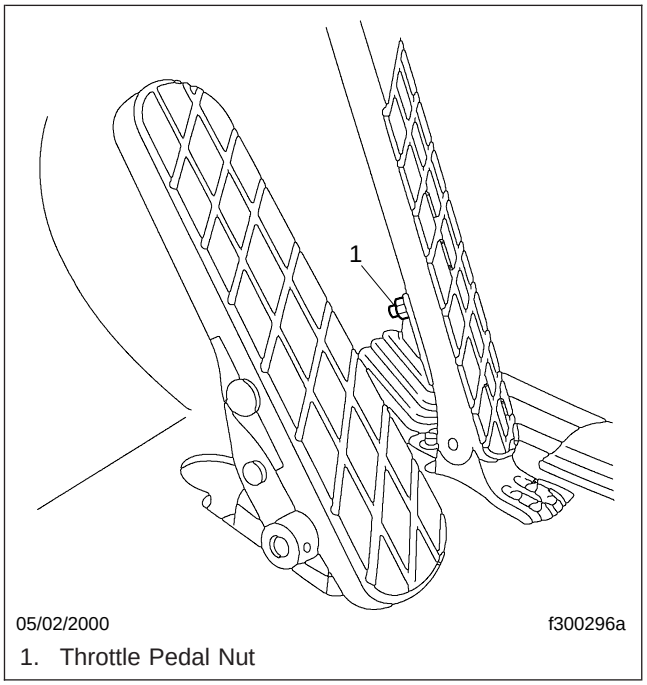
4. Remove the throttle pedal mounting fasteners. See **Fig. 2**.



1. Mounting Fasteners

Fig. 2, Throttle Pedal Mounting Fasteners

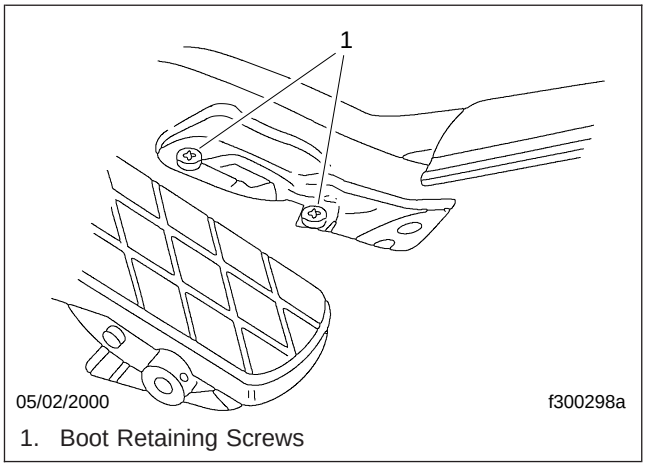
5. Remove the two nuts and the throttle pedal from the throttle pedal arm. See **Fig. 3**.



1. Throttle Pedal Nut

Fig. 3, Throttle Pedal Nut

6. Remove the screws attaching the throttle pedal arm boot to the vehicle. See **Fig. 4**.



1. Boot Retaining Screws

Fig. 4, Throttle Pedal Arm Boot Screws

7. Remove the throttle pedal arm and the boot from the vehicle.

Throttle Pedal Replacement, Engines with Electronic Automatic Transmissions

NOTE: Make sure that the roller on the throttle pedal switch is fully seated in the groove on the back side of the throttle pedal.

8. Place the throttle pedal arm and the boot in position in the vehicle.
9. Install the throttle pedal arm boot retaining screws. Tighten the screws securely.
10. Place the throttle pedal on the throttle pedal arm and install the retaining nuts. Tighten the nuts securely.
11. Attach the throttle linkage to the throttle pedal arm, install the retaining nut, and tighten it securely.
12. Place the throttle pedal in position and install the mounting fasteners. Tighten the fasteners securely.
13. Depress the throttle pedal several times and ensure that the pedal does not stick or bind.
14. Lower the hood.
15. Remove the chocks from the tires.
16. Test drive the vehicle and ensure that the throttle system operates properly.

Throttle Pedal Replacement, Engines with Non-Electronic Automatic Transmissions

Replacement

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Remove the nut and the throttle linkage from the throttle pedal arm. See **Fig. 1**.

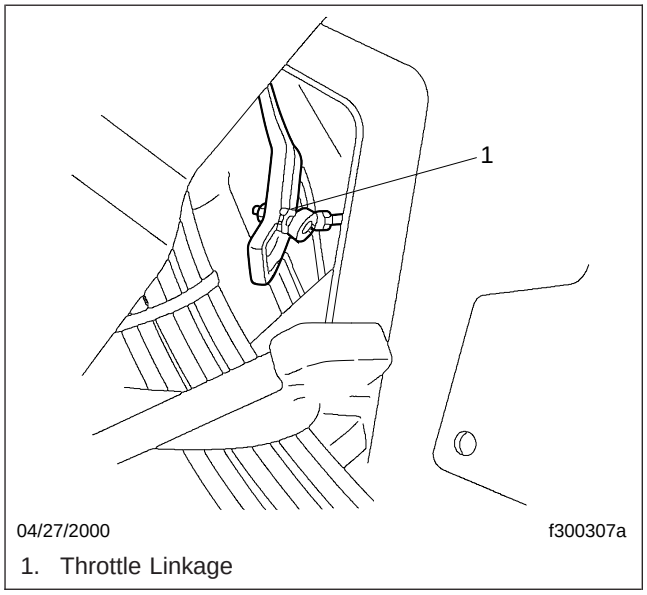


Fig. 1, Throttle Linkage

4. Remove the nut and the transmission modulator cable from the throttle pedal arm.
5. Remove the throttle pedal mounting fasteners. See **Fig. 2**.
6. Remove the two nuts and the throttle pedal from the throttle pedal arm. See **Fig. 3**.
7. Remove the two screws attaching the throttle pedal arm boot to the vehicle. See **Fig. 4**.
8. Remove the throttle pedal arm and boot from the vehicle.
9. Place the throttle pedal arm and the boot in position in the vehicle.
10. Install the throttle pedal arm boot retaining screws and tighten them securely.

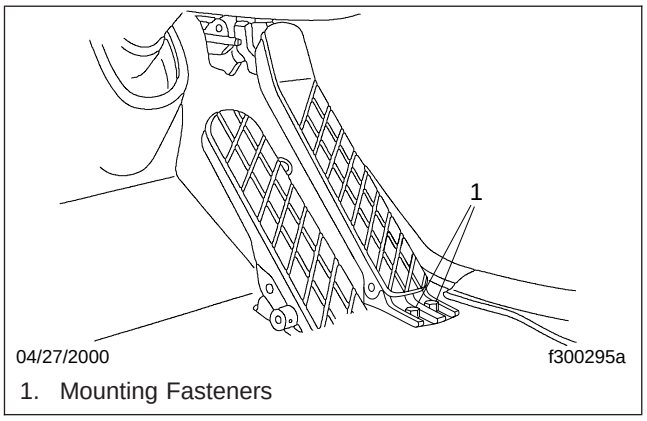


Fig. 2, Throttle Pedal Mounting Fasteners

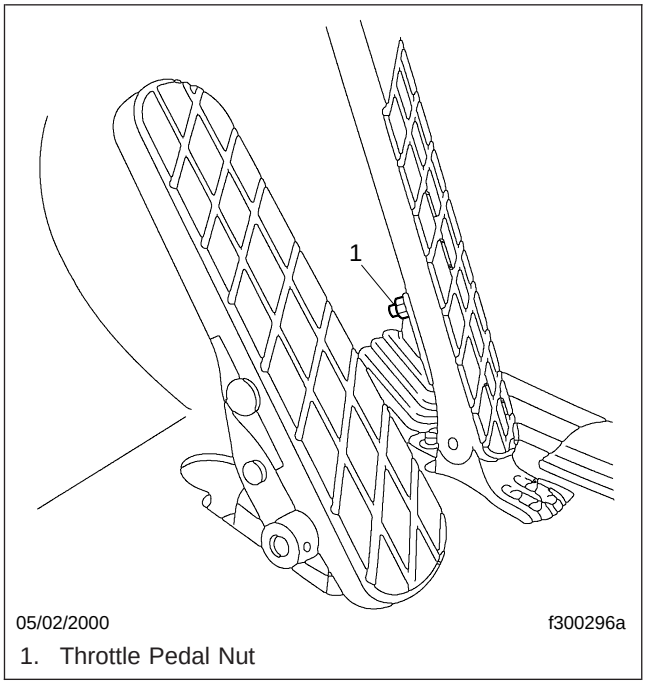
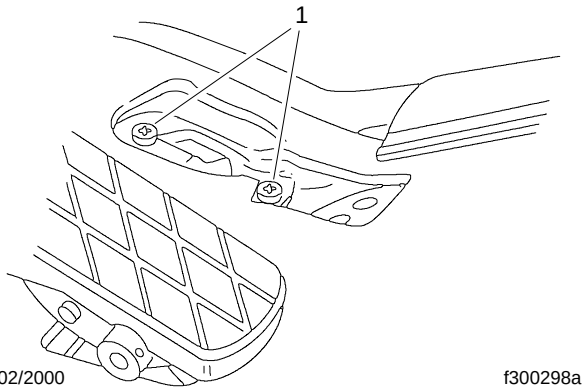


Fig. 3, Throttle Pedal Nut

11. Place the throttle pedal on the throttle pedal arm and install the retaining nuts. Tighten the nuts securely.
12. Place the throttle pedal in position and install the mounting fasteners. Tighten the fasteners securely.
13. Attach the transmission modulator cable to the throttle pedal arm and install the retaining nut. Tighten the nut securely.

Throttle Pedal Replacement, Engines with Non-Electronic Automatic Transmissions



1. Boot Retaining Screws

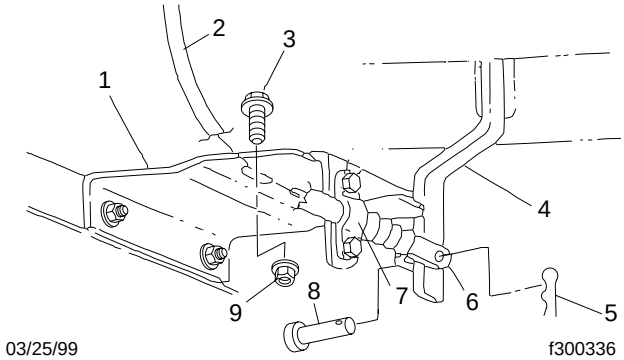
Fig. 4, Throttle Pedal Arm Boot Screws

14. Attach the throttle linkage to the throttle pedal arm and install the retaining nut. Tighten the nut securely.
15. Depress the throttle pedal several times and ensure that the pedal does not stick or bind.
16. Lower the hood.
17. Remove the chocks from the tires.
18. Test drive the vehicle and ensure that the throttle system operates properly.

Throttle Pedal Replacement, Engines with Manual Transmissions

Replacement

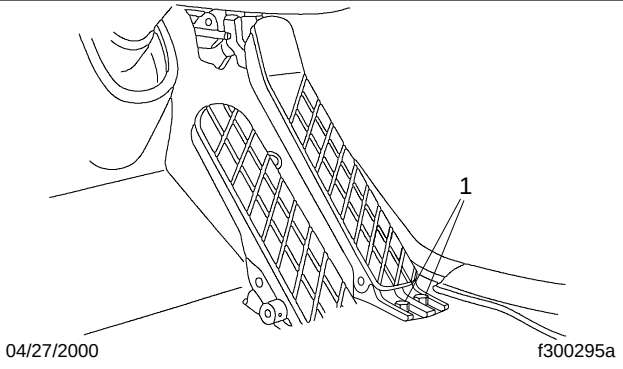
1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Disconnect the throttle cable from the throttle pedal arm. See **Fig. 1**.



1. Throttle Cable Mounting Bracket
2. Throttle Cable
3. Bolt
4. Throttle Pedal Arm
5. Clevis Pin Clip
6. Clevis
7. Throttle Cable Retaining Bracket
8. Clevis Pin
9. Locknut

Fig. 1, Throttle Pedal Arm-to-Cable and Components

4. Remove the two throttle pedal mounting fasteners. See **Fig. 2**.



1. Mounting Fasteners

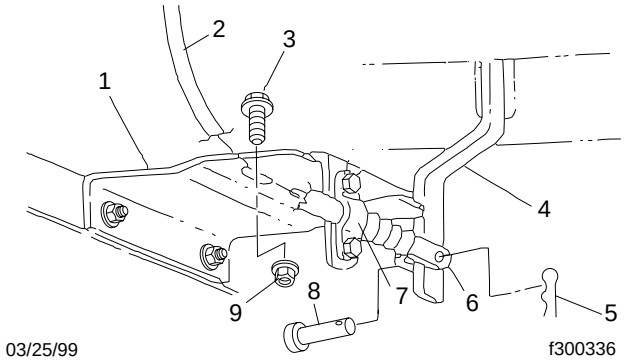
Fig. 2, Throttle Pedal Mounting Fasteners

5. Remove the pedal by pulling the arm through the grommet.
6. Insert the throttle pedal arm through the grommet.
7. Place the pedal in position, then install the throttle pedal mounting fasteners and tighten them securely. See **Fig. 2**.
8. Attach the throttle cable to the throttle pedal arm. See **Fig. 1**.
9. Lower the hood.
10. Remove the chocks from the tires.
11. Test drive the vehicle and ensure that the throttle system operates properly.

Cummins Engine Throttle Linkage Replacement

Replacement

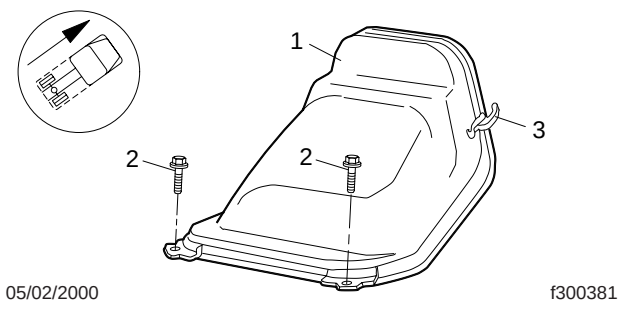
1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Disconnect the throttle cable from the throttle pedal arm. See **Fig. 1**.
4. Loosen the two throttle cable retaining bracket screws. See **Fig. 1**.



1. Throttle Cable Mounting Bracket
2. Throttle Cable
3. Retaining Screw
4. Throttle Pedal Arm
5. Clevis Pin Clip
6. Clevis
7. Throttle Cable Retaining Bracket
8. Clevis Pin
9. Locknut

Fig. 1, Throttle Pedal Arm-to-Cable and Components

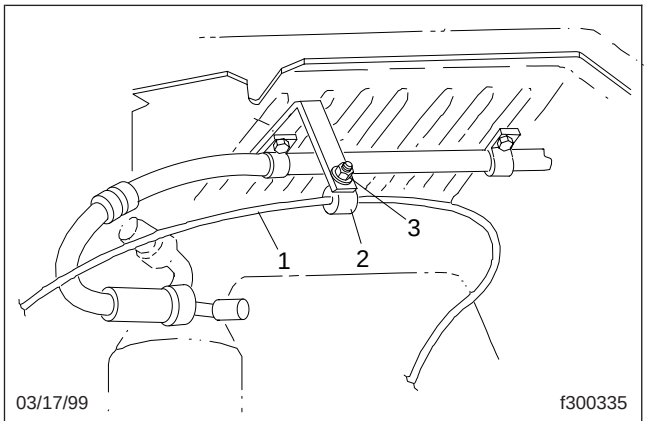
5. Remove the engine cover. See **Fig. 2**.



1. Engine Cover
2. Engine Cover Retaining Bolt (2)
3. Engine Cover Latch (2)

Fig. 2, Engine Cover Assembly

6. Loosen the throttle cable retaining bracket bolt. See **Fig. 3**.



1. Throttle Cable
2. Throttle Cable Retaining Bracket
3. Retaining Bracket Bolt

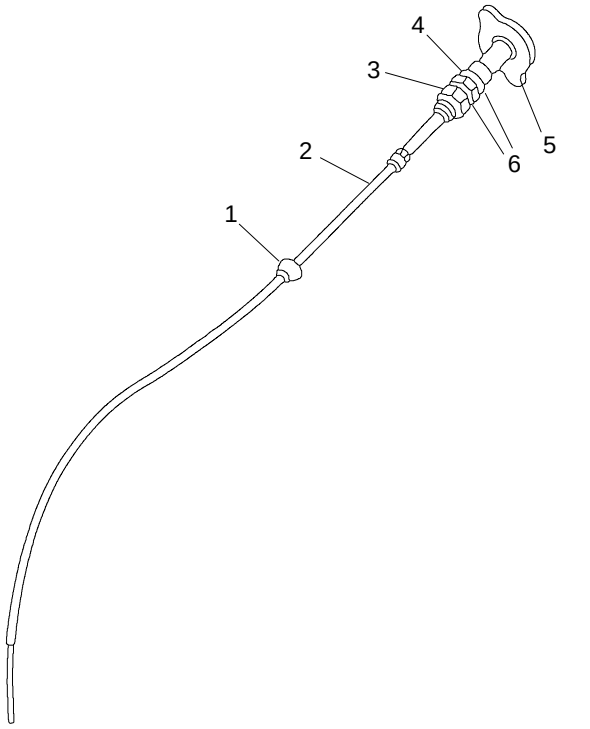
Fig. 3, Throttle Cable and Retaining Bracket

7. Loosen the jam nut on the throttle cable bracket.
8. Disconnect the throttle cable from the fuel injection pump throttle lever.
9. Replace the cable.
10. Route the throttle cable into position.
11. Insert the throttle cable into the jam nut bracket, then tighten the jam nut.
12. Connect the engine end of the throttle cable to the fuel injection pump throttle lever (insert the clevis pin and the cotter pin).
13. Install the engine cover. See **Fig. 2**.
14. Tighten the throttle cable bracket bolt. See **Fig. 3**.
15. Connect the throttle cable to the throttle pedal arm. See **Fig. 1**.
16. Lower the hood.
17. Remove the chocks from the tires.
18. Test drive the vehicle and ensure that the throttle system operates properly.

Locking T-Handle and Vernier Hand Throttle Control Cable Replacement

Replacement

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Loosen the setscrew and remove the hand throttle control cable from the bracket, see **Fig. 1** or **Fig. 2**.

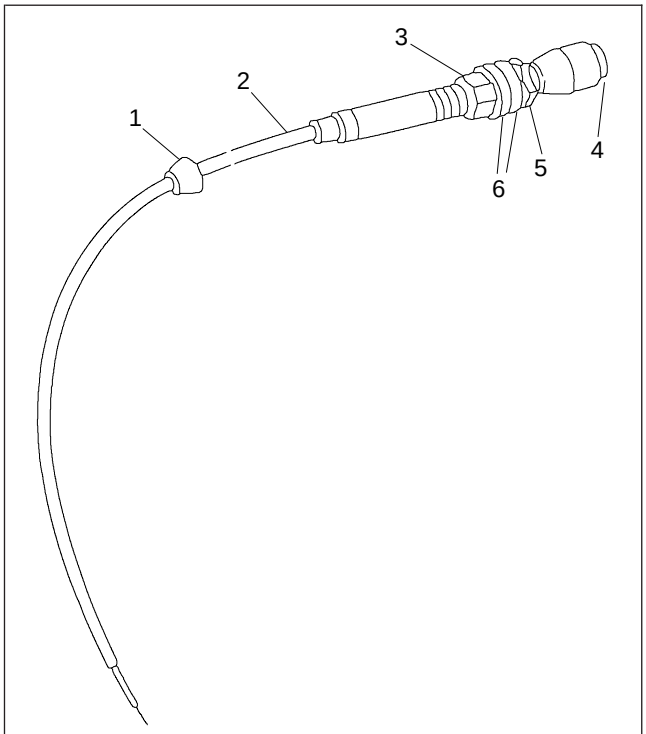


02/11/98 f300305

1. Grommet
2. Hand-Throttle Cable Assembly
3. Nut
4. Bezel
5. T-Handle
6. Washer

Fig. 1, Locking T-Handle Hand Control Throttle

4. Loosen the screw and remove the cable from the retaining clamp.
5. Remove the nut and washer from the cable.
6. Pull the cable and the upper and the lower bezel out of the dash panel.



02/11/98 f300306

1. Grommet
2. Hand-Throttle Cable Assembly
3. Nut
4. Vernier Handle
5. Bezel
6. Washer

Fig. 2, Vernier Hand Control Throttle

7. Install the upper and the lower bezel on the cable.
8. Place the cable in position in the dash panel.
9. Slide the washer and the nut onto the cable.
10. Install the nut on the cable.
11. Insert the cable through the bulkhead.
12. Slide the cable through the retaining clamp.
13. Tighten the screw on the retaining clamp.
14. Slide the cable through the fuel injection pump control lever.
15. With the hand control cable in the idle position (pushed fully in), pull the cable end tight. Then, tighten the setscrew on the fuel injection pump control lever.

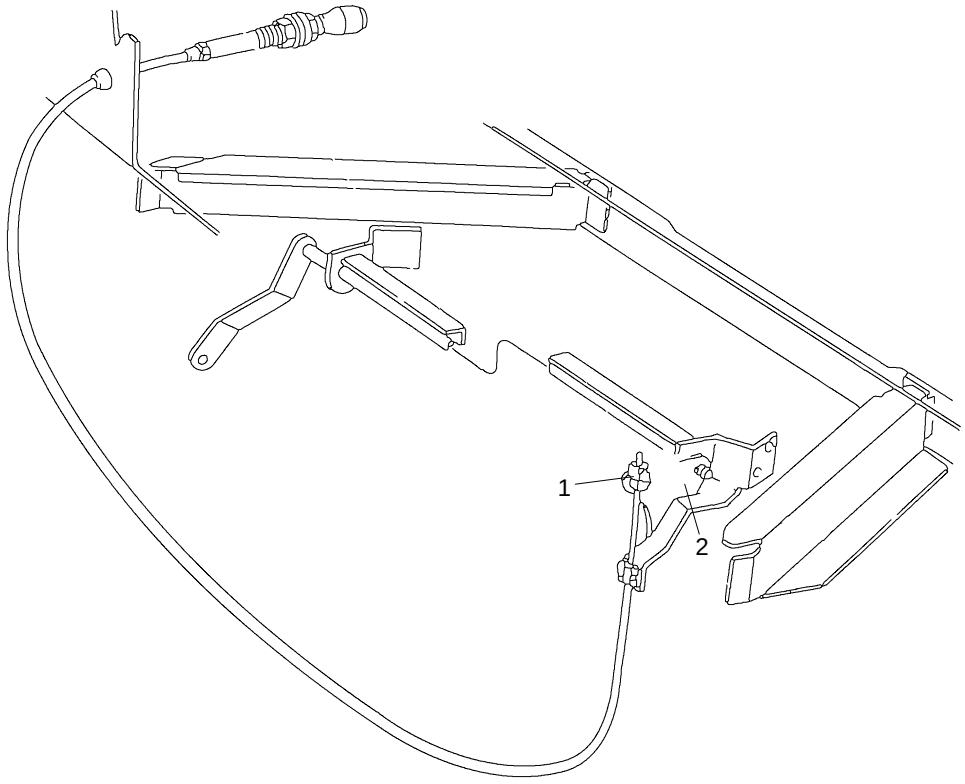
Locking T-Handle and Vernier Hand Throttle Control Cable Replacement

16. Start the engine and check the hand throttle for proper operation.
17. Lower the hood.
18. Remove the chocks from the tires.
19. Test drive the vehicle and ensure that the throttle system operates properly.

Caterpillar Engine Vernier Hand Throttle Control Cable Adjustment

Adjustment

CATERPILLAR 3306 (See Fig. 1)



07/20/98 f300317

1. Setscrew
2. Bellcrank

Fig. 1, Hand Throttle Adjustment (3306)

IMPORTANT: Make sure that the hand throttle control cable is completely depressed, and that it is not in the locked position.

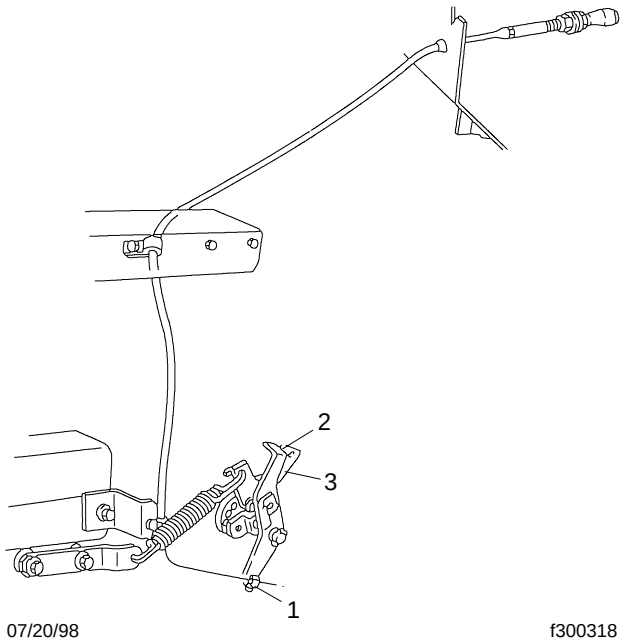
1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. Loosen the setscrew on the stop block.
4. Press the bellcrank downward against the stop.
5. Slide the stop block toward the bellcrank until it is 1/8 inch (3 mm) from the bellcrank.
6. Tighten the setscrew.
7. Test the hand throttle for proper operation.

CATERPILLAR 3406C (See Fig. 2)

IMPORTANT: Make sure that the hand throttle control cable is completely depressed, and that it is not in the locked position.

1. Loosen the setscrew on the stop block.
2. Pivot the swivel toward the throttle lever until it is 1/8 inch (3 mm) from the throttle lever.
3. Tighten the setscrew.
4. Test the hand throttle for proper operation.
5. Lower the hood.

Caterpillar Engine Vernier Hand Throttle Control Cable Adjustment



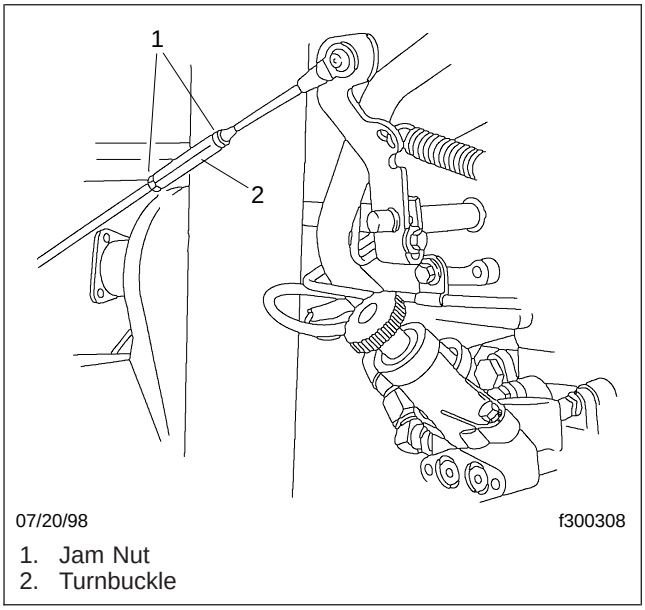
1. Setscrew
2. Swivel
3. Throttle Lever

Fig. 2, Hand Throttle Adjustment (3406C)

6. Remove the chocks from the tires.
7. Test drive the vehicle and ensure that the throttle system operates properly.

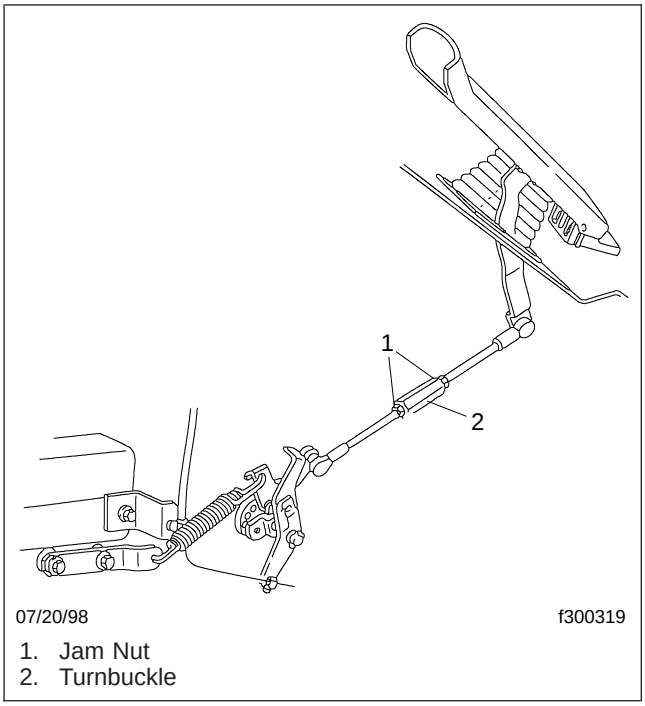
Caterpillar Engine Throttle Linkage Adjustment

Adjustment (See Fig. 1 or Fig. 2)



1. Jam Nut
2. Turnbuckle

Fig. 1, Throttle Linkage (3306)



1. Jam Nut
2. Turnbuckle

Fig. 2, Throttle Linkage (3406C)

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Open the hood.
3. For Caterpillar 3406C engines, hold the throttle pedal at full throttle.

   For Caterpillar 3306 engines, hold the throttle pedal 1/4 inch (6 mm) from full throttle.
4. Loosen the jam nuts on the throttle linkage.
5. Adjust the throttle linkage turnbuckle until the fuel injection pump throttle lever is tight against the full throttle stop.
6. Turn the turnbuckle two additional turns.
7. Tighten the jam nuts 84 to 120 lbf·in (949 to 1356 N·cm).

IMPORTANT: Do not allow any surrounding engine components to contact any moving part of the accelerator controls.

8. Depress and release the throttle pedal several times and ensure that no sticking or binding occurs.
9. Lower the hood.
10. Remove the chocks from the tires.
11. Test drive the vehicle and ensure that the throttle system operates properly.

Troubleshooting

INSPECTION AND VERIFICATION

Linkage

Exercise care when making a repair on or around the throttle pedal linkage and controls. Inspect the throttle pedal and the attaching linkage for damage or distortion that can bind or limit throttle pedal travel. Nothing should contact or rub the moving throttle components. Inspect the throttle linkage for interferences any time a repair is made around the linkage. Inspect the throttle linkage for damage or wear. Also, inspect the engine idle speed adjustment to make sure that the idle speed specification is correct after any throttle linkage adjustment or repair.

Problem—Throttle Pedal is Hard to Push Down or Has a Rough/Raspy or Sticky Feel

Problem—Throttle Pedal is Hard to Push Down or Has a Rough/Raspy or Sticky Feel	
Possible Cause	**Remedy**
Damaged or worn throttle pedal linkage	Operate the throttle pedal and shaft by hand, observing and feeling that the full pedal range of travel is not restricted by the dash panel insulator or carpet/mat/padding. If full pedal travel to maximum high idle is restricted, adjust the insulator or trim items as required. Disconnect the throttle linkage from the throttle pedal. Check the throttle pedal and shaft for free operation. If the pedal operation is free, service the throttle linkage as necessary.

Specifications

Torque Specifications	
Description	**lbf·in (N·cm)**
Throttle Linkage Jam Nut	84 to 120 (949 to 1356)

Table 1, Torque Specifications

Accelerator Pedal Assembly

The Williams electronic accelerator pedal provides an electrical signal to the engine in response to the driver's demand for engine power. The accelerator pedal converts pressure into an electrical signal via the pedal position sensor.

Pedal Position Sensor

Sterling Trucks uses various pedal position sensors, depending on the engine. The pedal position sensor is mounted on the side of suspended pedal assemblies, and on the cab wall above floor-mounted pedal assemblies. The sensor and the pedal assembly are both separately replaceable.

NOTE: Vehicles manufactured on or after July 16, 2007, do not have replaceable sensors. The new pedal assemblies use thread-forming screws to mount the sensor to the pedal housing. Sensor replacement will strip the threads, so the entire pedal assembly must be replaced when a new sensor is needed.

There are three basic technologies employed on pedal position sensors used with electronic engines:

- A ratiometric sensor that generates a DC voltage output in proportion to the pedal position. The ratiometric sensor is used on Detroit Diesel, Mercedes-Benz, and pre-EPA07 Cummins engines.
- A pulse-width-modulating (PWM) sensor that generates a series of discrete voltage pulses. The width of the pulses is proportional to the pedal position. A narrower pulse width indicates a smaller accelerator pedal request and a wider pulse width indicates a larger pedal request. The PWM sensor is used on Caterpillar engines.
- A dual ratiometric sensor that uses Hall effect technology to generate two analog outputs that are proportional to the pedal position. The primary output is twice the voltage of the secondary output. The dual sensor is used on EPA07 Cummins engines.

An idle validation switch (IVS) is integrated into some ratiometric pedal position sensors. The IVS is a single-pole, double-throw switch. Some engine models monitor both switched poles, and some monitor only one pole. When the accelerator pedal returns to idle, the IVS moves to the "idle" position to signal the engine that the pedal has returned to idle. The IVS is not a serviceable part. If the IVS malfunctions, the sensor must be replaced.

Floor-Mounted Pedal Removal and Installation

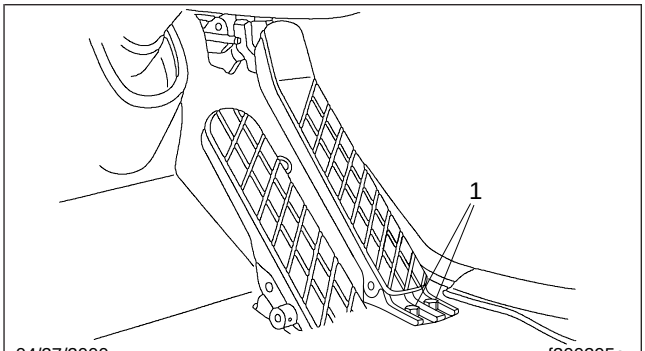
Left-hand drive (LHD) vehicles built on or after March 1, 2004, and right-hand drive (RHD) vehicles built after April 4, 2005, have suspended accelerator pedal assemblies only. For instructions on removing or installing a suspended accelerator pedal, see **Subject 130**.

Floor-mounted accelerator pedals can be removed in one of two ways, depending on the transmission type. Use the appropriate procedure below, based on the transmission in the vehicle.

Engines with Electronic Automatic Transmissions

Removal

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries.
3. Remove the accelerator pedal mounting fasteners. See **Fig. 1**. Remove the pedal.



1. Mounting Fastener

Fig. 1, Accelerator Pedal Mounting Fasteners

Installation

1. Align the accelerator pedal assembly with the mounting holes in the cab floor. Install the two mounting fasteners and tighten them securely.
2. Connect the batteries.
3. Test the pedal operation using the diagnostic software tool specified in **Table 1**.

Diagnostic Software Tools	
Engine Manufacturer	**Software Tool**
Caterpillar	Caterpillar Electronic Technician (CAT ET)
Cummins	INSITE
Detroit Diesel	Detroit Diesel Diagnostic Link
Mercedes-Benz	Detroit Diesel Diagnostic Link

Table 1, Diagnostic Software Tools

Engines with Non-Electronic Automatic Transmissions

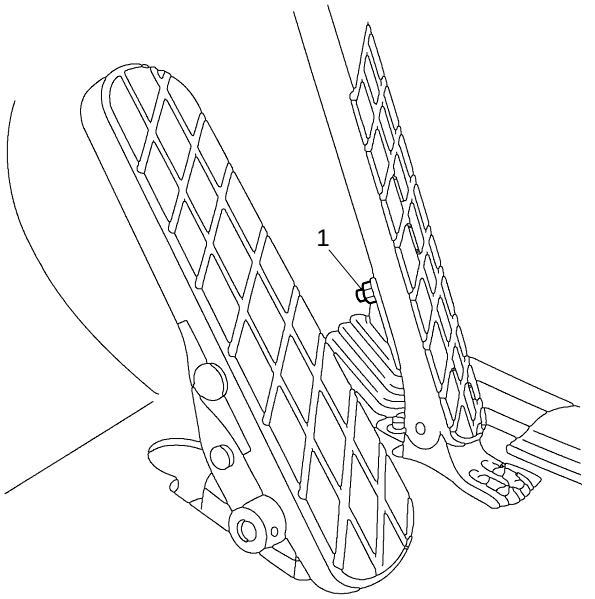
Removal

1. Apply the parking brakes and chock the tires.
2. Open the hood.
3. Remove the two accelerator pedal mounting fasteners. See **Fig. 1**.
4. Remove the two accelerator pedal nuts and the accelerator pedal from the pedal arm. See **Fig. 2**.
5. Disconnect the transmission modulator cable from the pedal arm.
6. Remove the screws that attach the pedal arm boot to the cab floor. See **Fig. 3**.
7. Remove the pedal arm and boot.

Installation

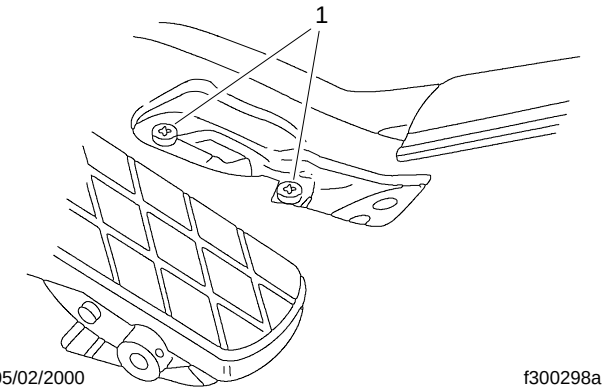
1. Align the pedal arm and boot on the boot retaining holes in the cab floor.
2. Connect the transmission modulator cable to the accelerator pedal arm.
3. Install the pedal arm boot retaining screws.
4. Place the accelerator pedal on the pedal arm and install the pedal nuts. Tighten the nuts securely.
5. Install the two accelerator pedal mounting fasteners and tighten them securely.
6. Test the pedal operation using the diagnostic software tool specified in **Table 1**.

Floor-Mounted Pedal Removal and Installation



1. Accelerator Pedal Nut (2nd nut not shown)

Fig. 2, Accelerator Pedal Nut



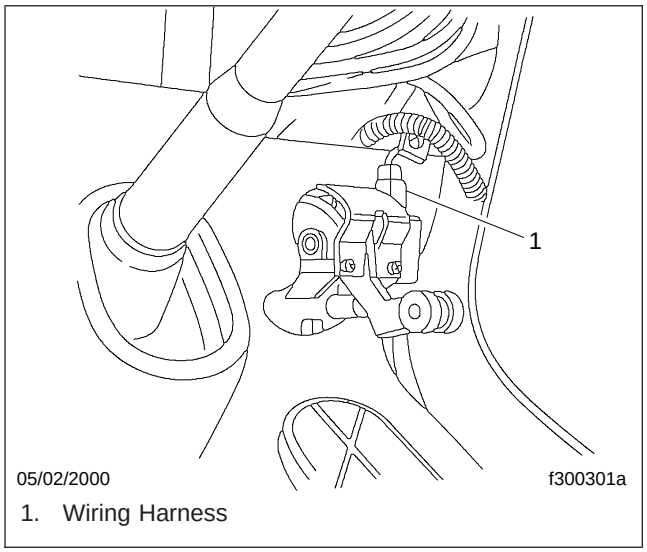
1. Boot Retaining Screw

Fig. 3, Pedal Arm Boot Screws

Floor-Mounted Pedal Position Sensor Replacement

Replacement

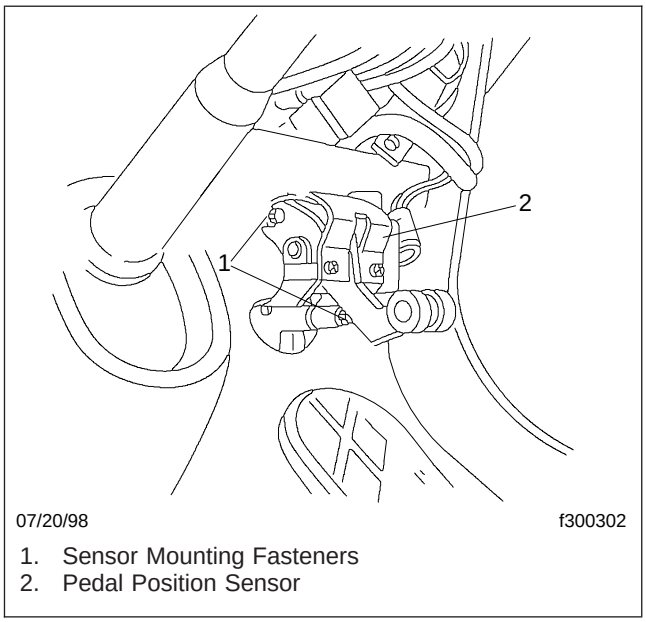
1. Apply the parking brakes and chock the tires.
2. Disconnect the pedal position sensor wiring harness. See **Fig. 1**.



1. Wiring Harness

Fig. 1, Pedal Position Sensor

3. Remove the accelerator pedal assembly. See **Subject 100** for instructions.
4. Remove the two pedal position sensor mounting fasteners. See **Fig. 2**. Remove the pedal position sensor.
5. Align the new pedal position sensor on the cab wall, and install the two mounting fasteners. Tighten the fasteners 80 to 115 lbf·in (900 to 1300 N·cm).
6. Connect the pedal position sensor wiring harness.
7. Install the accelerator pedal assembly. See **Subject 100** for instructions.



1. Sensor Mounting Fasteners
2. Pedal Position Sensor

Fig. 2, Pedal Position Sensor Assembly

Suspended Pedal Removal and Installation

The following procedures may be performed on suspended pedals only. For instructions on removing or installing a floor-mounted accelerator pedal assembly, see **Subject 100**.

Suspended accelerator pedals can be removed in one of two ways. Use the appropriate procedure below, based on the when the vehicle was manufactured.

Vehicles Built Before March 1, 2004

Removal

1. Apply the parking brakes and chock the tires.
2. Remove the carpeting from around the pedal mounting plate, if necessary.
3. Disconnect the pedal position sensor wiring harness.
4. Remove the two hexhead screws that secure the mounting plate to the bulkhead.
5. Remove the pedal assembly from the vehicle.
6. Disassemble the pedal assembly as needed to access the pedal pin or pedal lever.
   - 6.1 Remove the two screws that secure the saddle clamp to the housing. See **Fig. 1**.
   - 6.2 Remove the saddle clamp from the housing.
   - 6.3 Remove the pedal arm, return spring, and pin as an assembly from the housing.
   - 6.4 Separate the assembly by pressing the pedal pin out.

Installation

1. Assemble the pedal assembly, if necessary.
   - 1.1 Press the pedal pin into the return spring and pedal arm.
   - 1.2 Position the pedal lever and return spring assembly in the housing.
   - 1.3 Position the saddle clamp.
   - 1.4 Install the two screws that secure the saddle clamp to the housing.
2. Align the accelerator pedal assembly with the mounting holes on the inside of the bulkhead and install the two hexhead screws that secure the mounting plate to the bulkhead.
3. Connect the pedal position sensor wiring harness.
4. Install the carpeting around the pedal mounting plate, if necessary.
5. Depress the accelerator pedal several times and ensure that the pedal does not stick or bind.
6. Test the pedal operation using the diagnostic software tool specified in **Table 1**.

Diagnostic Software Tools	
Engine Manufacturer	**Software Tool**
Caterpillar	Caterpillar Electronic Technician (CAT ET)
Cummins	INSITE
Detroit Diesel	Detroit Diesel Diagnostic Link
Mercedes-Benz	Detroit Diesel Diagnostic Link

Table 1, Diagnostic Software Tools

Vehicles Built On or After March 1, 2004

Removal

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries.
3. Disconnect the pedal position sensor wiring harness.

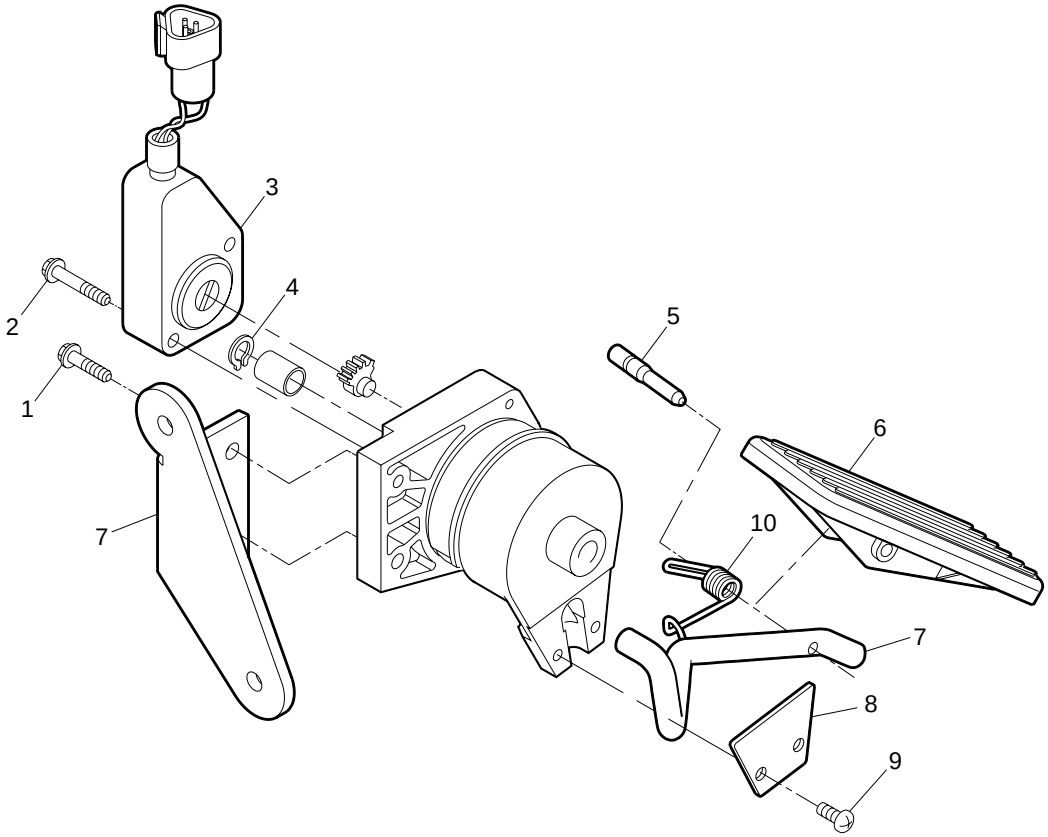
NOTE: It is not necessary to remove either the adaptor bracket or mounting plate when removing the pedal base cup assembly, see **Fig. 2**

4. Remove the four washers and locknuts that secure the accelerator pedal base cup to the mounting plate. Remove the pedal base cup assembly.

Installation

1. Ensure the mounting plate is secured on the four adaptor bracket mounting studs. Align the accelerator pedal base cup on the mounting plate.

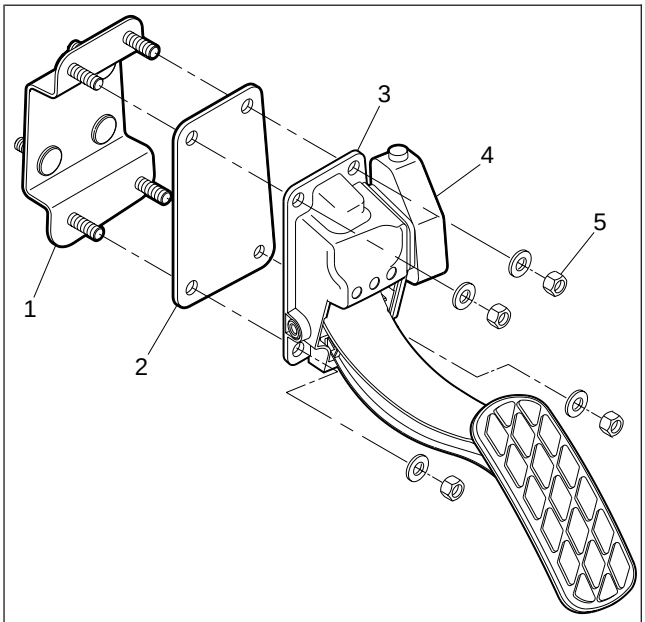
Suspended Pedal Removal and Installation



1. Screw
2. Screw
3. Pedal Position Sensor
4. Retaining Ring
5. Pedal Pin
6. Pedal Pad
7. Pedal Arm
8. Saddle Clamp
9. Screw
10. Pedal Return Spring

Fig. 1, Accelerator Pedal Assembly, Exploded View (vehicles built before March 1, 2004)

2. Install and tighten the pedal mounting washers and locknuts.
3. Connect the pedal position sensor wiring harness.
4. Depress the accelerator pedal several times and ensure that the pedal does not stick or bind.
5. Connect the batteries.
6. Test the pedal operation using the diagnostic software tool specified in **Table 1**.



1. Adaptor Bracket
2. Mounting Plate
3. Pedal Base Cup
4. Pedal Position Sensor
5. Mounting Washer and Locknut (4 qty)

Fig. 2, Accelerator Pedal Assembly (vehicles built on or after March 1, 2004)

Suspended Pedal Position Sensor Replacement

Replacement

This procedure can be performed on suspended pedals only. To replace the pedal position sensor on a floor-mounted pedal, see **Subject 110** for instructions.

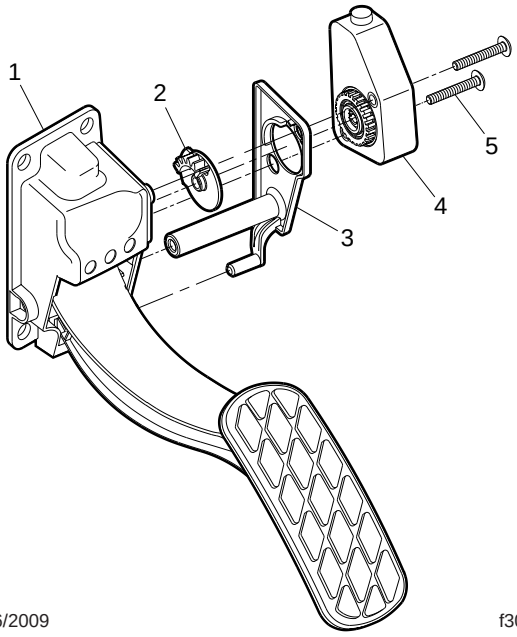
NOTE: Vehicles manufactured on or after July 16, 2007, do not have replaceable sensors. The new pedal assemblies use thread-forming screws to mount the sensor to the pedal housing. Sensor replacement will strip the threads, so the entire pedal assembly must be replaced when a new sensor is needed. See **Subject 130** for instructions.

Replace the pedal position sensor as follows:

1. Apply the parking brakes and chock the tires.
2. Remove the pedal assembly. See **Subject 130** for instructions.
3. Remove the two sensor mounting screws that connect the sensor to the pedal assembly. See **Fig. 1**. Remove the sensor.
4. Align the new sensor with the spline on the pinion gear, then push it into the pedal assembly. Rotate the sensor slightly so the mounting holes line up with the pedal assembly. See **Fig. 1**.
5. Install the sensor mounting fasteners and tighten them 25 to 30 lbf·in (280 to 340 N·cm).
6. Install the pedal assembly. See **Subject 130** for instructions.
7. Connect the sensor wiring harness.
8. Connect the batteries.
9. Test the pedal operation using the diagnostic software tool specified in **Table 1**.

Diagnostic Software Tools	
Engine Manufacturer	**Software Tool**
Caterpillar	Caterpillar Electronic Technician (CAT ET)
Cummins	INSITE
Detroit Diesel	Detroit Diesel Diagnostic Link
Mercedes-Benz	Detroit Diesel Diagnostic Link

Table 1, Diagnostic Software Tools



1. Accelerator Pedal Assembly
2. Pinion Gear
3. Pedal Position Sensor
4. Mounting Screws

Fig. 1, Pedal Position Sensor Installation

Complete the following procedures to diagnose accelerator pedal assembly and pedal position sensor problems.

Common Problems and Indications

The accelerator pedal assembly was designed so that the pedal position sensor will not reach the internal stop points when it is mounted to the pedal assembly. Attempting to modify the sensor or forcing the sensor shaft beyond the internal stop points will result in severe damage to the sensor.

A number of symptoms may be reported that can indicate a problem with the accelerator pedal, pedal position sensor, or wiring to the engine, including:

- low power or poor acceleration
- slow deceleration
- vehicle does not reach top speed
- engine is stuck at idle
- engine brake does not function
- check engine light comes on
- engine fault code indicates a pedal position sensor problem

Diagnostics

IMPORTANT: Vehicles manufactured on or after July 16, 2007, do not have replaceable sensors. The new pedal assemblies use thread-forming screws to mount the sensor to the pedal housing. Sensor replacement will strip the threads, so the entire pedal assembly must be replaced when a new sensor is needed. See **Subject 130** for instructions on replacing the entire pedal assembly.

1. Connect the vehicle to the appropriate diagnostic software tool. See **Table 1** for a list of diagnostic software tools for each engine.

Diagnostic Software Tools	
Engine Manufacturer	**Software Tool**
Caterpillar	Caterpillar Electronic Technician (CAT ET)
Cummins	INSITE
Detroit Diesel	Detroit Diesel Diagnostic Link
Mercedes-Benz	Detroit Diesel Diagnostic Link

Table 1, Diagnostic Software Tools

2. Make a note of the signal values at idle. See **Table 2** for the correct signal values.

NOTE: All desired signal values are approximate. Each individual vehicle and electrical system will exhibit some variation in signal values. The engine control system compensates for this variation. These diagnostic procedures are designed to identify malfunctioning components of the pedal assembly and electrical system.

3. Slowly depress the accelerator pedal and monitor the signals.

NOTE: There is a short time delay between pedal movement and display of the corresponding data.

4. Make a note of all signal values when the pedal has been pressed halfway.
5. Make a note of all signal values at full throttle.
6. Verify idle validation signal (IVS) inputs, if equipped.

NOTE: The pedal position sensor used with Caterpillar engines is a pulse-width modulated (PWM) sensor. It cannot be diagnosed using a digital multimeter set to measure voltage or resistance. A multimeter capable of measuring "duty cycle" may be used to view the sensor output.

The pedal position sensor used with EPA07 Cummins engines uses Hall effect technology. Attempting to measure resistance across the sensor will not provide valid results and may damage the sensor.

7. If any signal does not change, measure the sensor voltage supply and ground circuits with a digital multimeter as follows.

Troubleshooting

7.1 Use EZWiring™ in **www.AccessFreightliner.com** to identify the circuit(s) that supply voltage to the pedal position sensor.

IMPORTANT: The ignition key must be in the ON position.

7.2 Disconnect the connector nearest the pedal and measure the voltage supply.

8. If a 5-volt supply is not present, look for a fault in the circuit between the pedal and the common powertrain controller (Detroit Diesel and Mercedes-Benz) or the motor control module (Caterpillar and Cummins engines).
9. Inspect and ensure that all connector pins at the pedal position sensor, frontwall, and the engine controller are free of corrosion and are not bent or damaged. Inspect and ensure that the connections between the pins and the wires are secure and also free of corrosion.
10. If the problem has not been resolved, the problem is not with the pedal position sensor. See the engine manufacturer's service literature for further guidance.

Diagnostic Software Values*			
Engine	**Signal**	**Pedal Position**	**Desired Value†**
Caterpillar, pre-EPA07	Throttle Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	Duty Cycle	Idle	15%
		Full throttle	85%
		Between idle/full throttle	Varies smoothly between 15% and 85%
Caterpillar, EPA07	Accelerator Pedal Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	Throttle Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	Duty Cycle	Idle	15%
		Full throttle	85%
		Between idle/full throttle	Varies smoothly between 15% and 85%

Diagnostic Software Values*			
Engine	**Signal**	**Pedal Position**	**Desired Value†**
Cummins, pre-EPA07	Accelerator Pedal Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	Accelerator Pedal Sensor	Idle	0.5 volts
		Full throttle	4.5 volts
		Between idle/full throttle	Varies smoothly between 0.5 and 4.5 volts
	IVS	Idle	ON
		Full throttle	OFF
	Sensor Supply	Idle	5.0 volts
		Full throttle	5.0 volts
		Between idle/full throttle	5.0 volts
Cummins, EPA07	Accelerator Pedal Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	Accelerator Pedal Sensor	Idle	1.0 volts
		Full throttle	4.5 volts
		Between idle/full throttle	Varies smoothly between 1.0 and 4.5 volts
	Accelerator Pedal Sensor 2	Idle	0.5 volts
		Full throttle	2.25 volts
		Between idle/full throttle	Varies smoothly between 0.5 and 2.25 volts
	Sensor Supply (both)	Idle	5.0 volts
		Full throttle	5.0 volts
		Between idle/full throttle	5.0 volts
Detroit Diesel and Mercedes-Benz, pre-EPA07	Accelerator Pedal Raw Sensor	Idle	15%
		Full throttle	75%
		Between idle/full throttle	Varies smoothly between 15% and 75%
	Accelerator Pedal Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	IVS	Idle	ON (grounded)
		Full throttle	OFF (open)
	Supply Analog Accelerator Pedal	Idle	5.0 volts
		Full throttle	5.0 volts
		Between idle/full throttle	5.0 volts

Troubleshooting

Diagnostic Software Values*			
Engine	**Signal**	**Pedal Position**	**Desired Value†**
Detroit Diesel and Mercedes-Benz, EPA07	Accelerator Pedal Raw Sensor	Idle	15%
		Full throttle	75%
		Between idle/full throttle	Varies smoothly between 15% and 75%
	Accelerator Pedal Position	Idle	0%
		Full throttle	100%
		Between idle/full throttle	Varies smoothly between 0% and 100%
	IVS1	Idle	ON (grounded)
		Full throttle	OFF (open)
	IVS2	Idle	OFF (open)
		Full throttle	ON (grounded)
	Supply Analog Accelerator Pedal	Idle	5.0 volts
		Full throttle	5.0 volts
		Between idle/full throttle	5.0 volts

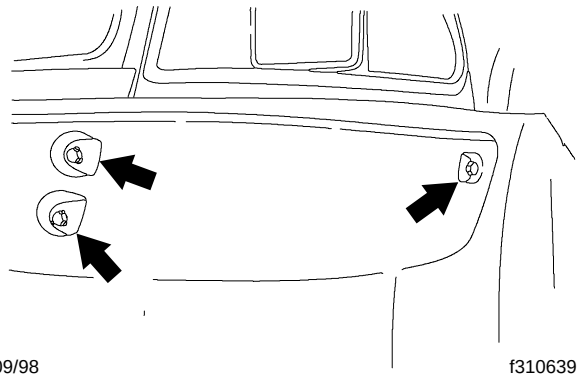
* All desired signal values are approximate. Each individual vehicle and electrical system will exhibit some variation in signal values.

† There is a short time delay between pedal movement and display of the corresponding data.

Table 2, Diagnostic Software Values

L-Line Bumper Removal and Installation

Removal (See Fig. 1)



NOTE: The left-hand bumper is shown; the right-hand bumper is symmetrically opposite.

Fig. 1, L-Line Bumper Bolts

1. Remove the fog lamps, if equipped. For instructions, see **Group 54** in this manual.
2. Remove the six bolts retaining the bumper to the bumper brackets.
3. Remove the bumper.

Installation

1. Position the bumper on the bumper brackets.
2. Install the six bolts and tighten them 110 to 115 lbf·ft (149 to 156 N·m) for steel bumpers and 70 to 95 lbf·ft (95 to 129 N·m) for aluminum bumpers.
3. Install the fog lamps, if equipped. For instructions, see **Group 54** in this manual.

A-Line Bumper Removal and Installation

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the battery.
3. Remove the fog lamps, if equipped. For instructions, see **Group 54** in this manual.
4. Remove the bolts retaining the right-side bumper bracket. See **Fig. 1**.

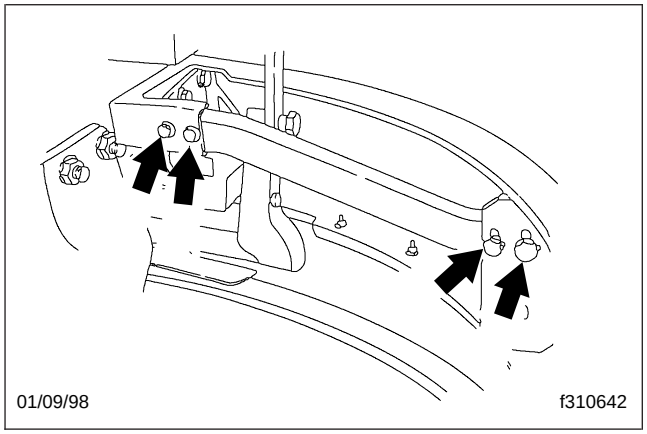


Fig. 1, Right-Side Bumper Bolts

5. Remove the bolts retaining the left-side bumper bracket. See **Fig. 2**.

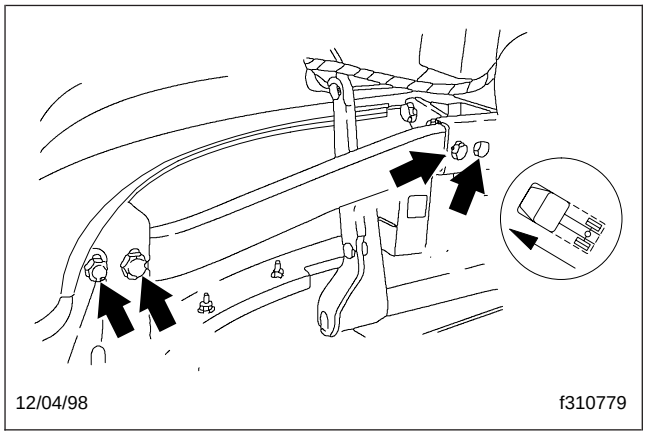


Fig. 2, Left-Side Bumper Bolts

6. Remove the bolts retaining the bumper to the bumper brackets and remove the bumper. See **Fig. 3**.

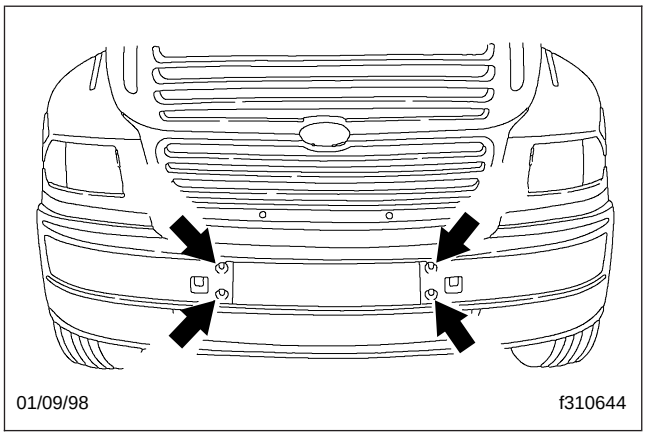


Fig. 3, Bumper-to-Bumper Bracket Bolts

Installation

1. Position the right-side bumper bracket and tighten the bolts 60 lbf·ft (82 N·m). See **Fig. 1**.
2. Position the left-side bumper bracket and tighten the bolts 60 lbf·ft (82 N·m). See **Fig. 2**.
3. Position the bumper on the bumper brackets and install the bumper bolts. Tighten the bolts 85 lbf·ft (115 N·m). See **Fig. 3**.
4. Install the fog lamps, if equipped. For instructions, see **Group 54** in this manual.
5. Connect the battery.
6. Remove the chocks from the tires.

L-Line Vocational Bumper Removal and Installation

Removal (See Fig. 1)

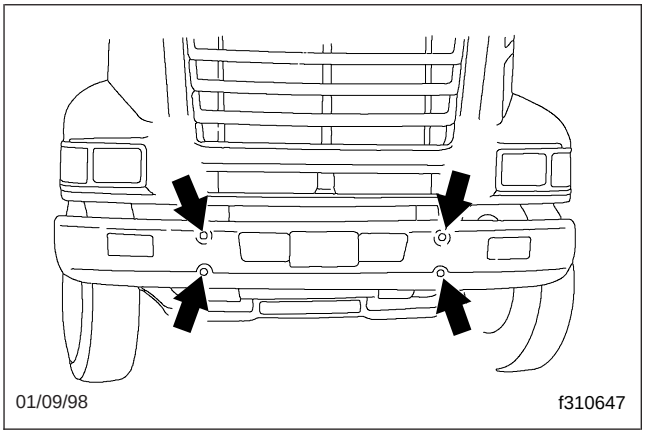


Fig. 1, L-Line Vocational Bumper Retaining Bolts

1. Remove the fog lamps, if equipped. For instructions, see **Group 54** in this manual.
2. Remove the bolts retaining the bumper to the bumper brackets, and remove the bumper.

Installation

1. Position the bumper on the bumper brackets.
2. Install the six bolts and tighten them 110 to 115 lbf·ft (149 to 156 N·m) for steel bumpers and 70 to 95 lbf·ft (95 to 129 N·m) for aluminum bumpers.
3. Install the fog lamps, if equipped. See **Group 54** in this manual.

111-Inch BBC Bumper Removal and Installation

Removal

1. Remove the fog lamps, if equipped. For instructions, see **Group 54** in this manual.
2. Remove the lower bracket bolts. See **Fig. 1**.

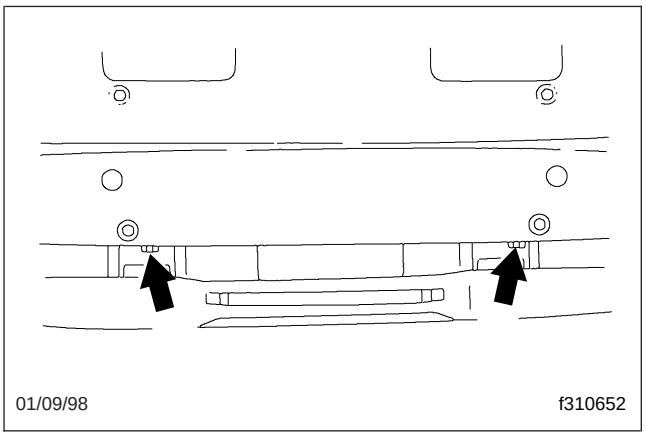


Fig. 1, 111-Inch BBC Bumper Lower Bracket Bolts

3. Remove the bolts retaining the bumper to the vehicle. See **Fig. 2**.

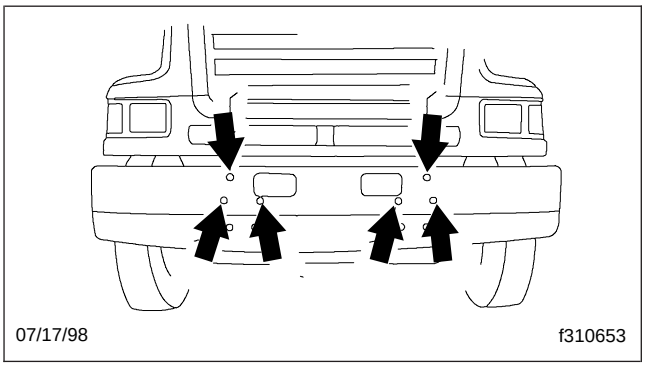


Fig. 2, 111-Inch BBC Bumper Retaining Bolts

Installation

1. Position the bumper on the bumper brackets.
2. Install the six bolts and tighten them 110 to 115 lbf·ft (149 to 156 N·m) for steel bumpers and 70 to 95 lbf·ft (95 to 129 N·m) for aluminum bumpers.
3. Install the lower bracket bolts and tighten them 110 to 115 lbf·ft (149 to 156 N·m) for steel bumpers and 70 to 95 lbf·ft (95 to 129 N·m) for aluminum bumpers.
4. Install the fog lamps, if equipped. See **Group 54** in this manual.

Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Bumper Bolts, L-Line (steel)	110–115 (149–156)
Bumper Bolts, L-Line (aluminum)	70–95 (95–129)
Bumper Bolts, A-Line (side bolts)	60 (82)
Bumper Bolts, A-Line (front bolts)	85 (115)
Bumper Bolts, Vocational, L-Line (steel)	110–115 (149–156)
Bumper Bolts, Vocational, L-Line (aluminum)	70–95 (95–129)
Bumper Bolts, 111-inch BBC (steel)	75–105 (102–142)
Bumper Bolts, 111-inch BBC (aluminum)	55–75 (75–102)
Bumper Bracket Bolts, A-Line	60 (82)

Table 1, Torque Specifications

Aerodynamic Bumper Removal and Installation

Removal

1. Apply the parking brakes, then chock the tires.
2. From both sides, remove the bolts, washers, and nuts that attach the bumper strut assembly to the bumper. See **Fig. 1**.

NOTE: The following step requires two persons.

3. While one person holds the bumper, the other one removes the four capscrews and washers that attach the bumper to the front closing crossmember. Together, remove the bumper from the vehicle. Retain the fasteners.

   If removing a bumper strut assembly, remove the three capscrews and washers that attach the bumper strut assembly to the tow device housing. Retain the fasteners. Repeat on the other side of the bumper as needed.

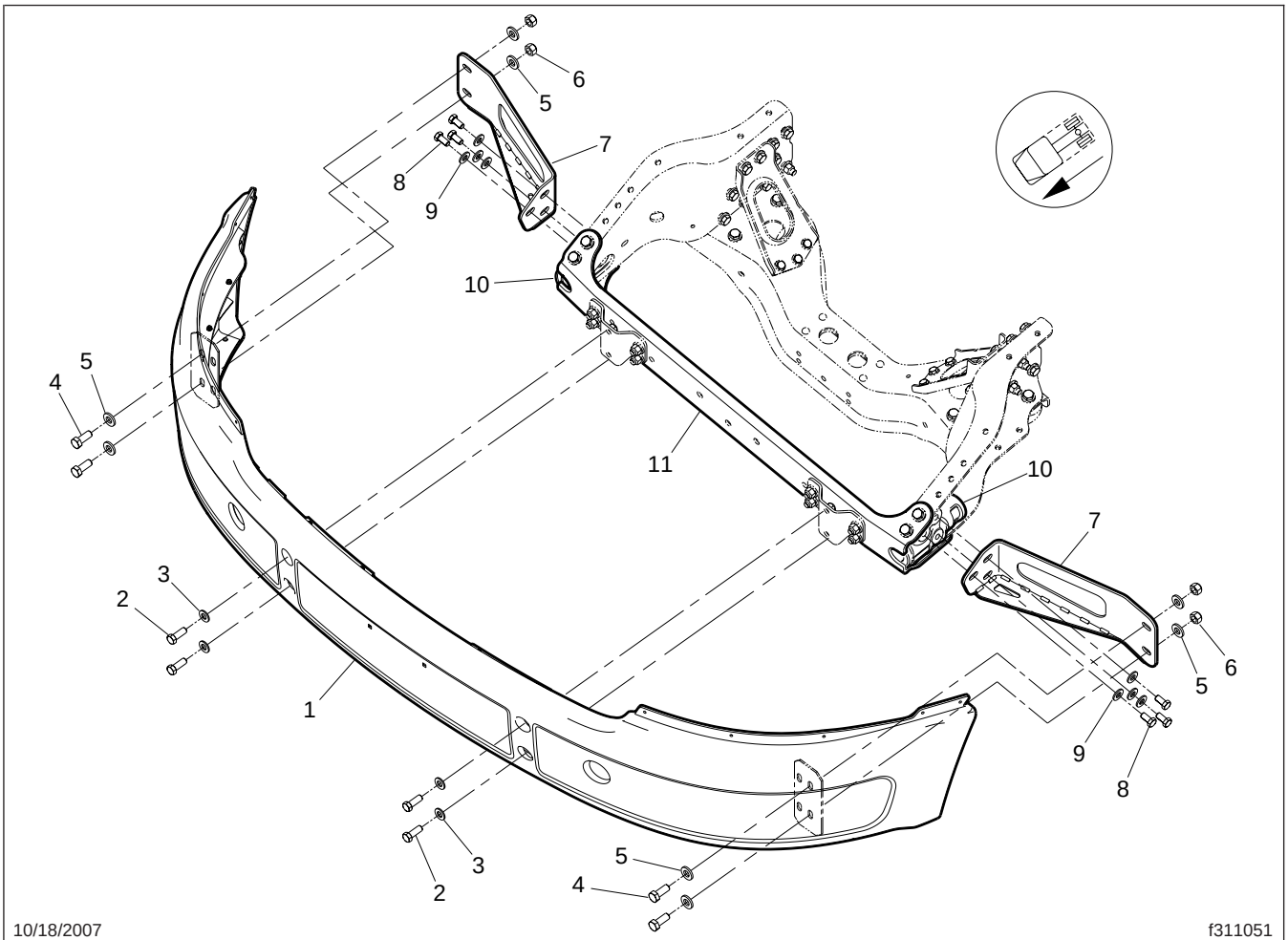
Installation

1. If a bumper strut assembly is not attached to either tow device housing, install the three capscrews and washers that attach a bumper strut assembly to a tow device housing, and tighten the capscrews 68 lbf·ft (92 N·m). Repeat on the other side of the bumper as needed.

NOTE: The following step requires two persons.

2. With each person supporting a side of the bumper, align the openings in the bumper (for the tow devices) with the tow device housings, and mount the bumper on the vehicle. Then, install the four washers and capscrews that attach the bumper to the front closing crossmember. Tighten the capscrews enough to secure the bumper to the vehicle and allow for any adjustments needed to align the bumper and the hood later in this procedure.
3. Install the bolts, washers, and nuts that attach the bumper strut assembly to the bumper. Tighten the fasteners securely, but not to their final torque value.
4. Make any adjustments needed to ensure a consistent gap between the bumper and hood.
5. At the front of the bumper, tighten the fasteners 92 lbf·ft (125 N·m).
6. At each side of the bumper, tighten the fasteners that attach the bumper strut assembly to the bumper 130 lbf·ft (176 N·m).
7. Remove the chocks from the tires.

Aerodynamic Bumper Removal and Installation



1. Bumper
2. Capscrew, Hex, 9/16–12
3. Washer, 1.186/1.149
4. Hexbolt, 9/16–12 x 1-1/2
5. Washer, 0.578 x 1.16 x 0.121
6. Nut
7. Bumper Strut Assembly
8. Capscrew, Hex, 1/2–13 x 1
9. Washer, 0.53 x 1.06 x 0.177
10. Tow Device Housing
11. Front Closing Crossmember

Fig. 1, Bumper and Frame Components

Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Bumper Bolts, L-Line (steel)	110–115 (149–156)
Bumper Bolts, L-Line (aluminum)	70–95 (95–129)
Bumper Bolts, A-Line (side bolts)	60 (82)
Bumper Bolts, A-Line (front bolts)	85 (115)
Bumper Bolts, Vocational, L-Line (steel)	110–115 (149–156)
Bumper Bolts, Vocational, L-Line (aluminum)	70–95 (95–129)
Bumper Bolts, 111-inch BBC (steel)	75–105 (102–142)
Bumper Bolts, 111-inch BBC (aluminum)	55–75 (75–102)
Bumper Bracket Bolts, A-Line	60 (82)

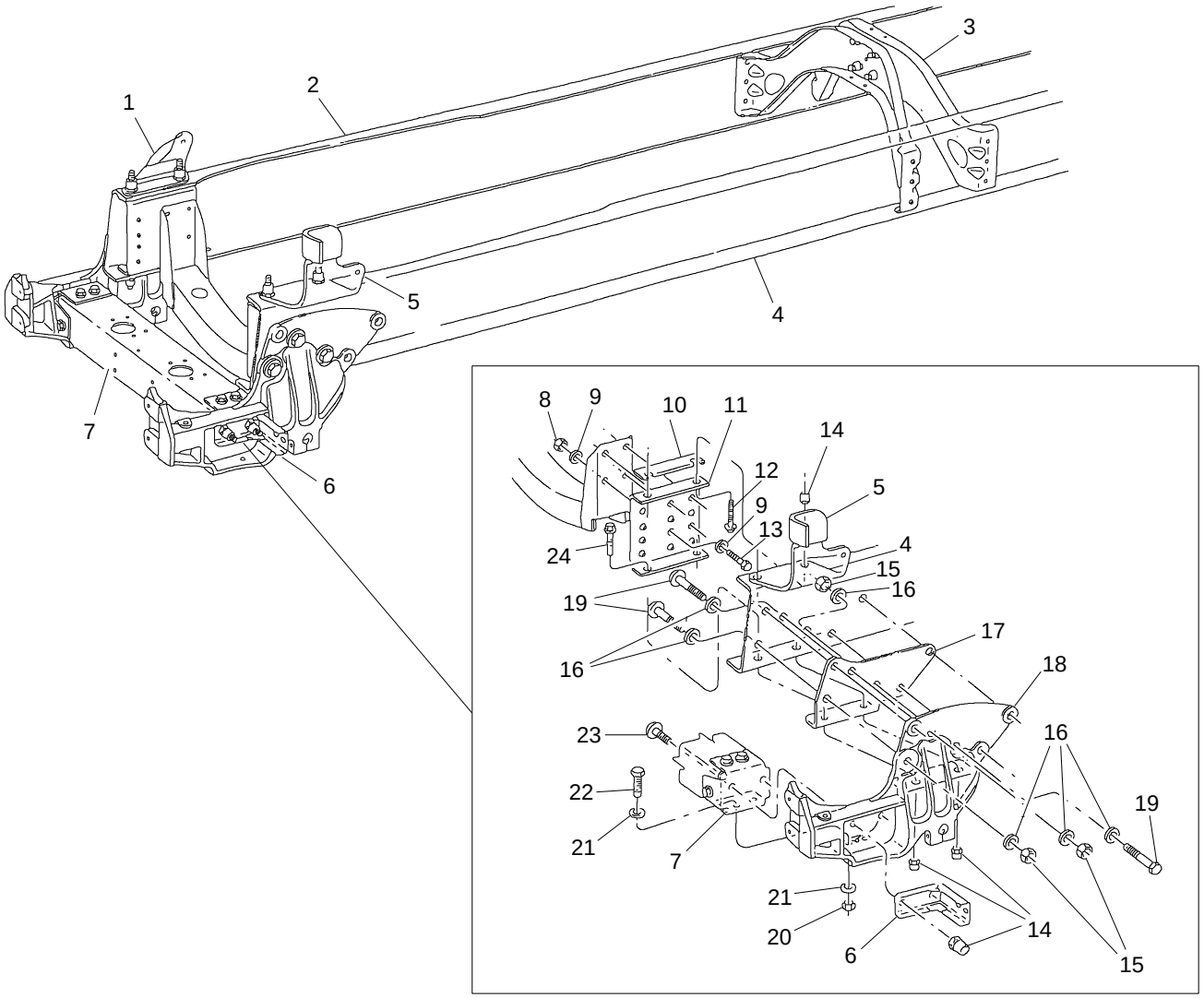
Table 1, Torque Specifications

General Information

The frame consists of two tempered U-channel sidemembers with crossmembers attached between them. The number of crossmembers varies with the vehicle application. See **Fig. 1**, **Fig. 2**, **Fig. 3**, **Fig. 4**, **Fig. 5**, **Fig. 6**, **Fig. 7**, **Fig. 8**, **Fig. 9**, **Fig. 10**, **Fig. 11**, **Fig. 12**, **Fig. 13** and **Fig. 14**.

The frame has provisions for mounting the cab, engine, axles, fifth wheel (tractor only) and body (special purpose vehicles only). Welding and drilling the frame is not permitted.

General Information



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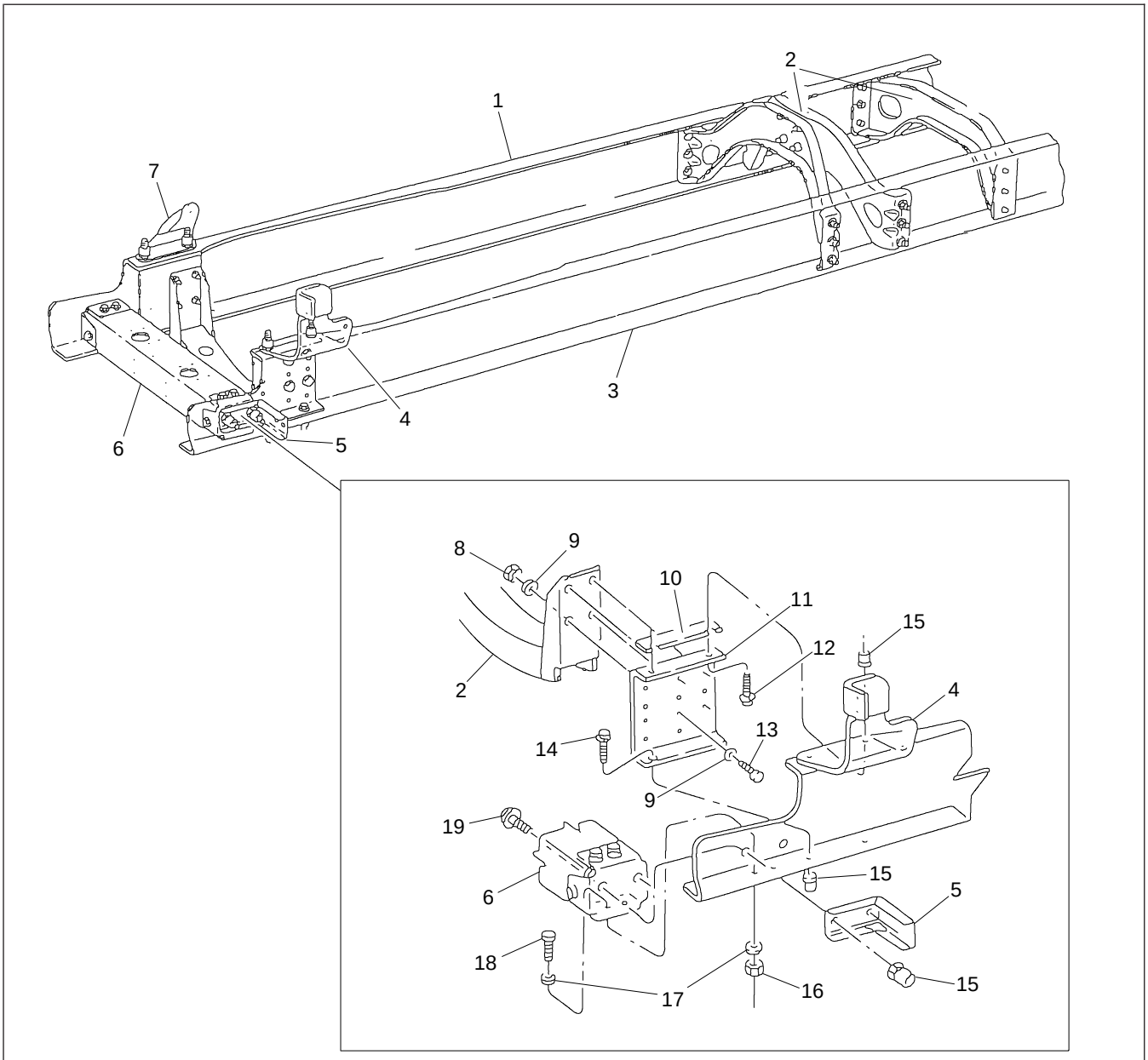
1. Radiator Support Bracket
2. Frame Sidemember (right-hand)
3. Crossmember
4. Frame Sidemember (left-hand)
5. Power Steering Bracket
6. Front Bumper Bracket
7. Radiator Support
8. Nut, 1/2–13 (locking)
9. Washer, 1/2-Inch
10. Spacer
11. Engine Support Bracket (left-hand)
12. Tension Pin, 0.62 x 1.00
13. Bolt, 1/2–13 x 1.50
14. Tension Collar, 0.65 (flagged)
15. Nut, 3/4–10 (locking)
16. Washer, 3/4-Inch
17. Spacer Plate (left-hand)
18. Front Suspension Bracket (left-hand)
19. Bolt, 3/4–10 x 2.75
20. Nut, 5/8–11 (locking)
21. Washer, 5/8-Inch
22. Bolt, 5/8–11 x 1.75
23. Tension Pin, 0.62 x 0.75
24. Tension Pin, 0.62 x 0.50

Fig. 1, Frame Assembly, Front Crossmember, A-Line With 1300 Square-Inch Radiator



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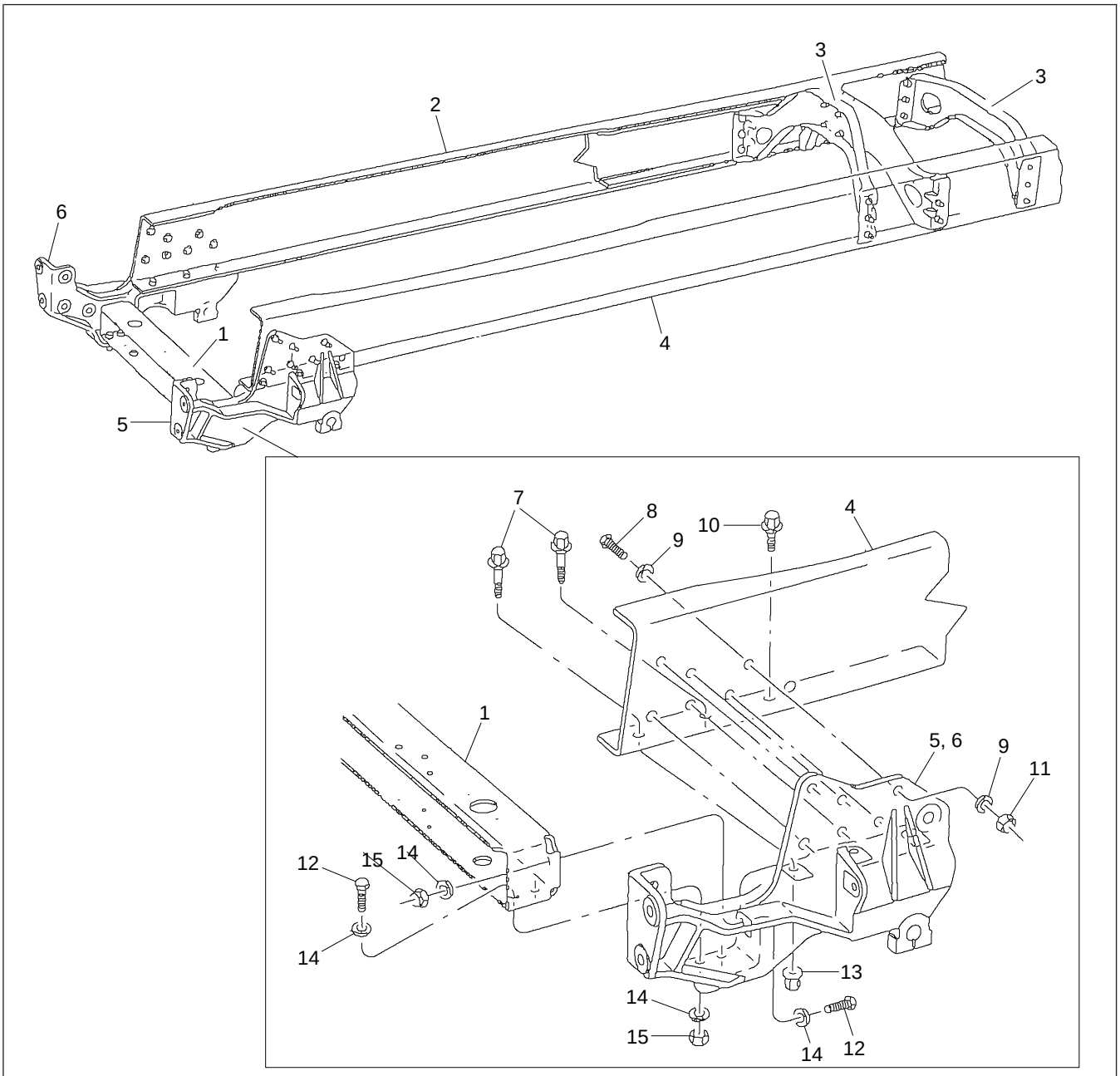
1. Frame Sidemember (right-hand)
2. Crossmember
3. Frame Sidemember (left-hand)
4. Power Steering Reservoir Bracket
5. Front Bumper Bracket
6. Radiator Support
7. Radiator Support Bracket
8. Nut, 1/2–13
9. Washer, 1/2-Inch
10. Spacer
11. Engine Support Bracket (left-hand)
12. Tension Pin, 0.62 x 1.00
13. Bolt, 1/2–13 x 1.50
14. Tension Pin, 0.62 x 0.50
15. Tension Collar, 0.65 (flagged)
16. Nut, 5/8–11 (locking)
17. Washer, 5/8-Inch
18. Bolt, 5/8–1 x 1.75
19. Tension Pin, 0362 x 0.75

Fig. 2, Frame Assembly, Front Crossmember, A-Line With 830, 900 or 1050 Square-Inch Radiator

General Information



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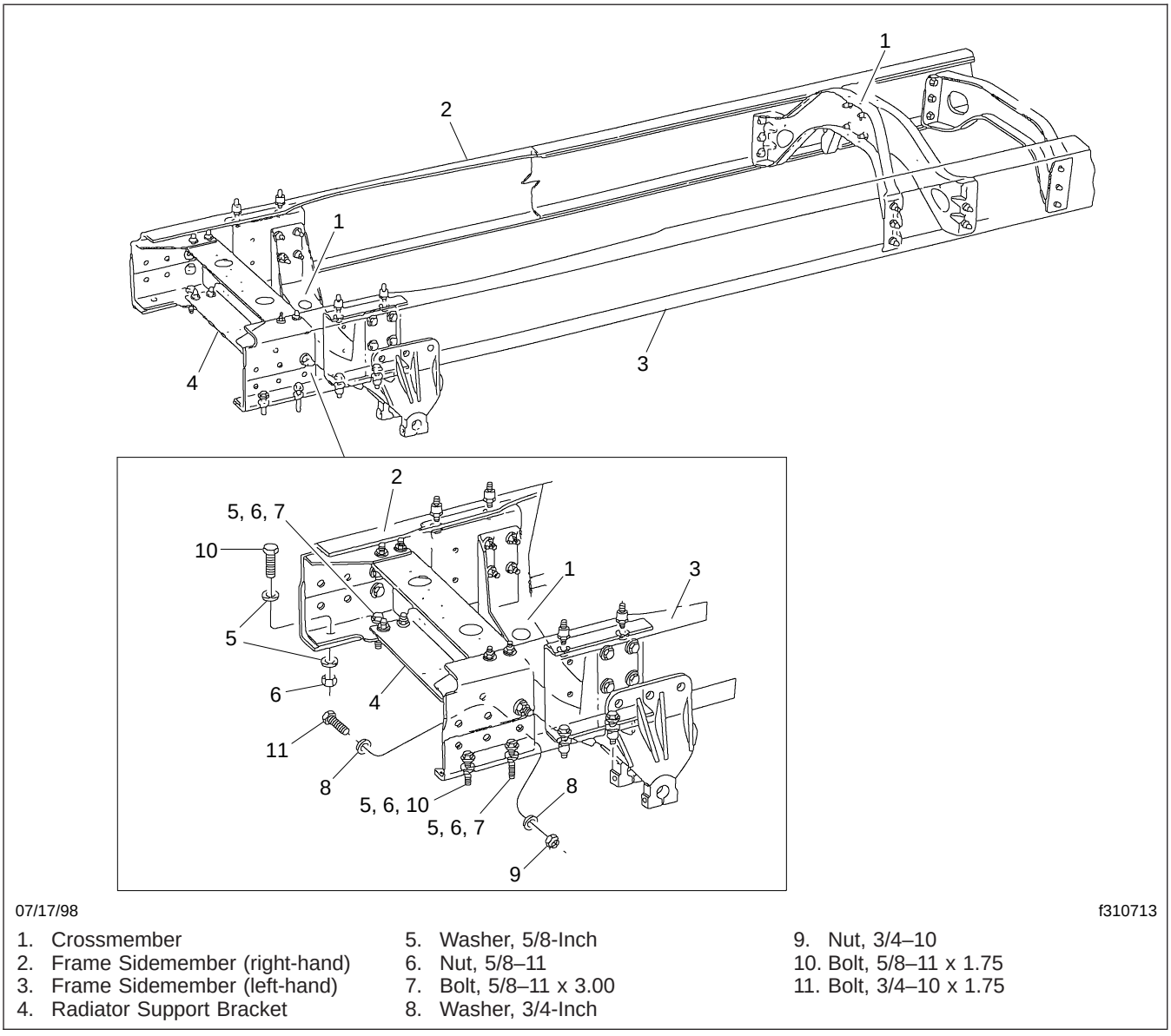
1. Radiator Support Bracket
2. Frame Sidemember (right-hand)
3. Crossmember
4. Frame Sidemember (left-hand)
5. Front Frame Bracket (left-hand)
6. Front Frame Bracket (right-hand)
7. Tension Pin, 0.62 x 1.00
8. Bolt, 3/4–10 x 2.50
9. Washer, 3/4-Inch
10. Tension Pin, 0.62 x 0.50
11. Nut, 3/4–10 (locking)
12. Bolt, 5/8–11 x 1.75
13. Tension Collar, 0.65
14. Washer, 5/8-Inch
15. Nut, 5/8–11 (locking)

Fig. 3, L-Line 113 and 122-Inch BBC With 1300 Square-Inch Radiator



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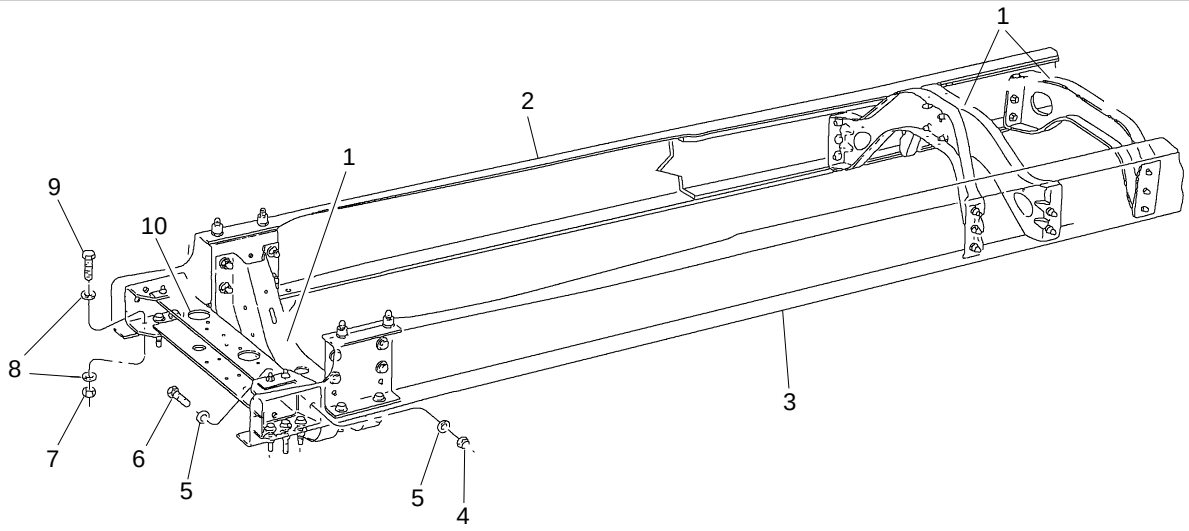
1. Crossmember
2. Frame Sidemember (right-hand)
3. Frame Sidemember (left-hand)
4. Radiator Support Bracket
5. Washer, 5/8-Inch
6. Nut, 5/8–11
7. Bolt, 5/8–11 x 3.00
8. Washer, 3/4-Inch
9. Nut, 3/4–10
10. Bolt, 5/8–11 x 1.75
11. Bolt, 3/4–10 x 1.75

Fig. 4, L-Line 113 and 122-Inch BBC With 830/900 Square-Inch Radiator, or 101 and 111-Inch BBC With All Radiators

General Information



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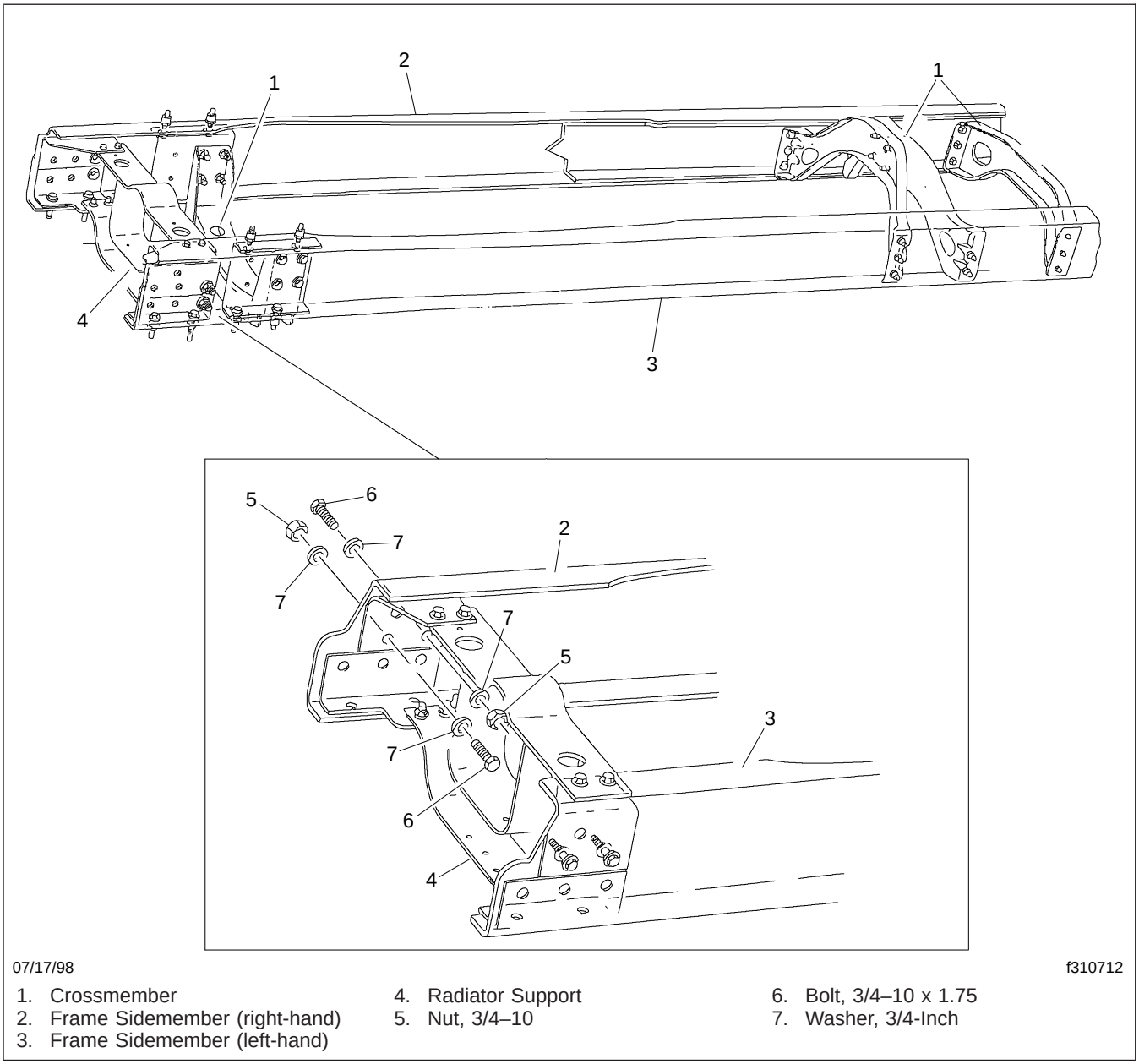
1. Crossmember
2. Frame Sidemember (right-hand)
3. Frame Sidemember (left-hand)
4. Nut, 3/4–10 (locking)
5. Washer, 3/4-Inch
6. Bolt, 3/4–10 x 1.75
7. Nut, 5/8–11 (locking)
8. Washer, 5/8-Inch
9. Bolt, 5/8–11 x 1.75
10. Radiator Support

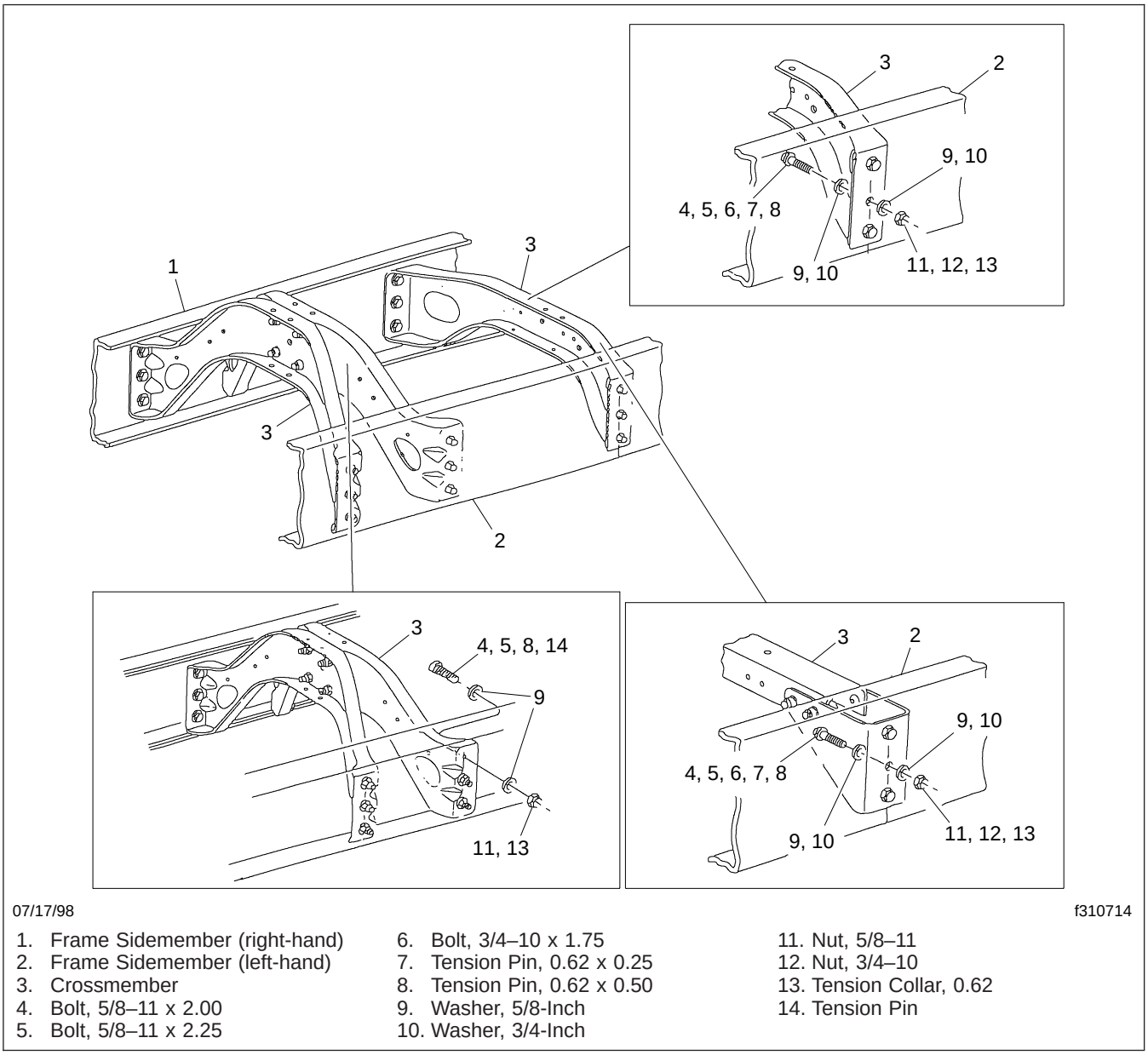
Fig. 5, L-Line 113 and 122-Inch BBC With 1050 Square-Inch Radiator



1. Crossmember
2. Frame Sidemember (right-hand)
3. Frame Sidemember (left-hand)
4. Radiator Support
5. Nut, 3/4–10
6. Bolt, 3/4–10 x 1.75
7. Washer, 3/4-Inch

Fig. 6, L-Line 113 and 122-Inch BBC With PTO and 830/900 Square-Inch Radiator, or 101 and 111-Inch BBC With PTO and All Radiators

General Information



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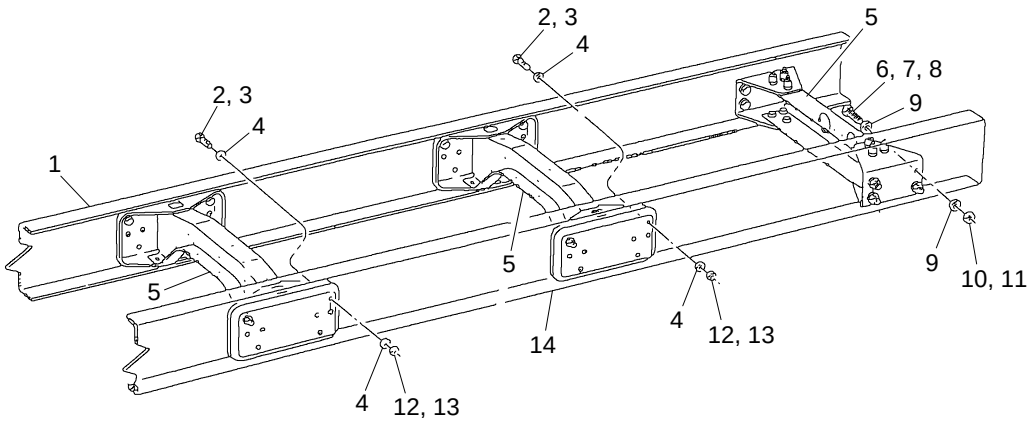
1. Frame Sidemember (right-hand)
2. Frame Sidemember (left-hand)
3. Crossmember
4. Bolt, 5/8–11 x 2.00
5. Bolt, 5/8–11 x 2.25
6. Bolt, 3/4–10 x 1.75
7. Tension Pin, 0.62 x 0.25
8. Tension Pin, 0.62 x 0.50
9. Washer, 5/8-Inch
10. Washer, 3/4-Inch
11. Nut, 5/8–11
12. Nut, 3/4–10
13. Tension Collar, 0.62
14. Tension Pin

Fig. 7, L-Line Intermediate Crossmember



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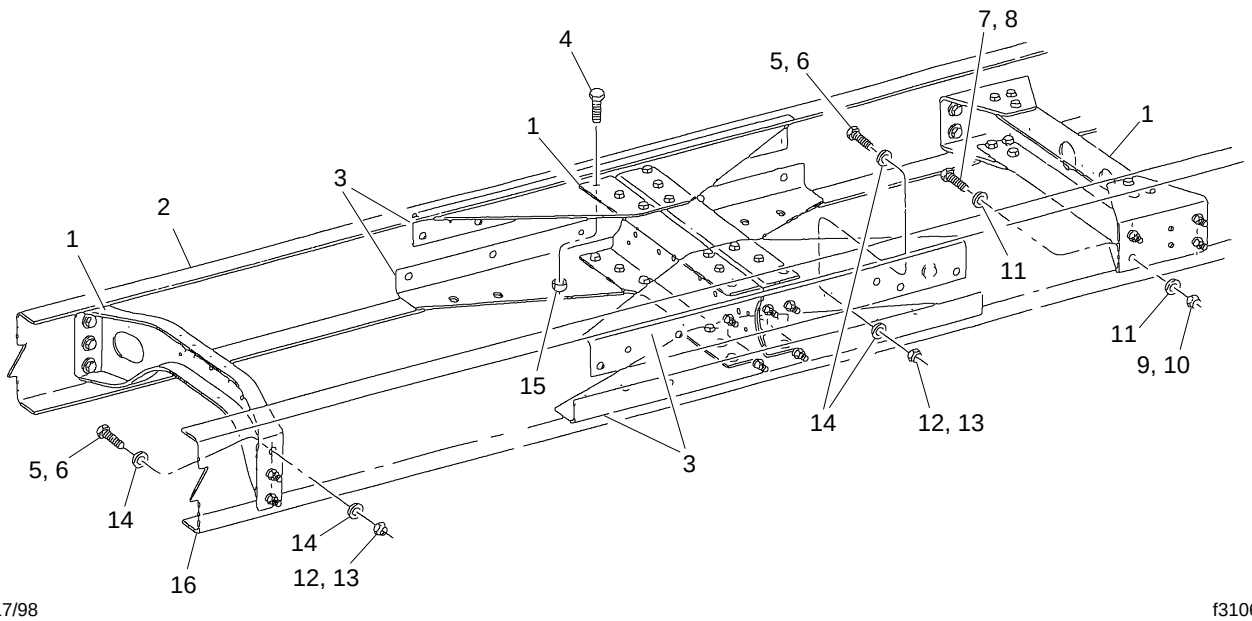
1. Frame Sidemember (right-hand)
2. Bolt, 5/8–11 x 2.00
3. Tension Pin, 0.62 x 0.50
4. Washer, 5/8-Inch
5. Crossmember
6. Bolt, 3/4–10 x 2.00
7. Bolt, 3/4–10 x 2.25
8. Tension Pin
9. Washer, 3/4-Inch
10. Nut, 3/4–10
11. Tension Collar
12. Nut, 5/8–11
13. Tension Collar
14. Frame Sidemember (left-hand)

Fig. 8, Frame Assembly, Hendrickson HAS/HFS Suspension Frame, Tandem Rear Axle

General Information



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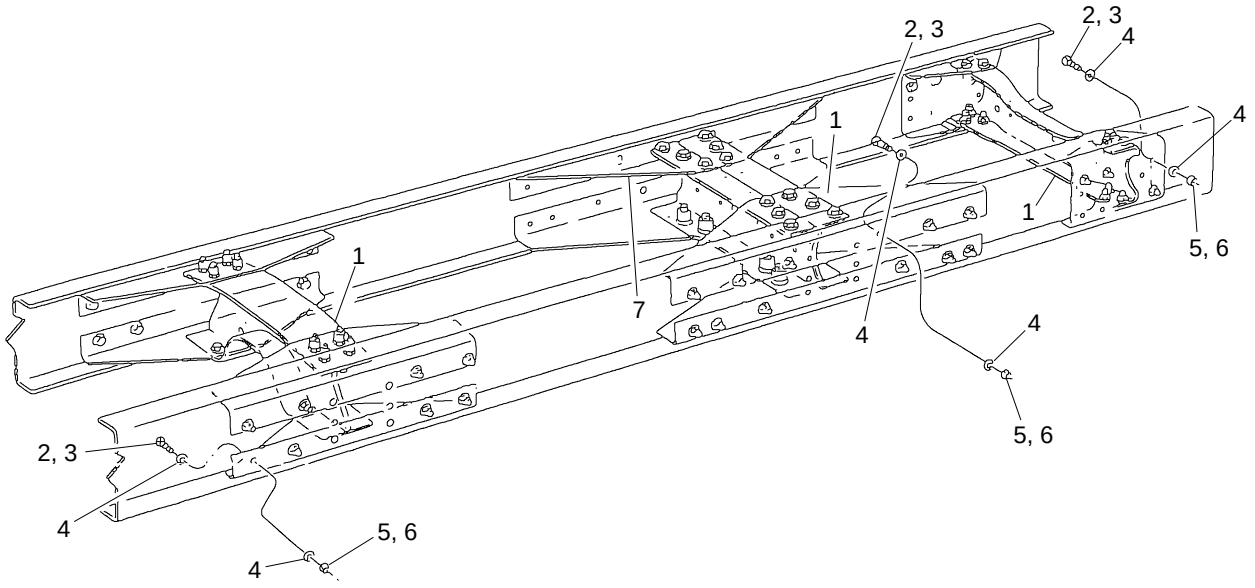
1. Crossmember
2. Frame Sidemember (right-hand)
3. Frame Gusset
4. Tension Pin
5. Bolt, 5/8–11 x 2.00
6. Tension Pin, 0.62 x 0.50
7. Bolt, 3/4–10 x 2.50
8. Tension Pin
9. Nut, 3/4–10
10. Tension Collar
11. Washer, 3/4-Inch
12. Nut, 5/8–11
13. Tension Collar
14. Washer, 5/8-Inch
15. Tension Collar
16. Frame Sidemember (left-hand)

Fig. 9, Frame Assembly, Hendrickson Walking Beam Suspension Frame, 52, 54 and 60-Inch Spread, Tandem Rear Axle



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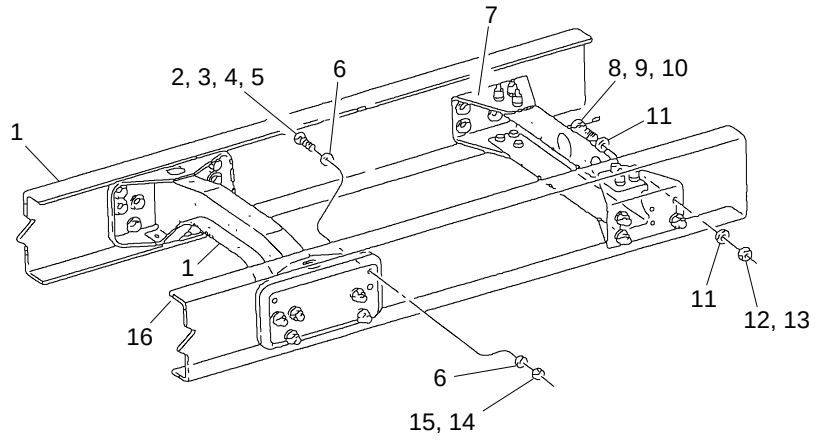
1. Crossmember
2. Bolt, 5/8–11 x 2.00
3. Tension Pin, 0.62 x 0.50
4. Washer, 5/8-Inch
5. Nut, 5/8–11
6. Tension Collar
7. Frame Gusset

Fig. 10, Frame Assembly, Neway AD246 Suspension Frames, Tandem Rear Axle



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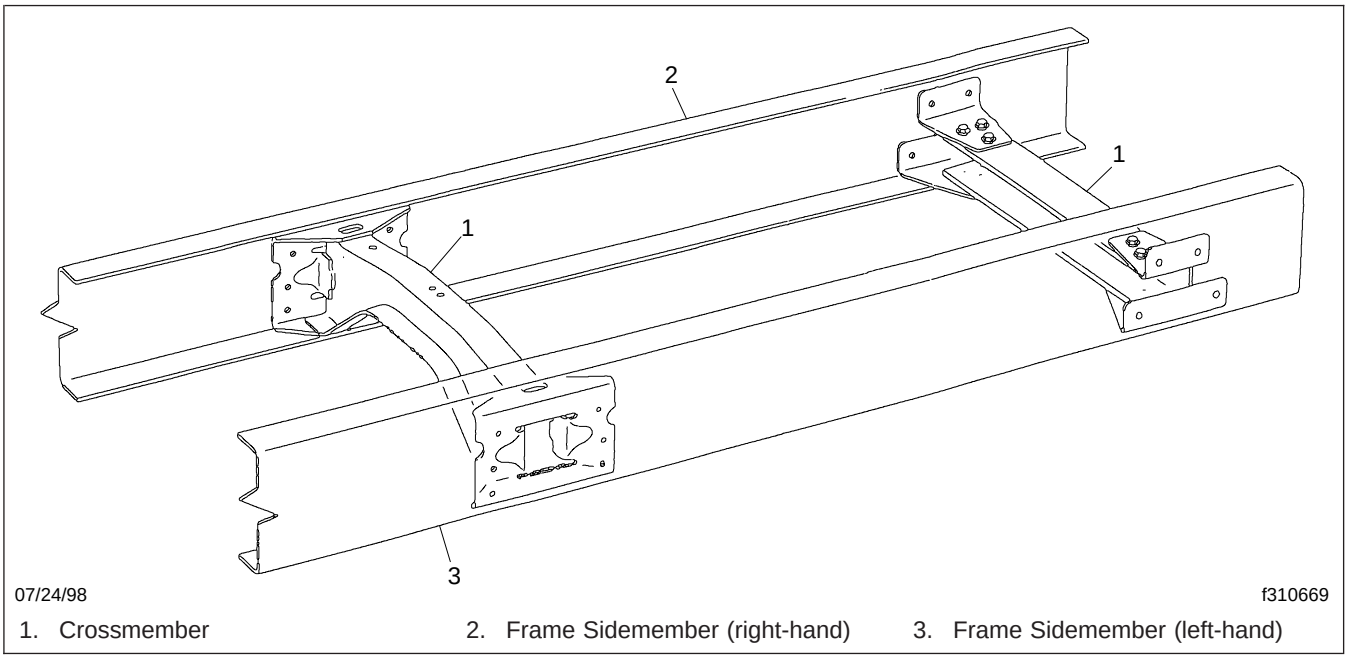
1. Frame Sidemember (right-hand)
2. Bolt, 5/8–11 x 2.00
3. Bolt, 5/8–11 x 2.25
4. Tension Pin, 0.62 x 0.25
5. Tension Pin, 0.62 x0.50
6. Washer, 5/8-Inch
7. Crossmember
8. Bolt, 3/4–10 x 2.00
9. Bolt, 3/4–10 x 2.25
10. Tension Pin
11. Washer, 3/4-Inch
12. Nut, 3/4–10
13. Tension Collar
14. Nut, 5/8–11
15. Tension Collar
16. Frame Sidemember (left-hand)

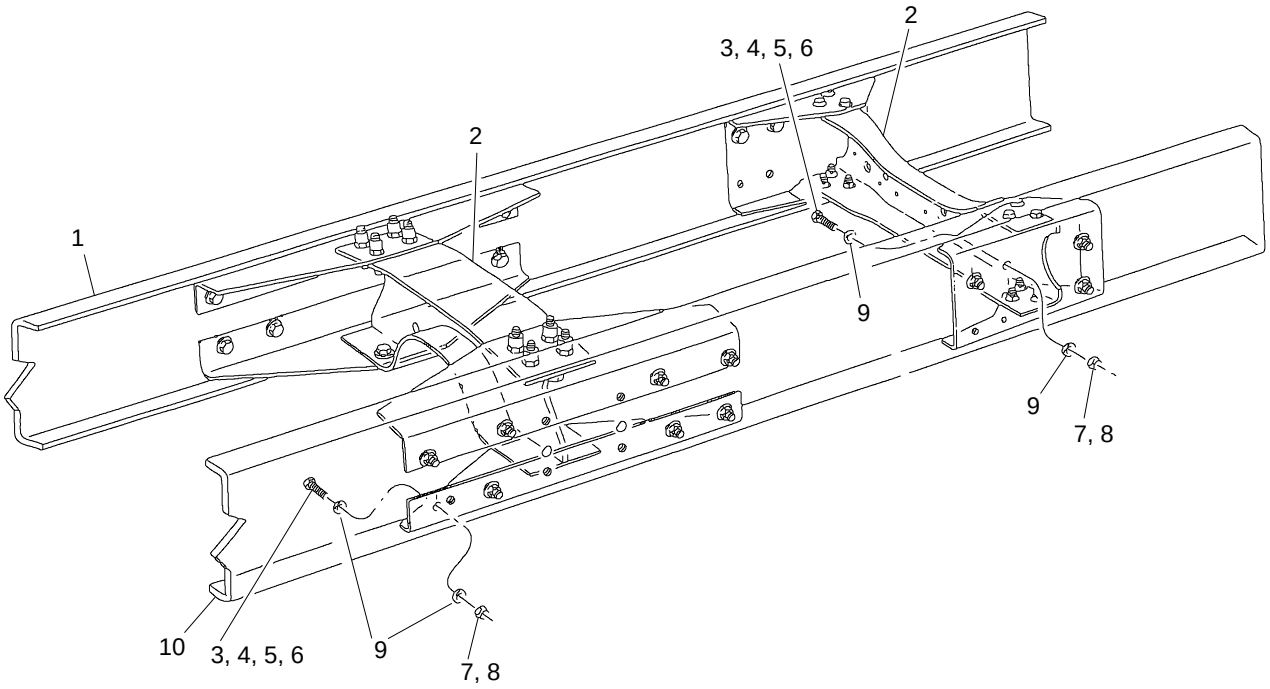
Fig. 11, Frame Assembly, Hendrickson HAS Suspension Frame, Single Rear Axle

General Information



1. Crossmember
2. Frame Sidemember (right-hand)
3. Frame Sidemember (left-hand)

Fig. 12, Frame Assembly, Hendrickson Taperleaf/Multileaf Suspension, Single Rear Axle



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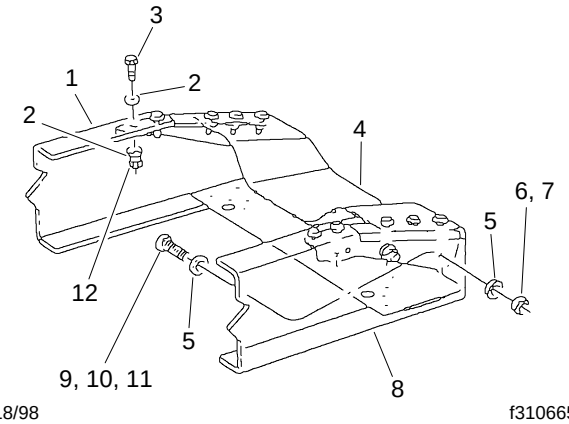
1. Frame Sidemember (right-hand)
2. Crossmember
3. Bolt, 5/8–11 x 2.00
4. Bolt, 5/8–11 x 2.25
5. Tension Pin, 0.62 x 0.25
6. Tension Pin, 0.62 x 0.50
7. Nut, 5/8–11
8. Tension Collar
9. Washer, 5/8-Inch
10. Frame Sidemember (left-hand)

Fig. 13, Frame Assembly, Neway Suspension, Single Rear Axle

General Information



07/18/98 f310665

1. Frame Sidemember (right-hand)
2. Washer, 1/2-Inch
3. Bolt, 1/2–13 x 1.75
4. Crossmember
5. Washer, 3/4-Inch
6. Nut, 3/4–10
7. Tension Collar
8. Frame Sidemember (left-hand)
9. Bolt, 3/4–10 x 2.00
10. Bolt, 3/4–10 x 2.25
11. Tension Pin
12. Nut, 1/2–13

Fig. 14, Frame Assembly With Tractor Ramp Rear Crossmember

Frame Inspection

NOTE: Frame misalignment is the result of damaged or loose frame components. It can affect front and rear wheel alignment and cause improper operation and abnormal wear of chassis parts.

1. Before checking the frame alignment, inspect the frame for damage and loose parts. Inspect all frame crossmembers for cracks, twists or bends.
2. Inspect all welded connections for cracks.
3. Check all bolts and support brackets for looseness.

Frame Rail Alignment

DIAGONAL OR X-FRAME CHECKING METHOD

NOTE: Frame alignment can be checked without removing the vehicle body by using the diagonal or X-frame checking method. An alternate method of checking frame alignment is to use a frame gauge, such as the Rotunda Laser Measuring System.

1. Check the frame for misalignment.
2. Park the vehicle on a clean, level floor and set the parking brake.

NOTE: Paper can be taped to the floor for the following step.

3. Select several points along the frame rails. Using a plumb bob, carefully transfer these points to the paper taped to the floor.
4. Move the vehicle, and measure between diagonal points. Both corresponding measurements must be equal within 1/4 inch (6.4 mm) of each other.
5. Measure between corresponding points parallel to the frame rails. These measurements must be within 1/4 inch (6.4 mm) of each other.
6. Measure between the frame rail web and the lower flanges of the spring hangers. The measurement must be within 1/16 inch (1.6 mm).
7. Measure between the frame rail web and the steering gear mounting location. The measurement must be within 1/16 inch (1.6 mm).
8. Measure between the frame rail web and the remaining flange points. The measurement must be within 1/8 inch (3.2 mm).
9. Measure trueness between the two frame rails. Any measurement point on one frame rail must be within 1/8 inch (3.2 mm) of the opposite frame rail.
10. Measure the frame rails for bowing. The frame rails must not be bowed more than 1/8 inch (3.2 mm) for each 100 inches (2540 mm) of frame length.
11. Measure the width between the frame rails. The measurement must not vary more than 1/8 inch (3.2 mm).

Drilling Precautions

CAUTION

Do not drill holes in the frame rails or crossmembers. The frame rails and crossmembers are tempered steel. Drilling tends to reduce the frame rail or crossmember strength, which can result in structural failure of the frame rails or crossmembers.

Welding Precautions

CAUTION

Except for pre-approved procedures listed in this service manual, or approved by Engineering through the DTNA District Service Manager, do not apply heat to, nor weld the frame rails or crossmembers. Heating or welding the frame in localized areas will reduce the strength of the frame in localized areas, which can result in structural failure of the frame.

L-Line and A-Line vehicles are equipped with 50,000 and 120,000 psi frames.

Welding of the frame rails or crossmembers is not permitted. This reduces the temper of the steel, causing reduction of frame strength.

Frame Strength Identification

A code symbol is punched in the side rails near the front spring rear hangers.

The code symbol shown in **Fig. 1** identifies a frame rated at 50,000 psi.

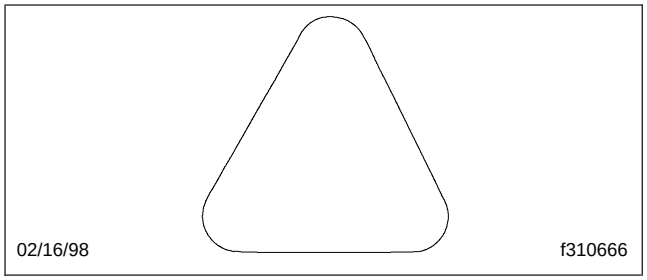


Fig. 1, Frame Strength Identification Symbol

Frame Straightening

To prevent internal stresses in the metal, limit frame straightening to parts that are not severely bent. Do not apply heat to the frames.

Correct any frame misalignment by straightening the out-of-line parts, or by replacing the crossmembers, braces, or brackets if they are badly damaged. Straightening should be attempted on frames that fail to meet specifications of the diagonal checking method, or where damage is visually apparent.

Frame Reinforcing

No repair method is approved. Frame reinforcements are not permitted.

After straightening a bent frame member, inspect the member closely for cracks. If any cracks show, the frame member must be replaced.

IMPORTANT: If a damaged frame member is replaced, use new Grade 8 fasteners for all replacement frame parts.

Safety Precautions

IMPORTANT: Only experienced, qualified persons using proper equipment should attempt welding the frame rails.

⚠ CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cable, and any electronic control units or similar devices installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, which could result in malfunction of the components.

1. Shut down the engine and set the parking brake. Chock the front and rear tires. Open the hood.
2. Disconnect the batteries.
3. Attach the welding ground strap as close to the work being done as safely possible.
4. Disconnect the engine ECU (electronic control unit) and all other electronic devices. Refer to the applicable manufacturer's engine operation manual for the location of the engine ECU.

Welding Requirements

IMPORTANT: Before welding anything on a frame rail, contact your regional service representative for approval. There are very few cases in which welding a heat-treated frame rail is allowable. If possible, avoid direct welding of the frame rail web.

⚠ WARNING

Wear protective welding masks and gloves when welding. Failure to do so could result in personal injury, due to the intensity of heat, sparks, and flying debris.

⚠ CAUTION

Weld only as instructed in this subject; all precautions and methods must be strictly followed. Failure to do so can reduce the structural strength in the welded area of the frame rail.

Read and comply with the following requirements:

- Do not weld attachments to the frame rail. For guidelines on the attachment of equipment on the frame rails, refer elsewhere in this group.
- Use only the applicable welding method under "Welding Methods."
- Before welding, clean off any oil, grease, paint, scale, and other contaminants. Wipe dry with a clean cloth.
- Do not weld in an area that allows drafts from any source such as windows, engines, or fans, as it will affect the soft flow of gas from the welding gun.
- Do not weld into the radius of the frame rail flanges or along the edge of the flange.
- Do not weld square with the frame side rail. Make all reinforcing welds at least 30 degrees from square. This will distribute the weld stresses over a larger area.
- Do not notch, undercut, or leave craters during the welding process.
- Keep as close to the weld centerline as possible.

Welding Methods

Gas-metal arc welding is the recommended method. If gas-metal arc welding is not available, coated-electrode arc welding can be used.

For both gas-metal arc welding and coated-electrode arc welding, direct current reverse polarity is recommended; however, alternating current can be used. Use either a short arc beading technique or a narrow weave technique.

Gas-Metal Arc Welding

For the gas-metal arc welding method:

- Use weld wire that meets American Welding Society (AWS) specification A 5.28, Class E110S.
- Use Linde M-5 gas or an equivalent argon-oxygen mixture of 5 percent oxygen.

Coated-Electrode Arc Welding

For the coated-electrode arc welding method:

Welding Frame Rails

- Use 1/8-inch-thick AWS-E-11018 type weld rod.

NOTE: On 1/4-inch-thick frame rails only, AWS-E-9018 type weld rod can be used, however, AWS-E-11018 type weld rod is recommended.

IMPORTANT: Always keep the weld rod free of moisture. The welding rod should be taken from a hermetically sealed container immediately before use, or be dried at least one hour in a 700 to 800°F (371 to 427°C) oven. Immediately after removal from a sealed container or after drying, store the welding rod in an oven at 250°F (121°C). A welding rod that has been exposed to the atmosphere longer than one-half hour must be dried before use.

Lengthening Frame Rails

Steel frame rails can be lengthened by welding an extension onto the rear of the frame rail. The end of the frame rail and the extension piece are cut so that they overlap each other. Obtain approval from your regional service representative before welding and lengthening the frame rail.

CAUTION

The vehicle is equipped with electronic control units. Serious damage to ECUs and components may result when welding unless the following precautions are taken.

- **Never allow an electronic component to be situated between the ground electrode and the weld site.**
- **Never lay welding cables on, near, or across any electronic component or wiring.**
- **Protect electronic components and wiring near the weld site from heat and splatter.**

1. Cut the frame-rail end and extension to the applicable dimensions. See **Fig. 1** for truck dimensions, or **Fig. 2** for tractor dimensions. Refer only to the figure that relates to the vehicle being modified.

NOTE: If the length of the extension is to be 6 inches (152 mm) or less, then straight-cut the frame rail end and extension.

2. Grind the cut ends of the frame rail and extension to the dimensions in **Fig. 3**.
3. Align the cut ends of the extension piece with the cut ends of the frame rail so that there is a 1/16- to 1/8-inch (1.5- to 3-mm) gap between them. See **Fig. 3**. Using a torch, heat the cut ends to 70°F (21°C), if necessary, before welding.

NOTE: A 1/16-inch (1.6-mm) gap is recommended. The ends must not contact each other. Maintain the joint spacing by placing a short piece of clean, 1/16-inch (1.6-mm) diameter bare steel wire between the extension and frame rail. The wire sections must be short enough to be completely fused by the welding process.

CAUTION

Weld the web area first, making sure that the flanges do not contact each other. Residual stresses will occur in the weld if the web area is not welded first, or if the flanges contact each other when welding the web.

4. Weld the extension to the frame rail, making full penetration. See **Fig. 4**. Weld the web area first, then the flange, working from the inside of the channel. When welding the web, make sure that the flanges do not contact each other.

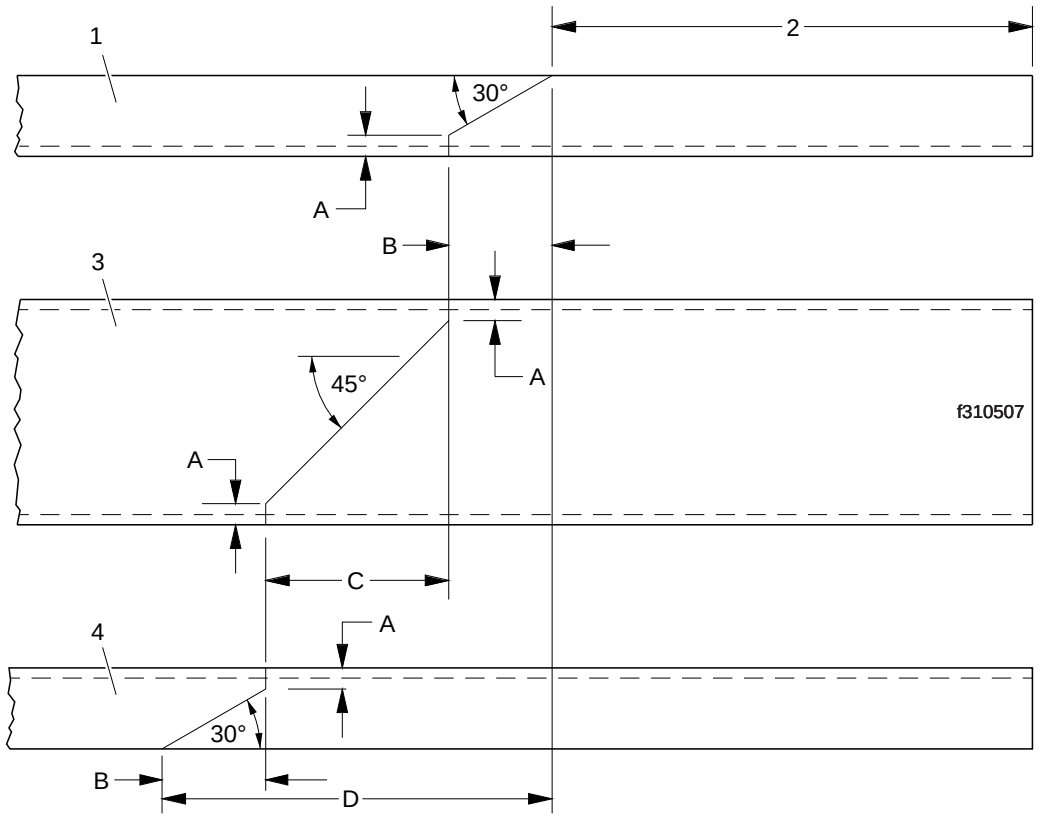
   Remove any slag between passes and back-gouge the root of the first vee before welding the other side.

CAUTION

Do not "hollow grind" the weld. Small depressions from improper grinding of the weld will reduce the strength of the frame rail.

5. When finished welding, sand the joint for appearance. Hold the sander so that the grind runs parallel with the length of the frame rail.

Lengthening Frame Rails



NOTE: Left rail shown; right rail will be opposite dimensions.

FRAME RAIL SIZE inches	DIMENSION			
	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)
10.06	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.12	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)

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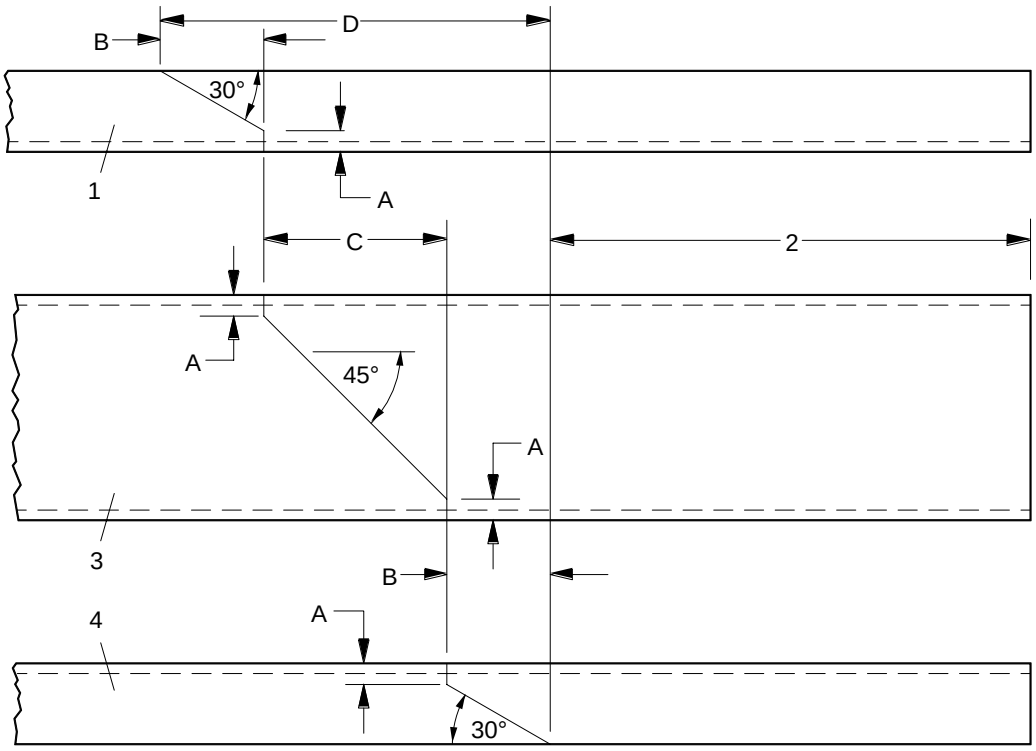
1. Upper Flange
2. Extension Length
3. Web
4. Lower Flange

Fig. 1, Frame Rail and Extension Cutting Dimensions for Truck Vehicles



NOTE: Left rail shown; right rail will be opposite dimensions.

FRAME RAIL SIZE inches	DIMENSION			
	A inches (mm)	B inches (mm)	C inches (mm)	D inches (mm)
10.06	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)
10.12	0.69 (17.5)	5.00 (127.0)	8.75 (222.2)	18.75 (476.2)

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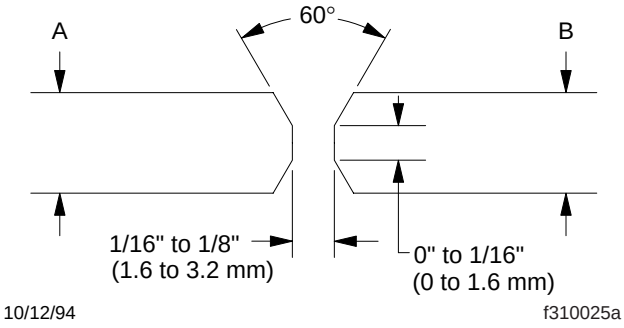
1. Upper Flange
2. Extension Length
3. Web
4. Lower Flange

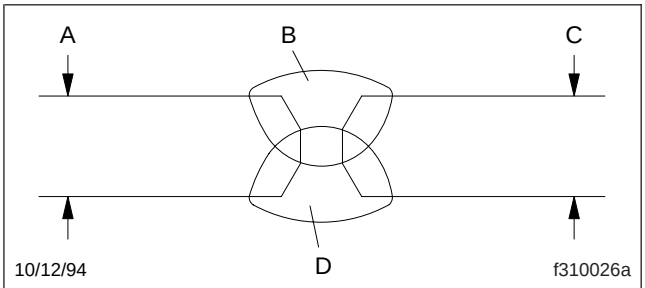
Fig. 2, Frame Rail and Extension Cutting Dimensions for Tractor Vehicles

Lengthening Frame Rails



A. Frame Rail Thickness
B. Extension Thickness

Fig. 3, Grinding Dimensions



A. Frame Rail Thickness
B. First Weld
C. Extension Thickness
D. Second Weld (penetrates the first weld).

Fig. 4, Correct Weld Penetration

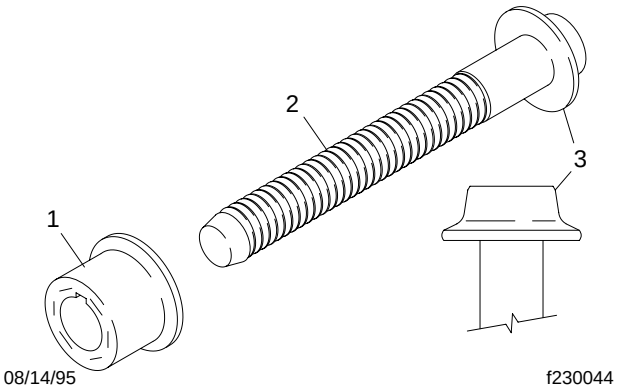
Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
1/4-Inch Diameter, Grade 5	7–10 (10–13)
5/16-Inch Diameter, Grade 5	12–17 (17–23)
3/8-Inch Diameter, Grade 8	32–41 (43–56)
7/16-Inch Diameter, Grade 8	50–70 (68–95)
1/2-Inch Diameter, Grade 8	75–105 (102–142)
9/16-Inch Diameter, Grade 8	110–150 (149–203)
5/8-Inch Diameter, Grade 8	150–205 (204–277)
3/4-Inch Diameter, Grade 8	220–300 (299–406)
7/8-Inch Diameter, Grade 8	360–480 (489–650)
1.0-Inch Diameter, Grade 8	540–730 (733–989)

Table 1, Torque Specifications

General Information

Either Huck® fasteners 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. Prevailing torque locknuts of both bolt types have distorted sections of threads to provide torque retention.



1. Spin Collar
2. Lock Pin
3. Round Head

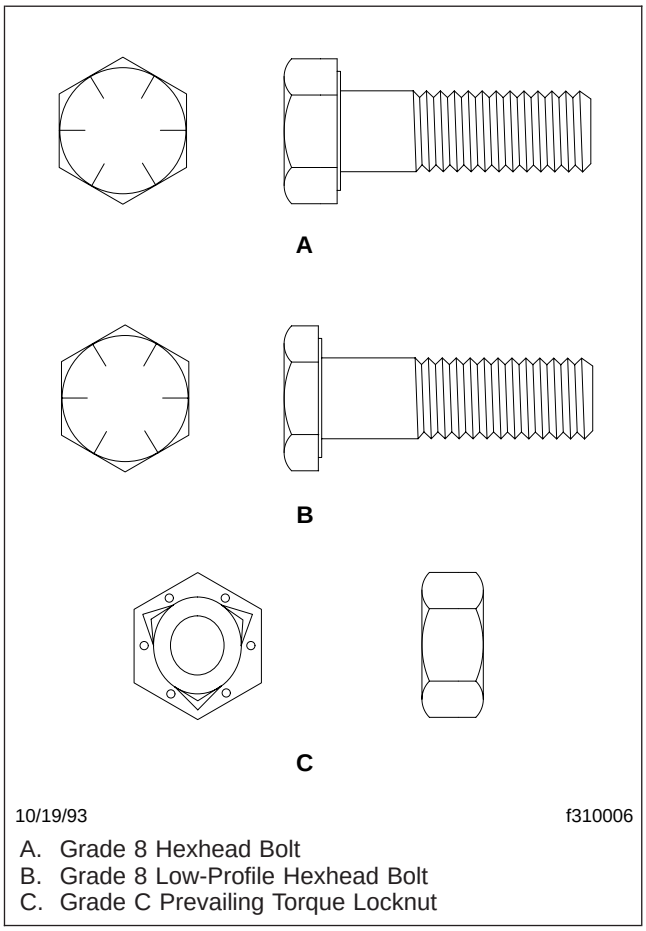
Fig. 1, Huck Fastener

When hexhead bolts and locknuts are used on an attached 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 the 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.

HEXHEAD BOLT REPLACEMENT

Replace hexhead bolts with identical fasteners. Refer to the *Sterling Parts Book* for fastener specifications.

Apply Alumilastic® compound, or an equivalent, to all surfaces where steel and aluminum parts contact each other.



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

Fig. 2, Hexhead Fasteners

⚠ CAUTION

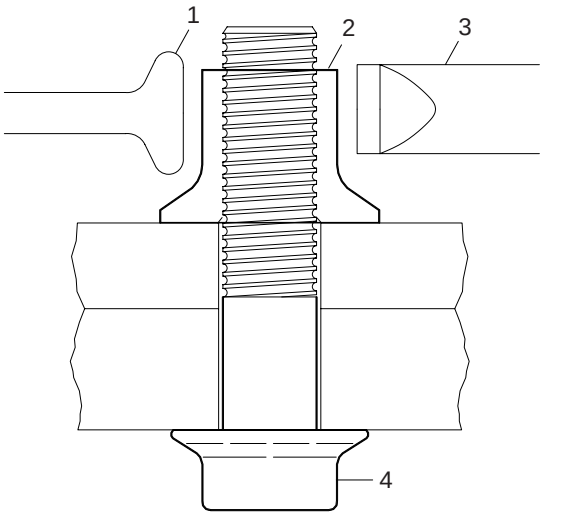
Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the frame or parts.

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 4 inches (102 mm), allow a minimum of three threads and a maximum of 3/4-inch (19-mm) bolt length.

General Information

HUCK FASTENER REMOVAL

The collar for Huck fasteners is spun on when the fasteners are installed, but the collar cannot be unscrewed. Use the Huck collar cutter to remove Huck fasteners. If the collar cutter is not available, split the collar with an air chisel while supporting the opposite side of the collar with an anvil. See **Fig. 3**. Drive out the lock pin with a punch. Discard the fastener after removing it. Replace Huck fasteners with standard grade 8 threaded fasteners.



1. Anvil
2. Spin Collar
3. Chisel
4. Lock Pin

Fig. 3, Huck Fastener Removal

CAUTION

Never attempt to reuse any Huck fastener that has been removed. Reusing any Huck frame fastener can result in damage to the vehicle frame or components attached to the frame.

FRAME FASTENER TIGHTENING

CAUTION

Make sure standard frame fasteners are tight. Continued vehicle operation with loose fasteners could result in component, bracket, and frame damage.

Check the torque for hexhead bolts and locknuts to offset the effects of "bedding in" (seating). Refer to the "Maintenance Operation Sets" and the "Maintenance Service" tables in Group 00 of the *Sterling L-Line and A-Line Maintenance Manual* for intervals, and to Group 31 of the same manual for procedures.

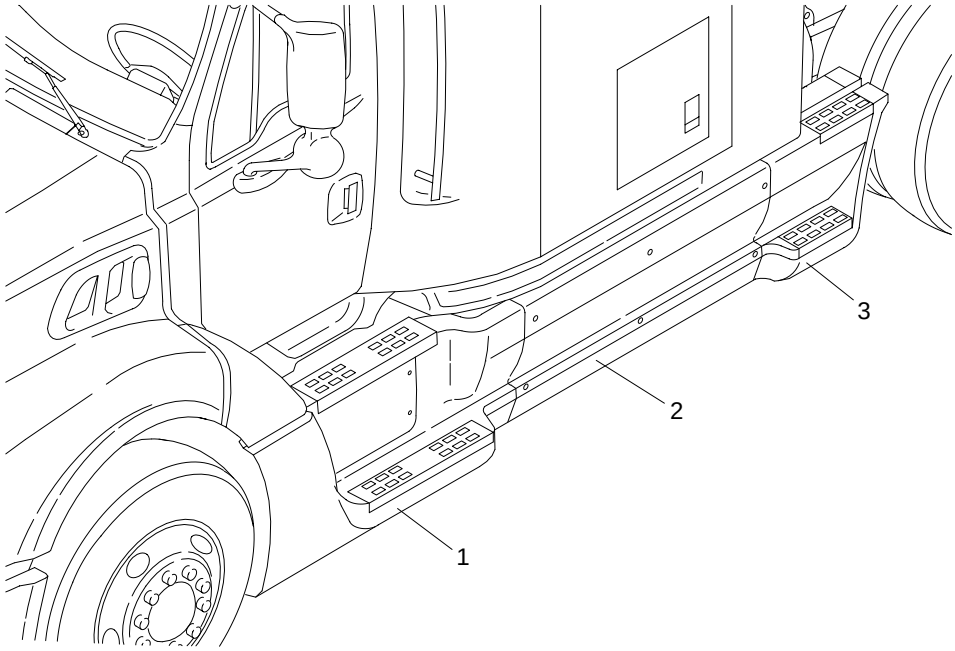
When tightening the fasteners, tighten the nut, not the bolt head. This will give a true torque reading by eliminating bolt body friction. For torque specifications, see **Section 00.06** in this manual.

NOTE: Huck fasteners do not require tightening.

General Information

Chassis side fairing assemblies are sized to the cab or wheelbase, and ease air turbulence around the fuel tanks. They also provide access to the sleeper (if equipped) and back of the cab. See **Fig. 1**.

The side fairings are made of plastic and are mounted on support rails. See **Fig. 2**. The support rails run parallel to the frame rails, and are mounted on brackets attached to the fuel tank mounting straps and the frame rail itself. On each side of the vehicle there may be one, two or three side fairings. The fairings are painted to match the color of the cab or are painted medium titanium, and have perforated metal plates on each step surface to prevent slipping. Machine screws inserted through the step plates hold the fairings to the support rails.



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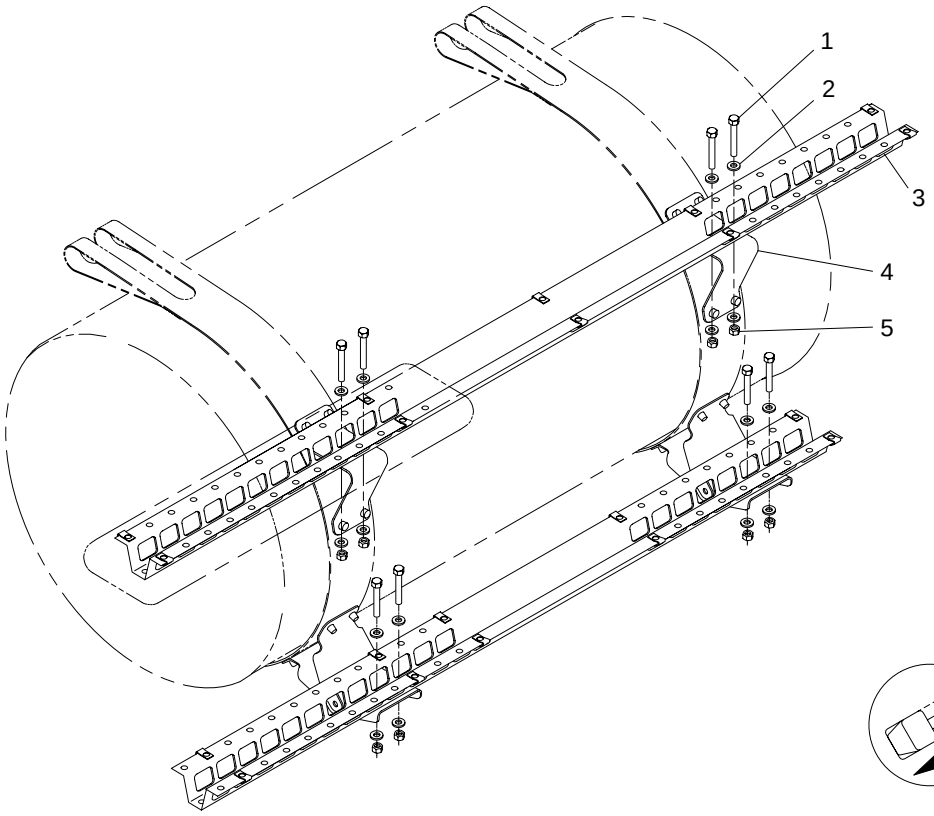
1. Front Fairing
2. Center Fairing
3. Rear Fairing

Fig. 1, Side Fairings

General Information



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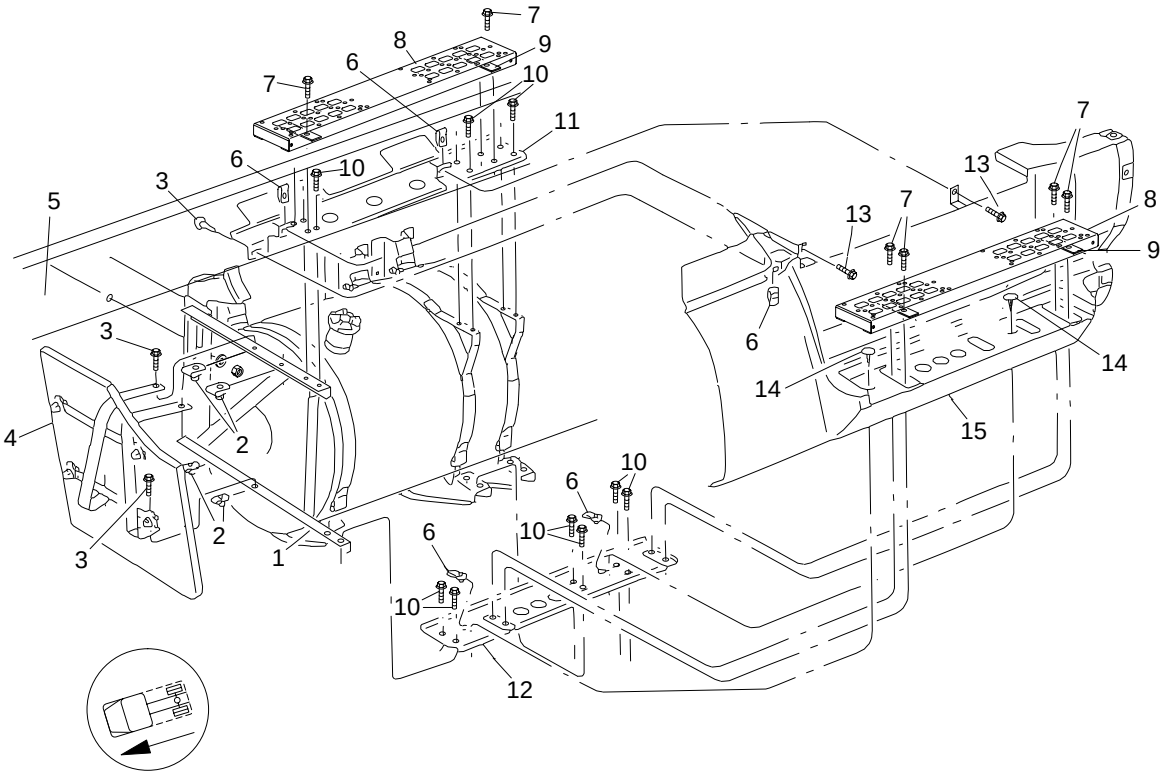
1. Capscrew (3/8–16, Grade 8)
2. Washer
3. Chassis Side Fairing Support Rail
4. Fairing Bracket (attached to fuel tank band)
5. Locknut (3/8–16)

Fig. 2, Side Fairing Supports

Side Fairing Removal and Installation

Removal (See Fig. 1, Fig. 2 and Fig. 3)



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1. Off-Frame Bracket
2. Spring U-Nut (3/8–16)
3. Hexhead Flange Bolt (3/8–16 x 1.15)
4. Splash Shield Assembly
5. Frame Rail
6. U-Nut Spring (3/8–16)
7. Hexhead Flange Bolt (5/16–18 x 1.38)
8. Step Assembly
9. Retainer Clip
10. Hexhead Flange Bolt (5/16–18 x 1.13)
11. Upper Side Fairing Reinforcement
12. Lower Side Fairing Reinforcement
13. Hexhead Flange Bolt (3/8–16 x 1.15)
14. Panhead Pilot Screw and Washer (3/8–16 x 1.53)
15. Front Side Fairing

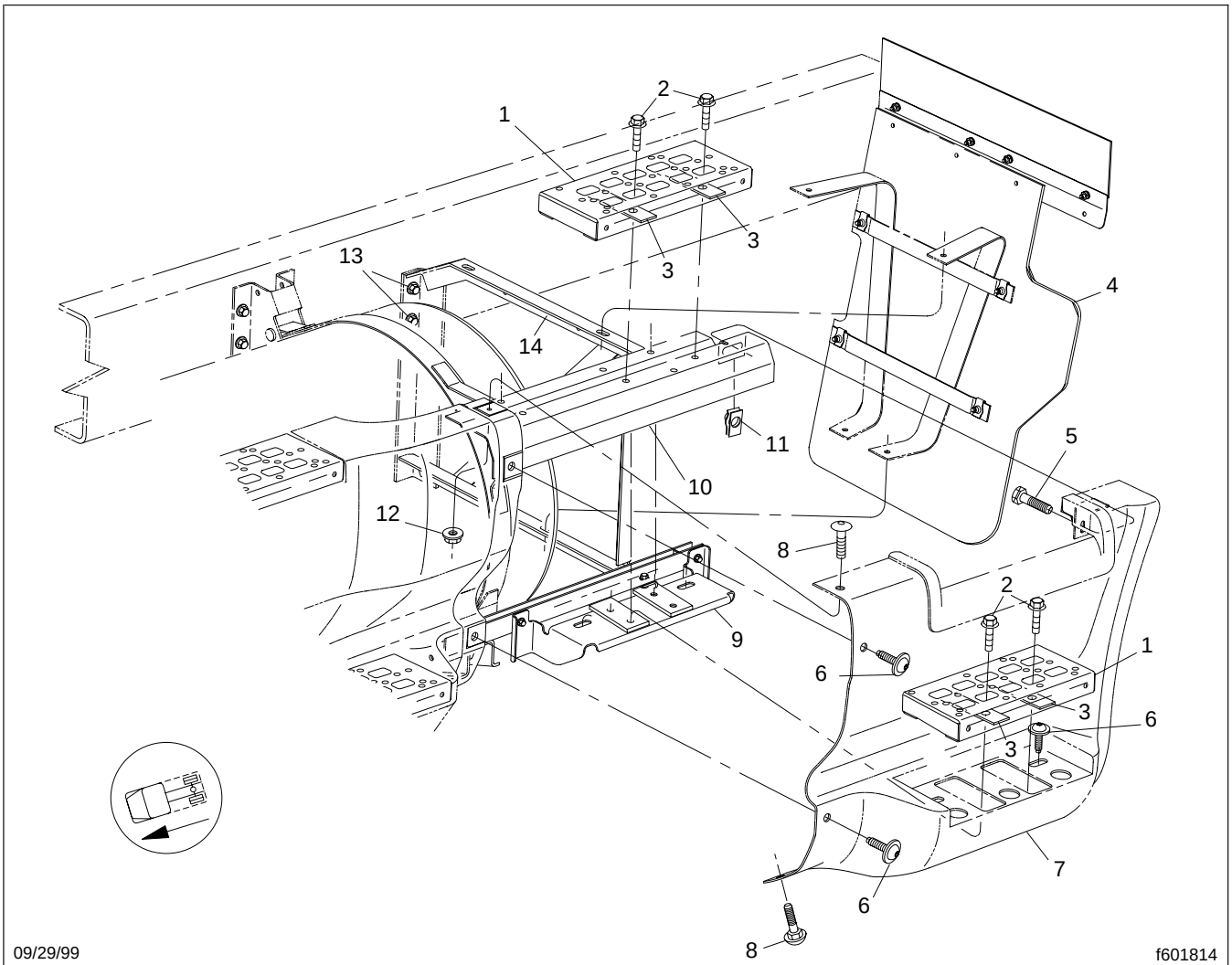
Fig. 1, Front Side Fairing Assembly (with rear mounted fuel tank)

NOTE: The following procedure covers the removal and installation of the front, center, and rear side fairings. Not all vehicles are equipped with three side fairings. Follow the applicable steps according to the side fairings equipped on the vehicle.

IMPORTANT: When removing the side fairings, it is easiest to remove the rear side fairing first, then the center side fairing, and finally the front side fairing.

1. Park the vehicle on a level surface. Apply the parking brakes. Chock the tires.
2. Remove the four screws on each step.
3. Remove the steps.
4. Remove the panhead screws holding the center side fairing to the support rails.
5. Remove the nuts that interlock the center side fairing to the front and rear side fairings.

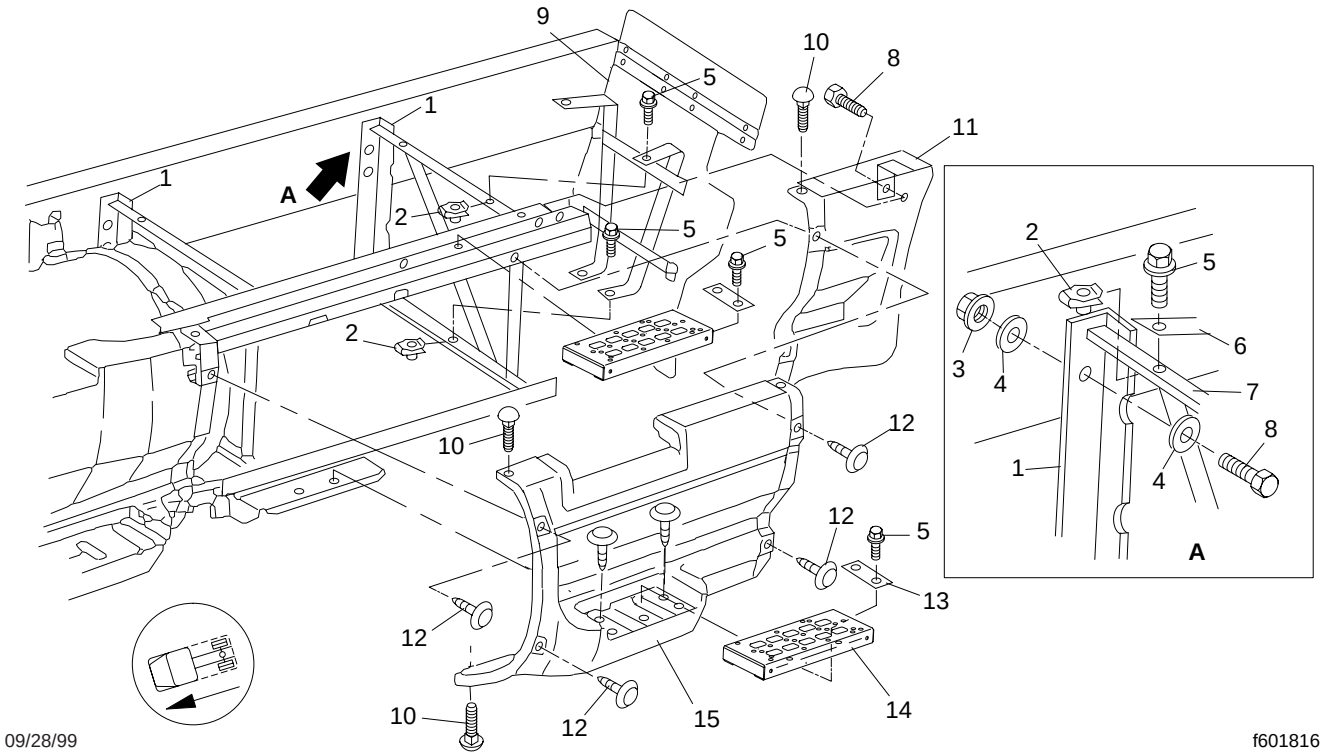
Side Fairing Removal and Installation



1. Step Assembly
2. Hexhead Flange Bolt (5/16–18 x 1.38)
3. Retainer Clip
4. Rear Splash Shield
5. Hexhead Bolt (3/8–16 x 1.15)
6. Panhead Screw and Washer (3/8–16 x 1.53)
7. Rear Side Fairing
8. Carriage Bolt (1/4–20 x 100)
9. Rear Lower Step Support Bracket
10. Side Fairing Reinforcement
11. Spring U-Nut (3/8–16)
12. Hexhead Flange Locknut (5/16–18)
13. Hexhead Bolt (5/8–11 x 1.75)
14. Off-Frame Bracket

Fig. 2, Rear Side Fairing Assembly (with forward mounted fuel tank)

6. Remove the panhead screws holding the rear side fairing to the support rails. Remove the bolt from the inside end of the side fairing bracket.
7. Remove the rear side fairing.
8. Remove the panhead screws holding the front side fairing to the support rails. Remove the bolt from the rear side fairing bracket by the splash shield.
9. Remove the center side fairing.
10. Remove the front side fairing.



1. Off-Frame Bracket
2. Spring U-Nut (3/8–16)
3. Locknut (5/8–11)
4. Washer
5. Hexhead Bolt (3/8–16 x 1.15)
6. Splash Shield Assembly Bracket
7. Off-Frame Bracket
8. Hexhead Bolt (5/8–11 x 1.75)
9. Splash Shield Assembly
10. Carriage Bolt (1/4–20 x 100)
11. Rear Side Fairing
12. Panhead Screw and Washer (3/8–16 x 1.53)
13. Retaining Clip
14. Step Assembly
14. Center Side Fairing

Fig. 3, Center and Rear Side Fairing Assemblies

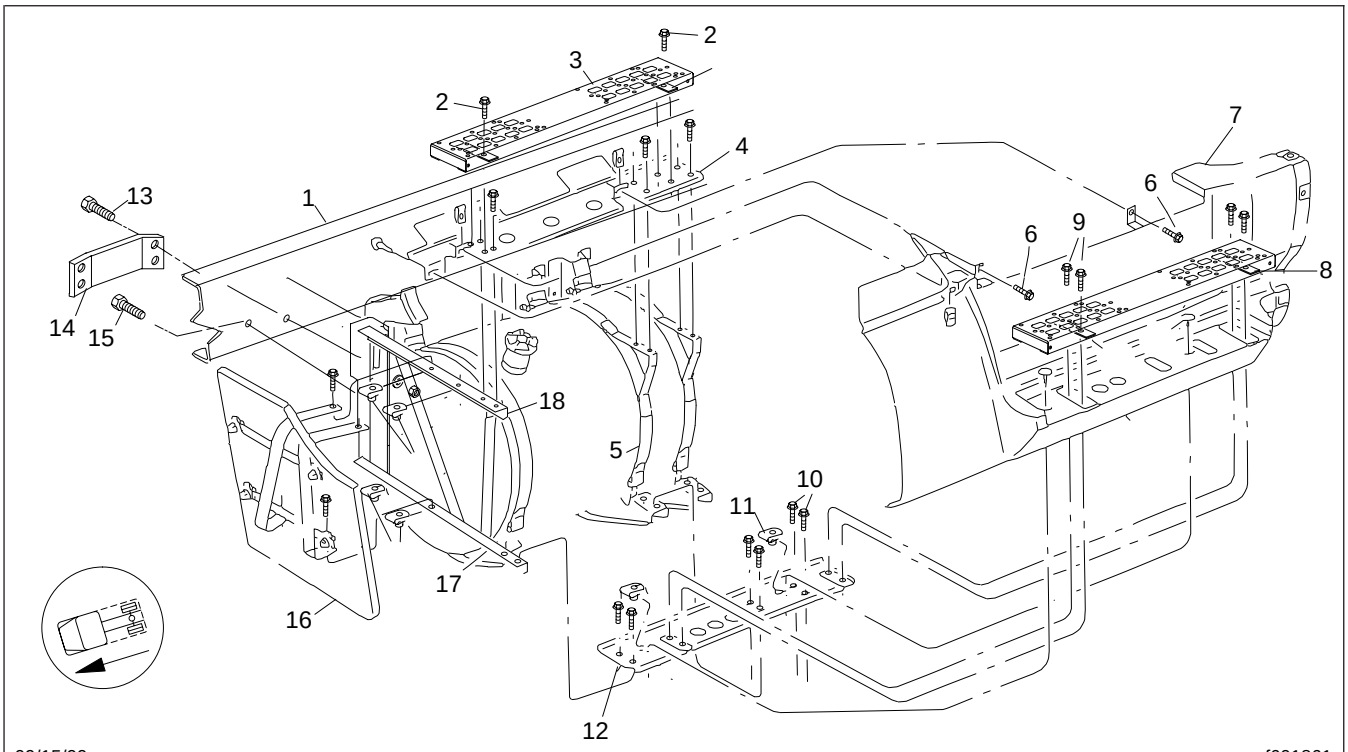
Installation

IMPORTANT: When installing the side fairing, install first the front, the rear, and finally the center section. This will allow them to fit together correctly.

1. Install the front side fairing. Finger-tighten the panhead screws and the bolt to the rear side fairing bracket by the mud flap.
2. Install the rear side fairing. Finger-tighten the panhead screw(s) and the bolt to the inside end of the side fairing bracket.
3. Install the center side fairing by fitting it to the front and rear side fairings. Finger-tighten the panhead screws.
4. Install and securely tighten the nuts interlocking the three side fairings together.
5. Tighten all the panhead screws firmly.
6. Position the steps and install the four screws on each step. Make sure the air tank pressure release is above the top step. Tighten the screws.
7. Remove the chocks from the tires.

Support Bracket Removal and Installation

Removal (See Fig. 1, Fig. 2 and Fig. 3)



1. Frame Rail
2. Hexhead Flange Bolt (5/16–18 x 1.38)
3. Step Assembly
4. Upper Side Fairing Reinforcement
5. Fuel Tank Strap
6. Hexhead Flange Bolt (3/8–16 x 1.5)
7. Side Fairing
8. Step Assembly
9. Hexhead Bolt (5/16–18 x 1.38)
10. Hexhead Bolt (5/16–16 x 1.13)
11. Spring U-Nut (3/8–16)
12. Lower Side Fairing Reinforcement
13. Hexhead Flange Bolt (3/8–16 x 1.5)
14. Strap
15. Hexhead Flange Bolt (3/8–16 x 1.5)
16. Splash Shield Assembly
17. Off-Frame Bracket, Lower Portion
18. Off-Frame Bracket, Upper Portion

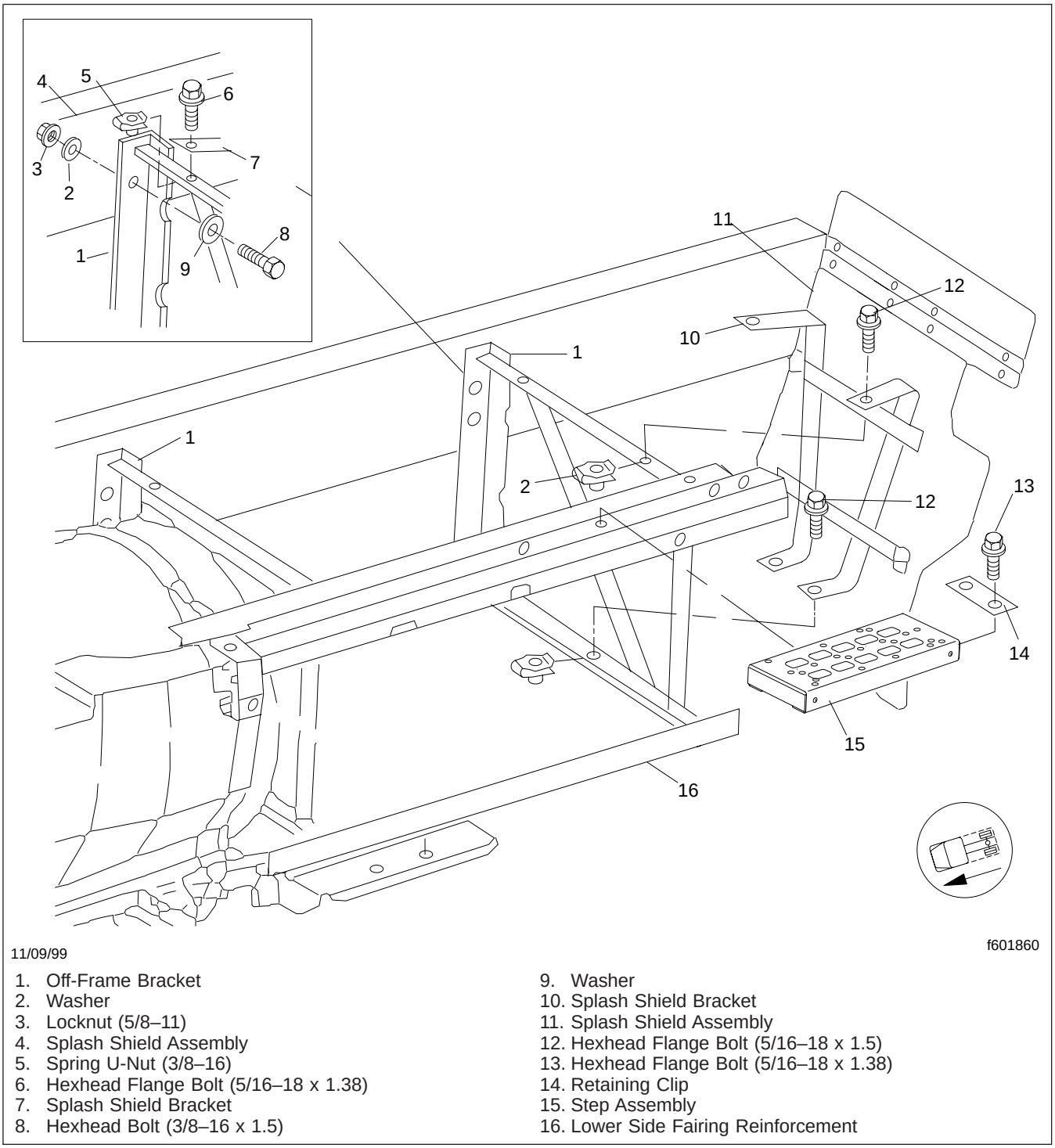
Fig. 1, Front Side Fairing and Support Brackets

1. Remove the side fairings. See **Subject 100** for instructions.
2. Remove the side fairing reinforcements from the vehicle.
   - 2.1 Remove the bolts that hold the upper side fairing reinforcement to the off-frame bracket. Remove the side fairing reinforcement.
   - 2.2 Remove the bolts that hold the lower side fairing reinforcement to the off-frame bracket. Remove the side fairing reinforcement.
3. Remove the off-frame brackets.
   - 3.1 Remove the fasteners that attach the off-frame bracket to the frame rail.
   - 3.2 Remove the bracket.

Installation

1. Install the off-frame brackets.

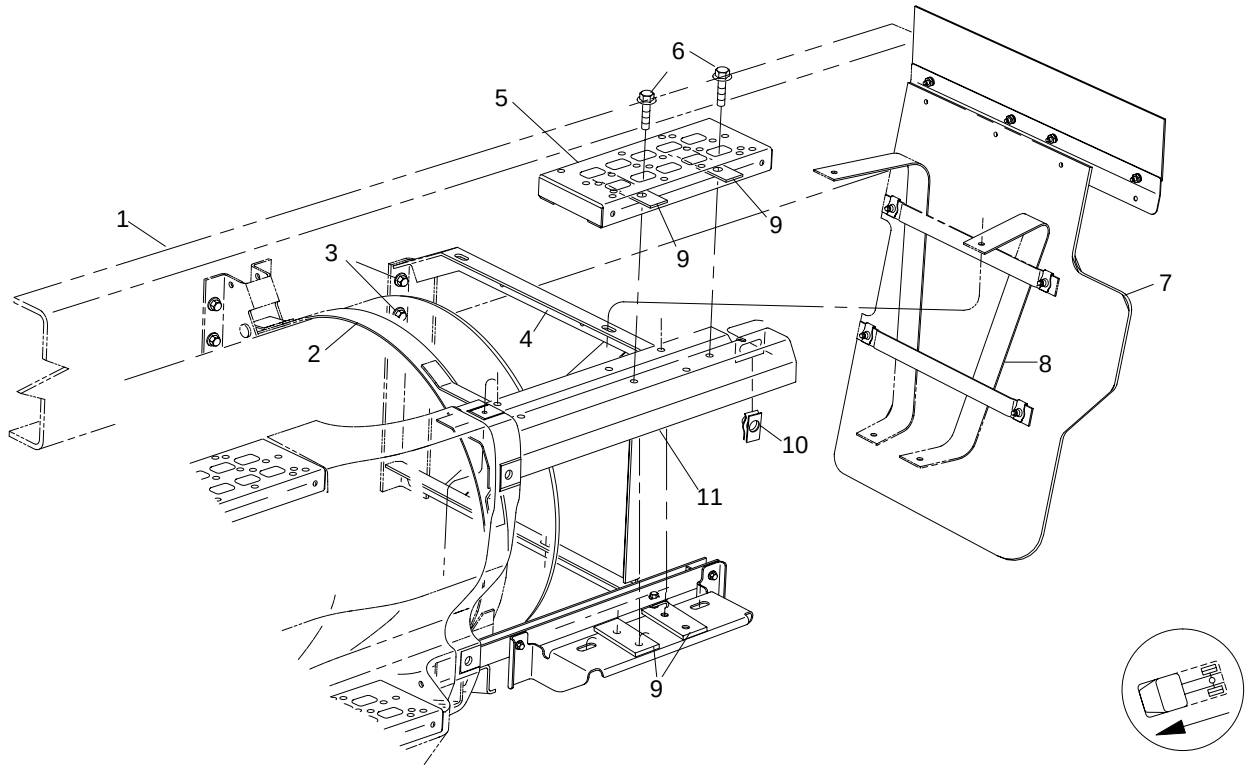
Support Bracket Removal and Installation



1. Off-Frame Bracket
2. Washer
3. Locknut (5/8–11)
4. Splash Shield Assembly
5. Spring U-Nut (3/8–16)
6. Hexhead Flange Bolt (5/16–18 x 1.38)
7. Splash Shield Bracket
8. Hexhead Bolt (3/8–16 x 1.5)
9. Washer
10. Splash Shield Bracket
11. Splash Shield Assembly
12. Hexhead Flange Bolt (5/16–18 x 1.5)
13. Hexhead Flange Bolt (5/16–18 x 1.38)
14. Retaining Clip
15. Step Assembly
16. Lower Side Fairing Reinforcement

Fig. 2, Center and Rear Side Fairing Support Brackets

Support Bracket Removal and Installation



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1. Frame Rail
2. Fuel Tank Strap
3. Locknut (5/8–11)
4. Off-Frame Bracket
5. Step Assembly
6. Hexhead Flange Bolt (5/16–18 x 1.38)
7. Splash Shield Assembly
8. Splash Shield Bracket
9. Retaining Clip
10. Spring U-Nut (3/8–16)
11. Upper Side Fairing Reinforcement

Fig. 3, Rear Side Fairing Support Brackets

1.1 Position the bracket and install the fasteners that attach the off-frame bracket to the frame rail.

1.2 Tighten the off-frame bracket fasteners 59 to 73 lbf·ft (80 to 100 N·m)

2. Install the upper side fairing reinforcement.

2.1 Put the upper side fairing reinforcement in place on the upper off-frame bracket.

2.2 Install and finger-tighten the retaining bolts.

2.3 Make sure the side fairing reinforcement is level and parallel with the frame rail. Clamp the side fairing in place. Check it's alignment with the hood and the bottom edge of the cab. If necessary, loosen the fasteners on the upper side fairing reinforcement. Move the front end of the side fairing reinforcement up or down as needed. Tighten the bolts 28 lbf·ft (38 N·m).

2.4 Put the lower side fairing reinforcement in place on the off-frame bracket.

2.5 Install and finger-tighten the retaining bolts.

2.6 Make sure the side fairing reinforcement is level and parallel with the frame rail.

Support Bracket Removal and Installation

Clamp the side fairing in place. Check it's alignment with the hood and the bottom edge of the cab. If necessary, loosen the fasteners on the upper side fairing reinforcement. Move the front end of the side fairing reinforcement up or down as needed. Tighten the bolts 28 lbf·ft (38 N·m).

3. Install the side fairings. See **Subject 100** for instructions.

General Information

Fontaine H5092 series fifth wheels couple to trailers having the standard 2-inch kingpin. When installed as a stationary mount, the fifth wheel is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. Sliding fifth wheels (**Fig. 1**), are mounted on the Fontaine HAWB or HMWS (previously called 5AWB and 5MWS) model slide mounts.

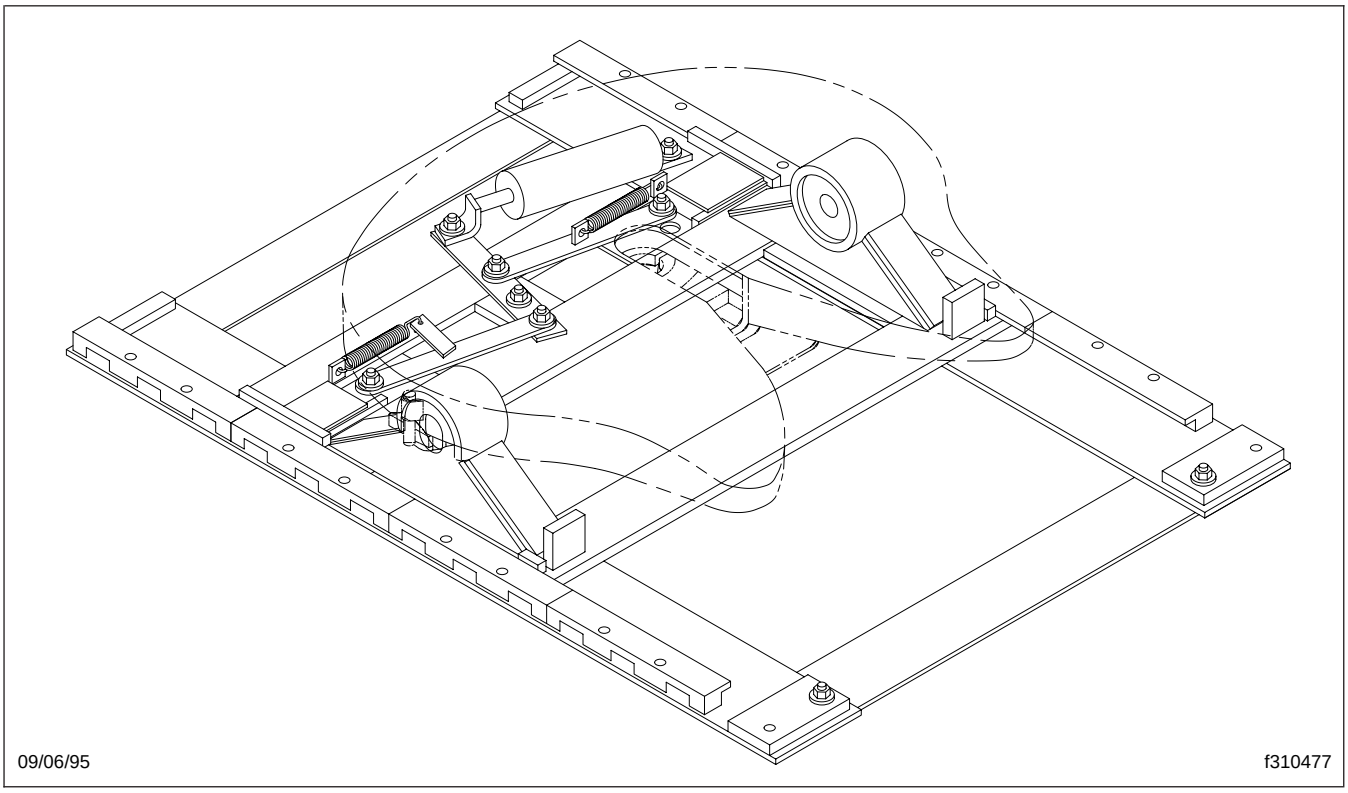


Fig. 1, Fontaine H5092 Series Air Slide Fifth Wheel

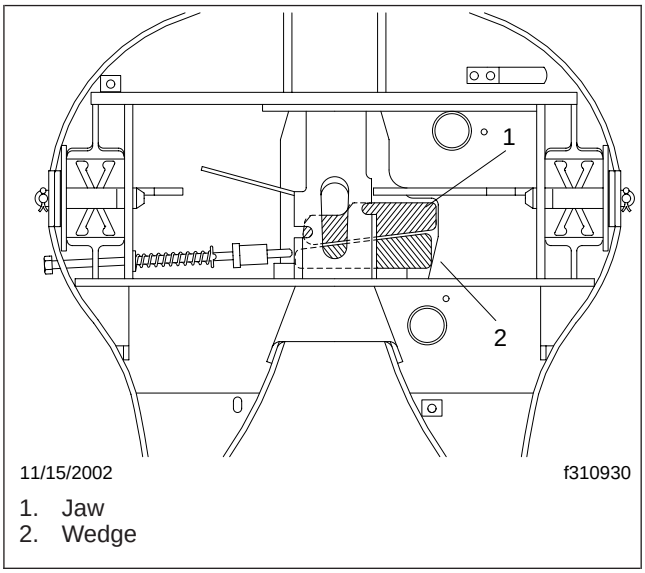
The Fontaine fifth wheel lock mechanism for the trailer kingpin consists of a spring-loaded jaw and sliding wedge. Kingpin release is accomplished by pulling a manual lock control handle located on either the right side or the left side of the fifth wheel. Kingpin coupling occurs when the kingpin enters the throat of the fifth wheel, triggers the jaw and wedge to slide into place behind the kingpin, and moves the lock control handle into the locked position.

As the kingpin enters the lock mechanism, the jaw is moved first with the spring-loaded wedge sliding in place against the jaw. See **Fig. 2**. 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 **Fig. 3**.

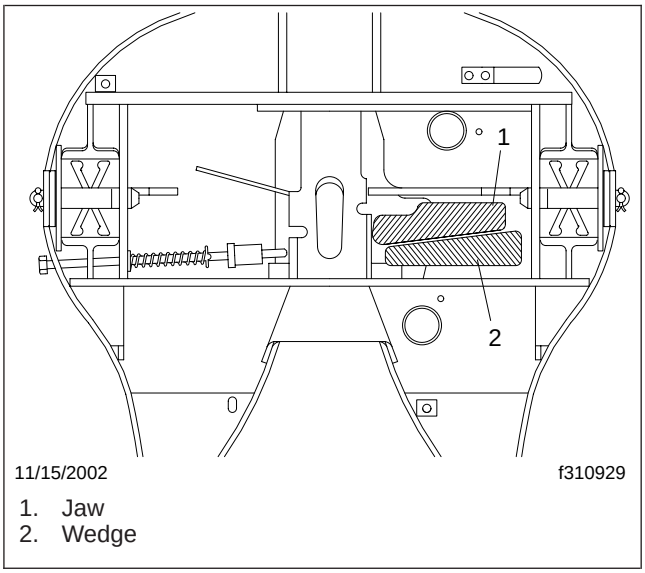
See Chapter 10 of the *L-Line and A-Line Driver's Manual* for complete operating instructions.

General Information



1. Jaw
2. Wedge

Fig. 2, Locked Position



1. Jaw
2. Wedge

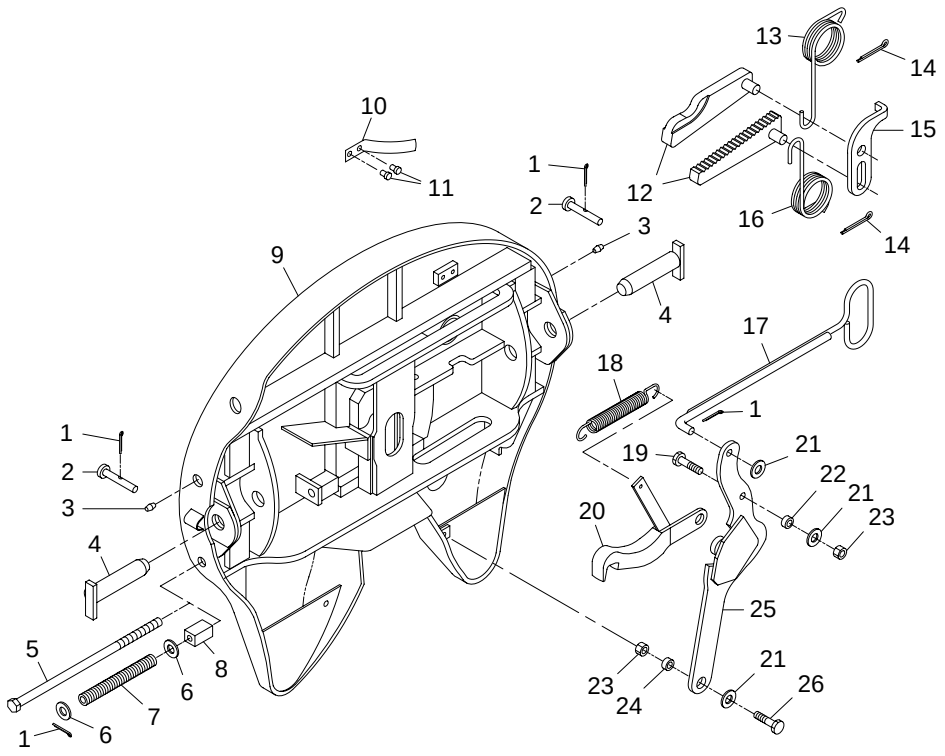
Fig. 3, Unlocked Position

Removal and Disassembly

See **Fig. 1** for an exploded view of a H5092 fifth wheel.

result in disengagement of the trailer from the tractor, leading to personal injury or property damage.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.



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1. Cotter Pin, 3/16 x 1 Inch
2. Lower Bracket Retainer Pin
3. Grease Fitting
4. Lower Bracket Pin
5. Wedge Stop Rod
6. Flatwasher
7. Wedge Stop Rod Spring
8. Nut, Wedge Stop Rod
9. Upper Assembly, Side Release
10. Leaf Spring
11. Thread-Cutting Screw, 1/4–20 x 3/8 Inch
12. Step Jaw and Wedge
13. Jaw Spring
14. Cotter Pin, 1/4 x 3 Inch
15. Timer
16. Wedge Spring
17. Pull Handle
18. Bumper Handle Spring
19. Hexhead Bolt, 1/2–13 x 2 Inch, Bumper Pivot
20. Bumper
21. Flatwasher
22. Bushing, 5/16 Inch, Bumper Pivot
23. Hex Locknut, 1/2–13
24. Bushing, 7/16 Inch, Handle Pivot
25. Operating Handle, Side Release Only
26. Hexhead Bolt, 1/2–13 x 2 Inch, Handle Pivot

Fig. 1, Fontaine H5092 Series Fifth Wheel (left-side release shown)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could

1. Steam clean the top plate. Remove it from the sliding mount by removing the cotter pins from the retaining pins. Remove the retaining pins and bushing pins from both sides of the top plate.

Fifth Wheel Removal and Disassembly

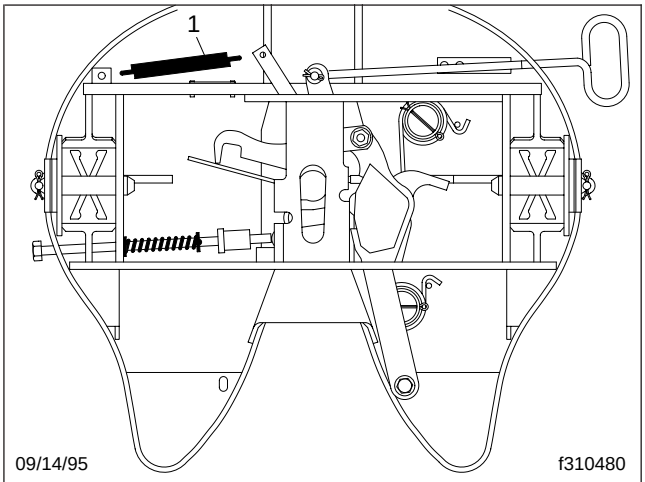
2. Using an overhead hoist, lift the fifth wheel off the sliding mount and tractor frame.
3. Turn the fifth wheel upside down.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

⚠ WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or if parts are damaged. The top plate or parts could malfunction. This could result in disengagement of the trailer during vehicle travel, possibly causing personal injury and property damage.

4. Set the fifth wheel in a locked position, then unhook the bumper spring from the bumper tang and the tab on the side of the fifth wheel substructure. See **Fig. 2**. Remove the bumper spring.



1. Bumper Spring

Fig. 2, Bumper Spring Removal

5. Remove the two bolts on the operating handle. See **Fig. 3**. Each bolt has a nut, washer, and bushing. Discard the bushings.
6. Remove the cotter pin and washer that holds the pull handle to the operating handle. Slide the pull handle out through the side of the fifth wheel. See **Fig. 4**.

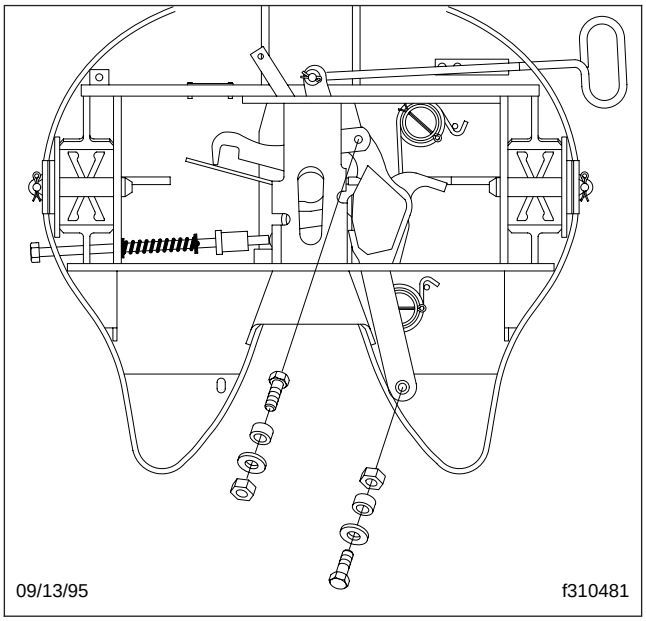


Fig. 3, Bolt Removal

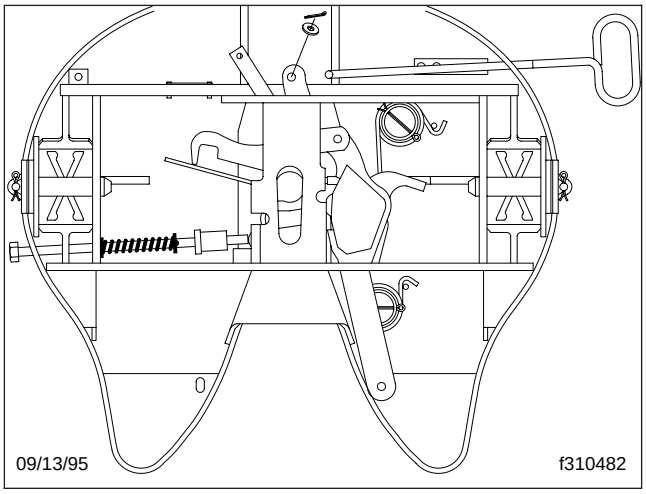
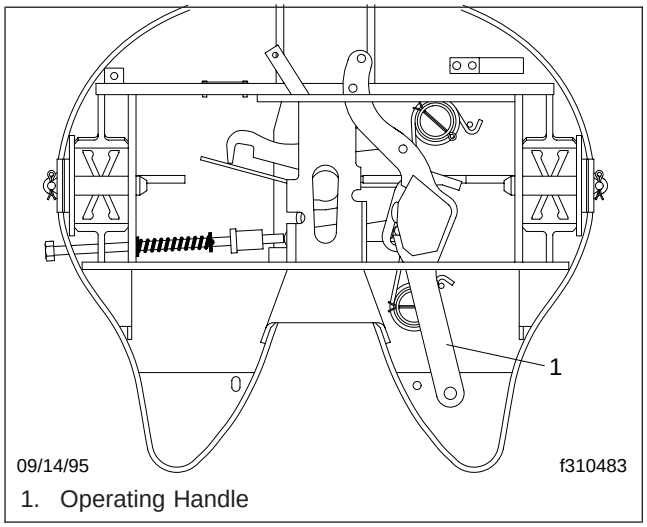


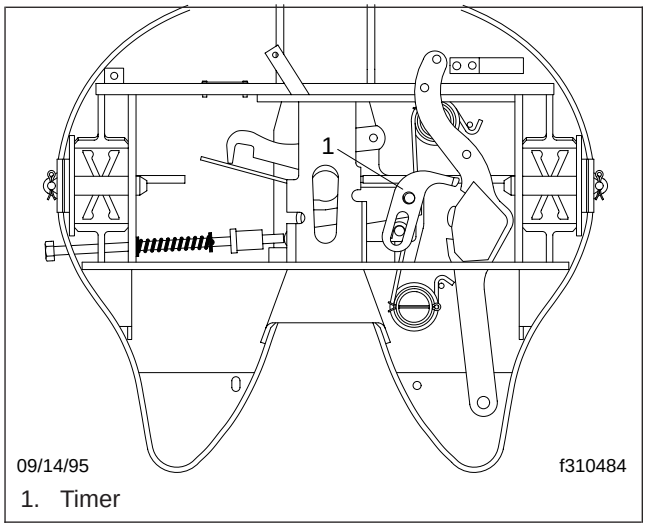
Fig. 4, Pull Handle Removal

7. Slide the operating handle over to the side of the fifth wheel. Slide the bottom part first. This will allow the handle to clear the jaw and wedge studs on the underside and clear the timer. See **Fig. 5**.
8. Remove the timer by lifting upward. See **Fig. 6**.
9. Slide the operating handle out through the slot in the rear crossmember of the fifth wheel. See **Fig. 7**.



1. Operating Handle

Fig. 5, Operating Handle Positioning



1. Timer

Fig. 6, Timer Removal

10. Slide the bumper toward the operating handle slot and to the rear of the fifth wheel until the bumper tang clears the operating handle slot. Lift upward and remove. See **Fig. 8**.

⚠ WARNING

The wedge spring is under extreme tension. Always wear safety glasses. Do not stand directly over the springs. A flying spring could cause personal injury.

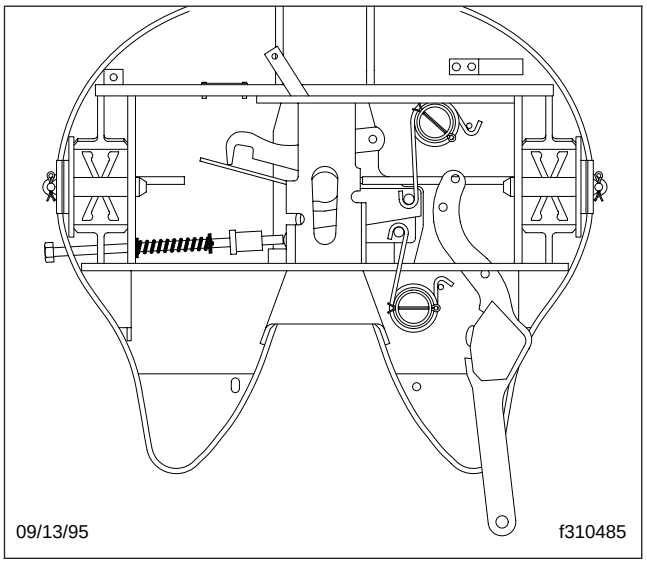
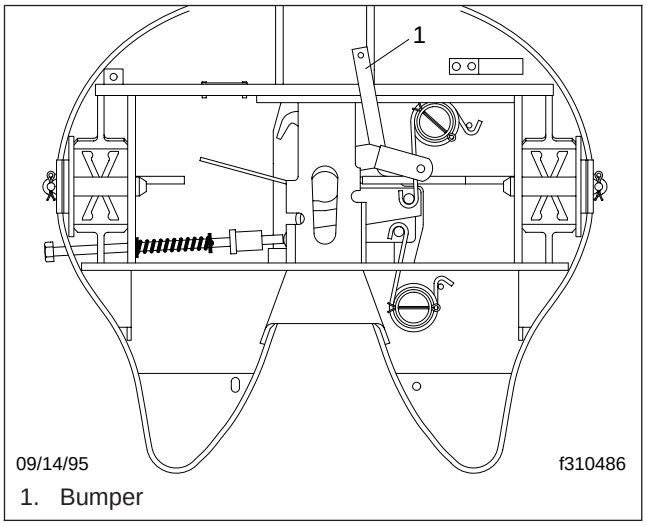


Fig. 7, Operating Handle Removal



1. Bumper

Fig. 8, Bumper Removal

11. Remove the cotter pins from the jaw and wedge springs. Discard the cotter pins, and pry the small hooked tail of the jaw and wedge spring up over the jaw and wedge studs. Remove and discard both springs. See **Fig. 9**.
12. Remove the wedge first, and then the jaw. Discard the jaw and wedge. See **Fig. 10**.

Fifth Wheel Removal and Disassembly

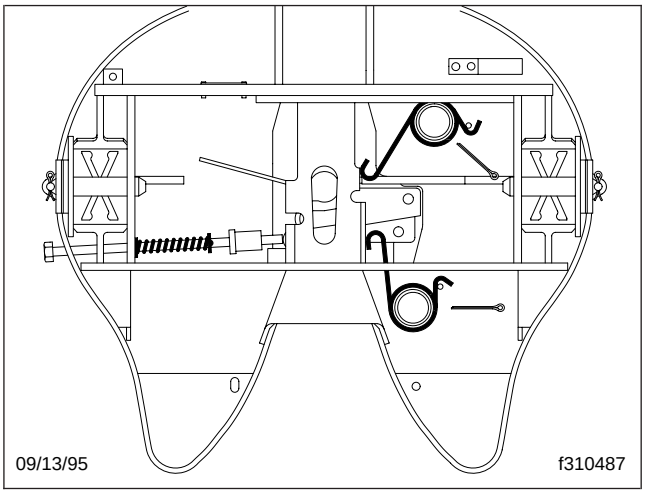


Fig. 9, Spring Removal

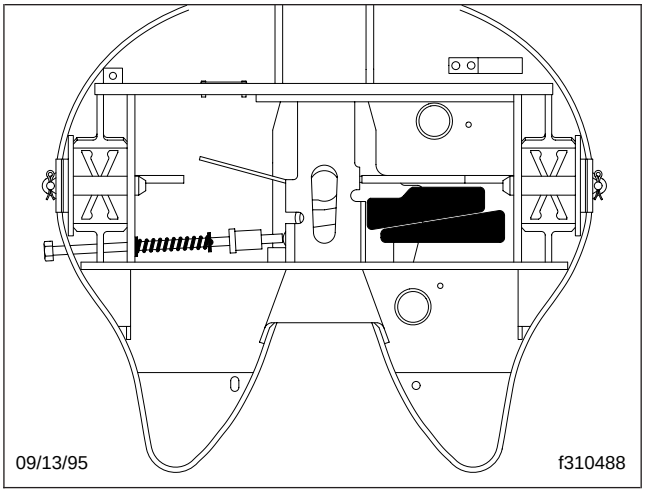
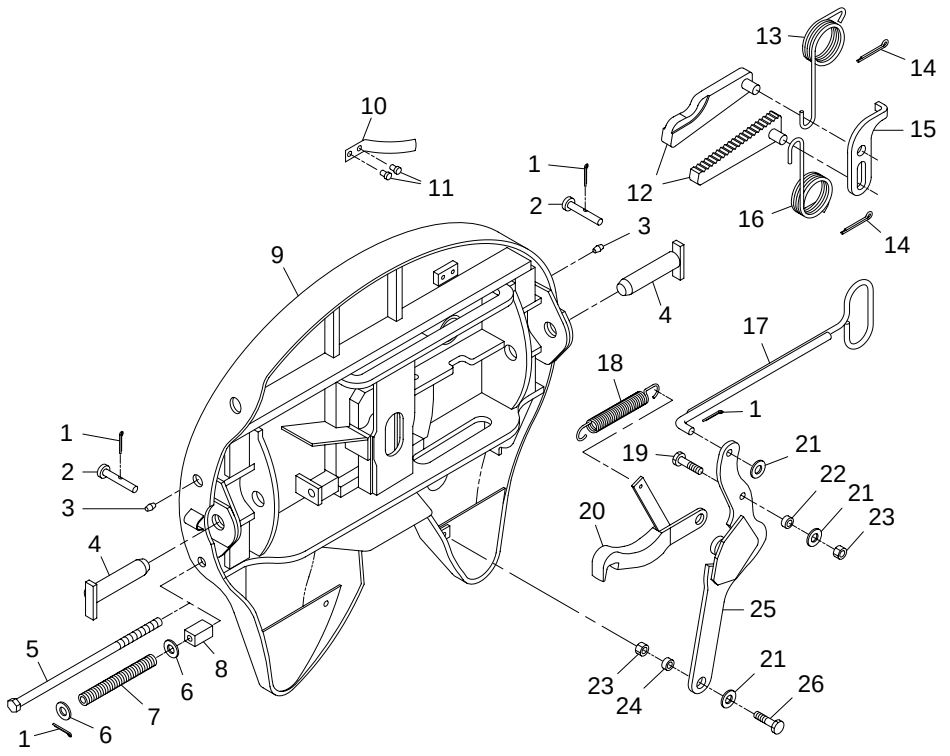


Fig. 10, Jaw and Wedge Removal

Assembly and Installation

See **Fig. 1** for an exploded view of a Fontaine® H5092 series fifth wheel.



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1. Cotter Pin, 3/16 x 1 Inch
2. Lower Bracket Retainer Pin
3. Grease Fitting
4. Lower Bracket Pin
5. Wedge Stop Rod
6. Flatwasher
7. Wedge Stop Rod Spring
8. Nut, Wedge Stop Rod
9. Upper Assembly, Side Release
10. Leaf Spring
11. Thread-Cutting Screw, 1/4–20 x 3/8 Inch
12. Step Jaw and Wedge
13. Jaw Spring
14. Cotter Pin, 1/4 x 3 Inch
15. Timer
16. Wedge Spring
17. Pull Handle
18. Bumper Handle Spring
19. Hexhead Bolt, 1/2–13 x 2 Inch, Bumper Pivot
20. Bumper
21. Flatwasher
22. Bushing, 5/16 Inch, Bumper Pivot
23. Hex Locknut, 1/2–13
24. Bushing, 7/16 Inch, Handle Pivot
25. Operating Handle, Side Release Only
26. Hexhead Bolt, 1/2–13 x 2 Inch, Handle Pivot

Fig. 1, Fontaine H5092 Series Fifth Wheel (left-side release shown)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in possible disengagement of the trailer from the tractor, leading to personal injury and property damage.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

IMPORTANT: Replace any parts that show signs of wear, damage, or deterioration.

Fifth Wheel Assembly and Installation

1. Clean all moving parts with No. 2 diesel fuel before assembly.
2. Always assemble the parts around a 2-inch kingpin or a shaft with a 2-inch diameter. Insert the jaw first and then the new wedge below it. Apply a moderate amount of grease having EP (extra pressure) additives to the sides and serrated edges of the jaw and wedge. Also apply grease to the stationary jaw in the throat of the fifth wheel. See **Fig. 2**.

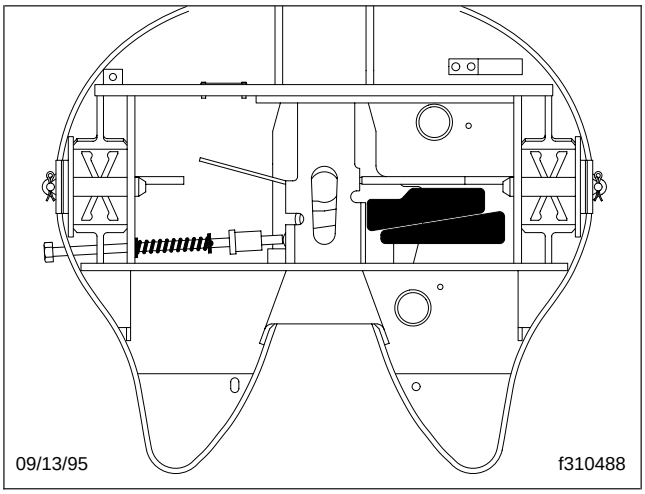


Fig. 2, Wedge and Jaw Installation

3. Insert the new wedge spring through the slot in the rear crossmember and lay the coil over the spring boss. Using a spring tool, engage the small hooked tail of the wedge spring and wind it around until it is directly over the small stud at the back of the bracket. Using a hammer, nudge the spring downward allowing it to catch on the stud. Insert a new cotter pin. See **Fig. 3**.

   Repeat these steps to replace the jaw spring.

NOTE: The jaw spring has minimal tension and can be replaced by hand.

4. Place the bumper back in position, sliding the bumper tang through the operating handle guide slot and toward the tab on the side of the fifth wheel substructure. See **Fig. 4**.
5. Apply a liberal amount of grease to the grooved middle section of the operating handle, then insert the operating handle and move it over to the side of the wheel. See **Fig. 5**.

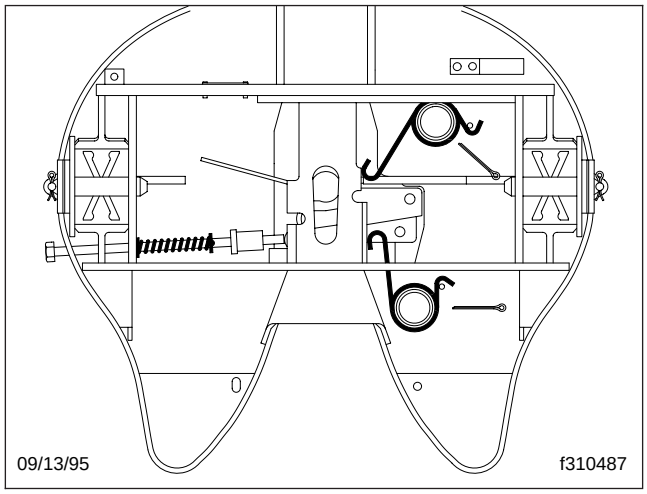
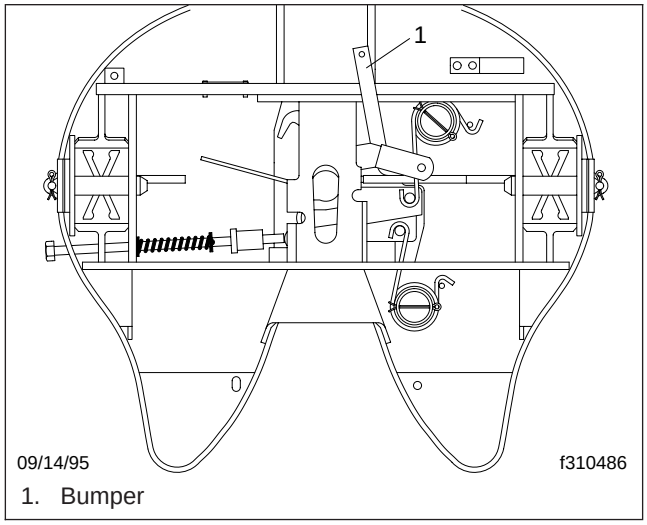


Fig. 3, Spring Installation



1. Bumper

Fig. 4, Bumper Installation

6. Insert the timer over the jaw and wedge studs. The small hole on the timer fits over the jaw stud and the slotted hole fits over the wedge stud. Be certain the small bent arm of the timer is facing downward. See **Fig. 6**.
7. Slide the operating handle toward the center of the wheel to engage the handle with the studs on the jaw and wedge. Slide the top part first. This will ensure that the grooves on the operating handle are aligned with the studs. A correctly aligned operating handle should be in a vertical position once it goes over the studs. See **Fig. 7**.

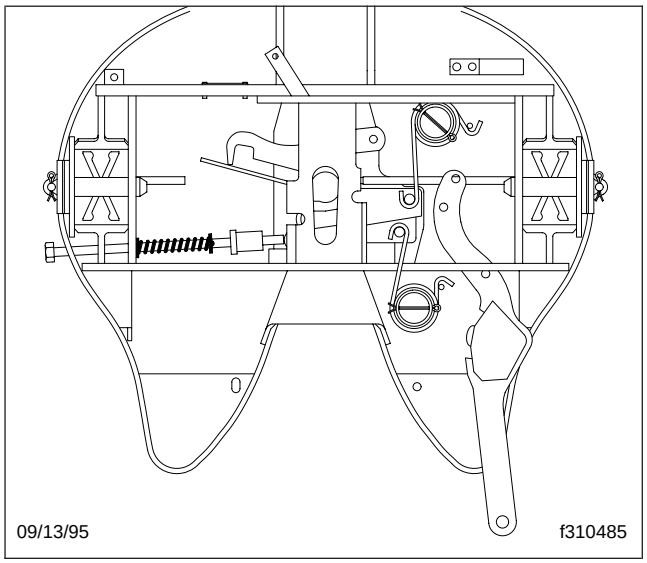


Fig. 5, Operating Handle Installation

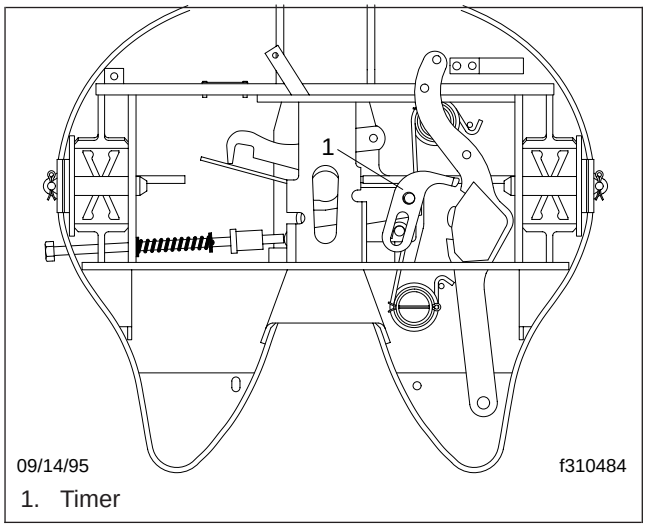


Fig. 6, Timer Installation

8. Slide the pull handle in through the safety lock and using the cotter pin and washer, fasten it in the top hole of the operating handle. See **Fig. 8**.

9. Align the bumper hole with the hole in the operating handle. Replace the bolts on the operating handle. The bolt which fastens the operating handle to the bumper must be inserted with the threads facing toward you to prevent interference with the jaw springs. The other bolt should be positioned with the threads facing downward. Each bolt has a nut, washer, and new bushings.

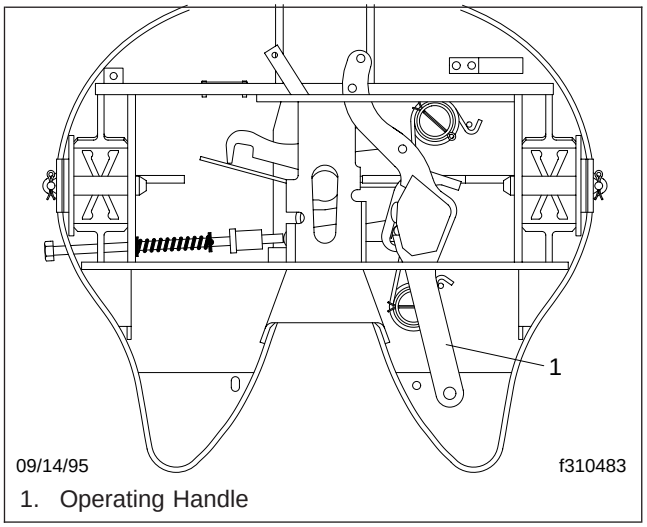


Fig. 7, Operating Handle Positioning

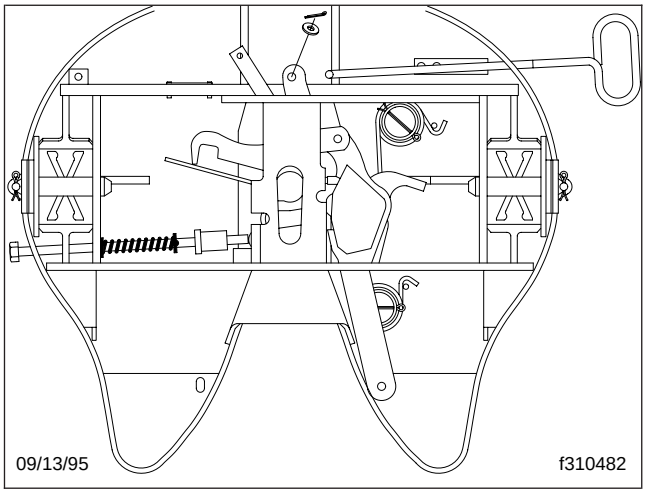


Fig. 8, Pull Handle Installation

Apply grease to the bolt parts and where there is metal to metal contact with the operating handle. See **Fig. 9**. Do not overtighten the bolts. Lubricate all pivot points.

IMPORTANT: The fifth wheel must be well lubricated to operate correctly. See Group 31 of the *L-Line and A-Line Maintenance Manual* for complete maintenance and lubrication instructions for the fifth wheel assembly.

10. Connect the bumper spring to its clasp. Apply grease to the bracket pockets and to the grease fittings on the side of the fifth wheel until grease

Fifth Wheel Assembly and Installation

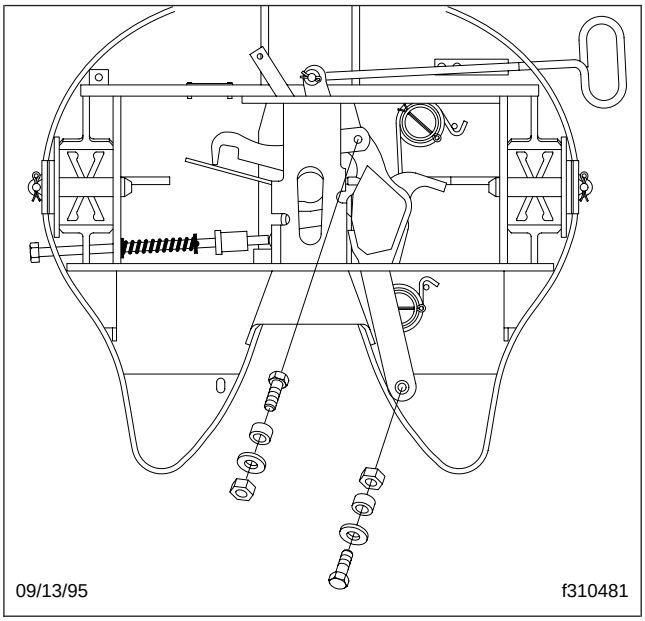
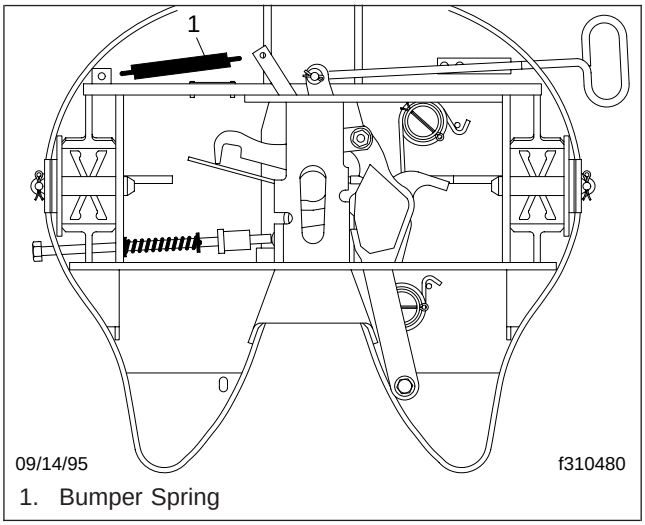


Fig. 9, Bolt Installation

flows into the upper brackets. Also apply a liberal amount of grease to the top plate. See **Fig. 10**.



1. Bumper Spring

Fig. 10, Spring Installation

WARNING

If the fifth wheel does not operate properly, do not use it. The fifth wheel could malfunction, resulting in personal injury or property damage due to possible disengagement of the trailer from the tractor.

11. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch-long cotter pins.

Troubleshooting Tables

Problem—Difficult Coupling

Problem—Difficult Coupling	
Possible Cause	**Remedy**
The kingpin is too high to trip the latch	Lower the landing gear.
The trailer plate or kingpin is damaged	Check the trailer plate for flatness. Check the kingpin for squareness with the trailer plate.

Problem—Excessive Wear on the Fifth Wheel Top Plate

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 the locking mechanism caused by truck drifting apart from the trailer putting excess pressure on the lock	Back up the trailer and set the brakes. Strike the wedge stop rod which protrudes through the side of the fifth wheel. This spring-loaded rod will release the pressure on the locking mechanism.
Oval-shaped kingpin	Lower the landing gear.
Debris build-up in the grease	

Problem—Slack

Problem—Slack	
Possible Cause	**Remedy**
Undersized kingpin	Replace the kingpin if worn greater than 1/8 inch (3 mm) at the 2-inch (5-cm) diameter.
Worn jaw and wedge	Jaw and wedge could have excessive wear. Replace them.

General Information

The Fontaine sliding fifth-wheel mount is designed to provide optimum axle loading for maximum tractor use with different lengths and types of trailers. The sliding fifth-wheel mount is used with the Fontaine 5092 series fifth wheel and is equipped with either an air-operated release slide (5AWB model), or a manual release slide (5MWS model).

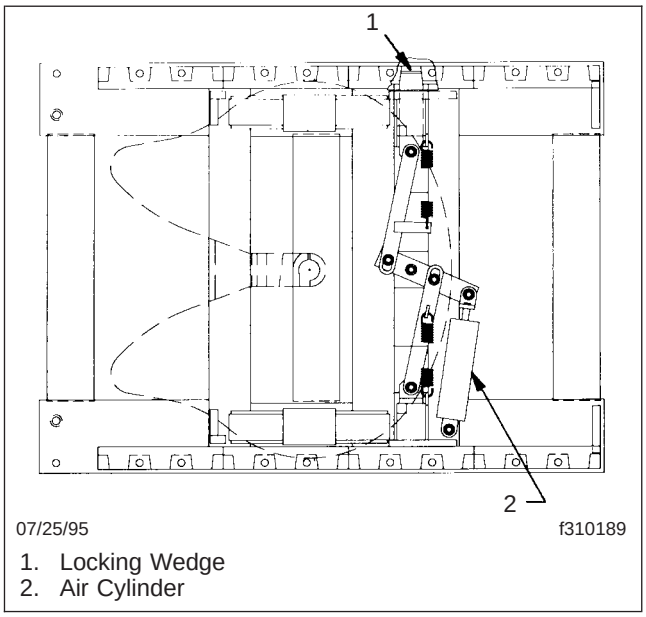
Sliding fifth wheel assemblies are mounted on slide rails that are attached to the vehicle frame. Slots are evenly spaced along the slide rails, and retractable tapered wedges are positioned through the slots to hold the fifth wheel in the desired position. This assembly allows forward or rearward movement of the fifth wheel along the slide rails for optimum weight distribution over the tractor axles. The slide rails are bolted to the tractor frame.

When the fifth wheel is in the desired position, it is locked in place by tapered wedges that engage in the slots under the sliding mount. To release the fifth wheel, the wedges are withdrawn (manually or air-operated).

The air-operated release slide contains an air cylinder (**Fig. 1**) which locks and unlocks both sides of the sliding mount at the same time. The air cylinder is activated by a two-position air-control valve in the tractor cab.

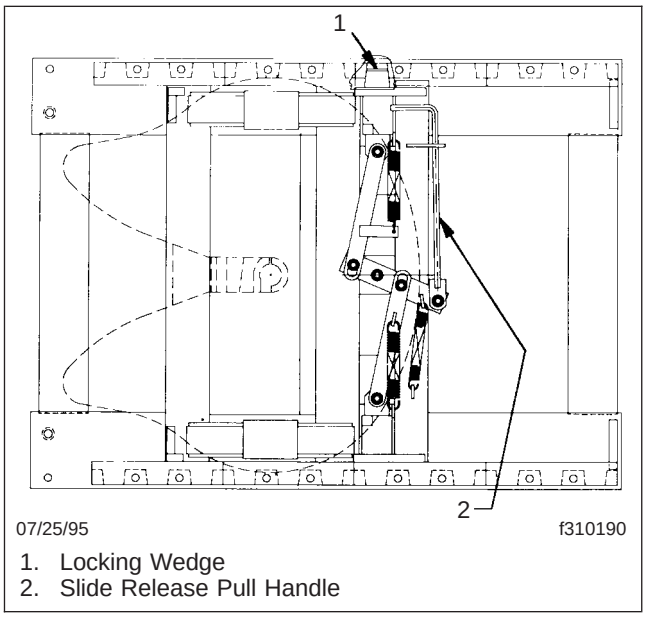
The manual release slide assembly (**Fig. 2**) contains a slide locking control handle, located on the left side of the fifth wheel, which locks or unlocks both sides of the sliding mount.

See Chapter 10 of the *L-Line and A-Line Driver's Manual* for complete operating instructions.



1. Locking Wedge
2. Air Cylinder

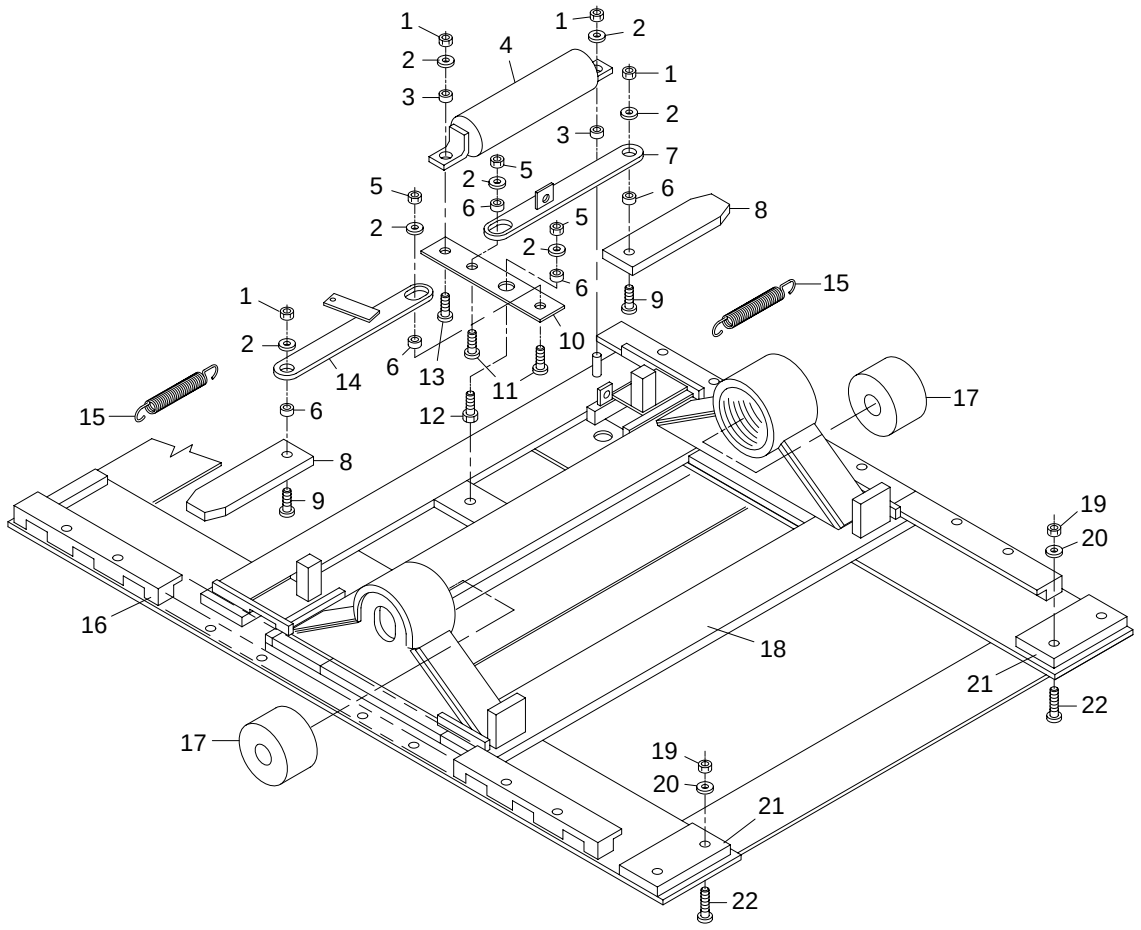
Fig. 1, Air-Operated Sliding Fifth Wheel Mount, 5AWB Model



1. Locking Wedge
2. Slide Release Pull Handle

Fig. 2, Manual Release Sliding Fifth Wheel Mount, 5MWS Model

Disassembly (See Fig.1 or Fig.2)



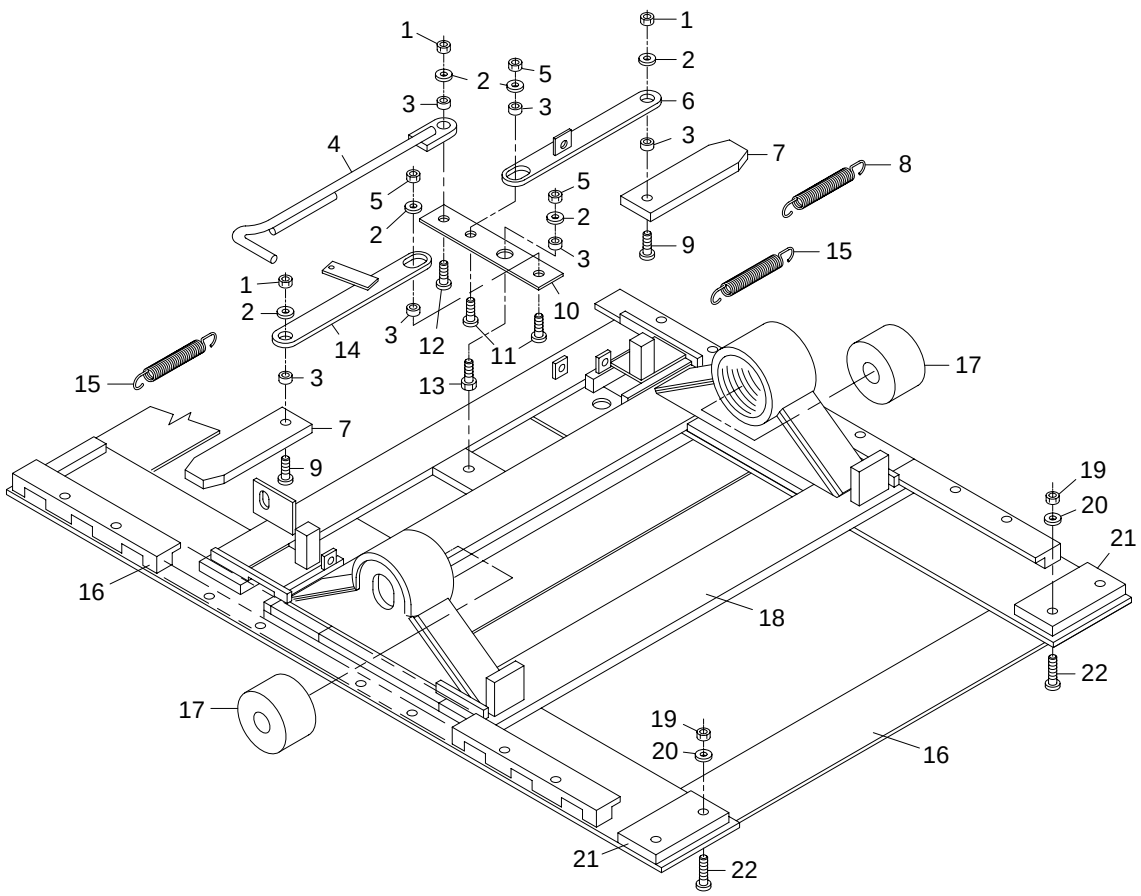
1. Hex Locknut, 1/2–13, Grade B
2. Flatwasher
3. Bushing Spacer, 7/16 Inch
4. Air Cylinder
5. Hex Jam Nut, 1/2–13
6. Bushing Spacer, 5/16 Inch
7. Locking Wedge Release Bar (right-side)
8. Locking Wedge
9. Capscrew, 1/2–13 x 2 Inch
10. Latching Lever
11. Capscrews, 1/2–13 x 1 Inch
12. Capscrew, 1/2–13 x 1 Inch
13. Capscrew, 1/2–13 x 1–1/2 Inch
14. Locking Wedge Release Bar (left-side)
15. Locking Member Spring
16. Slide Rail
17. Bracket Bushing
18. Slide Bracket
19. Locknut, 5/8 Inch Grade C
20. Flatwasher
21. Rear Slide Stop
22. Capscrew, 5/8–11 x 1–3/4 Inch

Fig. 1, Fontaine Sliding Fifth Wheel Mount, Model 5AWB (air-operated)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in possible disengagement of the trailer from the tractor, leading to personal injury and property damage.

Sliding Mount Disassembly and Assembly



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1. Hex Locknut, 1/2–13, Grade B
2. Flatwasher
3. Spacer Bushing, 5/16 Inch
4. Pull Handle
5. Hex Jam Nut, 1/2–13
6. Locking Wedge Release Bar (right-side)
7. Locking Wedges
8. Latching Lever Spring
9. Capscrew, 1/2–13 x 2 Inch
10. Latching Lever
11. Capscrews, 1/2–13 x 1 Inch
12. Capscrew, 1/2–13 x 1–1/2 Inch
13. Capscrew, 1/2–13 x 1 Inch
14. Locking Wedge Release Bar (left-side)
15. Locking Member Spring
16. Slide Rail
17. Bracket Bushing
18. Slide Bracket
19. Locknut, 5/8–11, Grade C
20. Flatwasher
21. Rear Slide Stop
22. Capscrew, 5/8–11 x 1–3/4 Inch

Fig. 2, Fontaine Sliding Fifth Wheel Mount, Model 5MWS (manual release)

⚠ WARNING

The lifting device used to remove the top plate must be able to lift 500 lb (227 kg). The top plate weighs 254 lb (115 kg) and if dropped could cause personal injury or property damage.

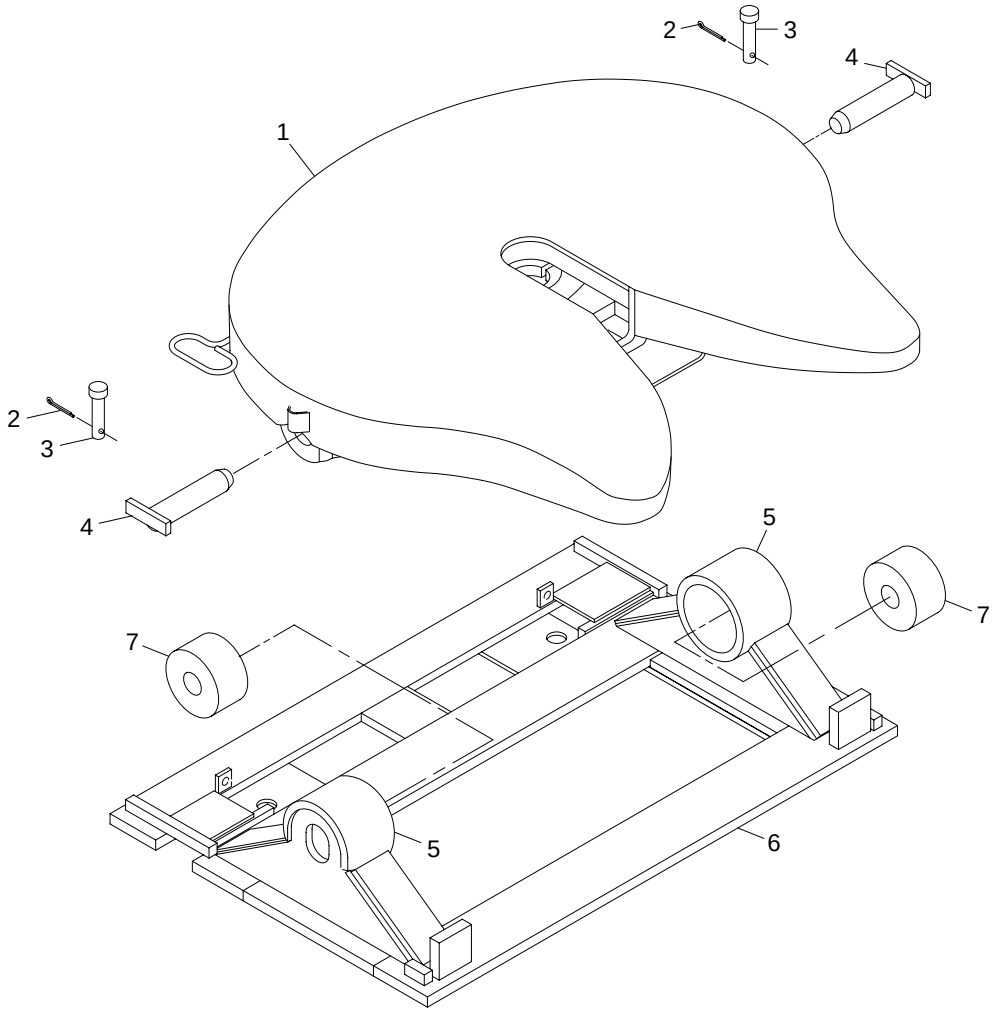
1. Remove the top plate. See **Fig.3**.

1.1 Using a lifting device to support the top plate, remove the two cotter pins.

1.2 Remove the two lower bracket retainer pins, and discard them.

1.3 Remove the lower bracket pins, and lift the top plate from the slide bracket.

1.4 Remove and discard the bracket bushings.



1. Top Plate
2. Cotter Pin
3. Lower Bracket Retainer Pin
4. Lower Bracket Pin
5. Mounting Bracket
6. Slide Bracket
7. Bracket Bushing

Fig. 3, Top Plate Removal

1.5 Clean and inspect all the parts. Replace parts as needed.

2. If the fifth wheel mount is equipped with a manual release (**Fig.2**), go to the next step for disassembly instructions.

   If the fifth wheel mount is equipped with an air release cylinder (**Fig.1**), disassemble it as follows:

2.1 Drain the air from the air cylinder, and disconnect the air line from the cylinder. Install plugs in the air line and the cylinder to prevent dirt or other matter from entering them.

2.2 Remove the locking wedge springs (**Fig.1**, Ref. 15), the capscrews (Ref. 9), the spacers, the washers, and the locknuts. Discard the locknuts and spacers.

2.3 Remove the locking wedge release bars.

Sliding Mount Disassembly and Assembly

2.4 Remove the capscrew (Ref. 12), the spacer, the washer, and the locknut. Discard the locknut.

Remove the capscrew (Ref. 11), the spacers, the washers, and the locknuts. Discard the locknuts and the spacers.

2.5 Remove the locking wedges.

2.6 Remove the capscrew (Ref. 13), the spacer, the washer, and the locknut. Discard the locknut and the spacer.

2.7 Remove the air cylinder.

3. If the fifth wheel mount is equipped with a manual release (**Fig.2**) disassemble it as follows:

3.1 Remove the three springs from the sliding mount assembly.

3.2 Remove the locknuts (**Fig.2**, Ref. 1), the washers, the spacer bushings, and the capscrews from the tapered wedges.

3.3 Remove the locking wedges.

3.4 Remove the locknuts from the pull handle, and the locking wedge release bars.

Remove the spacer bushings, washers, and capscrews.

Remove the locking wedge release bars and the pull handle from the latching lever.

3.5 Remove the locknut, washer, spacer bushing, and capscrew from the latching lever.

Remove the latching lever.

4. If the sliding mount assembly is damaged, remove it as follows:

4.1 Remove the nuts, washers, and capscrews that secure the rear slide stops to the rear of the slide rail.

4.2 Grind down the welded area to remove the rear stops.

4.3 Remove the sliding mount assembly from the baseplate by sliding it off the rear of the tracks.

5. Remove all dirt and grease from the parts. Replace any parts that show signs of wear, damage, or deterioration.

Assembly (See Fig.1 or Fig.2)

WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in possible disengagement of the trailer from the tractor, leading to personal injury or property damage.

1. Using a multipurpose chassis lube, grease the flanges on the sliding mount. Then, slide the assembly onto the tracks of the baseplate.

2. Slide the mounting assembly to the rearmost position. Position the wedges in the rail.

Install the capscrews, washers, and nuts that secure the rear stops to the baseplate.

3. Slide the mounting assembly out of the way, then weld the stops in place. The welds should be 1/4-inch (6 mm) fillet.

4. Slide the mounting assembly to the rearmost position and check for clearance. Make sure that the wedges seat in the rail.

5. If the fifth wheel mount is equipped with a manual release (**Fig.2**), go to the next step for assembly instructions.

If the fifth wheel mount is equipped with an air release cylinder (**Fig.1**), assemble it as follows:

NOTE: To avoid damaging the spacers, tighten the locknuts only one turn beyond finger tight.

5.1 Install the capscrews (**Fig.1**, Ref. 9) and spacers in the locking wedges.

5.2 Using capscrews, spacers, washers, and new locknuts, fasten the latching lever to the locking wedge release bars.

5.3 Slide the locking wedges into the slide assembly guide, and place the locking wedge bars and latching lever on the as-

sembly. Bolt down the locking wedge release bars with new washers and locknuts.

5.4 Apply grease to the locking member and the assembly.

5.5 Install the air cylinder using new spacers and locknuts. Install the locking member spring.

6. If the fifth wheel mount is equipped with a manual release (**Fig.2**) assemble it as follows:

NOTE: To avoid damaging the spacers, tighten the locknuts only one turn beyond finger tight.

6.1 Using a capscrew, spacer bushing, washer, and locknut, install the latching lever.

6.2 Using capscrews, spacer bushings, washers, and locknuts, attach the locking wedge release bars and pull handle to the latching lever.

6.3 Using capscrews, spacer bushings, washers, and locknuts, attach the locking wedges to the locking wedge release bars.

6.4 Install the three springs on the bracket assembly.

⚠ WARNING

The lifting device used to remove the top late must be able to lift 500 lb (227 kg). The top plate weighs 254 lb (115 kg) and if dropped could cause personal injury or property damage.

7. Install the top plate on the fifth wheel mount. See **Fig.3**.

7.1 Install new bracket bushings in the slide bracket.

7.2 Lubricate the brackets and the bearing pockets in the top plate with bearing grease.

7.3 Set the top plate on the mounting brackets, and align the bracket pin holes in the top plate with the mounting bracket holes.

7.4 Insert new lower bracket pins.

7.5 Insert new lower bracket retainer pins. Insert new cotter pins in the lower bracket retainer pins.

General Information

NOTE: Service operations for the Holland 3500 series slide mounts (FW35) are covered in **Section 31.08**.

MODEL XA–351 TOP PLATE

NOTE: The part number prefix for the stationary fifth wheel and the sliding fifth wheel is FW35.

The Holland 3500 series XA–351 fifth wheels are applicable for general over-the-road use. They are designed to pull trailers having a 2-inch SAE J700b kingpin. They have a capacity of 150,000 lbf (667 000 N) maximum drawbar pull and 55,000 lbf (244 652 N) maximum vertical load. These fifth wheels are available in three different mounting assemblies: the Kompensator®; the slide mount; and the stationary mount.

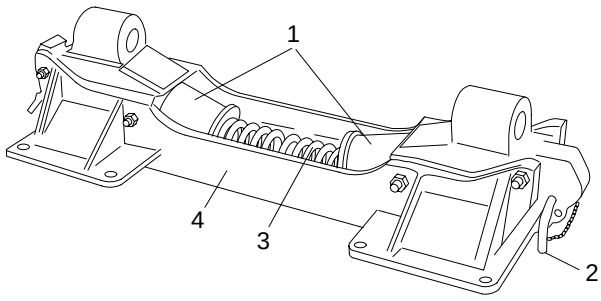
The stationary mount fifth wheels are available with four different mounting bracket styles, which include:

- A bracket with a mounting base for over-the-frame mounting;
- A bracket with a mounting angle for over-the-frame mounting;
- A bracket for angle mounting (designed to be welded to the angle) for over-the-frame mounting;
- And, a bracket for outboard angle mounting.

The mounting brackets use nylon-lined "up-shock" bushings. These fifth wheels come in a variety of heights to accommodate many applications.

The sliding fifth wheels are available with either an over-the-frame mounting bracket or an outboard angle mounting bracket. These mounting brackets are either equipped with a manual slide release or an air slide release mechanism. These sliding mounts have a position adjustment that gives the fifth wheel top plate the ability to be released, incrementally moved (by 1.5 inch {3.8 cm] displacements) and locked in alternate positions. The position adjustment feature allows the fifth wheel position to vary combination length and tractor axle load distribution for maximum equipment utilization. The mounting brackets use nylon-lined "up-shock" bushings. The sliding fifth wheels are available in a variety of heights and slide travel lengths.

The Kompensator fifth wheel is equipped with either a stationary or sliding mounting bracket. This fifth wheel is designed for rigid trailers that 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, The Kompensator Cradle

The 3500 series top plate consists of:

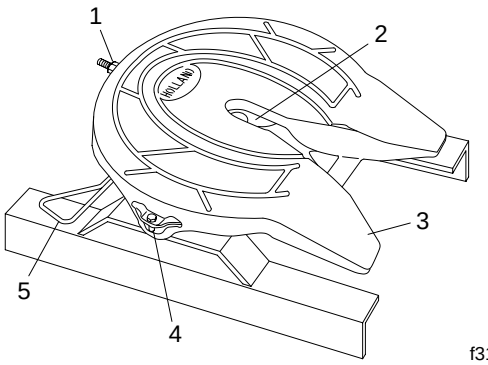
- The cast steel top plate;
- The bracket pin mount;
- The release handle;
- The infinite lock adjustment nut;
- And the kingpin lock mechanism.

See **Fig. 2**.

The kingpin lock mechanism consists of:

- The infinite lock adjustment nut;
- The secondary lock;
- The release handle;

General Information



1. Infinite Lock Adjustment Nut
2. Kingpin Lock
3. Cast Steel Top Plate
4. Bracket Pin Mount
5. Release Handle

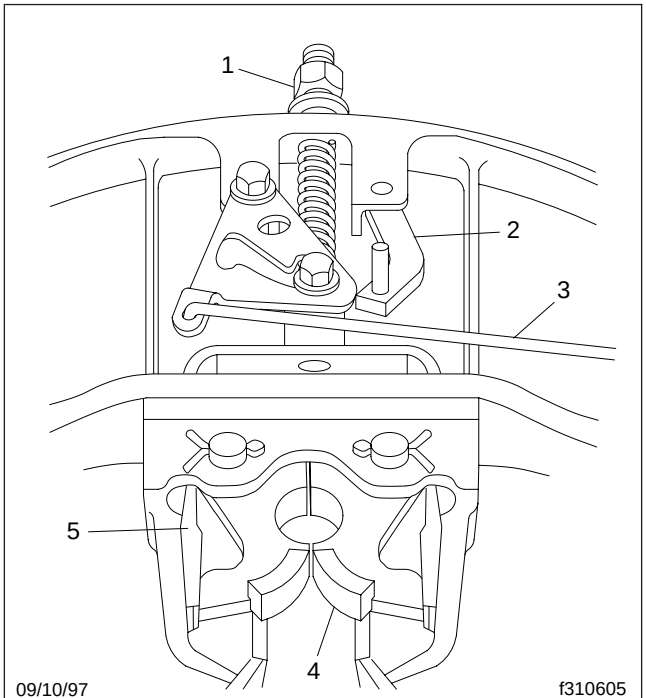
Fig. 2, XA-351 Fifth Wheel

- The type "B" forged steel split lock;
- And, the yoke.

See **Fig. 3**.

When the yoke is retracted, the two spring-loaded lock halves separate as the kingpin enters the lock mechanism. When the yoke engages, the final forward motion of the kingpin forces the lock to close in a 360 degree grip around the shoulder and neck of the kingpin. After the yoke is engaged (positioned between the lock halves and the tapered rib members of the top plate casting), the secondary lock moves behind the yoke. For fifth wheels with an automatic secondary lock, the kingpin is released by manually operating the release handle. For fifth wheels with a manual secondary lock, the fifth wheel is released by pulling the secondary release handle, then hooking the secondary release handle to the top plate casting, and finally manually operating the primary release handle. For high coupling protection, a one step rear lock is incorporated into the split lock. For increased durability of the kingpin lock mechanism, the infinite lock adjustment positions are available to compensate for wear in both the kingpin and the lock jaws.

See Chapter 10 of the *L-Line and A-Line Driver's Manual* for complete operating instructions.



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)

Model XA–351 Top Plate Removal and Disassembly

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

Fifth wheel rebuild kits are available for servicing the 3500 series XA–351 fifth wheels. For the rebuild kits, the part numbers include:

- RK–351AL (left-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, then the fifth wheel may need rebuilding.

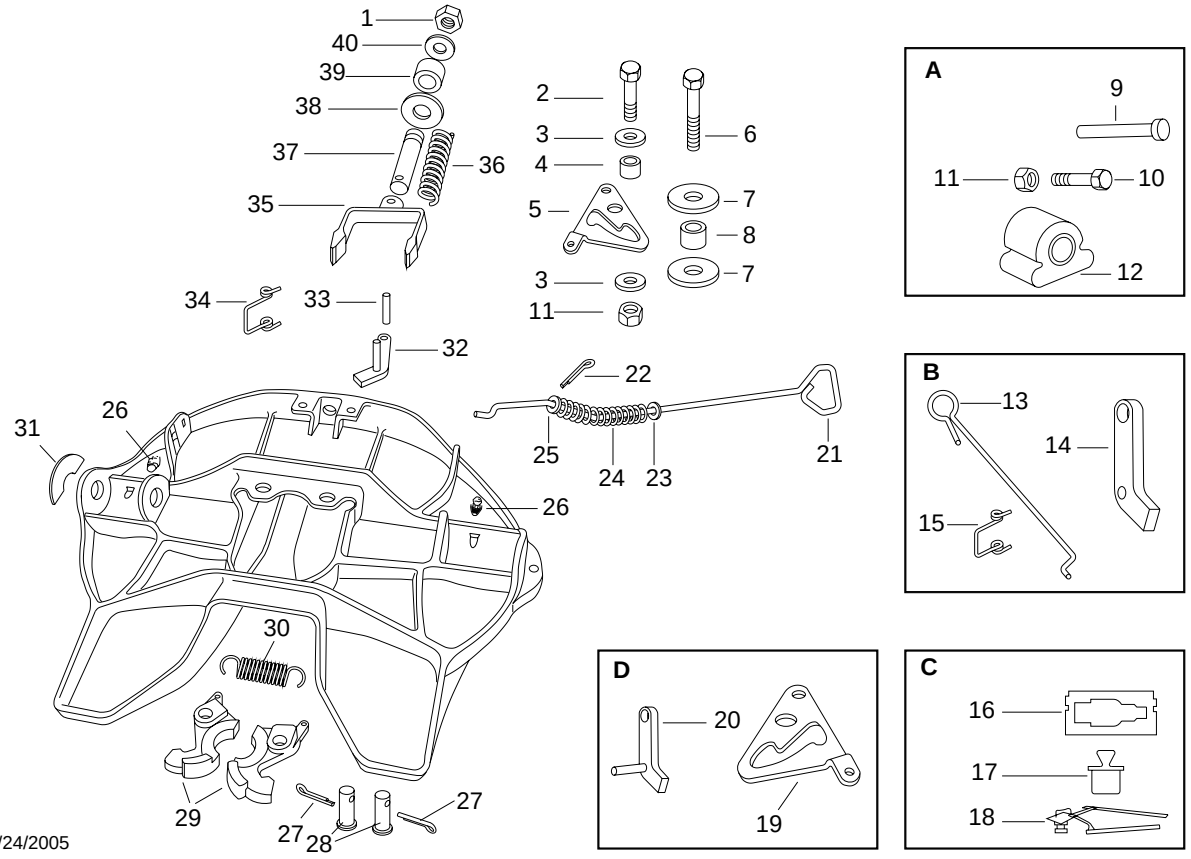
While disassembling the fifth wheel, check it for cracks and for missing or damaged parts. Discard all used components.

Removal and Disassembly

(See Fig. 1)

1. Steam clean the top plate.
2. Remove the top plate from the bracket assembly.
   - 2.1 Loosen and remove the 1/2–20 bushing pin capscrews and locknuts from the top plate.
   - 2.2 Remove the bushing pins from the bracket assembly. See **Fig. 2**.
   - 2.3 Using an overhead hoist, lift the fifth wheel from the bracket assembly and tractor frame.
3. Disassemble the secondary lock.
   - 3.1 Turn the fifth wheel upside down with the locks open.
   - 3.2 Using a suitable driver and hammer, drive the 1/2-inch by 2-3/4 inch roll pin from the top plate and the secondary lock. See **Fig. 3**.
   - 3.3 If the fifth wheel has an automatic secondary lock, proceed to the next substep, otherwise, remove the manual secondary release handle by passing the "S" bend of the release handle through the large hole in the secondary lock and then through the guide hole. See **Fig. 4**.
   - 3.4 Remove the secondary lock.
4. Disassemble the cam plate.
   - 4.1 Loosen and remove the 5/8-inch capscrew from the threaded hole in the yoke. Remove the washers, and the roller from the cam plate. See **Fig. 5**.
   - 4.2 Loosen and remove the 1/2-inch capscrew and nut from the top plate lug. Remove the washers, and the roller from the cam plate. See **Fig. 6**.
   - 4.3 Remove the release handle by passing the "S" bend of the release handle through the large hole in the raised tab of the cam plate and through the top plate casting hole. See **Fig. 6**.
5. Disassemble the yoke.
   - 5.1 Slide the yoke shaft assembly away from the yoke, through the compression spring, and out of the top plate casting. See **Fig. 7**.
   - 5.2 Remove the compression spring and remove the yoke.
6. Disassemble the lock.
   - 6.1 Remove the cotter pins from the lockpins.
   - 6.2 Using a suitable driver and hammer, drive the lockpins out of the casting. See

Model XA–351 Top Plate Removal and Disassembly



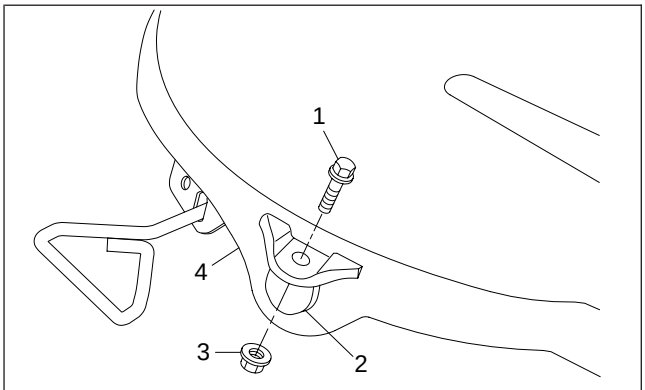
A. Bushing Pin Assembly
B. Manual Secondary Lock Assembly
C. Fifth Wheel Accessories
D. Right-Side Secondary Lock Assembly

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)

Fig. 8. This will free the lock jaws assembly. Remove the lock jaws and lock spring.

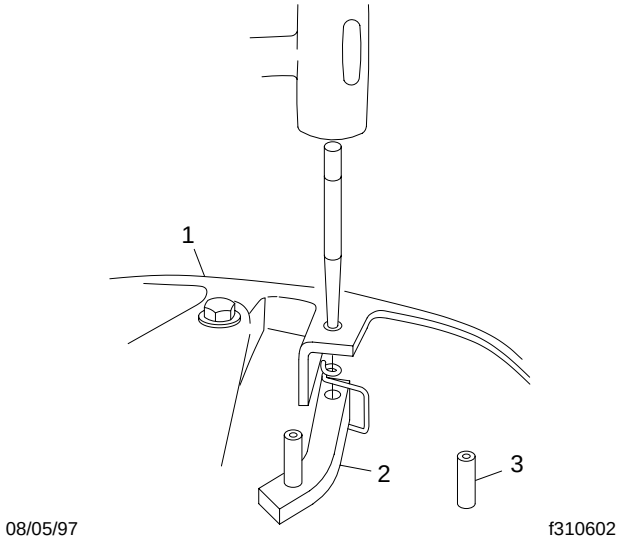
Model XA–351 Top Plate Removal and Disassembly



08/04/97 f310601

1. Capscrew
2. Bushing Pin
3. Locknut
4. Top Plate

Fig. 2, Remove the Bushing Pin



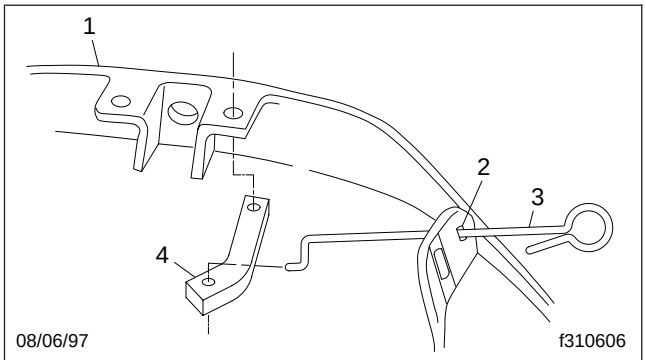
08/05/97 f310602

1. Top Plate
2. Secondary Lock
3. Roll Pin

Fig. 3, Disassemble the Secondary Lock

⚠ WARNING

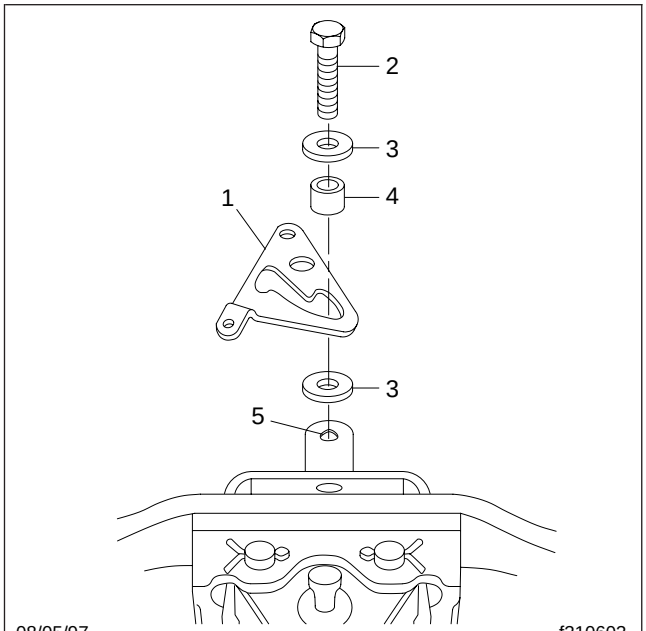
Do not attempt to repair or rebuild the top plate if it is cracked or if the lockpin does not fit tightly. The top plate could fail or the locks could malfunction. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.



08/06/97 f310606

1. Top Plate
2. Guide Hole
3. Release Handle
4. Secondary Lock

Fig. 4, Remove the Release Handle

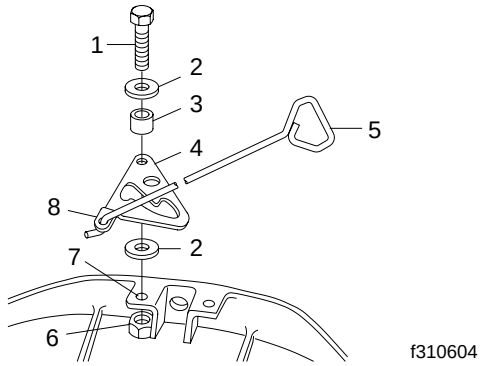


08/05/97 f310603

1. Cam Plate
2. Capscrew, 5/8–20
3. Washer
4. Roller
5. Threaded Hole In Yoke

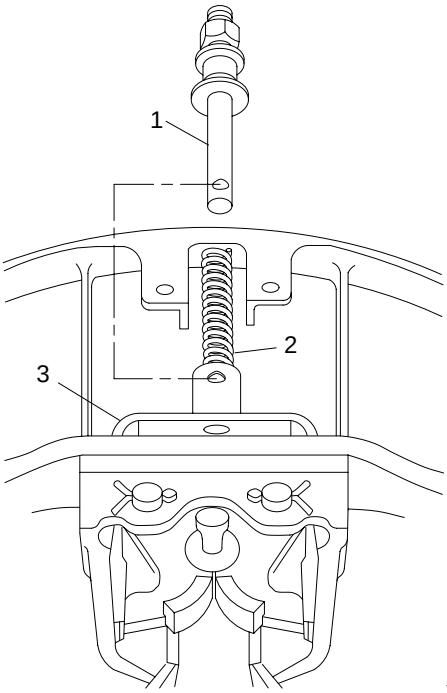
Fig. 5, Remove the Capscrew From the Yoke

Model XA–351 Top Plate Removal and Disassembly



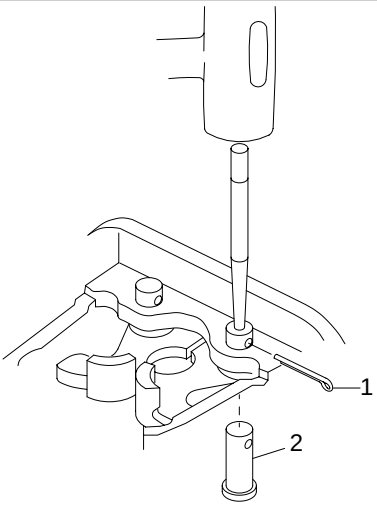
1. Capscrew, 1/2–20
2. Washer
3. Roller
4. Cam Plate
5. Release Handle
6. Nut, 1/2–20
7. Top Plate Lug
8. Raised Tab

Fig. 6, Disassemble the Cam Plate



1. Yoke Shaft Assembly
2. Compression Spring
3. Yoke

Fig. 7, Remove the Yoke Shaft Assembly



1. Cotter Pin
2. Lockpin

Fig. 8, Remove the Lockpins

Model XA–351 Top Plate Assembly and Installation

WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

Fifth wheel rebuild kits are available for servicing the 3500 series XA–351 fifth wheels. For the rebuild kits, the part numbers include:

- RK–351AL (left-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.

Review **Troubleshooting, 300** before rebuilding the fifth wheel. Rebuilding may be unnecessary.

IMPORTANT: Use only Holland rebuilding kits. Replace all roll pins, springs, capscrews, nuts, and washers that are included in the kit. Do not reuse all parts.

WARNING

Use only genuine Holland parts and do not modify, change or add to the product. Any alterations to the fifth wheel assembly could compromise its performance. This could result in the loss of the trailer connection during vehicle travel, possibly causing bodily injury and property damage.

Assembly and Installation

(See Fig. 1)

WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or distorted or if the lockpin does not fit tightly. The top plate could fail or the locks could malfunction. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

1. Inspect the top plate.
   - 1.1 If necessary, turn the fifth wheel upside down.
   - 1.2 Inspect the front lock surface for burrs or cracks. See **Fig. 2**. The front lock surface must be free of any burrs or cracks.
2. Install the lock.
   - 2.1 Lubricate the lockpin holes of the lock jaws with Never-Seez® (provided in the kit). See **Fig. 3**.

CAUTION

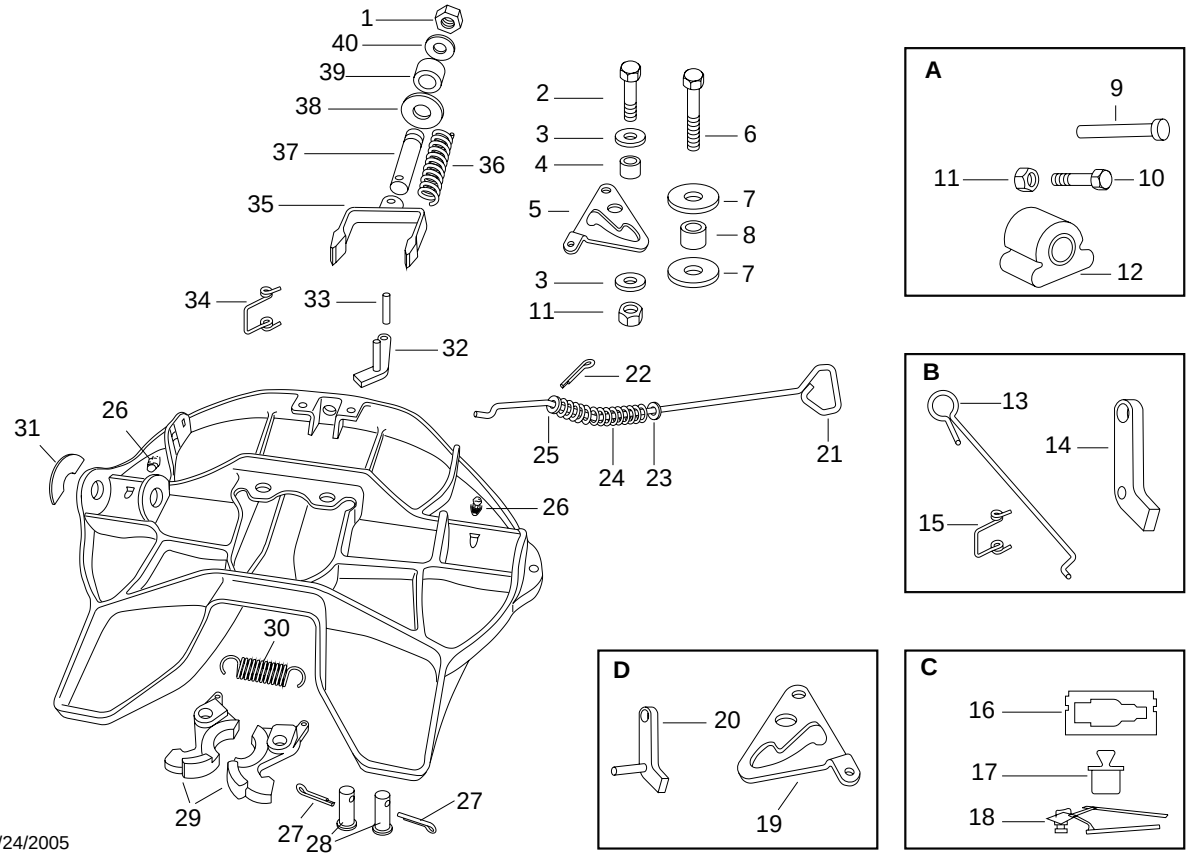
Use only Never-Seez®. Other lubricants can damage the lockpin holes.

   - 2.2 Align the lock jaws in the casting and position the lock jaws so that the raised edge of the kingpin guides are facing up. See **Fig. 4**.
   - 2.3 Align the holes in the lockpins so that the cotter pins can be inserted. Insert the lockpins into the casting and through the lock jaws. Using a suitable hammer, drive the lockpins into the casting until the heads are flush with the casting. See **Fig. 5**.
   - 2.4 Insert the cotter pins and spread.
   - 2.5 Check that the lock jaws move freely.

WARNING

You must use a Holland lock gauge (TF–0237) or a precision plug that is 2.000 ± 0.005 inch (5.08 ± 0.0127 cm) for proper installation of the locking

Model XA–351 Top Plate Assembly and Installation



A. Bushing Pin Assembly
B. Manual Secondary Lock Assembly
C. Fifth Wheel Accessories
D. Right-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)

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

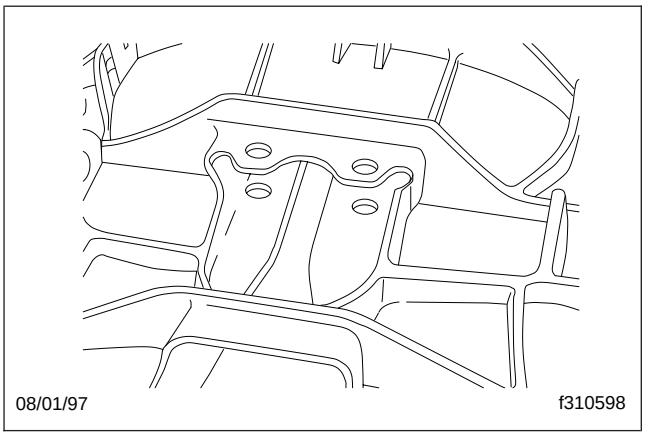
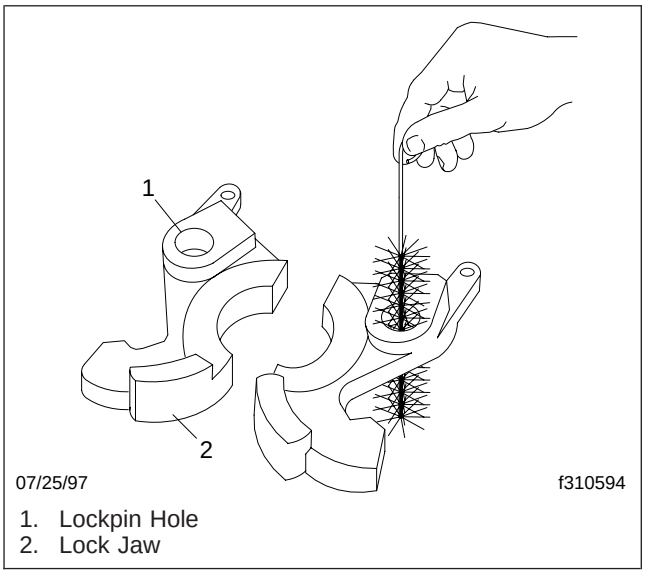


Fig. 2, Front Lock Surface Inspection



1. Lockpin Hole
2. Lock Jaw

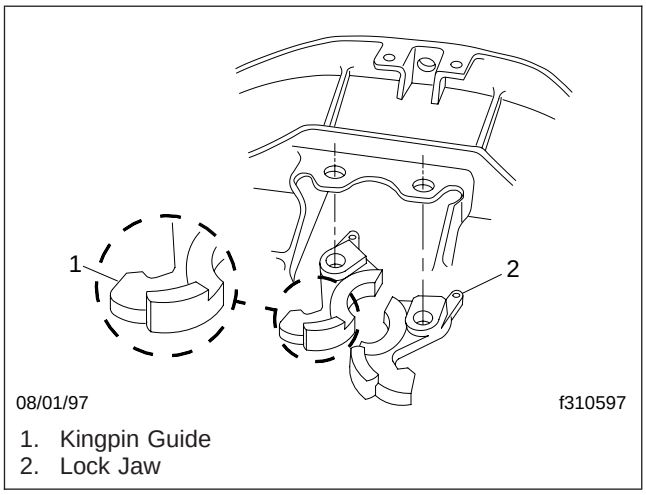
Fig. 3, Lubricate the Lockpin Holes

lock gauge, Holland part number TF–0237 is available at a Holland distributor.

3. Install the yoke.

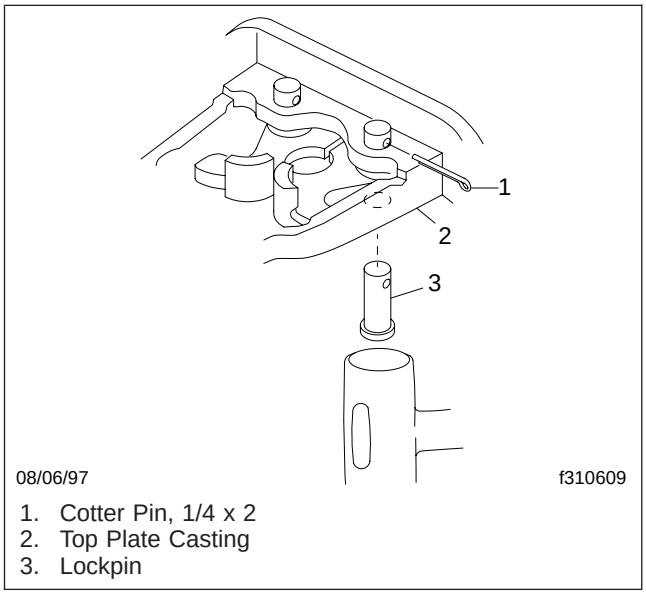
   3.1 Lubricate the surface area of the yoke tips with light grease. With the threaded hole facing up, slide the yoke into the casting and seat it around the locks. See **Fig. 7**.

   3.2 Inspect the amount of yoke tip engagement. Yoke tips must extend flush with the end of the locks and no more then 1/2 inch (12.7 mm) past the locks. See



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

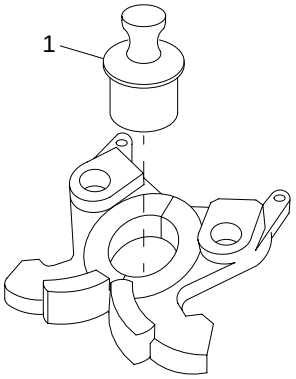
Fig. 5, Install the Lockpins

Fig. 8. If the new yoke extends more than 1/2 inch (12.7 mm) past the locks, *do not use it*. Discard it and order part number XA–07295–THK from your nearest Holland distributor.

   3.3 Install the lock spring. See **Fig. 9**.

   3.4 Install the yoke spring. Slide the yoke shaft into the casting, through the yoke spring and into the yoke. Align the re-

Model XA–351 Top Plate Assembly and Installation



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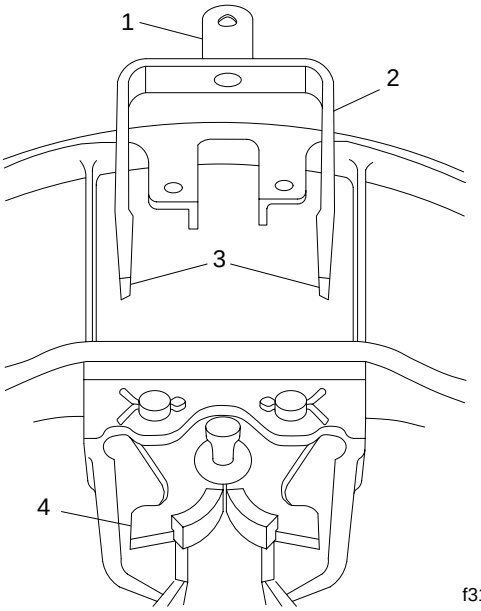
1. Lock Gauge (Plug)

Fig. 6, Install the Lock Gauge



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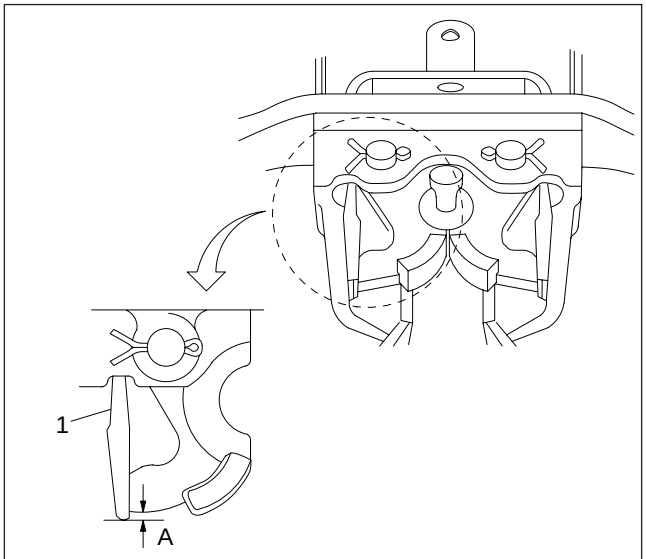
1. Threaded hole
2. Yoke
3. Yoke Tips
4. Lock

Fig. 7, Install the Yoke

cessed hole in the yoke shaft with the threaded hole in the yoke. See **Fig. 10**.

3.5 In this order, slide the lock adjustment tag, rubber washer, and 1-1/2 inch washer onto the yoke shaft. Then, start the locknut and turn it finger tight. See **Fig. 10**.



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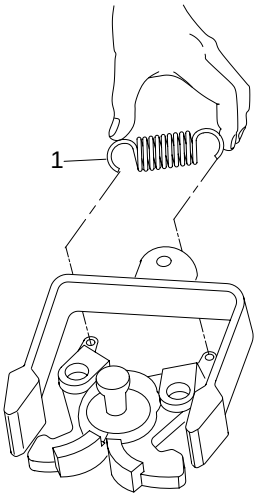
A. Measurement: 1/2 Inch (12.7 mm) Maximum
1. Yoke Tip

Fig. 8, Measure the Yoke Tip Engagement



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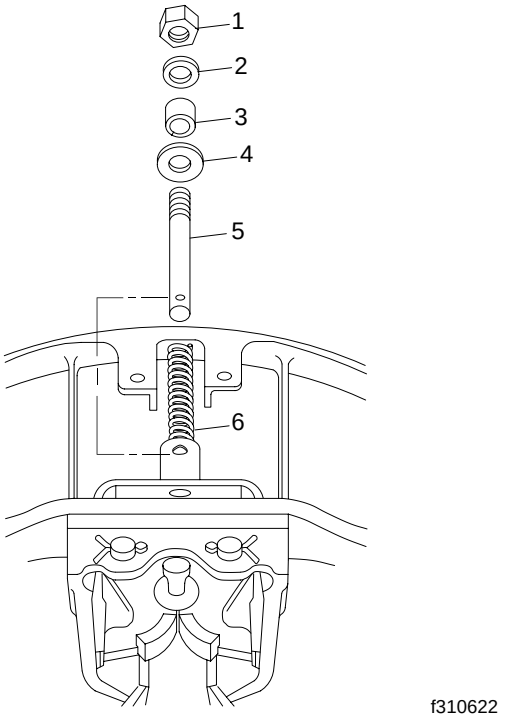
1. Lock Spring

Fig. 9, Install the Lock Spring

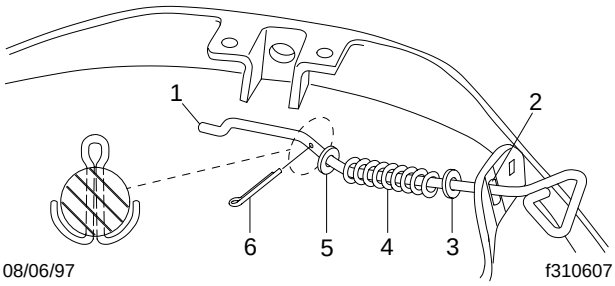
4. Install the release handle.

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**.



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



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

4.2 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.

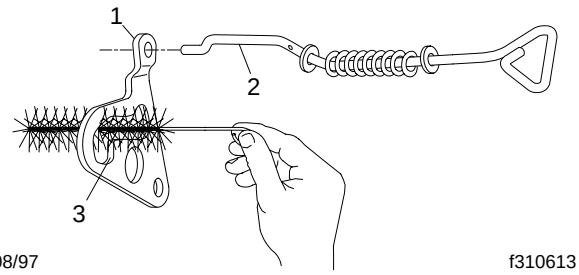
4.3 Compress the spring using the 1-1/16 inch washer until the cotter pin hole is exposed.

4.4 Insert the cotter pin; spread it and wrap it completely around the release handle. See **Fig. 11**.

5. Install the cam plate.

5.1 Inspect the cam plate for burrs and remove as required.

5.2 Lubricate the cam plate track and pivot hole with light grease. Then connect the raised tab in the cam plate to the "S" bend in the release handle. See **Fig. 12**.



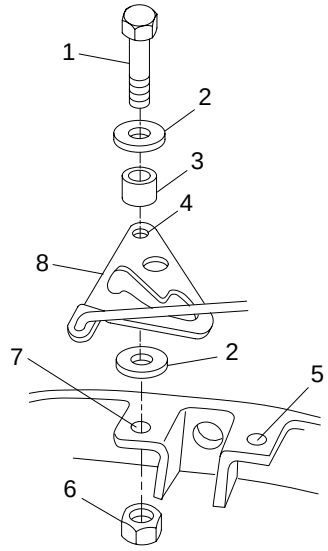
1. Cam Plate Raised Tab
2. Release Handle
3. Cam Plate Track

Fig. 12, Lubricate the Cam Plate

5.3 Position the cam plate attachment hole over the proper casting lug hole. Then, slide the 1-3/4 inch washer between the cam plate and casting lug hole with the rounded side of the washer facing the cam plate. Then install the 1/2-inch roller into the cam plate and place the second 1-3/4 inch washer on top of the roller with the rounded side facing the cam plate. See **Fig. 13**.

5.4 Install the 1/2-inch capscrew through the washers, roller, and top plate lug. Then, secure the capscrew with the 1/2-inch locknut and tighten securely. See **Fig. 13**.

Model XA–351 Top Plate Assembly and Installation



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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

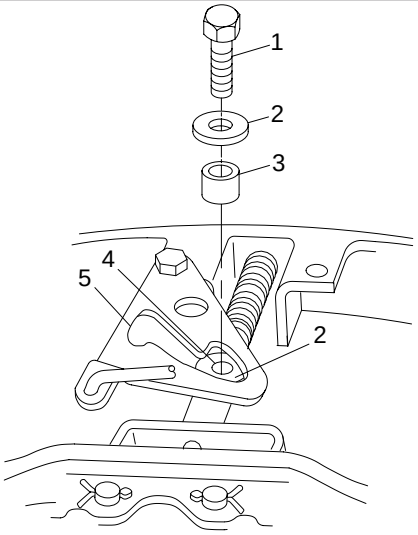
Fig. 13, Install the Cam Plate

5.5 Check for free movement of the cam plate.

NOTE: When installing the washers, the rounded edge of the washers *must* always face the cam plate.

5.6 Align the cam plate track over the threaded hole in the yoke. Then slide a 2-5/8 inch o.d. washer between the yoke and the cam plate with the rounded side of the washer facing the cam plate. Then place the 5/8-inch roller into the cam plate track and place the second 2-5/8 inch o.d. washer over the roller with the rounded side of the washer facing the cam plate. See **Fig. 14**.

5.7 Check the alignment of the recessed hole in the yoke shaft. Then, install the 5/8-inch capscrew through the washers, roller, and cam plate and into the threaded hole in the yoke. Make sure the capscrew enters the recessed hole in the yoke shaft. Then, tighten the capscrew securely. See **Fig. 14**.



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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

5.8 Check for free movement of the cam plate.

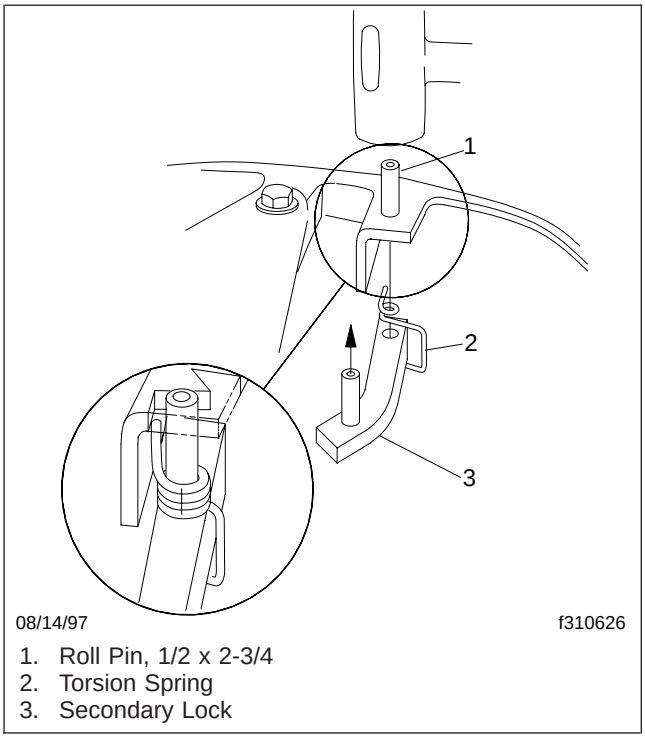
6. Install the secondary lock.

6.1 If equipped with the automatic version, start the roll pin into the hole in the top plate opposite the cam attachment capscrew. Then, assemble and install the secondary lock and torsion spring. Make sure the flats of the torsion spring are resting against the casting. See **Fig. 15**.

With a suitable hammer, drive the roll pin through the torsion spring and secondary lock until the roll pin is flush with the casting. See **Fig. 15**.

Check the lock spring for tension and lock for free movement.

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



1. Roll Pin, 1/2 x 2-3/4
2. Torsion Spring
3. Secondary Lock

Fig. 15, Install the Secondary Lock

handle through the large hole in the secondary lock. See **Fig. 16**.

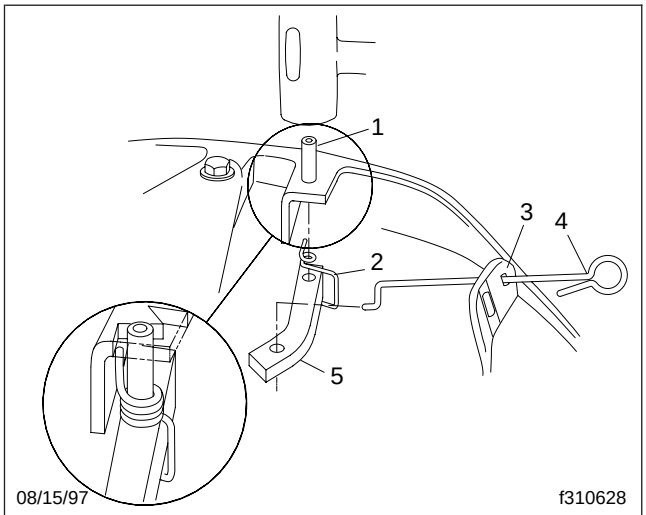
6.3 If equipped with the manual version, start the roll pin into the hole in the top plate opposite the cam attachment capscrew. Assemble and install the secondary lock and torsion spring. Make sure the flats of the torsion spring are resting against the casting. See **Fig. 16**.

6.4 If equipped with the manual version, 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. 16**.

6.5 Check the lock spring for tension and lock for free movement.

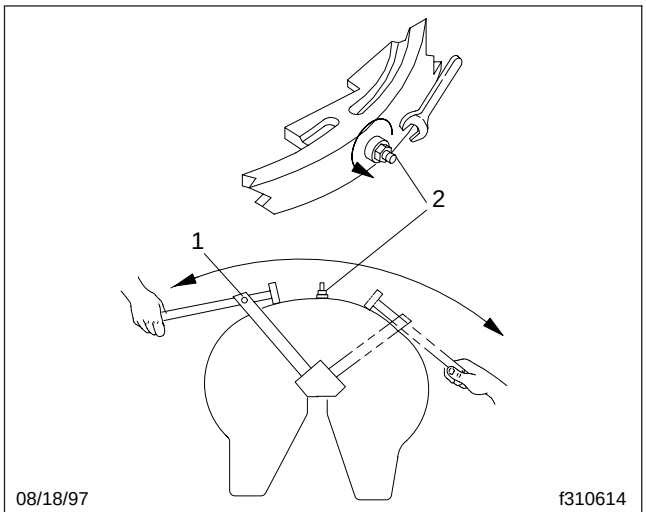
7. Adjust the lock. See **Fig. 17**.

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.



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



1. Lock Tester
2. Adjustment Nut

Fig. 17, Adjusting the Lock

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).

Model XA–351 Top Plate Assembly and Installation

7.3 Verify that the locks are completely closed around the kingpin. The lock halves should be seated against each other.

7.4 Alternate tightening the adjustment nut and attempting to turn the lock tester back and forth. Continue tightening the adjustment nut until there is some resistance felt in the lock tester (as it is turned back and forth).

The fifth wheel is properly adjusted when there is resistance between locks and the lock tester, but the lock tester can still be turned by hand.

7.5 Pull the release handle and remove the lock tester.

8. Check the fifth wheel for proper operation.

8.1 Using the Holland lock tester, open and close the fifth wheel at least three times.

Each time you close the locks, verify that the locks have closed completely around the kingpin and that the adjustment nut and rubber bushing are seated snug against the casting.

8.2 Check for resistance between the locks and the lock tester one final time, and adjust as needed.

⚠ WARNING

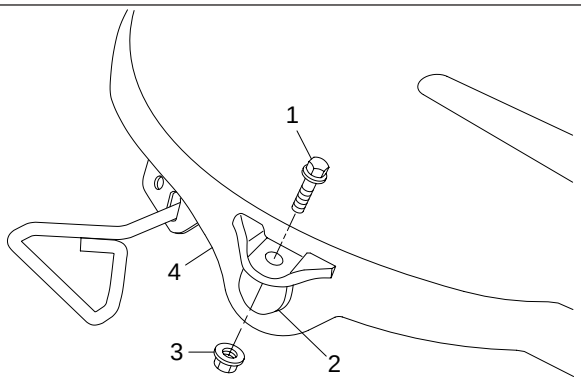
If the fifth wheel does not operate properly, do not use it. Either disassemble it and repeat the rebuilding procedure or contact your nearest Holland representative for assistance. Never use a fifth wheel that does not operate properly. The fifth wheel could malfunction, resulting in bodily injury or property damage due to a possible separation of the trailer from the tractor.

8.3 The fifth wheel is now ready for operation.

9. Install the top plate.

9.1 Using an overhead hoist, lift and position the fifth wheel over the bracket assembly.

9.2 Install the bushing pins through the fifth wheel and into the bracket assembly. Then, install and tighten securely the 1/2–20 bushing pin capscrews and locknuts. See **Fig. 18**. Remove the overhead hoist.



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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 of the *L-Line and A-Line Maintenance Manual*.

Troubleshooting Chart

Problem—The Fifth Wheel is Hard to Hook Up to the Trailer

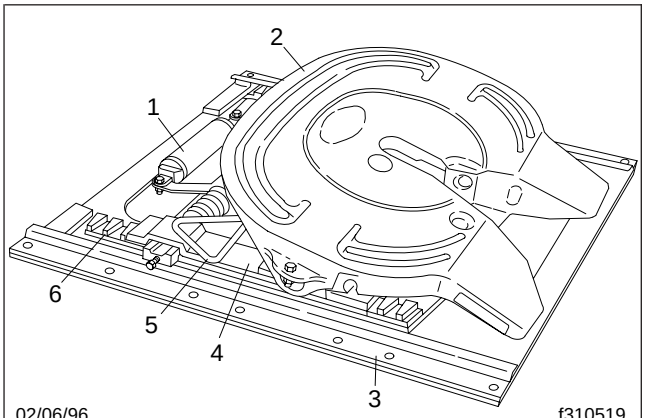
Problem—The Fifth Wheel is Hard to Hook Up to the Trailer	
Possible Cause	**Remedy**
The trailer may be too high; the kingpin is not entering the locks properly	Lower the trailer landing gear until the bolster plate contacts the fifth wheel.
The locks are closed	Pull the release handle and pry open the locks.
Rust or grime is interfering with the lock operation	Spray a light lubricant or diesel fuel on all moving parts including the release handle. Operate the release mechanism several times.
The fifth wheel locks are too tight	Check the lock adjustment. Correct as needed.
A bent release handle, bent kingpin, or damaged bolster plate is interfering with the lock movement	Check the release handle, kingpin, and bolster plate. Replace parts as required.
The locks are damaged	Inspect the locks and replace parts as required.
The fifth wheel needs rebuilding	Rebuild the fifth wheel, using the parts in the appropriate rebuilding kit.

Problem—The Fifth Wheel is Hard to Unhook from the Trailer

Problem—The Fifth Wheel is Hard to Unhook from the Trailer	
Possible Cause	**Remedy**
The secondary lock is not released	If equipped with a manual secondary lock, pull the release handle and lock it open by resting it against the top plate. If equipped with an automatic secondary lock, inspect the lock for missing or broken parts, and repair or replace as required.
The tractor is putting pressure against the locks	Set trailer brakes. Back the tractor into the trailer to relieve pressure and lock the tractor brakes before pulling the release handle.
There is rust or grime on the locking mechanism	Spray a light lubricant or diesel fuel on all moving parts including the release handle. Operate the release mechanism several times.
The kingpin is bent or the bolster plate is damaged	Check the kingpin, using a Holland TF–0110 Kingpin Gauge. Check the bolster plate, using a 48-inch (122 cm) straight edge. Repair or replace parts as required.
The fifth wheel locks are too tight	Check the lock adjustment. Correct as needed.
The release handle will not stay out or must be held out when unlocking	Replace the cam or release arm and the release handle spring.

General Description (See Fig. 1)

The Holland Fleetmaster fifth wheel is used for pulling trailers having the standard 2-inch diameter kingpin. When installed as a stationary fifth wheel, it is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. When used as a sliding fifth wheel, it is mounted to a slide bracket and plate assembly (air-operated or manual release).



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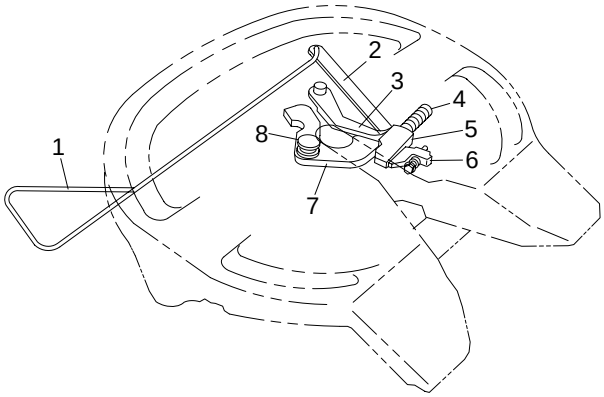
1. Air Cylinder
2. Top Plate
3. Outboard Mounting Plate
4. Slide Plate
5. Release Handle
6. Track

Fig. 1, Holland Fleetmaster Fifth Wheel Assembly

Principles of Operation

The fifth wheel lock mechanism for the trailer kingpin consists of a hinged lock, locking plunger, plunger spring, cam arm, release arm, and operating rod. The lock rotates on a lock pin during coupling and uncoupling operations. During coupling the hinged lock and cam arm pivot against the kingpin and are secured by the locking plunger. See **Fig. 2**.

Uncoupling is accomplished by pulling the release handle using 60 to 70 lbs. (27 to 32 kg) of force. The release arm pivots and forces the locking plunger against the plunger spring. The hinged lock is released and the trailer kingpin can be removed. See **Fig. 3**.



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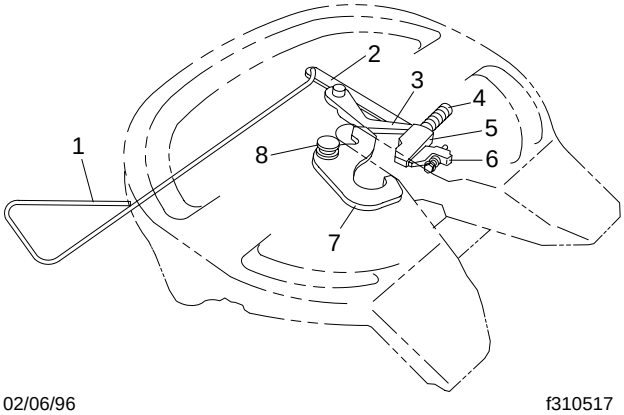
1. Release Handle
2. Release Arm
3. Cam Arm
4. Plunger Spring
5. Locking Plunger
6. Adjusting Wedge
7. Hinged Lock
8. Lock Pin

Fig. 2, Fifth Wheel in Locked Position



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1. Release Handle
2. Release Arm
3. Cam Arm
4. Plunger Spring
5. Locking Plunger
6. Adjusting Wedge
7. Hinged Lock
8. Lock Pin

Fig. 3, Fifth Wheel in Unlocked Position

Removal (See Fig. 1)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in a hazardous operating condition due to possible disengagement of the trailer from the tractor.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

1. Steam clean the top plate. Remove the cotter pins from the bracket pins. Remove the bracket pins. Discard the cotter pins and remove the top plate.
2. Using an overhead hoist, lift the fifth wheel off the mount and tractor frame.

Disassembly (See Fig. 1)

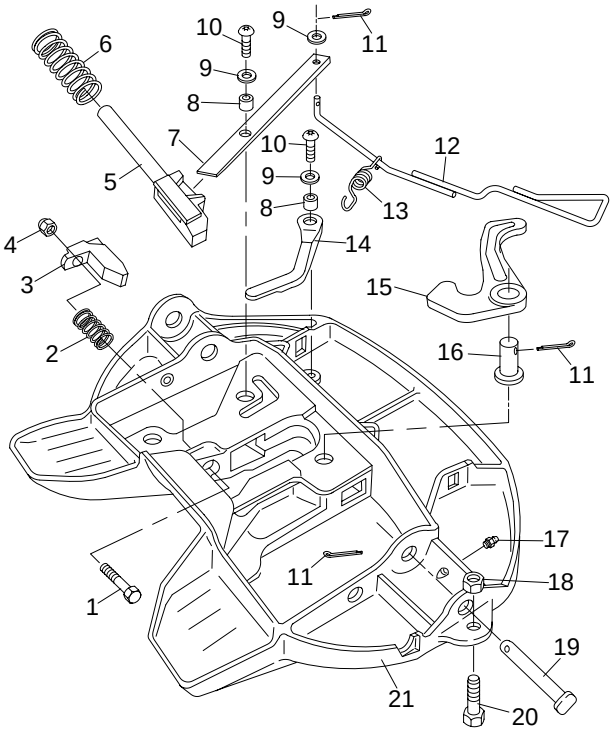
1. Turn the fifth wheel upside down.

⚠ WARNING

Do not attempt repair or rebuilding if the top plate is cracked or distorted or if the lock pin is sloppy in the top plate. These conditions could result in top plate failure or malfunction of the locks.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

2. Pull the release handle out, slide it forward and hook the handle to the unlock notch of the casting.
3. With the plunger in the unlocked position, remove and discard the cotter pin. Remove the lock pin.
4. Slide the hinged lock away from the locking plunger and remove it from the top plate.



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NOTE: Bottom view shown.

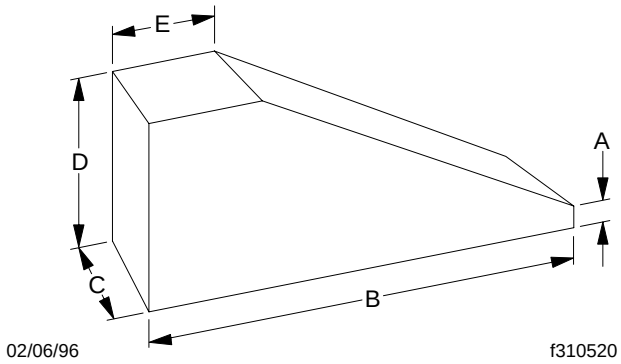
1. Hex Head Capscrew
2. Spring
3. Adjusting Wedge
4. Locking Nut
5. Locking Plunger
6. Plunger Spring
7. Release Arm
8. Roller
9. Washer
10. Torx Screw
11. Cotter Pin
12. Release Handle
13. Extension Spring
14. Cam Arm
15. Hinged Lock
16. Lock Pin
17. Grease Fitting
18. Locknut
19. Bracket Pin
20. Hex Head Capscrew
21. Top Plate

Fig. 1, Fifth Wheel Assembly Components (with left-side release)

NOTE: It may be necessary to fabricate a wedge to hold the plunger in the unlocked position during the disassembly and assembly procedure.

5. Insert the fabricated wedge. See **Fig. 2**.
6. Pull the release handle and slide it rearward to unhook it from the notch in the casting.

Removal and Disassembly

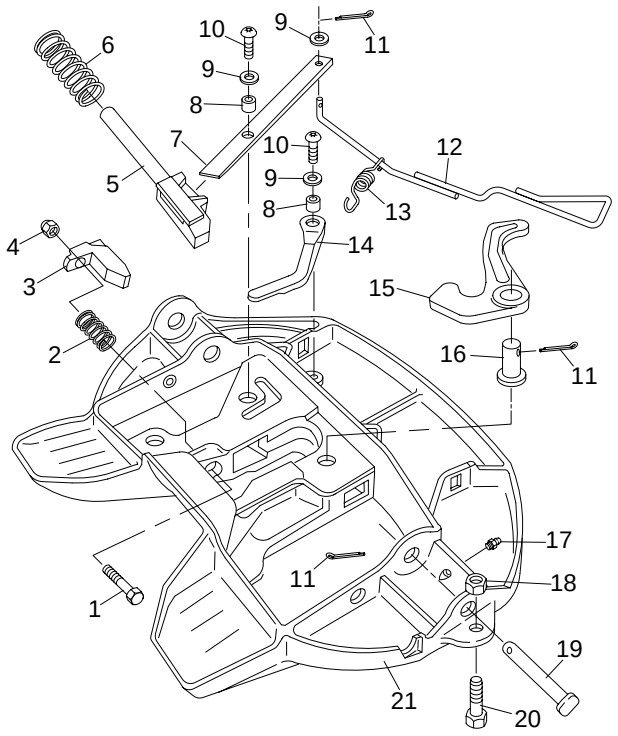


A. 0.3 inch (7.6 mm)
B. 8 inches (203.2 mm)
C. 1.5 inches (38.1 mm)
D. 3 inches (76.2 mm)
E. 2.5 inches (63.5 mm)

Fig. 2, Fabricated Wedge Dimensions

7. Remove the cotter pin and washer. Discard the cotter pin. Disconnect and pull the release handle away from the release arm.
8. Remove the release arm Torx screw, washer, and roller. Remove the release arm.
9. Slowly remove the fabricated wedge. Guide the locking plunger from the left throat of the fifth wheel to the right throat. Pull the plunger out of the right throat of the fifth wheel. Remove the plunger spring and adjusting wedge.
10. Remove the Torx screw, washer, and roller. Remove the cam arm.
11. Remove the extension spring and the release handle.
12. Remove the grease fittings.

Assembly (See Fig. 1)



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NOTE: Bottom view shown.

1. Capscrew
2. Spring
3. Adjusting Wedge
4. Locking Nut
5. Locking Plunger
6. Plunger Spring
7. Release Arm
8. Roller
9. Washer
10. Torx Screw
11. Cotter Pin
12. Release Handle
13. Extension Spring
14. Cam Arm
15. Hinged Lock
16. Lock Pin
17. Grease Fitting
18. Locknut
19. Bracket Pin
20. Capscrew
21. Top Plate

Fig. 1, Fifth Wheel Assembly Components (with left-side release)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in a hazardous operating condition due to possible disengagement of the trailer from the tractor.

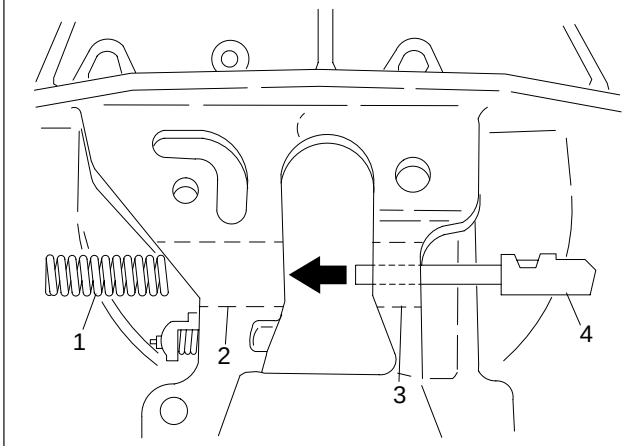
Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

IMPORTANT: When rebuilding use only Holland rebuilding kits. Replace all roll pins, cotter pins, springs, bolts, nuts, and washers. Inspect the rebuild kit to verify that all parts are present.

Check the lock pin holes. If the holes are elongated the top plate must be replaced. Replace any parts that show signs of wear, damage, or deterioration. Brackets, bracket bushings, bracket pins, and bracket shoes should be replaced in pairs.

1. Clean all moving parts with No. 2 diesel fuel before assembly.
2. Replace the grease fittings.
3. Apply a thin film of multipurpose chassis grease to the release arm, release arm roller, hinged lock, lock pin, cam arm and roller, adjusting wedge, and locking plunger.
4. Install a 5/8-inch capscrew through the hole in the right side of the throat of the fifth wheel.
5. Slide the wedge spring, and wedge over the capscrew. Thread a 5/8-inch locknut onto the capscrew. Hand tighten the locknut.
6. Install the plunger through the opening in the right throat of the fifth wheel, through the left throat, into the plunger spring, and through the hole in the rib of the casting. See **Fig. 2**.
7. Compress the plunger spring by inserting the fabricated block into the throat until the plunger is flush with the throat of the casting. See **Fig. 3**.
8. Insert the cam arm tail into the pocket in the plunger. Align the cam arm hole with the bolt hole in the casting. See **Fig. 4**.
9. Install the roller, washer (rounded edge towards the roller), and torx bolt. Tighten the torx bolt 85 to 120 lbf·ft (115 to 163 N·m).
10. Insert the tapered end of the release arm through the main rib of the casting into the

Assembly and Installation



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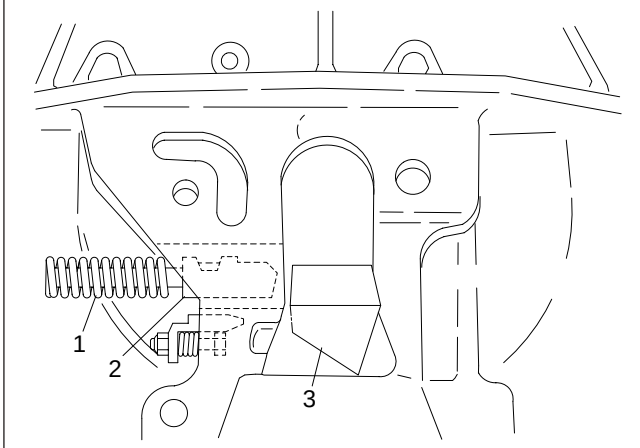
1. Plunger Spring
2. Left Throat
3. Right Throat
4. Locking Plunger

Fig. 2, Plunger Installation



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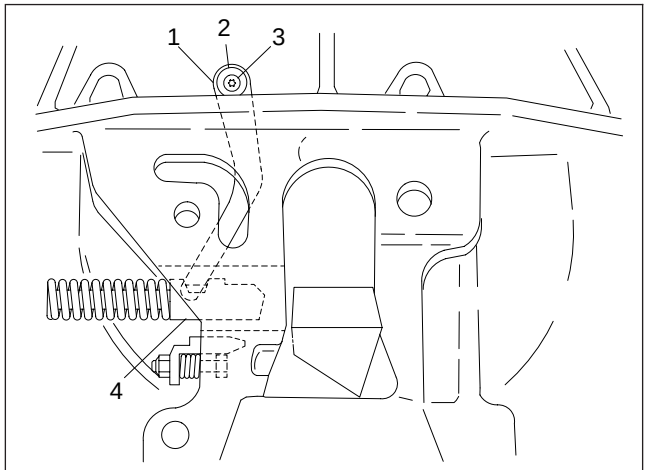
1. Plunger Spring
2. Locking Plunger
3. Fabricated Wedge

Fig. 3, Inserting Fabricated Wedge

plunger. The tapered end of the release arm must face down next to the cam arm. Align the release arm hole with the bolt hole in the casting.

NOTE: The following step applies only to fifth wheels equipped with a left-side release. Fifth wheels equipped with a right-side release (see



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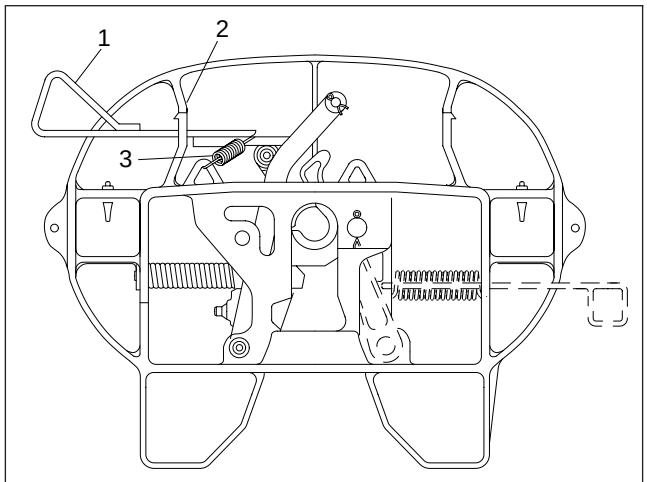
1. Cam Arm
2. Washer
3. Torx Screw
4. Locking Plunger

Fig. 4, Cam Arm Installation

Fig. 5) do not require a roller, washer, and torx bolt to install the release arm.

11. Install the roller, washer (rounded edge towards the roller), and torx bolt. Tighten the torx bolt 85 to 120 lbf·ft (115 to 163 N·m).



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1. Release Handle
2. Main Rib
3. Release Handle Spring

Fig. 5, Right-Side Release

12. Feed the release handle through the hole in the casting, through the closed end of the release

handle spring, and up through the bottom of the release arm.

13. Install the washer and cotter pin.
14. Lubricate the release handle spring contact areas with a light grease. Attach the release handle spring to the casting ear.
15. Pull the release handle and hook it on the unlock notch of the casting.
16. Remove the fabricated block. Keep hands and fingers clear.
17. Grease the lock pin hole and the lock contact areas. Slide the hinged lock through the opening in the right side of the throat of the fifth wheel. Align the lock pin hole with the hole in the casting.
18. Slide the lock pin through the casting from the face of the top plate through the lock, then through the bottom of the casting. Install a cotter pin.
19. Unhook the release handle from the notch in the casting.

Installation

NOTE: Before remounting the top plate, inspect the rubber bushings and bracket pins for wear. Replace as necessary. If bushing replacement is required, be sure to use the correct diameter bushing.

1. Using an overhead hoist, position the fifth wheel on the sliding or stationary mount brackets. Clamp the fifth wheel in place to compress the bracket rubbers.
2. Insert the bracket pins and new cotter pins. Lock the cotter pins.

Lock Adjustment

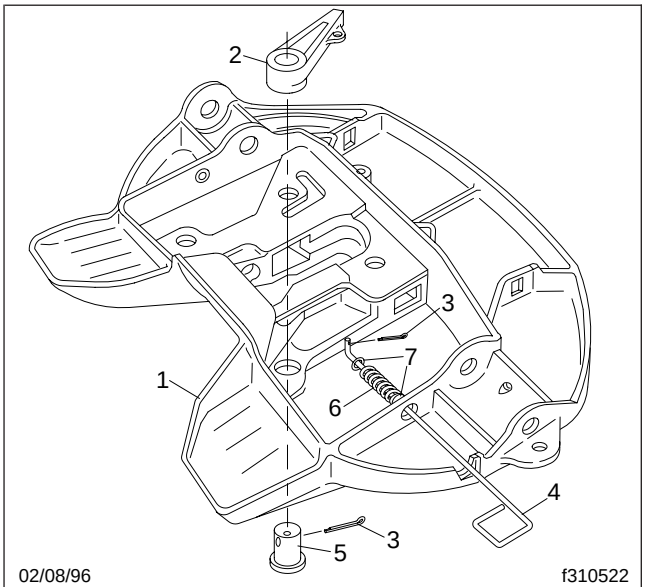
1. Open the hinged lock by pulling the release handle and putting pressure against the hinged lock, moving it towards the open position.
2. Close the fifth wheel using a Holland lock tester. Tighten the adjustment bolt while attempting to rotate the lock tester back and forth.
3. Slowly tighten the bolt until the lock tester just stops rotating. Loosen the adjustment bolt two full turns.
4. Verify proper operation by locking and unlocking the fifth wheel several times using the tester.

⚠ WARNING

If the fifth wheel top plate does not operate properly, do not use it. An improperly functioning fifth wheel could cause loss of vehicle or trailer control, resulting in personal injury. Repeat the above procedure or call your local Holland representative for assistance.

Secondary Lock Installation

1. Using the Holland lock tester, close the fifth wheel lock. See **Fig. 1**.



NOTE: Bottom view shown.

1. Top Plate
2. Secondary Lock Arm
3. Cotter Pin
4. Secondary Lock Release Handle
5. Secondary Lock Pin
6. Spring
7. 7/16-inch Washer

Fig. 1, Optional Secondary Lock Assembly

2. Lubricate the secondary lock arm pin hole with Never Seez® grease.
3. Slide the lock arm into the right side of the casting with the lock arm ear facing the outside of the casting.
4. Align the pin holes of the secondary lock arm and the casting. Drive the lock pin through the casting from the top plate, through the secondary lock. Install the cotter pin through the secondary lock.
5. Install a 45-degree lube fitting into the secondary lock pin.
6. Grasp the secondary lock handle handhold, and slide the other end of the handle through the rib of the casting, through the 7/16-inch washer, through the handle spring, through another 7/16-inch washer, and up through the bottom of the loop on the secondary lock arm.
7. Compress the release handle spring and secure the release handle using a cotter pin. Lock the cotter pin.
8. Check the secondary release handle for proper operation.

Troubleshooting

NOTE: After the fifth wheel is unlocked and moves freely from the kingpin, it is normal for the release handle to disengage from the notch in the casting to return to a position between locked and unlocked.

Problem—Hard to Hook Up the Fifth Wheel to the Trailer

Problem—Hard to Hook Up the Fifth Wheel to the Trailer	
Possible Cause	**Remedy**
The trailer may be too high; the kingpin is not entering the lock correctly	Lower the trailer landing gear until the trailer plate contacts the fifth wheel.
A bent kingpin or damaged trailer plate is interfering with the hinged lock movement	Check the kingpin and trailer plate. Replace parts as needed.
The hinged lock has not been adjusted correctly	Check the clearance between the lock and the kingpin. Adjust as described in **Subject 120**.
Attempting to couple too quickly	Pick up the trailer with the fifth wheel. Stop. Continue backing up until the fifth wheel locks firmly to the kingpin. Stopping helps prevent hitting the kingpin too hard.
The locks are closed	Pull the release handle. Hook the handle on the notch in the casting and pry the hinged lock open.
Accumulated rust or grime is interfering with lock operation	Spray a light lubricant or diesel fuel on all moving parts, including the release handle. Operate the unit several times.
The locks are damaged	Inspect and replace components as described in this section.
The fifth wheel requires rebuilding	Follow the procedures contained in this section using the appropriate rebuilding kit.
Using a lube plate with the wrong kingpin length	See Holland Service Bulletins 4 and 4A.

Problem—Hard to Unhook the Fifth Wheel from the Trailer

Problem—Hard to Unhook the Fifth Wheel from the Trailer	
Possible Cause	**Remedy**
The tractor is putting pressure against the locks	Back the tractor up a little to relieve kingpin load against the fifth wheel lock. Lock the tractor brakes before pulling the release handle and hooking it on the notch in the top of the plate casting.
The optional secondary lock (if equipped) is not released	Pull out the secondary release handle and move it forward to secure it on the top plate casting.
The release handle will not stay out or must be held out when unlocking	Follow the procedures contained in this section using the appropriate rebuilding kit.
The primary release handle is not pulled out completely and locked on the notch in the casting	Slide the primary release handle out and pull it forward. Slide the handle forward, hooking it on the notch on the top plate casting.
Rust or grime is on the locking mechanism	Spray a light lubricant or diesel fuel on all moving parts including the release handle. Operate the unit several times.
Bent kingpin or damaged bolster plate	Check the kingpin with a Holland TF–0110 Kingpin Gauge and bolster plate with a 48 inch straightedge. Repair or replace as required.

Troubleshooting

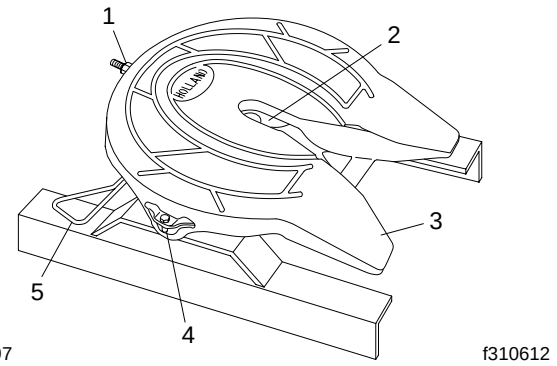
Problem—Hard to Unhook the Fifth Wheel from the Trailer	
Possible Cause	**Remedy**
Fifth wheel locks are adjusted too tight	Check the clearance between the lock and the kingpin. Adjust as described in **Subject 120**.

General Information

NOTE: For Holland 3500 series fifth wheel service operations, see **Section 31.06**..

The Holland sliding fifth wheel mount is designed to provide maximum tractor use for different lengths and types of trailers. The FW35 sliding fifth wheel mount is used with the Holland 3500 series fifth wheel, and is equipped with either a manually operated or an air-operated release slider.

Sliding fifth wheel assemblies are mounted on a baseplate with notched rails. See **Fig. 1**. Plungers are meshed into teeth on the baseplate to lock the fifth wheel. This assembly allows forward or rearward movement of the fifth wheel along the notched rails for optimum weight distribution over the tractor axles. The mounting baseplate is bolted to the tractor frame.



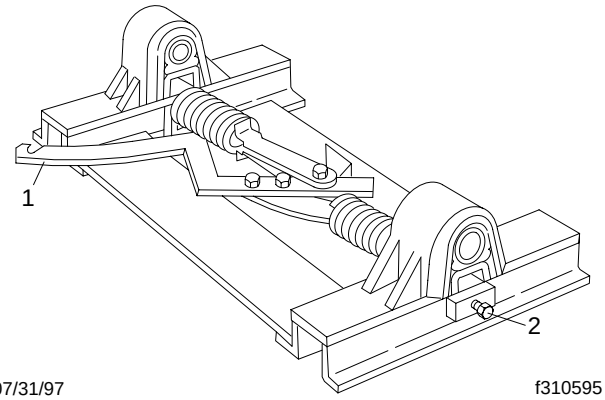
1. Infinite Lock Adjustment Nut
2. Kingpin Lock
3. Cast Steel Top Plate
4. Bracket Pin Mount
5. Release Handle

Fig. 1, XA-351 Sliding Fifth Wheel

When the fifth wheel is in the desired position, it is locked in place by wedge-shaped plungers that engage in the notched rails under the sliding mount. To release the fifth wheel, the plungers are withdrawn.

The manually operated release slider contains a release lever (**Fig. 2**), which when manually pulled or released, unlocks or locks both sides of the sliding mount at the same time.

The air-operated release slider contains a double-ended air cylinder (**Fig. 3**), which locks and unlocks

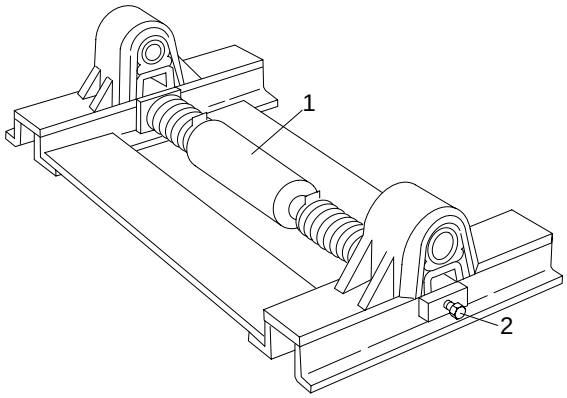


NOTE: Baseplate rails not shown.

1. Release Lever
2. Slider Plunger Release

Fig. 2, Manual Release Slider Assembly

both sides of the sliding mount at the same time. The air cylinder is activated by a two-position air-control switch in the tractor cab. See **Fig. 4**.



NOTE: Baseplate rails not shown.

1. Double-Ended Air Cylinder
2. Slider Plunger Release

Fig. 3, Air Valve Release Slider Assembly

See Chapter 10 of the *L-Line and A-Line Driver's Manual* for complete operating instructions.

General Information

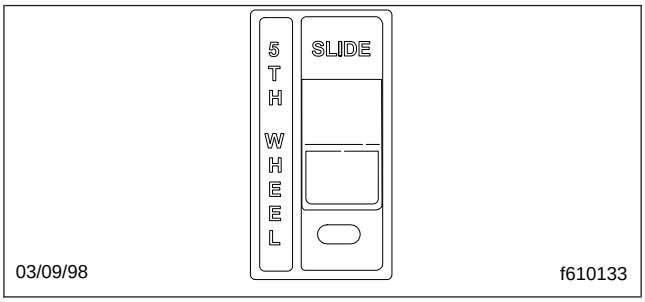


Fig. 4, Cab Control Switch

Disassembly

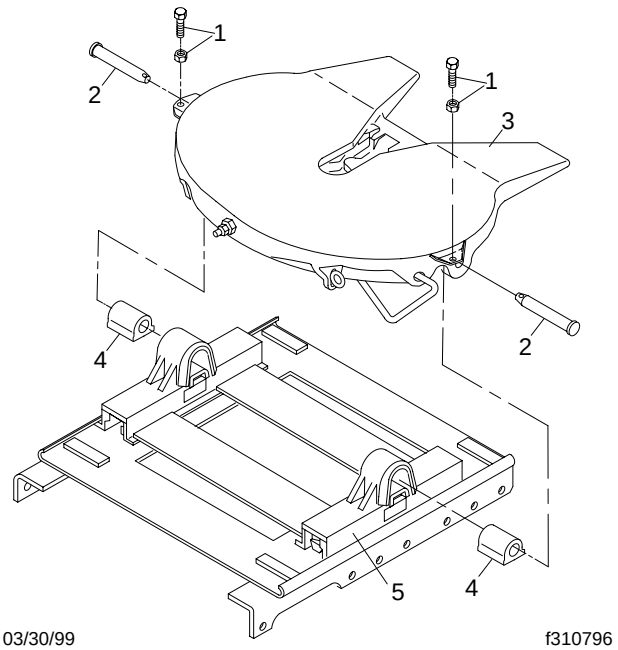
⚠ WARNING

Fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

1. Remove the top plate.

   1.1 Loosen and remove the 1/2–20 bushing pin capscrews and locknuts from both the left side and the right side of the top plate. Then, remove the bushing pins (**Fig. 1**) from the bracket assembly.

   1.2 Using an overhead hoist, lift the fifth wheel off the slide mount assembly.



1. Capscrew and Locknut
2. Bushing Pin
3. Fifth Wheel Top Plate
4. Rubber Bushing
5. Slide Mount Assembly

Fig. 1, Sliding Mount Components

⚠ WARNING

When draining the air reservoir, do not look into the air jets, or direct them toward anyone. Dirt or sludge particles may be in the airstream, and could cause injury if ejected.

2. If the fifth wheel has a manual release sliding mount, then go to the next step. Otherwise, drain the air reservoir; then disconnect and plug the air line from the air cylinder.

⚠ WARNING

Parts are under spring compression. Wear safety goggles during disassembly and assembly, and keep fingers away from possible pinch points at the ends of springs. Failure to do so can result in bodily injury, due to parts ejecting with force.

3. Using a Holland TF–TN 2500 spring compressor (**Fig. 2**), compress one of the plunger return springs (**Fig. 3**).

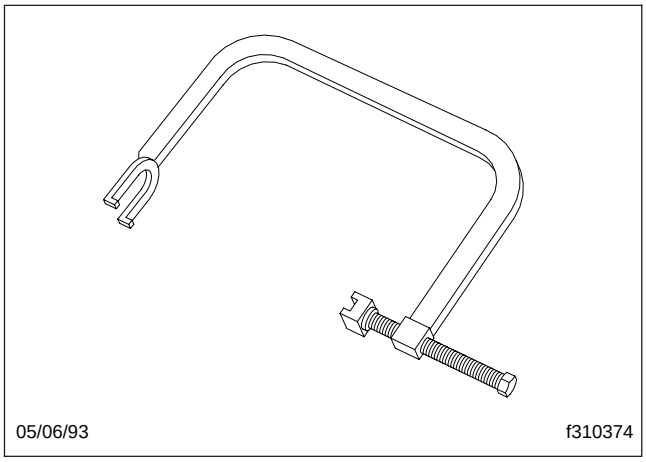
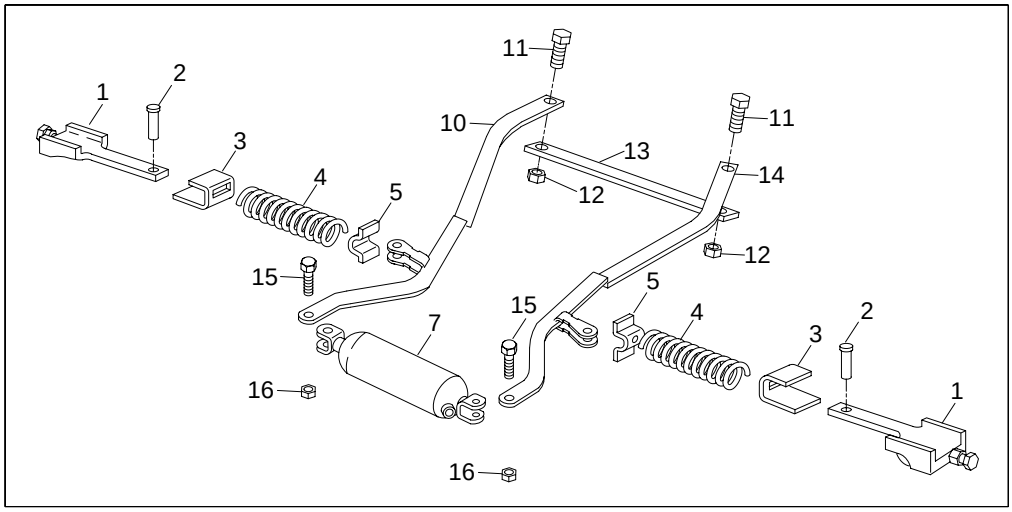


Fig. 2, Spring Compressor

4. Remove the plunger retaining pin (**Fig. 3**) from the plunger end, and either the air-release cylinder or manual release lever clevis. Then remove the plunger.

   If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), remove the plunger retaining pin from the release lever, then remove the plunger.

Sliding Mount Disassembly and Assembly



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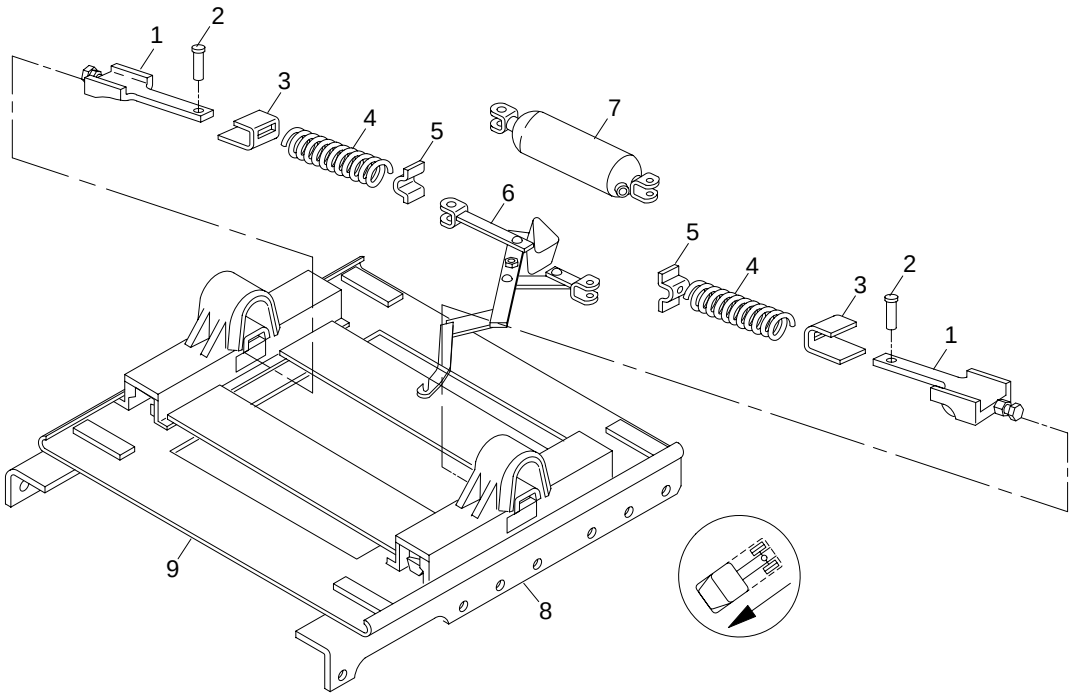

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A. Spring assembly for 6.62 and 8.12 inch (16.8 and 20.6 cm) fifth wheel heights.

1. Plunger
2. Retaining Pin
3. Spring Compression Stop
4. Plunger Return Spring
5. Spring Retainer
6. Manual Release Lever
7. Air-Release Cylinder
8. Slide Mount Assembly
9. Baseplate
10. Right-Side Release Lever
11. Capscrew, 3/8–16
12. Locknut, 3/8–16
13. Tie Bar
14. Left-Side Release Lever
15. Capscrew, 1/2–20
16. Locknut, 1/2–20

Fig. 3, Spring Assemblies

5. Carefully remove the spring compressor; then remove the plunger return spring, the spring compression stop, and the spring retainer (**Fig. 3**).

   Repeat the procedure for the other plunger.

6. Remove the air-release cylinder or the manual release lever.

   If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), remove the air-release cylinder or the manual release lever along with the right-side and left-side release levers (**Fig. 3**). Disconnect the release levers from the air-release cylinder or manual release lever.

⚠ WARNING

Wear protective eye and facial gear when grinding to remove the rear stops. Failure to do so could result in personal injury due to flying metal debris from the grinding.

7. If the slide mount assembly (**Fig. 3**) is damaged, dismantle it from the baseplate (Ref. 9).

   7.1 Grind down the welded area to remove the rear stops.

   7.2 Remove the slide mount assembly from the baseplate by sliding it off the rear of the tracks.

8. Remove all dirt and grease from the parts. Replace any parts that show signs of wear or damage.

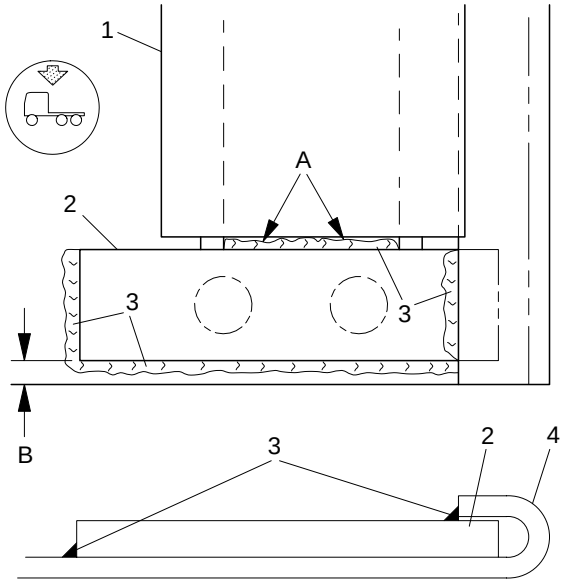
NOTE: If the rubber bushings (**Fig. 1**) are damaged, or if they allow movement of more than 1/8 inch (3 mm), replace them.

Assembly

⚠ WARNING

Fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

1. Using a rubber lubricant or a waterless hand cleaner, lubricate the outer surfaces of the new rubber bushings.
2. Install the rubber bushings (**Fig. 1**) into the slide mount assembly until they are flush with the outboard ends of the assembly.
3. Using a multipurpose chassis grease, lubricate the flanges on the slide mount assembly. Then slide the assembly onto the tracks of the baseplate.
4. Move the slide mount assembly to the rearmost position. Install the plungers into the outboard ends of the slide mount. Engage the plungers in the rail teeth.
5. Install the rear stops under the curled edge of the baseplate. Allow a clearance of about 1/8 inch (3 mm) from the rear stops to the slide mount when it is in the full rear position. The stops should be about 1/4 to 1/2 inch (6 to 13 mm) from the rear edge of the baseplate. See **Fig. 4**.



A. Weld carefully to avoid slide mount.
B. 1/4 to 1/2 inch (6 to 13 mm).

1. Slide Mount
2. Rear Stop
3. Weld
4. Baseplate

Fig. 4, Slide Stop Installation

Sliding Mount Disassembly and Assembly

6. Clamp the rear stops in place, then move the slide mount assembly forward and out of the way.
7. Weld the stops in place. The welds should be 1/4 inch (6 mm) fillet. On the forward edge, weld only the center area; not the area where the slide mount assembly contacts the stop. See **Fig. 4**.
8. Move the slide mount assembly to the rearmost position and check for clearance. Make sure the plungers seat into the rail with all teeth engaged.
9. If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), and if new release levers are being installed, attach the right-side and left-side release levers to the tie bar (**Fig. 3**). Install 3/8–16 capscrews and locknuts and tighten them firmly, but make sure the parts are not binding.

   Using the 1/2–20 capscrews and locknuts, attach the air-release cylinder or the manual release lever to the ends of the release levers, tighten the nuts firmly, but make sure the parts are not binding.
10. Install the spring compression stops and the plunger return springs on the inboard ends of the plungers. Then install the spring retainers.

⚠ WARNING

Parts are under spring compression. Wear safety goggles during disassembly and assembly, and keep fingers away from possible pinch points at the ends of springs. Failure to do so can result in bodily injury, due to parts ejecting with force.

11. Using a Holland TF–TN 2500 spring compressor, compress one of the plunger return springs and its spring retainer enough to access the hole through the end of the plunger shaft.
12. If equipped with a standard fifth wheel, position the air-release cylinder or the manual release lever so that the holes in its clevis line up with the hole through the end of the plunger shaft. Install the retaining pin.

    If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), line up the holes in the clevis of one of the release levers (**Fig. 3**) with the hole in the end of the plunger shaft. Install the retaining pin.
13. Carefully remove the spring compressor.
14. Repeat the procedure on the other side of the vehicle.
15. If the fifth wheel has a manual release sliding mount, then go to the next step, otherwise connect the air lines.

    15.1 Remove the plugs from the air line.

    15.2 Connect the air line to the inlet on the air-release cylinder.

    15.3 Start the engine to build air pressure, then check the operation of the slide mechanism.
16. Adjust the plungers, following the procedure in **Subject 110**.
17. Install the top plate.

    17.1 Using an overhead hoist, lift the fifth wheel onto the slide mount assembly.

    17.2 From both the right side and the left side of the top plate, install the bushing pins. Install and tighten snugly the 1/2–20 bushing pin capscrews and locknuts (**Fig. 1**).

Adjustment

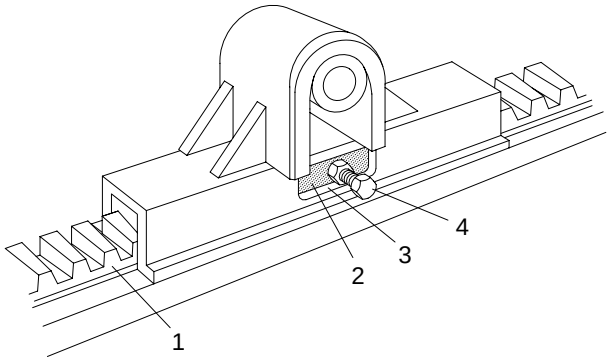
⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

NOTE: The locking plungers are adjusted at installation and again after one month of operation. Make additional adjustments as needed.

1. The plungers should seat in the pocket with a small amount of play when locked (engaged). See **Fig. 1**. If they wedge or bind, turn the adjusting bolt clockwise or counterclockwise as needed.

   Turning the adjusting bolt clockwise moves the plunger out of the pocket; turning it counterclockwise moves the plunger further into the pocket.



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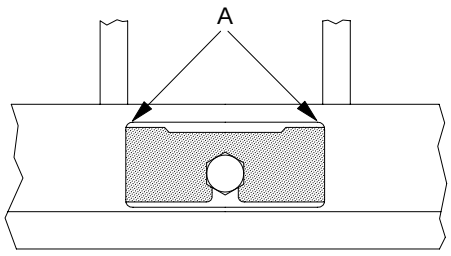
1. Plunger Adjusting Bolt
2. Pocket
3. Plunger
4. Rack

Fig. 1, Plunger Position

2. If the plungers do not unlock (release), check the air-release cylinder or the manual release lever for correct operation. Replace it if needed. See **Subject 100** for removal and installation instructions.

3. If the adjusted plunger binds on the bottom of the pocket, remove it; then grind the plunger top edges 1/16 inch (2 mm). See **Fig. 2**. Install the plunger. See **Subject 100** for plunger removal and installation instructions.

   Adjust the plunger, following the instructions above.



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A. Check for interference here.

Fig. 2, Plunger Checking

4. If the plungers are too loose, check the tension of the plunger return springs. If the springs are damaged or worn, replace them, following the instructions in **Subject 100**.

   If the plungers are still too loose, replace the plungers, following the instructions in **Subject 100**.

General Information

Fontaine 6000 and 7000 series fifth wheels couple to trailers having the standard 2-inch kingpin. When installed as a stationary mount, the fifth wheel is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. Sliding fifth wheels are mounted on the Fontaine AWB or MWS model slide mounts.

The Fontaine fifth wheel lock mechanism for the trailer kingpin consists of a spring-loaded jaw and sliding wedge. Kingpin release is accomplished by pulling a manual lock control handle located on either the right side (curbside) or left side (roadside) of the fifth wheel. Kingpin coupling occurs when the kingpin enters the throat of the fifth wheel, triggers the jaw and wedge to slide into place behind the kingpin, and moves the lock control handle into the locked position.

As the kingpin enters the lock mechanism, the jaw is moved first with the spring-loaded wedge sliding in place against the jaw. The jaw will move behind the kingpin, followed by the wedge. The wedge reinforces the jaw and automatically adjusts for slack around the kingpin. See **Fig. 1** for an illustration of the jaw and wedge in the locked position.

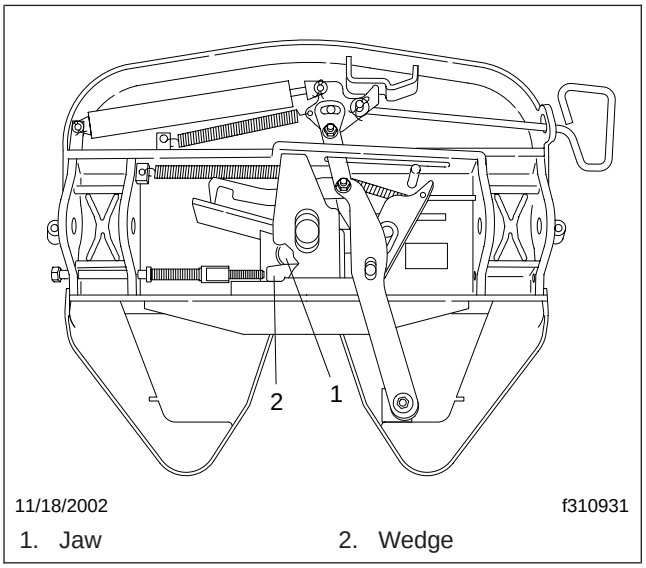


Fig. 1, Locked Position

Placing the lock control handle in the unlocked position moves the wedge and jaw out from behind the kingpin and unlocks the fifth wheel. See **Fig. 2** for an illustration of the jaw and wedge in the unlocked position.

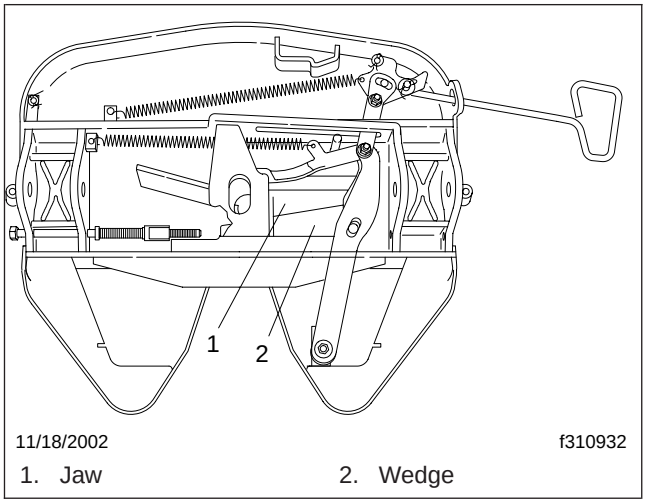


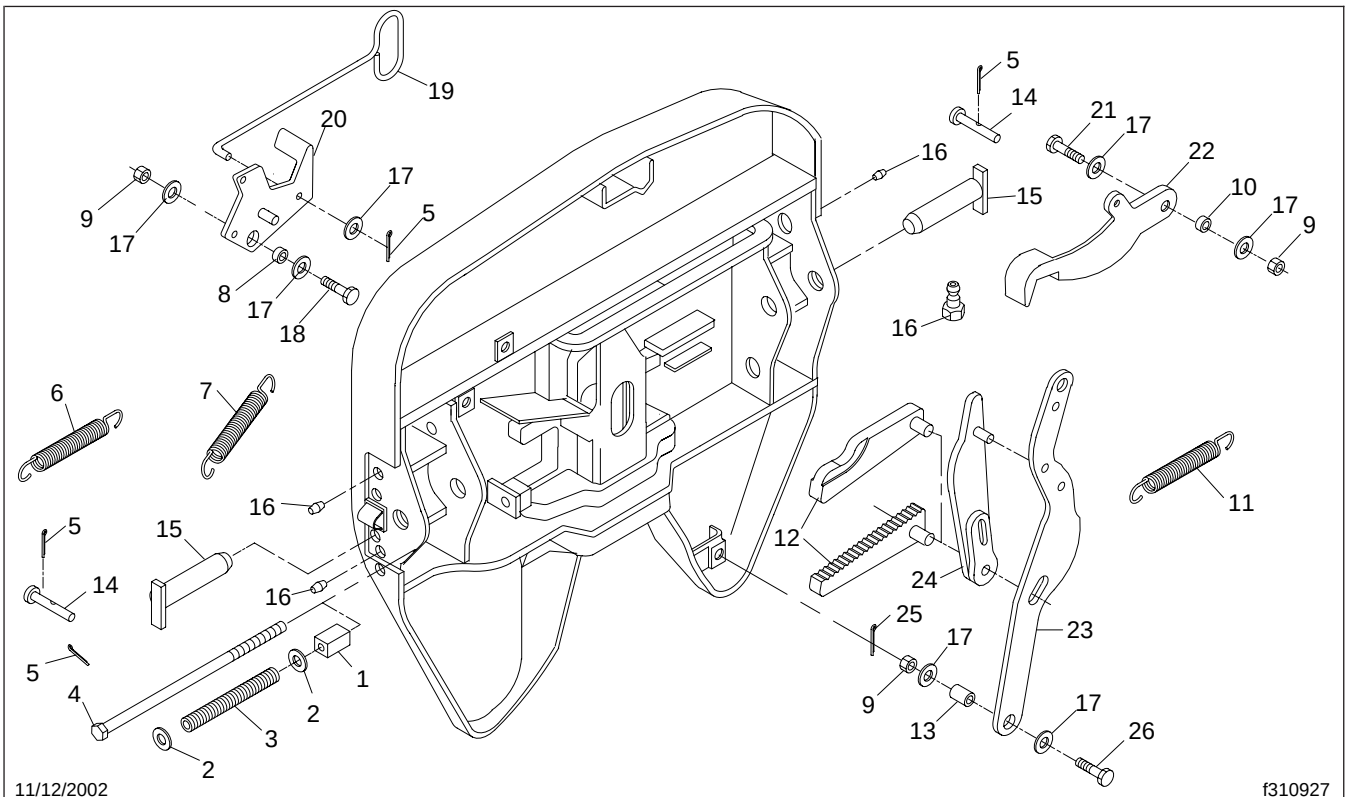
Fig. 2, Unlocked Position

Fifth Wheel Removal and Disassembly

See **Fig. 1** for an exploded view of a Fontaine® 6000 or 7000 No-Slack II series fifth wheel.

result in disengagement of the trailer from the tractor, leading to personal injury or property damage.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Fail-



1. Wedge Stop Rod Nut
2. Flatwasher, 5/8", Plain
3. Wedge Stop Rod Spring
4. Wedge Stop Rod
5. Cotter Pin, 3/16 x 1"
6. Bumper Spring
7. Handle Spring
8. Bushing, 7/16"
9. Hex Locknut, 1/2–13
10. Bushing, 5/16"
11. Timer Spring
12. Step Jaw and Wedge Set
13. Bushing
14. Bracket Retainer Pin
15. Bracket Pin
16. Grease Fitting
17. Flatwasher, 1/2" I.D. x 1-3/4" O.D., Plain
18. Hexhead Bolt, 1/2–13 x 1-1/2", Grade 5
19. Pull Handle
20. Secondary Lock
21. Hexhead Bolt, 1/2–13 x 1-3/4", Grade 5
22. Bumper
23. Operating Handle
24. Timer
25. Hairpin Cotter Pin
26. Hexhead Bolt, 1/2–13 x 2-3/4", Grade 5

Fig. 1, Fontaine 6000 and 7000 No-slack II Series Fifth Wheel (left-side release shown)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could

ure to do so can result in personal injury, due to parts ejecting with force.

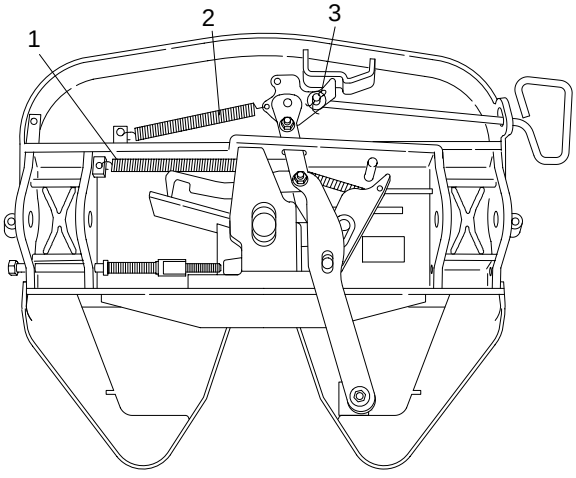
1. Steam clean the top plate. Remove it from the sliding mount by removing the cotter pins from the retaining pins. Remove the retaining pins and bushing pins from both sides of the top plate.

Removal and Disassembly

2. Using an overhead hoist, lift the fifth wheel off the sliding mount and tractor frame.
3. Turn the fifth wheel upside down.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

4. Remove the secondary lock spring and bumper spring. See **Fig. 2**. Remove the pull-handle cotter pin and washer, then slide out the pull handle.



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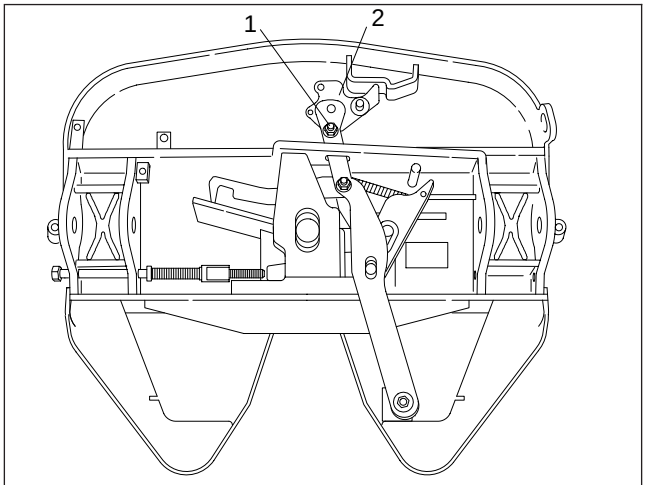
1. Bumper Spring
2. Secondary Lock Spring
3. Pull-Handle Cotter Pin

Fig. 2, Pull Handle

5. Unbolt and remove the secondary lock from the operating handle. Discard the locknut and bushing. See **Fig. 3**.
6. Unbolt and remove the bumper from the operating handle. Discard the locknut and bushing. See **Fig. 4**.
7. Unbolt the operating handle from the pivot mount and remove. Discard the locknut. See **Fig. 5**.
8. Remove the timer spring and timer. See **Fig. 6**.
9. Remove the jaw and wedge. See **Fig. 7**.



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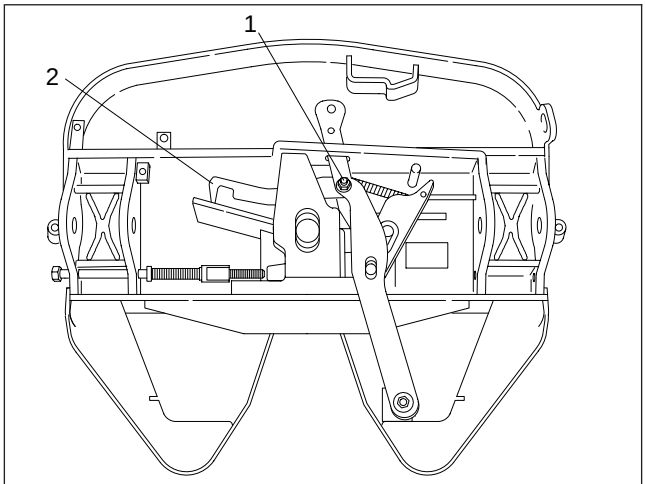
1. Bolt
2. Secondary Lock

Fig. 3, Secondary Lock



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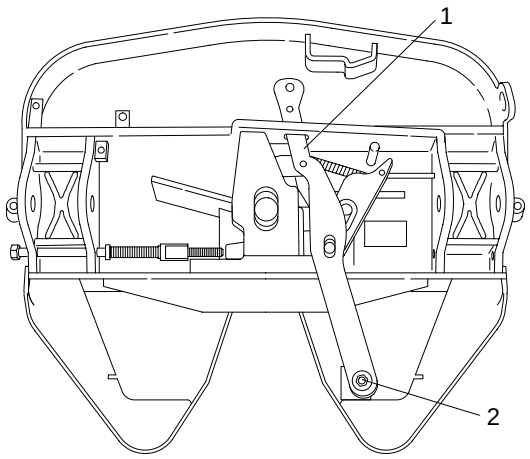
1. Bolt
2. Bumper

Fig. 4, Bumper



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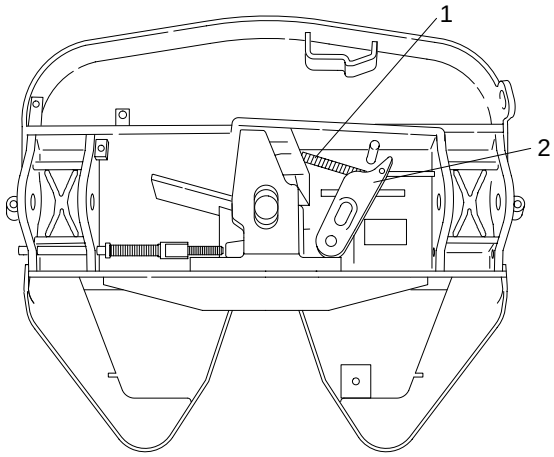
1. Operating Handle
2. Bolt

Fig. 5, Operating Handle



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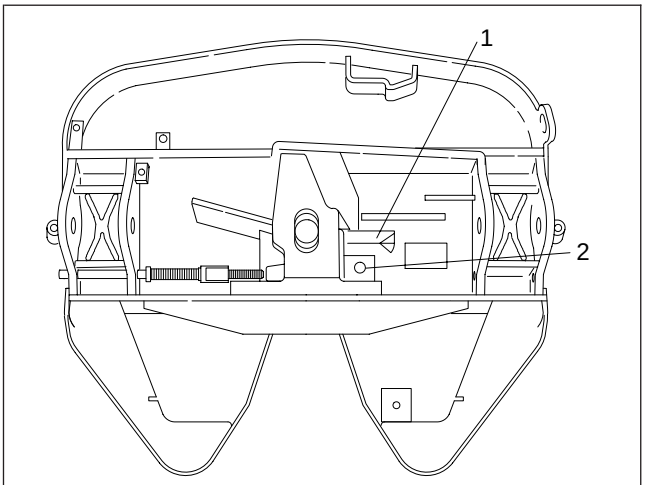
1. Timer Spring
2. Timer

Fig. 6, Timer Spring and Timer



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1. Jaw
2. Wedge

Fig. 7, Jaw and Wedge

Assembly and Installation

⚠ WARNING

Before rebuilding the assembly, check to make sure that there are no cracks in the crossmembers or other components. Also check the bracket pin holes to ensure they are not worn oversize (pins should fit snugly). Under no circumstances should a fifth wheel be repaired or used if any component (crossmember, saddle bearing, etc.) is cracked. Operating a fifth wheel with damaged components could result in disengagement of the trailer from the tractor, leading to personal injury or property damage.

Use a Moly-based lubricant such as Mobil grease Moly 50 or equivalent when applying lubricant to the locking jaw and wedge. Lightly oil other moving parts in the fifth wheel.

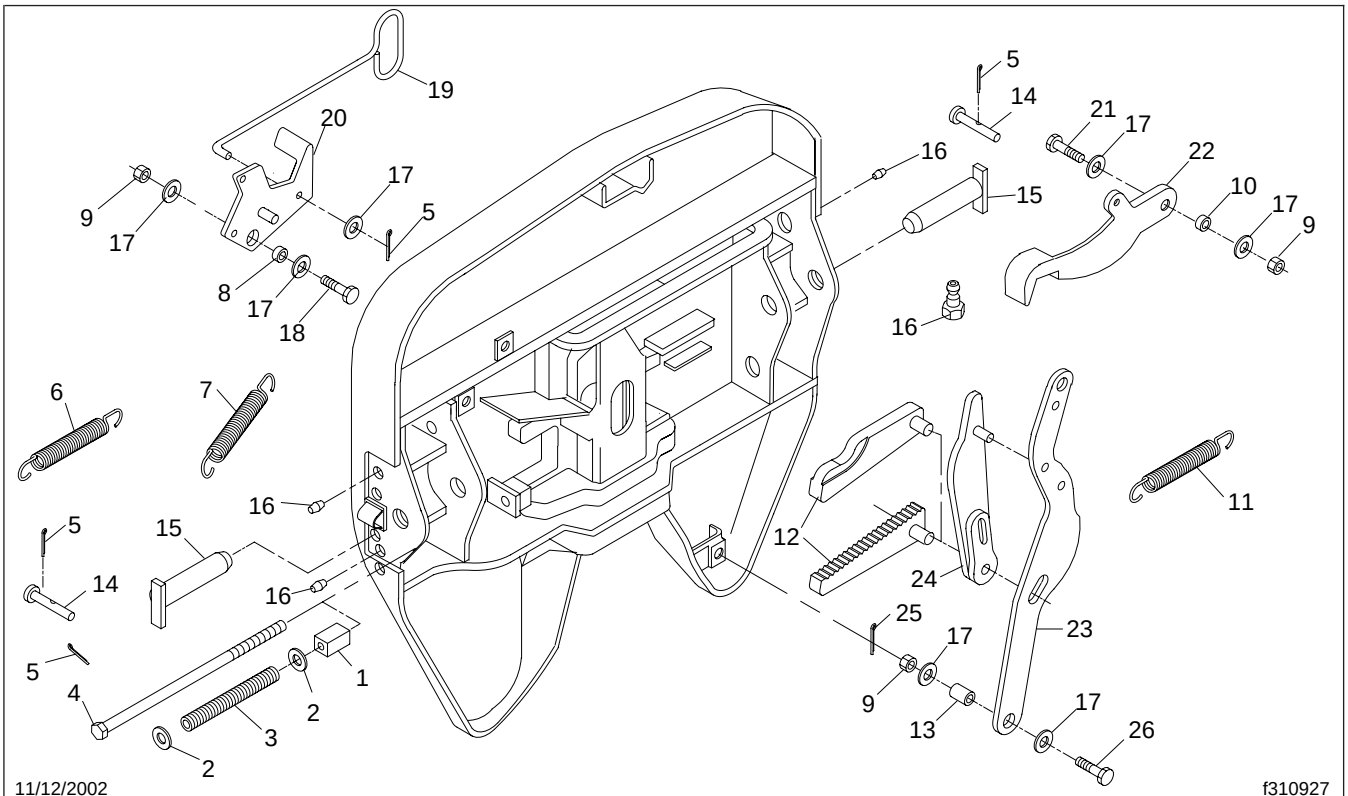
See **Fig. 1** for an exploded view of a Fontaine® 6000 or 7000 No-Slack II series fifth wheel.

1. Always assemble parts around a 2-inch kingpin or a 2-inch-diameter shaft. Insert the jaw first, then the wedge below it. See **Fig. 2**. Grease the jaw and wedge on the top and bottom.
2. Install the timer and the timer spring. See **Fig. 3**.
3. Install the operating handle and bolt to the pivot mount. See **Fig. 4**. Use the existing bolt, washer, hairpin cotter pin and bushing. Inspect the bushing for wear before using it and replace it if necessary. Use the new locknut that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**).
4. Install the bumper and bolt it to the operating handle. See **Fig. 5**. Use the existing bolt and washers (inspect for wear before using and replace if necessary). Use the new locknut and bushing that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**). After installing the bumper, check to make sure that it can pivot freely.
5. Insert the secondary lock and bolt it to the operating handle. See **Fig. 6**. Use the existing bolt and washers (inspect for wear before using and replace if necessary). Use the new locknut and bushing that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**).
6. Install the pull handle. See **Fig. 7**. Use the existing washer and cotter pin (inspect for wear before using and replace if necessary). Attach the new secondary lock/bumper spring that is supplied in the repair kit. Open and close the fifth wheel to ensure that it works properly. The fifth wheel must be properly lubricated before opening and closing the wheel.

Use a Moly-based lubricant such as Mobil grease Moly 50 or equivalent when applying lubricant to the locking jaw and wedge. Lightly oil other moving parts in the fifth wheel.

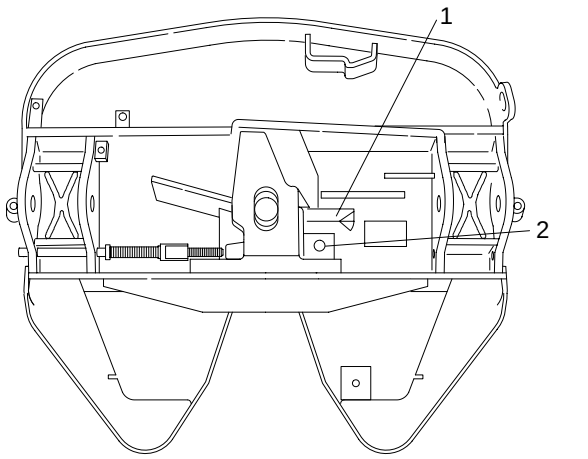
7. Close the fifth wheel several times with a standard 2-inch kingpin tool. With the lock closed, adjust the wedge stop rod so that the end is 1/4 inch (6 mm) from the wedge. See **Fig. 8**.
8. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch-long cotter pins.

Assembly and Installation



1. Wedge Stop Rod Nut
2. Flatwasher, 5/8", Plain
3. Wedge Stop Rod Spring
4. Wedge Stop Rod
5. Cotter Pin, 3/16 x 1"
6. Bumper Spring
7. Handle Spring
8. Bushing, 7/16"
9. Hex Locknut, 1/2–13
10. Bushing, 5/16"
11. Timer Spring
12. Step Jaw and Wedge Set
13. Bushing
14. Bracket Retainer Pin
15. Bracket Pin
16. Grease Fitting
17. Flatwasher, 1/2" I.D. x 1-3/4" O.D., Plain
18. Hexhead Bolt, 1/2–13 x 1-1/2", Grade 5
19. Pull Handle
20. Secondary Lock
21. Hexhead Bolt, 1/2–13 x 1-3/4", Grade 5
22. Bumper
23. Operating Handle
24. Timer
25. Hairpin Cotter Pin
26. Hexhead Bolt, 1/2–13 x 2-3/4", Grade 5

Fig. 1, Fontaine 6000 and 7000 No-slack II Series (left side release shown)



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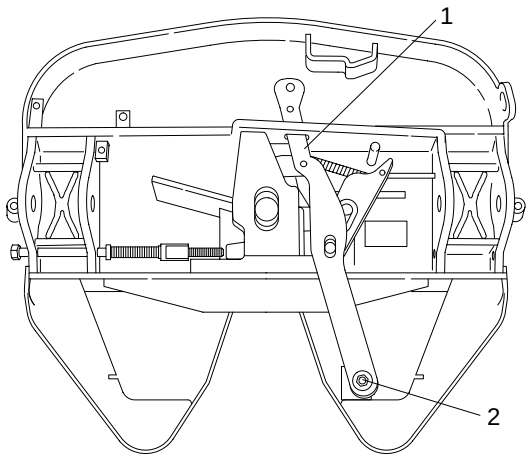
1. Jaw
2. Wedge

Fig. 2, Jaw and Wedge



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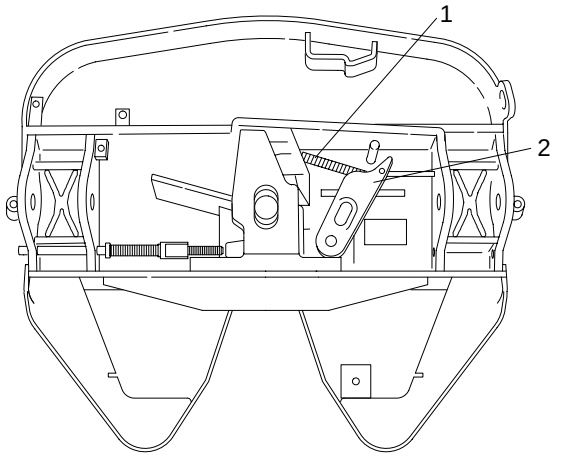
1. Operating Handle
2. Bolt

Fig. 4, Operating Handle



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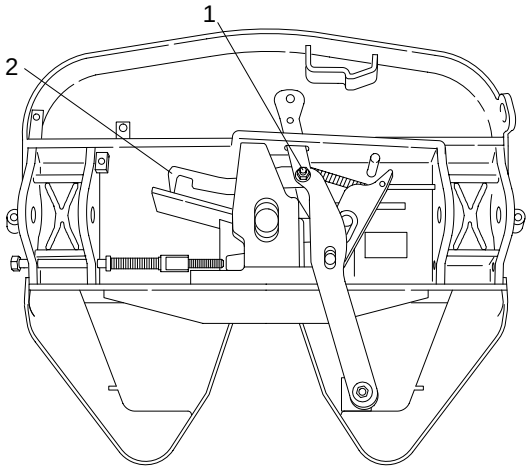
1. Timer Spring
2. Timer

Fig. 3, Timer Spring and Timer



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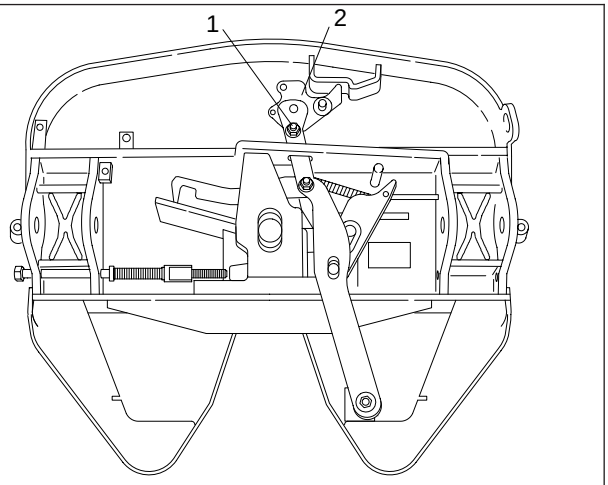
1. Bolt
2. Bumper

Fig. 5, Bumper

Assembly and Installation



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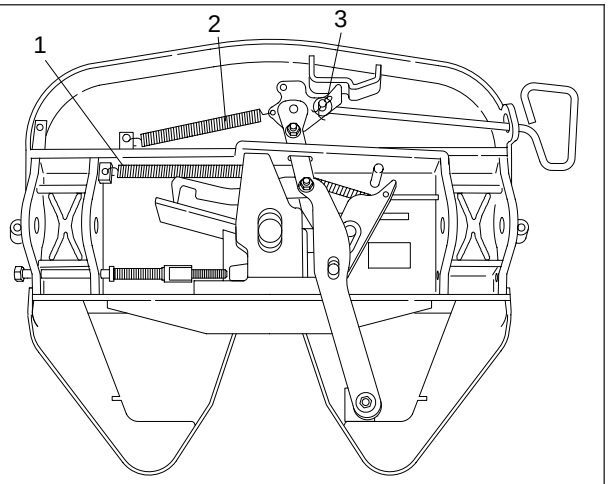
1. Bolt
2. Secondary Lock

Fig. 6, Secondary Lock



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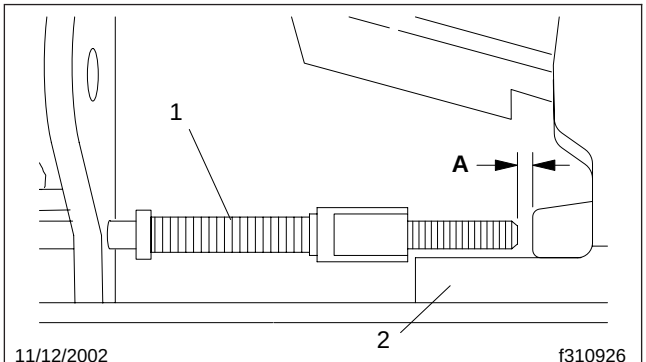
1. Bumper Spring
2. Secondary Lock Spring
3. Pull-Handle Cotter Pin

Fig. 7, Pull Handle



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A. 1/4 inch (6 mm)
1. Stop Rod
2. Wedge

Fig. 8, Wedge Stop Rod Adjustment

Troubleshooting Tables

Problem—Difficulty Coupling

Possible Cause	Remedy
The kingpin is too high to trip the latch	Lower the landing gear.
The trailer plate or kingpin is damaged	Check the trailer plate for flatness. Check the kingpin for squareness with the trailer plate.

Problem—Excessive Wear on the Fifth Wheel Top Plate

Possible Cause	Remedy
Damaged trailer plate	If the trailer plate is not flat, replace it.

Problem—Difficulty Uncoupling

Possible Cause	Remedy
Pressure on the locking mechanism caused by truck drifting apart from the trailer putting excess pressure on the lock	Back up the trailer and set the brakes. Strike the wedge stop rod which protrudes through the side of the fifth wheel. This spring-loaded rod will release the pressure on the locking mechanism.
Oval-shaped kingpin	Lower the landing gear.
Debris build-up in the grease	

Problem—Slack

Possible Cause	Remedy
Undersized kingpin	Replace the kingpin if worn greater than 1/8 inch (3 mm) at the 2-nch (5-cm) diameter.
Worn jaw and wedge	Jaw and wedge could have excessive wear. Replace them.

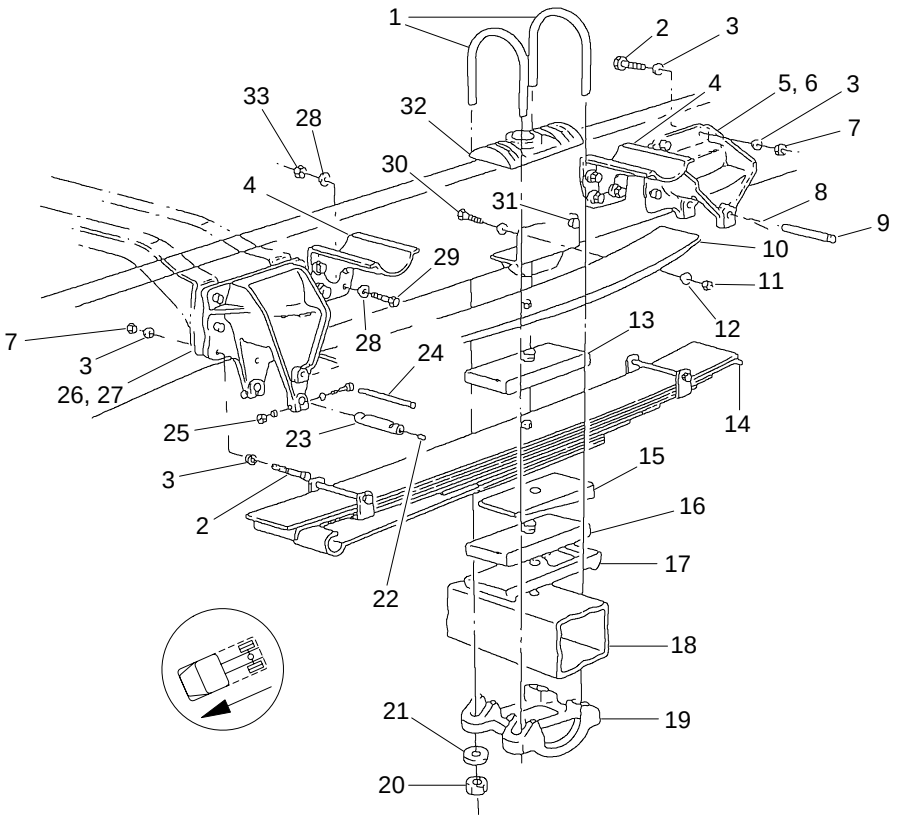
General Information

See **Fig. 1** and **Fig. 2** for this procedure.

Semi-elliptic, leaf-type rear springs are used on all vehicles. The springs are mounted to the frame side-members, and are held in place on the axle by U-bolts.

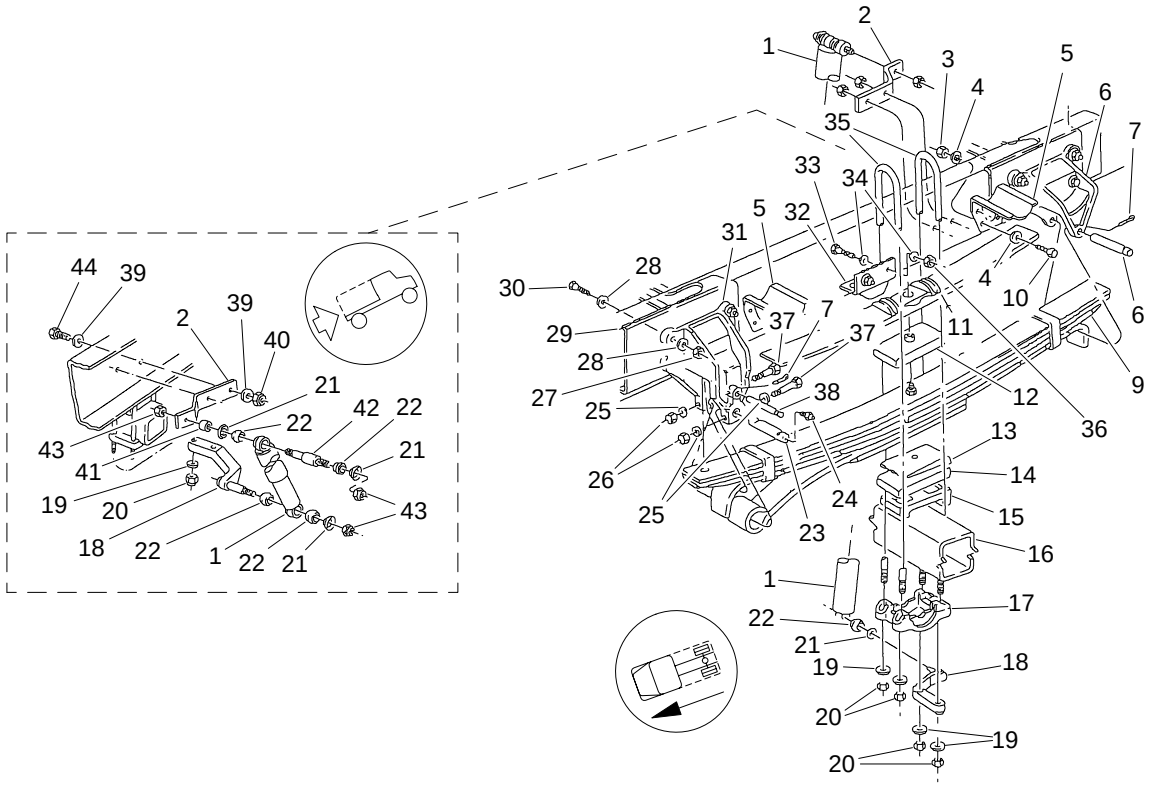
The front ends of the springs are hung from spring hanger brackets bolted to the frame side rails. The rear ends of the springs are mounted with a support-ing slipper bracket and rebound pin.

General Information



1. U-Bolts
2. Bolt
3. Flatwasher
4. Auxiliary Spring Bracket
5. Left-Hand Rear Spring Bracket
6. Right-Hand Rear Spring Bracket
7. Spring Bracket-to-Frame Nut
8. Cotter Pin
9. Rebound Pin
10. Auxiliary Spring
11. Bumper Assembly-to-Frame Nut
12. Washer
13. Spacer
14. Leaf Spring Assembly
15. Wedge
16. Spacer (21,000- or 23,000-lb suspensions only)
17. Seat
18. Axle Assembly
19. Cap
20. U-Bolt Lock Nut
21. Flatwasher
22. Lube Fitting
23. Shackle Pin
24. Rebound Pin
25. Shackle Pin Keeper Nut
26. Right-Hand Front Bracket
27. Left-Hand Front Bracket
28. Flatwasher
29. Auxiliary Spring Bracket-to-Frame Bolt
30. Bolt
31. Bumper Assembly
32. U-Bolt Spacer
33. Nut

Fig. 1, Rear Spring Assembly, Without Shock Absorbers



1. Shock Absorber
2. Upper Shock Absorber Bracket
3. Auxiliary Spring Bracket-to-Frame Nut
4. Washer
5. Auxiliary Spring Bracket
6. Rear Rear Spring Bracket
7. Cotter Pin
8. Pin
9. Spring Assembly
10. Bolt
11. U-Bolt Spacer
12. Spacer
13. Wedge
14. Spacer (21,000- or 23,000-lb suspensions only)
15. Spring Seat
16. Axle Assembly
17. Spring Seat Cap
18. Lower Shock Absorber Bracket
19. Washer
20. Spring Seat Cap Nut
21. Washer
22. Bushing
23. Shackle Pin
24. Lube Fitting
25. Washer
26. Shackle Pin Keeper Nut
27. Spring Bracket-to-Frame Nut
28. Washer
29. Frame
30. Bolt
31. Front Rear Spring Bracket
32. Axle Bumper
33. Bolt
34. Washer
35. U-Bolt
36. Bumper Assembly-to-Frame Nut
37. Shackle Pin Keeper Bolt
38. Rebound Pin
39. Washer
40. Shock Absorber Upper Bracket Nut
41. Spacer
42. Stud
43. Nut
44. Bolt

Fig. 2, Rear Spring Assembly, With Shock Absorbers

Replacement

1. Raise the vehicle frame enough to relieve the spring tension.
2. Remove the four nuts and washers. See **Fig. 1**.

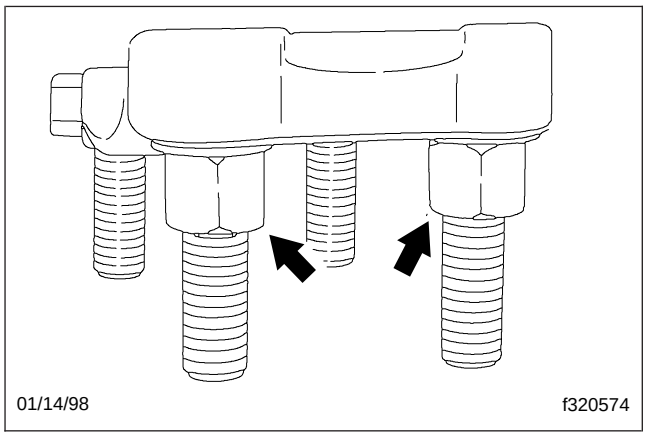


Fig. 1, U-Bolt Nuts

3. Remove the spring seat cap. See **Fig. 2**.

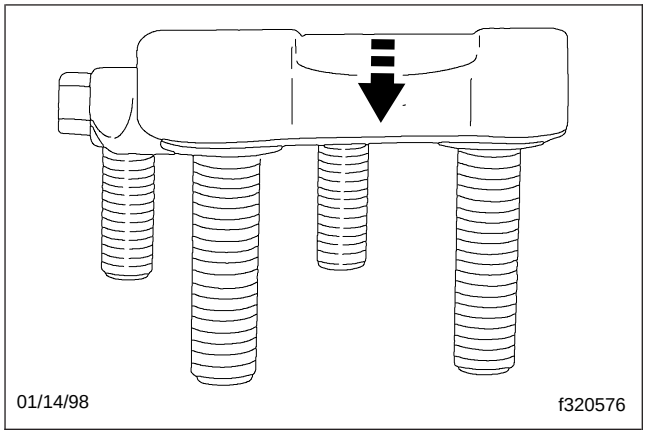


Fig. 2, Spring Seat Cap

4. Remove the auxiliary spring. See **Fig. 3**.
   - 4.1 Remove the U-bolts.
   - 4.2 Remove the spacer.
   - 4.3 Remove the auxiliary spring.
5. Position a suitable support for the spring.
6. Remove the cotter pin and the two nuts and bolts. See **Fig. 4**.

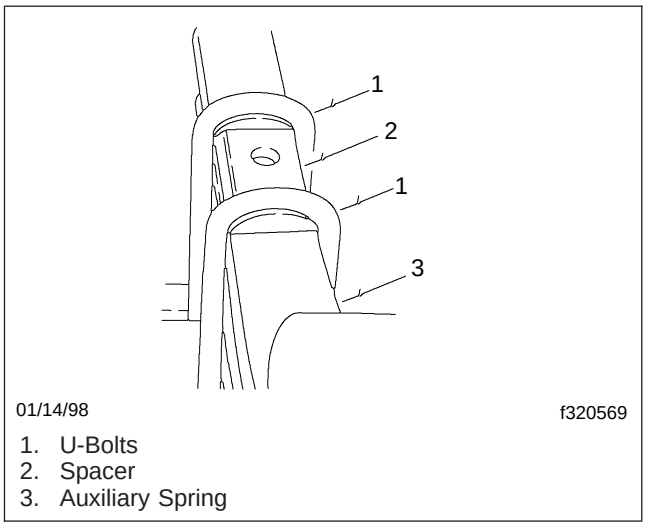


Fig. 3, Auxiliary Spring Assembly

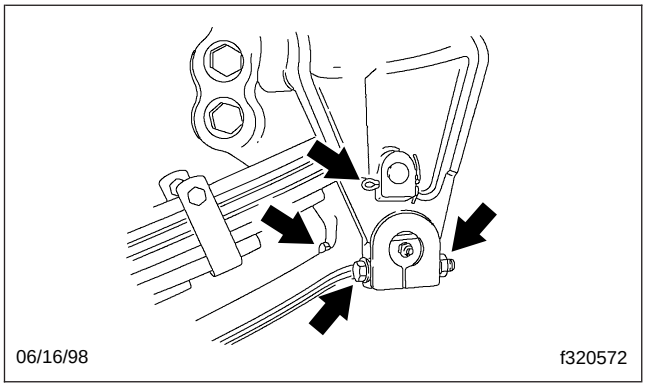


Fig. 4, Shackle Pin Bolt

7. Remove the rebound pin and the shackle pin. See **Fig. 5**.
8. Remove the rear spring. See **Fig. 6**.
   - 8.1 Remove the cotter pin.
   - 8.2 Remove the rebound pin.
   - 8.3 Remove the rear spring.
9. Install the rear spring. See **Fig. 6**.
   - 9.1 Install the cotter pin. Use new cotter pins.
   - 9.2 Install the rebound pin.
   - 9.3 Install the rear spring.

Spring Replacement

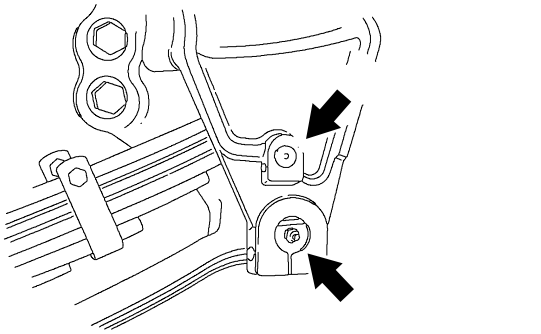


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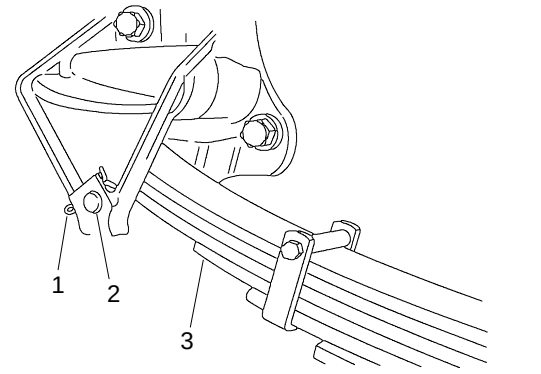
Fig. 5, Shackle Pin



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1. Cotter Pin
2. Rebound Pin
3. Rear Spring

Fig. 6, Rear Spring Assembly

10. Install the rebound pin and the shackle pin. Align the shackle pin grooves with the shackle pin keeper bolts. See **Fig. 5**.
11. Install the cotter pin and the two nuts and bolts. Tighten bolts 50 to 70 lbf·ft (68 to 95 N·m). See **Fig. 4**.
12. Install the auxiliary spring. See **Fig. 3**.
    - 12.1 Install the U-bolts.
    - 12.2 Install the spacer.
    - 12.3 Install the auxiliary spring.
13. Install the spring seat cap. See **Fig. 2**.
14. Install the four nuts and washers. Tighten nuts 359 to 479 lbf·ft (489 to 650 N·m). See **Fig. 1**.

Shock Absorber Removal and Installation

Removal

See **Fig. 1** for this procedure.

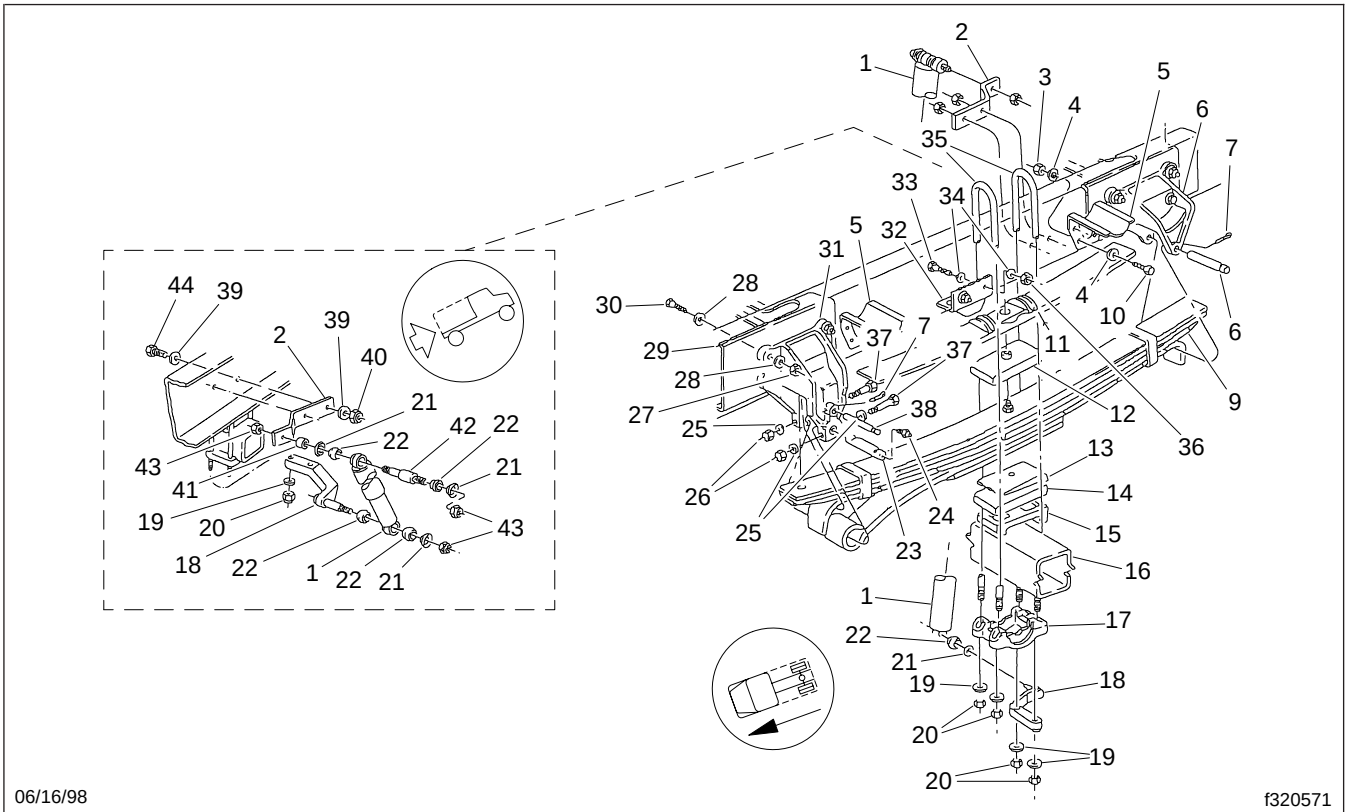
1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the locknuts and hardened washers from the shock absorber upper and lower bracket studs.
3. Pull straight out on the shock absorber and remove it.

Installation

See **Fig. 1** for this procedure.

1. Check the shock absorber bushings (two bushings in each eye) for wear or damage, and replace them if needed.
2. Make sure the 2-inch o.d. by 1-inch i.d. washer is installed on the stud of the shock absorber upper bracket.
3. Install the eyes of the shock absorber on the upper and lower bracket studs.
4. Install the washer and a new locknut on each of the bracket studs. Tighten the locknuts 115 to 150 lbf·ft (156 to 203 N·m).
5. Remove the chocks from the tires.

Shock Absorber Removal and Installation



1. Shock Absorber
2. Upper Shock Absorber Bracket
3. Auxiliary Spring Bracket-to-Frame Nut
4. Washer
5. Auxiliary Spring Bracket
6. Rear Rear Spring Bracket
7. Cotter Pin
8. Pin
9. Spring Assembly
10. Bolt
11. U-Bolt Spacer
12. Spacer
13. Wedge
14. Spacer (21,000- or 23,000-lb suspensions only)
15. Spring Seat
16. Axle Assembly
17. Spring Seat Cap
18. Lower Shock Absorber Bracket
19. Washer
20. Spring Seat Cap Nut
21. Washer
22. Bushing
23. Shackle Pin
24. Lube Fitting
25. Washer
26. Shackle Pin Keeper Nut
27. Spring Bracket-to-Frame Nut
28. Washer
29. Frame
30. Bolt
31. Front Rear Spring Bracket
32. Axle Bumper
33. Bolt
34. Washer
35. U-Bolt
36. Bumper Assembly-to-Frame Nut
37. Shackle Pin Keeper Bolt
38. Rebound Pin
39. Washer
40. Shock Absorber Upper Bracket Nut
41. Spacer
42. Stud
43. Nut
44. Bolt

Fig. 1, Rear Spring Assembly, With Shock Absorbers

Replacement

WARNING

Replace worn, cracked, or damaged spring brackets. 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 and set the parking brake. Shut down the engine. Chock the tires.

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.

2. Raise the rear of the vehicle, and block the rear axle 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 axle and frame.
3. Remove the fasteners that attach the spring bracket to the frame rail, and remove the spring bracket.
4. Place the new spring bracket on the frame rail. Align the mounting holes, and install the spring 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.

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.

5. Tighten the locknuts 221 to 299 lbf·ft (299 to 406 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 of the *L-Line and A-Line Maintenance Manual*.

6. Remove the safety stands from under the frame and axle, and lower the vehicle. Remove the chocks from the tires.
7. Check the axle alignment. For instructions, see **Group 35** of this manual. If necessary, adjust the rear axle alignment, using the instructions in **Section 35.04**.

Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
U-Bolt Nut	359–479 (489–650)
Spring Bracket-to-Frame Nut	221–299 (299–406)
Bumper Assembly-to-Frame Nut	32–41 (43–56)
Shackle Pin Keeper Nut	50–70 (68–95)
Auxiliary Spring Bracket-to-Frame Nut	110–150 (149–203)
Shock Absorber Nut	115–150 (156–203)
Shock Absorber Upper Bracket Nut	221–299 (299–406)
Shock Absorber Lower Bracket Nut	359–479 (489–650)

Table 1, Torque Specifications

Standard Bolt Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
1/4-Inch Diameter, Grade 5	—	89–115 (1000–1300)
5/16-Inch Diameter, Grade 5	12–17 (17–23)	—
3/8-Inch Diameter, Grade 8	32–41 (43–56)	—
7/16-Inch Diameter, Grade 8	50–70 (68–95)	—
1/2-Inch Diameter, Grade 8	75–105 (102–142)	—
9/16-Inch Diameter, Grade 8	110–150 (149–203)	—
5/8-Inch Diameter, Grade 8	150–205 (204–277)	—
3/4-Inch Diameter, Grade 8	220–300 (299–406)	—
7/8-Inch Diameter, Grade 8	360–480 (489–650)	—
1.0-Inch Diameter, Grade 8	540–730 (733–989)	—

Table 2, Standard Bolt Torque Specifications

Suspension

The L-Line and A-Line front suspension components are:

- A solid I-beam axle;
- Spindle pins through the spindle-to-axle joint;
- Wheel spindles to provide a mount for the hubs and the brake components;
- Leaf springs connecting the axle to the frame;
- Standard shock absorbers (if so equipped);
- A stabilizer bar (if so equipped).

SHOCK ABSORBERS

The hydraulic shock absorbers are the direct-acting type. This type of shock absorber is non-adjustable and non-refillable and cannot be repaired.

Wheel Alignment Angles

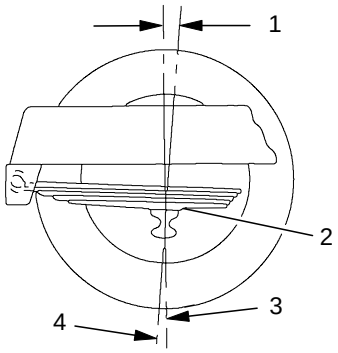
CASTER (See Fig. 1)

Caster is the amount in degrees that the top of the spindle pin is inclined toward the front or rear of the vehicle as viewed from the side of the vehicle. The caster angle can range from a positive angle to a negative angle.

Positive caster is the tilting of the top of the spindle pin toward the rear of the vehicle, while negative or reverse caster is the tilting of the spindle pin toward the front of the vehicle.

The correct amount of caster helps to keep the front wheels in the straight-ahead position. When in a turn, caster acts as a lever, assisting the driver to return the front wheels to the straight-ahead position.

Caster specifications are based on vehicle design load (no payload), which will usually result in a level frame. Because of this, raising (or lowering) the rear without changing front ride height will subsequently decrease (or increase) the caster angle by the same amount the frame angle changes. If the frame is not level when alignment checks are made, this must be considered in determining whether the caster setting is correct.



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1. Caster Angle
2. Tapered Wedge
3. Vertical Line
4. Centerline of Spindle Pin

Fig. 1, Caster Angle

CAMBER (See Fig. 2)

Camber is the amount in degrees that the wheel inclines away from the vertical at the top, as viewed from the front of the vehicle. Positive camber is an outward tilt or inclination of the wheel at the top. Negative or reverse camber is an inward tilt of the wheel at the top.

The amount of camber used depends on the amount in degrees the spindle pin is inclined. An incorrect camber angle causes the side of the tread to wear, resulting in reduced tire life.

Unequal camber in the front wheels may cause the vehicle to lead to the right or left on a level road. The vehicle will lead to the side that has the most positive camber.

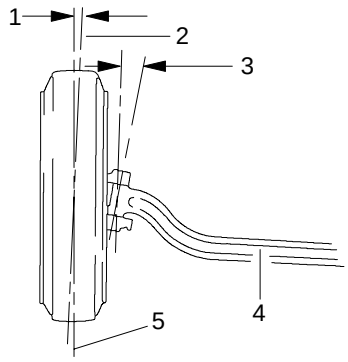
Spindle pin inclination working together with the camber angle puts the approximate center of the tire tread in contact with the road. Spindle pin inclination reduces steering effort and improves the directional stability of the vehicle.

There is no means of adjusting this angle; therefore, it will not change unless the front axle has been bent. Corrections or changes to this angle are accomplished by replacement of broken, bent or worn parts.

TOE

Toe-in is the amount in millimeters (or fractions of an inch) that the front wheels are closer together at the

General Information



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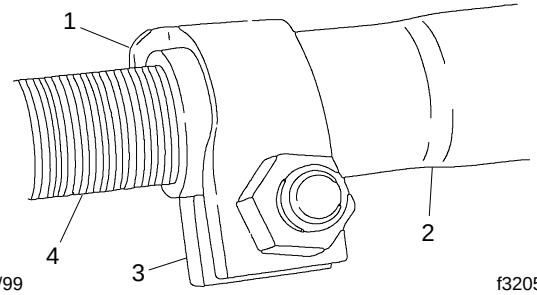
1. Camber Angle
2. Vertical Angle
3. Spindle Pin Inclination
4. Level of Spring Pad
5. Centerline of Tire

Fig. 2, Camber Angles

front than at the back as viewed from the top of the vehicle. With camber on the front wheels, the left front wheel tries to steer to the left and the right front wheel tries to steer to the right. This is due to the tendency of a wheel to turn in the same direction it leans. To overcome this condition, the wheels are given a certain amount of toe-in by an adjustment at the tie rod ends. See **Fig. 3**.



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1. Clamp Tab
2. Front Wheel Spindle Tie Rod
3. Tie Rod Clamp
4. Tie Rod End

Fig. 3, Tie Rod End

Do not adjust toe-in until the other factors of front wheel alignment are known to be within specifications.

LOAD EFFECT

Front end alignment settings change between loaded-vehicle and unloaded-vehicle conditions. The amount of this change will depend on vehicle suspension design, as well as the actual amount of load on the front axle.

TANDEM DRIVE AXLE ALIGNMENT

Vehicle alignment (axle alignment) is the process of setting the axles of the vehicle into a position to establish true rolling action of the tires on the ground. Misalignment of the axles will cause tire scrub. See **Fig. 4**. The amount of tire scrub is proportional to the amount of misalignment.

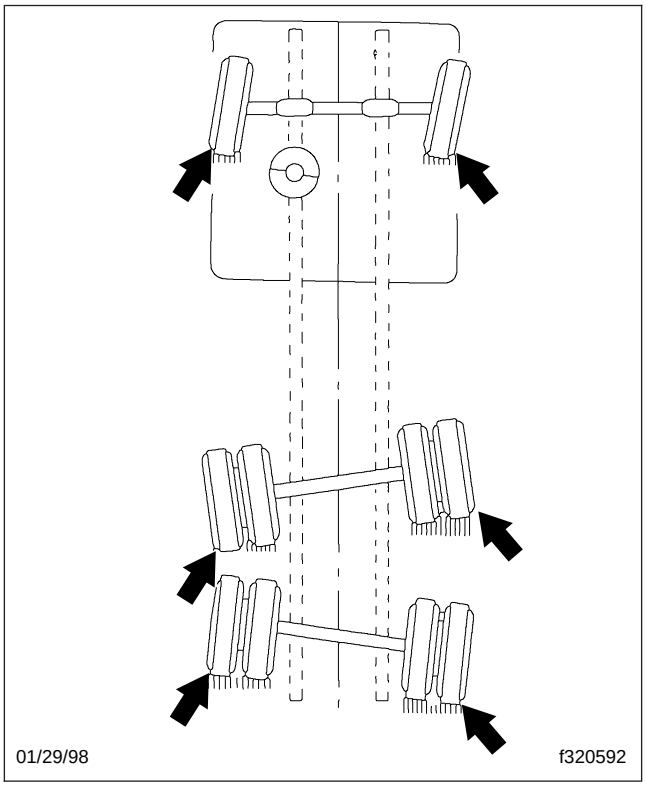

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Fig. 4, Tire Scrub

Drive axle alignment affects the overall wear rate and wear patterns of steering axle tires, as well as tires on the drive axles. Proper drive axle alignment must be confirmed before making final front end alignment settings.

The two primary objectives in setting drive axle alignment are first, that the drive axles be positioned per-

pendicular to the chassis centerline and second, that the two axles be parallel to one another. Most drive axle tandem suspensions have provisions for setting alignment.

Although single rear axles are not specifically addressed, the procedures in this section are applicable to both single and tandem rear axle vehicles. The procedure for aligning the axles with respect to squareness to the frame is the same. The portions discussing rear rear drive axle to forward rear drive axle alignment (parallelism) can be ignored for single rear axle vehicles.

Caster Adjustment

1. Raise and support the vehicle.
2. Support the axle and the chassis independently.
3. Remove the nuts. See **Fig. 1**.

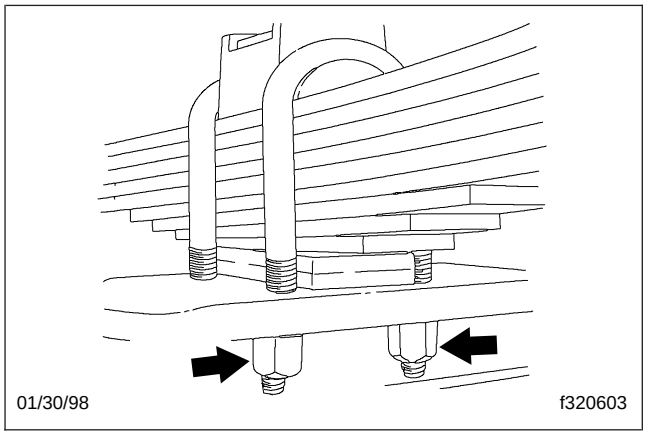


Fig. 1, U-Bolt Nuts

4. Lower the axle enough to insert the adjustment wedge.
5. Insert the caster adjustment wedge. See **Fig. 2**.

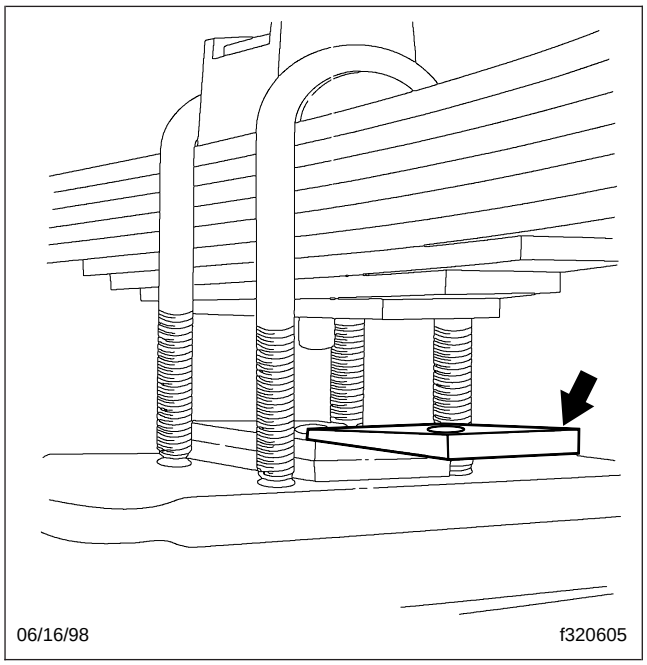


Fig. 2, Caster Adjustment Wedge Installation

6. Install and tighten the nuts. See **Fig. 1**. Note the U-bolt size and tighten to specification.
7. Lower the vehicle.
8. Recheck the caster.

Toe Adjustment

1. Raise and support the vehicle.
2. Loosen the clamp at both ends of the tie rod. See **Fig. 3**.

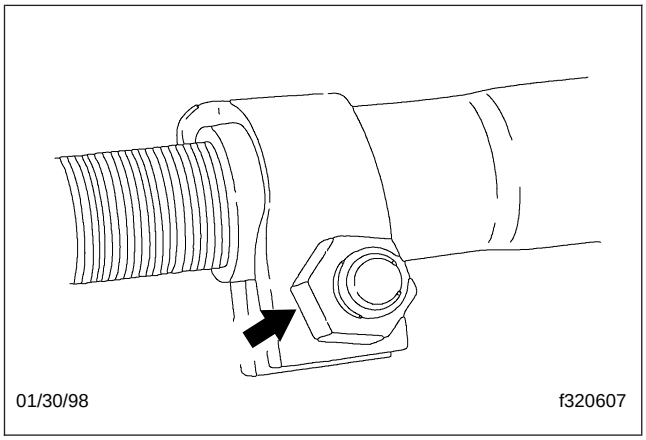


Fig. 3, Loosening the Tie Rod Clamp

3. Rotate the tie rod sleeve to bring the toe into specification. See **Fig. 4**.

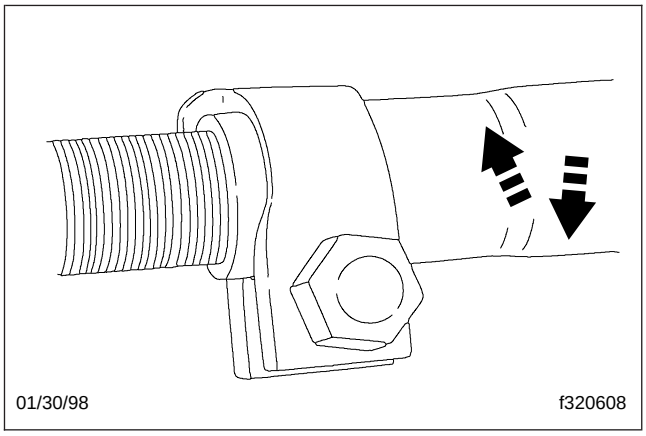


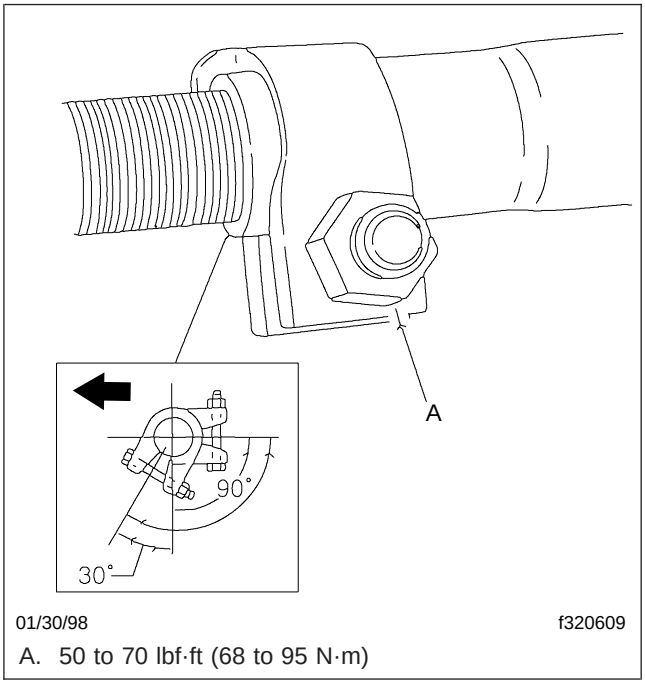
Fig. 4, Rotating the Tie Rod Sleeve

NOTE: For movable tie rod clamps, make sure the tab is against the end of the tie rod.

Alignment Adjustments

Position for the tie rod clamp as shown in **Fig. 5**.

4. Tighten the clamp 50 to 70 lbf·ft (68 to 95 N·m). See **Fig. 5**.



A. 50 to 70 lbf·ft (68 to 95 N·m)

Fig. 5, Tightening the Tie Rod Clamp

5. Recheck the toe.

Vehicle Lean Correction

IMPORTANT: Corrections should not be attempted on vehicles with a bumper-to-ground height right-to-left variation of 1 inch (25 mm) or less. Corrections should not be made if the ride height variation is 1/2 inch or less (13 mm).

1. Raise and support the vehicle.
2. Position a separate support for the front axle.
3. Lower the vehicle or raise the front axle to relieve front spring tension.
4. Remove the nuts, U-bolts and upper spacer. See **Fig. 6**.
5. Lower the front axle enough to insert the spacer. See **Fig. 7**.

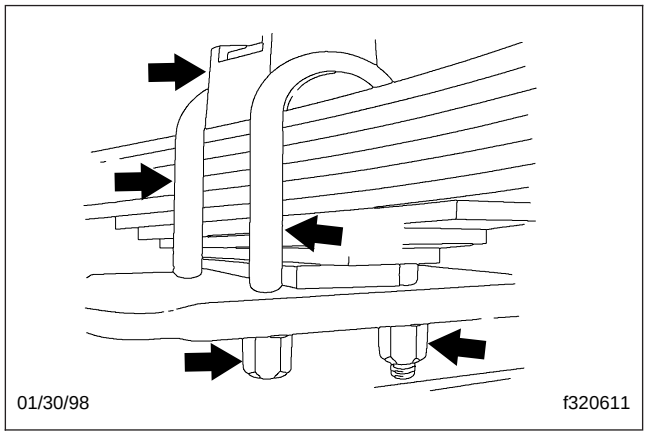


Fig. 6, U-Bolts and Upper Spacer

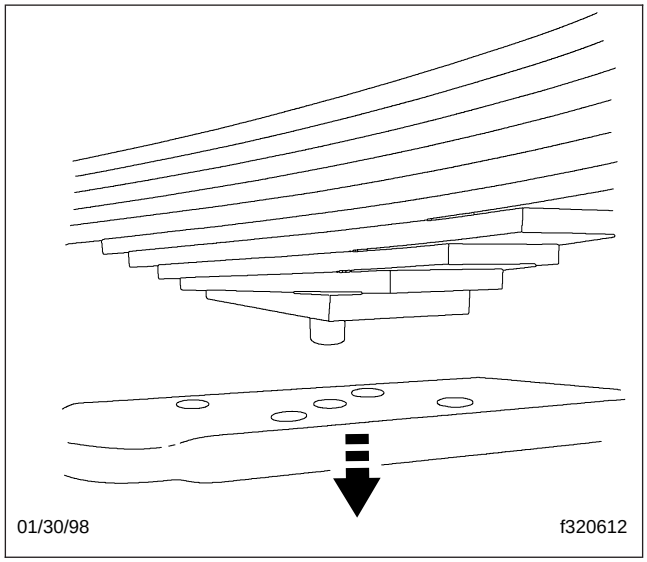


Fig. 7, Lowering the Axle

NOTE: Make sure the locator pin on the bottom of the spacer is in the locator hole in the spring pad.

6. Position the spacer and caster adjustment wedge (if required) on the spring pad. See **Fig. 8**.
7. Raise the axle.
8. Install the upper spacer, the U-bolts and the nuts. See **Fig. 6**. Tighten to specification.

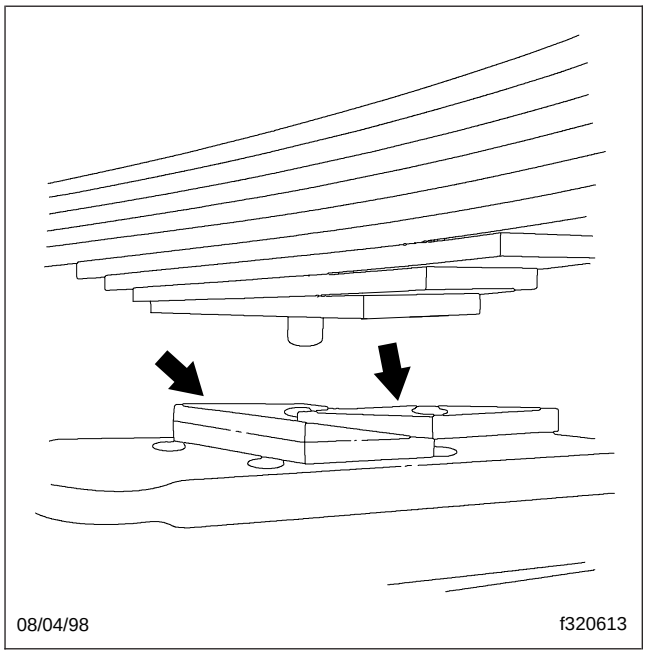


Fig. 8, Positioning the Spacer and the Caster Adjustment Wedge

Hendrickson Walking Beam

1. Determine the amount of adjustment necessary. Refer to "Drive Axle Alignment Check" under "Inspection and Verification" in **Troubleshooting, 300**.

⚠ CAUTION

Do not attempt to move the off-axle hanger brackets with respect to the axle housing. The welds at this interface are critical to the structural integrity of the axle housing. If the axle misalignment cannot be corrected by this procedure and is determined to be caused by the off-axle brackets, the condition must be reviewed with the service manager and the axle manufacturer's representative must be contacted.

2. Loosen the frame bracket fasteners and the spring saddle nuts enough to allow freedom of movement. See **Fig. 1**.

NOTE: Some experimentation will be necessary before the correct combination of component movements will achieve the desired adjustment.

3. Move the axles into squareness with the frame, (within 3/16 inch [5 mm]) and parallelism with each other, (within 1/8 inch [3 mm]).
4. Tighten the fasteners. Refer to **Specifications, 400**.
5. Recheck the drive axle alignment.

Hendrickson HFS and HAS Suspensions

1. Determine the amount of adjustment necessary. Refer to "Drive Axle Alignment Check" under "Inspection and Verification" in **Troubleshooting, 300**.

NOTE: The adjustment for the rear rear drive axle is done at the center spring hanger.

2. Determine if the adjustment can be made by removing or adding shims.
3. Loosen the two nuts. See **Fig. 2**.

NOTE: Available shims are 1/16 inch (1.65 mm). Total shims must not exceed 1/4 inch (6.35 mm).

4. Insert shims behind the torque rod bar pin to move an axle end forward or remove shims to move an axle end back. See **Fig. 3**.
5. Move the vehicle forward and backward to allow components to stabilize.
6. Tighten the nuts 150 to 205 lbf·ft (204 to 277 N·m). See **Fig. 2**.
7. Recheck the drive axle alignment.
8. If necessary, repeat the procedure for the forward rear axle.

Neway Air Suspension, AD-246 and AD-123

NOTE: The Neway air suspension alignment is adjustable at the lefthand side only.

1. Loosen the pivot bolt for the rear rear drive axle. See **Fig. 4**.
2. Remove the three welds from the alignment bushings at the inboard and outboard sides of the frame bracket. See **Fig. 5**.
3. Move the adjustment bushings forward or backward as required to bring the axle into alignment within 3/16 inch (5 mm) axle-to-frame.
4. Lubricate the threads and tighten the pivot bolt 600 to 700 lbf·ft (813 to 950 N·m). See **Fig. 4**.
5. Recheck the alignment. Refer to "Drive Axle Alignment Check" under "Inspection and Verification" in **Troubleshooting, 300**.

NOTE: Use welding rod E-7018 and make three welds 7/8 inch (22 mm) long.

6. Remove old weld residue and reweld the alignment bushing to the frame bracket. See **Fig. 5**.
7. Check the alignment and, if necessary, repeat the procedure for the forward rear axle.

Drive Axle Alignment

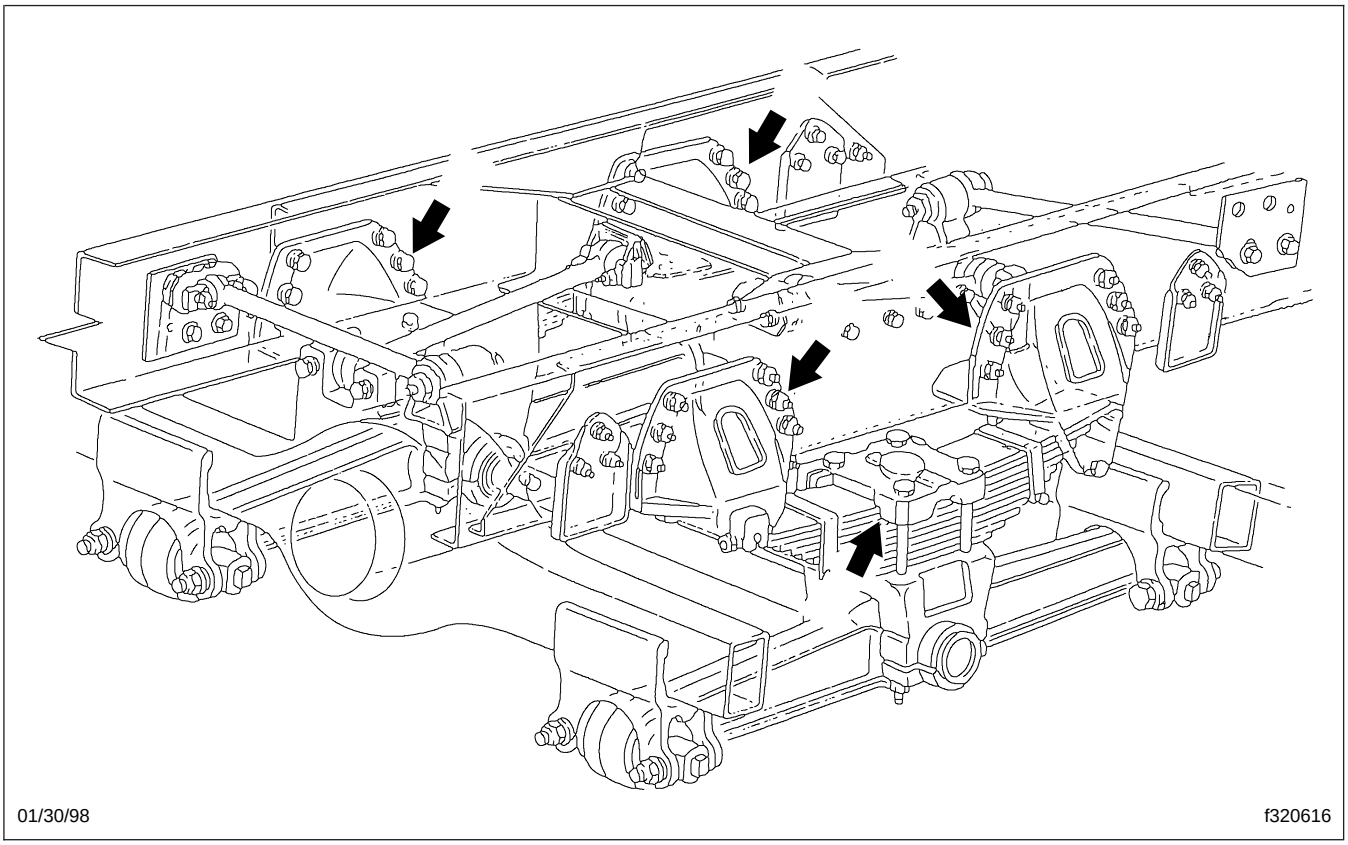


Fig. 1, Hendrickson Walking Beam Suspension Fasteners

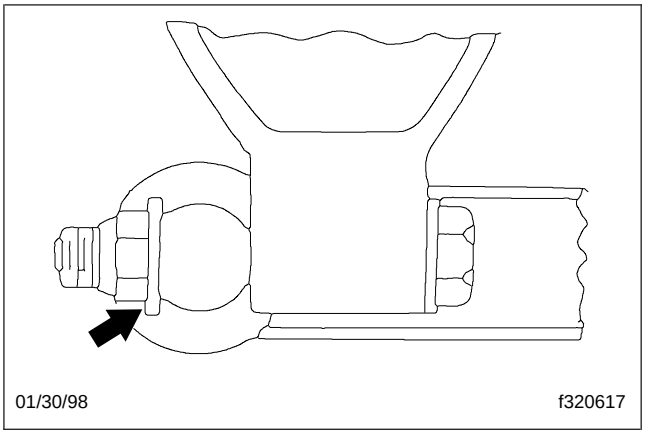


Fig. 2, Torque Rod Bar Pin Nuts, Hendrickson HFS and HAS Suspensions

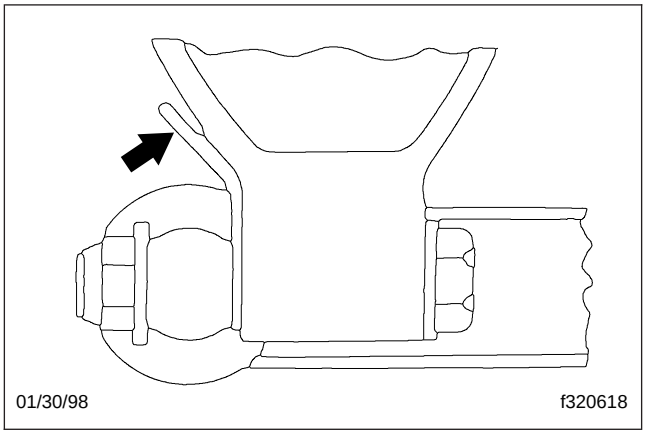


Fig. 3, Installing Shims, Hendrickson HFS and HAS Suspensions

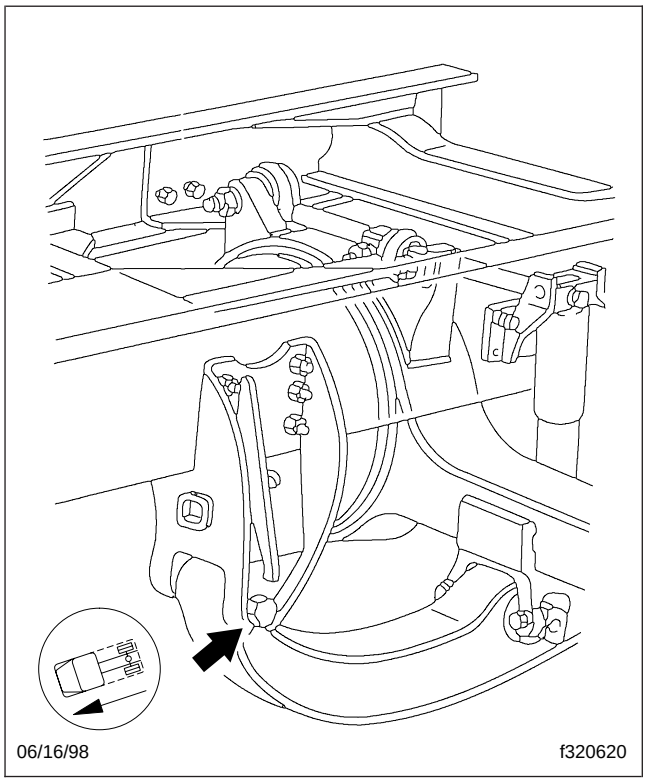


Fig. 4, Pivot Bolt, Neway Air Suspension, AD-246 and AD-123

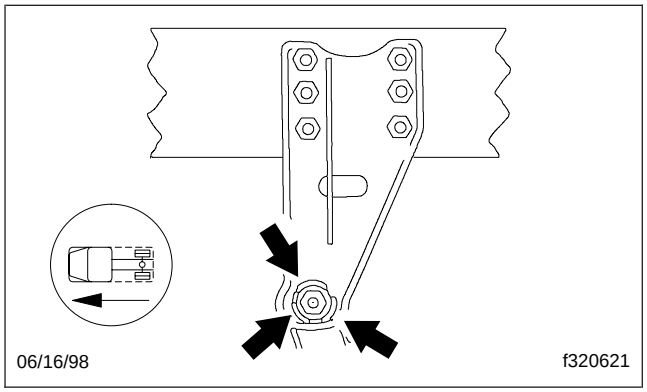


Fig. 5, Alignment Bushing Welds, Neway Air Suspension, AD-246 and AD-123

Troubleshooting

INSPECTION & VERIFICATION

Tires and Wheels

Certain abnormal tire wear patterns can be caused by worn, damaged or incorrectly installed suspension components. The cause for rapid tire wear or uneven tire wear patterns must be determined before realigning the vehicle suspension. See **Group 40** for instructions. Before proceeding with a front end alignment, replace tires worn unevenly or beyond useful life:

- Check for tires not matched in size or profile.
- Check for unbalanced tire and wheel assembly.
- Check for tire damage.
- Check for tires incompatible with expected usage.
- Check for radial and lateral runout.
- Check for loose lug nuts.
- Check for cracks or other wheel damage.

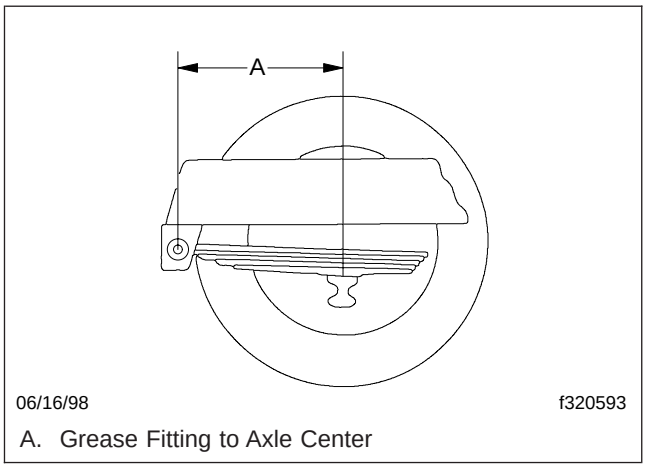
See **Group 40**, and correct as necessary.

Axle Alignment, Front

Inspect the spring-to-front axle connection. Look for signs of a shift in axle or spring position, such as clean areas or abrasion caused by movement. If the axle-to-spring alignment is suspect, measure from the grease fittings on the front spring pins to the center of the axle at both sides of the vehicle. See **Fig. 1**.

If the measurements are not equal:

1. Loosen the U-bolts at both sides of the vehicle and lower the axle.
2. Inspect for a sheared spring tie bolt at the bottom of the spring. See **Fig. 2**. Replace the sheared spring tie bolt.
3. Adjust the axle position to equalize the grease fitting-to-axle measurements.
4. Tighten the U-bolts to specification.



A. Grease Fitting to Axle Center

Fig. 1, Front Axle Alignment Measurement

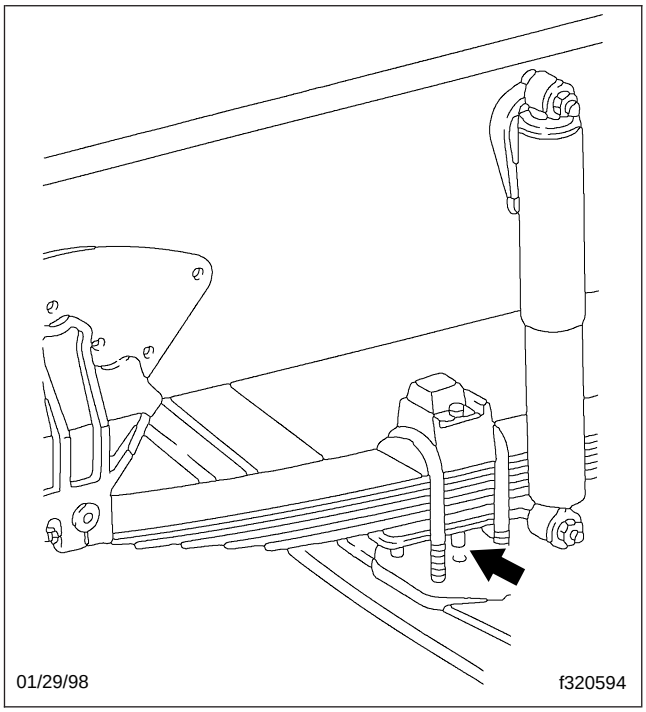


Fig. 2, Spring Tie Bolt Inspection

Caster

CAUTION

Do not heat or bend the axle to correct caster or to meet other alignment specifications as this may result in component damage or failure.

Troubleshooting

The caster angle is controlled by the angle of the front spring pads, and changes as the load on the front axle increases or as the springs sag. The spring pads must be parallel to each other. Any change in the caster angle results from a twisted axle or spring sag.

Caster specifications are based on a level frame front to rear. When checking caster, the frame angle must be measured with a bubble protractor or inclinometer. See **Fig. 3**.

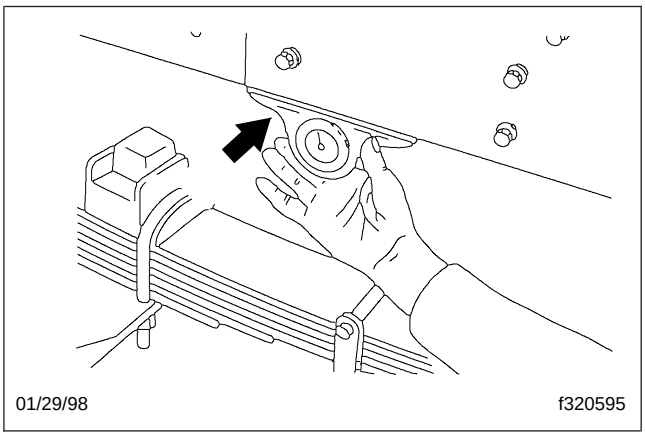


Fig. 3, Frame Angle Measurement

If the frame is low at the front, add the frame angle to the caster angle shown on the alignment equipment. If the frame is high in front, subtract the frame angle from the caster angle reading on the alignment equipment to get the true caster angle. Caster must be checked with the vehicle unloaded.

If the springs have sagged, the caster angle can be adjusted by replacing the springs or by installing tapered wedges between the springs and the spring pads. Use only one wedge per side. The wedges are available in different thicknesses. Position the thick edge of the wedge toward the rear of the vehicle to increase the caster, or toward the front to decrease the caster. When installing wedges, make sure the front spring tie bolts are positioned in the locator hole in the wedges. See **Fig. 4**.

After caster adjustment, recheck and adjust the toe as necessary.

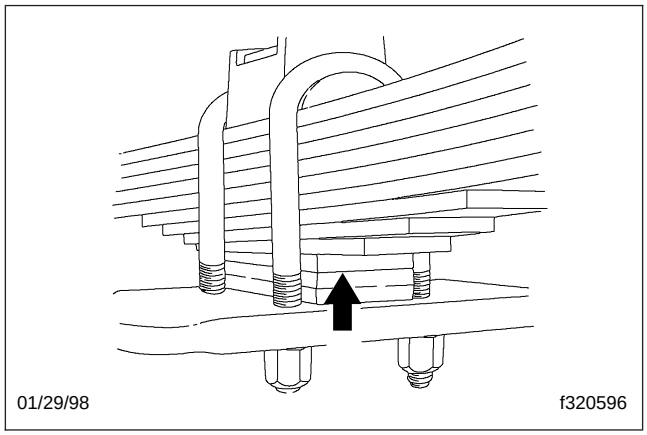


Fig. 4, Caster Adjustment Wedge

Camber

CAUTION

Do not heat or bend the axle to correct camber or to meet other alignment specifications as this may result in component damage or failure.

Check the camber angle and compare the measurement to specifications. Camber is built into the axle and cannot be changed. The axle must be replaced in order to correct camber.

Toe

Check the vehicle toe and compare to specification. If the toe is not within specification, see "Toe Adjustment" in **Subject 100**. If any camber adjustment is made, the toe must be rechecked.

Suspension

IMPORTANT: Do not attempt to adjust front wheel alignment without first making a preliminary inspection of the suspension components, and correcting where necessary.

- Fill all fluids to specification.
- Remove excess accumulation of mud, dirt or road deposits from the chassis and underbody.
- Retain all normal loads in the vehicle. Inflate all tires to the pressure specified on the Safety Compliance Certification Label (usually located on the inside driver door pillar).

- Check for excessive front wheel bearing end play. Adjust or replace the front wheel bearings as described in **Group 32**.
- Check for worn or damaged spindle pin bushings and loose spindle pin lock pins. See "Spindle Pin Bushing Wear Check" in this subject.

Steering System

IMPORTANT: Do not attempt to adjust front wheel alignment without first making a preliminary inspection of the steering components, and correcting where necessary.

- Check for worn or damaged steering linkage components. Repair or replace as necessary; see **Group 46**.
- Check the steering gear mounting bolts and tighten to specification; see **Group 46**.
- Check for aftermarket changes to steering, suspension, wheel and tire components (such as competition, heavy-duty, etc.). Specifications in this manual do not apply to vehicles with aftermarket changes.

Clear Vision

Drive the vehicle in a straight line and come to a stop with the front wheels pointing straight. Check the steering wheel alignment. If the steering wheel is more than 9 degrees off center, remove and reinstall the steering wheel at the correct angle.

Shock Absorber Checks

NOTE: It is not necessary to replace shock absorbers in sets.

Check the shock absorber:

- For leaks. Replace severely leaking shock absorbers;
- Upper and lower mountings. Replace worn or damaged insulators;
- Function. Disconnect the lower mounting. Push and pull the shock absorber and observe the action. Replace the shock absorber if there is little or no resistance in either direction. Replace the shock absorber if the action is not smooth and uniform throughout its range.

If a shock absorber is suspected of being excessively worn or damaged, replace it with a new one and retest vehicle suspension action. If the concern has been corrected, leave the new shock absorber in place. If the concern is still present, continue inspection to determine the cause.

Spindle Pin Bushing Wear Check

These procedures are for determining if front axle spindle pin bushing wear (side play) and spindle vertical end play measurements exceed the maximum wear limits for normal service, and to decide if maintenance is necessary.

Spindle pin and bushings must not have been recently lubricated before making this check. Measurements must be made before lubrication.

The simplest method for checking spindle pin looseness is to use a camber gauge. Instructions for the use of the camber gauge in this particular operation are as follows:

1. Chock the rear wheels.

IMPORTANT: If the axle has only one support, the measurement will not be accurate.

2. Raise and support the axle on two jack stands.

NOTE: Brakes must be applied to ensure an accurate measurement.

3. Apply the brakes.

NOTE: Accurate results depend upon measurement at the specified radius.

4. Set up the bushing check.
   - 4.1 Measuring from the center of the wheel hub, mark the tire at the specified radius.
   - 4.2 Position a dial indicator at the specified radius.
5. Push the wheel inward at the top and measure the movement obtained on the dial indicator. See **Fig. 5**. If the movement is more than 1/8 inch (3.2 mm), the spindle pin bushings must be replaced.

Spindle Vertical End Play Measurement

1. Block the rear wheels prior to performing this inspection.

Troubleshooting

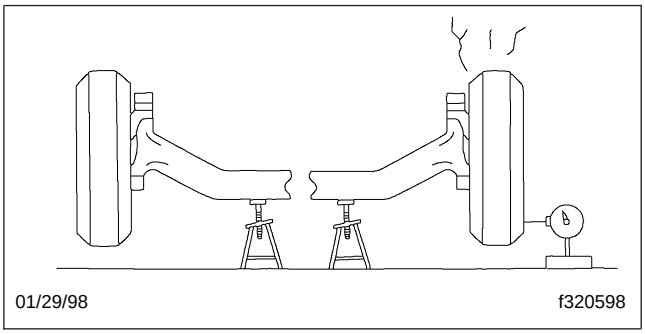


Fig. 5, Checking Bushing Wear

2. Raise and support the front axle at the wheel location to be checked.
3. Lift the wheel and tire (or the spindle only if the wheel is removed) so that all the weight is taken off the axle and there is maximum clearance between the upper spindle arm and the axle spindle pin boss.
4. Using a feeler gauge, measure the clearance between the upper spindle arm and the spindle pin boss. See **Fig. 6**.
5. If more than 0.060 inch (1.5 mm) is measured, add shims as needed to reduce clearance to specification.

Vehicle Lean Inspection

⚠ CAUTION

To avoid frame damage, neither frame twisting nor frame straightening should be attempted to correct vehicle lean.

NOTE: Sometimes it is necessary to loosen the crossmember-to-frame attachments as far back as the forward rear axle to find all the sources of frame assembly twist, bow, or matchboxing, which may contribute to vehicle lean. Shimming can be required to compensate for unequal length crossmembers.

Before attempting any correction, the cause for lean must be determined. The following measurements must be made with the vehicle unloaded and with all vehicle fluid levels at full:

1. Place the vehicle on a flat surface.
2. Inflate all tires to the recommended pressures.

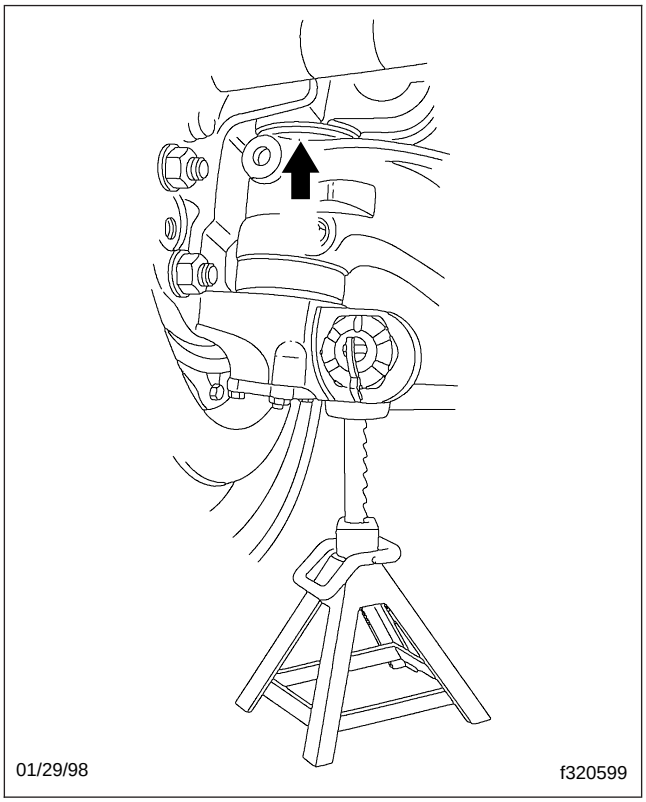


Fig. 6, Checking Clearance

3. Measure and record the ride height (ride height is the perpendicular distance between the top of the axle and the bottom of the frame rail) at both sides of the vehicle.
4. Measure and record the distance between the lower flange of the bumper ends and ground for both sides of the vehicle.

LEAN CORRECTION CONSIDERATIONS

Some vehicle lean correction considerations are:

- corrections should not be attempted on vehicles with a bumper-to-ground height right-to-left variation of 1 inch (25 mm) or less.
- corrections should not be made if the ride height variation is 1/2 inch (13 mm) or less.
- if lean correction requires a spacer of less than 1 inch (25 mm), removing a spacer from the opposite side can help the correction.

If the measurements indicate that an adjustment is required, see "Vehicle Lean Correction" in **Subject 100**.

Alignment Prechecks

Prior to front end alignment:

- The drive axle(s) must be aligned before attempting front end alignment. See "Drive Axle Alignment" in **Subject 110**;
- Frame straightness must be within 1/8 inch (3 mm);
- Loose crossmember fasteners must be tightened to specification;
- Elongated holes for crossmember fasteners must be drilled to the next larger size and new bolts installed;
- The tires and the suspension and steering systems must be thoroughly inspected. Refer to "Inspection and Verification" in this subject.

Drive Axle Alignment Check

1. Drive the vehicle back and forth in a straight line coasting to a stop in each direction. Do not use the brakes.
2. Park the vehicle on a level surface.
3. Chock the front wheels and release all brakes.
4. Securely clamp a 9-ft (2.75-M) section of angle iron or straight bar stock to both frame rails. Use a carpenter's square to ensure a 90-degree (perpendicular) relationship between the angle iron and frame rails. Locate the angle iron as far forward as practical. See **Fig. 7**.
5. Using a trammel gauge or other suitable device, measure from the angle iron to the center of the rear rear drive axle on both sides. See **Fig. 8**.
6. Compare the side-to-side measurements. If these measurements differ by more than 3/16 inch (5 mm), reposition the rear rear axle so that the two measurements are equal. Depending on the particular suspension, this adjustment can be made by repositioning brackets, changing the length of the torque rod(s), repositioning pivot bushings or adding or removing shims. Refer to "Drive Axle Alignment" in **Subject 110**.

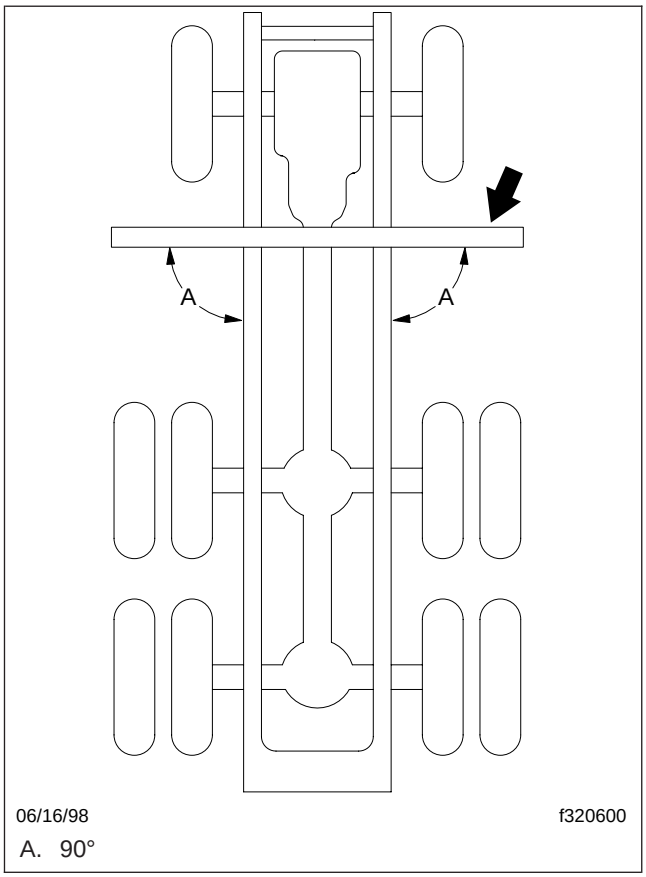
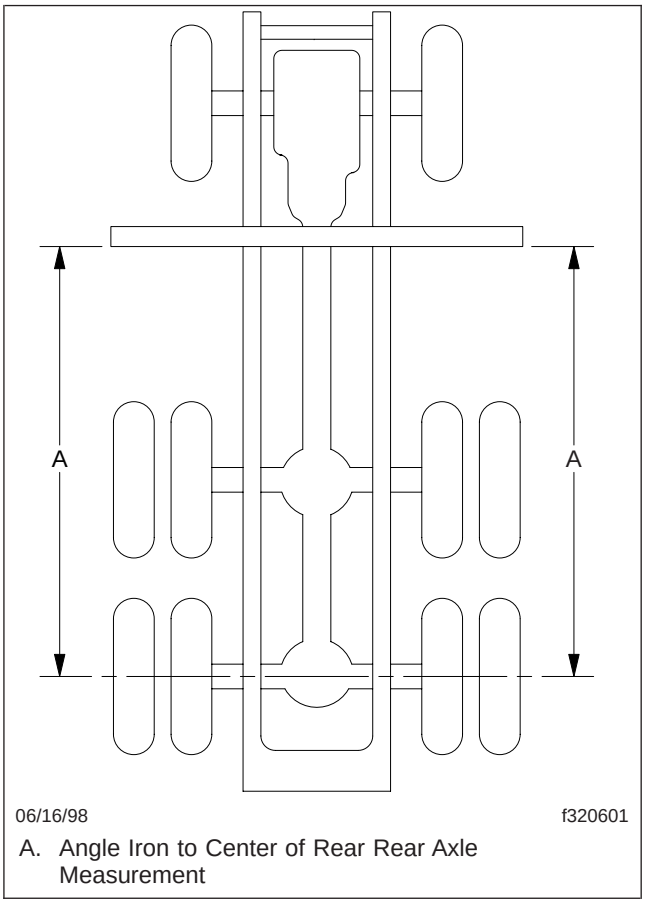


Fig. 7, Positioning Angle Iron or Bar Stock

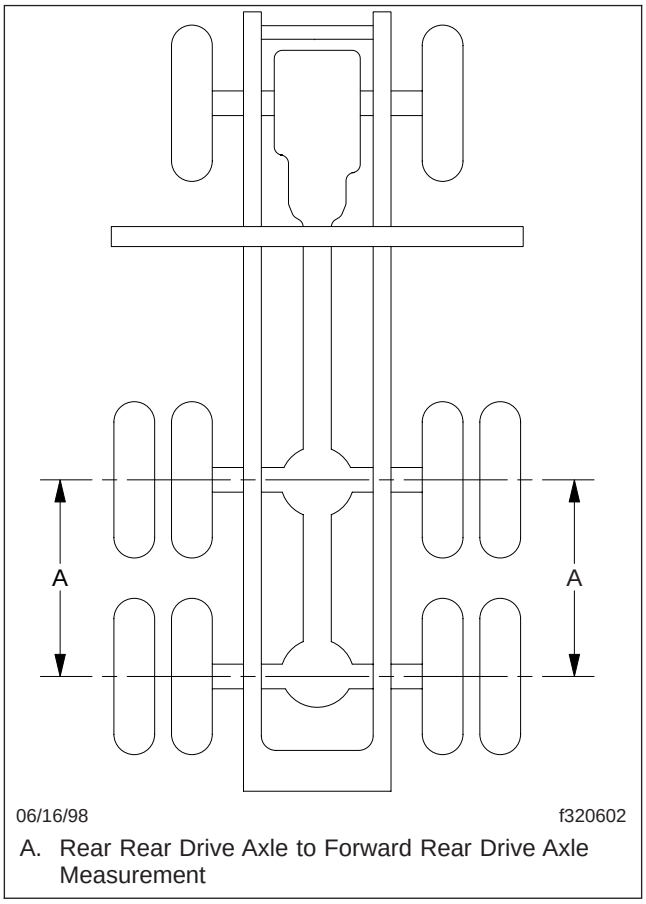
7. For the forward rear axle, measure from rear rear drive axle centers to forward rear drive axle centers on both sides. See **Fig. 9**.
8. If these measurements differ by more than 1/8 inch (3 mm), reposition the forward rear drive axle so that the side-to-side measurements are equal.

Troubleshooting



A. Angle Iron to Center of Rear Rear Axle Measurement

Fig. 8, Measuring to Center of Rear Rear Axle



A. Rear Rear Drive Axle to Forward Rear Drive Axle Measurement

Fig. 9, Measuring from Rear Rear Drive Axle to Forward Rear Drive Axle

Problem—Shimmy

Problem—Shimmy	
Possible Cause	**Remedy**
Tires or wheels.	Inspect the wheels and tires. See "Tires and Wheels" under "Inspection and Verification" in this subject.
Loose lug nuts.	Tighten to specification.
Wheel bearings.	Set wheel bearing preload; see **Group 32**.
Worn, damaged or incorrectly installed suspension components.	Inspect the suspension system. Correct as necessary.
Worn, damaged or incorrectly installed steering components.	Inspect the steering system. Correct as necessary.
Alignment.	Check alignment. Correct as necessary.
Loose spindle pin lock pin.	Reseat the lock pin and tighten to specification.

Problem—Sway Or Roll

Problem—Sway Or Roll	
Possible Cause	**Remedy**
Loading.	Correct the loading and road test.
Body height too high or excessive overhang.	Refer to *Body Builders Layout Book.*
Tire pressure.	Correct as necessary.
Loose lug nuts.	Tighten to specification.
Suspension system.	Inspect the suspension. Correct as necessary.
Steering system.	Inspect the steering system. Repair or replace as necessary.

Problem—Drift Or Pull

Problem—Drift Or Pull	
Possible Cause	**Remedy**
Loading.	Check loading and correct as necessary.
Tires.	Check tires for correct inflation, balance, mismatch or uneven wear. Correct the tire concern. Retest the vehicle for normal operation.
Brake drag.	Check Brakes, raise and support the vehicle at the pulling location. Turn the wheel by hand and check for brake drag. Correct the brake adjustment concern; see **Group 42**. Retest the vehicle for normal operation.
Rear axle-to-frame alignment.	Check and correct the rear axle-to-frame alignment; see "Drive Axle Adjustment" in **Subject 100**.
Steering gear.	Check the steering gear final adjustment; see **Group 46**.. Correct the steering gear concern. Retest the vehicle for normal operation.
Alignment.	Check the vehicle alignment. Correct as necessary. Retest the vehicle for normal operation.

Problem—Poor Returnability

Problem—Poor Returnability	
Possible Cause	**Remedy**
Steering linkage.	Check Steering Linkage and Spindle Pins. Raise and support the front of the vehicle. Disconnect the tie rod from the spindle arm. Push and pull the right-side and left-side tire and wheel assemblies to the full right-side and left-side turn positions. Repair the binding condition in the spindle pin and steering linkage at the affected wheel.
Steering gear.	Check Steering Gear. Disconnect the pitman arm from the steering gear. Turn the steering wheel one complete turn in each direction. Repair the binding condition in the steering gear. Restore the vehicle and Retest the vehicle for normal operation.

Troubleshooting

Problem—Poor Returnability	
Possible Cause	**Remedy**
Binding steering column.	**CAUTION** **To prevent damage to steering column components, do not turn the steering wheel more than one complete turn in either direction.** Check for Steering Column Binding. Disconnect the steering column shaft at the steering gear. Turn the steering wheel one complete turn in each direction. If the steering column binds, repair or replace the steering column; see **Group 46**.. If not, Reconnect the steering column shaft.
Alignment.	Check alignment. Correct as necessary. Retest the vehicle for normal operation.

Problem—Wander

Problem—Wander	
Possible Cause	**Remedy**
Loading.	Check loading and correct as necessary.
Tires.	Check tires for mismatch and low pressure. Correct as necessary.
Steering system.	Inspect the steering system for wear or damage.
Suspension.	Inspect the suspension system. Correct as necessary.
Alignment.	Check the alignment. Correct as necessary.

Problem—Vehicle Lean

Problem—Vehicle Lean	
Possible Cause	**Remedy**
Loading.	Check bumper and ride height. Remove all payload, fill all fluids to full. Measure from the bottom bumper flange to the ground at both bumper ends. Measure the distance between the top of the axle and the bottom of the frame rail (the ride height) at both sides of the vehicle. If the side-to-side difference is less than 1 inch (25 mm) at the bumper ends or 0.5 inch (13 mm) in ride height, the vehicle is within allowable variation. Inspect the low side spring. Replace the spring if any sag or reverse camber is found. If side-to-side difference is not as specified, check bumper adjustment. If the difference is greater than 1 inch (25 mm) at the bumper ends, but less than 0.5 inch (13 mm) in ride height. Adjust the bumper height by slotting the bumper bracket or using a spacer. If side-to-side difference is not as specified, check vehicle weight. Measure the vehicle weight at the right-side and left-side side. If the side-to-side difference is more than 500 lb (227 kg), check for vehicle equipment that can be moved to even out vehicle weight distribution. If equipment can be moved, move the equipment. Recheck the vehicle lean. If equipment cannot be moved, correct the lean with a spacer. Refer to "Vehicle Lean Correction" in **Subject 100**.
Springs.	Switch the right-side and left-side springs. If the vehicle lean moved to the opposite side, replace the right-side and left-side springs. Recheck the vehicle lean. If not, Correct the vehicle lean with a spacer. Refer to "Vehicle Lean Correction" in **Subject 100**.

Problem—Front Bottoming Or Riding Low

Problem—Front Bottoming Or Riding Low	
Possible Cause	**Remedy**
Tires.	Correct low tire pressure.
Loading.	Adjust or lighten vehicle load.
Springs.	Replace broken or sagging springs.
Spring shackles.	Inspect the spring shackles. Replace as necessary.

Specifications

- Set toe to minimum with radial ply tires.
- The actual toe-in can vary front axle load from the empty vehicle condition (as built) to the customer normal operating condition (complete vehicle and normal).
- Empty vehicle specifications only for toe-in and camber.
- The caster specifications shown are with the frame level from front to rear. Measure the front to rear frame angle when checking the alignment and compensate as follows. If the front of the frame is lower than the rear, the actual caster angle is obtained by adding the frame angle to the caster angle shown on the alignment equipment. If the front of the frame is higher than the rear, subtract the frame angle from the caster angle shown on the alignment equipment.
- Caster must be checked at vehicle empty load.

Drive Axle Alignment		
Description	**Inch**	**mm**
Rear Rear-to-Frame		
Maximum Difference Between Righthand and Lefthand Sides	3/16	5
Forward Rear-to-Rear Rear		
Maximum Difference, LH and RH	1/8	3

Table 1, Drive Axle Alignment

Front Wheel Alignment Specifications				
Front Axle Capacity	**Toe-In**		**Camber (Degrees)**	**Caster (Degrees)**
	Tractors	**Trucks**		
7000	1/16 inch ± 1/32 inch (1.50 mm ± 0.75 mm)	1/8 inch ± 1/16 inch (3.00 mm ± 1.50 mm)	5/8 ± 3/8	4-1/4 ± 1/2
9000	1/16 inch ± 1/32 inch (1.50 mm ± 0.75 mm)	1/8 inch ± 1/16 inch (3.00 mm ± 1.50 mm)	5/8 ± 3/8	4-1/4 ± 1/2
10,000	1/16 inch ± 1/32 inch (1.50 mm ± 0.75 mm)	1/8 inch ± 1/16 inch (3.00 mm ± 1.50 mm)	3/8 ± 3/8	4-1/2 ± 1/2
12,000				
13,000				
12,000	1/16 inch ± 1/32 inch (1.50 mm ± 0.75 mm)	1/8 inch ± 1/16 inch (3.00 mm ± 1.50 mm)	3/8 ± 3/8	4-1/2 ± 1/2
14,600	1/16 inch ± 1/32 inch (1.50 mm ± 0.75 mm)	1/8 inch ± 1/16 inch (3.00 mm ± 1.50 mm)	3/8 ± 3/8	3-1/2 ± 3/4
14,600	1/16 inch ± 1/32 inch (1.50 mm ± 0.75 mm)	1/8 inch ± 1/16 inch (3.00 mm ± 1.50 mm)	1/8 ± 3/8	3-1/2 ± 1/2
16,000				
18,000				
20,000				

Table 2, Front Wheel Alignment Specifications

Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Tie Rod Clamp Nut	50–70 (68–95)
U-Bolt Nuts, 5/8-Inch	150–205 (204–277)
U-Bolt Nuts, 3/4-Inch	220–300 (299–406)
U-Bolt Nuts, 7/8-Inch	360–480 (489–650)
Frame Bracket Bolts, Hendrickson Walking Beam	220–300 (299–406)
Alignment Adjustment Bolt	600–700 (813–950)
Spring Saddle Nut, Hendrickson Walking Beam, U2-340 and UE2-340	125–145 (170–196)
Spring Saddle Nut, Hendrickson Walking Beam, RT2-400, RTE2-400, RT2-460 and RTA2-380	225–275 (305–372)
Torque Rod Bar Pin Nuts	150–205 (204–277)

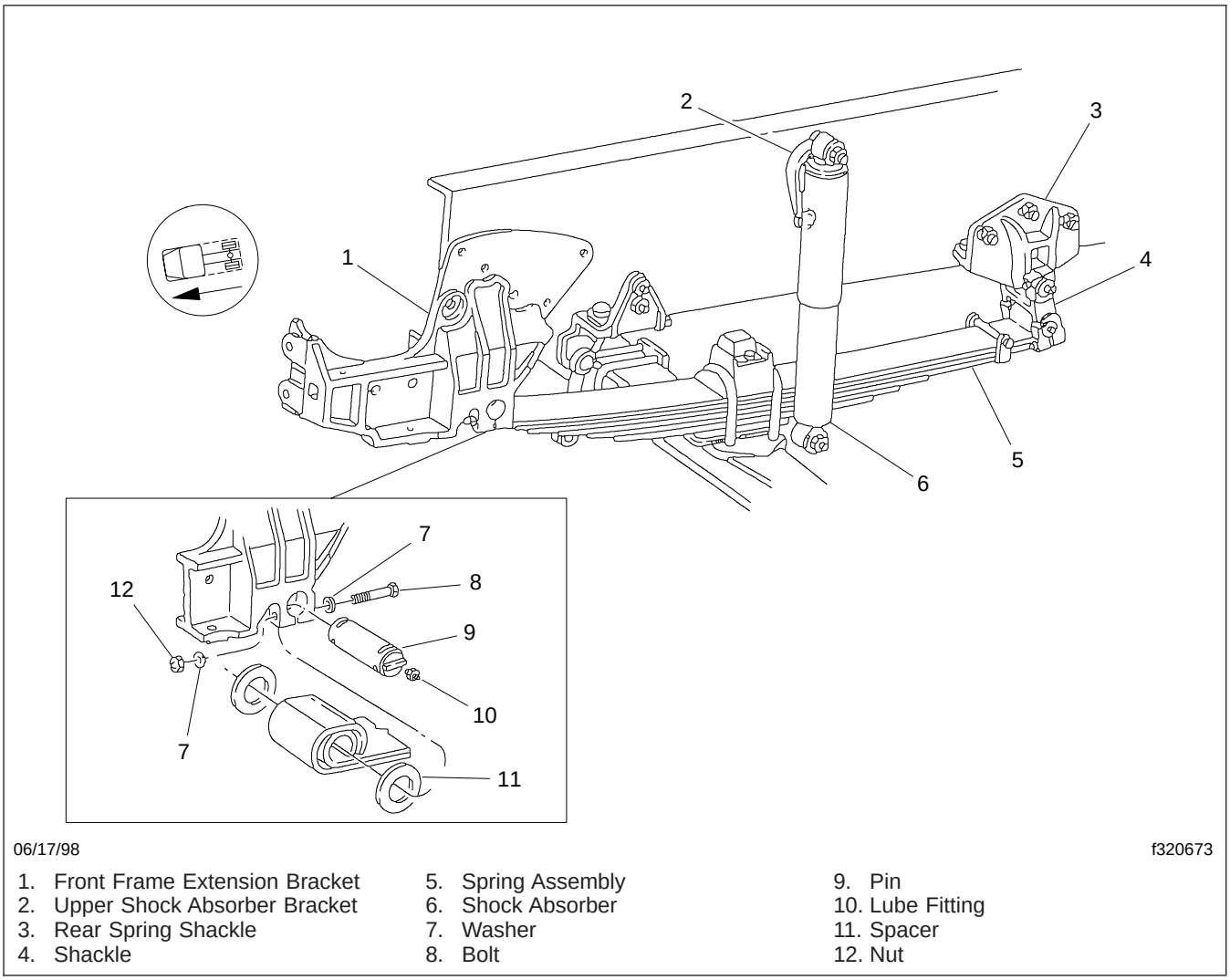
Table 3, Torque Specifications

Standard Bolt Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
1/4-Inch Diameter, Grade 5	—	89–115 (1000–1300)
5/16-Inch Diameter, Grade 5	12–17 (17–23)	—
3/8-Inch Diameter, Grade 8	32–41 (43–56)	—
7/16-Inch Diameter, Grade 8	50–70 (68–95)	—
1/2-Inch Diameter, Grade 8	75–105 (102–142)	—
9/16-Inch Diameter, Grade 8	110–150 (149–203)	—
5/8-Inch Diameter, Grade 8	150–205 (204–277)	—
3/4-Inch Diameter, Grade 8	220–300 (299–406)	—
7/8-Inch Diameter, Grade 8	360–480 (489–650)	—
1.0-Inch Diameter, Grade 8	540–730 (733–989)	—

Table 4, Standard Bolt Torque Specifications

General Information

See **Fig. 1** and **Fig. 2**.



06/17/98 f320673

1. Front Frame Extension Bracket
2. Upper Shock Absorber Bracket
3. Rear Spring Shackle
4. Shackle
5. Spring Assembly
6. Shock Absorber
7. Washer
8. Bolt
9. Pin
10. Lube Fitting
11. Spacer
12. Nut

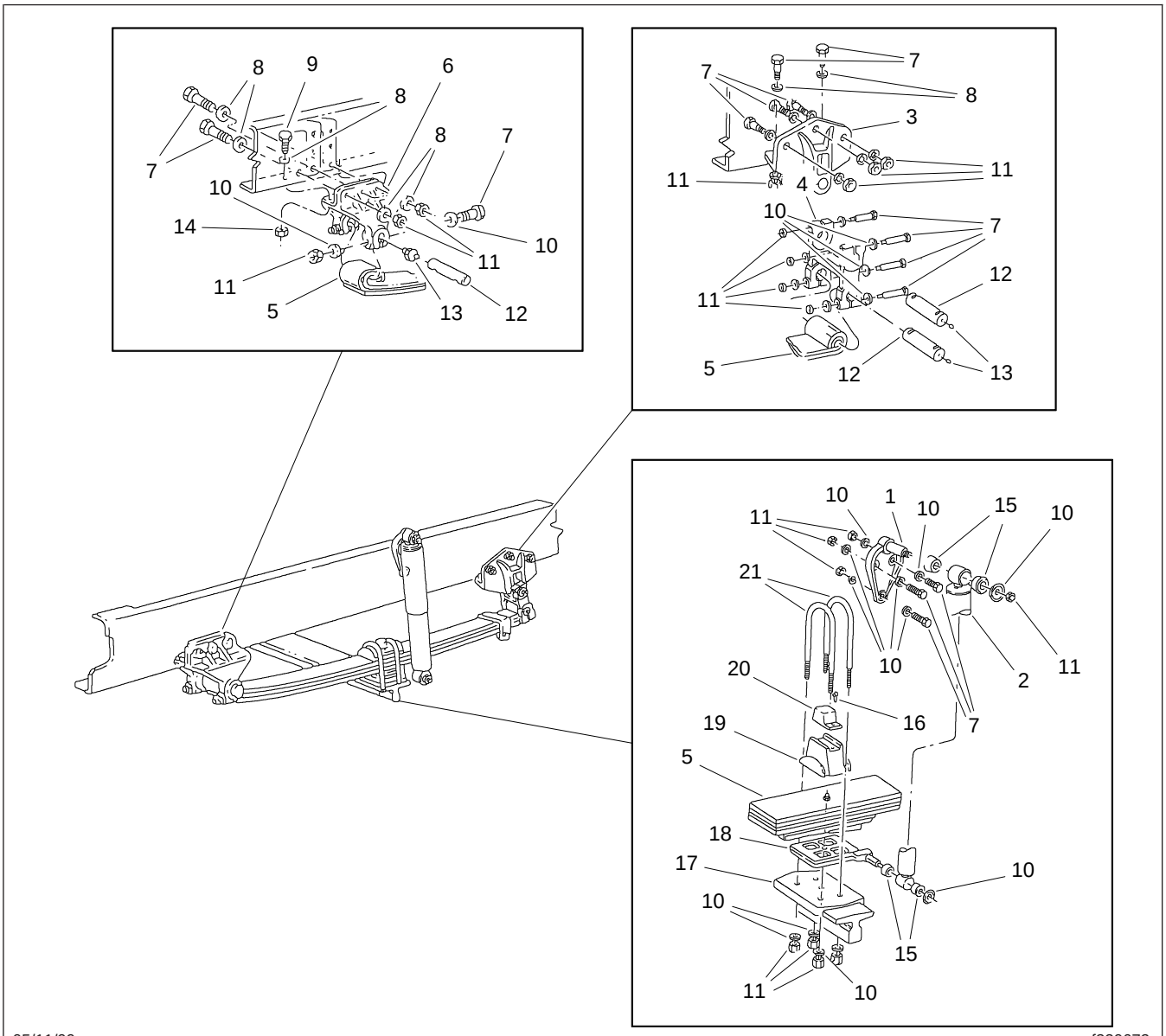
Fig. 1, Front Spring, 60-Inch with 1300-Square-Inch Radiator

When repairing the front axle, wheel hubs or suspension, replace any component that is damaged or out of specification. All major axle and suspension components are heat treated and, therefore, cannot be bent, twisted, welded, heated or reconditioned without experiencing a strength or fatigue life reduction.

Following are examples of specific prohibited operations:

- hot or cold bending or twisting of I-beam, tie rod assemblies, spindles, steering arms or tie rod arms for any reason
- welding of, or to, steering arms, tie rod arms, I-beams, steering spindles, spindle pins or tie rod assemblies
- redrilling or reboring of I-beam spindle pin holes for a bushing
- milling or machining of any component
- spray welding of bearing diameters or other machined surfaces

General Information



1. Upper Shock Absorber Bracket
2. Shock Absorber
3. Rear Spring Bracket
4. Shackle
5. Spring
6. Front Spring Bracket
7. Bolt
8. Washer
9. Huck Tension Pin
10. Washer
11. Nut
12. Pin
13. Lube Fitting
14. Huck Tension Collar
15. Bushing
16. Screw
17. Axle
18. Lower Shock Absorber Bracket
19. Spacer
20. Bumper
21. U-Bolt

Fig. 2, Front Spring, 54-Inch Taperleaf

- redrilling or reboring of draw keyholes
- relocation or removal of tie rod clamps

Shock Absorber Removal and Installation

Removal

See **Fig. 1** for this procedure.

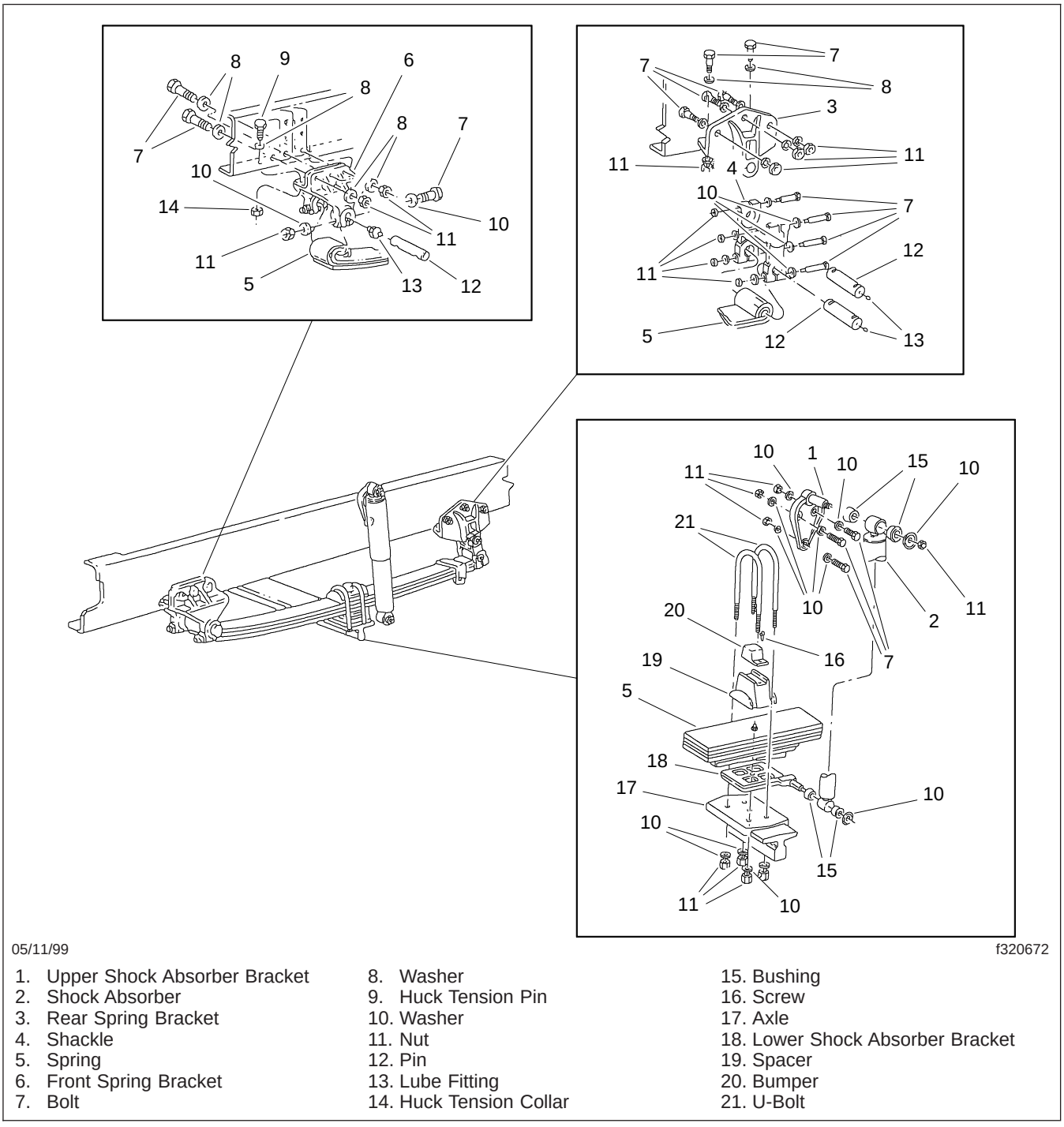
1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the locknuts and hardened washers from the shock absorber upper and lower bracket studs.
3. Pull straight out on the shock absorber and remove it.

Installation

See **Fig. 1** for this procedure.

1. Check the shock absorber bushings (two bushings in each eye) for wear or damage, and replace them if needed.
2. Make sure the 2-inch o.d. by 1-inch i.d. washer is installed on the stud of the shock absorber upper bracket.
3. Install the shock absorber on the upper and lower bracket studs.
4. Install the washer and a new locknut on each of the bracket studs. Tighten the locknuts 75 to 105 lbf·ft (102 to 142 N·m).
5. Remove the chocks from the tires.

Shock Absorber Removal and Installation



1. Upper Shock Absorber Bracket
2. Shock Absorber
3. Rear Spring Bracket
4. Shackle
5. Spring
6. Front Spring Bracket
7. Bolt
8. Washer
9. Huck Tension Pin
10. Washer
11. Nut
12. Pin
13. Lube Fitting
14. Huck Tension Collar
15. Bushing
16. Screw
17. Axle
18. Lower Shock Absorber Bracket
19. Spacer
20. Bumper
21. U-Bolt

Fig. 1, Front Suspension with Shock Absorber

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. 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.

1. Apply the parking brakes, and chock the rear tires. Raise the vehicle until the weight is off of the front springs, with the wheels still touching the floor. 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.

2. Remove the shock absorber. For instructions, see **Subject 100**.
3. Remove the bolts securing the spring pin in the front bracket. See **Fig. 1**.

CAUTION

To remove the spring pin, first rotate the pin using the flats on the outside of the pin. Do not try to spread the bracket as this may damage the bracket.

4. Remove the spring pin from the front bracket. See **Fig. 2**.
5. Remove the bolts securing the lower spring pin in the rear bracket. See **Fig. 3**.
6. Remove the lower spring pin from the rear bracket. See **Fig. 4**.
7. Remove the U-bolts.

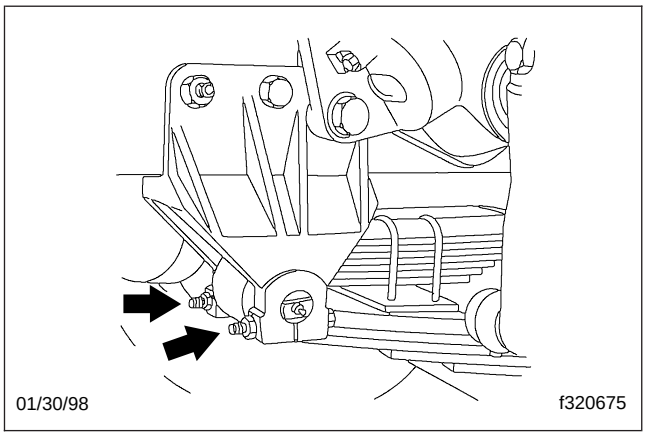


Fig. 1, Front Spring Pin Bolts

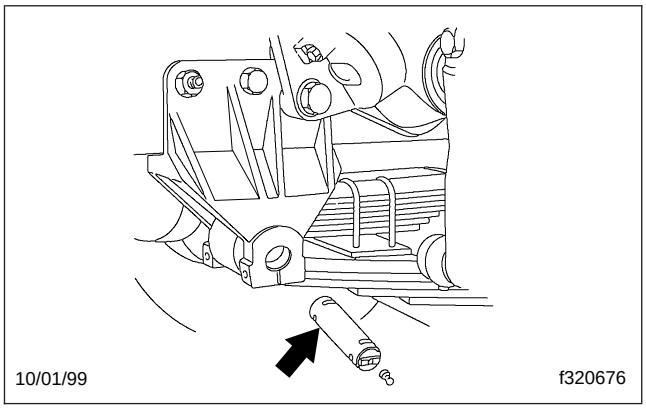


Fig. 2, Front Spring Pin

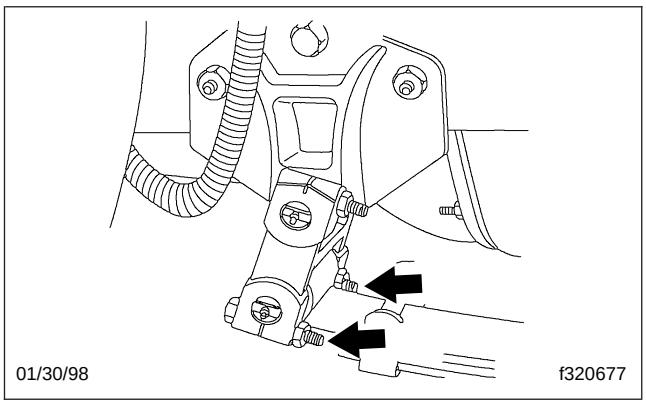


Fig. 3, Rear Spring Pin Bolts

8. Lift the spring from the axle. Note the position of any caster wedges or spacer.
9. Install the spring on the axle.

Spring Replacement

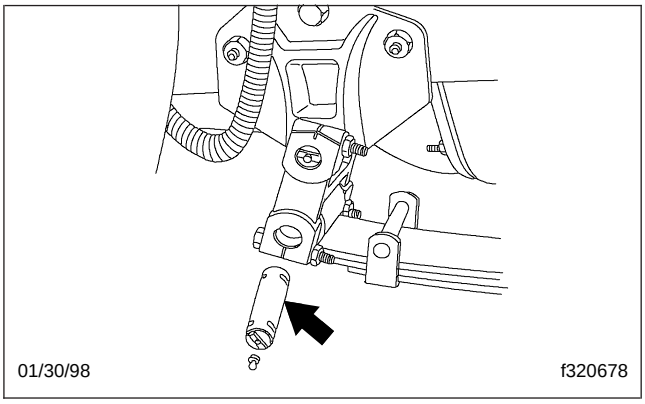


Fig. 4, Rear Lower Spring Pin

NOTE: To confirm all parts are properly centered on the spring tie bolt, make sure there are no gaps between mating parts.

10. Install and tighten the U-bolts. See **Fig. 5**. For proper torque values, see **Specifications 400**.

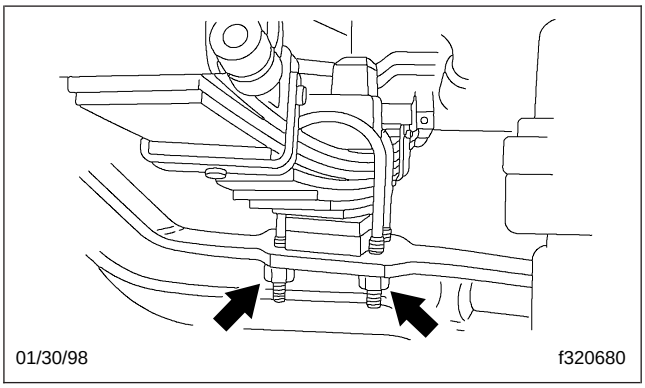


Fig. 5, U-Bolt Nuts

NOTE: The front and rear spring eye pins are the same on all vehicles except for A-Line vehicles with a 1300 square-inch radiator. On these vehicles the front pin is longer.

NOTE: Make sure the notches in the shackle pins are aligned with the lock bolt holes in the shackle and that the lube openings face outward.

NOTE: If equipped with frame extension brackets, a spacer must be installed on each side of the spring.

11. Install the lower spring pin in the rear bracket. See **Fig. 4**.
12. Install the bolts securing the lower spring pin in the rear bracket. See **Fig. 3**. Tighten the bolts 50 to 70 lbf·ft (68 to 95 N·m).

NOTE: Position the pin with the notches aligned with the bolt holes in the front bracket and the lubricator opening facing outward.

13. Install the spring pin in the front bracket. See **Fig. 2**.
14. Install the bolts securing the spring pin in the front bracket. See **Fig. 1**. Tighten the bolts 50 to 70 lbf·ft (68 to 95 N·m).
15. Install the lube fittings in the retaining pins.

NOTE: To ensure complete distribution of the grease around the spring pins, the load must be removed from the front suspension before lubrication.

16. Install the shock absorber. For instructions, see **Subject 100**.
17. Lower the vehicle.
18. Remove the chocks from the rear tires.

Bronze Spring Eye and Shackle Bushing Removal and Installation

Removal

⚠ WARNING

The tools specified in this procedure must be used with a press. Use of a hammer can result in damage to the spring eyes, bushings and tools. Eye injury or other personal injury is also a potential hazard if a hammer is used with these tools.

NOTE: If it is determined that the Horton-type roller bushing must be replaced, only the Horton-approved tools should be used. Horton Spring Bushing Kit 994505 is available and includes detailed instructions. Follow the removal and installation procedure for standard bronze bushings, with the following additions:

- do not ream Horton-type bushings
- use care to avoid the loss of the needle bearings if being reused
- to ensure proper expansion of the spring eye, use only the Horton inserter tool when pressing the bushing into place. Incorrect tools can cause bushing collapse, premature wear and damage
- to avoid seal damage, use only the correct spring pin for the Horton-type bushing. Do not install the standard spring pin which has sharp edges which can damage the seal
- use care to avoid contamination when lubricating the Horton-type spring bushing. Do not install used Zerk fittings

1. If a portable press is not available, remove the spring and the shackle bracket.
2. If a portable press is available, proceed as follows:
   - 2.1 Disconnect the lower ends of the shock absorbers.
   - 2.2 Raise the front of the vehicle until the vehicle weight is removed from the springs. Wheels must be touching the floor and the body must be supported on safety stands.
   - 2.3 Support the weight of the axle, using a floor jack.
   - 2.4 Remove the spring and shackle pin lock bolts.
   - 2.5 Remove the spring pins and rear shackles.
   - 2.6 Lower axle until the eyes of the front springs clear the mounting brackets.

⚠ CAUTION

Use care when removing the bushing to prevent gouging or other damage to the shackle bracket bushing bore.

3. Press the bushings from the shackle bracket.

⚠ CAUTION

Use care when removing bushings to prevent gouging or other damage to the spring eye.

4. Press the bushings from the spring eye.

Installation

⚠ CAUTION

Motorcraft Premium Long-Life Grease XG-1-C or equivalent meeting specification ESA-M1C75-B must be used as the bushing lubricant. Using an incompatible grease can result in breakdown of the grease and premature bushing wear.

1. Press the replacement bushings into the shackle brackets.

⚠ CAUTION

Use care when installing the bushing to prevent gouging, damage to the shackle bracket bushing bore, or other damage to the spring eye.

2. Press the replacement bushings into the spring eye.
3. Lubricate the bushing pins with a light coating of Motorcraft Premium Long-Life Grease XG-1-C or equivalent meeting specification ESA-M1C75-B.

NOTE: Always install new spring pins after installing new spring eye or shackle bushings.

Bronze Spring Eye and Shackle Bushing Removal and Installation

4. Test fit the bushing pin. The pin should slide through the bushing using hand pressure.
    - If the bushing pin binds or requires excessive pressure to install, ream the pin bushings as required. Follow the reamer manufacturer's instructions.
    - If bushing pins are a slip fit in the bushings, proceed to the next step.

IMPORTANT: Ream bronze bushings only.

5. If removed, install the spring and shackle bracket. If portable press was used, proceed as follows:
    - 5.1 Raise the axle until the spring eyes and shackles are aligned.
    - 5.2 Install the bushing pins.
    - 5.3 Install the bushing pin lock bolts.
    - 5.4 Install the lower end of the shock absorbers.
6. Install lubrication fittings in the bushing pins.

NOTE: To ensure complete distribution of the grease around the spring pins, the load must be removed from the front suspension before lubrication.

7. Lubricate the bushing pins with Motorcraft Premium Long-Life Grease XG-1-C or equivalent meeting specification ESA-M1C75-B before lowering the vehicle from the jack stands.
8. Remove the vehicle from the jack stands after the lube procedure is done.

Spindle

Removal

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the tires.
2. Press the bushings out of the spindle. See **Fig. 1**.

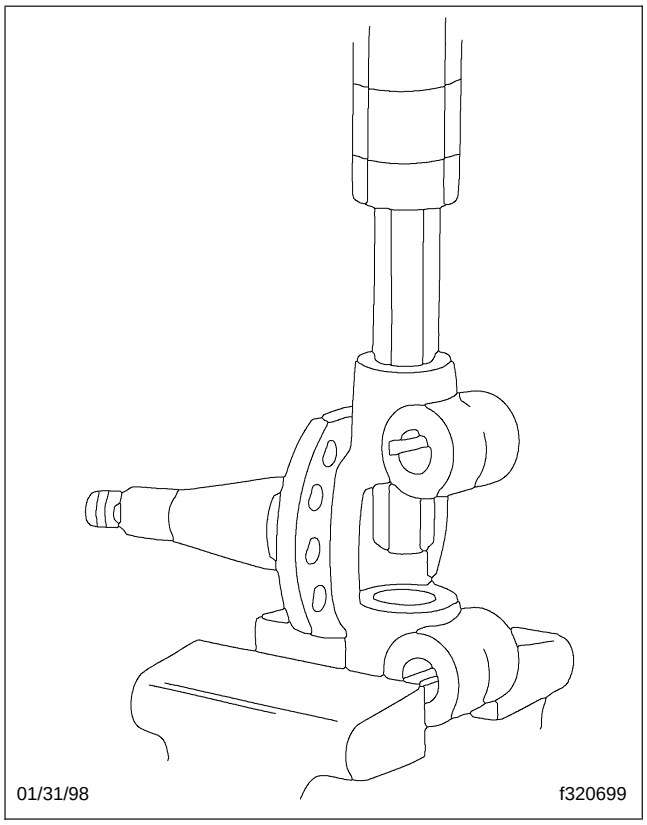


Fig. 1, Bushing Removal

3. Clean the spindle bores thoroughly, and make certain lubricating holes are not plugged.

Installation

1. Position a new bushing in the spindle bore with the open end of the oil groove toward the axle.
2. Press in the bushing. See **Fig. 2**.
3. Turn the spindle over and install the remaining bushing in the same manner. See **Fig. 3**.

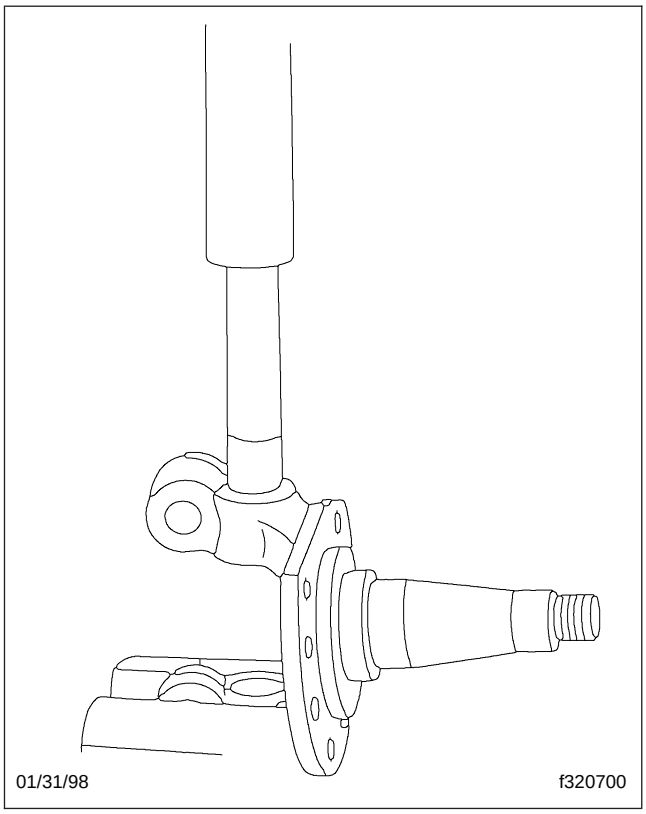
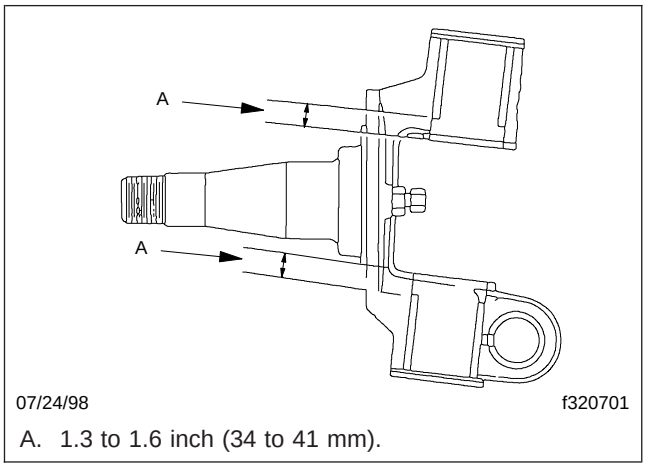


Fig. 2, Bushing Installation



A. 1.3 to 1.6 inch (34 to 41 mm).

Fig. 3, Checking Bushing Installation

4. Ream the bushings so the pin can be pushed in by hand. See **Fig. 4**.

NOTE: Always install new spindle pins with new spindle bushings.

Bushing Removal and Installation

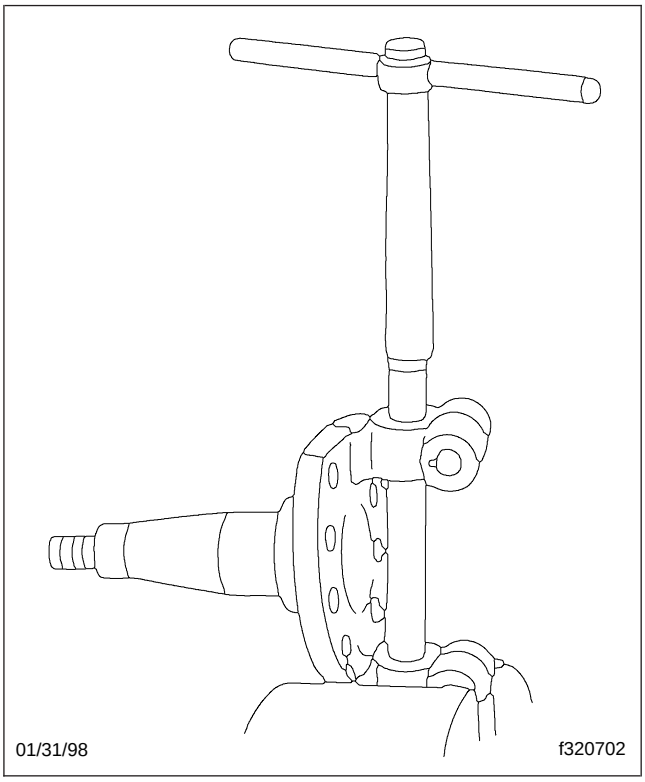


Fig. 4, Reaming Bushings

5. Clean all the shavings and coat the bushing and pin with lubricant prior to assembly.
6. Remove the chocks from the tires.

Spring Eye and Shackle, Bronze

Removal

⚠ WARNING

The tools specified in this procedure must be used with a press. Use of a hammer can result in damage to the spring eyes, bushings and tools. Eye injury or other personal injury is also a potential hazard if a hammer is used with these tools.

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.

NOTE: If it is determined that the Horton-type roller bushing must be replaced, only the Horton-approved tools should be used. Horton spring bushing kit 994505 is available and includes detailed instructions. Follow the removal and installation procedures for standard bronze bushings, with the following additions:

- Do not ream Horton-type bushings.
- Use care to avoid the loss of the needle bearings if being reused.
- To ensure proper expansion of the spring eye, use only the Horton inserter tool when pressing the bushing into place. Incorrect tools can cause bushing collapse, premature wear and damage.
- To avoid seal damage, use only the correct spring pin for the Horton-type bushing. Do not install the standard spring pin which has sharp edges which can damage the seal.
- Use care to avoid contamination when lubricating the Horton-type spring bushing. Do not install used Zerk fittings.

2. If a portable press is not available, remove the spring and the shackle bracket.
3. If a portable press is available, proceed as follows:
   - 3.1 Disconnect the lower ends of the shock absorbers.
   - 3.2 Raise the front of the vehicle until the vehicle weight is removed from the springs. Wheels must be touching the floor and the body must be supported on safety stands.
   - 3.3 Support the weight of the axle, using a floor jack.
   - 3.4 Remove the spring and shackle pin lock bolts.
   - 3.5 Remove the spring pins and rear shackles.
   - 3.6 Lower the axle until the eyes of the front springs clear the mounting brackets.

CAUTION

Use care when removing the bushing to prevent gouging or other damage to the shackle bracket bushing bore.

4. Press the bushings from the shackle bracket.

CAUTION

Use care when removing bushings to prevent gouging or other damage to the spring eye.

5. Press the bushings from the spring eye.

Installation

CAUTION

Motorcraft Premium Long-Life Grease XG-1-C or equivalent meeting specification ESA-M1C75-B must be used as the bushing lubricant. Failure to observe this caution or later lubrication of the bushing with an incompatible grease can result in breakdown of the grease and premature bushing wear.

Use care when installing the bushing to prevent gouging or other damage to the shackle bracket bushing bore.

1. Press the replacement bushings into the shackle brackets.

CAUTION

Use care when installing the bushing to prevent gouging or other damage to the spring eye.

2. Press the replacement bushings into the spring eye.
3. Lubricate the bushing pins with a light coating of Motorcraft Premium Long-Life Grease XG-1-C or equivalent meeting specification ESA-M1C75-B.

NOTE: Always install new spring pins after installing new spring eye or shackle bushings.

4. Test fit the bushing pin. The pin should slide through the bushing using hand pressure.
   - If the bushing pin binds or requires excessive pressure to install, ream the pin bushings as required. Follow the reamer manufacturer's instructions.
   - If bushing pins are a slip fit in the bushings, proceed to next step.

IMPORTANT: Ream bronze bushings only.

5. If removed, install the spring and shackle bracket. If portable press was used, proceed as follows:
   - 5.1 Raise the axle until the spring eyes and shackles are aligned.
   - 5.2 Install the bushing pins.
   - 5.3 Install the bushing pin lock bolts.
   - 5.4 Install the lower end of the shock absorbers.
6. Install lubrication fittings in the bushing pins.
7. Using a floor jack, lower the vehicle and remove the jack stands.
8. Lubricate the bushing pins with Motorcraft Premium Long-Life Grease XG-1-C or equivalent meeting specification ESA-M1C75-B.
9. Remove the chocks from the tires.

Removal

1. Raise and support the vehicle at the frame rails.
2. Remove the wheels.
3. Support the front axle with a suitable jack.
4. Remove the brake drum.
5. Remove hub assemblies.
6. Remove the brakes, slack adjusters, brake air chambers and brake camshafts. Refer to **Group 42**.
7. Remove the brake camshaft bracket. Refer to **Group 42**.
8. Remove steering arms and tie rods. Refer to **Group 46**.
9. Remove the spindles.
10. Remove the U-bolt retaining nuts. Note the position of shims and wedges. See **Fig. 1**.

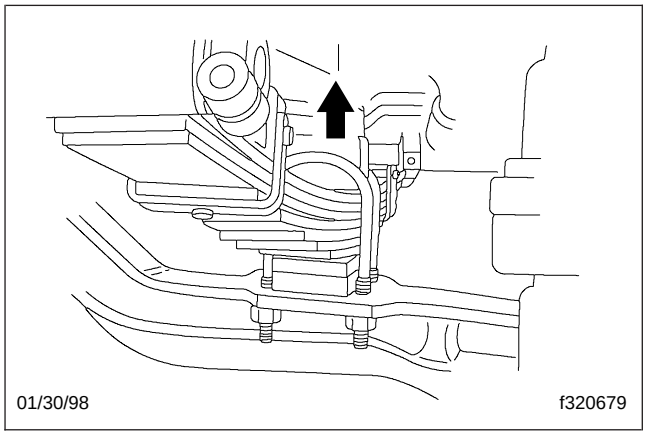


Fig. 1, U-Bolts and Shims

11. Lower the axle and remove from the vehicle.

Installation

1. Position the axle to the vehicle.
2. Position the shims and wedges and install the U-bolt retaining nuts. See **Fig. 1**.
3. Install the spindles.
4. Install steering arms and tie rods. Refer to **Group 46**.
5. Install the brake camshaft bracket. Refer to **Group 42**.
6. Install the brakes, slack adjusters, brake air chambers and brake camshafts. Refer to **Group 42**.
7. Install the hub assemblies.
8. Install the brake drum.
9. Install the wheels.
10. Remove jack from front axle.
11. Lower the vehicle.

Wheel Bearing Adjustment

CAUTION

If bearings are adjusted too tightly, they will overheat and wear rapidly. An adjustment that is excessively loose can cause pounding and contribute to uneven tire wear, steering difficulties and inefficient brakes.

1. Remove the hub cap.

NOTE: Inspect the Axilok nut to locate the wrench size stamped into the nut.

2. Using the appropriate, 6-point socket, push the socket onto the wheel bearing nut to unlock the nut.
3. Hand-start the wheel bearing nut onto the spindle. See **Fig. 1**.

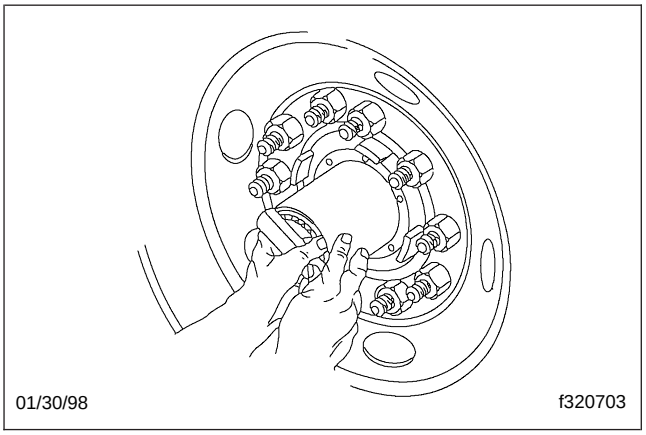


Fig. 1, Installing Wheel Bearing Nut

4. Rotate the wheel assembly.

CAUTION

Always use a properly calibrated torque wrench to install each Axilok nut. Do not exceed the equipment manufacturer's recommended installation torque to prevent creating an unsafe condition.

5. With the wheel assembly rotating, tighten the nut, refer to **Table 1**.

Axilok Wheel Bearing Adjusting Nut Size	Initial Torque
	lbf·ft (N·m)
1-1/2–18	75–105 (102–152)
1-3/4–12	75–105 (102–152)

Table 1, Initial Torque

6. Back the nut off one full turn, 360 degrees.
7. Tighten the nut to the final adjusting torque according to **Table 2**.

Axilok Wheel Bearing Adjusting Nut Size	Final Adjusting Torque
	lbf·ft (N·m)
1-1/2–18	75 (102)
1-3/4–12	75 (102)

Table 2, Final Adjusting Torque

8. Back the nut off the proper number of degrees as specified in **Table 3**.

Nut Size	Final Back-Off
1-1/2–18	90 Degrees
1-3/4–12	45 Degrees

Table 3, Final Back-Off

9. The wheel assembly must rotate freely with an end play of 0.001–0.005 inch (0.025–0.127 mm).

General Specifications	
Item	**Specification**
Motorcraft Premium Long-Life Grease XG-1-C or -K	ESA-M1C75-B
SAE 90 Premium Rear Axle Lubricant C6AZ-19580-E	ESW-M2C105-A

Table 1, General Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Shock Absorber to Upper and Lower Bracket	75–105 (102–142)
Front Spring Pin	50–70 (68–95)

Table 2, Torque Specifications

NOTE: All other torque limits (including Grade 8 U-bolts) are determined by the bolt or nut diameters in **Table 3**.

Standard Bolt Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
1/4-Inch Diameter, Grade 5	—	89–115 (1000–1300)
5/16-Inch Diameter, Grade 5	12–17 (17–23)	—
3/8-Inch Diameter, Grade 8	32–41 (43–56)	—
7/16-Inch Diameter, Grade 8	50–70 (68–95)	—
1/2-Inch Diameter, Grade 8	75–105 (102–142)	—
9/16-Inch Diameter, Grade 8	110–150 (149–203)	—
5/8-Inch Diameter, Grade 8	150–205 (204–277)	—
3/4-Inch Diameter, Grade 8	220–300 (299–406)	—
7/8-Inch Diameter, Grade 8	360–480 (489–650)	—
1.0-Inch Diameter, Grade 8	540–730 (733–989)	—

Table 3, Standard Bolt Torque Specifications

General Information (See Fig. 1, Fig. 2, Fig. 3, and Fig. 4)

CAUTION

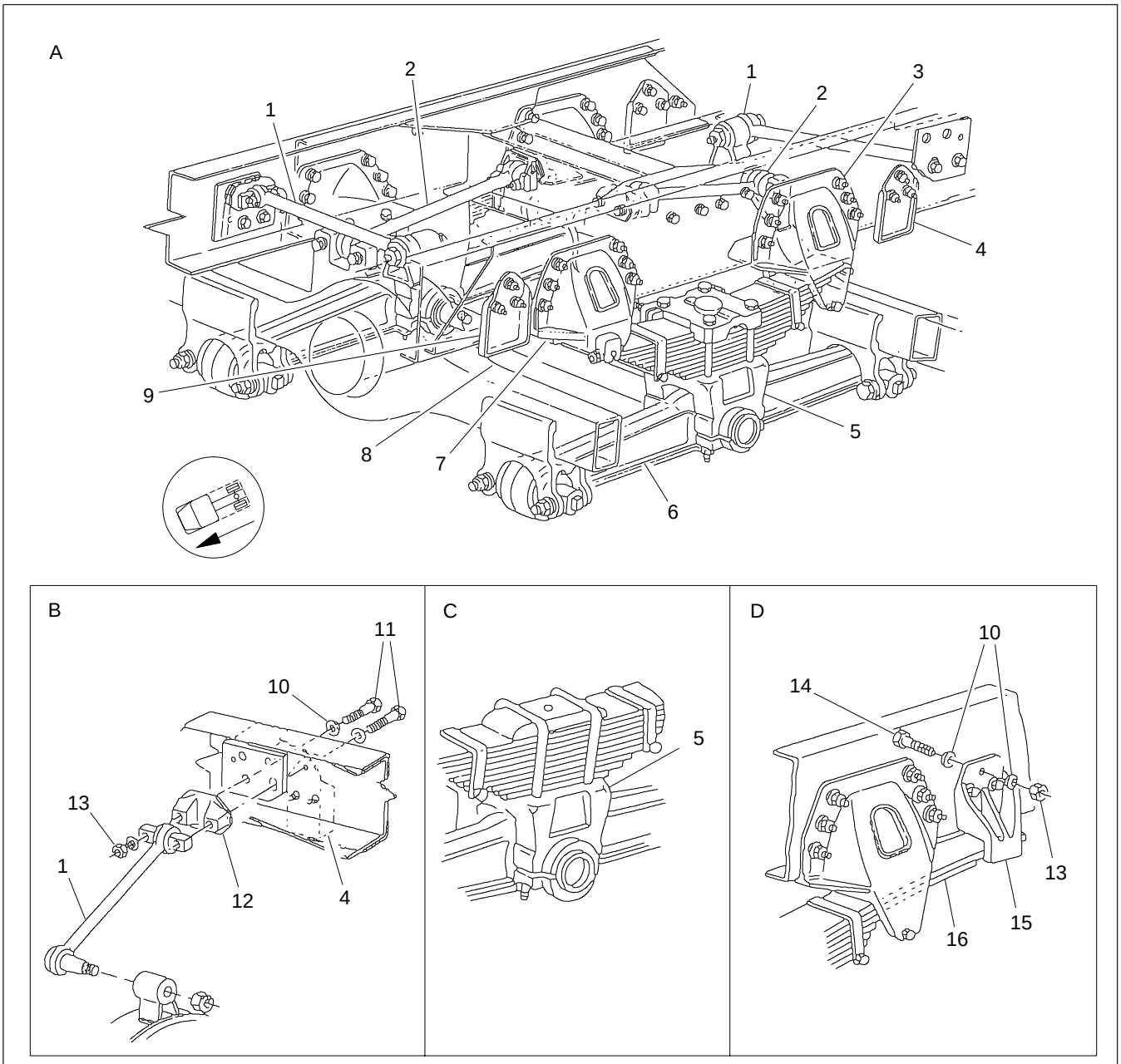
Never reinstall used suspension fasteners. Always use new nuts, bolts and washers for suspension repair. Reinstallation of fasteners may result in damage to suspension components or possible personal injury.

The Hendrickson U2- and RT2-Series rear suspension systems are designed for the heaviest duty applications, up to 46,000 lb (20 866 kg).

The extended leaf configuration gives a two-stage spring action to the suspension. With the vehicle unloaded, most of the weight is on the top two spring leaves at the rearmost spring hanger. As the load increases, the weight is taken up by the next spring hanger, effectively shortening the spring and increasing the spring rate.

The suspension system is available with either a steel or aluminum equalizing beam and rubber or bronze replaceable center bushings. A bronze center bushing must never be installed in an aluminum beam.

General Information



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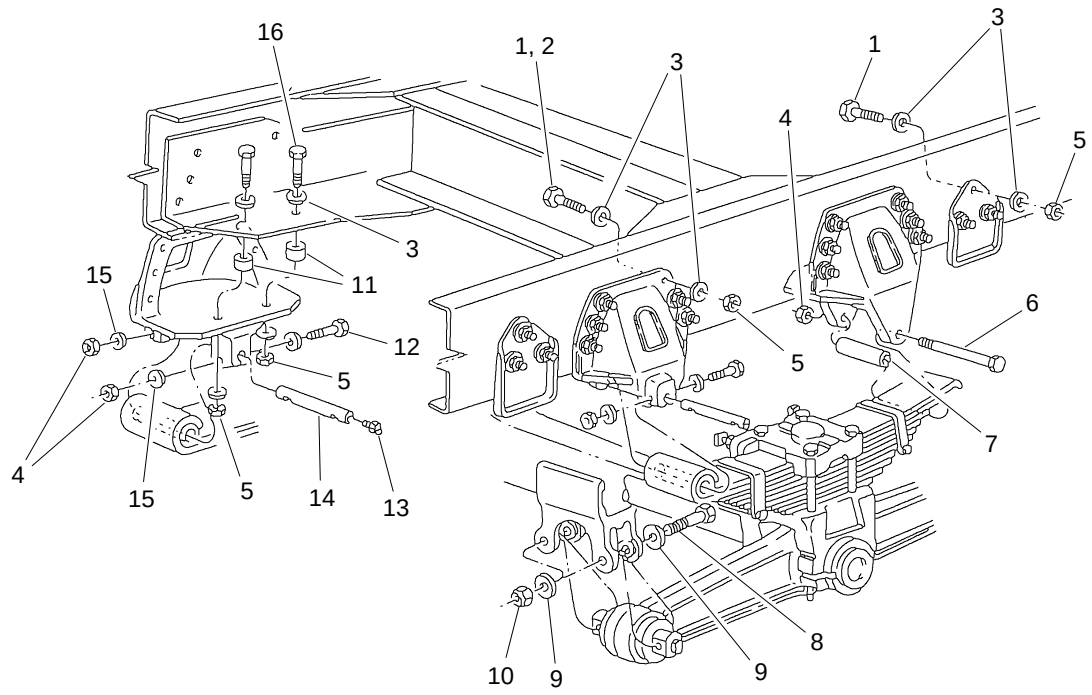
A. RT2–400–460
B. RT2–400–460, RTE2–400
C. U2, UE2
D. UE2–340, RTE2–400
1. Transverse Torque Rod
2. Longitudinal Torque Rod
3. Rear Spring Bracket
4. Axle Bumper
5. Spring and Saddle Assembly
6. Equalizing Beam
7. Rear Spring Bracket
8. Crosstube
9. Axle Bumper
10. Flatwasher
11. Bolt
12. Torque Rod Bracket
13. Nut
14. Bolt (all bolt heads inboard)
15. Bracket, Extended Rear Spring
16 Extended Rear Spring (part of spring and saddle assembly)

Fig. 1, U2- and RT2-Series Suspensions



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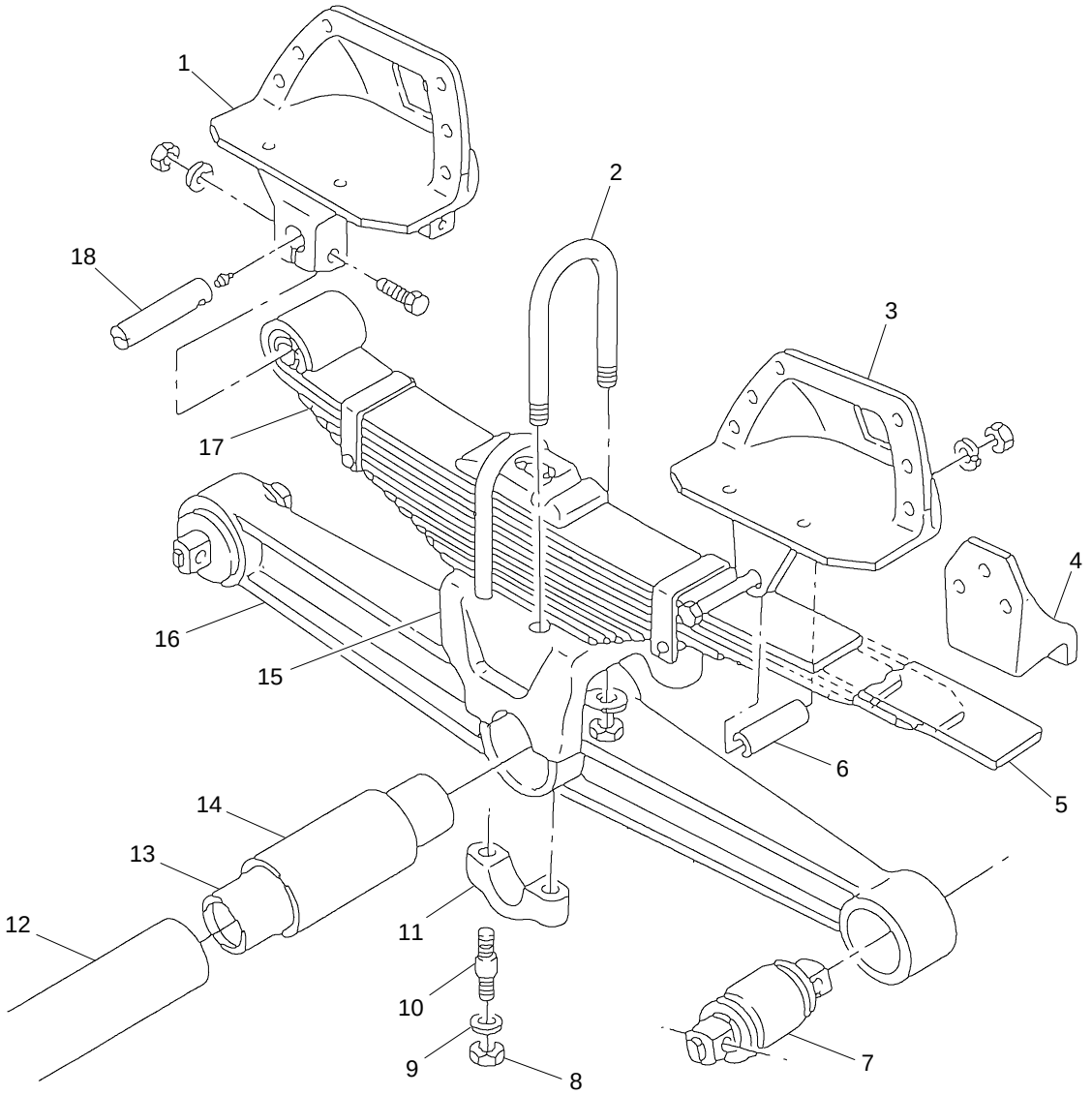
1. Bolt (non-reinforced frame)
2. Bolt (reinforced frame)
3. Flatwasher
4. Nut
5. Nut
6. Bolt
7. Spacer
8. Bolt
9. Washer
10. Nut
11. Spacer
12. Bolt
13. Grease Fitting
14. Spring Eye Pin
15. Flatwasher
16. Bolt

Fig. 2, Spring Installation, RT2 Suspensions

General Information



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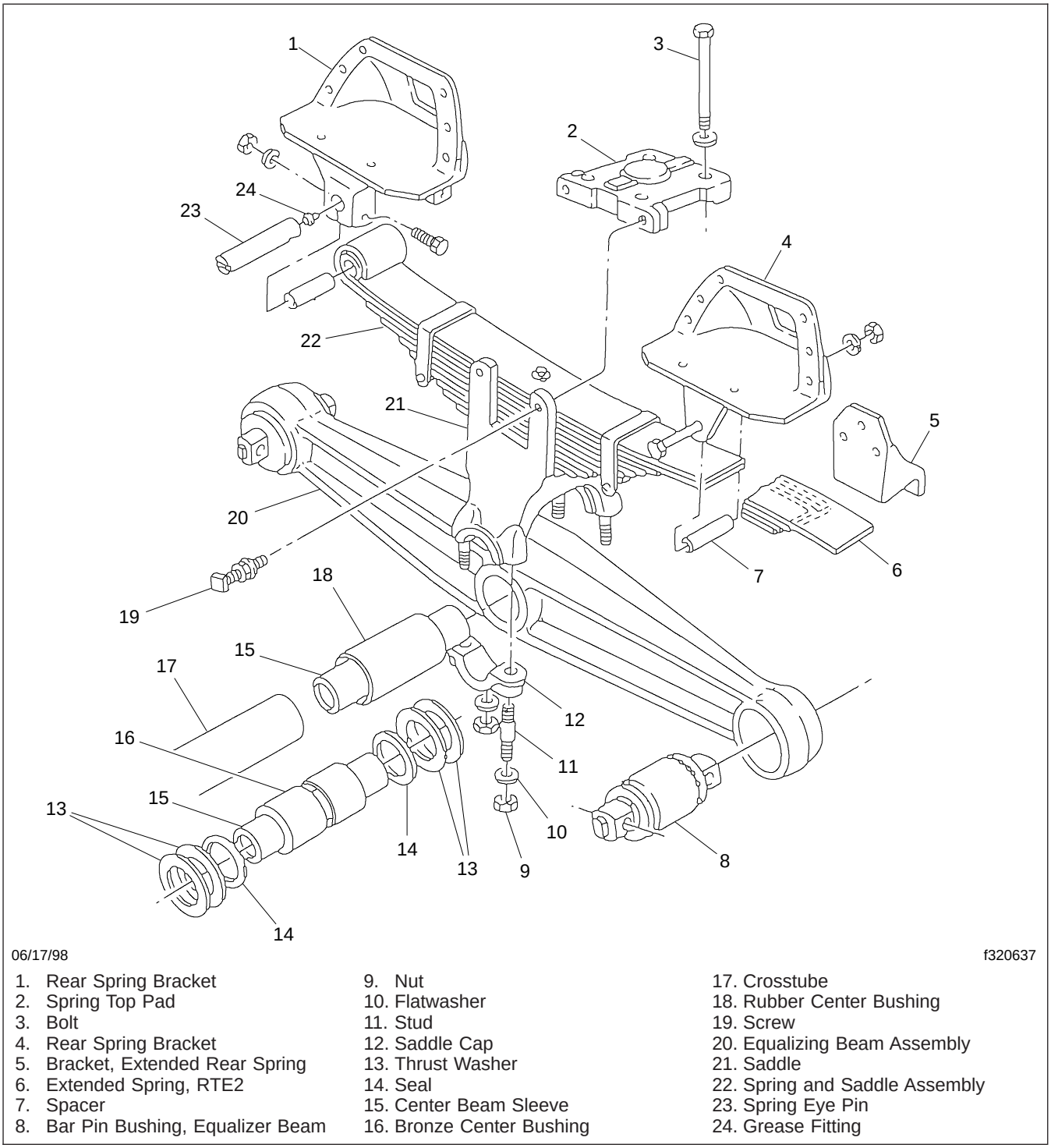
1. Rear Spring Bracket
2. U-Bolt
3. Rear Spring Bracket
4. Bracket, Extended Rear Spring
5. Extended Rear Spring Assembly
6. Spacer
7. End Bushing, Equalizing Beam
8. Nut
9. Washer
10. Stud
11. Saddle Cap
12. Crosstube
13. Center Bushing
14. Rubber Center Bushing
15. Saddle
16 Equalizing Beam
17 Spring and Saddle Assembly
18 Spring Eye Pin

Fig. 3, UE2-Series, Disassembled



1. Rear Spring Bracket
2. Spring Top Pad
3. Bolt
4. Rear Spring Bracket
5. Bracket, Extended Rear Spring
6. Extended Spring, RTE2
7. Spacer
8. Bar Pin Bushing, Equalizer Beam
9. Nut
10. Flatwasher
11. Stud
12. Saddle Cap
13. Thrust Washer
14. Seal
15. Center Beam Sleeve
16. Bronze Center Bushing
17. Crosstube
18. Rubber Center Bushing
19. Screw
20. Equalizing Beam Assembly
21. Saddle
22. Spring and Saddle Assembly
23. Spring Eye Pin
24. Grease Fitting

Fig. 4, RT2- and RTE2-Series, Disassembled

Removal

1. Raise and support the vehicle frame behind the rear rear axle.
2. Remove the wheels.
3. Support the equalizing beam. See **Fig. 1**.

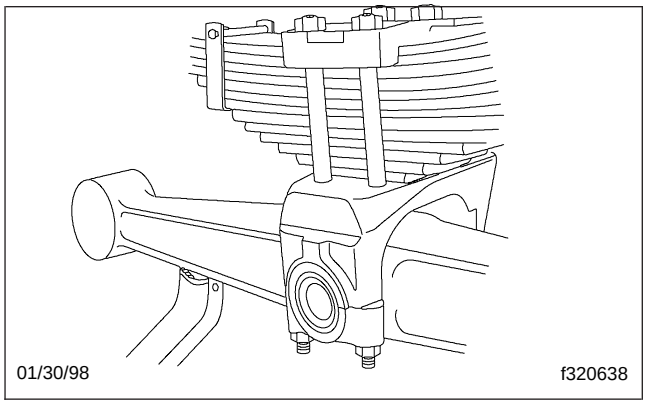
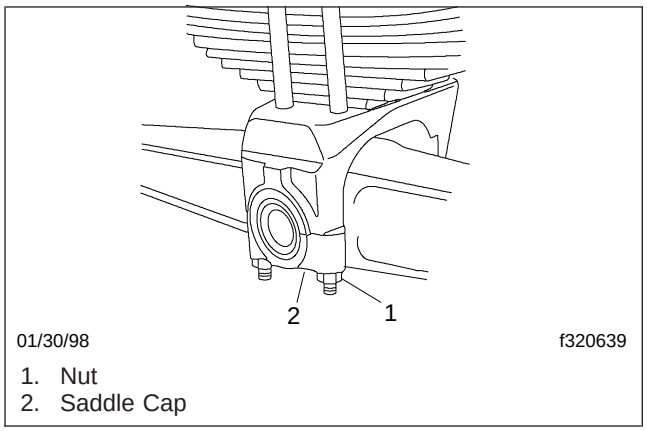


Fig. 1, Supporting Equalizing Beam

4. Remove the saddle caps. See **Fig. 2**.
   - 4.1 Remove the four nuts.
   - 4.2 Remove the inboard and outboard saddle caps.



1. Nut
2. Saddle Cap

Fig. 2, Saddle Cap Removal

5. Remove the lubrication fitting from the spring pin. See **Fig. 3**.
6. Remove the two bolts. See **Fig. 4**.
7. Remove the spring eye pin. See **Fig. 5**.

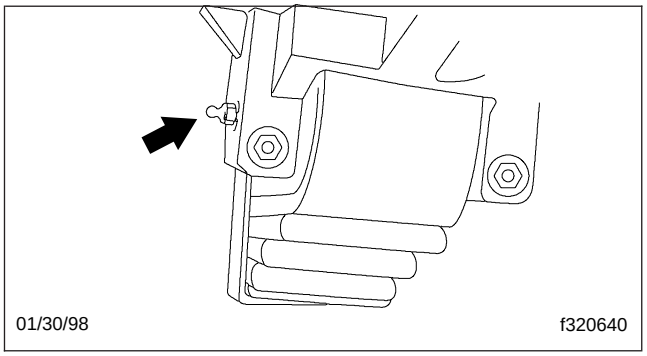


Fig. 3, Lubrication Fitting

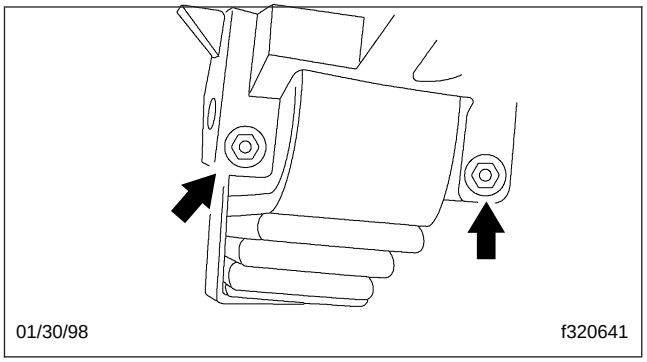


Fig. 4, Spring Eye Pin Retaining Bolts

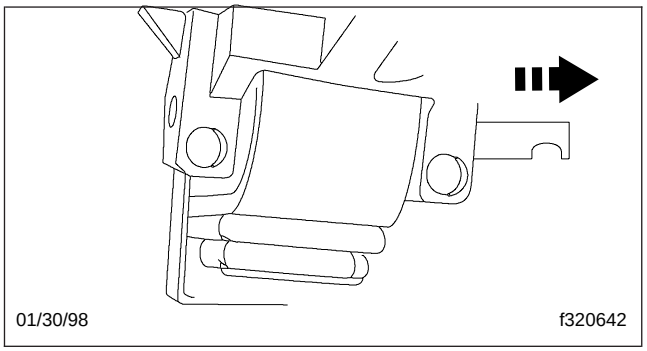


Fig. 5, Spring Eye Pin Removal

8. Remove the rebound bolt and spacer at the rear spring hanger. See **Fig. 6**.
9. Remove the spring and saddle assembly. See **Fig. 7**.
   - 9.1 Lower the beam and spring assembly.
   - 9.2 Using an assistant, lift the spring and saddle assembly off the beam.

Spring Removal and Installation

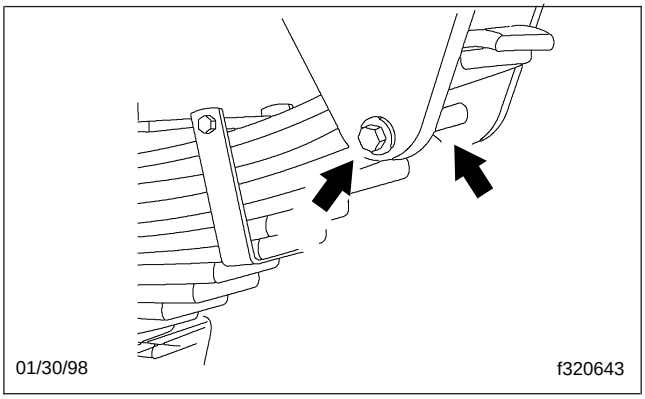
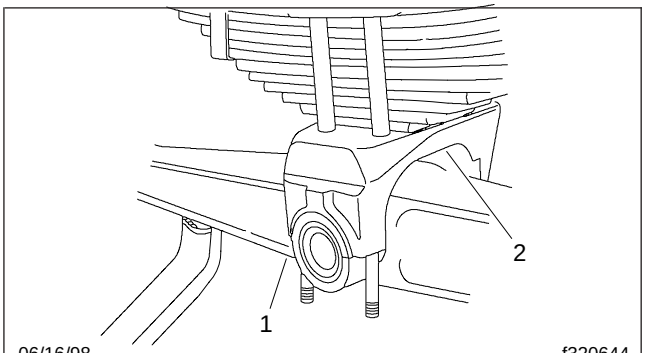


Fig. 6, Rebound Bolt and Spacer



1. Beam
2. Spring and Saddle Assembly

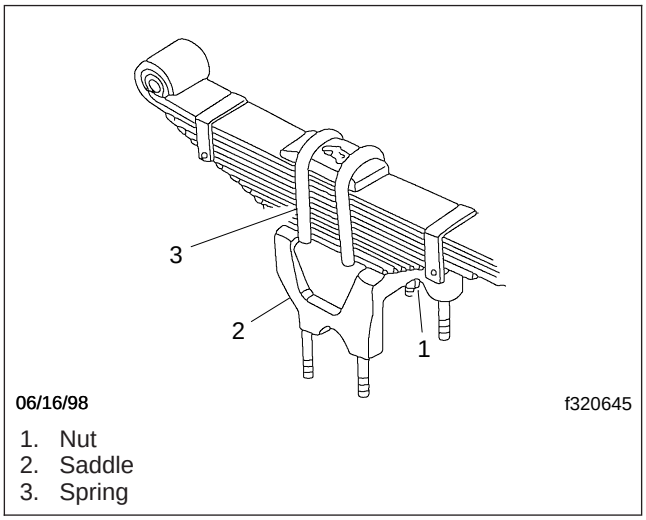
Fig. 7, Spring and Saddle Assembly Removal

10. For U-bolt equipped springs, separate the spring from the saddle. See **Fig. 8**.
    - 10.1 Remove the four nuts and washers.
    - 10.2 Remove the U-bolts and the saddle.
11. For bolt-and-spring pad systems, separate the spring from the saddle. See **Fig. 9**.
    - 11.1 Remove the four bolts.
    - 11.2 Loosen the set-screws.
    - 11.3 Remove the top pad and the saddle.

Installation

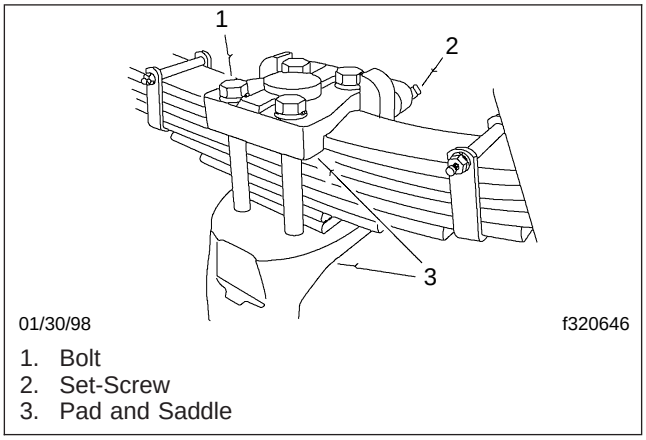
CAUTION

Do not reinstall used suspension fasteners. Always use new nuts, bolts and washers.



1. Nut
2. Saddle
3. Spring

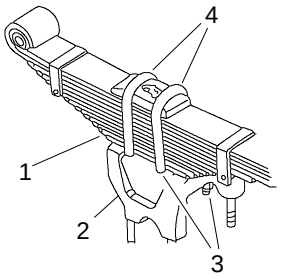
Fig. 8, Separating Spring and Saddle, U-Bolt Equipped Springs



1. Bolt
2. Set-Screw
3. Pad and Saddle

Fig. 9, Separating Spring and Saddle, Bolt-and-Spring Pad Systems

1. For U-bolt equipped springs, assemble the spring and saddle. See **Fig. 10**. Lubricate all threads with SAE-20 oil.
   - 1.1 Position the saddle under the spring.
   - 1.2 Install the U-bolts, washers and nuts.
   - 1.3 Seat the U-bolts by striking with a hammer and retighten.
2. For bolt and spring pad systems, assemble the spring, spring pad and saddle assembly. See **Fig. 11**. Lubricate all threads with SAE-20 oil.
   - 2.1 Position the spring on the saddle.



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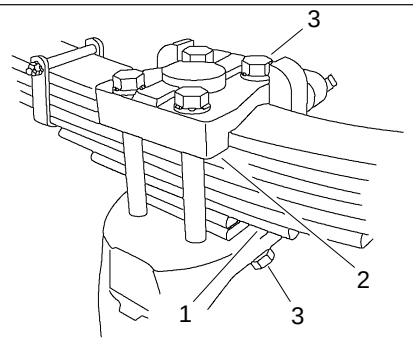
1. Spring
2. Saddle
3. Nut
4. U-Bolts

Fig. 10, Installing Spring and Saddle, U-Bolt Equipped Springs

2.2 Position the spring pad on the spring.

2.3 Install the four bolts and nuts and tighten evenly and alternately only enough to keep the parts from shifting.



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1. Spring
2. Saddle
3. Bolts

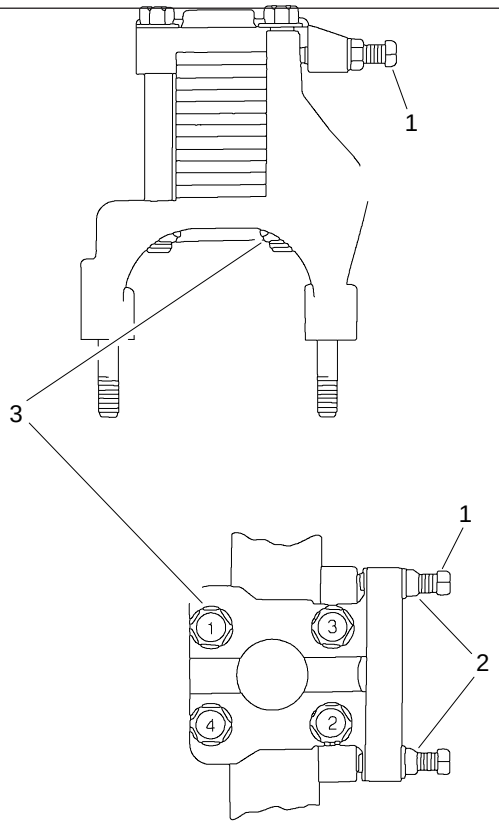
Fig. 11, Installing Spring and Saddle, Bolt-and-Spring Pad Systems

3. Tighten to specification. See **Fig. 12**.

3.1 Tighten the two setscrews to specification.

3.2 Tighten the setscrew jam nut until the lockwasher is flattened.

3.3 Tighten the four nuts, evenly and alternately in the sequence shown.



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1. Set-Screw
2. Jam Nut
3. Bolt

Fig. 12, Bolt Tightening Sequence

4. Position the spring and saddle assembly into the front and rear spring hangers. See **Fig. 13**.

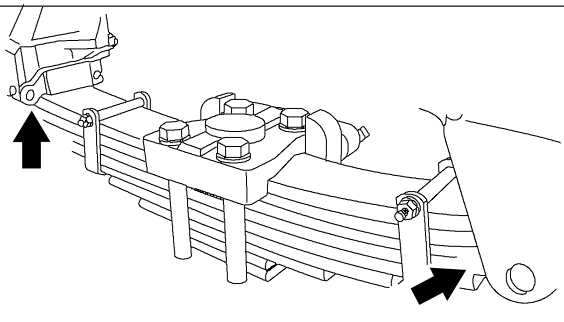

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Fig. 13, Positioning Spring and Saddle Assembly

Spring Removal and Installation

NOTE: The spring pin must be installed with the grease fitting opening on the inboard side.

5. Install the spring pin. See **Fig. 14**.

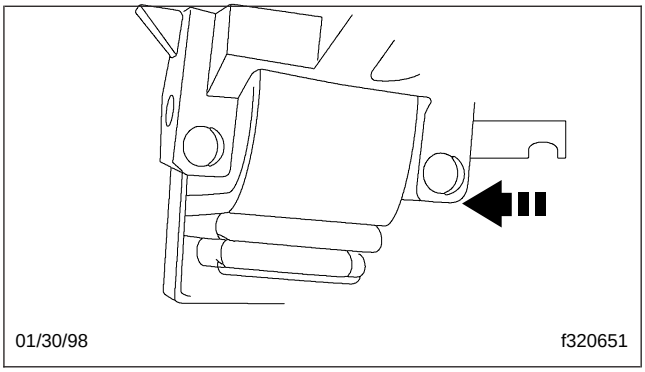


Fig. 14, Installing Spring Pin

NOTE: Align the spring pin notches above the bolt holes.

6. Install the bolts and nuts. See **Fig. 4**.
7. Install the lubrication fitting. Pressure lubricate with Motorcraft Premium Long-Life Grease XG–1–C or –K or equivalent meeting specification ESA–M1C75–B until lubricant appears at both ends of the spring eye bushing. See **Fig. 3**.
8. Install the spacer and the rebound bolt and nut at the rear spring hanger. See **Fig. 6**.
9. Install the wheels.
10. Lower the frame so that the spring and saddle assembly is positioned on the equalizing beam center bushing sleeve. See **Fig. 15**.

NOTE: Do not tighten to specification until directed.

11. Install the two saddle caps and four nuts and washers. Tighten only enough to keep components from shifting. See **Fig. 16**.

⚠ CAUTION

The full vehicle weight must be on the suspension before tightening the saddle cap nut to specification to prevent damage to the saddle and saddle caps.

12. Remove any support and lower the vehicle so that the full vehicle weight is on the suspension.

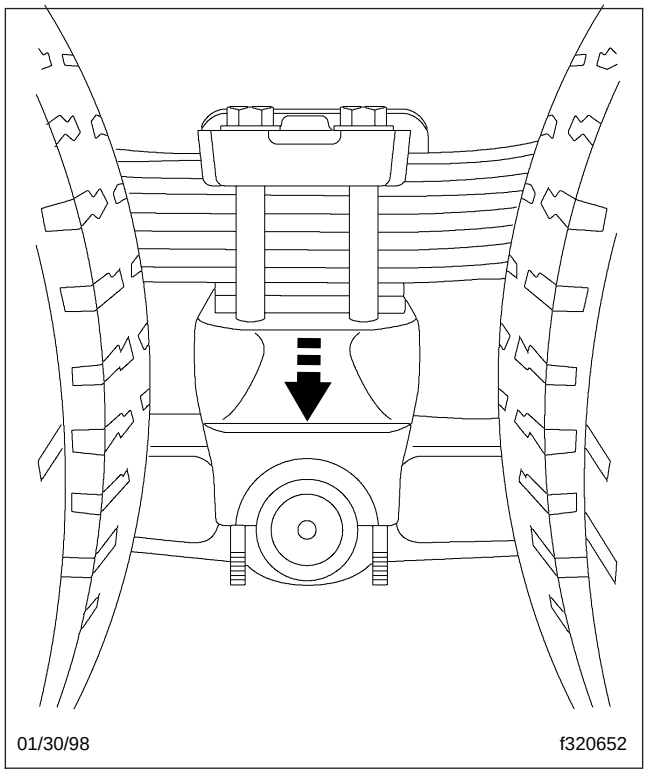


Fig. 15, Positioning Spring and Saddle Assembly

NOTE: Make sure the gap between the saddle caps and the saddle is equal at both sides.

13. Tighten to specification.

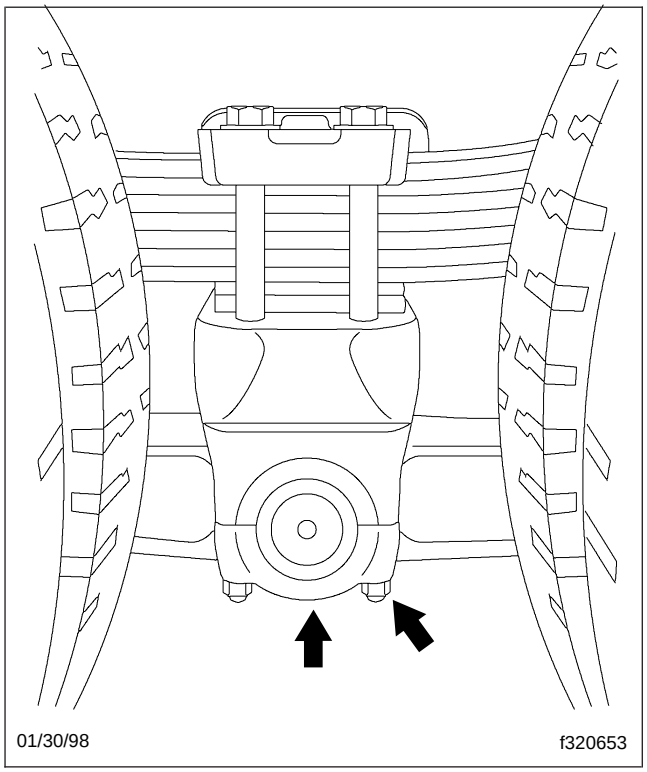


Fig. 16, Installing Saddle Cap and Nuts

Equalizing Beam Removal and Installation

Removal

1. Chock the wheels to prevent vehicle movement.
2. Disconnect all the torque rods at the axle brackets and position out of the way.

CAUTION

The axles will be free to pivot on the beam ends. Use necessary blocking to prevent damage to the inter-axle driveshaft, power divider and differential carriers.

3. Remove the nuts, washers and the two saddle caps at the RH and LH beams. See **Fig. 1**.

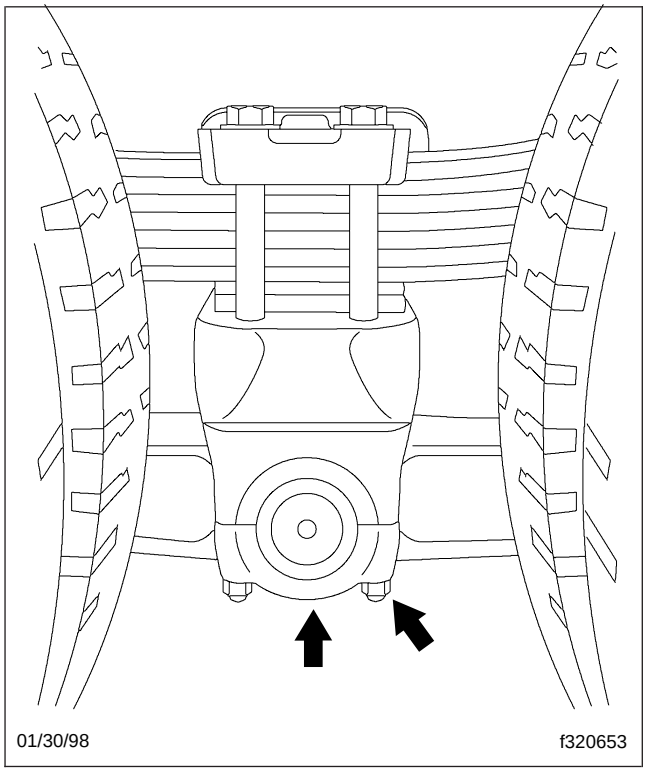


Fig. 1, Saddle Cap and Nuts

NOTE: The hoisting method must allow clearance to roll the tandem axles out from underneath the vehicle.

4. Raise the rear of the vehicle and roll the axles and beams out as an assembly.

WARNING

The equalizing beam can drop when the bar pin bushing bolts are removed. Support the equalizing beam to avoid injury or damage.

NOTE: Apply penetrating oil to aid bolt removal.

5. Remove and discard the bolts and nuts at both ends of the equalizing beam. See **Fig. 2**.

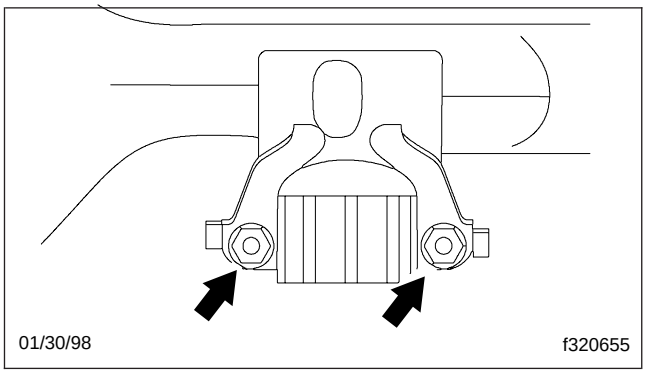


Fig. 2, Equalizing Beam Bolts and Nuts

6. Lower the equalizing beam out of the bar pin axle brackets.
7. Pull the equalizing beam from the crosstube. See **Fig. 3**.

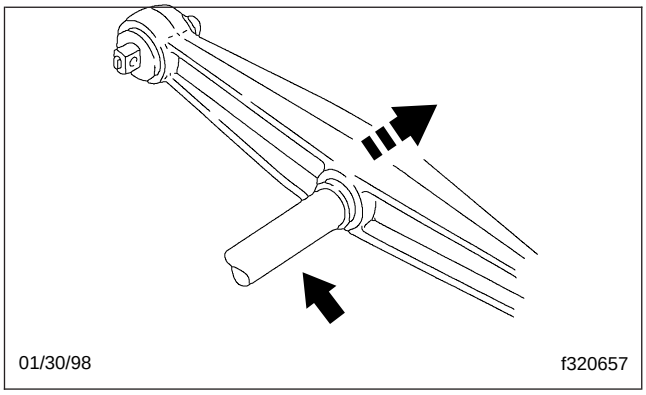


Fig. 3, Removing Equalizer Beam from Cross Tube

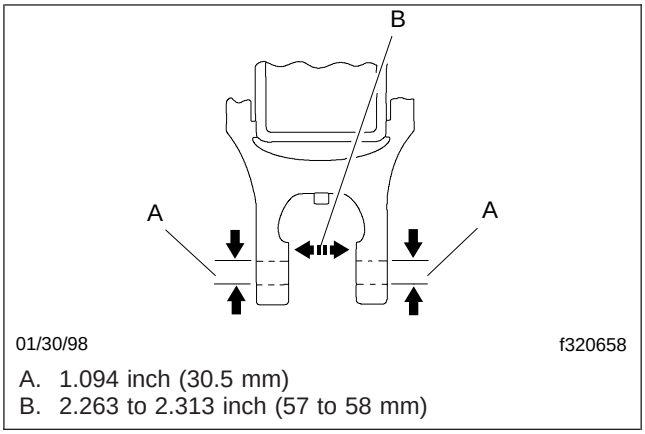
NOTE: If a bar pin axle bracket is worn, damaged or exceeds maximum specifications, it must be replaced. Contact the axle manufacturer for instructions.

8. Inspect the bar pin axle brackets.

Equalizing Beam Removal and Installation

8.1 Inspect for cracks, wear or damage.

8.2 Inspect bar pin gap and bolt hole specifications. See **Fig. 4**.



A. 1.094 inch (30.5 mm)
B. 2.263 to 2.313 inch (57 to 58 mm)

Fig. 4, Bar Pin Axle Bracket Inspection

Installation

1. Apply anti-seize compound to the bolt holes in the bar pin axle brackets. See **Fig. 5**.

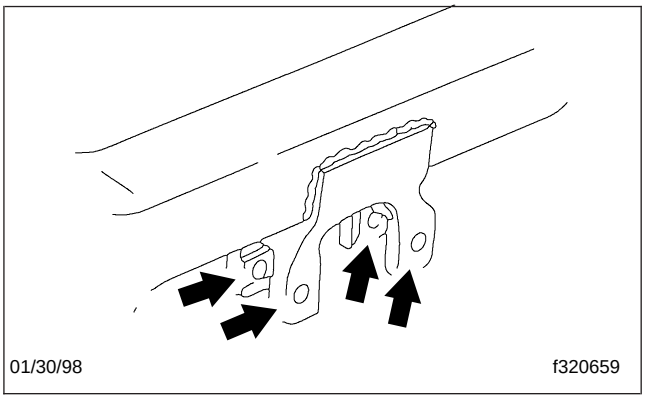


Fig. 5, Applying Anti-Seize Compound

NOTE: For rubber center bushing equipped equalizing beams, apply anti-seize compound to the inside and outside of the bushing sleeve before assembly. With a bronze center bushing, apply Motorcraft Premium Long Life Grease XG–1–C or –K or equivalent meeting specification ESA–M1C75–B.

2. Position the equalizing beam onto the crosstube. See **Fig. 6**.

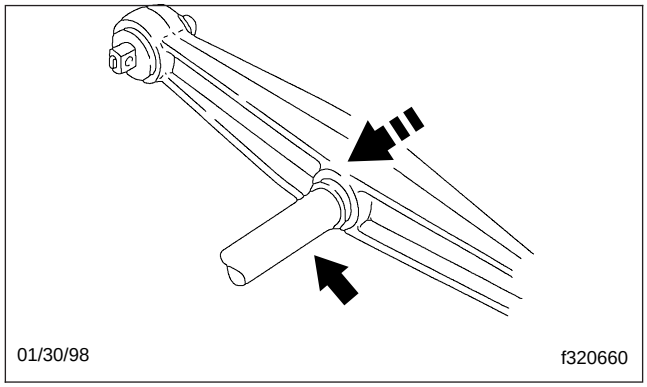


Fig. 6, Positioning Equalizing Beam to Cross Tube

3. Position the beam ends into the bar pin axle brackets.

⚠ WARNING

When using the shim-style bar pin bushing, a shim must be installed at each bolt location. The same part number shim in the same orientation must be used at both bolt locations on any one bushing assembly. Do not install or stack more than one shim at each bolt location. Use genuine Hendrickson shims. Do not use standard washers. Failure to follow this warning can result in the fracture of either the bracket or bar pin, which could result in the loss of vehicle control and possible personal injury or property damage.

NOTE: Lubricate the bolts with anti-seize compound. Do not tighten the nuts to specification in this step.

4. Install new nuts, bolts and washers. Tighten only enough to hold components together. See **Fig. 2**.

5. Roll the axle and beam assembly under the saddles.

6. Lower the frame making sure the saddles are centered on the center bushing sleeves. See **Fig. 7**.

NOTE: Do not tighten to specification in this step.

7. Install the saddle caps. See **Fig. 8**.

7.1 Use new nuts and washers.

7.2 Tighten only enough to keep components from shifting.

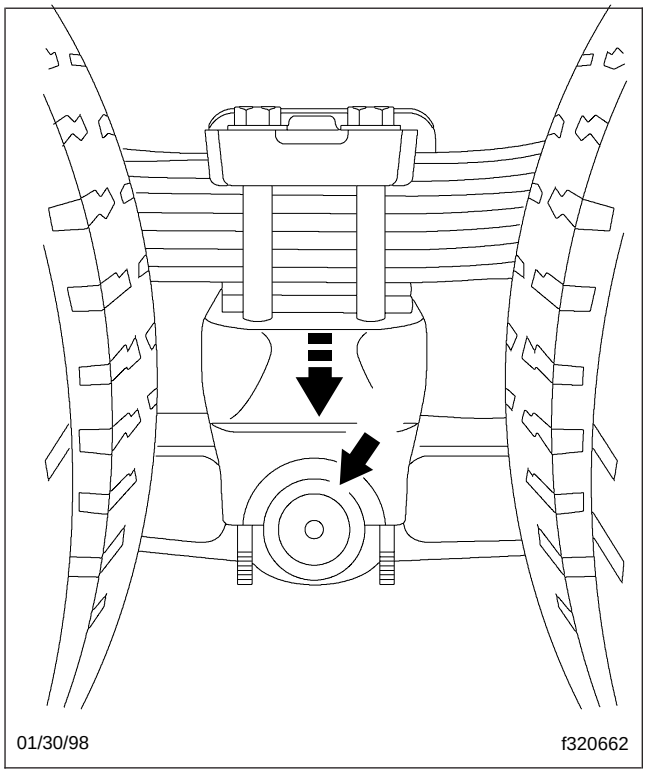


Fig. 7, Centering Saddles on Bushings

8. Install the longitudinal torque rods. See **Fig. 9**.
   - 8.1 Use new nuts, bolts and washers.
   - 8.2 Tighten to specification.

NOTE: Tighten the nut to specification, rap the bracket with a hammer and then retighten to specification.

9. Install the transverse torque rods. See **Fig. 10**.
   - 9.1 Use new nuts, bolts and washers.
   - 9.2 Tighten to specification.

10. Install new bolts and nuts at both ends of the equalizing beam. See **Fig. 11**.

CAUTION

Do not tighten the saddle cap nuts until the full vehicle weight is on the equalizing beams.

11. Lower the vehicle so that the full vehicle weight is on the equalizing beams.

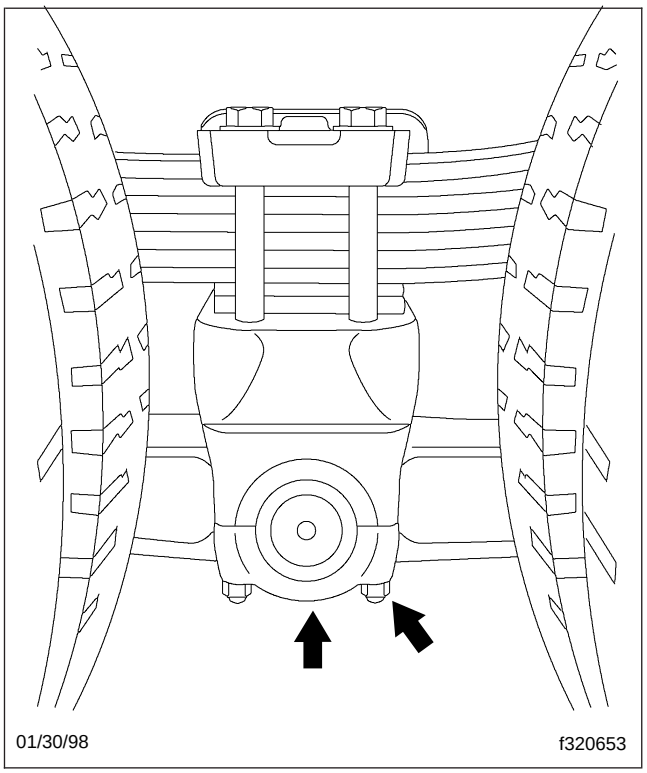


Fig. 8, Installing Saddle Caps

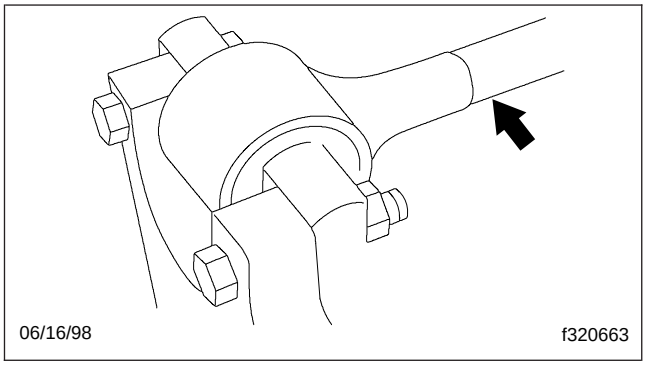


Fig. 9, Longitudal Torque Rod Installation

NOTE: Make sure the gap is even at both sides of the saddle caps.

12. Tighten to specification.

Equalizing Beam Removal and Installation

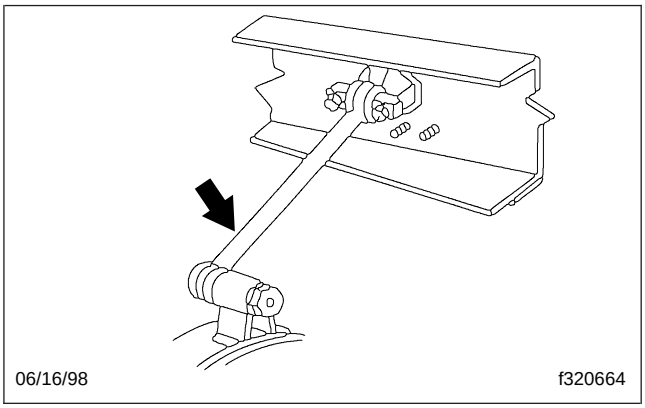


Fig. 10, Transverse Torque Rod Installation

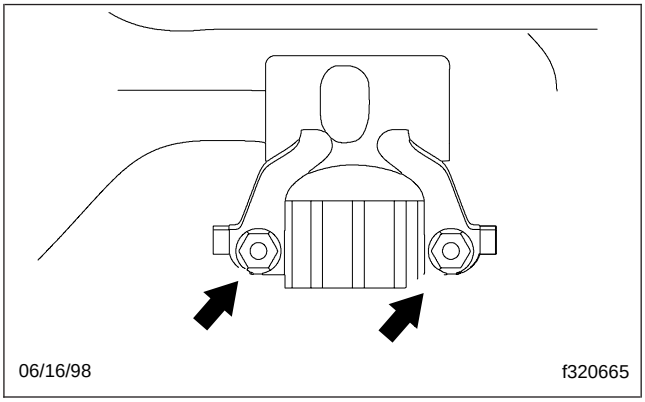


Fig. 11, Equalizer Beam Fastener Installation

Equalizing Beam End Bushing Replacement

⚠ WARNING

When removing and installing bushings in an equalizing beam, follow the procedures described in this section. Do not use a torch to remove the bushing outer metal pressed in the beam. Never weld, use a torch or attach material to the equalizing beam. All equalizing beams are heat-treated for strength and service life. The use of heat can adversely affect the strength of the beams.

IMPORTANT: After removing the equalizing beam bushings, inspect the beam bores thoroughly. If the beam bores are damaged, replace with a new equalizing beam.

1. Remove the equalizing beam. Refer to **Subject 110**.
2. Using a chisel or other means, remove the confinement washer. See **Fig. 1**.

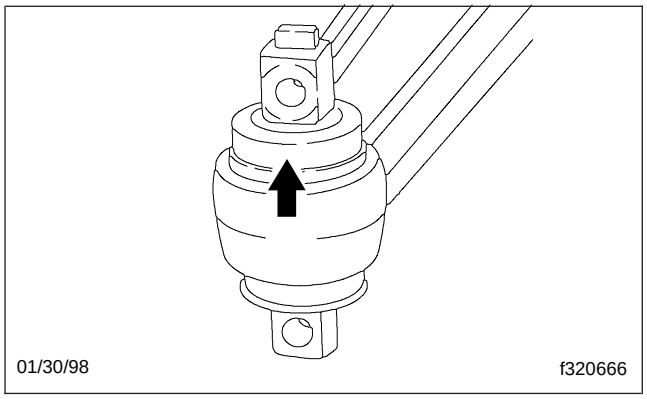


Fig. 1, Confinement Washer

3. Cut away the rubber to expose the inner sleeve. See **Fig. 2**.
4. If using the suspension system bushing tooling, follow the manufacturer's instructions to remove the end bushing.
5. If the suspension system bushing tooling is not available, support the beam and use a conventional hydraulic press to remove the end bushing. See **Fig. 3**.

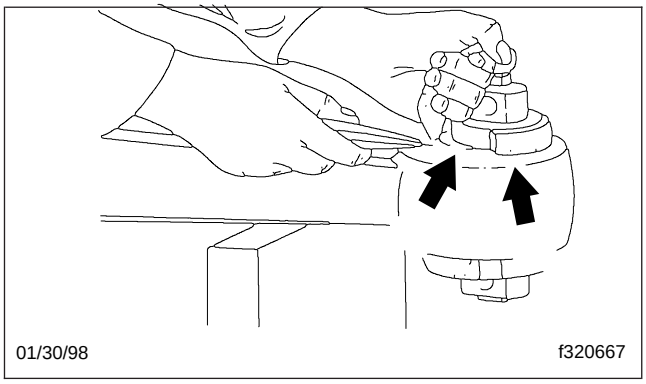


Fig. 2, Cutting Away Rubber

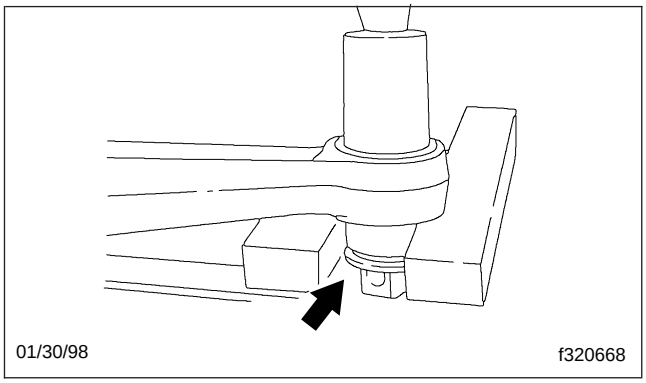


Fig. 3, Removing End Bushing

6. Inspect the bushing bore for damage. Replace the equalizing beam if the bushing bore is damaged.
7. Coat the bushing bore with Motorcraft Premium Long-Life Grease XG–1–C or –K or equivalent meeting specification ESA–M1C75–B.
8. Use emery cloth to remove the phosphate coating from the end bushing. See **Fig. 4**.

NOTE: The bolt holes in the end bushing must be aligned with the center line of the equalizing beam.

9. If using the suspension system bushing tooling, follow the manufacturer's instructions to install the new end bushing.

NOTE: The bolt holes in the end bushing must be aligned with the center line of the equalizing beam. If using a hydraulic press, fabricate an

Equalizing Beam Bushing Replacement

installation tool as shown to permit pressure to be applied to the bushing outer sleeve. See **Fig. 5**.

10. Press the end bushing into the equalizing beam.

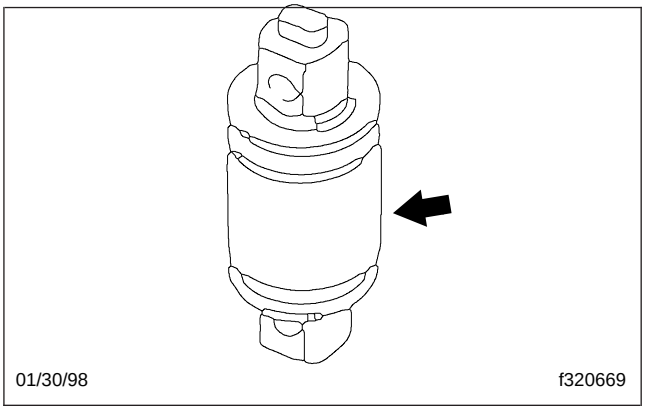


Fig. 4, Removing Phosphate Coating

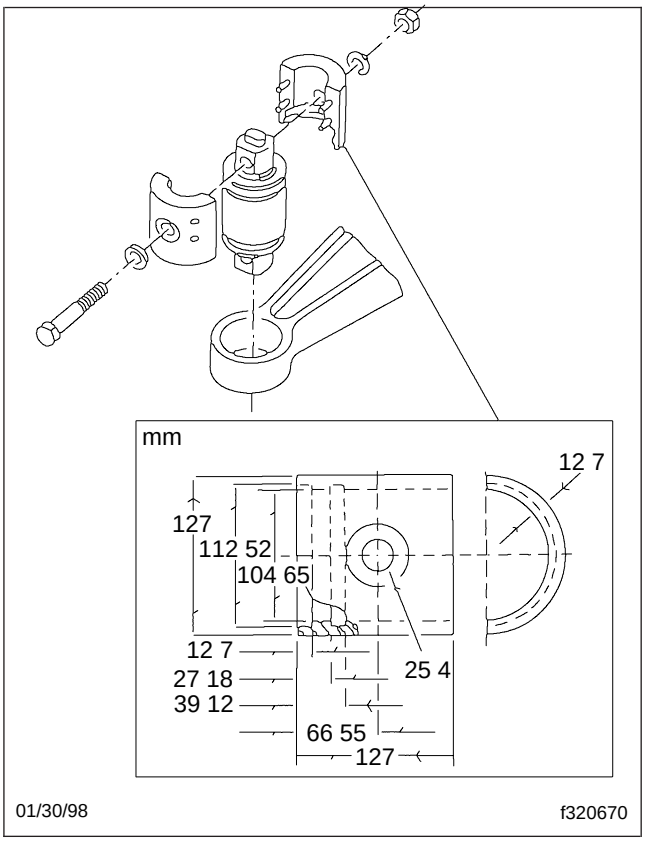


Fig. 5, End Bushing Tool Fabrication

11. Install the equalizing beam. Refer to **Subject 110**.

Equalizing Beam Center Bushing Replacement

EQUALIZING BEAM INSTALLED

IMPORTANT: Do not install a bronze bushing in an aluminum equalizing beam.

1. Remove the inboard and outboard saddle nuts and saddle caps. See **Fig. 6**.

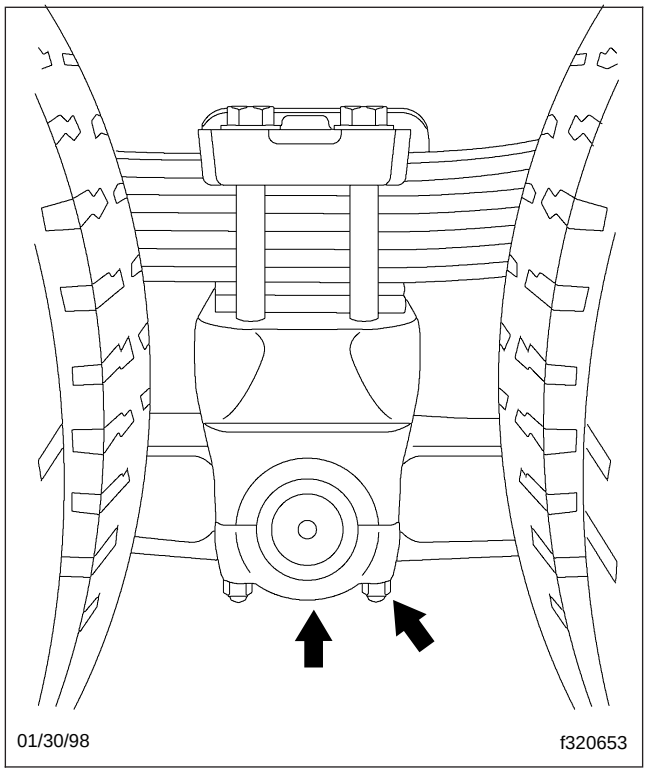


Fig. 6, Saddle Caps and Nuts

2. Using an appropriate hole saw, remove the weld bead from the sleeve plug and the bushing sleeve. See **Fig. 7**.
3. Slide the crosstube out. See **Fig. 8**.
4. Lift the frame high enough for the saddle studs to clear the equalizing beam.
5. Remove the thrust washers. See **Fig. 9**.

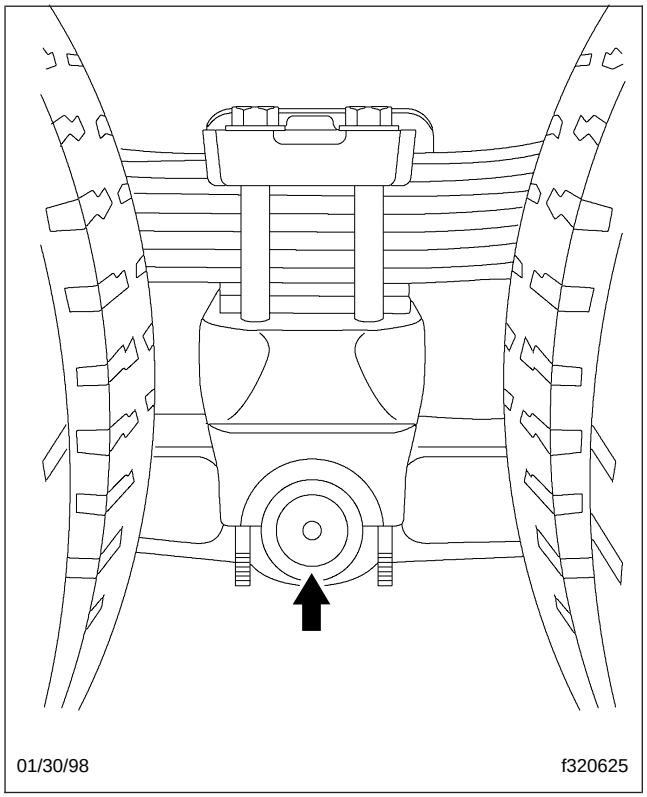


Fig. 7, Weld Bead

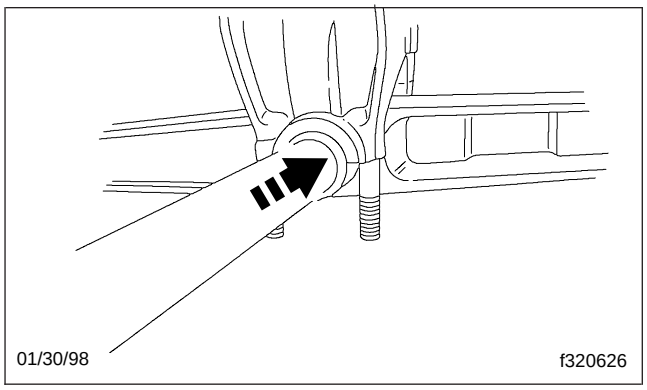


Fig. 8, Cross Tube Removal

6. Using the suspension system bushing tooling according to the manufacturer's instructions, remove the center bushing.
7. Inspect the bushing bore for wear or damage.
   - 7.1 Remove mushroomed metal.
   - 7.2 Remove minor nicks and burrs with emery cloth.

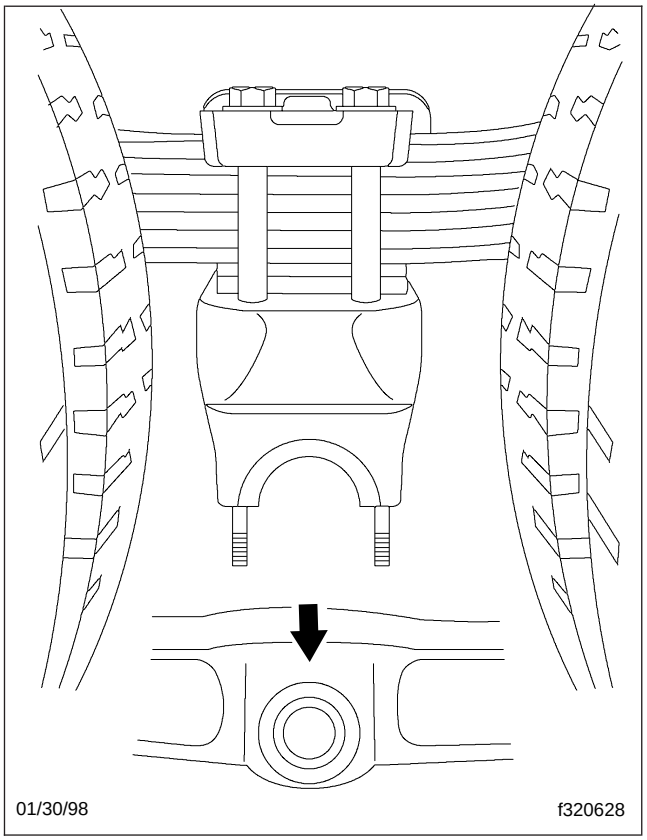


Fig. 9, Thrust Washers

8. Coat the new center bushing and the bushing bore with Motorcraft Premium Long-Life Grease XG–1–C or –K or equivalent meeting specification ESA–M1C75–B.
9. Using the suspension system bushing tooling according to the manufacturer's instructions, install the center bushing.
10. Install the thrust washers. See **Fig. 9**.
11. Slide the crosstube in.
12. Arc weld a new plug in the center bushing sleeve.

CAUTION

The full vehicle weight must be on the equalizing beam before tightening the saddle cap nuts to specification to prevent damage to the saddle caps and saddle.

Equalizing Beam Bushing Replacement

NOTE: Make sure the gap is even at both sides of the saddle caps.

13. Install the inboard and outboard saddle nuts and saddle caps. See **Fig. 6**.

EQUALIZING BEAM REMOVED

CAUTION

To avoid damage to the equalizing beam, do not use heat to remove the center bushing.

1. Remove the equalizing beam. Refer to **Subject 110**.
2. Remove the seals, if so equipped. See **Fig. 10**.

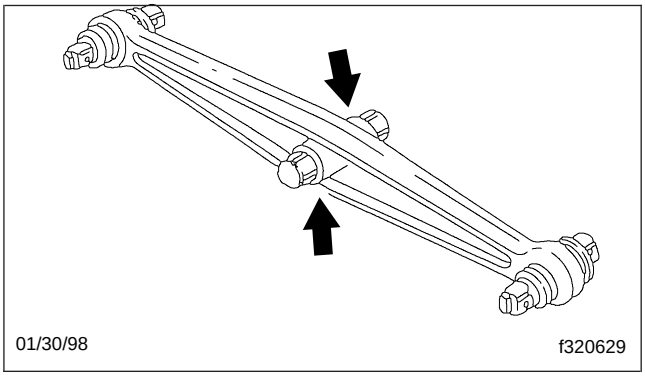


Fig. 10, Seals

3. Using the suspension system bushing tooling, remove the center bushing according to the manufacturer's instructions.
4. If the suspension system bushing tooling is not available, use a shop press and the appropriate driver to remove the center bushing. See **Fig. 11**.
5. Inspect the bushing bore for nicks, scratches or other damage. Remove burrs or nicks with emery cloth. See **Fig. 12**.
6. Coat the bushing bore and bushing outer sleeve with Motorcraft Premium Long-Life Grease XG–1–C or –K or equivalent meeting specification ESA–M1C75–B.
7. If using the suspension system bushing tooling, install the center bushing according to the manufacturer's instructions.
8. If the suspension system bushing tooling is not available, use a shop press and the appropriate driver to install the center bushing. See **Fig. 13**.

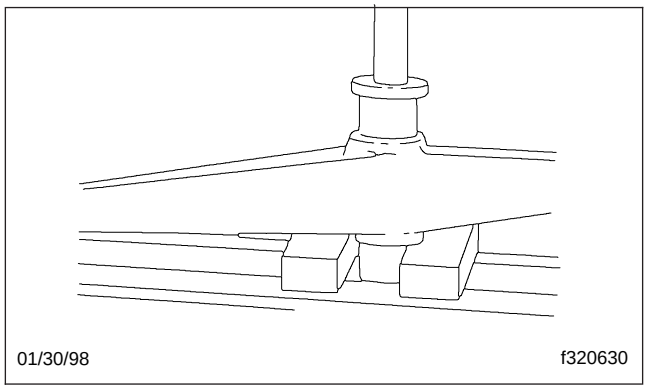


Fig. 11, Center Bushing Removal

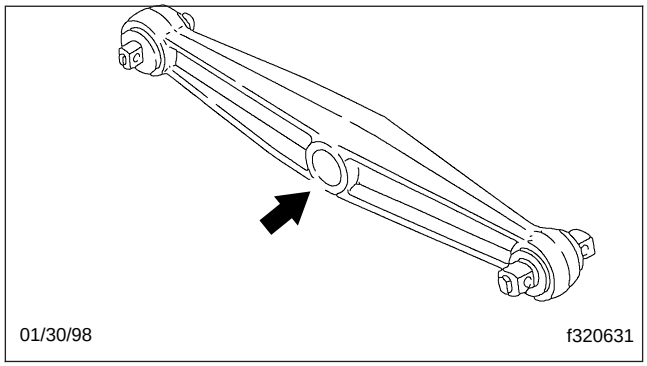


Fig. 12, Inspecting Bore

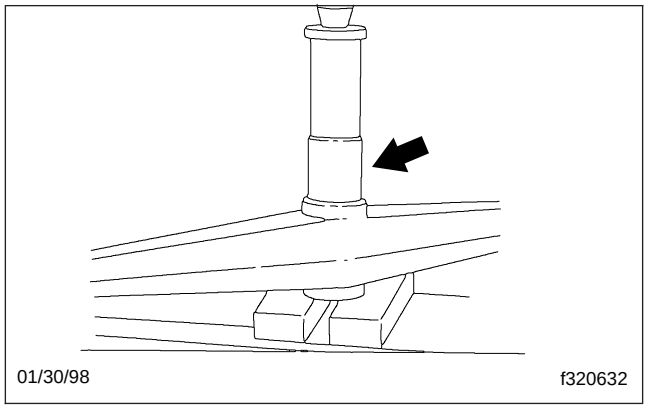


Fig. 13, Bushing Installation

9. Install the seals, if so equipped. See **Fig. 10**.
10. Install the equalizing beam. Refer to **Subject 110**.

Specifications

General Specifications	
Item	**Specification**
Motorcraft Premium Long-Life Grease XG–1–C or –K	ESA–M1C75–B

Table 1, General Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Axle Bumper to Frame	220–300 (299–406)
Beam End Adapter Nut and Bolt	450–600 (611–813)
Saddle Cap Nut (RT2-Series)	225–275 (306–372)
Saddle Cap Nut (U2-Series)	125–145 (170–196)
Spring Bracket to Frame	220–300 (299–406)
Spring Pin Lock Bolt and Nut	45–63 (61–85)
Top Pad Setscrew (RT2-Series)	100–150 (136–203)
Longitudinal Torque Rod to Crossmember and Axle	150–205 (204–277)
Transverse Torque Rod to Frame	220–300 (299–406)
Top Pad Bolt (RT2-Series)	275–300 (373–406)
U-Bolt Lock Nut (tighten to specification, strike the top of the U-bolt with a hammer and retighten to specification)	237–302 (321–408)
Transverse Torque Rod-to-Axle Bracket Nut (tighten to specification, rap the bracket with a hammer and retighten) (taper pin)	175–225 (238–305)
Spring Rebound Bolt	38–45 (52–61)
Spring and Saddle Assembly Nut	332–442 (450–600)
Beam End Bar Pin Nut	450–600 (611–813)
Saddle Cap Stud	55–65 (75–88)
Bushing Retainer	100–125 (136–169)

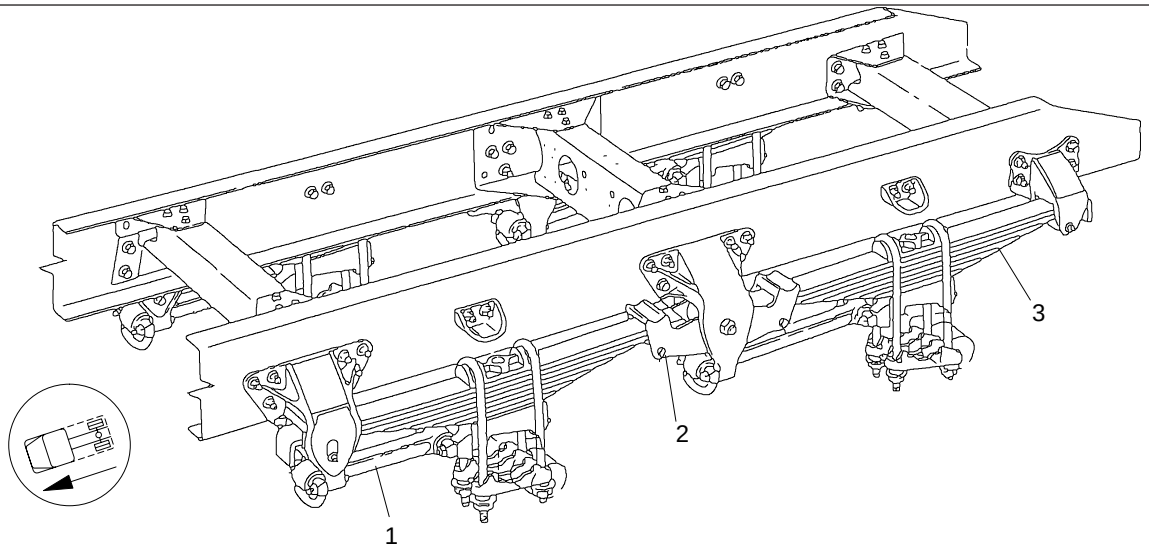
Table 2, Torque Specifications

Standard Bolt Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
1/4-Inch Diameter, Grade 5	—	89–115 (1000–1300)
5/16-Inch Diameter, Grade 5	12–17 (17–23)	—
3/8-Inch Diameter, Grade 8	32–41 (43–56)	—
7/16-Inch Diameter, Grade 8	50–70 (68–95)	—
1/2-Inch Diameter, Grade 8	75–105 (102–142)	—
9/16-Inch Diameter, Grade 8	110–150 (149–203)	—
5/8-Inch Diameter, Grade 8	150–205 (204–277)	—
3/4-Inch Diameter, Grade 8	220–300 (299–406)	—
7/8-Inch Diameter, Grade 8	360–480 (489–650)	—
1.0-Inch Diameter, Grade 8	540–730 (733–989)	—

Table 3, Standard Bolt Torque Specifications

General Information

The Hendrickson HFS-400 (40,000-lb capacity) tandem suspension (see **Fig. 1** and **Fig. 2**) is a lightweight, equalizing beam-type, four-spring suspension. It has four conventional multileaf springs operating in conjunction with four torque rods.

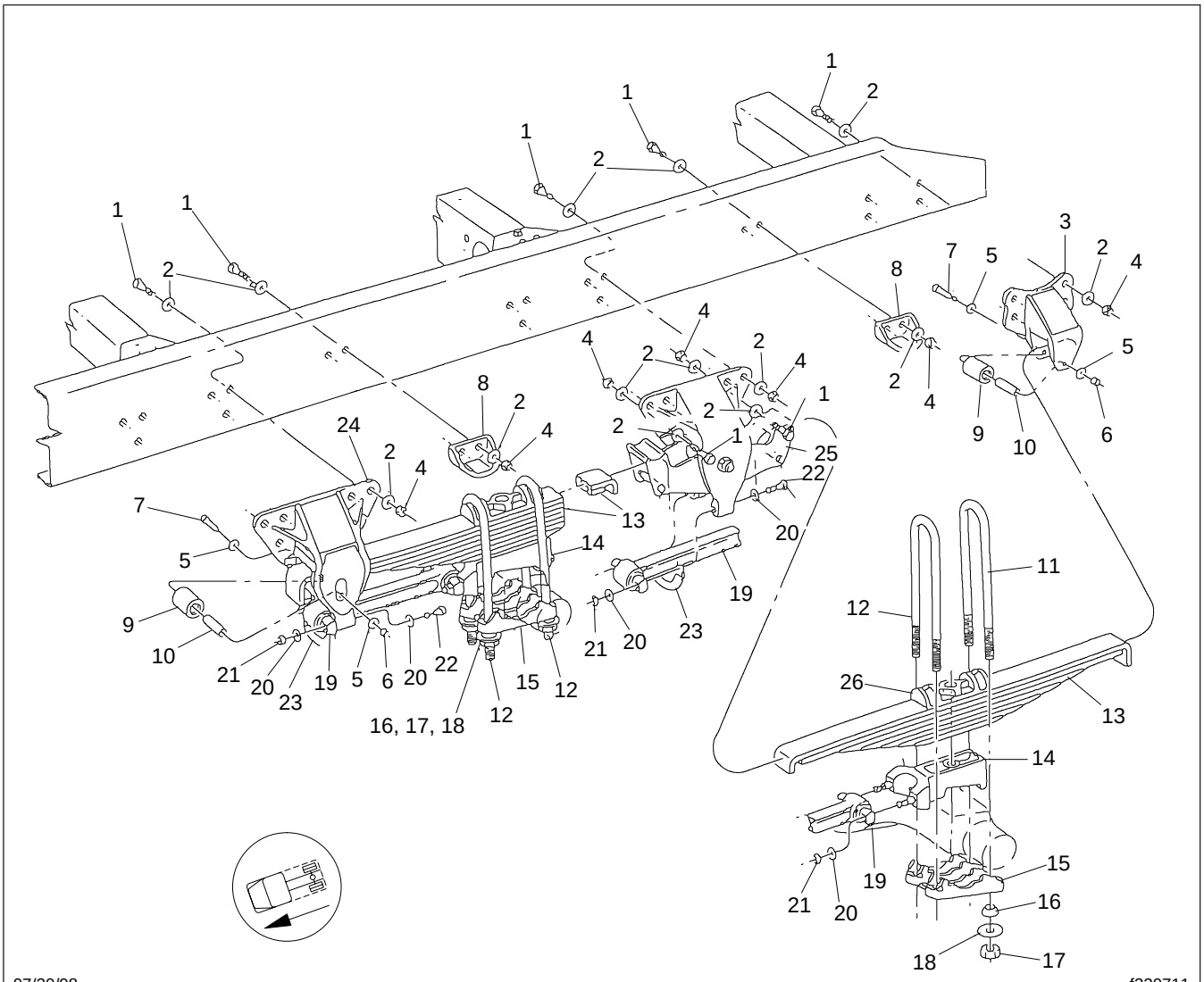


07/30/98 f320710

1. Torque Rod Assembly
2. Equalizing Beam Bracket Assembly
3. Spring Assembly

Fig. 1, Hendrickson HFS-400 Tandem Suspension

General Information



1. Bolt
2. Washer
3. Rear Spring Hanger Bracket
4. Nut
5. Washer
6. Nut
7. Axle Bumper
8. Rebound Bolt
9. Rebound Roller
10. Rebound Bolt Spacer
11. Rear Spring U-Bolt
12. Rear Spring U-Bolt
13. Spring Assembly
14. Spring Seat
15. Rear Spring U-Bolt
16. Cap Assembly
17. U-Bolt Spherical Washer
18. Nut
19. Washer
20. Flatwasher
21. Nut
22. Bolt
23. Front Spring Hanger Bracket
24. Center Hanger and Equalizing Beam Assembly
25. Rear Spring U-Bolt Pad

Fig. 2, Hendrickson HFS Tandem Suspension, Disassembled View

Removal

1. Chock the axle wheels. See **Fig. 1** .

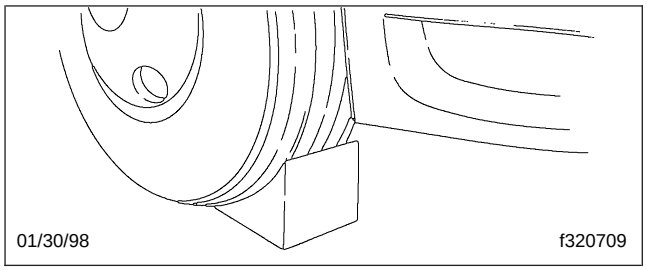


Fig. 1, Chocking the Wheels

⚠ WARNING

Do not use a cutting torch to remove any fasteners. Do not use a cutting torch to remove the bushings from the equilizing beam assembly. The use of heat on suspension components will adversely affect the strength of these parts. A component damaged in this manner can result in the loss of vehicle control and possible personal injury or property damage.

2. Remove the rebound bolt, rebound roller, lock nut, washers and spacer from the end spring hanger. See **Fig. 2** .
3. Remove the torque rod bar pin locknuts and washers at the axle end (spring seat) of the torque rod. See **Fig. 3** .

⚠ CAUTION

Note the number of shims at each location. These shims must be reinstalled in the same manner to avoid affecting suspension alignment.

NOTE: The torque rod can only be installed one way; note the direction.

4. Remove the torque rod bar pin lock nuts, washers, bolts and any shims from the center spring hanger, and remove the torque rod. See **Fig. 4**.
5. Remove the cotter pins, washers and the clevis pins from the equalizer assembly. See **Fig. 5**.
6. Raise the rear of the frame far enough to remove the load from the spring.

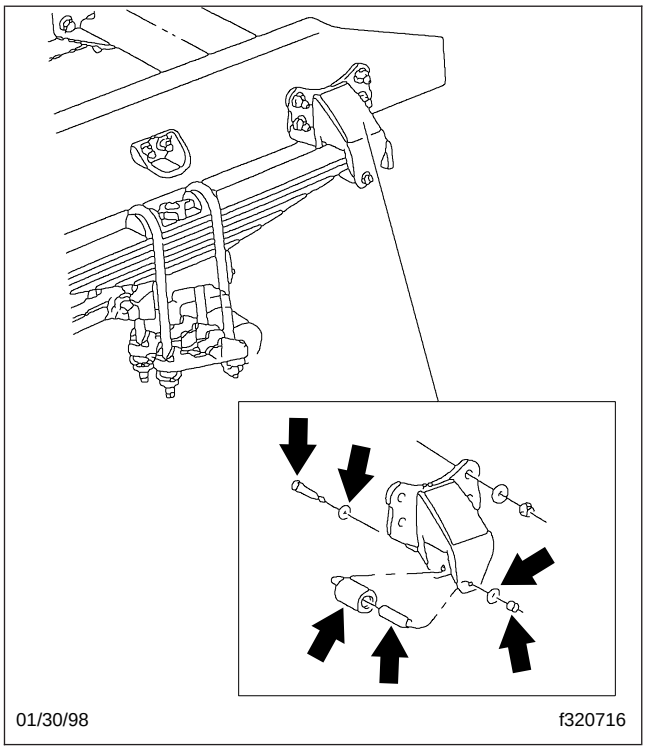


Fig. 2, Rebound Roller Assembly

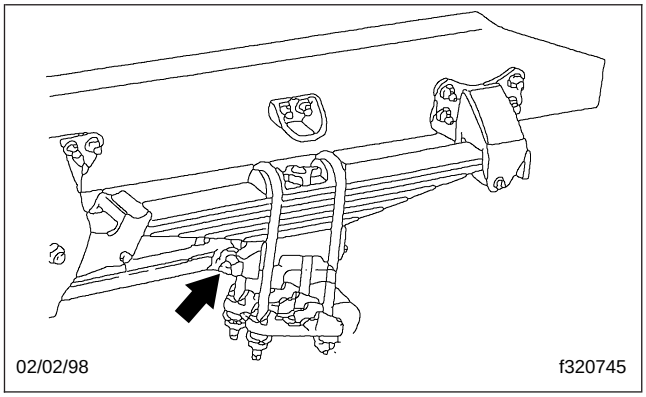


Fig. 3, Torque Rod Bar Pin Locknuts, Axle End

7. Remove the U-bolt locknuts and washers. See **Fig. 6**.
8. Remove the U-bolt, bottom cap and the U-bolt upper pad. See **Fig. 7**.
9. Remove the spring assembly. See **Fig. 8**.

Spring Removal and Installation

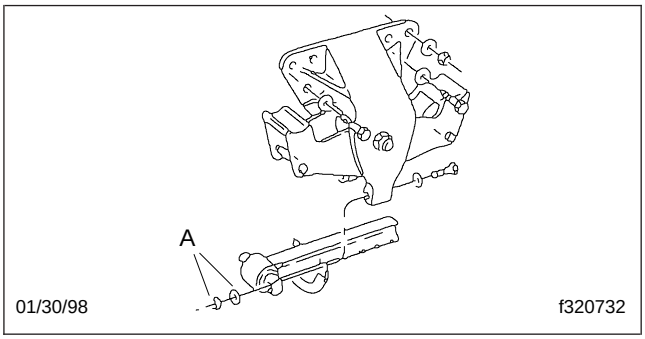


Fig. 4, Torque Rod Bar Pin Locknuts, Spring Hanger End

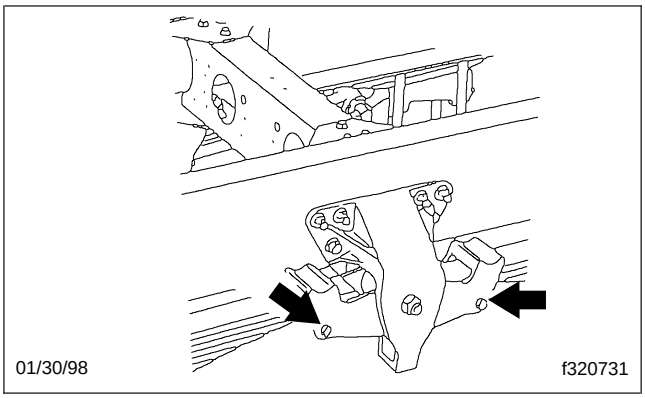


Fig. 5, Clevis Pins

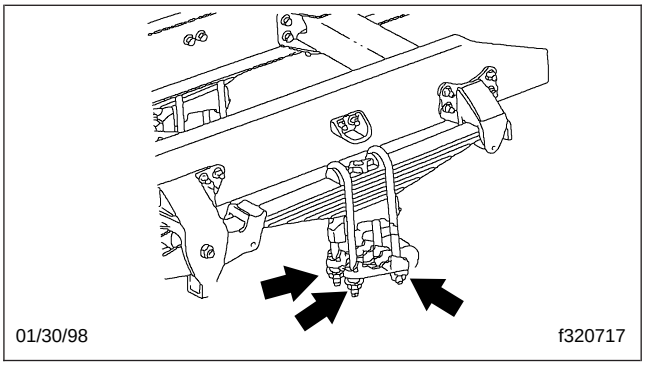


Fig. 6, U-Bolt Locknuts

Installation

1. Position the spring through the legs of the spring hanger and equalizer beam, and place the spring on the spring seat or spacer plate, if so equipped, with the spring center bolt piloting into the hole in the spring seat or spacer. See **Fig. 9** .

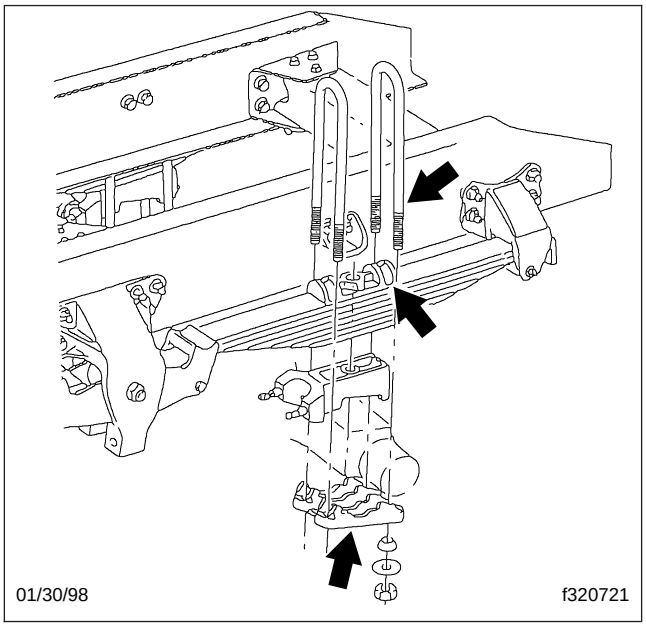


Fig. 7, U-Bolt, Bottom Pad and Upper Pad

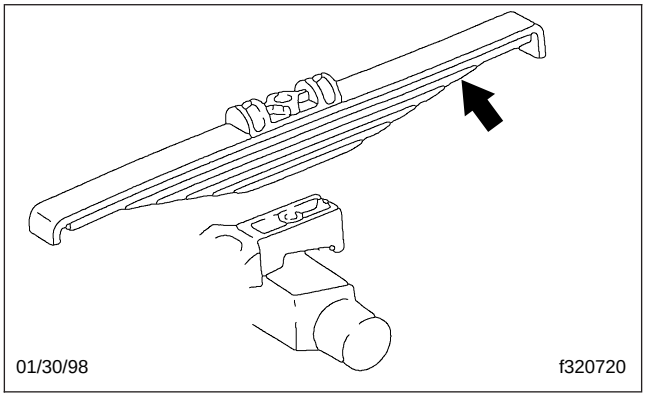


Fig. 8, Spring Assembly

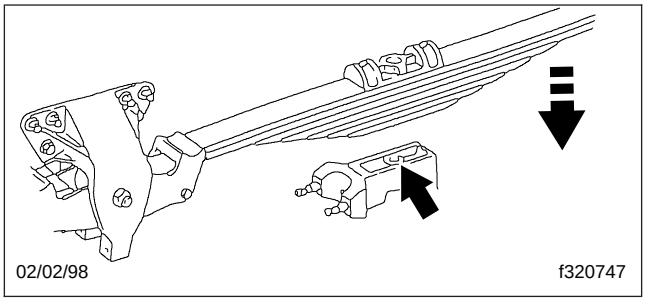


Fig. 9, Positioning Spring Assembly

2. Assemble the U-bolt upper pad, U-bolts, bottom cap, washers and lock nuts. Do not tighten the U-bolt lock nuts at this time. See **Fig. 7**.
3. Lower the frame so that the end spring hanger and equalizer beam engage the spring.

⚠ WARNING

Do not exceed the specified torque on the U-bolt locknuts or damage to the spring pads may result.

4. Tighten the U-bolt lock nuts evenly. Rap the top of the U-bolts, and retighten 3/4 inch nut: 220 to 300 lbf·ft (299 to 406 N·m), 7/8 inch nut: 360 to 480 lbf·ft (489 to 650 N·m). See **Fig. 6** .
5. Assemble the rebound spacer, rebound roller, bolt, washers and lock nuts on the end spring hanger, and tighten 50 to 70 lbf·ft (68 to 75 N·m). See **Fig. 2** .
6. Assemble the clevis pins, washers, and cotter pins in the equalizer beam assembly. See **Fig. 5** .

NOTE: The torque rod can only be installed one way; note the direction.

7. Install the torque rod, bar pin washers and lock nuts at the axle end (spring seat) of the torque rod. See **Fig. 3**.
8. Install the torque rod bar pin bolts, lock nuts, washers and any shims onto the center spring hanger. See **Fig. 4**.
9. Recheck the alignment after the new spring(s) are installed. Refer to **Group 40**.

Replacement

WARNING

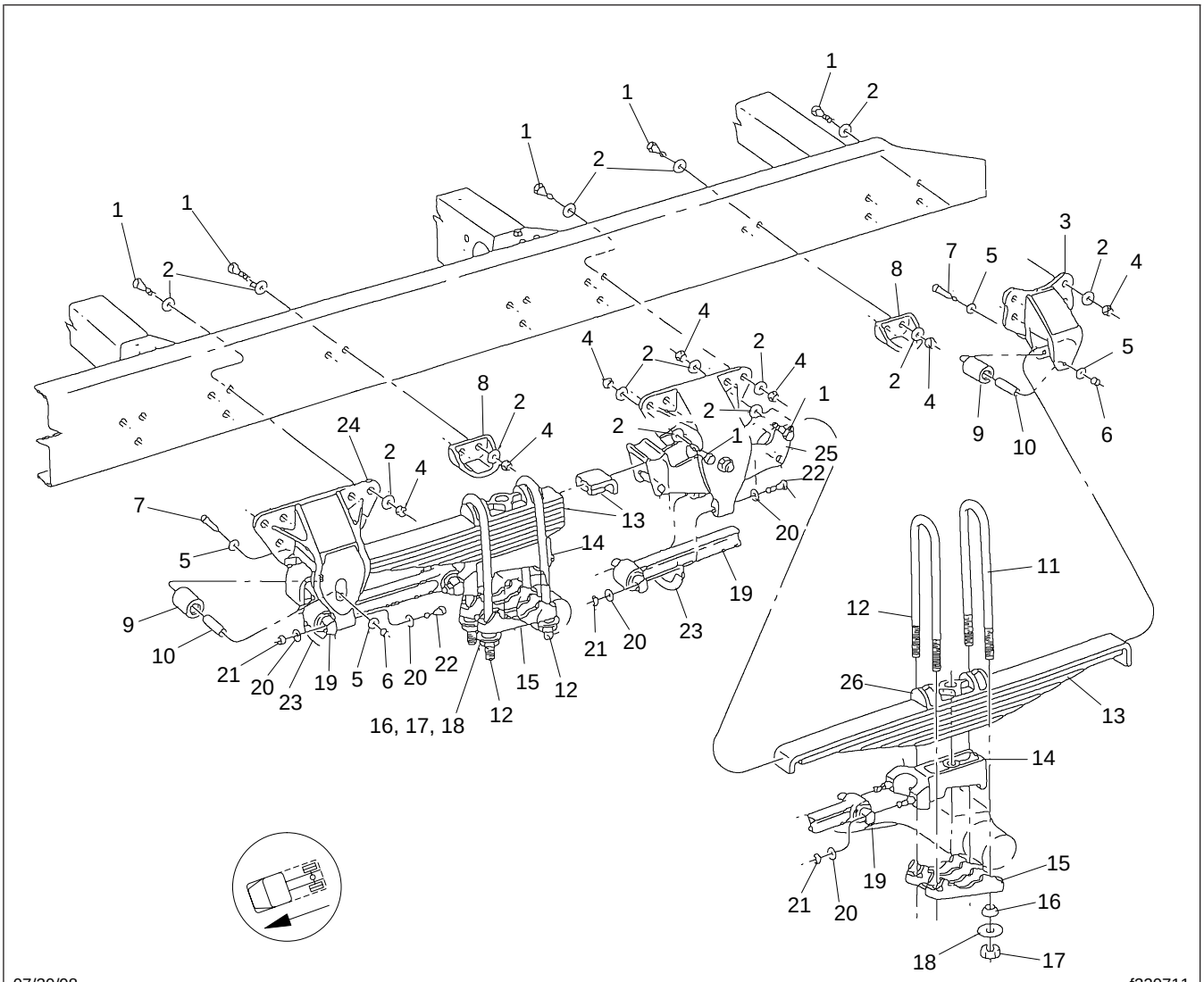
Do not use a cutting torch to remove any fasteners. Do not use a cutting torch to remove the bushings from the equalizing beam assembly. The use of heat on suspension components will adversely affect the strength of these parts. A component damaged in this manner can result in the loss of vehicle control and possible personal injury or property damage.

To replace the hanger, refer to **Fig. 1, Fig. 2, and Fig. 3**.

If the front or rear spring hanger requires replacement, remove the respective spring.

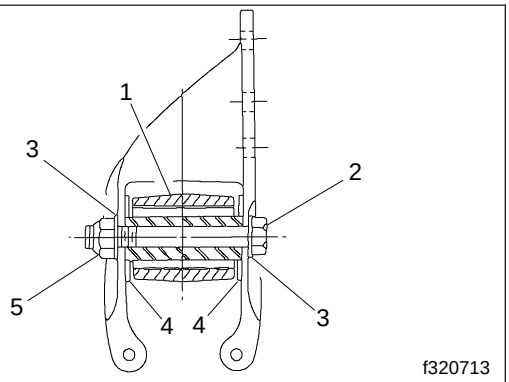
If the center spring hanger requires replacement, remove both springs.

Spring Hanger Replacement



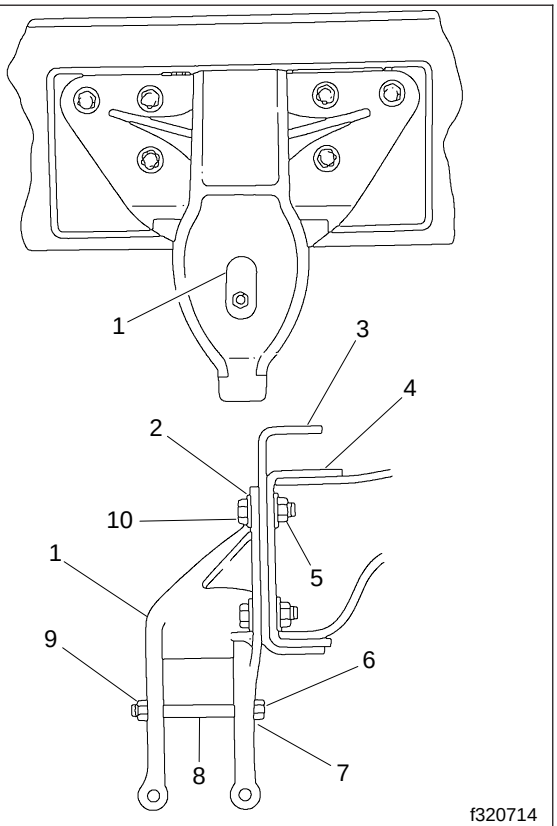
1. Bolt
2. Washer
3. Rear Spring Hanger Bracket
4. Nut
5. Washer
6. Nut
7. Axle Bumper
8. Rebound Bolt
9. Rebound Roller
10. Rebound Bolt Spacer
11. Rear Spring U-Bolt
12. Rear Spring U-Bolt
13. Spring Assembly
14. Spring Seat
15. Rear Spring U-Bolt
16. Cap Assembly
17. U-Bolt Spherical Washer
18. Nut
19. Washer
20. Flatwasher
21. Nut
22. Bolt
23. Front Spring Hanger Bracket
24. Center Hanger and Equalizing Beam Assembly
25. Rear Spring U-Bolt Pad

Fig. 1, Hendrickson HFS Tandem Suspension, Disassembled View



1. Equalizing Beam Bushing
2. Bolt
3. Washer
4. Thrust Washers
5. Locknut

Fig. 2, Center Hanger and Equalizing Beam Assembly



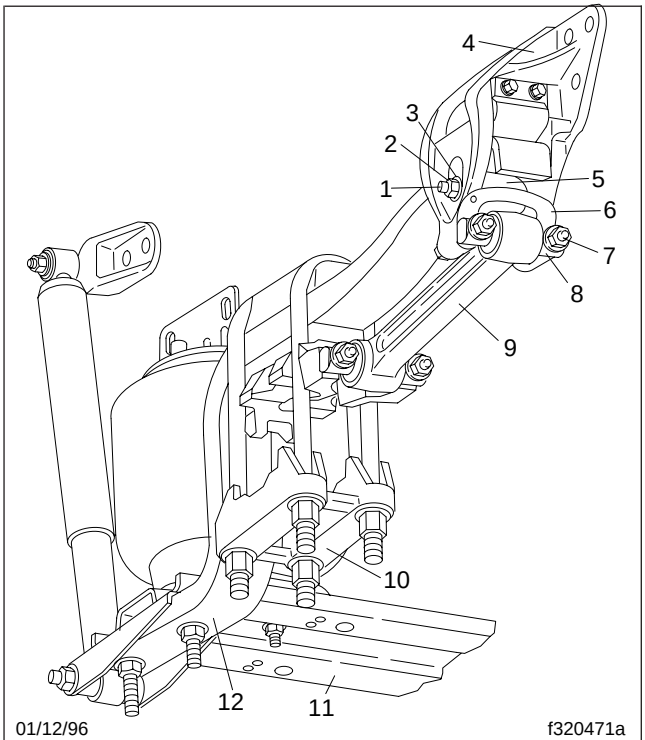
1. Front Spring Hanger Bracket
2. Washer
3. Frame
4. Crossmember
5. Locknut
6. Rebound Bolt
7. Washer (both sides)
8. Rebound Bolt Spacer
9. Locknut
10. Bolt

Fig. 3, Front Spring Hanger

Replacement (See Fig. 1)

Use the following procedure to replace the torque rod bushing.

1. Chock the front tires, and the tires of the drive axles.
2. Remove the bushing pin locknuts and washers at the axle end of the torque rod. See **Fig. 1**.



1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

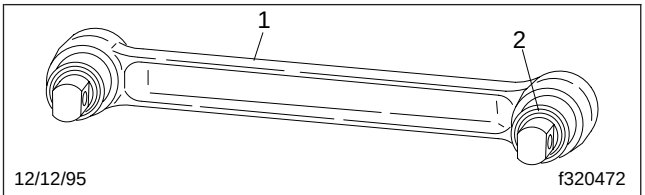
Fig. 1, Torque Rod Installation

3. Loosen the rebound bolt locknut in the hanger.
4. Remove the bushing pin locknuts, bolts and washers, and any alignment shims at the hanger end of the torque rod. Note the number of shims, as the same thickness shim pack must be reinstalled to avoid affecting the vehicle's alignment.
5. Push out the old bushings. Use a vertical shop press with a capacity of at least 10 tons. A 5-inch (127 mm) piece of 2-inch by 1/4-inch (50-mm by 6-mm) wall, steel-tubing receiving tool is required. The bushings are not cartridge-type bushings and do not have a metal outer sleeve.
6. Support the torque rod end on the receiving tool with the end tube of the torque rod centered on the tool.

⚠ WARNING

Do not use heat or a cutting torch to remove the bushings from the torque rod. The use of heat will weaken the torque rod, which could cause the rod to break. This could result in a loss of vehicle control, personal injury, or property damage.

7. Push directly on the bushing pin until the bushing is pushed out of the torque rod end tube.
8. Clean and inspect the torque rod ends. Remove any nicks with emery cloth.
9. Lubricate the torque rod ends and the new rubber bushings with a vegetable-based oil. Do not use a petroleum-based or soap-based lubricant.
10. Press in the new bushings while supporting the torque rod end on the receiving tool with the end tube of the torque rod centered on the receiving tool. The bushings must be installed with the mounting flats on the bar pin positioned 90 degrees to the shank of the torque rod. See **Fig. 2**.



1. Torque Rod
2. Bushing Bar Pin

Fig. 2, Positioning the Bar Pin Mounting Flats

11. Press directly on the bar pin of the bushings, which must be centered within the torque rod end tubes. When pressing in the new bushings, overshoot the final position by approximately 3/16 inch (5 mm).
12. Press the bushing again from the opposite side to center the bushing within the torque rod end.

Torque Rod Bushing Replacement

13. Position the torque rod into the axle seat and attach it with the washers and locknuts. Handtighten the locknuts.
14. Position the torque rod onto the forward face of the hanger legs. Assemble the bolts, washers and locknuts, and any alignment shims. Tighten locknut 175 lbf·ft (237 N·m). See **Fig. 1**.
15. Tighten locknuts at the axle end of the torque rods 175 lbf·ft (237 N·m).
16. Tighten rebound bolt locknut 60 lbf·ft (81 N·m).

Equalizing Beam Bushing Removal and Installation

Removal

⚠ WARNING

Do not use a cutting torch to remove any fasteners. Do not use a cutting torch to remove the bushings from the equalizing beam assembly. The use of heat on suspension components will adversely affect the strength of these parts. A component damaged in this manner can result in the loss of vehicle control and possible personal injury or property damage.

1. Chock the wheels of the rear drive axles, and raise the rear of the frame until the springs no longer contact the cam surface of the equalizer. See **Fig. 1**.

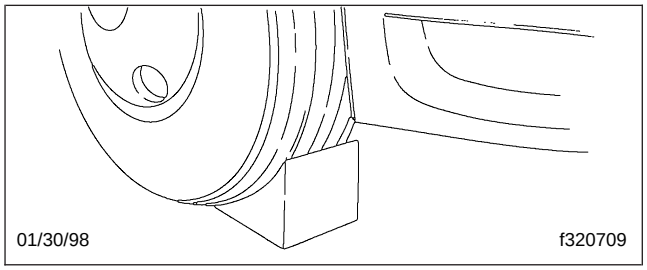


Fig. 1, Chocking the Wheels

NOTE: Note the number of shims at each location. These shims must be reinstalled in the same manner to avoid affecting suspension alignment.

2. Remove the torque rod bar pin lock nuts, bolts, washers and any shims from the center spring hanger. See **Fig. 2** .

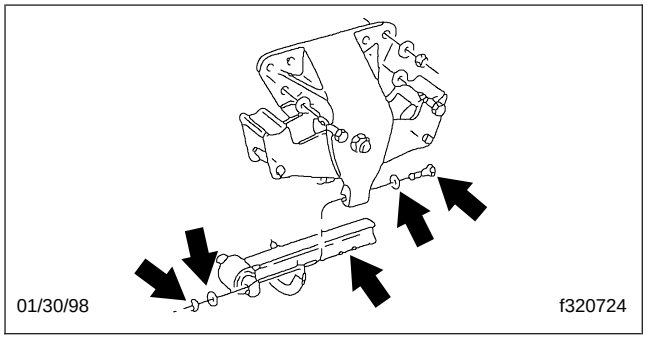


Fig. 2, Torque Rod Bar Pin Locknuts and Bolts

3. Remove the bolt, nut and washers that retain the equalizer beam to the spring hanger. See **Fig. 3** .

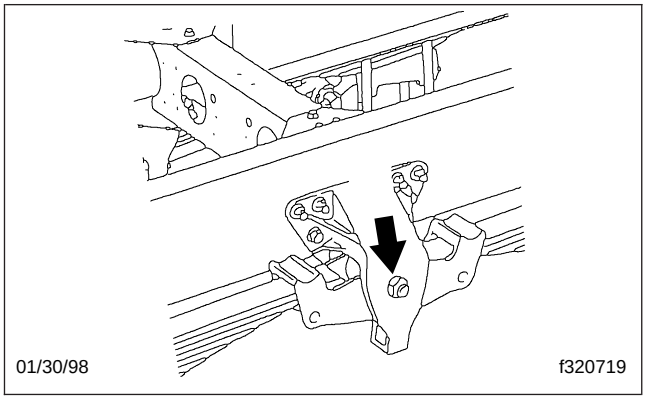


Fig. 3, Equalizer Beam to Spring Hanger Bolt

4. Remove the clevis pins, washers and cotter pins from the equalizer beam. See **Fig. 4** .

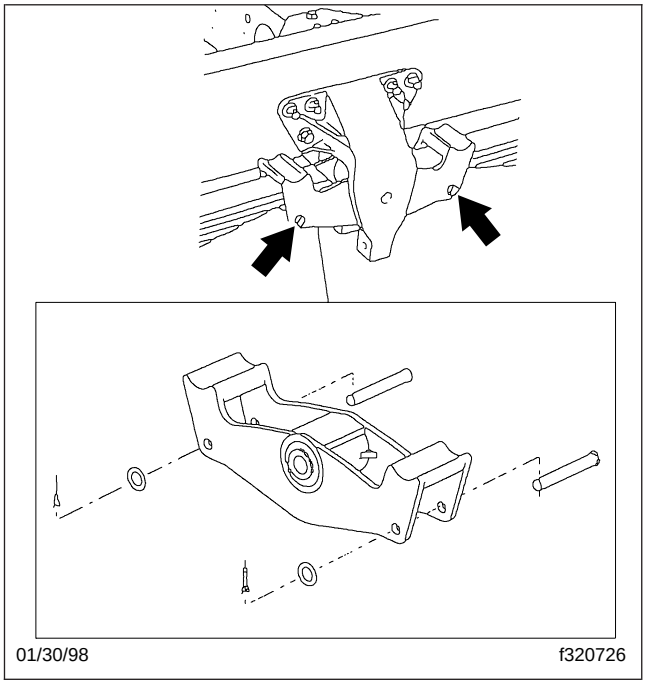


Fig. 4, Equalizer Beam Clevis Pins

5. Remove the equalizer beam from the center spring hanger.

Equalizing Beam Bushing Removal and Installation

⚠ WARNING

Do not use heat or a cutting torch to remove the bushing outer metals that are pressed in the beam assembly. The use of heat adversely affect the strength of the beam.

⚠ CAUTION

Make sure the beam is securely supported at the bore area on the press bed for safety and to avoid bending the equalizing beam.

6. Press out the old bushings, using a vertical shop press with a capacity of at least 15 tons. For bushing removal, use a 5 inch (127 mm) long piece of 2-5/8 inch OD x 1/4 inch wall steel tubing. See **Fig. 5** .

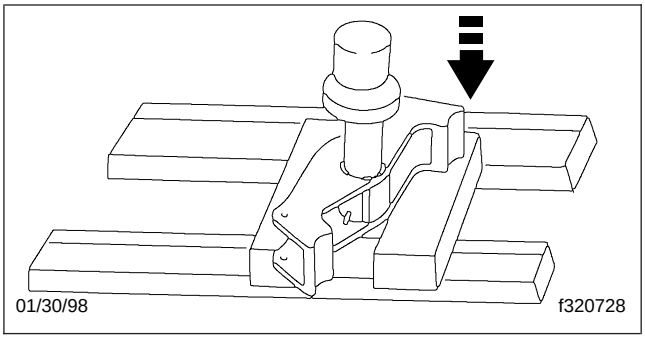


Fig. 5, Removing Bushing

Installation

1. Clean the bore of the equalizing beam with emery cloth to remove any nicks or metal buildup from the bushing removal.
2. Clean the outer metal of the new bushing with emery cloth to remove the phosphate coating that acts as a rust preventative. Apply a thin coat of grease on the outer metal of the bushing.

⚠ CAUTION

Make sure the beam is securely supported at the bore area on the press bed for safety and to avoid bending the equalizing beam.

3. Press in the new bushing. See **Fig. 6** .

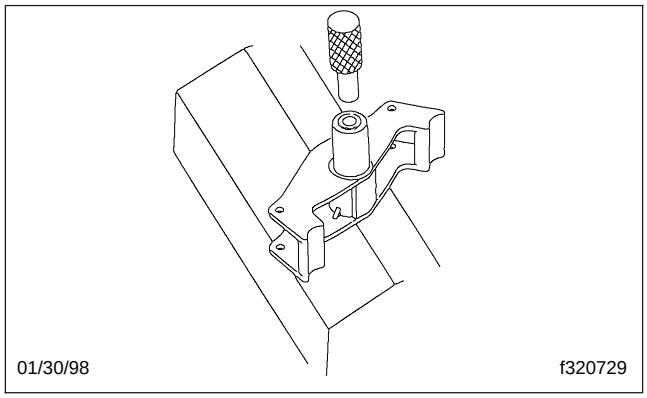


Fig. 6, Installing Bushing

3.1 For bushing installation, use a 3 inch (76 mm).

3.2 Center the bushing in the beam.

3.3 The pushing tool must contact only the outer metals of the bushing.

⚠ CAUTION

The end faces of the rubber bushing must be clean and dry before assembling the beam in the center spring hanger.

4. Remove any remaining grease from the ends of the rubber bushing.

NOTE: The inside diameters of the thrust washers must be on the outside diameter of the beam center bushing inner metal. There should be one thrust washer on each side of each beam.

5. Position the equalizing beam with the thrust washers in the center spring hanger. With the equalizing beam parallel to the frame as viewed from the side of the vehicle, tighten the lock nut. Assemble the bolt, washers and lock nut and tighten to 400 to 495 lbf·ft (542 to 671 N·m). See **Fig. 3** .
6. Assemble the clevis pins in the end of the equalizer. See **Fig. 4** .
7. Position the bar pin end of the torque rod at the forward face of the spring hanger legs, and reassemble the bolts, washers, lock nuts and any alignment shims. Tighten the lock nuts. See **Fig. 2** .

Torque Rod Removal and Installation

Removal

1. Chock the wheels of the drive axles. See **Fig. 1** .

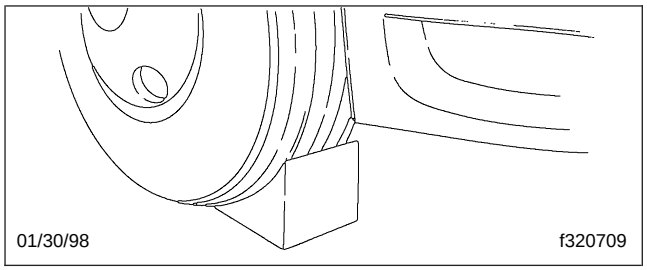


Fig. 1, Chocking the Wheels

⚠ WARNING

Do not use a cutting torch to remove any fasteners. Do not use a cutting torch to remove the bushings from the equalizing beam assembly. The use of heat on suspension components will adversely affect the strength of these parts. A component damaged in this manner can result in the loss of vehicle control and possible personal injury or property damage.

2. Remove the bar pin locknuts and washers at the axle end (spring seat) of the torque rod. See **Fig. 2** .

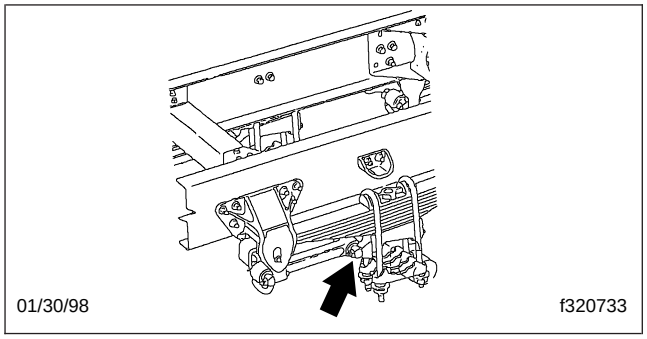


Fig. 2, Bar Pin Locknuts, Axle End

3. Loosen the rebound bolt in the spring hanger from which the torque rod is being removed. See **Fig. 3** .

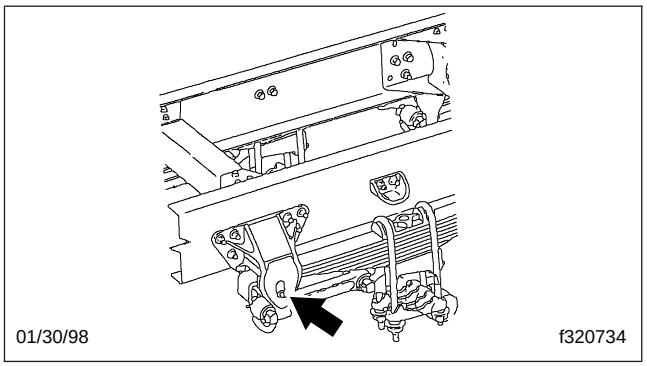


Fig. 3, Rebound Bolt

⚠ CAUTION

Note the number of shims at each location. These must be installed in the same manner to avoid affecting the alignment.

4. Remove the bar pin locknuts, bolts, washers and any alignment shims at the spring hanger end of the torque rod. See **Fig. 4** .

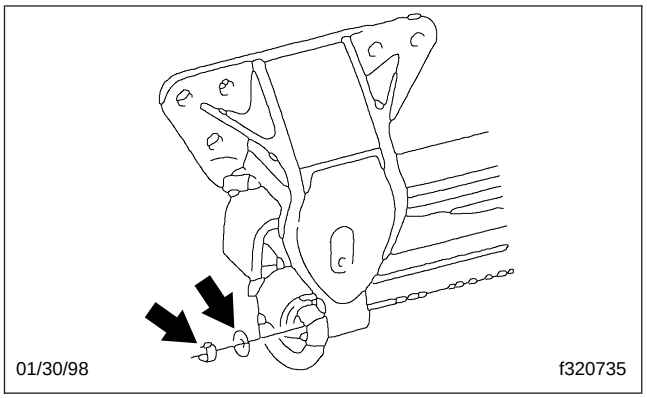


Fig. 4, Bar Pin Locknuts, Spring Hanger End

Installation

NOTE: The torque rod can be installed in one way only. Make sure to read the directional instructions on the rod before installation.

1. Position the axle end of the new torque rod on the axle cap studs, and assemble the washers and locknuts hand-tight. See **Fig. 2** .

Torque Rod Removal and Installation

NOTE: For the center spring hanger, the equalizing beam center bolt must be tightened before the rear torque rod is installed.

2. Position the forward bar pin end of the new torque rod at the forward face of the spring hanger legs, and assemble the bolts, washers, locknuts and any alignment shims that were removed. Tighten all four of the locknuts 150 to 205 lbf·ft (204 to 277 N·m). See **Fig. 4** .

Torque Rod Bushing Removal and Installation

Removal

WARNING

Do not use a cutting torch to remove any fasteners. Do not use a cutting torch to remove the bushings from the equalizing beam assembly. The use of heat on suspension components will adversely affect the strength of these parts. A component damaged in this manner can result in the loss of vehicle control and possible personal injury or property damage.

1. Use a press with a minimum capacity of 10 tons.

CAUTION

Make sure the torque rod is securely supported on the press bed to prevent damage to the component.

2. Support the torque rod on a piece of 1/4 inch (6.4 mm) wall steel tubing that is 5 inches (127 mm) long with an inside diameter of 2.0 inches (50.8 mm). See **Fig. 1** .

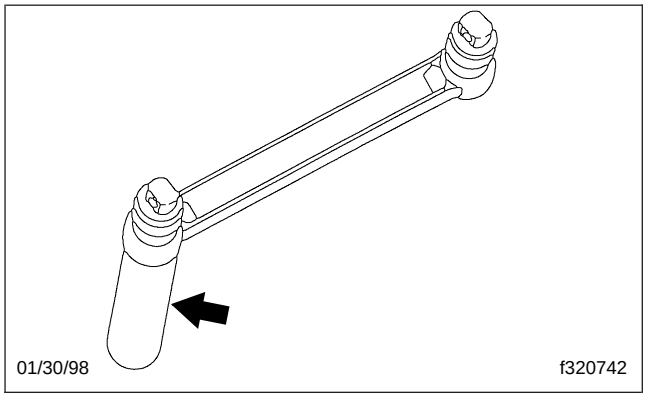


Fig. 1, Supporting Torque Rod for Bushing Removal

3. Push directly on the bar pin to remove the bushing from the torque rod. See **Fig. 2** .

Installation

1. Clean and inspect the inside diameter of the ends of the torque rod. Use emery cloth to remove any nicks and small scratches from the bore. See **Fig. 3** .

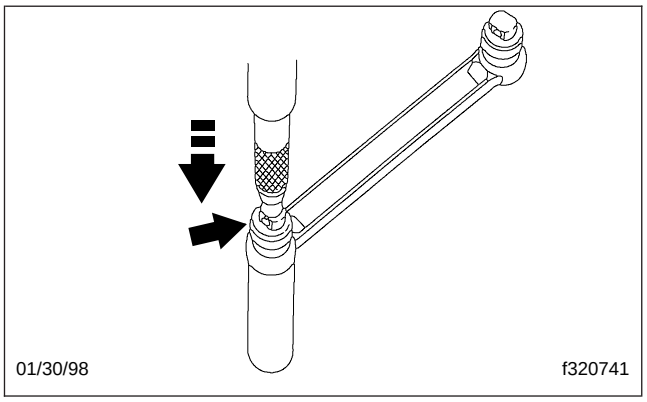


Fig. 2, Bushing Removal

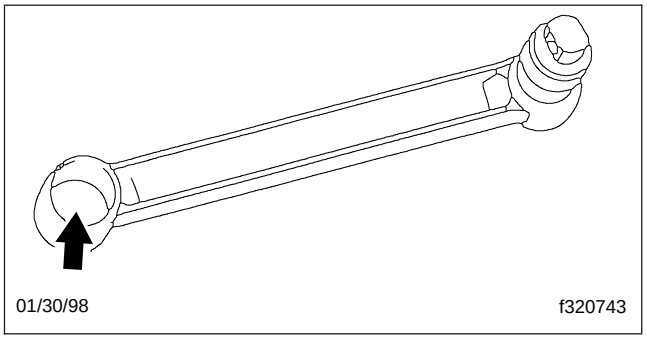


Fig. 3, Torque Rod Inspection

CAUTION

To prevent damage to the bushing, do not use a petroleum- or a soap-base lubricant.

2. Lubricate the inside diameter of the torque rod and the new bushing with a vegetable-base oil, such as cooking oil, or lard.

CAUTION

Make sure the torque rod is securely supported on the press bed to prevent damage to the component.

3. Support the torque rod on the piece of steel tubing used during removal. Make sure the bore of the torque rod is centered in the tube. See **Fig. 4**.

NOTE: The angles shown are counterclockwise to the shank of the rod.

Torque Rod Bushing Removal and Installation

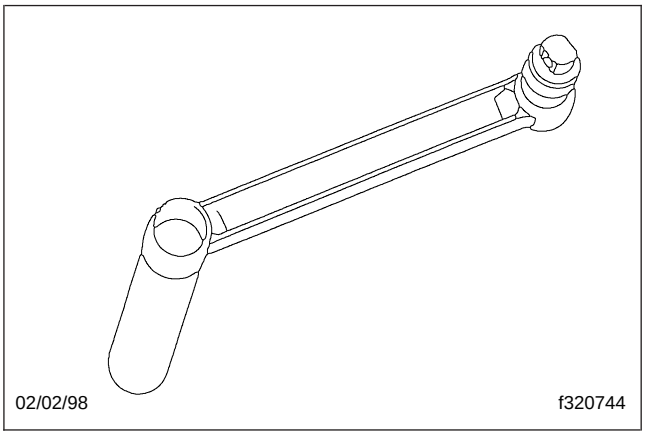


Fig. 4, Supporting Torque Rod, Bushing Installation

4. Put the bushing in the bore of the torque rod so the mounting flat of the bar pin is positioned as shown in **Fig. 5** and **Fig. 6** .

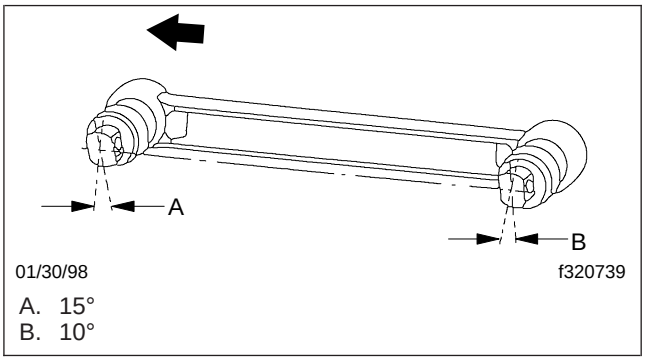


Fig. 5, Front Torque Rod Bushing Installation

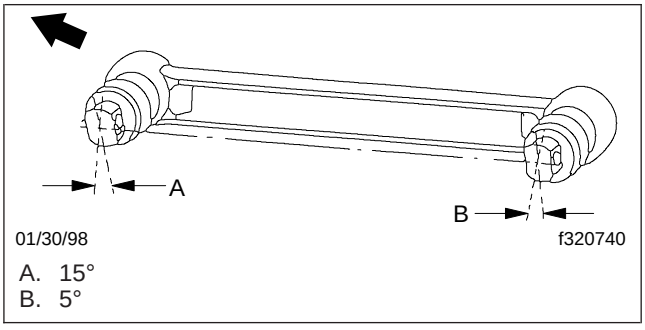


Fig. 6, Rear Torque Rod Bushing Installation

5. Press the bushing into the torque rod so the bushing extends 3/16 inch (4.8 mm) on the opposite side of the torque rod.

6. Turn the torque rod over, and press on the bar pin so the bushing is centered in the torque rod bore.

Torque Specifications	
Description	**lbf·ft (N·m)**
Front Spring Bracket Bolts	220–300 (299–406)
Center Spring Bracket Bolts	220–300 (299–406)
Rear Spring Bracket Bolts	220–300 (299–406)
Axle Bumper Bolts	220–300 (299–406)
Spring Bracket Rebound Spacer Bolt	150–205 (204–277)
Beam Assembly Center Bracket Bolt (After Rear Torque Rod Is Installed)	400–495 (542–671)
Rebound Bolt Lock Nut	75–105 (102–142)
Spring U-Bolts Nuts	360–480 (489–650)
Torque Rod Bolts, Front and Rear	150–205 (204–277)

Table 1, Torque Specifications

NOTE: All other torque limits (including Grade 8 U-bolts) are determined by the following bolt or nut diameters.

NOTE: Retighten to the specified torque after the first 1,000 miles (1 609 km) of service on a new vehicle or a vehicle with a serviced spring assembly, and each 100,000 miles (160 934 km) of service thereafter.

NOTE: All threads must be clean before assembly to obtain the correct relationship of torque and fastener tension. To obtain maximum service lift from the suspension system, mounting bolts and nuts must be checked periodically and tightened to the specified torque.

Standard Bolt Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
1/4-Inch Diameter, Grade 5	—	89–115 (1000–1300)
5/16-Inch Diameter, Grade 5	12–17 (17–23)	—
3/8-Inch Diameter, Grade 8	32–41 (43–56)	—
7/16-Inch Diameter, Grade 8	50–70 (68–95)	—
1/2-Inch Diameter, Grade 8	75–105 (102–142)	—
9/16-Inch Diameter, Grade 8	110–150 (149–203)	—
5/8-Inch Diameter, Grade 8	150–205 (204–277)	—
3/4-Inch Diameter, Grade 8	220–300 (299–406)	—
7/8-Inch Diameter, Grade 8	360–480 (489–650)	—
1.0-Inch Diameter, Grade 8	540–730 (733–989)	—

Table 2, Standard Bolt Torque Specifications

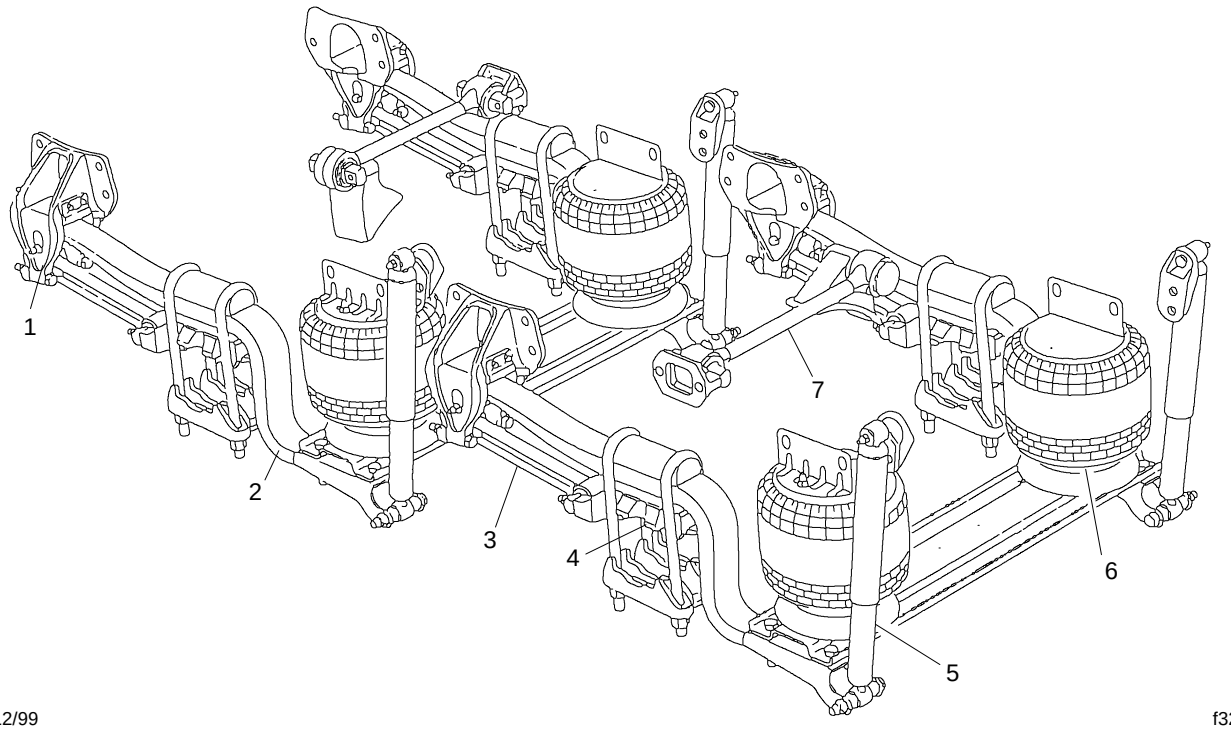
General Description

The Hendrickson HAS suspension (see **Fig. 1**) uses air bags to support the sprung weight on vehicles with both single and tandem axles. The air bags (air springs) mount on a crossmember between the two main support beams that are fastened to the axle housing and pivot on forward-mounted hanger brackets on the frame. Torque rods, running from the hanger brackets to the axle seats, transfer vehicle motion to the frame. Lateral stability is provided by transverse torque rods from the inside of the frame rails to brackets on the axle housings. The shock absorbers help to dampen the oscillations of the air springs and control the torque reaction of the axle housings on acceleration.

AIR CONTROL SYSTEM

The Hendrickson HAS air suspension system allows for a smooth ride while maintaining a constant ride height, even with varying loads. Although most vehicles with the HAS system use only one height control valve for the rear suspension, some vehicles with uneven loading may have a height control valve for each side of the vehicle. An optional suspension dump system permits the driver to temporarily lower the frame for trailer coupling or uncoupling without having to leave the cab. See **Subject 400** for a schematic of the air control system.

The suspension air control system uses air supplied from the secondary air brake system. The air supply line is connected to a secondary air manifold located behind the instrument panel. If a loss of air pressure occurs forward (upstream) of the protection valve,



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1. Hanger Bracket
2. Main Support Beam
3. Torque Rod
4. Axle Seat
5. Shock Absorber
6. Air Spring
7. Transverse Rod

Fig. 1, Rear Suspension, Hendrickson HAS-Series

the air spring system will be isolated and maintain the air pressure within the suspension system until repairs can be made. However, if a loss of air occurs rearward (downstream) of the protection valve, the air in the brake system will be protected, but the air pressure in the air springs will be lost.

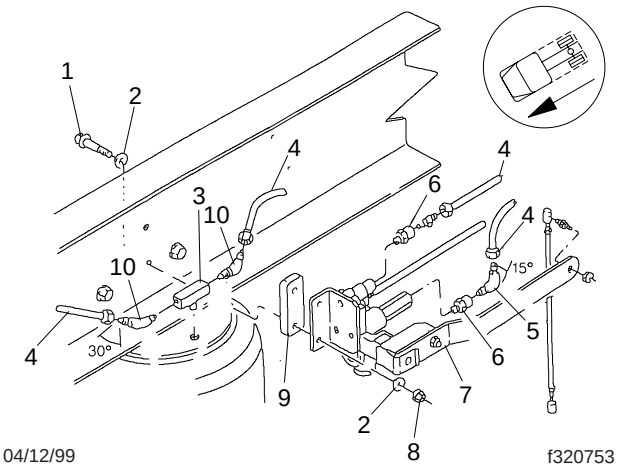
The vehicle ride height is maintained by a height control valve mounted on the frame and linkage that connects the valve to the suspension crossmember. (See **Fig. 2**). As the frame-to-axle housing clearance changes due to a change in the vehicle load, the linkage moves the lever on the height control valve, causing air to move in or out of the air bags. A slight delay in the operation of the height control valve prevents the system from trying to adjust the ride height for each suspension movement.

The optional air suspension dump system is used to deflate the rear suspension air springs during trailer coupling and uncoupling operations. The dump control valve is located on the dash in the cab. When the dump control valve is toggled, supply air flows through the dump control valve delivery port and pressurizes the signal line to the relay valve. The pressurization of the signal line closes the relay valve supply port while opening the ports from the air bags to the atmosphere. Air from the air bags exhausts through the relay valve until the dump control valve is released or until the frame rests on the stops inside the air bags. A pressure switch in the signal line to the relay valve senses the signal pressure and switches on an optional red status light on the dash. To allow the air springs to inflate after being dumped, the dump control valve must be first toggled downward to exhaust the pressure in the signal line.

The pilot-operated relay valve is used for rapid deflation of the air bags for trailer coupling and uncoupling. When pilot pressure from the dump control valve is applied to the relay valve, the supply air from the height control valve is stopped from flowing through the relay valve and, simultaneously, the air spring pressure is exhausted directly to the atmosphere through passages in the relay valve.

REAR SUSPENSION COMPONENTS

The axle housing, the lower shock mounts and the lower air bag mounts are all solidly attached to the HAS main support arms. See **Fig. 3 and Fig. 4**. The main support arm hanger brackets, the upper shock



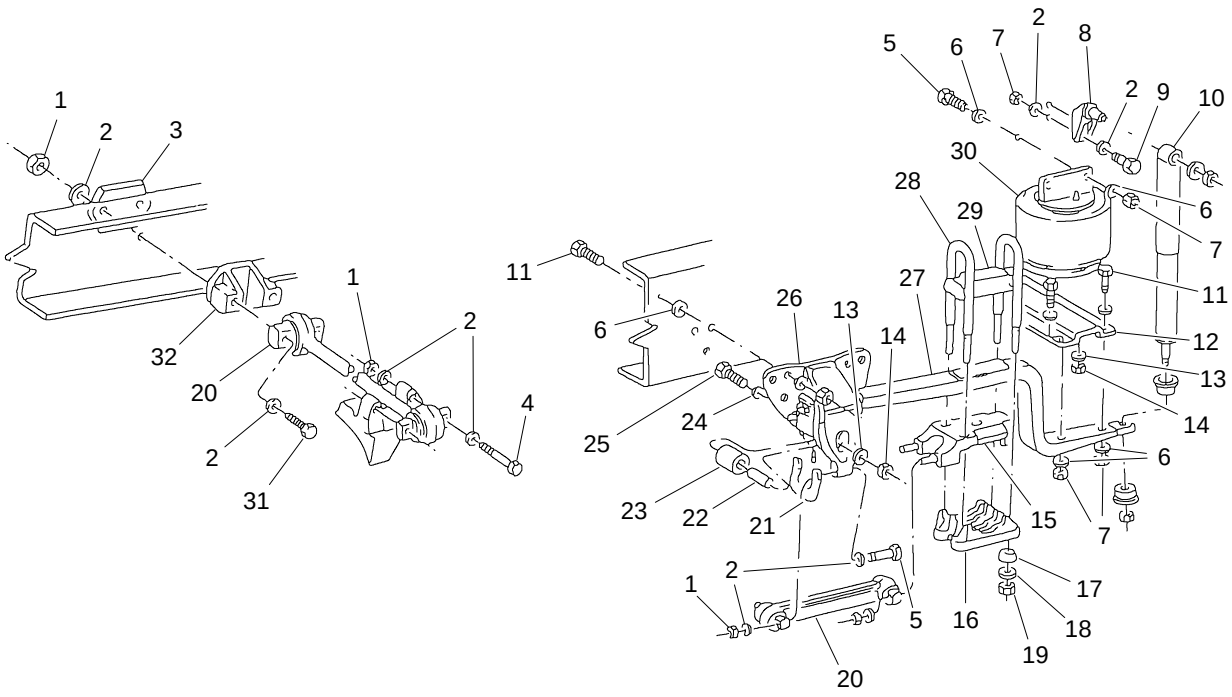
1. Bolt
2. Washer
3. Tee
4. Tube Assembly
5. Elbow
6. Adapter
7. Height Control Valve
8. Nut
9. Bracket
10. Elbow

Fig. 2, Height Control Valve Assembly (typical)

mounts and the upper air bag mounts are all solidly mounted to the frame rails. The torque rods, with flexible bushings in each end, connect the hangers to the axle seats. When the vehicle travels over a bump, the axle housing suddenly rises and compresses the air bags. The pressure in the air bags increases immediately, which absorbs most of the energy of the upward-moving axle housing without transferring that movement to the frame. The shock absorbers then help absorb the release of that higher pressure by slowing the downward movement of the axle housing after the bump.

The front of each main support arm is allowed to pivot and slide on replaceable slipper pads in the hanger brackets. A torque rod is attached to each hanger bracket and to each axle seat bracket by rubber bushings with internal pins, installed in the torque rods at specified angles. Shims are used for adjustment at the front of each torque rod to make sure that the wheels run parallel to the frame rails.

The torque rods control the forward and aft movement of the unsprung pieces during suspension travel. The flexible rubber bushings in the torque rods allow vertical movement of the axle housing while limiting its forward and aft movement. The driveline angles are kept within the specified limits by the torque rods' control of the rotational forces on the



1. Nut
2. Washer
3. Reinforcement
4. Bolt
5. Bolt
6. Washer
7. Nut
8. Shock Absorber Mounting Bracket
9. Bolt
10. Shock Absorber
11. Bolt
12. Suspension Support
13. Washer
14. Nut
15. Axle Seat
16. Bottom Cap Assembly
17. Spherical Washer
18. Washer
19. Nut
20. Transverse Rod Assembly
21. Alignment Shims
22. Spacer
23. Rebound Roller
24. Washer
25. Bolt
26. Hanger
27. Main Support Beam
28. U-Bolt
29. Top Pad
30. Air Spring Assembly
31. Bolt
32. Bracket

Fig. 3, Rear Suspension Components, Hendrickson HAS-40LH Series

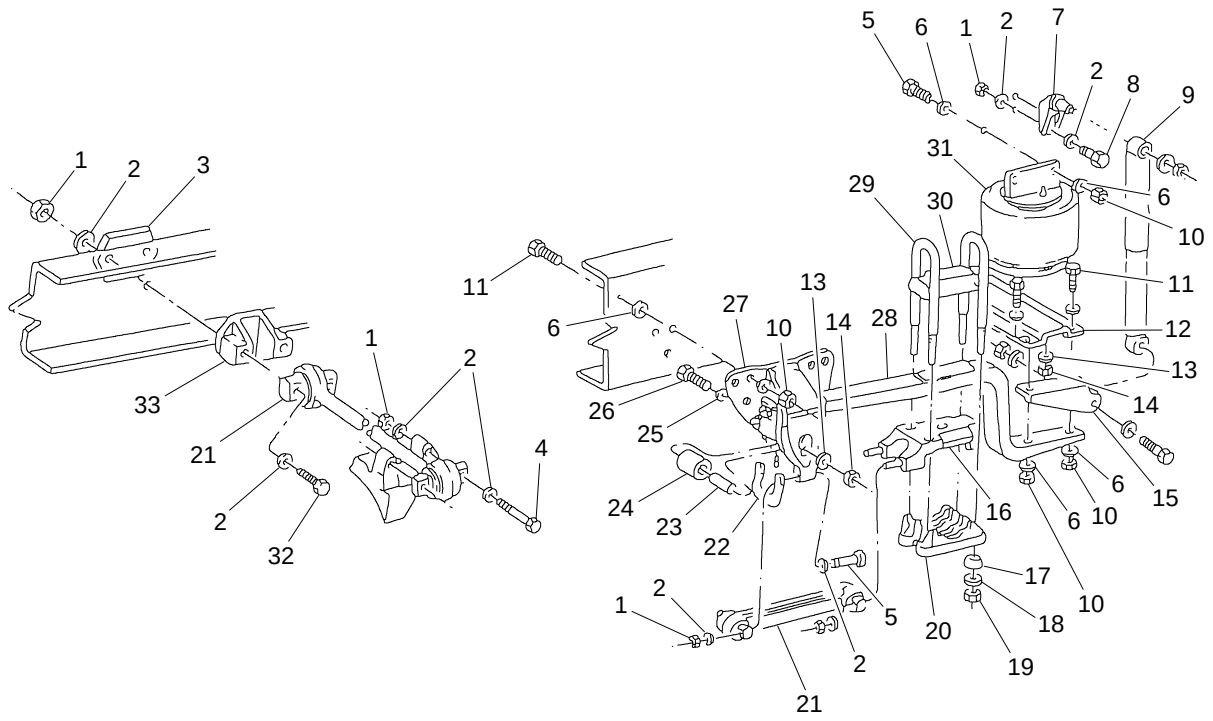
axle housings during acceleration and deceleration. The torque rods transfer the forward motion of the axle housing to the frame rails on acceleration and pull back on the frame during braking.

The transverse rods, also with rubber bushings in each end, connect the brackets on the axle housings to the brackets on the frame rails. The transverse rods keep a constant lateral relationship of the frame to the axle housing, while still allowing vertical movement of the axle housings.

The Hendrickson HAS suspension is available in varying capacities and for limited off-highway use.

The heavy-duty or off-highway suspensions have thicker main support arms, heavier crossmembers and torque rods, and heavy-duty air bags and shock absorbers. There are two HAS ride height specifications (measured from the bottom of the frame rail to the bottom of the main support arm at the axle seat) depending on which suspension is used. The HAS suspensions are available for single or tandem axle vehicles and can be ordered with or without the suspension dump feature.

General Information



1. Nut
2. Washer
3. Reinforcement
4. Bolt
5. Bolt
6. Washer
7. Shock Absorber Mounting Bracket
8. Bolt
9. Shock Absorber
10. Nut
11. Bolt
12. Suspension Support
13. Washer
14. Nut
15. Shock Absorber Mounting Bracket
16. Axle Seat
17. Spherical Washer
18. Washer
19. Nut
20. Bottom Cap Assembly
21. Transverse Rod Assembly
22. Alignment Shims
23. Spacer
24. Rebound Roller
25. Washer
26. Bolt
27. Hanger
28. Main Support Beam
29. U-Bolt
30. Top Pad
31. Air Spring Assembly
32. Bolt
33. Bracket

Fig. 4, Rear Suspension Components, Hendrickson HAS-400, HAS-402, and HAS-460 Series

REAR SUSPENSION SERVICE NOTES

⚠ WARNING

A main support member that has been subjected to heat, nicks or gouges can fail, causing loss of vehicle control and possible personal injury or property damage.

⚠ CAUTION

Do not use an arc welder on the suspension parts or use a cutting torch to remove any fasteners. The use of heat on suspension components will adversely affect the strength of these parts. Never reinstall used suspension fasteners. Always use the same part number or an exact equivalent part number when replacing any suspension fastener. All fasteners must be tightened

to their specified torque and the U-bolts must be tightened in stages as described in Specifications 400.

Check the axle alignment after replacing components that affect alignment, such as a main support beam, a torque rod or a hanger.

NOTE: During installation, apply Pipe Sealant with Teflon D8AZ–19554–A or equivalent meeting specification WSK–M2G350–A2 or ESR–M18P7–A to the air fitting threads.

NOTE: When replacing the torque rod bushings, lubricate the new bushings with a vegetable-based oil only. Make sure the new bushings are centered in the torque rod bores.

NOTE: A shim pack of three 0.11 inch (2.8 mm) thick spacers are used to adjust axle lateral tracking offset. Install the spacers as required to adjust tracking.

Main Support Member Removal and Installation

Removal

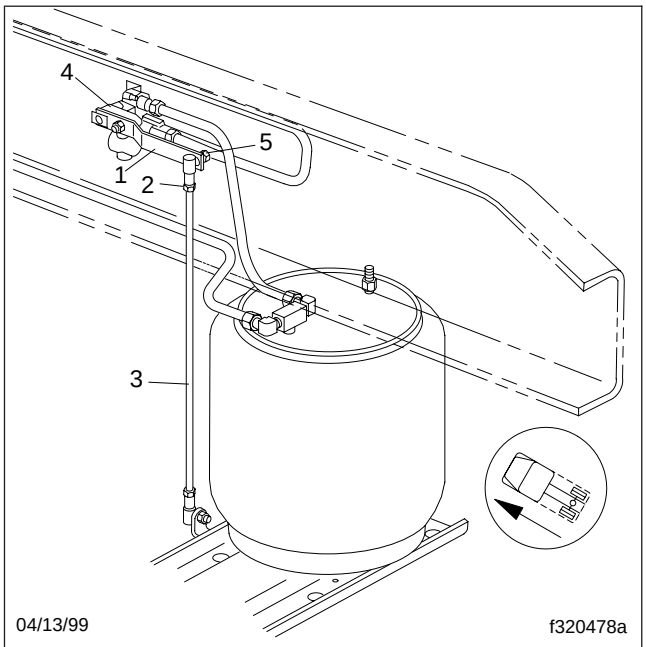
NOTE: Operation of the HAS suspension will result in wear between the main support member and the spring hanger slipper pad. In normal use, these components will function satisfactorily even though they show some wear. Premature wear may occur, however, and requires the replacement of one or both parts. A main support member should be replaced if it has 3/8 inch (9.5 mm) or more wear at the hanger cam contact area.

1. Stop the vehicle on a level surface, shut down the engine and apply the park brakes. Chock the front and rear tires.
2. Support the axle housing with a jack stand under the pinion nose to prevent the axle housing from rotating when the U-bolts are removed.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

3. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the frame about 3 inches (75 mm). Support the frame at that position with jack stands.
4. Remove the locknuts, washers and bolts that connect the cross channel and shock absorber brackets to both main support members. See **Fig. 2**. Remove the lower shock mount fasteners on the HAS–40LH models.
5. Use a floor jack to raise the cross channel about 3 inches (75 mm). Support the cross channel assembly with jack stands.
6. Remove the locknut, washers and bolt from the rebound roller assembly at the front hanger. See **Fig. 3**. Remove the rebound roller and spacer.
7. Remove the U-bolt high nuts and washers, then remove the bottom cap, U-bolts and the top pad and Delrin liner.

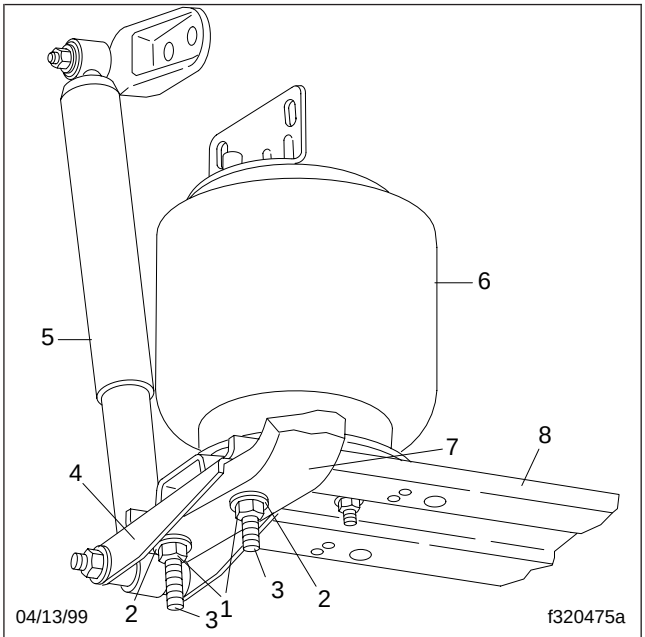


1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Ride Height Control Linkage

8. Slide the main support member out of the hanger and remove the main support assembly from the vehicle.
9. Inspect the main support member for wear. Replace the main support member if worn more than 3/8 inch (9.5 mm) at the hanger end where it contacts the slipper pad or if it has cracks, nicks or signs of the application of heat from a torch or welder.
10. Inspect the slipper pad for wear. Replace the slipper pad if worn. Remove the four bolts and washers that hold the slipper pad to the hanger. If rivets were installed instead of bolts to hold the slipper pad, use a grinder to remove the rivet heads.

Main Support Member Removal and Installation



1. Locknut
2. Washer
3. Bolt
4. Lower Shock Bracket
5. Shock Absorber
6. Air Spring
7. Main Support Member
8. Cross Channel

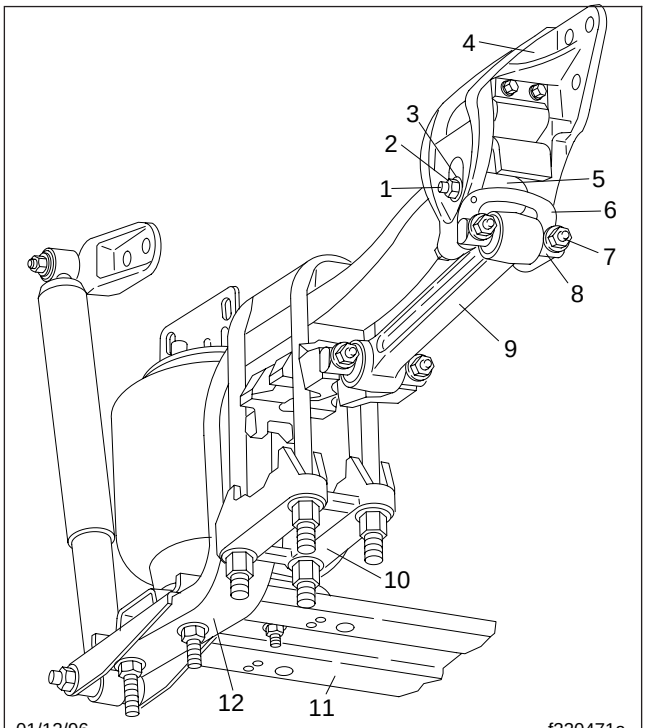
Fig. 2, Main Support Member

Installation

⚠ WARNING

Always use new fasteners when installing suspension components. Reuse of fasteners can lead to component damage and loss of vehicle control, possibly resulting in personal injury or property damage.

1. Install the slipper pad, bolts and washers into the hanger. Tighten the bolts 25 lbf·ft (34 N·m). Install new rivets if so equipped.
2. Slide the main support member into the hanger assembly.
3. Position the main support member on the axle seat, or on the spacer plate if the vehicle is so equipped, with the main support member center dowel sliding into the hole in the axle seat or spacer plate.



1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

Fig. 3, Removing the Rebound Roller

4. The Delrin liner must be positioned on the top of the main support member. Install the U-bolt top pad on the Delrin liner. Install the U-bolts over the top pad and liner and around the main support member, the spacer (if so equipped), the axle seat assembly, the axle housing, and the bottom cap. Install the washers and high nuts and tighten with your fingers, but do not fully tighten the U-bolt high nuts at this time.
5. Lower the floor jack under the cross channel until the cross channel is against the main support members. Install the shock absorber bracket (if so equipped) and bolts into the cross channel and main support members. See **Fig. 2**. Install the washers and tighten the locknuts 280 lbf·ft (380 N·m). On the HAS–40LH models, install the

lower shock absorber mount bolts, washers and nuts. Tighten the shock absorber nut 60 lbf·ft (82 N·m).

6. Install the rebound roller into the hanger. Install the bolt, washer and locknut. Tighten the locknut 60 lbf·ft (82 N·m).
7. Center the main support member between the hanger legs. Move the lever for the height control valve up to lift the frame from its jack stands. Remove the jack stands from the frame.
8. Tighten the U-bolt locknuts in stages as described in **Specifications 400**. Rap the top of the U-bolts with a hammer and then retighten the high nuts 500 lbf·ft (680 N·m).

IMPORTANT: Do not exceed the specified torque on the U-bolt high nuts. Retighten the U-bolt high nuts after 1000 miles (1600 km).

9. Move the lever for the height control valve down to lower the frame until the upper ball joint stud in the vertical linkage exactly aligns with the hole in the lever when the lever is in the horizontal position. Install the height control valve ball joint stud, washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
10. Remove the jack stand from under the nose of the axle housing.
11. Check and adjust the ride height as described in **Subject 180**.
12. Check the alignment after new main support members are installed.

Removal

1. Stop the vehicle on a level surface, shut down the engine and apply the park brakes. Chock the front and rear tires.
2. Support the axle housing with a jack stand under the pinion nose to prevent the axle housing from rotating when the U-bolts are removed.

⚠ WARNING

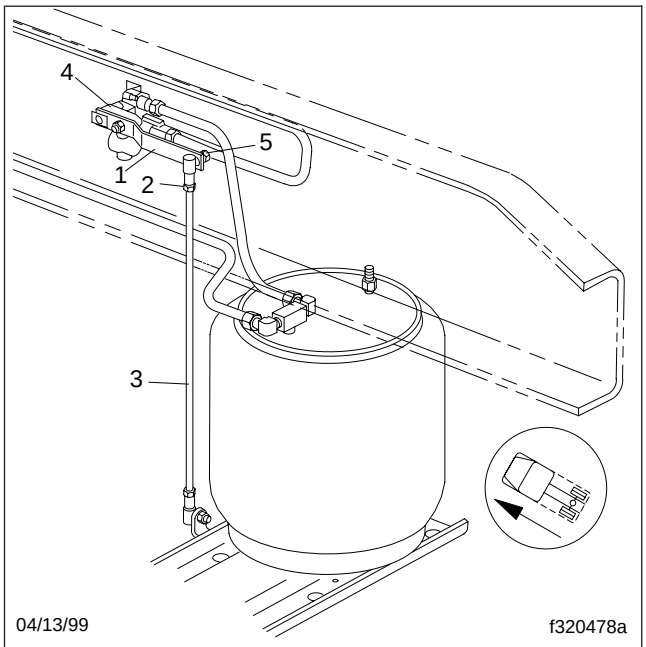
The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

3. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the rear of the frame about 3 inches (75 mm). Support the frame at that position with jack stands.
4. Remove the nuts, washers and bolts that hold the torque rod to the hanger legs.
5. Remove the nuts and washers that hold the torque rod to the axle seat. Remove the torque rod.
6. Remove the high nuts from the U-bolts and remove the bottom cap and top pad and Delrin liner.
7. Use a floor jack to raise the cross channel and main support member just enough to remove the axle seat.
8. Remove the axle seat. See **Fig. 2**.
9. If the axle seat studs need replacement, remove them with a hammer and brass drift.

Installation

⚠ WARNING

Always use new fasteners when installing suspension components. Reuse of fasteners can lead to component damage and loss of vehicle control, possibly resulting in personal injury or property damage.

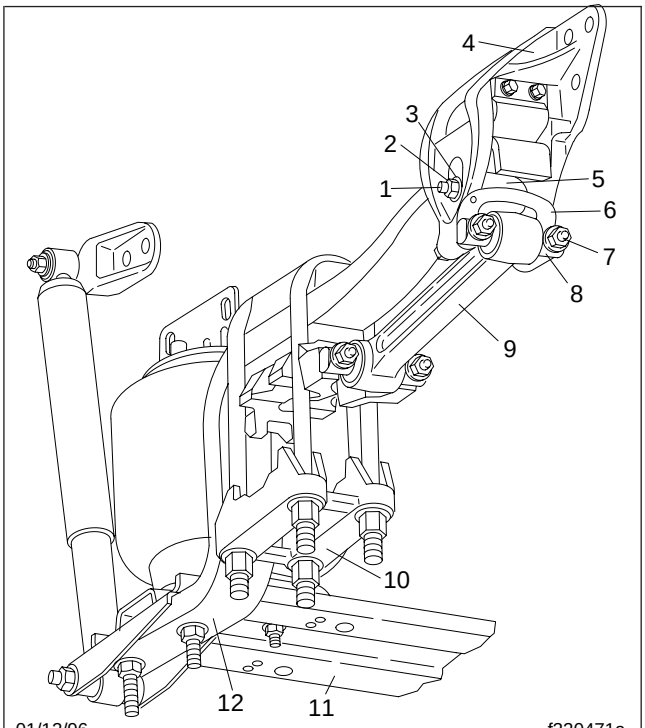


1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Ride Height Control Linkage

1. Install the new studs with a stud driver. Insert the stud in the hole of the axle seat and tap into position with a hammer and brass drift.
2. Lift the main support member with a floor jack and install the axle seat on the top of the axle housing. Install the spacer (if so equipped) above the axle seat.
3. Position the main support member on the axle seat, or on the spacer plate if the vehicle is so equipped, with the main support member center dowel sliding into the hole in the axle seat or spacer plate.
4. The Delrin liner must be positioned on the top of the main support member. Install the U-bolt top pad on the Delrin liner. Install the U-bolts over the top pad and liner and around the main support member, the spacer (if so equipped), the axle seat assembly, the axle housing, and the bottom cap. Install the washers and high nuts

Axle Seat Removal and Installation



1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

Fig. 2, Removing the Axle Seat

and tighten with your fingers, but do not fully tighten the U-bolt high nuts at this time.

5. Install the torque rod on the axle seat so that the holes in the bushing pin align with the axle seat studs. Install the washers and nuts, but do not tighten at this time.
6. Install the front end of the torque rod onto the hanger legs and install any shims that were removed. Install the bolts through the hanger legs, shims, and the front bushing pin.
7. Tighten the nuts on the front of the torque rod 175 lbf·ft (237 N·m).
8. Tighten the nuts for the torque rod pin at the axle seat 175 lbf·ft (237 N·m).
9. Move the lever for the height control valve up to lift the frame from its jack stands, Remove the jack stands from the frame.
10. Tighten the U-bolt locknuts in stages as described in **Specifications 400**. Rap the top of the U-bolts with a hammer and then retighten the high nuts 500 lbf·ft (680 N·m).

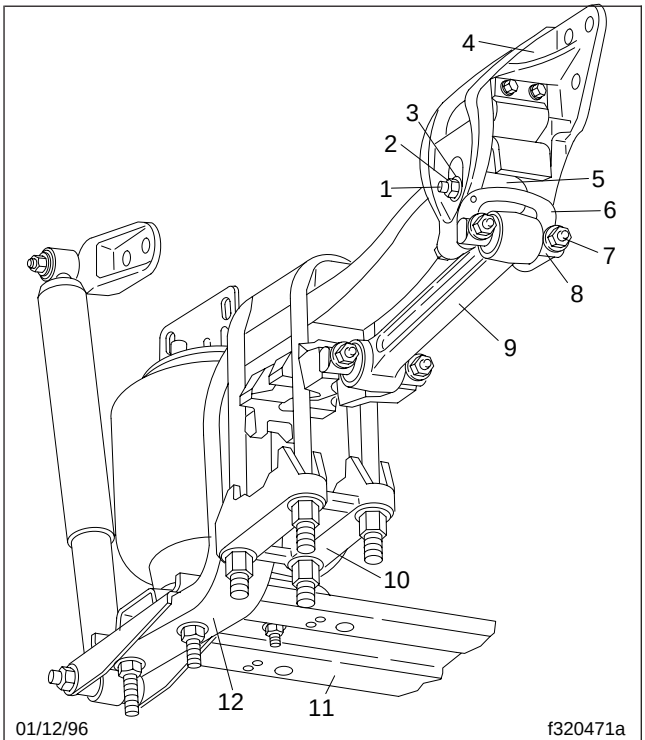
IMPORTANT: Do not exceed the specified torque on the U-bolt high nuts. Retighten the U-bolt high nuts after 1000 miles (1600 km).

11. Move the lever for the height control valve down to lower the frame until the upper ball joint stud in the vertical linkage exactly aligns with the hole in the lever when the lever is in the horizontal position. Install the height control valve ball joint stud, washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
12. Remove the jack stand from under the nose of the axle housing.
13. Check and adjust the ride height as described in **Subject 180**.
14. Check the alignment after new axle seats are installed.

Replacement (See Fig. 1)

Use the following procedure to replace the torque rod bushing.

1. Chock the front tires, and the tires of the drive axles.
2. Remove the bushing pin locknuts and washers at the axle end of the torque rod. See **Fig. 1**.



1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

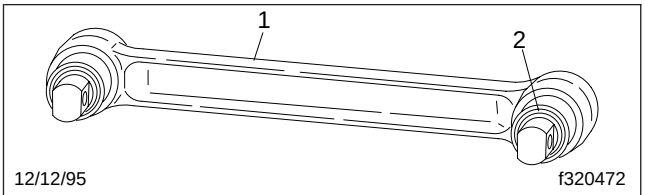
Fig. 1, Torque Rod Installation

3. Loosen the rebound bolt locknut in the hanger.
4. Remove the bushing pin locknuts, bolts and washers, and any alignment shims at the hanger end of the torque rod. Note the number of shims, as the same thickness shim pack must be reinstalled to avoid affecting the vehicle's alignment.
5. Push out the old bushings. Use a vertical shop press with a capacity of at least 10 tons. A 5-inch (127 mm) piece of 2-inch by 1/4-inch (50-mm by 6-mm) wall, steel-tubing receiving tool is required. The bushings are not cartridge-type bushings and do not have a metal outer sleeve.
6. Support the torque rod end on the receiving tool with the end tube of the torque rod centered on the tool.

⚠ WARNING

Do not use heat or a cutting torch to remove the bushings from the torque rod. The use of heat will weaken the torque rod, which could cause the rod to break. This could result in a loss of vehicle control, personal injury, or property damage.

7. Push directly on the bushing pin until the bushing is pushed out of the torque rod end tube.
8. Clean and inspect the torque rod ends. Remove any nicks with emery cloth.
9. Lubricate the torque rod ends and the new rubber bushings with a vegetable-based oil. Do not use a petroleum-based or soap-based lubricant.
10. Press in the new bushings while supporting the torque rod end on the receiving tool with the end tube of the torque rod centered on the receiving tool. The bushings must be installed with the mounting flats on the bar pin positioned 90 degrees to the shank of the torque rod. See **Fig. 2**.



1. Torque Rod
2. Bushing Bar Pin

Fig. 2, Positioning the Bar Pin Mounting Flats

11. Press directly on the bar pin of the bushings, which must be centered within the torque rod end tubes. When pressing in the new bushings, overshoot the final position by approximately 3/16 inch (5 mm).
12. Press the bushing again from the opposite side to center the bushing within the torque rod end.

Torque Rod Bushing Replacement

13. Position the torque rod into the axle seat and attach it with the washers and locknuts. Handtighten the locknuts.
14. Position the torque rod onto the forward face of the hanger legs. Assemble the bolts, washers and locknuts, and any alignment shims. Tighten locknut 175 lbf·ft (237 N·m). See **Fig. 1**.
15. Tighten locknuts at the axle end of the torque rods 175 lbf·ft (237 N·m).
16. Tighten rebound bolt locknut 60 lbf·ft (81 N·m).

Height Control Valve Removal and Installation

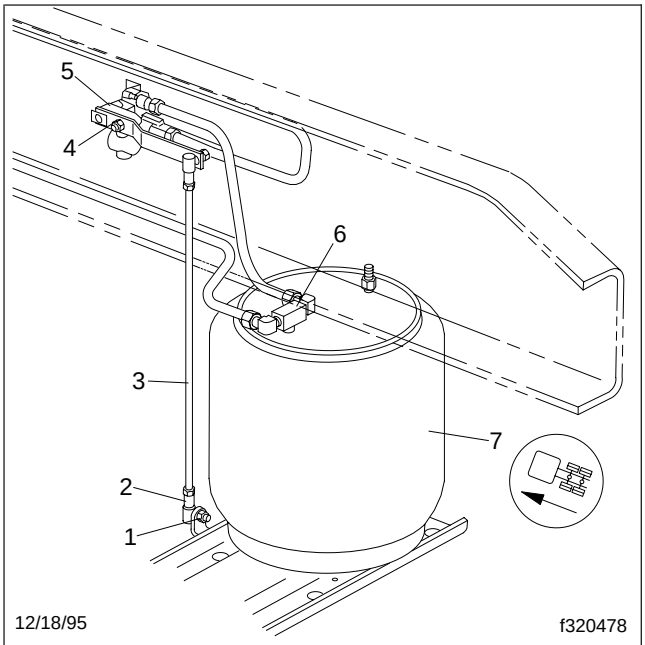
Removal

1. Chock the front tires.
2. Drain the vehicle's air system.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

3. Remove the height control valve vertical rod from the valve lever by removing the nut and lock washer. Push down on the lever of the height control valve to exhaust the air from the rear suspension air bags.
4. Remove the air lines attached to the height control valve. See **Fig. 1**.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Height Control Valve System

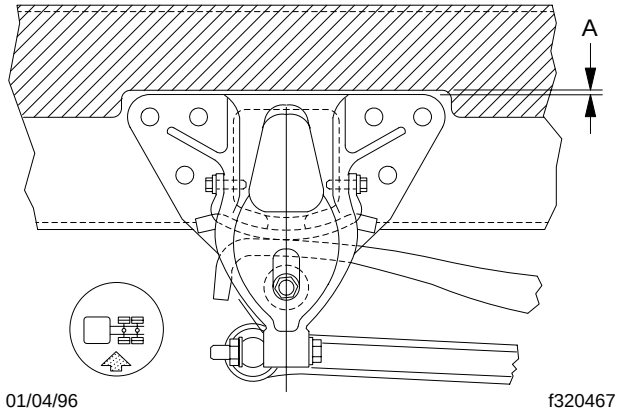
5. Remove the locknuts, washers, and bolts that attach the height control valve to the frame.
6. Remove the brass air fittings from the height control valve.

Installation

1. Install the brass air fittings into the height control valve ports.
2. Install the bolts, washers, and locknuts that attach the valve to the frame rail.
3. Attach the air lines to the height control valve.
4. Attach the height control valve vertical linkage rod to the height control valve lever, and install the lock washer and nut. See **Fig. 1**.
5. Return air to the system.
6. Adjust the height control valve for proper ride height as described in **Subject 180**.

Information

The HAS front hangers must have at least 1/4-inch (6 mm) clearance between the top of the hanger and the bottom of the fifth wheel mounting bracket on the sides of the frame rails. In some cases, the fifth wheel mounting bracket may have to be cut out to provide the correct clearance. See **Fig. 1** for an example of a fifth wheel mounting bracket that has been modified.

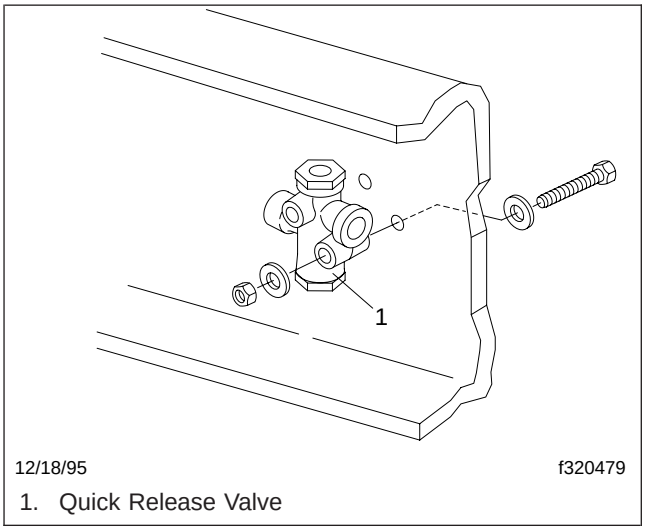


A. Clearance: 1/4 inch (6 mm)

Fig. 1, Fifth Wheel Mounting Angle Clearance

Replacement (See Fig. 1)

1. Chock the front tires.
2. Drain the vehicle's air system.
3. Disconnect the air lines from the quick release valve. Identify the air line at the top of the valve.
4. Remove the quick release valve from the frame or cross member.
5. Remove the brass air fittings from the valve.
6. Attach the brass air fittings to the replacement quick release valve.
7. Attach the valve to the frame or cross member.



1. Quick Release Valve

Fig. 1, Quick Release Valve Installation

8. Connect the air lines to the valve, making sure to attach the identified line to the top of the valve.
9. Build up pressure in the air system.
10. Remove the chocks from the front tires.

Removal

NOTE: Operation of the HAS suspension will result in wear between the main support member and the hanger slipper pad. In normal use, these components will function satisfactorily even though the components indicate some wear.

1. Chock the front tires.

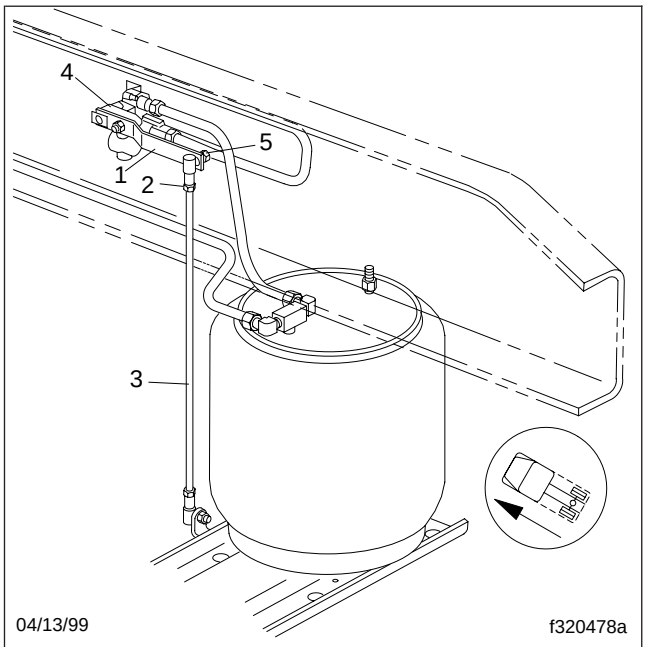
⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

2. Disconnect the vertical linkage from the lever of the height control valve and lift the lever to raise the rear of the frame about 3 inches (75 mm). See **Fig. 1**.
3. Support the frame with jack stands.
4. Apply an upward force on the cross channel with a jack or, on single axles, by pushing down on the height control lever to lift the cross channel. This will cause the tips of the main support members to drop away from the slipper pad. See **Fig. 2**.

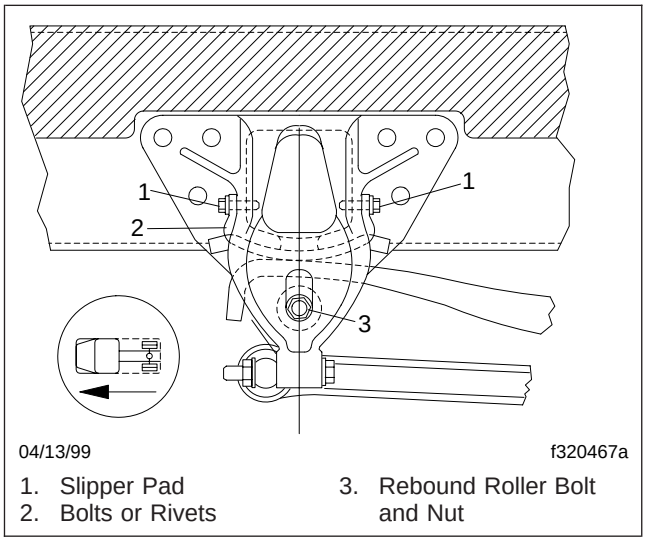
IMPORTANT: Do not nick or gouge the cross channel.

5. Remove the fasteners and the slipper pad. In some instances, the screws may have to be drilled out. See **Fig. 3**.
6. In some instances, remove the rebound roller to gain enough clearance to remove the slipper pad. Loosen the rebound bolt locknut, remove the washer, the bolt, and the rebound roller assembly.
7. For rivets, remove the four 1/4-inch (6-mm) rivets by grinding away the rivet heads. With a drift pin, punch the rivets through the holes and remove the slipper pad.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

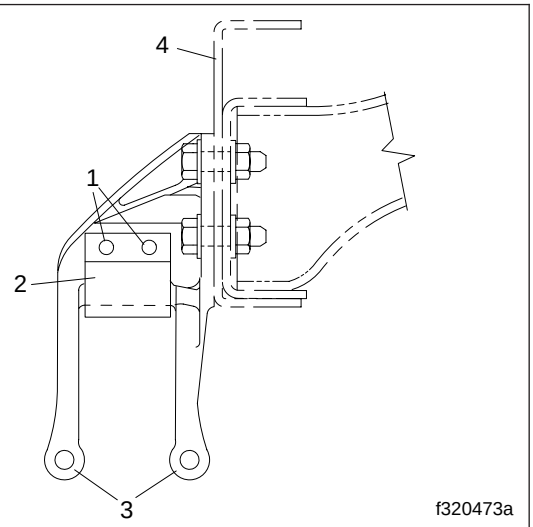
Fig. 1, Ride Height Control Linkage



1. Slipper Pad
2. Bolts or Rivets
3. Rebound Roller Bolt and Nut

Fig. 2, Slipper Pad Installation

Slipper Pad Removal and Installation



1. Bolts or Rivets
2. Slipper Pad
3. Hanger Legs
4. Frame Rail

Fig. 3, Hanger Assembly

Installation

1. Position the slipper pad and retainer plate on the frame hanger.
2. Tighten the hexhead self-tapping screws 25 lbf·ft (34 N·m).
3. Or, install the rivets using a rivet gun.
4. Raise the frame off the jack stands by pulling up on the height control valve lever. Remove the jack stands.
5. Push down on the height control valve lever to lower the frame until the upper ball stud on the vertical linkage rod exactly aligns with the hole in the lever when the lever is horizontal.
6. Install the ball stud into the hole in the lever and install the washer and nut. Tighten the nut 10 lbf·ft (14 N·m).
7. Remove the chocks from the tires.

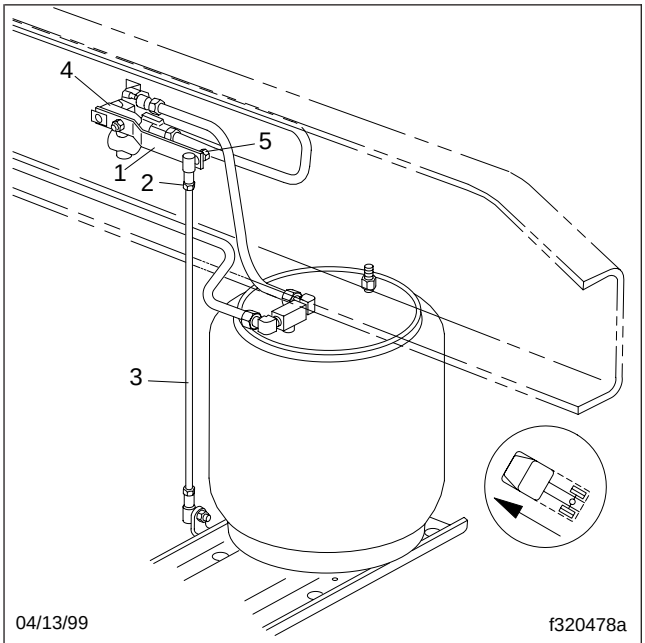
Removal

1. Stop the vehicle on a level surface and shutdown the engine. Chock the front and rear tires.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

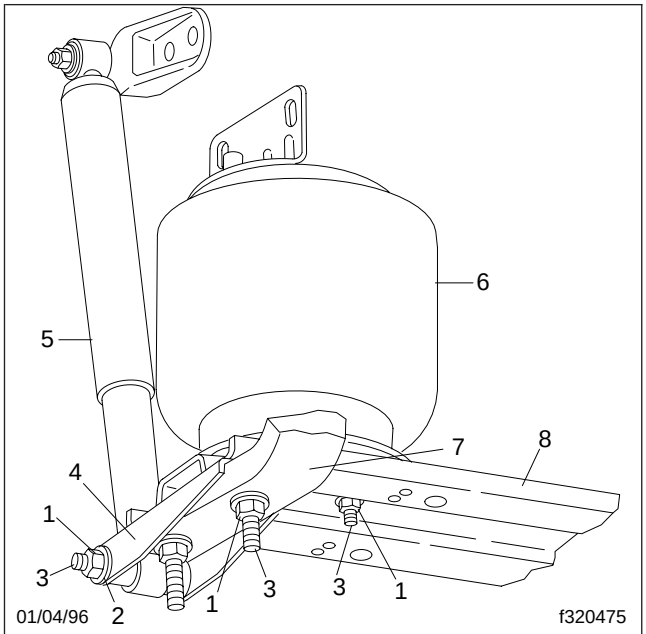
2. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the rear of the frame about 3 inches (75 mm). Support the frame at that position with jack stands.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Height Control Linkage

3. Remove the locknuts and washers that attach both the air springs to the cross channel. See **Fig. 2**.



1. Locknut
2. Washer
3. Bolt
4. Lower Shock Bracket
5. Shock Absorber
6. Air Spring
7. Main Support Member
8. Cross Channel

Fig. 2, Main Support Member

4. Remove the locknuts, washers, and bolts that attach the cross channel to the main support members and to the shock absorber lower mounting brackets.
5. Raise the cross channel by pushing down on the height control lever to compress the air springs just enough to clear the studs on the bottom of the air springs. Remove the cross channel.

Installation

1. Position the cross channel so that the holes in the cross channel are aligned under the studs of the air springs. Install the washers and nuts. Tighten the nuts on the air spring studs 25 lbf·ft (34 N·m).

Cross Channel Removal and Installation

2. Lower the cross channel assembly onto the main support members by pushing down on the height control valve lever.
3. Install the bolts, washers and locknuts that connect the cross channel to the main support member and lower shock absorber mounts. Tighten the locknuts 290 lbf·ft (393 N·m).
4. Raise the frame by lifting the height control valve lever and remove the jack stands.
5. Attach the ball joint stud of the vertical linkage rod to the height control valve link, and tighten the locknut on the ball joint stud 10 lbf·ft (14 N·m).
6. Remove the chocks from the tires.

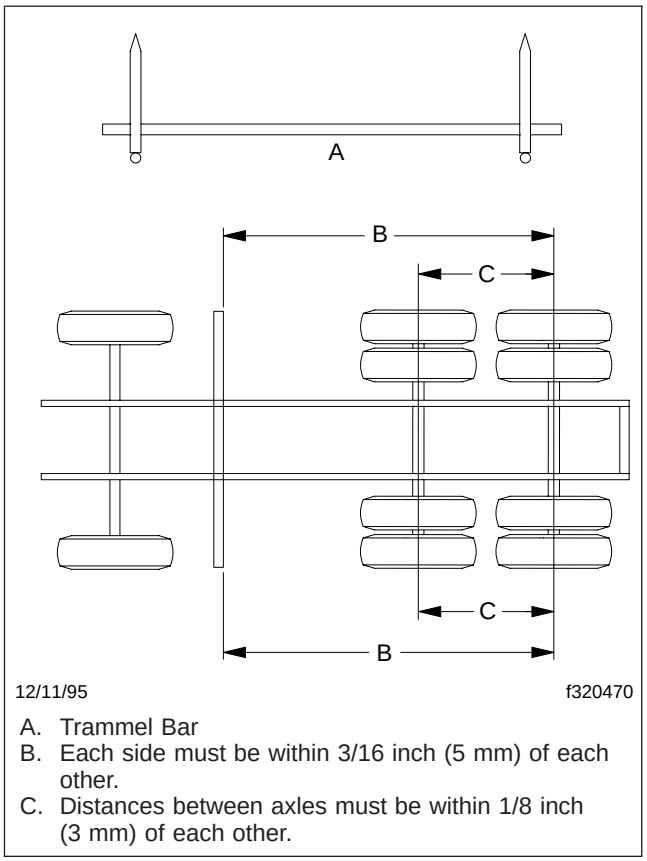
Checking and Adjustment

Use the following procedure after all repairs to the suspension:

1. Park vehicle on a level surface. Free and center all suspension joints by slowly moving the vehicle back and forth several times without applying the brakes.
2. Chock the front tires and the tires of drive axles.
3. C-clamp a nine-foot (2.74-m) piece of straight bar stock or angle iron across the frame. Select a location as far forward of the forward drive axle as possible where components will not interfere. The lower frame flange may be preferred on some vehicles, otherwise use the upper frame flange.
4. Align the straight bar stock or angle iron on the frame using a carpenter's square.
5. Check the rear drive axle first. See **Fig. 1** . Use a trammel bar or its equivalent to measure from the straight edge to the center line of the rear axle on both sides of the vehicle. If both sides measure within 3/16 inch (5 mm) of being the same, the alignment of the rear drive axle is acceptable. If the sides differ by more than 3/16-inch (5 mm), first loosen the rebound locknut, and then adjust the rear drive axle by loosening up the torque rod bar pin locknuts on the hangers. Add or remove drop-in shims as needed.

NOTE: The torque rod bar pin must be mounted to the forward face of the hanger legs. No more than four shims may be used (for a maximum thickness of 1/4 inch (6 mm).

6. Snug the torque rod bar pin locknuts but do not torque to specification.
7. With the rear drive axle properly aligned, the front drive axle alignment can be checked by measuring forward from the center of the axle shafts on the rear drive axle using a trammel bar. If the forward drive axle spacing measurements differ by more than 1/8 inch (3 mm), add or subtract shims at the forward hangers.
8. Following the adjustment of both axles, move the vehicle back and forth several times prior to removing the straight edge from the frame. Recheck the alignment.



A. Trammel Bar
B. Each side must be within 3/16 inch (5 mm) of each other.
C. Distances between axles must be within 1/8 inch (3 mm) of each other.

Fig. 1, Drive Axle Tracking Alignment

9. Tighten the torque rod bar pin locknuts 180 lbf·ft (244 N·m).
10. Remove the chocks from the tires.

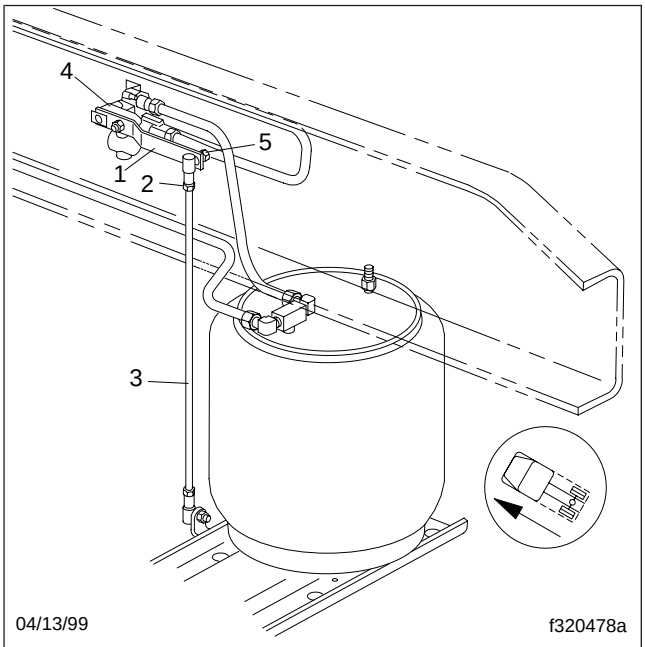
Replacement

1. Chock the front tires.
2. Support the frame with jack stands.
3. Drain the vehicle's air system.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

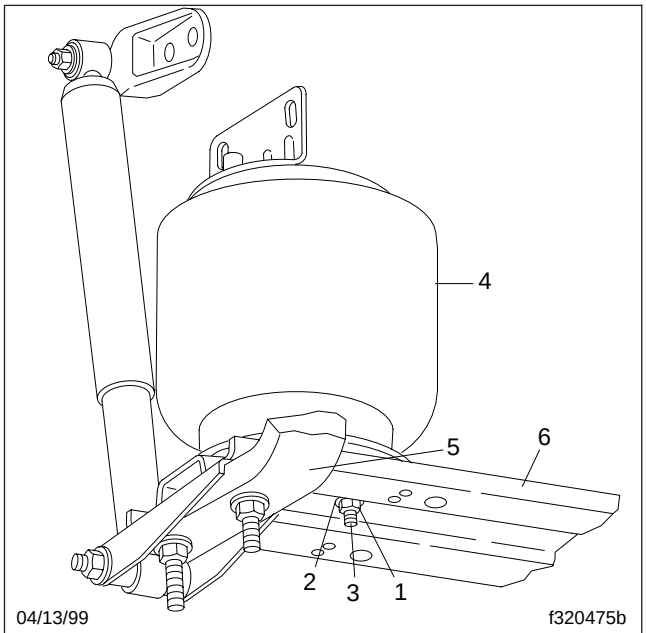
4. Remove the upper ball joint nut and stud from the lever on the height control valve. See **Fig. 1**. Move the height control valve lever down to exhaust all the air from the air bags.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Ride Height Control Linkage

5. Remove the locknuts and washers that attach the air spring to the cross channel. See **Fig. 2**.
6. Disconnect the air lines to the air spring.
7. Remove the brass air fittings from the air spring.
8. Remove the locknuts and washers that attach the air spring to the upper air spring frame hanger.
9. Remove the air spring.
10. Attach the new air spring to the air spring frame hanger by inserting the studs into the appropriate holes.
11. Attach the air spring to the cross channel. Tighten the nuts 25 lbf·ft (34 N·m).
12. Tighten the outboard locknut that attaches the air spring to the air spring frame hanger 25 lbf·ft (34 N·m).



1. Locknut
2. Washer
3. Bolt
4. Air Spring
5. Main Support Member
6. Cross Channel

Fig. 2, Air Spring Mounting

13. Attach the brass fittings to the air spring using a Teflon thread seal.
14. Connect the air lines to the air spring.

Air Spring Replacement

15. Connect the ball stud on the vertical linkage rod to the lever for the height control valve. Install the washer and tighten the nut 10 lbf·ft (14 N·m).
16. Remove the jack stands.
17. Build up pressure in the air system and check the ride height as described in **Subject 180**.
18. Remove the chocks from the tires.

Air Spring Frame Hanger Removal and Installation

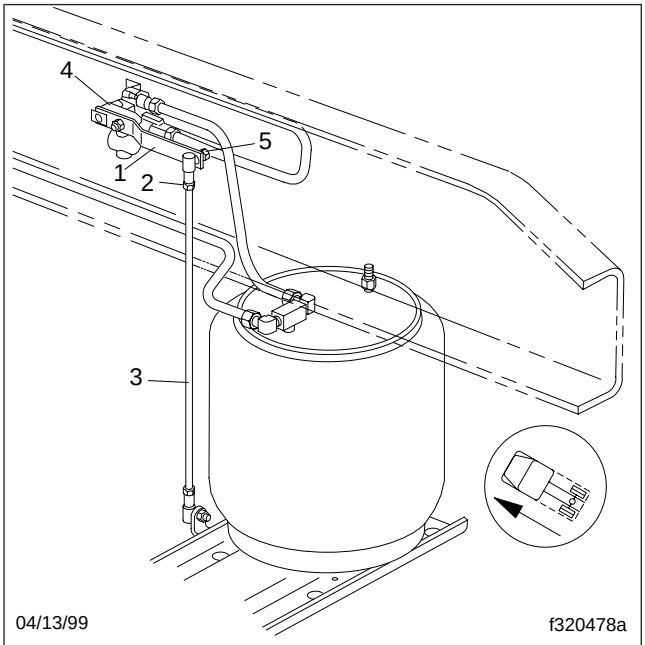
Removal

1. Chock the front tires.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

2. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the rear of the frame about 3 inches (75 mm). Support the frame at that position with jack stands.



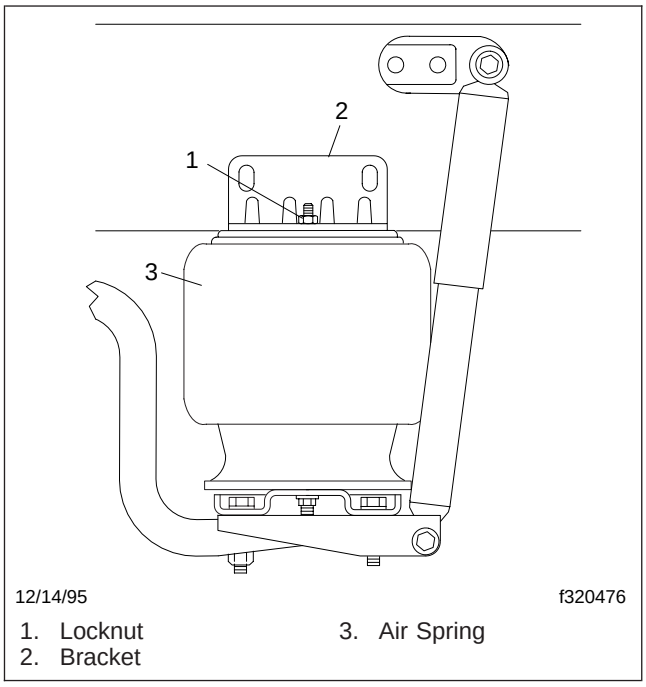
1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Height Control Valve Linkage

3. Drain the air from the vehicle's air system then lower the lever on the height control valve to exhaust the air from the air springs.
4. Disconnect the air lines from the air spring fittings.
5. Remove the brass air fittings from the air spring.
6. Remove the locknuts and washers that attach the air springs studs to the upper bracket on the frame rail. See **Fig. 2**.
7. Remove the nuts, washers and bolts that hold the upper air spring bracket to the frame rail. Remove the air spring bracket.

Installation

1. Position the air spring upper bracket on the frame rails. Install the bolts through the frame rail and upper bracket and install the washers, and locknuts. Tighten the locknuts 340 lbf·ft (461 N·m).
2. Attach the air spring to the air spring frame bracket. Tighten the outboard locknut 25 lbf·ft (34 N·m).



1. Locknut
2. Bracket
3. Air Spring

Fig. 2, Air Spring Installation

3. Attach the brass air fittings to the air spring port using Teflon thread sealant.
4. Connect the air lines to the air spring fittings.

Air Spring Frame Hanger Removal and Installation

5. Build up pressure in the air system and raise the height control lever to lift the frame off the jack stands. Remove the jack stands and lower the vehicle.
6. Align the ball joint stud in the vertical linkage rod with the hole in the height control lever. Install the ball joint stud, the washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
7. Remove the chocks from the tires.

Shock Absorber Bracket Removal and Installation

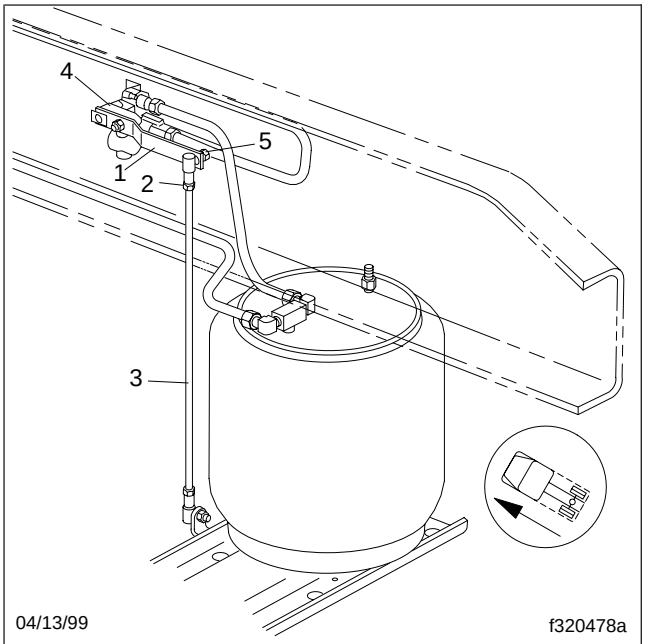
Removal

1. Chock the front tires.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

2. Remove the locknut and washer and disconnect the ball joint stud on the top of the vertical linkage rod from the height control valve lever. See **Fig. 1**.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

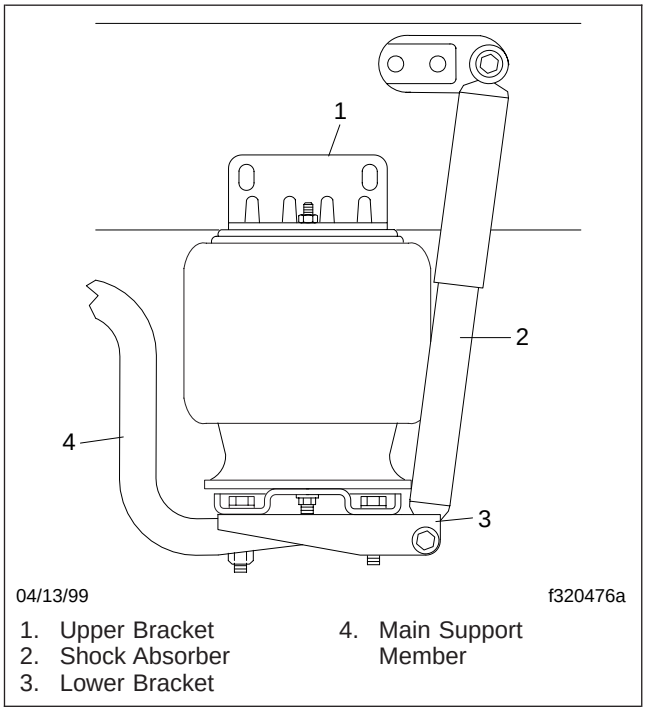
Fig. 1, Height Control Valve Linkage

3. Lift the height control lever to raise the rear of the frame enough to remove the load from the suspension.

   NOTE: The front of the main support member will move downward as the load is removed. Support the frame in this position with jack stands.

4. Remove the shock absorber. Refer to **Subject 170**.

5. Remove nuts, washers and bolts from the shock absorber frame hanger bracket. See **Fig. 2**. Remove the top shock absorber bracket from the frame.



1. Upper Bracket
2. Shock Absorber
3. Lower Bracket
4. Main Support Member

Fig. 2, Shock Absorber Mounts (typical)

6. Remove the nuts, washers and bolts that attach the cross channel and lower shock absorber bracket to the rear of the main support member.

7. Remove the lower bracket by sliding the bracket to the rear.

Installation

1. Install the bolts and washers that attach the frame hanger bracket from the inboard side of the frame. Install the brackets, washers and locknuts. Tighten the nuts 340 lbf·ft (461 N·m).

2. Position the lower bracket between the cross channel and the main support member.

Shock Absorber Bracket Removal and Installation

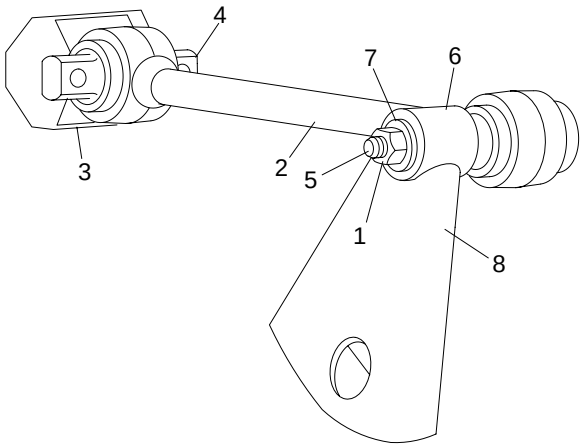
3. Install the bolts and washers from the top of the cross channel, through the shock bracket and main support member. Install the washers and locknuts and tighten the locknuts attaching the cross channel to the main support member 290 lbf·ft (393 N·m).
4. Install the shock absorber. Install the washers at both sides of each shock bushing for a total of four washers per shock absorber.
5. Tighten shock absorber locknuts 60 lbf·ft (81 N·m).
6. Lift the lever of the height control valve to raise the rear of the frame off the jack stands. Remove the jack stands and lower the frame by pushing down on the height control valve lever.
7. Align the ball joint stud in the vertical linkage rod with the hole in the height control valve lever. Install the washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
8. Remove the chocks from the tires.

Transverse Rod Removal and Installation

Removal (See Fig. 1)

NOTE: This procedure is for replacement of a transverse rod with a tapered stud at the axle connection and a straddle mount pin at the frame bracket end. Some installations have straddle mounts at both ends of the transverse rod.

1. Chock the front and rear tires.
2. Remove the nuts and washers from the bolts that fasten the pin in the transverse rod bushing to the frame bracket. Disconnect the transverse rod where it is attached to the frame bracket bracket.
3. Remove the nut from the tapered stud in the tube bracket on the axle housing. Hit the top of the axle bracket tube hard with a large hammer to momentarily distort the tube and loosen the tapered stud. Remove the stud and transverse rod from the bracket on the axle housing.



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1. Locknut
2. Transverse Rod
3. Frame Bracket
4. Straddle Mount Pin
5. Tapered Stud End
6. Axle Bracket Tube
7. Washer
8. Axle Bracket

Fig. 1, Transverse Rod Assembly

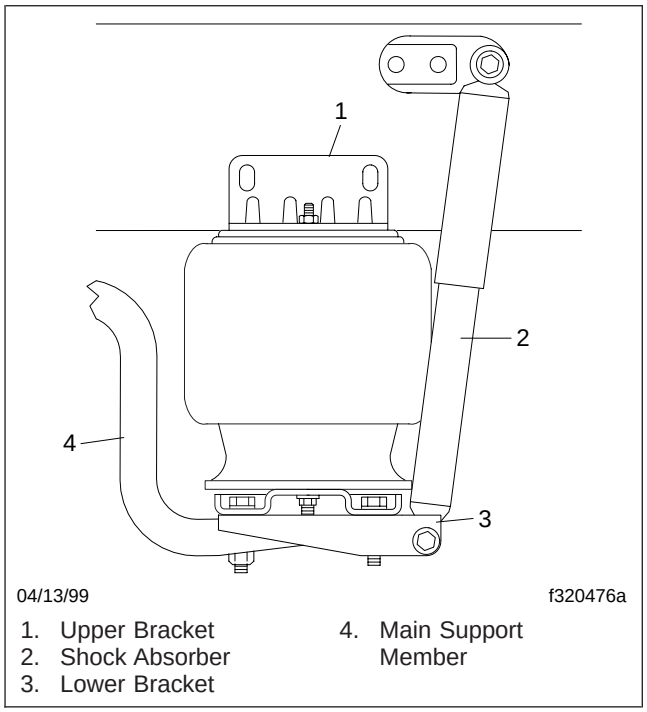
Installation

1. Clear the tapered hole in the axle bracket of all foreign matter.
2. Insert the tapered stud and torque rod bushing into the bracket.
3. Attach the washer and locknut to the stud. Tighten 200 lbf·ft (271 N·m).
4. After tightening, hit the top of the axle bracket tube with a hammer to seat the tapered stud. Retighten.
5. Position the straddle mount end of the transverse rod at the frame bracket, and tighten 200 lbf·ft (271 N·m).
6. Remove the chocks from the tires.

Replacement

NOTE: Shock absorbers are 1 3/8 inches (35 mm) in diameter with a compressed length of 18 1/3 inches (466 mm) and an extended length of 30 inches (762 mm).

1. Chock the front tires.
2. Remove the nut, washer and bolts that attach the shock absorber to the frame hanger bracket. See **Fig. 1**.



1. Upper Bracket
2. Shock Absorber
3. Lower Bracket
4. Main Support Member

Fig. 1, Shock Absorber Mounts (typical)

3. Remove the fasteners that attach the shock absorber to the lower bracket.
4. Remove the shock absorber.
5. Install the new shock absorber with the rod and shield tube at the top. Install the bolts, washers and nuts in the lower bracket and the frame hanger bracket. Install washers at both sides of each shock bushing, that is four washers per shock absorber.
6. Tighten the fasteners 60 lbf·ft (81 N·m).

General Information

NOTE: This subject applies only to Hendrickson series HAS 190/210/230/40LH/400/402/460 suspensions.

Adjust the vehicle ride height with the unloaded vehicle on a level surface. The frame slope, driveline angles, and axle mounting alignment should be checked after the ride height has been changed.

⚠ CAUTION

Failure to adjust the vehicle ride height could adversely affect driveline angles. Also, if the air springs are set too high, the driver may have difficulty (or be prevented from) backing the vehicle under a trailer. If the air springs are set too low, rapid wear of driveline parts will result.

Ride Height Adjustment

The vehicle ride height for Hendrickson HAS air suspension systems is changed by adjusting the length of the vertical linkage at the ride height control valve. Use the following procedure to adjust the ride height of the frame rails.

IMPORTANT: Before checking the ride height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks must be empty when checking the ride height.

1. Stop the vehicle on a level surface, using a light application of the brakes. Slowly move the vehicle forward and back several times without using the brakes to center the suspension joints. Do not apply the parking brakes.
2. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.

   NOTE: Allow several minutes for the air pressure to equalize in the system before checking the ride height.
3. Mark the location of the front and rear tires on the floor so that the vehicle can be checked in the same location after a test drive. Chock the front tires.

IMPORTANT: Any difference in height between the two sides of the vehicle must be corrected using spacers between the main support arm and the rear axle housing before setting the vehicle ride height. See the appropriate section in Group 32 in the vehicle's service manual for the alignment procedure.

4. Measure the distance from the bottom of the frame rail to the bottom of the main support arm at the rear axle U-bolts. See **Fig. 1**. The correct measurement for Hendrickson HAS suspension systems is 4-1/4±1/8 inches (108±3 mm) for vehicles with a specified ride height of 8-1/2 inches (215 mm) or greater. For vehicles with less than an 8-1/2-inch (215 mm) ride height, the distance between the bottom of the frame rail and the bottom of the main support arm must be 2-3/8 inches (60 mm).

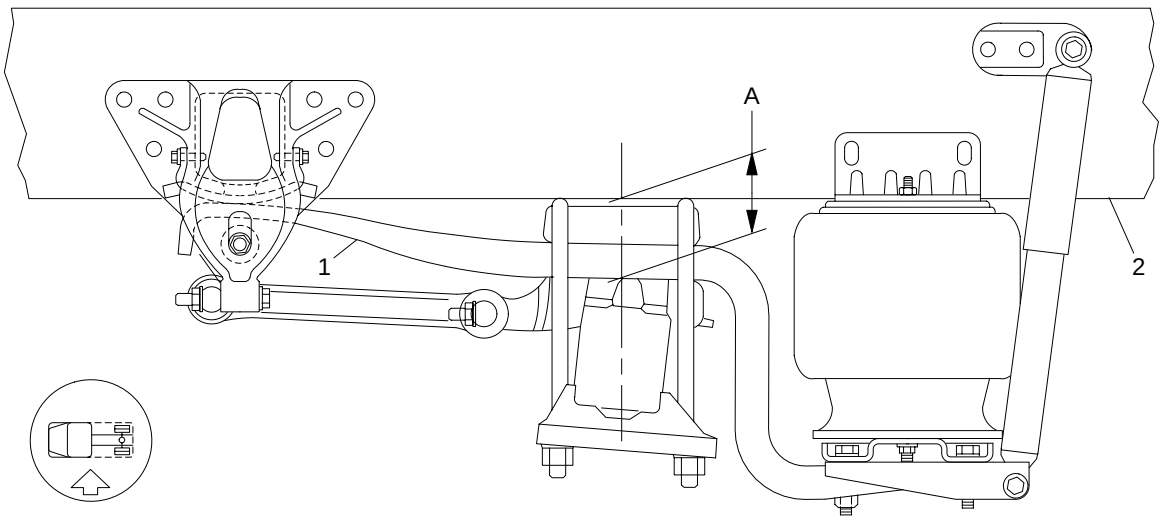
   If the measurement is the same as the specification at each support arm, the ride height is correctly adjusted. If the distance measured is not the same at each rear axle mount on the vehicle, correct this alignment problem before attempting to adjust the ride height.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

5. Remove the nut and lockwasher from the ball joint stud at the end of the lever on the ride height control valve. See **Fig. 2**. Separate the vertical rod assembly from the lever, being careful to avoid moving the lever while disconnecting the ball joint.
6. Push the lever down to lower the frame by removing the air in the suspension air bags.
7. Slowly pull the lever up to raise the frame until the ride height measurement is exactly correct for the specified ride height.
8. Make sure that the centering hole in the lever near its pivot aligns with the centering hole in the height control valve body. Check the height control valve to make sure that no air flows through

Ride Height Adjustment

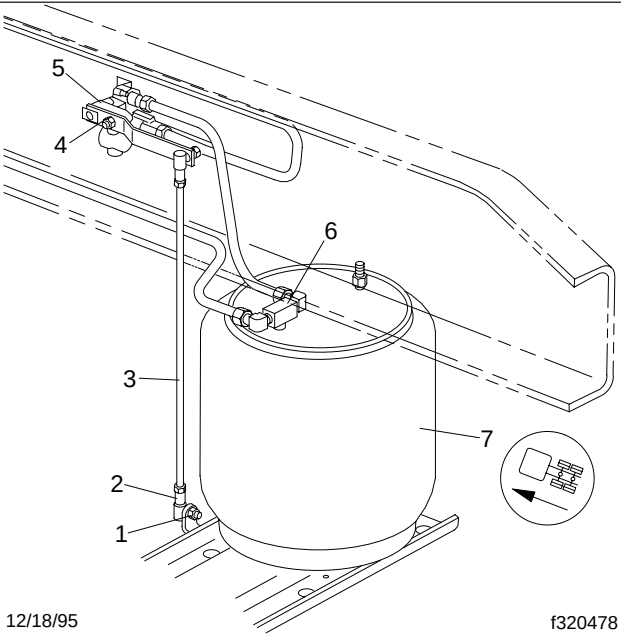


A. Measure ride height here.
1. Bottom of Main Support Arm
2. Bottom of Frame Rail

Fig. 1, Measuring the Ride Height

the ride height control valve when the lever is in the centered position.

9. Loosen the jam nuts a few turns at the top and bottom ball joints on the vertical rod that attaches to the height control lever. Note that one of the ball joints and jam nuts has left-hand threads. Hold the top ball joint with your hand and turn the vertical rod with a wrench until the top ball joint stud exactly aligns with the hole in the end of the lever when the lever is centered horizontally on the control valve.
10. Install the ball joint stud in the lever and install the lockwasher and nut on the stud. Tighten the nut on the stud to 125 lbf·inch (11 N·cm).
11. Tighten the jam nut on each ball joint without changing the length of the vertical rod.
12. Apply the parking brakes; then remove the chocks from the tires. Drive the vehicle unloaded for about 1/4 mile (1/2 km); then stop the vehicle in the exact location (as previously marked) of the original measurement.
13. Park the vehicle using only a light brake application. Chock the tires on one axle only and put the transmission in neutral. Do not apply the parking brakes.
14. Check the adjusted distance between the bottom of the frame and the bottom of the main support arm at the U-bolts. See **Fig. 1**.
15. If the distance is still not correct, loosen the ball joint jam nuts on the vertical rod and turn the rod to adjust the ride height. Lengthen the vertical rod to raise the frame or shorten the rod to lower the frame to the correct ride height. Drive the vehicle and again check the ride height.
16. Apply the parking brakes; then remove the chocks from the tires.



1. Lockwasher and Nut
2. Ball Joint and Jam Nut
3. Vertical Rod
4. Leveling Arm Locknut
5. Ride Height Control Valve
6. Brass Air Fitting
7. Air Spring

Fig. 2, Ride Height Control System

Problem—All Air Bags Are Deflated

Problem—All Air Bags Are Deflated	
Possible Cause	**Remedy**
The vehicle air system pressure is too low.	Run the engine until the air gauge indicates 100 psi (690 kPa).
Air is leaking from the vehicle air system.	Listen for air leakage at the air fittings, tanks, and brake componenets. Repair or replace fittings as needed.
The linkage for the height control valve is disconnected or maladjusted.	Connect the linkage and adjust as described in **Subject 180**.
The suspension dump valve is activated.	Toggle the dump control valve to the normal position.
The relay valve is stuck open.	Check and repair the relay valve.
The air bags have a leak.	Listen for leaks at the air bags, tubes, and fittings.
The height control valve is not operating correctly.	Disconnect the linkage and raise and lower the lever to check the operation of the height control valve. Make sure that no air flows through the valve when the lever is in the center position. Replace the valve if it is bad.
There is a obstruction in the lines to the height control valve.	Check the air pressure at theheight control valve supply port. Remove any obstruction or restriction to air flow to the valve.
The pressure protection valve is not allowing air to flow to the height control valve.	Check the operation of the pressure protection valve between the secondary air tank and the height control valve. Replace the valve if it is not operating correctly.

Problem—One Side of the Vehicle Is Higher Than the Other

Problem—One Side of the Vehicle Is Higher Than the Other	
Possible Cause	**Remedy**
The axle seat spacer thickness is not the same on each side.	Adjust the spacers so that the frame is level before adjusting the ride height.
The load on the vehicle is not distributed evenly.	Change the position of the load to ensure equal weight on each side.
There is an obstruction to air flow to the air bags on one side of the vehicle.	Disconnect the fittings and test the flow to the air bags on the lower side of the vehicle.
The height control valve or relay valve has an internal restriction.	Check for the same pressure at the ports on each side of the valve. Replace the valve if the pressure is not the same.
The air bags or fittings have a leak.	Listen for leaks at the air bags, tubes, and fittings. Tighten the fittings, if loose, or replace any bad parts.

Problem—The Ride Height Is Not Constant

Problem—The Ride Height Is Not Constant	
Possible Cause	**Remedy**
Air is leaking from the air bags or lines.	Listen or use soap bubbles to find air leaks. Tighten or replace leaking fittings or air bags.
The height control valve is not working correctly.	Make sure that no air is exhausted from the height control valve when the lever is in the horizontal position and that the air bags inflate when the lever is raised. The bags must deflate when the lever is pushed down. There must be a slight delay between the lever movement and the valve operation. Check for fluid leaks from the height control valve. Replace the valve if damaged.

Troubleshooting

Problem—The Ride Height Is Not Constant	
Possible Cause	**Remedy**
There is an obstruction to air flow to the air bags.	Disconnect the fittings and test the flow to the air bags.
The height control valve has a restriction at the exhaust port.	Check for air exhausting from the valve when the height control lever is pushed down.
The height control linkage is loose.	Make sure that all the jam nuts are tight and that the ball sockets are not worn.

Problem—The Ride Height Measurement Is Not Correct

Problem—The Ride Height Measurement Is Not Correct	
Possible Cause	**Remedy**
The vehicle is loaded.	The ride height of a loaded vehicle will be slightly lower than that of an unloaded vehicle. Adjust the ride only when the vehicle is unloaded.
The ride height adjustment is not correct.	Adjust the ride height as described in **Subject 180**.
Air is leaking from the air bags or lines.	Listen or use soap bubbles to find air leaks. Tighten or replace leaking fittings or air bags.
The height control valve is not working correctly.	Make sure that no air is exhausted from the height control valve when the lever is in the horizontal position and that the air bags inflate when the lever is raised. The bags must deflate when the lever is pushed down. There must be a slight delay between the lever movement and the valve operation. Check for fluid leaks from the height control valve. Replace the valve if damaged.
There is an obstruction to air flow to the air bags.	Disconnect the fittings and test the flow to the air bags.
The height control valve has a restriction at the exhaust port.	Check for air exhausting from the valve when the height control lever is pushed down.
The height control linkage is loose.	Make sure that all the jam nuts are tight and that the ball sockets are not worn.

Problem—The Air Springs Have Cuts

Problem—The Air Springs Have Cuts	
Possible Cause	**Remedy**
The ride height is adjusted too high.	Adjust the ride height so that the air bags are not continually overinflated.
The tires are too wide and are rubbing the air bags.	Install the correct tires.
A shock absorber or mount is broken.	Replace any broken components.

Problem—The Vehicle Does Not Track Straight

Problem—The Vehicle Does Not Track Straight	
Possible Cause	**Remedy**
The axle alignment is not correct.	Adjust the alignment with shims at the front of the torque rods.
The bushings in the torque rods are worn.	Replace the worn bushings.

Problem—The Vehicle Does Not Track Straight	
Possible Cause	**Remedy**
The bushings in the transverse rods are worn.	Replace the worn bushings.
A shock absorber or mount is broken.	Replace any broken components.
The U-bolt high nuts are loose.	Periodically tighten the nuts as described in **Specifications 400**.
The suspension fasteners are loose or damaged.	Tighten or replace the fasteners.

Problem—The Vehicle Vibrates When Driven

Problem—The Vehicle Vibrates When Driven	
Possible Cause	**Remedy**
The ride height is not correct.	Adjust the ride height as described in **Subject 180**.
The axle housing rotational alignment is not correct.	Adjust the rotational alignment of the axle housing with wedge-shaped shims at the axle seats. The driveline U-joint angles must be with 1% of each other.
The shock absorbers are worn or disconnected.	Replace the shock absorbers, if worn, or tighten the mounting fasteners.
The bushings in the torque rods are worn.	Replace the worn bushings.
The U-bolt high nuts are loose.	Periodically tighten the nuts as described in **Specifications 400**.
The suspension fasteners are loose or damaged.	Tighten or replace the fasteners.
The frame is not level from front to rear.	Check and adjust the ride height at the front suspension and each rear axle. The frame should not slope more than 1/2 inch (13 mm). Correct the ride height if not at specifications.

Specifications

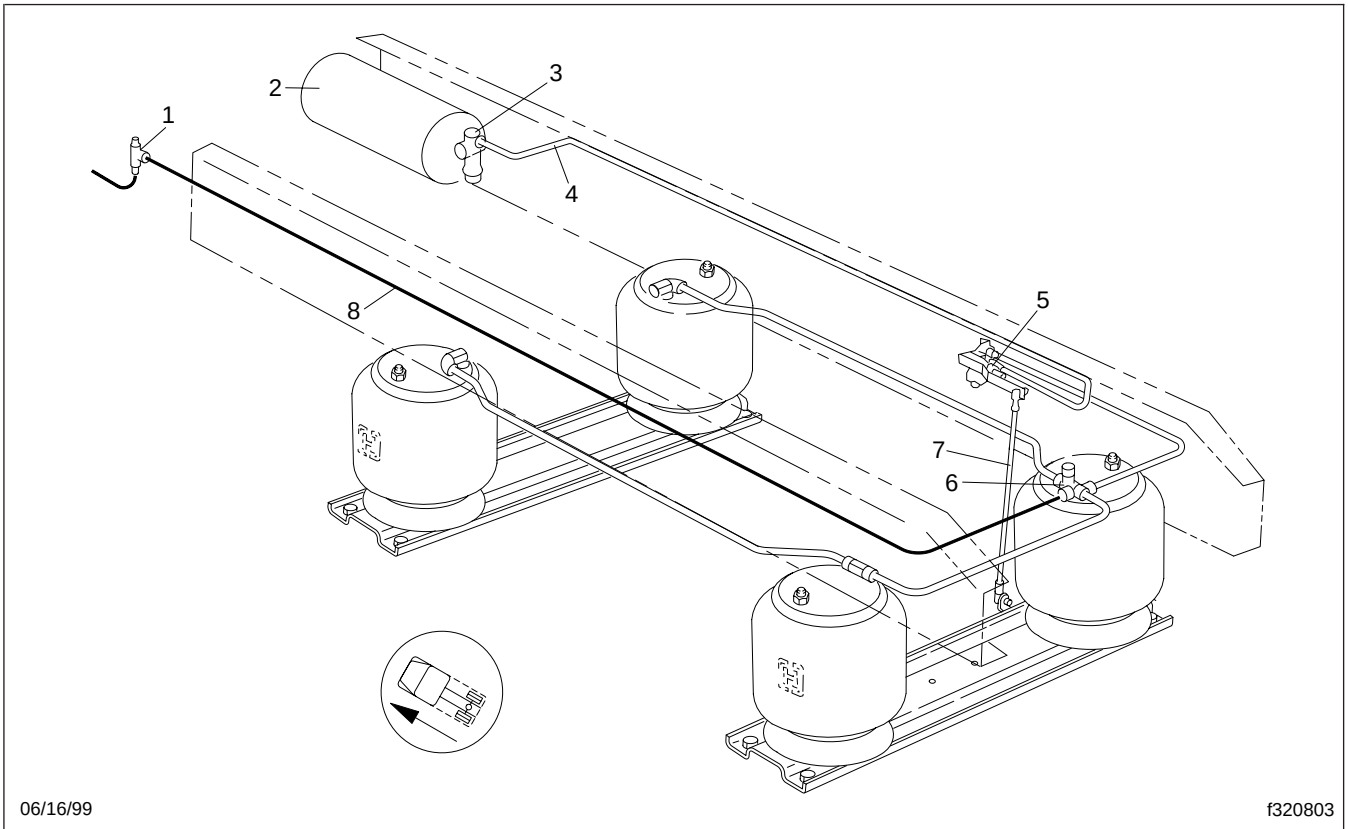
For an overview of the Hendrickson HAS air system plumbing, see **Fig. 1** and **Fig. 2**.

Torque Values		
Description	**Size**	**Torque: lbf·ft (N·m)**
U-bolt High Nuts	7/8–14	Stage 1: Hand tighten Stage 2: 60 (81) * Stage 3: 200 (271) * Stage 4: 420 to 500 (571 to 680) *
	1–14	Stage 1: Hand tighten Stage 2: 60 (81) * Stage 3: 200 (271) * Stage 4: 520 to 600 (707 to 816) *
Torque Rod Bar Pin Locknut	5/8–11	180 (244)
Axle Seat Stud	5/8–11	65 (88)
Rebound Bolt Locknut	1/2–13	60 (81)
Shock Absorber Locknut, Upper	1/2–13	60 (81)
Shock Absorber Locknut, Lower	3/4–10	60 (81)
Cross Channel to Main Support Member Locknut	3/4–10	290 (393)
Air Spring to Frame Hanger Locknut	1/2–13	25 (34)
Air Spring to Cross Channel Locknut	1/2–13	25 (34)
Transverse Rod Locknut	1-1/4–12	200 (271)
Extension Arm Jam Nut	5/16–24	125 (169)
Extension Arm Locknut	5/16–24	125 (169)

* Tighten in a diagonal pattern as shown in **Fig. 3**.

Table 1, Torque Values

Specifications



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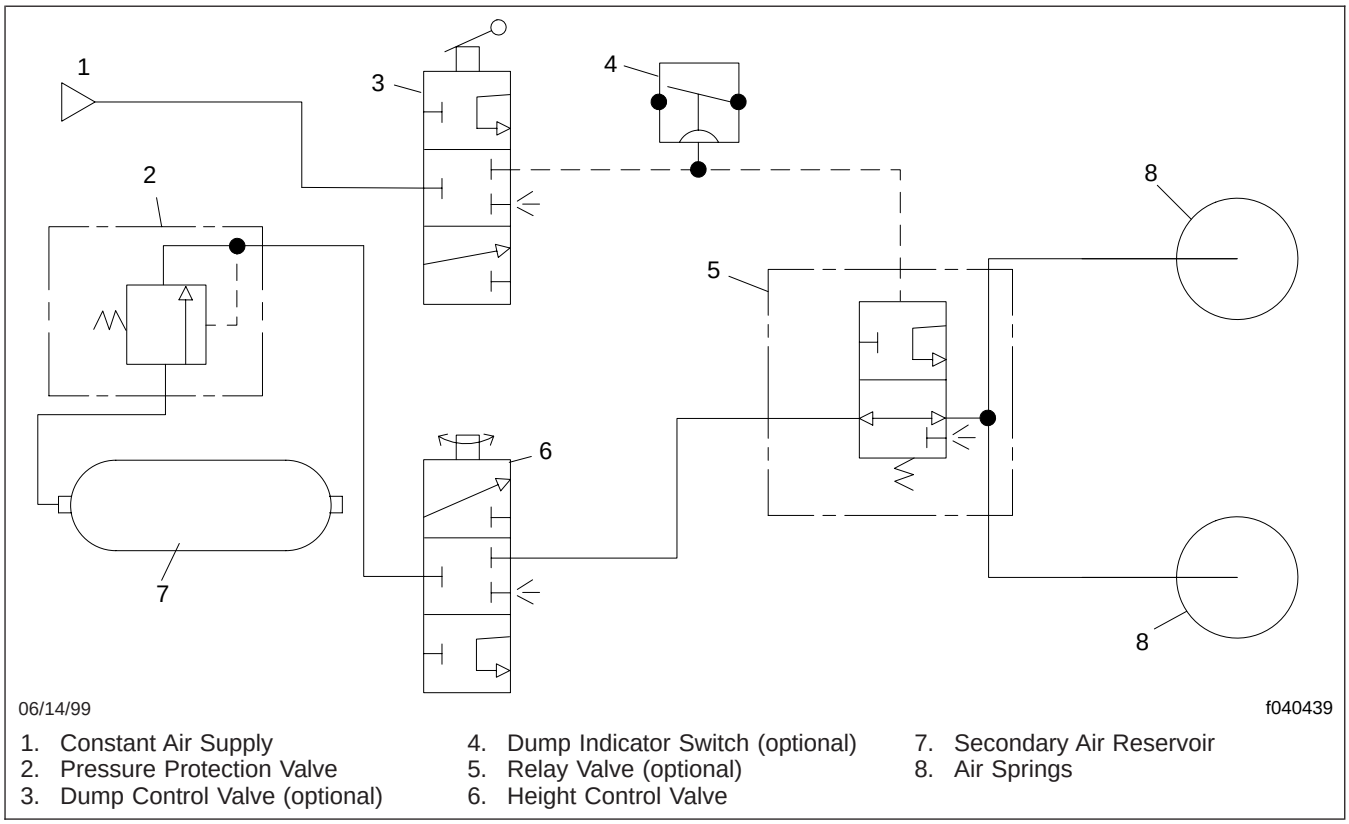
NOTE: The height control valve is activated by the forward axle on later HAS systems.

1. Switch Control Valve
2. Air Tank
3. Pressure Protection Valve
4. Air Supply Line
5. Height Control Valve
6. Quick Release Valve
7. Leveling Valve Extension Arm
8. Air Signal Line

Fig. 1, Suspension Air Plumbing



1. Constant Air Supply
2. Pressure Protection Valve
3. Dump Control Valve (optional)
4. Dump Indicator Switch (optional)
5. Relay Valve (optional)
6. Height Control Valve
7. Secondary Air Reservoir
8. Air Springs

Fig. 2, Air Suspension Dump System Schematic (typical)

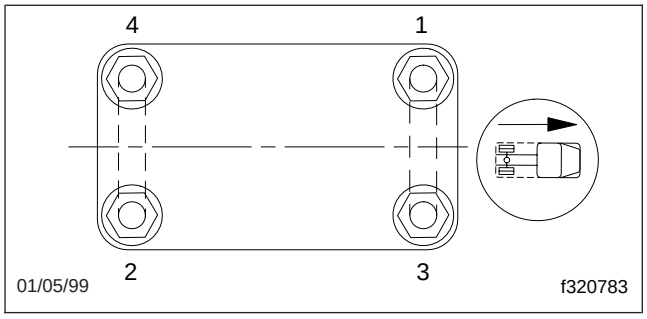
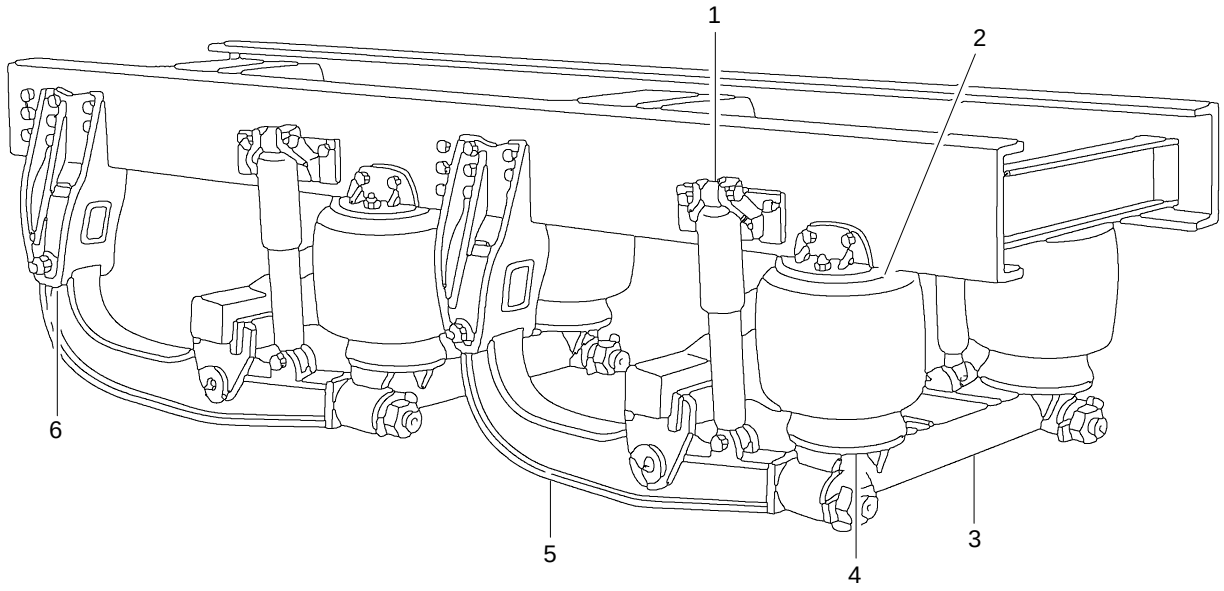


Fig. 3, Tightening Pattern for U-bolt High Nuts

General Information

The Neway AD123 air suspension system is used on vehicles with a single rear axle and the AD246 air suspension system is used on vehicles with tandem rear axles. See **Fig. 1**.



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1. Shock Absorber
2. Air Suspension Spring Assembly
3. Suspension Support Beam Bar
4. Composite Air Spring Pistons
5. Suspension Support Beam Assembly (righthand)
6. Suspension Support Beam Bracket (lefthand)

Fig. 1, Neway AD Suspension Systems

The Neway AD air suspension systems use air drawn from the vehicle air system to pressurize the air spring assemblies through height control valves. The valves regulate the air pressure according to the loads being carried and maintain a constant vehicle ride height at all times.

In the event of an air leak or air spring failure, air can be shut off to either side by disconnecting the air control valve linkage at the axle bracket.

The Neway AD air suspension system has independently mounted, rolling lobe air springs for exact load equalization, two on the AD123 and four on the AD246. The trailing arm beam is curved to provide clearance for spring brakes. The suspension support beam bar maintains trailing arm beam alignment and aids in roll control through rubber-mounted end connections. Heavy-duty shock absorbers control axle rebound and dampen oscillations, two on the AD123 and four on the AD246. Single-pin design rubber bushings are used for all pivot joints. The 6-inch axle articulation minimizes diagonal weight transfer between axles. Height control valves provide constant vehicle height.

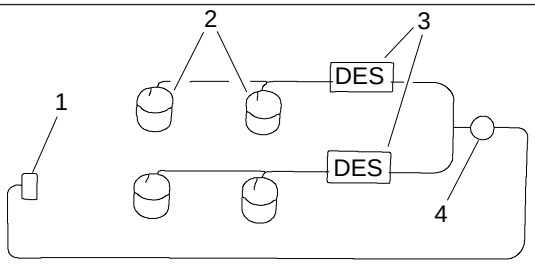
AIR CONTROL SYSTEM (See Fig. 2)

Air from the air supply system is used to inflate each of the air springs.

The suspension air control system uses air supplied from the secondary air brake supply system. The air suspension supply line is connected to the auxiliary No. 1 port on the dash-mounted air manifold.

The correct vehicle height is maintained through use of two adjustable, frame-mounted height control valves. The valve senses changes in the ride height

General Information



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1. Air Source
2. Air Suspension Spring Assembly
3. Height Control Valves
4. Pressure Protection Valve

Fig. 2, Air Control System

due to varying loads and either adds or exhausts air from the air springs until the correct ride height is reached.

If a loss of air occurs forward (upstream) of the protection valve, air pressure within the air spring system will be partially maintained until repairs can be made. However, if a loss of air occurs rearward (downstream) of the protection valve, the air in the brake system will be protected but the air pressure in the air springs will be lost.

Height Control Valve (See Fig. 3)

Correct vehicle ride height is maintained by adjustable, crossmember-mounted height control valve(s). The valve(s) senses changes in the ride height due to varying loads and allows supply air to be added to the air springs as required until the correct ride height is reached.

Air Control System Hose Routing

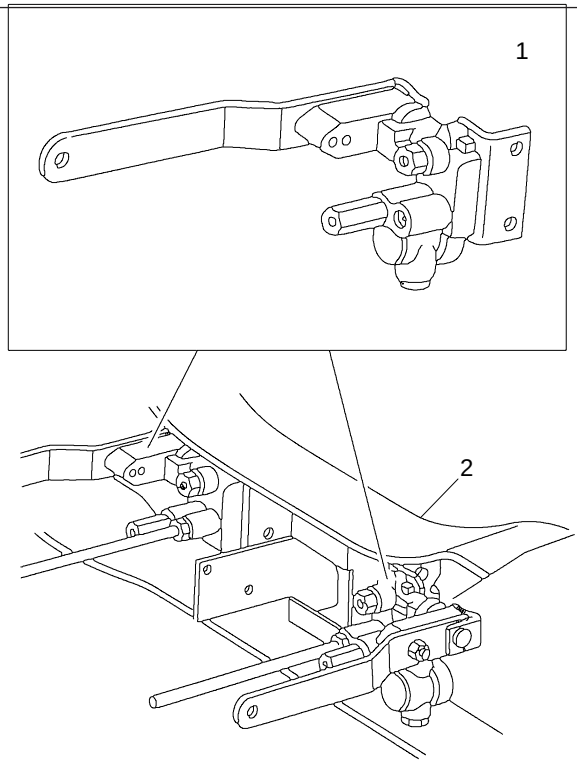
See **Fig. 4** and **Fig. 5**.

AIR DUMP SYSTEM (See Fig. 6)

⚠ CAUTION

The air dump system must not be operated with the vehicle in motion, as damage to the system or vehicle can occur.

The air dump system is used to deflate the rear suspension air springs during trailer coupling and uncoupling operations. The air suspension dump valve



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1. Height Control Valve
2. Crossmember Assembly

Fig. 3, Height Control Valve

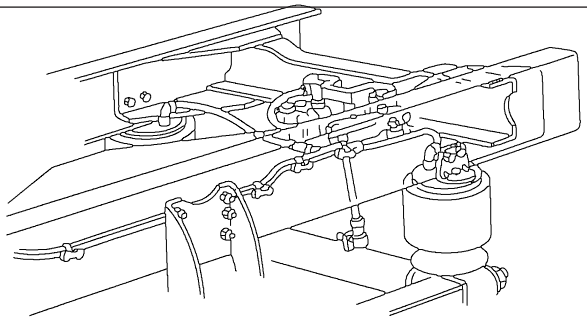

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Fig. 4, Single Axle Hose Routing, Typical

control (AIR SUSP) switch is located on the instrument panel. When set to EXH, the supply air flows through the AIR SUSP switch delivery port and pressurizes the signal line to the dump valve. The pressurization of the line closes the dump valve supply

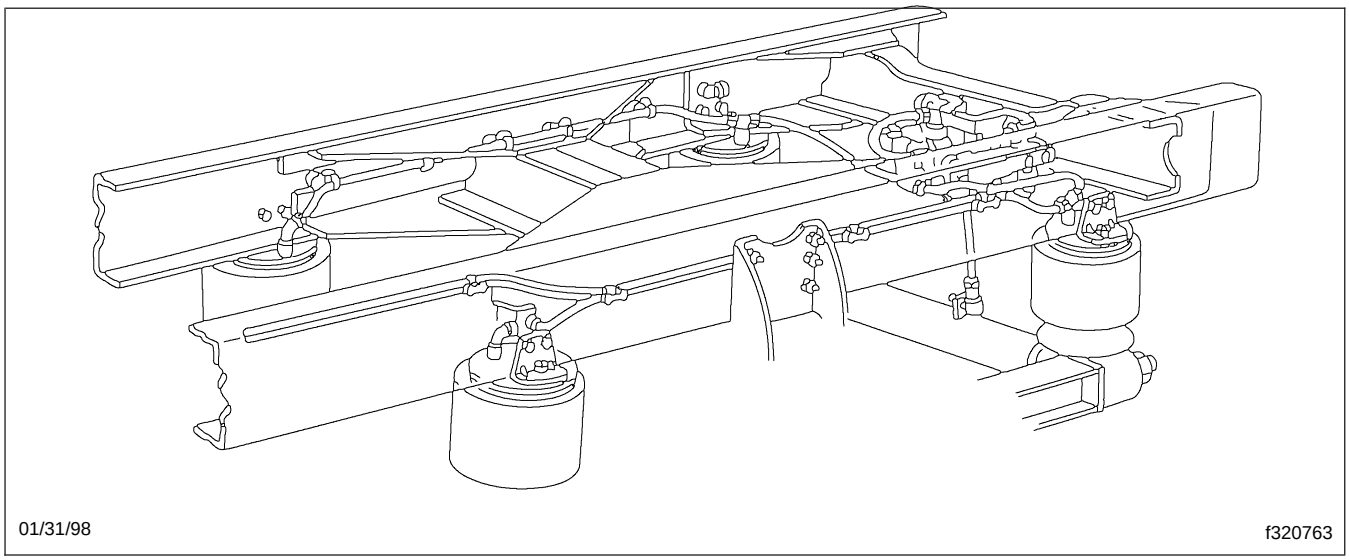


Fig. 5, Tandem Axle Hose Routing, Typical

port and opens the exhaust port, allowing air from the air springs to exhaust. A red status light on the AIR SUSP switch will come on, indicating that the air springs have been deflated.

To reinflate the air springs, the AIR SUSP switch must be set in the down position to shut off the supply air to the signal line and exhaust the pressure in the signal line.

Switch—Air Suspension Dump Valve Control (AIR SUSP)

(See **Fig. 7**)

With the AIR SUSP switch set in the EXH position, the exhaust passage is closed, allowing supply air to flow through the delivery port and signal line to the dump valve. A pressure switch in the valve senses the outlet pressure to turn on the red status light. This pressure switch is open below 10 psi (1.45 kPa) and closed above 30 psi (4.35 kPa).

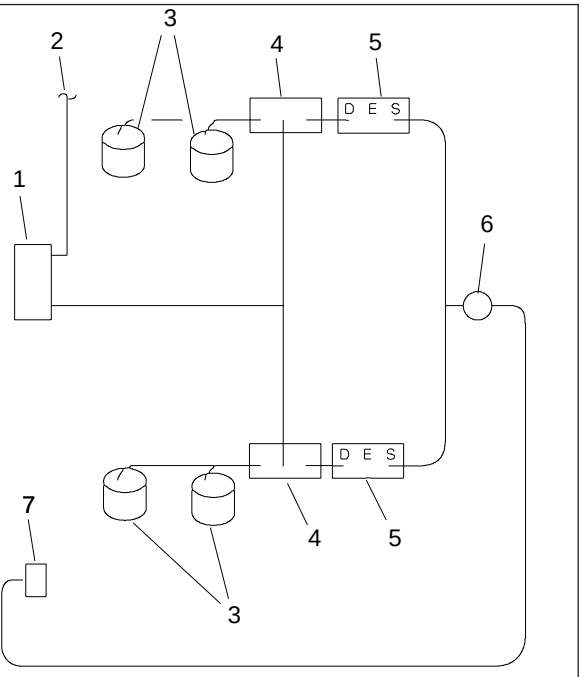
Dump Valve (See **Fig. 8**)

The dump valve is a pilot-operated three-way valve used for rapid deflation of the air bags. When the pilot pressure is applied to the dump valve, output from the height control valve is closed, and simultaneously the air spring pressure is exhausted directly to atmosphere through the valve.

REAR SUSPENSION COMPONENTS

Refer to **Fig. 9**, **Fig. 10**, **Fig. 11** and **Fig. 12** for the removal and installation of any Neway AD suspension system components.

General Information



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1. Air Suspension Dump Valve Control (AIR SUSP) Switch
2. Air Source
3. Air Suspension Spring Assembly
4. Dump Valves
5. Height Control Valves
6. Pressure Protection Valve
7. Air Source

Fig. 6, Air Dump System

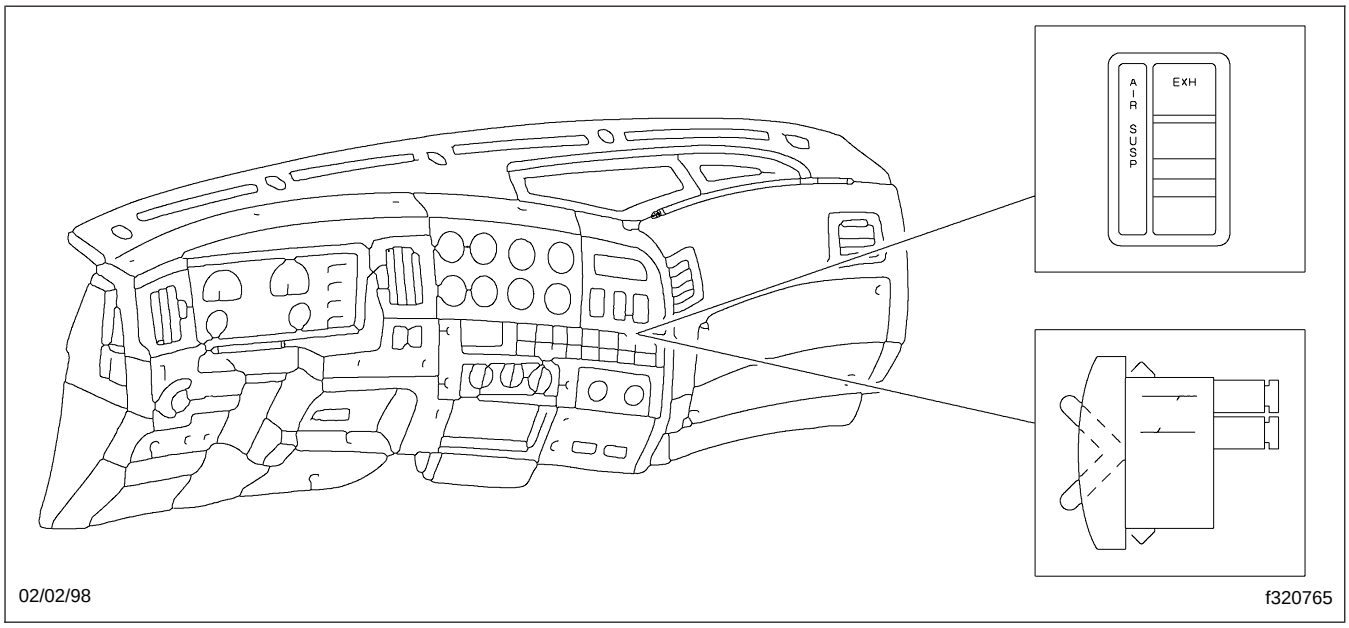
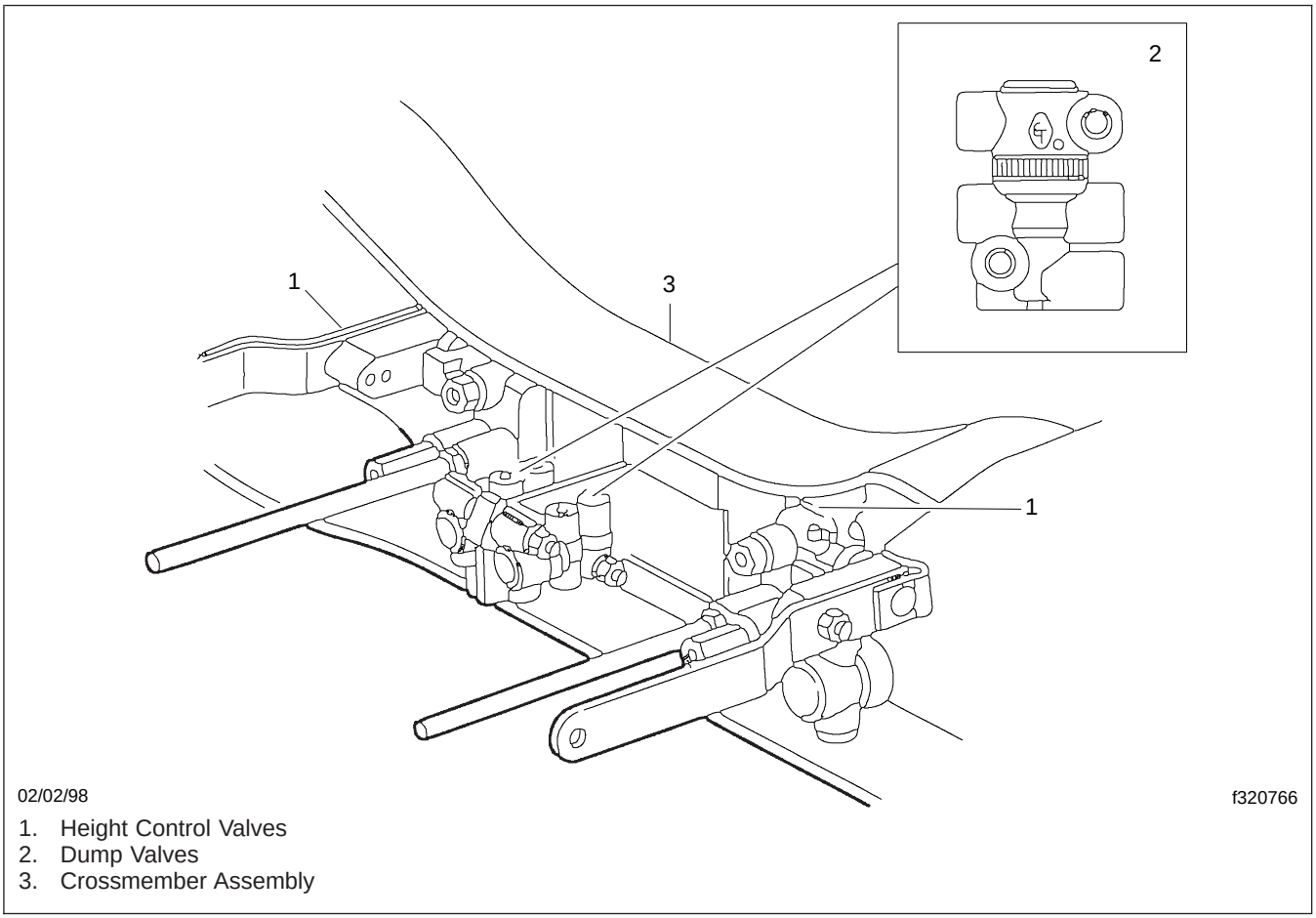


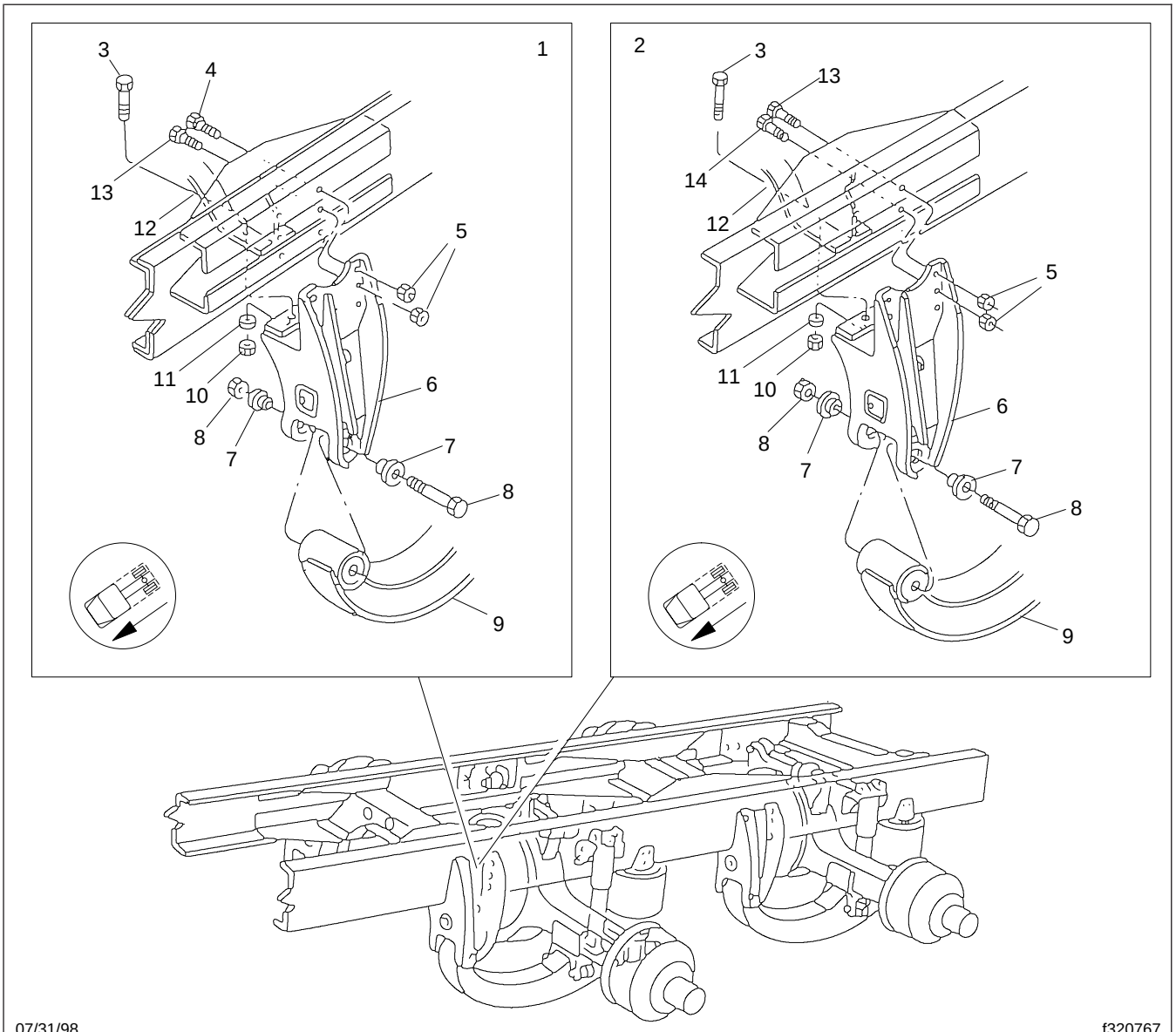
Fig. 7, Air Suspension Dump Valve Control Switch

General Information



1. Height Control Valves
2. Dump Valves
3. Crossmember Assembly

Fig. 8, Dump Valve



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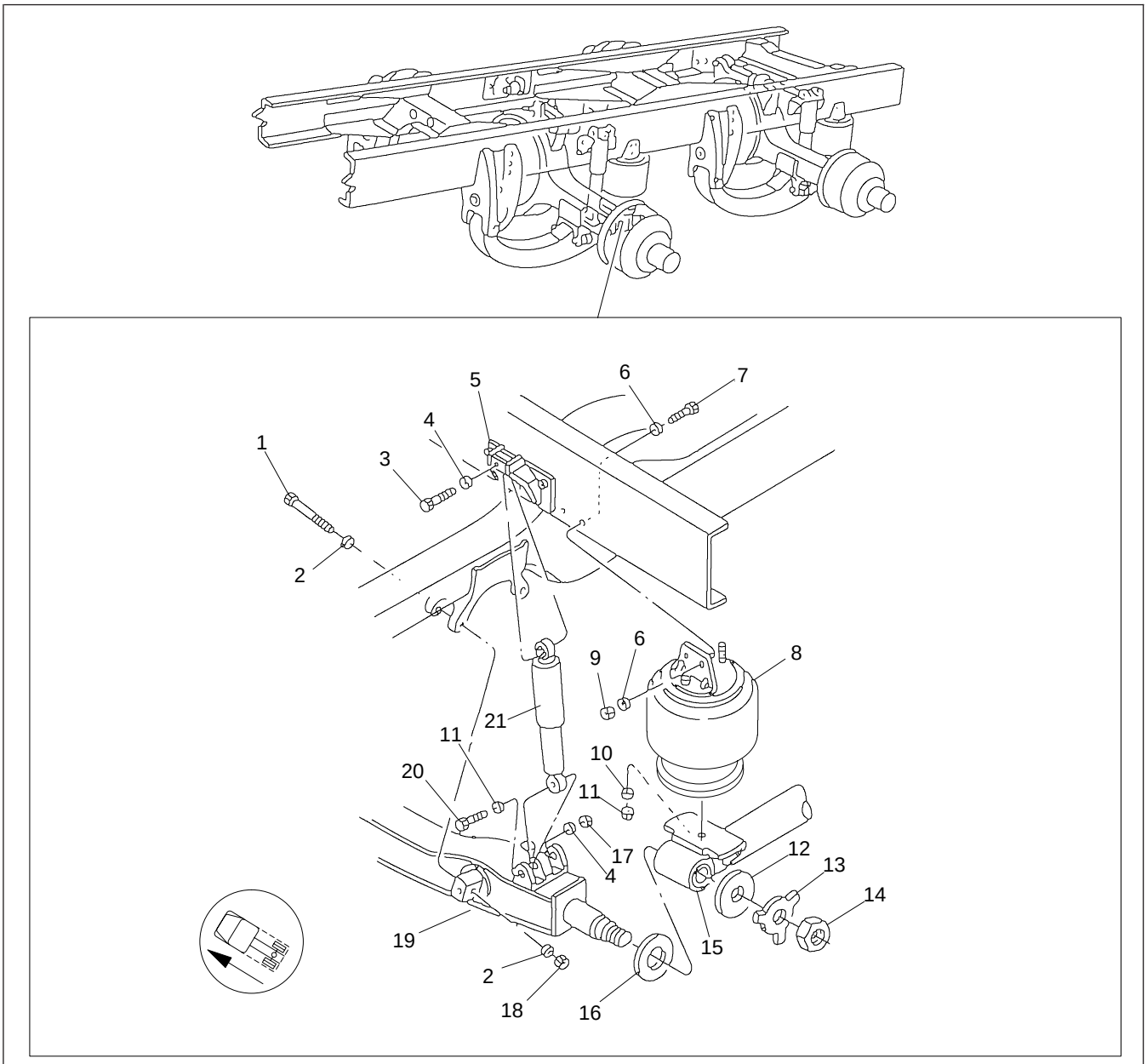
1. 20.25 SM and Reinforced Frames
2. 13.3 and 15.9 SM Frames
3. Bolt (3/4–10 x 3.50)
4. Tension Pin (0.74 x 1.0)
5. Tension Collar (0.78)
6. Suspension Support Beam Bracket (righthand)
6. Suspension Support Beam Bracket (lefthand)
7. Alignment Bushing (lefthand side only)
8. Adapter Assembly
9. Suspension Support Beam Assembly (righthand)
9. Suspension Support Beam Assembly (lefthand)
10. Nut (3/4–10)
11. Washer
12. Crossmember
13. Tension Pin (0.74 x 0.75)
14. Tension Pin (0.74 x 0.50)

Fig. 9, Suspension Support Beam Bracket, Disassembled View

General Information



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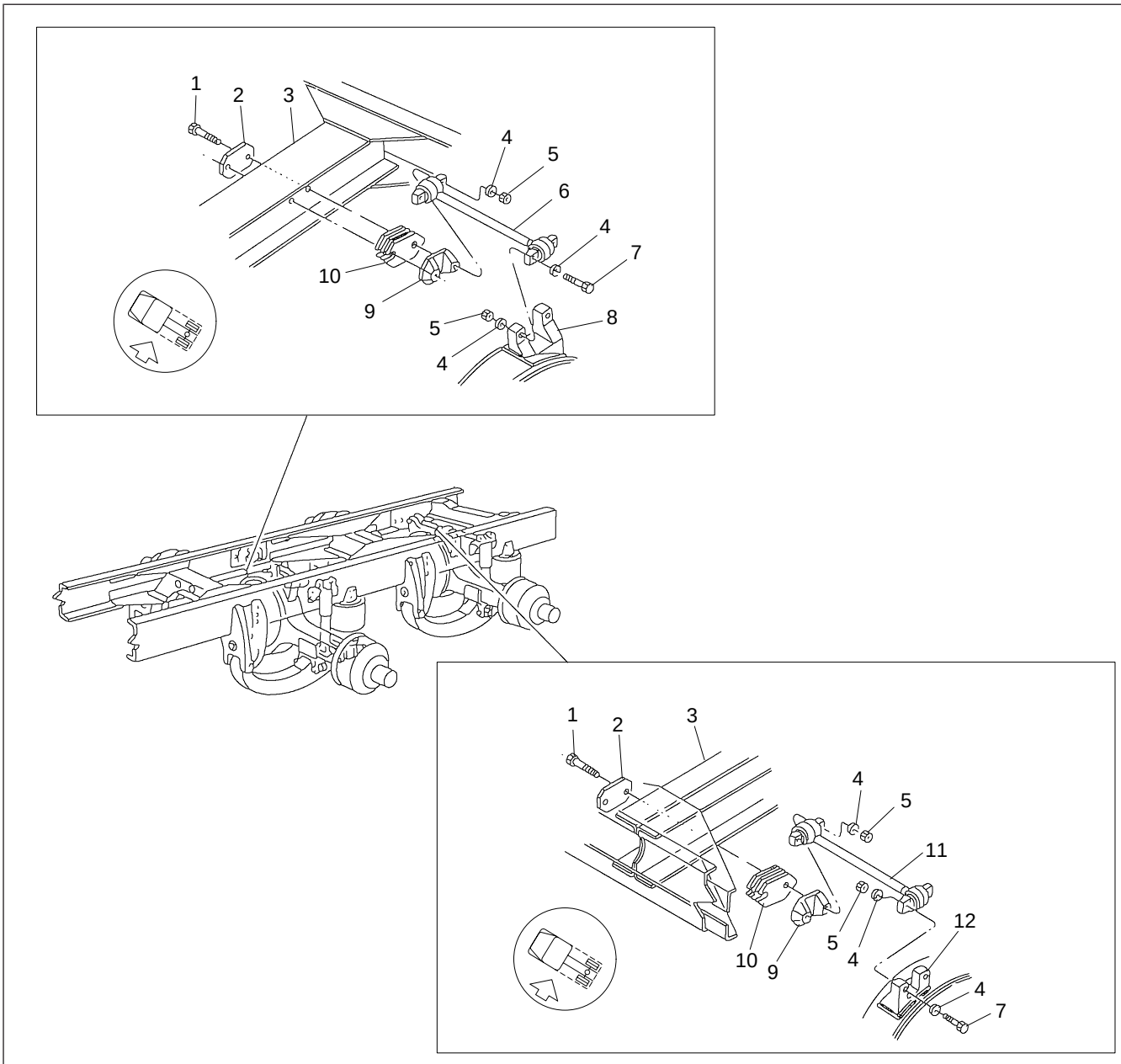
1. Bolt (1.00–8 x 6.00)
2. Washer
3. Bolt (3/4–10 x 3.25)
4. Washer
5. Upper Shock Absorber Bracket (righthand)
5. Upper Shock Absorber Bracket (lefthand)
6. Washer
7. Bolt (5/8–11 x 2.00)
8. Air Suspension Spring Assembly
9. Locknut (5/8–11)
10. Washer
11. Locknut (1/2–13)
12. Beam End Washer (0.75)
13. Locking Plate
14. Suspension Support Beam Nut
15. Suspension Support Beam Bar
16. Beam End Washer (0.25)
17. Locknut (3/4–10)
18. Locknut (1.00–8)
19. Suspension Support Beam Assembly
20. Bolt (3/4–10 x 4.25)
21. Shock Absorber

Fig. 10, Suspension Support Beam Assembly, Disassembled View



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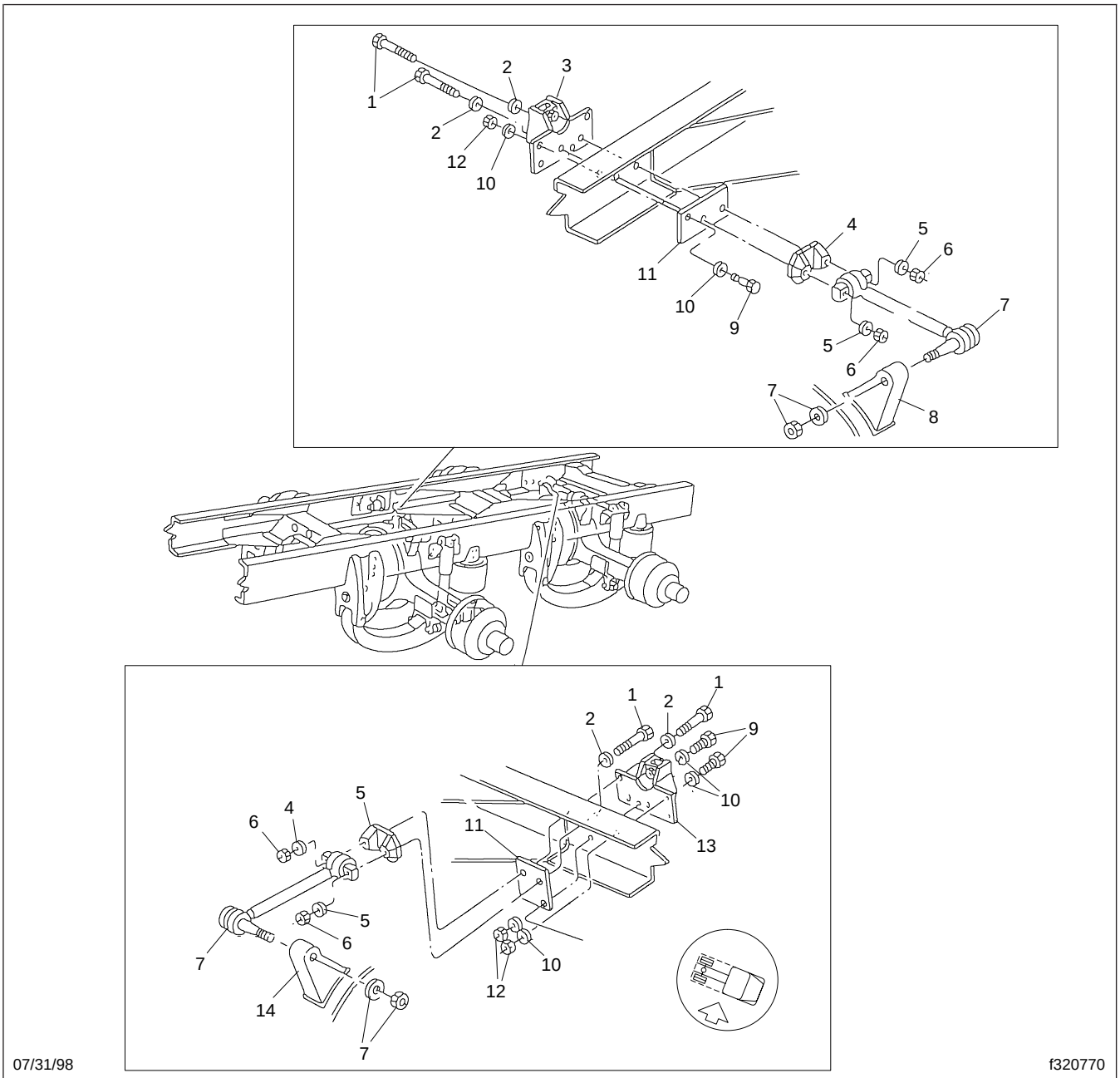
1. Bolt (5/8–11 x 6.50)
2. Torque Arm Bracket Reinforcement
3. Crossmember
4. Washer
5. Locknut (5/8–11)
6. Torque Rod (forward rear axle)
7. Bolt (5/8–S2)
8. Forward Rear Axle Assembly
9. Torque Rod Bracket
10. Torque Rod Bracket Spacer Assembly
11. Torque Rod (rear rear axle)
12. Rear Rear Axle Assembly

Fig. 11, Longitudinal Torque Rods, Disassembled View

General Information



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1. Bolt (3/4–10 x 5.50)
2. Washer
3. Upper Shock Absorber Bracket (righthand)
4. Transverse Torque Rod Bracket
5. Washer
6. Locknut (3/4–10)
7. Transverse Torque Rod Assembly
8. Forward Rear Axle Assembly
9. Bolt (5/8–11 x 2.00)
10. Washer
11. Torque Arm Bracket Reinforcement
12. Locknut (5/8–11)
13. Upper Shock Absorber Bracket (lefthand)
14. Rear Rear Axle Assembly

Fig. 12, Transverse Torque Rods, Disassembled View

Height Control Valve Adjustment

IMPORTANT: Prior to adjustment, the vehicle must be in an unloaded condition on a level surface with a 80 psi (552 kPa) minimum secondary air pressure.

1. Check all the suspension fasteners, including the equalizer beam pivot, axle and transverse beam connections, for tightness.

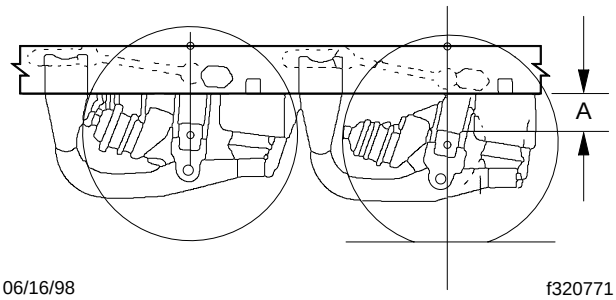
   Tighten to specifications, refer to **Specifications, 400**.

2. Check the suspension system for air leaks. Cycle the air dump system once with the engine running. Recheck the system for air leaks.

NOTE: The illustration shows the wheel and tire assembly removed for clarity.

3. Measure the distance between the bottom of the frame and the top of the rear rear axle housing. See **Fig. 1**.

   If the distance is not as specified, proceed as follows.



A. 5.8 inches (148 mm)

Fig. 1, Checking Clearance

4. Adjust the height control valve 9 to 12 lbf·ft (12 to 16 N·m).

   4.1 Loosen the locknuts.

   4.2 Lengthen or shorten the extension rod until the specified distance is obtained.

   4.3 Tighten the locknuts.

Specifications

General Specifications	
Item	**Specification**
Premium Long-Life Grease XG–1–C or –K	ESA–M1C75–B
Rubber Lubricant	ESA–M1B6–A

Table 1, General Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Air Suspension Spring Upper Retaining Bolts	150–205 (203–278)
Air Suspension Spring Lower Retaining Nut	75–105 (102–142)
Axle Mounting Bracket Mounting Bolts	540–730 (732–990)
Height Control Valve Assembly Retainer Nuts	7–10 (10–13)
Height Control Valve Mounting Bracket Retainer Nuts	32–41 (43–56)
Height Control Valve Extension Rod Lock Nuts	9–12 (12–16)
Longitudinal Torque Rod Mounting Bolts	150–205 (203–278)
Side Suspension Support Bracket Tension Pins	220–300 (299–406)
Shock Absorber Mounting Bolts	220–300 (299–406)
Suspension Support Beam Assembly Adapter Assembly	600–700 (814–948)
Suspension Support Beam Bar Retaining Nut	600–700 (814–948)
Transverse Torque Rod to Axle Retaining Nut	175–225 (237–305)
Transverse Torque Rod to Frame Mounting Bolts	220–300 (299–406)

Table 2, Torque Specifications

Standard Bolt Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
1/4-Inch Diameter, Grade 5	—	89–115 (1000–1300)
5/16-Inch Diameter, Grade 5	12–17 (17–23)	—

Standard Bolt Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
3/8-Inch Diameter, Grade 8	32–41 (43–56)	—
7/16-Inch Diameter, Grade 8	50–70 (68–95)	—
1/2-Inch Diameter, Grade 8	75–105 (102–142)	—
9/16-Inch Diameter, Grade 8	110–150 (149–203)	—
5/8-Inch Diameter, Grade 8	150–205 (204–277)	—
3/4-Inch Diameter, Grade 8	220–300 (299–406)	—
7/8-Inch Diameter, Grade 8	360–480 (489–650)	—
1.0-Inch Diameter, Grade 8	540–730 (733–989)	—

Table 3, Standard Bolt Torque Specifications

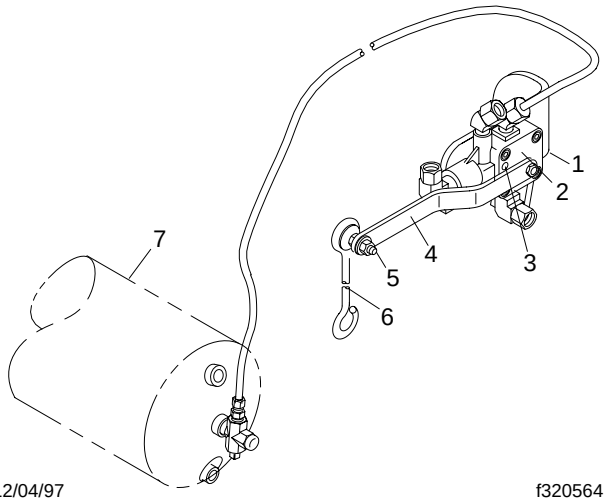
General Information

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.

A pressure holding valve, 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. Neutral-Position Hole
4. Horizontal Control Lever
5. Stud Bolt
6. Vertical Linkage
7. Secondary Air Reservoir

Fig. 1, Height-Control Valve Assembly

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.

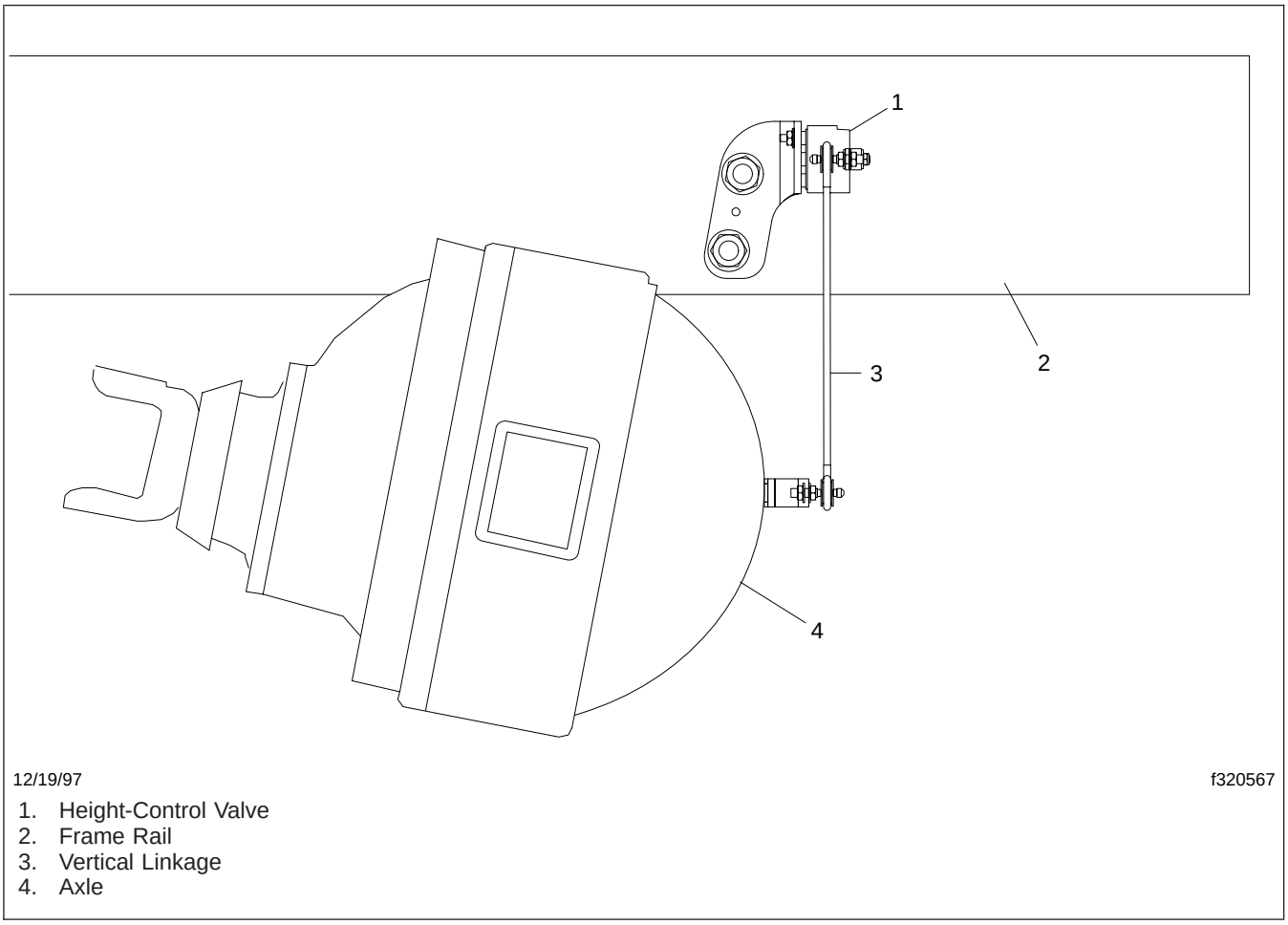
Principles of Operation

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. A horizontal control lever extends from the end of the height-control valve control shaft to a vertical linkage that connects to the height-control valve linkage bracket welded to the differential housing; see **Fig. 2**.

When the load changes, the horizontal control lever turns the height-control valve control shaft, activating either the intake or exhaust function 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 horizontal control lever returns to the (horizontal) neutral position.

General Information



1. Height-Control Valve
2. Frame Rail
3. Vertical Linkage
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 *L-Line and A-line 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 of the *L-Line and A-line Maintenance Manual*.

Ride Height Adjustment, Vehicle with a Barksdale Valve

NOTICE

Failure to adjust the suspension ride height could adversely affect driveline angles. Also, if the air springs are set too high, the driver may have difficulty (or be prevented from) backing the vehicle under a trailer. If the air springs are set too low, rapid wear of suspension parts will result.

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.

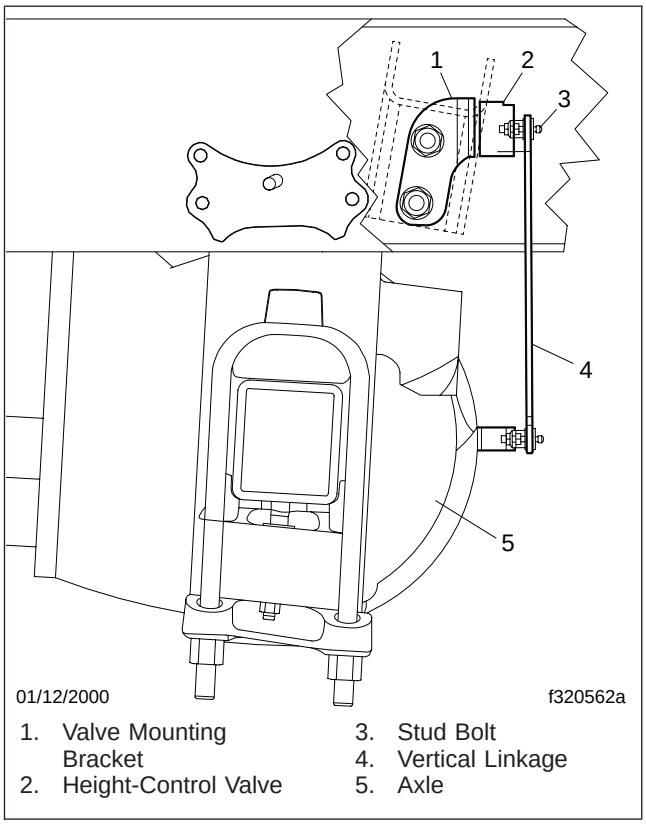
NOTE: The stud bolt that fastens the horizontal control lever to the vertical linkage is oriented correctly when the linkage rod is vertical as viewed from the side of the vehicle; see **Fig. 1**.

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, ride height is adjusted correctly. Apply the parking brakes.



1. Valve Mounting Bracket
2. Height-Control Valve
3. Stud Bolt
4. Vertical Linkage
5. Axle

Fig. 1, Barksdale Height-Control Valve Installation (side view)

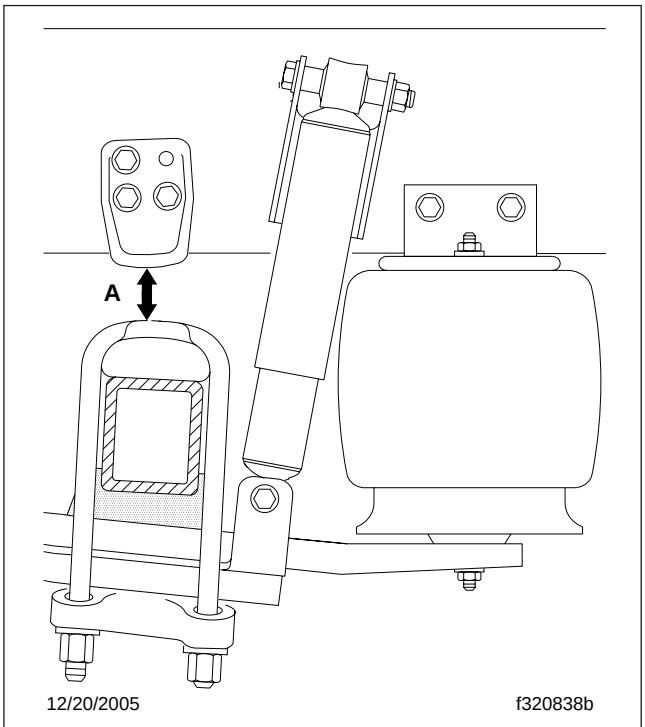
If the measurement is not within the acceptable range, go to the next step.

NOTICE

When loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

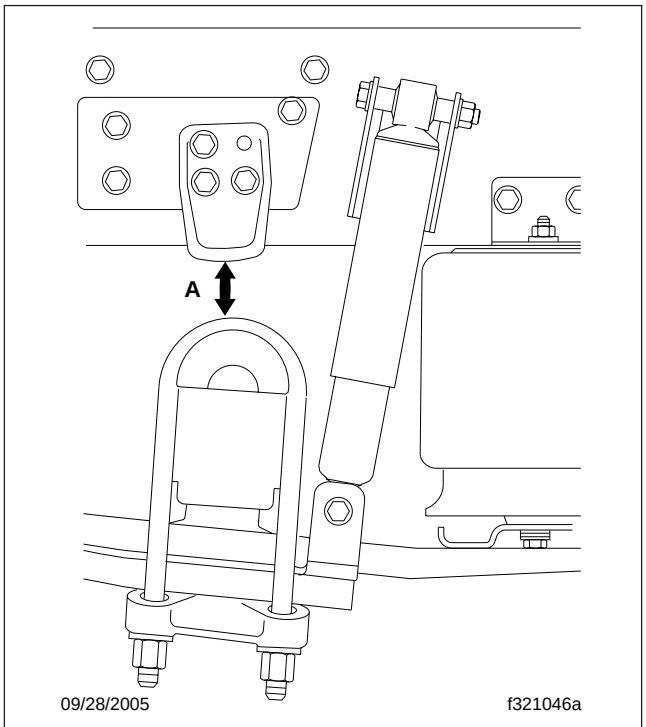
5. While holding the height-control valve mounting studs in place with an Allen wrench, loosen the nuts that attach the valve to the mounting bracket.

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



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

6. 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.
7. Center the horizontal control lever on the valve by inserting a 5/32-inch (4-mm) pin or drill bit into the neutral-position hole in the height-control valve and the horizontal control lever.
8. While holding the height-control valve mounting studs in place with an Allen wrench, tighten the nuts 95 lbf·in (1100 N·cm). Do not overtighten.
9. Remove the pin or drill bit previously inserted in the height-control valve.
10. 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.

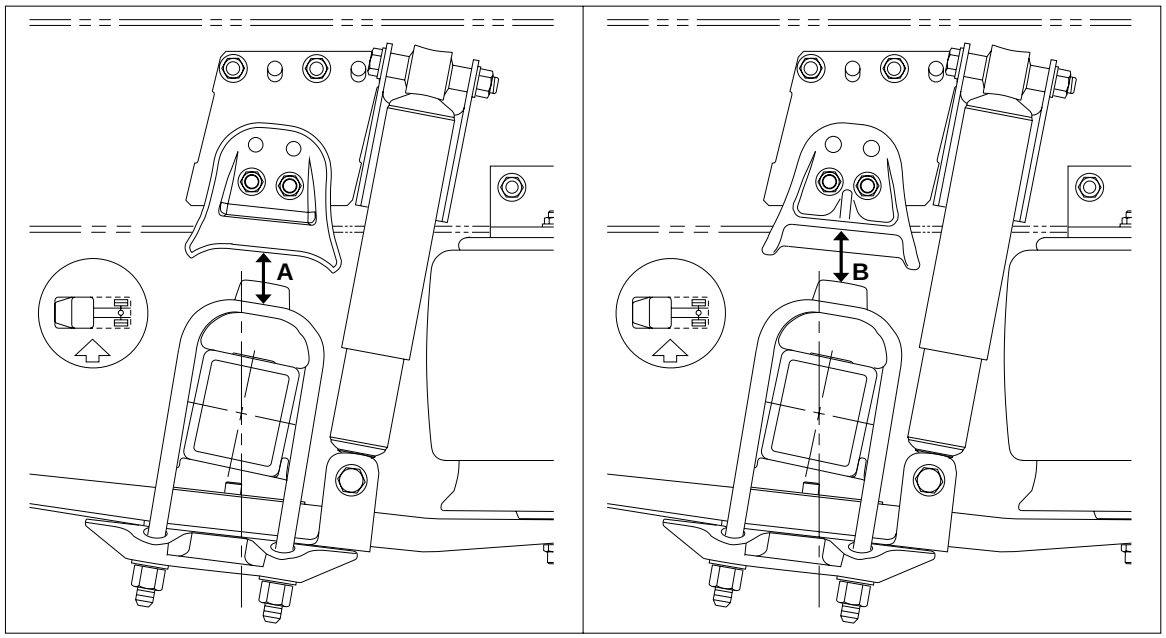
    Park the vehicle using a light brake application. Chock the tires on one axle only, and put the transmission in neutral. Do not apply the parking brakes.
11. Check the distance between the bottom of the left axle stop and the top of the axle U-bolt or U-bolt pad.

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).

12. If the distance is within the acceptable range, the ride height is adjusted correctly. Apply the parking brakes.

If the distance is not within the acceptable range, repeat the adjustment procedure.



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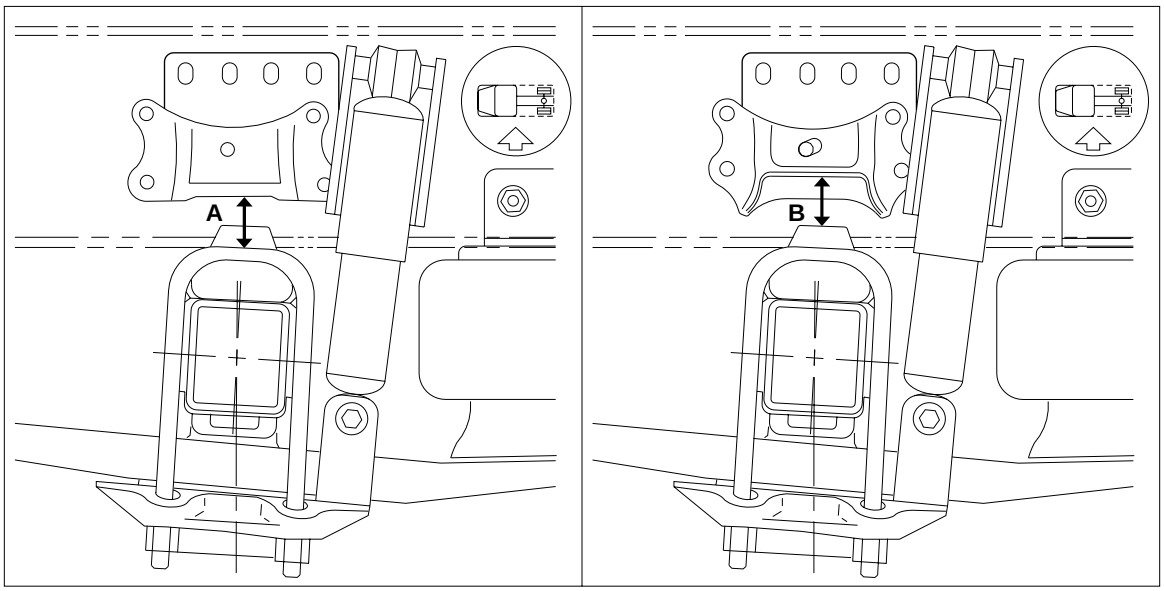
Measure Point	Suspension Height Measurement (A or B)		
	Min	Target	Max
A = Measure Here if Built Before August 24, 2001 B = Measure Here if Built After August 24, 2001	2-3/8 inch (60 mm)	2-5/8 inch (67 mm)	2-7/8 inch (73 mm)

Table 3, Suspension Ride Height Measurement, Single-Leaf Spring, 20k/40k, High Ride Height

Suspension Ride Height Adjustment



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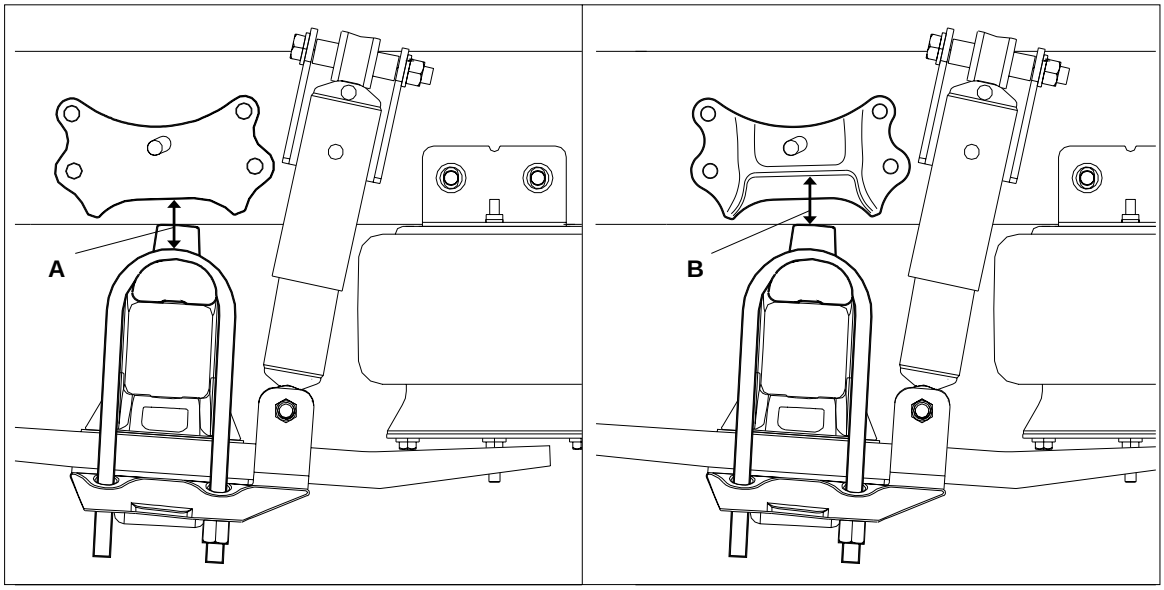
Measure Point	Suspension Height Measurement (A or B)		
	Min	Target	Max
A = Measure Here if Built Before August 24, 2001 B = Measure Here if Built After August 24, 2001	2-3/8 inch (60 mm)	2-1/2 inch (64 mm)	2-7/8 inch (73 mm)

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

Height-Control Valve Checking

It is normal to hear air escaping from the height-control valve for as much as 10 minutes after getting out of the vehicle when it is in an unladen condition. This air "leaking" is just the height-control valve exhausting air from the suspension air springs in order to return to the neutral mode.

The height-control valves used on the L-Line and A-Line are Barksdale valves. Two methods are available to check the operation of the Barksdale height-control valves. A leak in the valve may be discovered without using a test kit, but a test kit is necessary to determine if the valve has an unacceptable rate of leakage.

Some Barksdale height-control valves have been returned for warranty because the four bolts in the valve housing were overtightened, often, enough to crack the valve housing. These bolts should not be loose, and should not normally require tightening, as there are no serviceable parts in the valve.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

NOTICE

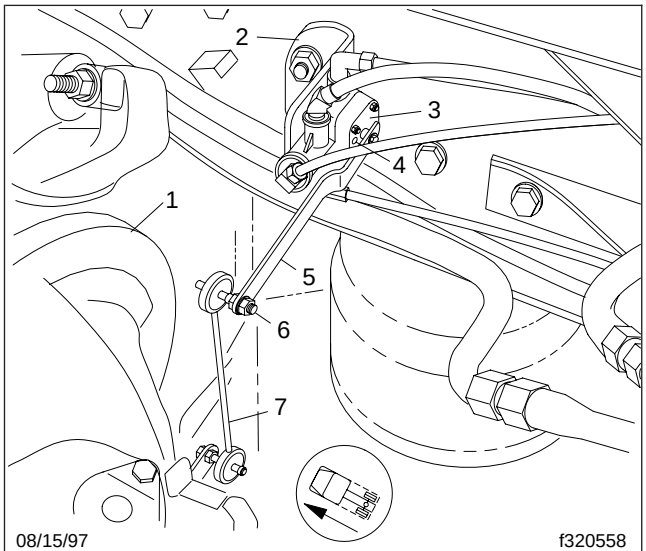
When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

Checking the Height-Control Valve Without Using a Test Kit

1. Apply the parking brakes and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. Disconnect the vertical linkage from the control lever; see **Fig. 1**.



1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height-Control Valve
4. Neutral-Position Hole
5. Horizontal Control Lever
6. Stud Bolt
7. Vertical Linkage

Fig. 1, Barksdale Height-Control Valve Assembly

5. Pull the control lever up about 45 degrees for 6 to 8 seconds. If air passes through the valve, that section of the valve is working.

Height-Control Valve Checking

6. Return the control lever to the neutral position. Air should stop flowing. If so, that section of the valve is working.
7. Push the control lever down about 45 degrees for 6 to 8 seconds. If air exhausts from the valve, that section of the valve is working.
8. Return the control lever to the neutral position. If the air stops again in the neutral position, the valve is working correctly.
9. If the valve works as stated in all of the above steps, then no further checking is necessary. Connect the vertical linkage to the control lever, then tighten the linkage nut.

   If needed, adjust the ride height or replace the height-control valve. For adjustment of the ride height, see **Subject 110**. For replacement of the height-control valve, see **Subject 130**.

NOTE: If a leak is detected on a Barksdale height-control valve, go to "Checking the Height-Control Valve Using a Test Kit". Barksdale valves have an acceptable leak rate of 3 cubic inches (50 cc) per minute. You can determine if a leak is acceptable only by using the Barksdale test kit.

Checking the Height-Control Valve Using a Test Kit

IMPORTANT: The procedure described below is for use on Barksdale height-control valves only.

NOTE: The Barksdale field test kit is designed to be used with the height-control valve installed on the vehicle. Refer to **Specifications 400** for information on ordering the Barksdale height-control valve test kit KD2264.

1. If not already done, park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. For valves without an integral dump port, go to the next step.

   For valves with an integral dump port, check the rubber exhaust flapper at the back of the valve housing for leaks; see **Fig. 2**. Use a soapy solution.

   If a leak is found, there may be contaminants blocking the piston. Cycle the height-control valve switch inside the cab for two-second bursts, four or five times, to clear away any contaminants.

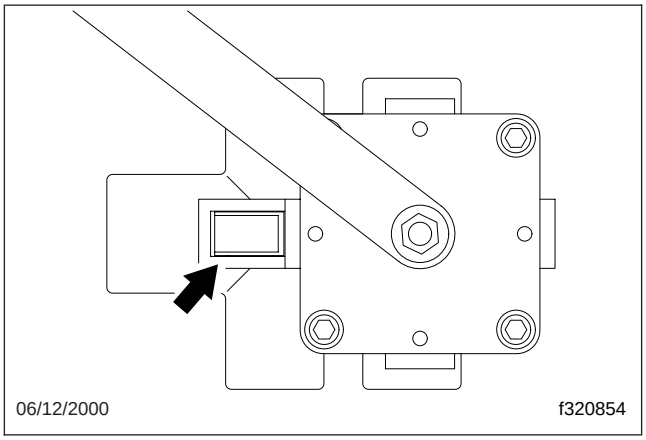
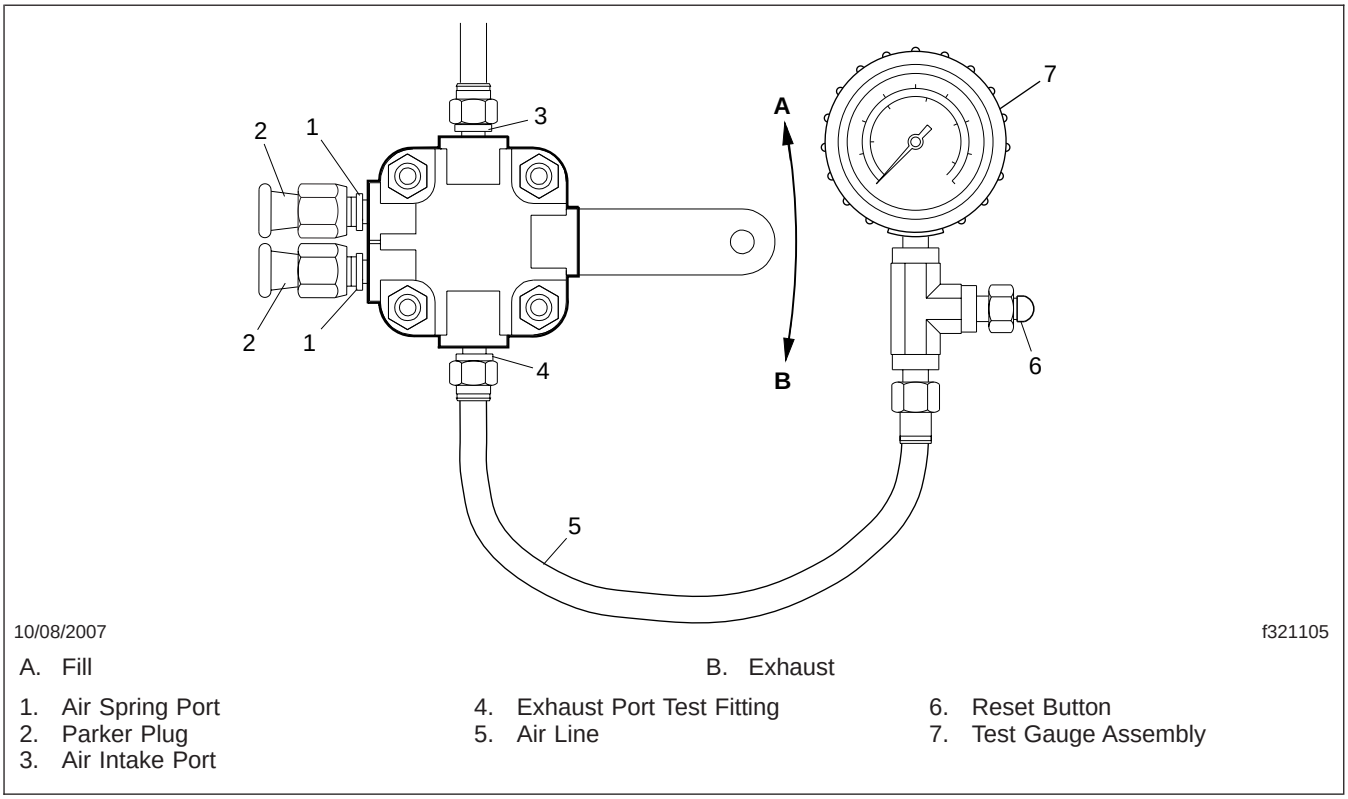


Fig. 2, Exhaust Flap Location (height-control valve with integral dump port)

5. Disconnect the vertical linkage from the horizontal control lever.
6. Rotate and hold the horizontal control lever down at about 45 degrees to exhaust air from the air springs.
7. *If equipped with an integral dump port,* turn on the quick dump switch on the dash. Leave the switch on until testing is complete.

   If not equipped with an integral dump port, disconnect the air lines from the air spring ports on the height-control valve. Leave the elbow fittings (if equipped) in place. Install a Parker plug into each air spring port (or elbow fitting); see **Fig. 3**.
8. If a flapper is present on the exhaust port of the height-control valve, remove it using needlenose pliers.



A. Fill
B. Exhaust

1. Air Spring Port
2. Parker Plug
3. Air Intake Port
4. Exhaust Port Test Fitting
5. Air Line
6. Reset Button
7. Test Gauge Assembly

Fig. 3, Test Connections

9. Clean the surface around the exhaust port, then install the test fitting into the exhaust port. The centering pin on the fitting must align with the slot on the exhaust port. Rotate the test fitting 45 degrees clockwise to lock it in place; see **Fig. 3**.

NOTE: It may be necessary to cut the tie straps that hold the chassis wiring running below the height-control valve, in order to access the exhaust port.

10. Connect one end of the air hose from the kit to the test connector on the exhaust port, and the other end to the test gauge.
11. Check the height-control valve in the fill mode, as follows.
    - 11.1 Rotate the valve control lever up 45 degrees from the horizontal to the fill position.
    - 11.2 Press the reset button on the test gauge.
    - 11.3 Observe the test gauge for 30 seconds. Refer to **Fig. 4** for the maximum allowable exhaust pressure change versus inlet pressure.

      The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

      If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

12. Check the height-control valve in the exhaust mode, as follows.
    - 12.1 Rotate the valve control lever down 45 degrees from the horizontal to the exhaust position.
    - 12.2 Press the reset button on the test gauge.
    - 12.3 Observe the test gauge for 30 seconds. Refer to **Fig. 4** for the maximum allowable

Height-Control Valve Checking

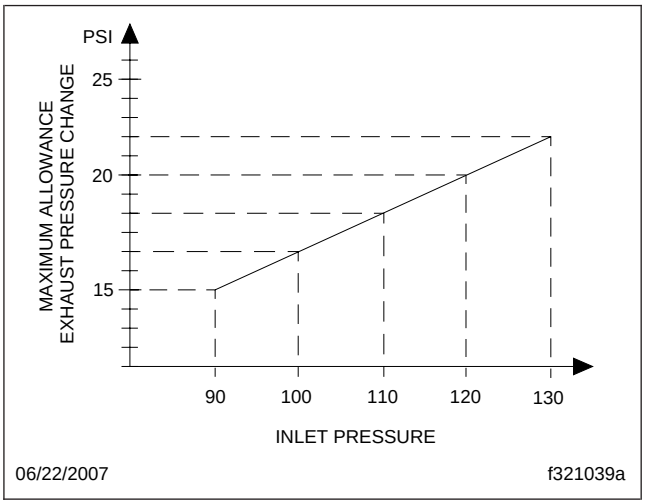


Fig. 4, Inlet Pressure vs. Exhaust Pressure Change in 30 Seconds

exhaust pressure change versus inlet pressure.

The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

13. Disconnect the test gauge and connector from the valve exhaust port.
14. If the height-control valve is defective, replace it; see **Subject 130**.
15. Install the flapper on the exhaust port by pressing it into place.
16. *For height-control valves with an integral dump port,* connect the vertical linkage to the height-control valve control lever. Turn off the quick dump switch on the dash. The ride height will automatically return to the correct position.

    For height-control valves without an integral dump port, remove the two Parker plugs from the air spring ports, and connect the air lines to the air spring ports (or elbow fittings). Connect the vertical linkage to the height-control valve control lever. The ride height will automatically return to the correct position.

Barksdale Height-Control Valve Replacement

The Barksdale valve does not use an adjustable linkage rod. To adjust the Barksdale valve, see **Subject 110**.

1. Apply the parking brakes and chock the tires.

⚠ WARNING

Keep your hands and all objects away from the area under and around the slack adjusters and suspension components when removing the pressure from the air system. These parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

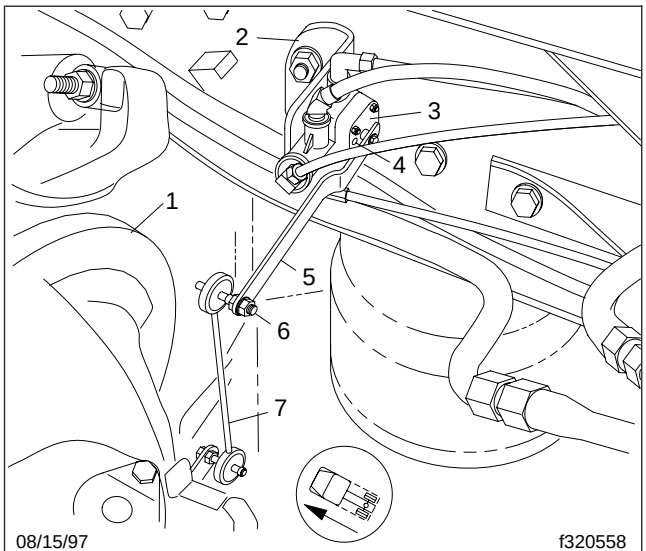
2. Drain all air from the air tanks.

⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

3. Remove the nut and washer that attaches the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
4. Rotate and hold the horizontal control lever down until all air is exhausted from the air springs.
5. 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.

IMPORTANT: For quick-connect tube fittings, do not remove the tube by cutting it close to the fitting. If the remaining part of the tube cannot be pulled from the fitting, the fitting will not be reusable and the warranty on that unit will be void.



1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height-Control Valve
4. Neutral-Position Hole
5. Horizontal Control Lever
6. Stud Bolt
7. Vertical Linkage

Fig. 1, Barksdale Height-Control Valve

NOTICE

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

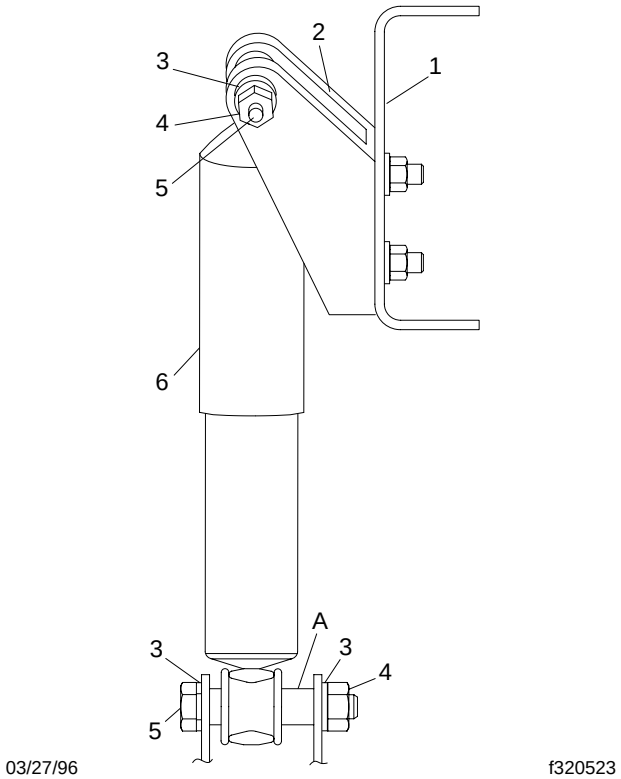
6. While holding the height-control valve mounting studs in place with an Allen wrench, remove the nuts and washers that attach the valve to the mounting bracket. Remove the height-control valve.
7. Position the new height-control valve on the height-control bracket. While holding the height-control valve mounting studs in place with an Allen wrench, install the nuts and washers, and

Height-Control Valve Replacement

tighten the nuts 95 lbf·in (1100 N·cm). Do not overtighten.

8. Remove the tape from the air lines and fittings, and connect the air lines to the height-control valve as marked earlier. Tighten nylon tube air fittings until only two threads show on the fitting. On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more.
9. Close the drain cocks on all reservoirs.
10. Build up normal operating pressure in the air system. Check all air lines and connections for leaks. Eliminate all leaks.
11. Adjust the height-control valve; see **Subject 110**.

Replacement (See Fig. 1)



A. Shock absorber is installed with long end of sleeve toward frame rail.

1. Frame Rail
2. Upper Bracket
3. Washer
4. Locknut
5. Bolt
6. Shock Absorber

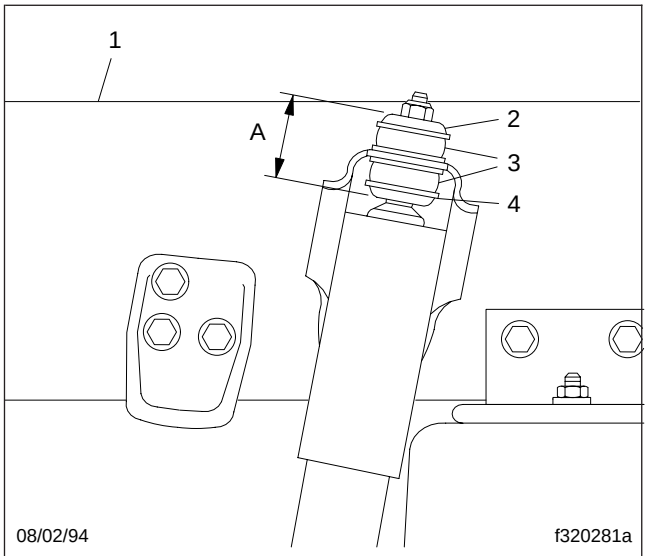
Fig. 1, Shock Absorber Mounting

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

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

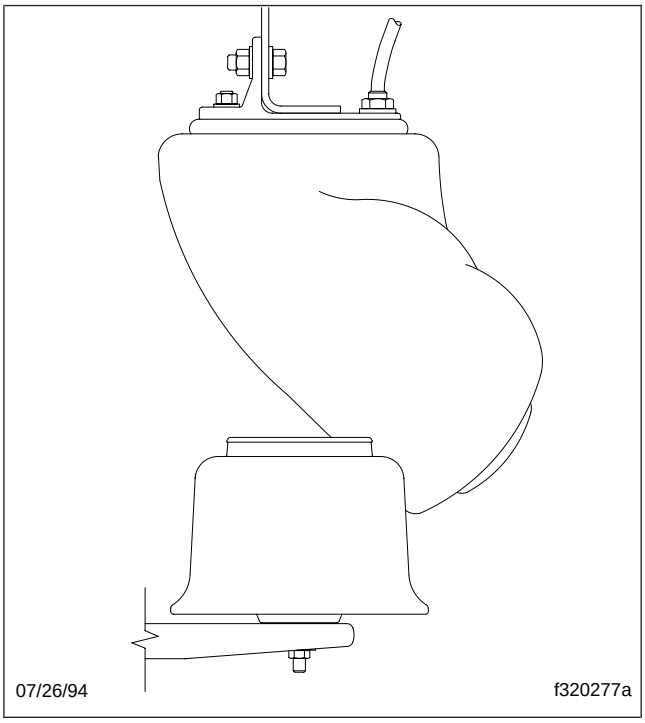


Fig. 1, Air Spring Bag Extended

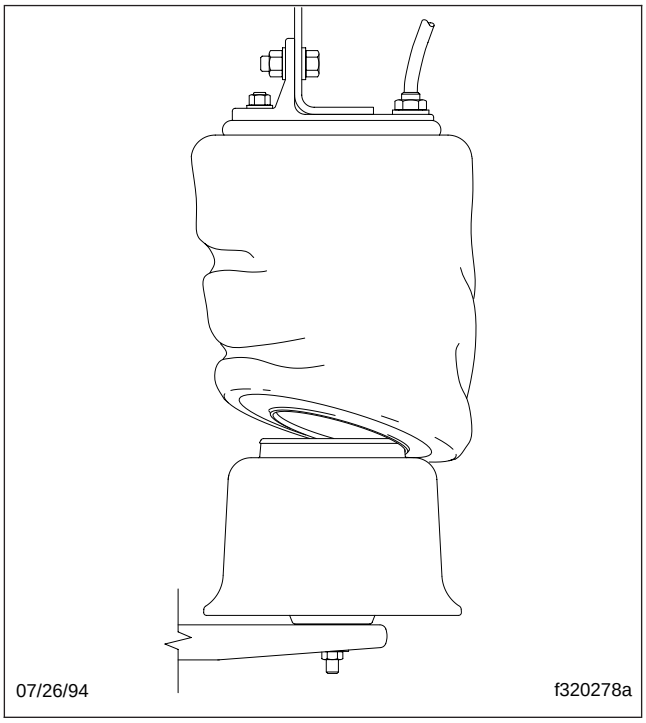


Fig. 3, Air Spring Bag Aligned with Piston

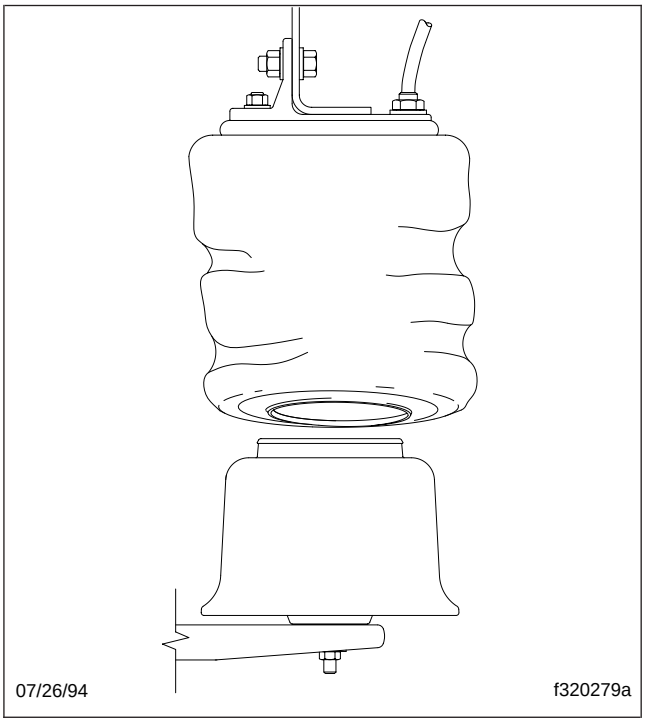


Fig. 2, Air Spring Bag Folded

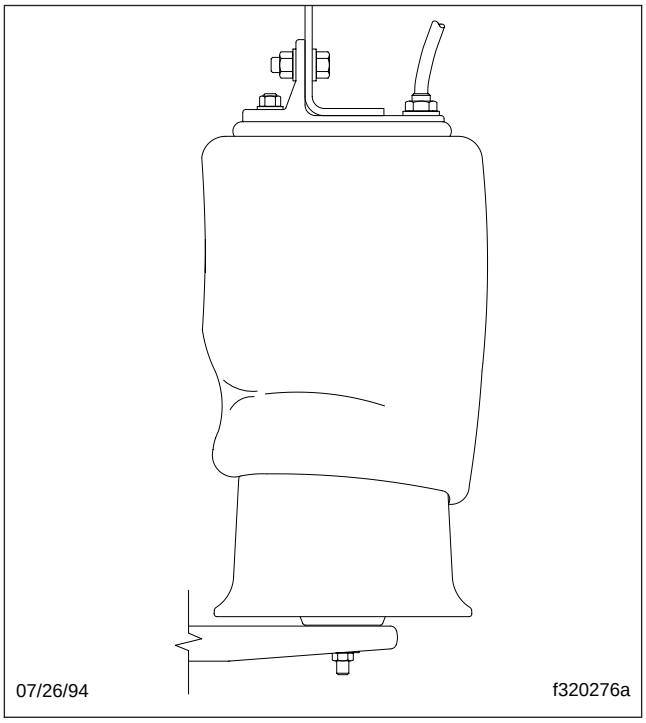
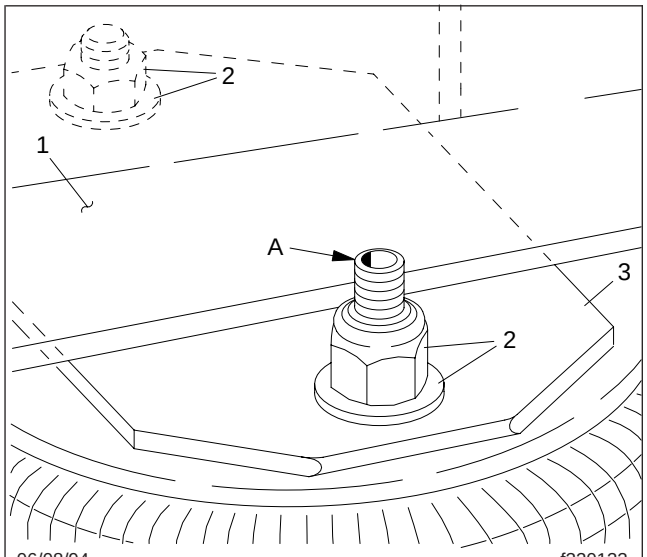


Fig. 4, Air Spring Bag Rolling Onto Piston

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**.

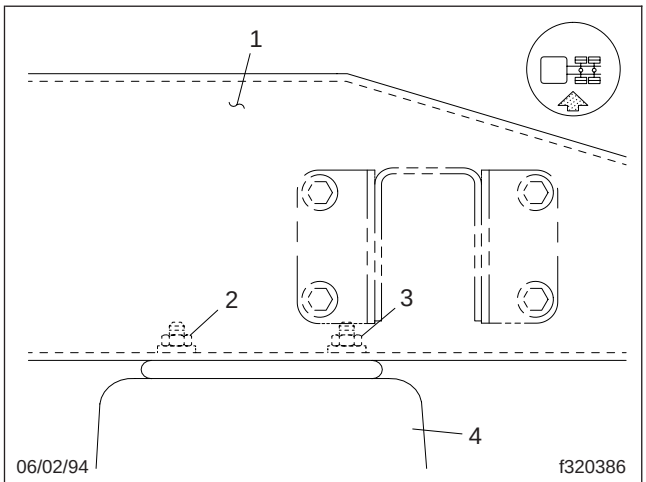


A. Air line connects here.
1. Right Frame Rail Flange
2. Locknut and Washer
3. Upper Mounting Bracket

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

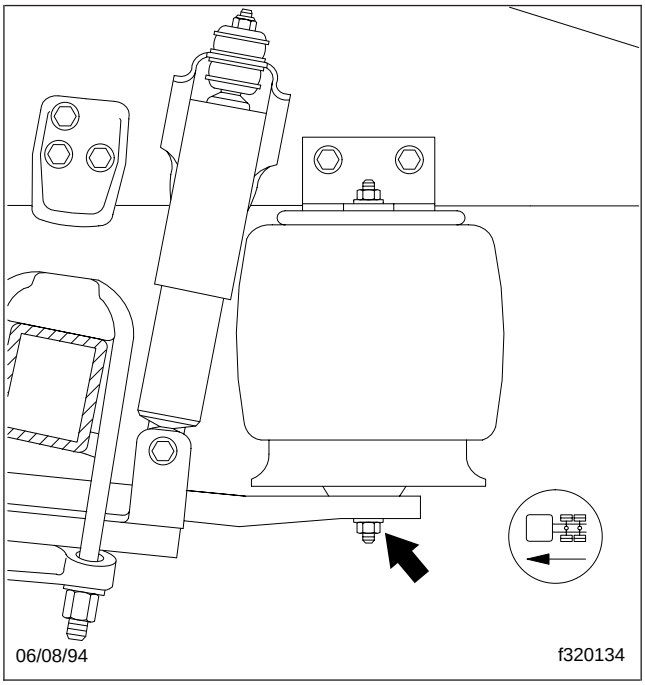
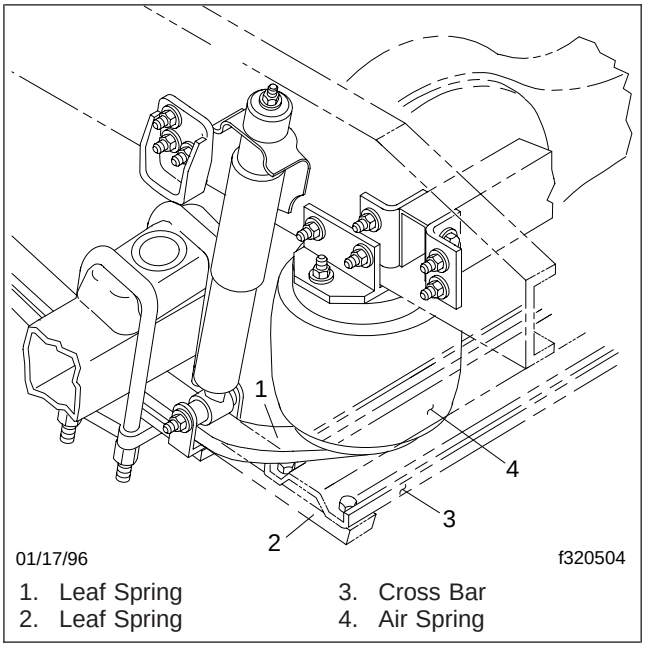


Fig. 3, Capscrew Connecting Leaf Spring and Air Spring



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)

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 instructions, 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**.
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**.

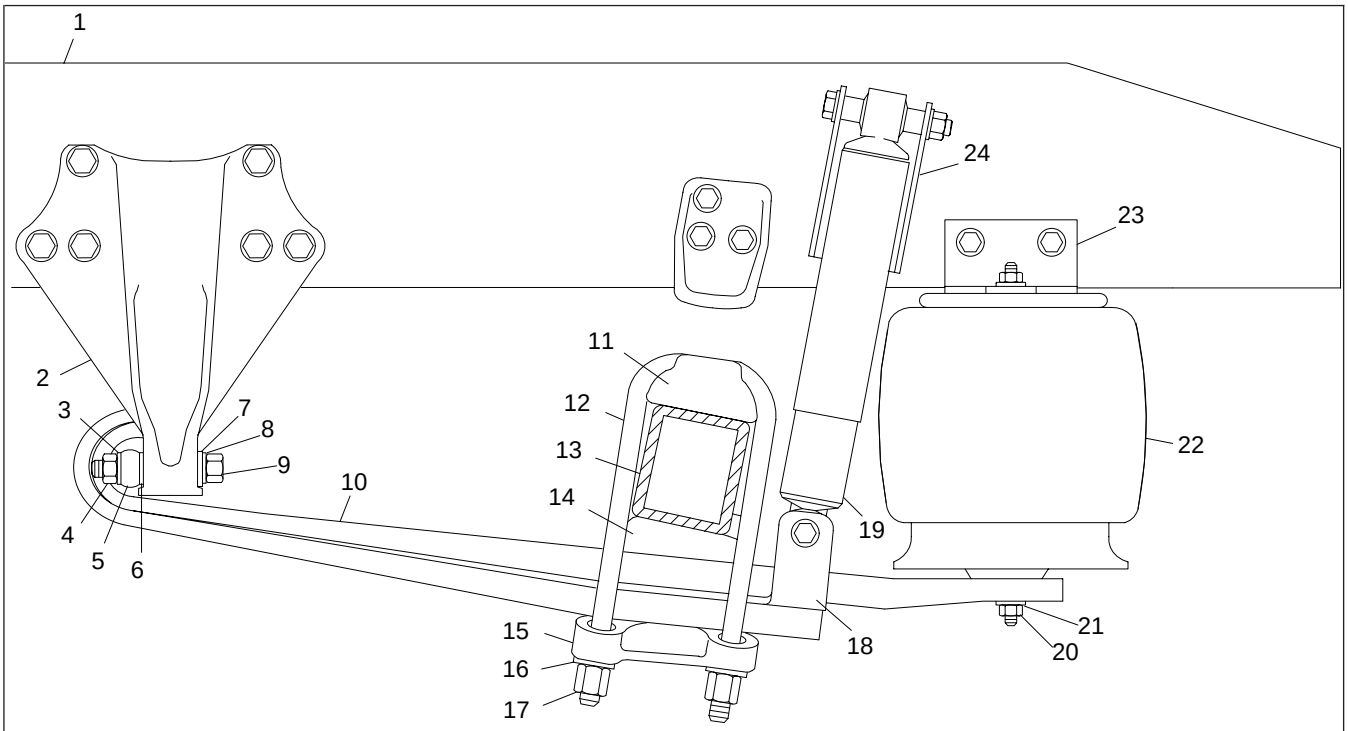
With both 5- and 3-degree single-drive axle angles, the arrow on the bottom of the axle clamp (**Fig. 1**) must point toward the rear of the vehicle.

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).

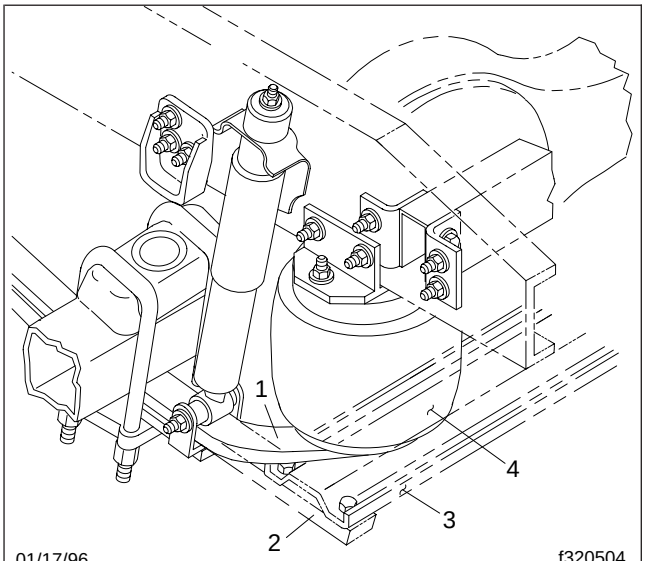
Leaf Spring Replacement



11/17/95 f320462

1. Frame Rail
2. Spring Hanger
3. Washer
4. Hexnut
5. Spring Mounting Eye Pin
6. Alignment Shim
7. Wear Shoe Clip
8. Washer
9. Spring Mounting Bolt
10. Leaf Spring Assembly
11. U-Bolt Pad
12. U-Bolt
13. Axle
14. Axle Seat
15. Axle Clamp
16. Flatwasher
17. High Nut
18. Shock Absorber Lower Mounting Bracket
19. Shock Absorber
20. Nylon Locknut
21. Washer
22. Air Spring
23. Air Spring Mounting Bracket
24. Shock Absorber Upper Mounting Bracket

Fig. 1, AirLiner Leaf Spring Assembly



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)

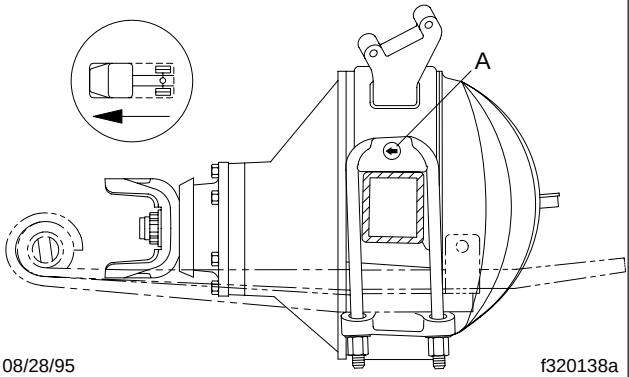
U-Bolt Pad Orientation for Axles		
Axle Designation		**U-Bolt Pad Orientation**
Meritor SQ 100, SSHD	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	No arrow; axle bump stop toward vehicle centerline.
Meritor RT40-145, RT44-145, RT46-160	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	Arrow toward front of vehicle.
Eaton 402, 461	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	No arrow; axle bump stop toward vehicle centerline.

Table 1, U-Bolt Pad Orientation for Axles

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).

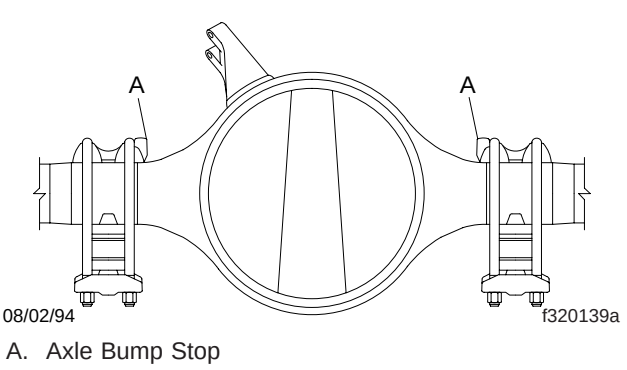
    On 23,000-pound and 46,000-pound suspensions, tighten the locknuts on the bottom of the cross bar 241 lbf·ft (327 N·m).
14. Tighten the hexnuts at the front of the leaf spring 170 lbf·ft (230 N·m).
15. Install the wheel and tire assembly. For instructions, see **Group 40**. Remove the safety stands, 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**.

Leaf Spring Replacement



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 Permabond HM–160 or Loctite RC–609 or 680, liberally around the outside surface of the bushing.

   6.3 Press the bushing into place.

   6.4 Allow the bonding agent to cure for 24 hours.

   NOTE: After the curing time, the bushing must resist a minimum 7,700 lb (3 490 kg) pushout force.

7. Install the leaf spring assembly. See the information in **Subject 170**.
8. Install the wheel and tire assembly. For instructions, see **Group 40**. Remove the safety stands, and lower the vehicle.
9. Check the rear axle alignment. For instructions, 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

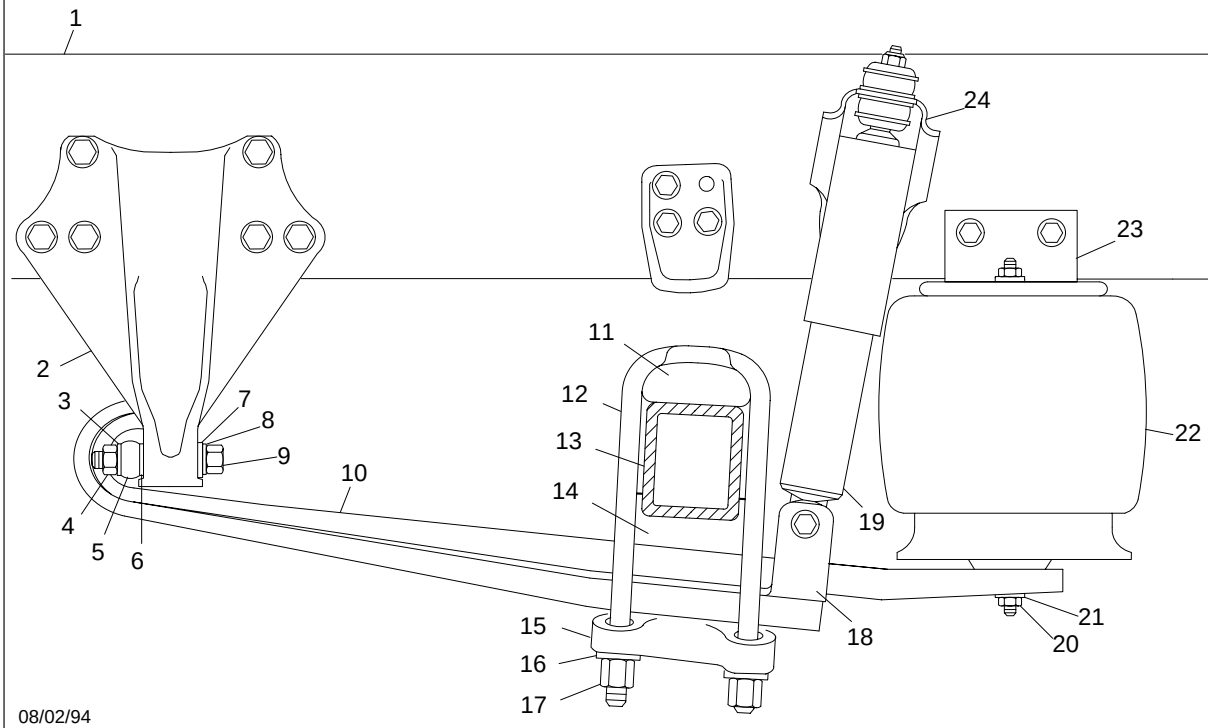
See **Fig. 1**.

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:

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**.
3. When the axle is in alignment, install alignment shim(s) to take up the slack between the spring hanger and the spring mounting eye pin.

IMPORTANT: Make sure the same number of shims is installed on both ends of the spring mounting eye pin.

4. Tighten the spring mounting eye bolts 170 lbf·ft (230 N·m).
5. Check the axle alignment again. If necessary, repeat the above procedure until the alignment is within tolerances.



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

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**.

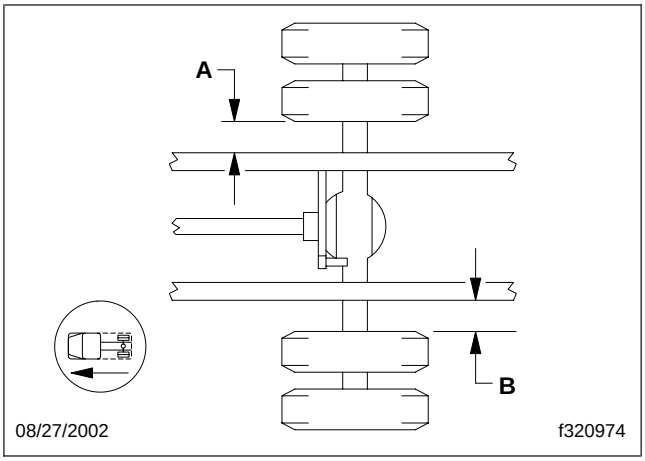


Fig. 2, Rear Axle Tracking Measurements (single axle)

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).

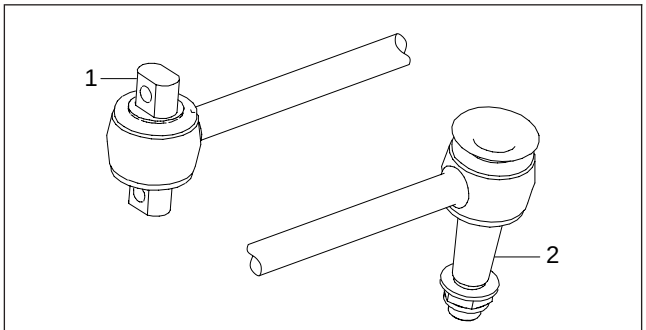
   For taper-pin style torque rods, tighten the fasteners 165 lbf·ft (224 N·m). See **Fig. 3**.

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**.
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.



1. Bar Pin
2. Taper Pin

Fig. 3, Torque Rod Types

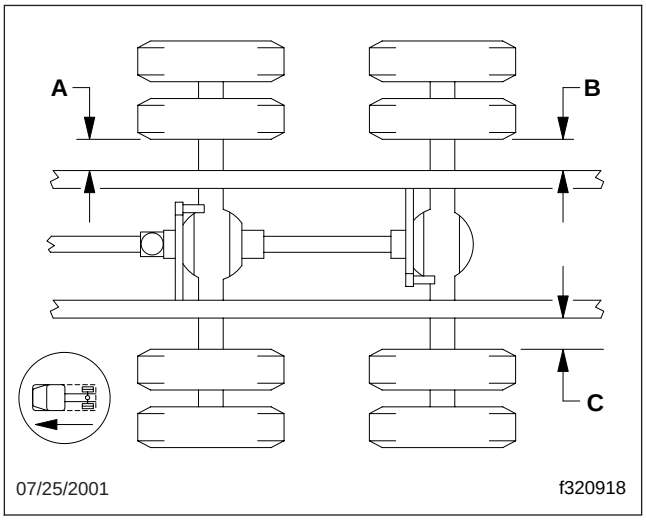
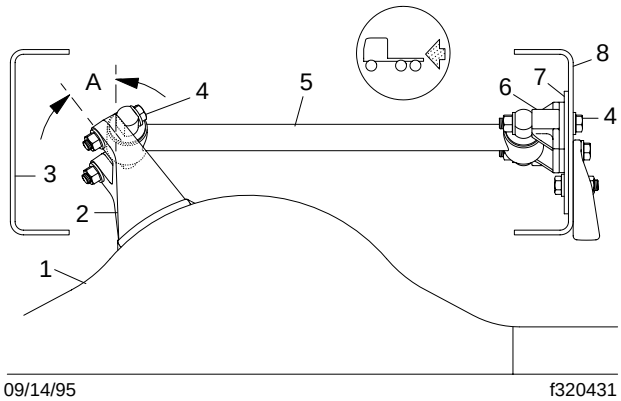


Fig. 4, Rear Axle Tracking Measurements (tandem axles)

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

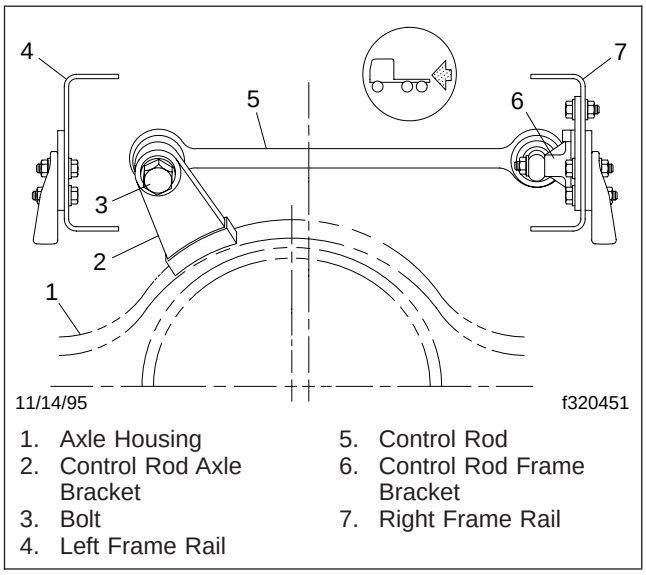
1. Park the vehicle. Shut down the engine, and apply the brakes.
2. Chock the tires. Raise the vehicle. Support the frame rails with jack stands.
3. Remove the fasteners holding the control rod to the frame rail bracket. Remove the shims, and set the shims aside.
4. Remove the control rod.
5. Position 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**.

Torque Specifications

For fastener torque values, see **Table 1**.

Torque Values			
Description	**Size**	**Torque**	
		lbf·ft (N·m)	**lbf·in (N·cm)**
Height-Control Valve Housing Bolts*	1/4–20	—	45 (500)
Height-Control Valve Mounting Locknuts*	1/4–20	—	95 (1100)
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 Tighten in a diagonal pattern as shown in **Fig. 1**.	7/8–14	Stage 1: Hand-tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 420 to 500 (571 to 680)	— — — —
Lateral Control Rod Mounting Bolt Nuts	5/8–11	136 (184)	—
Leaf Spring Mounting Eye Bolt Locknuts	5/8–11	170 (230)	—
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)	—

* See the cautionary statements below.

Table 1, Torque Values

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

NOTICE

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

Specifications

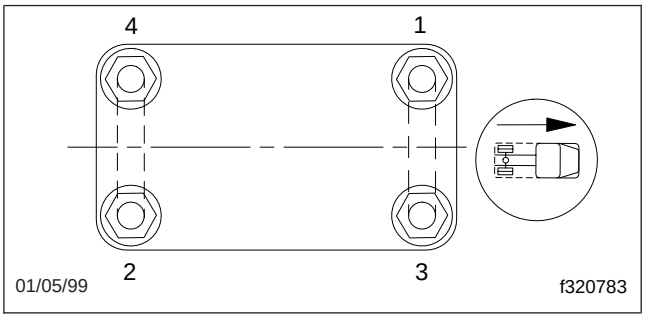
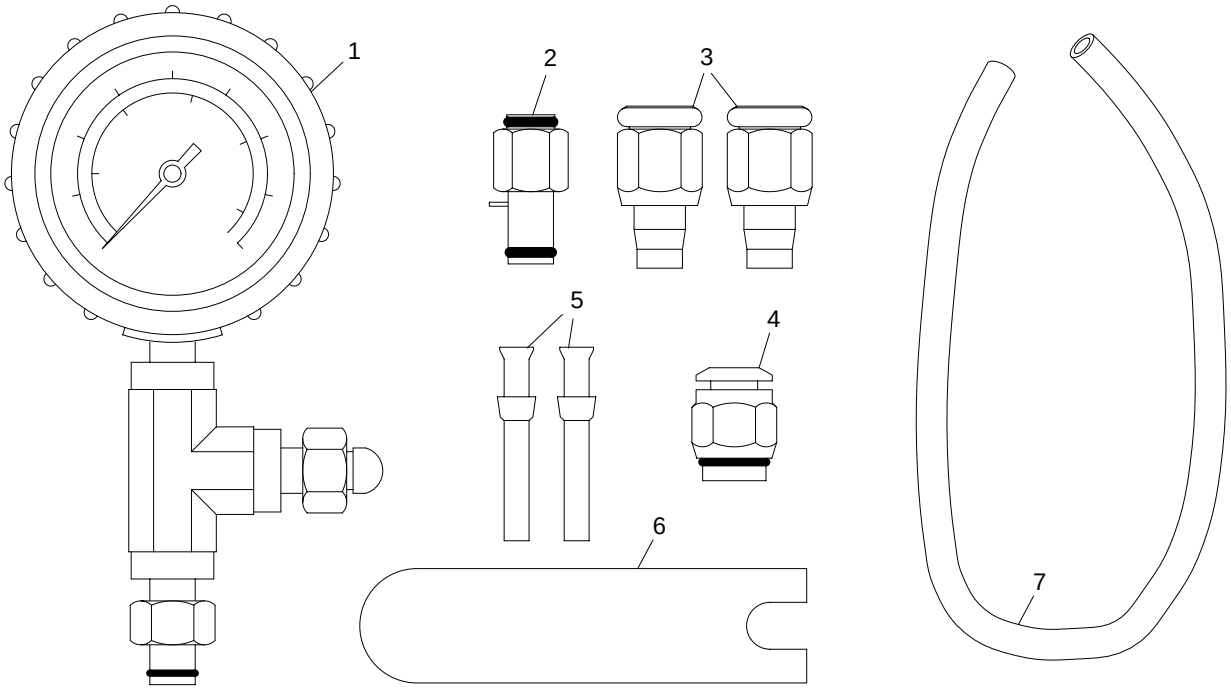


Fig. 1, Tightening Pattern for U-Bolt High Nuts

Special Tools

Use the kit shown in **Fig. 2** to test a Barksdale height-control valve. Test kit BKS KD2264 is available via the Direct Ship program in Paragon.



NOTE: Parts for cab suspension valve testing included.

1. Test Gauge Assembly with Reset Button
2. Exhaust Port Test Connector for Cab Suspension Valve (used for cab suspension valve testing)
3. Parker Plugs
4. Exhaust Port Test Connector for Chassis Suspension Valve
5. Test Plugs for Cab Suspension Valve (used for cab suspension valve testing)
6. Special Tool for Disconnecting Air Line
7. Air Line

Fig. 2, Barksdale Height-Control Valve Test Kit BKS KD2264

General Description

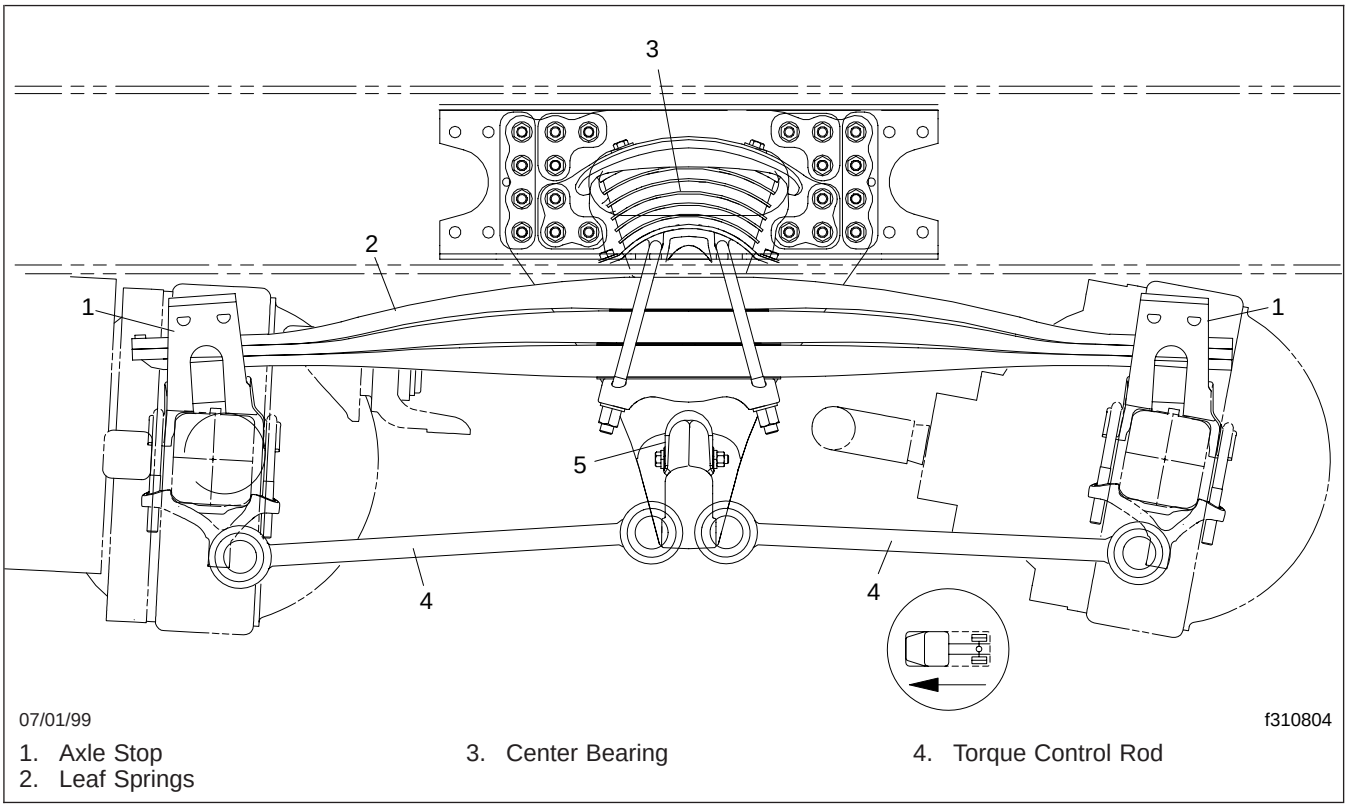
The TufTrac Suspension (**Fig. 1**) is heavy-duty "six rod" tandem axle suspension option for trucks built for severe on/off highway work. The TufTrac design allows a truck to maneuver over bumps, ridges and washboard roads that typically generate high rates of axle articulation, without bottoming out the suspension or losing traction.

The TufTrac suspension is available in two weight ratings – 40,000- and 46,000-pound (18 144-, 20 865-kilogram) capacities. The 40,000-pound (18 144-kilogram) capacity suspension uses two taper leaf springs and has an axle spacing of 54 inches. The 46,000-pound (20 865-kilogram) capacity suspension has three leaf springs (shown in this section). The 46,000-pound (20 865-kilogram) suspensions also have a standard axle spacing of 56 inches.

Principles of Operation

Six functional links in the TufTrac suspension maintain the positions of the axles. Side-to-side axle movement is controlled by two wishbone links from the frame to the axles at the top of the suspension. Four bar links from the frame to the axles at the bottom control the forces of driving and braking as well as fore-and-aft road shocks. Vertical loads are carried by the rubber-isolated parabolic taper leaf spring packs.

General Information

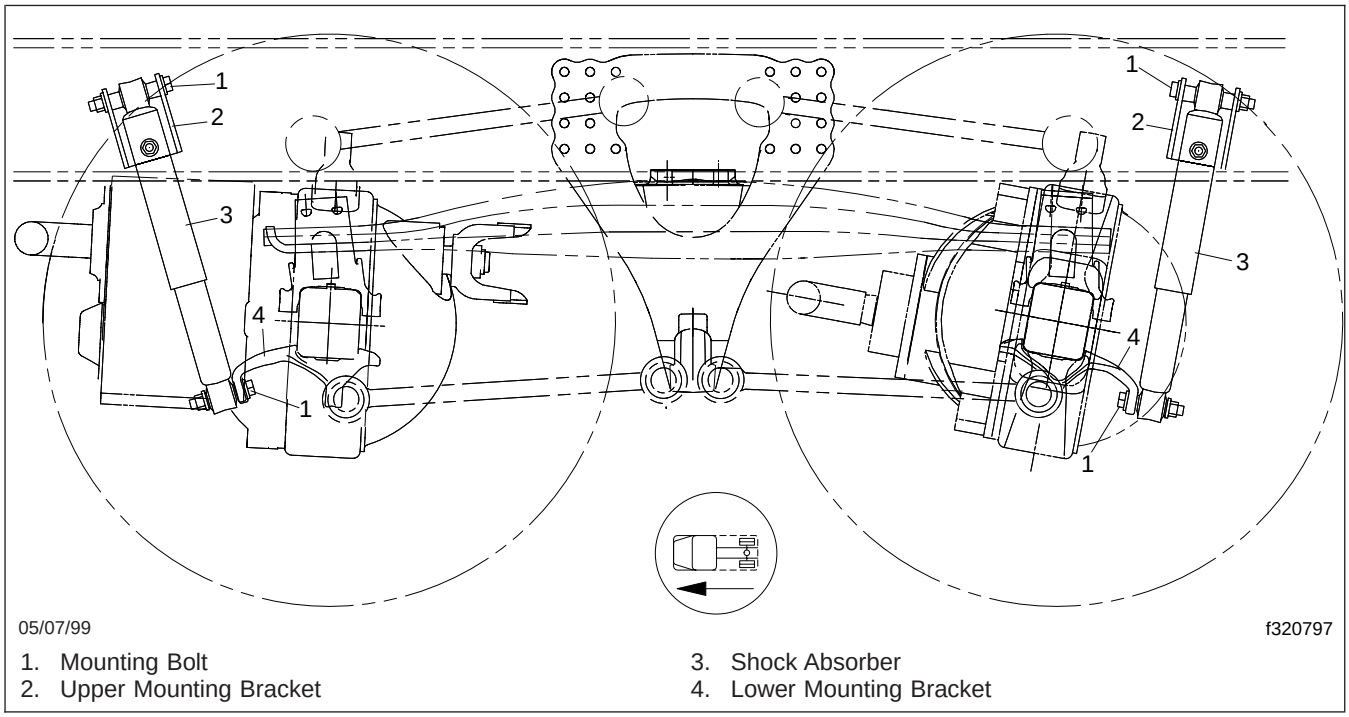


1. Axle Stop
2. Leaf Springs
3. Center Bearing
4. Torque Control Rod

Fig. 1, TufTrac Suspension (46,000-pound (20 865-kilogram) version)

Replacement

1. Park the vehicle on a level surface, shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the lower shock mounting nut and washer. See **Fig. 1**.
3. Remove the upper shock mounting nut and washer.
4. Remove the upper and lower mounting bolts and remove the shock absorber.
5. Position the new shock absorber in place and install the mounting bolts.
6. Loosely fasten the bolts with the nuts and washers removed from the old shock absorber.
7. Torque each mounting nut 241 lbf·ft (327 N·m).
8. Remove the chocks from the tires.

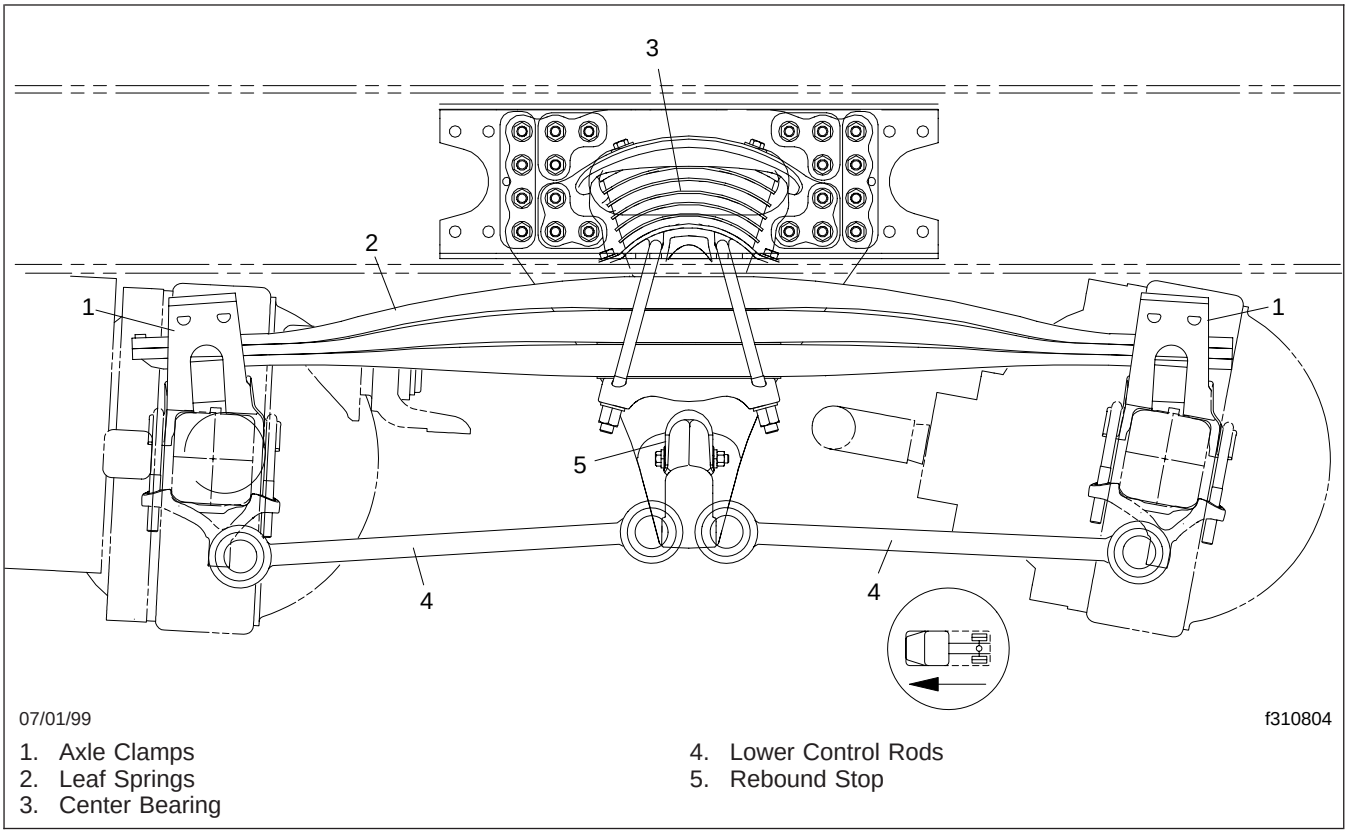


1. Mounting Bolt
2. Upper Mounting Bracket
3. Shock Absorber
4. Lower Mounting Bracket

Fig. 1, Shock Absorber Replacement

Replacement

1. Park the vehicle on a level surface, shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the rebound stop from the suspension. See **Fig. 1**.



1. Axle Clamps
2. Leaf Springs
3. Center Bearing
4. Lower Control Rods
5. Rebound Stop

Fig. 1, TufTrac Suspension (46,000-pound [20 865-kilogram] version shown)

   2.1 Remove the nut and bolt securing the rebound stop to the mounting bracket.

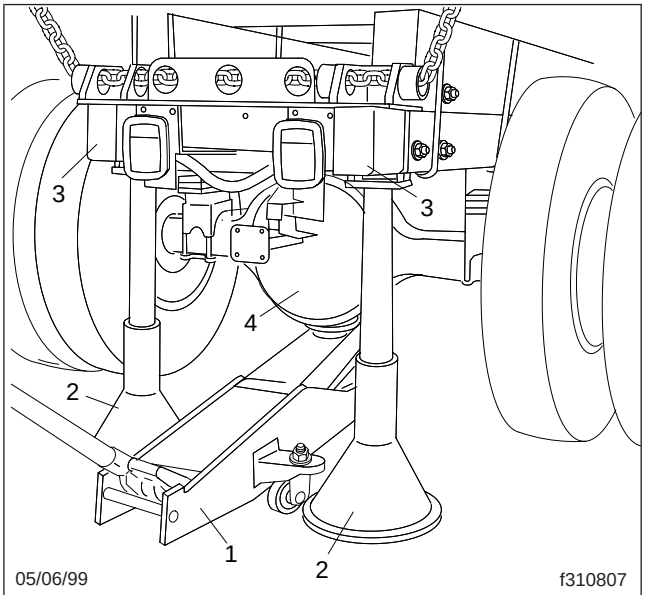
   2.2 Slide the rebound stop from the mounting bracket.

3. Remove the upper two fasteners on the center bearing.
4. Jack up the vehicle under the rear axle.
5. Support the rear frame rails with jack stands, then lower the jack. This will clear the center bearing from the top of the mounting bracket. See **Fig. 2**.
6. Remove the lower center bearing bolts attached to the spring assembly casting. Discard the bolts.
7. Remove the center bearing. See **Fig. 3**.
8. Position the new center bearing in the mounting bracket.
9. Install the upper mounting bolts and tighten 68 lbf·ft (92 N·m).
10. With the jack, raise the rear axle until bottom of the center bearing meets the mounting bracket on the leaf springs.

IMPORTANT: Be sure to use new bolts with loctite (p/n 23–12576–125) when attaching the center bearing to the leaf spring casting.

11. Install new lower mounting bracket bolts (p/n 23–12576–125). Tighten the bolts 155 lbf·ft (210 N·m).

Center Bearing Replacement



1. Jack
2. Jack Stand
3. Frame Rail
4. Rear Axle

Fig. 2, Jack and Jack Stand Placement

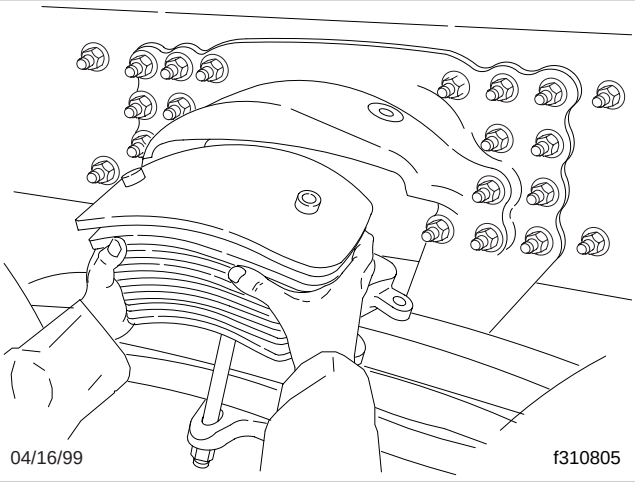


Fig. 3, Center Bearing Removal

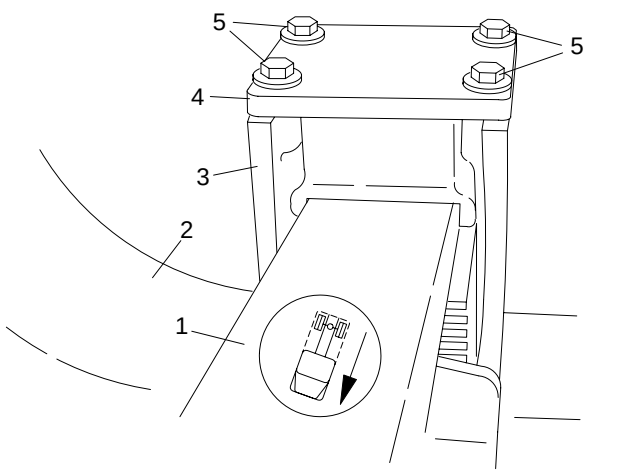
12. Return the vehicle to its normal operating position.
13. Install the rebound stop.
14. Remove the chocks from the tires.

Spring Assembly Removal, Assembly and Installation

IMPORTANT: The spring pack assembly is not available as an assembled unit in the aftermarket. If the spring pack assembly is to be replaced with a new assembly, the springs, center bearing seat and retainer bracket must be assembled before installation on the vehicle.

Removal

1. Park the vehicle on a level surface. Shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the tip pad bolts above each axle on the axle clamp. There are four bolts on each pad. See **Fig. 1**.



1. Leaf Springs
2. Axle
3. Axle Pad
4. Tip Pad
5. Tip Pad Bolts

Fig. 1, Tip Pad Installation

3. Remove the center bearing. See **Subject 110**.
4. With the vehicle still raised, remove the wheels on both rear axles on the side the spring assembly will be replaced. For instructions, see **Group 40**.

⚠ WARNING

Do not attempt to remove the spring assembly by hand. The assembly is very heavy and attempting to lift it could result in bodily injury.

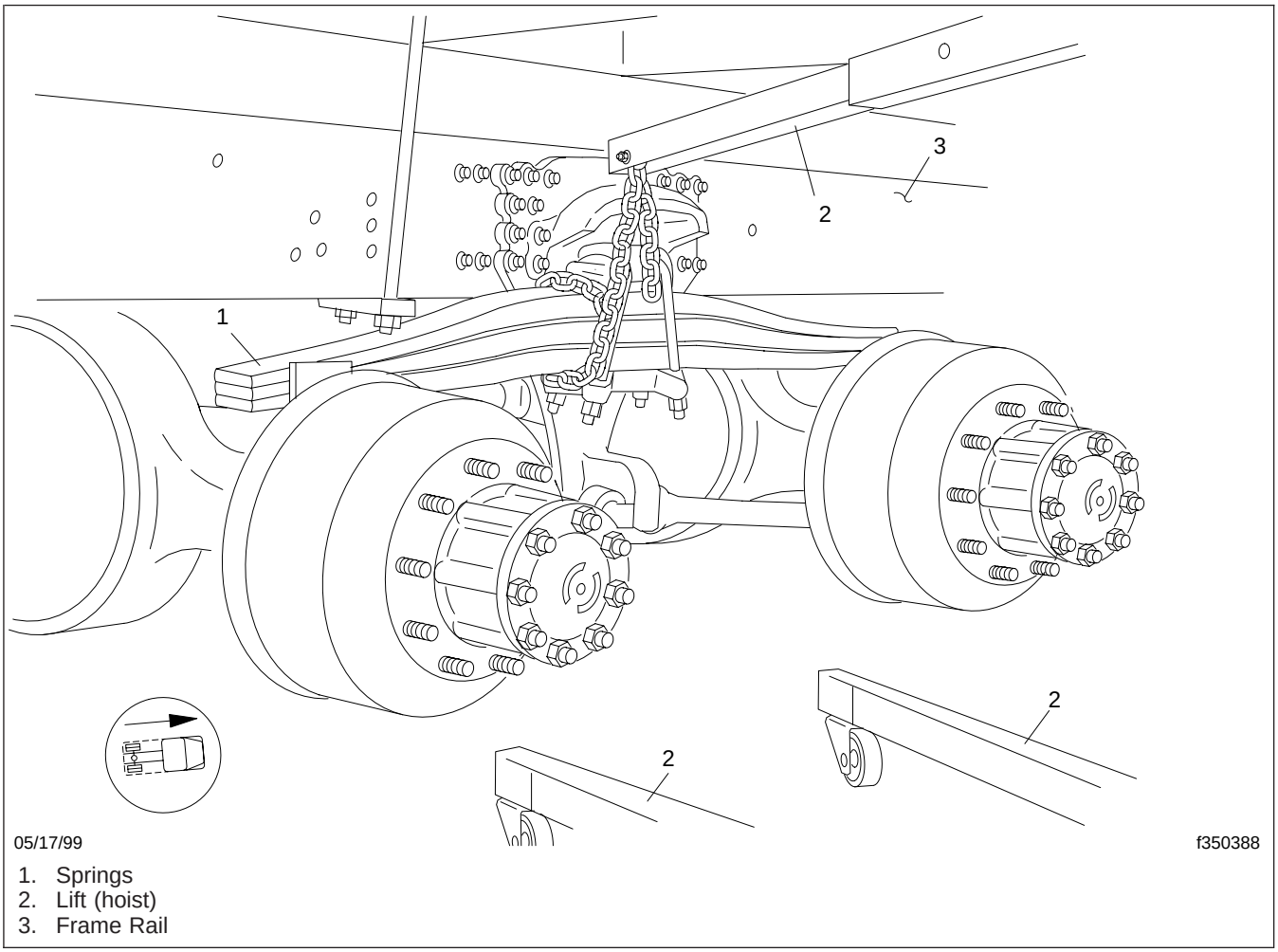
5. Using a lift (i.e. engine hoist), remove the leaf spring assembly from the vehicle. See **Fig. 2**.

Assembly

IMPORTANT: Leaf springs in a spring pack assembly cannot be replaced individually. The entire spring pack assembly must be replaced.

1. Support both sides of the new spring pack assembly on jack stands. Make sure all the leaf springs are interlocking with the studs and dimples at the centers of the leaf springs.
2. If the assembly contains a spacer, place it on the center of the top leaf spring. Make sure the dimple in the spacer is aligned with the stud in the center of the top leaf spring.
3. Place the center bearing seat on the top of the spacer or leaf spring, as applicable. Make sure the dimple in the middle of the center bearing seat aligns with the stud in the middle of the leaf spring or the spacer.
4. Install the two 3/4-inch U-bolts over the center bearing seat. Make sure the U-bolts rest in the grooves of the center bearing seat.
5. At the bottom of the spring pack, install the U-bolt retainer bracket over the threaded ends of the U-bolts.
6. Holding the retainer bracket in place, install a hardened washer and hexnut over the threaded end of each U-bolt.
7. Tighten the U-bolts in a diagonal sequence as follows:
   - Stage 1: 60 lbf·ft (81 N·m)
   - Stage 2: 200 lbf·ft (271 N·m)
   - Stage 3: 300 lbf·ft (407 N·m)

Spring Assembly Removal, Assembly and Installation



1. Springs
2. Lift (hoist)
3. Frame Rail

Fig. 2, Leaf Spring Replacement

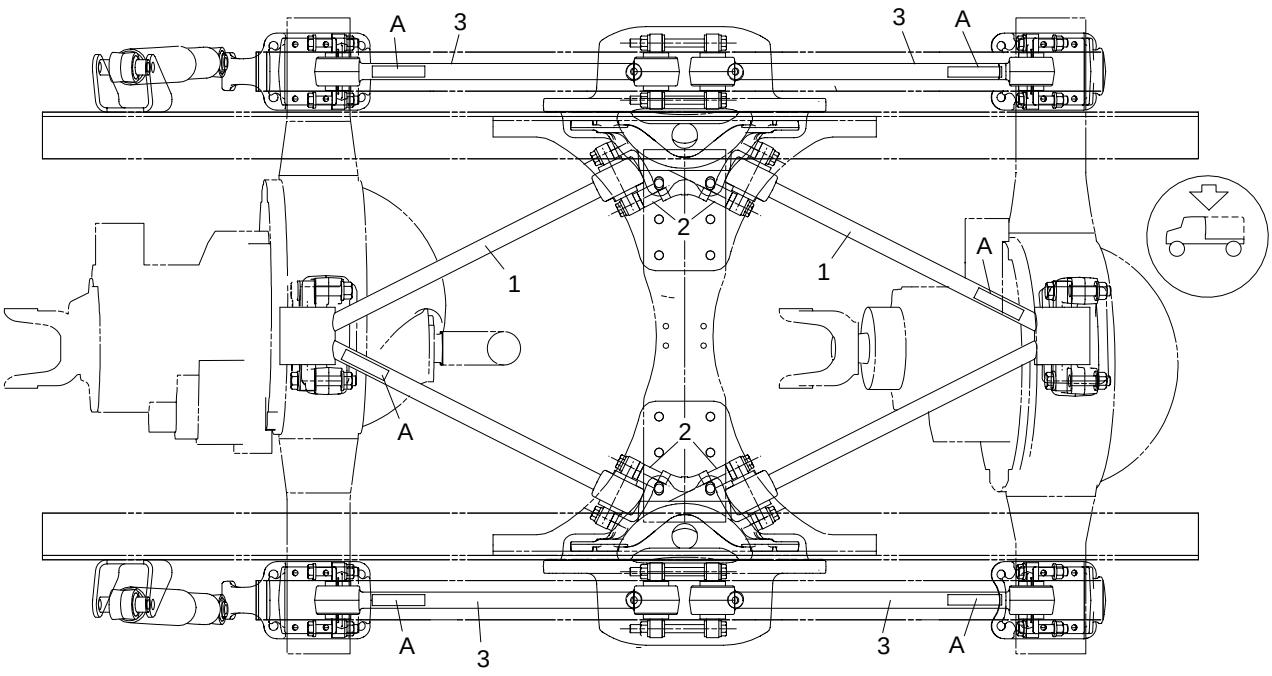
Installation

⚠ WARNING

Do not attempt to install the spring assembly by hand. The assembly is very heavy and attempting to lift it could result in bodily injury.

1. Place the new spring assembly on the vehicle.
   - 1.1 Attach the new assembly to the lift.
   - 1.2 Using the lift (hoist), lift the assembly into place on the axle clamps.
2. Install the center bearing. For instructions, see **Subject 110**.
3. Install the tip pad and bolts on each axle clamp. Tighten the bolts 37 lbf·ft (50 N·m). See **Fig. 1**.
4. If not already installed, install the rebound stop and mounting bolt. Tighten the nut 68 lbf·ft (92 N·m).
5. Install the wheels. For instructions, see **Group 40**.
6. Return the vehicle to its normal operating position.
7. Remove the chocks from the tires.

Lower Control Rod Replacement (See Fig. 1)



A. Label
1. V-Rod
2. Spacer
3. Lower Control Rod

Fig. 1, Control and V-Rod Replacement

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the front tires.
2. Raise the rear axle and support the frame rails with jack stands.
3. Lower the jack under the axle. See **Fig. 2**.
4. Remove the bolts holding both rods between the rear axles, below the rebound stop. See **Fig. 3**.
5. Remove the nut and bolt from the axle clamp.
6. Remove the control rod from the vehicle.

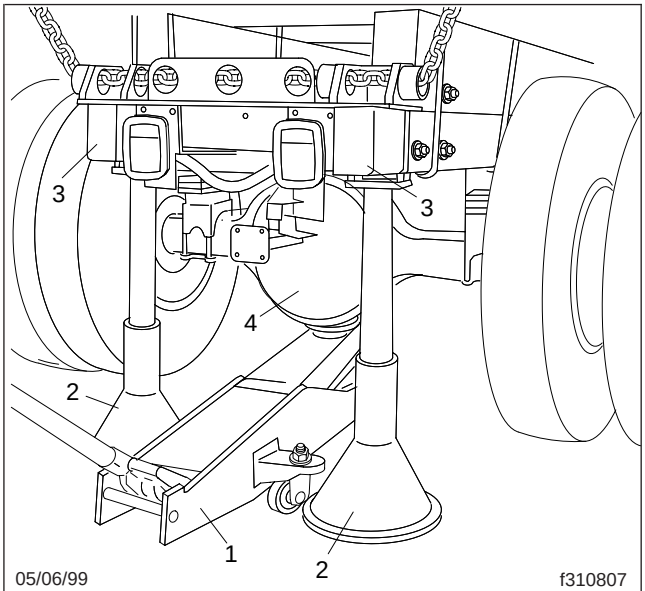
IMPORTANT: When installing the rods make sure the labels on the rods are facing upward. Forward axle rods are marked "FDA" and rear axle rods "RDA."

7. Fasten the new control rod to the axle clamp. Tighten the nut 136 lbf·ft (184 N·m).
8. Fasten the other end of the rod to the bracket below the rebound stop. Tighten the nut 136 lbf·ft (184 N·m).
9. Return the vehicle to the normal operating position.

V-Rod Replacement

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Raise the rear axle and support the frame rails with jack stands.
3. Lower the jack under the axle. See **Fig. 2**.

Lower Control Rod and V-Rod Replacement



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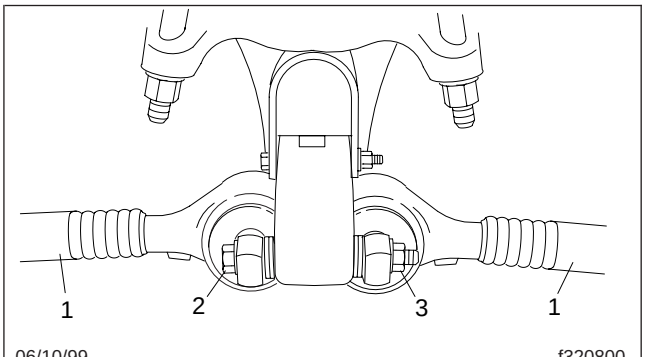
1. Jack
2. Jack Stand
3. Frame Rail
4. Rear Axle

Fig. 2, Jack and Jack Stand Placement



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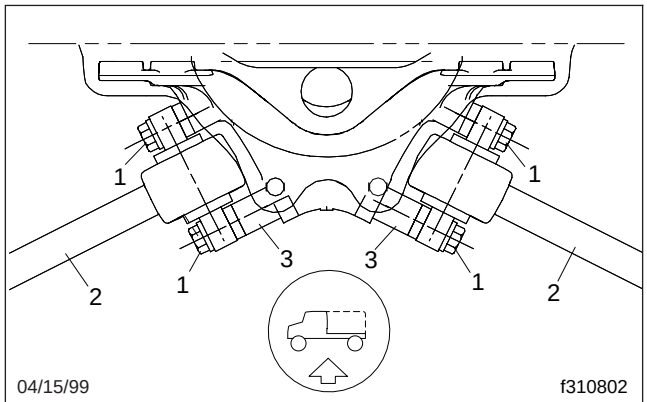
1. Lower Control Rod
2. Mounting Bolt
3. Mounting Nut

Fig. 3, Lower Control Rods

4. Remove all six mounting bolts securing the v-rod to the chassis and axle.
5. Remove the v-rod from the chassis.

IMPORTANT: When installing the rods make sure the labels on the rods are facing upward. Forward axle rods are marked "FDA" and rear axle "RDA."

6. Install the v-rod. See **Fig. 4**.



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1. Mounting Bolt
2. V-Rod
3. Spacer

Fig. 4, V-Rod Replacement

6.1 Place the new rod in position between the frame rails.

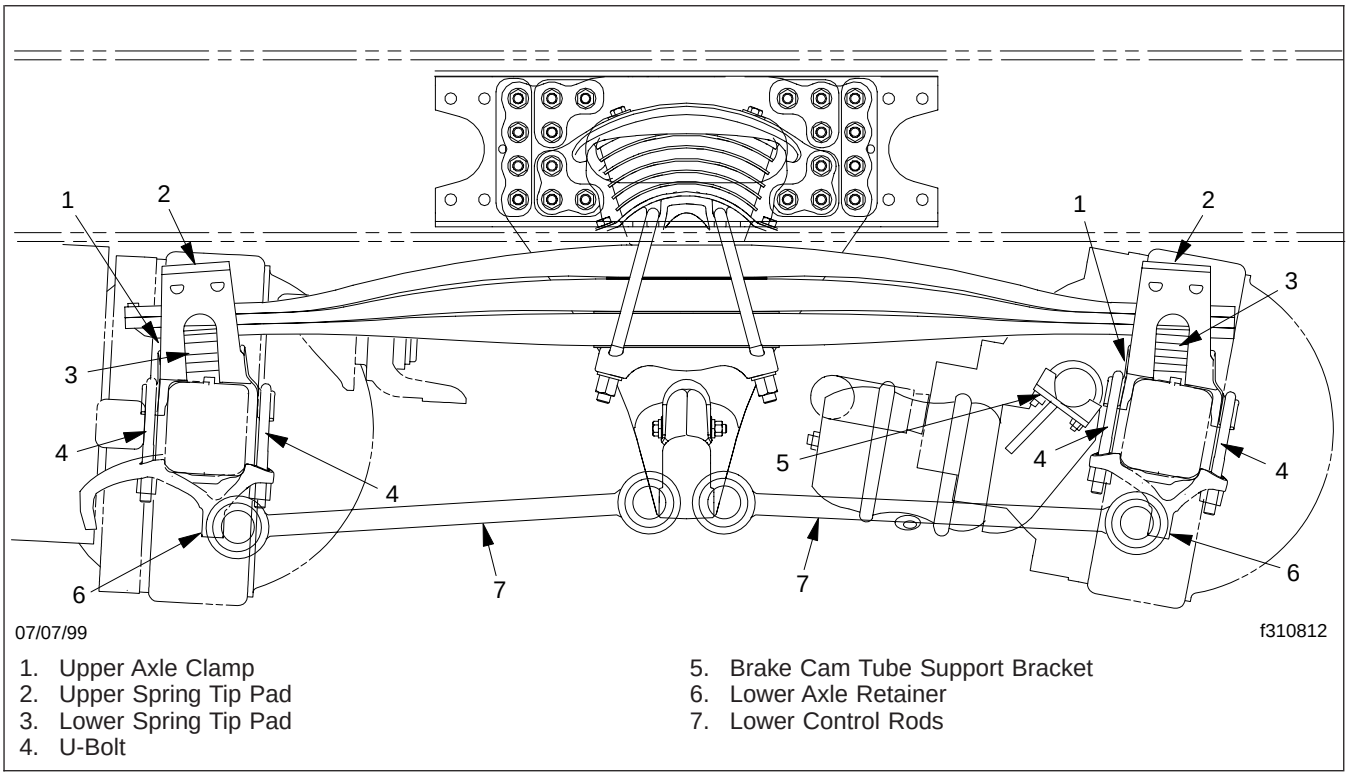
6.2 Install the bolts and spacers and loosely tighten all connections.

6.3 After all fasteners and spacers are installed, torque as follows:

- Tighten the bolts at the frame bracket 136 lbf·ft (184 N·m).
- Tighten the bolts at the axle bracket 427 lbf·ft (579 N·m).

7. Return the vehicle to normal operating position.
8. Remove the chocks from the tires.

Replacement (See Fig. 1)



1. Upper Axle Clamp
2. Upper Spring Tip Pad
3. Lower Spring Tip Pad
4. U-Bolt
5. Brake Cam Tube Support Bracket
6. Lower Axle Retainer
7. Lower Control Rods

Fig. 1, TufTrac Suspension (left-side view)

1. Park the vehicle on a level surface, shut down the engine and chock the tires.
2. Remove the two upper spring tip pads and bolts from the left suspension spring.
3. Disconnect the shock absorbers from the lower axle retainer on the left suspension spring.
   - 3.1 Remove the lower shock mounting nuts and washers.
   - 3.2 Remove the lower shock absorber mounting bolts.
4. Disconnect the two lower torque control rods from the lower axle retainers on the left side of the vehicle.
5. Loosen and remove the U-bolt nuts and washers, and discard.
6. Remove the brake cam tube support bracket from the left rear axle.
7. Remove the lower axle retainers from the left forward and left rear drive axles, and discard.
8. Remove the axle U-bolts from the left forward drive axle and the left rear drive axle, and discard.
9. Jack up the center of the left suspension spring (at the center bearing, between the tandem [**Fig. 2**]) and support with the jack stands at the frame. Make sure that all of the weight has been relieved from the axle clamp group and that there is sufficient clearance to remove the upper axle clamp.
10. Remove the lower spring tip pads from the left forward and left rear drive axles.
11. Remove the upper axle clamps from the left forward and left rear drive axles. Discard the clamps.
12. Install the new upper axle clamps from the applicable warranty kit to the left forward and left rear

Axle Clamp and Retainer Replacement

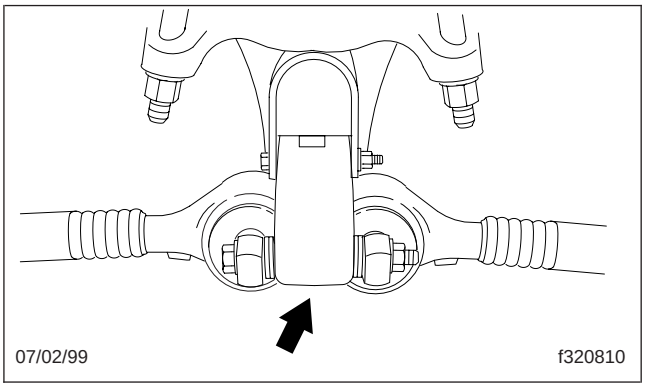


Fig. 2, Jack the Vehicle Here

drive axles. Locate the dowel pin through the hole in the bottom of each axle clamp to confirm proper alignment

NOTE: Confirm that you are installing the correct upper axle clamps before continuing. You are able to visually identify the new upper axle clamp because the step has been removed from the area directly above the U-bolt saddles. See **Fig. 3**.

13. Install the lower spring tip pads into the left front and rear axle clamps.
14. Jack up the left suspension spring, remove the jack stands, and lower the suspension spring. Ensure while the spring is being lowered that it is seated correctly onto the lower spring tip pads.
15. Install the new lower axle retainers onto the left forward and rear drive axles.
16. Install the brake cam tube support bracket onto the left rear axle.
17. Install the U-bolts on the left forward and rear drive axles.

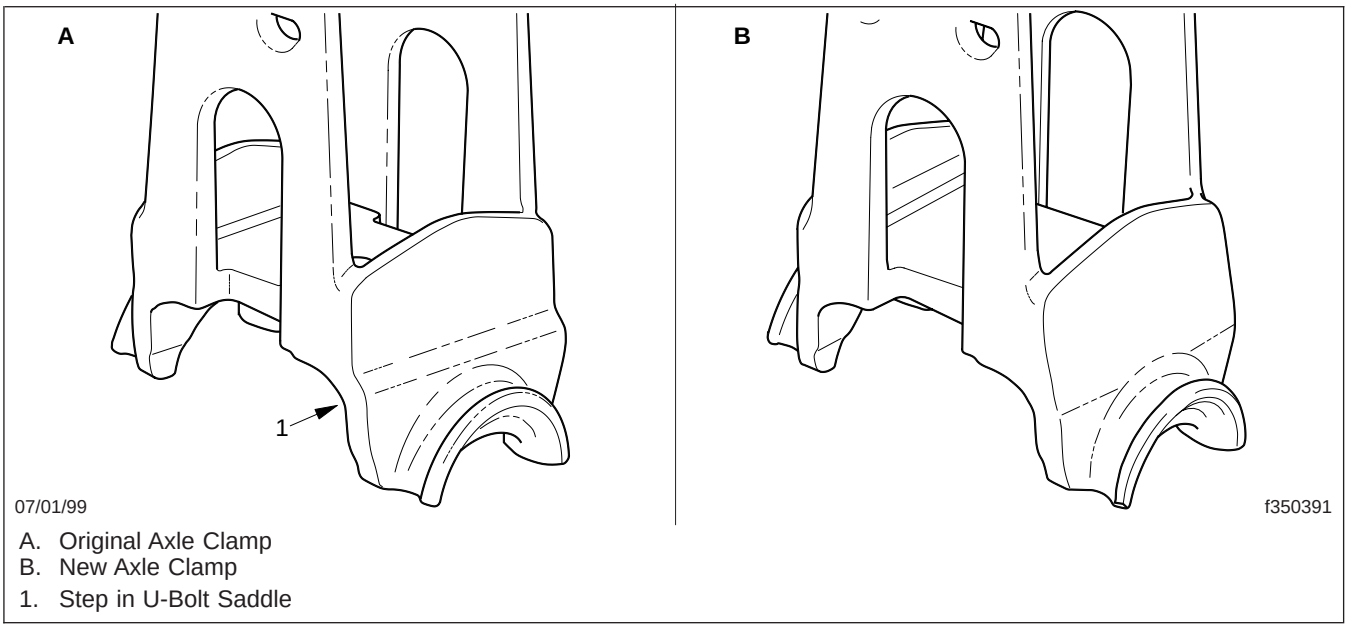
    IMPORTANT: Install two washers for each U-bolt nut.

    17.1 Install each U-bolt over the U-bolt saddle in the upper axle clamp and through the holes in the lower axle retainer.

    17.2 Install the washers and finger-tighten the nuts in the order shown in **Fig. 4**.

    Make sure all brackets are snug against the axle housing before proceeding to the next step.

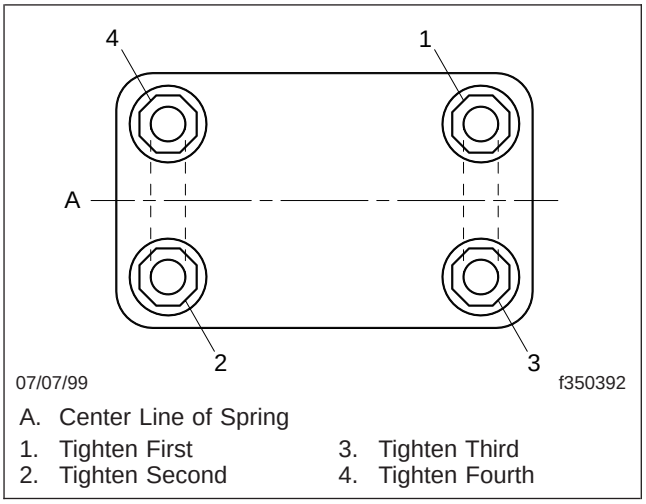
    IMPORTANT: U-bolt nuts must be tightened in the order shown in **Fig. 4**.



A. Original Axle Clamp
B. New Axle Clamp
1. Step in U-Bolt Saddle

Fig. 3, Upper Axle Clamps

17.3 Tighten the nuts 60 lbf·ft (81 N·m) and then to 200 lbf·ft (271 N·m) in two separate rotations following the order shown in **Fig. 4**.



A. Center Line of Spring
1. Tighten First
2. Tighten Second
3. Tighten Third
4. Tighten Fourth

Fig. 4, U-Bolt Nut Tightening Sequence

18. Install the lower torque control rods to the lower axle retainers on the left side of the vehicle and tighten 136 lbf·ft (184 N·m).
19. Install the shock absorbers to the lower axle retainers.
    - 19.1 Install the lower shock mounting bolts.
    - 19.2 Install the lower shock absorber mounting washers and nuts and tighten by hand.
    - 19.3 Tighten the lower shock absorber mounting nuts to 241 lbf·ft (327 N·m).
20. Install the spring tip pads to the left suspension spring.
    - 20.1 Install the spring tip pads to the upper axle clamps.
    - 20.2 Install the bolts to secure each upper spring tip pad and tighten 37 lbf·ft (50 N·m).
21. Repeat the above steps for the right suspension spring.
22. Remove the chocks from the tires.

Adjustments

Rear axle positioning and alignment on a vehicle equipped with the TufTrac suspension is determined by the length of the lower control rods and the V-rods. See **Fig. 1**. The length of the control rods and V-rods can be controlled by the addition or removal of shims at the mounting points of the control rods and/or V-rods. The addition of shim(s) between the control rod or V-rod and its mounting will effectively lengthen the rod moving the axle relative to the frame. Conversely, the removal of shim(s) will shorten the length of the rod, moving the axle in the opposite direction.

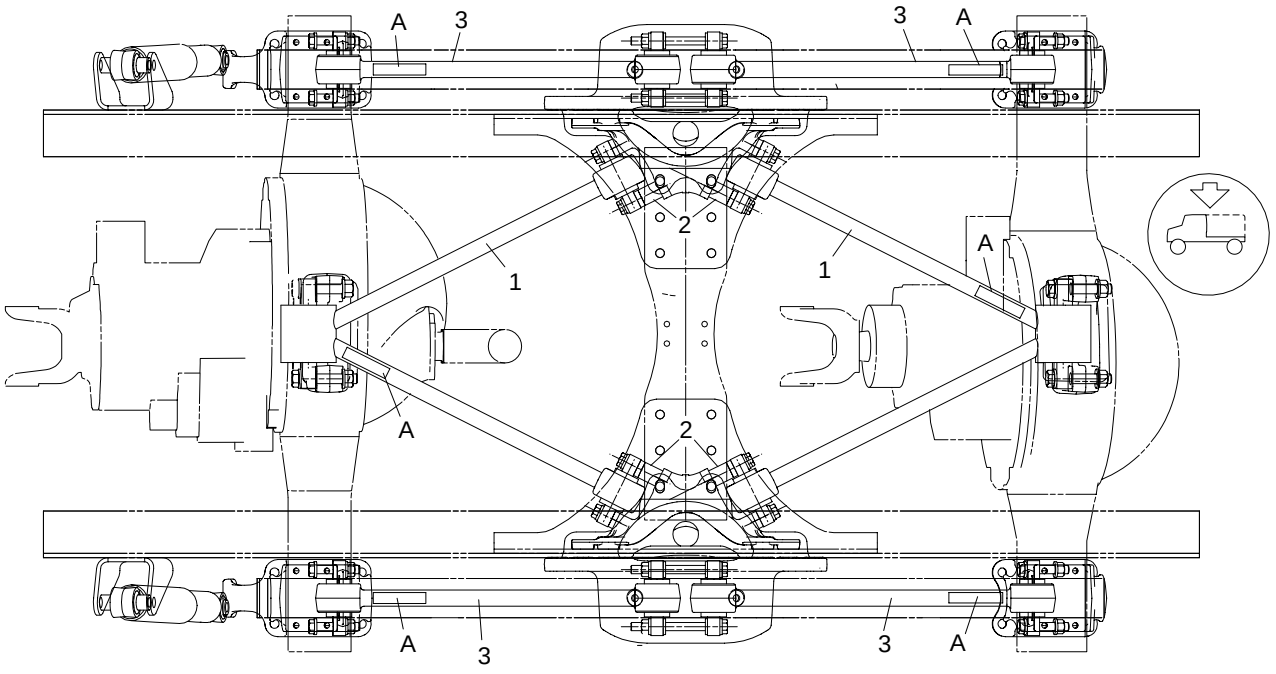
ment is to provide axle alignment and planing adjustment (angle of the axle from vertical in the side view).

Axle tracking (lateral axle positioning) is performed by inserting or removing hardened washers at the V-rod mounting at the frame end. See **Fig. 4**.

Lower Control Rods

Alignment Adjustments

NOTE: Alignment refers to the squareness of the axles to each other and the frame rails viewed from the top of the vehicle.



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A. Label
1. V-Rod
2. Spacer
3. Lower Control Rod

Fig. 1, Control Rod and V-Rod Installation

The lower control rods use a horse-shoe style of shim (**Fig. 2**) while the V-rods use hardened washers for shims.

Control rod shimming is performed at the center bracket. See **Fig. 3**. The purpose of this shim adjustment is to provide axle alignment and planing adjustment (angle of the axle from vertical in the side view).

Add or remove shims at the center bracket to achieve proper alignment. See **Fig. 3**. To minimize the effect on planing angles, if possible, add or remove shims from both sides of the vehicle.

When one 3mm thick shim is added and one removed (from the opposite side) the axle position is affected as follows:

Rear Axle Alignment Adjustments

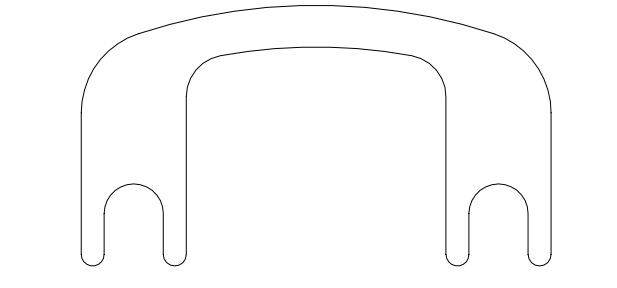
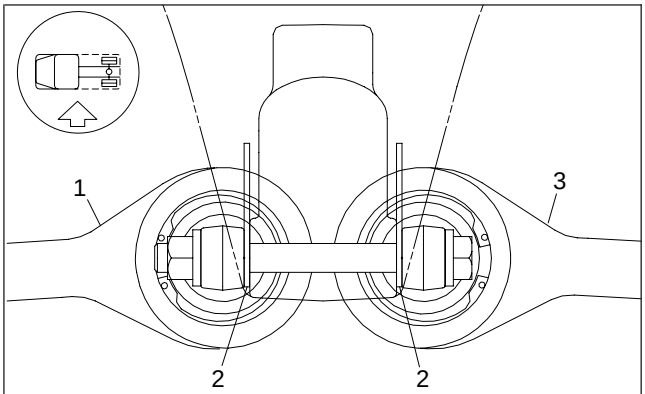


Fig. 2, Lower Control Rod Shim



1. Forward Lower Control Rod
2. Shims
3. Rear Lower Control Rod

Fig. 3, Lower Control Rod Shim Installation

- Angle of the axle in the plan view: 0.33 degrees
- Fore-aft movement of the wheel at the outside (assuming 97.6 in. (2480 mm) wheel to wheel distance): 0.283 in. (7.2 mm)

Planing Adjustments

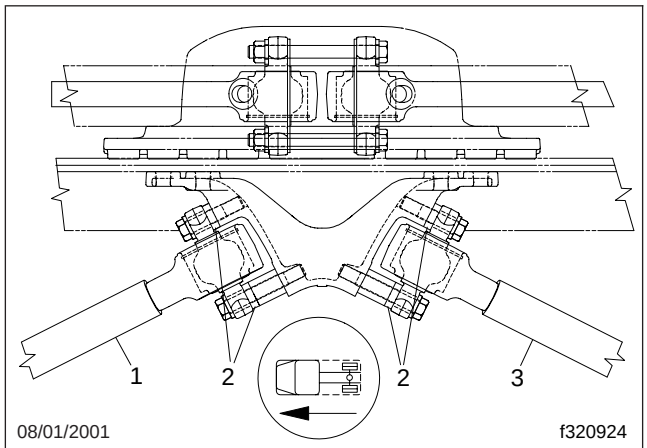
NOTE: planing refers to the angle of the axle from vertical in the side view.

Add or remove shims at the center bracket to change the planing angle. See **Fig. 3**. Unless alignment is required, an equal number of shims should be used left and right for a given axle; example, when adding one shim to the left forward rod add one shim to right forward rod. A shim 0.12 inch thick changes the planing angle 0.3 degrees.

V-Rods

Axle Tracking Adjustments

The tracking adjustment of the forward and rear axles is done by adding and/or removing hardened washers between the V-rod bar pin and the frame-mounted bracket. See **Fig. 4**.

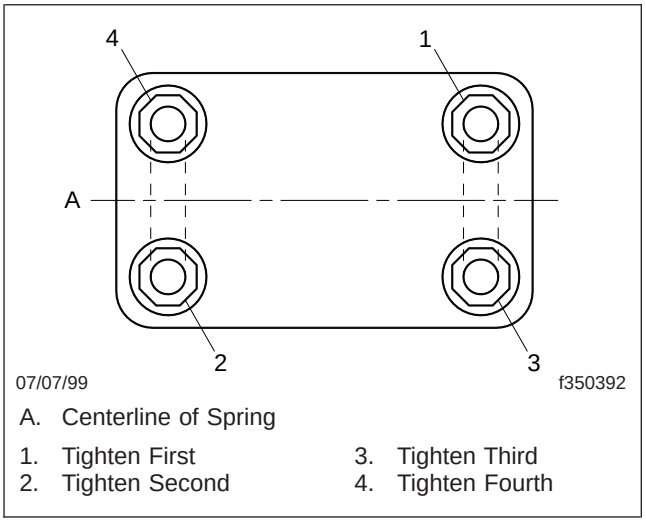


1. Forward Rear Axle V-Rod
2. Hardened Washers
3. Rear Rear Axle V-Rod

Fig. 4, V-Rod Hardened Washer Installation

Torque Specifications	
Description	**Torque Value lbf·ft (N·m)**
Shock Absorber Mounting Bolt	241 (327)
Center Bearing Upper Mounting Bolts	68 (92)
Center Bearing Lower Mounting Bolts	155 (210)
Tip Pad Bolts	37 (50)
Rebound Stop Mounting Bolt	68 (92)
Lower Control Rod Mounting Bolts	136 (184)
V-Rod Frame Bracket Mounting Bolts	136 (184)
V-Rod Axle Bracket Mounting Bolts	427 (579)
5/8–18 Axle Clamp U-Bolt Nuts (Tighten as shown in **Fig. 1**.)	Stage 1: Hand-Tighten Stage 2: 60 (81) Stage 3: 200 (271)
3/4-Inch Spring Pack U-Bolt Nuts	Stage 1: 60 (81) Stage 2: 200 (271) Stage 3: 300 (407)

Table 1, Torque Specifications



A. Centerline of Spring

1. Tighten First
2. Tighten Second
3. Tighten Third
4. Tighten Fourth

Fig. 1, U-Bolt Nut Tightening Sequence

General Information

Standard front suspensions for vehicles built from September 2003 use tapered leaf spring assemblies, with shock absorbers as standard equipment. See **Fig. 1**, **Fig. 2**, and **Fig. 3**.

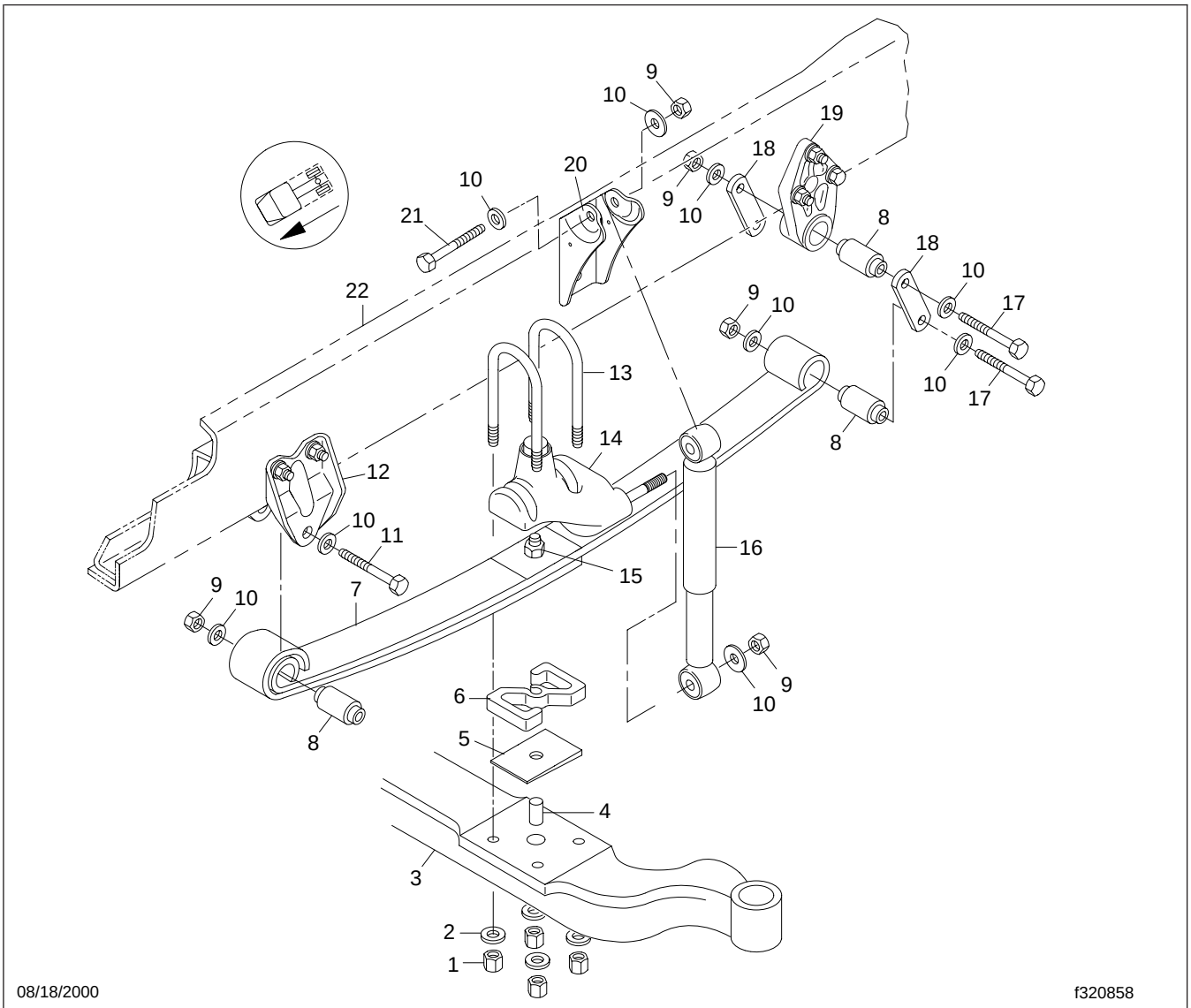
The spring assemblies are attached to the axle with U-bolts, hardened washers, and high nuts. The forward end of each spring contains a rubber bushing and a through-bolt that mounts to a stationary front suspension bracket. The rear of each spring mounts to a pair of spring shackles that are suspended from a frame-mounted bracket. The rear spring eye and shackle bracket each contain a rubber bushing and a through-bolt to allow the spring shackles to pivot. The spring shackles allow for variations in spring length during spring flexing.

The leaf spring assembly absorbs and stores energy, then releases it. The individual leaves are held together by a center bolt, with the center bolt nut used as a locating dowel for the axle stop and shock-absorber lower bracket installation on the vehicle.

Steel spring pins with bronze bushings are available as an option. See **Fig. 3**. These pins have a longitudinal lubrication groove in them. Bronze bushings are used with 12,000-pound or 14,000-pound leaf springs, and are graphite impregnated with a grease seal at each end.

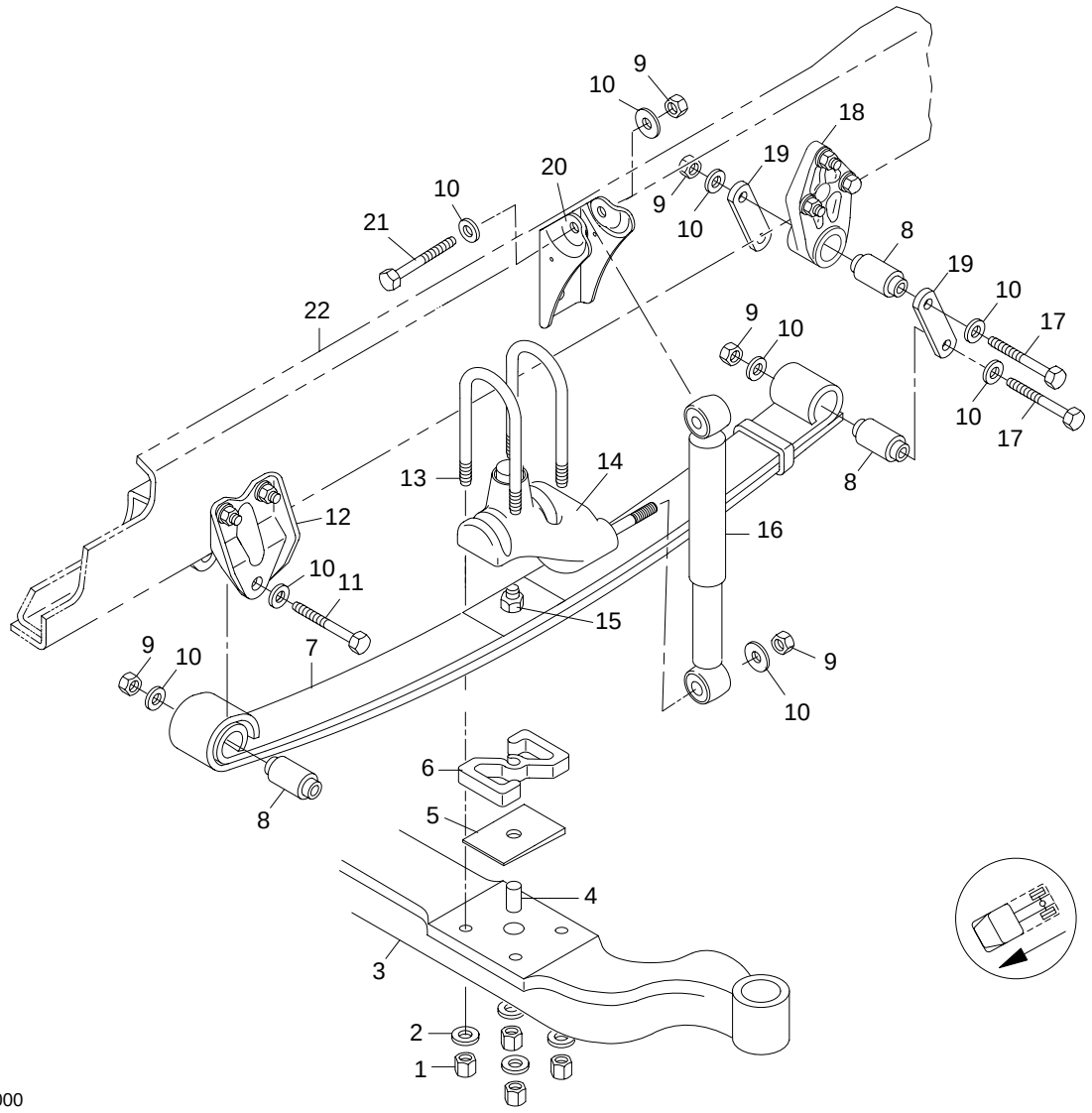
Threaded spring pins with threaded steel bushings are also available with 12,000-pound or 14,000-pound front leaf suspensions.

General Information



1. U-Bolt High Nut
2. Bearing Washer
3. Axle
4. Dowel
5. Caster Adjustment Shim
6. Spacer
7. Spring Assembly
8. Spring Pin and Rubber Bushing Assembly
9. Locknut, 3/4–10
10. Hardened Washer
11. Spring-Eye Bolt
12. Forward Spring Bracket
13. U-Bolt
14. Axle Stop and Shock Absorber Lower Mounting Bracket
15. Spring Center-Bolt and Nut
16. Shock Absorber
17. Shackle Bolt, 3/4–10
18. Spring Shackle
19. Shackle Bracket
20. Shock Absorber Upper Bracket
21. Hexbolt, 3/4–10
22. Frame Rail

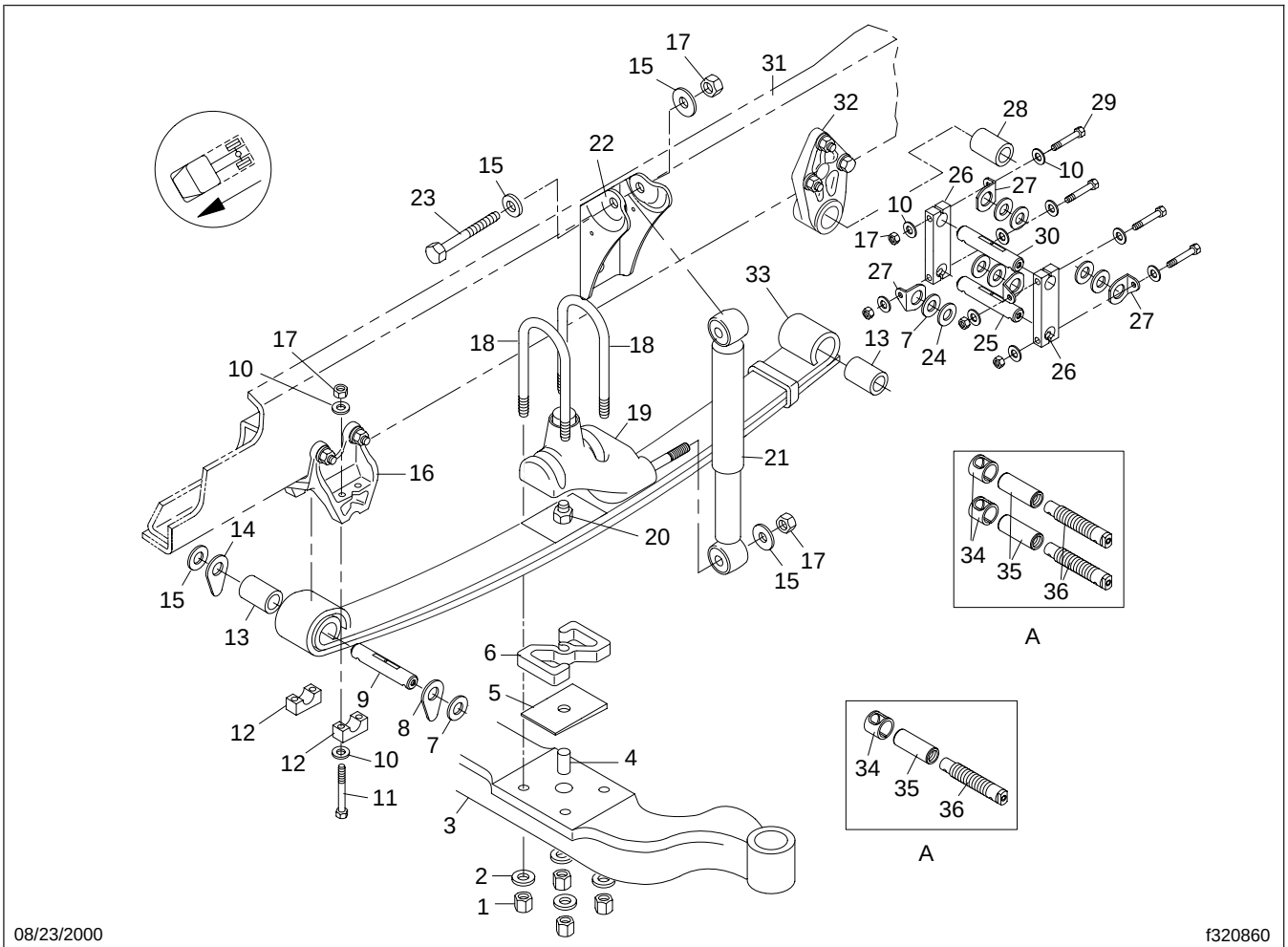
Fig. 1, Front Suspension with Rubber Bushings, Leaf and-a-Half Spring



1. U-Bolt High Nut
2. Bearing Washer
3. Axle
4. Dowel
5. Caster Adjustment Shim
6. Spacer
7. Spring Assembly
8. Spring Pin and Rubber Bushing Assembly
9. Locknut, 3/4–10
10. Hardened Washer
11. Spring-Eye Bolt
12. Forward Spring Bracket
13. U-Bolt
14. Axle Stop and Shock Absorber Lower Mounting Bracket
15. Spring Center-Bolt and Nut
16. Shock Absorber
17. Shackle Bolt
18. Shackle Bracket
19. Spring Shackle
20. Shock Absorber Upper Mounting Bracket
21. Hexbolt, 3/4–10
22. Frame Rail

Fig. 2, Front Suspension with Rubber Bushings, Full Leaf Springs

General Information



A. Equipped with Threaded Spring Pins

1. U-Bolt High Nut
2. Bearing Washer
3. Axle
4. Dowel
5. Caster Adjustment Shim
6. Spacer
7. Outboard Spacing Washer(s)
8. Outboard Spring Spacer
9. Spring Pin, Forward Spring Eye
10. Hardened Washer, 1/2–13
11. Hexbolt, 1/2–13 x 5
12. Spring Pin Retainer
13. Spring-Eye Bushing
14. Inboard Spring Spacer
15. Hardened Washer
16. Front Suspension Bracket
17. Self-Locking Nut, 3/4–10
18. U-Bolt
19. Axle Stop and Shock Absorber Lower Mounting Bracket
20. Spring Center-Bolt and Center-Bolt Nut
21. Shock Absorber
22. Shock Absorber Upper Mounting Bracket
23. Hexbolt, 3/4–10
24. Hardened Washer, 2-1/4" o.d
25. Spring Pin, Rear Spring Eye
26. Shackle
27. Wear Plate
28. Shackle Bracket Bushing
29. Pinch Bolt, 1/2–13 x 4
30. Spring Pin, Shackle Bracket
31. Frame Rail
32. Shackle Bracket
33. Leaf Spring
34. Split Ring
35. Threaded Bushing
36. Threaded Spring Pin

Fig. 3, Front Suspension with Bronze Bushings or Threaded Spring Pins

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

Removal

See **Fig. 1** and **Fig. 2** for for this procedure.

1. Apply the parking brakes and chock the rear tires. Raise the vehicle until both wheels are off the ground and the frame is supported with safety stands. The axle and leaf springs can then be manipulated with the floor jack.

IMPORTANT: Make sure the frame rails are level and an equal distance off the ground.

2. On vehicles with tapered leaf spring assemblies, unplug the road-light wires behind the front bumper. Remove the bumper mounting bolts; reference the location of the mounting bolt spacers for later assembly. Remove the bumper from the vehicle.

   On vehicles with flat leaf spring assemblies, remove the wheel and tire. For instructions, refer to **Group 40**.

3. Remove the U-bolts, stop assembly, and spring liner (if equipped) from the spring.
4. On vehicles equipped with shock absorbers, swing the lower shock absorber bracket assembly away from under the axle and compress the shock absorber fully. This prevents the shock absorber and its lower bracket from interfering with further work.

NOTE: if necessary, remove the mud guards to access the shackles.

5. Starting at the aft end of the spring, remove the flanged pinch bolts and flanged nuts securing the shackle spring pin.
6. If the spring pin is threaded, unscrew it from the bushing.

   If the spring pin is nonthreaded, drive it outboard with a suitable drift and remove it.

   Remove the spacing washers (used only with nonthreaded pins) and keep them with the pin. Make note of their correct location for later installation.

7. Remove the flanged pinch bolts and flanged nuts from the forward frame bracket.
8. If the spring pin is threaded, unscrew it from the bushing.

   If the spring pin is nonthreaded, drive it inboard with a suitable drift to remove it.

   Remove the spacing washers (used only with nonthreaded pins) and keep them with the pin. Make note of their correct location for later installation.

9. Remove the spring assembly by lifting it up off the axle and out the front of the truck. Note the taper direction of the caster shim so that it will not be reversed during installation
10. If the shackle pin or shackle bracket bushings are to be inspected or replaced, remove the pin.

    10.1 Remove the flanged pinch bolts and flanged nuts.

    10.2 Remove the spacing washers (used only with nonthreaded pins) and keep them with the pin. Make note of their correct location for later installation.

    10.3 If the shackle pin is threaded, unscrew it from the shackle pin bushing.

    10.4 If the shackle pin is nonthreaded, drive the pin outboard using a suitable drift to remove it.

11. Remove the shackle bracket for inspection; replace its bushing if necessary. See the applicable steps under "Cleaning and Inspection" in this subject.

Cleaning and Inspection

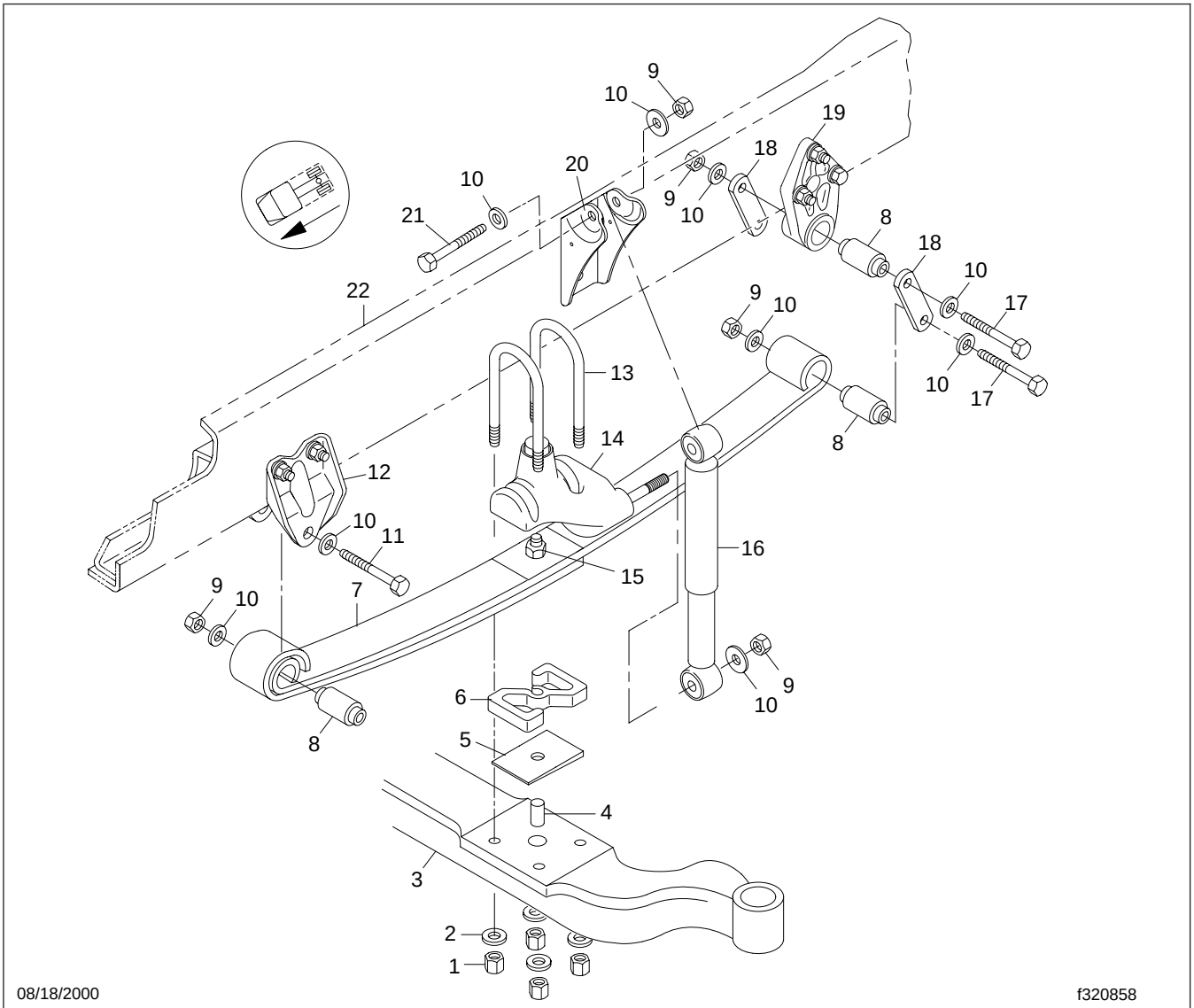
1. Using a wire brush and solvent or steam cleaning equipment, wash all parts to remove dirt, grease, and scale.

⚠ WARNING

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

2. Inspect the shackle bracket and the spring shackles for cracks, wear, or other damage. Replace damaged parts.
3. Inspect the spring for cracks and corrosion. If any leaves are cracked or broken, replace the entire spring assembly.

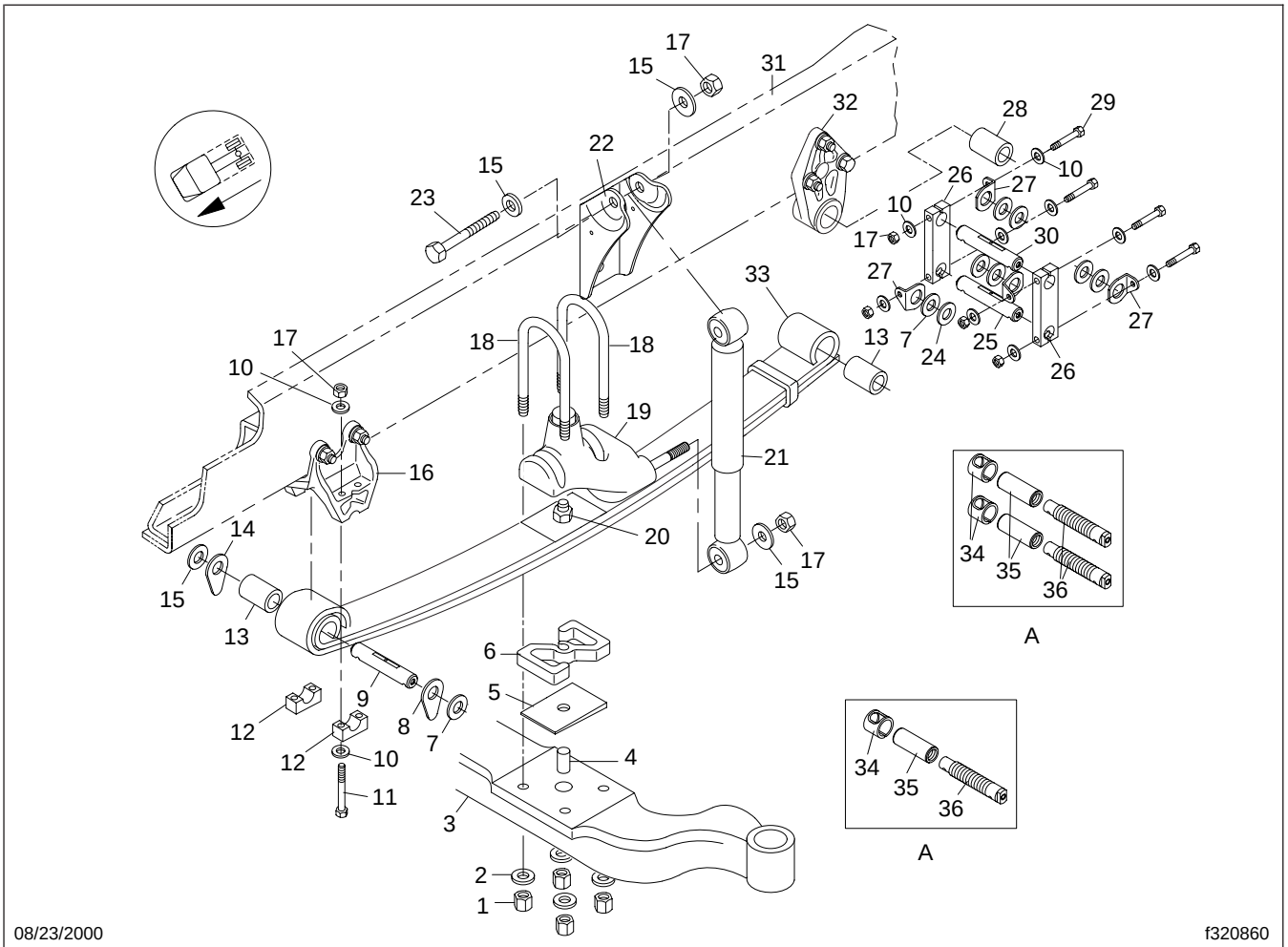
Leaf Spring and Components Removal, Cleaning and Inspection, and Installation



1. U-Bolt High Nut
2. Bearing Washer
3. Axle
4. Dowel
5. Caster Adjustment Shim
6. Spacer
7. Spring Assembly
8. Spring Pin and Rubber Bushing Assembly
9. Locknut, 3/4–10
10. Hardened Washer
11. Spring-Eye Bolt
12. Forward Spring Bracket
13. U-Bolt
14. Axle Stop and Shock Absorber Lower Mounting Bracket
15. Spring Center-Bolt and Nut
16. Shock Absorber
17. Shackle Bolt, 3/4–10
18. Spring Shackle
19. Shackle Bracket
20. Shock Absorber Upper Bracket
21. Hexbolt, 3/4–10
22. Frame Rail

Fig. 1, Front Suspension with Rubber Bushings, Leaf and-a-Half Spring

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation



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A. Equipped with Threaded Spring Pins

1. U-Bolt High Nut
2. Bearing Washer
3. Axle
4. Dowel
5. Caster Adjustment Shim
6. Spacer
7. Outboard Spacing Washer(s)
8. Outboard Spring Spacer
9. Spring Pin, Forward Spring Eye
10. Hardened Washer, 1/2–13
11. Hexbolt, 1/2–13 x 5
12. Spring Pin Retainer
13. Spring-Eye Bushing
14. Inboard Spring Spacer
15. Hardened Washer
16. Front Suspension Bracket
17. Self-Locking Nut, 3/4–10
18. U-Bolt
19. Axle Stop and Shock Absorber Lower Mounting Bracket
20. Spring Center-Bolt and Center-Bolt Nut
21. Shock Absorber
22. Shock Absorber Upper Mounting Bracket
23. Hexbolt, 3/4–10
24. Hardened Washer, 2-1/4" o.d
25. Spring Pin, Rear Spring Eye
26. Shackle
27. Wear Plate
28. Shackle Bracket Bushing
29. Pinch Bolt, 1/2–13 x 4
30. Spring Pin, Shackle Bracket
31. Frame Rail
32. Shackle Bracket
33. Leaf Spring
34. Split Ring
35. Threaded Bushing
36. Threaded Spring Pin

Fig. 2, Front Suspension with Bronze Bushings or Threaded Spring Pins

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

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.

4. If the protective coating is gone from some areas of the spring, paint the cleaned areas with a rust-inhibiting paint. If rusting or corrosion is severe, replace the spring.
5. Using a micrometer, check nonthreaded spring pins and shackle pin for wear.

   On tapered leaf spring assemblies, replace a pin if the diameter at any point on the pin is less than 1.245 inches (31.62 mm).

   On flat leaf spring assemblies, replace a pin if the diameter at any point on the pin is less than 1.122 inches (28.50 mm).
6. Inspect threaded spring and shackle pins for cracked or broken threads. Replace any pin that has damaged threads.
7. Inspect the spring and bracket bushings. Replace the bushings if gouged, cracked, pitted, or otherwise damaged. For instructions, see **Subject 110**
8. If nonthreaded bushings are not damaged, inspect them for wear. Using a micrometer, check the inside diameter of each bushing. The inside diameter of any bushing should not exceed the diameter of its pin by more than 0.010 inch (0.25 mm). Replace any bushing that exceeds this limit.

Installation

See **Fig. 1** and **Fig. 2** for for this procedure.

WARNING

Failure to install identical spring assemblies could affect the balance of the front suspension and cause difficult handling of the vehicle, resulting in injury or property damage.

1. Install the shackle bracket if previously removed. Tighten the mounting fastener locknuts 190 lbf·ft (260 N·m).

NOTE: All suspension bracket (frame) fasteners require periodic retorquing. Refer to the suspension section in the vehicle maintenance manual for instructions.

2. Using multipurpose chassis grease, lubricate both spring pins, the shackle pin, and the inside surfaces of the bushings.
3. If the shackle was disconnected from the shackle bracket, attach it to the bracket.

   3.1 Apply Alumilastic® or similar compound to all areas of the shackle that contact metal. This includes all capscrews, washers, and locknuts that contact the aluminum shackle. Do not apply the compound to the inner (bearing) surface of the bushing or on fastener threads.

CAUTION

Failure to apply Alumilastic or similar compound will result in electrolytic corrosion of dissimilar metal components, and will damage the suspension system.

3.2 Install the shackles.

NOTE: When nonthreaded shackle pins are used, make sure the correct spacing washers are inserted between bracket ends and shackles. Be sure the hardened wear washers are in direct contact with the spring eye.

3.3 Insert the nonthreaded pin or screw in the threaded pin with its grease fitting end toward the outboard side. Install the split ring on the inboard end of the threaded pin. Align the grooves of the pin with the flanged pinch-bolt bores.

3.4 Install the flanged pinch bolts and flanged nuts to hold the shackle pin and spacing washers in place. Torque the nuts 95 lbf·ft (130 N·m).

⚠ CAUTION

Do not overtighten the shackle pinch-bolt nuts. Overtightening these nuts could distort and weaken the aluminum shackles.

4. Place the caster shim on the front axle in the position referenced earlier.
5. Install the spring assembly on the caster shim; make sure the spring bolt head fits into the bore in the axle.
6. Place the axle stop assembly and spring liner (if equipped) on top of the spring assembly. Make sure the high leg is aft.
7. Place the U-bolts over the axle stop and spring assembly and through the holes in the axle. It may be necessary to slightly compress the sides of the U-bolts in order to get the U-bolt ends to align with the axle holes. A C-clamp attached above the U-bolt threads can be used for this purpose.
8. Attach the hardened washers and the high nuts finger-tight.
9. Attach the spring assembly to the frame bracket.

   9.1 With nonthreaded spring pins, hold the correct number of spacing washers, as referenced during removal, between the outboard end of the bracket and the spring; insert the grease fitting end of the pin far enough into the bushing to hold the spacers in place. Hold the remaining spacers in place and push the spring pin in until its grooves align with the frame bracket's flanged pinch-bolt bores.

   With threaded pins, screw the pin all the way into the bushing with the grease fitting end toward the outboard side until the spring pin grooves align with the frame bracket's flanged pinch-bolt bores. Install the split ring on the inboard end of the pin.

   9.2 With nonthreaded spring pins, check for play between the spring and the bracket ends. If needed, install additional 1/32-inch spacing washers (1-1/8 inch i.d., 1-7/8 inch o.d.) so that there is less than one washer thickness of end play. It is preferable to have an equal number of washers on each side of the spring. However, if the amount of play requires an uneven number of washers, the difference between the two sides should be no more than one spacing washer.

   9.3 Install the flanged pinch bolts and flanged nuts. Tighten the nuts 95 lbf·ft (130 N·m).

10. Attach the spring assembly to the shackle bracket.

    10.1 With nonthreaded spring pins, hold the correct number of spacing washers, as referenced during removal, between the outboard shackle and the spring. With the grease fitting pointed to the outboard side, insert the spring pin far enough into the bushing to hold the spacers in place. Hold the remaining spacers in place and push the pin until its grooves align with the shackle pinch-bolt bores.

    With threaded spring pins, screw the pin all the way into the bushing with the grease fitting end toward the outboard side until the spring pin grooves align with the shackle pinchbolt bores. Install the split ring on the inboard end of the pin.

    10.2 With nonthreaded spring pins, check for play between the spring and the shackle ends. If needed, install additional 1/32-inch spacing washers (1-1/8 inch i.d., 1-7/8 inch o.d.) so that there is less than one washer thickness of end play. It is preferable to have an equal number of washers on each side of the spring. However, if the amount of play requires an uneven number of washers, the difference between the two sides should be no more than one spacing washer.

    10.3 With both threaded and nonthreaded spring pins, install the flanged pinch bolts and flanged nuts. Tighten the nuts 95 lbf·ft (130 N·m).

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

CAUTION

Do not overtighten the shackle pinch-bolt nuts. Overtightening these nuts could distort and weaken the shackles.

11. On vehicles equipped with shock absorbers, remove the applicable pair of high nuts and hardened washers and align the lower shock absorber bracket assembly so that the U-bolt ends pass through the holes in the plate.
12. Attach the hardened washers and high nuts to the U-bolts. For U-bolt tightening instructions and torque values, see the applicable table in **Specifications 400**.

CAUTION

Failure to retorque the fasteners as instructed could result in spring breakage and abnormal tire wear.

13. Wipe all dirt from the grease fittings on the spring pins and the shackle pin. Apply multipurpose chassis grease with a pressure gun until grease appears at the opposite end of the pin.
14. On vehicles with flat leaf spring assemblies, install the tire and wheel. For instructions, refer to **Group 40**.
15. Remove the jack stands from the chassis, and lower the truck.
16. On vehicles with tapered leaf spring assemblies, install the bumper and attach the road-light wires. Make sure the spacers are in the locations referenced earlier.

Shackle Bracket Bushing Replacement

1. With the shackle bracket removed from the vehicle, press out the worn or damaged bushing.
2. With an inside micrometer or bore gauge, check the bracket bore for damage or wear. Replace the bracket if the bushing bore is damaged or worn.
3. *If installing rubber bushings,* check the shackle bracket bolt for ease of fit in the bushing. It should have an easy slip fit without wobble between it and the bushing.

⚠ CAUTION

Do not press in rubber bushings by the center sleeve. To do so could damage the bushings.

4. Press the new bushing into the bracket until the bushing is centered in the bracket.
5. Check the shackle bracket bolt again for ease of fit in the bushing. It should still have an easy slip fit without wobble between it and the bushing. If binding occurs, the bushing may have been distorted during installation. Replace the bushing and check again for correct fit.
6. *If installing bronze bushings,* check the shackle pin for ease of fit in the bushing. It should have an easy slip fit without wobble between it and the bushing.
7. Press the new bushing into the bracket until the bushing is centered in the bracket. The bushing ends must be flush or inside the vertical edges of the bracket bore, and the split in the bushing must be within 1/4 inch (6 mm) of the bottom of the bracket bore.

   Check the shackle pin again for ease of fit in the bushing. It should still have an easy slip fit without wobble between it and the bushing. If binding occurs, the bushing may have been distorted during installation. Replace the bushing and check again for correct fit.
8. *If installing threaded shackle pins,* check the fit of the threaded pin in the bushing. It should screw in easily by hand without binding. Press the new bushing into the bracket until the bushing is centered in the bracket. Check the threaded pin again for ease of fit in the bushing. It should still screw in easily by hand without binding. If binding occurs, the bushing may have been distorted during installation. Replace the bushing and check again for correct fit.

Spring Bushing Replacement

1. Remove the leaf spring. See **Subject 100** for instructions.
2. Press out the worn or damaged bushing.

⚠ CAUTION

Do not press in the bushing by the center sleeve. To do so could damage the bushing.

3. *If installing rubber bushings,* apply a coating of Perma-Bond® HM–160 or Loctite® RC–609 adhesive to the inside of the spring eye, and to the outside of the bushing. Press the new bushing into the spring eye until the bushing is flush with the edges of the spring eye.

   If installing bronze bushings, press the new bushing into the spring eye until the bushing and the spring edges are flush. The split in the bushing must be within 3/16 inch (5 mm) of the top of the spring eye.

   If installing bushings for threaded spring pins, press the new bushing into the spring eye until the bushing is flush with the edges of the spring eye.
4. Install the leaf spring. See **Subject 100** for instructions.

Shock Absorber Removal and Installation

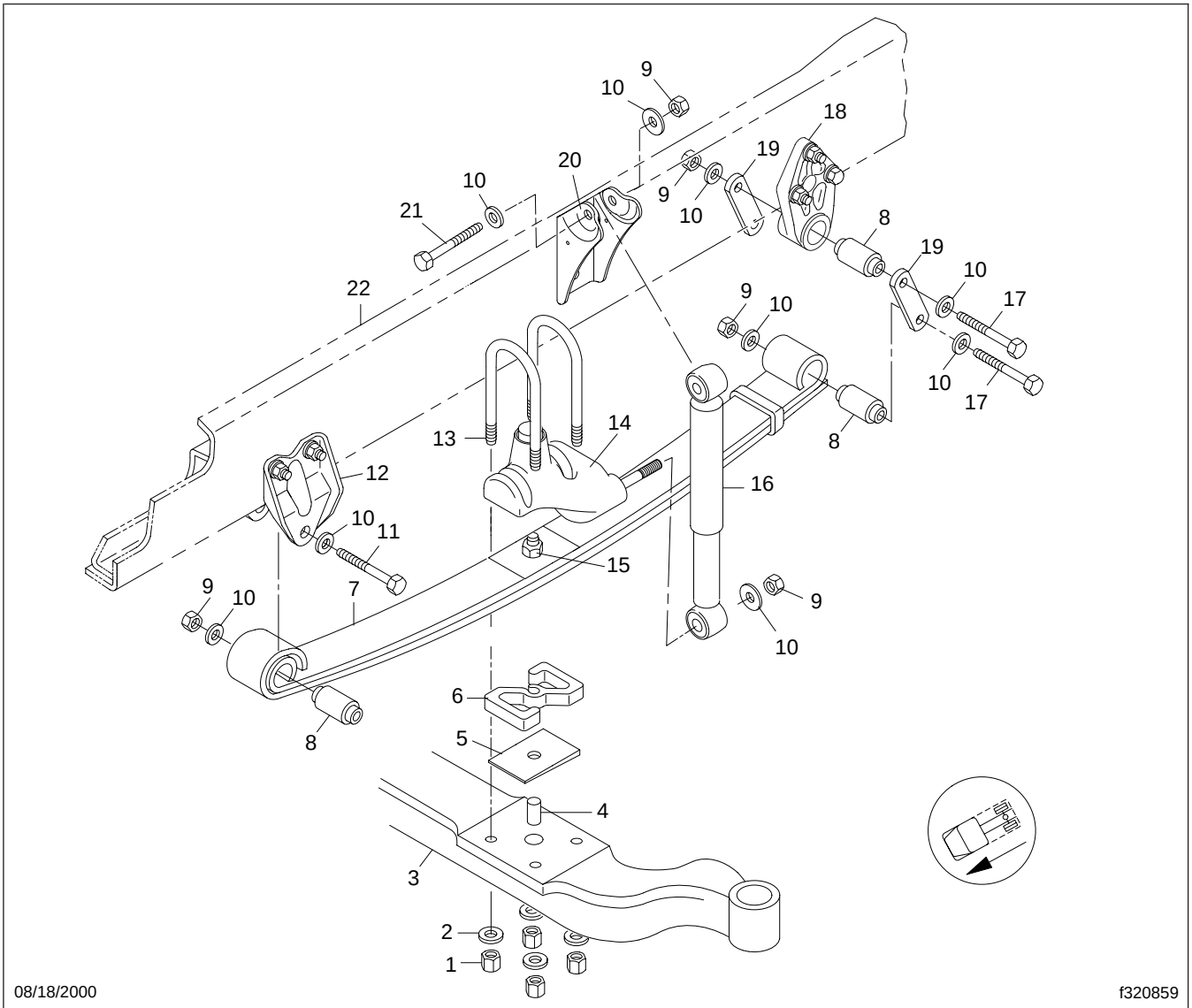
Removal

1. Remove the 3/4–10 hexbolt, the hardened washers, and locknut from the shock absorber and the upper mounting bracket. See **Fig. 1**.
2. Swing the shock absorber out and away from the upper mounting bracket.
3. Remove the 3/4–10 locknut and hardened washer from the stud of the lower mounting bracket.
4. Pull straight out on the lower part of the shock absorber to remove it.

Installation

1. Apply a suitable antiseize compound to the threads of the lower mounting-bracket stud, then slide the shock absorber onto the stud.
2. Install the washer and a new locknut onto the lower mounting-bracket stud and tighten the locknut just enough to hold the shock absorber in place.
3. Swing up the shock absorber and align the upper eye of the shock absorber with the holes of the upper mounting bracket.
4. Install a hardened washer and the 3/4–10 locknut onto the hexbolt. Tighten 241 lbf·ft (327 N·m).
5. Tighten the nut on the lower mount-bracket stud 241 lbf·ft (327 N·m).

Shock Absorber Removal and Installation



1. U-Bolt High Nut
2. Bearing Washer
3. Axle
4. Dowel
5. Caster Adjustment Shim
6. Spacer
7. Spring Assembly
8. Spring Pin and Rubber Bushing Assembly
9. Locknut, 3/4–10
10. Hardened Washer
11. Spring-Eye Bolt
12. Forward Spring Bracket
13. U-Bolt
14. Axle Stop and Shock Absorber Lower Mounting Bracket
15. Spring Center-Bolt and Nut
16. Shock Absorber
17. Shackle Bolt
18. Shackle Bracket
19. Spring Shackle
20. Shock Absorber Upper Mounting Bracket
21. Hexbolt, 3/4–10
22. Frame Rail

Fig. 1, Front Suspension with Rubber Bushings, Full-Leaf Springs

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 **Group 33**.
Caster is incorrect.	Install correct caster shims. Refer to **Group 33** for specifications.
Steering gear is not centered.	Adjust steering using the instructions in **Group 46**.
Drive axles are out of alignment.	Align the drive axles using the instructions in **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.	Tighten the U-bolt high nuts to the value listed in 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 torque table in **Specifications, 400**.
Worn or damaged spring pin bushings are allowing spring end-play.	Replace the spring pin and bushing.

Troubleshooting

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 the 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 pins are allowing spring end-play.	Replace any worn or damaged spring pins.

Problem—Rough Ride

Problem—Rough Ride	
Possible Cause	**Remedy**
Refer to **Group 32**.	

Specifications

Front Suspension Fastener Torque Values		
Description	**Size**	**Torque: lbf·ft (N·m)**
Shackle Bracket-to-Frame Locknut	1/2–13	68 (92)
	5/8–11	136 (184)
Spring Shackle Pinch-Bolt Locknut	1/2–13	45 (61)
Front Suspension Bracket Pinch-Bolt Locknut	1/2–13	68 (92)
Forward Spring-Eye Bolt	3/4–10	240 (325)
Upper and Lower Shackle Bolt	3/4–10	240 (325)
Spring-Pin Retainer Hexbolt	1/2–13	68 (92)
Axle U-bolt High Nuts (Tighten in a diagonal pattern as shown in **Fig. 1**.)	7/8–14	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 420–500 (571–680)
	1–14	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 520–600 (707–816)
Spring Assembly Center-Bolt Nut	1/2–20	65 (88)
Shock Absorber Upper and Lower Mounting Locknut	3/4–16 or 3/4–10	150 (203)
Shock Absorber Upper Mounting Hexbolt	3/4–10	241 (327)

Table 1, Front Suspension Fastener Torque Values

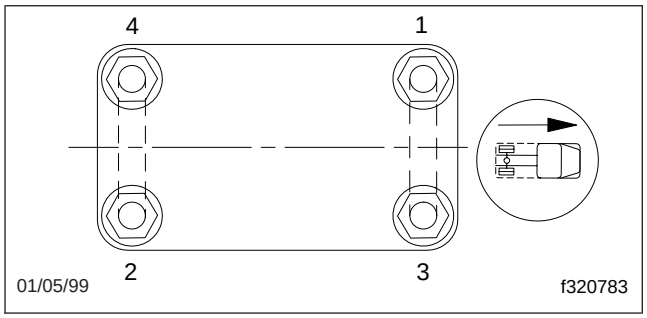
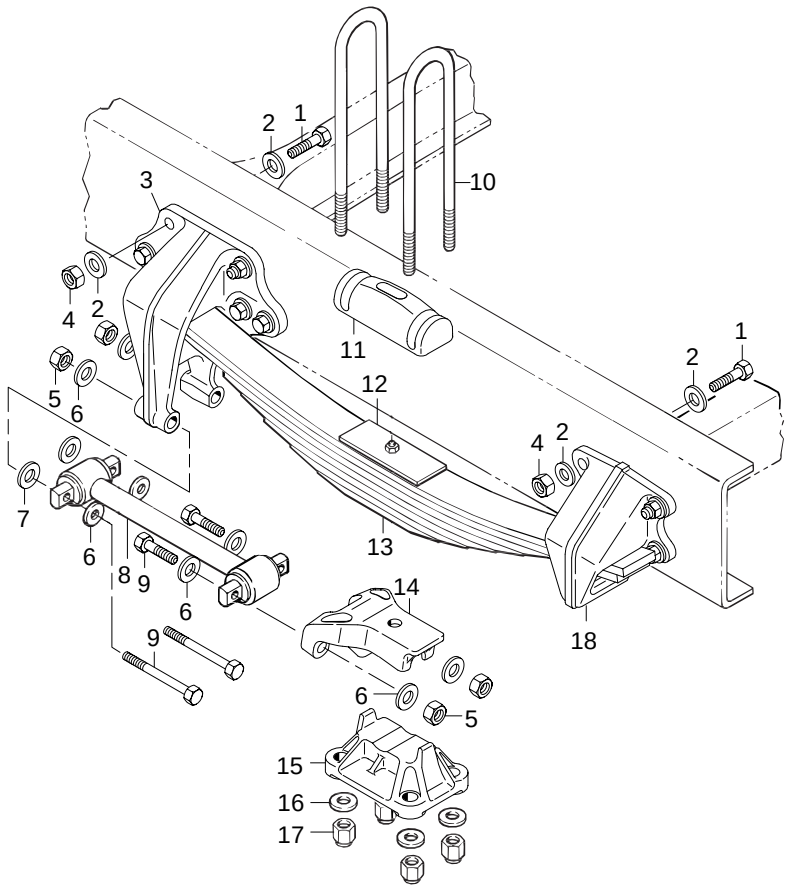


Fig. 1, Tightening Pattern for U-bolt High Nuts

General Information

The single-axle rear spring suspension uses a full-floating spring design. See **Fig. 1**. Semi-elliptical spring assemblies are attached to the axles with U-bolt assemblies. The spring ends ride in aluminum brackets that are mounted on the frame rails. Steel wear shoes are cast into each bracket. Radius rods attached to the axle seats and the forward spring brackets hold the axle in alignment.



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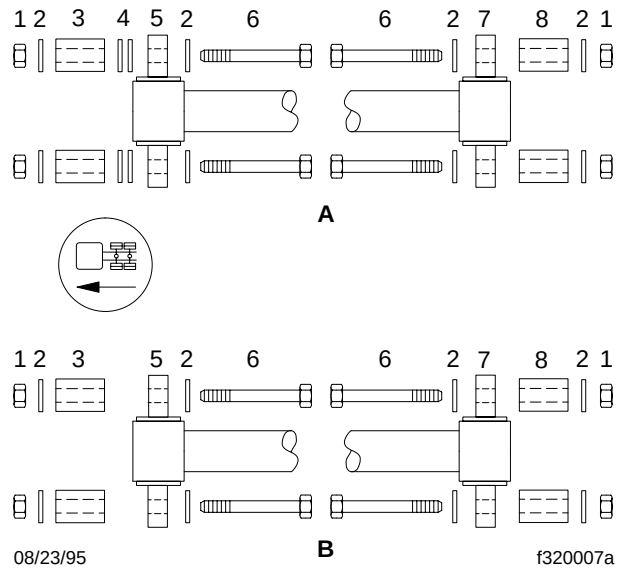
1. Suspension Bracket Hexhead Bolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hexhead Bolt
6. Hardened Washer
7. Axle Alignment Washer
8. Radius Rod
9. Radius Rod Hexhead Bolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Rear Spring Bracket

Fig. 1, Single-Axle Spring Suspension

Radius Rod Removal and Installation

Removal

See **Fig. 1** for this procedure.



A. Right-Side Radius Rod
B. Left-Side Radius Rod

1. Hex Locknut
2. Hardened Washer
3. Forward Spring Bracket
4. Alignment Washers (install only on one side; right-side installation shown.)
5. Radius Rod Front Pin
6. Hexbolt
7. Radius Rod Rear Pin
8. Axle Seat

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 the radius rod that is being removed.
3. Remove the fasteners that attach the radius rod to the forward spring bracket and to the axle seat.
4. Remove the radius rod and any axle alignment washers.

Installation

See **Fig. 1** for this procedure

IMPORTANT: At all points where steel parts contact the aluminum forward spring bracket, 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. Place the radius rod pins between the rear side of the forward spring bracket, and the front side of the axle seat.
2. Install the hexhead bolts, hardened washers, and locknuts in the axle seat and the radius rod rear pin.
3. 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 in the radius rod front pin and the forward spring bracket.
4. Tighten the radius rod locknuts to the torque value in **Specifications 400**.
5. Check the 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 130**.

Replacement

See **Fig. 1** for this procedure.

⚠ 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, then block the axle. 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; refer to **Group 40** for instructions.
3. Remove the U-bolt high nuts, hardened washers, U-bolt retainer, U-bolts, and upper U-bolt pad.
4. Lift the spring assembly off the axle seat, then move it to the rear, out of the forward spring bracket. Lift the front of the spring, then move it forward, out of the rear spring bracket.
5. Using chassis grease, lubricate the ends of the new spring where they contact the stationary wear shoes in the spring brackets.
6. Work the new spring assembly into the spring brackets, and place it on the axle seat. Make sure the spring center-bolt head seats in the axle seat hole.
7. Place the upper U-bolt pad on the spring assembly. Place the U-bolts over the upper U-bolt pad and the spring assembly.
8. Install the U-bolt retainer, hardened washers, and U-bolt high nuts. Tighten the high nuts until snug.
9. 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).

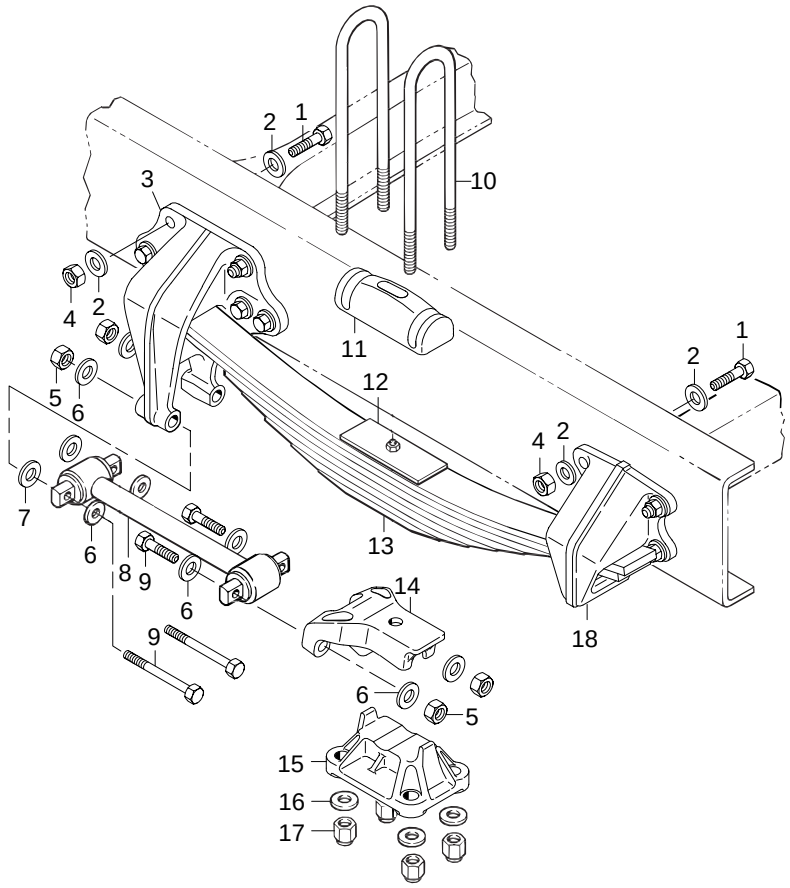
⚠ CAUTION

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 of the *L-Line/A-Line Maintenance Manual*.

10. Install the wheel assembly, using the instructions in **Group 40**. Remove the safety stands from under the frame and axle, and lower the vehicle.
11. Check the axle alignment. For instructions, see **Group 35**. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.

Spring Assembly Replacement



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1. Suspension Bracket Hexhead Bolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hexhead Bolt
6. Hardened Washer
7. Axle Alignment Washer
8. Radius Rod
9. Radius Rod Hexhead Bolt
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. Rear Spring Bracket

Fig. 1, Single-Axle Spring Suspension

Replacement

WARNING

Replace worn, cracked, or damaged spring brackets. Failure to do so could result in bracket breakage, possibly leading to loss of vehicle control and 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

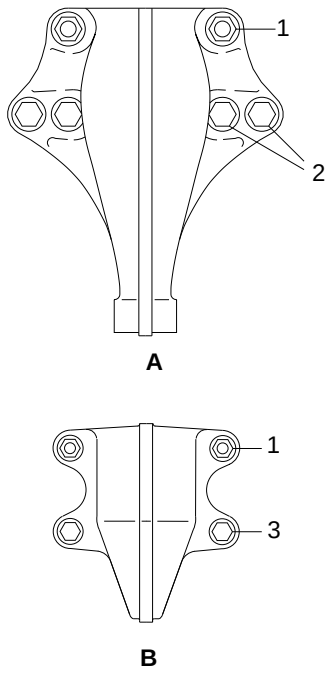
Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.

1. Chock the front tires.
2. Raise the rear of the vehicle, and block the rear axle 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 axle and frame.
3. If removing the forward spring bracket, note the number of axle alignment washers, if any, between the bracket and the radius rod front pin. Remove the fasteners that attach the radius rod to the bracket, and remove any axle alignment washers.
4. Remove the fasteners that attach the spring bracket to the frame rail, and remove the spring bracket.
5. Place the new spring bracket on the frame rail. Align the mounting holes, and install the spring 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. 1**.

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. 1.**

6. Tighten the locknuts to the applicable torque value in **Specifications 400**.



A. Forward Spring Bracket
B. Rear Spring Bracket
1. Nut (outboard)
2. Bolt Heads (outboard)
3. Bolt Head (outboard)

Fig. 1, Frame Brackets

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 inter-

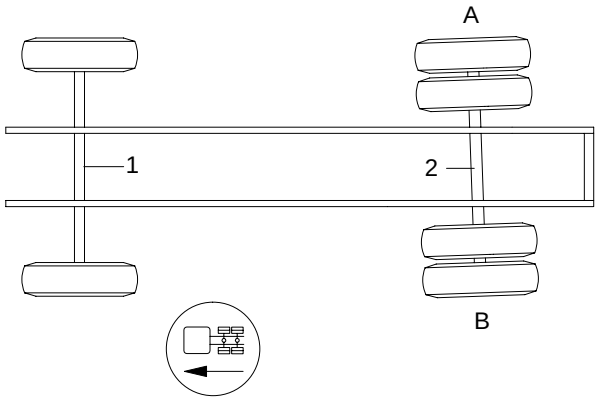
Spring Bracket Replacement

vals and instructions, refer to the suspension section in the vehicle maintenance manual.

7. If replacing the forward spring bracket, position any previously removed axle alignment washers between the bracket and the radius rod front pin. Install the bolts, hardened washers, and locknuts in the radius rod front pin and the forward spring bracket. Tighten the locknuts to the torque value in **Specifications 400**.
8. Remove the safety stands from under the frame and axle, and lower the vehicle.
9. Check the 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 130**.

Adjustment

1. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the axle at a right angle to the frame. For instructions, refer to the rear axle section in this manual. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the 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**.



A. Leading End
B. Trailing End
1. Front Axle
2. Rear Axle

Fig. 1, Single Axle, Shown Out of Alignment

NOTE: To adjust the axle alignment, add washers between the radius rod front pin and the forward spring bracket on the leading end, to adjust the leading end backward. Or, remove washers from the trailing end, to bring the trailing end forward. When possible, alignment washers should be removed instead of added.

2. On both sides of the 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 radius rod to the forward spring bracket. Remove any axle alignment washers.
4. Raise the frame just enough to relieve the weight from the springs. Place safety stands under the frame. Make sure the stands will 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 the correct thickness of axle alignment washers between the radius rod front pin and the forward spring bracket.
7. Install the hexhead bolt, hardened washers, and locknut in the radius rod pin and forward spring bracket. Place an equal thickness of washers on the other end of the radius rod pin, and install the fasteners.
8. Tighten the locknuts to the applicable torque value in **Specifications 400**.
9. Remove the safety stands, and lower the vehicle. Remove the chocks from the front tires.
10. Check the 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 the procedure 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, refer to the suspension section in the vehicle maintenance manual.

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)
Axle U-bolt High Nuts (Tighten in a diagonal pattern as shown in **Fig. 1**.)	7/8–14	C	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 420 to 500 (571 to 680)
	1–14	C	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 520 to 600 (707 to 816)
Rear Spring Bracket-to-Frame Rail Locknut *	5/8–11	C	135 (184)
Radius Rod Locknut *	5/8–18	C	135 (184)

* Cadmium-plated, wax-coated nuts, and grade 8 hexbolts with phosphate- and oil-coated threads; both used with hardened washers.

Table 1, Torque Values

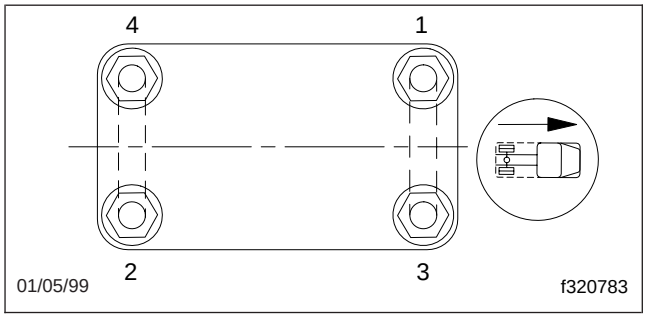


Fig. 1, Tightening Pattern for U-bolt High Nuts

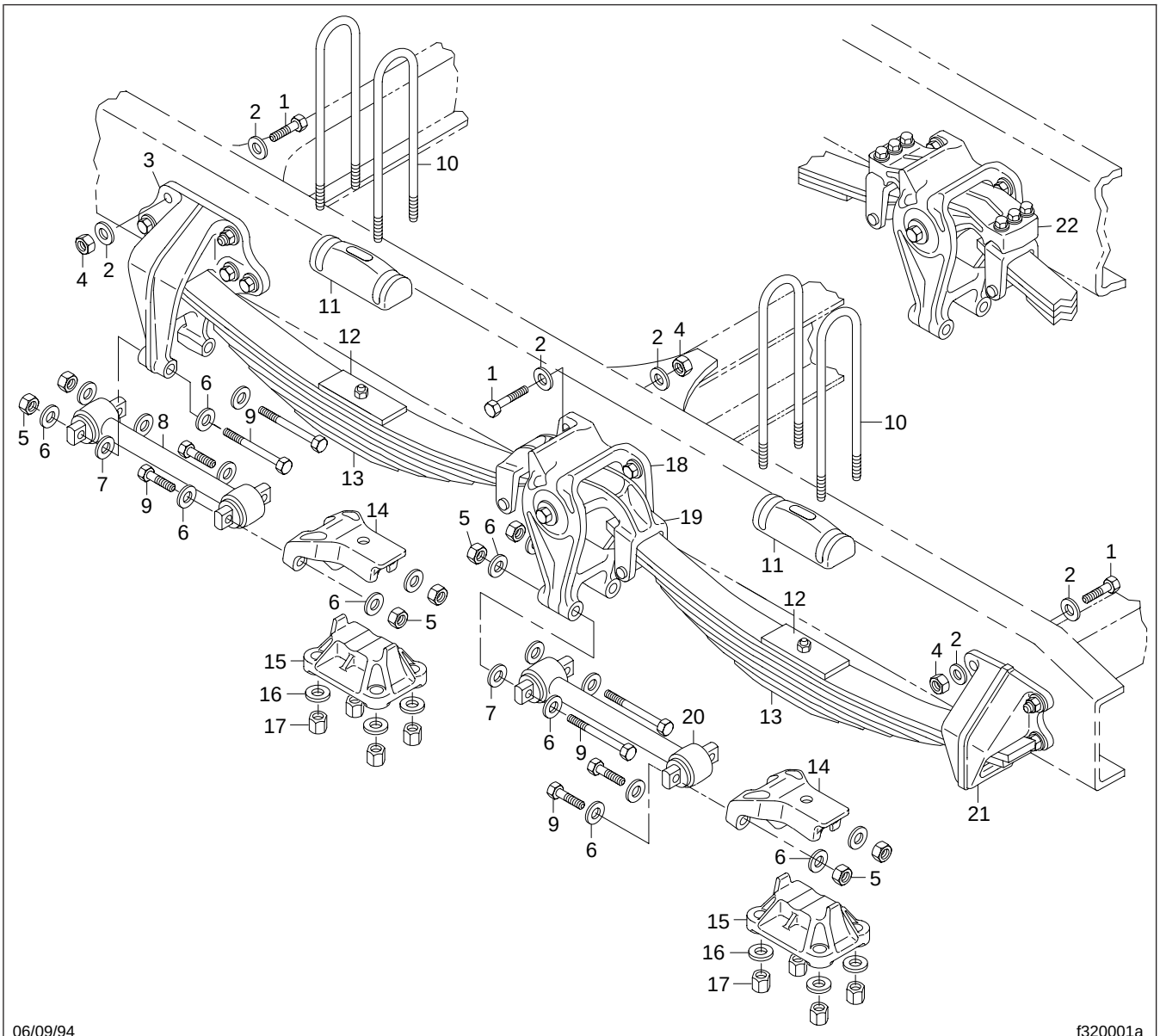
General Information

The tandem-axle rear spring suspension uses a six-point equalizing leaf spring design, which compensates for axle articulation, from side to side, and front to rear. See **Fig. 1**.

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 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



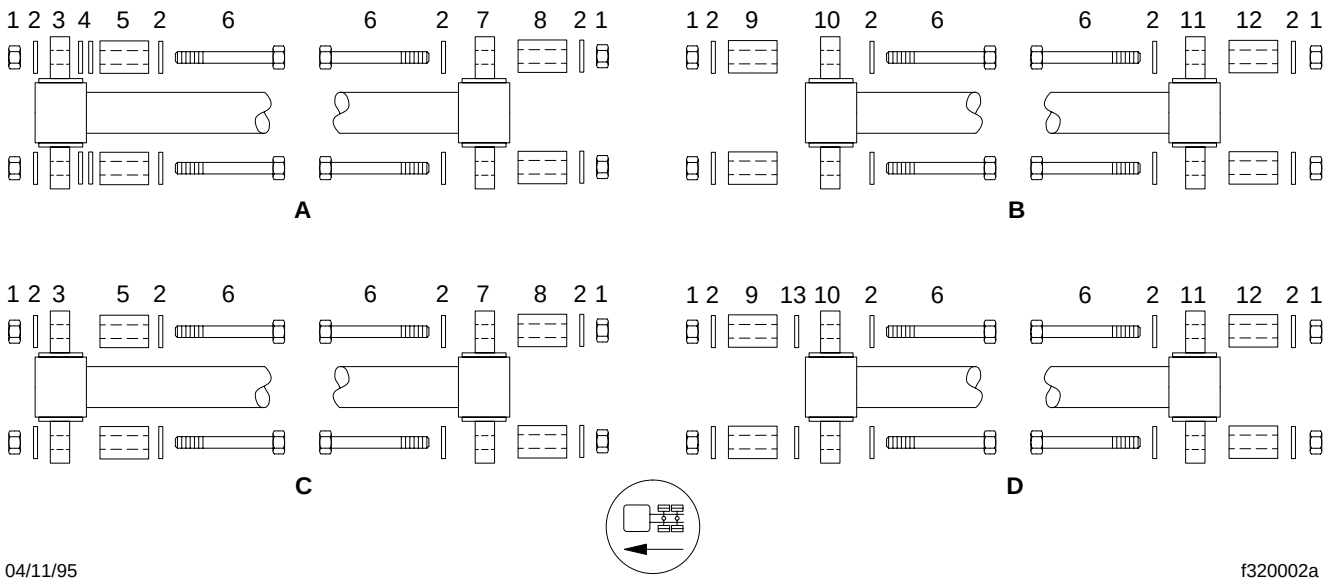
1. Suspension Bracket Hexbolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hex Locknut
6. Hardened Washer
7. Axle Alignment Washer
8. Forward Radius Rod
9. Radius Rod Hexbolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring 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** for this procedure.

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.



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. Hexbolt
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 Washers (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** for this procedure.

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.

Radius Rod Removal and Installation

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.

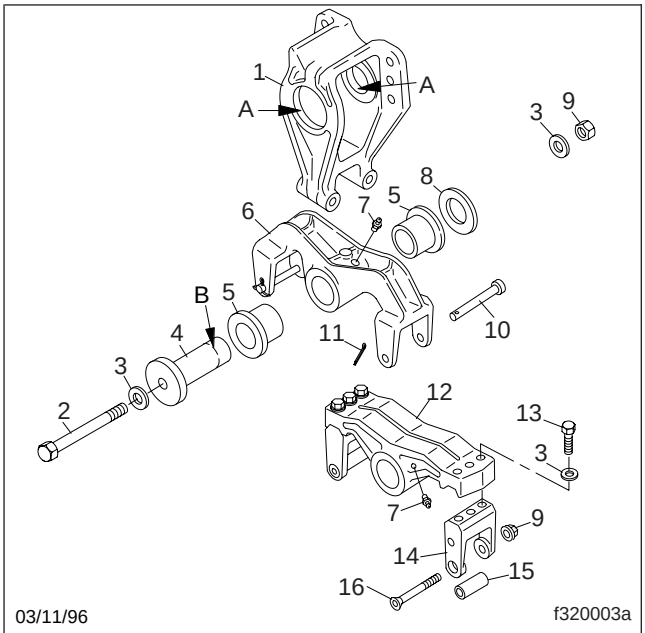
2. Install a hexhead bolt with a hardened washer through each end of the radius rod rear pin and the axle seat ears. Install the hardened washers and locknuts.
3. If installing a forward radius rod, install any previously removed axle alignment washers between the radius rod front pin and the forward 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 the rear axle section in this manual. If necessary, adjust the axle alignment, using the instructions in **Subject 140**.

Equalizer Removal, Inspection, and Installation

Removal

See **Fig. 1** for this procedure.



A. Apply Loctite here.
B. No grease.
1. Equalizer Bracket
2. Hexhead Bolt
3. Bearing Washer
4. Cap and Tube Assembly
5. Equalizer Assembly Bushing
6. Equalizer (used on vehicles with two drive axles)
7. Grease Fitting
8. Wear Washer(s)
9. Locknut
10. Spring Retainer Pin
11. Cotter Pin
12. Equalizer (used on vehicles with a 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 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.

CAUTION

Failure to replace the equalizer if it is cracked or otherwise damaged could result in progressive damage to, and eventual breakage of the equalizer. Breakage of the 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 for wear, cracks, or other damage. If any of these conditions are present, replace the bushings or the cap and tube assembly.

Equalizer Removal, Inspection, and Installation

Installation

See **Fig. 1** for this procedure.

1. Apply a thin film of multipurpose chassis grease to the outside of the equalizer bushings, then install the bushings in the equalizer.
2. Install the equalizer in the equalizer bracket.

NOTE: The next four steps must be completed before the Loctite begins to cure (approximately 5 to 10 minutes).

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. 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 in **Group 40**. Remove the safety stands from under the frame and axle, and lower the vehicle.
10. If the radius rods have been loosened, or the equalizer bracket has been removed, check the rear axle alignment. For instructions, refer to **Group 35**. If necessary, adjust the axle alignment using the instructions in **Subject 140**.

Replacement

See **Fig. 1** for this procedure.

⚠ WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Chock the front tires.
2. Raise the frame so that all weight is removed from the leaf springs; then block the frame with safety stands. Raise the rear axle until the spring no longer contacts the spring bracket wear shoes and the spring retainer pin (or side-restraint sleeve); then block the axle. Make sure the stands will securely support the weight of the axles and frame. To access the spring assembly, remove the wheel assembly. See **Group 40** for instructions.
3. If equipped with two drive axles, remove the cotter pin from the spring retainer pin on the end of the equalizer where the spring is being replaced. Drive the spring retainer pin out of the equalizer.

   If equipped with a pusher or tag axle, remove the nut from the flathead bolt on the end of the equalizer where the spring is being replaced. Remove the bolt and the side-restraint sleeve from the wear-shoe side-restraint.
4. Remove the U-bolt high nuts, hardened washers, U-bolt retainer, U-bolts, and upper U-bolt pad.
5. Remove the spring assembly by lifting it off the axle seat, then moving it toward the equalizer, out of the forward or rear spring bracket.
6. Using chassis grease, lubricate the new spring assembly where the ends will contact the stationary wear shoes in the spring bracket and equalizer.
7. Place the new spring assembly in the spring bracket and on the axle seat. Make sure the spring center-bolt head seats in the axle seat hole.
8. If the upper U-bolt pad is aluminum, apply Alumilastic compound, or an equivalent, to those areas of the pad that will come in contact with the U-bolts and with the upper spring leaf.

⚠ CAUTION

Failure to apply Alumilastic® compound, or an equivalent, to areas where aluminum and steel contact each other, could lead to corrosion of the metals, resulting in suspension damage.

9. Place the upper U-bolt pad on the spring assembly. Place the U-bolts over the upper U-bolt pad and the spring assembly.
10. Install the U-bolt retainer, hardened washers, and U-bolt high nuts. Tighten the high nuts until snug.
11. If installing a spring assembly on a vehicle with two drive axles, apply Alumilastic compound, or an equivalent, to the spring retainer pins, then install them from the inboard side. Be sure the hooked ends of the spring leaves are above the retainer pins. Install a cotter pin in the outboard end of each retainer pin, and lock it in place.

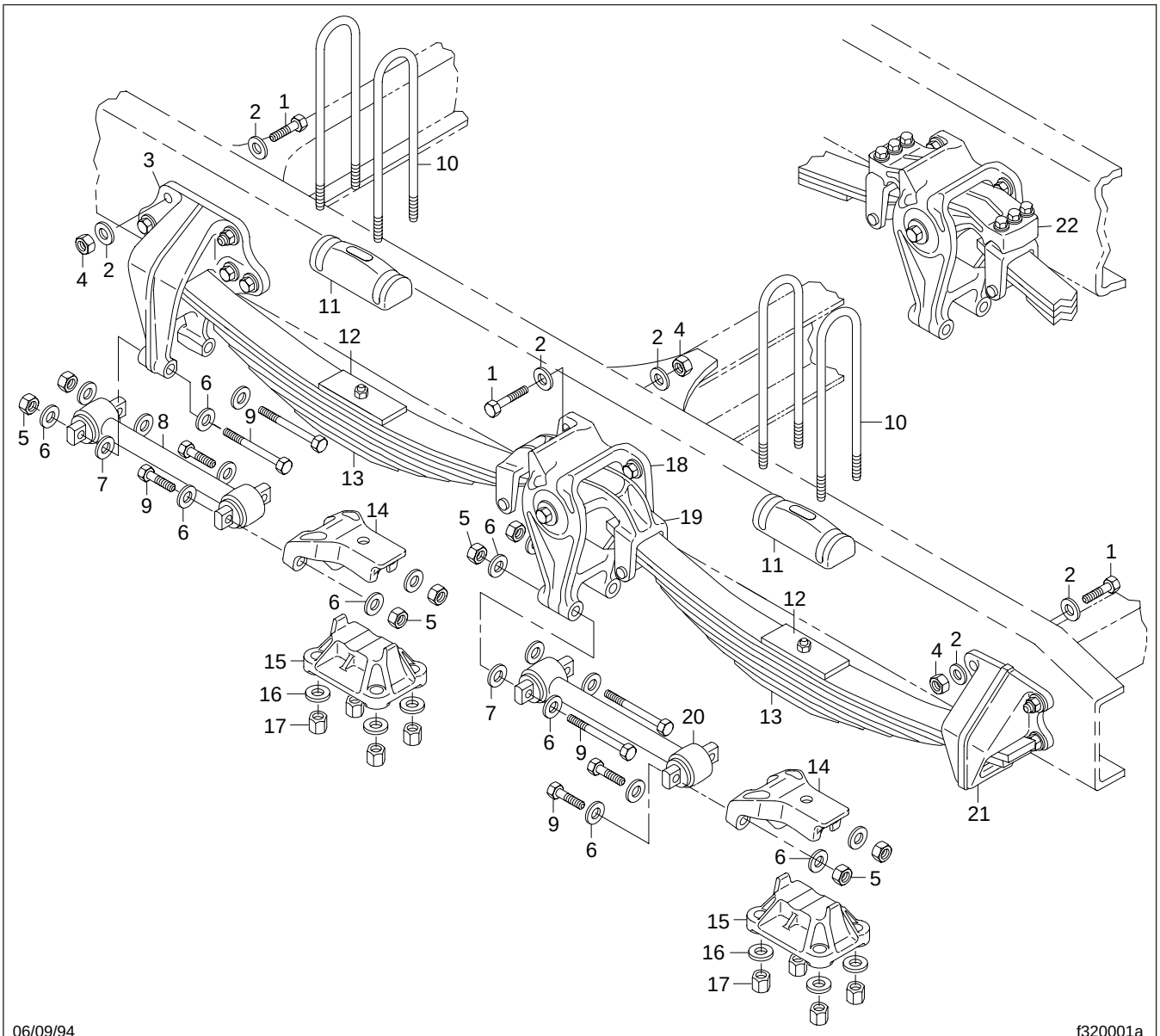
    If installing a spring assembly on a vehicle with a pusher or tag axle, install the side-restraint sleeves and flathead bolts in the wear-shoe side-restraints. Be sure the hooked ends of the spring leaves are above the side-restraint sleeves. Install the nuts, and tighten them to the applicable torque value in **Specifications 400**.
12. 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

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

inspecting and fastener torque checking inter-

vals and instructions, see Group 32 of the *L-Line/A-Line Maintenance Manual*.

13. Install the wheel assembly, using the instructions in **Group 40** of this manual. 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** for this procedure.

⚠ WARNING

Replace worn, cracked, or damaged spring brackets or equalizer brackets. Failure to do so could result in breakage of the bracket, possibly leading to loss of vehicle control and resulting in personal injury or property damage.

IMPORTANT: At all points where steel parts 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

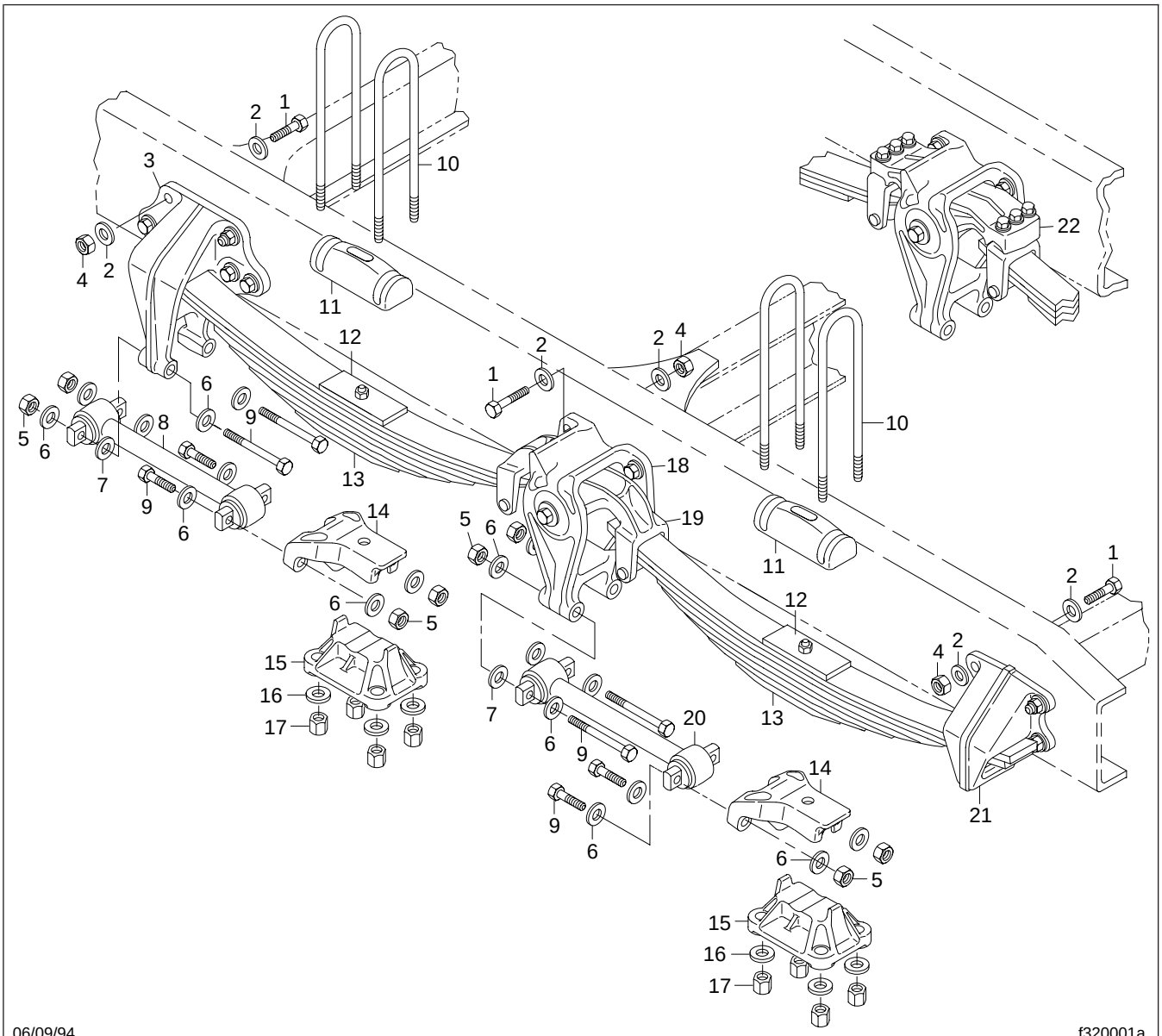
Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, refer to the suspension section 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** .

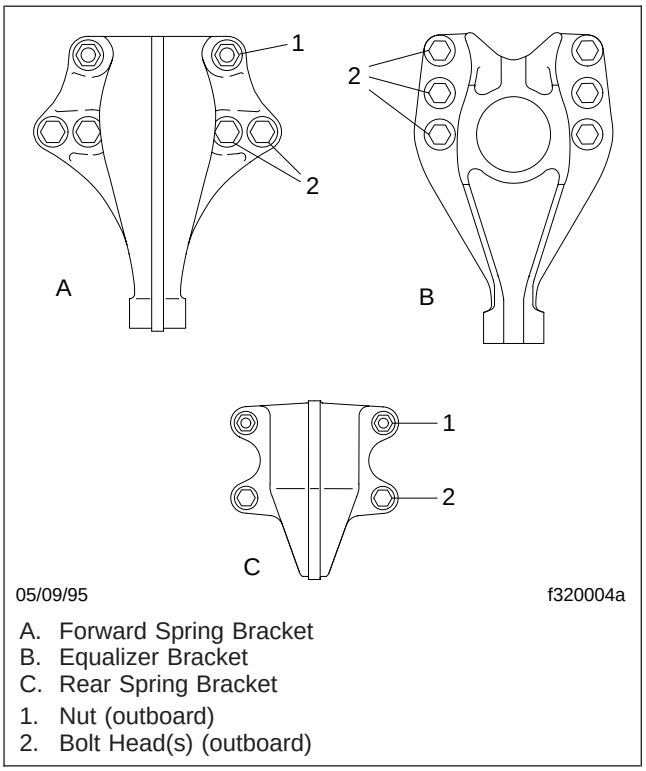
   Install bolts with hardened washers in the radius rod front pin, and the forward spring bracket or equalizer bracket. Install the hardened washers and locknuts, and tighten the locknuts to the torque value in **Specifications, 400**.
9. If replacing an equalizer bracket, install the equalizer. For instructions, refer to **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, refer to the rear axle section in this manual. 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)

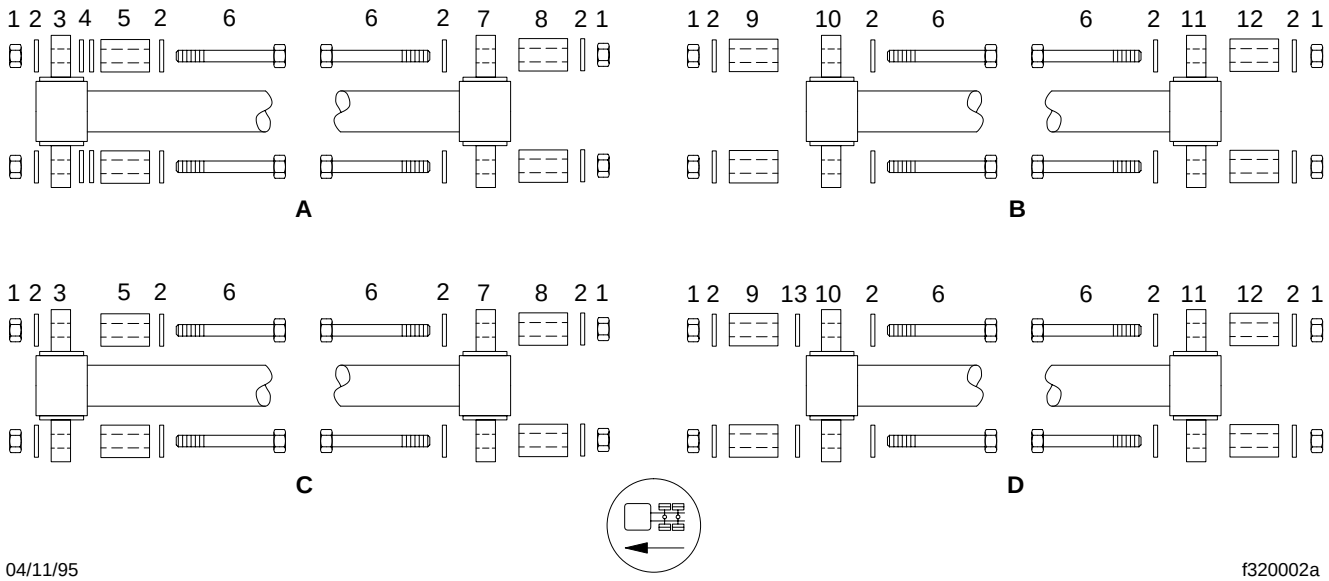
Fig. 1, Tandem-Axle Spring Suspension



A. Forward Spring Bracket
B. Equalizer Bracket
C. Rear Spring Bracket
1. Nut (outboard)
2. Bolt Head(s) (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. Hexbolt
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 Washers (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, refer to the rear axle section in this manual. 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.

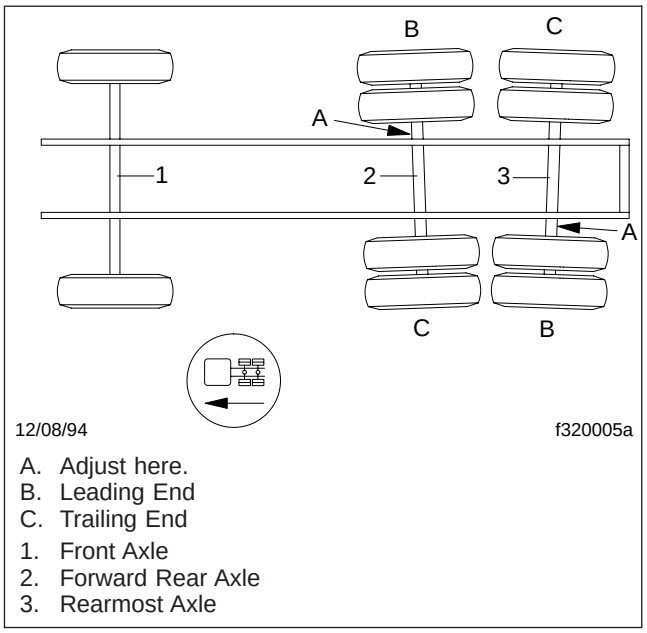
NOTE: To adjust the forward-rear axle alignment, add alignment washers between the radius rod and the forward spring bracket on the leading end, to adjust the leading end backward. Or, remove alignment washers from the trailing end, to bring the trailing end forward. When possible, alignment washers 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. Between one end of the radius rod front pin and the forward spring bracket, insert the correct thickness of axle alignment washers needed 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.

7. Place an equal thickness of washers on the other end of the radius rod pin, and install the fasteners.



A. Adjust here.
B. Leading End
C. Trailing End
1. Front Axle
2. Forward Rear Axle
3. Rearmost Axle

Fig. 1, Tandem Axle, Shown Out of Alignment

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, refer to the suspension section 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

Rear Axle Alignment Adjustment

side of the vehicle. For instructions, refer to the rear axle section in this manual. 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 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, refer to **Group 32** in the *L-Line/A-Line 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 (Tighten in a diagonal pattern as shown in **Fig. 1**.)	7/8–14	C	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 420 to 500 (571 to 680)
	1–14	C	Stage 1: Hand tighten Stage 2: 60 (81) Stage 3: 200 (271) Stage 4: 520 to 600 (707 to 816)
Radius Rod Locknut *	5/8–18	C	135 (184)
Equalizer Cap and Tube Assembly Locknut *	3/4–16	C	270 (365)
Equalizer Wear Shoe Capscrew	5/8–11	8	135 (184)
Side-Restraint Sleeve Locknut	1/2–13	C	68 (93)

* Cadmium-plated, wax-coated nuts, and grade 8 hexbolts with phosphate- and oil-coated threads; both used with hardened washers.

Table 1, Torque Values

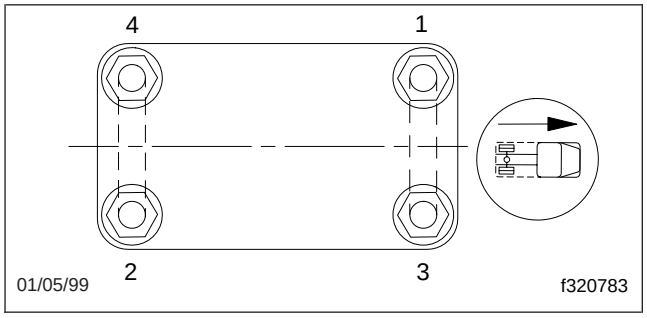


Fig. 1, Tightening Pattern for U-bolt High Nuts

General Information

The Front Airliner Suspension (also referred to as the Hendrickson AIRTEK suspension) is comprised of a front air suspension, and a welded steering axle (Hendrickson STEERTEK), that work together to form an integrated torsion system. See **Fig. 1**. See **Group 33** for Hendrickson STEERTEK front axle information.

Axle Clamp Group

The clamp group provides four-sided clamping pressure. The clamp group consists of the following:

- top axle wrap
- bottom axle wrap
- top axle wrap liner
- bottom axle wrap liner
- top pad
- 3/4-inch bolts, washers, nylon locknuts

Air Springs

The air springs are engineered to support 50 percent of the vertical load while providing very low spring rate. The "push-to-connect" air supply design also provides fast and easy installation and removal.

Leaf Spring Assembly

The leaf springs share loads equally with the air springs. Front and rear bushings are greaseless, and only require periodic inspections.

Shock Absorbers

The shock absorbers are tuned specifically for the AIRTEK system.

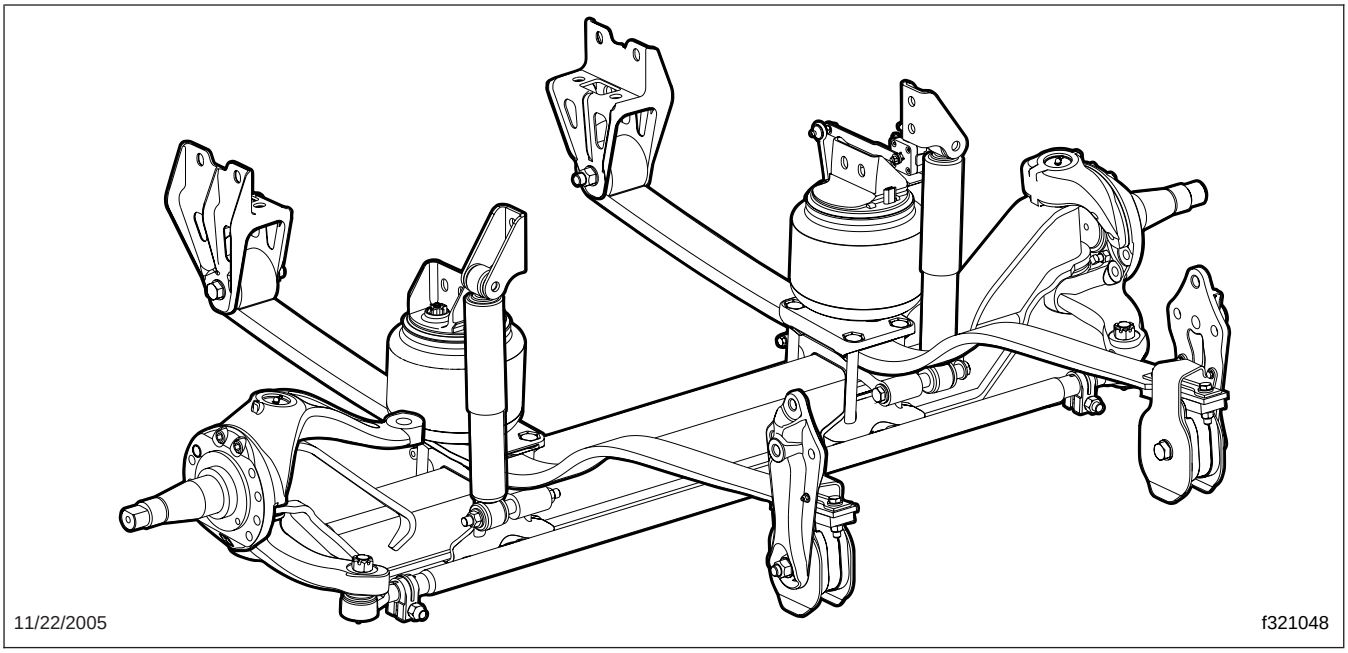


Fig. 1, Front AirLiner (Hendrickson AIRTEK) Suspension

Ride Height Adjustment

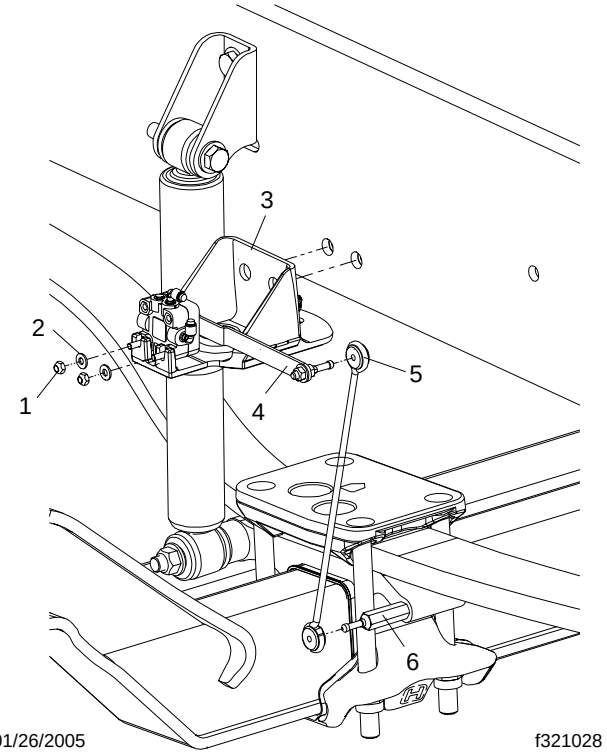
NOTE: As of August 2007, the Front AirLiner Suspension is equipped with dual height-control valves, one on each side of the vehicle. For vehicles with dual valves, inspect and adjust the ride height on both sides of the vehicle.

1. Use a work bay with a level floor. Drive the vehicle slowly, straight ahead. Try to slacken or loosen the suspension as the vehicle is positioned. End with all the wheels positioned straight ahead. Try to roll to a stop without the brakes being used.
2. Shut down the engine, then chock the tires. Do not set the parking brakes.
3. To ensure that the vehicle is level, check the tire pressure. The air pressure in both front tires should match.
4. Disconnect the vertical linkage from the stud on the horizontal control lever, and exhaust the suspension air by lowering the lever; see **Fig. 1**. If equipped with dual height-control valves, repeat for the other side of the vehicle.

NOTE: It is very important that the height-control valve be cycled completely before and after any ride height adjustments. This cycling of the height-control valve will help to make the adjustment as accurate as possible.

5. Attach the linkage to the stud on the horizontal control lever, and allow the suspension system to fill with air. If equipped with dual height-control valves, repeat for the other side of the vehicle. Wait until the airflow to the front air springs has stopped.
6. Measure the suspension ride height of the front axle. If equipped with dual height-control valves, measure the ride height on both sides of the vehicle.

   Using a Hendrickson AIRTEK height gauge, literature no. 45745-159, hold the gauge vertically and place it so the upper notch feature is between the height-control-valve mounting bolts, and sits flush against the bottom of the air-spring bracket; see **Fig. 2**. The piston-flange edge should contact the lower region marked "ACCEPTABLE."



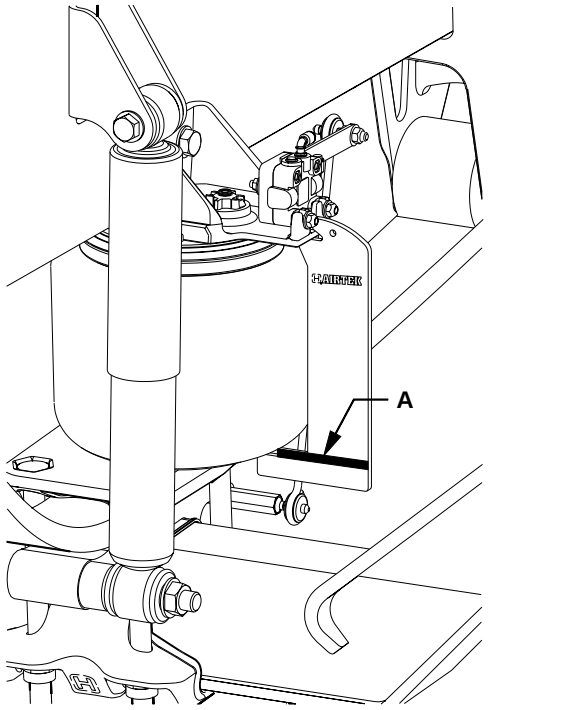
1. 1/4-Inch Locknut
2. 1/4-Inch Washer
3. Air Spring Hanger
4. Horizontal Control Lever
5. Vertical Linkage
6. Link Mount

Fig. 1, Height-Control Valve Linkage

   If the flange edge contacts at the "BELOW SPEC" region, the ride height is set too low. If the flange contacts at the "ABOVE SPEC" region, the ride height is set too high.

   If a gauge is not available, measure the vertical distance from the bottom of the upper air-spring bracket to the bottom of the air-spring piston flange. This distance should be between 7-3/4 and 8 inches (197 and 203 mm).
7. If the suspension ride height is not within specification, disconnect the vertical linkage from the horizontal control lever, fill and exhaust the suspension system, then fill the system until the suspension is at the proper ride height.
8. Move the control lever to the neutral position, then hold it in position by inserting a 5/32-inch

Ride Height Adjustment



A. Acceptable Range

Fig. 2, Using the Ride Height Gauge

(4-mm) pin or drill bit into the holes in the control lever and valve body.

NOTICE

When loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

9. While holding the height-control valve mounting studs in place with an Allen wrench, loosen the valve mounting just enough to allow movement of the height-control valve.
10. Adjust the height-control valve by rotating the valve body until the rubber grommet at the upper end of the vertical linkage lines up with the stud on the horizontal control lever.
11. Make sure the height-control valve stays in position. If necessary, hold the height-control valve mounting studs in place with an Allen wrench, and tighten the nuts slightly. Do not tighten the locknuts to the specified torque until after the proper ride height is verified.
12. Remove the pin or drill bit from the holes in the control lever and valve body.
13. Detach the linkage from the stud on the horizontal control lever, and exhaust the suspension system air, then attach the linkage to the stud on the horizontal control lever, and fill the suspension system with air. Wait until the airflow to the front air springs has stopped.
14. Measure the suspension ride height again. If necessary, repeat 6 through 14.
15. Once the proper ride height is attained, tighten the valve mounting locknuts 95 lbf·in (1100 N·cm), while holding the height-control valve mounting studs in place with an Allen wrench. Do not overtighten.

Height-Control Valve Test

It is normal to hear air escaping from the height-control valve for as much as 10 minutes after getting out of the vehicle when it is in an unladen condition. This air "leaking" is just the height-control valve exhausting air from the suspension air springs in order to return to the neutral mode.

The height-control valves used on the L-Line and A-Line are Barksdale valves. Two methods are available to check the operation of the Barksdale height-control valves. A leak in the valve may be discovered without using a test kit, but a test kit is necessary to determine if the valve has an unacceptable rate of leakage.

Some Barksdale height-control valves have been returned for warranty because the four bolts in the valve housing were overtightened, often, enough to crack the valve housing. These bolts should not be loose, and should not normally require tightening, as there are no serviceable parts in the valve.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

NOTICE

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

Checking the Height-Control Valve Without Using a Test Kit

1. Apply the parking brakes and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

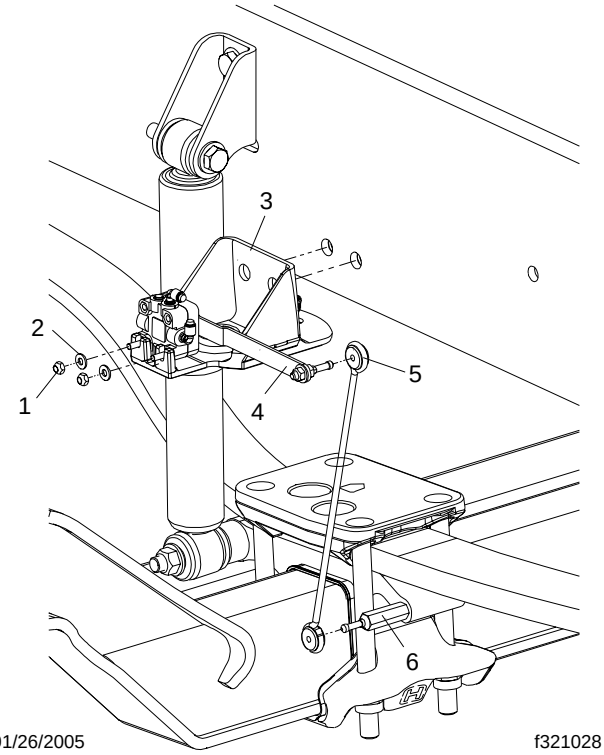
NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
5. Pull the control lever up about 45 degrees for 6 to 8 seconds. If air passes through the valve, that section of the valve is working.
6. Return the control lever to the neutral position. Air should stop flowing. If so, that section of the valve is working.
7. Push the control lever down about 45 degrees for 6 to 8 seconds. If air exhausts from the valve, that section of the valve is working.
8. Return the control lever to the neutral position. If the air stops again in the neutral position, the valve is working correctly.
9. If the valve works as stated in all of the above steps, then no further checking is necessary. Connect the vertical linkage to the control lever, then tighten the linkage nut.

   If needed, adjust the ride height or replace the height-control valve. For adjustment of the ride height, see **Subject 100**. For replacement of the height-control valve, see "Height-Control Valve Replacement" below.

NOTE: If a leak is detected on a Barksdale height-control valve, go to "Checking a Barksdale Height-Control Valve Using a Test Kit". Barksdale valves have an acceptable leak rate of 3 cubic inches (50 cc) per minute. You can

Height-Control Valve Test and Replacement



1. 1/4-Inch Locknuts
2. 1/4-Inch Washers
3. Air Spring Hanger
4. Horizontal Control Lever
5. Vertical Linkage
6. Link Mount

Fig. 1, Height-Control Valve Linkage

determine if a leak is acceptable only by using the Barksdale test kit.

Checking the Height-Control Valve Using a Test Kit

IMPORTANT: The procedure described below is for use on Barksdale height-control valves only.

NOTE: The Barksdale field test kit is designed to be used with the height-control valve installed on the vehicle. Refer to **Specifications 400** for information on ordering the Barksdale height-control valve test kit KD2264.

1. If not already done, park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. For valves without an integral dump port, go to the next step.

   For valves with an integral dump port, check the rubber exhaust flapper at the back of the valve housing for leaks; see **Fig. 2**. Use a soapy solution.

   If a leak is found, there may be contaminants blocking the piston. Cycle the height-control valve switch inside the cab for two-second bursts, four or five times, to clear away any contaminants.

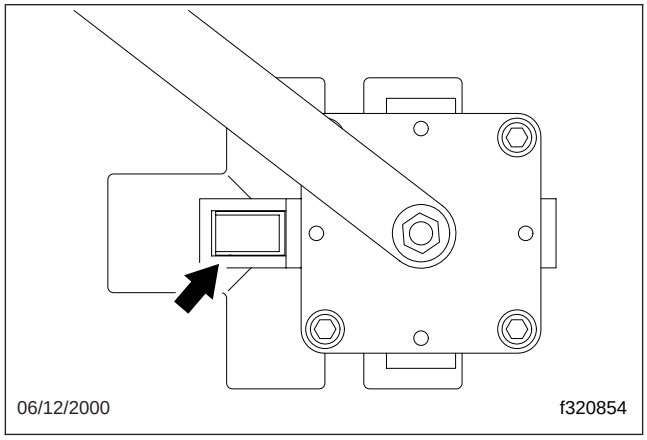


Fig. 2, Exhaust Flap Location (height-control valve with integral dump port)

5. Disconnect the vertical linkage from the horizontal control lever.
6. Rotate and hold the horizontal control lever down at about 45 degrees to exhaust air from the air springs.
7. *If equipped with an integral dump port,* turn on the quick dump switch on the dash. Leave the switch on until testing is complete.

If not equipped with an integral dump port, disconnect the air lines from the air spring ports on the height-control valve. Leave the elbow fittings (if equipped) in place. Install a Parker plug into each air spring port (or elbow fitting); see **Fig. 3**.

8. If a flapper is present on the exhaust port of the height-control valve, remove it using needlenose pliers.
9. Clean the surface around the exhaust port, then install the test fitting into the exhaust port. The centering pin on the fitting must align with the slot on the exhaust port. Rotate the test fitting 45 degrees clockwise to lock it in place; see **Fig. 3**.

NOTE: It may be necessary to cut the tie straps that hold the chassis wiring running below the height-control valve, in order to access the exhaust port.

10. Connect one end of the air hose from the kit to the test connector on the exhaust port, and the other end to the test gauge.
11. Check the height-control valve in the fill mode, as follows.

    11.1 Rotate the valve control lever up 45 degrees from the horizontal to the fill position.

    11.2 Press the reset button on the test gauge.

    11.3 Observe the test gauge for 30 seconds. Refer to **Fig. 4** for the maximum allowable exhaust pressure change versus inlet pressure.

    The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

    If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

12. Check the height-control valve in the exhaust mode, as follows.

    12.1 Rotate the valve control lever down 45 degrees from the horizontal to the exhaust position.

    12.2 Press the reset button on the test gauge.

    12.3 Observe the test gauge for 30 seconds. Refer to **Fig. 4** for the maximum allowable exhaust pressure change versus inlet pressure.

    The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

    If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

13. Disconnect the test gauge and connector from the valve exhaust port.
14. If the height-control valve is defective, replace it; see "Height-Control Valve Replacement" below.
15. Install the flapper on the exhaust port by pressing it into place.
16. *For height-control valves with an integral dump port,* connect the vertical linkage to the height-control valve control lever. Turn off the quick dump switch on the dash. The ride height will automatically return to the correct position.

    For height-control valves without an integral dump port, remove the two Parker plugs from the air spring ports, and connect the air lines to the air spring ports (or elbow fittings). Connect the vertical linkage to the height-control valve control lever. The ride height will automatically return to the correct position.

Height-Control Valve Replacement

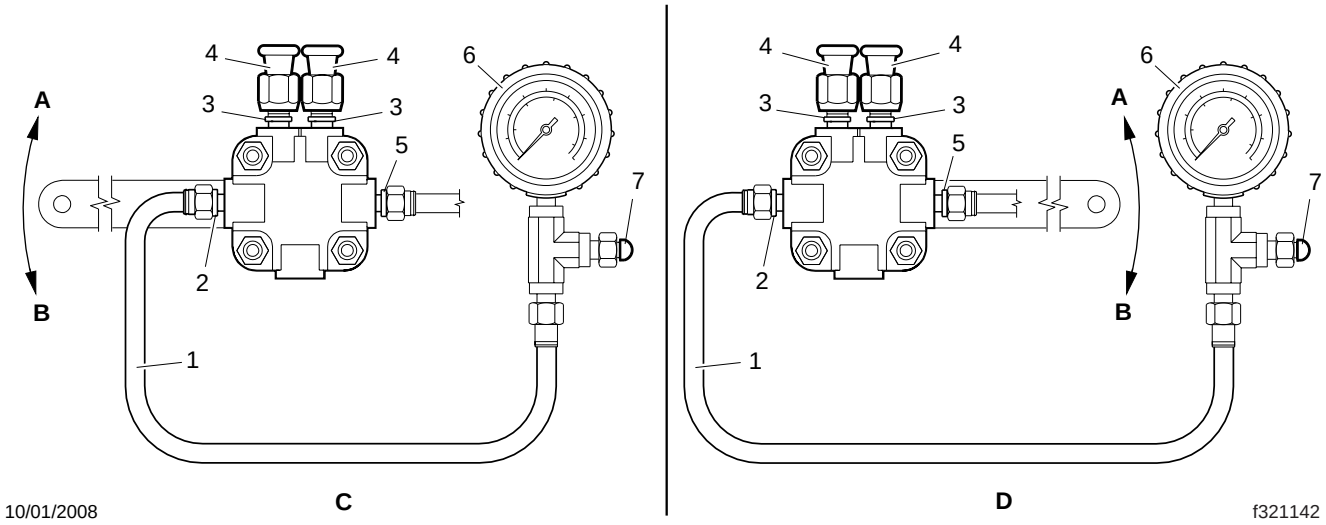
1. Apply the parking brakes and chock the tires.

⚠ WARNING

Keep your hands and all objects away from the area under and around the slack adjusters and suspension components when removing the pressure from the air system. These parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

2. Drain the air from the secondary air tank.

Height-Control Valve Test and Replacement



A. Fill
B. Exhaust
C. Left-Hand Valve
D. Right-Hand Valve

1. Air Line
2. Exhaust Port Test Fitting
3. Air Spring Port
4. Parker Plug
5. Air Intake Port
6. Test Gauge Assembly
7. Reset Button

Fig. 3, Test Connections

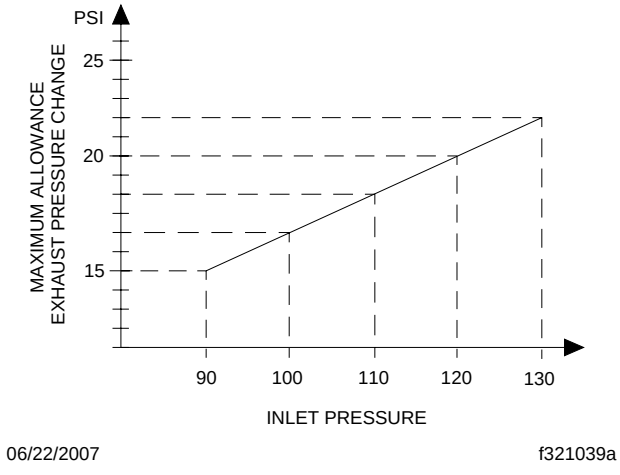


Fig. 4, Inlet Pressure vs. Exhaust Pressure Change in 30 Seconds

⚠ WARNING

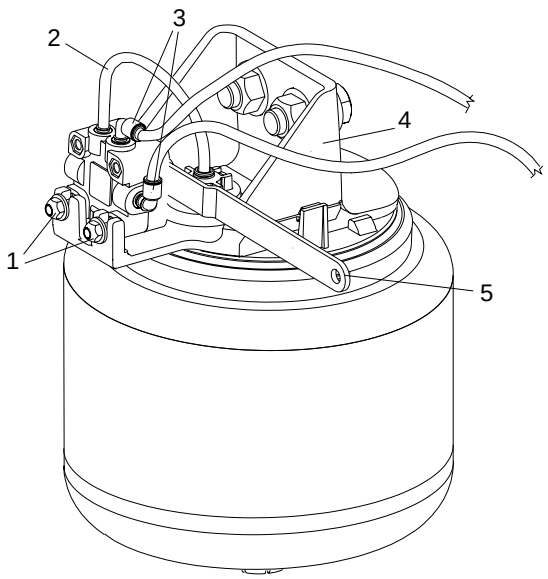
Air lines can whip dangerously if disconnected under pressure. Drain all air from the secondary air tank before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

3. Disconnect the vertical linkage, then lower the control lever to exhaust the air.
4. Remove the air lines from the height-control valve; see **Fig. 5**. Push in on the air line to release the tension, then push down on the collar and pull out the air line.

NOTICE

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

5. While holding the height-control valve mounting studs in place with an Allen wrench, remove the



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1. 1/4-Inch Locknuts
2. 1/4-Inch Nylon Air Line
3. Quick-Connect Fittings
4. Air-Spring Hanger Bracket
5. Horizontal Control Lever

Fig. 5, Height-Control-Valve Components

nuts and washers that attach the valve to the air-spring hanger bracket. Remove the height-control valve.

6. Position the new height-control valve on the hanger bracket, parallel to the flange. While holding the height-control mounting studs in place with an Allen wrench, install the nuts and washers. Do not tighten the locknuts to the specified torque until after the proper ride height is attained.

IMPORTANT: When replacing or installing nylon air lines on quick-connect fittings, it is critical that the end of the air line is cut square. An improper cut can cause the air line to seat improperly in the quick-connect fitting, allowing air leakage.

7. Install the air lines on the height-control valve.
8. Attach the vertical linkage to the horizontal control lever and the linkage mount.
9. Adjust the height-control valve to the proper specifications; see **Subject 100**.
10. While holding the height-control mounting studs in place with an Allen wrench, tighten the height-control valve mounting locknuts 95 lbf·in (1100 N·cm). Do not overtighten.

Shock Absorber Replacement

Removal

CAUTION

Anytime the front axle on an AIRTEK suspension is suspended, it is mandatory that the shock absorbers remain connected. The shock absorbers are the rebound travel stops for the springs. Failure to do so could cause the air springs to exceed their maximum length, causing the air springs to separate from the piston, or reverse arch the steel leaf springs. This could result in premature steel leaf spring failure.

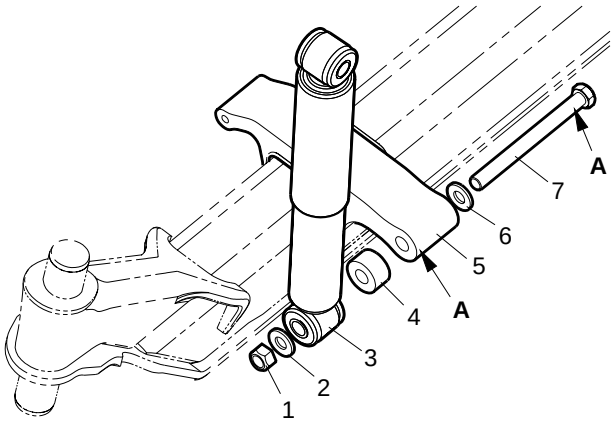
1. Set the parking brake, and shut down the engine. Chock the tires.

NOTE: It is not necessary to replace the shock absorbers in pairs if only one shock absorber requires replacement.

2. Remove the shock absorber lower mounting bolt, spacer, washers, and locknut.
3. Remove the shock absorber upper mounting bolt, washers, and locknut, then remove the shock absorber.
4. Inspect the shock absorber mounting brackets and hardware for damage or wear. Replace as necessary.

Installation

1. Place the shock absorber into the upper mounting bracket.
2. Install the shock absorber upper mounting bolt, washers, and locknut.
3. Apply a thin coating of antiseize compound to the shank of the shock absorber lower mounting bolt, the mating surfaces of the axle wrap and spacer, and the inside bore of the aluminum axle wrap. This is necessary to help prevent the bolt from seizing to the aluminum axle wrap. See **Fig. 1**.
4. Install the lower bolt from the inboard side of the axle wrap to the outboard side, then install the spacer, washers, and locknut.
5. Tighten both of the shock absorber mounting locknuts 225 to 255 lbf·ft (305 to 345 N·m).



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A, Apply a thin coating of antisieze compound to the shock absorber lower mounting bolt shank, the mating face of the axle wrap, the spacer, and to the inside bore of the aluminum top axle wrap.

1. 3/4-Inch Locknut
2. 3/4-Inch Washer
3. Shock Absorber
4. Spacer
5. Top Axle Wrap
6. 3/4-Inch Washer
7. 3/4–10 Bolt

Fig. 1, Shock Absorber Installation

Removal

1. Set the parking brake, and shut down the engine. Chock the tires.
2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure. Disconnect the air lines at the air springs.

⚠ WARNING

Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.

3. Raise the vehicle and support the frame with stands.
4. Separate the air spring from the upper air-spring bracket by applying downward pressure on the air spring, pushing outward on the lock tabs outside the bracket, and inward on the inlet lock tabs to dislodge the air spring from the upper air-spring bracket. See **Fig. 1**. See **Fig. 2** for lock tab locations.

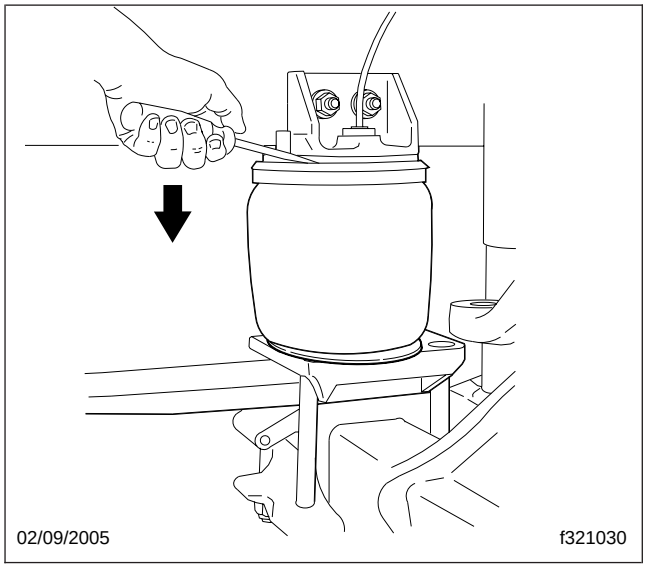
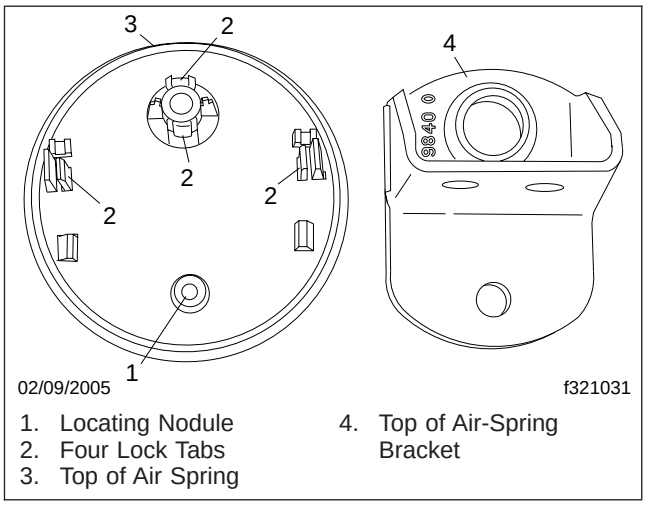


Fig. 1, Upper Air Spring Bracket

5. Apply upward pressure between the base of the air spring and the top-pad casting. This will dislodge the air spring from the top-pad casting. See **Fig. 3**.



1. Locating Nodule
2. Four Lock Tabs
3. Top of Air Spring
4. Top of Air-Spring Bracket

Fig. 2, Air Spring Mounting

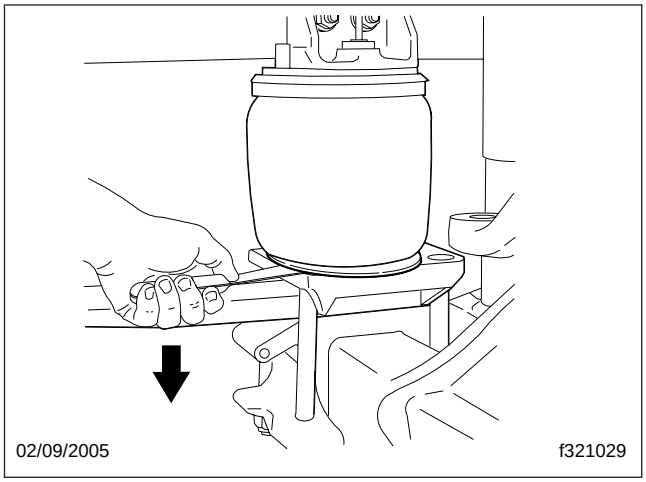


Fig. 3, Base of the Air Spring

6. Pull the air spring out from between the upper bracket and the top pad casting.

Installation

⚠ CAUTION

If the air spring will be re-installed, inspect the lock tabs for damage or cracks prior to installation. Damaged lock tabs may allow the air spring to become dislodged during operation, resulting in loss of vehicle control.

Air Spring Replacement

1. Insert the air spring into the top-pad casting. Make sure the lock tabs click in place.
2. Compress the air spring and slide it into position. Using the locating nodule, index the air spring position to the upper air-spring bracket.
3. Pull the air spring up into the upper air-spring bracket until the air spring snaps into place. Verify that all four lock tabs are engaged. See **Fig. 2**.

NOTE: When replacing or installing nylon air line tubing into quick-connect fittings, it is critical that the end of the air line is cut square. An improper cut can cause the air line to seat improperly in the quick-connect fitting, allowing air leakage.

4. Install the air lines on the air spring.
5. Inflate the air springs and check for leaks.
6. Lower the frame.
7. Charge the suspension system with air.

⚠ WARNING

Before charging the suspension system with air, make certain the air-spring locator is indexed into the upper air-spring bracket, the lock tabs are snapped into place, and that the air spring is fully seated. Failure to follow these instructions could result in premature air-spring failure, which could result in personal injury or property damage.

8. Check the ride height and adjust it if necessary. See **Subject 100** for instructions.
9. Remove the chocks.

Spring-Eye Bushing Replacement, and Spring-Eye Retorque

The spring-eye bushing for the front AirLiner suspension is designed for the life of the spring. If a premature failure occurs, careful consideration must be given to the contributing factor that made the bushing fail. This must be corrected in order to prevent the new bushing from failing in the same manner. It is recommended that in the event of a high-mileage bushing failure that the front leaf spring be replaced.

Spring-Eye Bushing Replacement

Remove the front spring, following the procedure in **Subject 150**. Once the leaf spring is removed from the chassis, it will be necessary to use:

- A hydraulic press with an operating capacity of a minimum of 10,000 lb (4500 kg).
- A receiving tool.
- A removal and installation driver.

⚠ WARNING

Do not use heat or a cutting torch to remove the bushing from the steel spring. The use of heat can adversely affect the strength of the spring. A component damaged in this manner can result in a loss of vehicle control, and possible personal injury or property damage.

1. Support the spring, and center the spring-end hub on the receiving tool. The leaf spring must be level to distribute the vertical-pushing load equally on the bushing.
2. Place the center of the bushing driver on the spring-eye bushing. See **Fig. 1**.
3. Pushing directly on the driver, press out the spring-eye bushing until it clears the spring-eye bore.
4. Inspect the spring eye for any cracks or burrs. If cracks are present, install a new leaf spring.
5. Remove any nicks or burrs with an emery cloth or a rotary sander.
6. Lubricate the inner diameter of the spring bore, and the new rubber bushing, with a vegetable-based oil (cooking oil). Do not use petroleum- or soap-based lubricant. They can cause an adverse reaction with the spring-eye material.

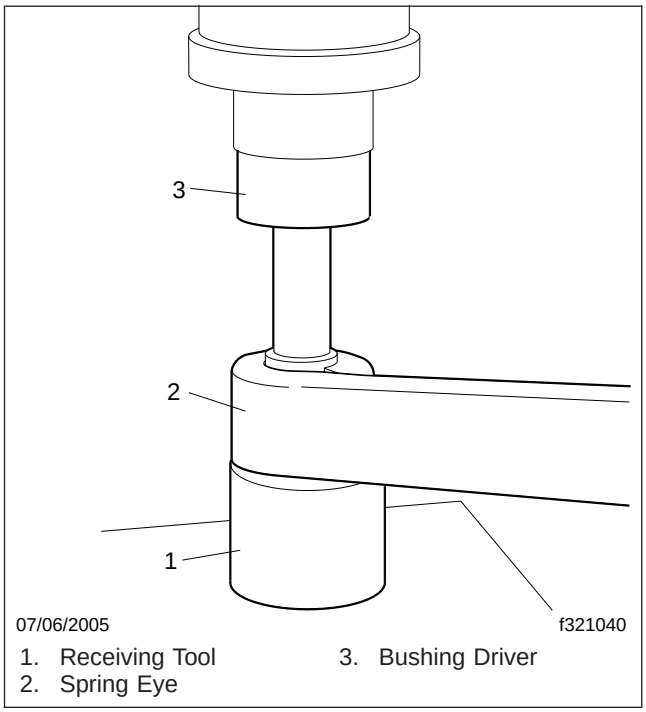


Fig. 1, Removing the Spring-Eye Bushing

7. Cut a strip of 3M Scotch® 890T black-fiber tape (duct tape or equivalent) 1-inch (25-mm) wide by 6-inches (150-mm) long.
8. Feed the tape into the spring eye, with the adhesive side facing the gap in the eye, to cover the sharp edge. Center the tape equally around each end.
9. Support the spring, and center it on the receiving tool.
10. Center the new bushing on the spring-eye bore, and line up the hydraulic press.
11. Press the bushing into the spring-eye bore, overshooting the desired final position by approximately 3/16 inch (5 mm). Press the bushing again from the opposite side, to center it in the spring-eye bore.
12. Once the bushing is installed, follow the instructions for the front leaf-spring installation in **Subject 150**.

Spring-Eye Bushing Replacement, and Spring-Eye Retorque

Spring-Eye Retorque

NOTE: This procedure is also necessary when replacing the front or rear hanger brackets, or the steel leaf spring.

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the tires.
2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure.

⚠ WARNING

Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.

IMPORTANT: Push-to-connect fittings are not serviceable. Clean dirt and debris away from the fittings to prevent foreign materials from entering the air system, or damaging the fittings. Clean the push-to-connect fittings using soapy water and a soft-bristled brush, then dry with compressed air.

3. Disconnect the air lines at the air springs.
4. Raise the vehicle and support the frame with stands.

⚠ WARNING

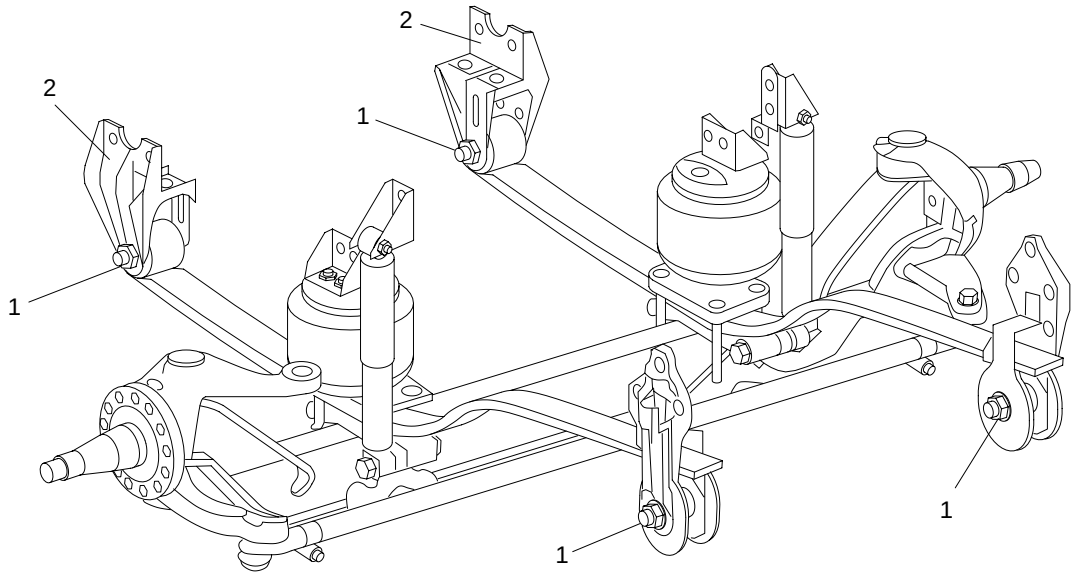
The shock absorbers must remain connected when the front axle is suspended. The shock absorbers are the rebound travel stops for the springs. Disconnecting the shock absorbers could cause the air springs to exceed their maximum length, causing the air springs to separate from the piston, or reverse arch the steel leaf springs, which may result in premature steel leaf spring failure.

5. Lower the front axle. Allow at least 3 inches (76 mm) of wheel clearance to the ground. The shock absorbers must be connected. DO NOT reverse arch the springs.
6. Loosen all four front and rear spring-eye bolts. See **Fig. 2**. The suspension may drop down slightly.

IMPORTANT: DO NOT remove the spring-eye bolts. The tires must not contact the ground.

7. Allow the suspension to settle.
8. Tighten the 3/4-inch locknuts on the front and rear spring-eye bolts 285 to 305 lbf·ft (385 to 415 N·m).
9. Raise the front axle and remove the frame stands.
10. Lower the vehicle.
11. Check the air springs to verify that they are seated properly, and install the air lines into the air springs.
12. Connect the height-control valve and charge the air system.
13. Affix a long straightedge to the bottom of the frame rails, in front of the air springs.
14. With the vehicle on a level surface, measure the distance from the top of the straightedge to the ground on both sides of the vehicle. Record the measurements.
15. Determine the difference from one side to the other. Remove the straightedge.
16. Perform a road test and repeat the previous three steps.
17. If the the difference in measurements is more than 3/8 inch (9.5 mm), contact Hendrickson Tech Services.

Spring-Eye Bushing Replacement, and Spring-Eye Retorque



1. Bolt
2. Front Leaf-Spring Hanger

Fig. 2, Front Spring Mounting

Removal

NOTE: When replacing both steel springs, use springs with the same camber designation. The camber designation of the new spring is located at the front of the top leaf and will be defined with a (+), (0), or a (–).

1. Park the vehicle on a level surface and shut down the engine. Chock the tires.
2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure.
3. Position a floor jack with a 4-inch lifting plate, below the axle, and raise the vehicle.
4. Remove the tires.
5. Position frame stands behind the rear spring mounts. It may be necessary to remove peripheral components for installation of the frame stands.
6. Lower the jack, allowing the axle to hang, but do not remove the jack from the axle.
7. Loosen both front spring-eye bolts, but do not remove the bolts.
8. Remove both rear spring-eye centerbolts.
9. Remove both lower shock absorber mounting bolts.

NOTE: To ease removal of the spring-eye bolts it may be necessary to raise or lower the axle.

10. Disconnect both air springs from the top pads of the clamp groups.
11. On the spring that is not being replaced, loosen the clamp group nylon locknuts.

⚠ WARNING

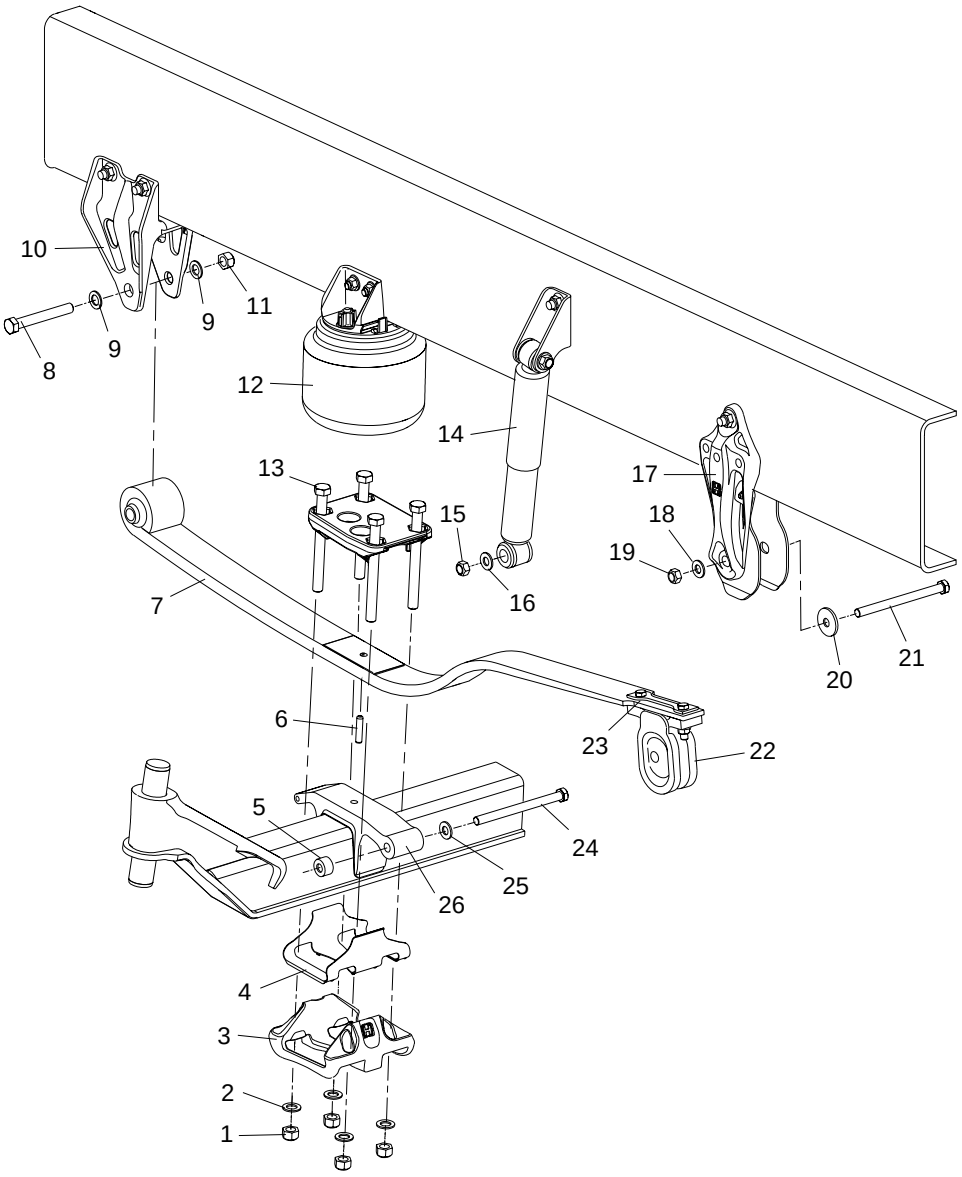
Do not use a cutting torch to remove clamp group bolts or attaching fasteners. The use of heat on suspension components can decrease the strength of these parts. A component damaged in this manner can result in a loss of vehicle control and possible personal injury or property damage.

12. Remove the 3/4-inch clamp group bolts, nuts, washers, top pad, galvanized liner, and the bottom axle wrap, from the spring that is going to be removed. See **Fig. 1**.
13. Lower the jack, allowing the suspension to pivot down and out of the rear hanger clamps.
14. Remove the front spring-eye bolt from the spring that is being removed, then remove the spring assembly.
15. Remove the thrustwashers from the rear spring-mount assembly. See **Fig. 1**.
16. Remove the 1/2-inch bolts, then remove the rear spring-mount assembly.
17. Inspect the thrustwashers, rear spring-mount bushing, rear-hanger clamp, top axle wrap, and the front and rear spring hangers. Replace them if worn, cracked, or damaged.

Installation

1. Lubricate the front spring-eye bushing and the front hanger with a vegetable-based oil (cooking oil). **DO NOT** use petroleum- or soap-based lubricants; they can cause an adverse reaction with the spring-eye-bushing material.
2. Install the spring over the axle, and into the front spring hanger.
3. Install the 5 1/2-inch long front spring-eye bolt, washers, and nut, but do not tighten.
4. Using the dowel pin located on the top axle wrap, engage the spring to the axle. It may be necessary to loosen the other clamp group to allow the axle to pivot when installing the spring on the dowel pin.
5. Install the top pad on top of the spring.
6. Install a new bottom axle wrap liner in the bottom axle wrap.
7. Install the bottom axle wrap.
8. Install new clamp group bolts, washers, and new nylon locknuts.
9. Snug the clamp group, but DO NOT torque at this time.
10. Raise the axle and the rear spring assemblies into the rear spring hangers.
11. Install the 5-inch long centerbolts in the rear hangers. The bolt must be installed from the in-

Leaf Spring Replacement



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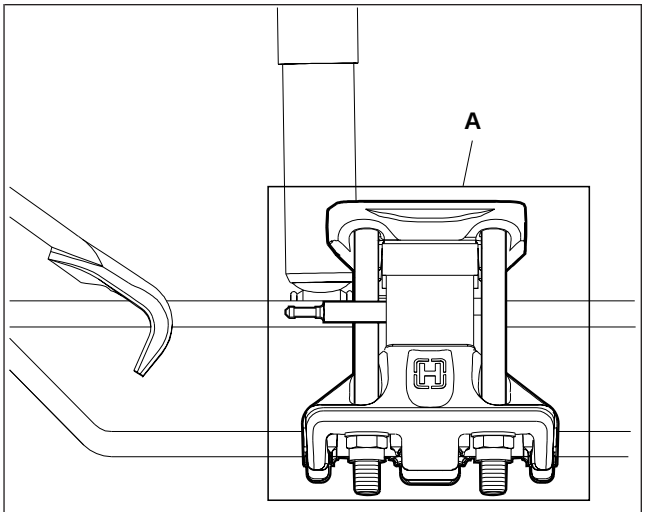
1. 3/4–10 Nylon Locknut
2. 3/4-Inch Flatwasher
3. Bottom Axle Wrap
4. Bottom Axle Wrap Liner
5. Shock Spacer
6. Dowel Pin
7. Leaf Spring
8. 3/4–10 x 5-1/2 Hexbolt
9. 3/4-Inch Flatwasher
10. Front Hanger
11. 3/4–10 Locknut
12. Air Spring
13. 3/4–10 Hexbolt
14. Shock Absorber
15. 3/4–10 Locknut
16. 3/4-Inch Hardened Washer
17. Rear Hanger
18. 3/4-Inch Flatwasher
19. 3/4–10 Locknut
20. 3/4-Inch Wide Washer
21. 3/4–10 x 5 Hexbolt
22. Thrustwasher
23. Rear Spring Mount
24. 3/4–10 x 7 Lower Shock Bolt
25. 3/4-Inch Hardened Washer
26. Top Axle Wrap

Fig. 1, Front AirLiner Spring Assembly

board side, to the outboard side. The 2-inch o.d. washer should be against the aluminum wrap on the inboard side. See **Fig. 1**.

IMPORTANT: Only the weight of the axle should be on the spring at the time of the spring eye tightening torque.

12. Tighten the lower shock mounting bolts to 225 to 255 lbf·ft (305 to 345 N·m).
13. Tighten the front and rear spring-eye 3/4-inch locknuts to 285 to 305 lbf·ft (385 to 415 N·m).
14. Install the tires.
15. Install the air springs into the top pads. Make sure the piston is correctly seated in the top pad.
16. Remove the frame supports and load the front axle with the vehicle weight.
17. Ensure that the clamp group is properly aligned, and the bottom axle wrap is centered on the top axle wrap. See **Fig. 2**. Ensure that the hexbolts are seated in the top-pad casting. See **Fig. 3**.



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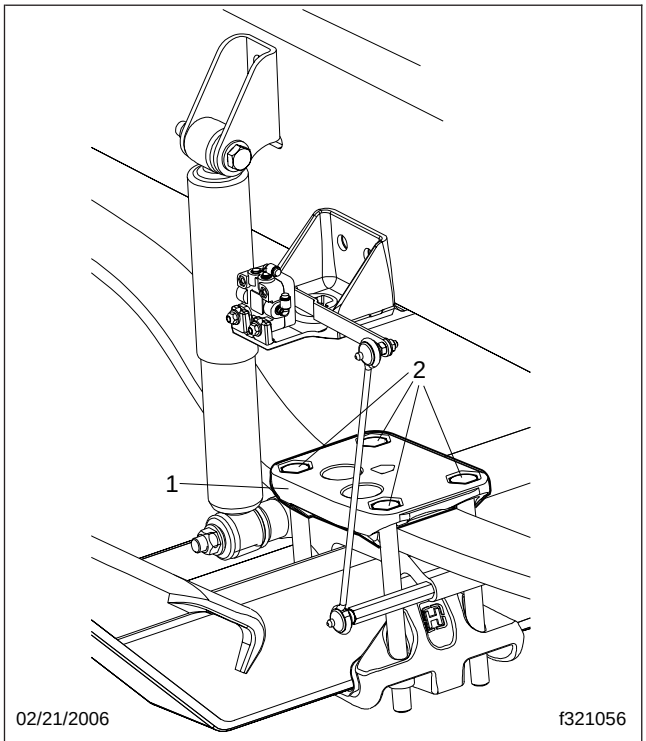
A Ensure the axle clamp group is properly aligned as shown.

Fig. 2, Axle Clamp Group

18. Tighten the clamp-group locknuts in sequence. See **Fig. 4**.

    18.1 Tighten the first diagonal to 100 lbf·ft (135 N·m).



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1. Top Pad 2. 3/4-Inch Bolts

Fig. 3, Top Pad Installation

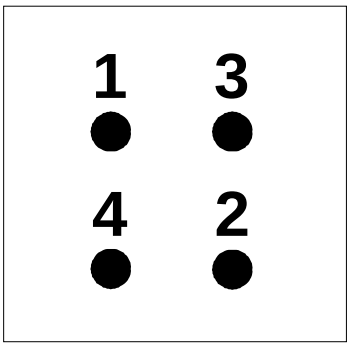

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Fig. 4, Clamp Group Locknut Tightening Sequence

    18.2 Tighten the second diagonal to 100 lbf·ft (135 N·m).

    18.3 Tighten the first diagonal to 270 to 330 lbf·ft (365 to 445 N·m).

    18.4 Tighten the second diagonal to 270 to 330 lbf·ft (365 to 445 N·m).

Leaf Spring Replacement

19. Raise the frame and remove the frame stands.
20. Lower the vehicle.
21. Inflate the air springs, then follow the instructions for ride height adjustment in **Subject 100**.

⚠ WARNING

Before charging the suspension system with air, make certain the air-spring locator is indexed into the upper air-spring bracket, the lock tabs are snapped into place, and that the air spring is fully seated. Failure to follow these instructions could result in premature air-spring failure, which could result in personal injury or property damage.

22. Remove the chocks from the tires.

Front Spring Hanger Replacement

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

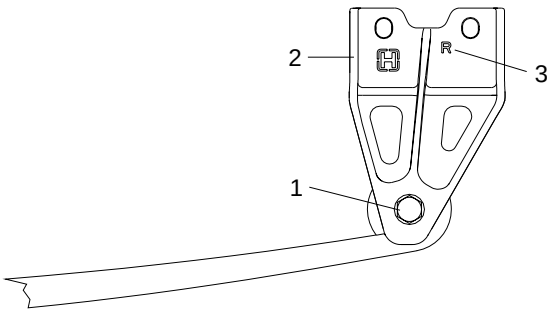
IMPORTANT: Push-to-connect fittings are not serviceable. Clean dirt and debris away from the fittings to prevent foreign materials from entering the air system, or damaging the fittings. Clean the push-to-connect fittings using soapy water and a soft-bristled brush, then dry with compressed air.

2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure. Disconnect the air lines at the air springs.

⚠ WARNING

Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.

3. Raise the vehicle and support the frame with stands.
4. Suspend the front axle from the shock absorbers.
5. Remove the front spring-eye bolt. See **Fig. 1**.



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1. Spring-Eye Bolt
2. Front Spring Hanger
3. Right or Left Hanger Designation

Fig. 1, Front Leaf Spring Hanger

NOTE: A bottle jack may be required to raise the axle slightly in order to remove the mounting bolt, then lower it until the spring eye is clear of the hanger.

6. Remove the frame fasteners, then remove the spring hanger.
7. Inspect the mounting surfaces on the frame for cracks or fretting.
8. Inspect the spring-eye bushing for damage or excessive wear. If damaged or worn excessively, replace the bushing. See **Subject 140** for replacement instructions.
9. Install the new hanger, flush with the bottom of the frame. Left or right hanger designation is stamped on the outboard surface of the hanger. See **Fig. 1**.
10. Install the 3/4 x 5-1/2 spring-eye bolt. Tighten the locknut 285 to 305 lbf·ft (385 to 415 N·m).

NOTE: A bottle jack may be required to raise the axle slightly to facilitate installation of the front spring-eye bolt.

11. Raise the vehicle and remove the jack stands or frame support, then lower the vehicle.
12. Inflate the air springs, then follow the instructions for ride height adjustment in **Subject 100**.

⚠ WARNING

Before charging the suspension system with air, make certain the air-spring locator is indexed into the upper air-spring bracket, the lock tabs are snapped into place, and that the air spring is fully seated. Failure to follow these instructions could result in premature air-spring failure, which could result in personal injury or property damage.

13. Remove the chocks.

Rear Spring Hanger Replacement

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

Front and Rear Spring Hanger Replacement

IMPORTANT: Push-to-connect fittings are not serviceable. Clean dirt and debris away from the fittings to prevent foreign materials from entering the air system, or damaging the fittings. Clean the push-to-connect fittings using soapy water and a soft-bristled brush, then dry with compressed air.

2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure. Disconnect the air lines at the air springs.

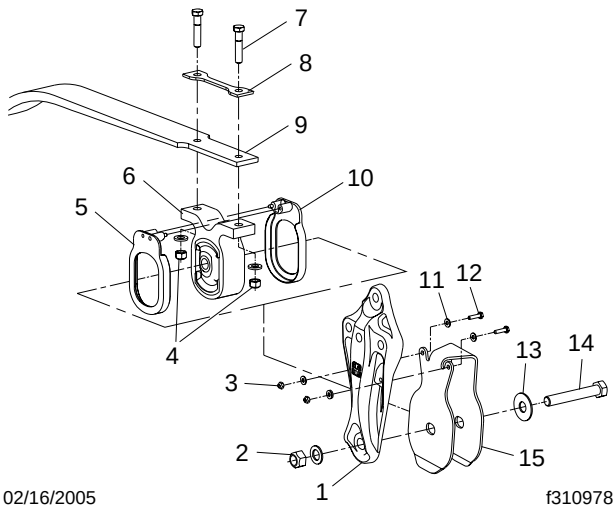
⚠ WARNING

Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.

3. Raise the vehicle and support the frame with stands.
4. Suspend the front axle from the shock absorbers.
5. Remove the rear hanger centerbolt.

NOTE: A bottle jack may be required to raise the axle slightly to facilitate removal of the rear hanger centerbolt.

6. Remove the two 1/4 x 1-1/4 hexbolts, washers, and the locknut, that attach the rear hanger to the hanger clamp.
7. Remove the frame fasteners, then remove the spring hanger. See **Fig. 2**.
8. Remove the clamp from the rear spring mount.
9. Remove the two thrustwashers.
10. Inspect the rear spring mount, rear hanger clamp, and both thrustwashers for excessive wear or damage. Replace if necessary.
11. Install the thrustwashers on the rear spring mount.
12. Slide the rear hanger clamp over the rear spring mount.
13. Using new fasteners, install the rear spring hanger on the frame.



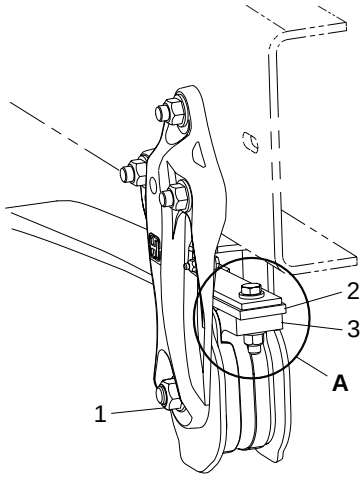
1. Rear Spring Hanger
2. 3/4-Inch Locknut
3. 1/4-Inch Locknut
4. 1/2-Inch Locknut
5. Thrustwasher
6. Rear Spring Mount
7. 1/2-Inch Hexbolt
8. Spring End Plate
9. Leaf Spring Taper
10. Thrustwasher
11. 1/4-Inch Washer
12. 1/4-Inch Bolt
13. 2-Inch o.d. Washer
14. 3/4-Inch Hexbolt (installed from the inboard side)
15. Rear Hanger Clamp

Fig. 2, Rear Spring Mount Assembly

14. Install the two 1/4 x 1-1/4 bolts, washers, and nuts, through the rear hanger, and rear hanger clamp assembly. Tighten the locknuts 84 to 120 lbf·in (950 to 1350 N·cm).
15. Place the 2-inch o.d. washer against the inboard side of the rear hanger clamp. Install the 3/4 x 5 centerbolt, through the center of the spring hanger from the inboard side towards the outboard side.

NOTE: A bottle jack may be required to raise the axle slightly to facilitate installation of the rear hanger centerbolt.

16. Install the washer and locknut. Tighten the locknut to 285 to 305 lbf·ft (385 to 415 N·m). See **Fig. 3**.
17. Raise the vehicle and remove the jack stands or frame support.
18. Lower the vehicle.



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A. Verify that the rear spring mount is centered on the leaf spring taper.

1. 3/4-Inch Locknut
2. Leaf Spring Taper
3. Rear Spring Mount

Fig. 3, Rear Spring Hanger Installation

19. Inflate the air springs, then follow the instructions for ride height adjustment in **Subject 100**.

⚠ WARNING

Before charging the suspension system with air, make certain the air-spring locator is indexed into the upper air-spring bracket, the lock tabs are snapped into place, and that the air spring is fully seated. Failure to follow these instructions could result in premature air-spring failure, which could result in personal injury or property damage.

20. Remove the chocks.

Thrustwasher and Rear Hanger Clamp Removal and Installation

Removal

1. Set the parking brake, and shut down the engine. Chock the tires.

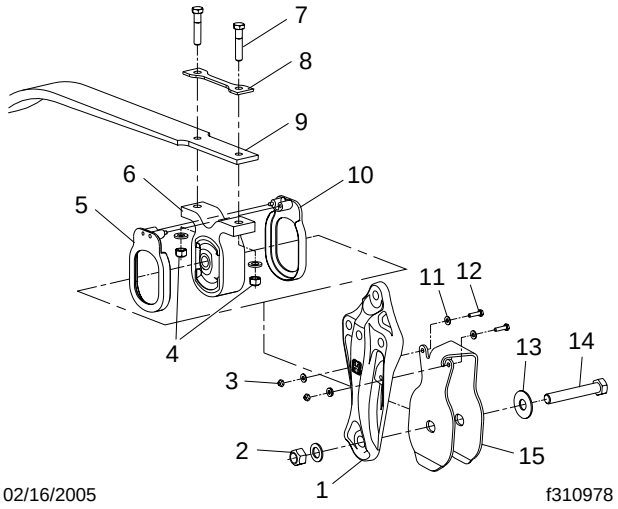
IMPORTANT: Push-to-connect fittings are not serviceable. Clean dirt and debris away from the fittings to prevent foreign materials from entering the air system, or damaging the fittings. Clean the push-to-connect fittings using soapy water and a soft-bristled brush, then dry with compressed air.

2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure. Disconnect the air lines at the air springs.

⚠ WARNING

Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.

3. Raise the vehicle and support the frame with stands.
4. Suspend the front axle, ensuring there is enough clearance to allow the rear spring mount to clear the bottom of the spring hanger.
5. Loosen, but do not remove the front spring-eye bolt.
6. Support the axle with a floor jack.
7. Remove the rear hanger centerbolt.
8. Remove the lower shock bolt.
9. Lower the jack until the rear spring mount is below the spring hanger.
10. Remove the 1/4 x 1-1/4 rear hanger clamp bolt, and remove the rear hanger clamp.
11. Remove the two thrustwashers from the rear spring mount. See **Fig. 1**.
12. Inspect the spring mount for torn rubber, a worn metal sleeve, or a cracked housing. If any of these conditions exist, replace the spring mount.



1. Rear Spring Hanger
2. 3/4-Inch Locknut
3. 1/4-Inch Locknut
4. 1/2-Inch Locknut
5. Thrustwasher
6. Rear Spring Mount
7. 1/2-Inch Hexbolt
8. Spring-End Plate
9. Leaf-Spring Taper
10. Thrustwasher
11. 1/4-Inch Washer
12. 1/4-Inch Bolt
13. 2-Inch o.d. Washer
14. 3/4-Inch Hexbolt (Centerbolt installed from inboard side)
15. Rear-Hanger Clamp

Fig. 1, Rear Spring Mount Assembly

Installation

1. Install the two 1/4 x 1 bolts, washers, and nuts, through the rear hanger, and rear hanger clamp assembly. Tighten the 1/4-inch locknuts 84 to 120 lbf·in (950 to 1350 N·cm).
2. Install two new thrustwashers onto the rear spring mount.
3. Raise the axle to install the rear spring mounts into the rear hanger clamps.
4. Install the 3/4 x 5 rear centerbolt, from the inboard side towards the outboard side. Place the 2-inch o.d. washer against the inboard side of the rear-hanger clamp.
5. Apply a thin coat of antiseize to the lower shock bolt.
6. Install the lower shock bolt, from the inboard side towards the outboard side. Tighten the shock bolt 225 to 255 lbf·ft (305 to 345 N·m).

Thrustwasher and Rear Hanger Clamp Removal and Installation

7. Remove the jack and let the suspension hang.
8. Tighten the front spring-eye bolt and rear center-bolt to 285 to 305 lbf·ft (385 to 415 N·m).
9. Raise the frame and remove the frame stands.
10. Lower the vehicle.
11. Inflate the air springs, then follow the instructions for ride height adjustment in **Subject 100**.

⚠ WARNING

Before charging the suspension system with air, make certain the air-spring locator is indexed into the upper air-spring bracket, the lock tabs are snapped into place, and that the air spring is fully seated. Failure to follow these instructions could result in premature air-spring failure, which could result in personal injury or property damage.

12. Remove the chocks from the tires.

Bottom Axle Wrap

Removal

1. Park the vehicle and chock the tires.
2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure.

⚠ WARNING

Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.

3. Raise the vehicle and support the frame with frame stands.
4. Remove the air spring from the side that is being worked on. For instructions, see **Subject 130**.
5. Remove the 3/4-inch hexbolts and the nylon locknuts that fasten the axle wrap to the axle. See **Fig. 1**.

⚠ WARNING

Do not use a cutting torch to remove clamp group bolts or attaching fasteners. The use of heat on suspension components can decrease the strength of these parts. A component damaged in this manner can result in a loss of vehicle control and possible personal injury or property damage.

6. Remove the bottom axle wrap. It may be necessary to use a deadblow mallet to dislodge the axle wrap.
7. Inspect the axle wrap, and replace if necessary.
8. Discard the used bottom axle wrap liner.

Installation

1. Install a new liner into the bottom axle wrap.
2. Using new 3/4-inch hexbolts and grade 8 nylon locknuts, install the bottom axle wrap on the axle. Ensure that the clamp group is aligned, the bottom axle wrap is centered on the top axle wrap, and the hexbolts are seated in the top-pad casting.
3. Tighten the clamp-group locknuts in sequence. See **Fig. 2**.
   - 3.1 Tighten the first diagonal to 100 lbf·ft (135 N·m).
   - 3.2 Tighten the second diagonal to 100 lbf·ft (135 N·m).
   - 3.3 Tighten the first diagonal to 270 to 330 lbf·ft (365 to 445 N·m).
   - 3.4 Tighten the second diagonal to 270 to 330 lbf·ft (365 to 445 N·m).
4. Following the instructions in **Subject 130**, install the air spring that was removed.

Top Axle Wrap

Removal

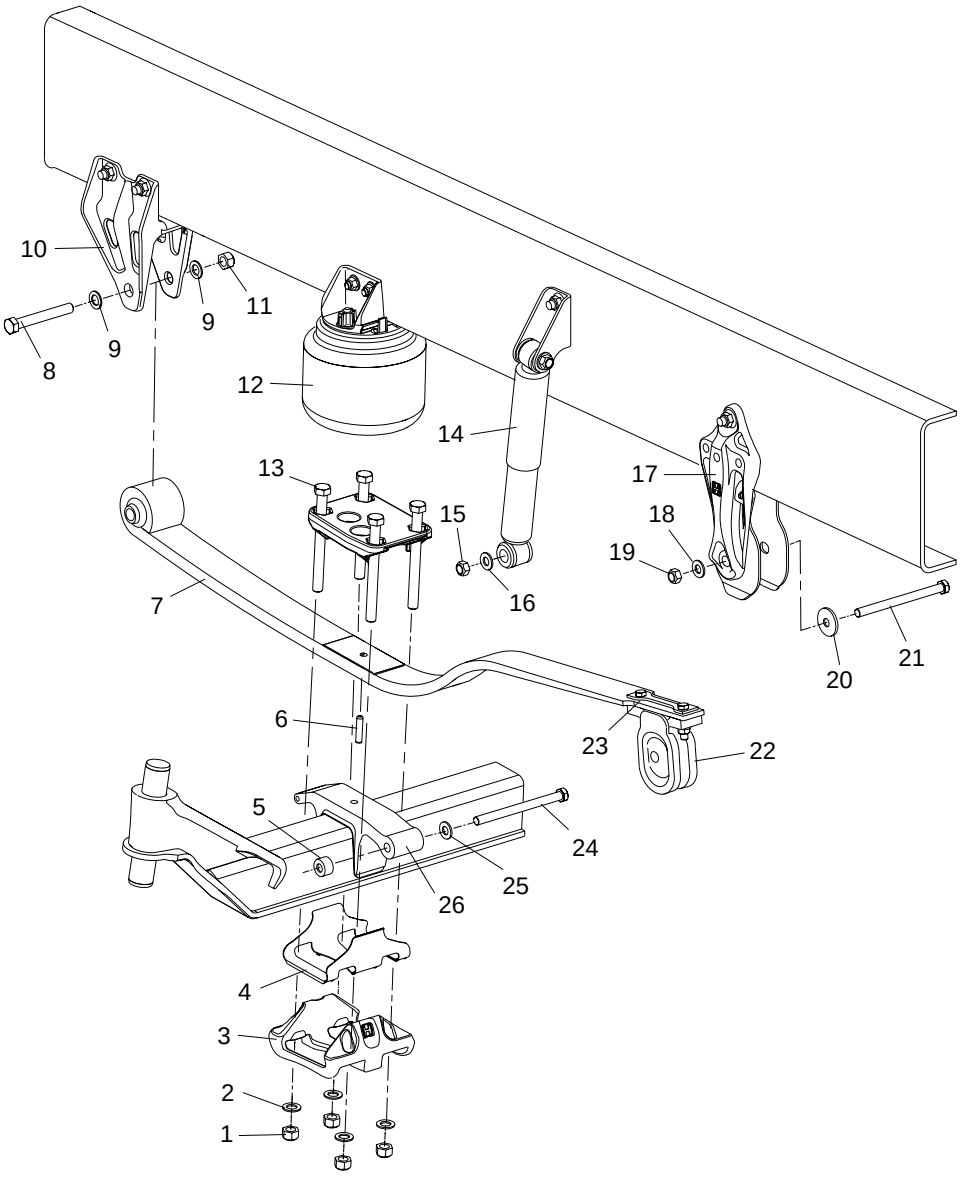
1. Park the vehicle and chock the tires.
2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure. Disconnect the air lines at the air springs.

⚠ WARNING

Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.

3. Raise the vehicle and support the frame with frame stands.
4. Remove the front tires.
5. Lower the floor jack and suspend the front axle to remove the load from the leaf springs.
6. Remove the air spring from the side that is being worked on. For instructions, see **Subject 130**.
7. Position a floor jack, that has a four-inch lifting plate, under the center of the axle.
8. Secure the axle on the jack to prevent the axle from rolling off the floor jack.
9. Remove the 3/4-inch hexbolts and the nylon locknuts that fasten the axle wrap to the axle.

Axle Wrap Removal and Installation



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1. 3/4–10 Nylon Locknut
2. 3/4-Inch Flatwasher
3. Bottom Axle Wrap
4. Bottom Axle Wrap Liner
5. Shock Spacer
6. Dowel Pin
7. Leaf Spring
8. 3/4–10 x 5-1/2 Hexbolt
9. 3/4-Inch Flatwasher
10. Front Hanger
11. 3/4–10 Locknut
12. Air Spring
13. 3/4–10 Hexbolt
14. Shock Absorber
15. 3/4–10 Locknut
16. 3/4-Inch Hardened Washer
17. Rear Hanger
18. 3/4-Inch Flatwasher
19. 3/4–10 Locknut
20. 3/4-Inch Wide Washer
21. 3/4–10 x 5 Hexbolt
22. Thrustwasher
23. Rear Spring Mount
24. 3/4–10 x 7 Lower Shock Bolt
25. 3/4-Inch Hardened Washer
26. Top Axle Wrap

Fig. 1, Front AirLiner Spring Assembly

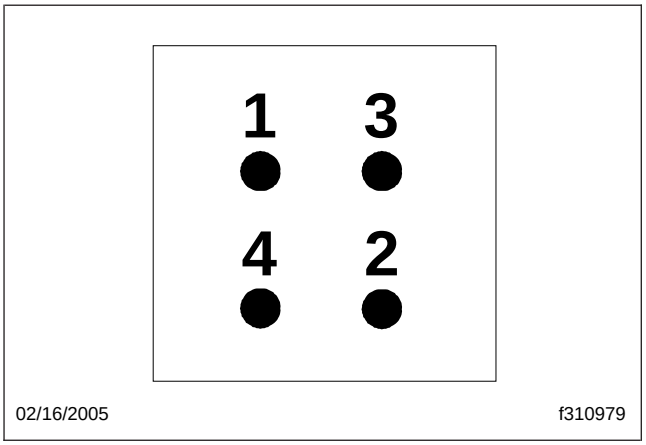


Fig. 2, Clamp Group Locknut Tightening Sequence

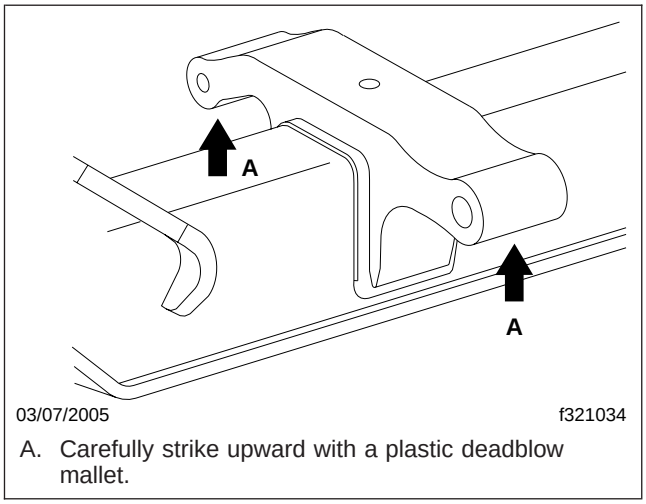
⚠ WARNING

Do not use a cutting torch to remove clamp group bolts or attaching fasteners. The use of heat on suspension components can decrease the strength of these parts. A component damaged in this manner can result in a loss of vehicle control and possible personal injury or property damage.

10. Remove the top spring pad casting, the bottom axle wrap, and the liner.
11. Remove the lower shock-mounting bolts.
12. Using the floor jack, lower the axle away from the leaf springs.
13. Remove the dowel pin, alignment shim, and spacer (if equipped).
14. Strike the axle wrap with a plastic deadblow mallet at the front and rear on the underside of the axle wrap, to dislodge it from the axle. See **Fig. 3**.
15. Clean the axle wrap and axle, then inspect for cracks or damage. Replace if cracks or damage are visible.

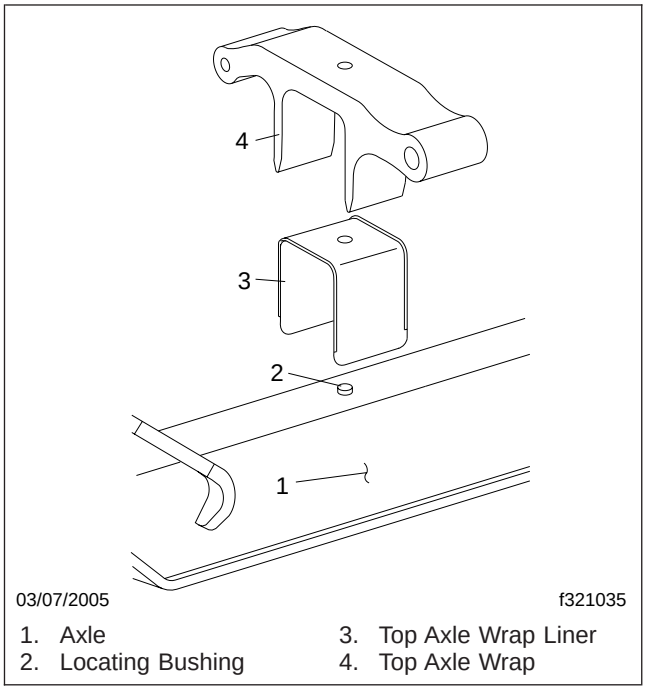
Installation

1. Install a new axle wrap liner on the axle. See **Fig. 4**.
2. Spray the axle wrap liner and the axle wrap with a silicon lubricant.



A. Carefully strike upward with a plastic deadblow mallet.

Fig. 3, Top Axle Wrap Removal



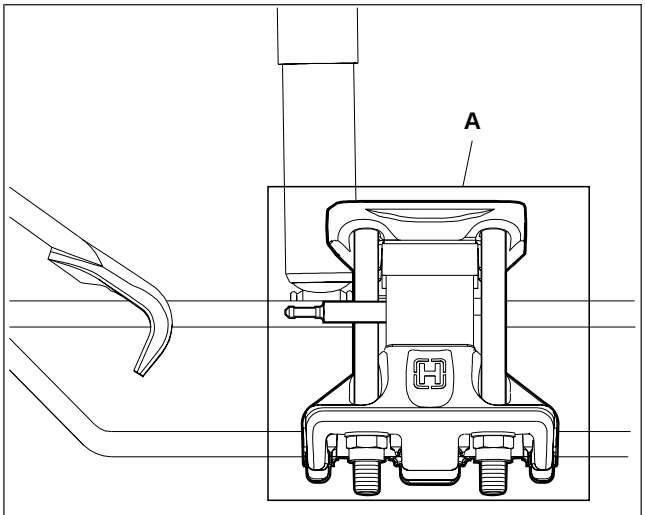
1. Axle
2. Locating Bushing
3. Top Axle Wrap Liner
4. Top Axle Wrap

Fig. 4, Top Axle Wrap Installation

3. Position the axle wrap on the axle.
4. Protect the top surface of the axle wrap with a block of wood, cardboard, or shop towels.
5. Using a deadblow mallet, drive the axle wrap onto the axle, indexing the locating bushing until the axle wrap is firmly seated on the axle.

Axle Wrap Removal and Installation

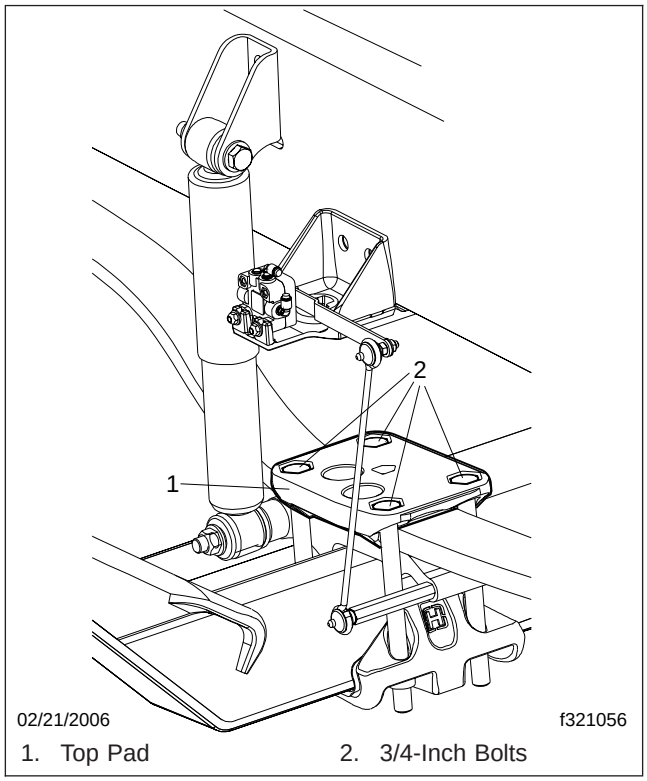
6. Install the dowel pin(s) into the axle wrap.
7. Install the alignment shims and spacer (if equipped).
8. Raise the axle assembly with a jack, and engage the dowel pins in the leaf spring bore.
9. Install the top pad with the arrows facing inboard on the leaf spring.
10. Install new clamp group hexbolts into the top pad.
11. Remove the old bottom axle-wrap liner, and install a new one.
12. Install the bottom axle wrap.
13. Install new clamp group washers and nylon locknuts (Grade 8).
14. Ensure that the clamp group is properly aligned and the hexbolts are seated in the top pad, and the bottom axle wrap is centered on the top axle wrap. See **Fig. 5** and **Fig. 6**.



A Ensure the axle clamp group is properly aligned as shown.

Fig. 5, Axle Clamp Group

15. Tighten the clamp-group locknuts in sequence. See **Fig. 2**.
    - 15.1 Tighten the first diagonal 100 lbf·ft (135 N·m).
    - 15.2 Tighten the second diagonal 100 lbf·ft (135 N·m).
    - 15.3 Tighten the first diagonal 270 to 330 lbf·ft (365 to 445 N·m).
    - 15.4 Tighten the second diagonal 270 to 330 lbf·ft (365 to 445 N·m).
16. Apply a thin coating of antiseize to the lower shock mounting bolt.
17. Install the lower shock bolt from the inboard side to the outboard side of the top axle wrap and attach the spacer, washer, and locknut.
18. Tighten the shock eye locknuts 225 to 255 lbf·ft (305 to 345 N·m).
19. Install the tires.
20. Install the air springs, following the instructions in **Subject 130**.



1. Top Pad 2. 3/4-Inch Bolts

Fig. 6, Top Pad Installation

Torque Specifications

For fastener torque values, see **Table 1**.

Front AirLiner (AIRTEK) Suspension Fastener Torque Values		
Fastener Application	**Torque**	
	lbf·ft (N·m)	**lbf·in (N·cm)**
Front Frame Hanger to Frame	160–180 (215–245)	—
Front Spring Eye	285–305 (385–415)	—
Rear Hanger to Rear Hanger Clamp	—	84–120 (950–1350)
Rear Spring Hanger to Rear Spring Mount	285–305 (385–415)	—
Rear Spring Mount to Leaf Spring	80–110 (110–150)	—
Upper Air-Spring Bracket	160–180 (215–245)	—
Height-Control Valve to Air-Spring Bracket Locknuts*	—	95 (1100)
Barksdale Height-Control Valve Housing Capscrews*	—	45 (500)
Clamp-Group Hardware	285–305 (385–415)	—
Shock-Absorber Eye Bolt	225–255 (305–345)	—
Shock Bracket to Frame	160–180 (215–245)	—

* See the cautionary statements below.

Table 1, Front AirLiner (AIRTEK) Suspension Fastener Torque Values

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

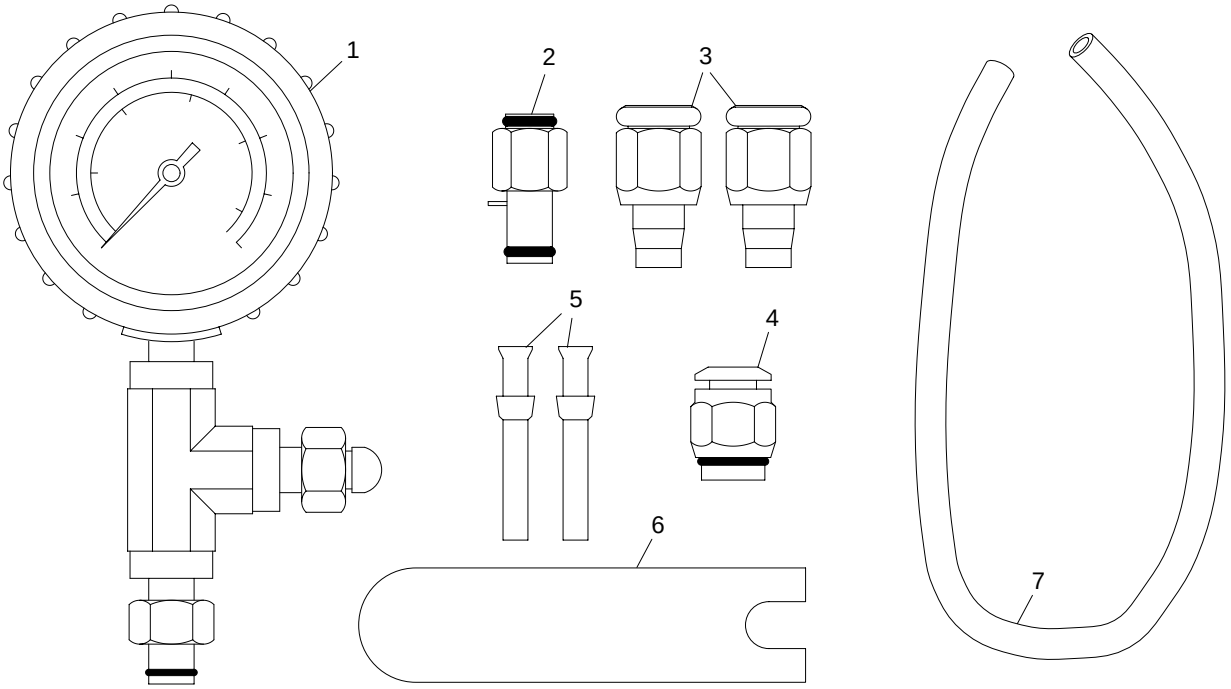
NOTICE

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.

Special Tools

Use the kit shown in **Fig. 1** to test a Barksdale height-control valve. Test kit BKS KD2264 is available via the Direct Ship program in Paragon.

Specifications



NOTE: Parts for cab suspension valve testing included.

1. Test Gauge Assembly with Reset Button
2. Exhaust Port Test Connector for Cab Suspension Valve (used for cab suspension valve testing)
3. Parker Plugs
4. Exhaust Port Test Connector for Chassis Suspension Valve
5. Test Plugs for Cab Suspension Valve (used for cab suspension valve testing)
6. Special Tool for Disconnecting Air Line
7. Air Line

Fig. 1, Barksdale Height-Control Valve Test Kit BKS KD2264

General Information

When repairing the front axle, wheel hubs or suspension, replace any component that is damaged or out of specification. All major axle and suspension components are heat-treated and, therefore, cannot be bent, twisted, welded, heated or reconditioned without experiencing a strength or fatigue life reduction.

Following are examples of specific prohibited operations:

- hot or cold bending or twisting of I-beam, tie rod assemblies, spindles, steering arms or tie rod arms for any reason
- welding of, or to, steering arms, tie rod arms, I-beams, steering spindles, spindle pins or tie rod assemblies
- redrilling or reboring of I-beam spindle pin holes for a bushing
- milling or machining of any component
- spray welding of bearing diameters or other machined surfaces
- redrilling or reboring of draw keyholes
- relocation or removal of tie rod clamps

Wheel Alignment Angles

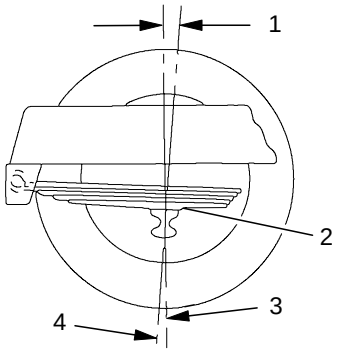
CASTER (See Fig. 1)

Caster is the amount in degrees that the top of the spindle pin is inclined toward the front or rear of the vehicle as viewed from the side of the vehicle. The caster angle can range from a positive angle to a negative angle.

Positive caster is the tilting of the top of the spindle pin toward the rear of the vehicle, while negative or reverse caster is the tilting of the spindle pin toward the front of the vehicle.

The correct amount of caster helps to keep the front wheels in the straight-ahead position. When in a turn, caster acts as a lever, assisting the driver to return the front wheels to the straight-ahead position.

Caster specifications are based on vehicle design load (no payload), which will usually result in a level frame. Because of this, raising (or lowering) the rear without changing front ride height will subsequently decrease (or increase) the caster angle by the same amount the frame angle changes. If the frame is not level when alignment checks are made, this must be considered in determining whether the caster setting is correct.



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1. Caster Angle
2. Tapered Wedge
3. Vertical Line
4. Centerline of Spindle Pin

Fig. 1, Caster Angle

CAMBER (See Fig. 2)

Camber is the amount in degrees that the wheel inclines away from the vertical at the top, as viewed from the front of the vehicle. Positive camber is an outward tilt or inclination of the wheel at the top. Negative or reverse camber is an inward tilt of the wheel at the top.

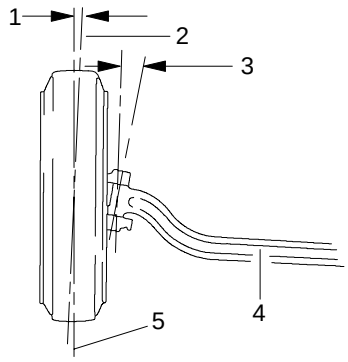
The amount of camber used depends on the amount in degrees the spindle pin is inclined. An incorrect camber angle causes the side of the tread to wear, resulting in reduced tire life.

Unequal camber in the front wheels may cause the vehicle to lead to the right or left on a level road. The vehicle will lead to the side that has the most positive camber.

Spindle pin inclination working together with the camber angle puts the approximate center of the tire tread in contact with the road. Spindle pin inclination reduces steering effort and improves the directional stability of the vehicle.

There is no means of adjusting this angle; therefore, it will not change unless the front axle has been

General Information



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1. Camber Angle
2. Vertical Angle
3. Spindle Pin Inclination
4. Level of Spring Pad
5. Centerline of Tire

Fig. 2, Camber Angles

bent. Corrections or changes to this angle are accomplished by replacement of broken, bent or worn parts.

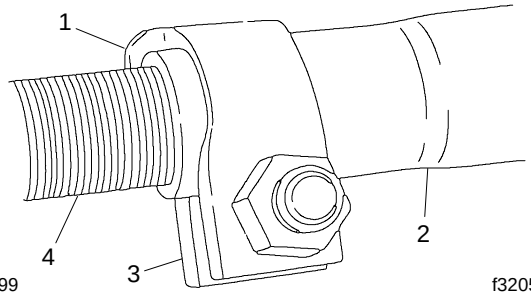
TOE-IN

Toe-in is the amount in millimeters (or fractions of an inch) that the front wheels are closer together at the front than at the back as viewed from the top of the vehicle. With camber on the front wheels, the left front wheel tries to steer to the left and the right front wheel tries to steer to the right. This is due to the tendency of a wheel to turn in the same direction it leans. To overcome this condition, the wheels are given a certain amount of toe-in by an adjustment at the tie rod ends. See **Fig. 3**.

Do not adjust toe-in until the other factors of front wheel alignment are known to be within specifications.

LOAD EFFECT

Front end alignment settings change between loaded-vehicle and unloaded-vehicle conditions. The amount of this change will depend on vehicle suspension design, as well as the actual amount of load on the front axle.



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1. Clamp Tab
2. Front Wheel Spindle Tie Rod
3. Tie Rod Clamp
4. Tie Rod End

Fig. 3, Tie Rod End

Preliminary Checks

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. Refer to **Group 40** of this manual and Group 40 of the *Sterling L-Line and A-Line Maintenance Manual* for more information. Replace any tire that is excessively worn.
3. Check the inflation pressure of the tires. Refer to **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. 1**.

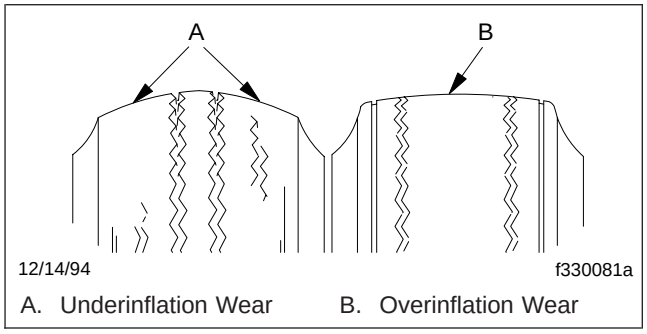


Fig. 1, Tire Damage Due to Underinflated or Overinflated Tires

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** of this manual.
6. Inspect the front axle beam (also called the axle center) for bends or twists. If the axle beam is bent or twisted over one-half 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** of this manual.
8. Check the steering angle and adjust the axle steering stops as needed. See **Subject 110**.

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.

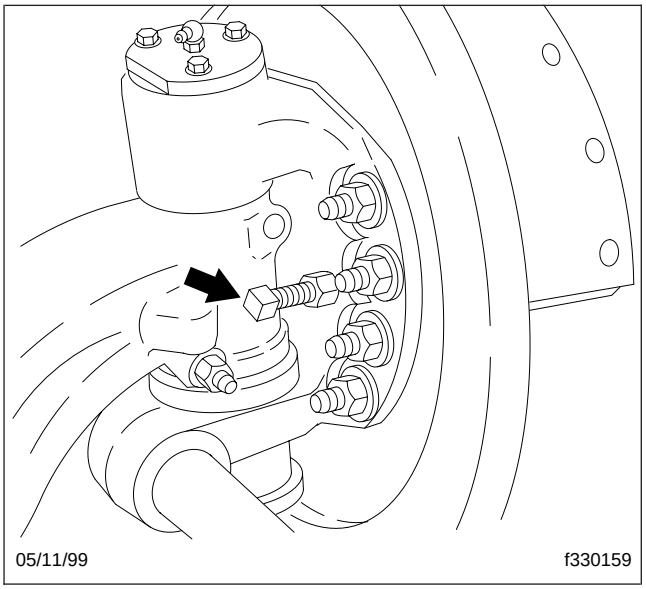


Fig. 1, Stopscrew-and-Locknut-Type Axle Stop

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. Sterling 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 section in this manual. 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.

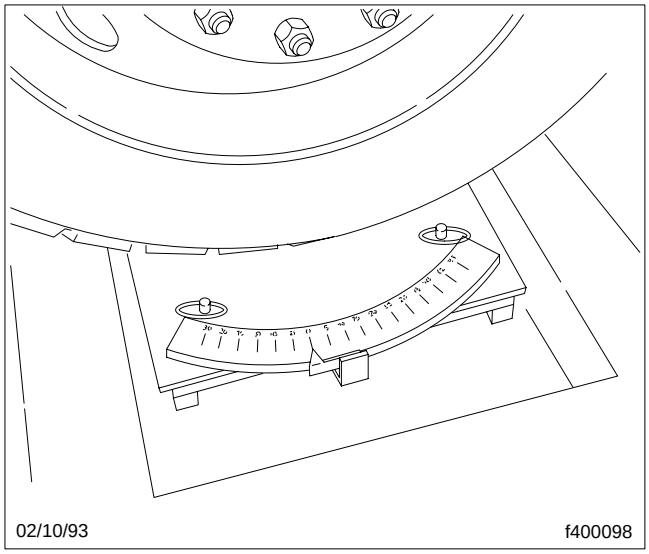


Fig. 2, Stationary Turn-Plate (Turntable)

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.

   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 under **Specifications, 400**.

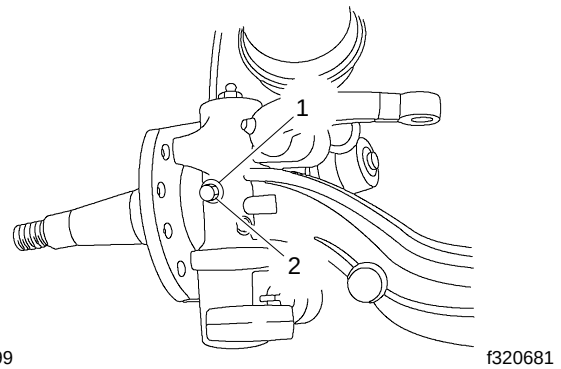
Steering Angle Checking and Adjusting

5. Repeat the step above with the steering wheel turned counterclockwise. Adjust the axle stop, as needed.
6. If equipped with power steering, adjust the steering gear so that pressure is released ahead of the axle stop. This will prevent possible damage to the steering or axle components. For poppet valve adjustment instructions, refer to **Group 46** in this manual.
7. Drive the vehicle off or remove the turn-plates (turntables). Lower the vehicle.

Wheel Spindle Removal and Installation

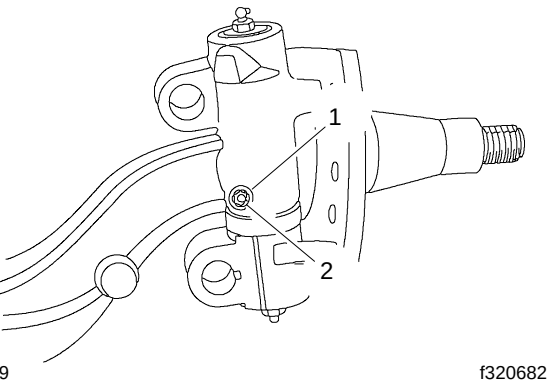
Removal

1. Remove the hub and drum assembly. For instructions, see **Section 33.01** of this manual.
2. Remove the brake assembly. For instructions, see **Group 42** of this manual.
3. Disconnect the drag link from the steering spindle arm. Disconnect the connecting rod from the steering arm. For instructions, see **Group 46** of this manual.
4. Remove the spindle arms. For instructions, see **Group 46** of this manual.
5. Remove the lock pins. See **Fig. 1** and **Fig. 2**.



1. Lock Pin Nut
2. Lock Pin

Fig. 1, Upper Lock Pin



1. Lock Pin Nut
2. Lock Pin

Fig. 2, Lower Lock Pin

5.1 Remove the nut from the upper and lower lock pins.

5.2 Remove the upper and lower lock pins.

- Using a brass drift and hammer, strike the threaded end of the pin.
- Note the direction of the threaded ends before removing the lock pins.

6. Remove the upper and lower spindle caps. See **Fig. 3**.

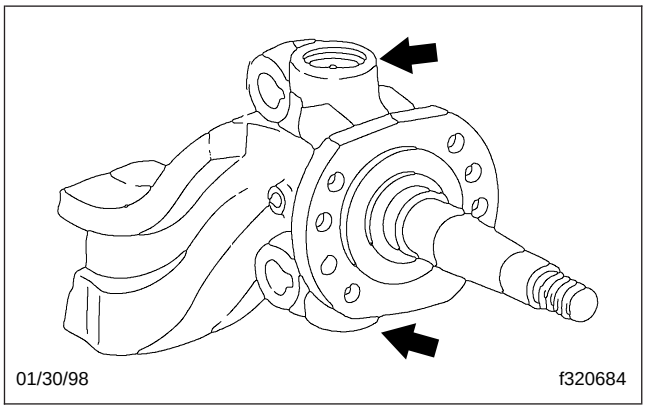


Fig. 3, Upper and Lower Spindle Caps

7. Drive out the spindle pin from the top of the axle. See **Fig. 4**.
8. Remove the spindle assembly, shim, pin seals and thrust bearing from the axle. See **Fig. 5**.

Installation

NOTE: The thrust bearing must be installed with the retainer lip facing down.

1. Pack the thrust bearing and coat all mating surfaces of the spindle and axle parts with Motorcraft Premium Long-Life Grease XG-1-C or -K or equivalent meeting specification ESA-M1C75-B prior to assembly.
2. Place the spindle in position on the axle. See **Fig. 6**.
3. Install the spindle pin seals and end play shim(s). See **Fig. 7**.
4. Insert the thrust bearing and seal between the bottom of the axle and the spindle. See **Fig. 8**.

Wheel Spindle Removal and Installation

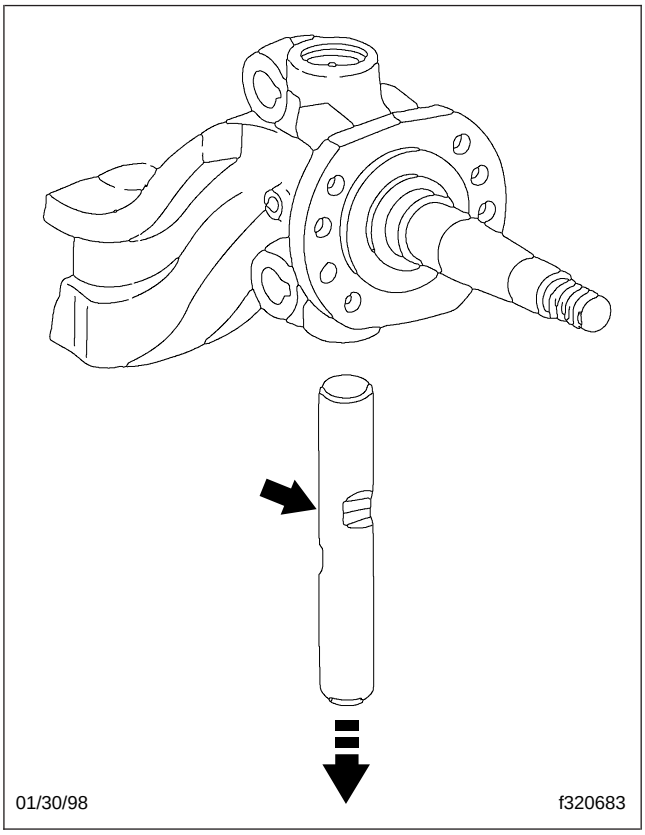


Fig. 4, Spindle Pin Removal

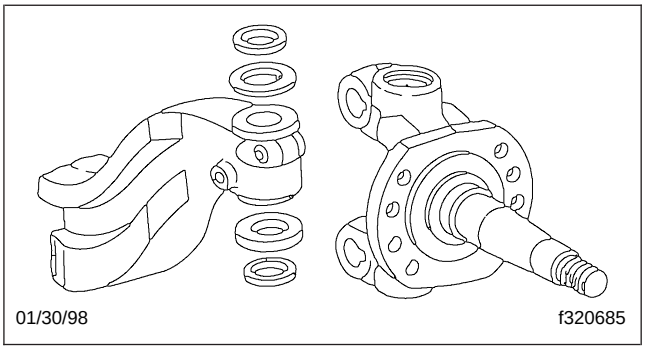


Fig. 5, Spindle Assembly

5. Line up the notches in the spindle pin with the lock pin holes in the axle.
6. Install the spindle pin through the axle until the notches and holes are aligned. See **Fig. 9**.
7. Seat pins by striking prior to installing the nut. See **Fig. 10**.

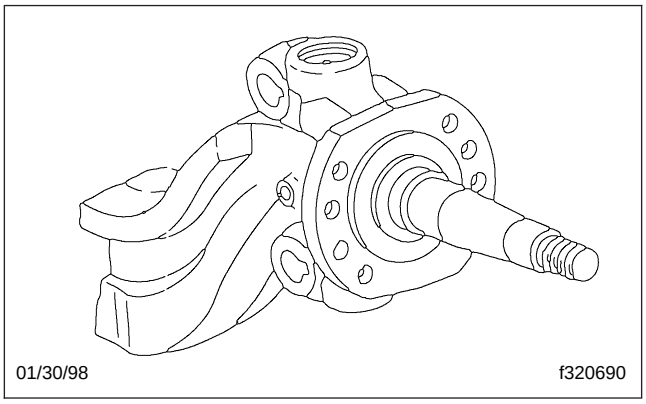


Fig. 6, Positioning Spindle to Axle

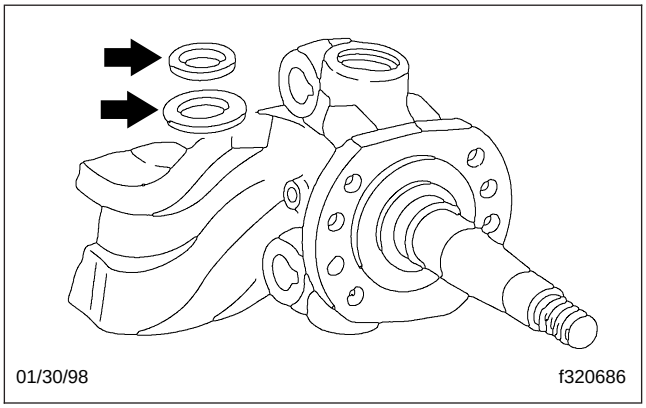


Fig. 7, Spindle Pin Seal and Shim

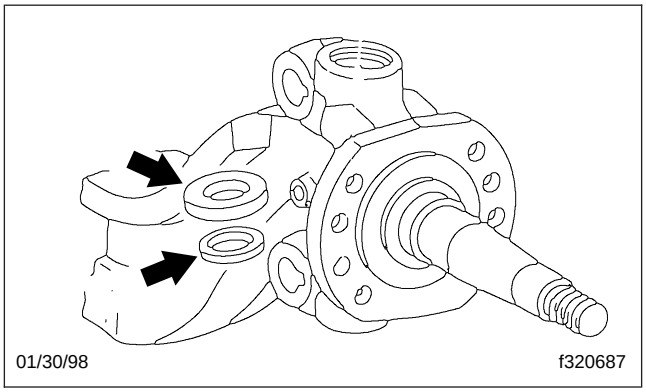


Fig. 8, Thrust Bearing and Seal

NOTE: Do not install both lock pins from the same side of the axle.

7.1 Install the lower (longer) lock pin.

7.2 Install the upper (shorter) lock pin.

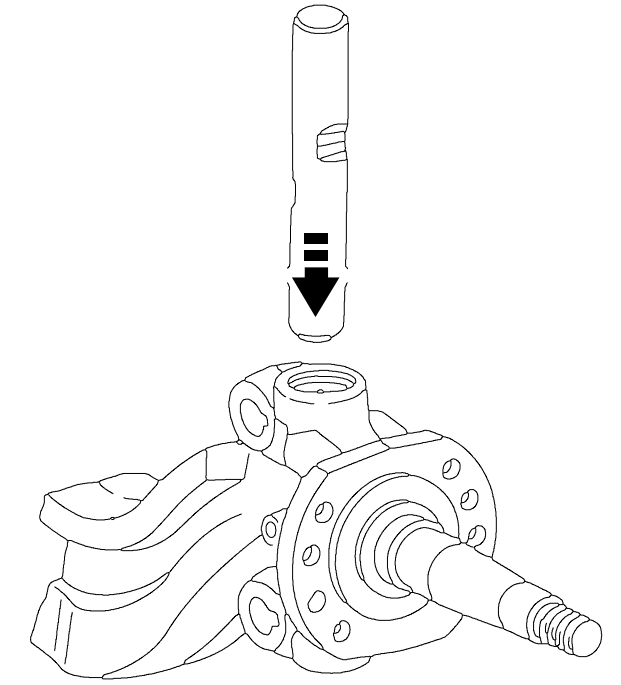
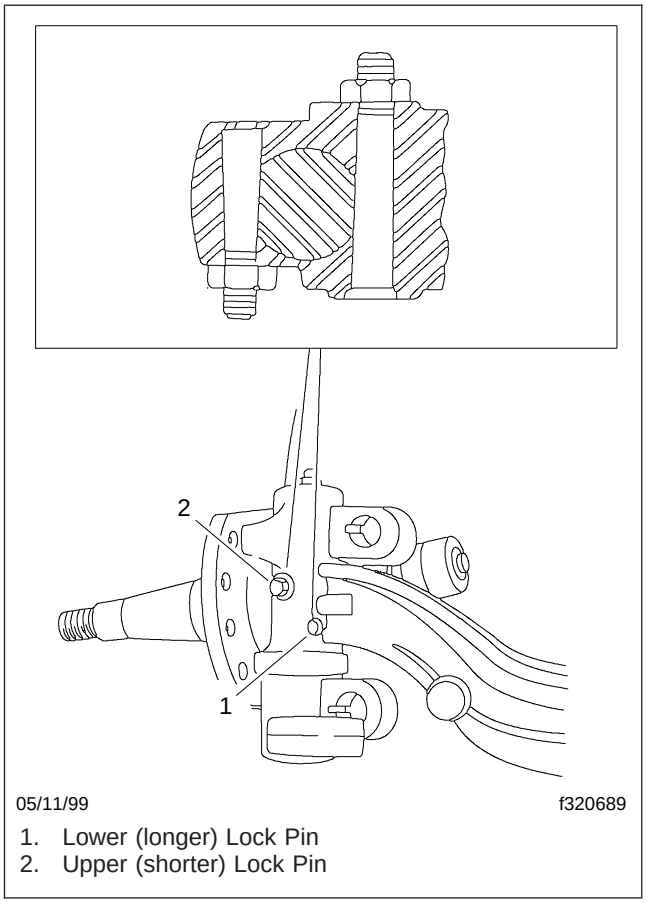


Fig. 9, Spindle Pin Installation

8. Tighten the nuts 50 to 70 lbf·ft (68 to 95 N·m). See **Fig. 11**.
9. Install the upper and lower spindle caps. See **Fig. 12**.
10. Install the spindle arms. Tighten 360 to 480 lbf·ft (489 to 650 N·m). See **Fig. 13**.

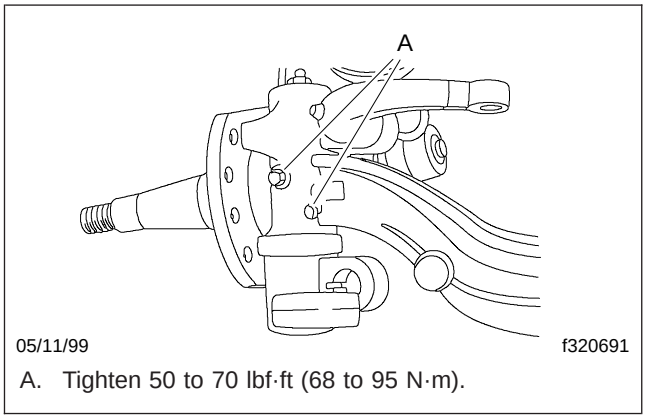
NOTE: To ensure complete distribution of the grease, the load must be removed from the front suspension before lubrication.

11. Lubricate the spindle bushings until lubricant is visible at the spindle-to-axle area.
12. Connect steering arm and drag link. For instructions, see **Group 46** of this manual.
13. Install the brake assembly. For instructions, see **Group 42** of this manual.
14. Install the hub and drum assembly. For instructions, see **Section 33.01** of this manual.
15. Adjust the wheel bearings.
16. Check and adjust the toe-in.



1. Lower (longer) Lock Pin
2. Upper (shorter) Lock Pin

Fig. 10, Lock Pin Installation



A. Tighten 50 to 70 lbf·ft (68 to 95 N·m).

Fig. 11, Lock Pin Nut Installation

Wheel Spindle Removal and Installation

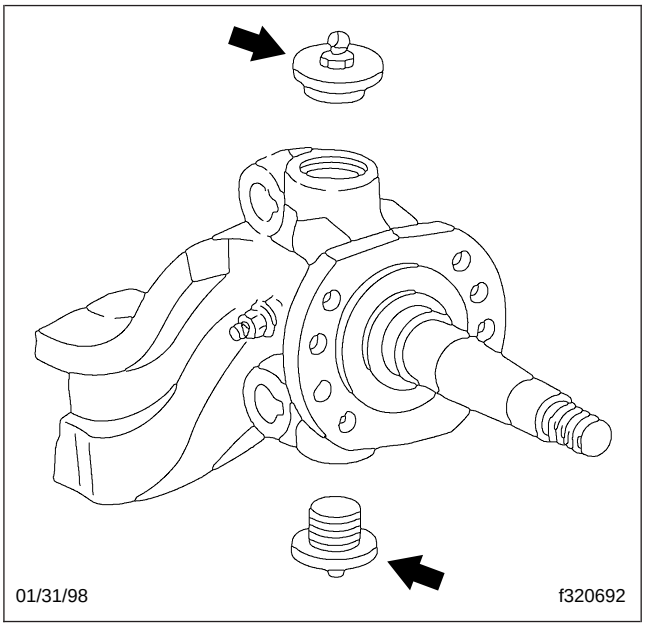
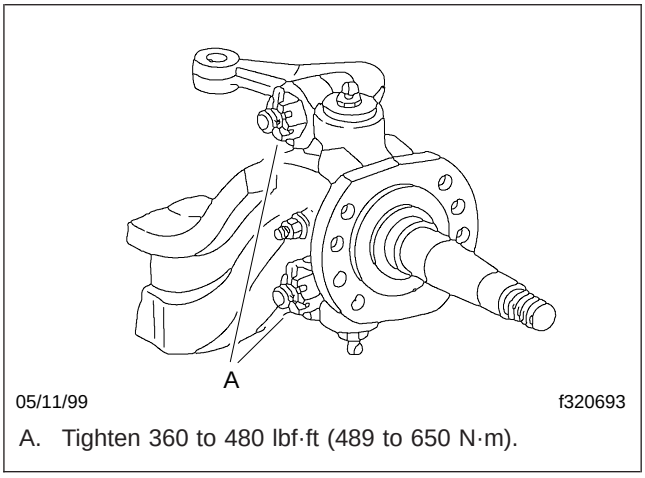


Fig. 12, Spindle Caps



A. Tighten 360 to 480 lbf·ft (489 to 650 N·m).

Fig. 13, Spindle Arm Installation

Spindle Bushing Removal and Installation

Removal

1. Press the bushings out of the spindle. See **Fig. 1**.

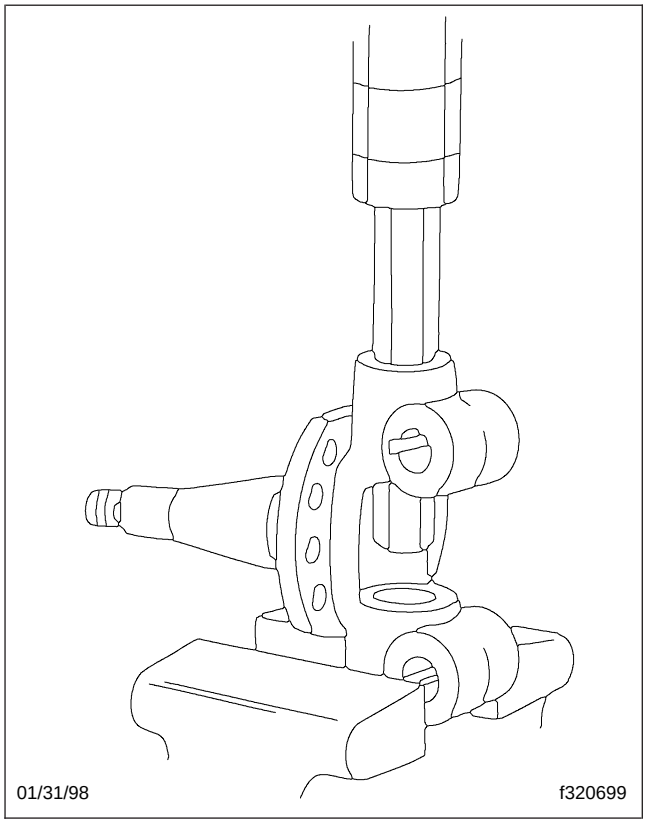


Fig. 1, Bushing Removal

2. Clean the spindle bores thoroughly, and make certain lubricating holes are not plugged.

Installation

1. Position a new bushing in the spindle bore with the open end of the oil groove toward the axle.
2. Press in the bushing. See **Fig. 2**.
3. Turn the spindle over and install the remaining bushing in the same manner. See **Fig. 3**.
4. Ream the bushings so the pin can be pushed in by hand. See **Fig. 4**.

NOTE: Always install new spindle pins with new spindle bushings.

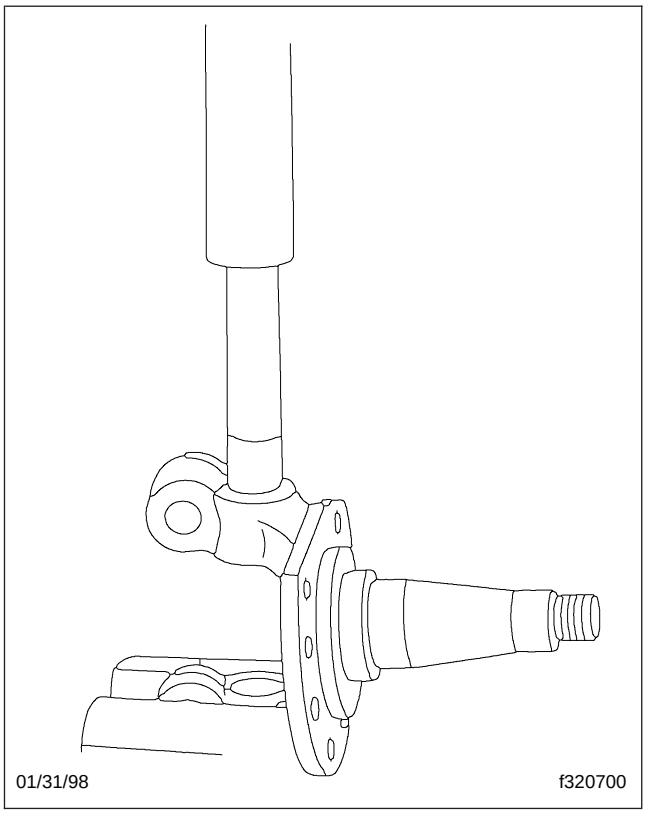
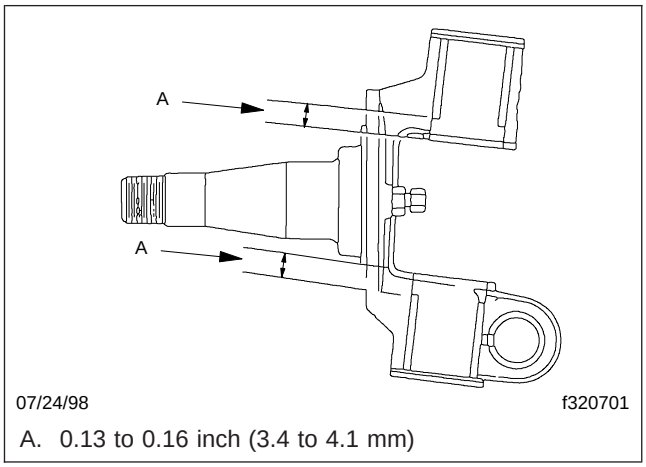


Fig. 2, Bushing Installation



A. 0.13 to 0.16 inch (3.4 to 4.1 mm)

Fig. 3, Checking Bushing Installation

5. Clean all the shavings and coat the bushing and pin with lubricant prior to assembly.

Spindle Bushing Removal and Installation

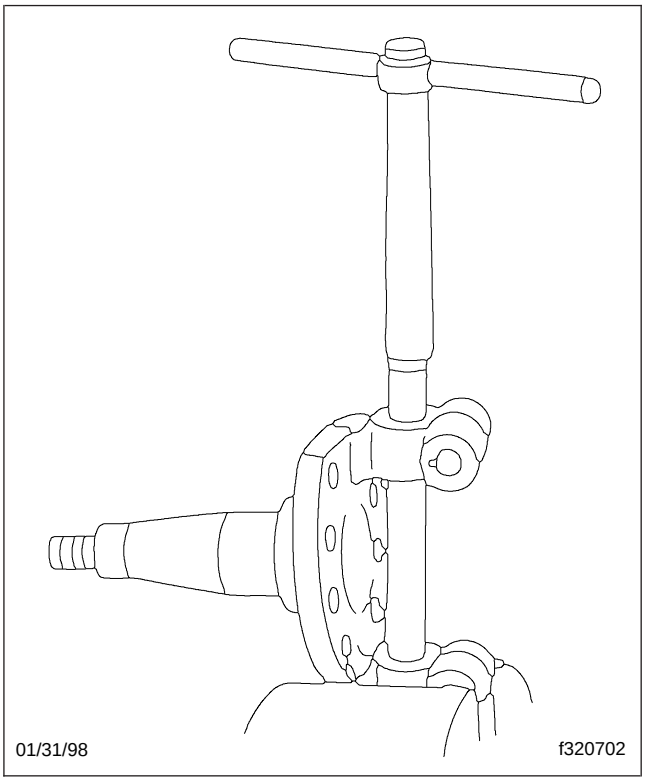


Fig. 4, Reaming Bushings

Removal

1. Raise and support the vehicle at the frame rails.
2. Remove the wheels. For instructions, see **Group 40** of this manual.
3. Support the front axle with a suitable jack.
4. Remove the brake drums. For instructions, see **Section 33.01** of this manual.
5. Remove the hub assemblies. For instructions, see **Section 33.01** of this manual.
6. Remove the brakes, slack adjusters, brake air chambers and brake camshafts. For instructions, see **Group 42** of this manual.
7. Remove the brake camshaft bracket. For instructions, see **Group 42** of this manual.
8. Remove the steering arms and the tie rods. For instructions, see **Group 46** of this manual.
9. Remove the spindles. For instructions, see **Subject 120**.
10. Remove the U-bolt retaining nuts. Note the position of the shims and wedges. See **Fig. 1**.

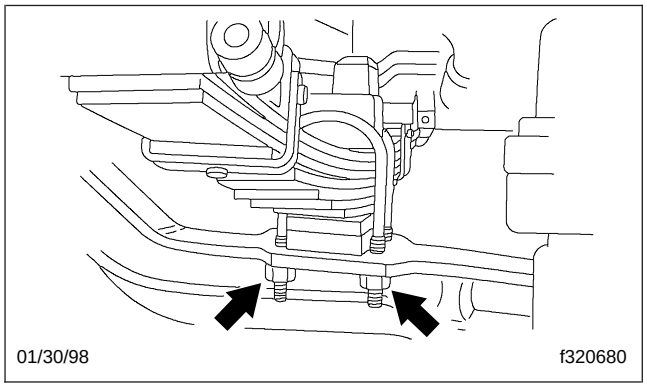


Fig. 1, U-Bolt Nuts

11. Lower the axle and remove it from the vehicle.

Installation

1. Position the axle to the vehicle.
2. Position the shims and wedges and install the U-bolt retaining nuts. See **Fig. 1**.
3. Install the spindles. For instructions, see **Subject 120**.
4. Install the steering arms and the tie rods. For instructions, see **Group 46** of this manual.
5. Install the brake camshaft bracket. For instructions, see **Group 42** of this manual.
6. Install the brakes, slack adjusters, brake air chambers and brake camshafts. For instructions, see **Group 42** of this manual.
7. Install the hub assemblies. For instructions, see **Section 33.01** of this manual.
8. Install the brake drums. For instructions, see **Section 33.01** of this manual.
9. Install the wheels. For instructions, see **Group 40** of this manual.
10. Remove the jack from the front axle.
11. Lower the vehicle.
12. Check the axle alignment (toe-in). See **Subject 180**.

Measuring and Adjusting Front Axle Wheel Alignment Angles

Measuring and Adjusting

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. Sterling dealers must have proof of this calibration history.

Precision instruments and equipment are needed for accurately measuring and adjusting wheel alignment. Refer to the operating instructions provided by the wheel alignment equipment manufacturer.

Before checking or correcting wheel alignment, make sure the vehicle is at curb weight. Curb weight is the weight of the unloaded vehicle complete with accessories and full fuel tanks.

If a road test is necessary, the route should be one that allows full left and right turns and full stops. It should also include a length of straight, level road to check the steering wheel position during straight-ahead driving.

During the road test, note any steering effort and possible roughness. Check for looseness, too much wheel play, any tendency for the vehicle to lead in one direction, and for pull during stopping.

Note the position of the steering wheel while driving on a straight, level road. When the steering gear is centered, the steering wheel spokes should be at the 4 and 8 o'clock positions, or within 10 degrees of that position. See **Fig. 1**.

If there are any problems, see **Section 33.01** of this manual.

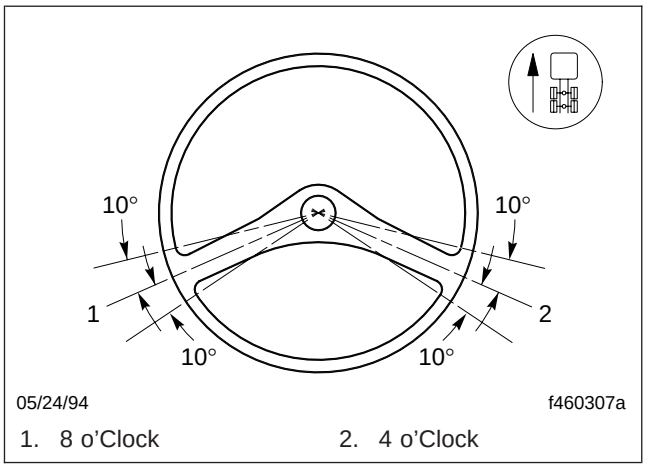
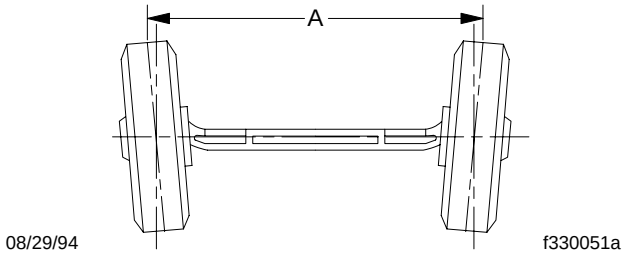


Fig. 1, Steering Wheel Position

Checking (See Fig. 1)



A. Camber (positive)

Fig. 1, Camber Angle

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. Sterling 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.
6. Compare the camber angles with those shown in the appropriate table in **Specifications, 400**. Differences between the measurements taken in the step above and the angles in the table 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. Do not 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.

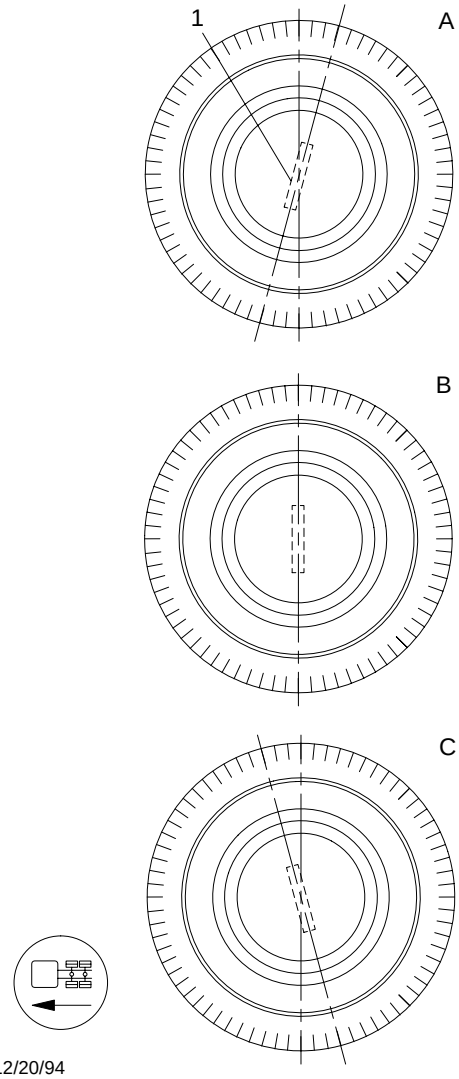
⚠ WARNING

Do not attempt to straighten any twisted or bent front axle component. This could crack or weaken the component, possibly resulting in a collapsed front axle, loss of a wheel, and serious personal injury.

7. Remove the chocks from the tires.

Checking and Adjusting

(See Fig. 1)



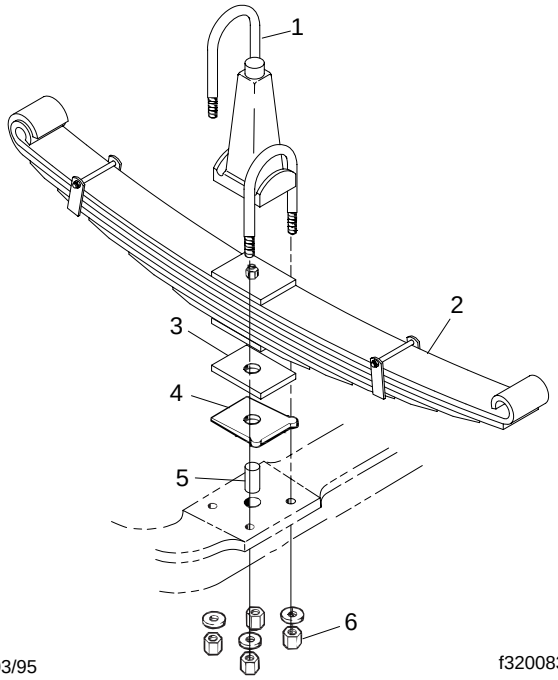
A. Positive Caster
B. Zero Caster
C. Negative Caster
1. Knuckle Pin (kingpin)

Fig. 1, Caster Angle

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. Sterling 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 appropriate 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**):



1. Axle Spring U-Bolt
2. Leaf Spring Assembly
3. Spacer
4. Front Caster Shim
5. Dowel Pin
6. U-Bolt High Nut

Fig. 2, Axle Spring Installation

IMPORTANT: Extreme angle shims cannot be used to correct caster angles that vary by more than 2 degrees from the values in the table. Weak or broken leaf springs, or worn shackle bushings, can cause extreme deviations to caster angles. Replace damaged parts before doing caster adjustments.

Caster Angle Checking and Adjusting

1. Apply the parking brakes. Chock the front and rear tires.
2. Back off the U-bolt 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 appropriate table in **Specifications, 400**. Install the dowel pin and check penetration.

IMPORTANT: Place front caster shims between the axle beam and the axle spacer, or between the axle beam and the shock absorber bracket. 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 appropriate table in **Specifications, 400**.

   U-bolt nuts need periodic retightening. Refer to Group 32 of the *Sterling L-Line and A-Line Maintenance Manual* for recommended intervals.

⚠ CAUTION

Failure to periodically retighten the U-bolt 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.

Wheel Toe-In Checking and Adjusting

Checking and Adjusting

(See Fig. 1)

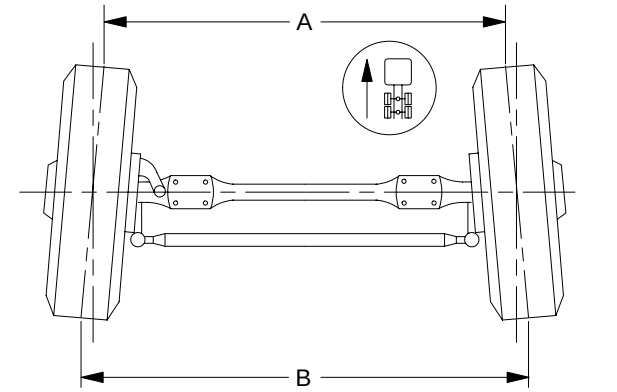
Using the alignment equipment manufacturer's operating instructions, measure the wheel toe-in. Compare the measurement with that shown in the appropriate table in **Specifications, 400**. If corrections are needed, go to the applicable (tie rod adjustment) step below.

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. Sterling 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.

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 6 feet (2 meters).

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: B minus A equals toe-in.

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 appropriate table in **Specifications, 400**. If corrections are needed, go to the next step.
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 6 feet (2 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 appropriate 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

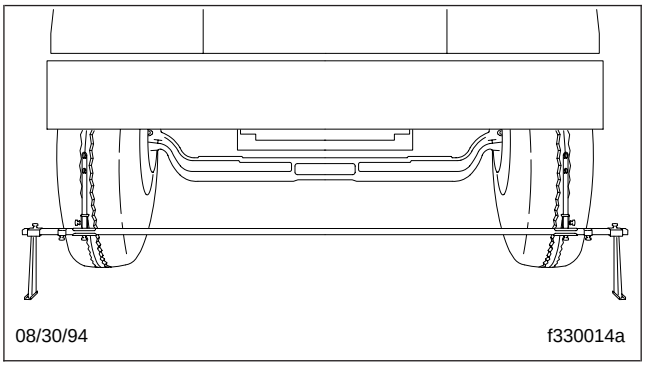


Fig. 2, Trammel Bar Positioning

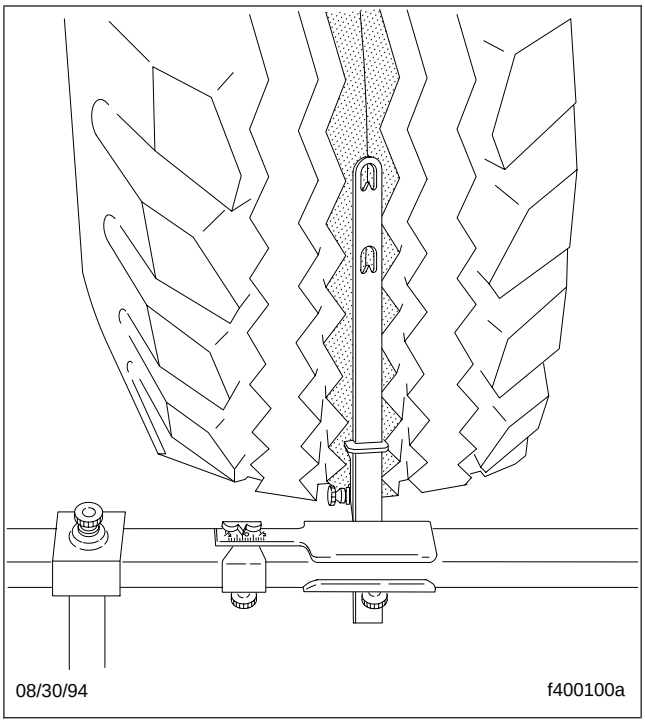


Fig. 3, Calculating Wheel Toe-In

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 35.04**.

NOTE: The alignment specifications below are for unloaded vehicles. These specifications will vary as weight is added to the vehicle and transferred to the front axle.

Camber and Toe-In					
Axle Manufacturer	**Axle Model**	**Left Camber: degrees**	**Right Camber: degrees**	**Toe-In Limits: in (mm)**	**Toe-In Target: in (mm)**
Meritor	All	–1/4 ± 7/16	–1/4 ± 7/16	0 to +1/8* (0 to +3.2)	+1/16 (+1.6)
Sterling	All				
Dana/Eaton	All E-Series	+1/4 ± 7/16	0 ± 7/16		

* If adjustment is required, set the toe-in as close as possible to +1/16 inch (1.6 mm).

Table 1, Camber and Toe-In

Caster				
Axle Manufacturer	**Bee Line**		**Hunter: degrees**	**Target, All Models: degrees**
	Except LC 4000: degrees	**LC 4000: degrees**		
Meritor	+3 to +6-1/2	+2-1/4 to +4-3/4	2 to 5	3-1/2 ± 1-1/2
Sterling				
Dana/Eaton				
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	All	5/8–11	50–60 (68–81)	50–60 (68–81)
Hendrickson	STEERTEK			
Sterling	All	5/8–11	60–80 (81–108)	60–80 (81–108)
Dana/Eaton	All	5/8–18	—	40–60 (55–81)

* All torque values in this table apply to parts lightly coated with rust-preventive type oil.

Table 3, Tie Rod Clamp Nut Torque Values

Miscellaneous Torque Values	
Description	**Torque: lbf·ft (N·m)**
U-Bolt Nuts 7/8–14	400 (542)
Meritor Stopscrew Locknut	50–65 (68–88)

Specifications

Miscellaneous Torque Values	
Description	**Torque: lbf·ft (N·m)**
Dana/Eaton Stopscrew Locknut	90–120 (122–163)

Table 4, Miscellaneous Torque Values

General Information

These vehicles are equipped with one of four different wheel end assemblies:

- The ConMet PreSet® hub

  This wheel end has the bearings and oil seal pre-installed in a hub. To install a new hub, mount it on the axle spindle, and secure it with an Axi-Lok® nut. For instructions, see **Subject 170**. A spacer between the inner and outer bearings adjusts the bearings to near zero end-play and preload when you tighten the retaining nut.

- The Meritor Easy Steer Plus® axle

  This axle has the hubs, bearings and oil seals factory-installed on the axle spindles. The hubs can be removed and installed on the axle, and the studs can be replaced, but the wheel bearings and oil seal are not serviceable in the field. To install a new hub, mount it on the axle spindle, and secure it. For instructions, see **Subject 180**.

- The traditional hub and bearings

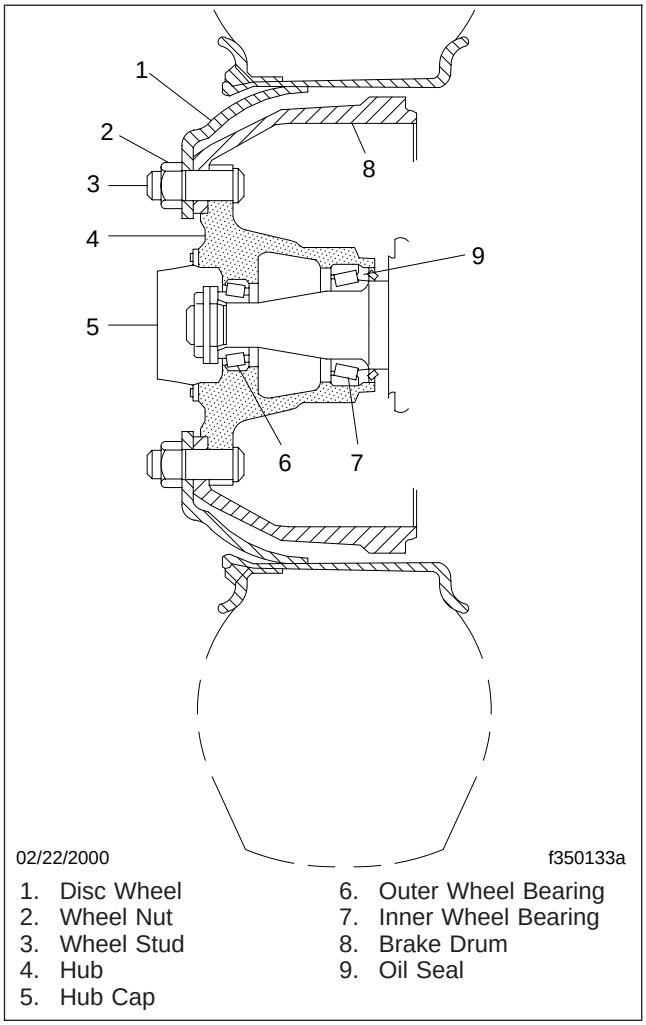
  With traditional wheel ends, the bearings and oil seal must be assembled with the hub when the hub is installed on the axle spindle. First the oil seal is placed on the spindle (some brands of oil seals are installed in the hub bore), then the inner bearing and the hub are mounted on the axle spindle. Then, the outer bearing is mounted in the hub bore. A nut is installed on the axle spindle end and tightened and loosened to adjust the bearings. Finally, a locking device and jam nut are installed to secure the hub and bearings on the axle. For instructions, see **Subject 160**.

- Pro-Torq® nut system

  This system has one adjusting nut and a lockring device. For instructions, see **Subject 190**.

All wheel hub assemblies consist of the following components (see **Fig. 1**):

- Wheel Bearings
- Wheel Hub
- Wheel Studs
- Brake Drum



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
9. Oil Seal

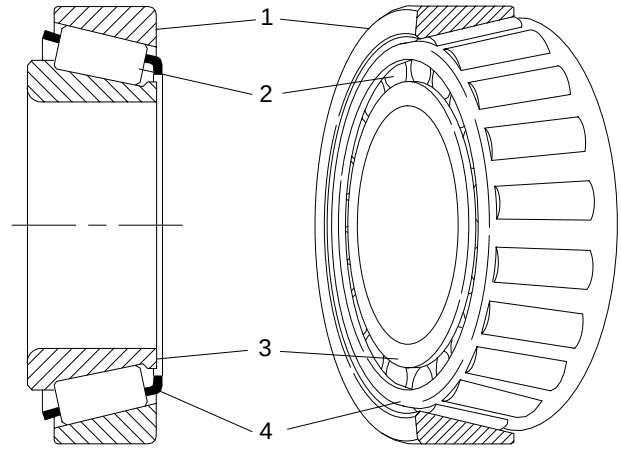
Fig. 1, Wheel Assembly, Cutaway View

TAPERED WHEEL BEARINGS

A traditional 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. On traditional hub and bearing assemblies, the bearing setting is locked in place on the axle spindle (steering knuckle) by an adjusting nut, a locking device such as a lockring or nut-lock, and a jam nut, or a Pro-Torq® nut. See **Fig. 3**.

General Information



1. Cup
2. Tapered Roller
3. Cone
4. Roller Cage

Fig. 2, Tapered Wheel Bearing Assembly

WHEEL HUB

The wheel and the brake drum are mounted on an aluminum 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 either serrations on the stud body or a flat area on the stud's head to prevent the stud from turning in the wheel hub.

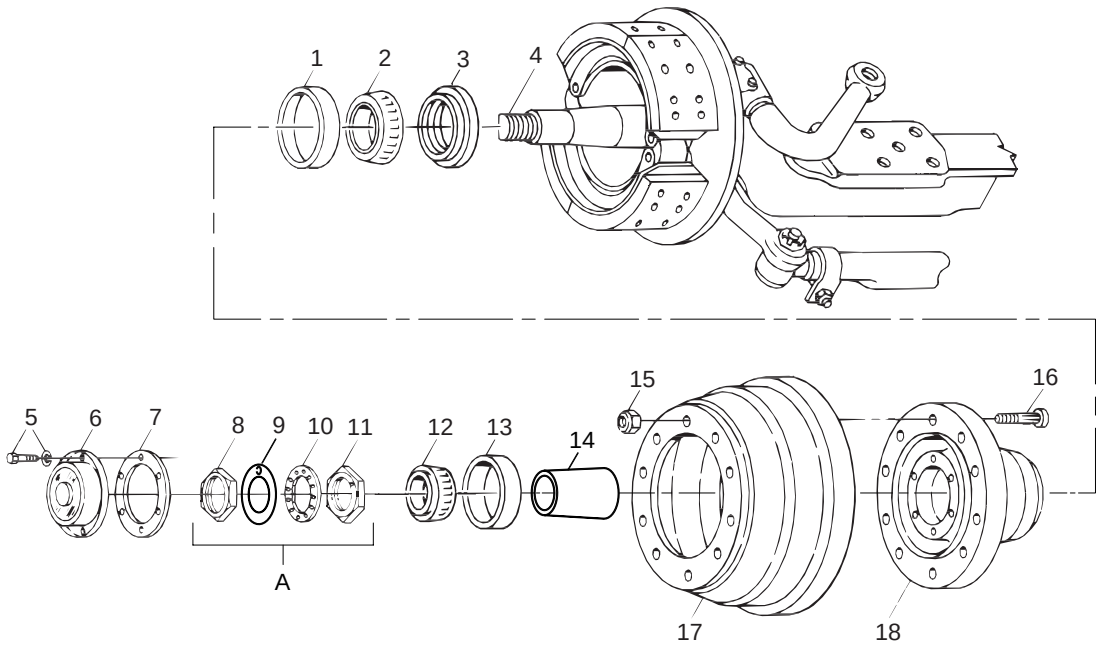
The end of the stud that faces away from the vehicle is stamped with an "L" or "R," depending on which side of the vehicle the stud is installed. Studs stamped with an "L" are left-hand threaded and are installed on the left side of the vehicle. Studs stamped with an "R" are right-hand threaded and are installed on the right side of the vehicle.

Hub-piloted disc wheel mountings use right-hand threads on both sides of the vehicle.

BRAKE DRUM

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.

The brake drum is mounted on the outboard face of the hub and fits over the wheel studs. See **Fig. 3**.



NOTE: On some Meritor axles, the hub, wheel bearings, studs, and oil seal are assembled at Meritor and installed as an assembly.

A. Four-piece bearing system shown; Pro-Torq® or Axi-Lok® locking nuts could be used.

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Hub Cap Capscrew
6. Hub Cap
7. Gasket
8. Jam Nut
9. Nut-Lock
10. Lockring
11. Adjusting Nut
12. Outer Wheel Bearing
13. Outer Bearing Cup
14. Bearing Spacer (ConMet PreSet® hubs only)
15. Wheel Nut
16. Wheel Stud
17. Brake Drum
18. Hub

Fig. 3, Typical Wheel and Axle Assembly

General Information

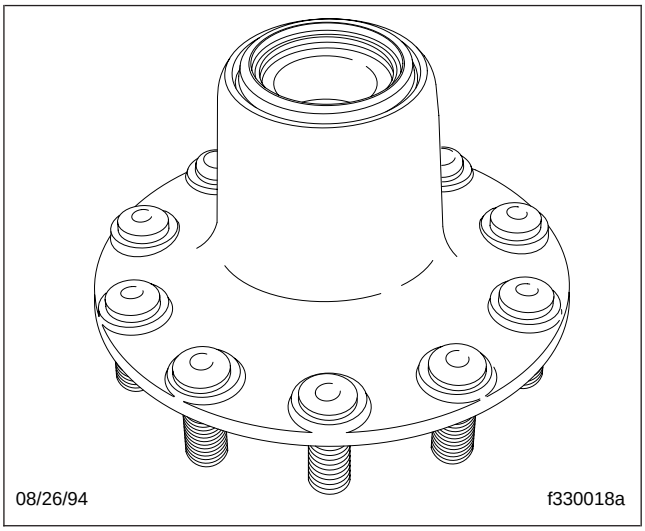
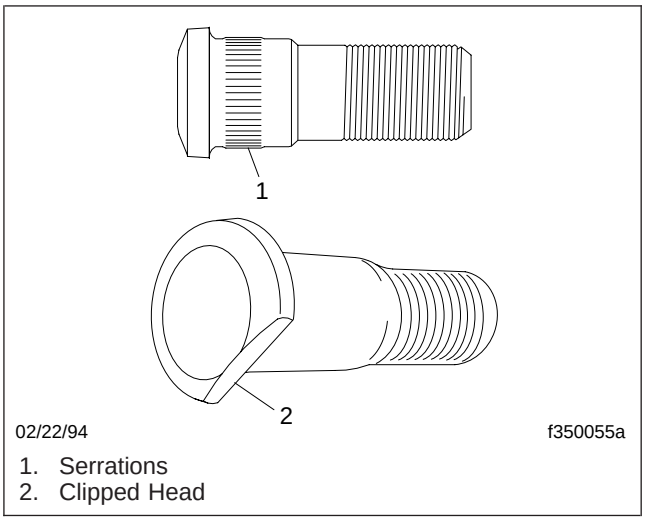


Fig. 4, Front Axle Wheel Hub



1. Serrations
2. Clipped Head

Fig. 5, Typical Wheel Studs

Hub Assembly Removal and Installation

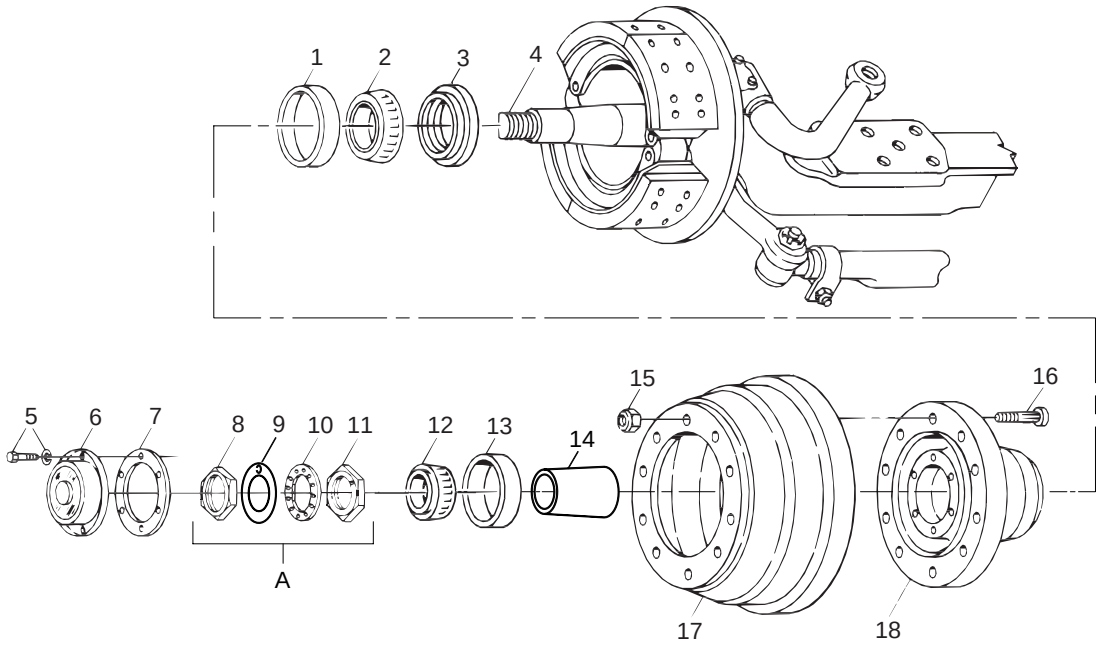
Removal

See **Fig. 1** for this procedure.

1. 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. Back off the slack adjuster to release the front axle brake shoes.
4. Remove the wheel and tire assembly. See **Group 40** in this manual for instructions.
5. Remove the brake drum. For instructions, see **Subject 110**.

NOTE: 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. Avoid contaminating the brake shoes with oil. Dispose of the oil properly.

6. Remove the capscrews, washers, and hub cap. Remove and discard the hub cap gasket.
7. If working with ConMet PreSet or Meritor Easy Steer Plus® hubs, remove the nut(s) and locking



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NOTE: On some axles, the hub, wheel bearings, studs, and oil seal are installed as a unitized wheel-end assembly. These wheel ends must be replaced as a unit.

A. Four-piece bearing system shown; Pro-Torq® or Axi-Lok® locking nuts could be used.

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Hub Cap Capscrew
6. Hub Cap
7. Gasket
8. Jam Nut
9. Nut-Lock
10. Lockring
11. Adjusting Nut
12. Outer Wheel Bearing
13. Outer Bearing Cup
14. Bearing Spacer (ConMet PreSet® hubs only)
15. Wheel Nut
16. Wheel Stud
17. Brake Drum
18. Hub

Fig. 1, Typical Wheel and Axle Assembly

Hub Assembly Removal and Installation

device and remove the wheel end (hub, bearings and oil seal) as a unit.

If working with an Axi-Lok nut system, the socket must be fully engaged to insure that the locking tabs are depressed.

If working with a traditional hub and bearing assembly, remove the jam nut, locking device(s), and adjusting nut.

If working with a Pro-Torq nut system, remove the lockring, then remove the nut.

CAUTION

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. On vehicles equipped with WABCO ABS, use care when working with the hubs. To prevent damage to the tone wheel, do not drop the hub, or lay it down in a way that would damage the tone wheel.

7.1 If working with a traditional hub and bearing assembly, 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).

7.2 Carefully remove the outer wheel bearing; handle the bearings with clean, dry hands. Wrap the bearings in either clean oil-proof paper or lint-free rags.

CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

7.3 Remove the hub from the axle spindle. Be careful not to damage the axle spindle threads as the assembly is removed.

7.4 Remove the inner wheel bearing from the axle; handle the bearings with clean, dry hands. Wrap the bearings in clean, oil-proof paper or lint-free rags. Occasionally, the inner wheel bearing will remain in the hub after the hub is removed. In those cases, place a protective cushion where it will catch the bearings. Use a hardwood drift and a light hammer to gently tap the bearing (and seal, if necessary) out of the cup.

7.5 Remove the oil seal from the axle spindle, if not already removed. See **Section 33.02** for additional information.

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, starting with removal of the wheels and continuing through assembly.

1. Using cleaning solvent, remove the old oil from the axle spindle (steering knuckle) 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 spindle threads.
2. When replacing a brake drum, verify that the replacement drum has the same drum pilot diameter as the hub. Also, check the stud length to verify that the stud standout will be correct for the new drum.

   Remove all foreign material to ensure that the drum fits the drum pilot properly and can fully seat against the hub mounting face.

   In environments where a corrosion inhibitor is beneficial, ConMet recommends the use of Corrosion Block, a product of Lear Chemical Research. In severely corrosive environments, a light coat of Corrosion Block on the drum and wheel pilots has proven beneficial.

   Before installation of brake drums and wheels that use the hub piloted system, rotate the hub so one of the wheel pilot bosses is at the top.

   Position the brake drum over the hub so it seats on the drum pilot and against the hub face.

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 corrosive) and could cause damage to both wheel bearing assemblies and the wheel hub.

3. If working with traditional hub and bearing assemblies, coat both bearing assemblies with fresh oil. Install the inner wheel bearings and oil seal. Handle the bearings with clean, dry hands. See **Section 33.02** for oil seal installation instructions.
4. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.

CAUTION

On vehicles equipped with WABCO ABS, use care when installing the hubs. To prevent damage to the tone wheel, do not drop the hub or lay it down in a way that would damage the tone wheel.

5. Mount the hub assembly on the axle spindle.
6. Adjust the wheel bearings according to the instructions in the applicable wheel bearing subject in this section.

   For traditional hub and bearing assemblies, see **Subject 160**.

   For ConMet PreSet hubs, see **Subject 170**.

   For Meritor Easy Steer Plus axle ends, see **Subject 180**.

   For the Pro-Torq nut system, see **Subject 190**.
7. Place the hub cap and a new gasket in position. Install the washers and capscrews. Tighten the capscrews 15 lbf·ft (20 N·m).
8. If applicable, add fresh oil to the wheel hub to the level indicated on the hub cap. For the recommended axle lubricants, see **Specifications, 400**.

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. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

9. Install the brake drum on the wheel hub. For instructions, see **Subject 110** in this section.

WARNING

If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking action, and the wheel hub flange is probably damaged. In 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.

10. Install the wheel and tire assembly. See **Group 40** for instructions.
11. Adjust the front axle brakes. See **Group 42** in the Sterling *L-Line and A-Line Maintenance Manual*.
12. Remove the safety stands from under the axle; lower the vehicle.
13. Remove the chocks from the rear tires.

Outboard-Mounted Drum Removal and Installation

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.

For an exploded view of a typical wheel and axle assembly, including the brake drum, see **Fig. 1**.

Removal

1. Chock the rear tires to prevent vehicle movement. Apply the parking brakes.

WARNING

Use safety stands to securely support all axle and frame weight during axle procedures. Unsecured components may drop when fasteners are loosened or removed, which could cause serious personal injury and component damage.

2. Raise the front of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. Back off the slack adjuster to release the front axle brake shoes.

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.

4. Remove the wheel and tire assembly. See **Group 40** for instructions.

   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. Using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Do not use compressed air or dry brushing to clean the brake assembly.
5. Remove the brake drum.
6. Inspect the drum. See **Subject 120** for instructions.

Installation

1. When replacing a brake drum, verify that the replacement drum has the same drum pilot diameter as the hub. Also, check the stud length to verify that the stud standout will be correct for the new drum.

   Remove all foreign material to ensure that the drum fits the drum pilot properly and can fully seat against the hub mounting face.

   In environments where a corrosion inhibitor is beneficial, ConMet recommends the use of Corrosion Block, a product of Lear Chemical Research. In severely corrosive environments, a light coat of Corrosion Block on the drum and wheel pilots has proven beneficial.

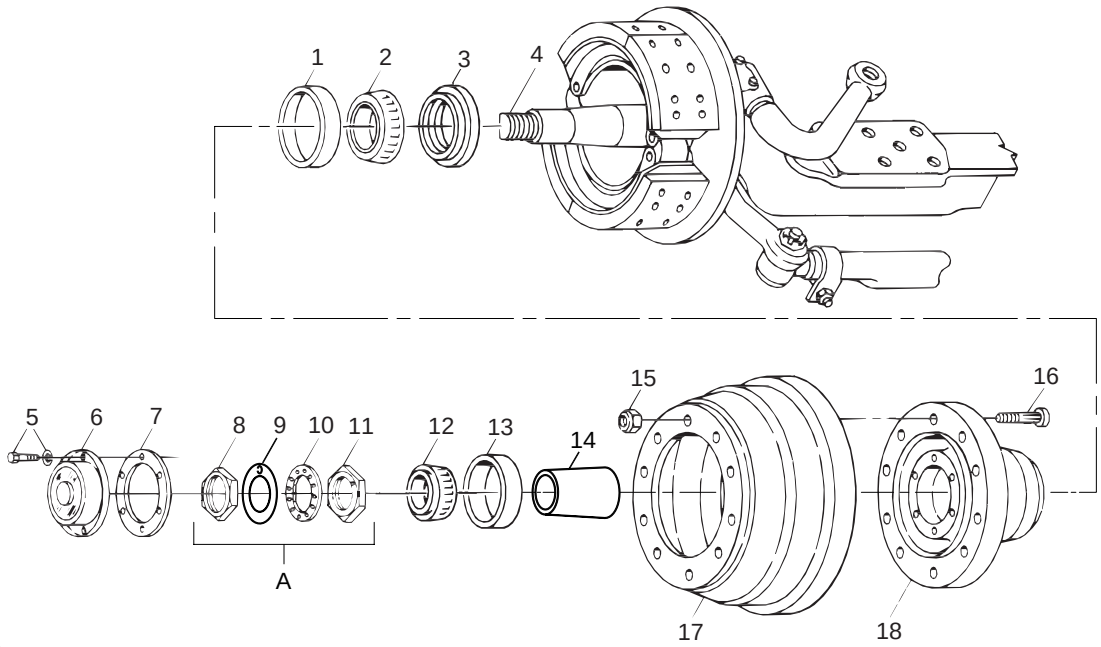
   Before installation of brake drums and wheels that use the hub piloted system, rotate the hub so one of the wheel pilot bosses is at the top. See **Fig. 2**.

   Position the brake drum over the hub so it seats on the drum pilot and against the hub face.
2. Install the brake drum on the wheel hub.

   2.1 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 12 o'clock (top center) position. See **Fig. 2**.

   IMPORTANT: If the drum is not positioned correctly, the pilot pad could be damaged when the wheel nuts are torqued.

Outboard-Mounted Drum Removal and Installation



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NOTE: On some Meritor axles, the hub, wheel bearings, studs, and oil seal are assembled at Meritor and installed as an assembly.

A. Four-piece bearing system shown, Pro-Torq® or Axi-Lok® locking nuts could be used.

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Hub Cap Capscrew
6. Hub Cap
7. Gasket
8. Jam Nut
9. Nut-Lock
10. Lockring
11. Adjusting Nut
12. Outer Wheel Bearing
13. Outer Bearing Cup
14. Bearing Spacer (ConMet PreSet® hubs only)
15. Wheel Nut
16. Wheel Stud
17. Brake Drum
18. Hub

Fig. 1, Typical Wheel and Axle Assembly

2.2 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.

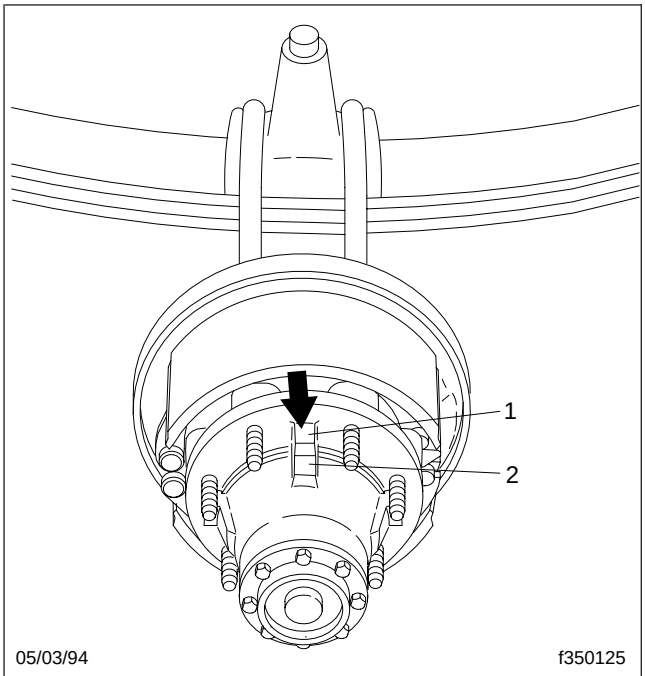
3. Install the wheel and tire assembly. To ensure that the drum does not slip off the pilot pad, follow the proper nut tightening sequence. For instructions, see **Group 40**.

⚠ 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.

4. Adjust the front axle brakes. See Group 42 in the vehicle maintenance manual.

5. Remove the safety stands from under the axle; lower the vehicle.
6. Remove the chocks from the rear tires.



NOTE: The pilot pad should be at the 12 o'clock position.

1. Drum Pilot
2. Wheel Pilot

Fig. 2, Hub Pilot Pads

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.

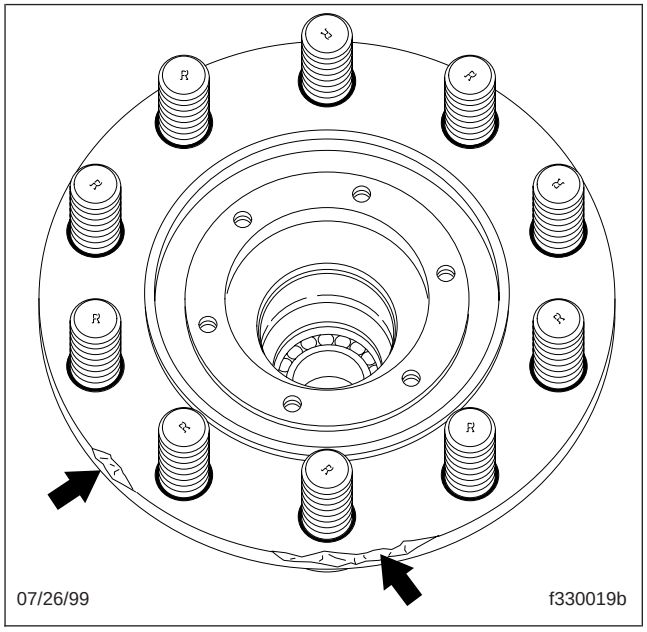


Fig. 1, Wear Spots

2. Remove all the old oil from the wheel hub cavity. Inspect the inner surface of the hub for cracks, dents, wear, or other damage. Replace the wheel hub if damage exists.

3. Remove all the old grease or oil from the surfaces of the wheel bearing cups. Inspect the wheel bearing cups for cracks, wear, spalling, or flaking. See **Fig. 3**. Replace the cups if damaged in any way. See **Subject 130** or **Subject 140**.

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.

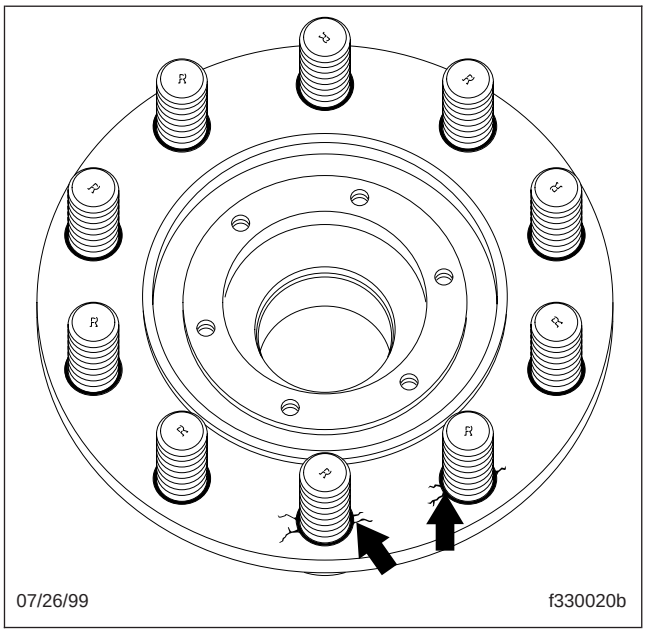


Fig. 2, Cracked Stud Grooves

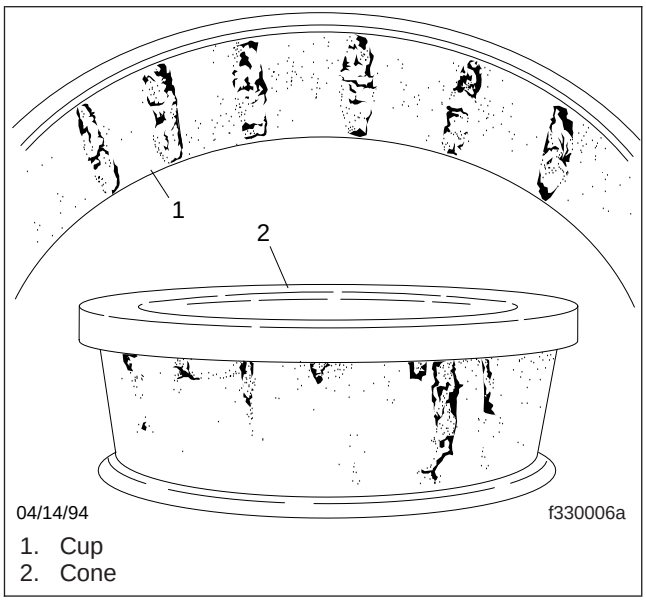
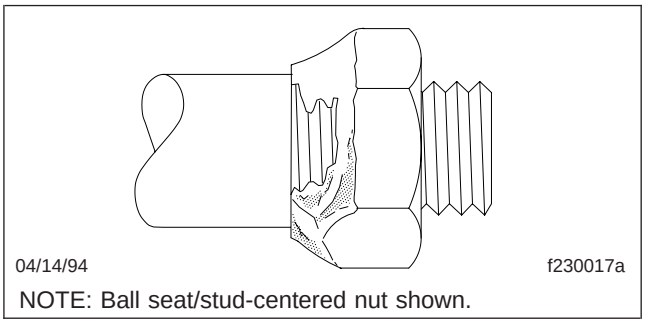


Fig. 3, Spalling (Flaking) of Wheel Bearing Assembly

5. Inspect the wheel or rim studs. Replace studs that are stripped, broken, bent, or otherwise damaged. See **Subject 150**.

Axle Components Cleaning and Inspection



NOTE: Ball seat/stud-centered nut shown.

Fig. 4, Damaged Wheel Stud Nut

Wheel Bearing Inspection

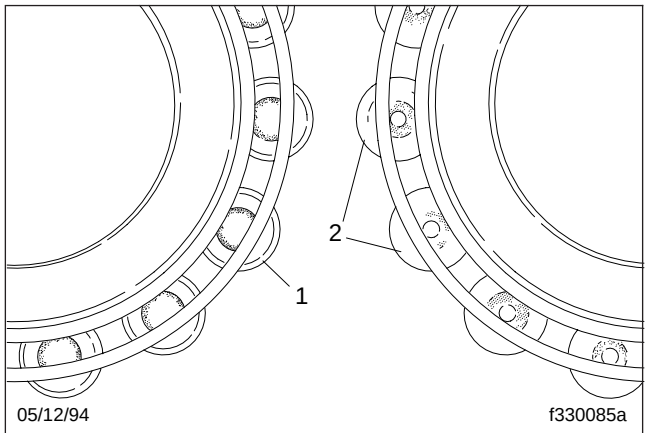
IMPORTANT: Wheel bearings should be very closely inspected at the time of disassembly. Optimal inspection conditions are possible only after the bearings have been thoroughly cleaned using kerosene or diesel fuel oil and a stiff brush.

1. Remove the wheel hub and bearing cones. See **Subject 100**.
2. Clean all old oil from the bearings and hub cavity with kerosene or diesel fuel and a stiff brush. Do not use gasoline or heated solvent.
3. 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 which is wet with kerosene or diesel fuel, and the kerosene or diesel fuel may dilute the lubricant.

CAUTION

Do not 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.

4. 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:
   - large ends of rollers worn flush to the recess, or radii at the large ends of the rollers worn sharp (see **Fig. 5**)
   - visible step wear, particularly at the small end of the roller track; deep indentations,



1. New Bearing
2. Worn Bearing Rollers

Fig. 5, Wheel Bearing Roller Wear

cracks, or breaks in the cone surfaces (see **Fig. 6**)

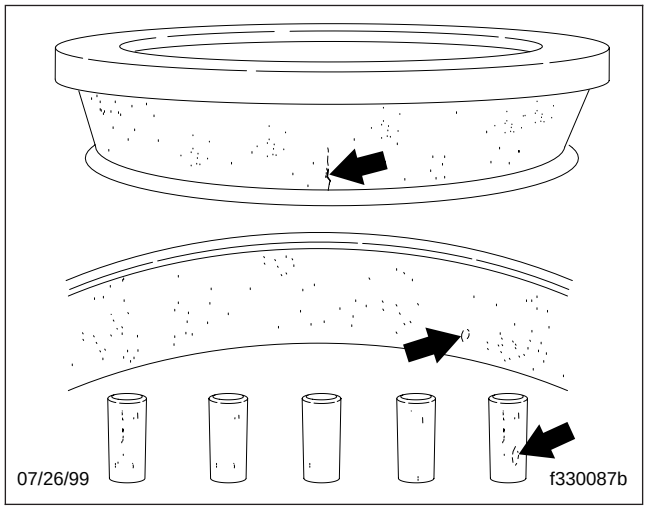


Fig. 6, Indentations, Cracks, or Breaks in Bearing Surfaces

- bright rubbing marks on the dark phosphate surfaces of the bearing cage (see **Fig. 7**)
- 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
- etching or pitting on functioning surfaces (see **Fig. 8**)

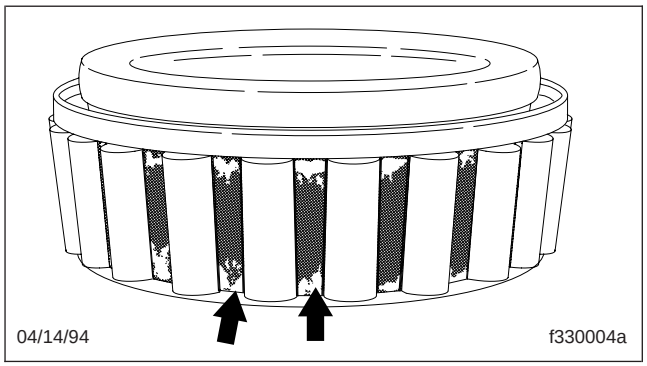


Fig. 7, Rubbing Marks on Bearing Cage

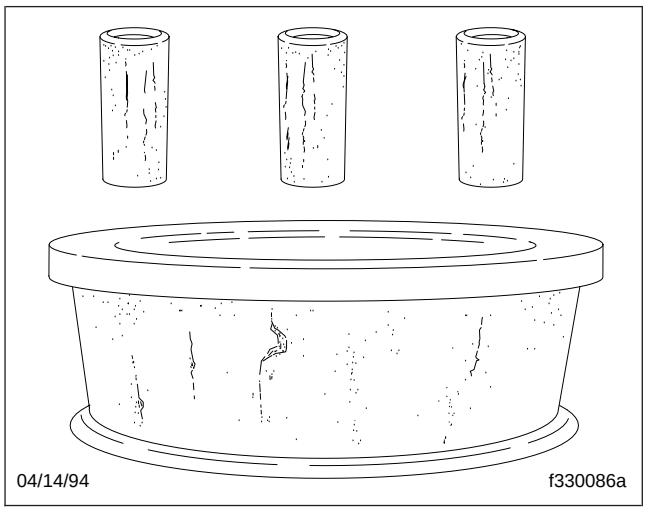


Fig. 8, Etching (Pitting) on Bearing Surfaces

- spalling (flaking) of the bearing cup, roller, or cone surfaces (see **Fig. 3**)

5. After inspection, brush the bearings with fresh axle lubricant.

Brake Drum Inspection

New brake drums are purposely undersized to allow for turning (remachining). Prior to new drum installation, the protective coating on the inner friction surface must 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 drum on the axle also must be turned or replaced to provide the same braking power on both wheels. Turned drums should not exceed the maximum allowable diameter stamped on the outside surface of the drum. See **Fig. 9** for a typical location of this stamp.

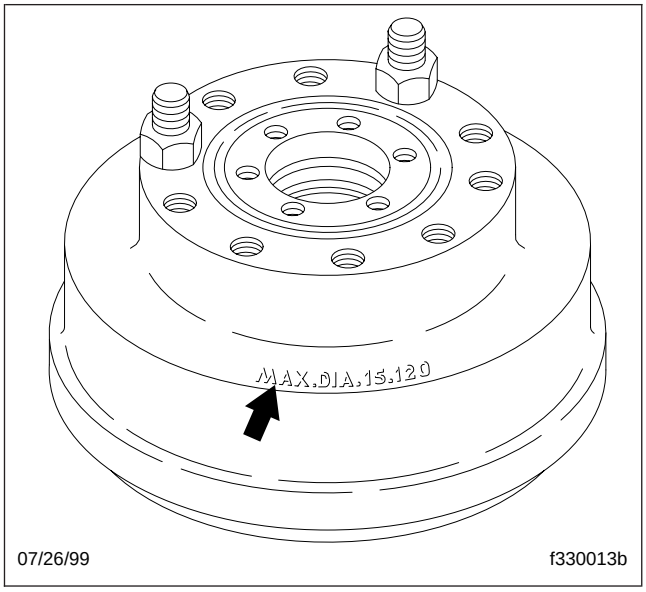


Fig. 9, Maximum Diameter Stamp

NOTE: Turned drums should be cleaned using a fine emery cloth and then rinsed with a hot water wash.

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.

If the drums are turned or replaced, replace the brake linings. See **Group 42** in this manual for instructions.

1. Inspect the inner friction surface. If a veneered (highly glossed) or glazed surface exists, renew the drum by using 80–grit emery cloth or by turning the drums.
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 impair performance and lining life if the network

Axle Components Cleaning and Inspection

of fine hairline cracks remains small. Examine heat checks of drums frequently to be certain the checks have not widened into drum weakening cracks (substantial cracks extending to the open edge of the drum). Replace the same-axle drums if substantial cracks are present, or if widening of the fine hairline cracks occurs.

NOTE: If normal heat checking as described above is present, inspect the drums at least every 12,000 miles (19 300 km) thereafter. 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 the contaminants. 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 brake lining replacement procedures, see **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 the measured diameter is greater than the maximum allowable diameter, replace the same-axle drums and linings.
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.
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 or for a bluish cast on the brake parts, both of which are caused by high temperatures. If the drums' maximum allowable diameters have not been exceeded, remachine both same-axle drums. If the spots or discoloration cannot be removed, or if remachining is not possible, replace the drums. Also replace the brake shoe return springs.

Wheel Bearing Cup Removal and Installation, Aluminum Hubs

Removal (See Fig. 1)

To insure a tight fit, wheel bearing cups are purposely larger than the wheel hub bores they occupy. To remove the bearing cups, aluminum hub bores must be temporarily expanded by heating the hub in an oven (the bearing cups will also expand, but to a considerably lesser extent). If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

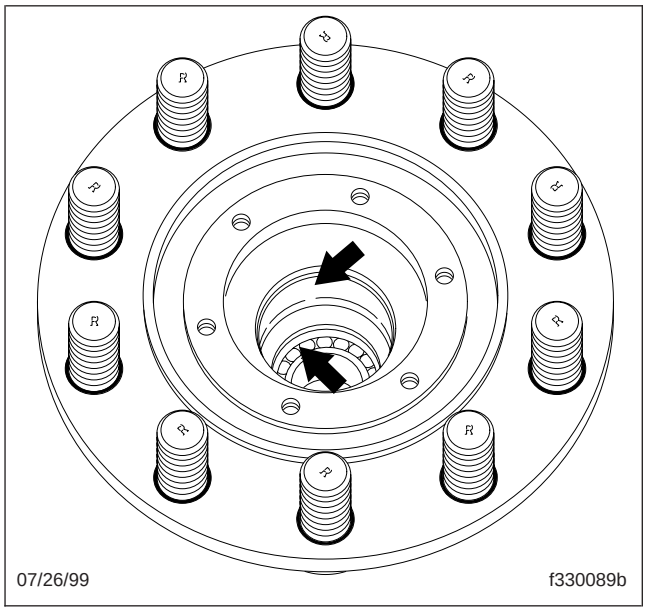


Fig. 1, Wheel Bearing Cup Locations

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Oven-heat the hub to a temperature range of 240° to 280°F (116° to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

   If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

⚠ WARNING

Do not use oxyacetylene equipment or similar equipment to heat the hub. Oxyacetylene equipment or similar equipment will cause cracks in the hub which could cause loss of a wheel and loss of vehicle control, leading to personal injury or property damage.

3. Wearing heavy protective gloves, remove the hub from the oven. Place the hub on a suitable press so that the base is fully supported. Quickly press out the bearing cups.

Installation

To install the bearing cups, aluminum hubs must again be temporarily expanded using oven heating. When the hub is properly heated, the bearing cup and hub can be press-fit together, using a suitable press.

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. Oven-heat the hub to a temperature range of 240° to 280°F (116° to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

⚠ WARNING

Do not use oxyacetylene equipment or similar equipment to heat the hub. Oxyacetylene equipment or similar equipment will cause cracks in the hub which could cause loss of a wheel and loss of vehicle control, leading to personal injury or property damage.

4. Coat the replacement bearing cup hub contact surface with a film of grease.
5. Wearing heavy protective gloves, remove the hub from the oven.
6. Place the hub on a suitable press so that the base is fully supported. Quickly press-fit the bearing cup into the wheel hub until it is completely and evenly seated. Be careful not to shave the sides of the bearing cup bore as the bearing cup is seated. The accumulation of debris will prevent the cup from being seated and

Wheel Bearing Cup Removal and Installation, Aluminum Hubs

will also cause permanent damage to the wheel hub. If the sides of the bearing cup bore are damaged during installation, replace the wheel hub assembly.

7. Allow the wheel hub to cool before handling. Using a 0.0015-inch feeler gauge, check at several places for the seating of the bearing cup in the bearing cup bore. The gauge should not enter beneath the cup. If it does, there is probably dirt or debris preventing the cup from seating. Using the instructions above, remove the cup, then remove the foreign matter. Reinstall the cup.
8. Wipe off the accumulation of grease left after the bearing cup has been seated. 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 Bearing Cup Removal and Installation, Ferrous Hubs

Removal

Wheel bearing cups on ferrous hubs are removed and installed by driving them out and pressing them in without heating the hub.

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

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 replacement bearing cup hub contact surface 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. 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 supported evenly around and next to the stud being removed. With steady movement, press the damaged stud out of the hub.

⚠ CAUTION

Do not use a drift and hammer or concentrated heat for removing and installing 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 coating 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 supported evenly around and next to the stud being installed.
6. Position the stud in its hole. *Be sure the flat edge of the head flange on clipped studs is in line with the shoulder on the hub.*

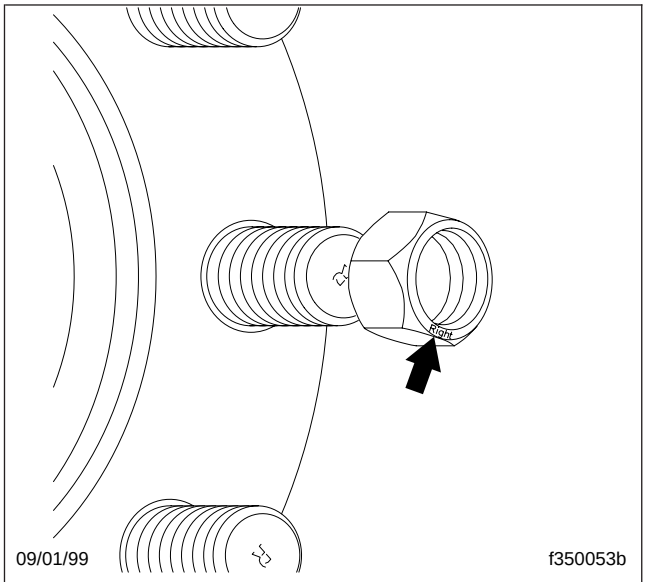
⚠ CAUTION

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.

NOTE: If the left side of the vehicle is being serviced, the replacement wheel stud must be stamped with an "L" (left-hand threaded), and the nut's face must be stamped "Left". If the right 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. 1**).

For 8-hole and 10-hole hub piloted disc wheel mountings, both sides have right-hand metric threads.

7. With steady movement, press the new stud all the way into the hub.



NOTE: Ball seat/stud-centered disc wheel mounting shown.

Fig. 1, Right Thread Stamp Location

8. Make sure the stud is fully seated and that its head (flange) is not embedded into the hub. If the head of the stud is embedded into the hub, replace the hub.

Wheel Stud Replacement

WARNING

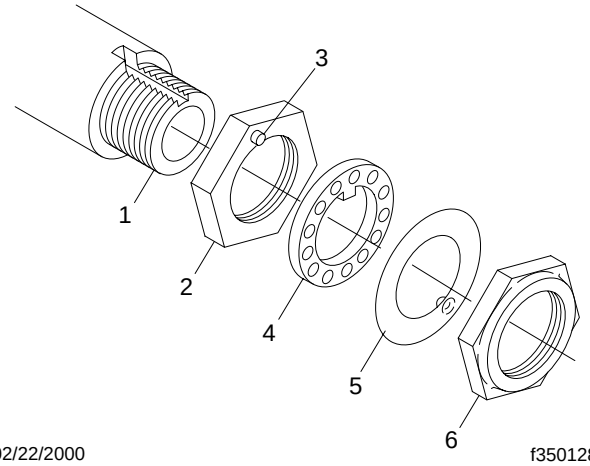
Do not embed the wheel stud heads in the wheel hub. Wheel studs with heads embedded in the wheel hub will weaken the wheel hub flange. Weakness in the wheel hub can result in the loss of a wheel or loss of steering control, possibly resulting in personal injury.

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**.

Four-Piece Wheel Bearing System Installation and Adjustment

Installation and Adjustment

1. Carefully mount the hub and inner wheel bearing assembly on the axle spindle. See **Fig. 1**. Be careful not to unseat the inner wheel bearing or seal.



1. Axle Spindle
2. Adjusting Nut
3. Dowel
4. Lockring
5. Nut-Lock
6. Jam Nut

Fig. 1, Four-Piece Wheel Bearing Assembly

2. Fill the hub cavity with oil. 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.

3. Install the wheel bearing adjusting nut.

   3.1 After the wheel hub and bearings are assembled on the spindle, tighten the inner adjusting nut finger-tight.

   3.2 While rotating the wheel hub assembly, tighten the adjusting nut 100 lbf·ft (136 N·m).

   3.3 Back off the adjusting nut completely.

   3.4 Tighten the adjusting nut 20 lbf·ft (27 N·m) while rotating the wheel hub assembly.

   3.5 Back off the adjusting nut one-third turn.

   NOTE: If any holes in the lockring do not align with the dowel on the adjusting nut, remove the lockring, turn it over and install it again. If a hole still does not align with the dowel, loosen the adjusting nut, but only enough to align the dowel with a hole in the lockring.

4. Install the locking device and jam nut.

   4.1 Install the lockring and nut-lock.

   4.2 Then install the jam nut, and tighten it to the applicable torque in **Table 1**.

Dual-Nut Wheel Bearing Lock Torque Values		
Application	**Size**	**Torque: lbf·ft (N·m)**
Adjusting Nut	—	Stage 1: Tighten to 100 (135)
		Stage 2: Back Off Completely
		Stage 3: Tighten to 20 (25) While Rotating Hub
		Stage 4: Back Off 1/3 Turn
Jam Nut (with Wheel Bearing Nut, Pierced Lockwasher, and Bendable Lockwasher)	1-1/8	Target: 175 (235) Permissible Range: 150–225 (205–305)
	1-1/2 to 2-1/2	Target: 250 (340) Permissible Range: 200–300 (270–405)
	2-5/8 or Larger	Target: 325 (440) Permissible Range: 250–400 (340–540)

Table 1, Dual-Nut Wheel Bearing Lock Torque Values

Four-Piece Wheel Bearing System Installation and Adjustment

5. With the jam nut installed and tightened, adjust the wheel bearings.

   IMPORTANT: Do not adjust the wheel bearings with the wheel mounted on the hub. You cannot accurately adjust or measure the bearing end play with the wheel mounted on the hub.

   5.1 Attach a dial indicator to the hub and set the point of the indicator in line with the end of the axle spindle.

   If using aluminum hubs, you may have to install the brake drum on the hub to provide a steel base for the magnet of the dial indicator. Mount the drum on the hub's drum pilot. 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.

   5.2 Release the brakes if you used them to hold the drum while installing it.

   5.3 Grip the sides of the hub at the three o'clock and nine o'clock positions. Push in on the hub (and drum, if applicable), to seat the inboard bearing set. Zero the dial indicator.

   5.4 Once more, grip the sides of the hub at the three o'clock and nine o'clock positions. Pull out on the hub (and drum, if applicable). Read the dial indicator, and note the end play.

   5.5 Push the hub back in to confirm that the needle of the dial indicator returns to zero.

6. The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm). If the end play is not within this range, adjust the end play.

   6.1 Remove the jam nut and locking device. Back off or tighten the inner adjusting nut.

   6.2 Install the locking device and jam nut as described earlier, and measure the end play. If the end play is not between 0.001 and 0.005 inch (0.03 and 0.13 mm), turn the adjusting nut again.

   6.3 Once the end play is correct, bend two tabs of the nut-lock over opposing flats on the jam nut. This will lock the jam nut in place.

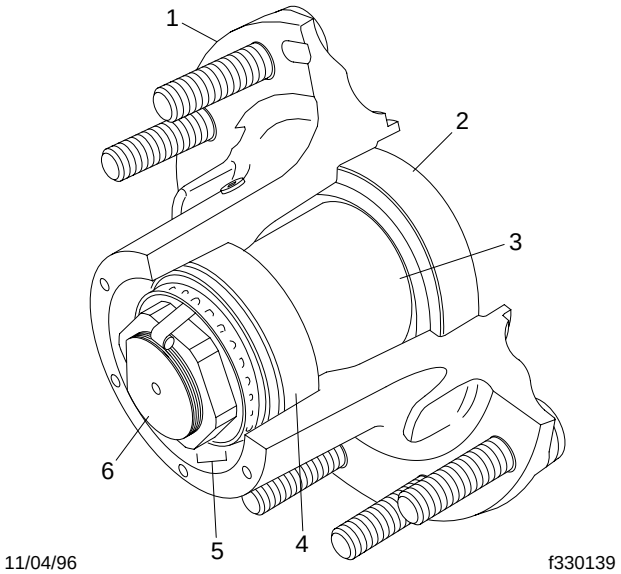
   6.4 Rotate the wheel in both directions. It should turn freely with no dragging or binding.

ConMet PreSet® Hub Installation and Adjustment

General Information

ConMet PreSet® steer axle hubs are equipped with a special tubular spacer inside the hub, between the inner and outer bearings. See **Fig. 1**.

Wheel bearing adjustment is unnecessary when installing these hubs, because the spacer, together with specially toleranced bearings, automatically sets the bearing end-play. Front axle PreSet hubs can be identified by the part number NP874005 stamped on the outer bearing cone. The outer bearing cone is visible when the retaining nut is removed. See **Fig. 2**.



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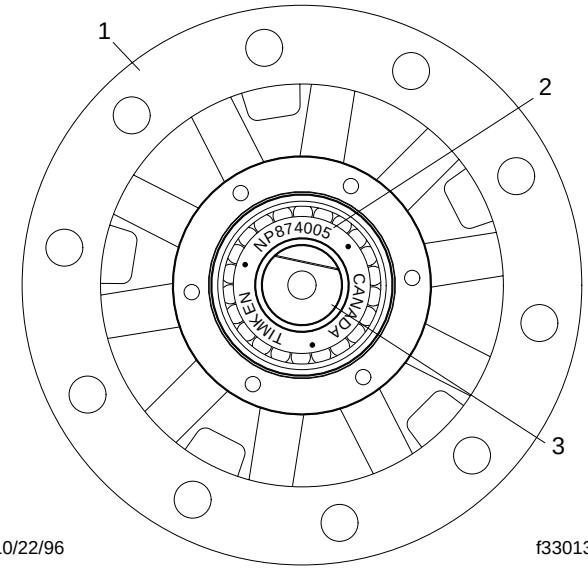
1. Hub
2. Inner Bearing
3. Bearing Spacer
4. Outer Bearing
5. Axilok® Retaining Nut
6. Axle Spindle

Fig. 1, ConMet PreSet Hub, Cut-Away View

NOTE: If you are replacing the bearings for a PreSet hub, and the required bearings are not available, use standard wheel bearings. Remove the bearing spacer and adjust the bearings manually. See the installation instructions for standard bearings under "Installation" in this subject.



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1. Front Axle Hub
2. Outer Bearing Cone and Part Number
3. Axle Spindle

Fig. 2, Identifying a ConMet PreSet Hub

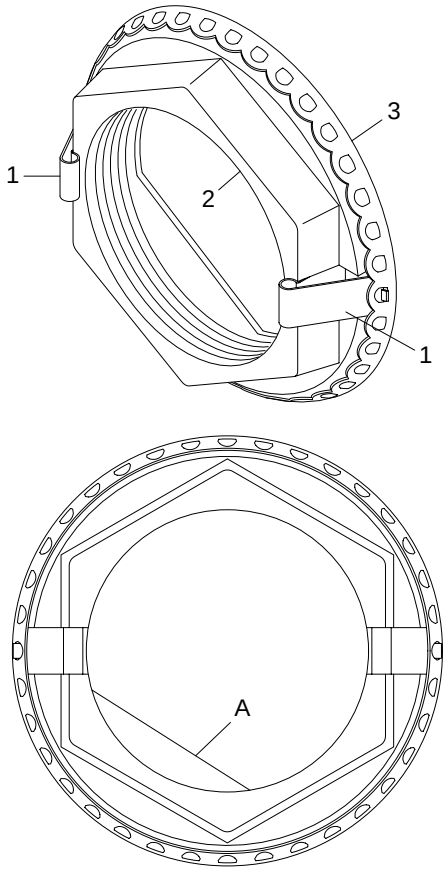
⚠ CAUTION

Do not use the bearing spacer with standard wheel bearings. To do so may result in too much bearing end-play, which could damage the wheel bearings, oil seals, the axle spindle, and the hub.

ConMet PreSet hubs use Axilok® retaining nuts. See **Fig. 3** and **Fig. 4**. Axilok retaining nuts can be damaged if they are not removed or installed correctly. Use the following guidelines when removing and installing Axilok retaining nuts:

- Use only the correct size, *six-point* socket to remove or install Axilok retaining nuts. Do not use a worn or loose-fitting socket. *Do not use a 12-point socket.*
- Do not use hammers, chisels, pliers, wrenches, or power tools to remove or install Axilok nuts.
- Do not use an Axilok nut if the locking clips are damaged or missing, or if the retainer cage tab or D-flat is damaged or missing.
- Never try to repair a damaged Axilok nut; always replace it with a new one.
- Always start an Axilok installation by hand. A good-fitting six-point socket will completely dis-

ConMet PreSet® Hub Installation and Adjustment



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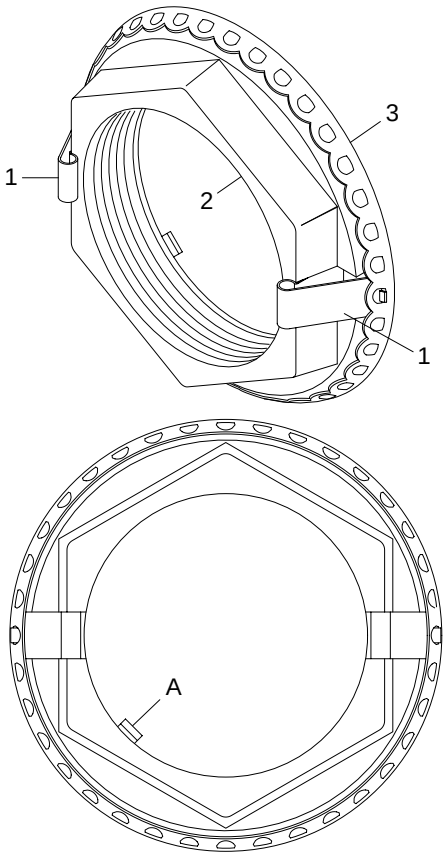
A. The flat side of the retainer must engage the flat side of the axle spindle.

1. Locking Clip
2. Nut
3. Retainer

Fig. 3, Axilok Retaining Nut, Meritor Front Axle



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A. This retainer tab must engage the keyway of the axle spindle.

1. Locking Clip
2. Nut
3. Retainer Cage

Fig. 4, Axilok Retaining Nut, Eaton Front Axle

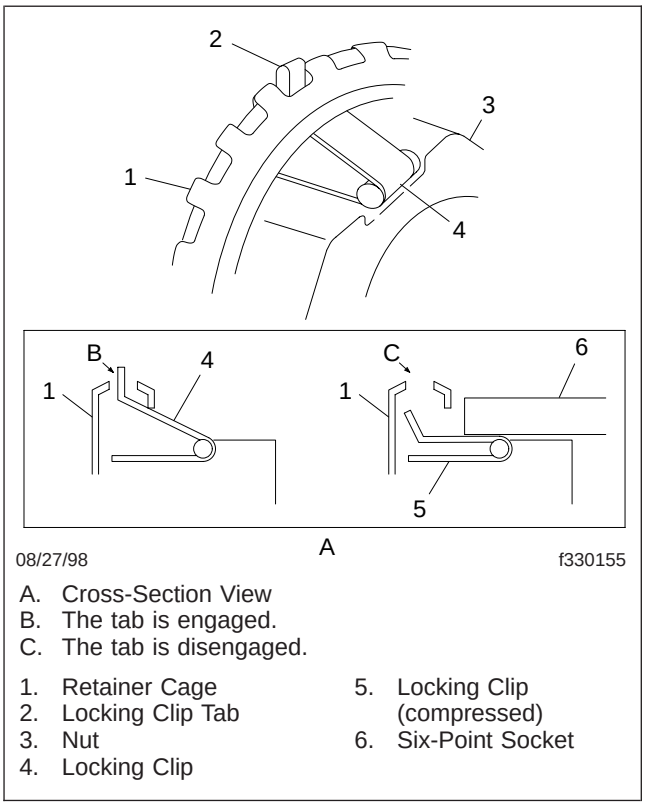
engage the nut's locking clips, allowing it to spin freely by hand. See **Fig. 5**. Use an accurately calibrated torque wrench to tighten the nut to its final torque value.

- After the nut is installed, always make sure that both locking clips are present and engaged in the retainer cage. See **Fig. 5**. If the locking clips are not engaged, the nut is not locked in position and can rotate freely.

Installation

Using PreSet Bearings

1. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.
2. If present, remove the temporary plastic bearing cover from the front of the hub.
3. Install the PreSet hub assembly all the way onto the axle spindle. A temporary plastic alignment



A. Cross-Section View
B. The tab is engaged.
C. The tab is disengaged.

1. Retainer Cage
2. Locking Clip Tab
3. Nut
4. Locking Clip
5. Locking Clip (compressed)
6. Six-Point Socket

Fig. 5, Axilok Nut, Checking the Position of the Locking Clip

sleeve may be installed in the center of a new hub. It will be pushed out when the hub is installed on the axle spindle. If it is present, remove and discard this sleeve.

4. To prevent damage to the oil seal, do not pull the hub back after beginning the hub installation.

CAUTION

Do not remove the outer wheel bearing once the hub is installed on the axle. Removing the outer bearing could cause the oil seal to become misaligned, which could cause damage to the wheel bearings, the hub, and the axle spindle.

WARNING

Follow the guidelines at the beginning of this subject when installing an Axilok nut. Axilok retaining nuts secure the hub assemblies on the axle. If the Axilok nut is not correctly installed, the hub could separate from the axle, resulting in severe personal injury or death.

5. Install the Axilok retaining nut (see **Fig. 3** or **Fig. 4**) onto the axle spindle.
6. Tighten the retaining nut 250 lbf·ft (339 N·m). Do not back off the retaining nut. The nut should lock in place when you remove the wrench. If it does not, advance it until it does.
7. Install the hub cap, using a new gasket. Tighten the capscrews 15 lbf·ft (20 N·m).

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. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

8. Fill the hub with fresh oil to the level shown on the hub cap. Do not overfill.

Using Standard Bearings

NOTE: Save the spacer for use when converting the hub back to the PreSet system.

CAUTION

Do not use the spacer with standard wheel bearings. To do so may result in too much bearing end-play, which could damage the wheel bearings, oil seals, the axle spindle, and the hub.

1. If not already done, remove the tubular spacer from inside the hub. Save it for future use to convert the hub back to the PreSet system.
2. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.
3. Coat both bearing assemblies with fresh oil. Install the inner wheel bearing and oil seal in the hub. See **Section 33.02** for instructions on installing the various types of oil seals.
4. Install the hub with the inner bearing and oil seal onto the axle spindle. Be careful not to unseat the inner bearing or oil seal.
5. Fill the hub cavity with oil, and install the outer wheel bearing.

ConMet PreSet® Hub Installation and Adjustment

CAUTION

Do not remove the outer wheel bearing once the hub is installed on the axle. Removing the outer bearing could cause the oil seal to become misaligned, which could cause damage to the wheel bearings, the hub, and the axle spindle.

6. Adjust the wheel bearings as follows.

WARNING

Follow the guidelines at the beginning of this subject when installing an Axilok nut. Axilok retaining nuts secure the hub assemblies on the axle. If the Axilok nut is not correctly installed, the hub could separate from the axle, resulting in severe personal injury or death.

CAUTION

To prevent damage to the locking clips, use the correct socket size. See Fig. 5. The socket is used to compress the locking clips, which allows the nut to rotate.

6.1 Install the Axilok nut (see **Fig. 3** or **Fig. 4**) and turn it against the bearing while spinning the hub.

6.2 Tighten the nut 90 to 110 lbf·ft (122 to 149 N·m) while spinning the hub in both directions.

6.3 Loosen the nut to zero torque and spin the hub a few turns.

6.4 Tighten the nut 50 lbf·ft (68 N·m) while spinning the hub in both directions. Back off the nut one-eighth to one-sixth turn.

6.5 Remove the wrench from the nut. The Axilok nut should automatically lock in place. If it does not, advance it until it does.

7. Using a dial indicator, measure the end play as follows.

IMPORTANT: Do not measure the wheel bearings with the wheel mounted on the hub. You cannot accurately measure or adjust bearing end play with the wheel mounted on the hub.

7.1 Attach a dial indicator to the hub and set the point of the indicator in line with the end of the axle spindle. The point of the indicator should be parallel to the spindle axis.

If equipped with aluminum hubs and air brakes, it may be necessary to install the brake drum onto the hub to provide a steel base for the magnet of the dial indicator. Mount the drum on the hub's drum pilot. Adjust the brake or have someone apply the brakes to hold the drum secure. Secure the drum using the stud at the 12 o'clock position. Then secure the studs at about the 4 o'clock and 8 o'clock positions.

If using a stud-piloted hub and a steel drum, install 1-1/4-inch washers between the nuts and the drum.

7.2 Grip the sides of the hub at the 3 o'clock and 9 o'clock positions. Push in on the hub (and drum, if applicable), to seat the inboard bearing set. Zero the dial indicator.

7.3 Again, grip the sides of the hub at the 3 o'clock and 9 o'clock positions. This time, pull out on the hub (and drum, if applicable). Read the dial indicator, and note the end play.

7.4 Push the hub back in to confirm that the needle of the dial indicator returns to zero.

WARNING

The wheel-bearing end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm). Correct end play is crucial: if the wheel-bearing end play is not correct, the wheel bearings could fail. This could cause the loss of the wheel and hub assembly, resulting in an accident causing serious injury or property damage. Use the dial indicator to measure the end play.

8. **The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm)**. If it is not within this range, remove the Axilok nut, and repeat the tightening sequence as described earlier in this procedure. Once the end play is correct, go to the next step.

9. Install the hub cap, using a new gasket. Tighten the capscrews 15 lbf·ft (20 N·m).

⚠ 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. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

10. Fill the hub with fresh oil to the level shown on the hub cap. Do not overfill.

Meritor Easy Steer Plus Hub Installation and Adjustment

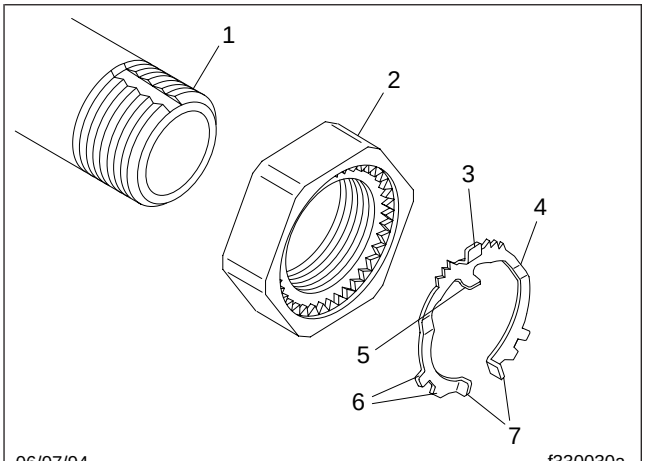
Installation and Adjustment

1. Apply Loctite® RTV 5699 sealant to the threads.
2. With the hub mounted on the axle spindle, install the inner (adjusting) nut and tighten it 600 lbf·ft (813 N·m).
3. Install the locking device (nut-lock, lockwasher, or both).
4. Install the jam nut and tighten it 350 lbf·ft (475 N·m).
5. Bend two opposing tangs of the nut-lock as needed to lock the jam nut and adjusting nut.

Pro-Torq® Nut Wheel Bearing-Lock System Installation and Adjustment

Installation and Adjustment

1. Carefully mount the hub and inner wheel bearing assembly on the axle spindle. See **Fig. 1**. Be careful not to unseat the inner wheel bearing or seal.



1. Axle Spindle
2. Pro-Torq Nut
3. Keeper Tab
4. Lockring
5. Keyway Tab
6. Keeper Arms
7. Keeper Projections

Fig. 1, Pro-Torq Nut Wheel Bearing-Lock Assembly, Eaton Front Axle Shown

2. Fill the hub cavity with oil. 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.
3. Install the Pro-Torq® nut, and turn it against the bearing while spinning the hub.
4. Tighten the adjusting nut 200 lbf·ft (270 N·m) while spinning the hub in both directions.

   Loosen the nut to zero torque and spin the hub a few turns.
5. *For Meritor and Sterling axles:* Tighten the nut 100 lbf·ft (136 N·m). Back off the nut one quarter-turn.

   For Eaton axles: Tighten the nut 75 lbf·ft (102 N·m). Back off the nut one third-turn.
6. Using a dial indicator, measure the end play as follows.

IMPORTANT: Do not measure the wheel bearings with the wheel mounted on the hub. You cannot accurately measure or adjust bearing end play with the wheel mounted on the hub.

6.1 Attach a dial indicator to the hub and set the point of the indicator in line with the end of the axle spindle. The point of the indicator should be parallel to the spindle axis.

If equipped with aluminum hubs and air brakes, it may be necessary to install the brake drum onto the hub to provide a steel base for the magnet of the dial indicator. Mount the drum on the hub's drum pilot. Adjust the brake or have someone apply the brakes to hold the drum secure. Secure the drum using the stud at the 12 o'clock position. Then secure the studs at about the 4 o'clock and 8 o'clock positions.

If using a stud-piloted hub and a steel drum, install 1-1/4-inch washers between the nuts and the drum.

6.2 Grip the sides of the hub at the three o'clock and nine o'clock positions. Push in on the hub (and drum, if applicable), to seat the inboard bearing set. Zero the dial indicator.

6.3 Again, grip the sides of the hub at the three o'clock and nine o'clock positions. This time, pull out on the hub (and drum, if applicable). Read the dial indicator, and note the end play.

6.4 Push the hub back in to confirm that the needle of the dial indicator returns to zero.

⚠ WARNING

The wheel-bearing end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm). Correct end play is crucial: if the wheel-bearing end play is not correct, the wheel bearings could fail. This could cause the loss of the wheel and hub assembly, resulting in an accident causing serious injury or property damage. Use the dial indicator to measure the end play.

Pro-Torq® Nut Wheel Bearing-Lock System Installation and Adjustment

7. **The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm)**. If it is not within this range, remove the Pro-Torq nut, and repeat the tightening sequence as described in previous steps. Once the end play is correct, go to the next step.
8. Hold the lockring with the keeper projections facing outboard. See **Fig. 2**.

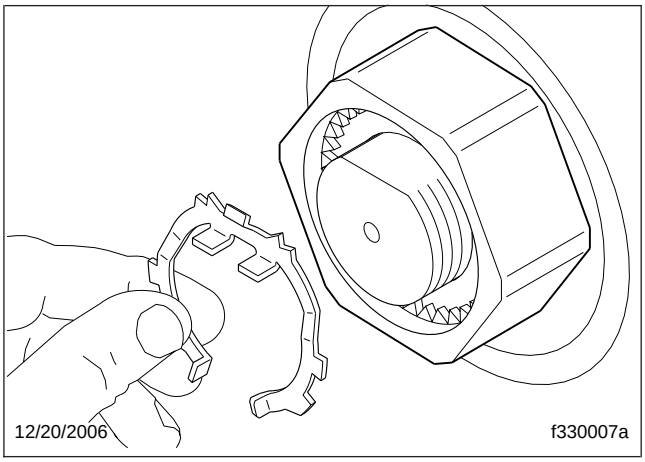


Fig. 2, Lockring Position, Meritor Front Axle Shown

WARNING

The keeper must be installed. If the keeper is not installed, the nut will back off, causing wheel loss. Wheel loss could cause an accident, possibly resulting in personal injury or property damage.

9. *For Meritor and Sterling axles:* Insert the keeper tab in the undercut groove of the Pro-Torq nut, while pressing the keyway tabs on the flat surface of the axle spindle, engaging the mating teeth.

   For Eaton axles: Insert the keeper tab in the undercut groove of the Pro-Torq nut, while pressing the keyway tab into the keyway of the axle spindle, engaging the mating teeth.
10. Insert a screwdriver, or similar tool, in the undercut groove of the nut, between the keeper arms. See **Fig. 3**. Using the tool, compress the lockring to lock it in place.

    Using the screwdriver, press around the edges of the lockring to be sure it is locked in place. See **Fig. 4**.

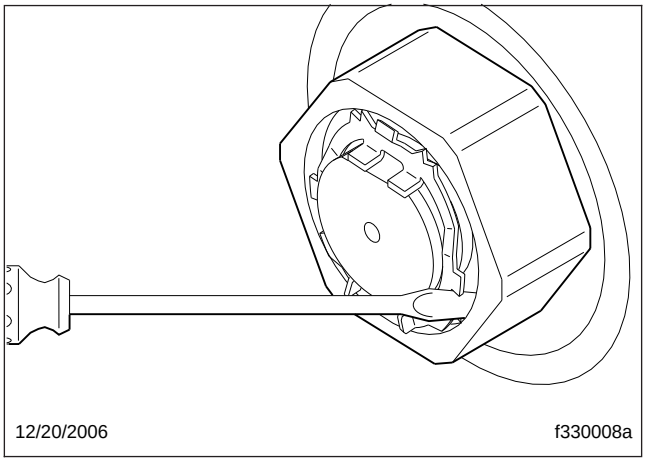


Fig. 3, Compressing the Lockring, Meritor Front Axle Shown

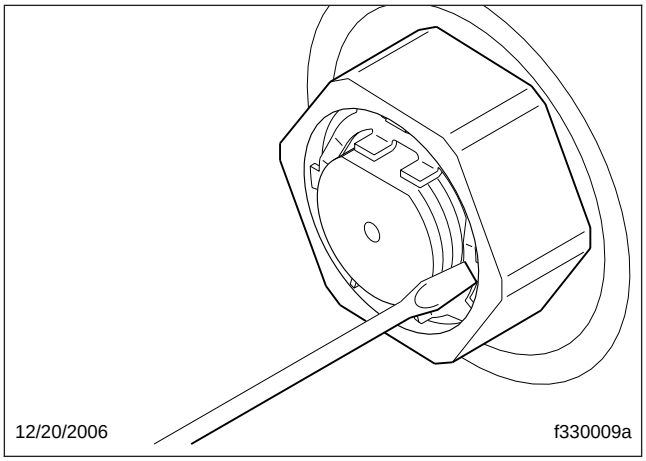


Fig. 4, Making Sure the Lockring is Locked, Meritor Axle Shown

CAUTION

Do not use pliers or similar devices on the keeper projections to compress the lockring. This could result in damage or breakage of the lockring.

Troubleshooting Tables

Problem—Noisy Bearings or Excessive Bearing Replacement Intervals

Problem—Noisy Bearings or Excessive Bearing Replacement Intervals	
Possible Cause	**Remedy**
Not enough, or wrong type of oil on bearings	Clean, then inspect the bearings for wear. Replace worn seals. Coat the bearing assemblies with fresh oil. Fill the hub to the level indicated on the hub cap. Check the hub cap for cracks or a damaged plug.
Foreign matter or corrosive agents entered bearing assembly; dirt or metallic debris not removed from bearings	Clean, then inspect the bearings for wear. Replace worn seals. Also clean the wheel hub, the axle spindle, and any other component in contact with the bearing lubricant. Fill the hub to the level indicated on the hub cap. Check the hub cap for cracks or a damaged plug.
Noise and wear caused by incorrect adjustment of wheel bearings	Adjust the wheel bearings following the applicable instructions in this section.
Flat spots or dents on roller surface caused by skidding of roller, or improper handling of 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**. Fill the hub to the level indicated on the hub cap. Check the hub cap for cracks or a damaged plug.

Problem—Broken Wheel or Rim Studs

Problem—Broken Wheel or Rim Studs	
Possible Cause	**Remedy**
Under-torqued wheel nuts	Replace the studs. Inspect the disc wheel and replace it if the mounting hole shows wear. Install the disc wheel using the proper torque and torque sequence.
Overtightened wheel or rim nuts	Replace the wheel or rim studs. See **Group 40** for the wheel or rim nut tightening sequence.
Incorrect nut tightening sequence used	
Mismatched wheels (hub-piloted wheels mixed with stud-piloted wheels)	Install properly matched wheels.
Overloaded vehicle	Do not exceed the maximum load-carrying capacity of the vehicle.

Problem—Damaged Hub

Problem—Damaged Hub	
Possible Cause	**Remedy**
Cracked hub; local surface of an aluminum hub was heated higher than 350°F (177°C) during bearing cup removal	Replace the hub assembly. When removing the bearing cup, oven-heat the hub.
Bent flange; incorrect installation of wheel studs, such as using a hammer and drift, or hub flange not fully supported on press during wheel stud replacement	Replace the hub assembly. Replace the wheel studs.
Wrong brake drums installed	Install new brake drums.
Insufficient tightening of wheel nuts to wheel hub	Replace the hub assembly and tighten the wheel nuts to the values in the torque table in **Specifications, 400**.

Troubleshooting

Problem—Damaged Hub	
Possible Cause	**Remedy**
Overloaded vehicle	Do not exceed the maximum load-carrying capacity of the vehicle.
Brake drum not seated properly before disc wheel installed and nuts torqued	Make sure brake drum is seated properly on hub before disc wheel is installed.

Problem—Loss of Lubricant from the Wheel Hubs

Problem—Loss of Lubricant from the Wheel Hubs	
Possible Cause	**Remedy**
Loose capscrew on hub cap	Tighten capscrews.
Cracked or damaged hub or missing or loose plug	Replace hub or plug.
Worn or damaged seals or gaskets	Replace worn or damaged parts.
Cracked hub barrel	Replace the hub.

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**
Dirt or grease has built up on brake linings (glazing), or brake linings have worn excessively	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums. Inspect the hub and seals for oil or grease leaks. Replace as required.
Heat-checked or cracked brake drums	Install new brake drums.
Air system failure	Make sure both front and rear brakes are working properly.

Problem—Service Brakes Grab or Pull

Problem—Service Brakes Grab or Pull	
Possible Cause	**Remedy**
For detailed information, see **Group 42**.	

Problem—Poor Lining-to-Drum Contact

Problem—Poor Lining-to-Drum Contact	
Possible Cause	**Remedy**
Scored or grooved inside surface of the brake drum	Install new brake linings on both sets of axle brake shoes. Install new brake drums or turn the drums.
Stretched or bent brake shoes	Replace the brake shoes.
Undersized linings installed	Install new brake linings on both sets of axle brake shoes.
Incorrect grind was used on the brake linings	
Wrong brake drums were installed	Install new brake drums.

Problem—Poor Lining-to-Drum Contact	
Possible Cause	**Remedy**
Incorrect adjustment of the wheel bearings is causing wheel instability	Adjust the wheel bearings following the applicable instructions in this section.

Problem—Brake Linings are Tapered Across the Width

Problem—Brake Linings are Tapered Across the Width	
Possible Cause	**Remedy**
Inside surface of the brake drum is scored or grooved	Install new brake linings on both sets of axle brake shoes. Turn or replace the drums.
Bent brake shoes	Replace the brake shoes.
Incorrect adjustment of the wheel bearings is causing wheel instability	Adjust the wheel bearings following the applicable instructions in this section.

Problem—Brake Shoes on the Same Brake are Wearing Unequally

Problem—Brake Shoes on the Same Brake are Wearing Unequally	
Possible Cause	**Remedy**
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 on both sets of axle brake shoes. Clean, turn, or replace the drums.
Stretched brake shoes	Replace the brake shoes.

Problem—Shoes on Each Side of the Axle (Side-to-Side Brakes) are Wearing Unequally

Problem—Shoes on Each Side of the Axle (Side-to-Side Brakes) are Wearing Unequally	
Possible Cause	**Remedy**
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 on both sets of axle brake shoes. Clean, turn, or replace the drums.
Inside surface of the brake drum is in poor condition	Turn or replace the drums.
Out of adjustment wheel bearings	Adjust the wheel bearings following the applicable instructions in this section.

Problem—Edge of the Lining is Showing Wear

Problem—Edge of the Lining is Showing Wear	
Possible Cause	**Remedy**
Brake lining too wide	Install new brake linings on both sets of axle brake shoes.
Brake linings are misaligned because of incorrectly drilled brake lining holes	
Undersized brake drums installed	Install new brake drums.
Out of adjustment wheel bearings	Adjust the wheel bearings following the applicable instructions in this section.

Troubleshooting

Problem—Edge of the Lining is Showing Wear	
Possible Cause	**Remedy**
Incorrect fit of the hub onto the spindle due to the wrong wheel bearings	Install new wheel bearings and adjust them following the applicable instructions in this section.
Bent brake shoes	Replace the brake shoes.

Problem—Brake Linings are Scored or Grooved

Problem—Brake Linings are Scored or Grooved	
Possible Cause	**Remedy**
Worn or scored brake drums have been causing poor contact with the brake linings	Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums.
Abrasive material between the lining and drum	

Problem—Brake Linings are Loose

Problem—Brake Linings are Loose	
Possible Cause	**Remedy**
Rivet holes in brake shoes are too large	Replace the brake shoes.
Incorrectly crimped rivets are working loose and allowing the linings to move	Replace the rivets.
Rust has built up on the shoe table	Clean the brake shoe table of all rust, dirt, scale, and paint.

Problem—Brake Lining is Cracked at the Rivet Holes or Bolt Holes

Problem—Brake Lining is Cracked at the Rivet Holes or Bolt Holes	
Possible Cause	**Remedy**
Overtightening of the lining bolts is causing cracks	Install new brake linings. Replace the rivets or bolts with the correct size.
Wrong size counter bore for the rivet holes was made	
Wrong rivets or bolts were used	Replace the rivets or bolts with the correct size.
Incorrectly crimped rivets are working loose and allowing the linings to move	Replace the rivets.
Rust has built up on shoe table	Clean the brake shoe table of all rust, dirt, scale, and paint.

Problem—Out-of-Round Rivet Holes or Bolt Holes

Problem—Out-of-Round Rivet Holes or Bolt Holes	
Possible Cause	**Remedy**
Loose rivets or bolts	Replace the brake shoes or linings.

Problem—Brake Drums are Heat-Checked

Problem—Brake Drums are Heat-Checked	
Possible Cause	**Remedy**
Out-of-round brake drums	Turn or replace the brake drums.
Wrong brake drums installed	Install new brake drums.
Out of adjustment wheel bearings	Adjust the wheel bearings following the applicable instructions in this section.
Brake linings glazed (dirt or grease build-up) or worn unevenly	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
Incorrect lining friction material for operation of vehicle	
Brake imbalance between tractor and trailer	Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed.
Drum not seated properly before disc wheel installed and nuts torqued	Make sure brake drum is properly seated on the hub before the disc wheel is installed.

Problem—Brake Drums are Heavily Scored

Problem—Brake Drums are Heavily Scored	
Possible Cause	**Remedy**
Damaged brake linings	Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums.
Excessive wear on linings	
On the last brake reline, the drums were not turned	Turn the brake drums.

Problem—Excessive Brake Lining Wear

Problem—Excessive Brake Lining Wear	
Possible Cause	**Remedy**
Brake imbalance between tractor and trailer	Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed.

Problem—Hard Steering

Problem—Hard Steering	
Possible Cause	**Remedy**
Low tire pressure in one or both front tires	Inflate tires to the correct pressure.
Binding in steering gear due to lack of lubrication	Test the steering system for binding with the front tires off the ground. For instructions, see **Group 46**.
Too much caster angle in front wheels	Check the caster angle and adjust as needed.
Sagging front suspension due to damaged spring	Repair or replace the spring as needed. For instructions, see **Group 32**.
Bent axle spindle	Replace the spindle.
Misaligned frame	Check the frame alignment; correct, as needed.

Troubleshooting

Problem—Erratic Steering When the Brakes are Applied

Problem—Erratic Steering When the Brakes are Applied	
Possible Cause	**Remedy**
Low tire pressure in one or both front tires	Inflate the tires to the correct pressure.
One or more loose front axle spring U-bolt nuts	Check the U-bolt nuts for looseness. If loose, check the U-bolt for damage. Replace damaged parts; tighten loose nuts.
Brakes not adjusted evenly	Adjust the brakes on all axles. Also, check the operation of the slack adjusters.
Grease or oil contamination of brake linings reducing brake effectiveness	Replace the brake linings and clean the drums. Find and correct the cause of grease or oil contamination.
Wrong caster angle	Check, and adjust as needed.
Bent axle spindle	Replace the axle spindle.
Worn or incorrectly adjusted front axle wheel bearings	Check the bearings for wear or damage; replace as needed.

Problem—Vehicle Pulls to One Side During Operation

Problem—Vehicle Pulls to One Side During Operation	
Possible Cause	**Remedy**
Low tire pressure in one or both front tires	Inflate the tires to the correct pressure.
One or more incorrect alignment measurements	Check all the alignment measurements. Correct as needed.
Out-of-round wheels or tires	Inspect the wheels and tires. Replace out-of-round parts.
Too tightly adjusted front axle wheel bearings	Check the bearings for wear or other damage. Replace the bearings if needed.
Sagging front suspension due to damaged spring	Repair or replace the spring as needed. For instructions, see **Group 32**.
Bent axle spindle	Replace the spindle.
Misaligned frame	Check the frame alignment; correct as needed.
Out of alignment rear axle(s)	Check, and if needed, adjust the rear axle alignment.

Problem—Front Wheel Wander

Problem—Front Wheel Wander	
Possible Cause	**Remedy**
One or more out-of-balance wheels or brake drums	Balance the wheels. Check for out-of-round brake drums; correct as needed.
One weak or broken front springs	Repair or replace the spring as needed. For instructions, see **Group 32**.

Problem—Front Wheel Shimmy

Problem—Front Wheel Shimmy	
Possible Cause	**Remedy**
Low tire pressure in one or both front tires	Inflate the tires to the correct pressure.

Troubleshooting

Problem—Front Wheel Shimmy	
Possible Cause	**Remedy**
One or more out-of-balance wheels or brake drums	Balance the wheels. Check for out-of-round brake drums, correct or replace as needed. Check hub and drum for proper installation.
One or more out-of-round or bulged tires	Replace the tire.
Worn or incorrectly adjusted front axle wheel bearings	Check the bearings for wear or other damage. Replace the bearings if needed.
Worn parts of steering gear or linkage	Test for play in the steering gear and linkage with the front tires off the ground. Replace parts as needed.
Bent axle spindle	Replace the spindle.
One or more incorrect alignment measurements	Check all alignment measurements and correct as needed.
Loose knuckle pin due to worn bushings	Inspect the knuckle pin and bushings for damage. Replace worn or damaged parts as needed.
Worn or damaged shock absorbers	Check the shock absorbers and replace if needed.

Problem—Vehicle Wanders

Problem—Vehicle Wanders	
Possible Cause	**Remedy**
Low tire pressure in one or both front tires	Inflate the tires to the correct pressure.
One or more incorrect alignment measurements	Check all of the alignment measurements; correct as needed.
Out of alignment rear axle(s)	Check the rear axle alignment and adjust as needed.
Worn parts of steering gear or linkage	Test for play in the steering gear and linkage with the front tires off the ground. Replace parts as needed.
Loose knuckle pin due to worn bushings	Inspect the knuckle pin and bushings for damage. Replace worn or damaged parts.
Bent axle spindle	Replace the spindle.

Problem—Cupped Tires

Problem—Cupped Tires	
Possible Cause	**Remedy**
Too low or too high tire pressure in one or both front tires	Inflate or deflate the tires to the correct pressure.
One or more out-of-balance wheels or brake drums	Balance the wheels. Check for eccentric brake drums; correct or replace as needed. Check hub and drum for proper installation.
Incorrect wheel toe-in	Adjust the wheel toe-in.
Brakes not adjusted evenly	Adjust the brakes on all axles. Also, check the operation of the slack adjusters.
Worn or incorrectly adjusted front axle wheel bearings	Check the bearings for wear or other damage; replace them if needed.

Troubleshooting

Problem—Cupped Tires	
Possible Cause	**Remedy**
Camber angle 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**
Steering gear not centered	Center the steering gear.
If adjustable, out of adjustment drag link	Adjust the drag link.
Steering wheel not installed (positioned) correctly on steering column	Reposition the steering wheel on the steering column.
Pitman arm not correctly aligned with timing mark on steering gear output shaft	Reposition the pitman arm on the steering gear output shaft. For instructions, see **Group 46**.

Specifications

Dual-Nut Wheel Bearing Lock Torque Values		
Application	**Size**	**Torque: lbf·ft (N·m)**
Adjusting Nut	—	Stage 1: Tighten to 100 (135)
		Stage 2: Back Off Completely
		Stage 3: Tighten to 20 (25) While Rotating Hub
		Stage 4: Back Off 1/3 Turn
Jam Nut (with Wheel Bearing Nut, Pierced Lockwasher, and Bendable Lockwasher)	1-1/8	Target: 175 (235) Permissible Range: 150–225 (205–305)
	1-1/2 to 2-1/2	Target: 250 (340) Permissible Range: 200–300 (270–405)
	2-5/8 or Larger	Target: 325 (440) Permissible Range: 250–400 (340–540)

Table 1, Dual-Nut Wheel Bearing Lock Torque Values

Dana Spicer® Axle Recommended Lubricant		
Lubricant Type	**Condition**	**SAE Viscosity Grade**
Eaton Roadranger® Synthetic Axle Lubricants, or Equivalent with Military Specification MIL–L–2105D	Over-the-Road Service	75W–90
	Off-Highway Equipment, or Under Extra Heavy Loads	80W–140

Table 2, Dana Spicer Axle Recommended Lubricant

Meritor Axle Recommended Lubricant			
Lubricant Type	**Ambient Temperature**	**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

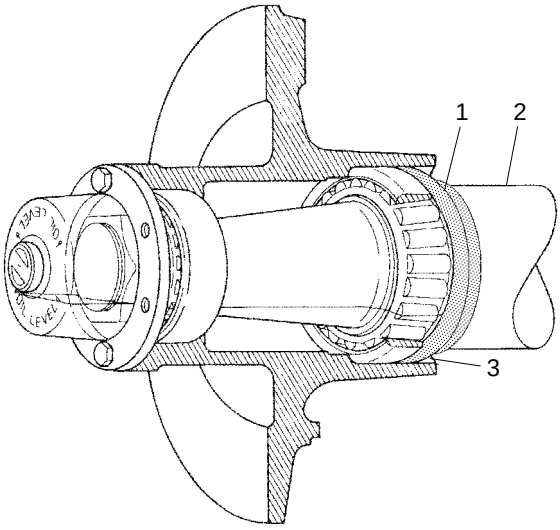
* There is no upper limit on these ambient temperatures, but axle sump temperature must never exceed 250°F (121°C).

Table 3, Meritor Axle Recommended Lubricant

General Information

Wheel oil seals (also called "oil bath seals" or "hub seals") work as a dam to keep oil in the hub cavity so that it constantly "bathes" the wheel bearings. The seals also protect the wheel bearings by keeping dirt, dust, and water out of the hub.

The oil seal fits between the hub bore and the axle spindle (see **Fig. 1**). The sealing element either turns with the wheel and seals against the axle spindle (*hub-mounted seals*), or the sealing element stays stationary with the axle spindle and seals against the turning hub (*spindle-mounted seals*).



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1. Wheel Oil Seal
2. Axle Spindle
3. Wheel Hub Bore

Fig. 1, Stemco Spindle-Mounted Wheel Oil Seal

Most wheel oil seals consist of four basic parts:

- the outside edge (also called the outer "cup" or "case")
- the inside edge (also called the inner "cup" or "case")
- the sealing element
- the garter spring

The outside edge is usually metal coated with rubber or another sealing agent so that it grips the hub bore tightly enough to prevent oil escaping between the outer edge of the seal and the hub bore.

The inside edge is usually metal or rubber with a metal ring within it to prevent the sealing element from wearing a groove in the axle spindle.

The sealing element is usually molded rubber, leather, or a synthetic such as nitrile or silicone. The element is molded into lips which will seal against the axle spindle or against the outside or inside edge described above. The innermost lip, called the "primary lip," keeps the oil inside the hub cavity. The outermost lip, called the "secondary lip," keeps dirt out of the hub cavity.

The garter spring is a coiled wire spring with its ends connected to make a loop. On hub-mounted seals, the spring runs around the outside of the sealing element to press the element inwards against the sealing surface. On spindle-mounted seals, the spring runs around the inside of the sealing element to press the element outward against the sealing surface.

Sterling uses two brands of axle oil seals:

- Chicago Rawhide (Scotseal® and Scotseal Plus®)
- Stemco (Guardian® and SS4®)

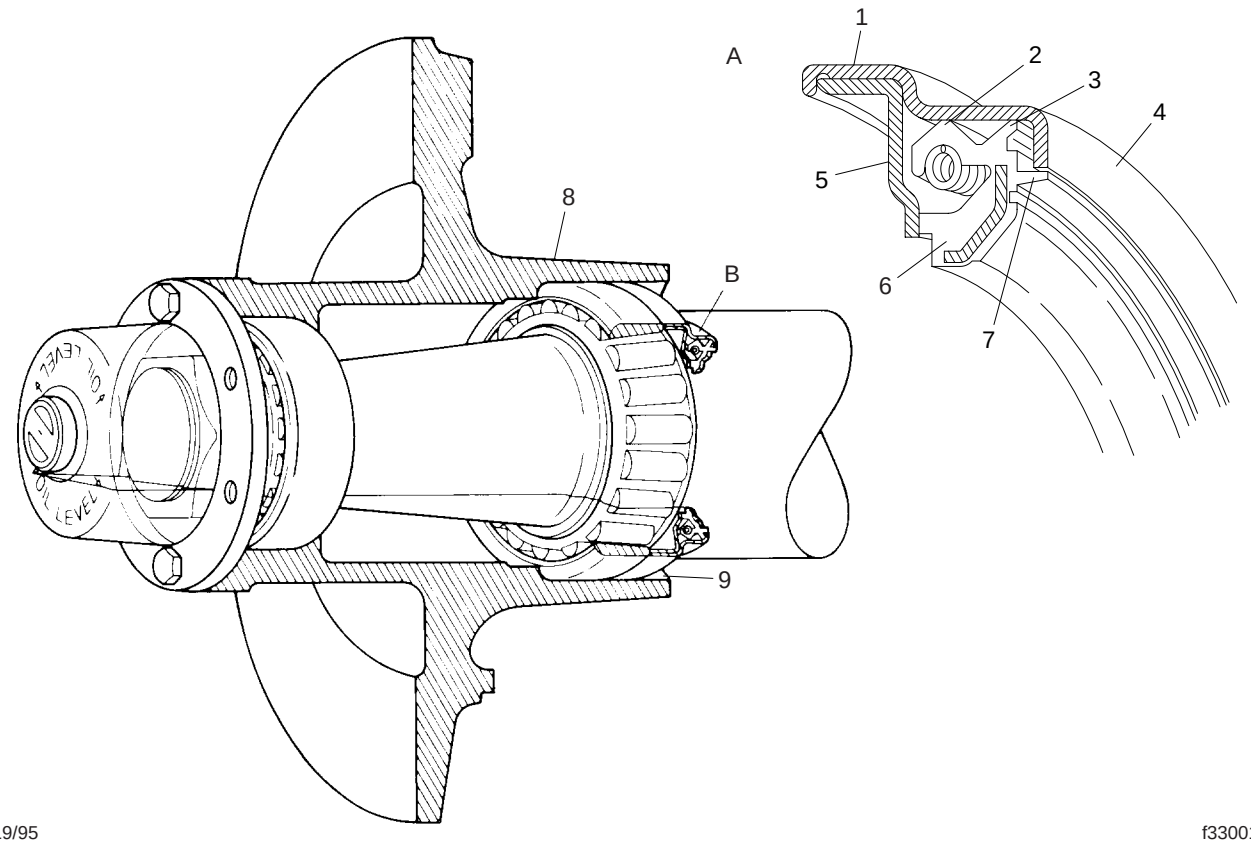
Chicago Rawhide (See Fig. 2)

The Chicago Rawhide Scotseal® is a unitized, one-piece design consisting of a sealing element (packing) that is assembled between metal outer and inner cups. The sealing element consists of three sealing lips; a spring-loaded primary sealing lip that is factory pre-lubed and two dirt exclusion lips. The seal is press fit into the hub bore using Scotseal® service installation tools. *Do not install the Scotseal® directly onto the axle spindle.*

Although you install the Scotseal® into the hub bore, the seal's element grips the axle spindle tightly enough that the sealing element stays stationary with the spindle and seals against the outer cup which turns with the hub.

The Chicago Rawhide Scotseal® maintains a metal-to-metal contact between the outer cup and the hub bore surface as well as a metal-to-metal contact between the sealing element inside edge and the axle spindle.

General Information



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A. Oil Seal (sectional view)
B. Oil Seal

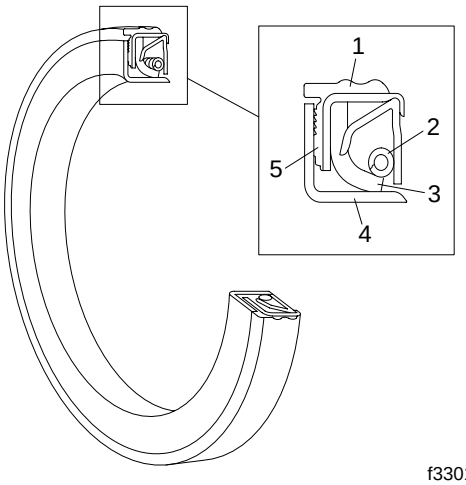
1. Bore-Tite® Coating
2 Primary Sealing Lip
3. Dirt Lip
4. Outer Cup
5. Inner Cup
6. Sealing Element (Packing)
7. Bumper Lip
8. Hub
9. Hub Bore

Fig. 2, Chicago Rawhide Scotseal®

Stemco (See Fig. 3 and Fig. 4)

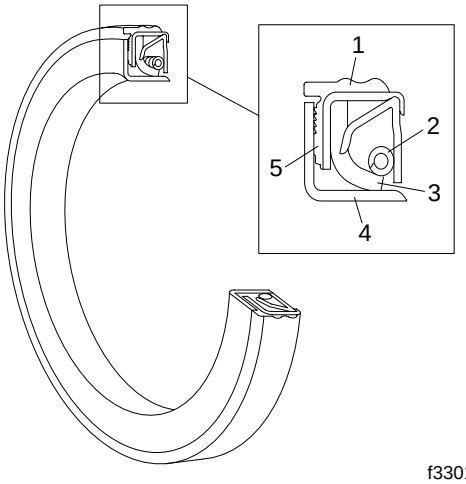
The Stemco wheel oil seals are spindle-mounted, with a rubber-coated outside edge that grips inside the hub bore and also holds the sealing element.

Although you install the Stemco seal onto the axle spindle, the outside edge grips the hub bore tight enough that the sealing element turns with the hub and seals against the inside edge which grips the axle spindle and acts as a wear sleeve.



1. Metal and Rubber Outside Edge
2. Garter Spring
3. Sealing Element (Elasto-Leather, Primary Lip)
4. Inside Edge
5. Secondary Lips

Fig. 3, Stemco Guardian® Wheel Oil Seal



1. Metal and Rubber Outside Edge
2. Garter Spring
3. Sealing Element (Teflon, Primary Lip)
4. Inside Edge
5. Secondary Lips

Fig. 4, Stemco SS4® Wheel Oil Seal

Seal Replacement, Chicago Rawhide

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

NOTE: This procedure applies to the Chicago Rawhide Scotseal®.

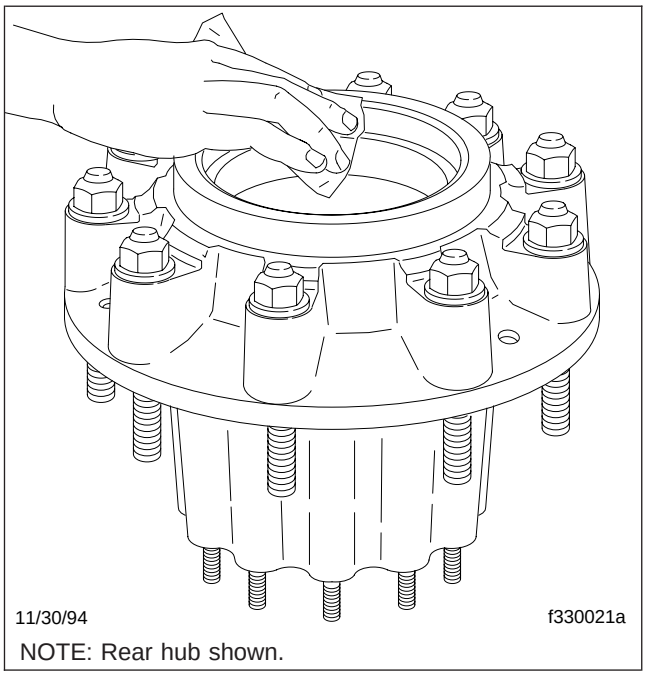
1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 33.01**.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity. See **Fig. 1** and **Fig. 2**.
4. Remove all burrs from the shoulder and the seal bore with an emery cloth or a file. Clean any metal filings from the components.

⚠ CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

5. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.
6. Coat the wheel bearing cones with oil.
7. Install the inner wheel bearing cone in the inner wheel bearing cup.



NOTE: Rear hub shown.

Fig. 1, Clean the Hub

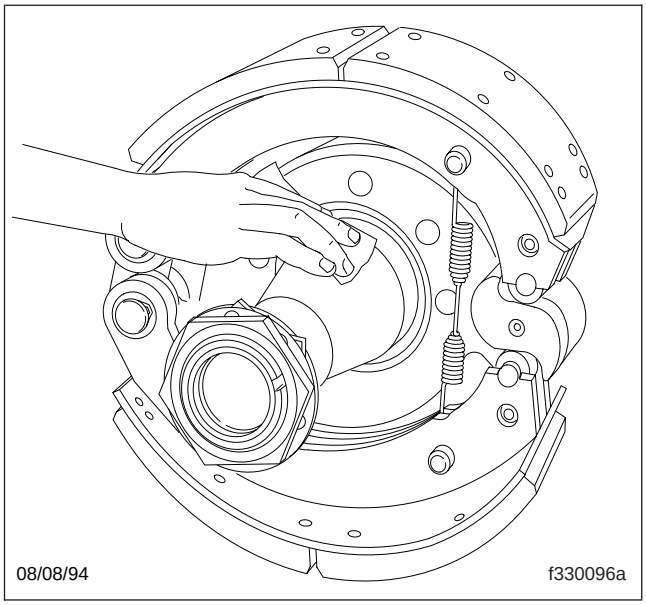


Fig. 2, Clean the Spindle

8. Seat the small outside edge of the seal in the recess of the tool adapter. See **Fig. 3**. The correct adapter is identified on the box.

Seal Replacement, Chicago Rawhide

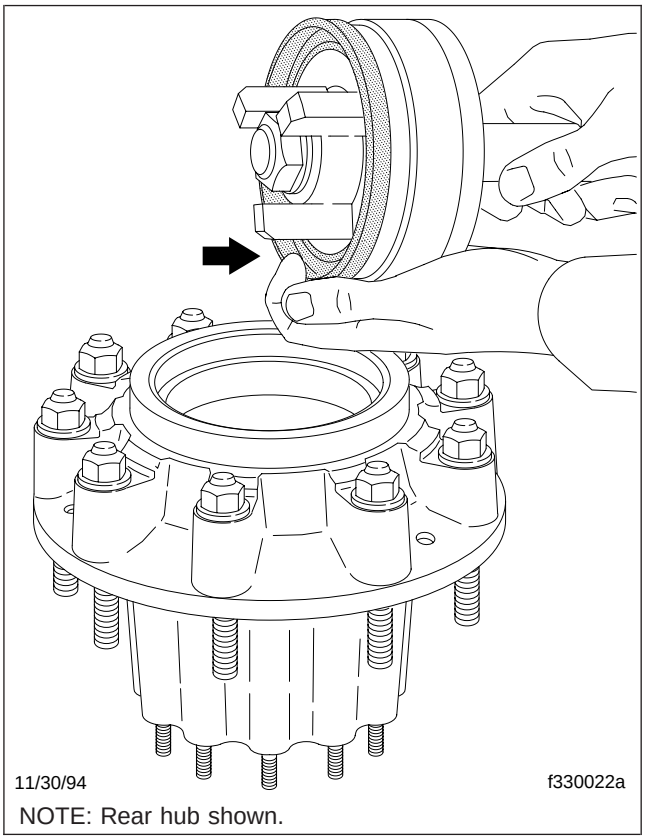


Fig. 3, Place the Seal on the Installation Tool

9. Insert the centering plug of the tool in the bore of the inner bearing cone. See **Fig. 4**. The plug prevents cocking of the seal in the bore.
10. Hold the tool handle firmly, and strike it until the sound of the impact changes as the seal bottoms out. See **Fig. 5**. Hold the tool firmly to avoid bounce or unseating of the seal from the adapter.
11. 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.
12. Install the wheel hub on the axle, and adjust the wheel bearings. For instructions, see **Section 33.01**.

IMPORTANT: When starting the wheel on the spindle, center the hub carefully to avoid seal damage from the leading edge of the spindle.

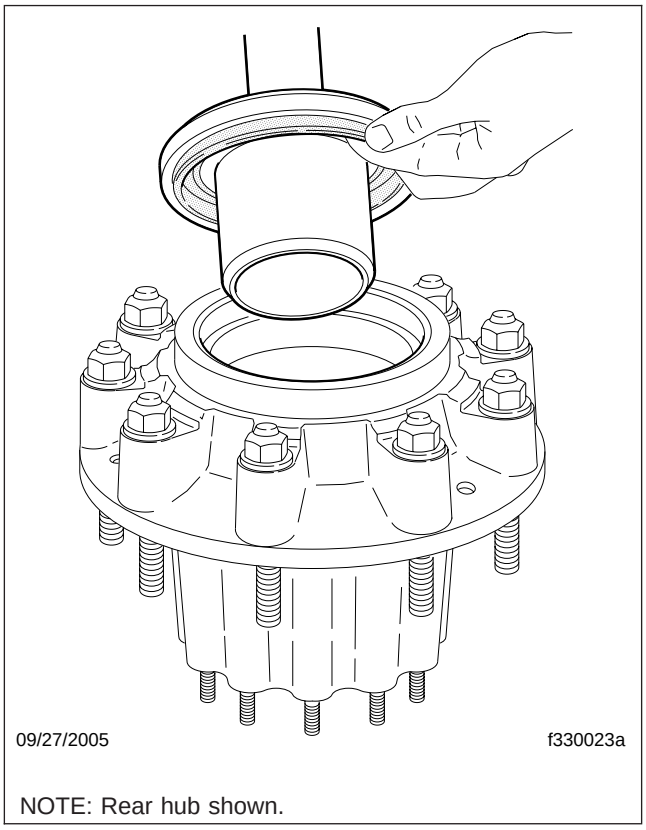
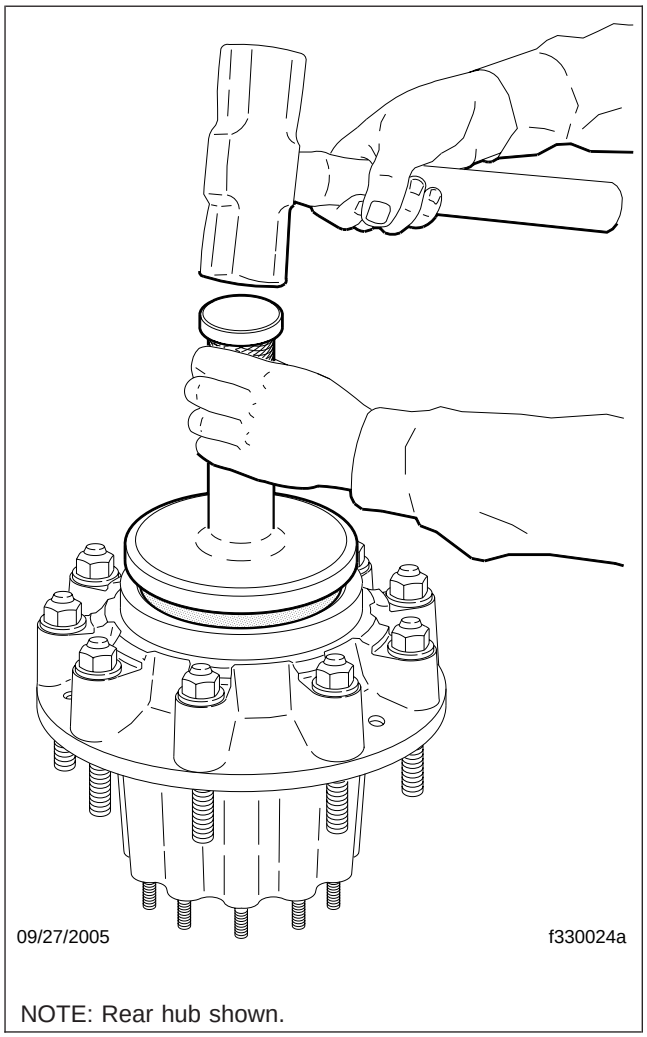


Fig. 4, Insert the Tool in the Hub Bore

13. Place the hubcap and a new gasket in position. Install the capscrews. Tighten the capscrews 15 lbf·in (20 N·m).
14. Fill the hub with oil to the level shown on the hubcap. See **Fig. 6**. Do not overfill.
15. Spin the wheel and check the oil level.
16. Adjust the brake shoe-to-drum clearance. For instructions, see **Group 42**.

Seal Replacement, Chicago Rawhide



NOTE: Rear hub shown.

Fig. 5, Strike the Tool

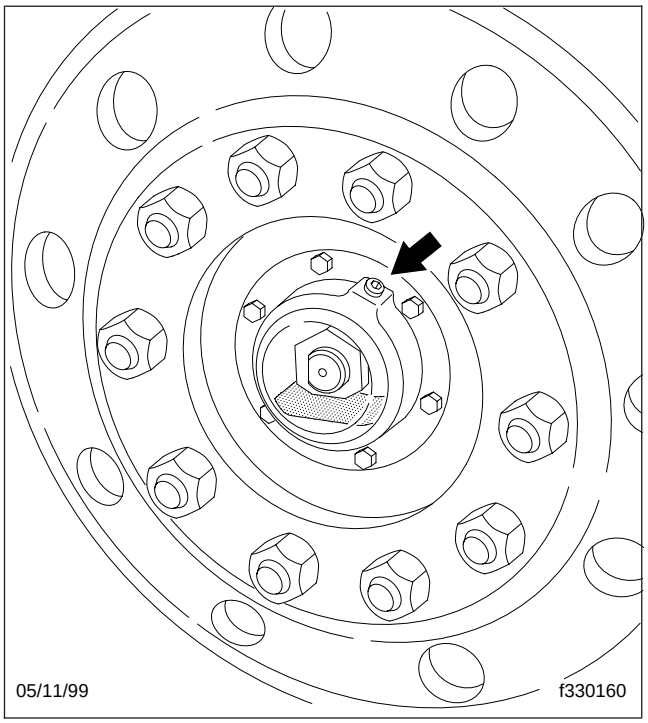


Fig. 6, Hub Filler Plug

Seal Replacement, Stemco®

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 33.01**.
2. Remove the old oil seal from the hub or spindle.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity.

⚠ CAUTION

Never use a sharp chisel to cut through an axle ring. A sharp chisel could damage the spindle or shoulder.

4. Remove the steel axle ring by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.

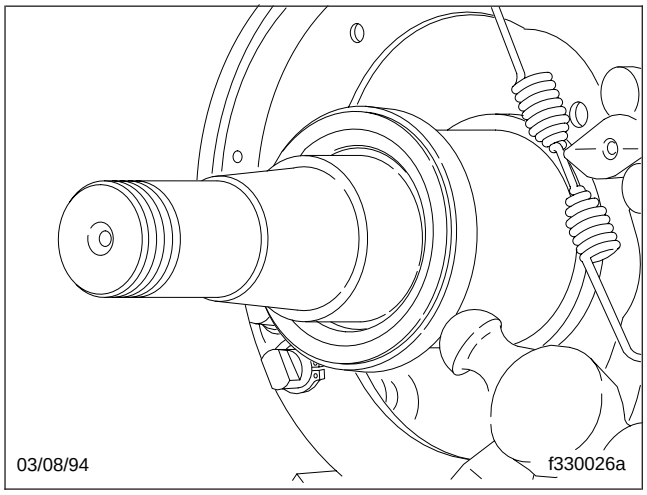


Fig. 1, Remove the Axle Ring

5. Using a wire brush, remove any old sealant and corrosion from the axle spindle and shoulder. Remove any burrs with an emery cloth. See **Fig. 2**. Wipe the spindle and shoulder clean with safety solvent.

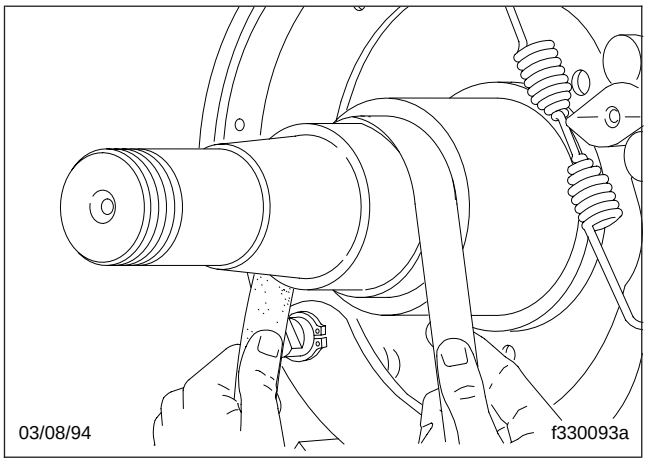
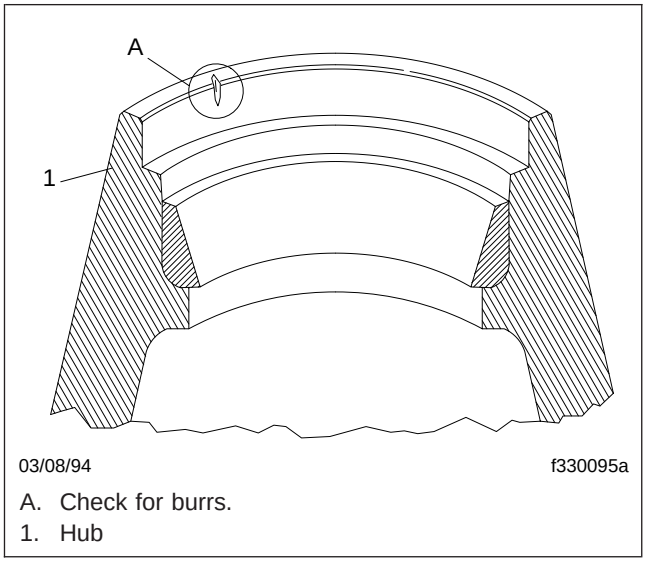


Fig. 2, Clean the Axle Spindle

6. Remove any burrs from the inside of the hub bore. See **Fig. 3**. The hub bore must be free of burrs that will scratch the outer surface of the seal and allow oil to escape from the hub. Remove any spacer rings or washers, if so equipped.



A. Check for burrs.
1. Hub

Fig. 3, Inspect the Hub Bore

IMPORTANT: Clean the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause rapid wear of the bearing assembly.

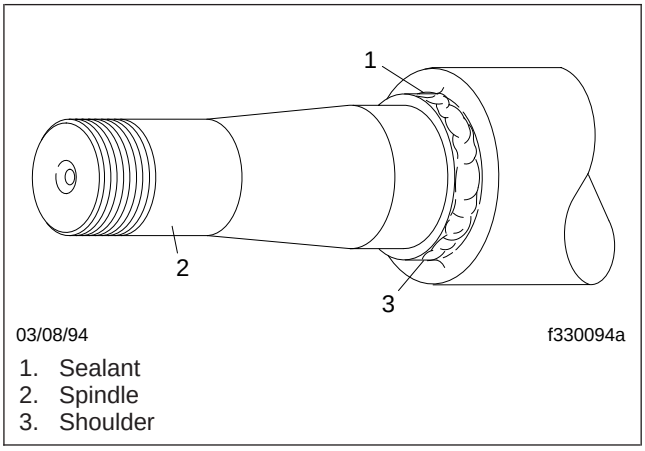
Seal Replacement, Stemco®

7. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged parts as necessary.

⚠ CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

8. If burrs were removed from the spindle shoulder, apply a thin layer of non-hardening sealant to the spindle shoulder. See **Fig. 4**.



1. Sealant
2. Spindle
3. Shoulder

Fig. 4, Apply Sealant to the Spindle Shoulder

NOTE: Use a non-hardening sealant such as Permatex® Number-2 or Loctite® 515.

9. Place the oil seal on the spindle so the words "oil-bearing side" are exposed to the oil. A slight step on the inside circumference of the seal ring will allow it to be placed by hand about 1/8 inch (3 mm) onto the shoulder. See **Fig. 5**.

⚠ CAUTION

Do not install the oil seal in the hub bore. Incorrect seal installation will damage the seal and lead to possible spindle, hub, and bearing damage.

10. Position the Stemco installation tool over the spindle. See **Fig. 6**. Using a 3 to 5 lb (1 to 2 kg) hammer, drive the seal on the spindle until the tool bottoms against the shoulder. After the tool bottoms, turn it while applying several light taps with the hammer to ensure the seal ring is flush with the face of the shoulder. Wipe off all excess sealant.

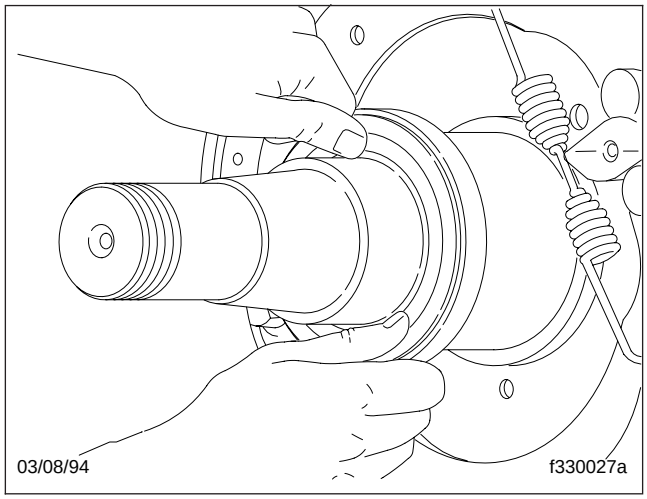


Fig. 5, Place the Seal on the Spindle

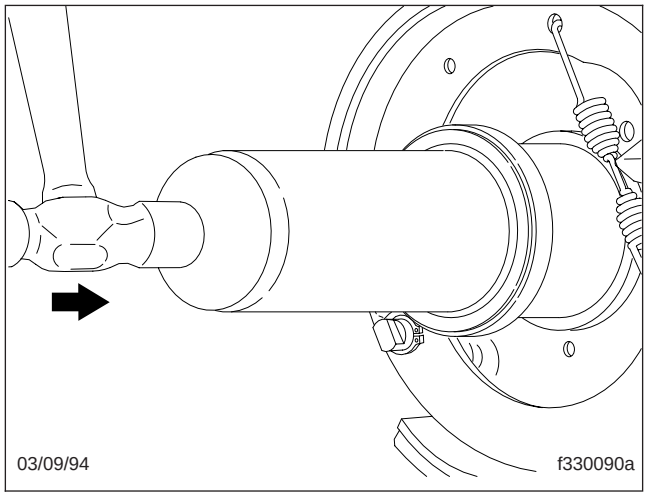


Fig. 6, Drive the Seal onto the Spindle

IMPORTANT: Use only the tool specified by Stemco for the vehicle's axle. In order for the Stemco warranty to apply, the product must be correctly installed using the correct tool made by Stemco or a tool approved by Stemco.

11. Make sure there are not any gaps between the ring and shoulder. See **Fig. 7**.

12. Coat the inner wheel bearing with oil and install it on the spindle. See **Fig. 8**. No additional oil is

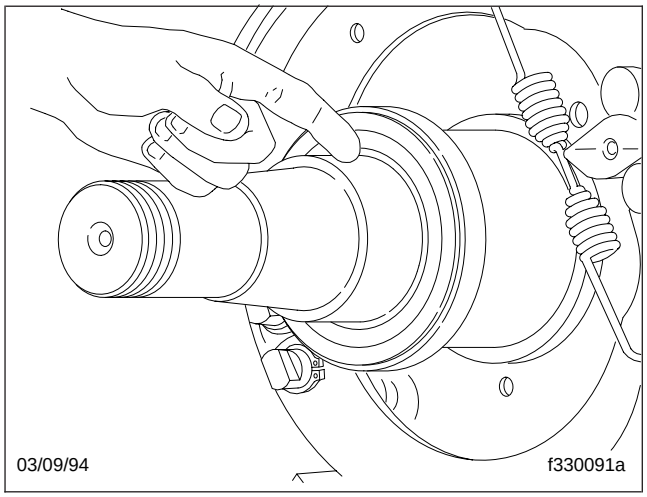


Fig. 7, Check the Ring for Gaps

needed on the outside of the seal. The seals are lubed at the factory.

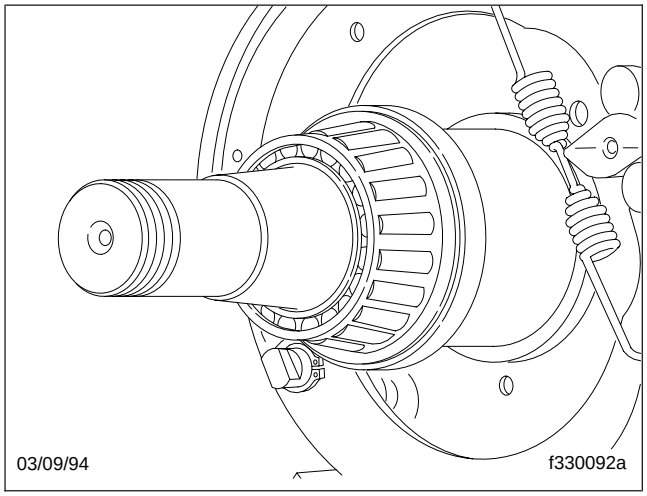


Fig. 8, Install the Inner Bearings

13. Install the hub and wheel bearings. For instructions, see **Section 33.01**.

IMPORTANT: Do not force the wheel onto the seal. The wheel will seat on the seal when the adjustment nut is tightened.

14. Adjust the wheel bearings. For instructions, see **Section 33.01**.
15. Install the hub cap with a new gasket. Tighten the hub cap nuts 15 lbf·ft (20 N·m). Add oil to the level shown on the window. See **Fig. 9**. Turn the hub and allow the oil to settle. Recheck the hub and fill to a level between the oil line and about 1/4 inch (6 mm) above the oil line. Do not overfill the hub. Install the vent plug or threaded filler plug.

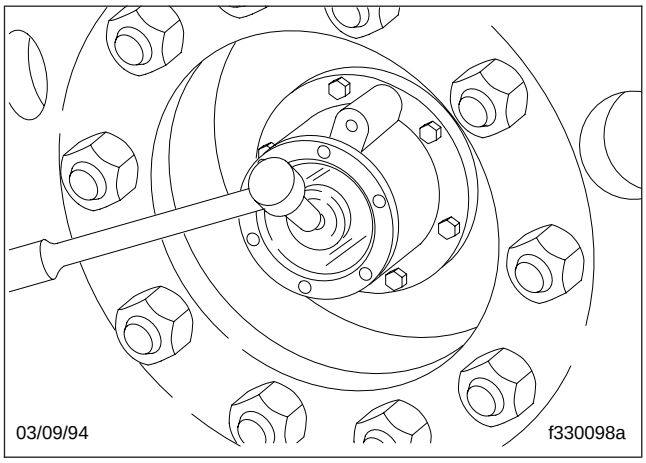


Fig. 9, Fill the Hub with Oil

16. Spin the wheel and check the oil level.
17. Adjust the brake shoe-to-drum clearance. For instructions, see **Group 42**.

Specifications

Bearing Centering Tool Interchange				
Spindle Type	Bearing Cone	Centering Tool Number		
		Dana Spicer® Outrunner™	Chicago Rawhide	National®
—	641	BCT-6	706	RD-406
—	39581	BCT-2	702	RD-402
—	557A	BCT-3	703	RD-403
FL	6461A	BCT-8	708	RD-418
—	H715345	BCT-16	716	RD-407
—	HM212044	BCT-3	703	RD-403
—	HM212047	BCT-4	704	RD-404
FF	HM212049	BCT-6	706	RD-406

Table 1, Bearing Centering Tool Interchange

Adapter Plates		
Seal	Adapter Plate	Color
847	847-T	Blue
855	855-T	
857	857-T	
863	863-T	

Table 2, Adapter Plates

General Information

Detroit front axles have a unique steering knuckle design that reduces vibration and wear. Low-friction, high-strength needle bearings roll on a large-diameter kingpin, replacing the conventional bushings. They are compatible with all standard industry model brakes, hubs, and wheel bearings.

The basic model is indicated by the numbers on the axle's identification tag. The following explains a typical model number.

Typical Model Number: AF-12-3.

- *AF* = front axle
- *12* = Weight Rating (times 1000 lbs.)
- *3* = Model Number

NOTE: Detroit axles are a proprietary product, though in some applications they may be referred to as "Sterling" or "Axle Alliance" axles or "MB components."

Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the rear tires. Put the transmission in neutral.
2. At both ends of the front axle, loosen all the wheel nuts.

⚠ WARNING

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

3. Raise the front of the vehicle and support it with safety stands.
4. Drain the air system.
5. Remove the front wheel and tire assemblies. For instructions, see **Group 40**.
6. Remove the brake drums and front hubs from the axle. For instructions, see **Section 33.01, Subject 100**.
7. Remove the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
8. Remove the ABS sensors and wiring from the brake spiders (anchor plates) and secure them and their wiring out of the way.
9. Remove the brake air chambers and the slack adjusters. For instructions, see the applicable sections in **Group 42**.
10. Remove the brake spiders from the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
11. Disconnect the drag link from the axle steering arm.
12. If so equipped, disconnect the sway bar from the axle brackets.
13. Using a suitable jack, support the front axle.
14. Remove the U-bolt nuts or remove the nuts that hold the axle beam to the leaf springs and the air bag brackets, as applicable.
15. Remove the U-bolts, if applicable.
16. Remove the axle from the vehicle.
17. If you are replacing the steering knuckles, put the axle on a suitable stand and secure it to prevent it from moving.

Installation

1. With the axle on a suitable jack, position it under the vehicle.
2. For vehicles with front air suspension, raise the axle so that the holes in the axle beam line up with the bolts that hold the air bags to the leaf springs. Install the nuts and washers and tighten the nuts 220 lbf·ft (298 N·m).

   For vehicles with a leaf-spring front suspension, install the U-bolts and nuts. For instructions on tightening U-bolt nuts, see the applicable section in **Group 32**.
3. If so equipped, connect the sway bar to the axle brackets. Tighten the sway bar fasteners 100 lbf·ft (136 N·m).
4. Connect the drag link to the steering arm. For instructions, see the applicable section in **Group 46**.
5. Install the brake spiders on the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
6. Install the brake air chambers and slack adjusters on the axle. For instructions, see the applicable sections in **Group 42**.
7. Install the ABS sensors.
8. Install the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
9. Install the hubs and adjust the wheel bearings. For instructions, see **Section 33.01, Subject 100**.
10. Install the brake drums.
11. Adjust the slack adjusters. For instructions, see the applicable section in **Group 42**.
12. Install the tire and wheel assemblies. For instructions, see **Group 40**.
13. Raise the vehicle, remove the safety stands, and lower the vehicle.
14. Start the engine and build the air pressure.

Axle Removal and Installation

15. If equipped with a front air suspension, check that the suspension air bags are inflating correctly.
16. Remove the chocks from the rear tires.

Disassembly

NOTE: The following procedures can be done with the axle installed on the vehicle or with the axle removed from the vehicle.

1. If the axle has been removed, make sure it is securely mounted on a suitable stand. Go to the step for removing the tie rod from the tie-rod arm.

   If the axle is on the vehicle, park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the rear tires. Drain the air system.

2. If the axle is on the vehicle, do the following substeps to gain access to the steering knuckle.

   2.1 Remove the wheel and tire assembly from the applicable side of the vehicle.

   2.2 Remove the brake drum and hub. For instructions, see **Section 33.01, Subject 100**.

   2.3 Remove the brake shoes. For instructions, see the applicable service brake section in **Group 42**.

   2.4 If so equipped, remove the ABS sensor and wiring from the brake spider (anchor plate) and secure the sensor and the wiring out of the way.

   2.5 Disconnect the air line from the brake air chamber, then remove the air chamber and the slack adjusters. For instructions, see the applicable sections in **Group 42**.

   2.6 Remove the brake spider from the axle flange. For instructions, see the applicable service brake section in **Group 42**.

   2.7 Disconnect the drag link from the steering arm, if present.

   NOTE: On the driver's side of the vehicle, the steering arm connects to the steering knuckle. On the passenger's side, no steering arm is present.

3. If not already done, disconnect the tie rod from the tie-rod arm.

4. Remove the tie-rod arm from the steering knuckle. See **Fig. 1**.

5. If applicable, remove the steering arm. See **Fig. 1**.

6. Remove the steering knuckle and spindle assembly from the axle beam. See **Fig. 1**.

   6.1 Remove the upper and lower snap rings that hold the cover plates in place.

   6.2 Remove the upper and lower cover plates from the steering knuckle.

   6.3 Remove and discard the O-ring from the edges of each cover plate.

   6.4 Note the orientation of the draw keys and the kingpin, then remove the draw keys and nuts that hold the kingpin in place.

   6.5 Using a brass drift, remove the kingpin by driving it downward. Make a note of where the needle bearings were installed.

   6.6 Remove the spacer(s) and shim(s) from the upper surface of the axle beam bore.

   6.7 On the side with a steering arm, push down on the steering knuckle and spindle assembly to clear the lip on the thrust friction bearing and remove the assembly from the axle beam bore.

NOTE: The steering knuckle on the passenger's side (side without a steering arm) has a thrust roller bearing instead of a thrust friction bearing. Unlike the thrust friction bearing, the thrust roller bearing has no protruding lip at the top. When removing the thrust roller bearing from the axle beam bore, it is not necessary to push down on the steering knuckle.

7. Remove the grease seal from the upper steering-knuckle bore.

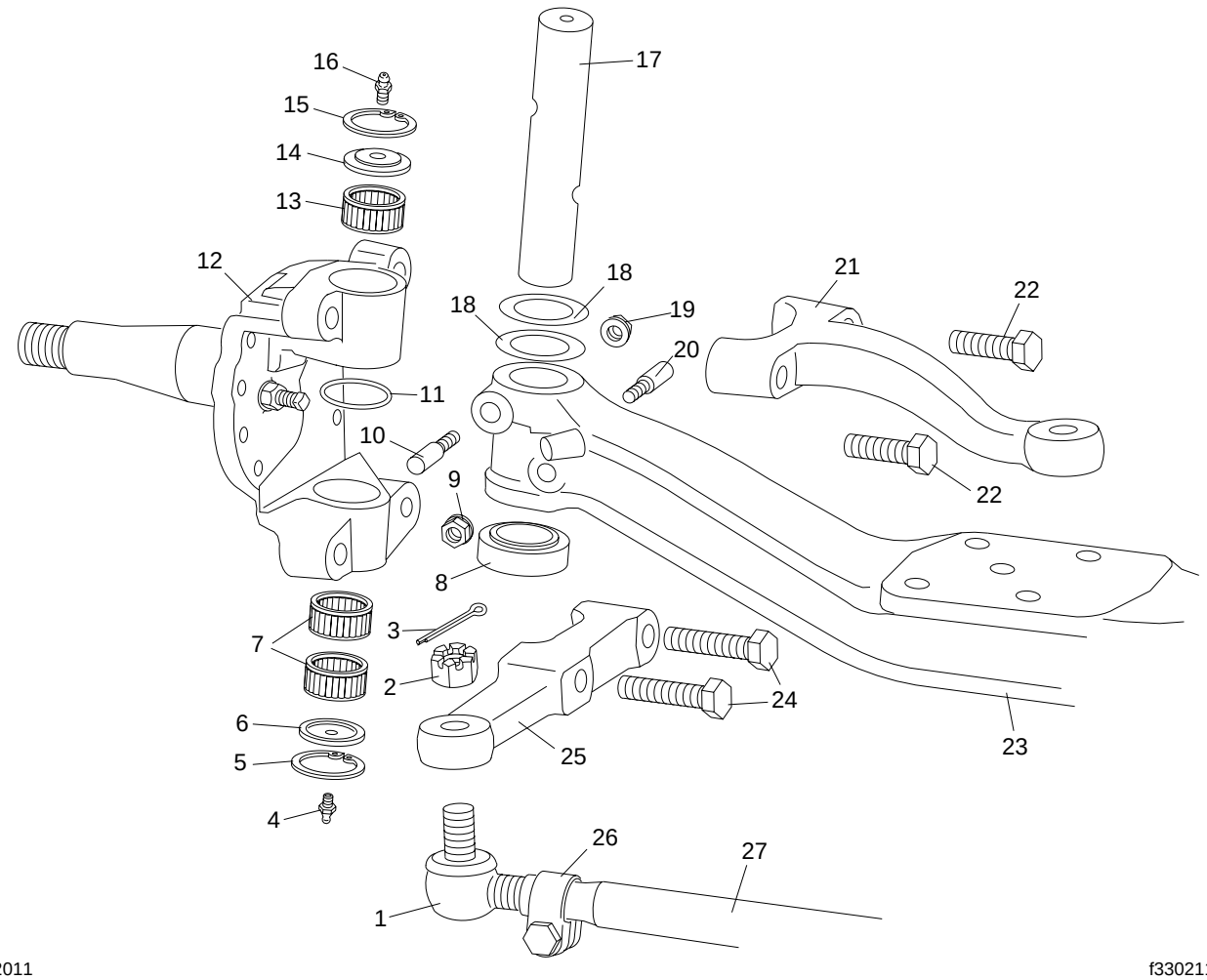
8. Remove the thrust friction bearing (driver's side) or the thrust roller bearing (passenger's side) from the top of the lower steering knuckle bore.

NOTE: If removing the thrust friction bearing (driver's side), note the orientation of the bearing for future reference.

9. Using a brass drift, drive out the needle bearings from the steering knuckle bores.

10. If needed, repeat the entire procedure for the other side of the axle assembly.

Steering Knuckle Disassembly and Assembly



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NOTE: The number of upper and lower needle bearing sets may vary, depending on the axle model.

1. Tie-Rod Ball Joint
2. Castle Nut
3. Cotter Pin
4. Lower Grease Fitting
5. Lower Snap Ring
6. Lower Cover Plate
7. Lower Needle Bearings (may be one or two sets)
8. Thrust Friction Bearing (thrust roller bearing on the passenger side)
9. Lower Draw Key Nut
10. Upper Draw Key
11. Grease Seal
12. Steering Knuckle
13. Upper Needle Bearing (may be one or two sets)
14. Upper Cover Plate
15. Upper Snap Ring
16. Upper Grease Fitting
17. Kingpin
18. Shim
19. Upper Draw Key Nut
20. Lower Draw Key
21. Steering Arm
22. Steering Arm Capscrew
23. Axle Beam
24. Tie-Rod Arm Capscrews
25. Tie-Rod Arm
26. Tie-Rod Clamp
27. Tie-Rod Tube

Fig. 1, Front Axle Components (driver side shown)

Assembly

IMPORTANT: If replacing the kingpin, use a complete rebuild kit with all new components.

1. Clean the steering knuckle bores and the axle beam bores. Check for damage such as grooves, scratches, and pitting.

   If any bores show significant damage, replace the component.

2. Install the grease seal — with the grooved side down (toward the road) — into the top of the upper steering knuckle bore. Carefully drive the seal down into the bore until the outer edge of the seal is flush with the bottom edge of the bore. Make sure the seal is not cocked.

3. Install new needle bearings into the bores of one of the steering knuckles. Install the same number of bearings as was removed.

NOTE: Install the needle bearings just far enough into the bores so that the cover plates can be installed.

4. Install a new thrust friction bearing (driver's side) or thrust roller bearing (passenger's side) into the top of the lower steering knuckle bore. Install the thrust friction bearing (or thrust roller bearing) with the sealed side up.

NOTE: The thrust friction bearing has a protruding lip at the top. The thrust roller bearing has no such protruding lip.

5. Partially install the steering knuckle on the axle beam.

   5.1 Making sure the flats on the kingpin are aligned with the draw-key holes in the axle beam, put the new kingpin into the top bore of the steering knuckle. Note that the top of the new kingpin is clearly marked. Push the kingpin through the axle beam bore until the upper end of the kingpin is flush with the upper surface of the axle beam bore.

   5.2 Align the steering knuckle with the axle beam, then check the clearance between the axle beam bore and the upper steering knuckle bore. Clearance is to be a maximum of 0.003 inch (0.08 mm).

   IMPORTANT: To correctly check the clearance, the thrust friction or thrust roller bearing must be installed correctly, and upward pressure must be applied to the steering knuckle.

   5.3 If needed, install sufficient spacers to reduce the clearance to 0.002 to 0.003 inch (0.05 to 0.08 mm).

6. Install the kingpin fully into the steering knuckle bores, making sure the flats on the kingpin are still aligned with the draw-key holes in the axle beam.

7. Install new upper and lower draw keys and nuts. See **Fig. 1**.

   7.1 Install the upper draw key from the back of the axle, and the lower one from the front of the axle.

   IMPORTANT: Make sure the new draw keys are the same length as those removed. On some axle models the lower draw key is longer than the upper one.

   7.2 Tighten the draw-key nuts 30 to 55 lbf·ft (40 to 75 N·m).

8. Install new grease fittings and cover plates.

   8.1 Install the new upper cover plate (with a new O-ring) and the snap ring. Install the new grease fitting into the cover plate.

   8.2 Install the new lower cover plate (with a new O-ring) and the snap ring. Install the new grease fitting into the cover plate.

9. Install the steering arm. Apply Loctite® 277 to the threads and tighten the steering arm capscrews: if M20 capscrews are used, tighten them 425 lbf·ft (575 N·m); if M24 capscrews are used, tighten them 664 lbf·ft (900 N·m).

10. Attach the tie-rod arm to the steering knuckle. Apply Loctite® 277 to the threads and tighten the tie-rod arm capscrews: if M20 capscrews are used, tighten them 425 lbf·ft (575 N·m); if M24 capscrews are used, tighten them 664 lbf·ft (900 N·m).

11. Attach the tie-rod arm to the tie rod. Tighten the castle nut 120 to 170 lbf·ft (163 to 230 N·m) plus a maximum of one-sixth of a turn to align a slot in the castle nut with the cotter pin hole in the tie

rod stud. Insert the cotter pin and bend the tangs to secure it.

12. If removed, install the axle.
13. If removed, connect the drag link to the steering arm.
14. Install the brake spider on the axle flange. For instructions, see the applicable service brake section in **Group 42**.
15. Install the brake air chambers and slack adjusters on the axle. For instructions, see the applicable sections in **Group 42**.
16. Install the ABS sensor.
17. Install the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
18. Install the hub and adjust the wheel bearings. For instructions, see **Section 33.01**.
19. Install the brake drum.
20. Install the tire and wheel assembly. For instructions, see **Group 40**.
21. If necessary, repeat the entire procedure for the other side of the vehicle.
22. Raise the vehicle, remove the safety stand, then lower the vehicle.
23. Remove the chocks from the tires.

Specifications

Torque Values			
Application	**Size**	**Class**	**Torque: lbf·ft (N·m)**
Air Bag-to-Leaf Spring Nuts	—	—	220 (298)
Draw-Key Nuts	—	—	30–55 (40–75)
Sway Bar Fasteners	—	—	100 (136)

Table 1, Torque Values

General Information

WHEEL HUBS AND BEARINGS

(See Fig. 1)

A unitized wheel bearing seal is a standard item on all rear axles. The unitized wheel seal combines the functions of a wear sleeve and seal in one self-contained unit, with the seal and sleeve surface inside. The unitized design provides maximum protection for the sealing surface during installation and operation. The tools required for unitized seal installation are only available from C.R. Industries.

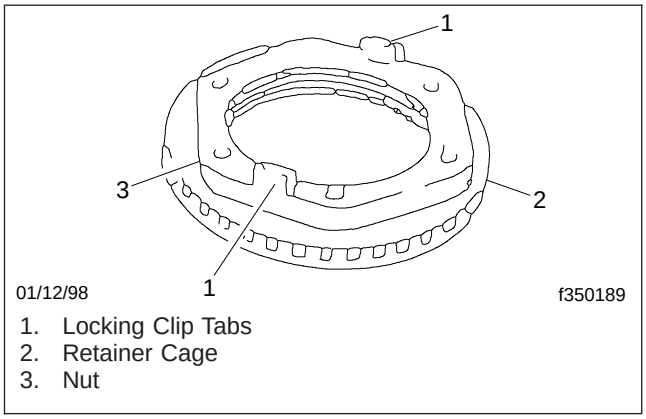
A two-piece seal is available as a regular production option. The seal consists of a lip-type oil seal and a wiper sleeve. The seal is installed in the wheel hub and the wiper sleeve is installed on the axle tube housing. When the hub is installed, a seal is formed between the wear sleeve and seal lip. The tools required for seal installation are only available from the Stemco warehouse.

New hub seals must be installed whenever the hub is removed. A damaged or worn seal can permit bearing lubricant to reach the brake linings, resulting in ineffective brake operation and necessitating premature replacement of linings.

AXILOK WHEEL BEARING ADJUSTING NUT **(See Fig. 2)**

A new wheel bearing adjustment nut is available for both front and rear axles on L-Line and A-Line vehicles.

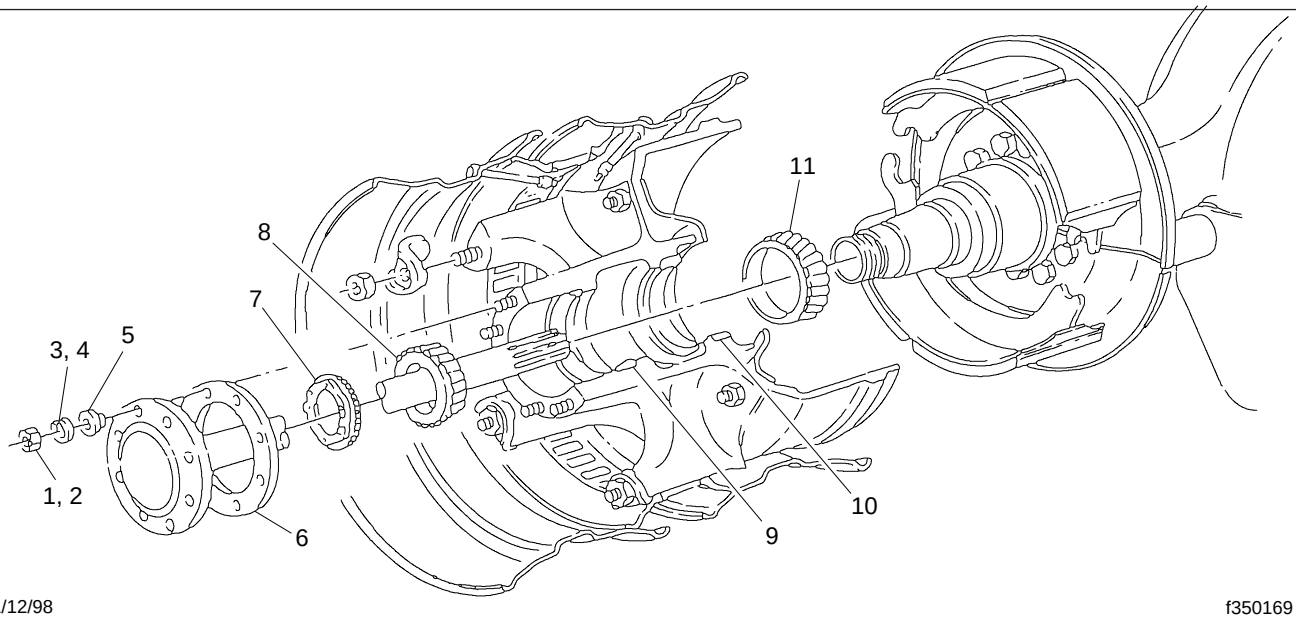
The Axilok wheel bearing adjusting nut is self-locking, eliminating any other retainers (such as cotter keys). It allows precise wheel bearing adjustment to within 0.002 to 0.003 inch (0.0500 to 0.0762 mm), is easy to install and service following the proper procedure, replaces a three part adjusting nut system, and is reusable.



1. Locking Clip Tabs
2. Retainer Cage
3. Nut

Fig. 1, Axilok Wheel Bearing Adjusting Nut

General Information



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1. Nut, 1/2–20
2. Nut, 5/8–18
3. Lockwasher
4. Lockwasher
5. Tapered Dowel
6. Gasket
7. Axilok Wheel Bearing Adjusting Nut
8. Outer Cone and Roller Assembly
9. Outer Bearing Cup
10. Inner Bearing Cup
11. Inner Cone and Roller Assembly

Fig. 2, Typical Rear Wheel Hub

Removal

1. Chock the front tires.
2. Raise the rear wheels off the floor and place safety stands under the rear axle housing so the axle is parallel with the floor. See **Fig. 1**.

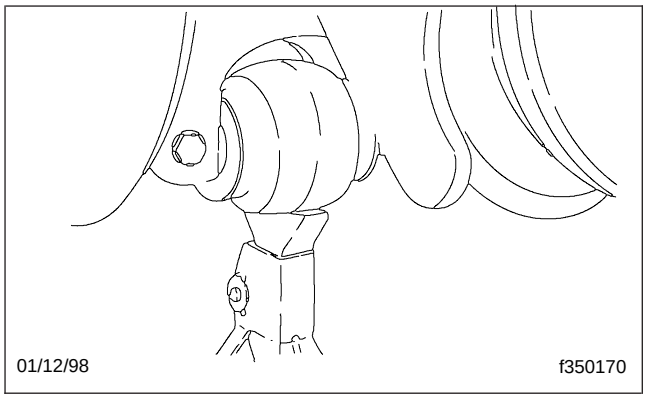


Fig. 1, Safety Stand Under Rear Axle

3. Back off the rear brake adjustment.
4. Remove the drive axle stud nuts and lockwashers. See **Fig. 2**.

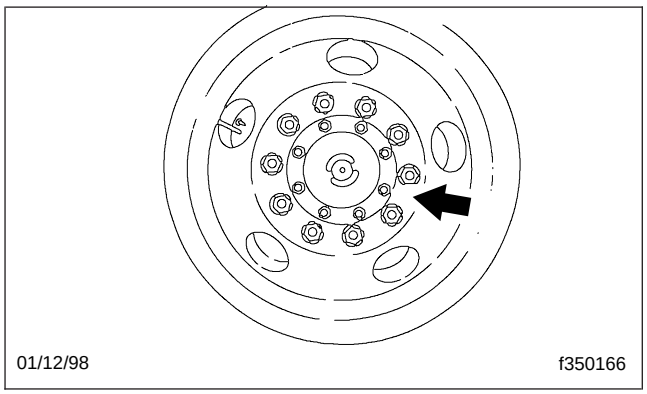


Fig. 2, Drive Axle Stud Nuts

5. If tapered dowels are installed in the axle shaft flange, place a drift in the center of the flange and strike it sharply to loosen the dowels. See **Fig. 3**.
6. Remove the axle shaft. See **Fig. 4**.

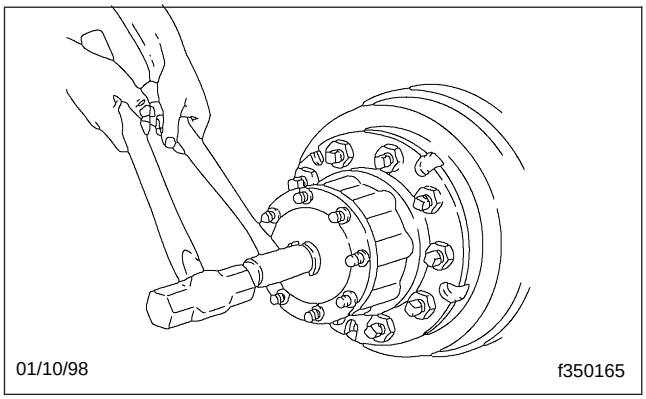


Fig. 3, Loosening Tapered Dowels With a Drift and Hammer

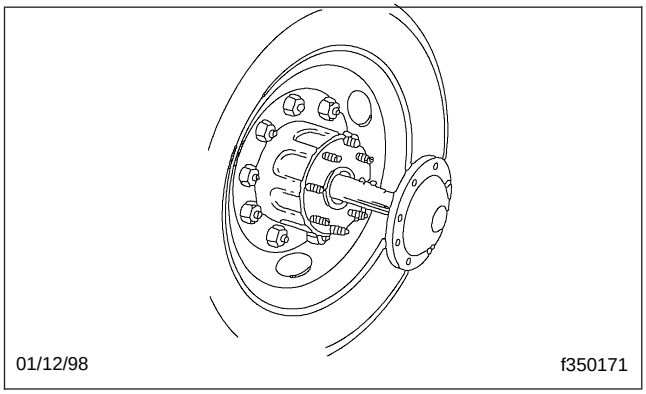


Fig. 4, Axle Shaft

CAUTION

Do not chisel, hammer, or use an impact tool to remove the Axilok wheel bearing adjusting nut. Use only the proper size 6-point socket as stamped on the nut to remove or install it. Do not use a 12-point socket. Failure to follow this precaution can cause damage to the nut.

7. Remove the Axilok wheel bearing adjusting nut. See **Fig. 5**.

   7.1 Apply a small amount of torque in the removal direction, but not over 50 lbf·ft (68 N·m).

   7.2 If the Axilok nut rotates freely, remove it from the spindle.

   If the Axilok nut does not rotate freely, check the socket size and make sure the

Wheel Hubs Removal and Installation

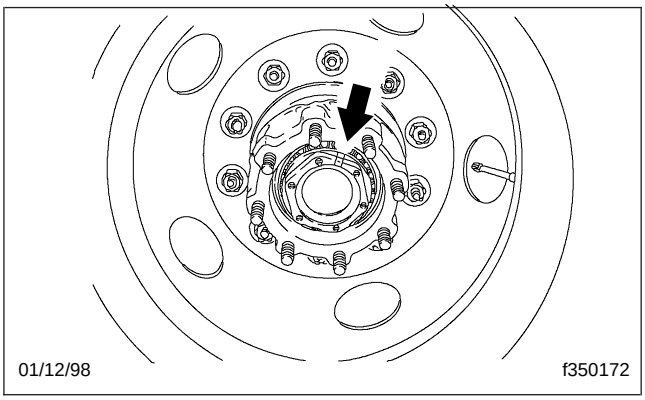


Fig. 5, Axilok Wheel Bearing Adjusting Nut

locking clip tabs are fully disengaged from the retainer cage holes.

8. Using a wheel dolly, raise the wheel so that all the wheel weight is removed from the wheel bearings. See **Fig. 6**.

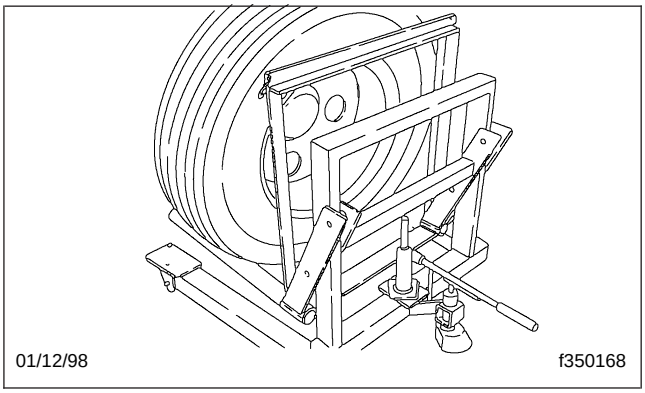


Fig. 6, Wheel Dolly

9. Remove the outer bearing cone. See **Fig. 7**.

NOTE: This step will remove the wheel, tire, and brake drum housing simultaneously.

10. Pull the wheel straight out and away from the axle.
11. Thoroughly clean the spindle of the axle housing. See **Fig. 8**.
12. Inspect the bearing cups and bearings for pitting, galling, and erratic wear patterns. See **Fig. 9**.

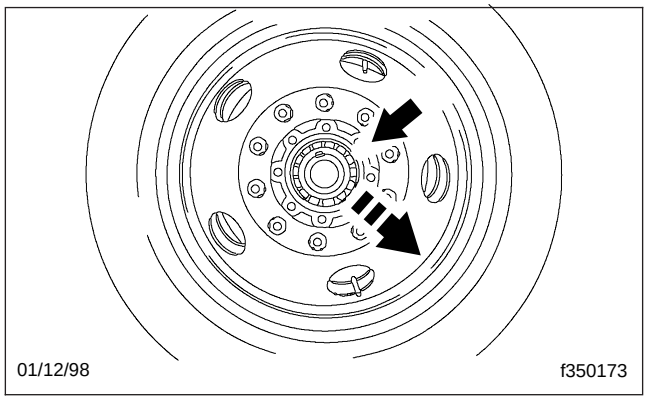


Fig. 7, Outer Bearing Cone

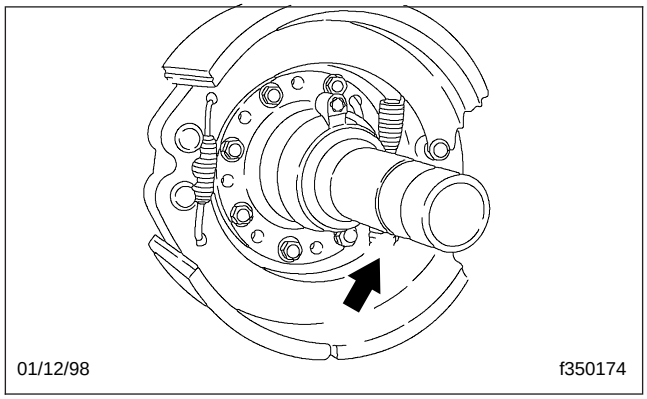


Fig. 8, Clean Axle Housing Spindle

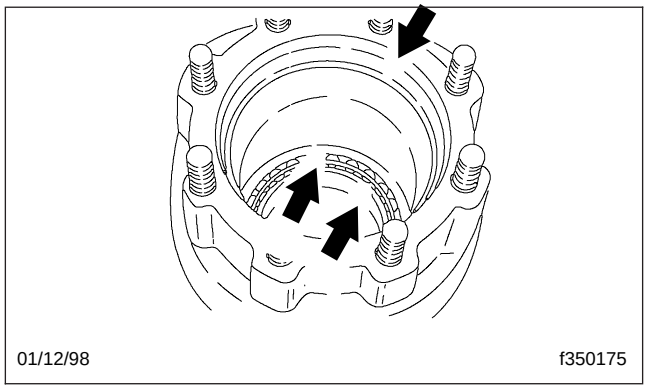


Fig. 9, Inspect Bearing Cups for Wear

Installation

1. Apply a light film of lithium-base grease to the axle spindle, and position a seal protector tool over the axle spindle threads.

NOTE: Use Premium Long-Life Grease XG–1–C or XG–1–K (or equivalent meeting Sterling specification ESA–M1C75–B).

2. With the hub centered on the axle spindle, carefully slide the hub, wheel, and brake drum assembly straight (to avoid seal damage or bumping the antilock brake sensor out of adjustment) onto the axle housing spindle. See **Fig. 10**. After performing this step, remove the seal protector from the axle spindle.

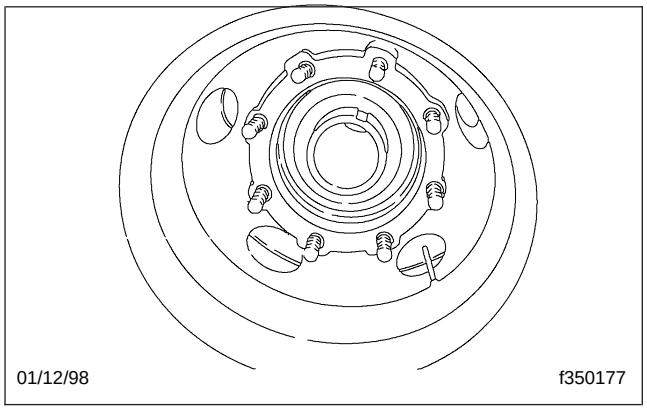


Fig. 10, Hub, Wheel, and Brake Drum Assembly

3. Fill the wheel cavity with rear axle lubricant before installing the outer bearing. See **Fig. 11**.

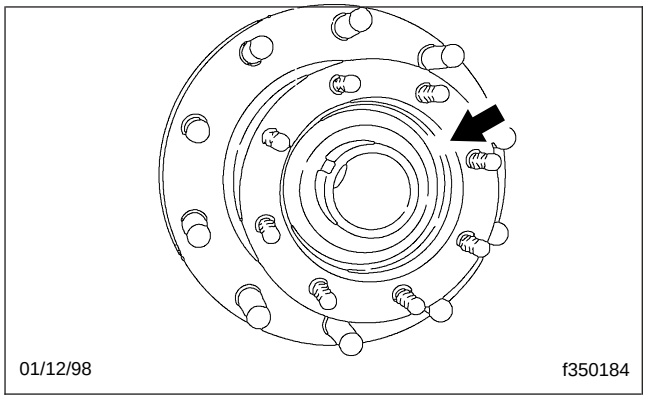


Fig. 11, Lubricating Wheel Cavity

⚠ CAUTION

Use only the proper size 6-point socket as stamped on the nut to install it. Do not use a 12-point socket. Failure to follow this precaution can cause damage to the nut.

4. Install the outer wheel bearing and start the Axilok wheel bearing adjusting nut. See **Fig. 5**.

   IMPORTANT: Do not install the Axilok wheel bearing adjusting nut if it is damaged in any way.

   4.1 Inspect the spindle threads and slot for damage. Do not install the Axilok wheel bearing adjusting nut on a damaged spindle.

   4.2 Inspect the locking clips, retainer cage, and threads. The components must not be damaged. If the nut assembly is damaged, use a new one.

5. Remove the wheel dolly.
6. Adjust the wheel bearings.
7. Install the axle shaft and a new gasket. See **Fig. 4**.
8. Install the tapered dowels, lockwashers, and drive axle stud nuts. See **Fig. 12**. Tighten the drive axle stud nuts to the torque values given in the table in **Specifications, 400**.

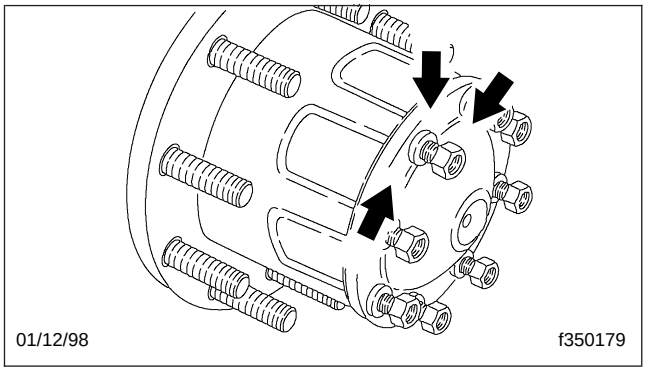


Fig. 12, Tapered Dowels, Lockwashers, and Drive Axle Stud Nuts

9. Adjust the brakes. See **Group 42** for instructions.
10. Check the rear axle oil level and fill with the recommended lubricant as required. For recommended lubricants and capacities, see **Group 35** of the Sterling *L-Line and A-Line Maintenance Manual*.
11. Remove the safety stands and lower the vehicle.
12. Remove the chocks from the front tires.

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See the "Bearing Centering Tool Interchange" and "Adapter Plates" tables in **Specifications, 400**.

Unitized Rear Hub Seal

Removal

1. Remove and discard the old oil seal. See **Fig. 1**.

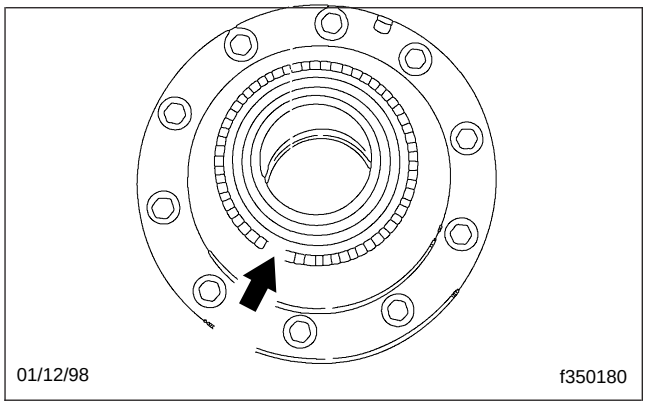


Fig. 1, Oil Seal

2. Thoroughly clean all grease and dirt from the spindle and threads. See **Fig. 2**.

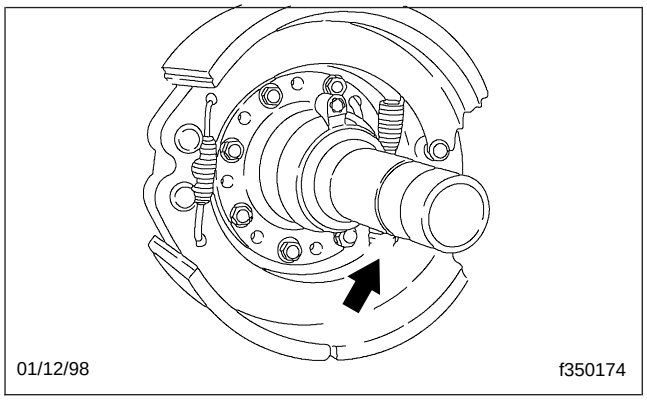


Fig. 2, Cleaning Axle Spindle

NOTE: Scratches in the hub seal bore may be too deep to be dressed out by light polishing with an emery cloth. In this case, apply a thin layer of non-hardening sealer such as Silicone Rubber D6AZ-19562-AA or -BA or equivalent sealer meeting Sterling specification ESB-M4G92-A or ESE-M4G195-A to the colored outside diameter of the new seal prior to installation.

3. Remove all burrs, nicks and scratches from the shoulder of the spindle and seal bore in the hub with emery cloth.

Installation

1. Seat the smaller outside diameter of the seal in the recess of the tool adapter. See **Fig. 3**.
   - Use the green tool with green seal E1HT-1175-AA
   - Use the red tool with red seal E1HT-1175-B

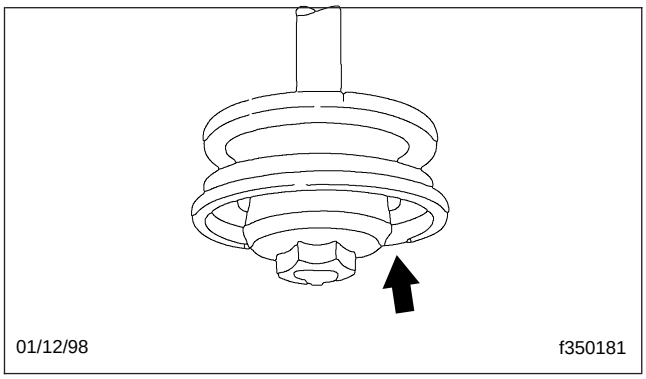


Fig. 3, Seal Installing Tool

NOTE: The plug prevents cocking of the seal in the bore.

2. Insert the centering plug of the tool in the bore of the inner bearing cone. See **Fig. 4**.
3. Using a 4- or 5-lb hammer, hold the tool handle firmly and strike until the sound of the impact changes to a ringing as the seal bottoms out.
4. Check for freedom of movement by manually moving the interior rubber component of the seal backward and forward. A slight movement indicates damage-free installation.

Two-Piece Rear Hub Seal

Removal

1. Remove and discard the old oil seal. See **Fig. 1**.

Rear Hub Seal Replacement

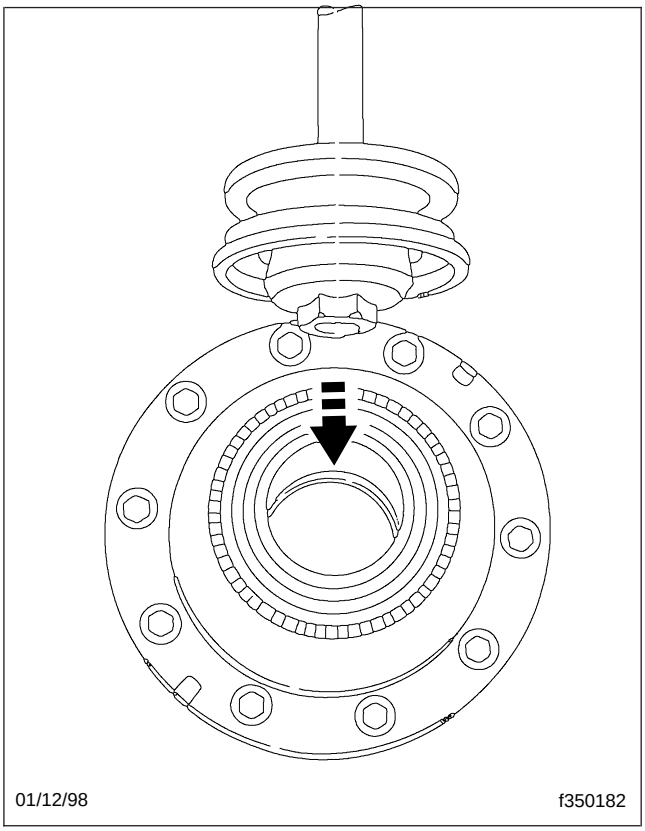


Fig. 4, Positioning the Seal Installing Tool

⚠ CAUTION

Do not use a chisel to cut through the wear sleeve. Damage to the spindle can occur.

2. Remove the old wear sleeve by striking the ring surface several times with a ball peen hammer. See **Fig. 5**.

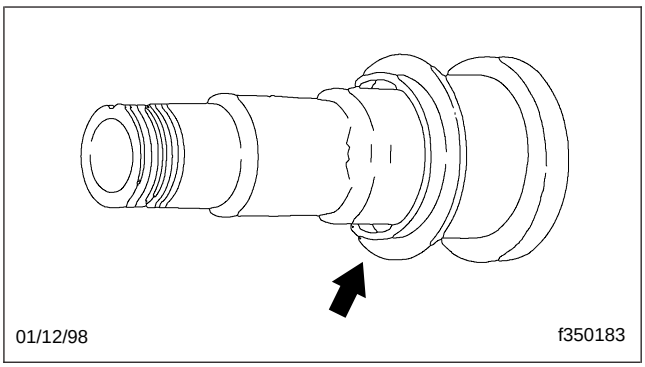


Fig. 5, Removing Old Wear Sleeve

Installation

1. Thoroughly clean the axle spindle. Remove all burrs with an emery cloth. See **Fig. 2**.
2. If the spindle shoulder is scored or pitted, apply a thin coat of non-hardening sealant such as Silicone Rubber D6AZ-19562-AA or -BA or equivalent meeting Sterling specification ESB-M4G92-A or ESE-M4G195-A.

NOTE: After bottoming, rotate the tool while applying several light hammer blows to make sure the seal ring is flush and square with the face of the shoulder.

3. Install the wear sleeve on the axle housing. See **Fig. 6**.

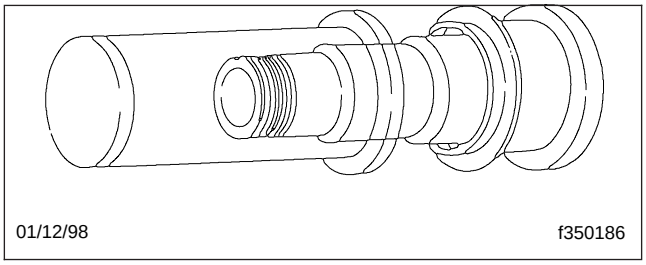


Fig. 6, Installing Wear Sleeve

4. Remove all burrs and protrusions from the oil seal area of the wheel hub.
5. Pack grease such as Premium Long-Life Grease XG-1-C or -K or equivalent meeting Sterling specification ESA-M1C75-B between the spring and seal lip to prevent the spring from dislocating when the seal is installed.
6. Position the oil seal in the hub bore and drive it squarely into position. See **Fig. 1**.

Bearing Cup Replacement (Aluminum Hubs)

Replacement

WARNING

Do not use oxyacetylene or similar equipment to heat the hub. This can cause overheating in localized areas, which will result in loss of strength that can cause failure of the hub assembly and, ultimately, loss of vehicle control.

1. Remove the brake drums and wheel bearings.
2. Thoroughly clean and degrease the hub with a nonflammable solvent.
3. Heat the hub evenly throughout in an oven to 175 to 205°F (79 to 96°C).

WARNING

You must replace damaged hubs. Using a damaged hub on a vehicle can result in hub failure and, ultimately, loss of vehicle control.

NOTE: Variations in tolerances of materials and oven temperatures may allow the bearing cup to drop in and out easily.

4. Remove the hub from the oven, and quickly press out the bearing cup.

   Use care to avoid damage to the bearing cup bore and shoulder.
5. Heat the hub evenly, as done previously.

NOTE: Make sure the cup is aligned properly and seated fully.

NOTE: Use care to avoid damage to the bearing cup and shoulder.

6. Remove the hub from the oven, and quickly press in the new bearing cup. See **Fig. 1**.
7. Check for proper seating of the new bearing cups by trying to insert a 0.0015-inch (0.038-mm) feeler gauge between the bottom of the cup and the wheel hub seat. You should not be able to insert the feeler gauge. See **Fig. 2**.
8. Install the wheel bearings. See **Fig. 3**.

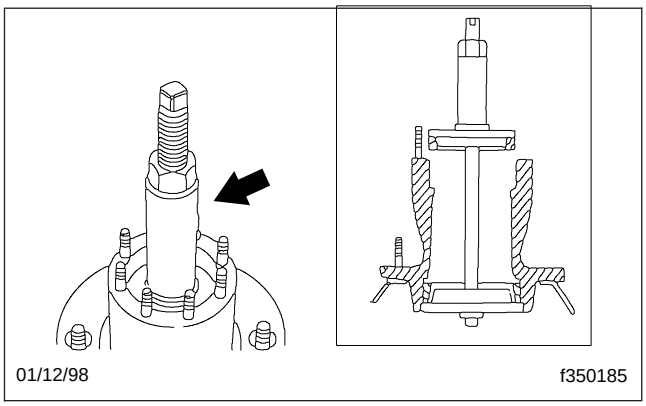


Fig. 1, Pressing Bearing Cup into Hub

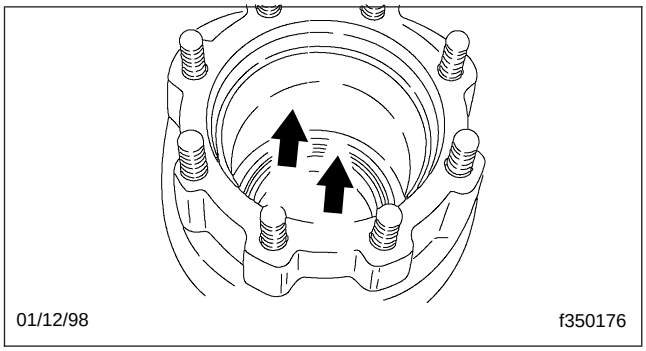


Fig. 2, Checking Installation of Bearing Cup

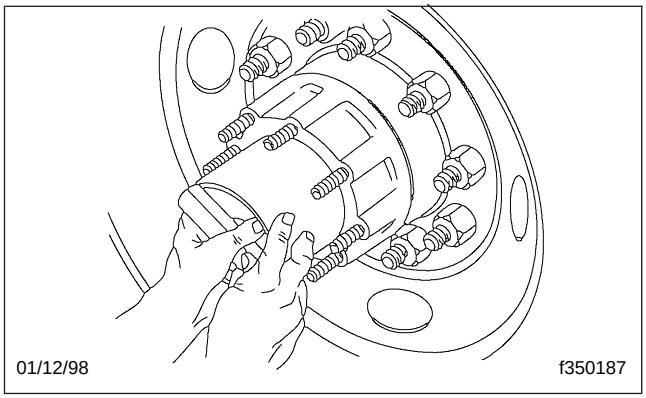


Fig. 3, Wheel Bearings

Replacement

1. Inspect Axilok nut to locate wrench size stamped into the nut.

   Using the appropriate, 6-point socket, push the socket onto the wheel bearing nut to "unlock" the nut.

   If the retainer cage does not spin freely about the nut by hand, the socket is not properly engaged. See **Fig. 1**.

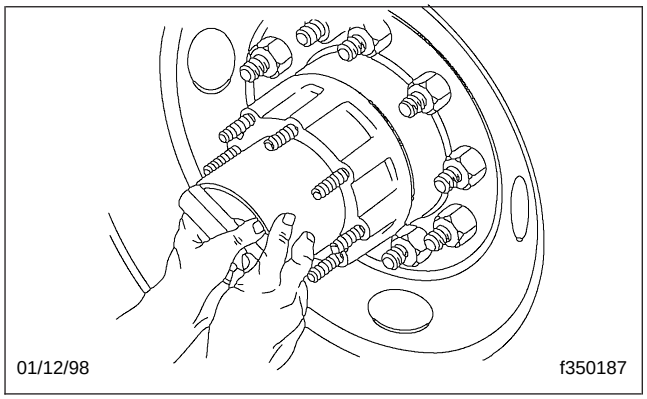


Fig. 1, Checking Socket Engagement

2. Using the socket, hand-start the wheel bearing nut onto the spindle.
3. Rotate the wheel assembly.

⚠ CAUTION

Always use a properly calibrated torque wrench to install each Axilok nut. Do not exceed the equipment manufacturer's recommended installation torque to prevent creating an unsafe condition.

4. With the wheel assembly rotating, tighten the nut. Refer to **Table 3** and **Fig. 2**.
5. Back the nut off one full turn (360 degrees).
6. Tighten the nut to the final adjusting torque according to **Table 1**.
7. Back the nut off as specified in **Table 2**.
8. The wheel assembly must rotate freely with an end play of 0.001 to 0.005 inch (0.025 mm to 0.127 mm).
9. Verify the nut assembly will lock and that the locking clips are not damaged. If damaged, replace the nut assembly.

   If the Axilok nut is not locked (the locking clips are not engaged with the retainer cage holes), then rotate the nut to advance the locking clips until they engage with the next set of holes in the retainer cage.

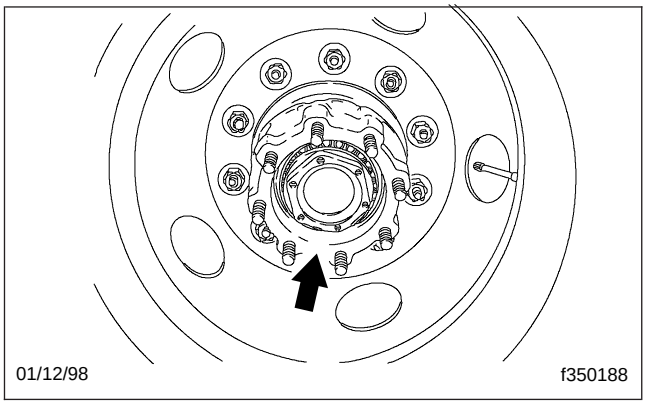


Fig. 2, Wheel Bearing Nut

Axilok Wheel Bearing Adjusting Nut Size	lbf·ft (N·m)
1-14 Inch	50 (68)
1-1/2-18 Inch	75 (102)
1-3/4-12 Inch	75 (102)
2-1/2-16 Inch	75 (102)
2-5/8-12 Inch	75 (102)
3-1/4-12 Inch	75 (102)

Table 1, Final Torque

Nut Size	Final Back-Off
1-14 Inch	3/16 Turn (70 degree)
1-1/2-18 Inch	1/4 Turn (90 degree)
1-3/4-12 Inch	1/8 Turn (45 degree)
2-1/2-16 Inch	3/16 Turn (70 degree)
2-5/8-12 Inch	1/8 Turn (45 degree)
3-1/4-12 Inch	1/8 Turn (45 degree)

Table 2, Final Back-Off

Axilok Wheel Bearing Adjusting Nut Size	lbf·ft (N·m)
1-14 Inch	50 (68)

Wheel Bearings Replacement

Axilok Wheel Bearing Adjusting Nut Size	lbf·ft (N·m)
1-1/2-18 Inch	105 (142)
1-3/4-12 Inch	105 (142)
2-1/2-16 Inch	140 (190)
2-5/8-12 Inch	200 (271)
3-1/4-12 Inch	200 (271)

Table 3, Initial Torque

Specifications

General Specifications	
Item	**Specification**
Premium Long-Life Grease XG-1-C or XG-1-K	ESA-M1C75-B
Silicone Rubber D6AZ-19562-AA or -BA	ESB-M4G92-A or ESE-M4G195-A

Table 1, General Specifications

Drive Axle Stud Nut Torque Values (all axles)	
Thread Size	**Torque: lbf·ft (N·m)**
7/16–20	35–45 (48–61)
1/2–20	50–70 (68–95)
5/8–18	150–170 (203–230)
3/4–16	150–205 (203–277)

Table 2, Drive Axle Stud Nut Torque Values (all axles)

Wheel End Play Adjustment Increment (Hole-to-Hole)		
Axilok Wheel Bearing Adjusting Nut Size	**Wheel End Play Adjustment Increment (Hole-to-Hole)**	
	Inch	**mm**
1–14	0.0030	0.0762
1-1/2–18	0.0023	0.0584
1-3/4–12	0.0030	0.0762
2-1/2–16	0.0022	0.0559
2-5/8–12	0.0030	0.0762
3-1/4–12	0.0023	0.0584

Table 3, Wheel End Play Adjustment Increment (Hole-to-Hole)

Bearing Centering Tool Interchange				
Spindle Type	**Bearing Cone**	**Centering Tool Number**		
		Dana Spicer® Outrunner™	**Chicago Rawhide**	**National®**
—	580	BCT-10	710	RD-410
—	582	BCT-10	710	RD-410
—	594	BCT-15	715	RD-416
—	595	BCT-10	710	RD-410
—	598	BCT-14	714	RD-415
—	663	BCT-10	710	RD-410
—	665	BCT-11	711	RD-411
—	759	BCT-12	712	RD-412
—	5760	BCT-8	708	RD-418
15K	33287	BCT-7	707	RD-408
—	47678	BCT-8	708	RD-418
L	47686	BCT-10	710	RD-410
—	495AX	BCT-8	708	RD-418
R	594A	BCT-15	715	RD-416
—	598A	BCT-14	714	RD-415
—	HM516449	BCT-10	710	RD-410

Table 4, Bearing Centering Tool Interchange

Specifications

Adapter Plates		
Seal	**Adapter Plate**	**Color**
848	848-T	Gold
849	849-T	
852	852-T	
854	854-T	
856	856-T	
858	858-T	
860	860-T	
861	861-T	

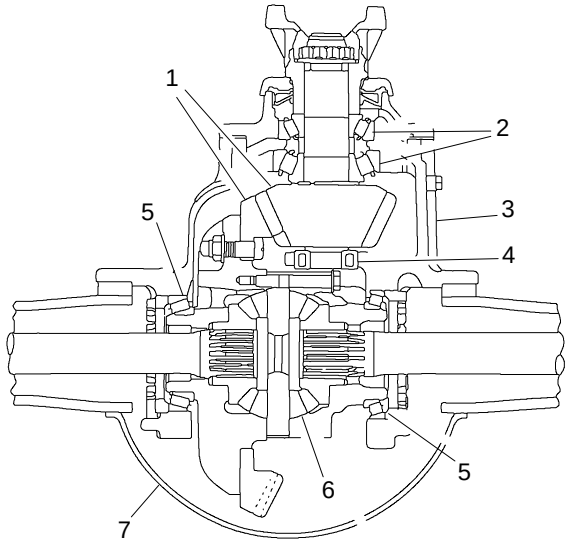
Table 5, Adapter Plates

Standard Single Reduction Carriers

The single reduction carriers are front-mounted into the axle housing. These carriers have a hypoid drive pinion and ring gearset and bevel gears in the differential assembly. See **Fig. 1** and **Fig. 2**.

A straight roller bearing (pilot) is mounted on the head of the drive pinion. All other bearings in the carrier are tapered roller bearings.

When the carrier operates, there is normal differential action between the wheels all the time.



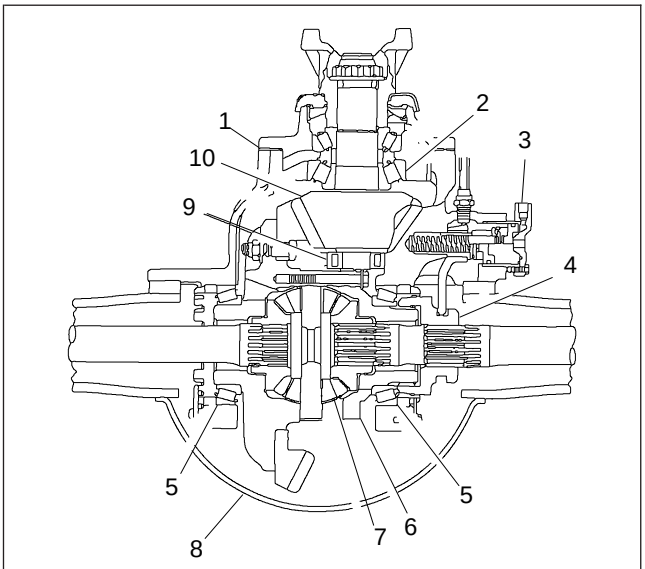
09/18/98 f350262

1. Drive Pinion and Ring Gear
2. Drive Pinion Bearings
3. Rear Axle Differential Carrier
4. Drive Pinion Pilot Bearing
5. Differential Bearing
6. Differential Pinion Gears
7. Rear Axle Housing

Fig. 1, Standard Carrier

Axle Speed Sensor

Speed sensors are multi-point, variable reluctance devices that provide individual wheel speed data at a 100 pulse-per-wheel revolution, resulting in high-quality output signals.



09/18/98 f350209

1. Rear Axle Differential Carrier
2. Drive Pinion Bearings
3. Shift Assembly
4. Shift Fork
5. Differential Bearing
6. Differential Case
7. Differential Pinion Gears
8. Rear Axle Housing
9. Drive Pinion Pilot Bearing
10. Drive Pinion and Ring Gear

Fig. 2, Carrier With Differential Lock

The sensor is used in the antilock brake system (ABS) to monitor and report individual wheel speeds to the ABS electronic controller.

There are two sensor assemblies in each differential carrier. The speed sensors are mounted in each differential bearing adjusting ring.

Removal

NOTE: If the rear tandem axle is being repaired and if it is equipped with a driver-controlled main differential lock, refer to **Section 35.03** in this manual before performing any repair procedures.

1. Chock the front tires. See **Fig. 1**.

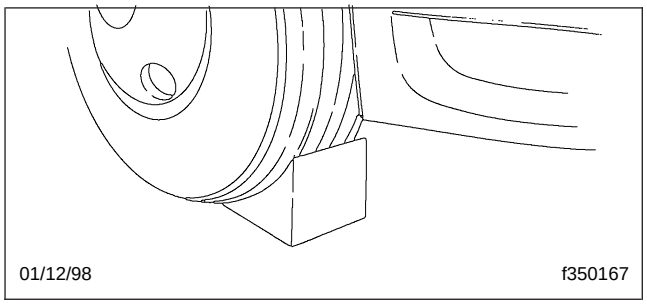


Fig. 1, Chock the Tires

NOTE: If the brake drums are to be removed, the brakes should be manually released before disconnecting the air brake hoses. Refer to **Group 42** in this manual.

2. Disconnect the air brake hoses. See **Fig. 2**.

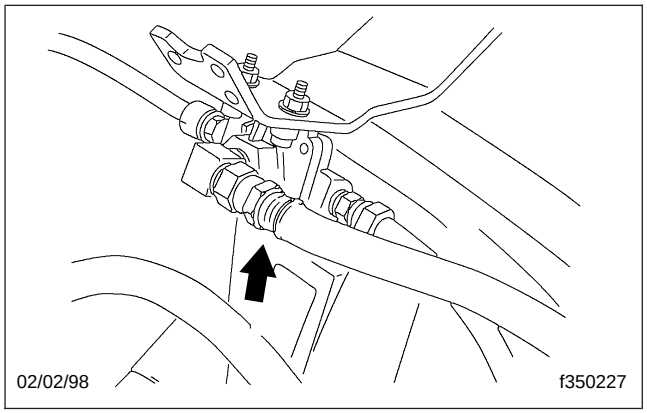


Fig. 2, Air Brake Hoses

3. For a single rear axle, disconnect the shock absorbers at the axle. See **Fig. 3**.
4. For a rear tandem axle, remove the torque rod bolts from the axle housing and loosen the torque rod. See **Fig. 4**.

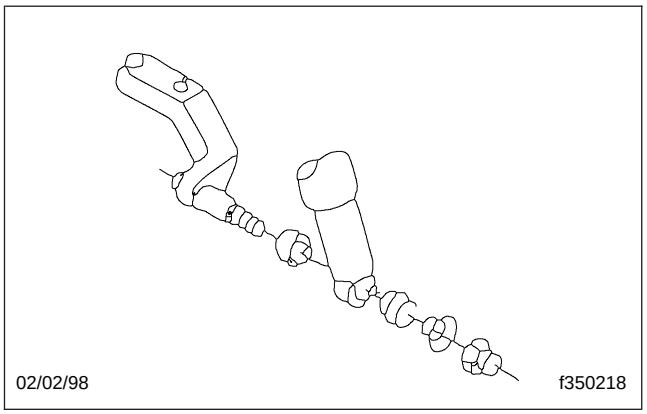


Fig. 3, Shock Absorber

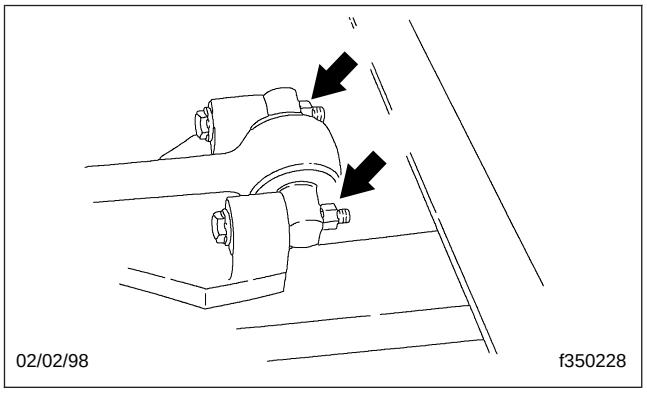


Fig. 4, Torque Rod Bolts at Rear Axle

5. Disconnect the driveshaft from the rear axle input flange or yoke and wire it out of the way. See **Fig. 5**.

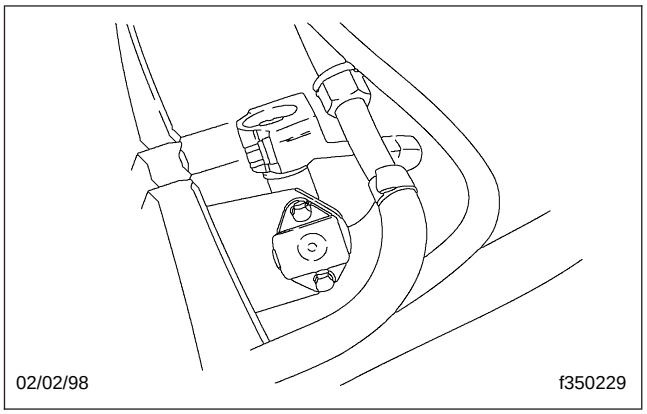


Fig. 5, Driveshaft

Removal and Installation

6. Raise the rear of the vehicle with a suitable jack high enough to clear the axle when it is to be removed, and insert jack stands.

NOTE: On a rear tandem axle or a single rear axle, the tires do not have to be removed.

7. If necessary, remove the tires. See **Fig. 6**.

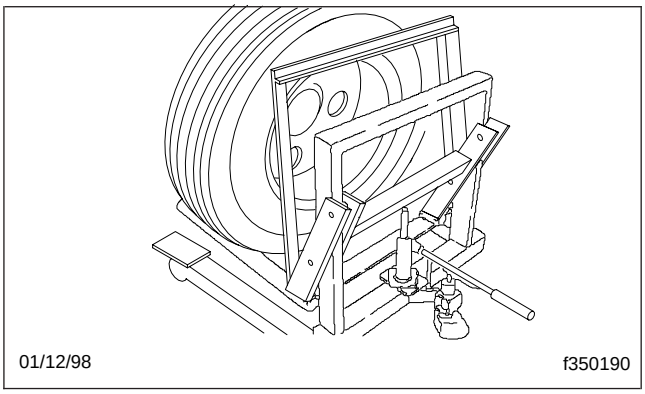


Fig. 6, Removing the Tire With Wheel Jack

8. Support the carrier housing with a floor jack.

NOTE: U-bolts and U-bolt nuts cannot be reused.

9. Remove the U-bolts and the U-bolt nuts and discard them. See **Fig. 7**.

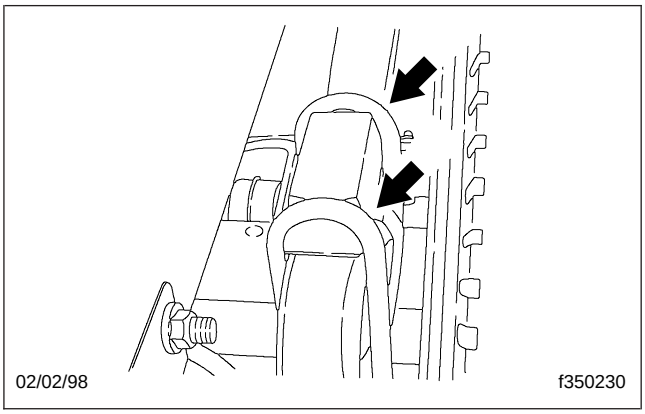


Fig. 7, U-Bolts and U-Bolt Nuts

IMPORTANT: While lowering the axle, watch for obstructions.

10. Carefully lower the axle with the floor jack and slide the axle out from under the vehicle.

Installation

NOTE: When tightening the air fittings, a minimum of two turns past finger-tight is required. Directional fittings are to be oriented in a tightening direction only.

1. Carefully raise the axle with the floor jack and slide the axle under the vehicle.

NOTE: U-bolts and U-bolt nuts cannot be reused.

2. Position the axle and install the U-bolts and the U-bolt nuts. Tighten the nuts to 260 to 320 lbf·ft (353 to 433 N·m). See **Fig. 7**.
3. Support the carrier housing with a floor jack.
4. If necessary, install the tires and tighten the nuts to 450 to 500 lbf·ft (611 to 677 N·m). See **Fig. 6**.
5. Raise the rear of the vehicle with a suitable floor jack. Remove the jack stands and lower the vehicle.
6. Connect the driveshaft at the rear axle input flange or yoke. Tighten the nuts and bolts 5/16-24: 35 to 41 lbf·ft (47 to 56 N·m) and 3/8-24: 45 to 60 lbf·ft (61 to 81 N·m). See **Fig. 5**.
7. For a rear tandem axle, install the torque rod bolts to the axle housing. Tighten the bolts 150 to 205 lbf·ft (204 to 277 N·m). See **Fig. 4**.
8. For a single rear axle, connect the shock absorbers at the axle, tighten nuts until firm. See **Fig. 3**.
9. Connect the air brake hoses. See **Fig. 2**.
10. Remove the chocks from the front tires. See **Fig. 1**.

Adjustment

NOTE: If the rear tandem axle is being repaired and if it is equipped with a driver-controlled main differential lock, refer to **Section 35.03** in this manual before performing any repair procedures.

NOTE: Some Meritor axles are not equipped with a thrust screw.

NOTE: If the carrier does not have a thrust block, skip the first three steps.

1. Rotate the carrier in the repair stand until the back surface of the ring gear is up. See **Fig. 1**.

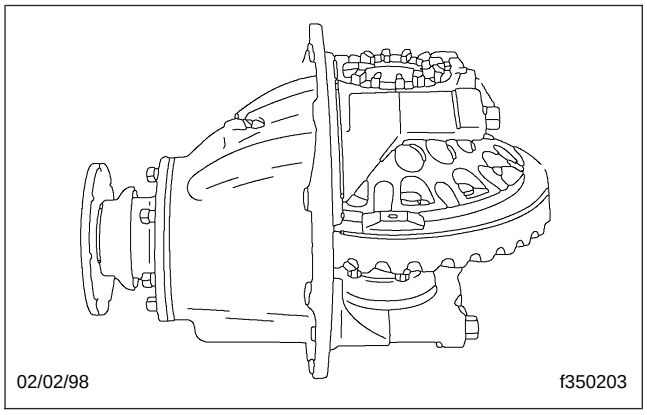


Fig. 1, Rotate the Carrier So the Ring Gear is Up

2. Put the thrust block on the back surface of the ring gear. The thrust block must be in the center between the outer diameter of gear and differential case.
3. Rotate the ring gear until the thrust block and the hole for the drive gear thrust screw in the carrier are aligned.
4. Install the jam nut in the middle of the drive gear thrust screw. See **Fig. 2**.
5. Install the drive gear thrust screw into the carrier until the screw stops against the ring gear or thrust block. See **Fig. 3**.
6. Loosen the drive gear thrust screw one-half turn, 180 degrees. See **Fig. 4**.
7. Tighten the jam nut to the correct torque value. Refer to **Specifications, 400**. See **Fig. 5**.

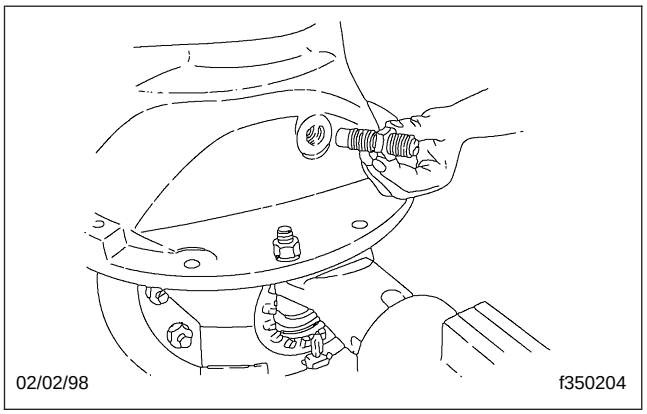


Fig. 2, Jam Nut Installation

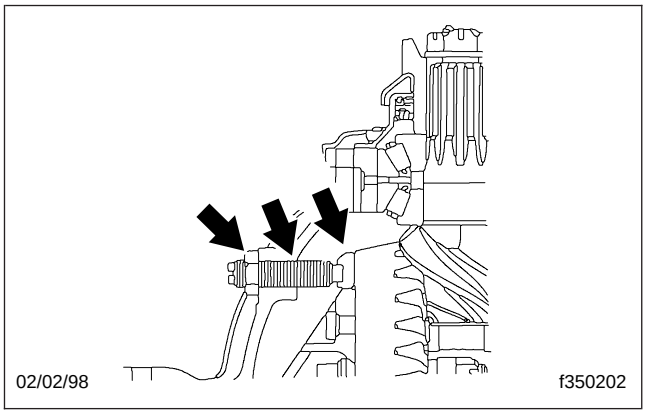


Fig. 3, Drive Gear Thrust Screw Installation

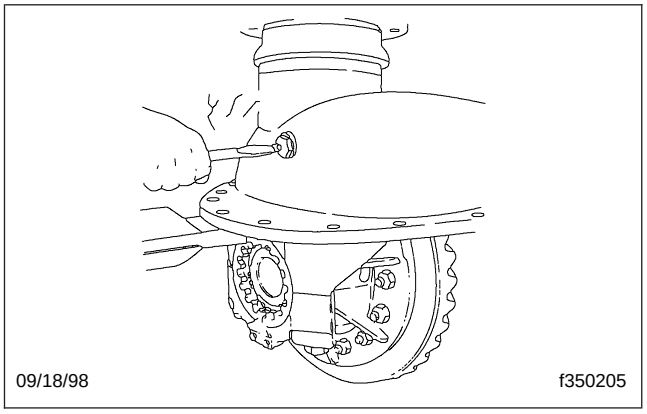


Fig. 4, Loosening the Drive Gear Thrust Screw 180 Degrees

Thrust Screw Adjustment

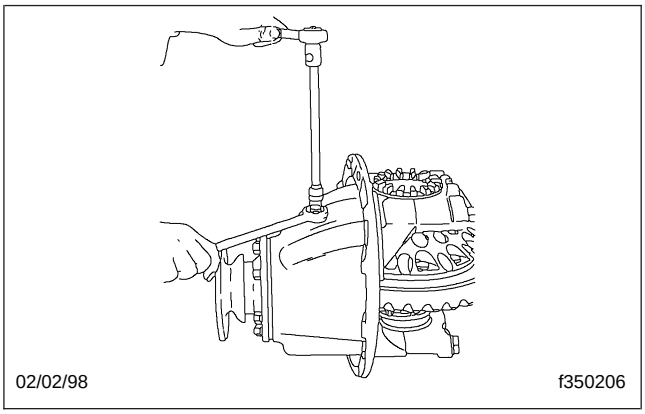


Fig. 5, Tightening the Jam Nut

Speed Sensor Removal and Installation

Removal

1. Disconnect the battery ground cable. On vehicles equipped with dual batteries, refer to **Group 54** in this manual.

CAUTION

Do not disconnect the sensor plug from the receptacle by pulling the wiring harness. Damage to the plug will occur and cause an open circuit. Always disconnect the sensor by pulling the plug housing.

2. Disconnect the left-hand and right-hand sensor plugs from the receptacles. Grasp the plug, press the lock tab on the top of the plug housing and pull the plug from the receptacle.
3. Remove the rear axle differential carrier. For instructions, refer to **Subject 130**.
4. With snap ring pliers, remove the snap ring that holds the speed sensor in the adjusting ring of the differential bearing.

CAUTION

When prying the speed sensor from the bearing adjusting ring, always position the screwdrivers under the two metal tabs. Do not pry the sensor from the plastic coil housing. Damage to the coil will occur.

5. Pry the speed sensor loose, but do not completely remove it from the bearing adjusting ring. Use two screwdrivers to pry the sensor at the two opposite tabs.

NOTE: Both sensor receptacles are mounted through bores in the flange of the carrier.

6. Using two screwdrivers, pry the snap ring out of the groove in both the left-hand and right-hand sensor receptacles.

NOTE: If the receptacle cannot be removed using this procedure, position a small block of wood against the receptacle and tap the block with a leather or plastic mallet until the receptacle is removed from the carrier flange.

7. Remove the receptacle from the differential carrier flange by pushing the receptacle from the outside surface of the flange toward the inside surface of the carrier.

CAUTION

When removing the speed sensor assembly from the bearing adjusting ring, do not drop the assembly. Damage to the components can occur.

8. Completely remove the speed sensor assembly by pulling it out from the bearing adjusting ring.
9. Remove the wave washer from inside the bore of the bearing adjusting ring.

NOTE: Removal of the drive tubes from the differential case halves is not a requirement to remove the speed sensors. Remove the drive tubes from the case halves only if required due to damaged parts.

10. Remove and disassemble the differential and ring gear assembly. For instructions, refer to the axle manufacturer's service literature.
11. Using a screwdriver, remove the snap ring that holds the drive tube in position inside the differential case half.
12. Lift out the backup washer that is behind the snap ring, inside the differential case half.
13. Pull the drive tube out from the bearing side of the differential case half.

Installation

CAUTION

Do not use cleaning solvents to clean the speed sensor assembly. Damage to components can occur. Clean the speed sensor assembly only with a clean dry rag or paper towel.

NOTE: If the drive tube was not removed, omit the next two steps.

1. Install the drive tube into the differential case half from the bearing side.
2. While holding the drive tube in position, place the backup washer over the drive tube and against the inside of the differential case half.
3. Install the snap ring into the groove in the drive tube, using a screwdriver, if necessary.

Speed Sensor Removal and Installation

4. Assemble and install the differential and ring gear assembly. For instructions, refer to the axle manufacturer's service literature.

CAUTION

Before installing the speed sensor assembly and components into the bearing adjusting ring, check the position of the roll pin that locks the adjusting ring in place. The speed sensor cannot be correctly installed if the roll pin extends beyond the snap ring groove in the lugs of the adjusting ring.

5. Adjust the position of the roll pin, if necessary, by using a drift and hammer.

NOTE: Check the outside of the speed sensor receptacle. There must be an O-ring positioned in the first groove.

6. Install an O-ring, if necessary.
7. Install the speed sensor by pushing the receptacle through the large hole in the carrier flange. Push from the inside of the flange toward the outside surface.
8. Apply and hold pressure against the back of the receptacle and install the snap ring into the first full groove that appears past the outside surface of the carrier flange.
   - 8.1 Using needle nose pliers, install the snap ring.
   - 8.2 Temporarily rest the sensor on the inside flange of the carrier.
9. Install the wave washer inside the bore of the bearing adjusting ring.
10. Apply axle lubricant to the outer surface of the drive tube and on the drive seal of the speed sensor.
11. Install the speed sensors in the bearing adjusting rings. The wire outlet area of the coil of each sensor must face out and align with the correct slot in the bearing adjusting ring.
12. Place the speed sensor over the bearing adjusting ring with the wire outlet area of the coil in the correct position. Turn the rotor in the sensor until the tabs align with the slots in the drive tube.

CAUTION

The speed sensor must be installed carefully and evenly into the bore of the bearing adjusting ring or damage to the sensor can occur.

NOTE: If the drive seal slips off the rotor of the speed sensor, remove the speed sensor from the bearing adjusting ring. Place the drive seal in position on the rotor.

13. Press the speed sensor evenly into the bore of the bearing adjusting ring manually, while carefully sliding the drive seal over the drive tube.
    - 13.1 Make sure the wire outlet area of the coil freely enters the selected slot in the bearing adjusting ring.
    - 13.2 Use even pressure around the sensor, near the outer diameter, until the sensor is seated against the wave washer.
14. Press the speed sensor down into the bearing adjusting ring so that the top of the sensor is past the snap ring grooves in the lugs. Hold the sensor in this position.

NOTE: The sensor should be positioned firmly and evenly against the snap ring. If it is not, apply hand pressure to the sensor, depressing it against the wave washer until sensor alignment is obtained.

NOTE: After the sensor is installed, make sure the outlet wires of the sensor are as close to the carrier leg as possible to make sure the wires are not pinched when the carrier is installed in the axle housing.

15. Place the snap ring over the speed sensor with the opening aligned with the wire outlet area of the coil housing.
16. Install the differential carrier into the axle housing. Refer to **Subject 130**.
17. Reconnect the electrical connectors.
18. Reconnect the battery ground cable. On vehicles equipped with dual batteries, refer to **Group 54** in this manual.
19. Refer to **Group 42** in this manual for diagnostic and repair procedures for the antilock brake system.

Differential Carrier Removal and Installation

Removal

WARNING

Do not work under the vehicle if it is supported by jacks or lifting tools. Jacks and lifting tools can slip and cause injury.

NOTE: If the rear tandem axle is being repaired and if it is equipped with a driver-controlled main differential lock, refer to **Group 35** in this manual before performing any repair procedures.

1. Raise the vehicle. Put jack stands under each spring seat of the axle to hold the vehicle in the raised position. See **Fig. 1**.

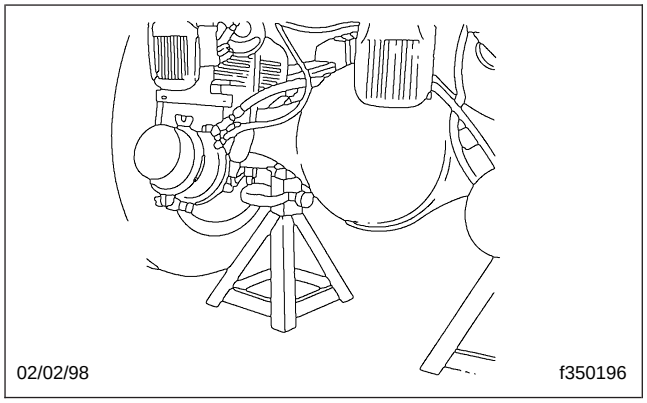


Fig. 1, Supporting Axle With Jackstands

2. Remove the plug from the bottom of the axle housing and drain the lubricant from the assembly.
3. Disconnect the driveline universal joint from the pinion input yoke or flange on the carrier. See **Fig. 2**.
4. Remove the capscrews and washers, or stud nuts and washers from the flanges of both axle shafts. See **Fig. 3**.

WARNING

Wear safe eye protection. Do not hit the round driving lugs on the head of the axle shafts. Lugs can break and cause injury.

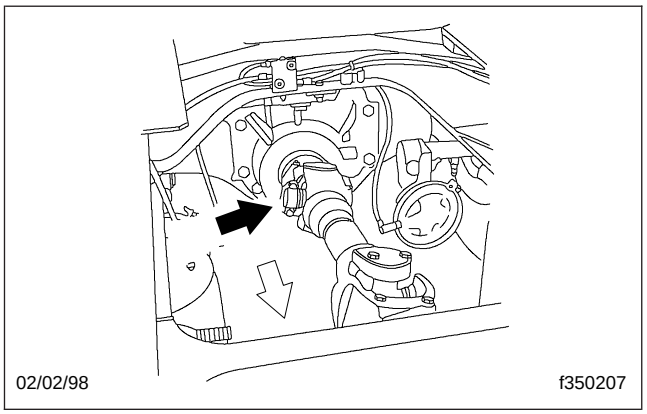


Fig. 2, Disconnecting the Universal Joint from the Pinion Input Yoke

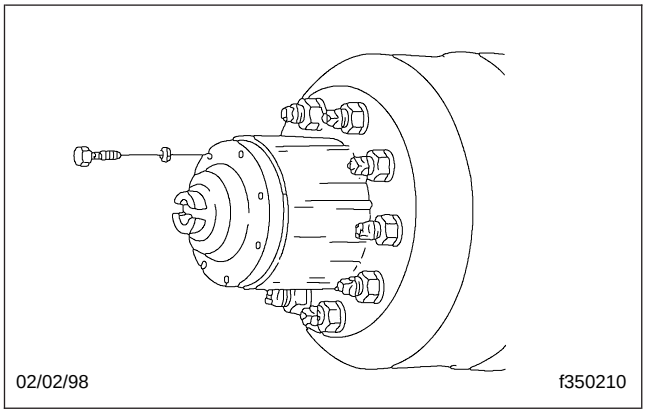


Fig. 3, Axle Shaft Flange Retainers

CAUTION

Do not use a chisel or wedge to loosen the axle shafts and dowels. The chisel or wedge can damage the hub, axle shafts and, if used, oil seals.

5. Loosen the tapered dowels in the flanges, if so equipped, of both axle shafts by holding a 1-1/2-inch diameter brass drift against the center of the axle shaft, inside the circular driving lugs (a 1-1/2-inch diameter brass hammer can be used as a drift). Hit the end of the drift with a large hammer (five to six pounds), and the axle shaft and the tapered dowels will loosen. See **Fig. 4**.
6. Remove the tapered dowels and both axle shafts from the axle assembly. See **Fig. 5**.
7. Place a suitable floor jack under the differential carrier to support the assembly. See **Fig. 6**.

Differential Carrier Removal and Installation

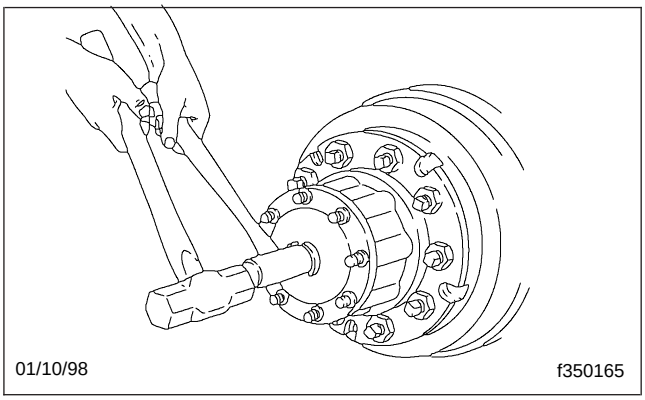


Fig. 4, Loosening Tapered Dowels

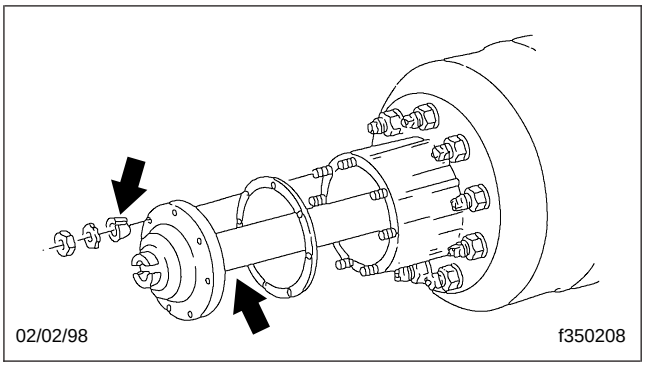


Fig. 5, Removing Tapered Dowels and Axle Shaft

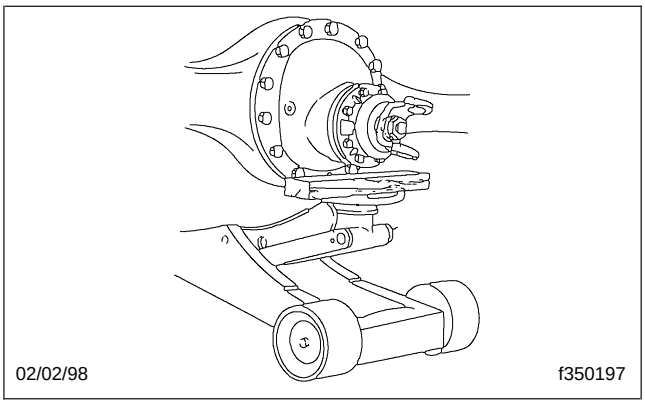


Fig. 6, Supporting Axle Carrier

NOTE: Loosen the top two differential carrier-to-housing fasteners and leave attached to the assembly. The fasteners will hold the differential carrier in the housing.

8. Remove all but the top two carrier-to-housing capscrews or stud nuts and washers. See **Fig. 7**.

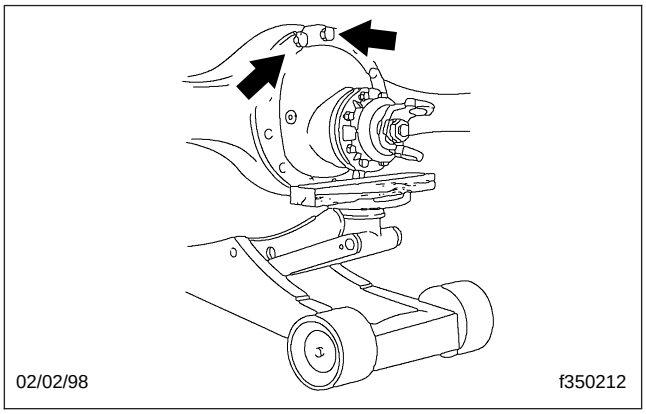


Fig. 7, Carrier-to-Housing Capscrews

9. Loosen the differential carrier in the axle housing. Use a leather mallet to hit the mounting flange of the carrier at several points.

NOTE: Some differential carrier models have threaded puller screw holes in the mounting flange. Puller screws can be used to loosen and pull the carrier from the axle housing. If puller screws are used, clean the threaded holes before the puller screws are installed.

10. Remove the top two fasteners after the differential carrier is loosened. See **Fig. 7**.

⚠ CAUTION

When using a pry bar, be careful not to damage the differential carrier or housing flange. Damage to these surfaces will cause oil leaks.

11. Remove the carrier from the axle housing carefully, using the floor jack.

⚠ WARNING

Use a lifting tool for this procedure. Do not lift by hand. Failure to observe this warning can result in damage to the unit and possible person injury.

12. Lift the differential carrier by the input yoke or flange and put the assembly in a suitable repair stand. See **Fig. 8**.

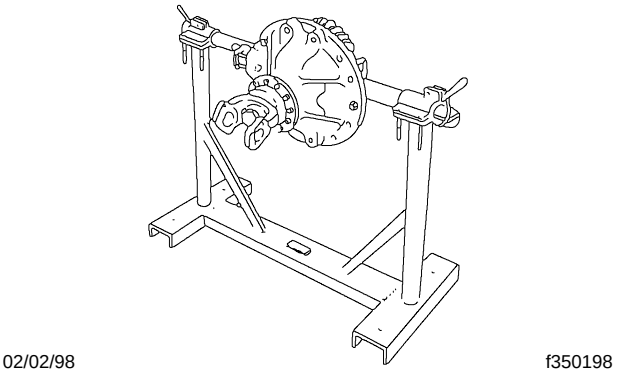


Fig. 8, Differential Carrier Mounted On a Repair Stand

Installation

1. Clean the inside of the rear axle housing and the mounting surface where the differential carrier fastens.
   - 1.1 Use a cleaning solvent and rags to remove dirt.
   - 1.2 Blow dry the cleaned areas with air.
2. Inspect the axle housing for damage.

   Repair or replace the axle housing.
3. Check for loose studs in the mounting surface of the housing where the differential carrier fastens. Remove and clean the studs that are loose (some Meritor axles are equipped with capscrews and some are equipped with stud nuts).
4. Apply liquid adhesive to the threaded holes and install the studs into the rear axle housing.
5. Apply silicone gasket material to the mounting surface of the rear axle housing where the carrier fastens. See **Fig. 9**.

CAUTION

Do not install the differential carriers using a hammer or mallet. A hammer or mallet will damage the mounting flange of the carrier and cause oil leaks.

6. Install the differential carrier into the rear axle housing, using a suitable floor jack.
7. Install the nuts and washers or capscrews and washers in the four corner locations around the differential carrier and rear axle housing. Tighten the fasteners hand-tight at this time. See **Fig. 10**.

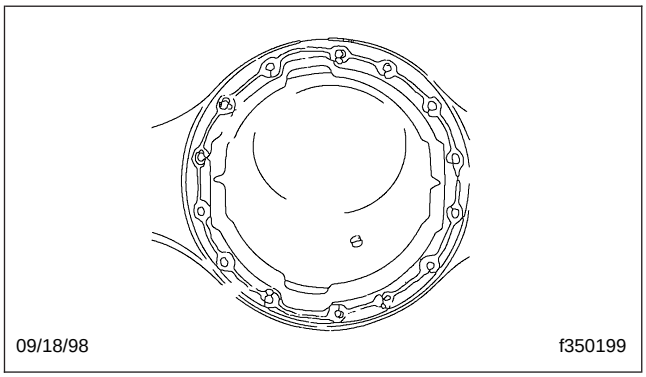


Fig. 9, Applying Silicone to the Mounting Surface

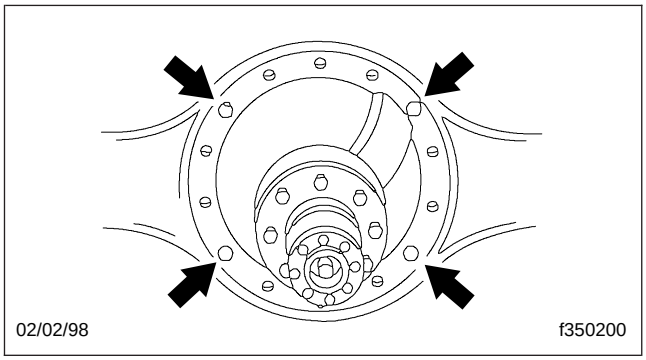


Fig. 10, Install the Bolts In Four Corners of Carrier

8. Push the differential carrier into position.
   - 8.1 Tighten the four fasteners, two or three turns each, in a pattern opposite each other.
   - 8.2 Repeat until the four fasteners are tightened to the correct torque value. Refer to **Specifications, 400**.
9. Install the other fasteners and washers that hold the carrier in the rear axle housing and tighten to the correct torque value. Refer to **Specifications, 400**. See **Fig. 11**.
10. Connect the driveline universal joint to the pinion input yoke or flange on the carrier. See **Fig. 4**.

CAUTION

The gasket and flange of the axle shafts must fit flat against the wheel hub to prevent fluid leakage and component damage.

Differential Carrier Removal and Installation

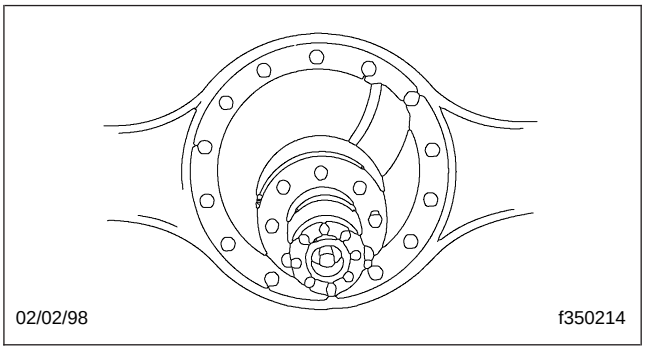


Fig. 11, Install the Carrier Bolts

11. Install the gaskets and axle shafts into the rear axle housing and carrier. See **Fig. 12**.

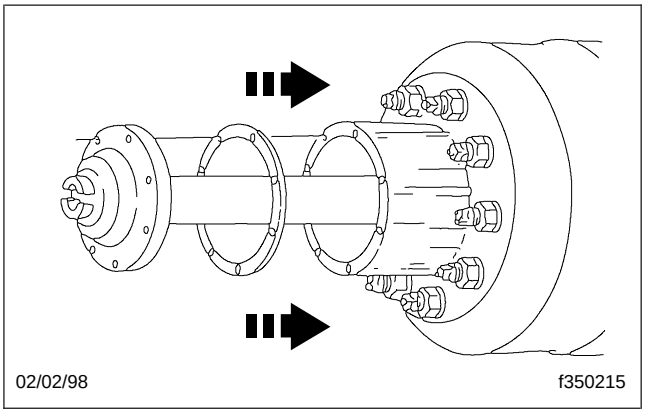


Fig. 12, Installing the Gaskets and Axle Shafts

12. Install the capscrews and washers that hold the axle shaft to the wheel hub and tighten the capscrews. See **Fig. 13**.

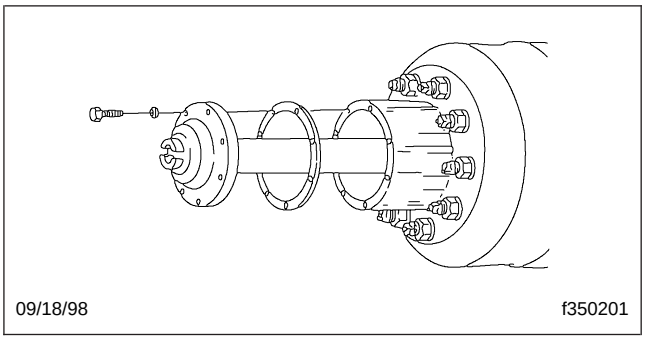


Fig. 13, Installing the Axle Shaft Bolts

13. Install the tapered dowels at each stud, if so equipped, and into the flange of the axle shaft. Use a punch or a drift and hammer, if needed. See **Fig. 7**.
14. Install the nuts and washers on the studs, and tighten the nuts to the correct torque value. Refer to **Specifications, 400**. See **Fig. 14**.

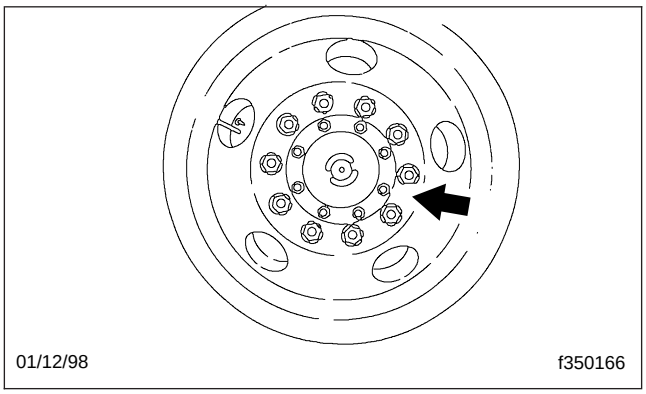


Fig. 14, Install the Nuts and Washers On the Studs

15. Install the drain plug and tighten.
16. Fill the rear axle with the specified lubricant. Refer to **Group 41** in this manual.
17. Remove the jack stands and lower the vehicle.

Specifications

General Specifications	
Item	**Specification**
Drive Pinion Bearing Preload	
New Bearings	5–45 lbf·in (56–508 N·cm)
Used Bearings	10–30 lbf·in (113–339 N·cm)
Main Differential Bearing Preload	15–35 lbf·in (170–390 N·cm)
Expansion Between Bearing Caps	
RS-XX-140 and 145 Carriers	0.003–0.009 inch (0.08–0.22 mm)
All Other Carriers	0.006–0.013 inch (0.15–0.33 mm)
Main Differential Gears Rotating Resistance	50 lbf·ft (68 N·m)
Ring Gear Backlash	
17 inches (less than 431.8 mm)	0.008–0.018 inch (0.20–0.46 mm)
New Gearset 17 inches (431.8 mm) or Greater	0.012 inch (0.30 mm) 0.25–0.51 mm
New Gearset	(0.010–0.020 inch) 0.38 mm (0.015 inch)
Ring Gear Runout (maximum) Adhesive	0.008 inch (0.20 mm)
Stud and Bearing Mount EOAZ–19554–BA	WSK–M2G349–A1

Table 1, General Specifications

Torque Specifications		
Description	**Thread Size**	**lbf·ft (N·m)**
Plug, Heat Indicator	0.50–14	25 (34) minimum
Plug, Oil Fill (Housing)	0.75–14	35 (47) minimum
Breather	0.38–18	20 (27) minimum
Nut, Axle Shaft Stud, Plain Nut	0.44–20	50–75 (68–102)
	0.50–20	75–115 (102–156)
	0.56–18	110–165 (149–224)
	0.62–18	150–230 (203–312)

Torque Specifications		
Description	**Thread Size**	**lbf·ft (N·m)**
Nut, Axle Shaft Stud, Locknut	0.44–20	40–65 (54–88)
	0.50–20	65–100 (88–136)
	0.56–18	100–145 (136–197)
	0.62–18	130–190 (176–258)
Capscrew, Axle Shaft	0.31–24	18–24 (24–33) 85–115
	0.50–13	85–115 (115–156)
Capscrew, Differential Case	0.38–16	35–50 (48–68)
	0.44–14	60–75 (81–102)
	0.50–13	85–115 (115–156)
	0.56–12	130–165 (176–224)
	0.62–11	180–230 (244–312)
Capscrew, Flange Head	M12 x 1.75	85–103 (115–140)
Capscrew, Standard Hex-Head	M12 x 1.75	74–95 (100–130)
Capscrew, Flange Head	M16 x 2	203–251 (275–340)
Capscrew, Standard Hex-Head	M16 x 2	220–310 (300–420)
Capscrew/Plug, Air Cylinder Cover, Operating Position	M10 x 1.5	44–55 (60–75)
Capscrew/Plug, Air Cylinder Cover, Storage Position	M10 x 1.5	20–28 (30–38)
Capscrew, Air Cylinder Cover	M6 x 1	7.4–8.9 (10–12)
Capscrew, Lock Plate	0.31–18	20–30 (27–41)
	M8 x 1.25	21–26 (28–35)

Specifications

Torque Specifications		
Description	**Thread Size**	**lbf·ft (N·m)**
Nut, Ring Gear Bolt	0.50–13	75–100 (102–136)
	0.50–20	85–115 (115–156)
	0.62–11	150–190 (203–258)
	0.62–18	180–230 (244–312)
	M12 x 1.25	66–81 (90–110)
	M12 x 1.75	77–85 (104–115)
Nut, Ring Gear Bolt, Flange Head	M16 x 1.5	192–214 (260–290)
Nut, Ring Gear Bolt, Standard Hex-Head	M16 x 1.5	192–225 (260–305)
Nut, Differential Case Bolt	0.50–13	75–100 (102–136)
	0.50–20	85–115 (115–156)
	0.62–11	150–190 (203–258)
	0.62–18	180–230 (244–312)
	M12 x 1.75	74–95 (100–130)
Capscrew, Bearing Cap	0.56–12	110–145 (149–197)
	0.62–11	150–190 (203–258)
	0.75–10	270–350 (366–475)
	0.88–14	360–470 (488–637)
	0.88–9	425–550 (576–746)
	M16 x 2	181–221 (245–300)
	M20 x 2.5	347–431 (470–585)
	M22 x 2.5	479–597 (650–810)

Torque Specifications		
Description	**Thread Size**	**lbf·ft (N·m)**
Jam Nut, Thrust Screw	0.75–16	150–190 (203–258)
	0.88–14	150–300 (203–407)
	1.12–16	148–210 (200–285)
	M22 x 1.5	148–210 (200–285)
	M30 x 1.5	236–295 (320–400)
Nut, Housing to Carrier Stud	0.44–20	50–75 (68–102)
	0.50–20	75–115 (102–156)
	0.56–18	110–165 (149–224)
	0.62–18	150–230 (230–312)
Capscrew, Bearing Retainer	0.38–16	30–50 (41–68)
	0.44–14	50–75 (68–102)
	0.50–13	75–115 (102–156)
	0.56–12	110–165 (149–224)
	0.62–11	150–230 (203–312)
	M12 x 1.75	74-96 (100–130)
Nut, Drive Pinion	0.88–20	200–275 (271–373)
	1.0–20	300–400 (407–542)
	1.25–12 (1.25–18)	700–900 (949–1220)
	1.50–12 (1.50–18)	800–1100 (1085–1491)
	1.75–12	900–1200 (1220–1627)
	M32 x 1.5	738–922 (1000–1250)
	M39 x 1.5	922–1129 (1250–1530)
	M45 x 1.5	996–1232 (1350–1670)

Torque Specifications		
Description	**Thread Size**	**lbf·ft (N·m)**
Capscrew, Differential Carrier to Housing	0.44–14	50–75 (68–102)
	0.50–13	75–115 (102–156)
	0.56–12	110–165 (149–224)
	0.62–11	150–230 (203–312)
	0.75–10	270–400 (366–542)
	M12 x 1.75	74–89 (100–120)
	M16 x 2	181-221 (245–300)
Plug, Oil Drain	0.50–14	25 (34) minimum
Locknut, Sensor Switch	M16 x 1	26–33 (35–45)
Plug, Oil Fill (Carrier)	0.75–14	25 (34) minimum
	1.5–11.5	120 (163) minimum
	M24 x 1.5	35 (47) minimum
Capscrew, Manual Actuation (Storage Position)	M10 x 1.5	22–28 (30–38)
Adapter, Air Cylinder	M12 x 1.5	22–30 (30–40)
U-Bolt Nuts	—	260–320 (353–433)
Wheel Nuts	—	450–500 (611–677)
Torque Rod Bolts	—	150–205 (204–277)
Driveshaft/Interaxle Shaft Bearing Strap Capscrews	5/16–24	35–41 (47–56)
	3/8–24	45–60 (61–81)

Table 2, Torque Specifications

Rear Drive Axle and Differential

MERITOR TWO-SPEED AXLE

The Meritor two-speed rear axle (see **Fig. 1**) has a first reduction differential ring gear and pinion set and a second reduction planetary gearset.

The differential pinion is supported by two differential pinion bearings mounted on the pinion shaft in front of the gear head.

A rear axle drive pinion pilot bearing supports the pinion in the rear axle differential carrier.

The main differential and the planetary gearset are mounted in the differential case halves that are contained in the planetary support case. See **Fig. 2**.

The planetary support case is mounted in the rear axle differential carrier on two tapered differential bearings (see **Fig. 3**). An electric shift unit is mounted on the carrier and is actuated by a switch in the cab of the vehicle. The driver can actuate the switch to shift the drive unit into high or low gear range.

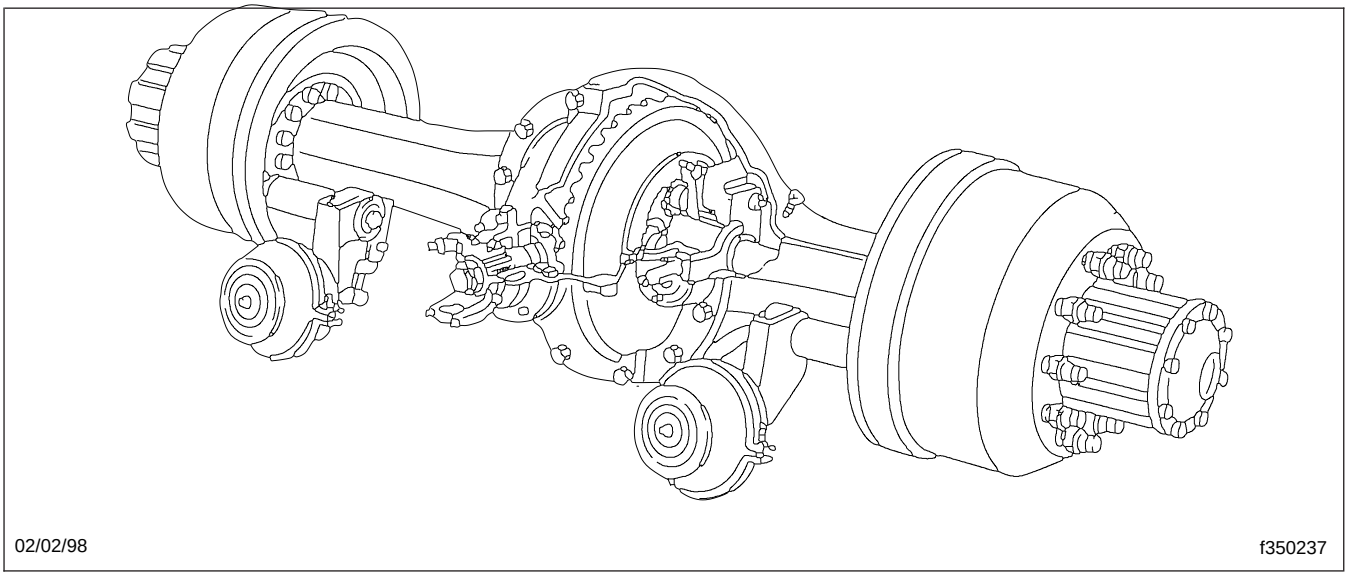


Fig. 1, Meritor Two-Speed Axle

In low gear range, the sun gear is shifted to engage with the clutch plate. The four planetary pinions are then free to rotate and become the second reduction gearset. See **Fig. 4**. The hypoid gearset ratio is now multiplied by the planetary gearset ratio. This gives the drive unit a higher numerical ratio for increased pulling power, but decreases the top speed. See **Fig. 5**.

In high gear range, the sun gear is engaged with the support case and the planetary pinions are locked in place. When the planetary pinions are locked, there is no second reduction and the power is sent directly from the hypoid gearset to the main differential (see **Fig. 6**). This hypoid single-reduction drive gives a lower numerical ratio for higher road speeds, but less pulling power.

SHIFT CONTROL, ELECTRIC

A slider block-type, electric shift control is used in conjunction with the two-speed axles.

The electric shift control system is composed of the control switch, the speedometer adapter, the electric shift unit, the relay, and the wiring harness.

The control switch, mounted on the gearshift lever, has two positions: up for high range and down for low range. See **Fig. 7**.

For vehicles with automatic transmission, the two-speed rear axle switch is located in the instrument panel. Push the top of the rocker switch for high range and push the bottom of the rocker switch for low range. When the switch is in either of these posi-

General Information

tions, the switch contacts complete the circuit between the battery and the motor in the axle shift unit (see **Fig. 8**).

A fuse (standard) or circuit breaker (optional) protects the two-speed axle system against a short circuit.

Relays are used in the circuit to connect the shift motor to battery power. The rear axle shift control switch connects the high gear or low gear relay coil to battery power. The contacts in the relays complete the circuit to the motor.

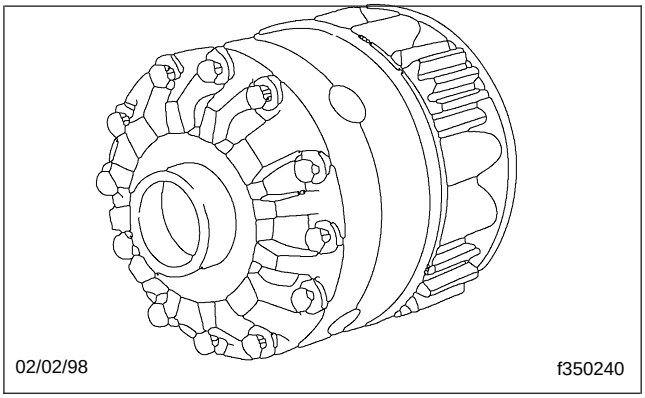


Fig. 2, Planetary Gearset

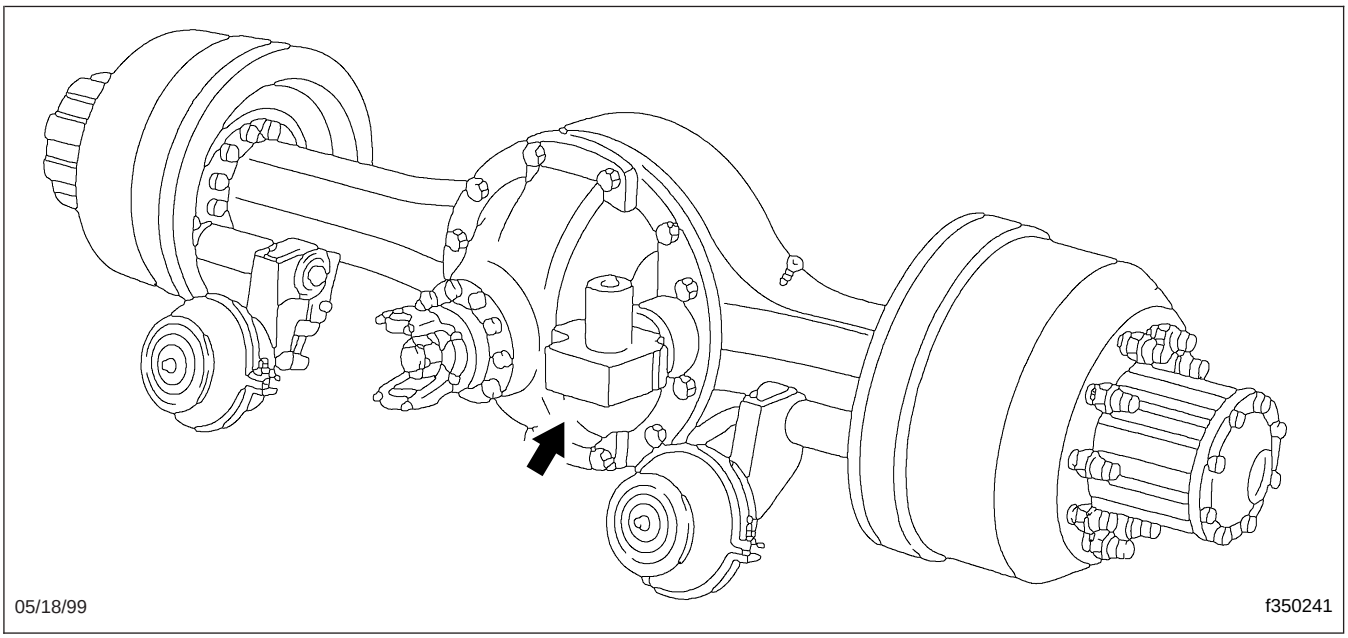
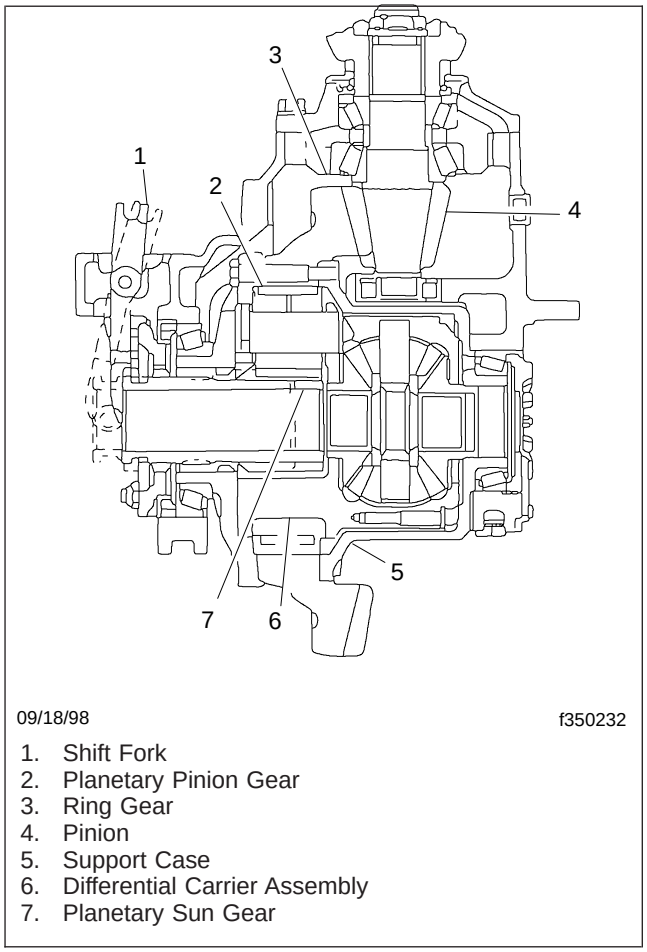


Fig. 3, Planetary Support Case



1. Shift Fork
2. Planetary Pinion Gear
3. Ring Gear
4. Pinion
5. Support Case
6. Differential Carrier Assembly
7. Planetary Sun Gear

Fig. 4, Differential Carrier

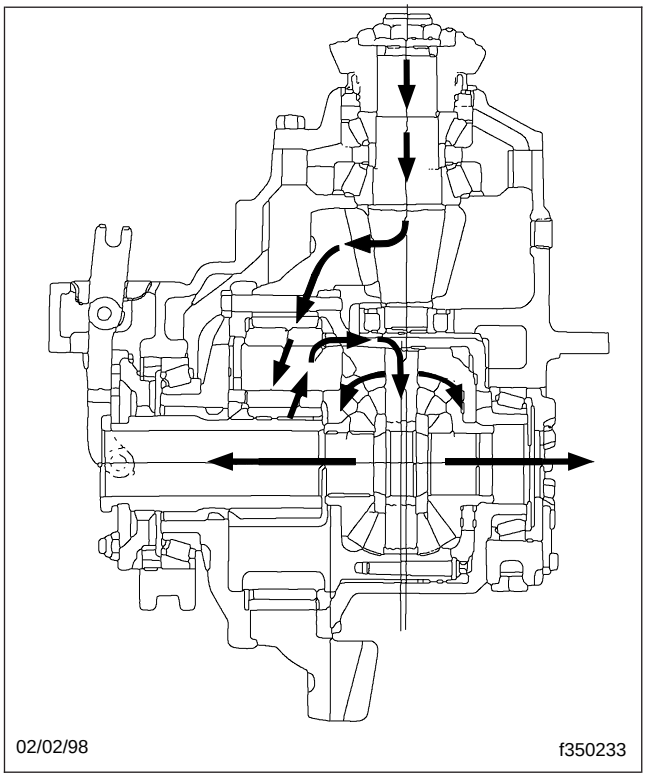


Fig. 5, Hypoid Gearset Powerflow With Secondary Reduction

General Information

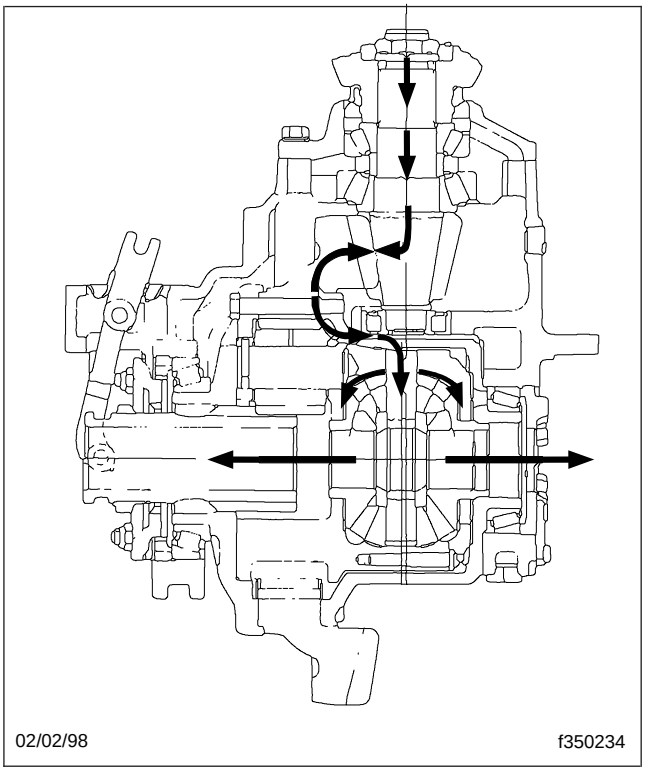


Fig. 6, Hypoid Gearset Powerflow With No Secondary Reduction

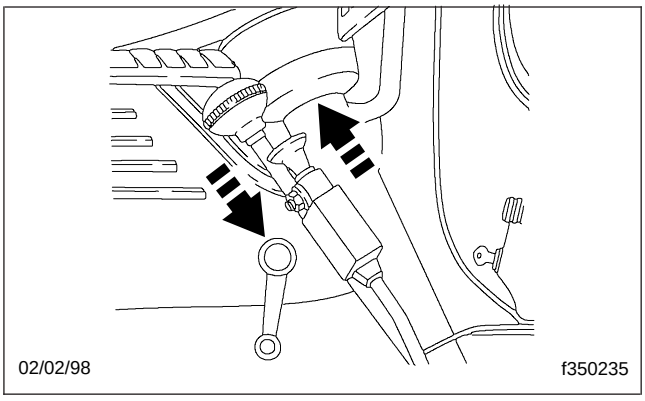


Fig. 7, Electric Shift Control Switch

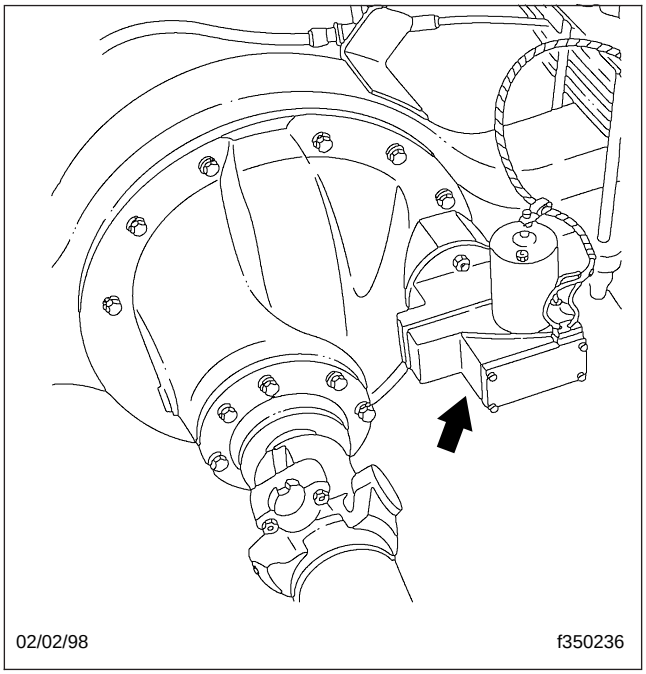


Fig. 8, Axle Shift Unit

Removal

1. Chock the front tires. See **Fig. 1**.

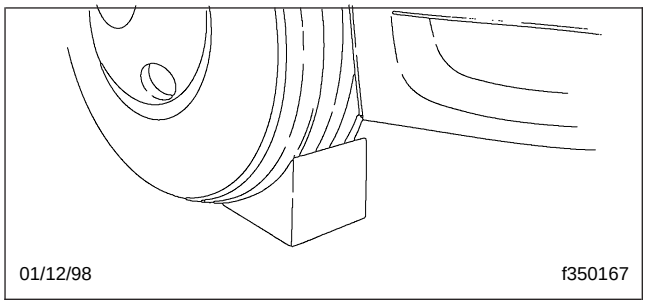


Fig. 1, Chock the Tires

2. Disconnect the electrical connectors. See **Fig. 2**.

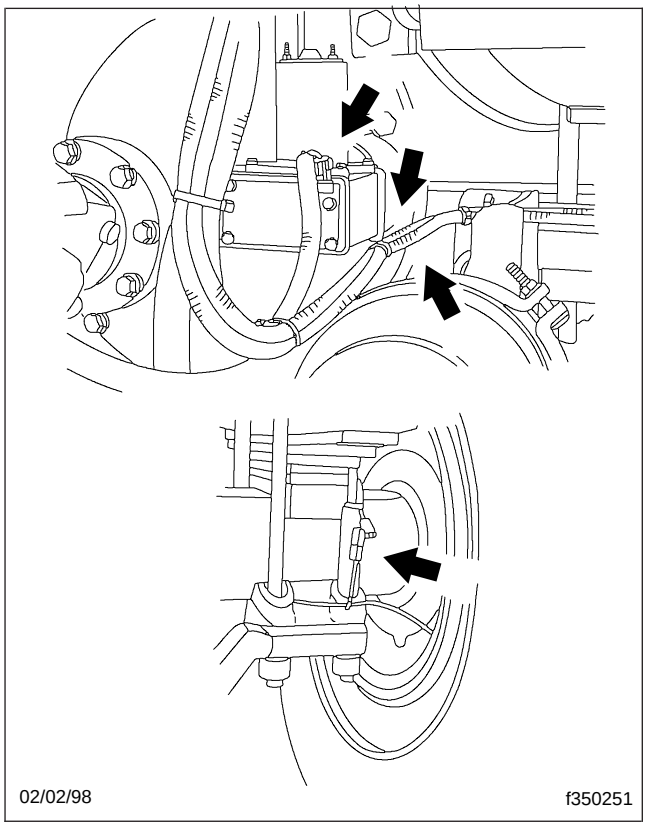


Fig. 2, Electrical Connectors

NOTE: If the brake drums are to be removed, the brakes should be caged before disconnecting the air brake hoses. Refer to **Group 42** for the caging procedure.

3. Release the brakes and bleed the air from the brake system. See **Fig. 3**.

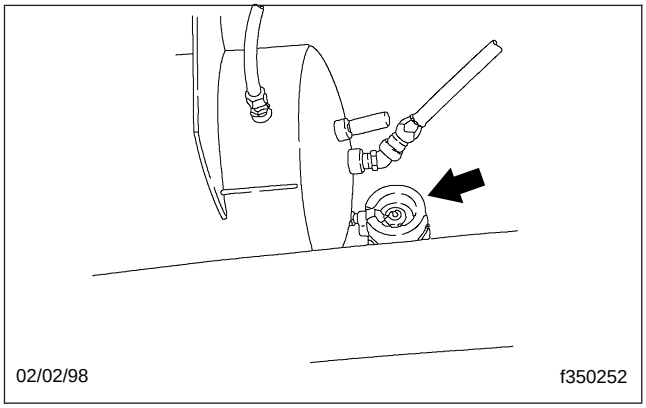


Fig. 3, Bleeding Air from Air Compressor

4. Disconnect the air brake hoses. See **Fig. 4**.

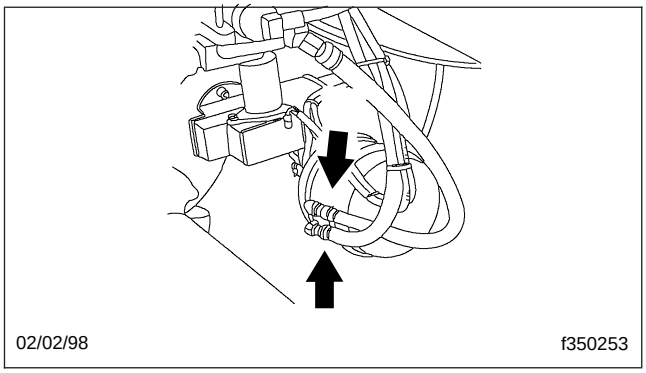


Fig. 4, Air Compressor Hoses

5. Disconnect the driveshaft at the axle and wire the driveshaft out of the way. See **Fig. 5**.

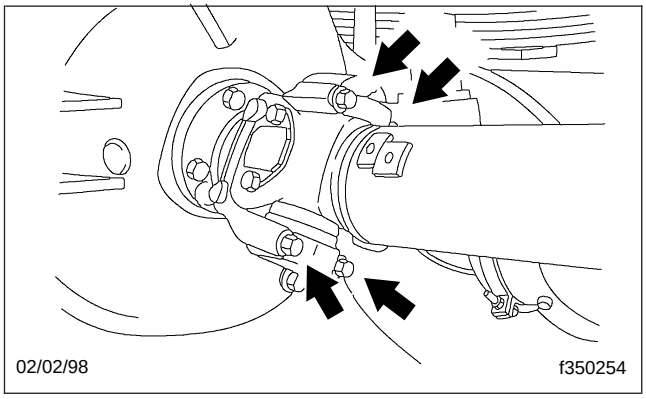


Fig. 5, Driveshaft at Axle

Removal and Installation

6. Disconnect the shock absorbers at the axle. See **Fig. 6**.

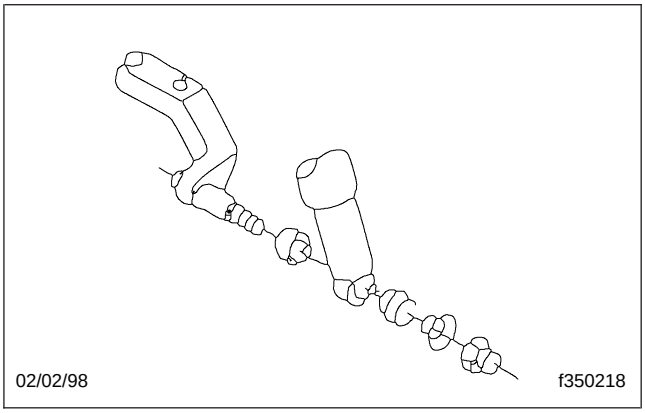


Fig. 6, Shock Absorbers at Axle

7. Raise the rear of the vehicle high enough to clear the axle so it can be removed and insert jack stands.
8. If necessary, remove the wheels and tires. See **Fig. 7**.

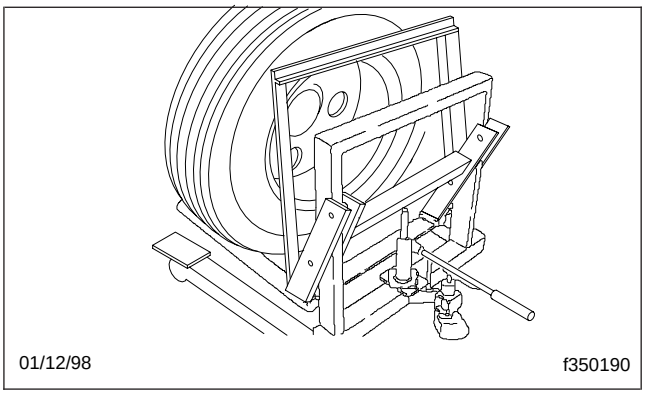


Fig. 7, Remove Wheels and Tires

9. Support the carrier housing with a floor jack.

NOTE: The U-bolts and U-bolt nuts cannot be reused.

10. Remove the U-bolts and U-bolt nuts and discard them. See **Fig. 8**.
11. Carefully lower the axle with the floor jack.

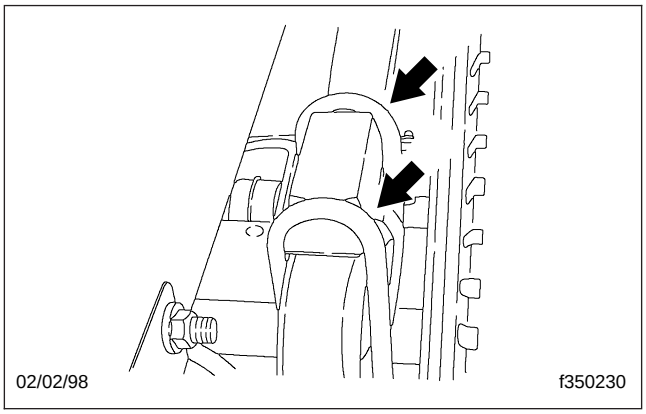


Fig. 8, U-Bolts and Nuts

Installation

NOTE: When tightening the air fittings, a minimum of two turns past finger-tight is required. Directional fittings are to be oriented in a tightening direction only.

1. Carefully raise the axle with the floor jack and slide the axle under the vehicle.

NOTE: U-bolts and U-bolt nuts cannot be reused.

2. Position the axle and install the U-bolts and the U-bolt nuts, tighten nuts to 260 to 320 lbf·ft (353 to 433 N·m). See **Fig. 8**.
3. Support the carrier housing with a floor jack.
4. If necessary, install the tires and tighten nuts to 450 to 500 lbf·ft (611 to 677 N·m). See **Fig. 7**.
5. Raise the rear of the vehicle with a suitable floor jack, remove the jack stands, and lower the vehicle.
6. Connect the driveshaft at the rear axle input flange or yoke, tighten nuts 5/16-24: 35 to 41 lbf·ft (47 to 56 N·m) and 3/8-24: 45 to 60 lbf·ft (61 to 81 N·m). See **Fig. 5**.
7. Connect the shock absorbers at the axle, tighten nuts until firm. See **Fig. 6**.
8. Connect the air brake hoses. See **Fig. 4**.
9. Connect the electrical connectors. See **Fig. 2**.
10. Remove the chocks from the front tires. See **Fig. 1**.

Removal

NOTE: All parts for models RS–17–220, RS–19–220, RS–21–230 and RS–23–240, except the shift unit to carrier studs and carrier to housing capscrews, are manufactured in metric dimensions. When the carriers are repaired, use the correct size tools.

NOTE: Before starting any repair or maintenance work on the differential carrier assembly, make sure the drive unit is shifted into the LOW range position. This will eliminate interference between the sun gear and the carrier mounting ring of the axle housing to allow differential carrier removal. To ensure a complete shift and positive gear engagement, drive the vehicle a short distance while shifting the drive unit into the low range position.

1. Remove the plug from the bottom of the axle housing and drain the lubricant.
2. Disconnect the driveline universal joint from the pinion input yoke or flange on the differential carrier. See **Fig. 1**.

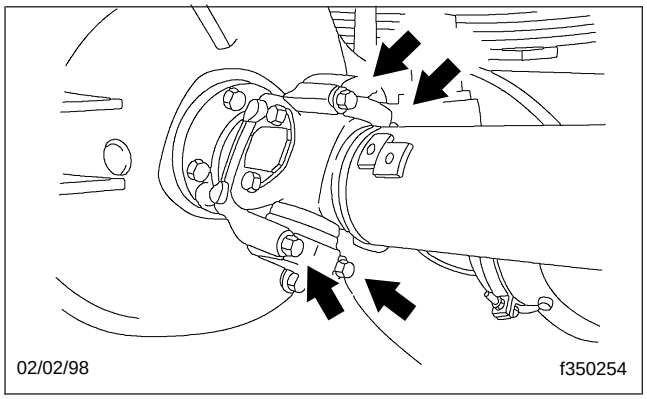


Fig. 1, Driveshaft

3. Remove the stud nuts and washers from the flanges of both axle shafts. See **Fig. 2**.

⚠ WARNING

Wear safe eye protection. Do not hit the round driving lugs on the head of the axle shaft. Lugs can break and cause injury.

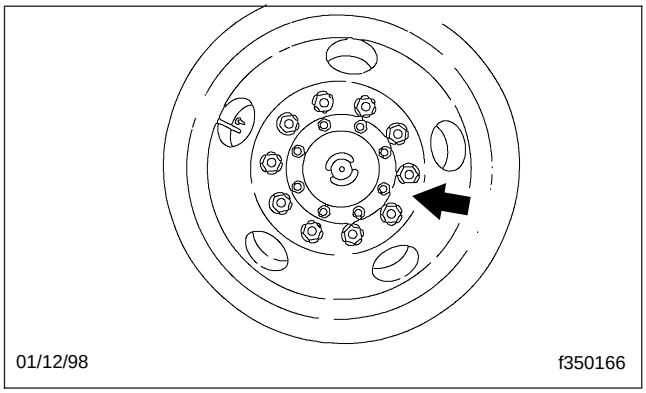


Fig. 2, Stud Nuts and Washers

⚠ CAUTION

Do not hit the circular driving lugs on the shaft head. This can cause the lugs to shatter and splinter. Do not use chisels or wedges to loosen the shaft or dowels. This will damage the hub, shaft and oil seal.

NOTE: A 1.5-inch (38-mm) diameter brass hammer can be used as a drift.

4. Loosen the tapered dowels in the flanges of both axle shafts by holding a 1.5-inch (38-mm) diameter brass drift against the center of the axle shaft head, inside the circular driving lugs and striking the drift with a 5- to 6-lb (2.7-kg) hammer or sledge. See **Fig. 3**.

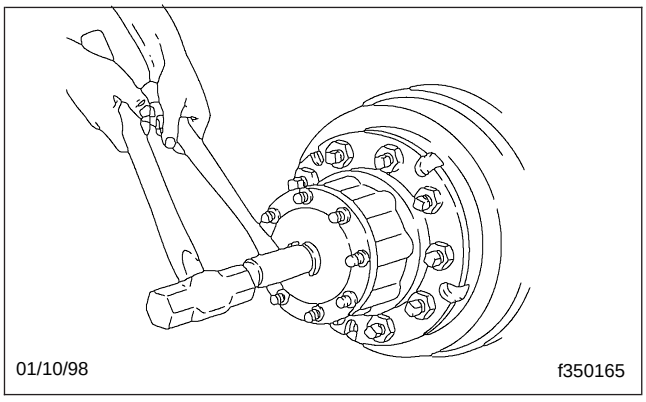


Fig. 3, Loosening Tapered Dowels

5. Remove the tapered dowels and axle shafts from the axle assembly. See **Fig. 4**.

Differential Carrier Removal and Installation

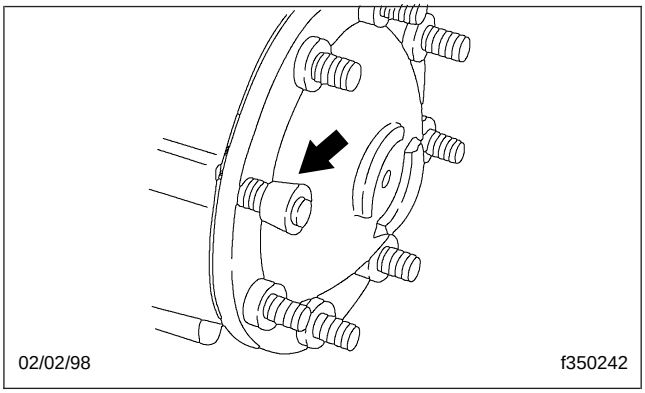


Fig. 4, Removing Tapered Dowels

NOTE: The shift motor can be removed altogether to facilitate carrier removal and to avoid inadvertent damage to the shift unit.

6. Disconnect the electric lines from the shift unit. See **Fig. 5**.

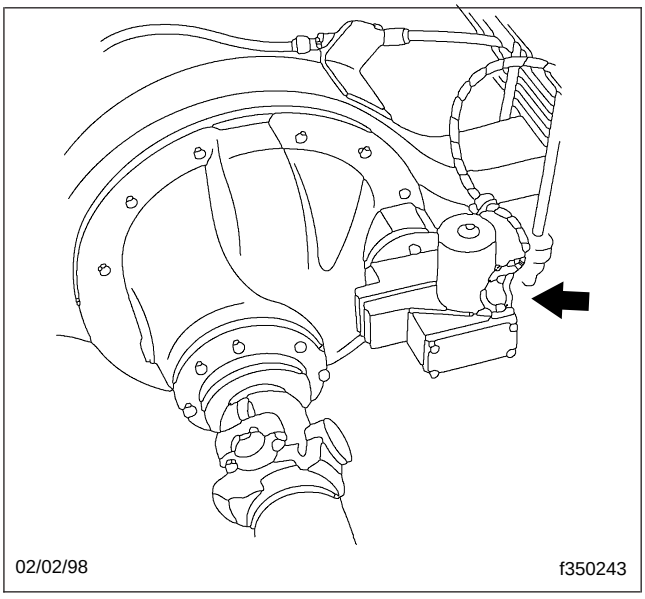


Fig. 5, Electrical Lines at Shift Unit

7. Remove all but the top two differential carrier-to-housing capscrews and washers. See **Fig. 6**.
8. Loosen the top two differential carrier-to-housing fasteners but leave them attached to the assembly. The fasteners will hold the carrier in the housing.

NOTE: If it is necessary to use puller bolts, there are two threaded holes in the differential carrier flange. Use the carrier-to-housing bolts.

9. Loosen the differential carrier in the axle housing. Use a soft mallet to hit the mounting flange of the carrier in several places. See **Fig. 7**.
10. Place the Rotunda Heavy Duty Truck Transmission Jack under the differential carrier to support the assembly. See **Fig. 8**.

CAUTION

Take care not to damage the differential carrier or housing flange as damage to these surfaces will cause oil leaks.

NOTE: Use a pry bar with a round end to help remove the differential carrier from the housing.

11. Remove the top two differential carrier-to-housing fasteners and carefully remove the differential carrier from the housing with the roller jack. See **Fig. 9**.
12. Place the differential carrier in a suitable repair stand. See **Fig. 10**.

Installation

1. Clean the inside of the axle housing and the mounting surface where the carrier fastens.
2. Inspect the axle housing for damage.
3. Apply silicone gasket material to the mounting surface of the housing where the carrier fastens. See **Fig. 11**.

CAUTION

Do not install the differential carrier using a hammer or mallet. A hammer or mallet can damage the mounting flange of the carrier and cause oil leaks.

Make sure the differential carrier is shifted into the low speed gear range. This will permit clearance between the sun gear and the differential carrier mounting ring on the housing.

4. Install the carrier into the axle housing using the Rotunda Heavy Duty Truck Transmission Jack.

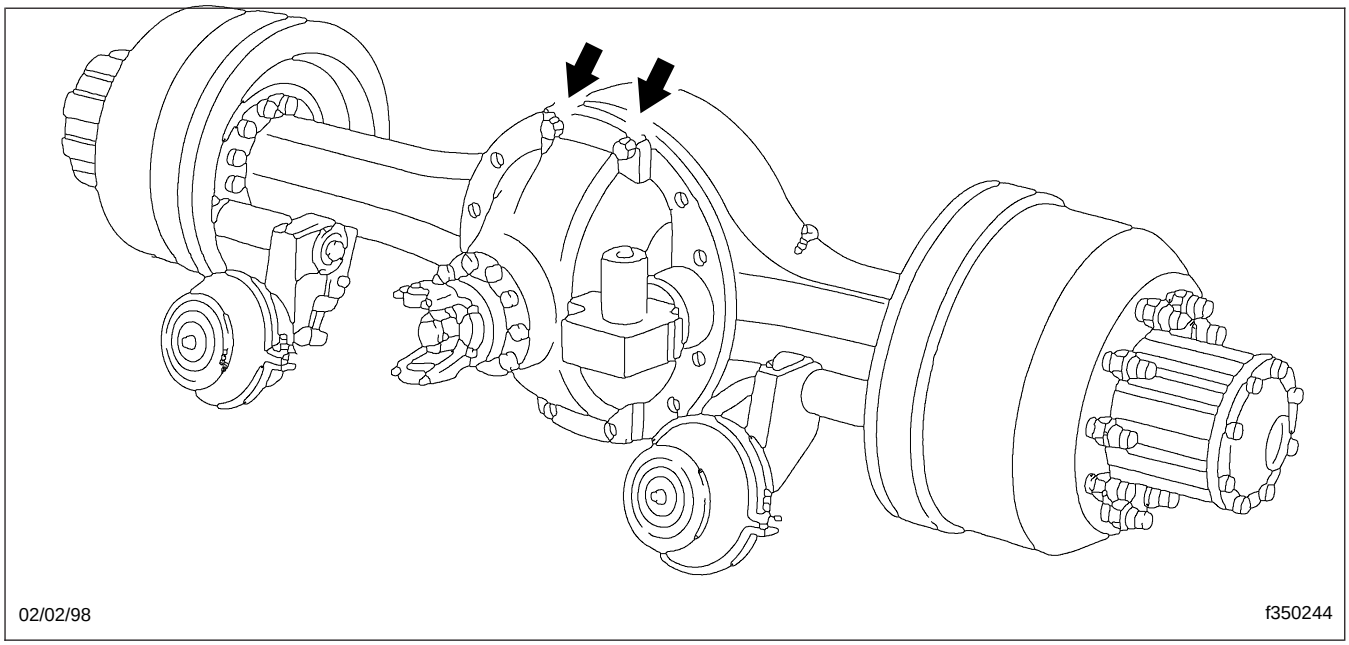


Fig. 6, Top Two Differential Carrier-to-Housing Bolts

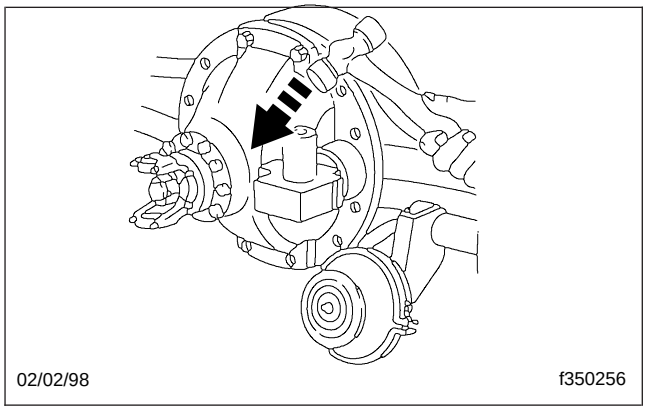


Fig. 7, Loosen the Differential from the Housing Using a Soft Mallet

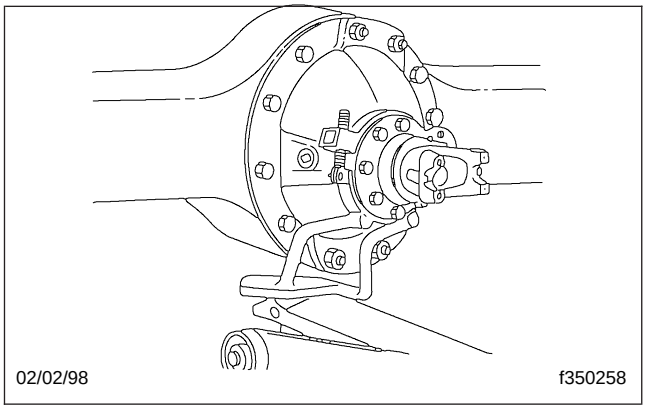


Fig. 8, Heavy Duty Truck Transmission Jack Supporting Carrier During Removal

NOTE: Apply four or five drops of Stud and Bearing Mount EOAZ–19554–BA or equivalent meeting Sterling specification WSK–M2G349–A1 on the capscrew threads.

5. Install the capscrews and washers in the four corner locations around the carrier and axle housing. Tighten the capscrews hand-tight at this time. Push the carrier into position. Tighten the four capscrews two or three turns each in a pattern opposite each other until you reach 199 to 243 lbf·ft (270 to 330 N·m). See **Fig. 12**.

6. Install the remaining capscrews that hold the carrier in the axle housing. Tighten to 199 to 243 lbf·ft (270 to 330 N·m).

   6.1 Tighten the fasteners to the specified torque.

   6.2 Remove the Rotunda Heavy Duty Truck Transmission Jack.

7. Connect the driveline universal joint to the pinion input yoke or flange on the carrier. See **Fig. 13**.

Differential Carrier Removal and Installation

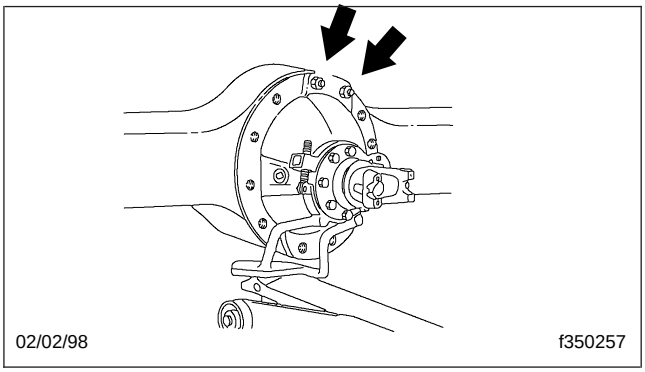


Fig. 9, Two Carrier-to-Housing Bolts, Removal

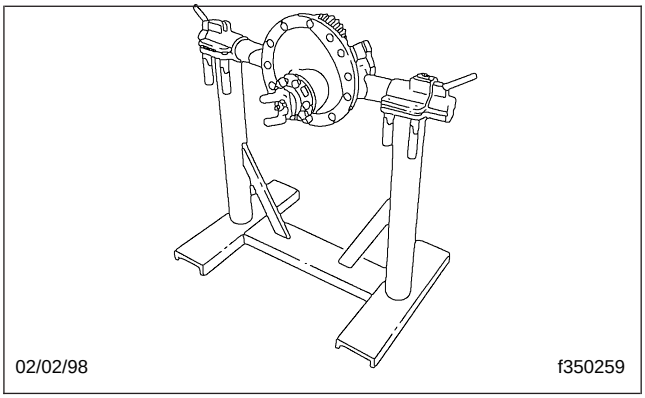


Fig. 10, Carrier Repair Stand

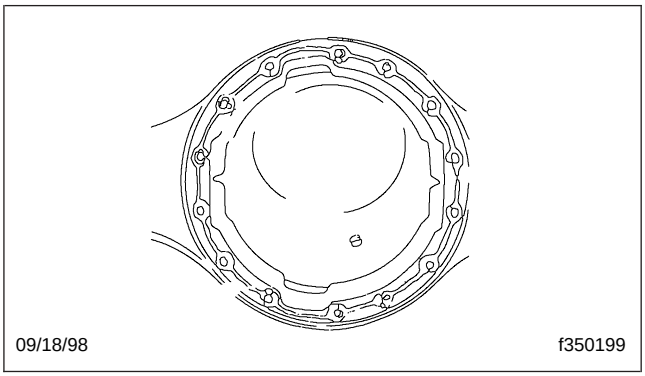


Fig. 11, Silicone Gasket Material Application

8. Install the gaskets and axle shafts into the axle housing. The gasket and flange of the axle shaft must fit flat against the wheel hub. See **Fig. 14**.
9. Install the tapered dowels over each stud and into the flange of the axle shaft, if used. Use a punch or drift and hammer, if necessary. See **Fig. 4**.

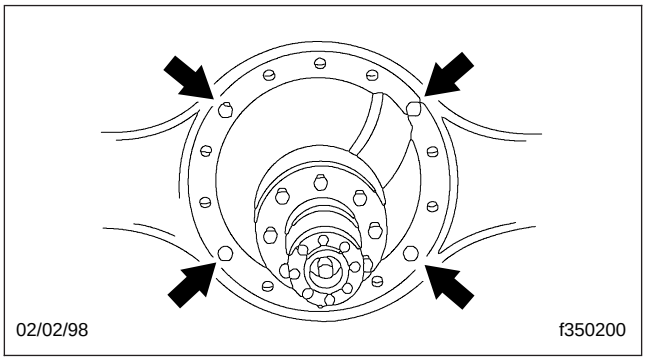


Fig. 12, Capscrews and Washers in Four Corners Around Carrier

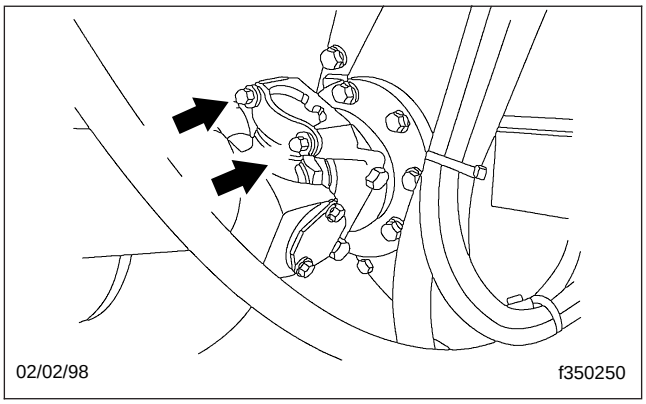


Fig. 13, Connect the Driveline Universal Joint to the Pinion Input Yoke

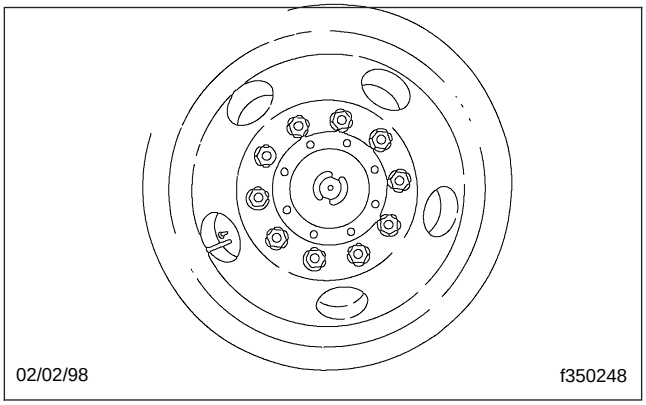


Fig. 14, Gasket and Axle Shaft Installation

10. Install Grade 8 nuts and lockwashers on the studs and tighten the stud nuts to the specified torque. Refer to **Specifications, 400**. See **Fig. 2**.
11. Connect the electric lines to the shift unit. See **Fig. 5**.

NOTE: For additional lubrication information, refer to **Specifications, 400**.

12. Fill the rear axle with the specified lubricant according to the following procedure.
    - 12.1 Make sure the vehicle is parked on a level surface.

      When the angle of the drive pinion changes, the lubricant capacity of the rear axle assembly will change.
    - 12.2 Remove the fill plug from the axle housing.
    - 12.3 Fill the rear axle with lubricant until the lubricant level is to the bottom of the filler plug hole.
13. Install the fill plug and tighten to 35 lbf·ft (47 N·m). When correctly installed, one complete thread of the fill plug is visible. See **Fig. 15**

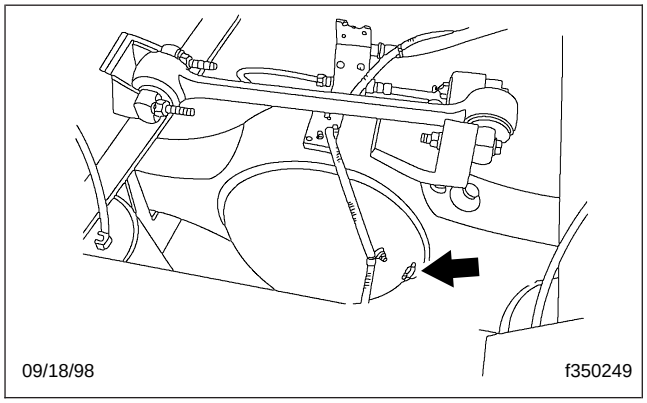


Fig. 15, Install the Fill Plug

14. Drive the vehicle in an unloaded condition for 1 to 2 miles (1.6 to 3.2 km) at speeds not more than 25 mph (40 km/h). Operating the vehicle ensures that the lubricant flows through the complete rear axle assembly.

Troubleshooting

Axle shafts, wheel hubs, wheel hub bearings, wheel hub grease seals, the electric shift unit and the differential drive pinion oil seal can be replaced without removing the differential carrier assembly from the axle housing or the rear axle assembly from the vehicle.

The axle shafts, wheel hub, bearings, and grease seal can be replaced, lubricated or adjusted.

For axle alignment, refer to **Section 35.04** in this manual.

INSPECTION AND VERIFICATION

Visually inspect the wiring harness for broken or frayed wires. Replace as necessary. Check harness connectors for corrosion and contact. Clean, if necessary. Verify that the connectors are properly mated (wiring into connector matches designated color out of connector).

Problem—Axle Does Not Shift

Problem—Axle Does Not Shift	
Possible Cause	**Remedy**
Fuses	Test and replace as necessary.
Wiring	
Switch	
Shift unit	

General Specifications	
Item	**Specification**
Drive Pinion Bearing Preload	
New Bearings	5–45 lbf·in (0.56–5.08 N·m)
Used Bearings	10–30 lbf·in (1.13–3.39 N·m)
Main Differential Bearing Preload	15–35 lbf·in (1.7–3.9 N·m)
Main Differential Gears Rotating Resistance	50 lbf·ft (68 N·m)
Ring Gear Backlash	
17 Inches (less than 431.8 mm)	0.008–0.018 inch (0.20–0.46 mm)
New Gearset	0.12 inch (0.30 mm)
17 Inches (431.8 mm) or Greater	0.010–0.020 inch (0.25–0.51 mm)
New Gearset	0.015 inch (0.38 mm)
Ring Gear Runout (Maximum)	0.008 inch (0.20 mm)
Thrust Screw Clearance (RS–23–240 Axles Only)	0.025–0.045 inch (0.65–1.14 mm) or loosen the thrust screw 1/2-turn after tightening the thrust screw hand-tight against the ring gear.
Sealant	
Black Non-Acid Cure Silicone Rubber Sealant E7TZ–19562–A	ESL–M4G273–A
Silicone Rubber D6AZ–19562–AA or -BA	ESB–M4G92–A or ESE–M4G195–A
Adhesive	
Stud and Bearing Mount EOAZ–19554–BA	WSK–M2G349–A1

General Specifications	
Item	**Specification**
Lubricant	
Premium Long-Life Grease XG–1–C or–K	ESA–M1C75–B

Table 1, General Specifications

Axle Lubricant Capacities			
	Approximate Capacity		
Axle	**U.S. Pints**	**Imperial Pints**	**Liters**
RS-17220	26.4	22	12.5
RS-19220	26.4	22	12.5
RS-21230	41.2	34.3	19.5
RS-23240	42.3	35.2	20

Table 2, Axle Lubricant Capacities

Ambient Temperature Range Chart	
Grade *	**Ambient Temperature Range**
75W	-40°F to +35°F (-40°C to +1.6°C)
80W-90	-15°F and Above (-26°C and Above)
80W-140	-15°F and Above (-26°C and Above)
85W-140	+10°F and Above (-12°C and Above)

* Use multigrade oils meeting specification MIL–L–2015–C. For the operating ambient temperature range, refer to the above chart.

Table 3, Ambient Temperature Range Chart

Torque Specifications			
	RS–17–220 and RS–19–220	**RS–21–230**	**RS–23–240**
Description	**lbf·ft (N·m)**	**lbf·ft (N·m)**	**lbf·ft (N·m)**
Gear to Support Case Capscrews *	151–184 (205–250)	151–184 (205–250)	151–164 (205–250)
Pinion Shaft Nut	738–922 (1000–1250)	738–922 (1000–1250)	922–1129 (1250–1530)

Specifications

Torque Specifications			
Description	RS–17–220 and RS–19–220 lbf·ft (N·m)	RS–21–230 lbf·ft (N·m)	RS–23–240 lbf·ft (N·m)
Differential Case Capscrews *	96–118 (130–160)	96–118 (130–160)	96–118 (130–160)
Carrier to Cage Capscrews *	66–92 (90–125)	66–92 (90–125)	66–92 (90–125)
Shift Unit to Carrier Nuts	34–46 (46–62)	34–46 (46–62)	35–45 (46–62)
Differential Bearing Cap Capscrews *	218–266 (295–360)	218–266 (295–360)	424–520 (575–705)
Clutch Plate to Carrier Nuts or Capscrews *	424–472 (575–640)	129–162 (175–220)	129–162 (175–220)
Oil Filler and Level Plug	35 (47) Minimum	35 (47) Minimum	35 (47) Minimum
Oil Drain Plug	35 (47)	35 (47)	35 (47)
Breather	10 (14) Minimum	10 (14) Minimum	10 (14) Minimum
Carrier to Housing Capscrews *	199–243 (270–330)	199–243 (270–330)	199–243 (270–330)
Thrust Screw Lock Nut	—	—	150–190 (203–258)

* Apply Stud and Bearing Mount EOAZ–19554–BA or equivalent meeting Sterling specification WSK–M2G349–A1 to stud or capscrew threads.

Table 4, Torque Specifications

Torque Specifications		
Description	Thread Size	lbf·ft (N·m)
Axle Shaft Plain Nut	0.44–0.32	50–75 (68–102)
	0.50–20	75–115 (102–156)
	0.56–18	110–165 (149–224)
	0.62–18	170–230 (230–312)
Axle Shaft Lock Nut	0.44–20	37–65 (54–88)
	0.50–20	65–100 (88–136)
	0.56–18	100–145 (136–197)
	0.62–18	130–190 (176–258)

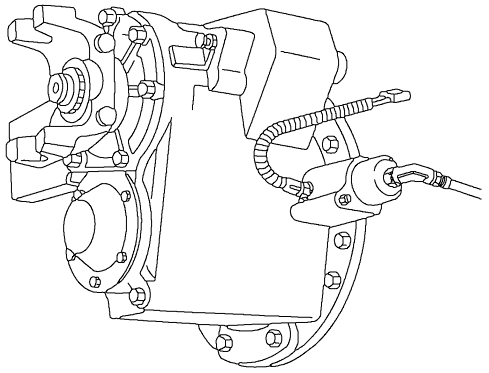
Torque Specifications		
Description	Thread Size	lbf·ft (N·m)
U-Bolt Nuts	—	260–320 (353–433)
Wheel Nuts	—	450–500 (611–677)
Torque Rod Bolts	—	150–205 (204–277)
Driveshaft/Interaxle Shaft Bearing Strap Capscrews	5/16–24	35–41 (47–56)
	3/8–24	45–60 (61–81)

Table 5, Torque Specifications

General Information

DRIVE UNIT

The 145-Series and 160-Series forward axle drive units of these tandem axles have a single-reduction, through-drive carrier. See **Fig. 1**.



02/04/98 f350339

Fig. 1, Forward Axle Drive Unit

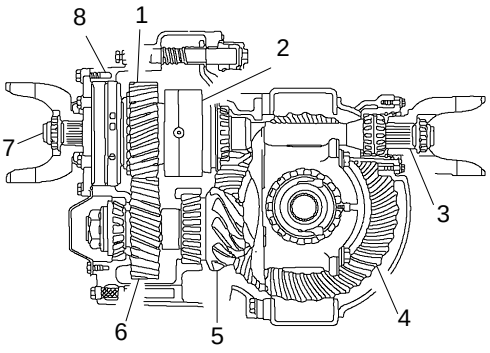
The drive gearing consists of a two-helical geartrain and a hypoid ring gear and pinion. Bevel gears are used in the main differential and the inter-axle differential.

The inter-axle differential is located behind the helical drive gear on the input shaft. The forward side gear of the inter-axle differential is part of the upper helical gear hub and the through-shaft is splined to the rear side gear of the inter-axle differential. See **Fig. 2**.

The 160-Series axle is different from the 145-Series axle in the following components: The 160-Series axle has a wider helical driven gear. There are two notches on the inter-axle differential case of the 160-Series axle. The notches permit the differential case to clear the helical driven gear when the input shaft assembly is removed from the carrier. See **Fig. 3**.

PRESSURIZED LUBRICATION SYSTEM

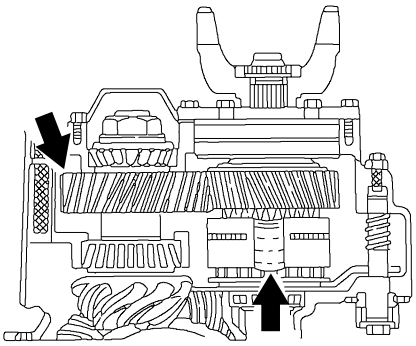
The forward axle can be equipped with an optional pressurized lubrication system. This filtered system has an oil pump that is driven by the input shaft and circulates lubricant to the journals in the forward and rear input shaft bearings and through the inter-axle differential.



09/18/98 f350272

1. Helical Drive Gear
2. Inter-Axle Differential
3. Output Shaft
4. Ring Gear
5. Drive Pinion
6. Helical Driven Gear
7. Input Shaft
8. Oil Pump

Fig. 2, Inter-Axle Differential



02/03/98 f350273

Fig. 3, Notches for Clearance When Removing Input Shaft Assembly from Carrier

DRIVER-CONTROLLED MAIN DIFFERENTIAL LOCK

Both the forward and rear axles can be equipped with an optional driver-controlled main differential lock. This differential lock is operated by an air-actuated shift unit that is mounted on the carrier. When the differential lock is activated, the shift collar is moved along the splines of the axle shaft toward the differential case. When the splines on the collar are engaged with the splines on the differential case, the axle shaft and the differential assembly are locked together.

General Information

When the carrier operates in the locked position, there is no differential action between the wheels of the axle. When the carrier is operated in the unlocked position, there is normal differential action between the wheels at all times.

IDENTIFICATION TAG

An identification tag is riveted on the axle housing or on the differential carrier (see **Fig. 4**). Use the model number and the ratio number marked on the identification tag and the number on the carrier to order replacement parts.

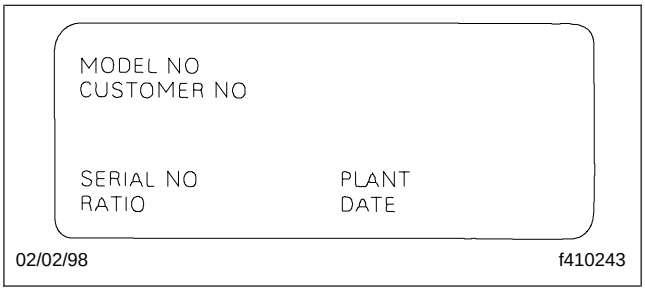


Fig. 4, Identification Tag

The illustration shows the location of the identification tag (or stamp number) for the axles (see **Fig. 5**). Location is determined from the left (driver) side looking toward the front of the vehicle. On front engine drive vehicles, the tag is located on the right rear of the axle, next to the cover. On rear drive vehicles, the tag is located on the left or right rear of the axle, next to the drive unit.

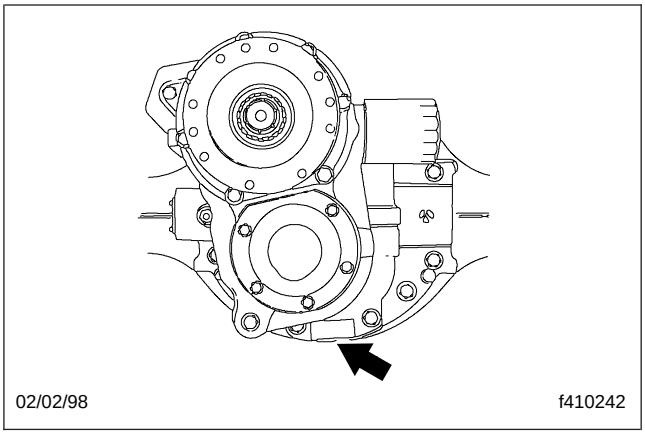
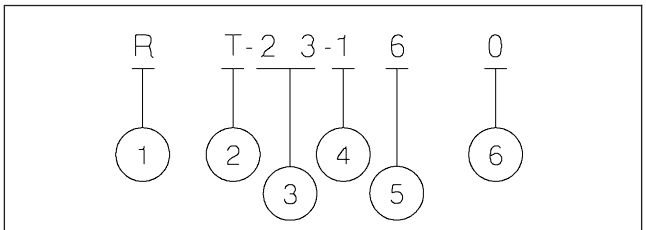


Fig. 5, Location of Identification Tag

Refer to the model number information chart for the meaning of the model number. Individual forward and rear axles of a tandem set (D, N, P, R) are rated as single axles. A tandem set (T) is rated as the combination of two axles. See **Fig. 6**.



1. Meritor
2. **Axle Type** D = Tandem Forward/Rear Axle with Inter-Axle Differential. N = Tandem Forward/Rear Axle Less Inter-Axle Differential. P = Tandem Forward/Rear Axle with Inter-Axle Differential and Pump. T = Tandem Set (2 Axle Assemblies)
3. **Nominal Axle Load Rating (GAWR) (Two Digits)** Thousands of pounds to the nearest thousand pounds for axles made in U.S.A., Mexico and Brazil. All others in metric tonnes.
4. **Gearing Type** 1= Single Speed. 2 = Two Speed. 3 = Helical Double Reduction.
5. **Carrier Series** Identified by ring gear size (dimension). Larger number means bigger ring gear (more capacity and rating).
6. **Carrier Design Series or Variation** 0 = Original Design. 1- 2 = Variation Sequence. 3 = from original design. 4 = etc.

Fig. 6, Model Number Information Chart

Meritor Tandem Axle With Hendrickson HAS Suspension Removal and Installation

Removal

NOTE: The use of assistants to balance the axle as it is being lowered, raised or moved with the floor jack is highly recommended.

1. Chock the front tires.
2. Release the brakes and bleed the air from the brake system. See **Fig. 1**.

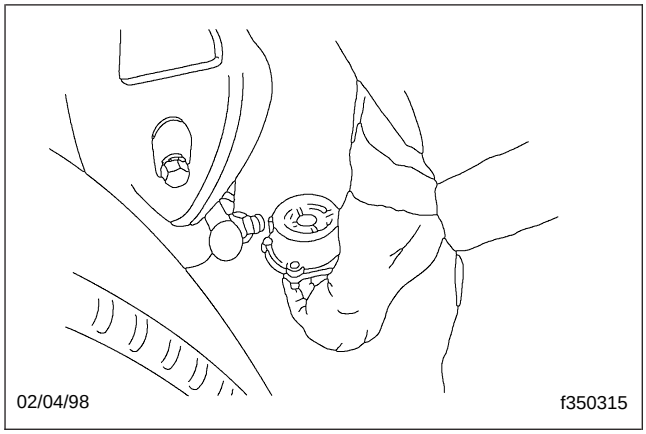


Fig. 1, Bleed the Air from the Brake System

NOTE: If the brake drums are to be removed, cage the brakes before disconnecting the air brake hoses. Refer to **Group 42** for the caging procedure.

3. Disconnect the air hoses to the brakes. See **Fig. 2**.

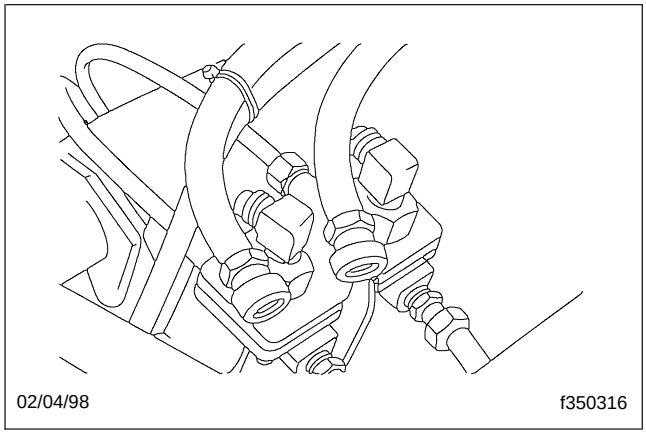


Fig. 2, Disconnect Brake Air Hoses

4. For forward tandem axles, disconnect the wiring harness connectors.
5. For forward tandem axles, disconnect the driveshaft and wire it out of the way. See **Fig. 3**.

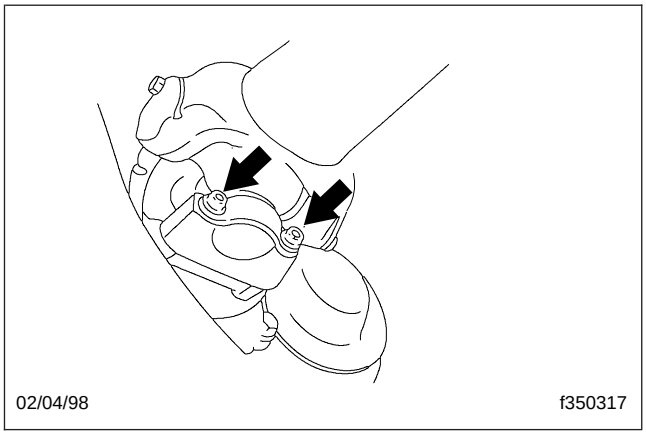


Fig. 3, Disconnect the Driveshaft

6. For forward tandem axles, disconnect the inter-axle driveshaft at the forward axle output flange or yoke and allow it to rest on the air shock support plate. See **Fig. 4**.

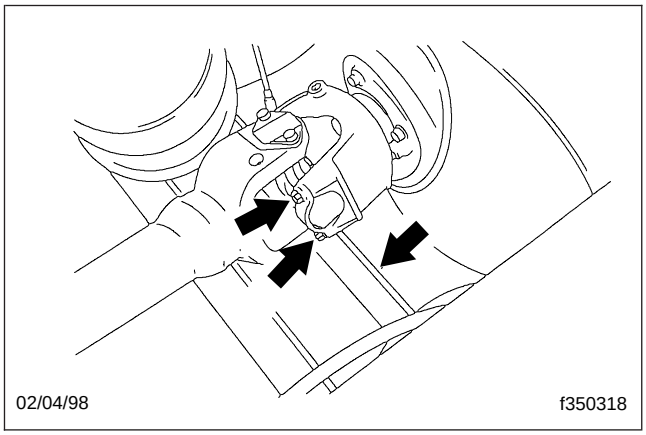


Fig. 4, Disconnect the Inter-Axle Driveshaft

7. For rear tandem axles, disconnect the inter-axle driveshaft at the rear axle input flange or yoke and wire it out of the way.
8. Disconnect the torque rod at the axle housing. See **Fig. 5**.

NOTE: Make sure to raise the vehicle high enough to clear the axle when it is ready to be lowered with the wheels and tires removed.

Meritor Tandem Axle With Hendrickson HAS Suspension Removal and Installation

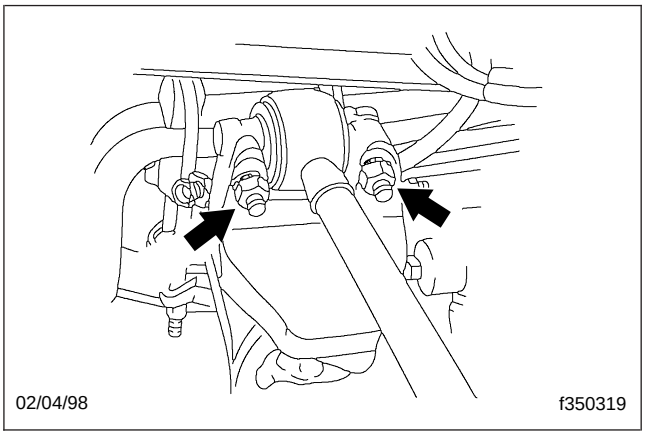


Fig. 5, Disconnect the Torque Rod

9. Raise the rear of the vehicle and insert jack stands under the axle not being removed.
10. Remove the wheels and tires from the axle to be removed.

NOTE: Supporting the drive unit on the forward axle is not necessary. The axle will not tip forward.

11. Support the housing of the axle to be removed with a floor jack. See **Fig. 6**.

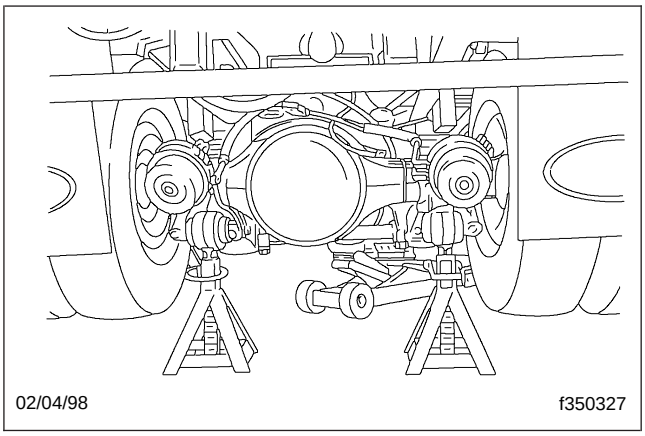


Fig. 6, Support the Axle to Be Removed With a Floorjack

12. Remove the U-bolts and nuts and discard them. See **Fig. 7**.

IMPORTANT: Watch for the axle hanging up on obstructions as it is being lowered.

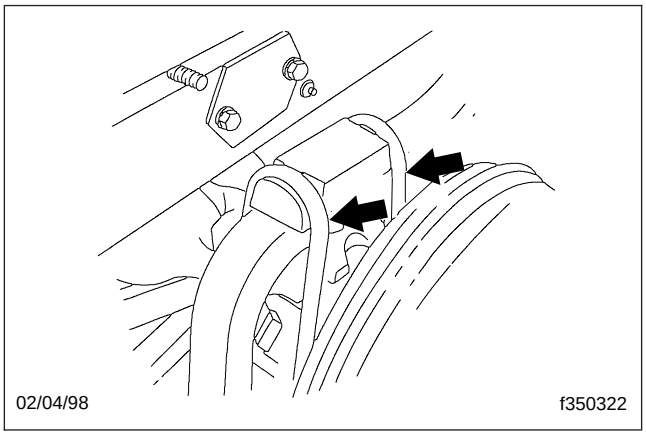


Fig. 7, U-Bolts and Nuts

13. Carefully lower the axle with the floor jack and slide it out from under the vehicle. See **Fig. 8**.

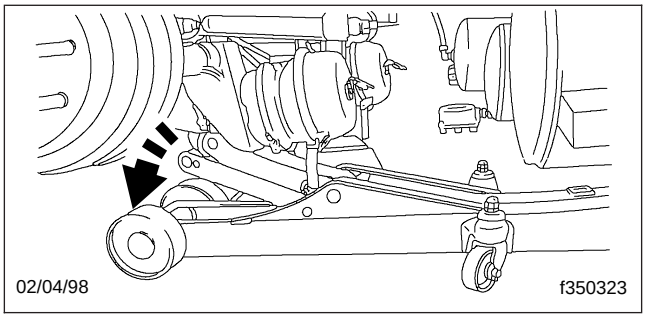


Fig. 8, Lower the Axle

Installation

NOTE: The use of assistants to balance the axle as it is being positioned or moved with the floor jack is highly recommended.

IMPORTANT: Use new U-bolts and U-bolt nuts for installation.

NOTE: When tightening the air fittings, a minimum of two turns past finger-tight is required. Directional fittings are to be oriented in a tightening direction only.

1. Position the axle with the floor jack under the vehicle. See **Fig. 8**.
2. Install the new U-bolts and nuts tighten nuts 260 to 320 lbf·ft (353 to 433 N·m). See **Fig. 7**.
3. Install the wheels and tires tighten nuts to 450 to 500 lbf·ft (611 to 677 N·m).

Meritor Tandem Axle With Hendrickson HAS Suspension Removal and Installation

4. Raise the rear of the vehicle and remove the jack stands.
5. Lower the rear of the vehicle and remove floor jack.
6. Connect the torque rod at the axle housing tighten to 150 to 250 lbf·ft (204 to 277 N·m). See **Fig. 5**.
7. For rear tandem axles, connect the inter-axle driveshaft at the rear axle input flange or yoke tighten 5/16-24: 35 to 41 lbf·ft (47 to 56 N·m) and 3/8-24: 45 to 60 lbf·ft (61 to 81 N·m).
8. For forward tandem axles, connect the inter-axle driveshaft at the forward axle output flange or yoke tighten 5/16-24: 35 to 41 lbf·ft (47 to 56 N·m) and 3/8-24: 45 to 60 lbf·ft (61 to 81 N·m). See **Fig. 4**.
9. For forward tandem axles, connect the drive-shaft. See **Fig. 3**.
10. For forward tandem axles, connect the wiring harness connectors.
11. Connect the air hoses to the brakes. See **Fig. 2**.
12. Remove the tire chocks.

Meritor Tandem Axle With Hendrickson RT2, UE2 and U2 Suspensions Removal and Installation

Removal

1. Chock the front tires.
2. Jack up the rear of the vehicle under the axle not being removed and insert jack stands under the ends of the walking beam attached to that axle. See **Fig. 1**.

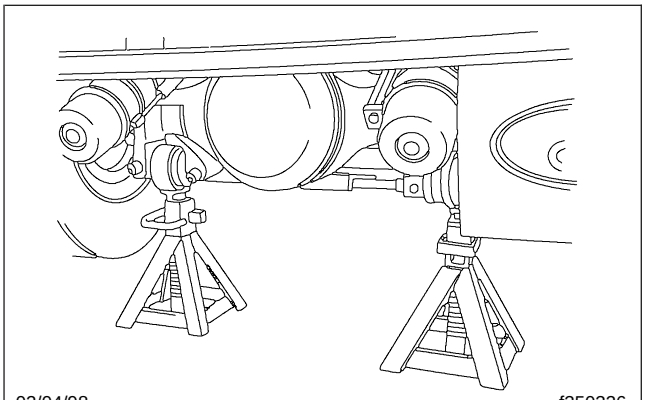


Fig. 1, Jack Up the Rear of the Vehicle

3. Support the axle to be removed with a floor jack. See **Fig. 2**.

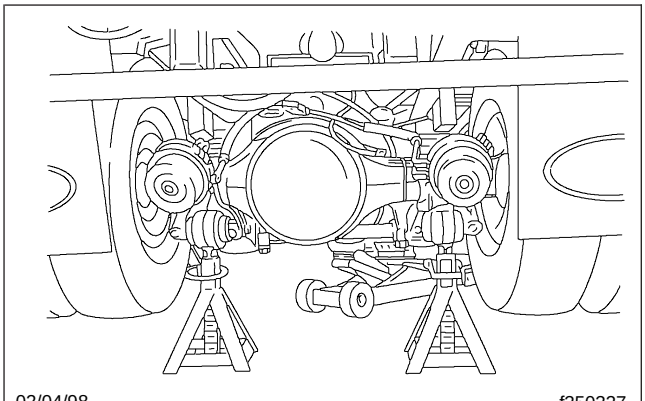


Fig. 2, Support the Axle to Be Removed With a Floor Jack

4. Remove the wheels and tires from the axle to be removed.
5. Disconnect the electrical connectors.
6. Release the brakes and bleed the air from the brake system. See **Fig. 3**.

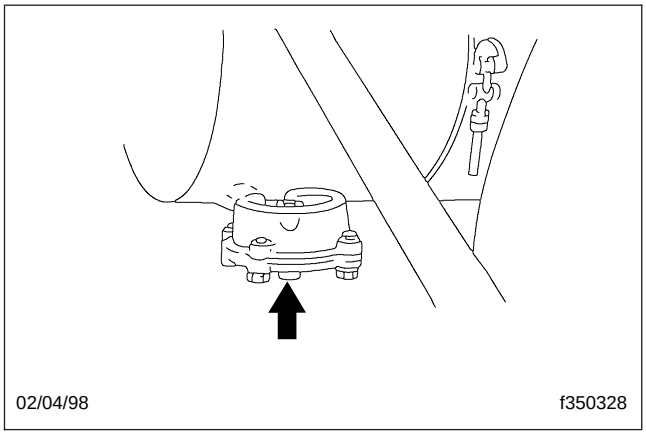


Fig. 3, Release the Brakes and Bleed the Air from the Brake System

NOTE: If the brake drums are to be removed, cage the brakes before disconnecting the air brake hoses. Refer to **Group 42**.

7. Disconnect the brake air hoses. See **Fig. 4**.

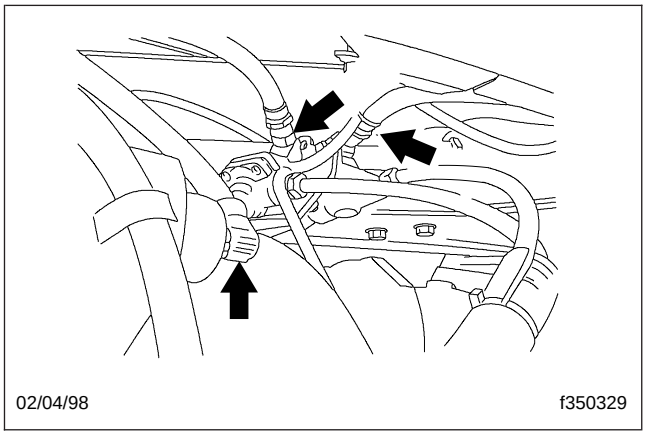


Fig. 4, Disconnect the Brake Air Hoses

8. Remove the torque rod nuts and bolts from the rear axle. See **Fig. 5**.
9. Disconnect the driveshaft(s) and wire it out of the way.
10. Remove the nuts from the bolts that retain the axle to the walking beam, but do not remove the bolts.

NOTE: Do not let the ends of the walking beams touch the floor, as they will be difficult to raise.

Meritor Tandem Axle With Hendrickson RT2, UE2 and U2 Suspensions Removal and Installation

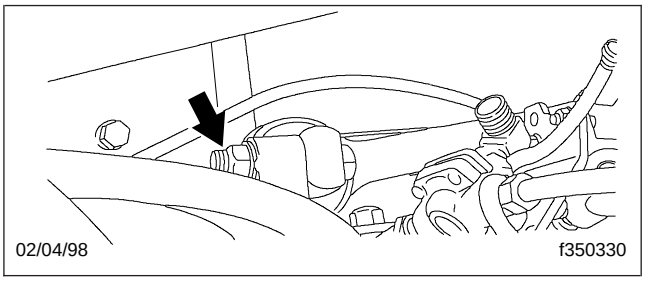


Fig. 5, Remove the Torque Rod Nuts and Bolts from the Rear Axle

11. Place short jack stands under the walking beam of the axle being removed, and carefully lower the axle.
12. Remove the bolts that retain the axle to the walking beam.

NOTE: The end of the walking beam should sit on the short jack stand.

13. Carefully jack up the axle high enough to clear the walking beam, making sure that the walking beam does not rise with the axle. See **Fig. 6**.

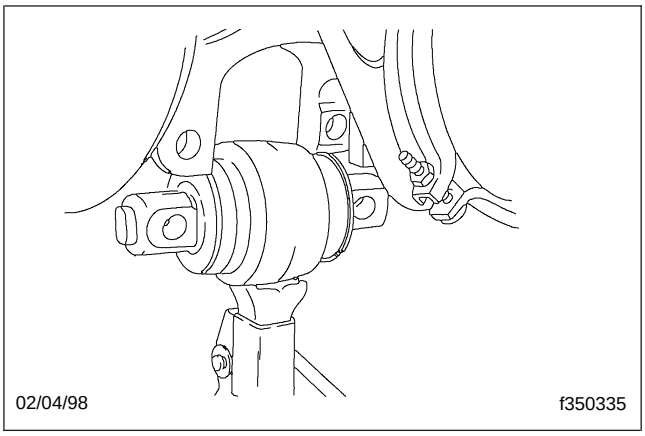


Fig. 6, Raise Axle High Enough to Clear Walking Beam

14. Remove the axle from under the vehicle.

Installation

NOTE: When tightening the air fittings, a minimum of two turns past finger-tight is required. Directional fittings are to be oriented in a tightening direction only.

1. Position the axle under the vehicle.
2. Install the nuts and bolts that retain the axle to the walking beam tighten 450 to 600 lbf·ft (610 to 813 N·m). See **Fig. 7**.

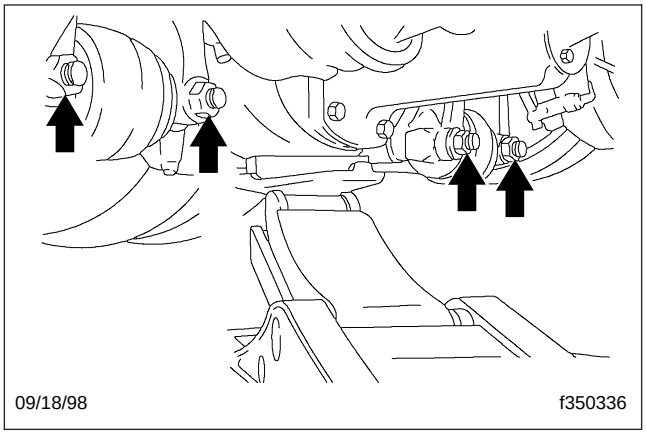
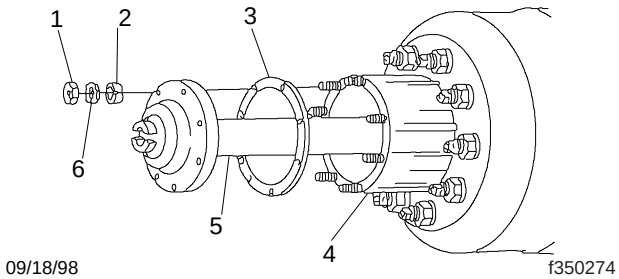


Fig. 7, Install Axle to Walking Beam Bolts and Nuts

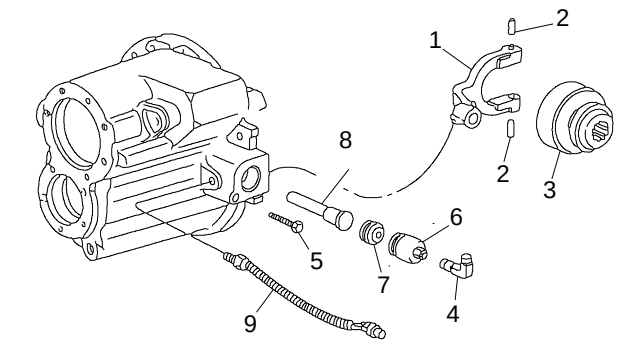
3. Connect the driveshaft(s) tighten 5/16-24: 35 to 41 lbf·ft (47 to 56 N·m) and 3/8-24: 45 to 60 lbf·ft (61 to 81 N·m).
4. Install the rear axle torque rod nuts and bolts tighten 150 to 250 lbf·ft (204 to 277 N·m). See **Fig. 5**.
5. Connect the brake air hoses. See **Fig. 4**.
6. Connect the electrical connectors.
7. Install the wheels and tires tighten nuts 450 to 500 lbf·ft (611 to 677 N·m).
8. Remove the jack stands and floor jack.
9. Remove the tire chocks.

Removal (See Fig. 1 and Fig. 2)



1. Nut
2. Tapered Dowels
3. Rear Axle Gasket
4. Rear Hub
5. Rear Axle Shaft
6. Washer

Fig. 1, Differential Carrier



1. Shift Fork
2. Roll Pins
3. Shift Collar
4. Hose Fitting
5. Manual Engagement Capscrew
6. Shift Unit Cover
7. Piston
8. Shift Shaft
9. Sensor Switch

Fig. 2, Differential Carrier

REMOVAL

1. Remove the oil drain plug from the bottom of the axle housing and drain the lubricant from the assembly. See **Fig. 3**.
2. Remove the oil filter shield from the input bearing retainer. See **Fig. 4**.

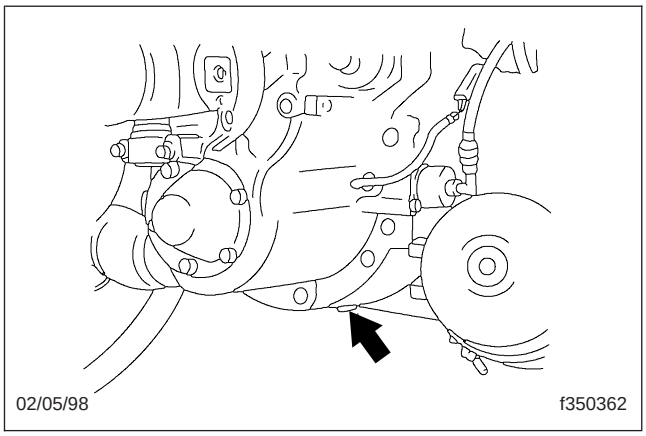


Fig. 3, Remove Oil Drain Plug

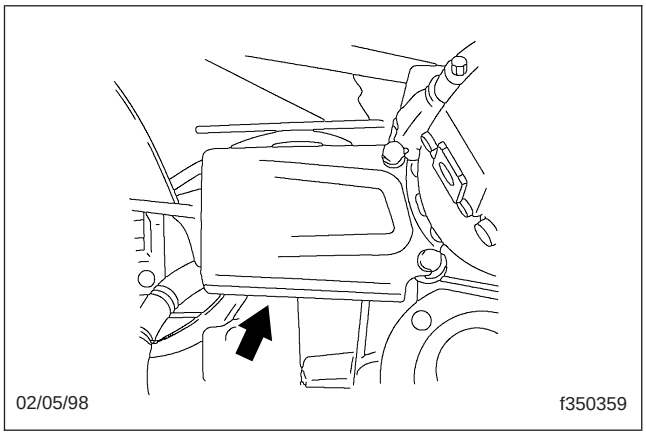


Fig. 4, Remove the Oil Filter Shield

IMPORTANT: There can be approximately 1 pint (0.47 liter) of lubricant remaining in the filter. Be careful that the oil does not spill when removing the filter.

NOTE: Replace the oil filter with a new filter at assembly.

3. Use a filter strap wrench to remove the oil filter. See **Fig. 5**.
4. Remove the oil filter adapter, if necessary. See **Fig. 6**.
5. For axles so equipped, shift the differential lock into the locked (engaged) position. Refer to "Driver-Controlled Differential Lock Engagement Procedures" in **Subject 130** or **Subject 140**.
6. Remove the stud nuts or capscrews and the washers from the flanges of both axle shafts.

Differential Carrier Removal and Installation

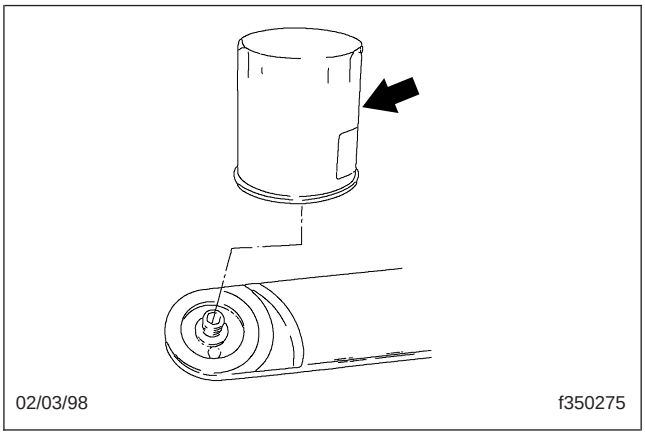


Fig. 5, Remove the Oil Filter

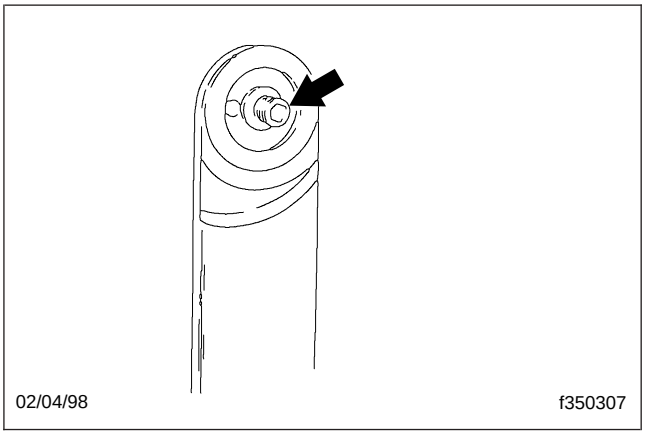


Fig. 6, Remove the Oil Filter Adapter

⚠ WARNING

Wear safe eye protection. Do not hit the round driving lugs on the flanges of the axle shafts. The lugs can break and cause injury.

NOTE: A 1-1/2-inch diameter brass hammer can be used for a drift.

7. Hold a 1-1/2-inch diameter brass drift against the center of the axle shaft, inside the round driving lugs, and hit the end of the drift with a large hammer (5-6 pounds) to loosen the axle shaft and tapered dowels.

⚠ CAUTION

Do not use a chisel or wedge to loosen the axle shafts and dowels. The chisel or wedge can damage the hub, axle shafts and, if used, the oil seals.

8. Remove the tapered dowels, if used, and remove both axle shafts from the axle assembly.
9. Disconnect the forward and rear driveshafts.
10. If not done previously, disconnect the air lines at the inter-axle differential and the main differential lock shift unit.

⚠ CAUTION

Do not use a hammer to loosen or remove the output yoke or flange. A hammer can damage the parts and cause difficulty with alignment.

NOTE: Use a suitable yoke puller to remove the output yoke or flange from the shaft.

11. Remove the output shaft nut, washer and output yoke or flange. See **Fig. 7** and **Fig. 8**.

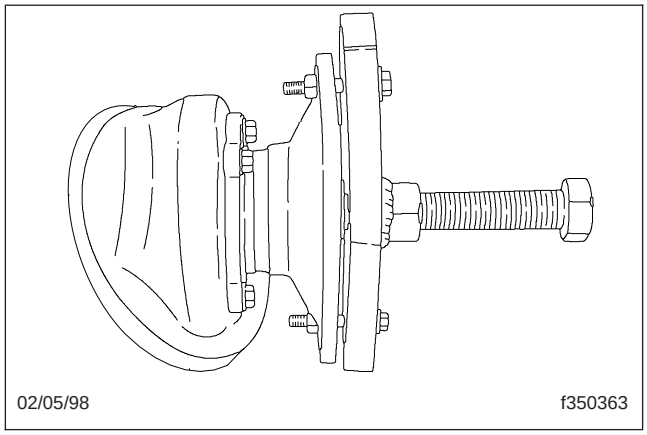


Fig. 7, Output Flange Removal

12. Position a hydraulic roller jack under the differential carrier to support the assembly. Secure the axle to the jack.

NOTE: If necessary, loosen the retainer from the housing with a soft mallet. Be careful that the oil seal is not damaged.

13. Remove the bearing retainer capscrews and washers, and pull the bearing retainer, gasket

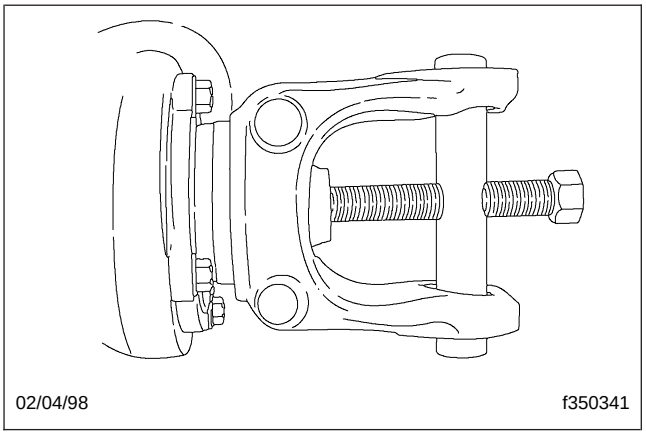


Fig. 8, Remove the Output Yoke

and bearings, and through-shaft assembly from the axle housing.

NOTE: Loosen, but do not remove, the top two fasteners. The fasteners will hold the carrier in the housing.

14. Remove all but the top two capscrews or stud nuts and washers. See **Fig. 9**.

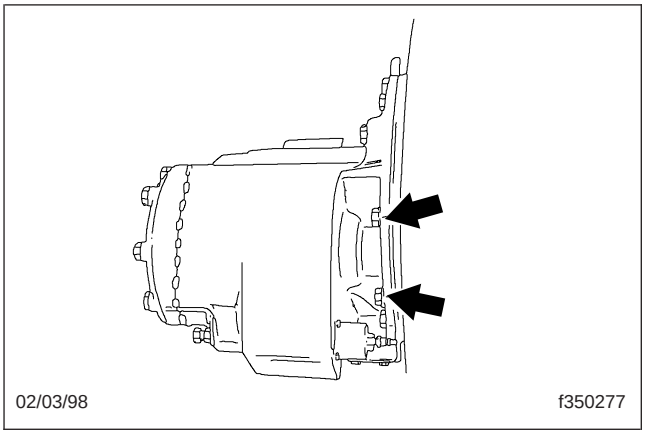


Fig. 9, Top Two Capscrews or Stud Nuts

15. Use a leather mallet to loosen the differential carrier in the axle housing. See **Fig. 10**.
16. Remove the top two capscrews or stud nuts and washers. See **Fig. 9**.

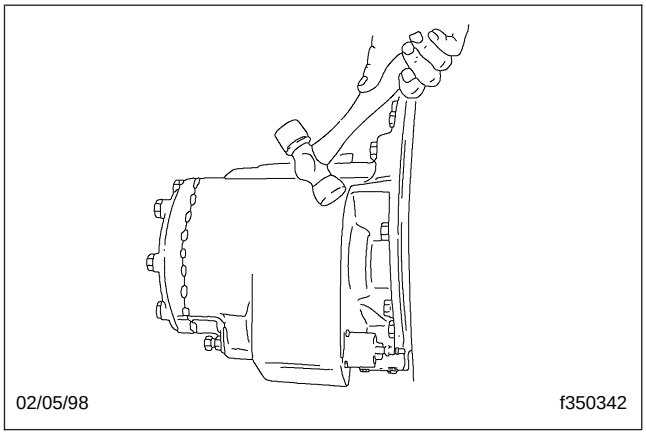


Fig. 10, Loosen the Differential Carrier With a Leather Mallet

CAUTION

When using a pry bar, be careful not to damage the carrier or housing flange. Damage to these surfaces will cause oil leaks.

NOTE: Use a pry bar that has a round end to help remove the carrier from the housing.

17. Remove the carrier from the axle housing, using the hydraulic roller jack.
18. For axles equipped with main differential lock, release the air pressure used to shift the differential into the locked (engaged) position and disconnect the air hose and electrical connector of the sensor unit from the shift unit.

WARNING

Use the endless lifting sling to lift the carrier. Do not lift by hand. Use care when handling it to prevent injury.

19. Lift the differential carrier by the input yoke or flange and put the assembly in a suitable stand. See **Fig. 11**.

Installation

NOTE: Use a cleaning solvent and clean rags to remove dirt.

NOTE: Blow dry the cleaned areas with air.

Differential Carrier Removal and Installation

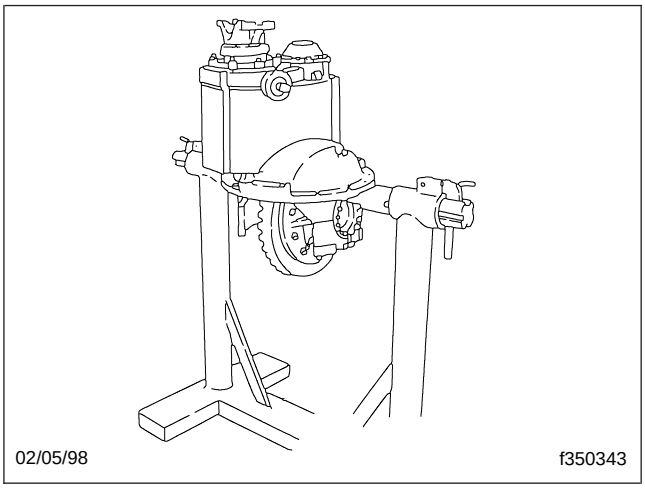


Fig. 11, Differential Carrier in a Suitable Stand

1. Clean the inside of the axle housing and the mounting surface where the carrier fastens.
2. Inspect the axle housing for damage and repair or replace the axle housing as necessary.
3. Check for loose studs, if used, in the mounting surface of the housing where the carrier fastens. See **Fig. 12**.

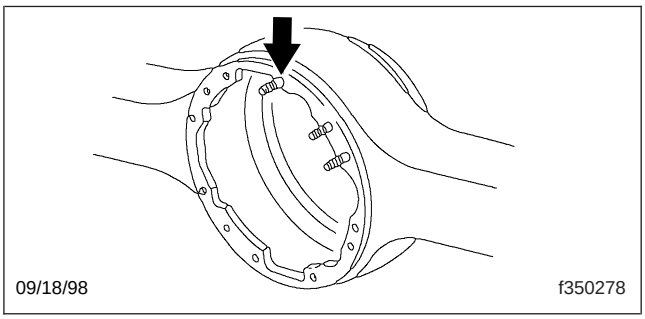


Fig. 12, Check for Loose Studs

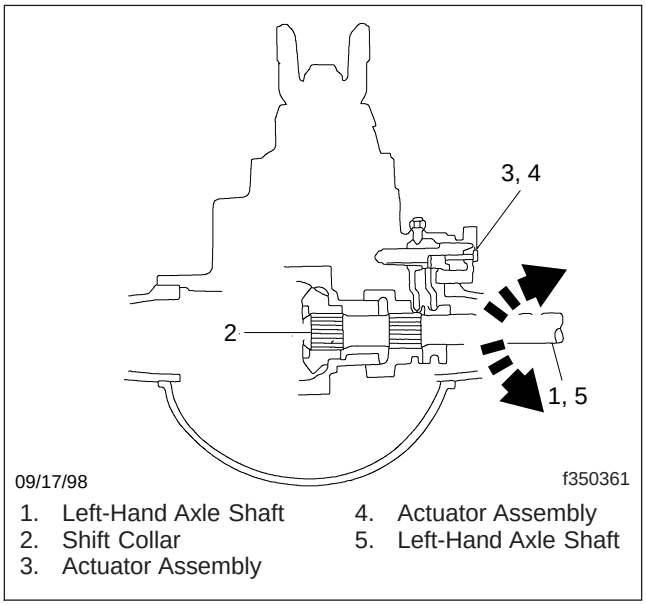
3.1 Remove and clean the loose studs.

3.2 Apply liquid adhesive to the threaded holes and install the studs in the axle housing. Tighten the studs.

IMPORTANT: On axles that use a main differential lock, the lock must be shifted into and held in the locked (engaged) position. The locked position gives enough clearance between the shift collar and the axle housing to permit the installation of the carrier.

NOTE: When the differential carrier is to be installed into the axle housing, the shift collar must be held in the engaged position. This can be done by keeping the air pressure applied to the shift cylinder or by using the manual engaging bolt. Failure to keep the differential in the locked (engaged) position will make it impossible to install the carrier assembly into the axle housing. After the differential carrier is installed into the axle housing, shift the differential into the unlocked (disengaged) position to permit the installation of the left-hand axle shaft.

4. Use the following procedure to install the shift cylinder if an auxiliary air supply is available. See **Fig. 13**.



1. Left-Hand Axle Shaft
2. Shift Collar
3. Actuator Assembly
4. Actuator Assembly
5. Left-Hand Axle Shaft

Fig. 13, Shift Cylinder, Installation

NOTE: A spline alignment tool can be made from a damaged left-hand axle shaft by cutting off approximately 24 inches (610 mm) from the spline end.

4.1 Before the differential carrier is installed into the housing, install the left-hand axle shaft through the shift collar and into the side gear.

⚠ WARNING

Do not use your hands to hold the collar in position. Injury can result when air pressure is applied to the actuator.

4.2 Align the splines of the shift collar and the differential case half by rotating the axle shaft tool or drive pinion.

4.3 Connect an auxiliary air supply to the actuator assembly.

NOTE: The air pressure will move the shift collar to engage the differential case half and lock the assembly.

4.4 Apply and hold pressure to the actuator assembly.

4.5 Rotate the axle shaft tool or the drive pinion one complete rotation to the right or left if the shift collar has not moved the full distance on the splines of the differential case half.

NOTE: Continue to hold the main differential in the locked (engaged) position with air pressure until the differential carrier is completely installed in the axle housing.

5. Remove the axle shaft tool from the carrier.
6. Use the following procedure to install the shift cylinder if an auxiliary air supply is not available. See **Fig. 14**.

6.1 Install the manual engaging capscrew into the threaded hole in the center of the shift unit.

IMPORTANT: Do not turn the capscrew beyond its normal stop.

NOTE: Lift the shift collar as required and rotate to align the splines of the collar and the case half while turning in the manual engaging capscrew.

6.2 Turn the manual engaging capscrew until it stops turning.

7. Apply silicone gasket material to the mounting surface of the housing where the carrier fastens.

⚠ CAUTION

Do not use a hammer or a mallet to install the differential carrier. A hammer or a mallet will damage the mounting flange of the carrier and cause oil leaks.

8. Install the differential carrier into the axle housing, using a hydraulic roller jack or a lifting tool.

NOTE: Do not tighten the fasteners to the specified torque.

9. Install the nuts and the washers or the capscrews and the washers in the four corner locations around the differential carrier and the axle housing, and tighten the fasteners by hand. See **Fig. 9** and **Fig. 15**.

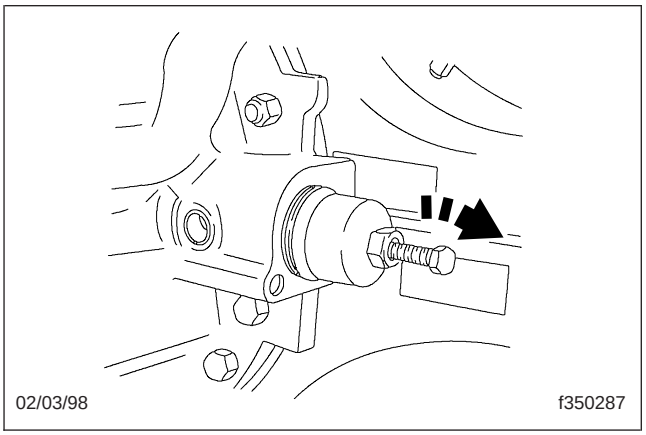


Fig. 14, Manual Procedure for Installing Shift Cylinder

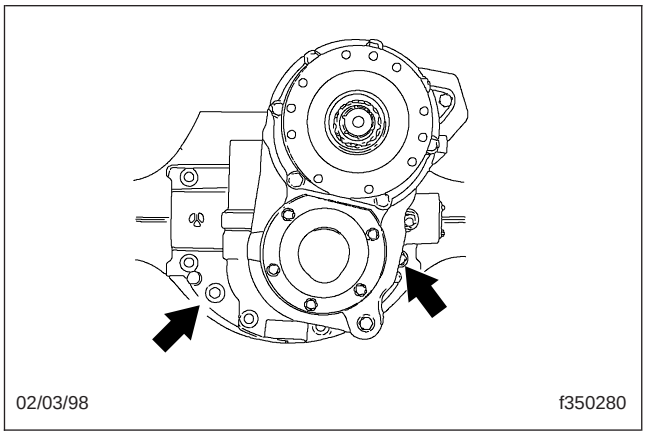


Fig. 15, Differential Carrier Installation

Differential Carrier Removal and Installation

10. Push the differential carrier into position and tighten the four fasteners two or three turns each in a pattern opposite each other.
11. Continue tightening in a pattern opposite each other until the four fasteners are tightened to specification. See **Fig. 9** and **Fig. 15**.
12. Install the remaining fasteners and washers that retain the carrier in the axle housing and tighten the fasteners. See **Fig. 16**.

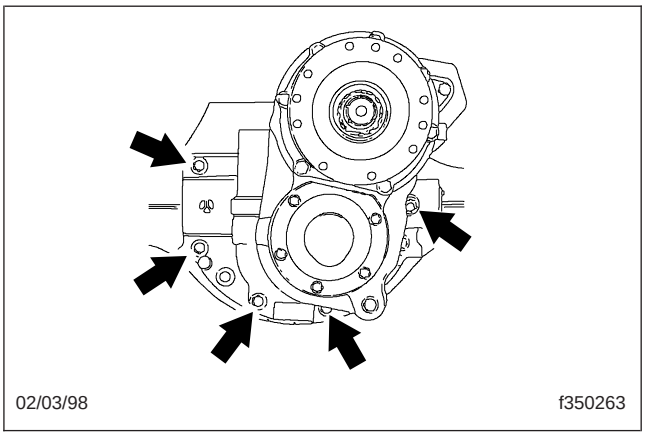


Fig. 16, Install Remaining Fasteners

13. If air pressure was used to engage the differential, release the air pressure from the differential lock and disconnect the auxiliary air supply.

NOTE: When the manual engaging capscrew is removed from the service position in the actuator, the main differential lock becomes disengaged.

14. Remove the manual engaging capscrew from its service position. See **Fig. 17**.
15. Clean the cylinder cover and threaded hole in the center of the cylinder cover. See **Fig. 18**.
16. Install the manual engaging capscrew into its storage position. See **Fig. 19**.

NOTE: The gasket and the flange of the axle shaft must fit flat against the wheel hub.

17. Install the gaskets and the axle shafts into the axle housing and the carrier. See **Fig. 20**.

NOTE: If necessary, use a hammer and a punch or a drift to install the dowels.

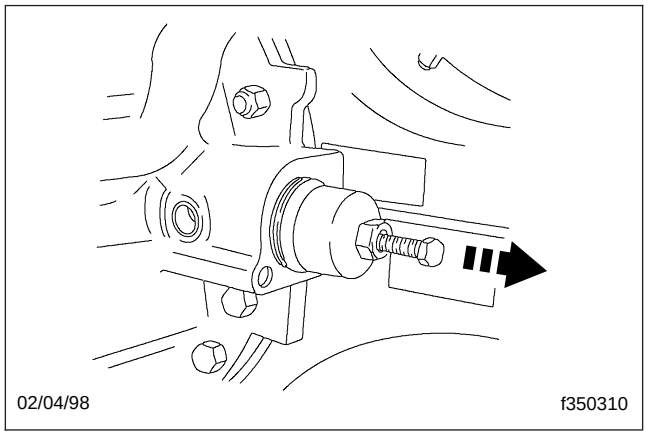


Fig. 17, Manual Engaging Capscrew Removal

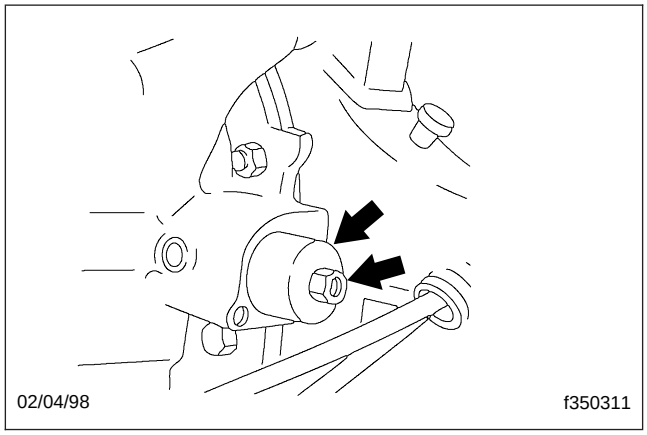


Fig. 18, Cleaning Cylinder Cover

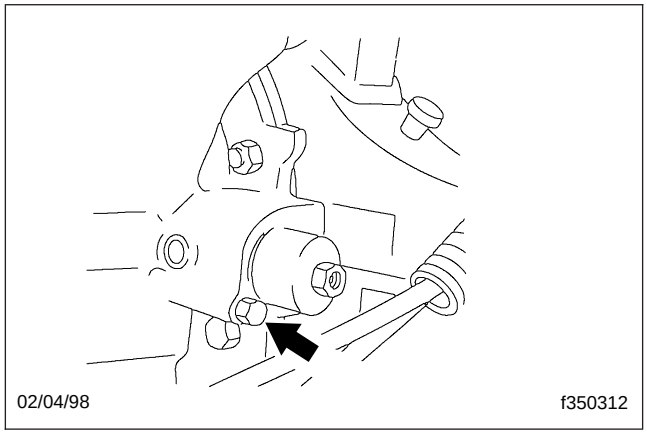


Fig. 19, Manual Engaging Capscrew Installation

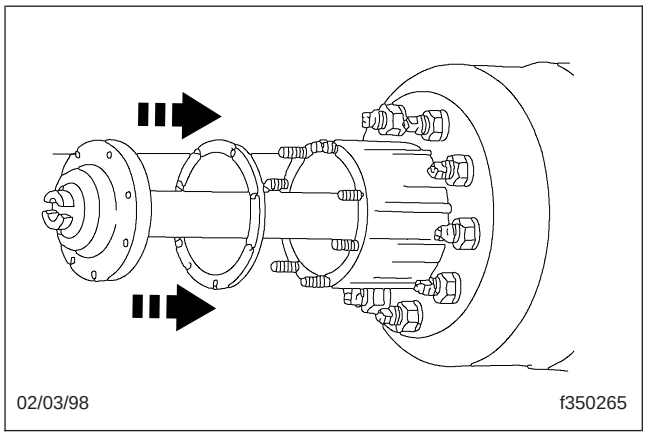


Fig. 20, Gaskets and Axle Shafts Installation

18. Install the tapered dowels, if so equipped, at each stud and on the flange of the axle shaft. See **Fig. 21**.

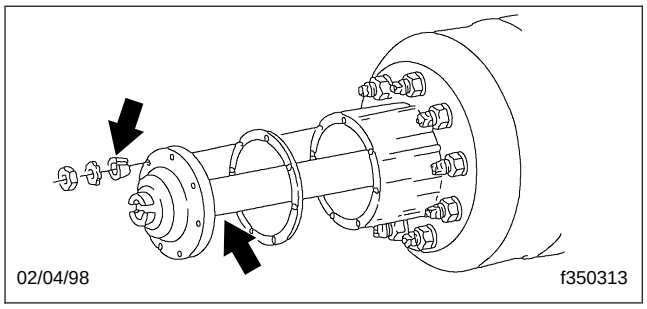


Fig. 21, Tapered Dowels Installation

19. Install the nuts or capscrews and the washers, as equipped, and tighten the nuts to specification. Refer to **Specifications, 400**. See **Fig. 22**.

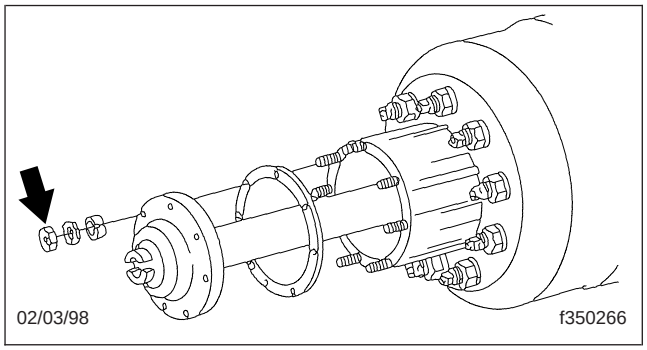


Fig. 22, Nuts or Capscrews Installation

20. Install the gasket between the through-shaft bearing retainer and the axle housing.
21. Position the through-shaft and bearing retainer assembly in the axle housing and rotate the through-shaft to align the splines of the through-shaft with the splines of the rear side gear.
22. Install the washers and the capscrews that fasten the output bearing retainer to the axle housing, and tighten the capscrews 35 to 50 lbf·ft (47 to 68 N·m). See **Fig. 23**.

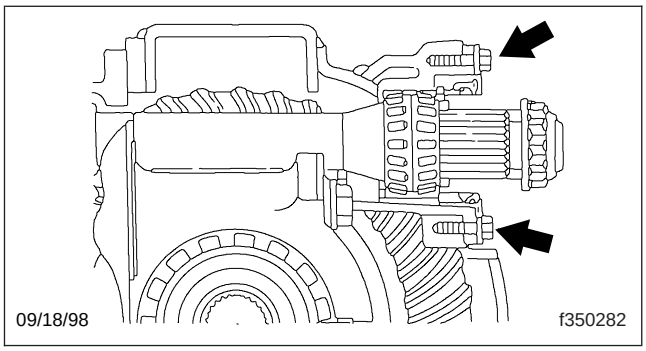


Fig. 23, Output Bearing Retainer Installation

23. Install the output shaft nut, washer, and yoke and tighten the nut 450 to 600 lbf·ft (610 to 813 N·m). See **Fig. 24**.

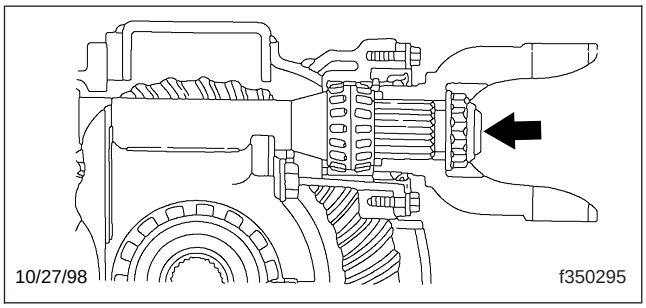


Fig. 24, Output Shaft Yoke Installation

NOTE: The movement of the shift fork is controlled by the adjusting screw for the air shift cylinder.

24. Loosen the jam nut on the adjusting screw and loosen the adjusting screw so that the screw does not touch the shift shaft when the shift collar engages the inter-axle differential case. See **Fig. 25**.
25. Apply and hold the specified air pressure to the shift cylinder so that the shift collar engages the splines in the inter-axle differential case.

Differential Carrier Removal and Installation

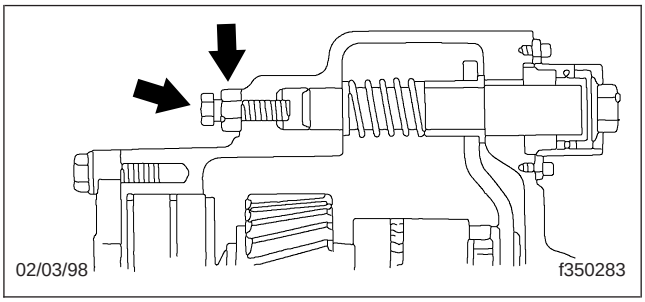


Fig. 25, Adjusting Screw Jam Nut

Air pressure must be held until after the jam nut is tightened. See **Fig. 26**.

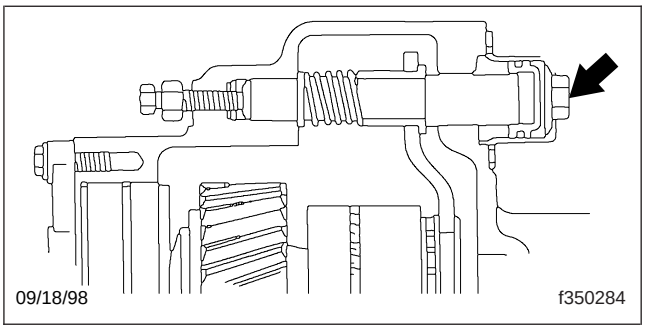


Fig. 26, Apply Air Pressure Here

26. Tighten the adjusting screw until the tip of the screw touches the end of the shift shaft.

    When the screw touches the shaft, tighten the adjusting screw an additional 1/4-1/2 turn. See **Fig. 27**.

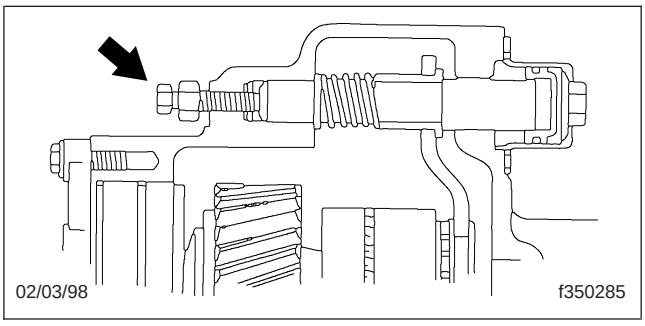


Fig. 27, Adjusting Screw

27. Release the air pressure.
28. Check that the inter-axle differential is disengaged by holding the input yoke or flange and rotating the output yoke or flange, which must rotate freely.
29. Apply and hold the specified air pressure to the shift collar to make sure the shift collar engages the splines in the inter-axle differential case.

    29.1 When the input yoke or flange is rotated, the output yoke or flange must rotate.

    29.2 Release the air pressure.
30. Apply a rust prevention oil such as Meritor Part Number 1199–U–1113 or equivalent to the inlet of the air cylinder.
31. Connect the driveshafts to the input and the output yokes or flanges.
32. Connect the air hoses to the air cylinder for the inter-axle differential lock and (if used) the main differential lock shift unit.
33. Connect the electrical connector of the sensor unit for axles equipped with a main differential lock.

NOTE: Apply Stud and Bearing Mount EOAZ–19554–BA or equivalent meeting Sterling specification WSK–M2G349–A1 to the bore in the carrier for the adapter.

34. Install the adapter for the oil filter on the differential carrier, if removed and tighten the adapter to specification.

IMPORTANT: If the oil filter is tightened more than 3/4 turn after it touches the carrier, the oil filter will be damaged and will leak fluid.

NOTE: Lubricate the gasket of the new oil filter with the lubricant that is used in the axle housing.

NOTE: If necessary, use an oil filter wrench to tighten the filter.

35. Install the oil filter on the adapter and tighten the oil filter 3/4 turn after the gasket on the filter touches the differential carrier.
36. Install the oil filter shield to the input bearing retainer, if so equipped. See **Fig. 28**.
37. Install the axle drain plug and tighten. See **Fig. 29**.
38. Fill the axle with the specified lubricant.
39. Check the operation of the main differential lock, if used.

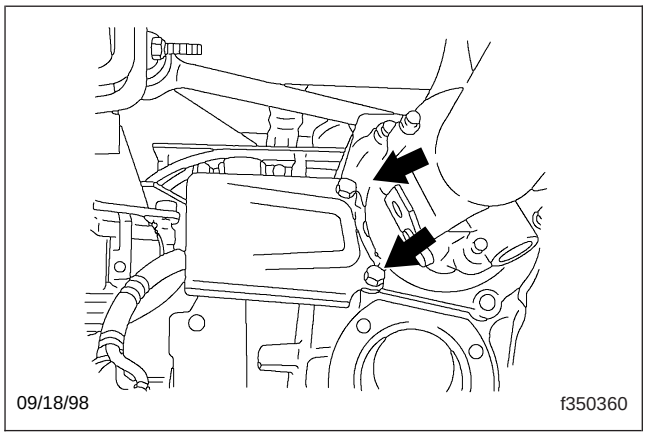


Fig. 28, Install the Oil Filter Shield to the Input Bearing Retainer

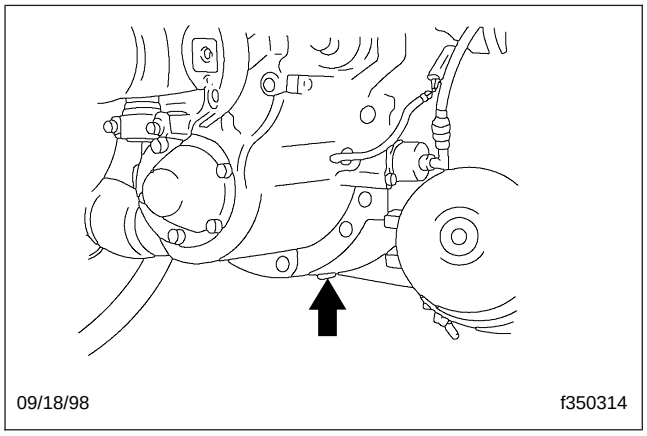


Fig. 29, Install Axle Drain Plug

Driver-Controlled Differential Lock Air Pressure Engagement Procedure

Engagement Procedure

NOTE: The Meritor carrier models with driver-controlled differential lock equipment are manufactured in metric dimensions and sizes. When these carriers are repaired, it is important to use the correct metric size tools on the fasteners.

NOTE: If the axle shafts were removed for towing with the differential in the unlocked (disengaged) position, install the right-hand axle shaft into the housing before continuing.

NOTE: Before the differential carrier can be removed or installed, the differential lock must be shifted into and held in the locked (engaged) position. The locked position gives enough clearance between the shift collar and the axle housing to permit the removal or installation of the carrier.

NOTE: To shift into the locked position, use either the following air pressure method or the manual engaging method.

1. Remove the drain plug from the bottom of the housing and drain the lubricant. See **Fig. 1**.

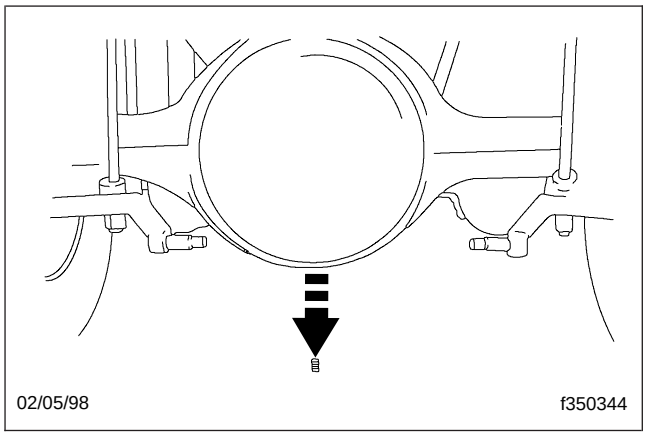


Fig. 1, Drainplug Removal

⚠ WARNING

Do not start the vehicle engine and engage the transmission with one wheel raised from the floor. When the differential is in the locked (engaged) position, power will go to the wheel on the floor and cause the vehicle to move, possibly causing personal injury and property damage.

2. Raise the right-hand wheel of the drive axle off the floor with a hoist or jack.

⚠ WARNING

Do not work under a vehicle supported only by jacks. Jacks can slip or tip over and cause personal injury and property damage.

3. Put a jack stand under the right-hand spring seat to hold the vehicle in the raised position.
4. Disconnect the driveshaft from the pinion input yoke. See **Fig. 2**.

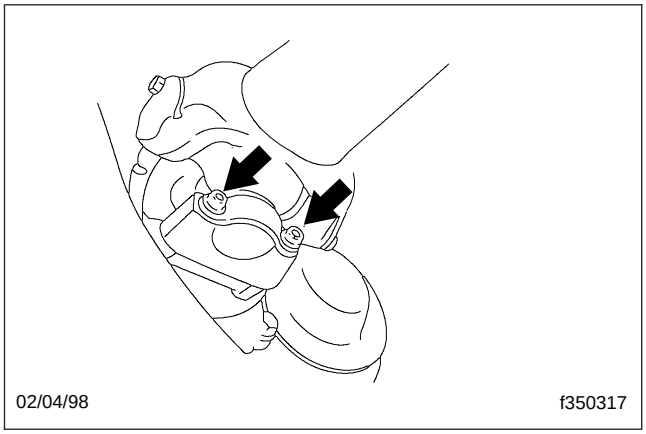


Fig. 2, Disconnect the Driveshaft

5. Disconnect the vehicle air line from the differential lock actuator assembly. See **Fig. 3**.

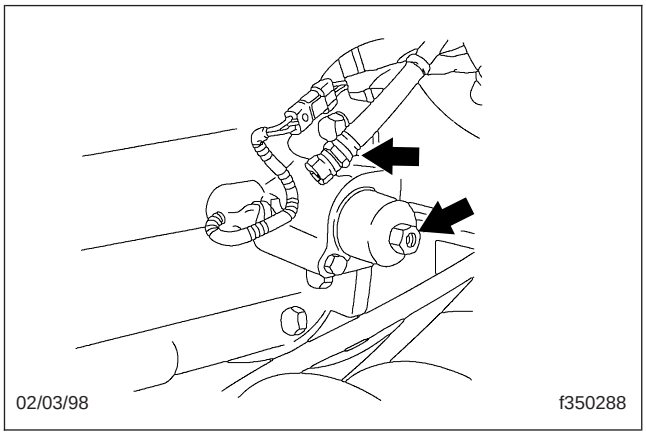


Fig. 3, Disconnect Vehicle Air Line from Differential Lock Actuator Assembly

Driver-Controlled Differential Lock Air Pressure Engagement Procedure

6. Remove the sensor switch.

NOTE: If an auxiliary air supply is not available, refer to **Subject 140**.

7. Connect an auxiliary air supply to the differential lock actuator assembly.

NOTE: The air pressure will move the shift collar to engage with the splines on the differential case half and lock the assembly.

8. Apply and hold air pressure to the actuator assembly.
9. Make sure that the shift collar has moved the full distance on the splines of the differential case half.
    - 9.1 Rotate the drive pinion or the right-hand wheel until the right-hand wheel makes one complete rotation (forward or backward).
    - 9.2 Continue to hold the main differential in the locked position with air pressure until the carrier assembly is completely removed from the axle housing.

Engagement Procedure

NOTE: If an auxiliary air supply is not available or if the differential carrier is to be stored for later use, use this manual engaging method.

1. Remove the manual engaging capscrew from the storage hole in the cylinder cover.

⚠ CAUTION

Do not turn the capscrew beyond its normal stop as damage to cylinder cover may occur.

2. Install the manual engaging capscrew into the threaded hole in the center of the cylinder cover and turn the manual engaging capscrew to the right until it stops turning. See **Fig. 1**.

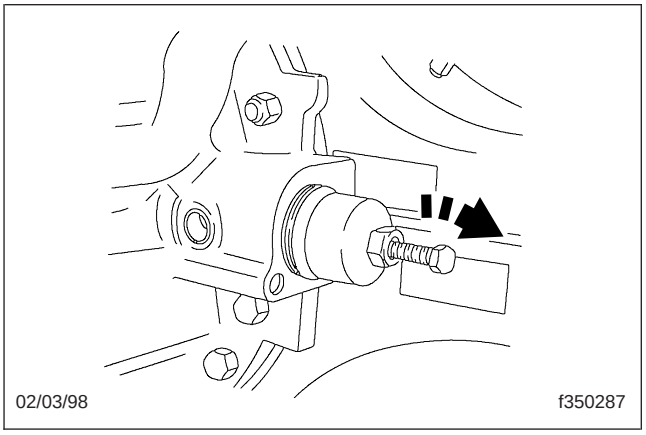


Fig. 1, Turning the Capscrew

NOTE: A high resistance on the capscrew indicates that the splines of the shift collar and the differential case half are not aligned or engaged.

3. Rotate the drive pinion or left-hand wheel to align the splines of the shift collar and case half while turning in the manual engaging capscrew.

Differential Shift Assembly Removal and Installation

Removal

NOTE: Install the differential shift assembly after the differential carrier is assembled and the gear and bearing adjustments are made. Parts of the shift assembly are shown.

NOTE: Release the differential lock if it is manually engaged.

1. Remove the differential lock sliding shift collar by tapping out the two retainer roll pins until they are level with the inner face of the shift fork.
2. Remove the sensor switch. See **Fig. 1**.

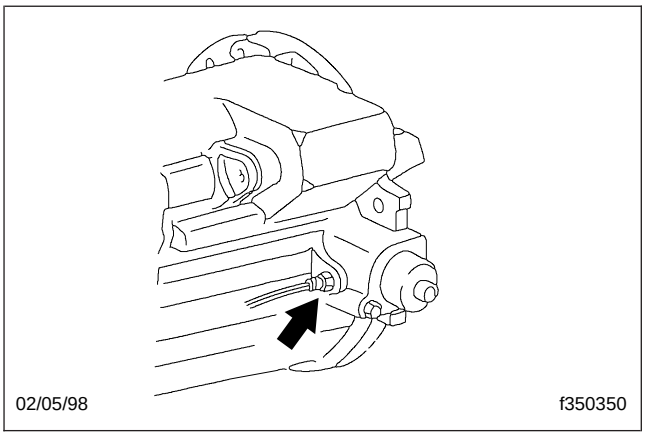


Fig. 1, Sensor Switch

NOTE: The piston will come off with the shift unit cover.

3. Remove the shift unit cover and the piston. See **Fig. 2**.
4. Remove the shift shaft. See **Fig. 3**.
5. Remove the O-ring from the piston.
6. Remove the shift fork. See **Fig. 4**.

Installation

1. Install the two roll pins into the ends of the shift fork.

   Tap the pins into position until they are level with the inner yoke faces.
2. Position the shift fork in the carrier case. See **Fig. 4**.

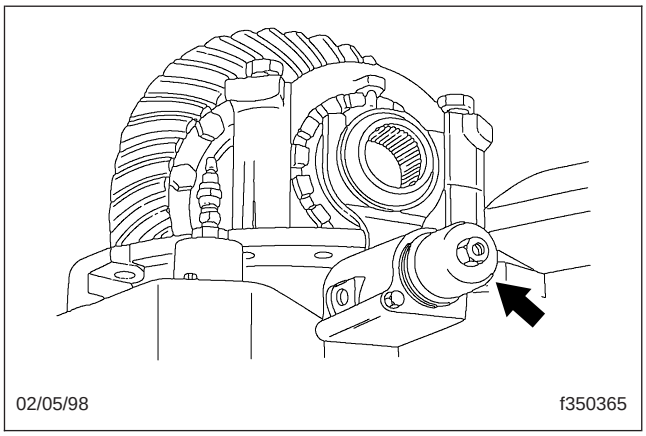


Fig. 2, Shift Unit and Cover

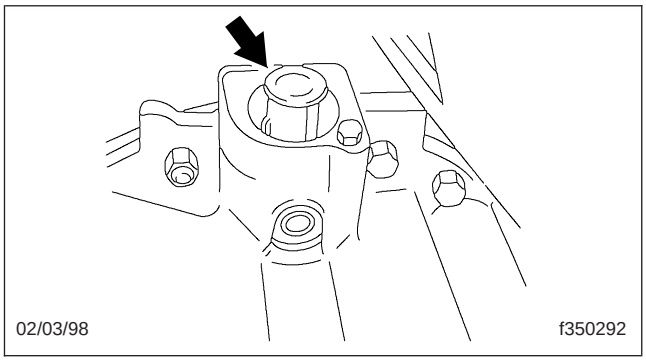


Fig. 3, Shift Shaft

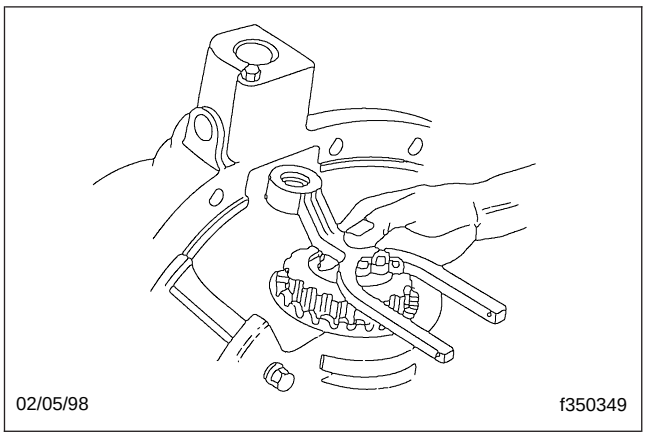


Fig. 4, Shift Fork

3. Install the shift shaft into the shift fork. See **Fig. 3**.

NOTE: Lubricate the O-ring with axle lubricant.

4. Install the O-ring into its groove on the piston.

Differential Shift Assembly Removal and Installation

5. Install the piston into the shift cover. See **Fig. 5**.

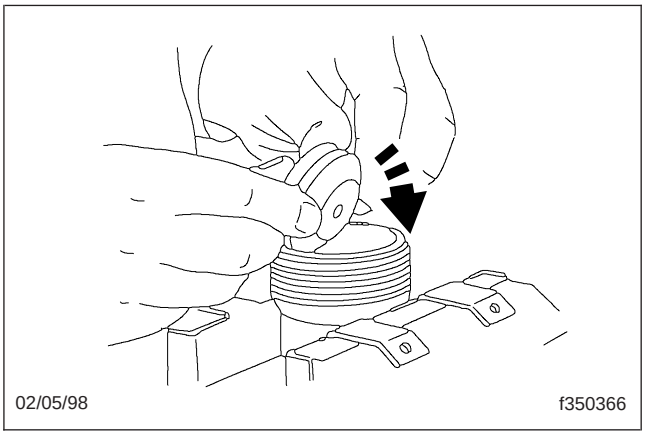


Fig. 5, Piston into Shift Cover Installation

NOTE: Make sure the pilot journal on the piston is against its bore on the shift shaft.

6. Install the shift cover into the housing bore. See **Fig. 6**.

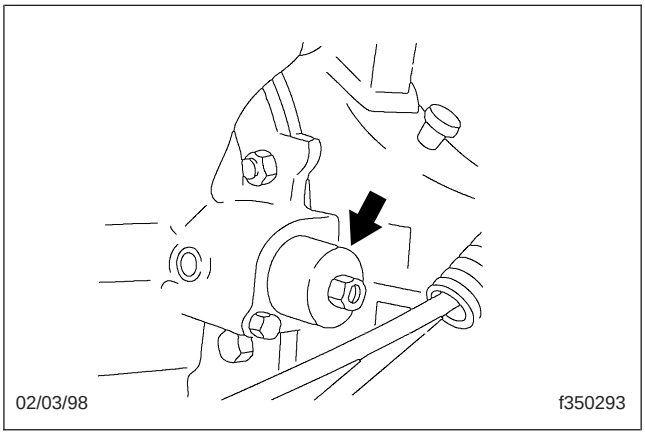


Fig. 6, Shift Cover into the Housing Bore Installation

NOTE: Use the manual engaging capscrew to move the shift collar splines into the differential case splines. Refer to **Subject 140**.

7. Slide the shift collar into the fork and engage the shift collar splines with the splines of the differential case.
8. Hold the shift collar in the locked (engaged) position and tap in the two roll pins in the shift fork ends until they are level with the outer yoke faces.
9. While the shift collar is still in the locked position, put the sensor switch into its hole. See **Fig. 1**.
10. For carriers without the differential lock (Less Air Shift), install the washer and plug into the hole for the sensor switch and tighten the plug.

Main Differential Case and Ring Gear Assembly Removal and Installation

Removal

1. Move the carrier so the ring gear is toward you.
2. Use a punch and a hammer to mark the position of the bearing caps on the legs of the differential carrier. See **Fig. 1**.

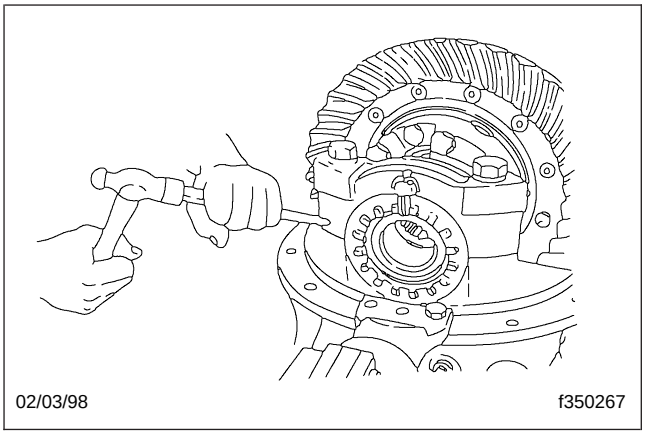


Fig. 1, Marking Position of Bearing Caps

3. Use a hammer and a drift to remove the adjusting ring lock pins on the bearing caps. See **Fig. 2**.

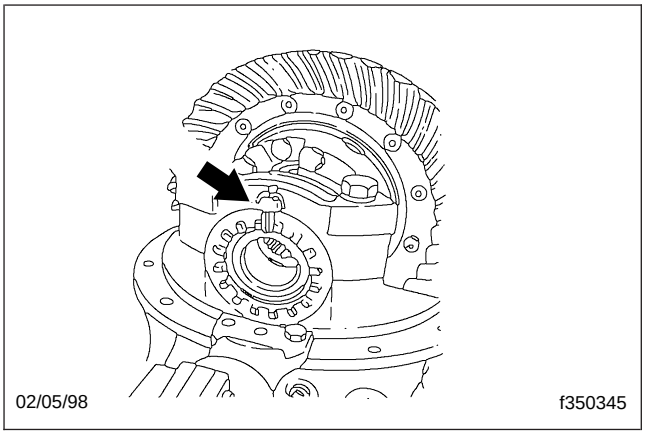


Fig. 2, Removing Adjusting Ring Lock Pins

CAUTION

Do not hit the adjusting ring with a hammer. Do not use a hammer and a drift to loosen the adjusting rings. These methods damage the adjusting rings.

4. Use a T-bar wrench tool to loosen the adjusting rings, but do not remove the adjusting rings.
5. Remove the capscrews and the washers retaining the bearing caps to the legs of the differential carrier.

IMPORTANT: Each bearing cap must be installed on the carrier leg from which it was removed. The cap is matched to the carrier leg before removal. Do not mix bearing caps on carrier legs.

6. Remove the bearing caps, the adjusting rings and the bearing cups from the differential carrier. See **Fig. 3**.

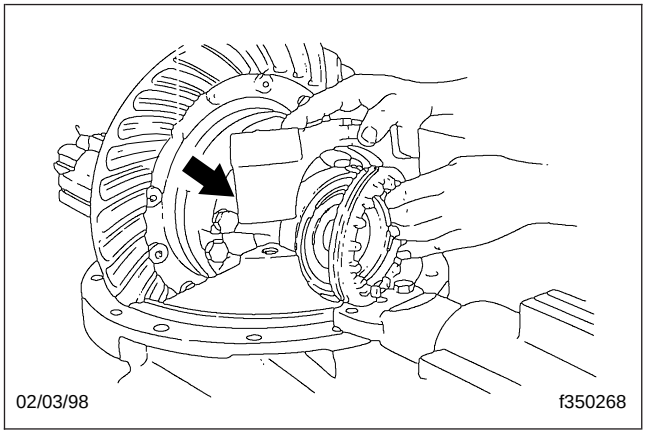


Fig. 3, Remove Bearing Caps, Adjusting Rings and Bearing Cups

7. Use the endless lifting sling to remove the main differential case and ring gear assembly from the differential carrier. See **Fig. 4**.

NOTE: If either the bearing cup or the cone needs to be replaced, both parts must be replaced in a set from the same manufacturer.

The bearing cones are not interchangeable.

8. Use a suitable bearing puller to remove the cones if the bearing cones on the main differential case need to be replaced.

Installation

NOTE: Use a press and a sleeve to install the cones on the case. Press on the inner race of the bearing.

Main Differential Case and Ring Gear Assembly Removal and Installation

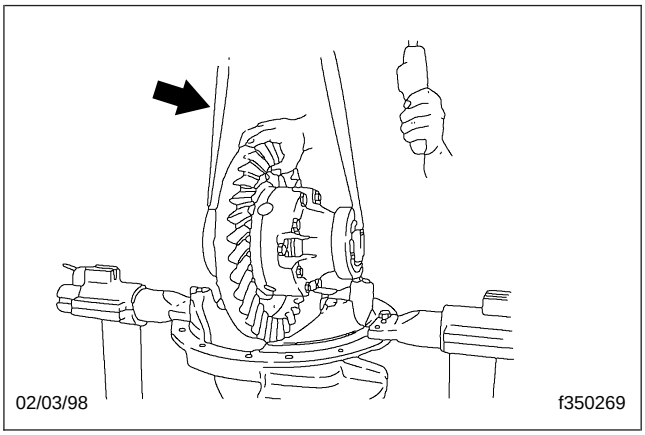


Fig. 4, Main Differential Case and Ring Gear Removal

1. Install a new cone and cup in a set from the same manufacturer if the bearing cones on the main differential case were removed. See **Fig. 5**.

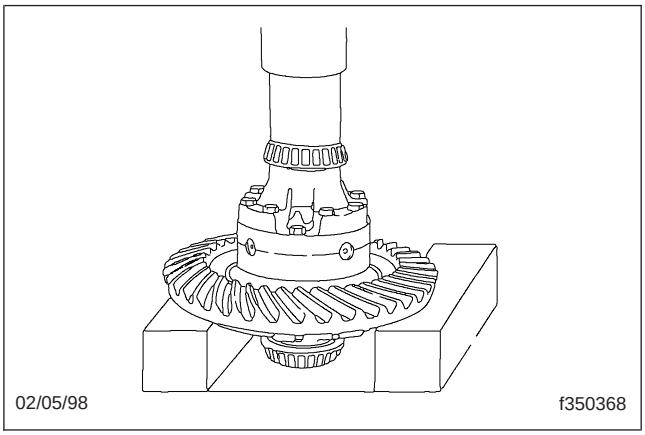


Fig. 5, New Cone and Cup Installation

2. Clean and dry the bearing cups and bores of the carrier legs and bearing caps.
3. Lubricate the bearing cups and cones with the lubricant used in the axle housing.
4. Apply Stud and Bearing Mount EOAZ–19554–BA or equivalent meeting Sterling specification WSK–M2G349–A1 in the bearing bores of the carrier legs and bearing caps.
5. Install the cups over the bearing cones. See **Fig. 6**.

NOTE: The bearing cups must be flat against the bores between the carrier legs.

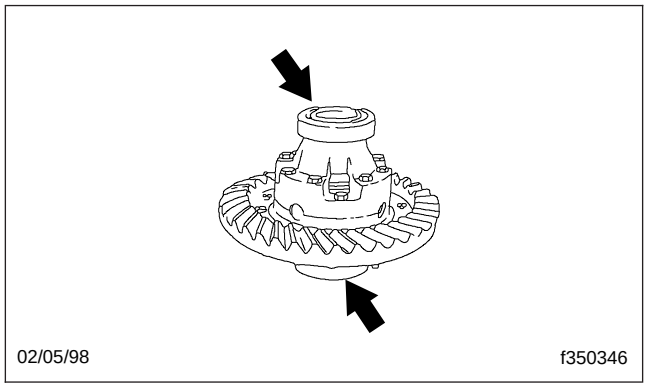


Fig. 6, Bearing Cone Installation

6. Using endless lifting sling, lift the main differential case and ring gear assembly, and install in the carrier.
7. Install both of the bearing adjusting rings into position between the carrier legs and turn each adjusting ring hand-tight against the bearing cup. See **Fig. 7**.

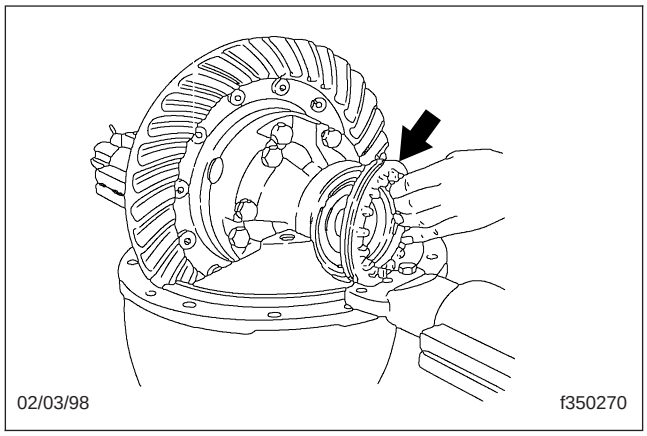


Fig. 7, Bearing Adjusting Rings Installation

8. Install the bearing caps over the bearings and adjusting rings in the correct locations as marked before removal. See **Fig. 8**.

⚠ WARNING

Wear eye protection. Do not hit steel parts with a steel hammer. Parts or tools can break and cause injury.

Main Differential Case and Ring Gear Assembly Removal and Installation

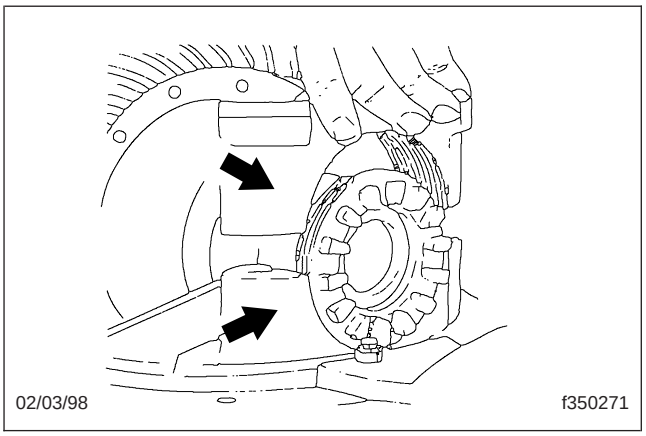


Fig. 8, Install Bearing Caps Over Bearings and Adjusting Rings as Marked at Removal

⚠ CAUTION

The bearing caps must be correctly installed and fit easily against the bearings, adjusting rings and carrier, or the adjusting rings will be damaged by cross-threading. Forcing the caps into position damages the caps and the carrier housing.

9. Hit each bearing cap into position with a light leather, plastic or rubber mallet. See **Fig. 9**.

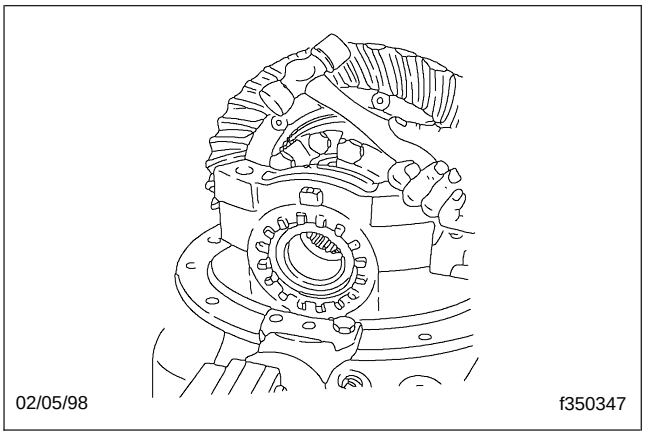


Fig. 9, Bearing Cap Installation

10. Install the capscrews and washers that retain the bearing caps to the carrier.

NOTE: The lock pins for the adjusting rings are installed after the tooth contact pattern is checked.

11. Tighten the capscrews by hand four to six turns and then, tighten the capscrews to the specification shown in the illustration for the appropriate axle model. See **Fig. 10**.

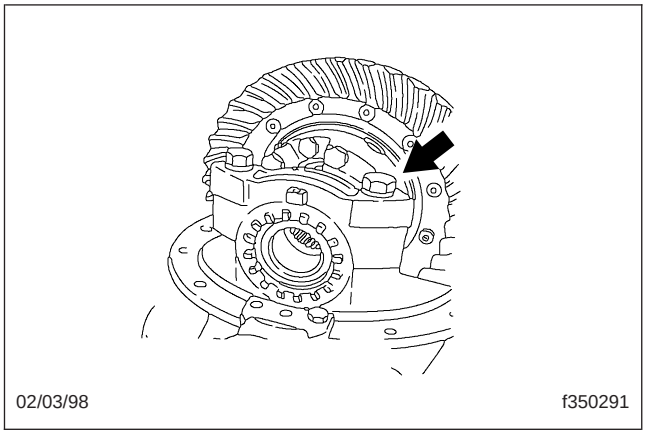


Fig. 10, Tighten the Capscrews

12. Adjust preload on the differential side gear bearings.
13. Check the ring gear runout.
14. Adjust the ring gear backlash.

Adjustment

NOTE: If the depth of the drive pinion was changed, then the amount of the change must be added or subtracted to the size of the spacer between the outer bearing cup and the helical driven gear.

NOTE: After the correct gear tooth contact pattern is obtained and the correct thickness of the shim pack behind the pinion inner bearing cup is installed, the bearing preload on the drive pinion is adjusted.

NOTE: The preload on the inner and outer bearings of the drive pinion is controlled by a spacer between the helical driven gear and the outer bearing. Preload is adjusted by replacing the spacer between the helical driven gear and the outer bearing. The spacer between the helical driven gear and the outer bearing is available in different sizes. The spacer between the inner bearing and the helical driven gear is available in only one size.

1. Check and record the backlash of the ring gear.
2. Remove the main differential case and ring gear assembly from the differential carrier.
3. Remove the nut and the washer from the drive pinion. See **Fig. 1**.

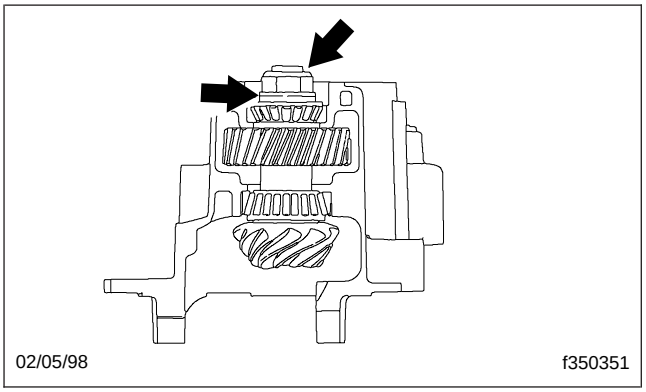


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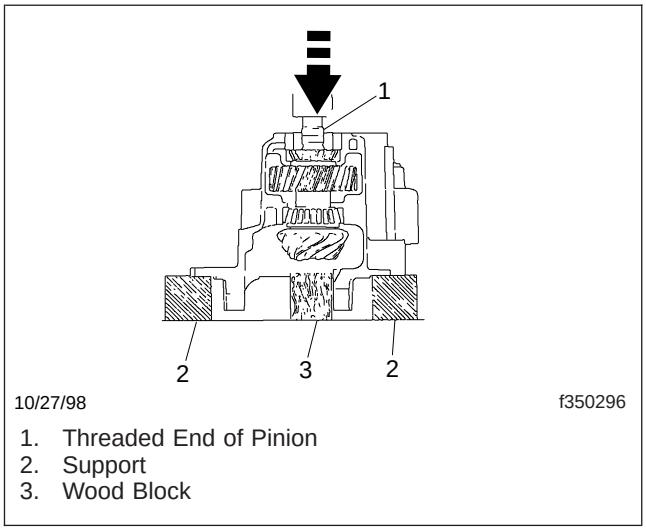
Fig. 1, Remove the Drive Pinion Nut and Washer

4. Put the drive pinion in a press. Press the drive pinion out of the outer bearing cone and remove the cone. See **Fig. 2**.



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1. Threaded End of Pinion
2. Support
3. Wood Block

Fig. 2, Pressing Drive Pinion Out of the Outer Bearing Cone

4.1 Position the carrier in a press so that the threaded end of the pinion is toward the top of the press.

4.2 Position supports under the flange of the carrier so that the carrier is level.

4.3 Place a wood block under the head of the pinion.

5. Turn the carrier over so that the legs of the carrier are toward the top of the press. Position supports under the carrier so that the carrier is level.

NOTE: Make sure to position the helical driven gear in the pinion bore.

NOTE: Make sure the splines inside the gear are toward the front of the carrier.

6. Place the large spacer on top of the helical driven gear so that the spacer is toward the rear bearing cup. See **Fig. 3**.

NOTE: Make sure the splines on the pinion engage the splines inside the gear.

7. Install the drive pinion in the helical driven gear. See **Fig. 4**.

Bearing Preload Adjustment on Drive Pinion

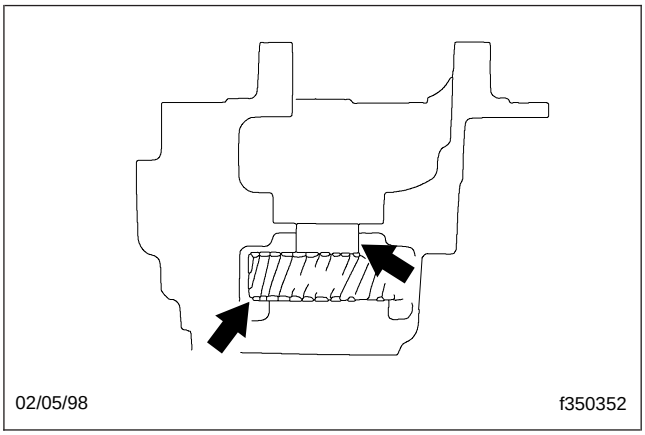


Fig. 3, Large Spacer on Top of the Helical Driven Gear

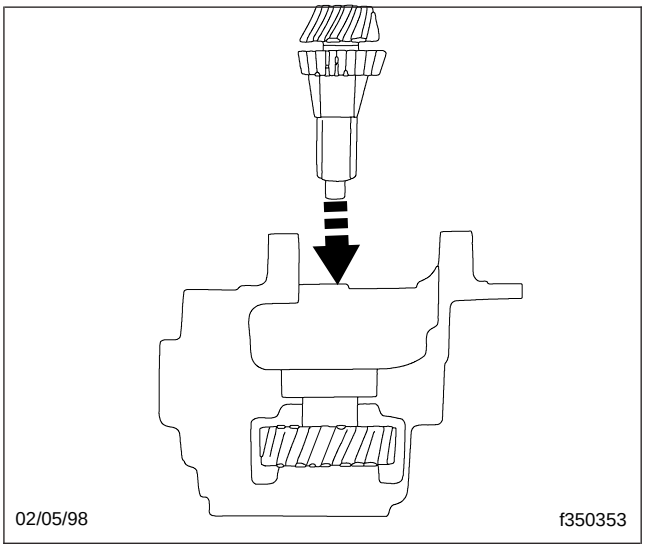


Fig. 4, Drive Pinion in the Helical Driven Gear Installation

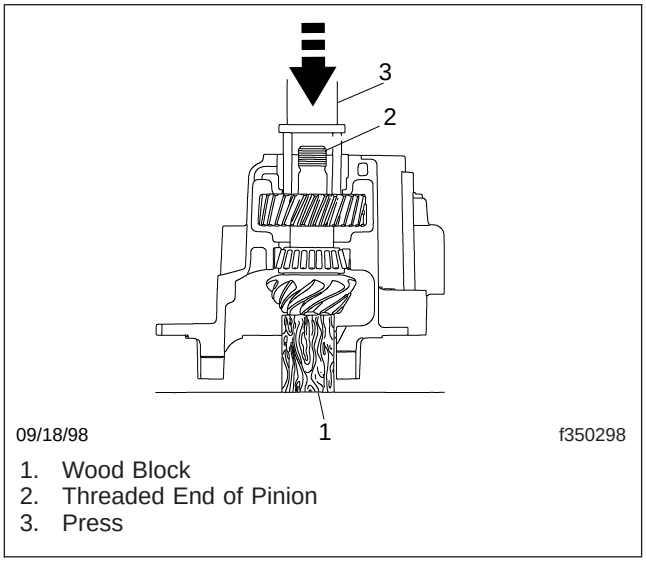
⚠ CAUTION

Do not apply pressure after the inner bearing cone touches the inner bearing cup. If pressure is applied, the cup, cone and drive pinion will be damaged.

NOTE: At this time, the helical driven gear will not be completely installed on the drive pinion.

NOTE: The inner bearing cone on the drive pinion must touch the inner bearing cup in the carrier when the helical driven gear is being installed.

8. Install the drive pinion into the carrier. See **Fig. 5**.



1. Wood Block
2. Threaded End of Pinion
3. Press

Fig. 5, Install the Drive Pinion into the Carrier

8.1 Place a wood block under the head of the drive pinion.

8.2 Position the carrier in a press so that the threaded end of the pinion is toward the top of the press.

8.3 Use the press to install the pinion into the carrier so that the inner bearing cone touches the bearing cup.

⚠ CAUTION

Do not apply pressure after the helical driven gear touches the spacer in front of the inner bearing on the drive pinion. If pressure is applied after the parts touch each other, the gear will damage the spacer.

9. Use a press and a sleeve to completely install the helical driven gear on the drive pinion.

   9.1 Use a sleeve on the hub of the gear that fits inside the pinion bore in the carrier.

   9.2 Press the gear on the drive pinion until the gear touches the spacer.

10. Cut two pieces of lead or solder approximately 9/16 inch (14 mm) long and 5/8 inch (16 mm) wide. Use the two pieces of solder or lead as

gauge blocks to determine the correct thickness of the spacer between the helical driven gear and the outer bearing.

11. Position the two pieces of lead or solder so that the pieces are opposite each other on top of the helical driven gear. See **Fig. 6**.

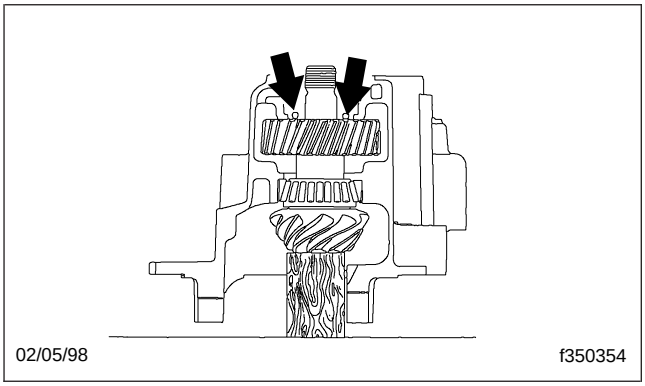


Fig. 6, Two Pieces of Lead or Solder Opposite Each Other On Top of the Helical Driven Gear

12. Place the outer bearing cone in the cup over the two pieces of lead or solder on top of the helical driven gear. See **Fig. 7**.

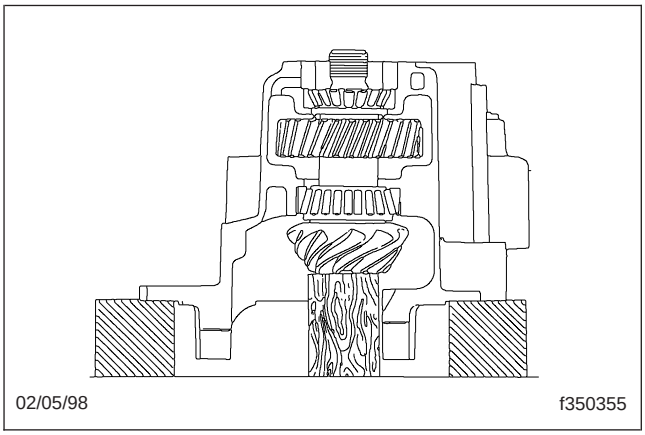


Fig. 7, Outer Bearing Cone In the Cup Over the Helical Driven Gear

⚠ WARNING

Do not apply more than the specified pressure with the press. Excessive pressure may cause damage to components.

13. Place a sleeve on top of the outer bearing cone, and use a press to apply the specified pressure to the outer bearing cone. The pressure of the press compresses the lead or solder pieces to the correct size. See **Fig. 8**.

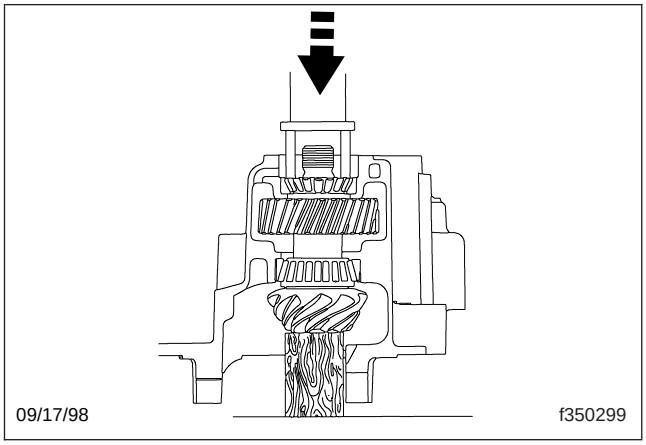


Fig. 8, Compressing the Lead or Solder

14. Release the pressure on the outer bearing cone. Remove the wood block from under the head of the drive pinion.
15. Use a press and a sleeve to press the shaft of the drive pinion out of the outer bearing cone. Do not press the shaft of the drive pinion out of the helical driven gear.
16. Remove the outer bearing cone and the two pieces of lead or solder from the outer bearing cone.

NOTE: If the depth of the drive pinion was changed, the thickness of the spacer that controls the preload of the pinion bearings must be changed by the same amount. If shims were added to increase the depth of the drive pinion, then the total amount of added shims must be added to the size of the spacer. If shims were removed to decrease the depth of the drive pinion, then the same amount of removed shims must be removed from the size of the spacer.

17. EXAMPLE:

    Determined size of the spacer for bearing preload: 0.509 inch (12.926 mm).

    Amount of shims added to increase the depth of the pinion: 0.003 inch (0.076 mm).

    Final size of the spacer for bearing preload: 0.512 inch (12.902 mm).

Bearing Preload Adjustment on Drive Pinion

Determined size of the spacer for bearing preload: 0.509 inch (12.926 mm).

Amount of shims removed to decrease the depth of the pinion: 0.003 inch (0.076 mm).

Final size of the spacer for bearing preload: 0.506 inch (12.850 mm).

Use a micrometer to measure the thicknesses of the compressed pieces of lead or solder. Add the measurements of the two pieces and divide by two to determine the average size of the pieces. Add 0.004 inch (0.100 mm) to the average size. Use this dimension to determine the size of the spacer to install between the helical drive gear and the outer bearing.

Determining Pinion Bearing Preload Spacer Thickness		
Description	**Inch**	**mm**
Thickness of Piece No. 1	0.504	12.800
Thickness of Piece No. 2	0.506	12.852
Total Thickness	1.010	25.652
Divided By 2 to Get the Average Thickness	0.505	12.826
Add 0.004 inch (0.100 mm) to Get the Thickness of the Spacer	0.509	12.926

Table 1, Pinion Bearing Preload Spacer Thickness

NOTE: The inner bearing cone on the drive pinion must touch the inner bearing cup in the carrier when the helical driven gear is being installed.

18. Place a wood block under the head of the drive pinion so that the inner bearing cone on the pinion touches the inner bearing cup in the carrier.

⚠ CAUTION

Do not apply pressure after the helical driven gear touches the spacer in front of the inner bearing on the drive pinion. If pressure is applied after the parts touch each other, the gear will damage the spacer.

19. Use a press and a sleeve to completely install the helical driven gear on the drive pinion. See **Fig. 9**.

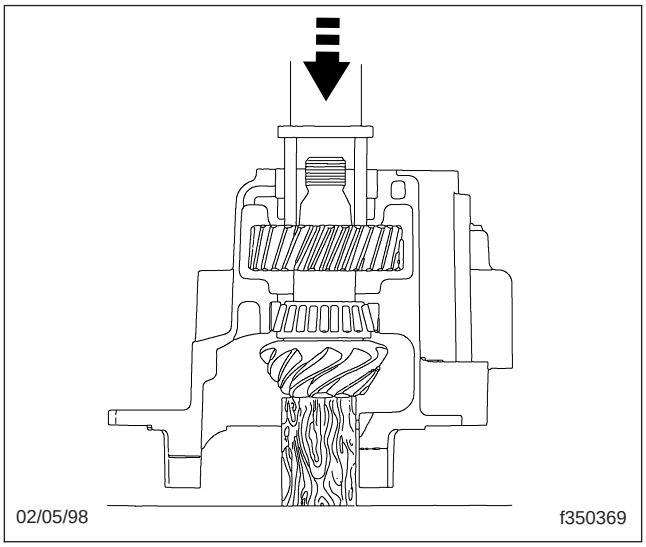


Fig. 9, Helical Driven Gear On the Drive Pinion Installation

19.1 Use a sleeve on the hub of the gear that fits inside the pinion bore in the carrier.

19.2 Press the gear on the drive pinion until the gear touches the spacer.

19.3 Do not remove the wood block at this time.

20. Install the correct size spacer on the shaft on the pinion in front of the helical driven gear. See **Fig. 10**.

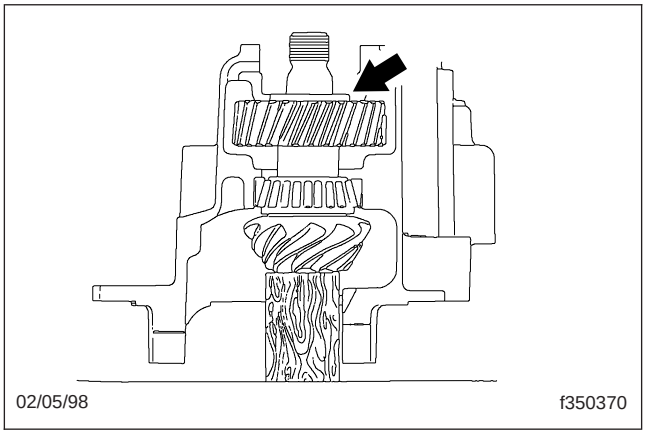
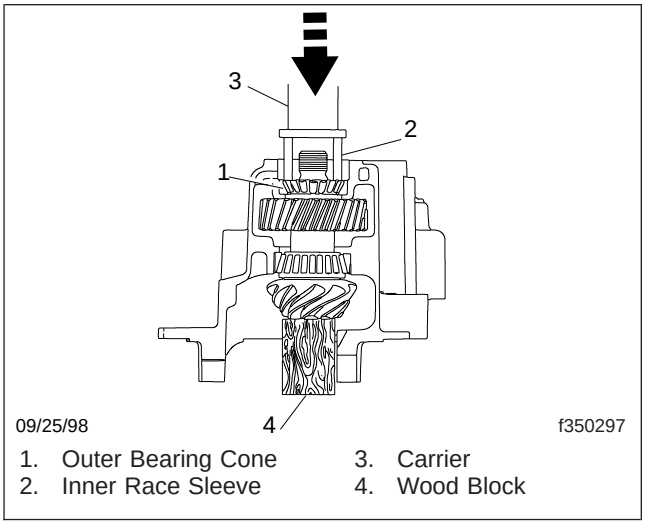


Fig. 10, Install the Correct Size Spacer

NOTE: Make sure the wood block is still under the head of the drive pinion. The inner bearing cone on the pinion must touch the cup in the carrier.

21. Use the following procedure to install the outer bearing cone on the shaft of the drive pinion. See **Fig. 11**.



1. Outer Bearing Cone
2. Inner Race Sleeve
3. Carrier
4. Wood Block

Fig. 11, Outer Bearing Cone Installation

21.1 Place the outer bearing cone on the shaft of the drive pinion.

21.2 Place a sleeve on the inner race of the outer bearing cone.

21.3 Use a press to apply pressure on the bearing cone to install the cone on the shaft of the drive pinion.

Move the carrier in both directions (so that the carrier pivots on the drive pinion) while the cone is being installed to make sure that the bearing cone is correctly installed.

21.4 Release the pressure on the bearing cone and remove the wood block from under the head of the drive pinion.

22. Remove the carrier from the press, and place the carrier in a suitable stand.

23. Install the washer and the nut on the drive pinion, preventing the drive pinion assembly from rotating by using a fixture to hold the teeth of the helical driven gear or putting wood blocks between the head of the pinion and the carrier wall.

Tighten the nut to 1200 to 1500 lbf·ft (1627 to 2034 N·m), and remove the holding fixture or the wood blocks. See **Fig. 12**.

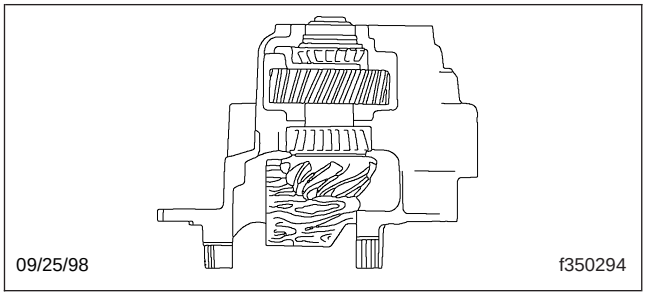


Fig. 12, Tighten the Drive Pinion Nut

NOTE: Use a lbf·in (N·cm) torque wrench or a spring scale to check the preload of the bearings on the drive pinion. If a spring scale is used, go to next step.

24. Place a lbf·in (N·cm) torque wrench and the correct socket on the nut of the drive pinion, and use the torque wrench to rotate the drive pinion assembly. Look at the reading on the torque wrench. See **Fig. 13**.

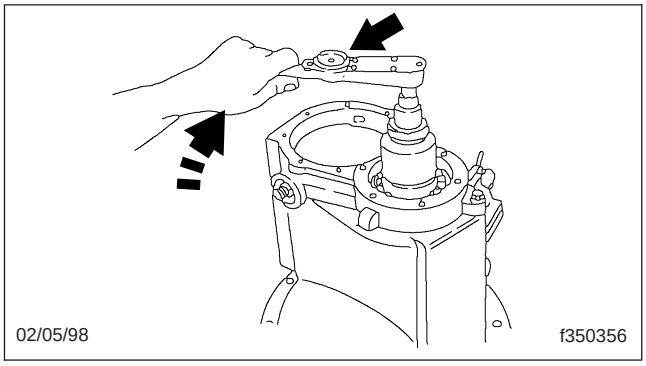


Fig. 13, Turning Torque Check

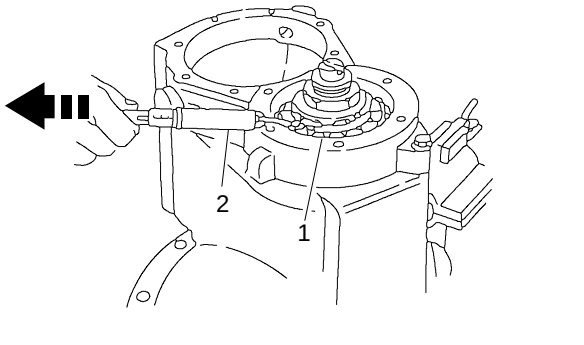
24.1 Record the torque required to rotate the assembly.

24.2 Do not use the torque required to start the rotation.

25. Use the following procedure to check the drive pinion bearing preload with the spring scale. See **Fig. 14**.

25.1 Wind a cord around the washer under the nut f the drive pinion.

Bearing Preload Adjustment on Drive Pinion



1. Cord
2. Spring Scale

Fig. 14, Drive Pinion Bearing Preload Procedure

25.2 Attach the Spring Scale to the end of the cord.

25.3 Pull the spring scale and cord in a horizontal direction while looking at the reading on the spring scale.

26. Calculate the bearing preload (torque) as follows: Pounds pulled x radius (inches) = lbf·in preload, x 0.113 = N·m preload, or kilograms pulled x radius (millimeters) = kg·mm preload, x 0.098 = N·m preload. EXAMPLE: Outer diameter of washer = 3.00 inches (76.20 mm). Spring scale reading = 9 lb (4 kg).

Drive Pinion Bearing Preload Calculation		
Description	**Inch**	**mm**
Outer Diameter of Washer	3.00	76.20
Divide the Outer Diameter By 2 to Get the Radius of the Washer	1.50	38.10
Multiply the Radius of the Washer By the Spring Scale Reading	13.5 lbf·in	152.4 kg·mm
Multiply the Lbf·In Reading By 0.113. Multiply the kg·mm Reading By 0.098 to Get N·m Preload	1.52	14.9

Table 2, Drive Pinion Bearing Preload Calculation

27. The preload of the drive pinion bearings must be within the specified limits. If the preload is not within the specified limits, remove and replace the spacer between the outer bearing assembly and the helical drive gear. See **Fig. 15**.

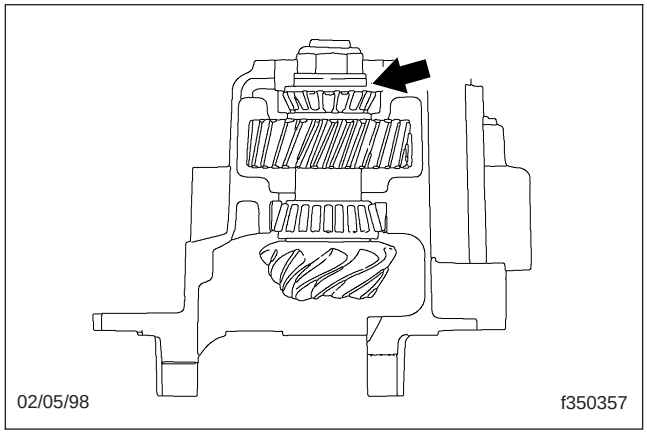


Fig. 15, Outer Bearing Assembly Spacer

27.1 New pinion bearings: 5 to 45 lbf·in (0.56 to 5.08 N·m) rotational torque.

27.2 Used pinion bearings: 10 to 30 lbf·in (1.13 to 3.39 N·m) rotational torque.

27.3 Install a thicker spacer to decrease the preload.

27.4 Install a thinner spacer to increase the preload.

NOTE: Prevent the drive pinion assembly from rotating by using a fixture to hold the teeth of the helical driven gear or by putting wood blocks between the head of the pinion and the carrier wall.

28. Remove the nut and the washer from the shaft of the drive pinion. See **Fig. 16**.

NOTE: Position supports under the flange of the carrier so that the carrier is level. Place a wood block under the head of the pinion. Make sure the wood block does not touch the head of the drive pinion.

29. Position the carrier in a press so that the threaded end of the pinion is toward the top of the press. Press the drive pinion out of the bearing cone and remove the inner bearing cone from the differential carrier. See **Fig. 17**.

30. Install the correct size spacer on the shaft of the pinion over the helical driven gear.

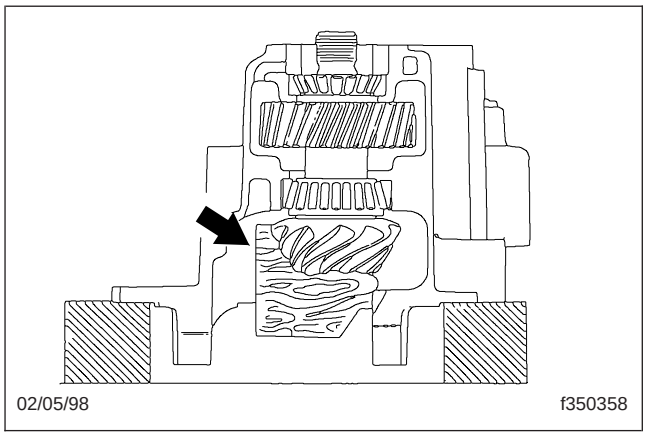


Fig. 16, Drive Pinion Nut and Washer Removal

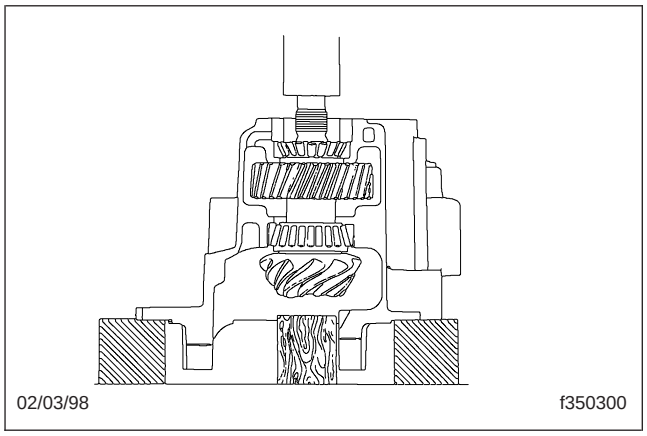


Fig. 17, Removing Drive Pinion from Bearing Cone

31. When the preload is within the specified range, install the main differential case and ring gear assembly in the carrier. Adjust the preload on the main differential bearings and the backlash of the ring gear, and check the contact pattern on the teeth of the ring gear.

Output Bearing End Play

1. Place the through-shaft and the bearing retainer assembly in a vise with soft metal covers on the jaws of the vise. See **Fig. 1**.

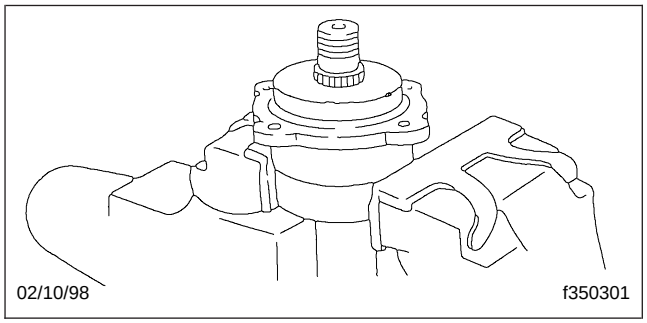


Fig. 1, Through-Shaft and Bearing Assembly

NOTE: Do not install the oil seal at this time.

2. Use a suitable installation tool to install the yoke or flange on the through-shaft. See **Fig. 2**.

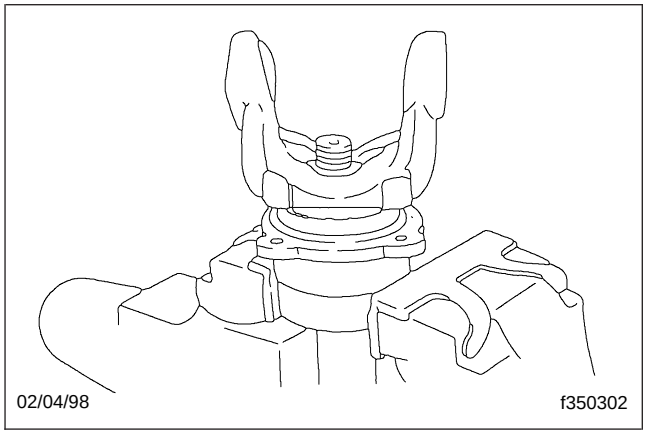


Fig. 2, Yoke or Flange Installation

3. Install the nut that fastens the yoke or flange to the through-shaft. Using a holding tool such as the companion flange holding tool to hold the yoke or flange in a stationary position, tighten the nut. See **Fig. 3**.
4. Push the yoke or flange toward the retainer and rotate the shaft in each direction to make sure that the bearings are correctly installed.
5. Install the dial indicator with bracketry so the base of the indicator is on the mounting flange of the retainer and the pointer of the indicator is touching the yoke or flange end of the through-shaft.

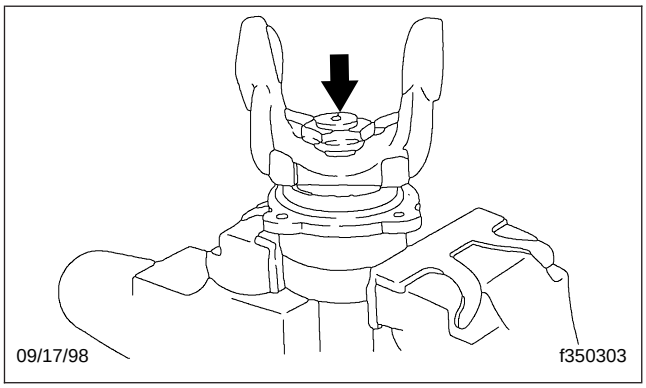


Fig. 3, Yoke or Flange Installation

Adjust the dial indicator to the zero (0) setting. See **Fig. 4**.

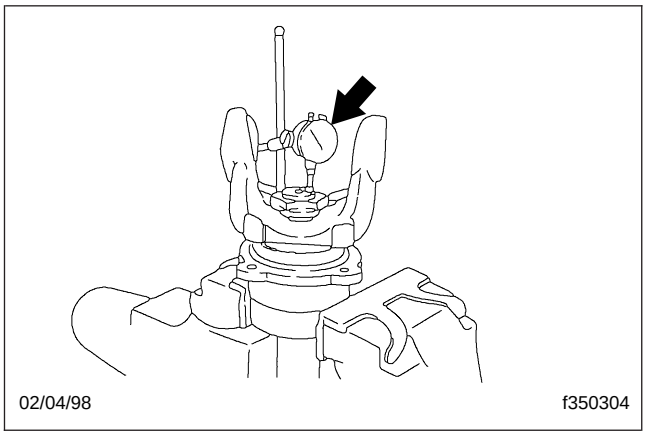


Fig. 4, End Play Check Setup

6. Position pry bars under the yoke or flange and push the yoke or flange away from the retainer. Record the reading on the dial indicator. The reading must be as specified. See **Fig. 5**.
7. Remove the nut that fastens the yoke or flange to the through-shaft.
8. Use a suit able puller tool to remove the yoke. See **Fig. 6**.
9. Remove and replace the snap ring that fastens the bearings in the retainer if the end play reading is not within specification (0.001 to 0.004 inch [0.025 to 0.102 mm]).

Output Bearing End Play

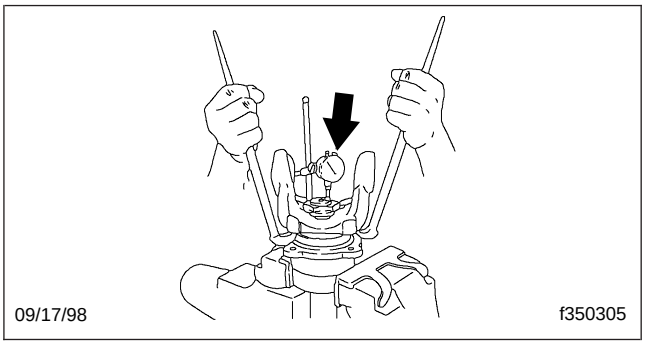


Fig. 5, End Play Specification Check

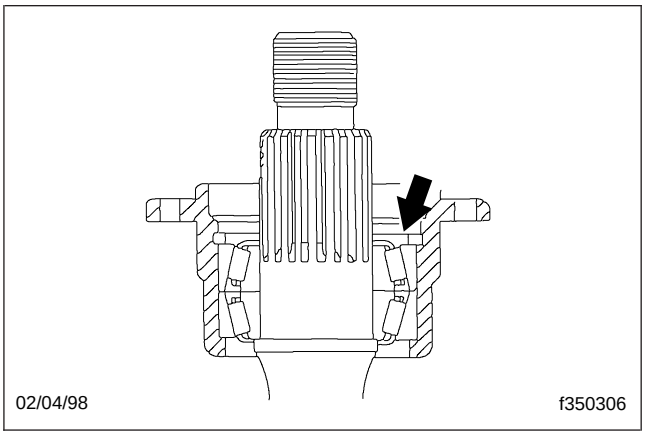


Fig. 6, Bearing Snap Ring

9.1 Install a thinner snap ring to increase end play.

9.2 Install a thicker snap ring to decrease end play.

Ring Gear Backlash

Check the backlash at three places on the ring gear. Record the reading found on the dial indicator. For instructions, refer to **Group 41** in this manual.

Check Rolling Resistance of Side Gears on Main Differential Case

For instructions, refer to **Group 41** in this manual.

Lubricant Capacities, On-Highway Axles			
Model	**Carrier**	**Capacity**	
		Pints	**Liters**
RT-145	Forward	26.2	12.4
	Rear	23.9	11.3
RT-160	Forward	39.3	18.6
	Rear	34.7	18.4

Table 1, Lubricant Capacities, On-Highway Axles

General Specifications	
Item	**Specification**
Drive Pinion Bearing Preload	
New Bearings	5–45 lbf·in (0.56–5.08 N·M)
Used Bearings	10–30 lbf·in (1.13–3.39 N·M)
Main Differential Bearing Preload	15–35 lbf·in (1.7–3.9 N·M)
Expansion Between Bearing Caps	
RS-XX-140 and 145 Carriers	0.003–0.009 inch (0.08–0.22 mm)
All Other Carriers	0.006–0.013 inch (0.15–0.33 mm)
Main Differential Gears Rotating Resistance	50 lbf·ft (68 N·M)
Ring Gear Backlash	
Less than 17 inches (431.8 mm)	0.008–0.018 inch (0.20–0.46 mm)
New Gearset	0.012 inch (0.30 mm)
17 inches (431.8 mm) or Greater	0.010–0.020 inch (0.25–0.51 mm)
New Gearset	0.015 inch (0.38 mm)
Ring Gear Runout (Maximum)	0.008 inch (0.20 mm)
Input Shaft End Play	0.002–0.008 inch (0.50–0.200 mm)
Output Bearing End Play and Preload	0.001–0.004 inch (0.025–0.102 mm)
Adhesive	
Stud and Bearing Mount EOAZ–19554–BA	WSK–M2G349–A1

General Specifications	
Item	**Specification**
Threadlock® and Sealer EOAZ–19554–AA	WSK–M2G315–A5

Table 2, General Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
U-Bolt Nuts	260–320 (353–433)
Wheel Nuts	450–500 (611–677)
Torque Rod Bolts	150–205 (204–277)
Driveshaft/Inter-Axle Shaft Bearing Strap Capscrews	
5/16–24	35–41 (47–56)
3/8–24	45–60 (61–81)
Axle-to-Walking Beam Retaining Bolts	450–600 (610–813)
Axle Housing Studs	150–230 (203–312)
Drive Unit-to-Carrier Bolts	150–230 (203–312)
Output Bearing Retainer Capscrews	35–50 (47–68)
Oil Filter Adapter	45–60 (61–81)
Oil Filter Shield Retainer Capscrews	75–95 (100–127)
Axle Drain Plug	35 (47)
Bearing Cap Retainer Capscrews	
145 Model	320–400 (434–542)
160 Model	480–600 (650–810)
Differential Lock Plug	45–55 (61–75)
Ring Gear Nuts	
145	160–210 (217–285)
160	196–262 (265–355)
Main Differential Case Halves—Capscrew	
M12 x 1.75 Class 10.9	75–95 (102–129)
M12 x 175 Class 12.9	125–195 (169–264)
Drive Pinion Nut	1200–1500 (1627–2034)
Oil Pump to Input Bearing Retainer Capscrews	22–33 (30–45)
Pressure Relief Valve Plug	20–40 (27–54)

Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Inter-Axle Differential Case Halves, Capscrew	45–55 (60–75)
Input Shaft Bearing Retainer Capscrews	75–95 (102–129)
Input Yoke Nut	600–800 (813–1085)
Through Shaft Nut	450–600 (610–813)
Inter-Axle Cover Retainer Capscrews	35–52 (40–70)

Table 3, Torque Specifications

General Information

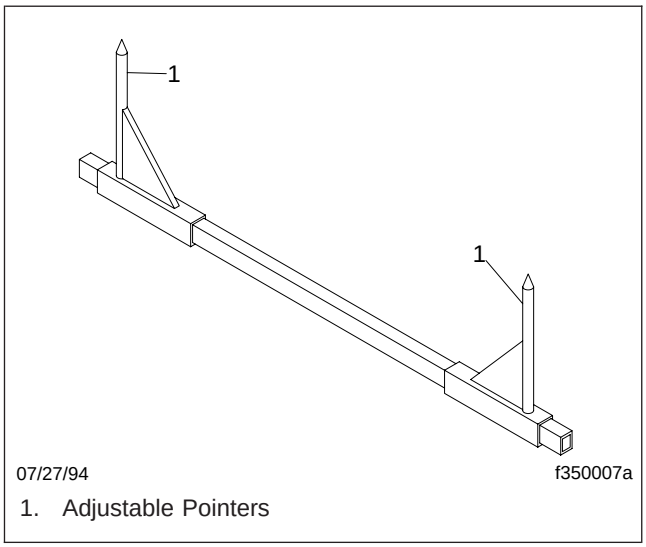
Rear axle alignment should be checked whenever rear axle or suspension components are replaced. It should also be checked when there is excessive front and rear tire wear or hard or erratic steering.

Manufacturers of axle alignment equipment offer a variety of systems to precisely measure and correct rear axle alignment. If this type of 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 a 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 (see **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 that are inserted into the axle cap holes of each axle. It can be determined if the axles are parallel by comparing the distance between the two axles on one side to the distance on the other side.

Refer to **Subject 120** for instructions and a list of materials for making the center point bar.



1. Adjustable Pointers

Fig. 1, Center Point Bar

Checking

NOTE: Before checking the axle alignment, make sure the wheel bearings are adjusted. For instructions, refer to **Section 35.00** in this manual. Make sure that no wheel rims are bent and that all rims are correctly seated. Refer to **Group 31** in this manual for instructions on checking the frame rail alignment. Correct the frame rail alignment if necessary.

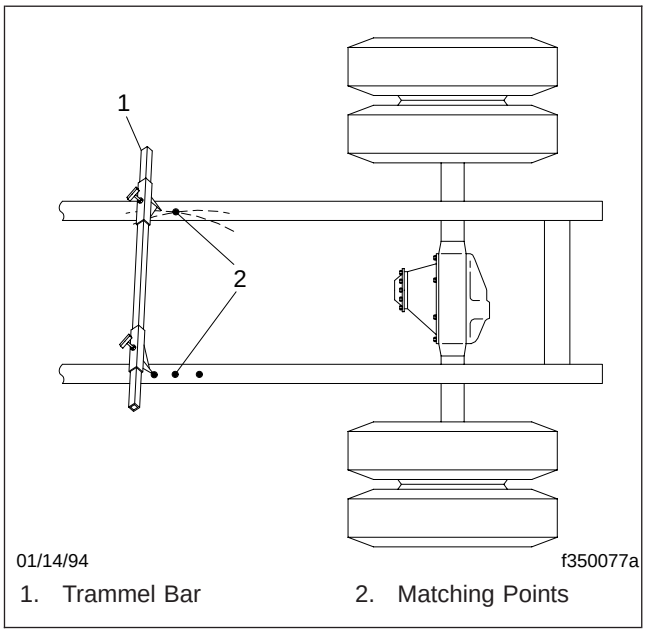
IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Sterling 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

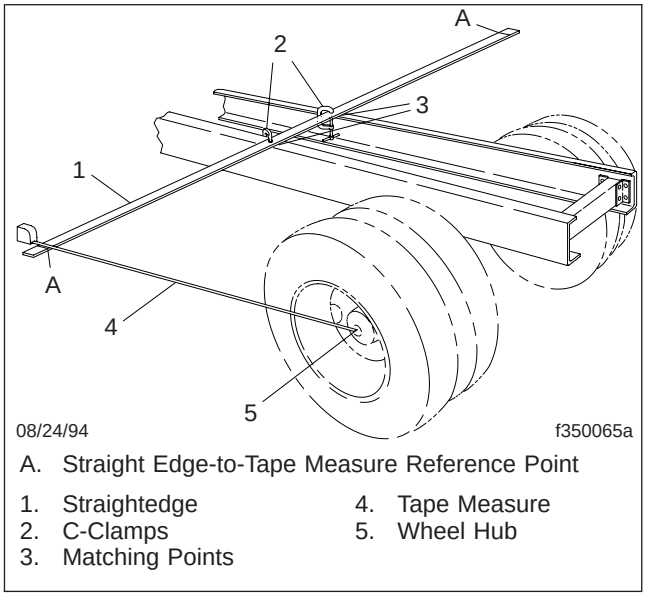
Do not use scribe lines for marking on frame rails. Scribe lines, which cut or scratch the metal, can develop into starting points for structural damage to the frame.

3. Select a point on the frame rail forward of the rear axle. Using a pencil or soapstone, mark two other points, exactly 4 inches (102 mm) forward and to the rear of the original point. 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.
4. 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.
5. Measuring from the outside edge of each frame rail, mark the straightedge on both sides of the



1. Trammel Bar
2. Matching Points

Fig. 1, Marking an Arc With the Trammel Bar



A. Straight Edge-to-Tape Measure Reference Point

1. Straightedge
2. C-Clamps
3. Matching Points
4. Tape Measure
5. Wheel Hub

Fig. 2, Straightedge to Wheel Hub Measurement

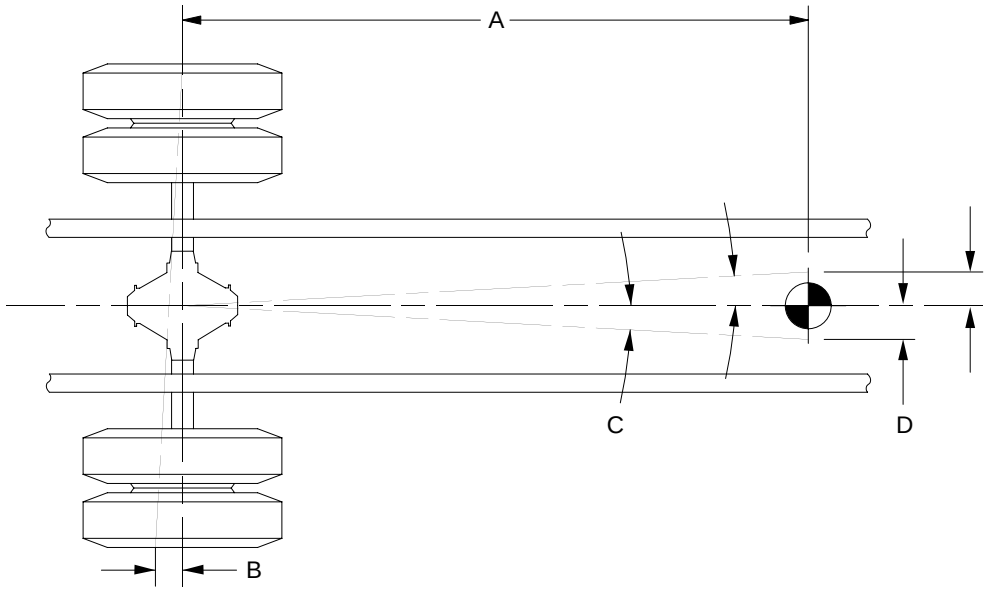
Manual Alignment Checking, Single Axle

frame. Reference "A" (see **Fig. 2**) 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.

6. 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 1/4 inch (6 mm) or less. See **Fig. 3**. If the difference is more than 1/4 inch (6 mm), adjust the axle alignment. For instructions, refer to the applicable suspension section in this manual, or to the suspension manufacturer's service literature.



A. Distance from Rear Axle to Target (using Bee Line alignment tools)
B. Maximum Allowable Difference if Aligned Manually = ±1/4 inch (6 mm)
C. Maximum Allowable Tolerance if Aligned With Hunter Tools = ±0.18 degrees
D. Maximum Allowable Tolerance if Aligned With Bee Line Tools

Fig. 3, Alignment Measurements

Manual Alignment Checking, Tandem Axle

Checking

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.

Refer to **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.

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. Sterling dealers must have proof of this calibration history.

1. Using the center point bar, set the two points into the axle cap holes. See **Fig. 1**. Lock them in place by tightening the setscrews.
2. With the points still locked in place, move the center point bar to the other side of the vehicle, set the two points into the axle cap holes, and compare the axle spacing. If there is a difference of 1/8 inch (3 mm) or less between the spacing on one side of the vehicle compared to the other, no further action is necessary.

   If the difference is more than 1/8 inch (3 mm), adjust the forward-rear axle alignment. See **Fig. 2**. For instructions, refer to **Group 32** in this manual, or to the suspension manufacturer's service literature.

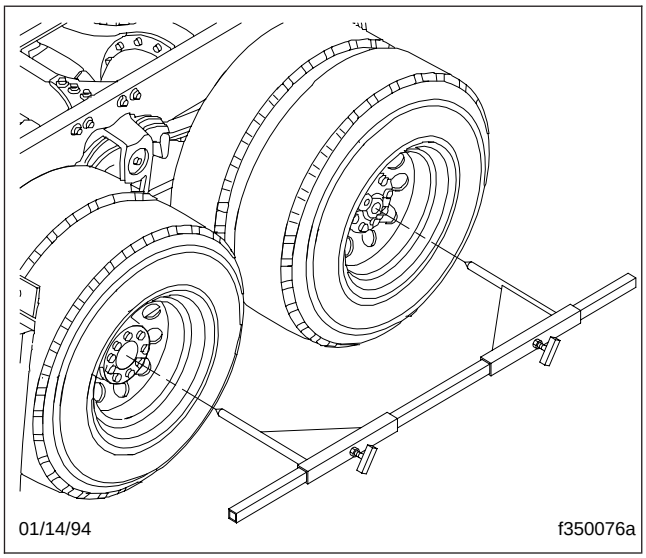
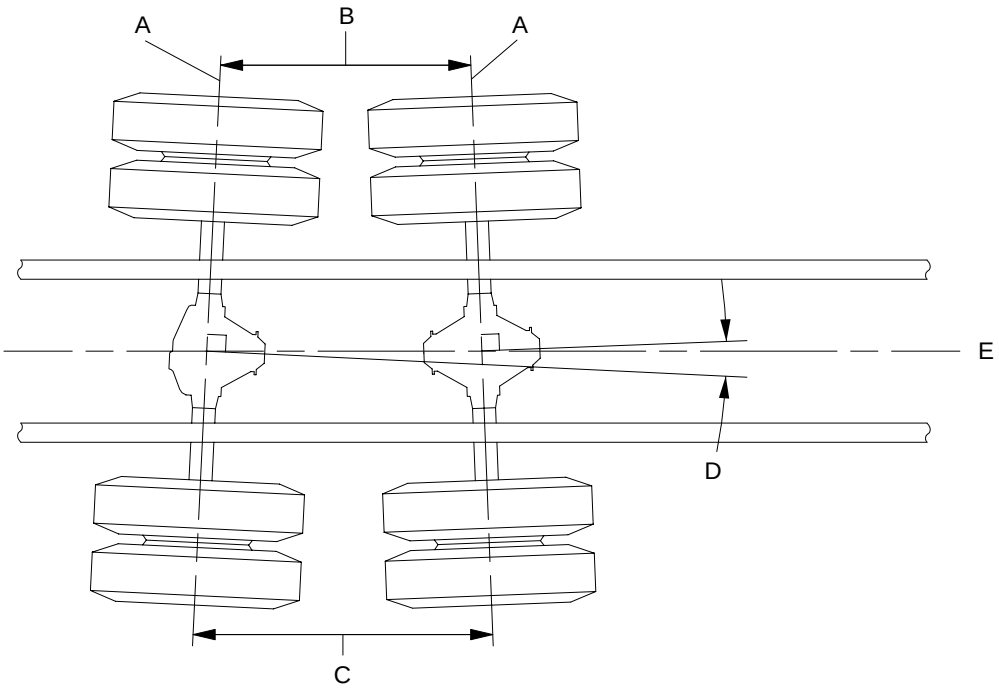


Fig. 1, Centerpoint Bar Placement

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 degrees
E. Vehicle Centerline

Fig. 2, Tandem Axle Measurements

Center Point Bar Construction

Materials Required

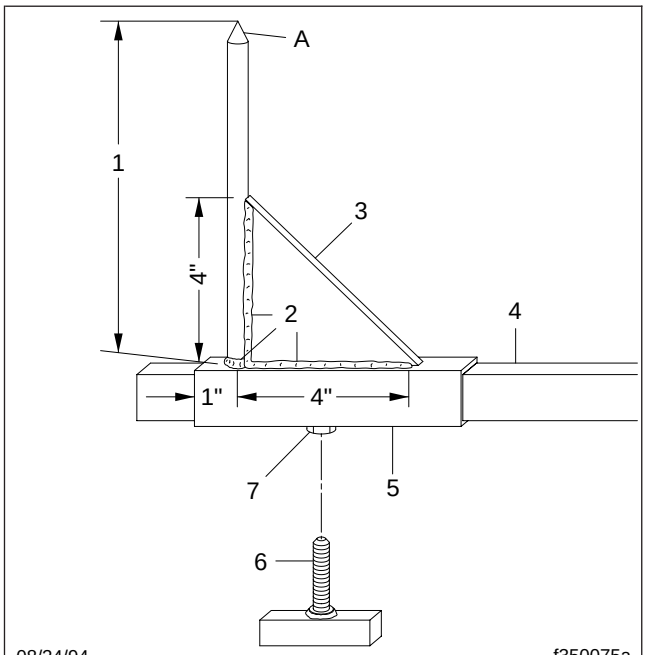
NOTE: To obtain metric conversions (millimeters), multiply the number of inches by 25.4.

Required materials are listed below:

- 62 inches of square steel tube (1-inch o.d.)
- 12 inches of square steel tube (1-1/8-inch i.d.)
- 20 inches of 3/8-inch steel rod
- two 1/2-inch x 3-inch pieces of steel square-bar stock
- one 4-inch x 4-inch steel plate, 1/8-inch thick
- two 3/8–16 capscrews (grade 5), 2 inches long
- two 3/8–16 hexnuts (equivalent to grade 5)

Construction Procedures

1. Cut the 1-1/8-inch i.d. square steel tube in half to obtain two pieces 6 inches long. These will be the sliding members (slides) of the center point bar.
2. Cut the 4-inch x 4-inch steel plate diagonally into two pieces (gussets). Weld one gusset to each slide. See **Fig. 1**.
3. Cut the steel rod in half to obtain two 10-inch rods. Grind one end of each to form a point.
4. Weld the pointed steel rods to the slides and gussets, as shown in **Fig. 1**.
5. Drill a 1/2-inch (12.7 mm) hole in the center of each slide, on the side opposite where the pointer was welded. Drill through only one side of the tube.
6. Directly over each hole drilled in the step above, weld a 3/8–16 nut (equivalent to grade 5).
7. Weld a piece of steel stock, about 1/2-inch wide x 3-inch long, over the head of each of two 3/8–16 x 2-inch long capscrews.
8. Place a slide over each end of the 60-inch piece of steel tube, with the pointed rods to the outside. Screw the handscrews (made in the step above) into the slides until they are clamped tightly to the cross tube.



A. Grind to a point.

1. 3/8-inch Diameter Rod
2. Weld
3. Gusset
4. 1-inch Square Steel Tube
5. 1–1/8-inch Square Steel Tube
6. 3/8–16 Bolt
7. 3/8–16 Nut

Fig. 1, Center Point Bar Construction

Method	Maximum Tolerance ± from Perpendicular
Manual	1/4-inch (6 mm)

Table 1, Maximum Tolerance from Perpendicular, Manual Method

Method	Maximum Tolerance ± from Perpendicular
Hunter *	0.18 degrees

* To use Hunter alignment equipment, refer to the applicable Hunter service literature.

Table 2, Maximum Tolerance from Perpendicular, Hunter 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)

* To use Bee Line alignment equipment, refer to the applicable Bee Line service literature.

Table 3, Maximum Tolerance from Perpendicular at Target, Bee Line Equipment

Method	Maximum Tolerance
Hunter	±0.08 degrees maximum axle-to-axle difference; reference "C", see **Fig. 1**.
Bee Line or Manual	±1/8-inch maximum difference in axle end-spacing; reference "B" minus "A", see **Fig. 1**.

Table 4, Rear Axle Parallelism Specifications

Specifications

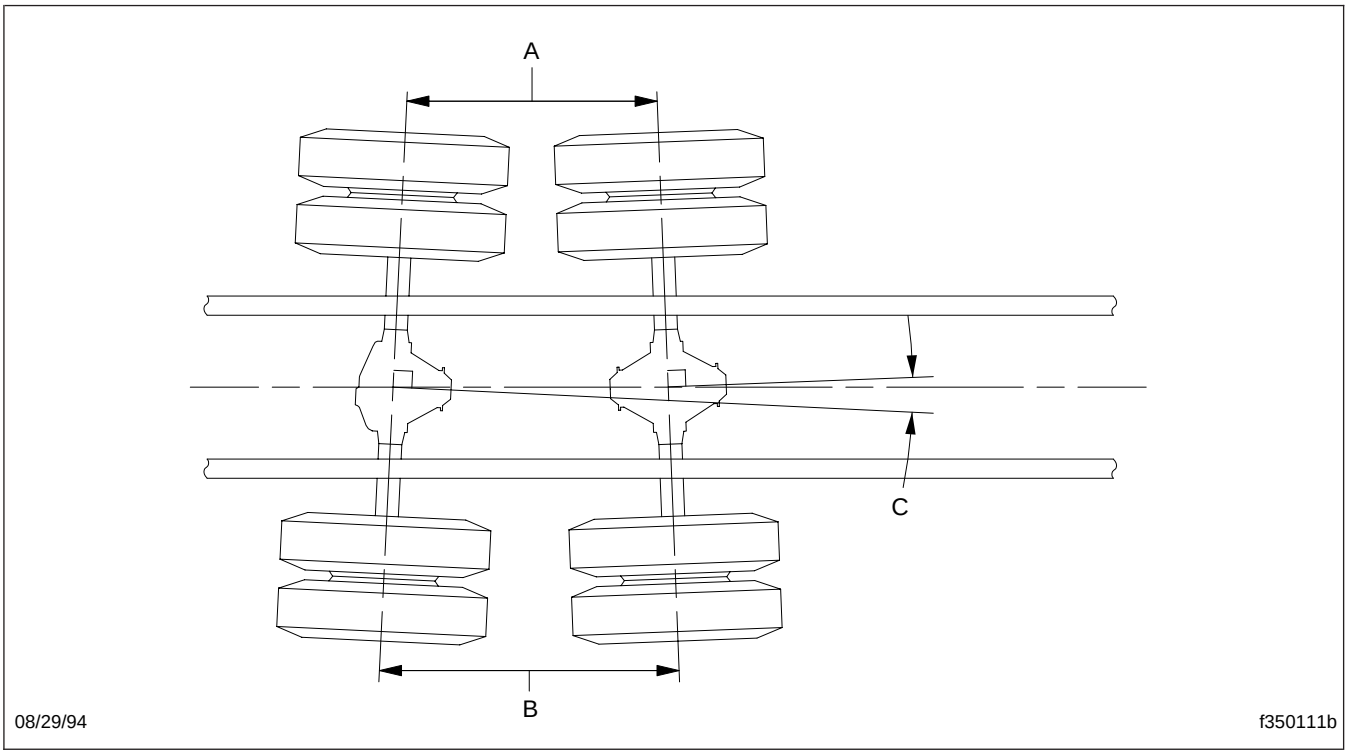


Fig. 1, Tandem Axle Measurements

General Information

Detroit rear axles are compatible with industry-standard brakes, hubs, and wheel bearings.

The following explains an example of the number found on a Detroit rear axle identification tag, which is located on the carrier. See **Fig. 1**.

Typical Model Number: ART-40.0-4

- *ART* = tandem rear axle
- *40.0* = weight rating (times 1000 lb)
- *4* = basic model number

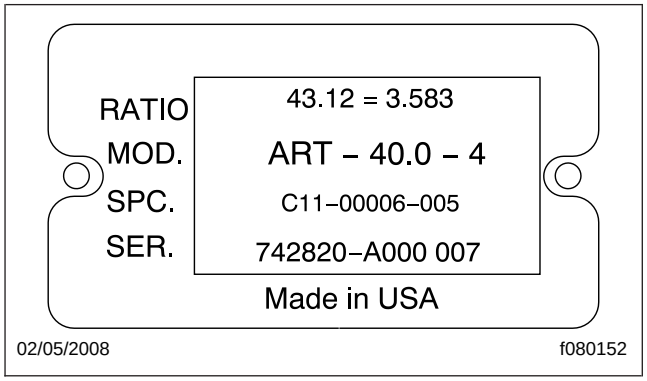


Fig. 1, Rear Axle ID Tag

Detroit rear axles may have a main differential lock, which is commonly known as the "DCDL" (Driver-Controlled Differential Lock). The DCDL is an optional feature that can lock the differential assembly to improve traction on icy road conditions. When the differential lock is engaged, the clutch collar completely locks the differential case, gearing, and axle shafts together to maximize traction of both wheels and protect against spinout. Each part of the DCDL is replaceable; see **Subject 180**.

On tandem axles there are three possible differential lock options: forward-rear carrier only, rear-rear carrier only, or both rear carriers.

NOTE: Detroit axles are a proprietary product, though in some applications they may be referred to as "Sterling" or "Axle Alliance" axles or "MB components."

Warranty

To assist in the determination of warrantable and non-warrantable failures for these axles, warranty evaluation guides are available through WarrantyLit on **www.accessfreightliner.com**. These guides help determine whether or not pre-approval is needed for a repair. The following evaluation guides are available:

- **Warranty Evaluation Guide**
- **Submission Guidelines - Differential Cross Failure**
- **Submission Guidelines - Pinion Bearing Cage Damage**
- **Submission Guidelines - Pinion Nut Failure**
- **Submission Guidelines - Thrust Bearing Failure**
- **Submission Guidelines - Yoke (Pinion) End Play**

Single Axle or Rearmost Tandem Axle Removal and Installation

Removal

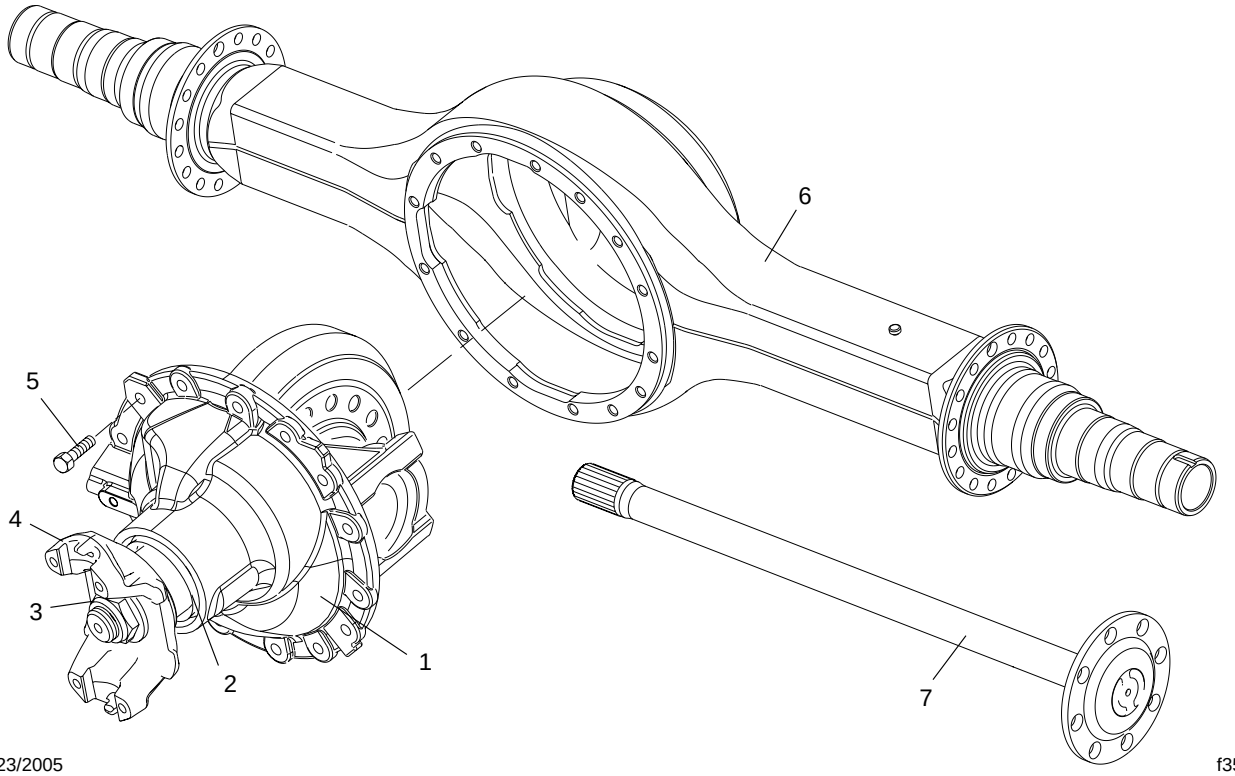
For rear axle components, see **Fig. 1**.

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires. Put the transmission in neutral.
2. Using a suitable jack, raise the vehicle enough to take the weight off the axles, but not enough to raise the tires off the ground.
3. At both ends of the axle, loosen all the wheel nuts.
4. Continue to raise the vehicle evenly until there is room to fit a jack underneath the axle housing.

⚠ WARNING

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

5. Support the vehicle with safety stands.
6. Remove the tire and wheel assemblies.
7. Drain the oil from the differential housing. Install the drain plug.
8. Disconnect the driveshaft from the differential carrier. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.



1. Differential Carrier
2. Radial Shaft Seal
3. Yoke Nut
4. Carrier Yoke
5. Carrier Capscrew
6. Rear Axle Housing
7. Axle Shaft

Fig. 1, Rear Axle Components

Single Axle or Rearmost Tandem Axle Removal and Installation

9. Release the parking brakes.
10. Cage the parking brake springs to prevent the parking brakes from engaging. For instructions, see **Group 42**.
11. If DCDL is installed on the vehicle, use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged. Turn the appropriate hubs to ensure the lock is fully engaged.
12. Place a basin under the axle shaft flanges to catch any oil, then remove the axle shafts. For instructions, see **Subject 120**.
13. Drain the air system.
14. Disconnect the DCDL air line from the carrier housing.
15. If necessary, back off the slack adjusters, then remove the brake drums.
16. Remove the hubs from the axle spindles. For instructions, see **Section 35.00, Subject 100**.
17. Remove the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
18. If applicable, disconnect the leveling valve rod(s) from the suspension.
19. Disconnect the air lines from the rear brake chambers. Then remove the brake air chambers and the slack adjusters from the axle housing. For instructions, see **Group 42**.
20. Remove the brake spiders from the axle flanges, as follows.
    - 20.1 At the frame rail or crossmember, disconnect the wiring for the ABS sensors. Remove any tie straps that hold the wires to the frame rails.
    - 20.2 Remove the ABS sensors and wiring.
    - 20.3 Remove the fasteners that hold the brake spiders to the axle flanges. Remove the spiders from the axle.
21. Using a suitable jack, support the axle housing.
22. If applicable, remove the hexnuts that hold the bottom of each suspension air bag to its suspension bracket.
23. Remove the suspension components that attach the axle to the vehicle. If applicable, remove the U-bolt nuts from the U-bolts. Discard the U-bolt nuts and U-bolts.
24. Lower the axle enough to clear the suspension components.
25. Remove the axle from the vehicle.
26. If you are going to replace the differential carrier, place the axle on a secure axle stand.

Installation

1. Position the axle underneath the vehicle.
2. Install the suspension components that attach the axle to the vehicle, as follows.

   NOTE: U-bolts and U-bolt nuts cannot be reused.

   - 2.1 On vehicles with conventional suspensions, install the upper U-bolt brackets, new U-bolts, lower U-bolt brackets, and new U-bolt nuts.

     On vehicles with air suspensions, in addition to the U-bolts, install the hexnuts that attach the air springs to the suspension brackets. For torque values, see **Group 32**.

     On vehicles without U-bolts, install the walking beams.
   - 2.2 If applicable, tighten the new U-bolt nuts in a diagonal pattern. For torque values, see **Group 32**.
3. Connect the driveshaft to the differential carrier yoke. For instructions, see **Section 41.00, Subject 100**.
4. Install the brake spiders on the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
5. Install the ABS sensors and connect the wiring at the frame rail. Secure the wiring with tie straps as needed.
6. Install the brake air chambers and slack adjusters on the axle housing brackets. For instructions, see **Group 42**.
7. Connect the air lines to the brake air chambers.

8. Install the brake shoes, as removed. For instructions, see the applicable service brake section in **Group 42**.
9. Fill each hub with enough 80W/90 gear oil until you can see a little amount of oil trickling out of the back of the hub (fill with about 0.8 quart, or 0.75 liter). Install the hubs on the axle spindles, and adjust the wheel bearings. For instructions, see **Section 35.00, Subject 100**.
10. If DCDL is installed on the vehicle, connect the DCDL air line, fill the air system, and use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged.
11. Using new gaskets, install the axle shafts. For instructions, see **Subject 120**.
12. Install the brake drums on the hubs.
13. Install the wheels and tires. For instructions, see **Group 40**.
14. Adjust the brakes. For instructions, see the applicable service brake section in **Group 42**.
15. Uncage the parking brake springs.
16. Using approved axle oil, fill the axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 1**.

Approved Single Rear Axle Oil Type and Capacity				
Model	Oil Type		Capacity: quarts (liters)	
	Mineral	Synthetic	Hubs Full	Hubs Dry
2	80W-90	75W-90	5.8 (5.5)	7.4 (7.0)
4			10.6 (10.0)	12.2 (11.5)

Table 1, Approved Single Rear Axle Oil Type and Capacity

17. If the hubs are dry, raise one side of the vehicle about 8 inches (20 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

NOTICE

Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage.

18. Turn the wheels, wait one minute, and check the lubricant level.
19. Raise the vehicle, remove the safety stands, then lower the vehicle.
20. If applicable, connect the suspension leveling valve(s). Start the engine, build the air pressure, and make sure the suspension air bags inflate correctly. Make sure the ride height is correct. For instructions, see **Group 32**.
21. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.
22. Set the parking brake, then remove the chocks from the tires.

Single Axle or Rearmost Tandem Axle Differential Carrier Removal and Installation

When the wheel lock is removed, inspect the carrier for damage and replace it if damage is found. If no damage is found, install the carrier again.

Removal

NOTE: The differential carrier can be removed either with the rear axle installed on the vehicle or with the rear axle removed from the vehicle.

Axle Installed on Vehicle

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.
2. Put the transmission in neutral.
3. If applicable, release the suspension air pressure.
4. Using suitable jacks, raise the vehicle evenly until there is room to fit a jack underneath the axle housing.
5. Remove the tire and wheel assemblies.
6. Drain the oil from the axle housing.
7. Disconnect the driveshaft from the carrier yoke. For instructions, see **Section 41.00, Subject 100**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
8. If DCDL is installed on the vehicle, use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged. Turn the appropriate hubs to ensure the lock is fully engaged.
9. Place a basin under the axle shaft flanges, then remove the axle shafts. For instructions, see **Subject 120**.
10. Do the steps under the heading, "Axle Removed from Vehicle."

Axle Removed from Vehicle

1. Using a suitable jack, support the differential carrier. Chain the differential carrier to the jack.
2. If DCDL is installed on the vehicle, ensure the lock is engaged. Turn the appropriate hubs to verify it is fully engaged.
3. Remove the carrier capscrews that hold the differential carrier to the axle housing. See **Fig. 1**.

⚠ WARNING

The differential carrier is heavy. Do not try to move it without a suitable support. To do so could result in the carrier falling, which could cause serious personal injury and component damage. Support the carrier with a suitable jack and chain it to the jack, or use a hoist if the axle has been removed from the vehicle.

4. With the differential carrier securely supported, remove it from the axle housing.

Installation

IMPORTANT: If you replace the yoke on the differential carrier, use a *new* nut when installing the new yoke.

NOTE: Use a cleaning solvent and clean rags to remove dirt. Blow dry the cleaned areas with air.

1. Remove any old sealant material from the mating surfaces of the axle housing. Clean the inside of the rear axle housing and the forward carrier mating surface.
2. Inspect the axle housing for damage. Repair or replace the axle housing as necessary.
3. Apply a thin bead of Loctite® 5900 sealant all the way around the mating surface of the axle housing, and around each bolt hole.

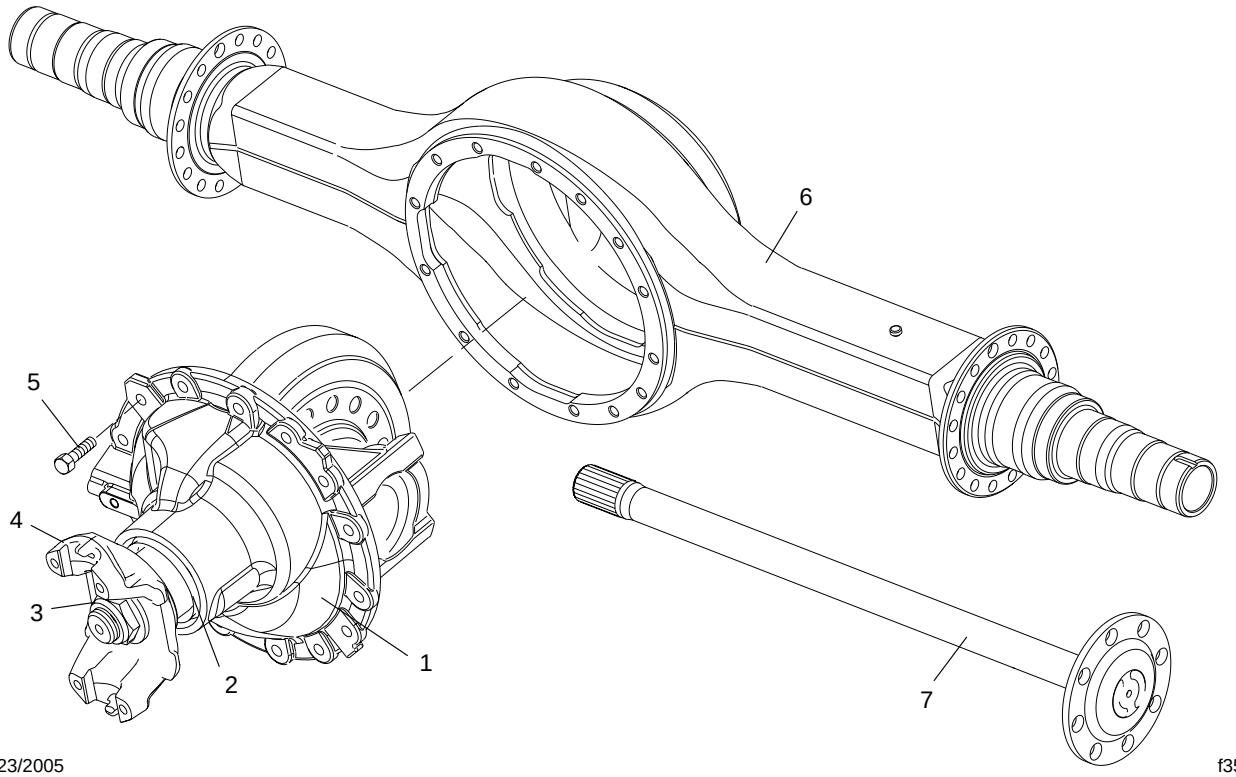
NOTE: Alignment dowels for installing the differential carrier can be made by sawing off the heads of two M12 x 1.5 x 100 mm bolts (for Model 2 axles) or M16 x 1.5 x 100 mm bolts (for Model 4 axles).

4. Install alignment dowels 180 degrees apart at the 3 o'clock and 9 o'clock positions on the axle housing flange.
5. If DCDL is installed on the vehicle, ensure it is engaged.

NOTICE

Make sure the differential carrier is centered and straight on the axle housing before you install the mounting capscrews. Attempting to install the carrier when it is not centered or straight may cause damage to the carrier.

Single Axle or Rearmost Tandem Axle Differential Carrier Removal and Installation



1. Differential Carrier
2. Radial Shaft Seal
3. Yoke Nut
4. Carrier Yoke
5. Carrier Capscrew
6. Rear Axle Housing
7. Axle Shaft

Fig. 1, Rear Axle Components

6. Using a hoist (if the axle is removed from the vehicle) or a suitable transmission jack, install the differential carrier into the axle housing. Use the alignment dowels to center the carrier on the axle housing.
7. Install the end caps at the sides of the carrier into the corresponding slots in the axle housing, as follows. See **Fig. 2**.

   7.1 For the last 3/4 inch (19 mm) or so of travel, walk the carrier slowly into the housing.

   IMPORTANT: The end caps fit tightly into the axle housing. Be very careful not to cock the carrier.

   7.2 Install the carrier capscrews finger-tight. Make sure the carrier capscrews turn easily in the axle housing.

   7.3 In a star pattern, gradually tighten the carrier capscrews to the values given.

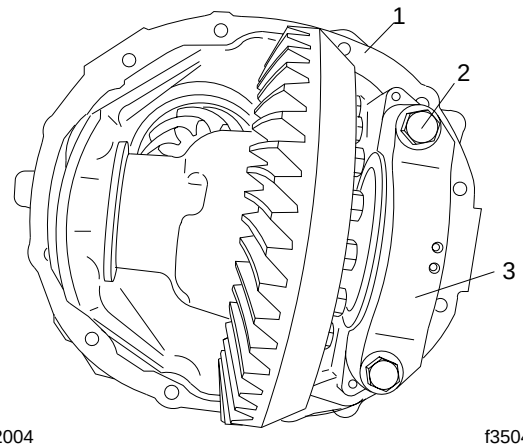
   - M12 capscrews: 115 lbf·ft (156 N·m)
   - M16 capscrews: 200 lbf·ft (270 N·m)

8. If removed, install the axle on the vehicle. For instructions, see **Subject 100**.

   If the axle is already on the vehicle, go to the next step.

9. Connect the driveshaft to the carrier yoke. For instructions, see **Section 41.00, Subject 100**.
10. Using new gaskets, install the axle shafts. For instructions, see **Subject 120**.
11. Install the wheels and tires. For instructions, see **Group 40**.
12. Using 80W/90 gear oil, fill the axle housing to the bottom of the fill hole, or until a small amount of

Single Axle or Rearmost Tandem Axle Differential Carrier Removal and Installation



1. Differential Carrier
2. End Cap Bolt
3. End Cap

Fig. 2, Carrier End Caps

oil trickles out of the fill hole. See **Table 1** for the oil capacities of axle models.

Approved Single Rear Axle Oil Type and Capacity				
Model	Oil Type		Capacity: quarts (liters)	
	Mineral	Synthetic	Hubs Full	Hubs Dry
2	80W-90	75W-90	5.8 (5.5)	7.4 (7.0)
4			10.6 (10.0)	12.2 (11.5)

Table 1, Approved Single Rear Axle Oil Type and Capacity

13. Raise one side of the vehicle about 8 inches (20 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

NOTICE

Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage.

14. Raise the vehicle, remove the safety stands, then lower the vehicle.
15. Start the engine, build the air pressure, and check that the suspension air bags inflate evenly and correctly. Make sure the ride height is correct.
16. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.
17. Remove the chocks from the tires.

Removal

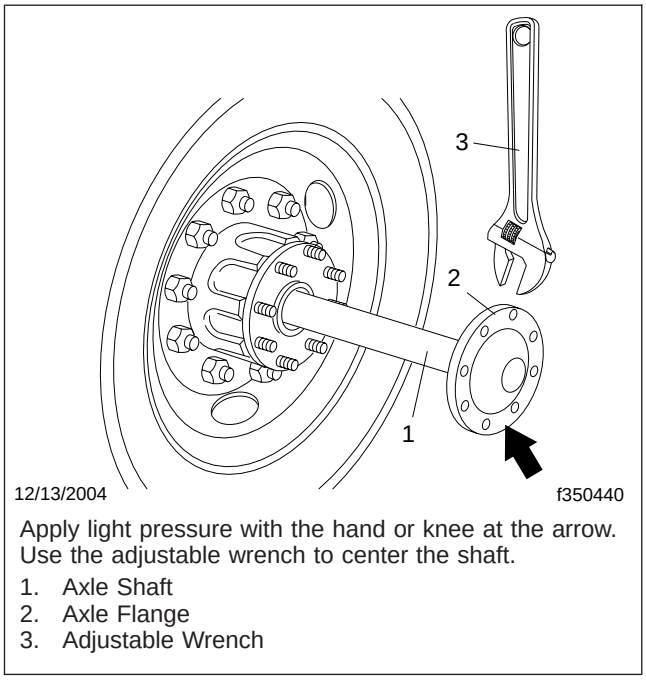
1. Chock the front tires.
2. Raise the rear of the vehicle with a suitable jack high enough to clear the axle. Support the axle with jack stands.
3. If DCDL is installed on the vehicle, use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged. Turn the appropriate wheels to ensure the lock is fully engaged.
4. Place a basin under the axle shaft flanges to catch any oil. Dispose of used oil properly.
5. If necessary, remove the tires. For procedures, see **Group 40**.

NOTE: This procedure can be done with the wheels and tires installed or with the wheels and tires removed.

6. Remove the drive axle stud nuts that attach the axle shaft to the wheel hub.
7. Tap the axle shaft flange if necessary to loosen it, then slide the axle shaft out of the axle. Remove and discard the gasket.

Installation

1. Position a new gasket on the axle shaft flange.
2. If DCDL is installed on the vehicle, ensure it is engaged.
3. Install the axle shaft, as follows. See **Fig. 1**.
   - 3.1 Carefully raise the axle with a floor jack, and support the axle with jack stands. Slide the axle shaft into the axle.
   - 3.2 Apply light pressure with the hand or knee to the axle flange.
   - 3.3 Use an adjustable wrench to center the shaft. Turn the shaft with a slight rotating motion.
   - 3.4 Install the drive axle stud nuts and tighten them to the values given.
     - 1/2–20 nuts: 75 to 115 lbf·ft (102 to 156 N·m)
     - 5/8–18 nuts: 150 to 170 lbf·ft (203 to 230 N·m)



Apply light pressure with the hand or knee at the arrow. Use the adjustable wrench to center the shaft.

1. Axle Shaft
2. Axle Flange
3. Adjustable Wrench

Fig. 1, Installing the Axle Shaft

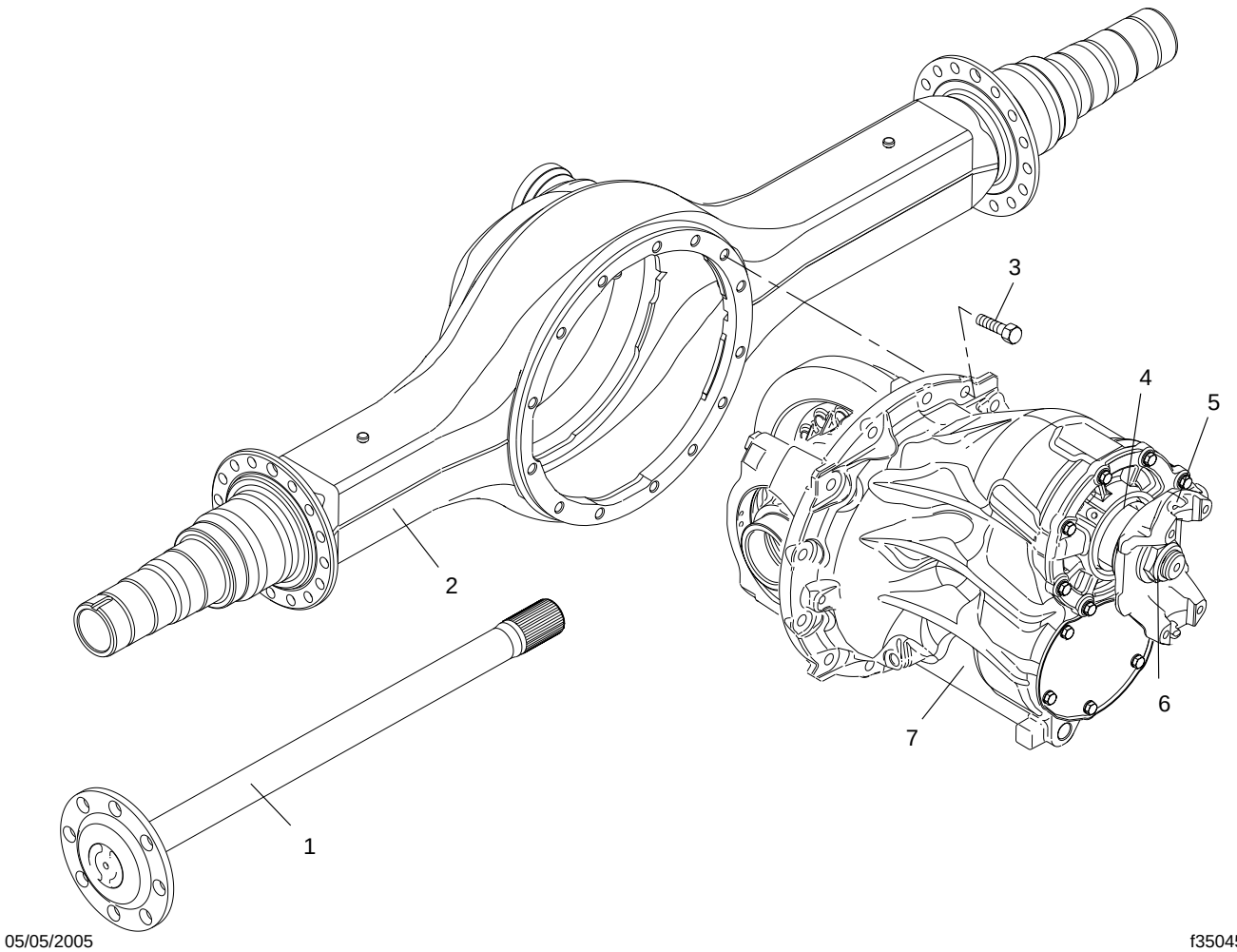
4. If removed, install the tires and tighten the wheel nuts according to the procedures in **Group 40**.
5. Remove the supports and lower the vehicle.
6. As needed, replace any oil that was drained from the hub when the axle shaft was removed.
7. Remove the chocks.

Forward-Rear Tandem Axle Removal and Installation

Removal

For forward-rear axle components of a tandem installation, see **Fig. 1**.

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires. Put the transmission in neutral.
2. Using a suitable jack, raise the vehicle enough to take the weight off the axles, but not enough to raise the tires off the ground.
3. At both ends of the axle, loosen all the wheel nuts.
4. Using a suitable jack, continue to raise the vehicle evenly until there is room to fit a stand underneath the axle housing.



1. Axle Shaft
2. Forward-Rear Axle Housing
3. Carrier Capscrew
4. Input Seal
5. Carrier Yoke
6. Input Yoke Nut
7. Forward Differential Carrier

Fig. 1, Forward-Rear Axle Components

Forward-Rear Tandem Axle Removal and Installation

⚠ WARNING

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

5. Support the vehicle with safety stands.
6. Remove the oil drain plug from the bottom of the axle housing and drain the oil. Install the drain plug after emptying.
7. Remove the wheels and tires. For instructions, see **Group 40**.
8. Release the parking brakes.
9. If necessary, back off the slack adjusters, then remove the brake drums.
10. If installed, make sure the optional DCDL (main differential lock) has been shifted into the engaged (locked) position.
11. Disconnect the air lines at the interaxle lock and (if installed) the wheel lock. Drain the air system.
12. Disconnect the main driveshaft from the forward differential carrier. For instructions, see **Section 41.00, Subject 100**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
13. Disconnect the interaxle driveshaft from the output yoke of the forward tandem axle and the input yoke of the rear tandem axle. For instructions, see **Section 41.00, Subject 100**.
14. Cage the parking brake springs to prevent the parking brakes from engaging. For instructions, see **Group 42**.
15. Place a basin under the axle shaft flanges to catch any oil; then remove the axle shafts. For instructions, see **Subject 120**.
16. Remove the hubs from the axle spindles. For instructions, see **Section 35.01, Subject 100**.
17. Remove the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
18. Remove the brake spiders from the axle flanges, as follows.
    - 18.1 At the frame rail or crossmember, disconnect the wiring for the ABS sensors. Remove any tie straps that hold the wires to the frame rails.
    - 18.2 Remove the ABS sensors and wiring.
    - 18.3 Remove the fasteners that hold the brake spiders to the axle flanges. Remove the spiders from the axle.
19. If applicable, disconnect the leveling valve rod(s) from the suspension.
20. Disconnect the air lines from the rear brake chambers.
21. Remove the brake air chambers and the slack adjusters from the axle housing. For instructions, see **Group 42**.
22. Using a suitable jack, support the axle housing.
23. If applicable, remove the hexnuts that hold the bottom of each suspension air bag to its suspension bracket.
24. Remove the suspension components that attach the axle to the vehicle. If applicable, remove the U-bolt nuts from the U-bolts. Discard the U-bolt nuts and U-bolts.
25. Lower the axle enough to clear the suspension components.
26. Remove the axle from the vehicle.
27. If you are going to replace the differential carrier, place the axle on a secure axle stand.

Installation

1. Position the axle underneath the vehicle.
2. Install the suspension components that attach the axle to the vehicle, as follows.

   NOTE: U-bolts and U-bolt nuts cannot be reused.

   - 2.1 On vehicles with conventional suspensions, install the upper U-bolt brackets, new U-bolts, lower U-bolt brackets, and new U-bolt nuts.

     On vehicles with air suspensions, in addition to the U-bolts, install the hexnuts that attach the air springs to the suspension brackets. For torque values, see **Group 32**.

Forward-Rear Tandem Axle Removal and Installation

On vehicles without U-bolts, install the walking beams.

2.2 If applicable, tighten the new U-bolt nuts in a diagonal pattern. For torque values, see **Group 32**.

3. Connect the interaxle driveshaft to the output yoke of the forward carrier and the input yoke of the rear carrier. For instructions, see **Section 41.00, Subject 100**.
4. Install the brake spiders on the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
5. Install the ABS sensors and connect the wiring at the frame rail. Secure the wiring with tie straps as needed.
6. Install the brake air chambers and slack adjusters on the axle housing brackets.
7. Connect the air lines to the brake air chambers. For instructions, see **Group 42**.
8. Install the brake shoes, as removed. For instructions, see the applicable service brake section in **Group 42**.
9. If installed, disengage the wheel lock (main differential lock).
10. Install the hubs on the axle spindles, and adjust the wheel bearings. For instructions, see the applicable subject in **Section 35.00**.
11. Using new gaskets, install the axle shafts. For instructions, see **Subject 120**.
12. Connect the main driveshaft to the forward input yoke. For instructions, see **Section 41.00, Subject 100**.
13. Connect the air hoses to the air cylinder for the interaxle lock and (if installed) the wheel lock.
14. Connect the electrical connector of the sensor unit for axles equipped with a wheel lock.
15. Fill each hub with approved axle oil until you can see a little amount of oil trickling out of the back of the hub (use about 0.8 quart, or 0.75 liter).
16. Install the brake drums on the hubs.
17. Install the wheels and tires. For instructions, see **Group 40**.
18. Adjust the brakes. For instructions, see the applicable service brake section in **Group 42**.
19. Uncage the parking brake springs.
20. Using approved axle oil, fill the forward-rear axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 1**.

Forward-Rear Axle Oil Type and Capacity		
Approved Oil Type	**Capacity: quarts (liters)**	
	Hubs Full	**Hubs Dry**
80W-90 Gear Oil	14.3 (13.5)	15.9 (15.0)
75W-90 Synthetic Gear Oil		

Table 1, Forward-Rear Axle Oil Type and Capacity

21. Raise one side of the vehicle about 8 inches (20 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

NOTICE

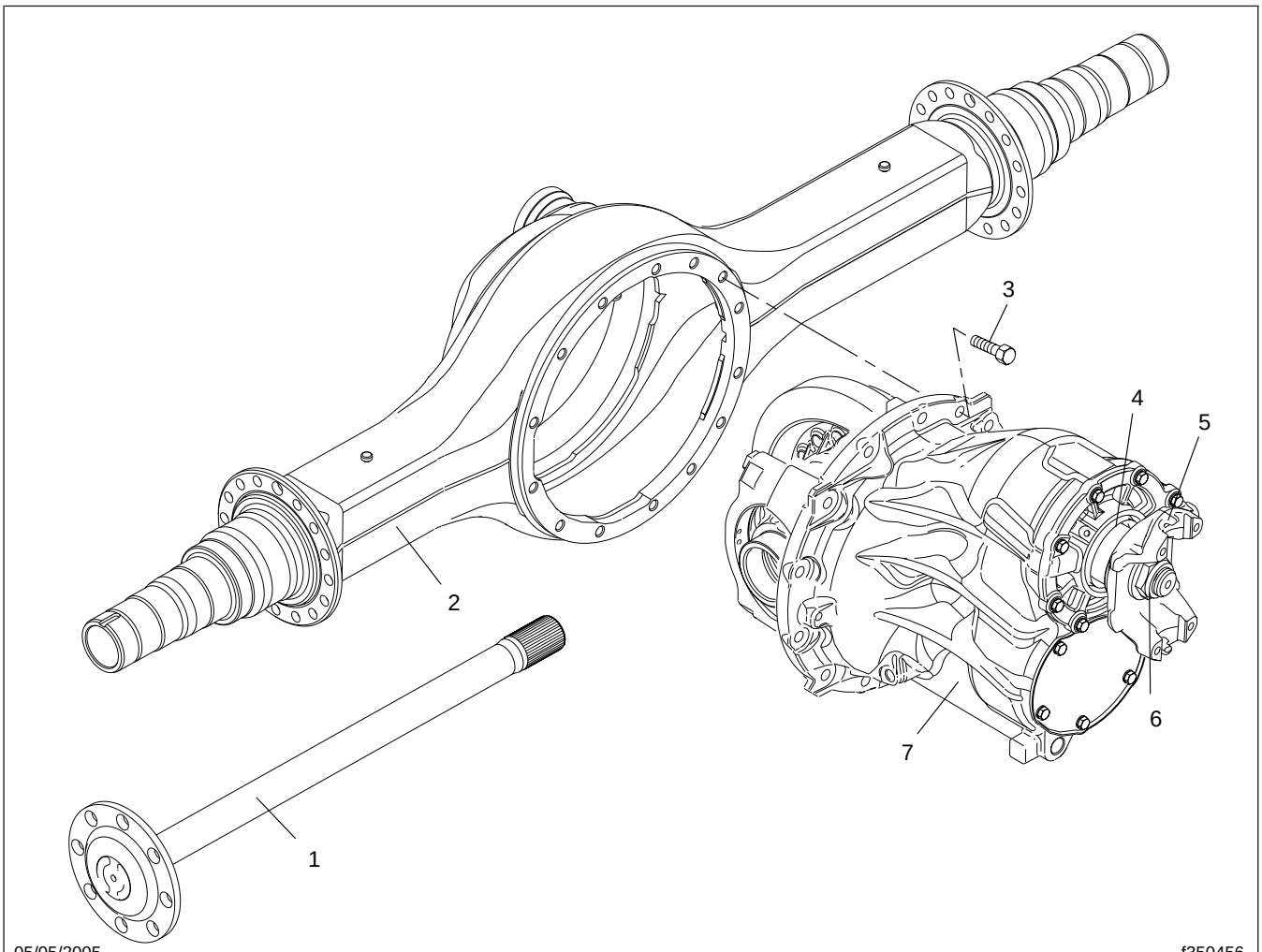
Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage.

22. Turn the wheels, wait one minute, and check the lubricant level.
23. Raise the vehicle, remove the safety stands, then lower the vehicle.
24. If applicable, connect the suspension leveling valve(s). Start the engine, build the air pressure, and make sure the suspension air bags inflate correctly. Make sure the ride height is correct. For instructions, see **Group 32**.
25. Check the operation of the wheel lock, if installed.
26. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.
27. Set the parking brake, then remove the chocks.

Forward-Rear Axle Differential Carrier Removal and installation

For forward-rear axle components of a tandem installation, see **Fig. 1**.

Forward-Rear Axle Differential Carrier



1. Axle Shaft
2. Forward-Rear Axle Housing
3. Carrier Capscrew
4. Input Seal
5. Carrier Yoke
6. Input Yoke Nut
7. Forward Differential Carrier

Fig. 1, Forward-Rear Axle Components

Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires. Put the transmission in neutral.
2. If applicable, release the suspension air pressure.

Forward-Rear Axle Differential Carrier Removal and installation

3. Using suitable jacks, raise the vehicle evenly until there is room to fit a jack underneath the axle housing.
4. Remove the tires and wheels. For instructions, see **Group 40**.
5. Remove the oil drain plug from the bottom of the axle housing and drain the oil. Install the drain plug after emptying.
6. Disconnect the driveshaft from the carrier yoke. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
7. Place a basin under the axle shaft flanges to catch any oil; then remove the axle shafts. For instructions, see **Subject 120**.

⚠ WARNING

The differential carrier is heavy. Do not try to move it without a suitable support. To do so could result in the carrier falling, which could cause serious personal injury and component damage. Support the carrier with a suitable jack and chain it to the jack, or use a hoist if the axle has been removed from the vehicle.

8. Using a suitable jack, support the differential carrier. Chain the differential carrier to the jack.

NOTICE

When using a pry bar, be careful not to damage the carrier or housing flange. Damage to these surfaces will cause oil leaks.

9. Remove the differential carrier from the axle housing, as follows.
   - 9.1 If equipped with a wheel lock, engage the lock with air. This will help separate the carrier assembly from the axle housing.
   - 9.2 Remove all but the top two forward carrier capscrews.
   - 9.3 Loosen and back off, but do not remove, the top two carrier capscrews. The capscrews will hold the carrier in the housing.
   - 9.4 Using a pry bar, separate the mating surfaces of the forward differential carrier and axle housing.

     NOTE: Use a pry bar that has a round end to help separate the carrier from the housing.
   - 9.5 When the surfaces are separated, remove the top two capscrews.
   - 9.6 With the carrier on the jack, slide the carrier away from the rear axle housing.
   - 9.7 Lift the carrier assembly onto a suitable stand.

Installation

NOTE: Use a cleaning solvent and clean rags to remove dirt. Blow dry the cleaned areas with air.

1. Remove any old sealant material from the mating surfaces of the axle housing. Clean the inside of the rear axle housing and the forward carrier mating surface.
2. Inspect the axle housing for damage. Repair or replace the axle housing as necessary.
3. Apply a thin bead of Loctite® 5900 sealant all the way around the mating surface of the axle housing, and around each bolt hole.

NOTE: Alignment dowels for installing the differential carrier can be made by sawing off the heads of two M16 x 1.5 x 100 mm bolts.

4. Install alignment dowels 180 degrees apart at the 3 o'clock and 9 o'clock positions on the axle housing flange.

⚠ WARNING

The differential carrier is heavy. Do not try to move it without a suitable support. To do so could result in the carrier falling, which could cause serious personal injury and component damage. Support the carrier with a suitable jack and chain it to the jack, or use a hoist if the axle has been removed from the vehicle.

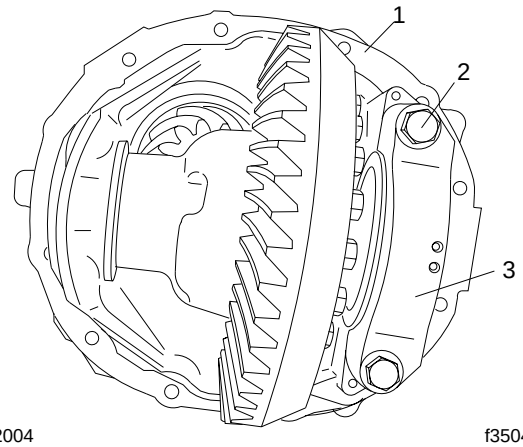
5. Position the forward differential carrier in front of the axle housing, using an axle jack or other suitable lifting tool.
6. If equipped with a wheel lock, engage the lock with air. This will help the carrier assembly join the axle housing.

Forward-Rear Axle Differential Carrier Removal and installation

NOTICE

Do not use a hammer or a mallet to install the differential carrier. A hammer or a mallet will damage the mounting flange of the carrier and cause oil leaks.

7. Install the end caps at the sides of the forward differential carrier into the corresponding slots in the axle housing. See **Fig. 2**.



1. Differential Carrier
2. End Cap Bolt
3. End Cap

Fig. 2, Carrier End Caps

7.1 For the last 3/4 inch (19 mm) or so of travel, walk the carrier slowly into the housing.

IMPORTANT: The end caps fit tightly into the axle housing. Be very careful not to cock the carrier.

7.2 Install the forward carrier capscrews finger-tight. Make sure the carrier capscrews turn easily in the axle housing.

7.3 In a star pattern, gradually tighten the M16 capscrews 200 lbf·ft (270 N·m).

8. Connect the driveshaft to the carrier yoke. For instructions, see **Section 41.00, Subject 120**.
9. Using new gaskets, install the axle shafts. For instructions, see **Subject 120**.
10. Install the wheels and tires. For instructions, see **Group 40**.
11. Using approved axle oil, fill the axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 1**.

Forward-Rear Axle Oil Type and Capacity		
Approved Oil Type	Capacity: quarts (liters)	
	Hubs Full	Hubs Dry
80W-90 Gear Oil	14.3 (13.5)	15.9 (15.0)
75W-90 Synthetic Gear Oil		

Table 1, Forward-Rear Axle Oil Type and Capacity

12. If the hubs are dry, raise one side of the vehicle about 8 inches (20 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

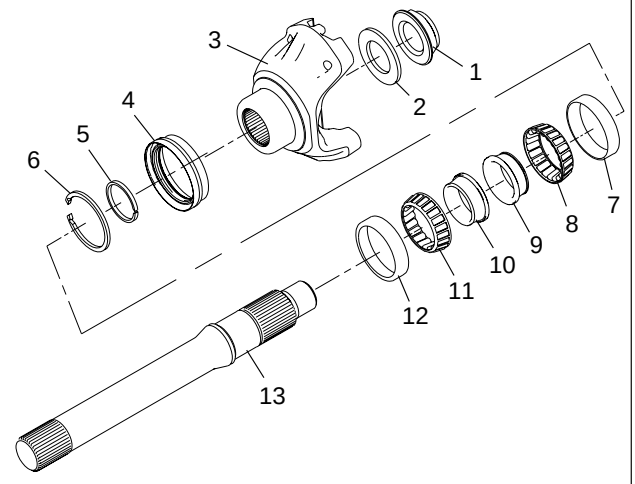
NOTICE

Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage.

13. Turn the wheels, wait one minute, and check the lubricant level.
14. Raise the vehicle, remove the safety stands, then lower the vehicle.
15. Start the engine, build the air pressure, and check that the suspension air bags inflate evenly and correctly. Make sure the ride height is correct.
16. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.
17. Remove the chocks from the front tires.

Repair

1. Remove the output yoke nut, washer, and output yoke. Then remove the output oil seal from the thru-shaft bore. See **Subject 170**.
2. Remove the snap ring and spacer from the thru-shaft. See **Fig. 1**.



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1. Output Yoke Nut
2. Washer
3. Output Yoke
4. Output Oil Seal
5. Spacer
6. Snap Ring
7. Outer Bearing Race
8. Outer Bearing
9. Outer Bearing Cup
10. Inner Bearing Cup
11. Inner Bearing
12. Inner Bearing Race
13. Thru-Shaft

Fig. 1, Thru-Shaft Components

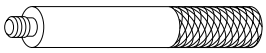
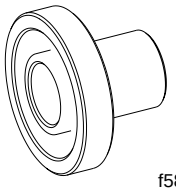
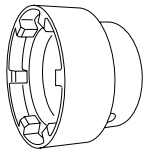
3. Using a suitable shaft puller, draw the thru-shaft out of the bore.
4. Using a suitable bearing puller on the outer races, remove both the inner and outer bearings from the thru-shaft.
5. Inspect the bearings for wear and damage. Replace both bearings if any damage is found.
6. Install the bearings, as follows.
   - 6.1 Install the inner bearing race in the thru-shaft bore.
   - 6.2 Using an arbor press or other suitable pressing tool, press the bearings and bearing cups onto the thru-shaft.
   - 6.3 Insert the thru-shaft into its bore.
   - 6.4 Install the outer bearing race onto the thru-shaft and bore.
7. Install the snap ring and spacer. Use the next thicker snap ring from the snap ring pack supplied with the bearings.
8. Install a new output oil seal. See **Subject 170**.
9. Install the output yoke, and the new nut and washer. See **Subject 170**. Make sure the output yoke nut is firmly tightened, but do not tighten the nut to specifications at this time.
10. Attach a dial indicator to the flat surface of the output yoke.
11. Using a pry bar or other lever, apply force to the base of the output yoke. If the dial indicator shows a deflection of 0.0012 to 0.0024 inch (0.03 to 0.06 mm), the end play is correct.

    If the deflection is too large, use a thicker snap ring. If the deflection is too small, use a thinner snap ring.
12. Remove the yoke nut, and coat its threads with Loctite® 577. Install the nut, and tighten it 516 lbf·ft (700 N·m).

Single Axle or Rearmost Tandem Axle Yoke and Seal Replacement

Special Tools

Special tools are required for this procedure. See **Table 1**.

Special Tools			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580400	Universal Handle*	Kent-Moore	J-8092
 f580406	Rear Pinion Seal Installer*	Kent-Moore	J-47354
 f580450	Yoke Nut Socket†	Daimler	MBA 742589020700

* To order Kent-Moore tools call 1-800-328-6657.

† The yoke nut socket is needed to remove the round, slotted yoke nut installed on some vehicles. It can be ordered through Paragon.

Table 1, Special Tools

Replacement

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.
2. Disconnect the driveshaft from the input yoke. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
3. Remove the yoke nut from the center of the carrier yoke. If the yoke nut is round and slotted, use the yoke nut socket shown in **Table 1**. See **Fig. 1**. Be careful not to damage the seal bore.

NOTE: Older models may not require the special socket for yoke nut removal.

4. Remove the carrier yoke from the input shaft. Be careful not to damage the seal bore.
5. Pry up the seal, using a prybar or large screwdriver. Clean any old sealant from the axle housing. Do not allow dirt or grease to contaminate the seal bore or shaft bearings. See **Fig. 2**.
6. Install a new rear pinion seal on the input shaft, as follows. See **Fig. 3**.
   - 6.1 Inspect the area around the seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.
   - 6.2 Assemble the rear pinion seal installer onto the threaded end of the universal handle. See **Table 1**.

Single Axle or Rearmost Tandem Axle Yoke and Seal Replacement

IMPORTANT: Be careful not to cock the seal during installation.

6.3 Using the rear pinion seal installer assembly, press the seal into the bore until the seal surface is flush with the bottom surface of the counterbore.

7. Install the carrier yoke on the input shaft. If the yoke is damaged or worn, install a new yoke.

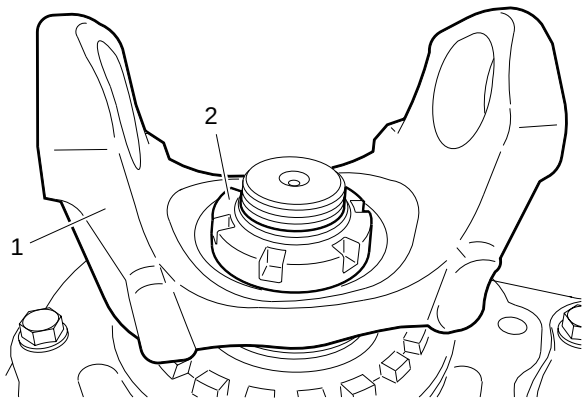
NOTE: It is not necessary to replace the yoke when replacing the seal.

8. Install a new M45 x 1.5 pinion nut on the carrier yoke, and tighten the nut 627 lbf·ft (850 N·m).

9. Punch in the cylindrical area at the pinion groove to lock the nut in place.

IMPORTANT: The bent area has to reach the bottom of the pinion groove.

10. Connect the driveshaft. For instructions, see **Section 41.00, Subject 120**.



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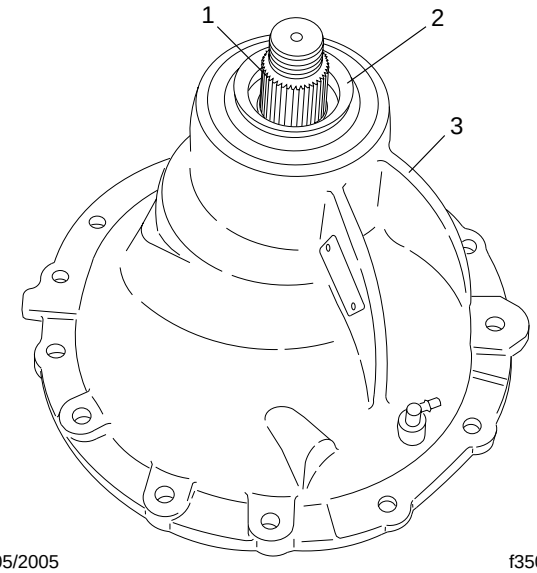
NOTE: The yoke nut may be a hexnut rather than the round, slotted nut shown here.

1. Yoke
2. Yoke Nut

Fig. 1, Yoke Nut on the Carrier



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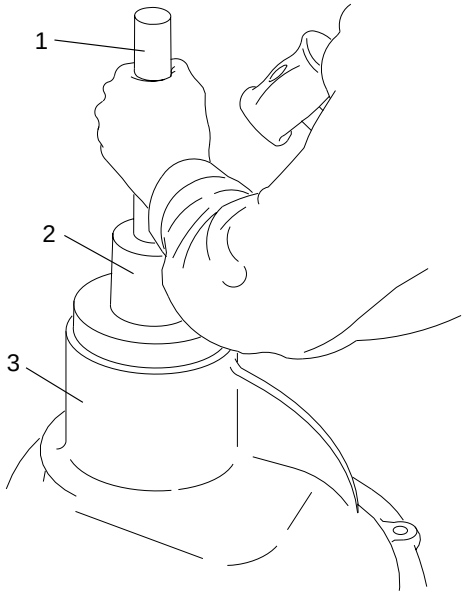
1. Input Shaft
2. Rear Pinion Seal
3. Carrier Housing

Fig. 2, Rear Pinion Seal



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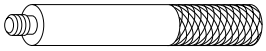
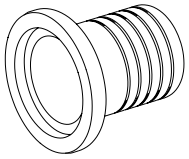
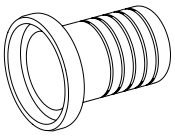
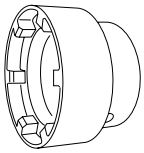
1. Universal Handle
2. Rear Pinion Seal Installer
3. Carrier Housing

Fig. 3, Installing the Rear Pinion Seal

Forward-Rear Tandem Axle Yoke and Seal Replacement

Special Tools

Special tools are required for this procedure. See **Table 1**.

Special Tools for Forward-Rear Axle Yoke and Seal Replacement			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580400	Universal Handle*	Kent-Moore	J-8092
 f580410	Input Seal Installer*	Kent-Moore	J-47369
 f580408	Output Seal Installer*	Kent-Moore	J-47368
 f580450	Yoke Nut Socket†	Daimler	MBA 742589020700

* To order Kent-Moore tools call 1-800-328-6657.

† The yoke nut socket is needed to remove the round, slotted yoke nut installed on some vehicles. It can be ordered through Paragon.

Table 1, Special Tools for Forward-Rear Axle Yoke and Seal Replacement

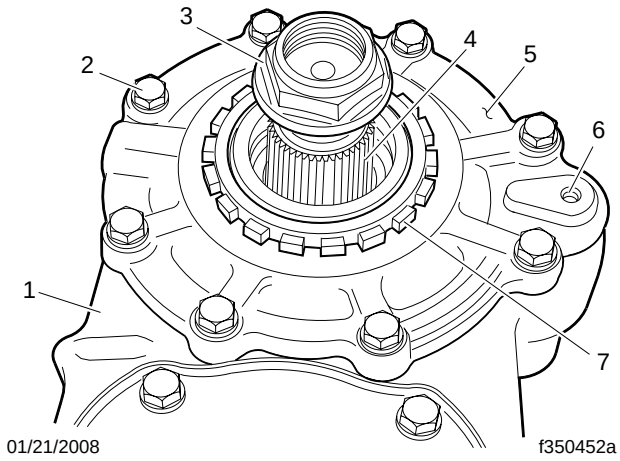
Replacement

Forward Carrier Input Yoke and Seal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.
2. Disconnect the main driveshaft from the forward carrier input yoke. For instructions, see **Section 41.00, Subject 100**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
3. Remove the input yoke nut and washer.
4. Remove the forward carrier input yoke from the forward input shaft.

Forward-Rear Tandem Axle Yoke and Seal Replacement

5. If there is an oil leak at the threaded ring, repair it; for instructions, see **Subject 200**.
6. If there is a leak between the bearing cage and the carrier housing, remove the bearing cage from the forward differential carrier, as follows. See **Fig. 1**.



1. Forward Carrier Housing
2. Bearing Cage Mounting Capscrew
3. Input Yoke Nut
4. Input Shaft
5. Bearing Cage
6. Interaxle Lock Bore
7. Threaded Ring

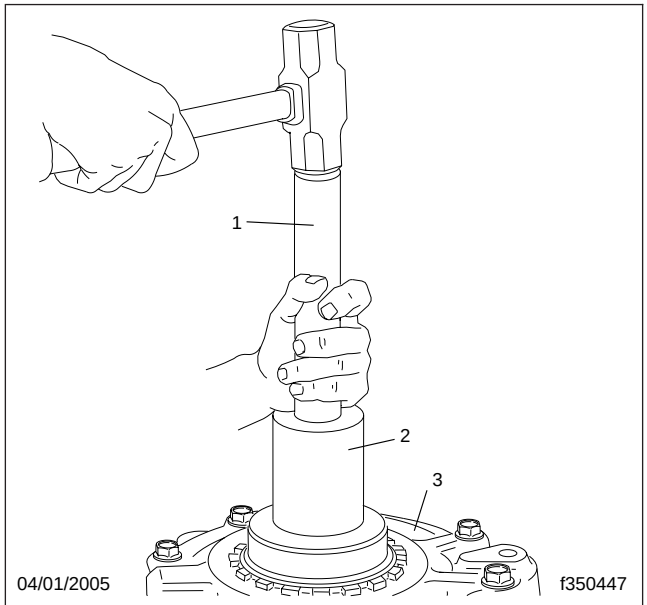
Fig. 1, Bearing Cage

6.1 Remove the bearing cage capscrews.

6.2 Pry the bearing cage from the forward carrier housing. Clean any remnants of sealant clinging to the mating surfaces of the carrier housing and the bearing cage.

7. Pry up the input seal, using a prybar or large screwdriver. Clean any old sealant from the axle housing. Do not allow dirt or grease to contaminate the seal bore or shaft bearings.
8. Install a new seal in the input shaft bore, as follows. See **Fig. 2**.

8.1 Inspect the area around the seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.



1. Universal Handle
2. Input Seal Installer
3. Carrier Housing

Fig. 2, Installing the Forward Carrier Input Seal

8.2 Assemble the input shaft seal installer onto the threaded end of the universal handle. See **Table 1**.

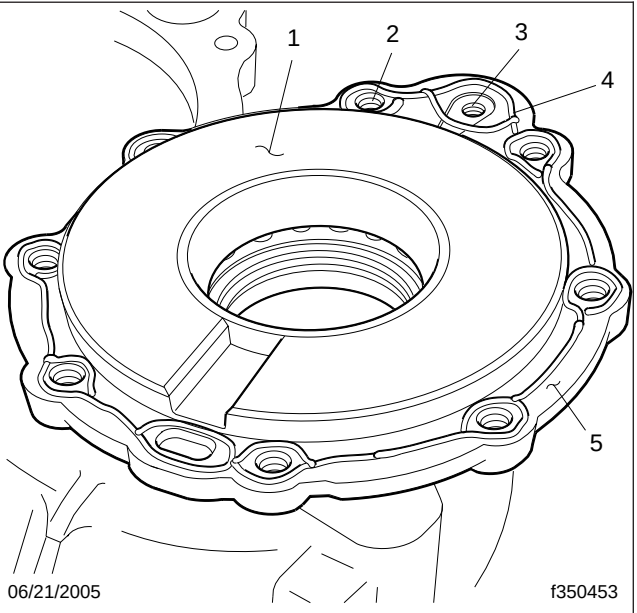
8.3 Using the input shaft seal installer assembly, press the seal into the bore until the seal surface is flush with the threaded ring.

9. On the mating surface of the bearing cage, lay down a bead of Loctite® 5900 sealant, or equivalent. Go around all of the bolt holes and other openings in the inside cover of the bearing cage. See **Fig. 3**.

IMPORTANT: Do not allow sealant to get into the interaxle lock bore. See **Fig. 4**. Do not attempt to repair the interaxle lock (IAD). No repairs to this component are possible.

10. Install the bearing cage onto the forward carrier housing. Tighten the M12 bearing cage capscrews 107 lbf·ft (145 N·m).
11. Install the forward carrier input yoke on the forward input shaft. If the yoke is damaged or worn, install a new yoke.

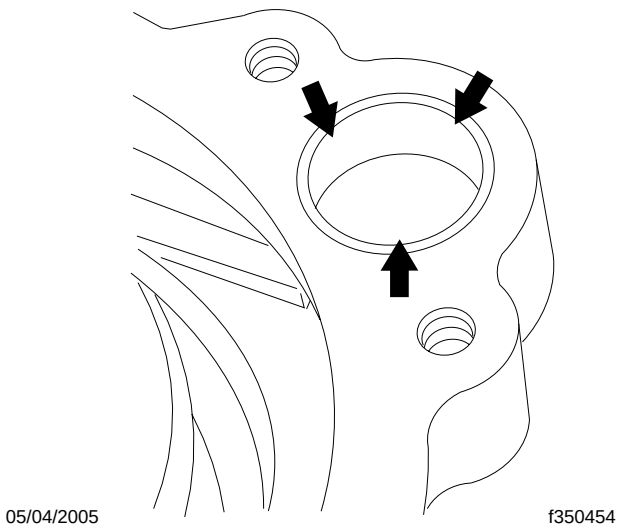
NOTE: It is not necessary to replace the yoke when replacing the seal.



Apply a bead of sealant to the inner mating surface as shown.

1. Inside Cover
2. Mounting Capscrew Hole
3. Interaxle Lock Bore
4. Sealant
5. Mating Surface

Fig. 3, Sealant Application



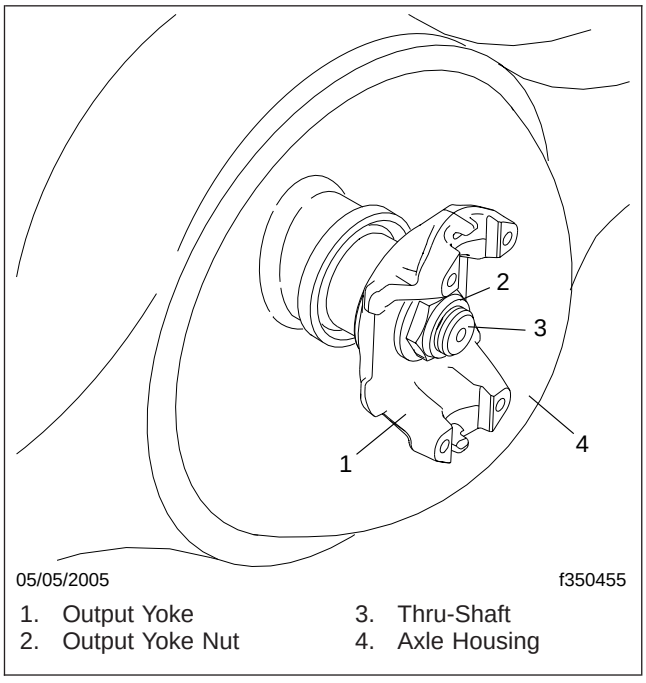
Keep sealant away from this bore.

Fig. 4, Interaxle Lock Bore

12. Coat the threads of a new M45 x 1.5 input yoke nut with Loctite® 277. Install the new washer and input yoke nut on the forward carrier input yoke. Tighten the nut 627 lbf·ft (850 N·m).
13. Connect the main driveshaft. For instructions, see **Section 41.00, Subject 100**.

Output Yoke and Seal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.
2. Disconnect the interaxle driveshaft from the output yoke. For instructions, see **Section 41.00, Subject 100**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
3. Remove the output yoke nut and washer from the center of the output yoke.
4. Remove the output yoke from the thru-shaft. See **Fig. 5**.



1. Output Yoke
2. Output Yoke Nut
3. Thru-Shaft
4. Axle Housing

Fig. 5, Output Yoke

5. Pry up the output oil seal, using a prybar or large screwdriver. Clean any old sealant from the axle housing. Do not allow dirt or grease to contaminate the seal bore or thru-shaft bearings.
6. Install a new seal on the thru-shaft, as follows.

Forward-Rear Tandem Axle Yoke and Seal Replacement

6.1 Inspect the area around the output oil seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.

6.2 Assemble the output seal installer onto the threaded end of the universal handle. See **Table 1**.

6.3 Using the output seal installer assembly, press the seal into the bore until the seal surface is flush with the thru-shaft receptacle.

7. Install the output yoke on the thru-shaft. If the yoke is damaged or worn, install a new yoke.

NOTE: It is not necessary to replace the yoke when replacing the seal.

8. Coat the threads of a new M39 x 1.5 output yoke nut with Loctite® 577. Install the new washer and output yoke nut on the yoke. Tighten the nut 516 lbf·ft (700 N·m).
9. Connect the interaxle driveshaft. For instructions, see **Section 41.00, Subject 100**.

Main Differential Lock Disassembly and Assembly

Special Tool

A special tool is required for this procedure. See **Table 1**.

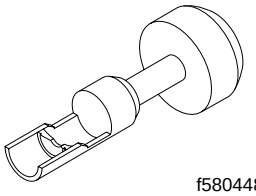
Special Tool for Main Differential Lock Disassembly and Assembly			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580448	Spring Compression Tool	Axle Alliance Special Tool	W742 589 00 16 00

Table 1, Special Tool for Main Differential Lock Disassembly and Assembly

General Information

Commonly known as DCDL (Driver-Controlled Differential Lock), a main differential lock is available on single and tandem rear axles. On tandem rear axles DCDL is available for the forward, rear, or both axles. The following procedures only apply to Model 4 rear axles with optional DCDL.

Each part of the main differential lock is replaceable. See **Fig. 1**.

Disassembly

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires.
2. Remove the differential carrier, and place it on a work stand.

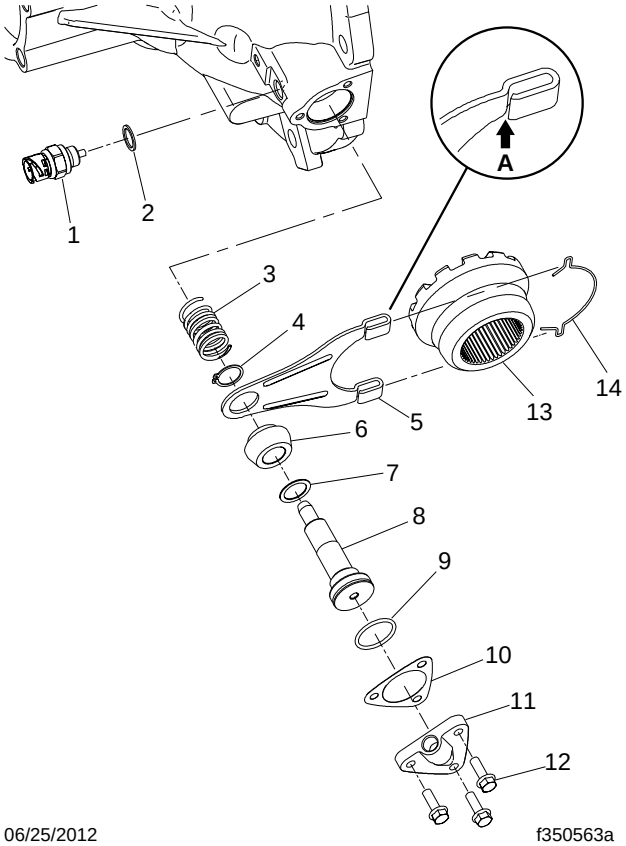
   To remove a single or rearmost axle differential carrier, see **Subject 110**.

   To remove a forward-rear differential carrier, see **Subject 140**.
3. Unlatch the retaining clip, and remove it. See **Fig. 1**.
4. Remove the clutch collar.
5. Remove the DCDL sending unit from the carrier housing.
6. Remove the three bolts that attach the air interface to the carrier housing.
7. Remove the air interface and gasket.
8. Remove the shift shaft piston from the bore in the carrier housing, and note the number of shims found on the piston. There should be at least one shim, and a maximum of three.
9. Using the spring compression tool (see **Table 1**), compress the spring and pull the shift fork from the carrier housing.
10. Remove the spring from the carrier housing.

Assembly

1. Install the spring in the carrier housing, and, using the spring compression tool, compress it to install the shift fork in the housing. Ensure that the spring is centered in the bore.
2. Ensure the O-ring on the shift shaft piston is properly installed and lubricated. Then install the piston, being careful to properly align it in the bore. Do not force the piston into the bore.
3. Place the air interface and gasket over the air interface bore, and insert the three capscrews that attach the air interface to the carrier housing. Tighten the capscrews in a regular sequence that ensures it seats evenly. Tighten the capscrews 19 lbf·ft (25 N·m).
4. Install the clutch collar.

Main Differential Lock Disassembly and Assembly



A. Opening in fork loop faces away from the clutch collar as shown.

1. Sending Unit
2. Sending Unit Seal
3. Spring
4. Snap Ring
5. Shift Fork
6. Alignment Boss
7. Shim(s)
8. Shift Shaft Piston
9. O-Ring
10. Air Interface Gasket
11. Air Interface
12. Capscrew
13. Clutch Collar
14. Retaining Clip

Fig. 1, DCDL Components

5. Install the retaining clip on the shift fork.
6. Install the DCDL sending unit in the carrier housing, as removed.
7. Connect the DCDL air line, and engage the DCDL. Ensure the teeth of the lock fully engage the teeth of the gear inside the carrier housing.
8. The clearance between the clutch collar and ring gear must be between 0.4 and 1.4 mm. Engage the DCDL, and use a feeler gauge to measure the gap.

   If the gap between the clutch collar and ring gear measured between 0.4 and 1.4 mm, ensure the same number of shims are on the shift shaft piston (as when it was removed).

   If the gap between the clutch collar and ring gear was not between 0.4 and 1.4 mm, add or remove shims to vary the gap until it measures within the acceptable range. The acceptable maximum number of shims is three, and the minimum is one.
9. Install the differential carrier.

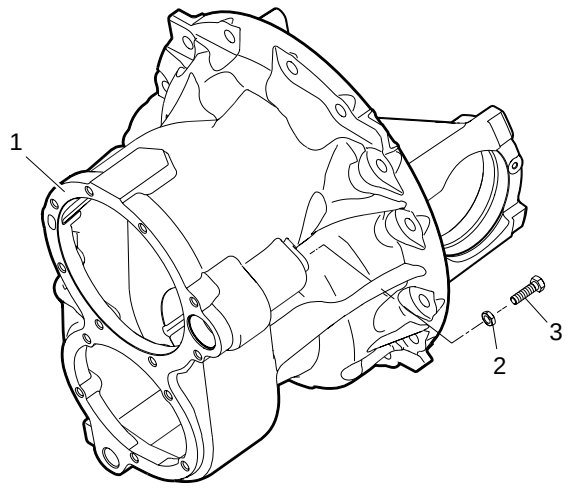
   For instructions on installing a single or rearmost axle differential carrier, see **Subject 110**.

   For instructions on installing a forward-rear axle differential carrier, see **Subject 140**.
10. Remove the chocks.

Adjustment

The Interaxle Differential (IAD) has an adjustment screw that can become loose or even fall out, causing an oil leak, and malfunction of the IAD. To ensure the adjustment screw is properly tightened and secured, follow the steps below. The IAD is sometimes called the power divider. See **Fig. 1**.

1. Chock the front tires.
2. Use the IAD switch in the cab to engage the lock.
3. At the forward-rear axle, rotate one of the wheels to ensure the teeth of the lock fully engage the teeth of the gear inside the carrier housing.
4. Remove the adjustment screw, and using a suitable solvent (such as brake cleaner), clean the threads of the screw and bore. Dry the surfaces completely, making sure no cleaning solvent remains.
5. Coat the threads of the adjustment screw with Loctite® 577, install it, and hand-tighten it until it hits the shaft.
6. Disengage the IAD to relieve the air pressure exerted on the adjustment screw.
7. Hand-tighten the adjustment screw one quarter turn, then tighten the locknut 30 lbf·ft (41 N·m).
8. Remove the chocks.

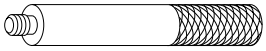
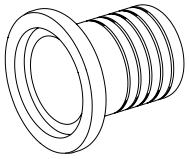


1. Carrier Housing
2. Locknut
3. Adjustment Screw

Fig. 1, Interaxle Differential and Adjustment Screw

Special Tools

Special tools are required for this procedure. See **Table 1**.

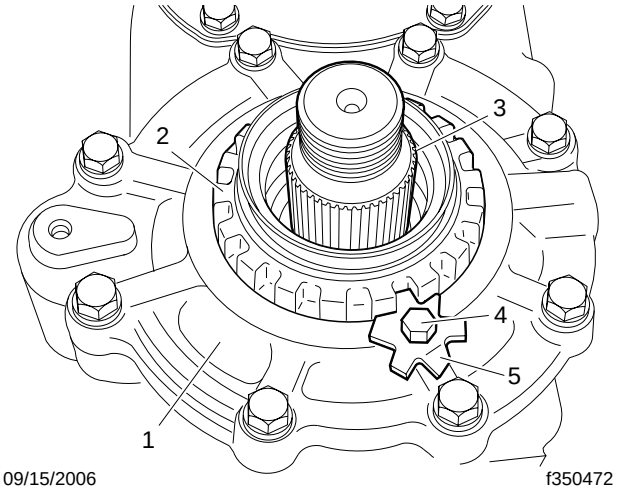
Special Tools for Threaded Ring Repair			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580400	Universal Handle*	Kent-Moore	J-8092
 f580410	Input Seal Installer*	Kent-Moore	J-47369

* To order Kent-Moore tools call 1-800-328-6657.

Table 1, Special Tools for Threaded Ring Repair

Repair

1. Apply the parking brakes, shut down the engine, and chock the tires.
2. Disconnect the main driveshaft from the forward carrier input yoke. For instructions, see **Section 41.00, Subject 100**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
3. Remove the yoke nut and washer from the input shaft of the forward differential carrier, then remove the yoke.
4. Remove the capscrew and the locking plate from the bearing cage on the front of the differential carrier. See **Fig. 1**.
5. Using a spanner wrench, remove the threaded ring to expose the bearing cavity. See **Fig. 2**.
6. Using a suitable solvent, such as brake cleaner, clean the surface of the bearing cavity. See **Fig. 2**. Dry the surface, making sure no cleaning solvent remains.
7. Coat the threads of the threaded ring with Loctite® 577 sealant. Apply a 1/8-inch (3-mm) diameter bead all the way around the bottom thread, then spread the sealant evenly over the threads, so that all threads are thoroughly covered with the sealant.

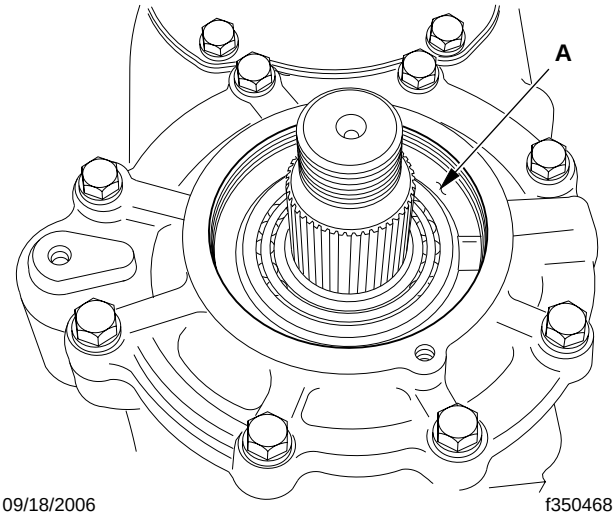


09/15/2006 f350472

1. Bearing Cage
2. Threaded Ring
3. Input Shaft (yoke removed)
4. Capscrew
5. Locking Plate

Fig. 1, Forward-Rear Axle Differential Housing

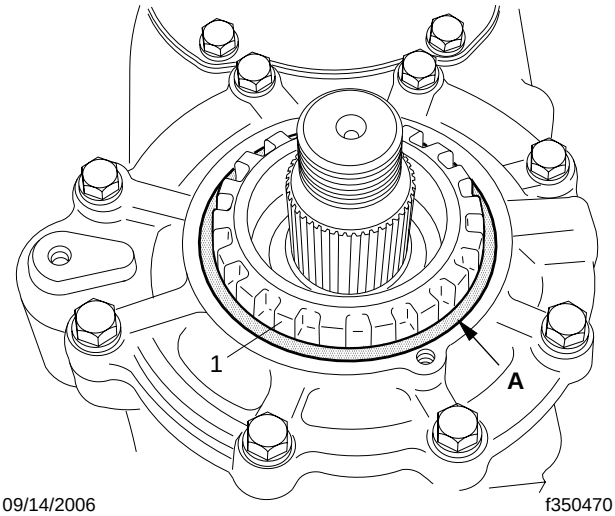
Threaded Ring Repair



A. Clean and dry this entire surface.

Fig. 2, Bearing Cavity Exposed

8. Install the threaded ring (without the new input-shaft seal) and turn it clockwise (tighten it) enough to form a uniform bead of sealant all the way around the threaded ring. See **Fig. 3**.

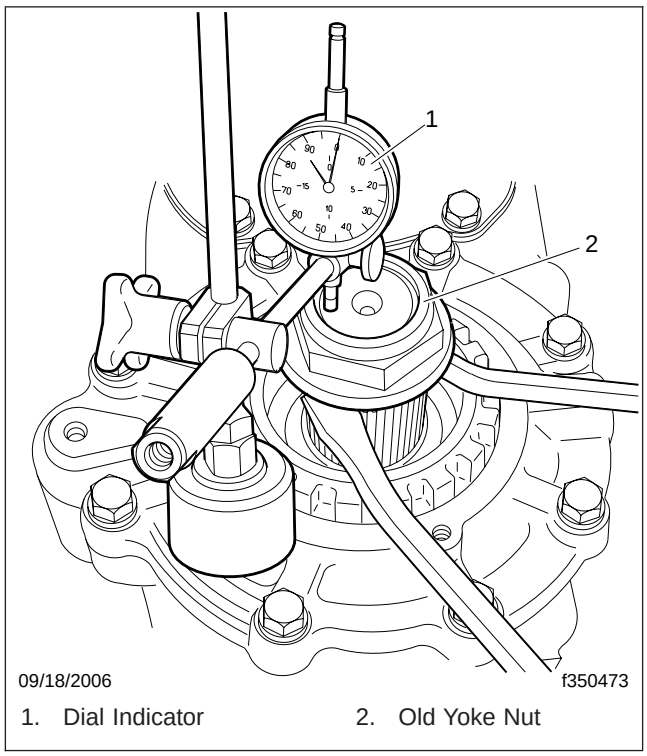


A. Loctite Bead from the Threads

1. Threaded Ring

Fig. 3, Preliminary Installation of the New Threaded Ring

9. Install the old yoke nut on the input shaft to protect the threads, then strike the nut sharply with a brass mallet to unseat the bearing.
10. Adjust the initial bearing preload to 0.002 inch (0.05 mm), as follows:
    10.1 Install a dial indicator on the bearing cage, and using two pry bars, pry up evenly on the yoke nut (and the input shaft) to determine the bearing preload. See **Fig. 4**.



1. Dial Indicator
2. Old Yoke Nut

Fig. 4, Measuring Bearing Preload

    10.2 Tighten the threaded ring until the dial indicator reads 0.002 inch (0.05 mm).
11. Using a suitable marker or paint, mark the center of one of the teeth on the threaded ring and the surface of the bearing cage. See **Fig. 5**.

IMPORTANT: The next step is critical. Tightening the threaded ring by advancing it one tooth will set the bearing preload to 0.00 to 0.0012 inch (0.00 to 0.03 mm). If you tighten the threaded ring beyond this tolerance, you cannot back it off; you will need to remove the threaded ring and repeat the entire installation procedure.

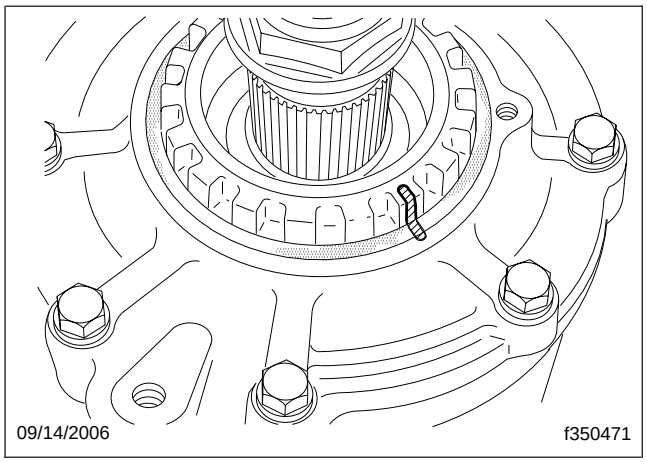


Fig. 5, Marking the Tooth and Bearing Cage

12. Very carefully advance the threaded ring one tooth while checking the paint mark. Stay close to a one-tooth advancement when making the final adjustment. Bear in mind that the new locking plate must fit into place once the correct tightness is achieved. The locking tab should fit in place either slightly before or slightly past a one-tooth advancement of the threaded ring. *You cannot back off the threaded ring once it is tightened.*

    Try fitting the new locking plate in place by turning and flipping it over as you slowly tighten the threaded ring. Tighten the threaded ring so the bearing preload is 0.00 to 0.0012 inch (0.00 to 0.03 mm). When the correct tolerance is reached, the mark on the surface of the bearing cage should line up with the center of the next tooth. See **Fig. 6**. Do not tighten the threaded ring any further.

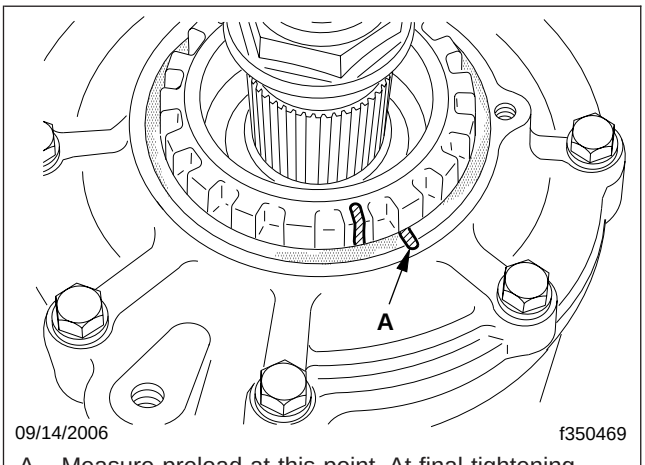
13. When the bearing preload is correct, install the new locking plate and capscrew. Tighten the capscrew 18 lbf·ft (24 N·m).

14. Install the new input-shaft seal as follows (see **Fig. 7**):

    14.1 Inspect the area around the seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.

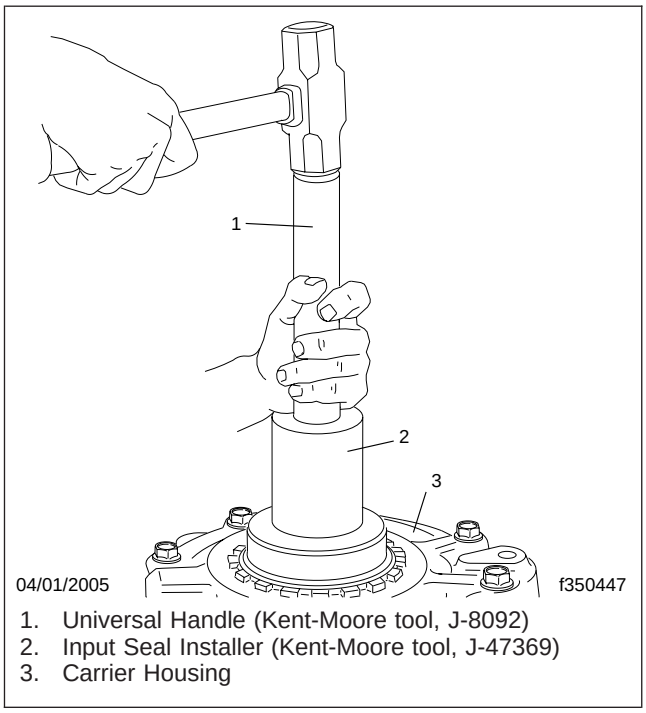
    14.2 Apply a light coating of axle oil to the seal bore.

    14.3 Coat the mating surfaces of the new seal with Loctite® 5900 sealant, or equivalent.



A. Measure preload at this point. At final tightening, this mark should be opposite the center of the next tooth, but no further.

Fig. 6, Advancing the Threaded Ring



1. Universal Handle (Kent-Moore tool, J-8092)
2. Input Seal Installer (Kent-Moore tool, J-47369)
3. Carrier Housing

Fig. 7, Installing the Forward Carrier Input Seal

14.4 Assemble the input shaft seal installer onto the threaded end of the universal handle. See **Fig. 7**.

Threaded Ring Repair

14.5 Using the input shaft seal installer assembly, press the seal into the bore until the seal surface is flush with the threaded ring.

15. Apply Loctite 242 to the threads of the new yoke nut, then using it and a new washer, install the existing yoke on the input shaft. Tighten the yoke nut 628 lbf·ft (850 N·m).
16. Connect the main driveshaft to the input shaft. For instructions, see **Section 41.00, Subject 100**.
17. Remove the chocks.

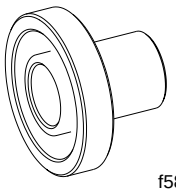
Specifications

Torque Values		
Application	**Size**	**Torque: lbf·ft (N·m)**
Carrier Capscrews (Model 2 Axles)	M12	115 (156)
Carrier Capscrews (Model 4 Axles)	M16	200 (270)
Drive Axle Stud Nuts	1/2–20	75–115 (102–156)
	5/8–18	150–170 (203–230)
Pinion Nut (model 2 axles)	M40 x 1.5	370 (502)
Pinion Nut (model 4 axles)	M45 x 1.5	627 (850)
Forward Tandem Axles		
Bearing Cage Capscrews	M12	107 (145)
Input Yoke Nut	M45 x 1.5	627 (850)
Output Yoke Nut	M39 x 1.5	516 (700)

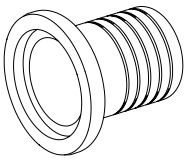
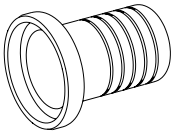
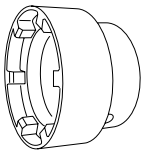
Table 1, Torque Values

Approved Rear Axle Lubricant Type and Capacity				
Lubricant Type	**Axle**		**Oil Capacity: quarts (liters)**	
			Hubs Full	**Hubs Dry**
80W/90 Gear Oil, or 75W/90 Synthetic Gear Oil	Single	Model 2	5.8 (5.5)	7.4 (7.0)
	Forward Tandem	Model 4	14.3 (13.5)	15.9 (15.0)
	Single & Rear Tandem	Model 4	10.6 (10.0)	12.2 (11.5)

Table 2, Approved Rear Axle Lubricant Type and Capacity

Special Tools for Detroit Rear Axles			
Tool	**Description**	**Manufacturer**	**Part Number**
f580400	Universal Handle*	Kent-Moore	J-8092
 f580406	Rear Pinion Seal Installer*	Kent-Moore	J-47354

Specifications

Special Tools for Detroit Rear Axles			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580410	Input Seal Installer*	Kent-Moore	J-47369
 f580408	Output Seal Installer*	Kent-Moore	J-47368
 f580450	Yoke Nut Socket†	Daimler	MBA 742589020700

* To order Kent-Moore tools call 1-800-328-6657.

† The yoke nut socket is needed to remove the round, slotted yoke nut installed on some vehicles. It can be ordered through Paragon.

Table 3, Special Tools for Detroit Rear Axles

General Information

Radial ply tubeless tires are standard on all L-Line and A-Line vehicles. Tubeless tires are mounted on 15-degree drop-center wheels.

NOTE: Do not mix 10-hole two-piece flange nut hub mount disc wheels with 10-hole ball seat lug nut stud mount disc wheels.

Heavy-duty 10-hole two-piece flange nut disc wheels have an 11.25-inch (285.75-mm) bolt circle with M22 x 1.5 wheel mounting studs.

CAST SPOKE WHEELS

Cast spoke wheels consist of a cast spider and a brake drum and a separate demountable one-piece rim. See **Fig. 1** and **Fig. 2**. Clamps and hold-down nuts on the 3/4-inch studs secure the rim to the wheel. On dual rear wheels, a ring-shaped spacer holds the inner and outer rims apart.

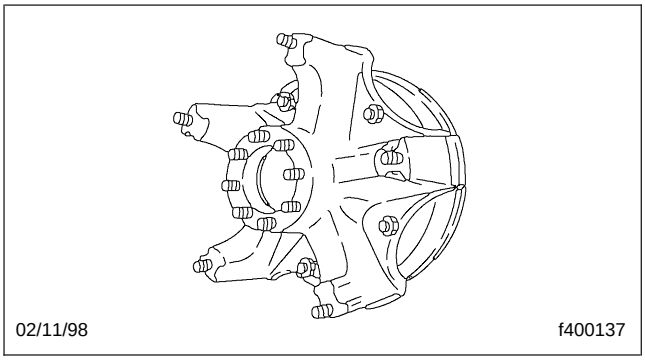


Fig. 1, Cast Spoke Wheel Cast Spider and Brake Drum

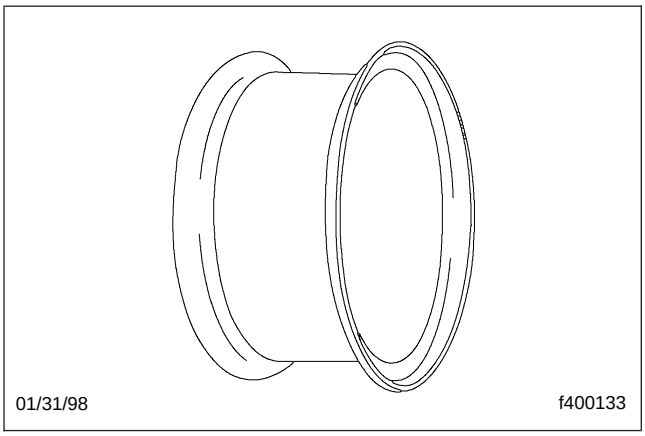


Fig. 2, Cast Spoke Wheel Demountable One-Piece Rim

Rear cast spoke wheels have five spokes on the 17,500- and 19,000-pound 2-speed axles, and six spokes on the 17,500- and 19,000-pound single-speed, and 21,000-, 23,000-, 34,000-, 40,000- and 46,000-pound rear axles.

The cast spoke wheel uses a one-piece steel, demountable rim. The demountable rim is mounted onto the cast wheel by clamps and stud nuts. See **Fig. 3**.

DISC WHEELS

The disc wheel is a one-piece wheel assembly and mounts onto the wheel hub using 22-mm wheel studs and two-piece wheel nuts. See **Fig. 4** and **Fig. 5**.

On dual rear wheel applications, the inner wheel mounts in the reverse direction of the outer wheel. See **Fig. 5** and **Fig. 6**.

WHEEL ORNAMENT SYSTEM

(See Fig. 7 and Fig. 8)

The wheel ornament system is designed for use on 22.5-inch and 24.5-inch hub-piloted wheels with a 10-hole 11.25-inch (285.75-mm) bolt circle. This system requires a minimum of four threads on the stud to extend through the top of the two-piece wheel nut.

The ornament system uses 10 screw-on Hug-a-Lug® nut covers to attach the center hub cover to the wheel. The lug nut covers screw on over the lug nuts.

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 tractors) or "Statement of Compliance" label (Canadian-purchased tractors) attached to the driver's side rear door post. See **Fig. 9**.

General Information

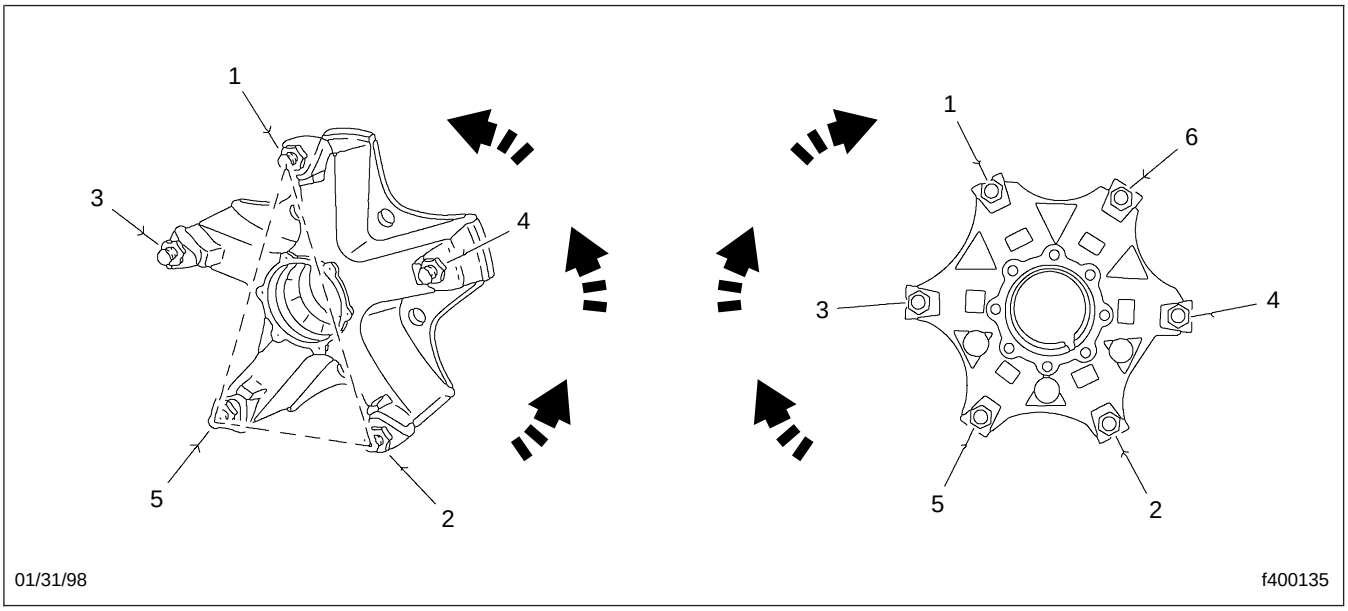


Fig. 3, Demountable Rim Tightening Sequence

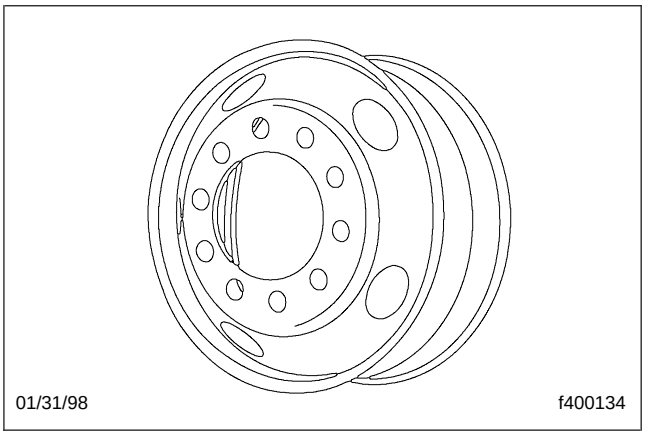


Fig. 4, Front Axle Disc Wheel

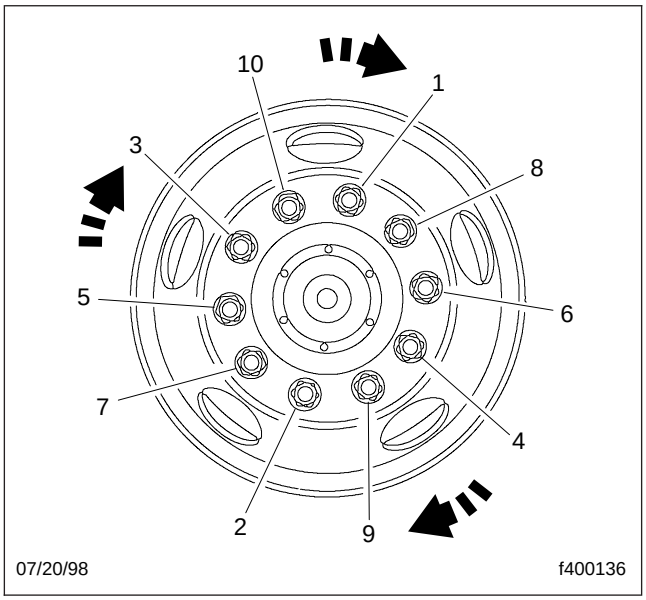


Fig. 5, Disc Wheel Tightening Sequence

Tire and rim labels (**Fig. 9** and **Fig. 10**) 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).

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). The total tire circumference of one driving rear

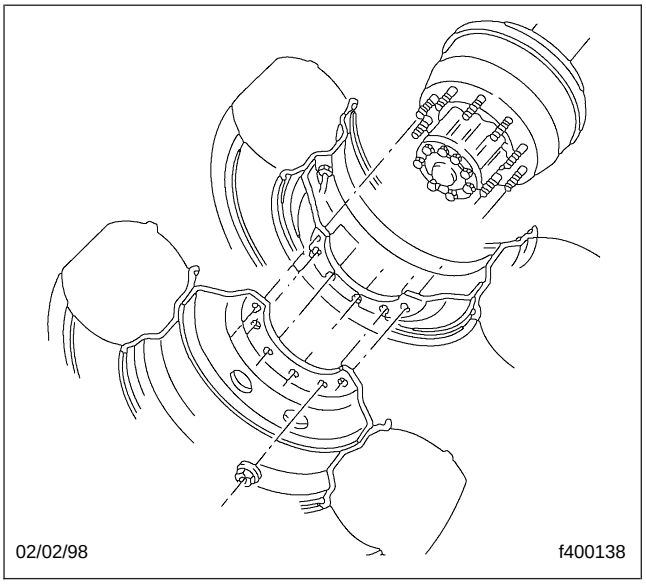


Fig. 6, Rear Axle Disc Wheel

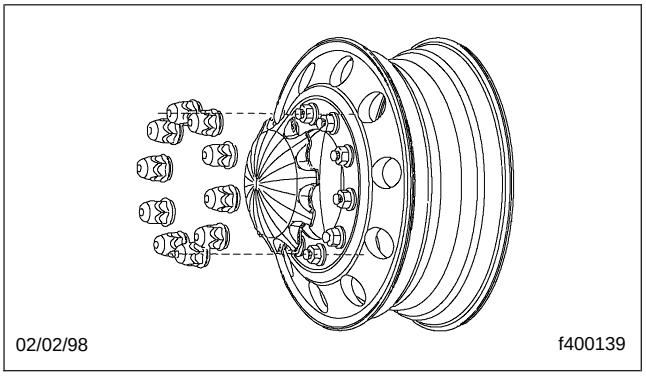


Fig. 7, Front Wheel Ornament System

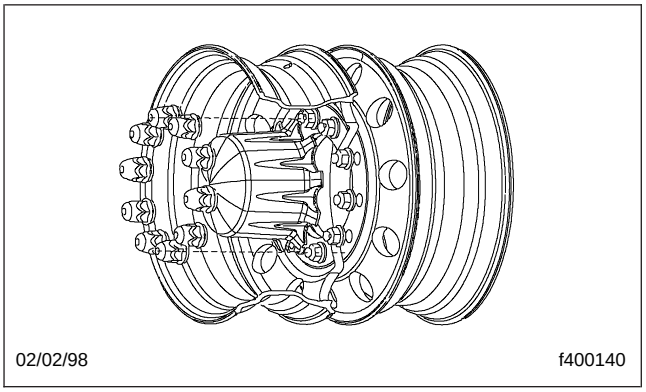
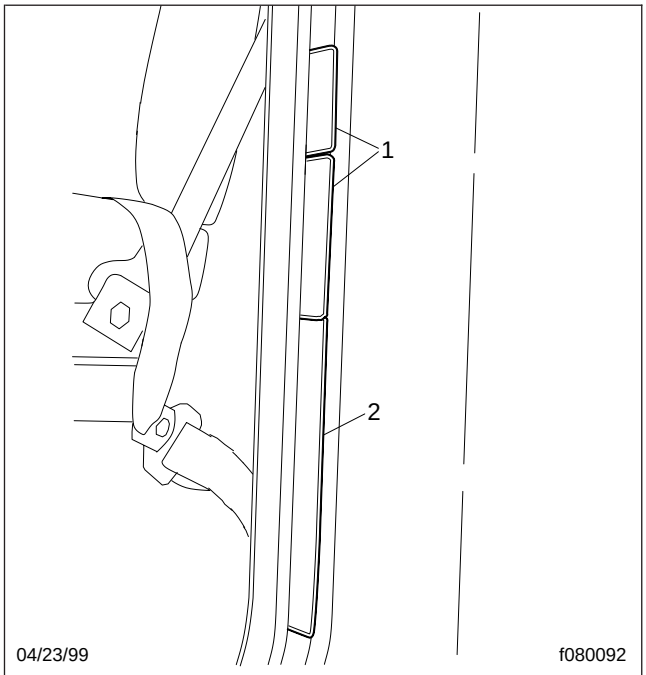
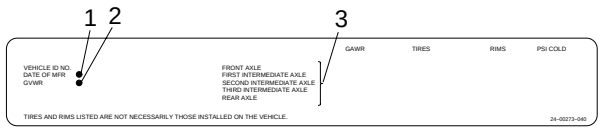


Fig. 8, Rear Wheel Ornament System



1. Tire and Rim Labels
2. Certification Label

Fig. 9, Labels Location



NOTE: Example only. Actual specifications may vary from vehicle to vehicle.

1. Date of manufacture by month and year.
2. Gross vehicle weight rating; developed by taking the sum of all the vehicle's gross axle ratings.
3. Gross axle weight ratings; developed by considering each component in an axle system, including suspension, axle, wheels, and tires. The lowest component capacity is the value for the system.

Fig. 10, Tire and Rim Label

axle must match, as nearly as possible, the total tire circumference of the other driving rear axle.

⚠ CAUTION

Mismatching dual tires overloads the larger diameter tire, causing it to overdeflect and overheat.

General Information

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 (see **Fig. 11**) or square (see **Fig. 12**), measure the diameter of the tires 24 hours after inflation. A matching stick (see **Fig. 13**), string gauge (see **Fig. 14**), or tire straight edge (see **Fig. 15**) can also be used to determine the difference in tire radius, which is then doubled to calculate the diameter difference.

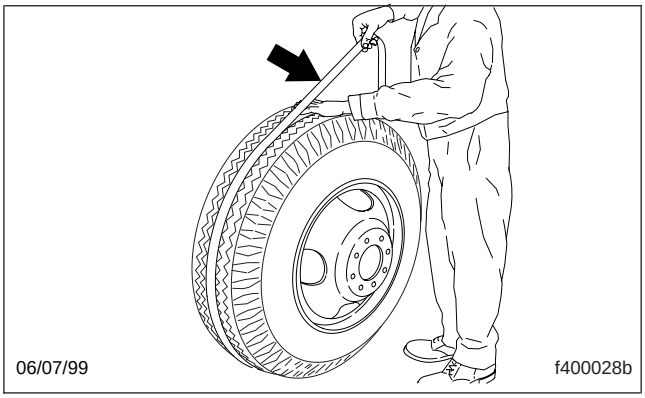


Fig. 11, Endless Pi Tape

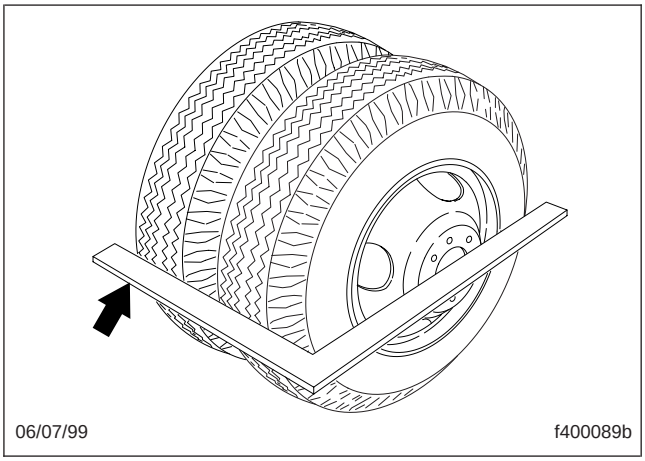


Fig. 12, Square

When pairing tires of unequal diameters (but within the above limits), mount the larger tire on the outside.

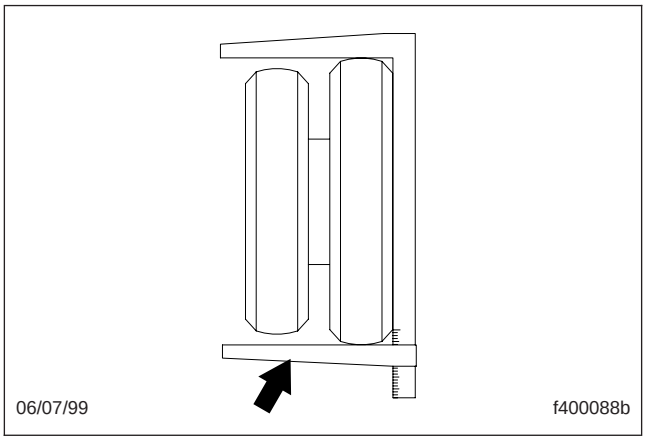


Fig. 13, Matching Stick

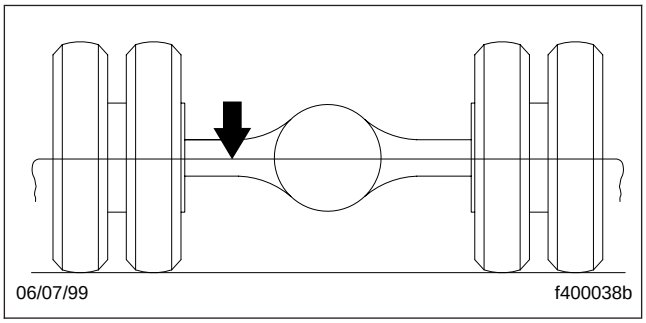


Fig. 14, String Gauge

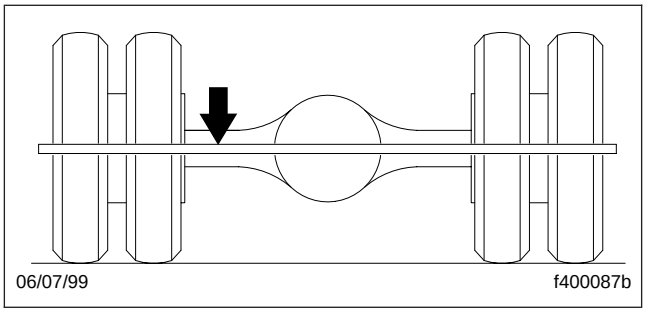


Fig. 15, Tire Straight Edge

⚠ WARNING

Both tires of a dual assembly must be used when driving a vehicle. Driving with only 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 tire and wheel. This may also result in loss of vehicle

control, which could cause personal injury and property damage.

Inflate all tires on an axle, or on both axles of a tandem unit, to within 5 psi (35 kPa) of one another. For tire inflation specifications, refer to **Specifications, 400**.

There must be sufficient space between dual tires for air to flow and cool the tires, and to prevent them from rubbing against one another. Rims and wheels of the same size, but of different makes and types, can have different offsets, which would affect dual 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.
- Use either all radial or all bias ply tires on the non-driving rear axles of a vehicle. However, all radial or all bias ply tires must be used on vehicles with tandem drive-axles.

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 **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. Also, refer to the front axle section in this manual for information on the possible differences in toe-in setting between radial and bias ply tires.

Tire Demounting and Mounting Service Precautions

Service Precautions

⚠ WARNING

Failure to follow the safety 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 personal injury and equipment damage.

IMPORTANT: Do not mount or demount tires without proper training as required in "Servicing Multi-Piece and Single Piece Rim Wheels", *Occupational Safety and Health Administration (OSHA) Rules and Regulations 1910.177*. 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 in **Subject 110** and **Subject 120**. 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 aid).
- 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.
- Do not reinflate a tire that has been run flat or has been run at 80 per cent 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.

Inspection

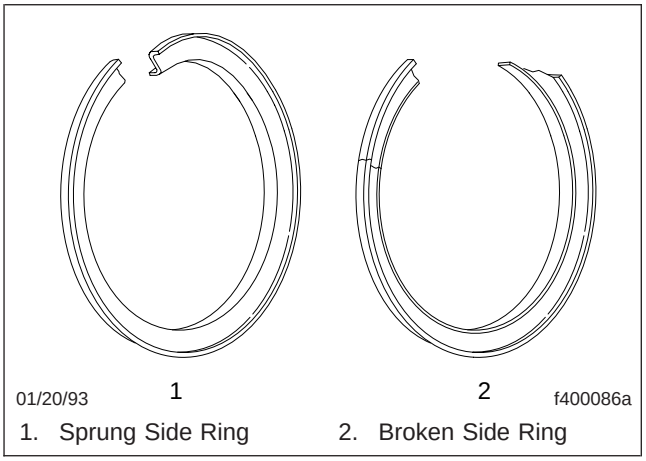
⚠ WARNING

Inspect the tires and wheels, and correct any problems. Failure to do so 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: Do not paint Alcoa aluminum disc wheels. If the wheels are corroded, contact the manufacturer for instructions.

Sprung or broken rings (**Fig. 1**), a cracked rim, wheel (**Fig. 2**), or brake drum, damaged inner or outer wheel nuts (**Fig. 3**), or an out-of-round wheel or rim, requires the replacement of the damaged part. Replace the wheel if it has out-of-round stud holes.



1. Sprung Side Ring
2. Broken Side Ring

Fig. 1, Sprung and Broke Side Rings

NOTE: Refer to the front and rear axle sections in this manual for inspection and service procedures for the hub, wheel studs, wheel, and brake drum 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.

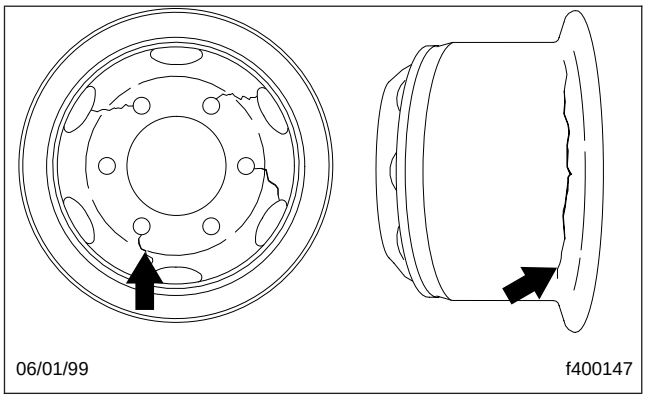


Fig. 2, Cracked Wheel and Rim

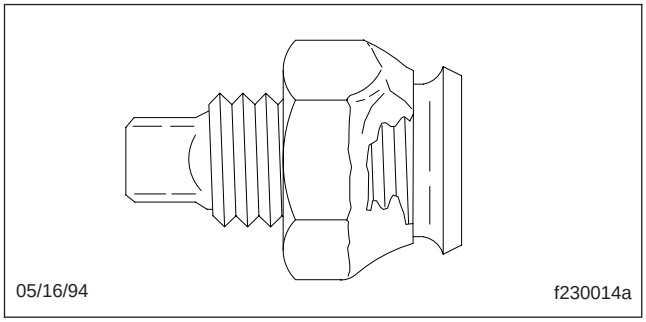


Fig. 3, Damaged Outer Wheel Nut

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. 4**). 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 thick (1.5-mm). See **Fig. 5**. 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.

Wheel and Components Inspection

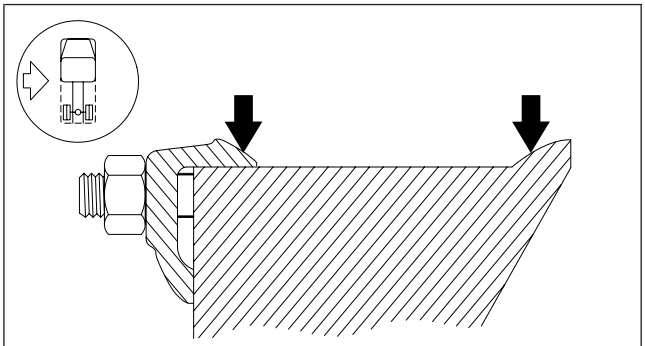
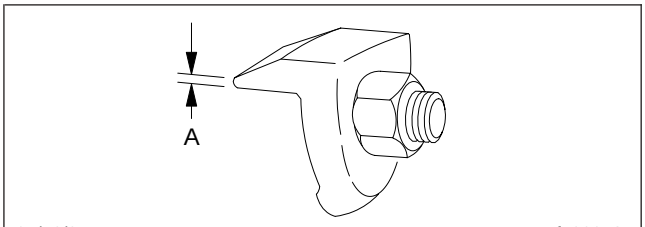


Fig. 4, 28 Degree Tapered Rim Mounting Surface



A. End of wedge must be at least 1/16-inch (1.5-mm) thick.

Fig. 5, Rim Clamp

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.

Inspection

WARNING

Inspect the tires and wheels, and correct any problems. Failure to do so 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(s) or trailer axles. 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.

Clean and inspect the tube and flap of tube-type tires. Discard tubes or flaps that are buckled or creased. Do not use an old tube in a new tire, and always mount a used flap in the same size tire and on the same size rim as the one from which it was removed. Michelin Tire Corporation recommends using only new tubes, flaps, valve cores, caps, and O-rings in a new mounting.

Tire Inflation

1. Check all parts to make sure they are correctly seated prior to inflation.

NOTE: Inflate tires in a safety cage (see **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.

⚠ 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.

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.

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.

2. 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.

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, such as:

- 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.

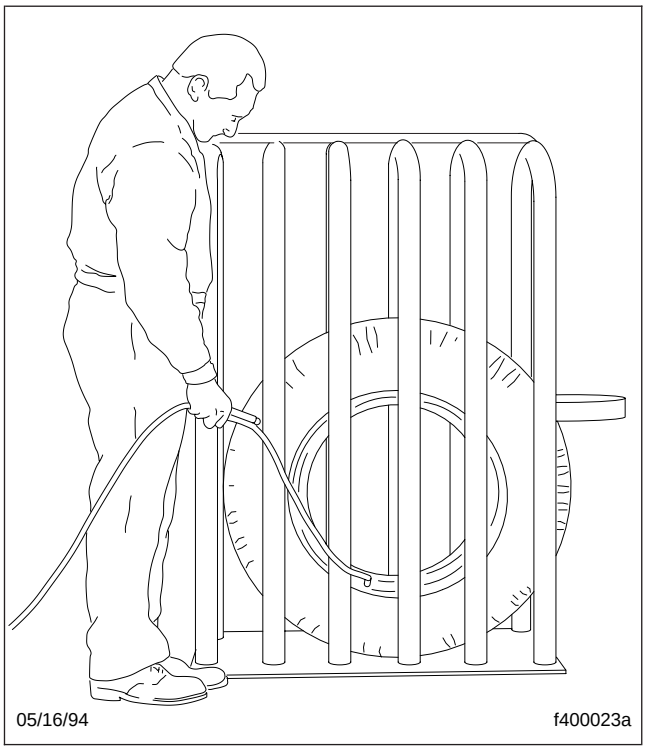


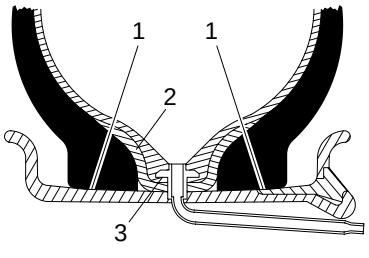
Fig. 1, Safety Cage

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 **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.

NOTE: The position of the beads, flap, and tube with 4 to 5 psi (28 to 35 kPa) pressure is shown in **Fig. 2**. The tube is fully rounded-out within the tire, but there is not enough pressure to move the beads on wide-base rims. Depending on the tire size and rim condition, from 20 to 40 psi (140 to 275 kPa) pressure is needed to push the beads onto the bead seat. See **Fig. 3**.

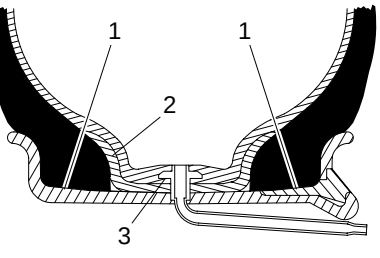
4. After the initial inflation, completely deflate the tire by removing the valve core. This ensures correct bead seating, and prevents buckling or overstretching the tube in tube-type tires. Then inflate the tire to the recommended cold inflation pressure listed in **Specifications, 400**. Install valve caps and finger-tighten them.

Tire Inflation



1. Tapered Bead Seat
2. Flap
3. Valve Base

Fig. 2, Position of Beads, Flap, and Tube at 4 to 5 psi (28 to 35 kPa)



1. Tapered Bead Seat
2. Flap
3. Valve Base

Fig. 3, Beads Pressured Onto the Bead Seat

⚠ CAUTION

Improperly inflating tube-type tires can crack or tear the edge or inside of the valve base. Once seated, the tube can stretch only in the rim area. Because resistance to stretch is greatest at the valve base, there is often enough tension to break the tube at the edge of the valve base or in the valve base.

IMPORTANT: Use tires of the same size, type, and capacity to carry the load at the recommended cold pressure. Attempting to increase the load capacity of a tire by overinflation will damage the tire assembly.

NOTE: Inflate the tires to the recommended pressure. Driving on overinflated tires will weaken the cords by reducing their ability to absorb road shocks, and will increase the danger of cuts, snags, and punctures. Overinflation will overstress and damage the rims. Driving on underinflated tires will generate excessive heat. This weakens the tire body, and reduces tire strength.

⚠ WARNING

Inflate tires to the specified pressure. Tire underinflation or overinflation will damage wheels and tires, and could result in a blowout, causing possible personal injury and property damage.

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.

10-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock all tires that will not be serviced to prevent vehicle movement.
2. If working on the front axle wheels, raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.

   If working on the rear axle wheels, raise the rear of the vehicle 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 hub-pilot pads. Keep the wheel square to the hub during removal.

IMPORTANT: On both sides of the vehicle, the two-piece flange nuts have right-hand metric threads.

7. Remove the wheel. Do not let it drop on or drag across the stud threads.

Installation

IMPORTANT: Before installing the wheels, it is recommended that an anti-seize compound be applied on the 360 degree wheel pilot hubs of Meritor FF-981 "Easy Steer Plus" front axles. After time in service, a small amount of rust or corrosion may make the wheel difficult to remove because of the extended wheel-to-hub contact. Applying an anti-seize compound on the wheel pilot of the hub will ensure easy wheel removal at a later date. Compounds such as the following may be used:

- Armite Led-Plate No. 250
- Loctite® Anti-Seize No. 767
- Never-Seez
- Permabond Anti-Seize No. 82-9839

Compounds are available for purchase locally.

IMPORTANT: "Turbo" wheel assemblies require directional mounting, as shown in **Fig. 1**.

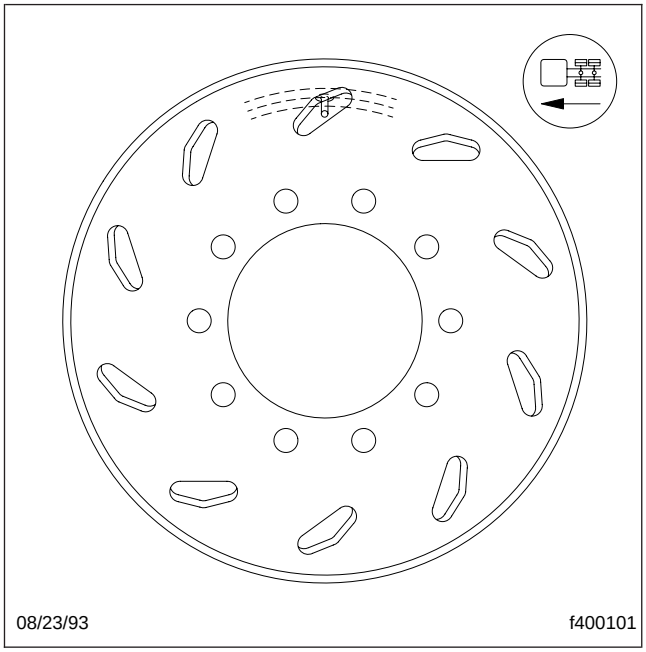


Fig. 1, Side View

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 110**. Also, follow the tire matching and mixing requirements in **Subject 050**.

1. Clean the hub and wheel mounting surfaces, and all disc faces of dual wheels. Make sure the tire is correctly inflated. For instructions, see **Subject 130.**
2. Apply a few drops of light engine oil to the wheel studs and the area between the body and the flange of each two-piece flange nut. Wipe off any excess oil.

10-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

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 hub-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. If installing a rear wheel assembly, go to the next step. Install the front wheel assembly.
   - 3.1 Locate one hub-pilot pad in the top-center position. Using a jack or wheel-and-tire dolly, position the wheel assembly on the hub. Make sure the wheel is square to the hub so that the stud threads or hub-pilot pads are not damaged by contact with the wheel during installation.
   - 3.2 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 wheel is 180 degrees opposite the balance weight(s) on the brake drum.

4. Install the rear wheel assembly.
   - 4.1 Locate one hub-pilot pad in the top-center position. Using a jack or wheel-and-tire dolly, position the inner wheel assembly on the hub. Make sure the wheel is square to the hub so that the stud threads or hub-pilot pads are not damaged by contact with the wheel during installation.
   - 4.2 Using the same procedure, mount the outer wheel against the inner wheel. 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 wheel is 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 rear wheel assemblies, mount the outer wheel so that the outer wheel balance weight(s) is on the same side as the brake drum balance weight(s).

5. Install and hand-tighten a two-piece flange nut on the top and bottom studs.

CAUTION

The two-piece flange nuts have right-hand metric threads. Do not try to install a similar size SAE nut on a stud, or the stud and nut will be damaged.

6. Install and hand-tighten the remaining two-piece flange nuts. Tighten the nuts 50 lbf·ft (68 N·m) following the sequence in **Fig. 2**.

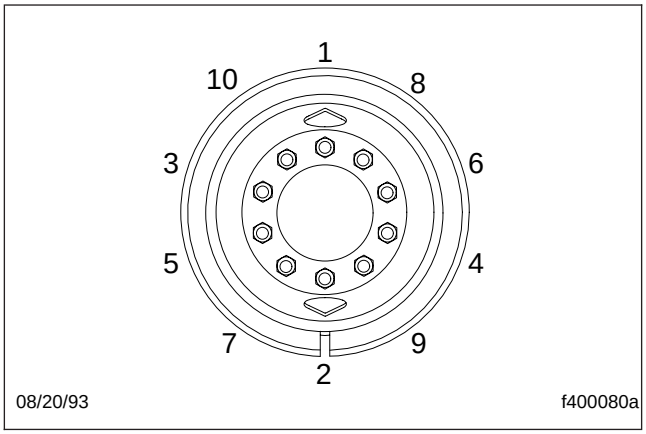


Fig. 2, 10-Stud Disc Wheel Tightening Sequence

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 450 to 500 lbf·ft (610 to 678 N·m).

WARNING

Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.

IMPORTANT: 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 situation, 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.

9. Remove the safety stands, lower the vehicle, and remove the chocks.

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. After operating the vehicle for 50 to 100 miles (80 to 160 km), retighten the wheel nuts 450 to 500 lbf·ft (610 to 678 N·m). Follow the sequence in Fig. 2.

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.
2. If removing wheels and tires from a rear axle, go to the next step. Remove the wheels and tires from the front axle.
   - 2.1 Apply the parking brakes.
   - 2.2 Raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.
   - 2.3 Deflate the tire being serviced by removing the valve core.
   - 2.4 Place a jack or wheel-and-tire dolly under the front 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.
3. Remove the wheels and tires from a rear axle.
   - 3.1 Raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
   - 3.2 Deflate both tires of the dual assembly being serviced by removing the valve cores.
   - 3.3 Place a jack or wheel-and-tire dolly under the outer wheel assembly. Remove the outer wheel nuts, then raise and remove the outer wheel. Be careful not to damage the threads of the inner wheel nuts as the outer wheel is pulled away.
   - 3.4 Place a jack or wheel-and-tire dolly under the inner wheel assembly. Remove the inner wheel nuts, then raise and remove the inner wheel. Be careful not to damage the threads of the wheel studs as the inner wheel is pulled away.

Installation

IMPORTANT: Before installing the wheels, it is recommended that an anti-seize compound be applied on the 360 degree wheel pilot hubs of Meritor FF–981 "Easy Steer Plus" front axles.

After time in service, a small amount of rust or corrosion may make the wheel difficult to remove because of the extended wheel-to-hub contact. Applying an anti-seize compound on the wheel pilot of the hub will ensure easy wheel removal at a later date. Compounds such as the following may be used:

- Armite Led-Plate No. 250
- Loctite® Anti-Seize No. 767
- Never-Seez
- Permabond Anti-Seize No. 82–9839

Compounds are available for purchase locally.

IMPORTANT: "Turbo" wheel assemblies require directional mounting, as shown in **Fig. 1**.

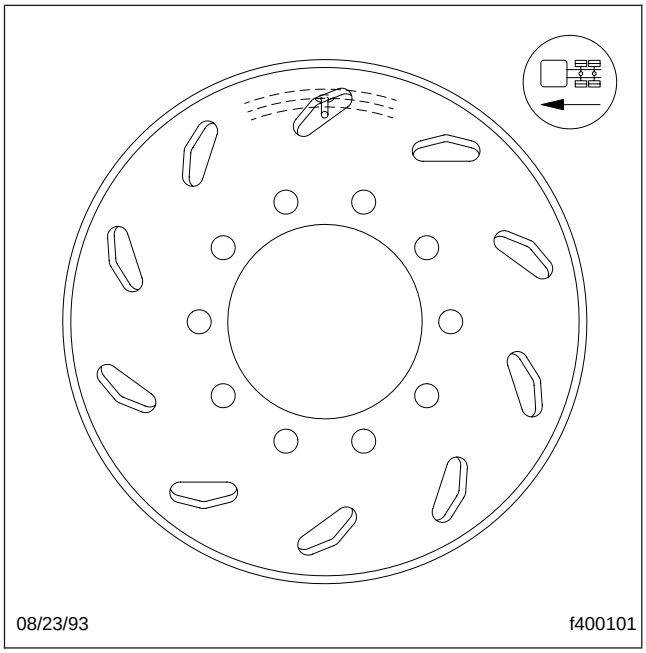


Fig. 1, Side View

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 110**. Also, follow the tire matching and mixing requirements in **Subject 050**.

1. Clean the hub and wheel mounting surfaces, and between the rims of dual wheels. Make sure the tire is inflated using the procedures in **Subject 130**.

10-Hole Disc Wheel With Inner and Outer Nuts Removal and Installation

WARNING

Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.

IMPORTANT: 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 situation, 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.

2. If installing a rear wheel assembly, go to the next step. Install the front wheel assembly.

   2.1 Use a jack or wheel-and-tire dolly to mount the wheel assembly on the wheel studs. Be careful not to damage the threads of the wheel studs when installing the wheel assembly.

   2.2 Install a wheel nut 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.

   2.3 Tighten the wheel nuts 50 lbf·ft (68 N·m), following the sequence in **Fig. 2**.

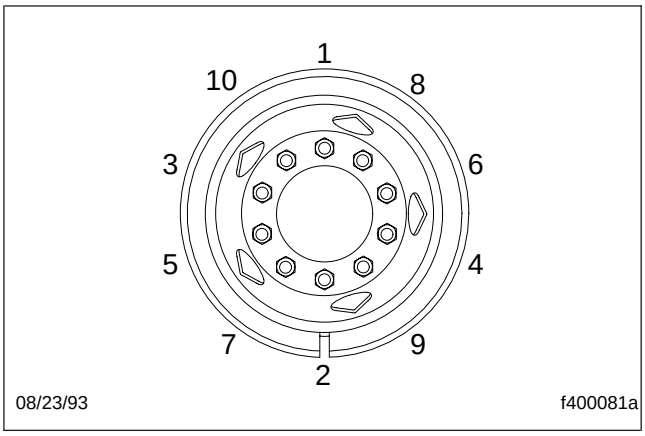


Fig. 2, 10-Stud Disc Wheel Tightening Sequence

   2.4 Using the same sequence, tighten the wheel nuts again to the torque in the disc-type wheel fastener torque table in **Specifications, 400**.

WARNING

Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.

IMPORTANT: 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 situation, 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.

3. Install a rear wheel assembly.

   3.1 Use a jack or wheel-and-tire dolly to mount the inner wheel assembly 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 wheel is 180 degrees opposite the balance weight(s) on the brake drum (**Fig. 3**).

   If, on two-handhole wheels, this causes the valve stems to be in the same wheel hole, mount the outer wheel so that the outer wheel balance weight(s) is on the same side of the assembly as the brake drum balance weight(s). See **Fig. 4**.

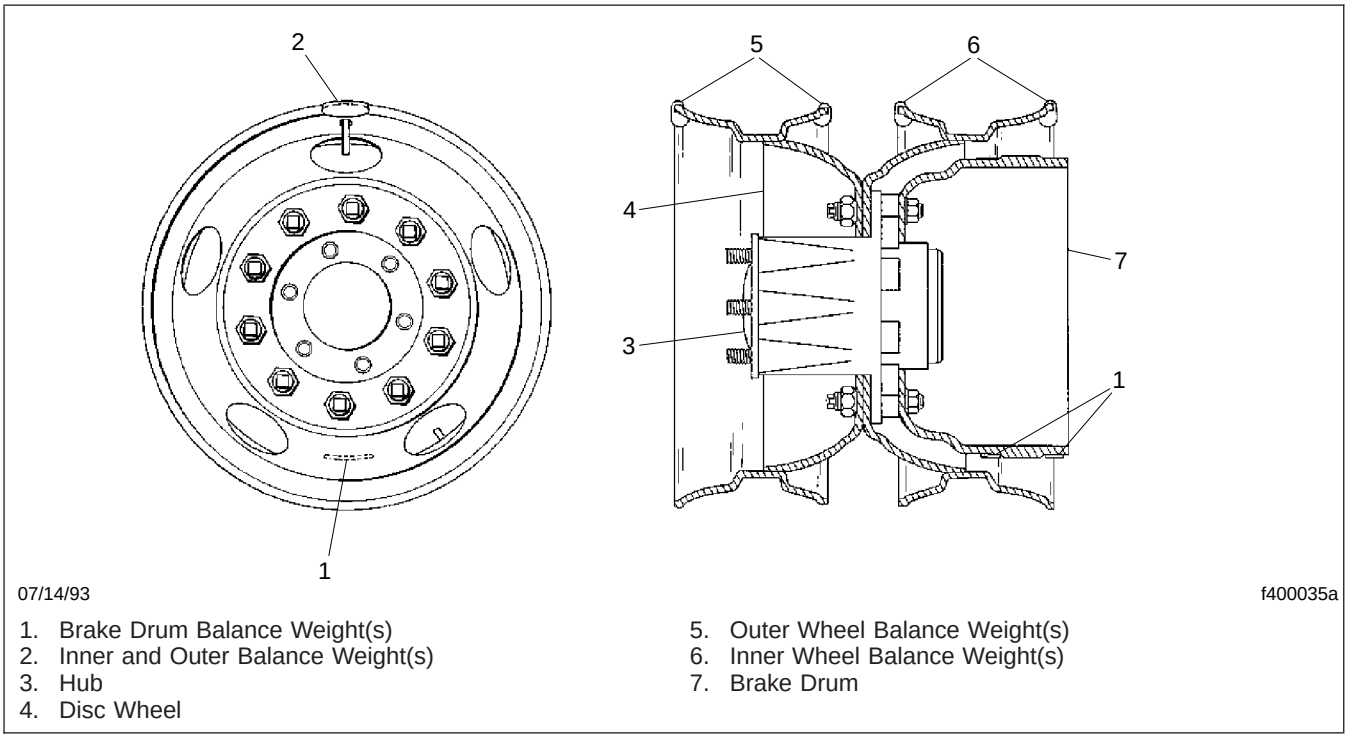
   If, on five-handhole or aluminum wheels, the valve stems are in the same handhole, separate the valve stems by one hole. If balancing the wheels, install the wheel weights evenly and as close to 180 degrees opposite the brake drum balance weight(s) as possible. See **Fig. 5**.

   3.2 Install the inner wheel nuts on each wheel stud, and run them up until each

10-Hole Disc Wheel With Inner and Outer Nuts Removal and Installation

nut is flush with the face or the chamfer of the wheel. Rotate the wheel a half turn to seat the parts.

3.3 Tighten the inner wheel nuts 50 lbf·ft (68 N·m), following the sequence in **Fig. 2**.



1. Brake Drum Balance Weight(s)
2. Inner and Outer Balance Weight(s)
3. Hub
4. Disc Wheel
5. Outer Wheel Balance Weight(s)
6. Inner Wheel Balance Weight(s)
7. Brake Drum

Fig. 3, Recommended Location of Wheel and Brake Drum Balance Weights

3.4 Using the same sequence, tighten the inner wheel nuts again to the torque in the disc-type wheel fastener torque table in **Specifications, 400**.

3.5 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.

3.6 Install the outer wheel nuts following the procedures above.

4. Remove the safety stands, lower the vehicle, and remove the chocks.

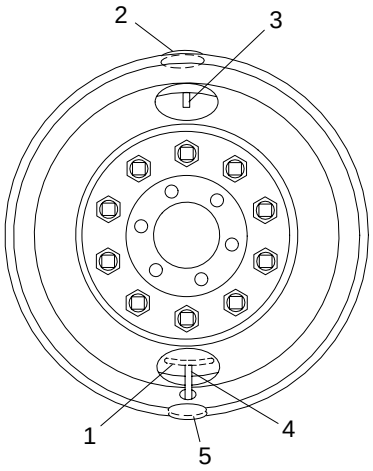
CAUTION

Locknuts seat during vehicle operation. It is necessary to periodically tighten the wheel nuts to the specified torque. Not enough 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.

5. After operating the vehicle for 50 to 100 miles (80 to 160 km), retighten the wheel nuts to the torque in the disc-type wheel fastener torque table in **Specifications, 400**. Follow the sequence in **Fig. 2**.

NOTE: When retightening the inner wheel nuts, loosen the outer wheel nuts several turns, retighten the inner wheel nuts, then the outer wheel nuts.

10-Hole Disc Wheel With Inner and Outer Nuts Removal and Installation



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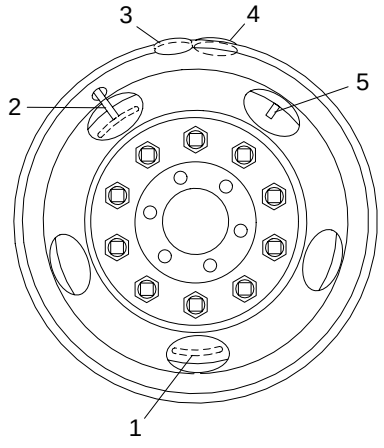
1. Brake Drum Balance Weight(s)
2. Inner Wheel Balance Weight(s)
3. Inner Wheel Valve Stem
4. Outer Wheel Valve Stem
5. Outer Wheel Balance Weight(s)

Fig. 4, 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. 5, Alternate Location of Wheel and Brake Drum Balance Weights, Five-Handhole or Aluminum Wheels

Spoke Wheel Tire and Rim Assembly Removal and Installation

Removal

1. Chock all tires that will not be serviced to prevent vehicle movement.
2. If removing tire and rim assemblies from a rear axle, go to the next step. Remove the tire and rim assembly from the front axle.
   - 2.1 Apply the parking brakes.
   - 2.2 Raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.
   - 2.3 Deflate the tire being serviced by removing the valve core.
   - 2.4 Place a jack or wheel-and-tire dolly under the front tire and rim assembly being serviced. Remove the rim nuts and rim clamps. Slide the tire and rim assembly off.
3. Remove a tire and rim assembly from a rear axle.
   - 3.1 Raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
   - 3.2 Deflate the tire(s) being serviced by removing the valve core(s).
   - 3.3 Place a jack or wheel-and-tire dolly under the outer tire and rim assembly being serviced. Remove the rim nuts and clamps. Slide the outer tire and rim assembly off.
   - 3.4 Remove the rim spacer. Place a jack or wheel-and-tire dolly under the inner tire and rim assembly. Slide the inner tire and rim assembly off.

Installation

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 110**. Also, follow the tire matching and mixing requirements in **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**.

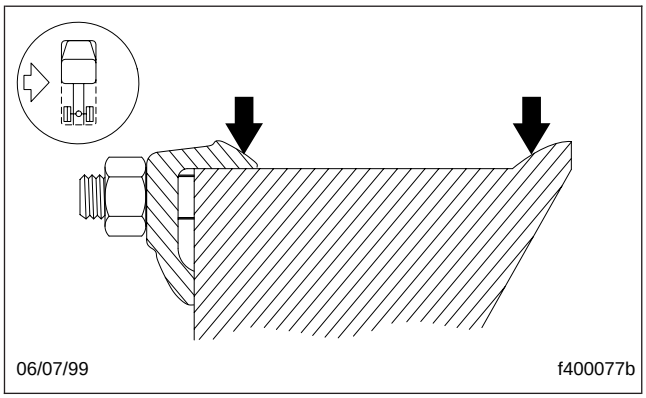


Fig. 1, 28 Degree Tapered Rim Mounting Surfaces

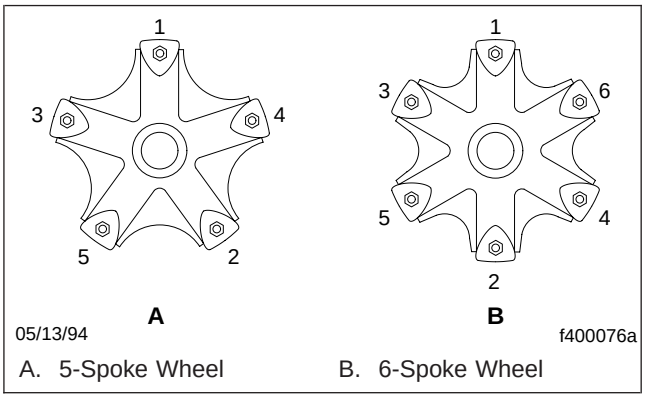
2. Make sure the tire and rim assembly is inflated using the procedures in **Subject 130**.
3. If installing a rear tire and rim assembly, go to the next step. Install a front tire and rim assembly.
   - 3.1 Slide the assembly over the wheel and push it into place against the tapered mounting surface. It should fit snugly against all the tapers. Be sure that the valve stem faces out and is centered between two spokes.
   - 3.2 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.

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 (see Fig. 3). This would result in excessive vehicle vibration and permanent damage to the rim and wheel.

   - 3.3 Tighten the rim nuts a quarter turn at a time, following the star pattern shown in **Fig. 2**. Continue until all the rim nuts are tightened to the torque shown in the applicable torque table in **Specifications, 400**.

Spoke Wheel Tire and Rim Assembly Removal and Installation



A. 5-Spoke Wheel B. 6-Spoke Wheel

Fig. 2, Spoke Wheel Tightening Sequence

WARNING

Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.

IMPORTANT: 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 situation, 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.

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.

4. Install a rear tire and rim assembly.

   4.1 Slide the inner tire and rim over the wheel hub. Push it into position against the tapered mounting surface. Make sure the valve stem faces out and is centered between two spokes.

   4.2 Slide the rim spacer over the wheel hub.

   4.3 Slide the outer tire and rim over the wheel hub. Make sure the valve stem faces inward, and is in the same position as the inner valve stem.

   4.4 Push the whole assembly in place, so that the inner rim fits snugly against the tapers. The spacer is seated against the inner rim, and the outer rim is seated against the spacer.

   4.5 Install the rim clamps and nuts. Run the nuts up until the end of each stud is flush with the face of its nut. Rotate the wheel a half turn to allow the parts to seat.

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 (see Fig. 3). This would result in excessive vehicle vibration and permanent damage to the rim and wheel.

   4.6 Tighten the rim nuts a quarter turn at a time, following the star pattern shown in **Fig. 2**. Continue until all the rim nuts are tightened to the torque shown in the applicable torque table in **Specifications, 400**.

   4.7 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.

WARNING

Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.

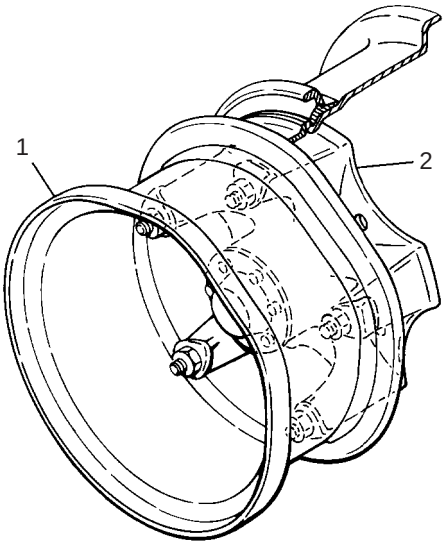
IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

Spoke Wheel Tire and Rim Assembly Removal and Installation

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.

5. 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 torque shown in the applicable torque table in **Specifications, 400**.



1. Rim
2. Spoke Wheel

Fig. 3, Out-of-Round Rim (rim chording)

6. Remove the safety stands, lower the vehicle, and remove the chocks.
7. After driving the vehicle for 50 to 100 miles (80 to 160 km), retighten the rim nuts to the torque specified in the applicable torque table in **Specifications, 400**. Follow the sequence shown in **Fig. 2**.

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims

Five Degree Full Drop Center

WARNING

Read the information in Subject 100. 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 personal injury and equipment damage.

To demount or mount tubeless tires on 5 degree full drop center rims, regular or safety type, follow the same procedures used to demount or mount tubeless automobile tires.

Fifteen Degree Tapered Drop Center

WARNING

Read the information in Subject 100. 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 personal injury and equipment damage.

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 (see **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 (see **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.

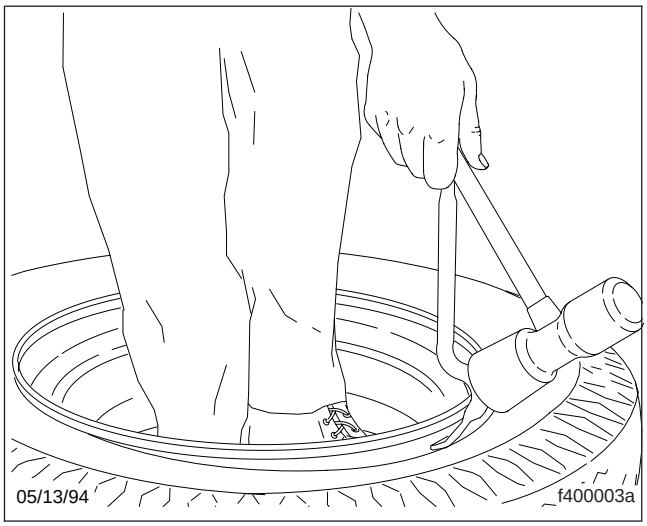


Fig. 1, Loosening the Beads

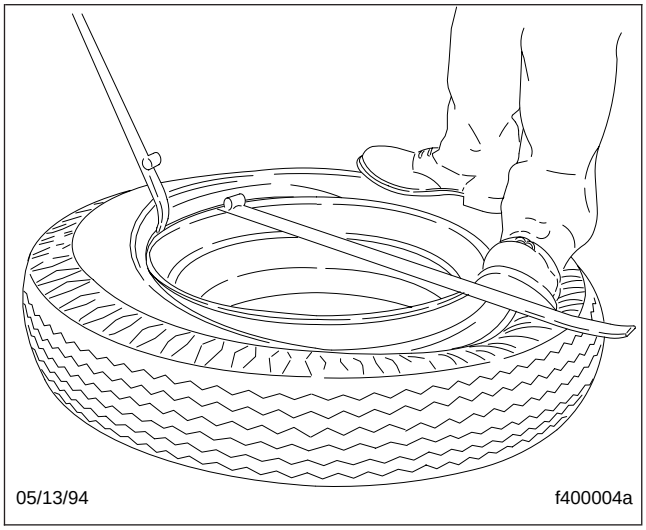


Fig. 2, Forcing the Bead into the Rim Well

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**.

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims

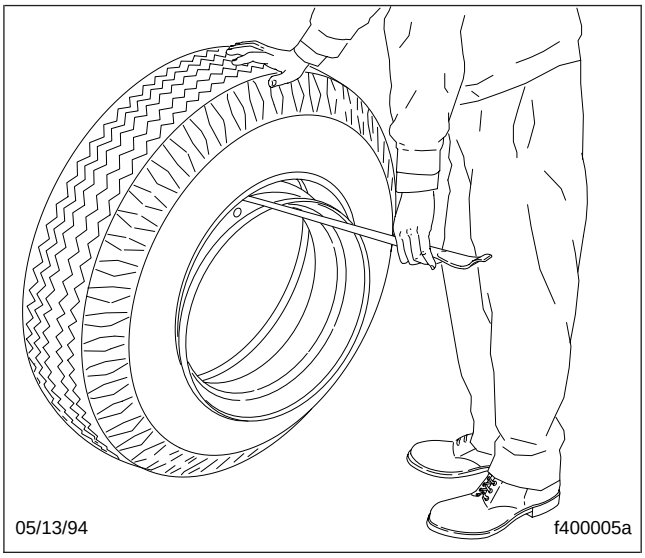


Fig. 3, Prying the Rim Out of the Tire

5. Clean and inspect all parts. Refer to **Subject 110** and **Subject 120** for procedures.

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 (see **Fig. 4**). Tighten the nut securely.

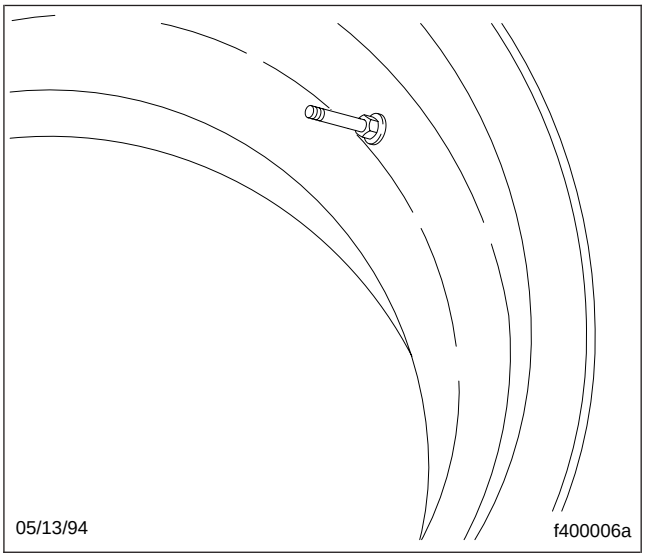


Fig. 4, Valve Stem Installation

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 lubricant to enable correct bead seating, and to make mounting easier. Do not 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**.

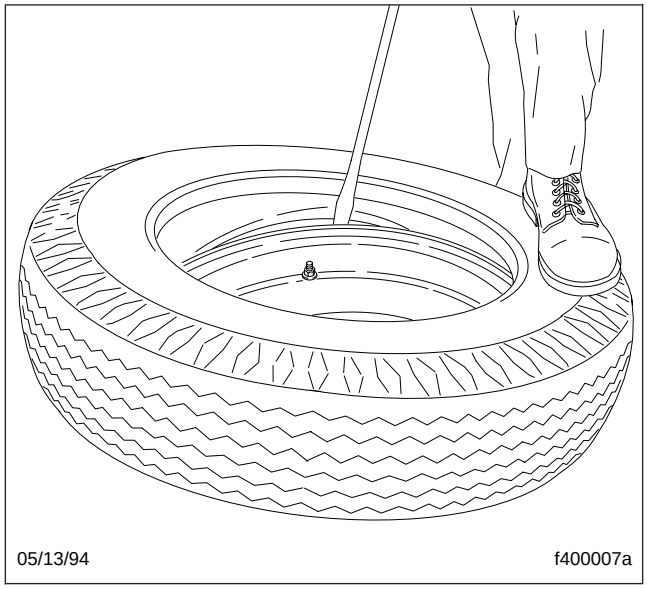


Fig. 5, Working the Lower Bead into the Rim

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 (see **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 130** for procedures.

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims

Fig. 6, Working the Upper Bead into the Rim

General Information

Runout is side-to-side (lateral) or up-and-down (radial) movement when the tire/wheel assembly is rotated. Runout can be measured with a dial indicator, a tire runout gauge, or another instrument capable of measuring small movements of the tire/wheel assembly.

Lateral runout, shown in **Fig. 1**, is side-to-side movement of the rotating tire/wheel assembly. This may cause a perceived "shimmy" or "wobble".

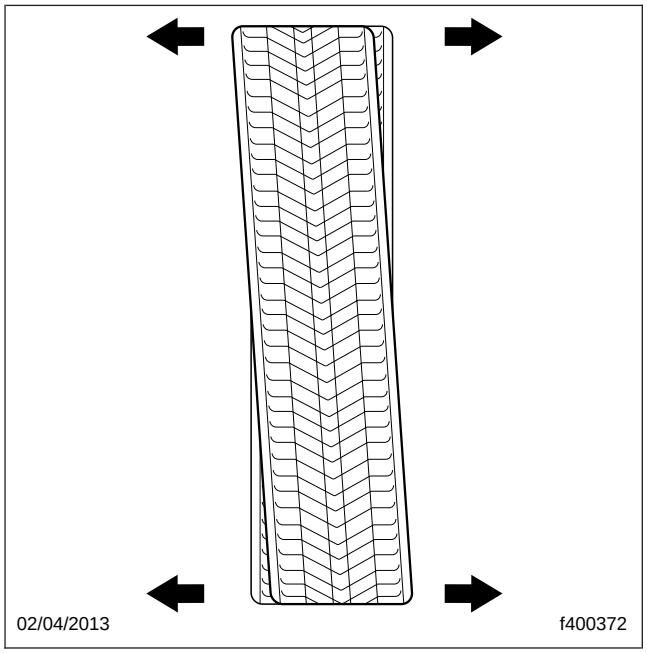


Fig. 1, Lateral Runout

Radial runout, shown in **Fig. 2**, is a changing radius of the rotating tire/wheel assembly. For a tire or wheel, its effect is to raise and lower the vehicle as it rolls along, giving the perception of a vertical "hop" or "bounce".

If a tire and wheel assembly shows visible up-and-down or side-to-side movement, it may have excessive runout. Use the inspection procedure that follows to measure runout.

Inspection

IMPORTANT: Before checking wheel runout, check the tires for proper:

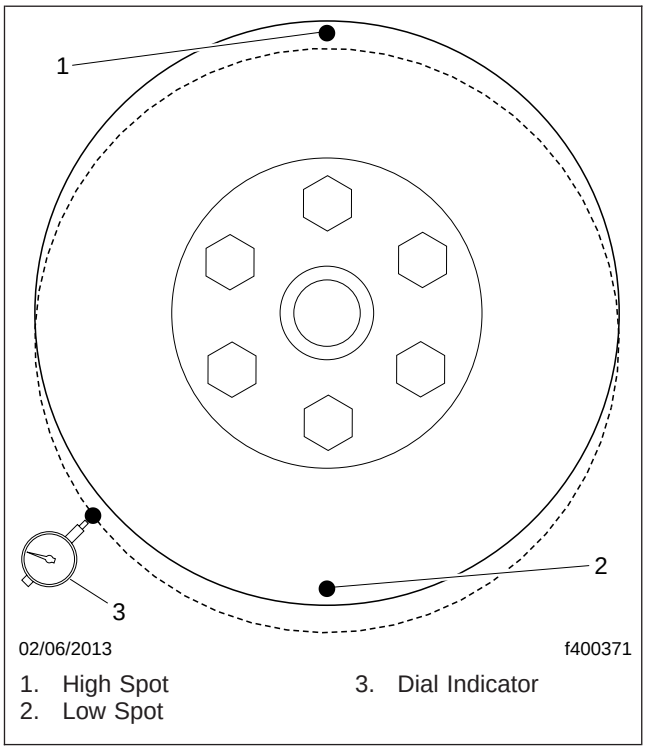


Fig. 2, Radial Runout

- inflation;
- wheel nut torque;
- bead seating on the rim.

Use a tire runout gauge, as shown in **Fig. 3**, to check lateral and radial runouts of the entire wheel end assembly.

Check radial runout on a smooth rib in the center of the tread. Check lateral runout on a smooth surface along the tire's mid-sidewall. If the wheel end assembly radial runout exceeds 0.060 inch (0.2 cm), or the lateral runout exceeds 0.150 inch (0.4 cm), the tire/wheel assembly should be removed to check the brake drum and hub runouts. Brake drum and hub runout tolerances are as follows:

- brake drum lateral runout—0.045 inch (0.11 cm)
- brake drum radial runout measured inside of the drum—0.020 inch (0.050 cm)
- hub lateral runout measured at the face of the hub—0.015 inch (0.38 cm)

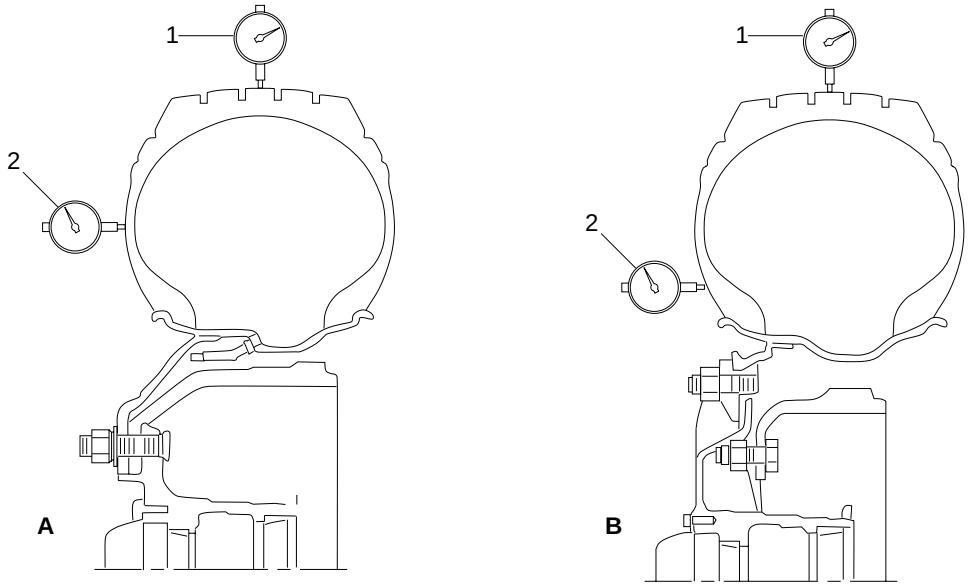
Wheel and Tire Runout Measurements

- hub radial runout measured near the hub pilots—0.015 inch (0.38 cm)

If hub and brake drum runouts are within specification, then the wheel runout will need to be checked. Demount the tire from the wheel and check lateral and radial runouts for the wheel as shown in **Fig. 4**. For tire demounting instructions, see **Section 40.00, Subject 170**. Make certain the wheel is properly fixed in a wheel balancer or remounted on the hub. See **Table 1** for wheel runout specifications.

Wheel Runout Specifications		
Wheel Type	**Lateral Runout: inches (cm)**	**Radial Runout: inches (cm)**
Aluminum	0.030 (0.08)	0.030 (0.08)
Steel	0.060 (0.15)	0.060 (0.15)

Table 1, Wheel Runout Specifications



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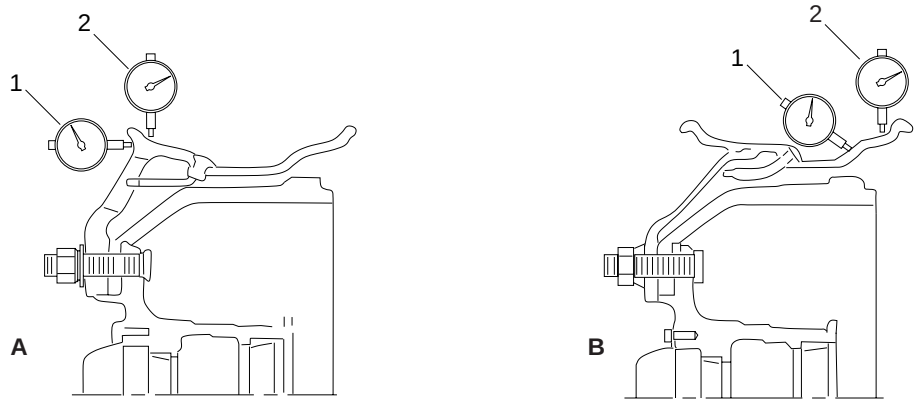
A. Tubeless Steel Disc Wheel
1. Radial Runout
B. Tubeless Demountable Wheel
2. Lateral Runout

Fig. 3, Runout Check for Tires

Wheel and Tire Runout Measurements



A. Tubeless Aluminum Disc Wheel
B. Tubeless Steel Disc Wheel
1. Lateral Runout
2. Radial Runout

Fig. 4, Runout Check for Wheels

Troubleshooting

Inspection and Verification

1. Verify the operator's original concern regarding the tires by duplicating the condition.

NOTE: Tires that show irregularities and definite roughness must be replaced.

2. Refer to the visual inspection list below and inspect for any of the conditions:
    - incorrect mounting
    - misalignment
    - loose wheel bearings
    - bent wheels
    - cupping or scalping of tires from imbalance
    - possible loose or worn steering connecting rod, drag link
    - underinflation and mechanical irregularities such as out-of-balance condition of wheel or tire and bent or damaged wheel
    - loose, damaged or worn front suspension parts
3. Determine if the tires and wheels have been subjected to road hazards that possibly contributed to the concern.
4. Check the vehicle for excessive or uneven loading. Correct as necessary.
5. Check the following:
    - wheels and tires installed properly
    - wheel clamps and lug nuts are tight
    - correct tire and wheel usage for vehicle specification

Problem—Tires Show Excess Wear on Edges of Tread

Problem—Tires Show Excess Wear on Edges of Tread	
Possible Cause	**Remedy**
Underinflated tires	Adjust air pressure in the tires.
Vehicle overloaded	Correct as required.
High speed cornering	Correct as required.
Incorrect toe setting	Set the toe to specifications.

Problem—Tires Show Excess Wear in Center of Tread

Problem—Tires Show Excess Wear in Center of Tread	
Possible Cause	**Remedy**
Tires overinflated	Adjust air pressure in the tires.

Problem—Excessive Tire Wear Concerns

Problem—Excessive Tire Wear Concerns	
Possible Cause	**Remedy**
Improper tire pressure	Adjust air pressure in the tires.
Incorrect tire/wheel usage	Install the correct tire and wheel combination.
Loose or leaking shock absorbers	Tighten or replace as necessary.
Front wheels out of alignment	Align the front wheels.
Front wheel bearings out of adjustment	Adjust the front wheel bearings.

Troubleshooting

Problem—Excessive Tire Wear Concerns	
Possible Cause	**Remedy**
Loose, worn or damaged steering linkage or joints	Inspect, repair or replace as required.
Loose, worn or damaged suspension components, bushings and spindle pin bushings	Inspect, repair or replace as required.
Wheels and tires out of balance	Balance the wheels and the tires.
Excessive lateral/radial runout of wheels and tires	Check, realign or reindex the tire rim or rim/wheel to hub or spider.

Problem—Wheel Hop (Excessive Vehicle Vibration, Rough Steering and Excessive Fatigue)

Problem—Wheel Hop (Excessive Vehicle Vibration, Rough Steering and Excessive Fatigue)	
Possible Cause	**Remedy**
Demountable rims—improper procedures in mounting the rim to the cast wheel; failure to follow proper tightening sequence and recommended torque results in "rim chording" where the rim clamps exert pressure as they are tightened which forces the rim out of round forming flat sides on the rim	Replace the chorded rims. Check shop practices and tools to be sure manufacturer's recommended torque and procedures are followed.
Out-of-balance rim or cast wheel, tire or hub and drum assembly	Determine the out-of-balance component and balance or replace.
Out-of-round rim (excessive radial runout) more than 0.060 inch (1.5 mm)	Check for: • Proper handling of the rim prior to use; • Overloading and unbalanced loads; • Road hazards and rugged operating conditions; • Proper rim specifications; • Proper mounting; • Tightening sequencing and alignment.
Disc wheels—dirt and rocks wedged between disc and rim	Clean.
Out-of-balance wheel/tire or hub and drum assembly	Determine the out-of-balance component and balance.
Out-of-round wheel (excessive radial runout) more than 0.060 inch (1.5 mm)	Check for: • Road hazards and rugged operating conditions; • Proper wheel specifications. Reindex the tire on the rim/wheel.
Vehicle—loose or worn driveline or suspension parts	Identify the location of the vibration carefully as it can be transmitted through the frame, making a rear end vibration appear to come from the front. Then repair or replace loose and worn parts.

Problem—Wobble (Excessive Vehicle Vibrations, Rough Steering, Excessive Fatigue, Severe Tire Wear and Wheel Shimmy)

Problem—Wobble (Excessive Vehicle Vibrations, Rough Steering, Excessive Fatigue, Severe Tire Wear and Wheel Shimmy)	
Possible Cause	**Remedy**
Demountable rims—excessive lateral runout	Check the mounting. Realign and retighten the wheels. Lateral runout must not exceed: • 0.090 inch (2.3 mm) for the front; • 0.125 inch (3.2 mm) dual rear.
Loose or improper attaching parts	Tighten or replace.
Worn or distorted spacers	Replace.
Overloading or unbalanced loads	Check the rim specifications against work load requirements. Recommend the correct tire and rim. Check on loading procedures.
Road hazards (curb and rock impacts, etc.)	Check operating conditions for possible change to heavier duty tire and rim.
Improperly installed rim	Recommend that the clamp nuts be retightened after a 50 to 100 mile (80 to 160 kilometer) seating-in period of the rim assembly to the wheel. Five and six spoke: 240 to 260 lbf·ft (325 to 352 N·m).
Disc wheels—excessive lateral runout	Replace the wheel if rim runout is more than 0.060 inch (1.5 mm).
Cracked, bent or distorted disc from overloading, road impact hazards or improper handling	Replace the wheel. Attempts to straighten the wheel can result in fractures in the steel and weakening of the disc or the weld between the disc and rim. Check loading and operating conditions and shop practices.
Loose mountings, damaged studs or wheel nuts, enlarged stud holes, worn or broken hub face, or foreign material on mounting surfaces	Tighten or replace worn or damaged parts. Clean mounting surfaces. Tighten the wheel nuts 450 to 500 lbf·ft (610 to 678 N·m).
Vehicle—improper alignment	Align the vehicle.
Loose, worn or broken suspension parts	Repair or replace.

Problem—Cracked Or Broken Wheel Rims (Cracks Develop in Rim Base, Back Flange or the Gutter Area)

Problem—Cracked Or Broken Wheel Rims (Cracks Develop in Rim Base, Back Flange or the Gutter Area)	
Possible Cause	**Remedy**
Demountable rims or disc wheel rims—overloading or road hazards	Replace the rim or wheel. Check loading and operating conditions. Avoid overinflation of the tires. Check the specifications for rim load capacity, working loads, tire size, ply rating and tire construction.
Improper use of tools	Check mounting, demounting and maintenance procedures.

Troubleshooting

Problem—Cracked Or Broken Wheel Discs (Cracks Develop in the Wheel Disc from Hand Hole to Hand Hole, from Hand Hole to Rim, or from Hand Hole to Stud)

Problem—Cracked Or Broken Wheel Discs (Cracks Develop in the Wheel Disc from Hand Hole to Hand Hole, from Hand Hole to Rim, or from Hand Hole to Stud)	
Possible Cause	**Remedy**
Metal fatigue resulting from overloading/road hazards	Replace the wheel. Check position of the wheel on the vehicle for working load specifications.
Loose wheel nuts	Tighten 450 to 500 lbf·ft (610 to 678 N·m).
Damaged holes	Replace the wheel.

Problem—Damaged Stud Holes (Stud Holes Become Worn, Elongated or Deformed, Metal Builds Up Around Stud Hole Edges, Cracks Develop from Stud Hole to Stud Hole)

Problem—Damaged Stud Holes (Stud Holes Become Worn, Elongated or Deformed, Metal Builds Up Around Stud Hole Edges, Cracks Develop from Stud Hole to Stud Hole)	
Possible Cause	**Remedy**
Truck operated with loose wheel mounting	Replace the wheel and check for: • Installation of correct studs and nuts; • Cracked or broken studs. Replace the stud. Also, replace the studs on each side of the damaged stud; • Worn hub face. Repair if not excessive, or replace if severe; • Broken or cracked hub barrel. Replace; • Worn stud grooves. Replace or install the recommended serrated bolts; • Rust streaks fanning out from the stud holes (an indication that the wheel nuts are, or have been, loose). Clean the mounting surfaces. Tighten the wheel nuts 450 to 500 lbf·ft (610 to 678 N·m).

Problem—Corrosion (Decreased Strength Because of Excessive Rust or Corrosion, Bead Seating Problems, or Loss of Pressure with Tubeless Tires)

Problem—Corrosion (Decreased Strength Because of Excessive Rust or Corrosion, Bead Seating Problems, or Loss of Pressure with Tubeless Tires)	
Possible Cause	**Remedy**
Demountable rims or disc wheel rims — adverse storage or operating conditions	Correct as required.
Poor maintenance practices	Follow the recommended cleaning and protective procedures.
Wheel disc—poor maintenance	Clean and protect with paint. Do not exceed 1.5 mil thickness of paint.

Problem—Severe Tire Damage (Related Maintenance Complaints on Tire Damage Including Erratic or Spotty Wear, Tire Slippage, Ply Separation, Excessive Flexing, Bead Chafing, Valve Stem Tear-Outs)

Problem—Severe Tire Damage (Related Maintenance Complaints on Tire Damage Including Erratic or Spotty Wear, Tire Slippage, Ply Separation, Excessive Flexing, Bead Chafing, Valve Stem Tear-Outs)	
Possible Cause	**Remedy**
Demountable rims or disc wheel rims — wrong rim selection	Match the rims and tires to the working loads and operating conditions.
Rims of different size in dual mountings	Match the rim size before mounting duals.
Improper inflation	Follow the specifications.
Severe hop and wobble	Follow the recommendations under "Problem—Wheel Hop (Excessive...)."
Wheel disc—bent or distorted disc.	Refer to "Disc wheels—excessive lateral runout" under "Problem—Wobble (Excessive...)."
Other conditions	Refer to tire mounting difficulties, rim mounting difficulties, and wheel mounting in the tire manufacturer's literature.

Problem—Tire Mounting Difficulties

Problem—Tire Mounting Difficulties	
Possible Cause	**Remedy**
Demountable rims or disc wheel rims—mismatched tire and rim sizes	Follow the specifications.
Tire mounting lubricant not used	Remount the tires using lubricant.
Overinflation of tires	Follow the recommended tire pressures.
Corrosion and dirt	Refer to "Problem—Corrosion (Decreased...)."

Problem—Rim Mounting Difficulties

Problem—Rim Mounting Difficulties	
Possible Cause	**Remedy**
Demountable rims—improper application or mismatched parts, including spacer and clamps	Follow the manufacturer's specifications. Check the specifications when chains, or special load tires are involved.
Corroded or worn parts	Clean or replace.

Problem—Wheel Mounting Difficulties

Problem—Wheel Mounting Difficulties	
Possible Cause	**Remedy**
Disc wheels—improper application or mismatched parts, including studs and nuts	Follow the manufacturer's specifications. Check the specifications for disc and spacing when chains, or special load tires are involved.
Corroded or worn parts	Clean or replace.

Troubleshooting

Problem—Dual Tires Rubbing

Problem—Dual Tires Rubbing	
Possible Cause	**Remedy**
Insufficient wheel spacing	Check the tire and wheel sizes. Make certain the proper size tire, rim and spacer/ wheel offsets are used.

Problem—Damaged Stud Threads

Problem—Damaged Stud Threads	
Possible Cause	**Remedy**
Sliding wheel across studs during assembly	Replace the studs. Follow the proper wheel installation procedures.

Problem—Loose Drum

Problem—Loose Drum	
Possible Cause	**Remedy**
Stud too long	Replace the stud with proper length stud.

Problem—Loose Inner Wheel

Problem—Loose Inner Wheel	
Possible Cause	**Remedy**
Excessive stud standout from mounting face of hub permitting wheel nut to bottom out	Replace the stud with a proper length stud.

Problem—Broken Studs

Problem—Broken Studs	
Possible Cause	**Remedy**
Loose wheel nuts	Replace the studs. Follow the proper tightening procedure. Replace all studs with OEM replacement components.
Overloading	Replace the studs. Compare the actual load against the wheel load ratings.

Problem—Stripped Threads

Problem—Stripped Threads	
Possible Cause	**Remedy**
Excessive torque	Replace the studs. Follow the proper tightening procedure.

Problem—Rust Streaks from Stud Holes

Problem—Rust Streaks from Stud Holes	
Possible Cause	**Remedy**
Loose wheel nuts	Check the complete assembly. Replace the damaged parts. Follow the proper tightening procedure.

Problem—Damaged Wheel Nuts

Problem—Damaged Wheel Nuts	
Possible Cause	**Remedy**
Loose wheel assembly	Replace the wheel nuts. Check for proper stud nut standout. Follow the proper tightening procedure.

Problem—Frozen Wheel Nuts

Problem—Frozen Wheel Nuts	
Possible Cause	**Remedy**
Corrosion or galling	If corrosion is slight, remove with a wire brush. If corrosion is excessive, replace the studs and nuts. If the condition persists, lubricate the first three threads of each stud with a graphite-based lubricant.

Tire Pressure

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.

IMPORTANT: 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 (other than Michelin), and for inflation and load limits, refer to the "Tire and Rim Association Yearbook." Contact the Michelin Tire Corporation for further information on their tires.

Wheel Fastener Torque Values

Wheel Fastener Torque	
Description	**lbf·ft (N·m)**
5 and 6 Spoke Wheel Nut	240–260 (325–352)
Cast Wheel Rim Nut	240–260 (325–352)
Disc Wheel 2-Piece Flange Nut, 10-Hole, M22 x 1.5	450–500 (610–678)

Table 1, Wheel Fastener Torque

General Information

DRIVELINE

The driveline is composed of the universal joints (U-joints), connecting shafts and the attaching yokes.

All the vehicle U-joint spiders and sliding splines are equipped with lubrication fittings. They must be lubricated periodically with high-temperature 4x4 front axle and wheel bearing grease meeting specification ESA–M1C198–A.

The vehicles are equipped with center support bearings that are prelubricated and sealed for the life of the bearing.

NOTE: All driveline shafts are balanced. If a vehicle is to be undercoated, cover all shafts to prevent getting undercoating material on the shafts.

DRIVESHAFT

The driveshaft, coupling shaft and inter-axle shaft are composed of universal joints (U-joints), connecting shaft(s) and the attaching yokes.

Vehicles have the following types of driveshafts:

- Primary driveshaft: the shaft that accommodates the change in length (slip) in the driveline system and connects to the input shaft of the rear single axle or the forward tandem axle. See **Fig. 1**.

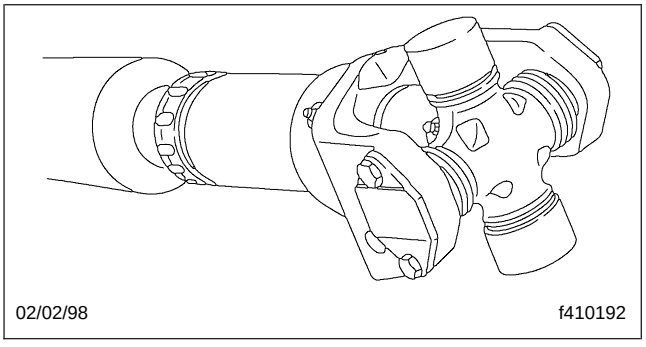


Fig. 1, Primary Driveshaft

- Coupling shaft: the front shaft in a two-piece driveline system. Coupling shafts are attached to a support plate via a shaft support bearing. See **Fig. 2**.

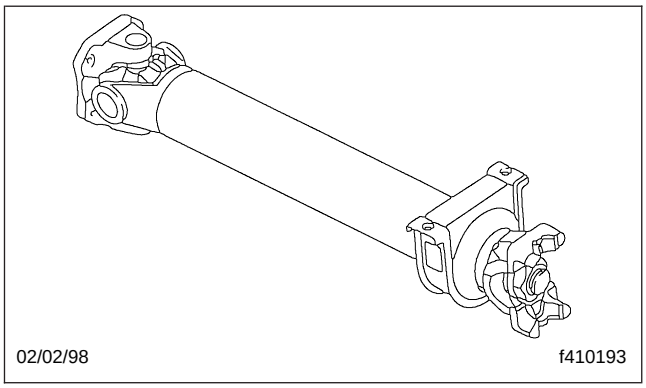


Fig. 2, Coupling Shaft

- Inter-axle shaft: the shaft that connects the forward axle of a tandem drive unit to the rear axle. See **Fig. 3**.

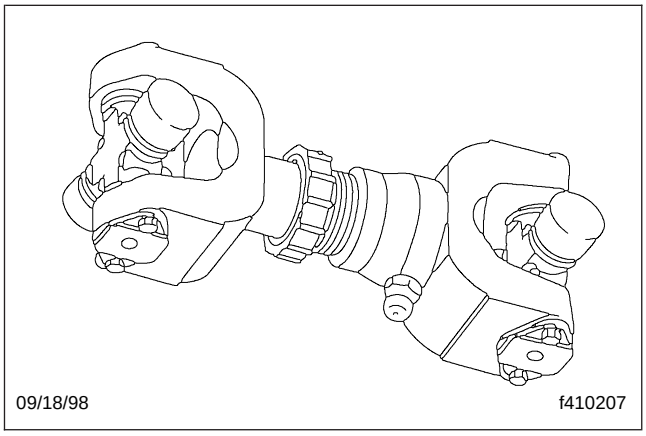
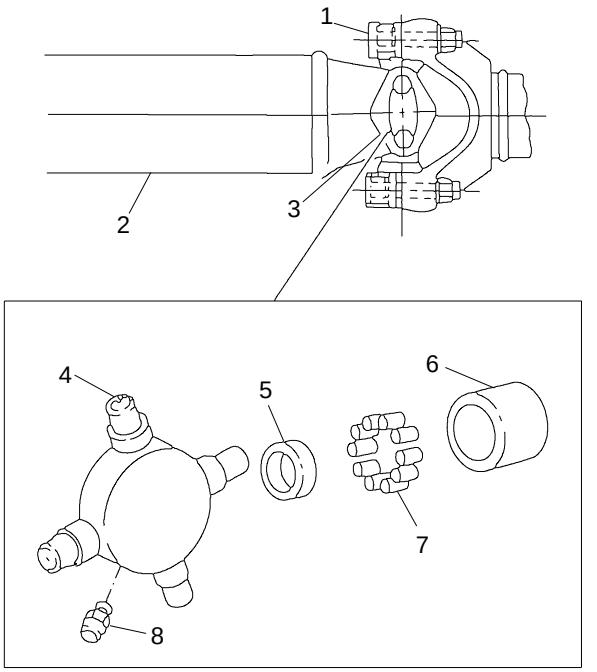


Fig. 3, Inter-Axle Shaft

UNIVERSAL JOINTS (U-JOINTS)

All U-joints are needle bearing type and are defined by the shape of the bearing caps (plate or bearing strap type). The U-joints are held in the yoke by bearing straps and bolts or snap rings. See **Fig. 4** and **Fig. 5**.

General Information



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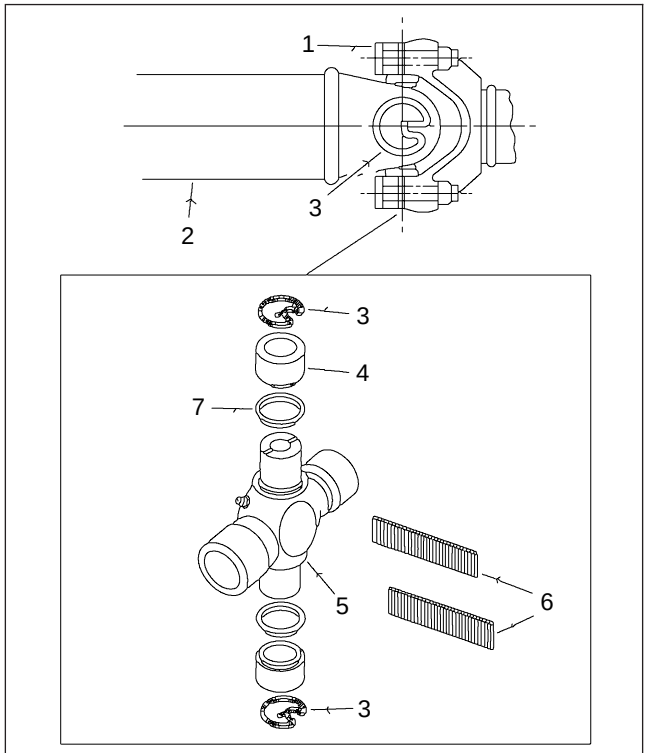
1. Bearing Strap
2. Driveshaft to Rear Axle
3. Plate
4. Spider
5. Seal
6. Bearing Cap
7. Needle Rollers
8. Zerk Fitting

Fig. 4, Plate Design



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1. Bearing Retainer
2. Driveshaft
3. Snap Ring
4. Bearing Cap
5. Spider
6. Needle Bearings
7. Grease Seal

Fig. 5, Outside Snap Ring Design

One-Piece Driveshaft

REMOVAL

NOTE: Index mark the slip-yoke and slip tube shafts as well as the yokes before removing the shaft to maintain the proper phase.

1. Set the parking brake and chock the tires.

NOTE: Support the driveshaft so that it does not hang from the opposite U-joint and yoke.

2. Remove the retaining bolts and disconnect the driveshaft at the axle. See **Fig. 1**.

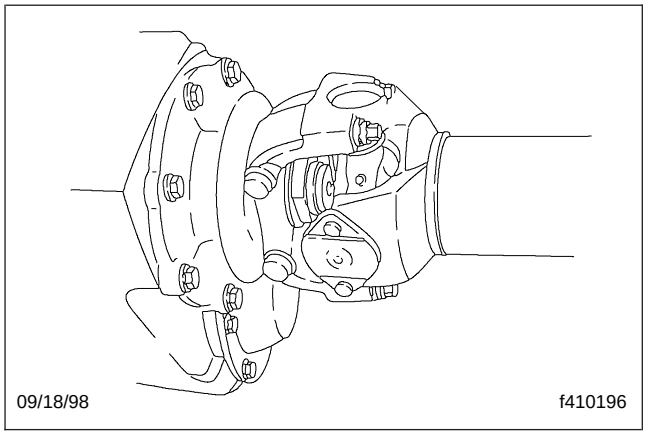


Fig. 1, Driveshaft Connection at the Axle

3. Unscrew the grease seal on the slip-yoke and remove the driveshaft from the slip-yoke. See **Fig. 2**.

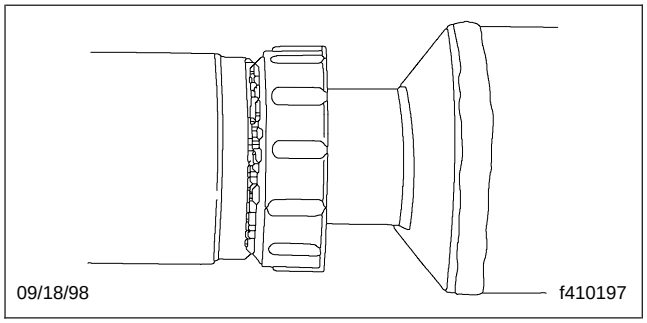


Fig. 2, Driveshaft Slip-Yoke and Grease Seal

4. Remove the retaining bolts and disconnect the slip-yoke at the transmission. See **Fig. 3**.

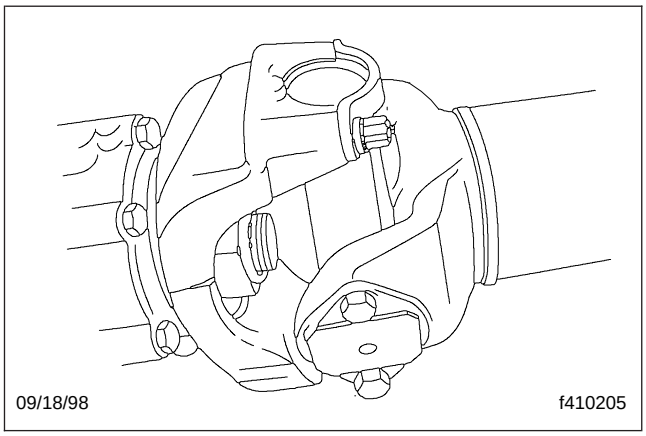


Fig. 3, Slip-Yoke Connection at the Transmission

INSTALLATION

NOTE: Make sure that the shaft is installed with the index marks aligned to maintain proper phasing of the yokes.

1. Connect the slip yoke to the transmission yoke and install the yoke retaining bolts. Tighten the yoke retaining bolts to the applicable torque value in **Specifications, 400**.
2. Install the driveshaft into the slip-yoke and hand-tighten the grease seal firmly on the slip-yoke.
3. Connect the driveshaft to the axle and install the yoke retaining bolts. Tighten the yoke retaining bolts to the applicable torque value in **Specifications, 400**.

Interaxle Driveshaft

REMOVAL

NOTE: Index mark the slip-yoke and slip tube shafts as well as the yokes before removing the shaft to maintain the proper phase.

1. Set the parking brake and chock the tires.
2. Remove the retaining bolts and disconnect the shaft at the axle. See **Fig. 1**.
3. Unscrew the grease seal on the slip-yoke and separate the shaft and slip-yoke. See **Fig. 2**.
4. Remove the retaining bolts from the yoke at the opposite axle and remove the shaft.

Driveshaft Removal and Installation

INSTALLATION

NOTE: Make sure that the shaft is installed with the index marks aligned to maintain proper phasing of the yokes.

1. Connect the shaft at the axle and install the yoke retaining bolts. Tighten the yoke retaining bolts to the applicable torque value in **Specifications, 400**.
2. Install the driveshaft into the slip-yoke and hand-tighten the grease seal firmly on the slip-yoke.
3. Connect the shaft to the axle and install the yoke retaining bolts. Tighten the yoke retaining bolts to the applicable torque value in **Specifications, 400**.

Coupling Driveshaft

REMOVAL

NOTE: Index mark the yokes before removing the shaft to maintain the proper phase.

1. Set the parking brake and chock the tires.
2. Remove the slip-yoke and position it aside. See **Fig. 4** and **Fig. 5**.

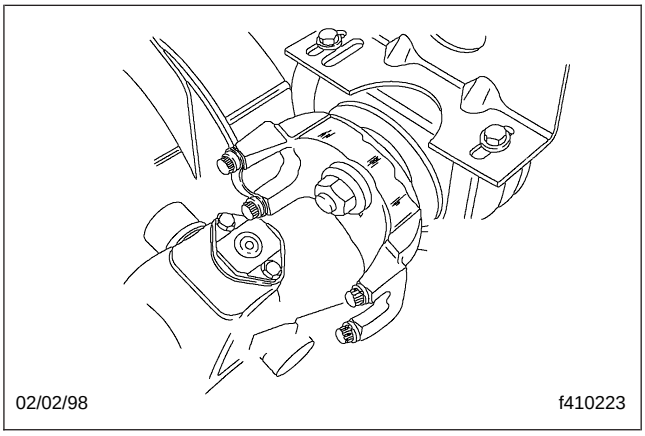


Fig. 4, Disconnecting the Slip-Yoke

NOTE: Support the coupling shaft so that is does not hang from the U-joint and yoke at the opposite end of the shaft.

3. Remove the retaining bolts at the coupling shaft. See **Fig. 6**.

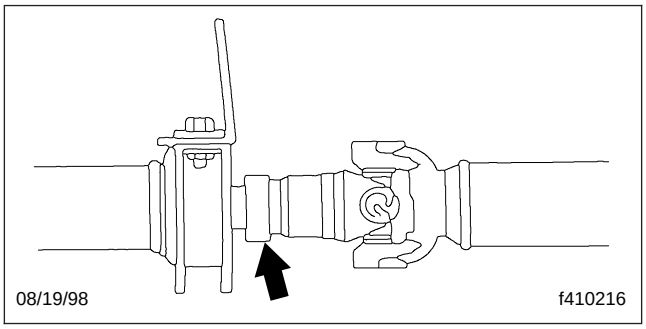


Fig. 5, Removing Slip-Yoke

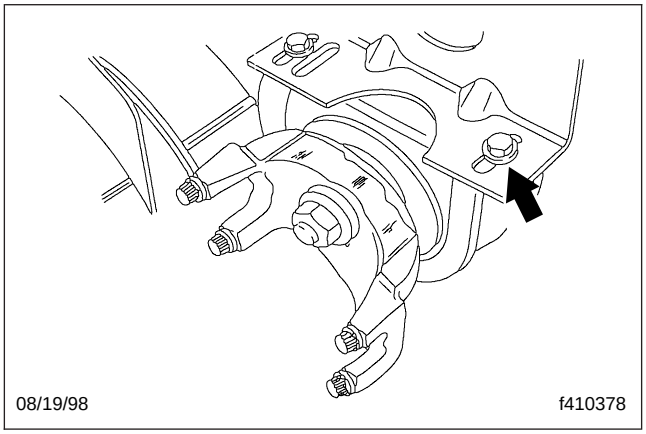


Fig. 6, Coupling Shaft

4. Remove the retaining bolts and disconnect the coupling shaft at the transmission. See **Fig. 3**.
5. Remove the yoke retaining nut. See **Fig. 7**.

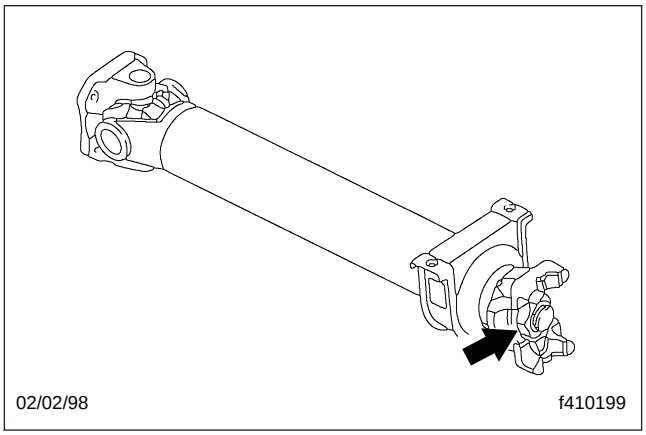


Fig. 7, Yoke Retaining Nut

NOTE: For the reverse slip type coupling shaft, proceed to Steps 9 through 11 of this procedure for bearing removal.

6. Remove the yoke. See **Fig. 8**.

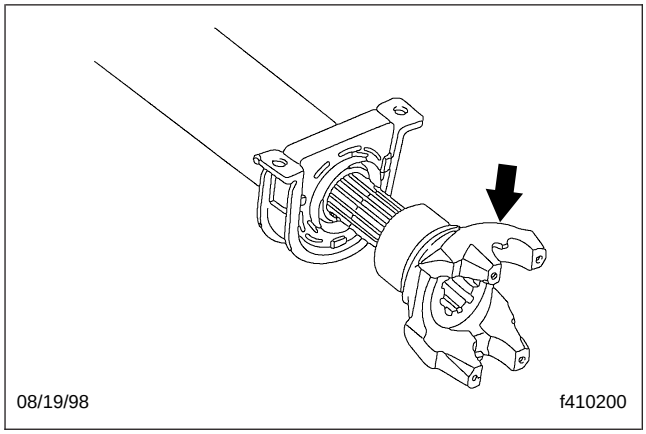


Fig. 8, Yoke

7. Slide the center bearing off the splined shaft. See **Fig. 9**.

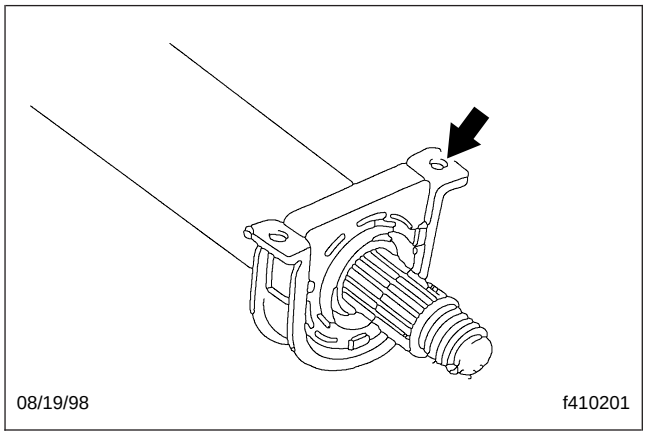
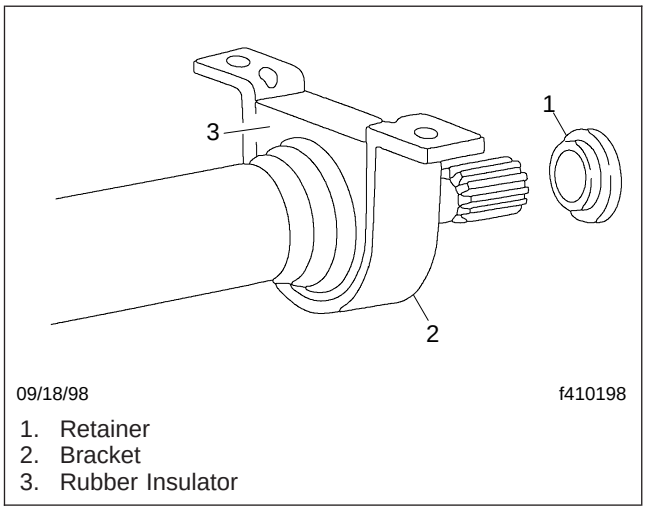


Fig. 9, Center Bearing

8. For reverse slip type couplingshaft, remove the rubber insulator. See **Fig. 10**.
   - 8.1 Remove the retainer.
   - 8.2 Remove the bracket.
   - 8.3 Remove the rubber insulator.
9. Use a suitable press to press the bearing and the retainer off the coupling shaft. See **Fig. 11**.



1. Retainer
2. Bracket
3. Rubber Insulator

Fig. 10, Rubber Insulator

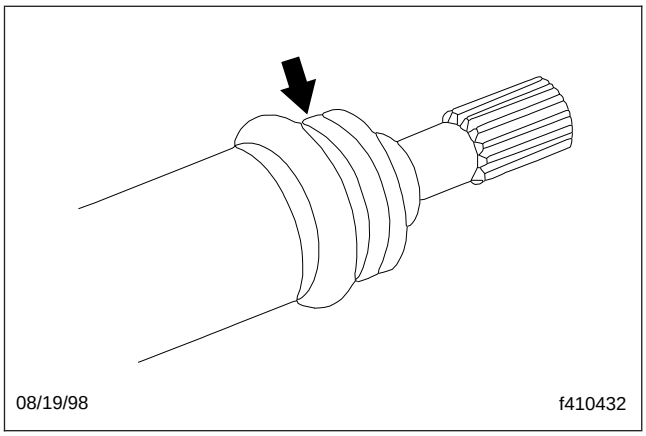


Fig. 11, Bearing and Retainer

10. Remove the dust slinger from the coupling shaft. See **Fig. 12**.

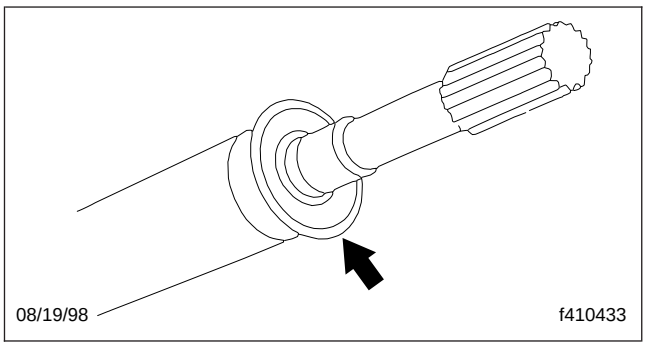


Fig. 12, Dust Slinger

Driveshaft Removal and Installation

11. Clean the splines.
    - 11.1 Use a suitable cleaning fluid.
    - 11.2 Clean all the dirt and old grease from the slip-yoke, slip-yoke splines and shaft splines.
12. Check the splines for wear, warpage and cracks. If the shaft is worn, warped or cracked, replace the shaft.
13. Carefully inspect the slip-yoke splines for wear or evidence of twisting. Check the clearance between the slip-yoke splines and shaft splines. See **Fig. 13**.

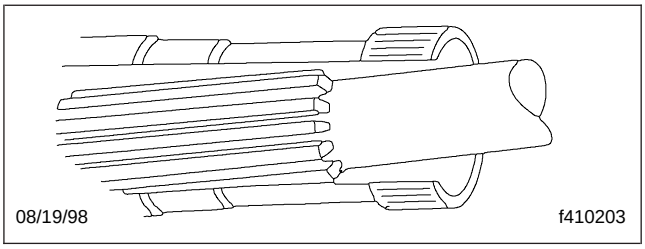


Fig. 13, Slip-Yoke Spline Inspection

14. Wipe the bearing and cushion clean with a cloth dampened with cleaning fluid.

NOTE: Do not immerse the sealed bearing in cleaning fluid.

15. Examine the rubber cushion for evidence of hardening, cracking or deterioration. Replace the cushion if damaged in any way.

NOTE: The retainers and slingers are serviced only as part of the bearing assembly.

16. Check the bearing for wear or rough action by rotating the inner race while holding the outer race. If wear or roughness is evident, replace the bearing. See **Fig. 14**.
17. Clean and inspect the yoke.
    - 17.1 Inspect the crosshole surfaces for damage and raised metal.

      Remove raised metal with a file or emery cloth.
    - 17.2 Check the crossholes for wear and misalignment.

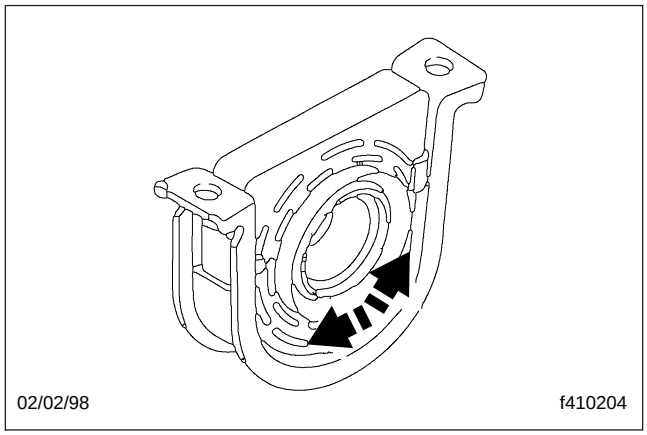


Fig. 14, Checking Bearing for Wear

INSTALLATION

NOTE: Make sure that the shaft is installed with the index marks aligned to maintain proper phasing of the yokes.

1. Fill the entire cavity around the bearing to the extreme edge of the surrounding slinger with a suitable waterproof grease. See **Fig. 15**.

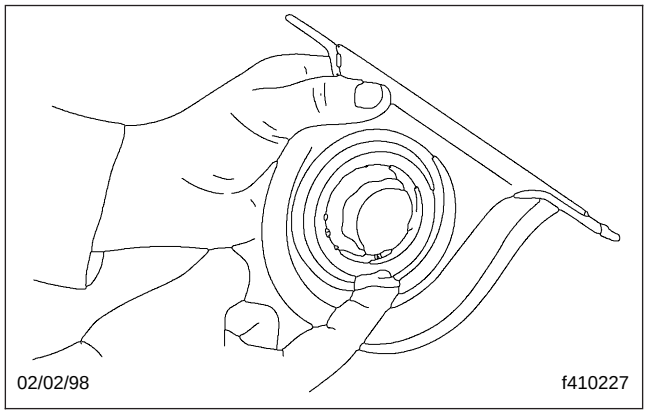


Fig. 15, Applying Waterproof Grease to Bearing Cavity

2. For reverse slip type couplingshaft, install the dust slinger on the coupling shaft. See **Fig. 12**.
3. Using a suitable press, press the bearing and the retainer onto the coupling shaft. See **Fig. 11**.
4. Install the rubber insulator. See **Fig. 10**.
    - 4.1 Install the rubber insulator.
    - 4.2 Install the bracket.

4.3 Install the retainer.

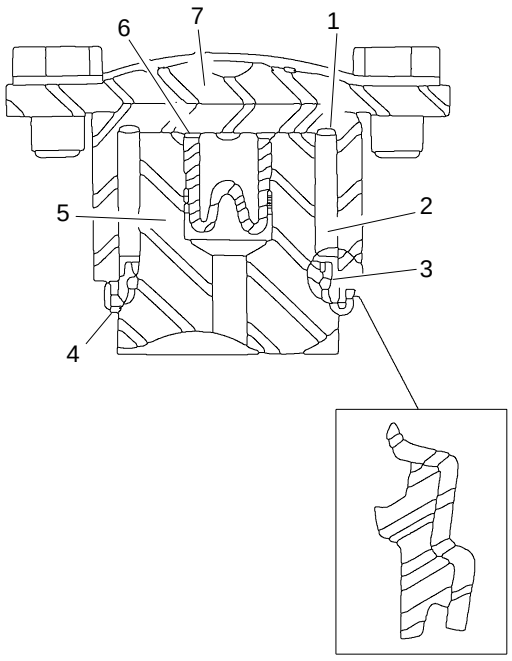
5. Slide the center bearing onto the splined shaft. See **Fig. 9**.
6. Install the yoke. See **Fig. 8**.
7. Install the yoke retaining nut. Tighten the yoke retaining bolt to the applicable torque value in **Specifications, 400**. See **Fig. 7**.
8. Connect the coupling shaft at the transmission and install the retaining bolts. Tighten the coupling shaft retaining bolts to the applicable torque value in **Specifications, 400**. See **Fig. 3**.

NOTE: Make sure the center bearing is not twisted in the support plate.

9. Install the retaining bolts at the coupling shaft. Tighten center bearing support retaining bolts to the applicable torque value in **Specifications, 400**. See **Fig. 6**.
10. Install the slip-yoke. Tighten the U-joint retaining bolts to the applicable torque value in **Specifications, 400**. See **Fig. 4** and **Fig. 5**.

Plate-Type Universal Joint

DISASSEMBLY (See Fig. 1)



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1. Plate-Type Bearing Cap
2. Needle Bearings
3. Grease Seal
4. Oil Slinger
5. Spider
6. Lube Check Valve
7. Bearing Plate

Fig. 1, Plate-Type Universal Joint

1. Place the driveshaft in V-blocks to remove the cross and bearing assembly. See **Fig. 2**.

⚠ CAUTION

Do not distort the tube with excessive grip or damage to the driveshaft may result.

2. Remove the serrated retaining bolts. See **Fig. 3**.
3. Lightly tap the bearing cap clockwise. See **Fig. 4**.
4. Pry evenly on the bearing cap ends until removed from the yoke. See **Fig. 5**.
5. Repeat the previous steps as needed for the bearing cap on the opposite side.

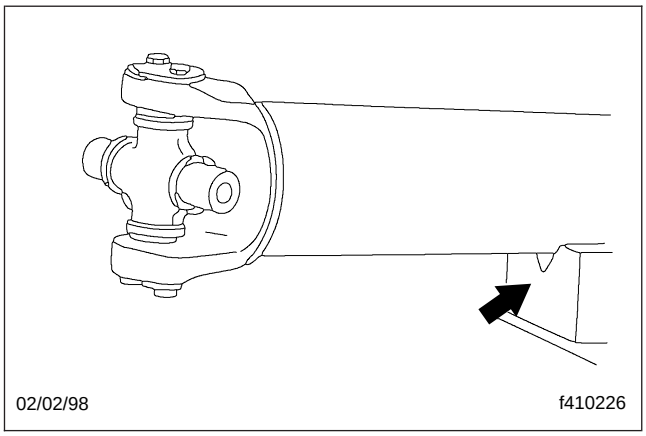

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Fig. 2, Driveshaft in V-Blocks

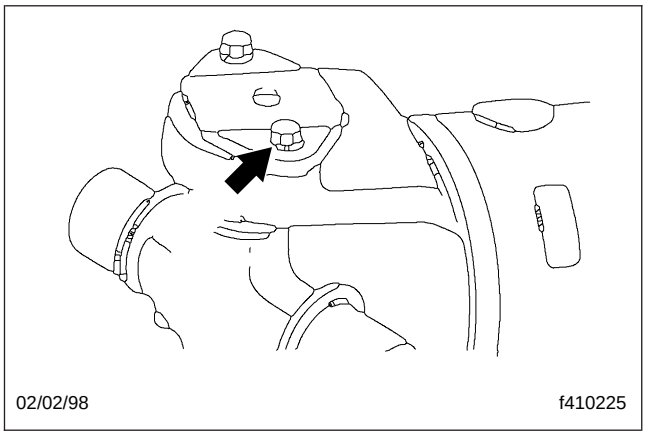

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Fig. 3, Serrated Retaining Bolts

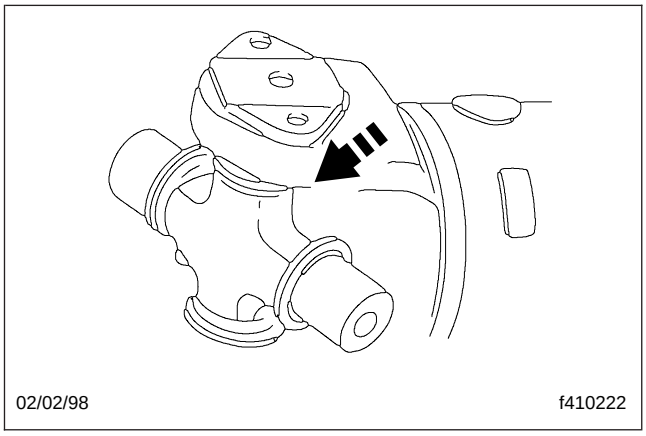

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Fig. 4, Tapping Bearing Cap

6. Remove the spider. See **Fig. 6**.
7. Clean and inspect the yokes. See **Fig. 7**.

Universal Joint Disassembly and Assembly

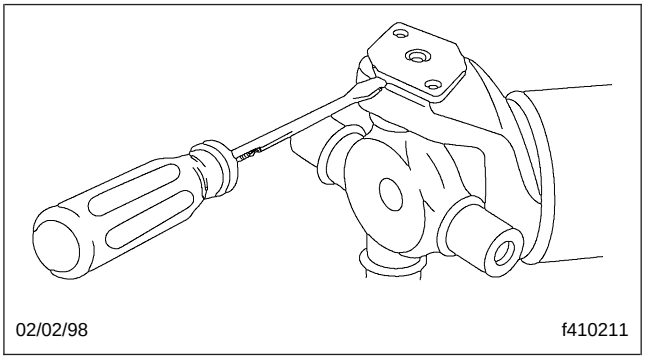

Fig. 5, Prying Bearing Cap

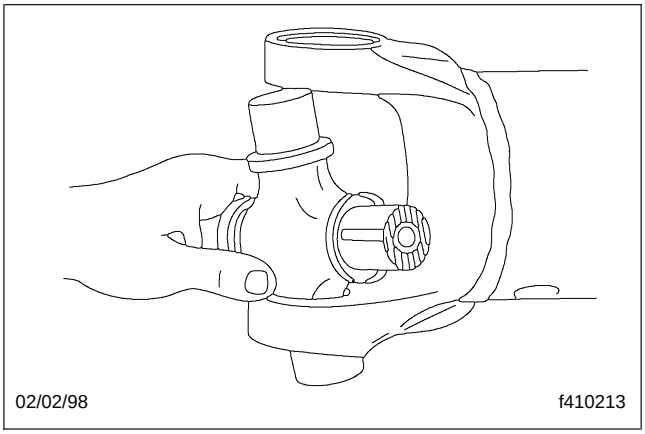

Fig. 6, Removing Spider

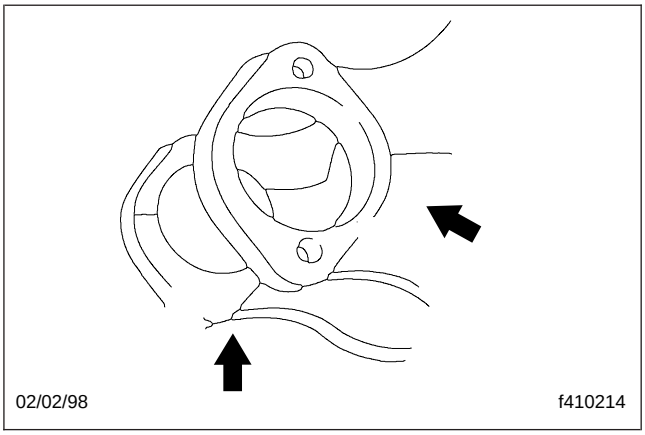

Fig. 7, Yoke Inspection

7.1 Inspect the crosshole surfaces for damage and raised metal.

Remove raised metal with a file or emery cloth.

7.2 Check the crossholes for wear and misalignment.

ASSEMBLY

1. Fill the journal passages with high-temperature 4x4 front axle and wheel bearing grease or equivalent meeting specification ESA–M1C198–A. See **Fig. 8**.

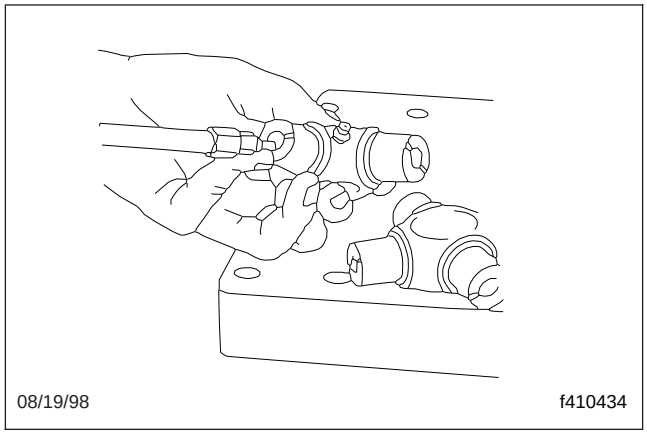

Fig. 8, Lubricating Universal Joints

2. Fill the bearing caps approximately one-third full with the same lubricant.
3. Lightly lubricate the seal lips with a lightweight oil to prevent seal damage during installation.
4. Apply anti-seize compound to the outside diameter of the four bearing assemblies.

NOTE: The lubrication fitting must point toward the driveshaft (inboard side). For slip-yoke installation, the fitting must also be in close orientation to the slip-yoke lubrication fitting.

5. Position the spider in the yoke, and install the bearing caps. Press or tap directly in the center of the cap with a soft drift. See **Fig. 9**.

⚠ CAUTION

Do not tap on the outer edges of the bearing cap or damage to the universal joint may result.

6. Install new serrated bolts. See **Fig. 3**.

NOTE: Lubricate with high-temperature 4x4 front axle and wheel bearing grease or equiva-

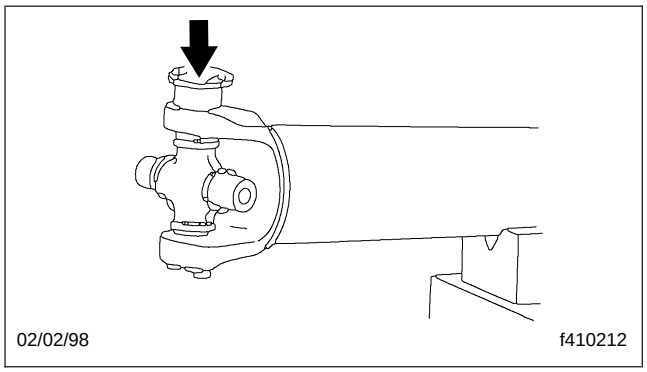

Fig. 9, Installing Bearing Caps

lent meeting specification ESA–M1C198–A through the zerk fittings.

7. Lubricate the U-joints, applying lubricant through the zerk fitting until fresh grease purges at each of the four seals. See **Fig. 10**.

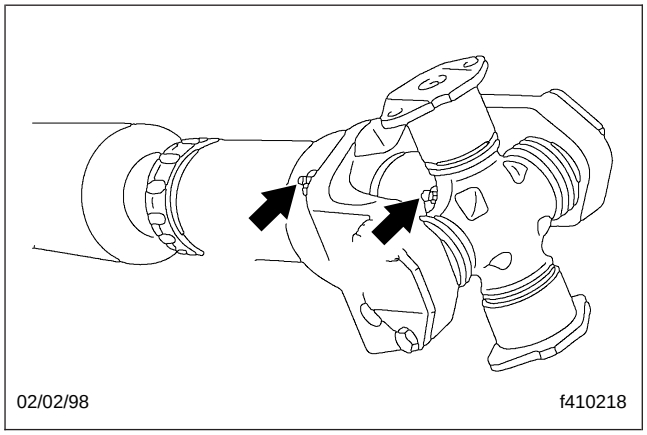

Fig. 10, Universal Joint Lubrication Points

8. Lubricate the slip-yoke, applying lubricant through the zerk fitting until it purges at the vent hole in the welch plug. Place a finger over the hole in the welch plug and apply the lubricant until it purges at the seal at the rear of the slip-yoke.

Outside Snap Ring Type Universal Joint

DISASSEMBLY (See Fig. 11)

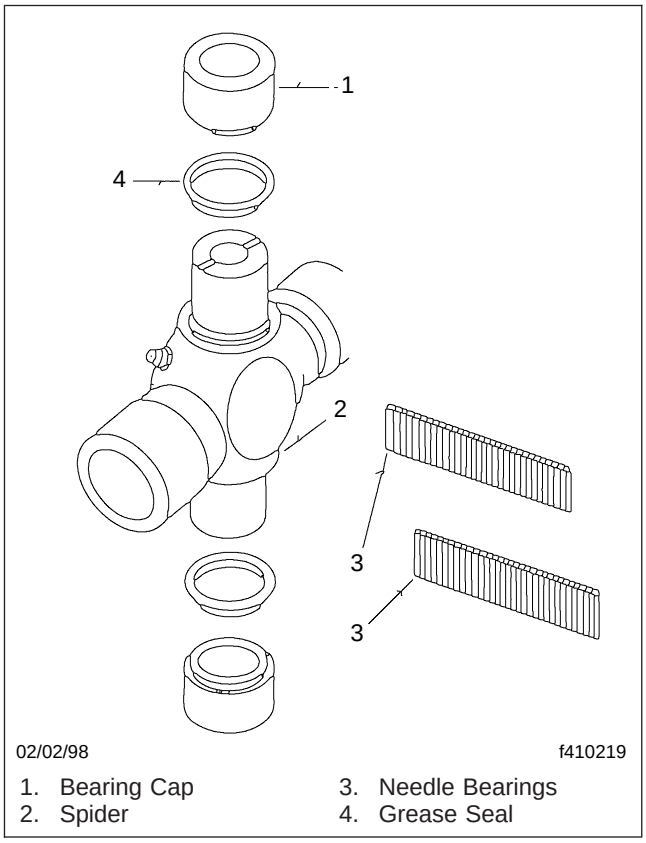

Fig. 11, Outside Snap Ring Type Universal Joint

CAUTION

Do not clamp the driveshaft in the jaws of a vise or similar holding fixture or damage to the driveshaft may result.

1. Place the driveshaft on a suitable workbench, being careful not to damage the tube.

NOTE: If components are not marked and therefore installed incorrectly, driveline imbalance may occur.

2. Index the driveshaft components. See **Fig. 12**.
3. Clamp U-joint tool in a vise. See **Fig. 13**.

Universal Joint Disassembly and Assembly

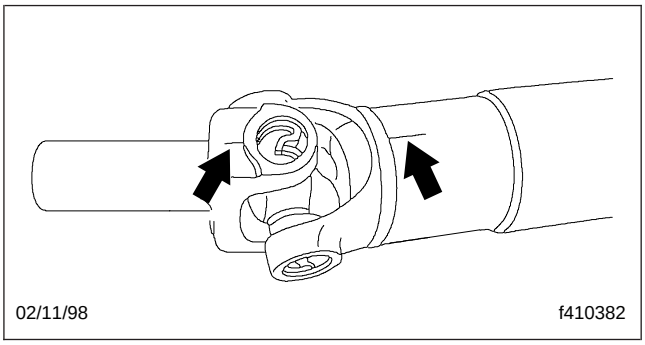

Fig. 12, Index Driveshaft Components

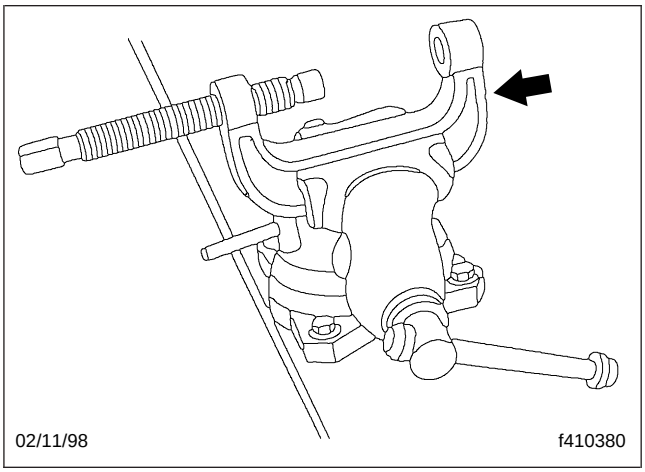

Fig. 13, U-Joint Tool

4. Remove the snap rings. See **Fig. 14**.

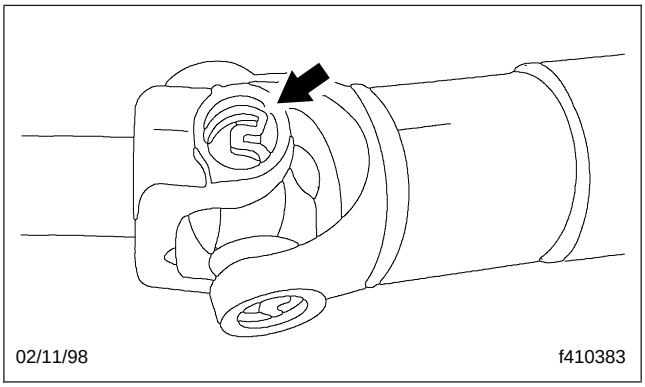

Fig. 14, Snap Ring

NOTE: If necessary, use a pair of pliers to remove the bearing cup if it cannot be pressed out all the way.

5. Remove the driveshaft slip-yoke. See **Fig. 15**.

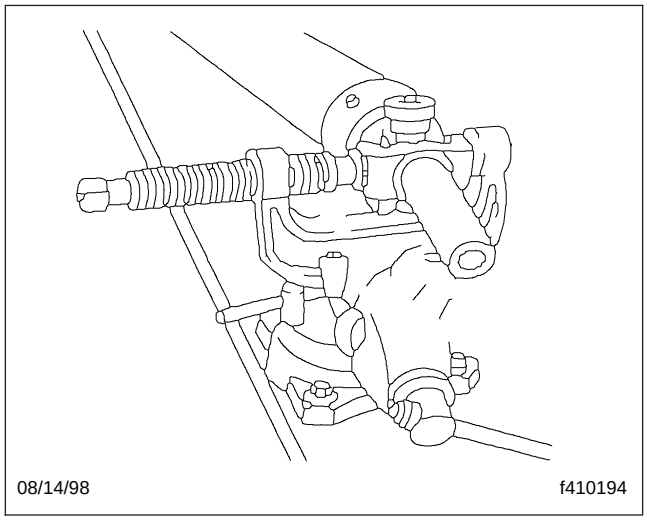

Fig. 15, Driveshaft Slip-Yoke Removal

5.1 Position the driveshaft slip-yoke in U-joint tool.

5.2 Press out the bearing cup.

5.3 Rotate the driveshaft slip-yoke.

5.4 Press on the spider to remove the remaining bearing cup.

5.5 Remove the driveshaft slip-yoke.

6. Repeat the previous step as needed to remove the remaining bearing cups, spiders and yoke from the driveshaft.

7. Clean the yoke area at each end of the driveshaft.

ASSEMBLY

NOTE: Universal joint service kits are to be installed as complete assemblies only. Do not use components from other universal joints.

1. Fill the journal passages with high-temperature 4x4 front axle and wheel bearing grease or equivalent meeting specification ESA–M1C198–A. See **Fig. 8**.

2. Fill the bearing caps approximately one-third full with the same lubricant.

NOTE: The lubrication fitting must point toward the driveshaft (inboard side).

3. Install the bearing cup. See **Fig. 16**.

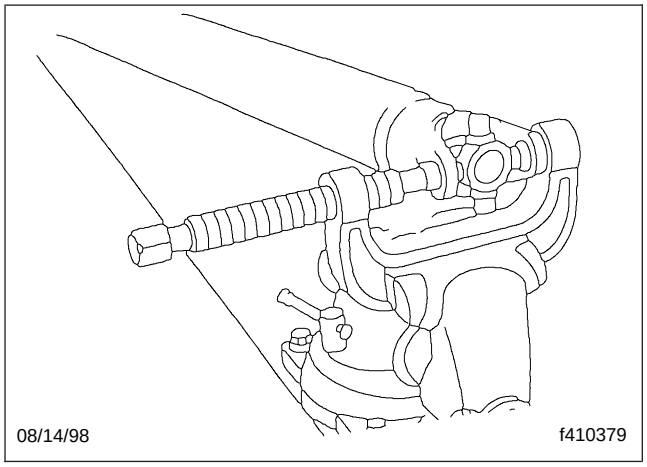

Fig. 16, Bearing Cup Installation

3.1 Start a new bearing cup into the driveshaft yoke.

3.2 Position the new spider in the driveshaft yoke.

3.3 Position the driveshaft in the U-joint tool.

3.4 Press the bearing cup just below the snap ring groove.

4. Remove the driveshaft from the U-joint tool and install the snap ring. See **Fig. 17**.

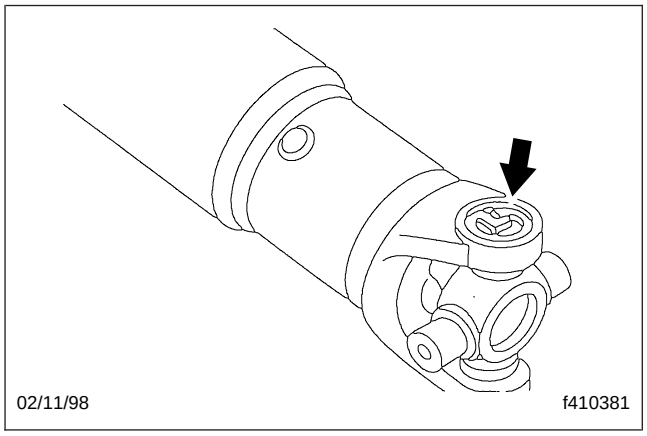

Fig. 17, Snap Ring Installation

5. Repeat the previous steps as needed for the opposite side of the driveshaft yoke.

NOTE: Re-index the slip-yoke and flange yoke.

6. Repeat the previous steps as needed to install the remaining new bearing cups, spider, and snap rings.

NOTE: Do not strike the bearings.

7. Check the U-joints for freedom of movement. If binding, strike the yoke with a brass or plastic hammer.

Driveline Cleaning and Inspection

SLIP-YOKE SPLINE

NOTE: Vehicle noise and vibration can be caused by a seized driveshaft slip-yoke spline resulting in the rubber isolator being pulled out of the driveshaft center bearing bracket.

NOTE: The repair procedure to minimize driveshaft slip-yoke spline contamination and ultimate seizure is as follows:

1. Disconnect the driveshaft from the rear axle yoke and remove it from the vehicle.
2. Clean the male splines of the coupling shaft, using care not to damage the plastic coating. Fine abrasive cloth may be required to dress and polish the male spline. Remove all hardened grease deposits, dirt or rust. Inspect for worn or galled splines. The plastic coating on the stub spline must not be removed. Replace the coupling shaft if necessary.
3. Clean and inspect the female splines of the driveshaft slip-yoke, removing any hardened grease deposits, dirt or rust. Inspect the splines for worn or galled conditions; replace the driveshaft slip-yoke if necessary.
4. Apply a coating of high-temperature 4x4 front axle and wheel bearing grease or equivalent meeting specification ESA–M1C198–A to the entire splined stub end of the coupling shaft prior to the assembling of the driveshaft to the coupling shaft.
5. Using a clean, long-handle (stencil-type) brush, apply high-temperature 4x4 front axle and wheel bearing grease or equivalent meeting specification ESA–M1C198–A, spread evenly on all the female splines of the slip-yoke. The spline joint must slide freely by hand.
6. Assemble the driveshaft to the coupling shaft with the yokes phased properly. Attach the driveshaft to the rear axle yoke.
7. Using a hand-type grease gun, lubricate the driveshaft slip-yoke through the zerk fitting with high-temperature 4x4 front axle and wheel bearing grease or equivalent meeting specification ESA–M1C198–A.

Driveline Lubrication

U-JOINTS

1. Apply high-temperature 4x4 front axle and wheel bearing grease or equivalent meeting specification ESA–M1C198–A through the zerk fitting until fresh lubricant purges at each of the four seals. This flushes abrasive contaminants from each bearing and ensures all four bearings are filled properly.
2. Move the driveshaft from side to side while applying gun pressure if any seal fails to purge. This allows greater clearance on the thrust end of the bearing that is not purging. See **Fig. 1**.

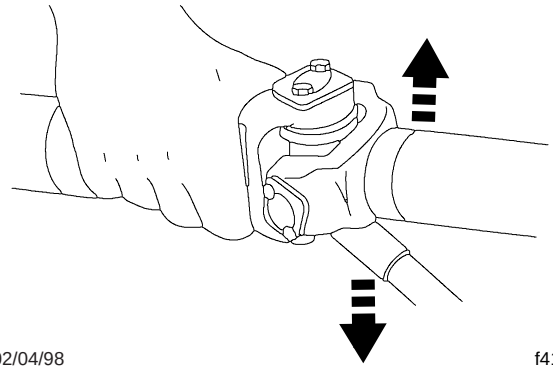

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Fig. 1, Moving Driveshaft from Side-to-Side

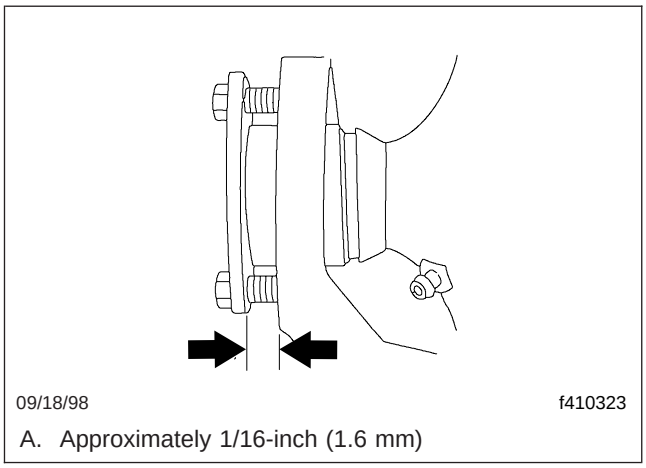
CAUTION

After lubricating, make sure that the bearing caps are firmly in place and that the retaining bolts are tightened per specifications.

3. If the seal still will not purge, release the seal tension by removing the bearing straps or loosening the bearing cap bolts and backing off the bearing cap assembly approximately 1/16 inch (1.6 mm). See **Fig. 2**.

SLIP-YOKE

1. Apply high-temperature 4x4 front axle and wheel bearing grease or equivalent meeting specification ESA–M1C198–A through the zerk fitting until the lubricant appears at the pressure relief hole



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A. Approximately 1/16-inch (1.6 mm)

Fig. 2, Backing Off Bearing Cap Assembly

in the welch plug at the slip-yoke end of the spline. See **Fig. 3**.

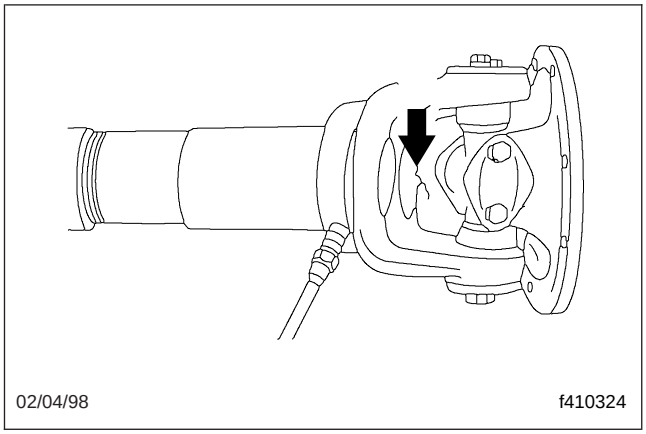

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Fig. 3, Welch Plug Pressure Relief Hole

2. After the lubricant appears at the pressure relief hole, cover the hole with a finger and continue to apply grease gun pressure until grease appears at the slip-yoke seal. See **Fig. 4**.

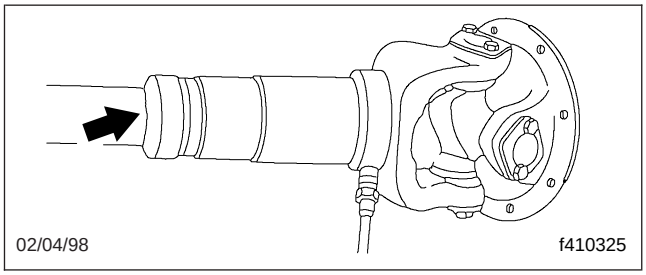

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Fig. 4, Slip-Yoke Seal

Troubleshooting

INSPECTION AND VERIFICATION

Certain driveline concern symptoms are also common to the engine, transmission, rear wheel bearing, tires and other parts of the vehicle. For this reason, be sure that the cause of the concern is in the driveline before adjusting, repairing or replacing any of the parts. Refer to **Group 00** in this manual.

U-Joint Inspection

Perform a visual inspection of the driveshaft and U-joints. Inspect for any buildup of foreign material, such as mud or undercoating, on the driveshaft or in the U-joints. Check the shaft for damaged or bent tubing or missing balance weights.

Lubricate the U-joints and road test the vehicle to see if the condition improves. Refer to "U-Joints" in **Subject 130**.

If the condition does not improve, perform the following steps:

1. Remove the driveshaft.
2. Manipulate the rear axle shaft universal joint in each direction of rotation. If the U-joint feels stiff or has a "lumpy," "gritty" feel in any direction, replace the rear axle shaft universal joint.

Specifications

Torque Specifications		
Description	**Size**	**lbf·ft (N·m)**
Bearing Cap Bolt	5/16–24	35–41 (47–56)
	3/8–24	45–60 (61–81)
Bearing Strap Bolt to U-Joint Yoke	3/8–16	35–42 (47–57)
	3/8–24	45–60 (61–81)
	1/2–20	115–135 (156–183)
Bolt, Yoke (1480 and 1550 Series) Attaching Parts per Joint 2 Straps 4 Bolts (Gr. 8) 4 Nuts (Gr. 8)	3/8–16 x 1.75	35–41 (47–56)
Bolt, Yoke (1610 Series) Attaching Parts per Joint 2 Straps 4 Bolts (Gr. 8)	3/8–24 x 0.75	45–60 (61–81)
Bolt, Yoke (1710, 1760 and 1810) Attaching Parts per Joint 2 Straps 4 Bolts (Gr. 8)	1/2–20 x 1.00	115–135 (156–183)
Center Bearing to Support	1/2–13	75–105 (102–142)
Driveshaft Center Bearing Support to Support Plate	7/6–14	50–70 (68–95)
	1/2–13	75–105 (102–142)
Nut — Yoke to Coupling Shaft or Intermediate Shaft	1–20	275–325 (373–440)
	1–1/4–18	475–550 (644–745)
Support Plate to Bracket	3/8–16 x 1.25	31–42 (42–57)
Support Plate/Bracket to Frame Crossmember	3/8–16 x 1.25	31–42 (42–57)

Table 1, Torque Specifications

General Specifications	
Item	**Specification**
Lubricants	
High-Temperature 4x4 Front Axle and Wheel Bearing Grease	ESA–M1C198–A
Premium Long-Life Grease	ESA–M1C75–B
Adhesives	
Stud and Bearing Mount	WSK–M2G349–A1
Black Non-Acid Cure Silicone Rubber Sealant	ESL–M4G273–A

Table 2, General Specifications

Driveshaft Alignment

CAUTION

Perform this procedure before adjusting components for correct driveshaft alignment.

1. Inflate all tires to the pressure at which they are normally operated.
2. Park the empty vehicle on a surface which is as nearly level as possible both from front-to-rear and side-to-side.
3. The tractor must be in its normal operating position. Do not attempt to level the truck by jacking up the front or rear axles to obtain a level condition.

NOTE: All angles must be read within one-quarter degree and they must be measured with the protractor held plumb on a clean, flat surface.

4. Determine driveshaft angles, using a suitable digital inclinometer or spirit level protractor. When angles are read from the 0-degree mark (horizontally on the driveshaft), record and use the angle shown on the protractor. See **Fig. 1**.

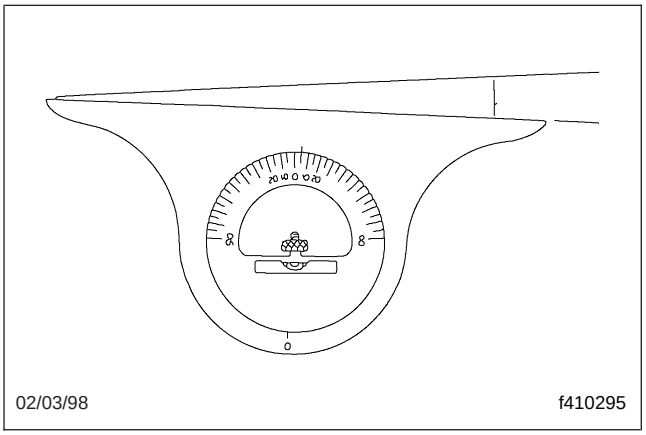


Fig. 1, Spirit Level Protractor

5. When angles are read from either of the 90-degree marks (vertically — on the flange), such as when measuring yoke angles, do not record the angle shown on the protractor since the 90-degree marks must be understood to be the same as 0 degrees on a horizontal plane. Thus, if a vertical reading is 85 degrees, the angle being measured is 5 degrees (90 degrees – 85 degrees = 5 degrees). See **Fig. 2**.

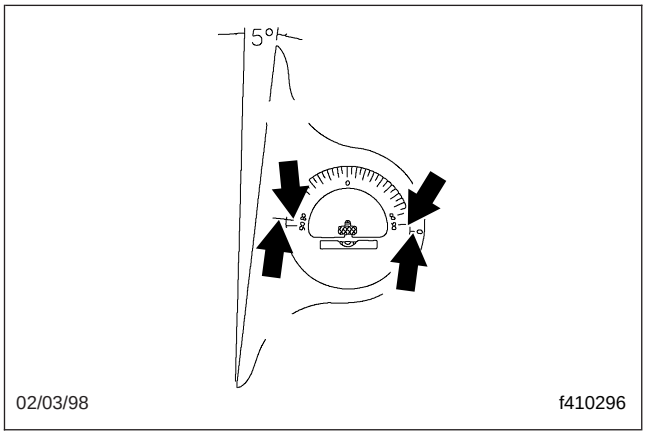


Fig. 2, Spirit Level Protractor Vertical Reading

Driveshaft Runout and Balance

DRIVESHAFT AND YOKE RUNOUT CHECK

NOTE: With the transmission in neutral, turn the rear wheel/drum to rotate the coupling shaft and driveshaft when checking runouts.

1. Check the coupling shaft for proper phasing. Check all U-joint to yoke installations for improperly seated U-joint bearing caps.

⚠ CAUTION

Measurements are to be made on the tube near the end welds, but not on them.

2. Check the runouts at the front and rear of the coupling shaft and the front, center and rear of the driveshaft. The runout check at the rear of the driveshaft is to be made on the tube, as close to the universal joint as possible. See **Fig. 1**.

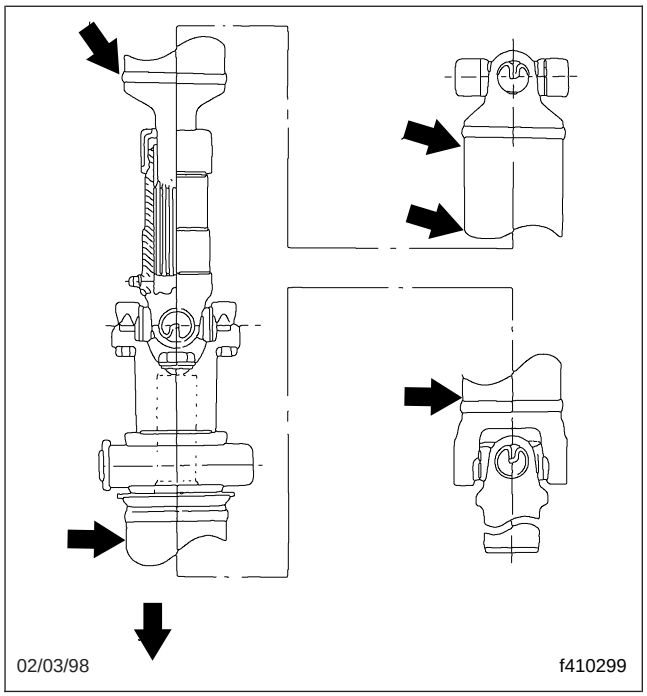


Fig. 1, Driveshaft Runout Check

NOTE: The runout at the rear of the driveshaft can be caused by either the driveshaft or the rear axle yoke.

3. Mark the points of the greatest runouts on the coupling shaft and driveshaft.
   - 3.1 If the runout on the coupling shaft or at the front or center of the driveshaft is equal to or greater than the specification given, replace the shaft.
   - 3.2 If the runout at the rear of the driveshaft is less than the specification given and the front and center runouts are also less than the specification given, proceed to driveshaft balancing.
   - 3.3 If the runout at the rear is more than the specification given and the front and center runouts are less than the specification given, mark the point of greatest runout on the shaft.
4. To determine the cause of the runout at the rear of the driveshaft, mark the U-joint and yoke, remove and rotate the driveshaft 180 degrees to the rear axle yoke, and check and mark the greatest runout at the rear of the driveshaft. If the runout is less than the specification given, evaluate on the hoist. Road test if the vibration is not present. Proceed to driveshaft balance if vibration is present. If the runout is more than the specification given, proceed to the following step.
5. Compare the first and second marks at the rear of the driveshaft to determine the cause of the runout. If the marks are within approximately 25.4 mm (1 inch), replace the driveshaft. If the marks are approximately on opposite sides of the shaft, replace the yoke.
6. After replacing either the driveshaft or rear axle yoke, recheck the runouts. If excessive runout is still evident after replacement of the rear axle yoke, it will be necessary to replace the ring gear and pinion and repeat the above checks until runout is within specifications.
7. Evaluate on a hoist. If the vibration is still present, proceed to "Driveshaft Balancing."

Driveshaft Runout and Balance

DRIVESHAFT BALANCING

Standard Procedure

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 the driveshaft separating from the vehicle, possibly causing loss of vehicle control that could result in serious personal injury or death.

NOTE: Vibration or shudder that is noticeable either on fast acceleration, when coasting, or when using the engine for braking can be caused by the rear axle housing being loose on the rear springs, improper tire balance, improper driveline installation or driveline imbalance.

NOTE: If detailed parts of the driveshaft are replaced and shaft vibration is encountered after installation, disconnect the shaft at the slip-spline. Rotate the slip-spline 180 degrees. Reconnect the shaft to the slip-spline. If the vibration persists, disconnect the shaft at the rear axle yoke. Rotate the rear axle yoke 180 degrees and reconnect the shaft to the yoke.

NOTE: If rotating the driveshaft 180 degrees does not eliminate vibration, the driveshaft may need to be balanced, using the following procedure. Two people are required to perform this operation: one in the vehicle, and one under the vehicle to make adjustments.

1. Raise the vehicle on a twin-post hoist so that both the front and rear axles are safely supported, with all wheels free to rotate.
2. With the transmission in gear, increase the vehicle speed to the maximum vibration level. Note and record the speedometer speed at this vibration level as a baseline speed.
3. Check the attachments of all U-joint bearing caps of the driveshaft or coupling shaft to the transmission yoke, front or rear axle pinion yokes and all transfer unit drive yokes for improper installation or damaged U-joint bearing cap locating lugs. All yokes with worn, shaved or damaged locating lugs must be replaced.
4. Check the driveshaft and coupling shaft for correct phasing.

WARNING

Do not wear loose clothing that could get caught on the rotating shaft.

Use caution when checking the driveshaft near the balance weights, to prevent injury to the hands.

5. With the transmission (and transfer unit) in gear, run the vehicle with the driveshaft and coupling shaft rotating at a speedometer speed of 40 to 50 mph (65 to 80 km/h). Carefully bring a crayon, piece of chalk, or colored pencil up until it just barely contacts the rear end, center and front end of the driveshaft. The chalk marks will indicate the heavy side of the driveshaft. See **Fig. 2**.

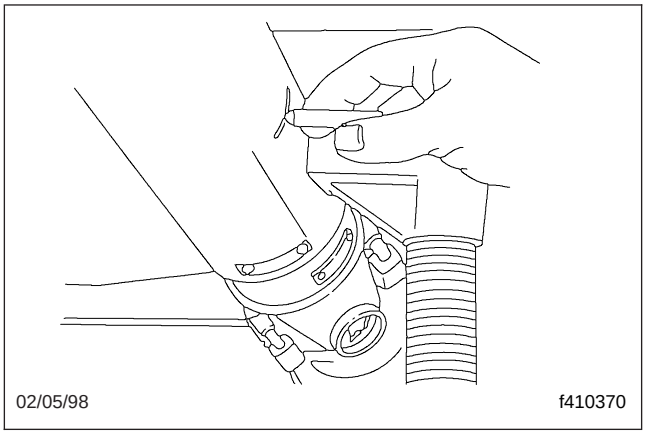


Fig. 2, Marking the Driveshaft

6. Install two screw-type hose clamps on the driveshaft so that their heads are located 180 degrees from the chalk mark, starting at the pinion yoke end of the driveshaft. Tighten the clamps and cut off the excess band from the clamps. See **Fig. 3**.
7. Run the vehicle up to the baseline speed. If vibration is still evident, rotate the clamps approximately 90 degrees away from each other and test for correction of vibration. See **Fig. 4**.

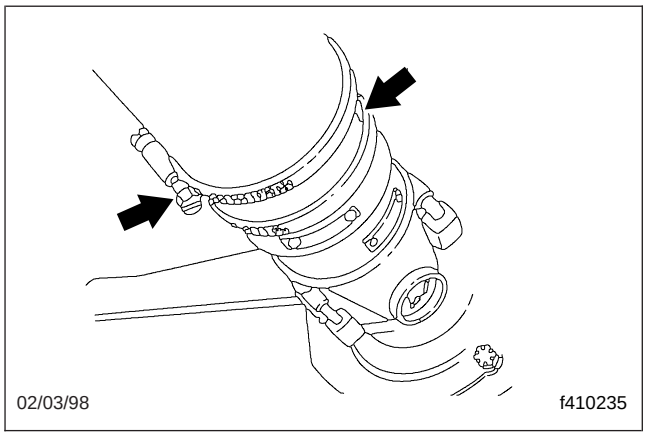


Fig. 3, Installing Screw-Type Hose Clamps

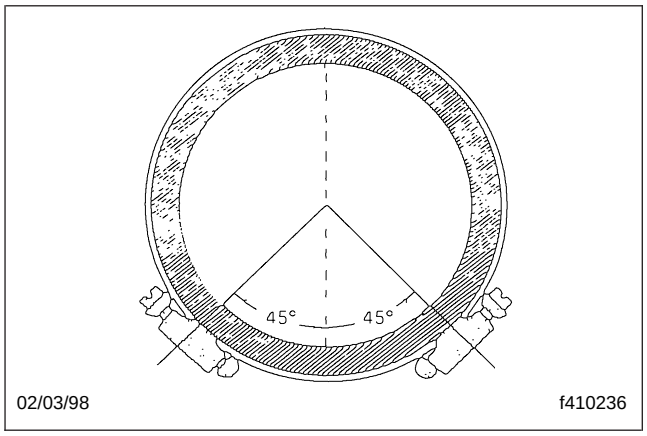


Fig. 4, Rotating Clamps 90 Degrees

8. If necessary, continue to rotate the clamps apart in smaller increments until the vibration is eliminated or begins to be reduced.
9. If the vibration is not completely eliminated, repeat this procedure and balance the front end of the driveshaft, checking for elimination or reduction in the vibration level.

⚠ CAUTION

To prevent overheating, do not run the vehicle on the hoist for an extended period.

10. To completely eliminate the driveline vibration, it may be necessary to balance the coupling shaft, following the same procedure as for the driveshaft.
11. Remove the vehicle from the hoist and road test.

Alternate Procedure

1. Road test. Evaluate and record the road speed at which the vibration occurs.
2. Raise the vehicle on a twin-post hoist or jack stands and re-evaluate by starting the engine, engaging the transmission and accelerating to the indicated speeds at which the vibration was most severe during the road test.
3. Disconnect the driveshaft from the axle yoke. Rotate the driveshaft 180 degrees from its original position and reinstall. Repeat the previous step. In some cases, rotating the driveshaft 180 degrees may decrease the vibration to an acceptable level. However, if the vibration level is increased, install the driveshaft in its original position and proceed to the following step.
4. A vehicle is more sensitive to excessive imbalance and runout at the rearward end of the driveshaft; therefore, locate the heavy side of the driveshaft by the use of a strobe light, such as the electronic strobe balancer and transducer.
5. Remove the rear wheels and tires, and reinstall all the wheel lug nuts in reverse, flat side of the nuts toward the drum or disc to avoid lug nut imbalance and to prevent the drum or disc from dislodging.
6. Scribe an axial chalk line (at any radial location) approximately 4 inches (101 mm) long at the rear of the driveshaft.
7. Locate the transducer so it is contacting the bottom side of the differential carrier and secure it in place. See **Fig. 5**.
8. Run the engine and driveline at the worst vibration speed noted and visually note the position of the chalk line by use of the strobe light. This provides a starting point for the initial location of the hose clamps.
9. Stop the engine and rotate the driveshaft so that the chalk line is in the same position as was noted under the strobe light. See **Fig. 6**.
10. Install two screw-type (stainless steel) hose clamps on the driveshaft. Position the clamp heads 180 degrees from the transducer and tighten the clamps. See **Fig. 7**.

Driveshaft Runout and Balance

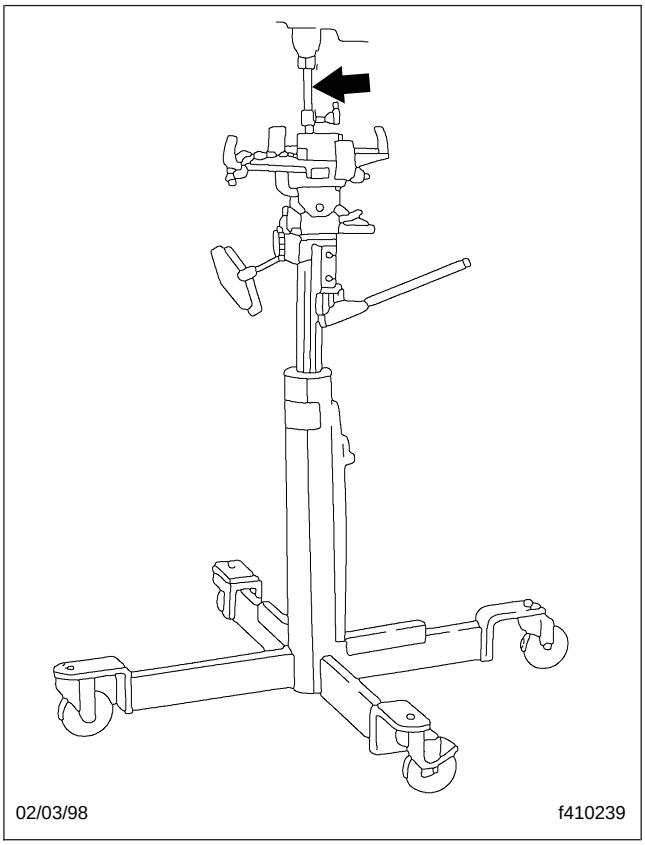


Fig. 5, Locating the Transducer

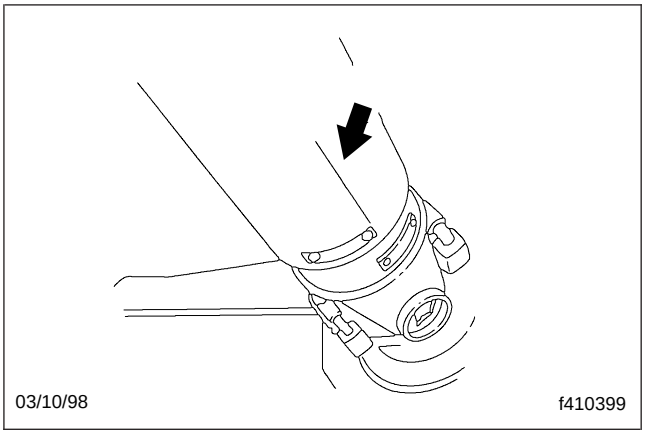


Fig. 6, Positioning the Chalk Line

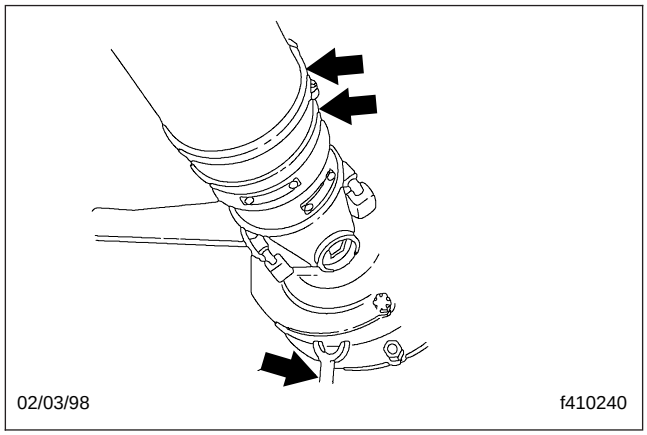


Fig. 7, Positioning the Hose Clamps 180 Degrees from the Transducer

⚠ CAUTION

Do not run the engine with the transmission engaged on the hoist for extended periods due to the danger of overheating the engine and transmission.

11. Run the engine and driveline through the speed range. If no vibration is felt, remove the lug nuts, install the wheels and tires, reinstall the lug nuts in the correct position and proceed to the last step in this procedure. However, if any vibration still exists, the combined weight of the two hose clamp heads may be excessive. To reduce this excess weight, rotate the clamp heads away from each other approximately 15 degrees (one each way from the original position). Run the engine and driveline and note if the vibration has been reduced.
12. Continue to rotate the clamp heads apart in smaller angular increments until the feel of balance is best. At this point, install the wheels and tires as described in the previous step and road test the vehicle to determine the actual degree of improvement. If satisfactory improvement has been obtained, proceed to the following step. If no improvement has been obtained, the clamps must be removed and diagnosis redirected to other areas, such as wheels, tires, driveline angle and yoke runout.
13. When the vehicle has been corrected to a satisfactory level, as determined by a road test evaluation, tighten the clamps securely. Clean thor-

oughly with lacquer thinner, and spray the clamps with a commercially available black paint for a finished appearance.

Universal Joint Phasing

NOTE: When universal joint yokes are assembled to their shafts in the same plane, they are in phase. When they are assembled to the shafts in different planes, they are out of phase.

NOTE: On vehicles with a slip-spline on the last coupling shaft, the yoke, which is part of the slip-yoke assembly, should be considered part of the coupling shaft. See **Fig. 1**.

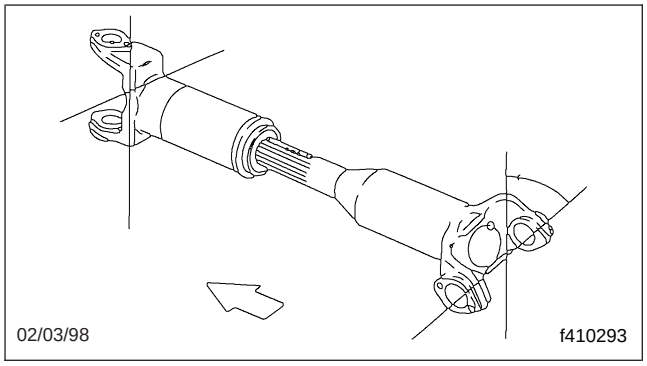


Fig. 1, Slip-Yoke Assembly

CAUTION

Do not revise universal joint phasing unless approved by engineering.

1. Check and correct universal joint phasing, as necessary, according to the following specifications (see **Fig. 2**):
   - 1.1 The universal joints between the rear axle and transmission must be in phase.
   - 1.2 The universal joints between tandem rear axles must be in phase (parallel).
   - 1.3 Tandem axle models will often require 90° phasing on one shaft of a 2-piece driveline.
2. Mark splined main driveline components prior to disassembly, to ensure reassembly in the same relative orientation.

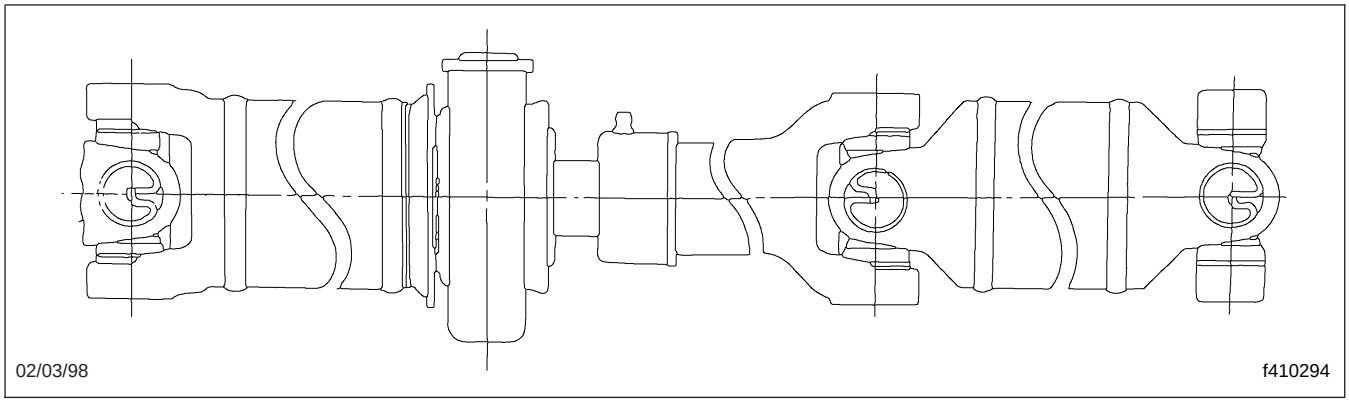


Fig. 2, U-Joint Phase

Driveshaft Angle Checking and Adjustment

SINGLE REAR AXLES

1. Check and record the angle of the engine and main transmission. This reading can be taken at the rear of the main transmission on the output yoke or flange. Record this reading. See **Fig. 1**.

   EXAMPLE: 1 degree (down from horizontal)

2. Check the angle of the driveshaft. Record this reading.

   EXAMPLE: 4 degrees 30 min. (down from horizontal)

3. Check the axle yoke angle. Record this reading.

   EXAMPLE: 2 degrees (down from horizontal)

4. Subtract the engine and main transmission angle from the driveshaft angle.

   4° 30 min. (driveshaft angle down from horizontal) -1° (engine and main transmission angle down from horizontal) = 3° 30 min. (transmission output shaft U-joint operating angle down from horizontal)

5. Use the axle yoke angle, and subtract it from the driveshaft angle.

   4° 30 min. (driveshaft angle down from horizontal) -2° (axle yoke angle down from horizontal) = 2° 30 min. (axle yoke U-joint operating angle down from horizontal)

6. Now, subtract the sum of the engine and main transmission angle minus the driveshaft angle from the sum of the axle yoke angle minus the driveshaft angle.

   3° 30 min. (transmission output shaft U-joint operating angle down from horizontal) -2° 30 min. (axle yoke U-joint operating angle down from horizontal) = 1° (U-joint operating angle difference)

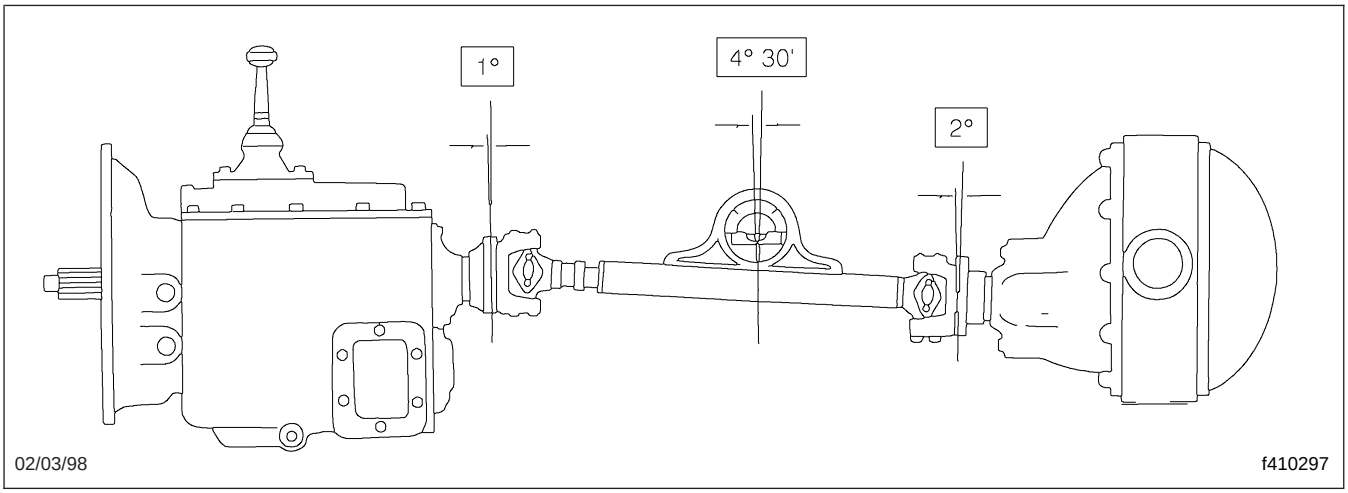


Fig. 1, Single Rear Axle Driveshaft Angles

TANDEM AXLES

CAUTION

This procedure must be performed for all tandem axle suspensions in which both axle pinion angles are set by longitudinal torque rod lengths and adjusted by varying the number of shims under the torque rod mounting brackets at the frame crossmember.

CAUTION

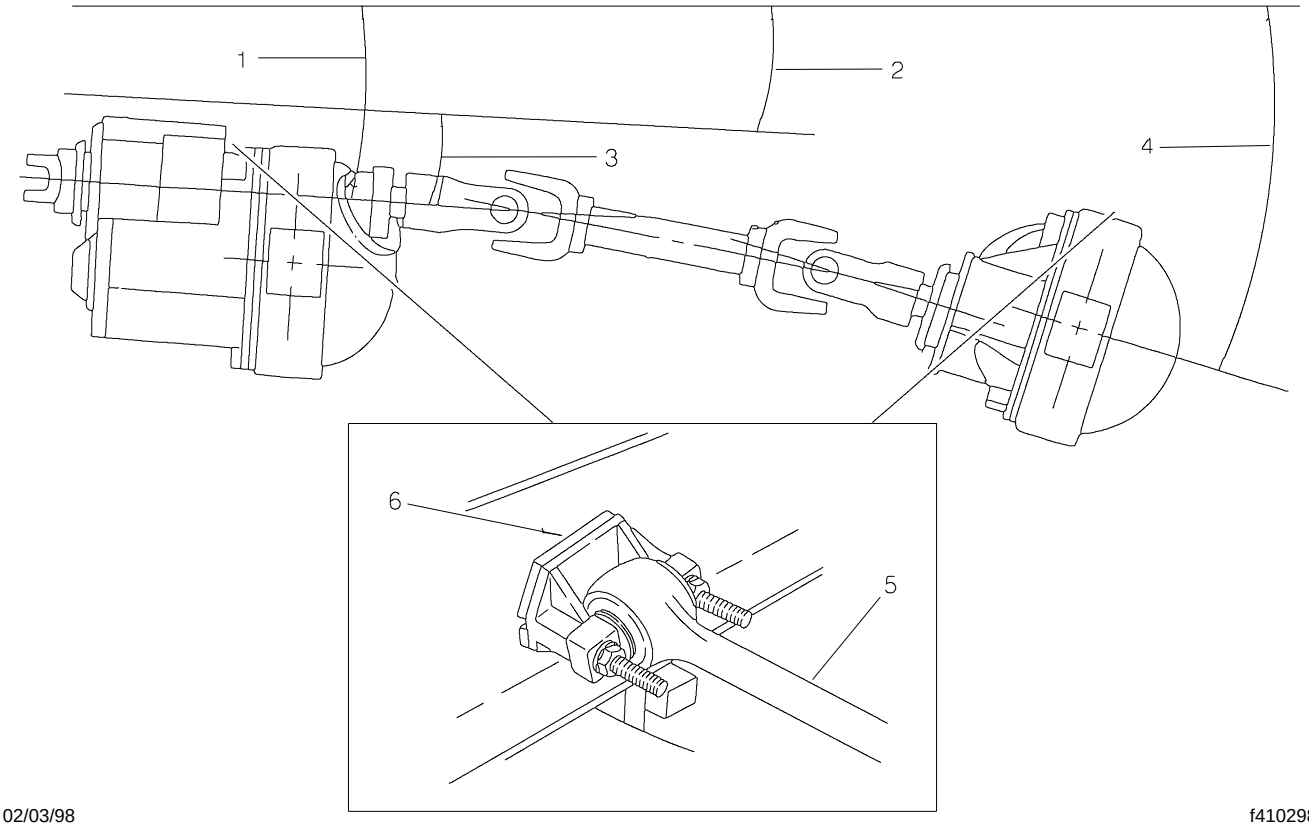
Before measurements are made, make sure the vehicle is in cab-chassis condition and tires are inflated to normal pressure ±69 kPa (10 psi).

Before any angles are measured, the vehicle must be standing on a level surface.

Driveshaft Angle Checking and Adjustment

1. With the forward torque arm installed, measure the forward axle pinion angle vs. the horizontal to the nearest 5 minutes, using a vernier inclinometer or electronic level gauge. The measuring instrument must be calibrated to provide repeated readings within ± 5 minutes of 0 degrees when placed on the level surface. See **Fig. 2**.

NOTE: Compare the calculated difference of the angles to the range shown for the suspension. Refer to the "Tandem Axle Angle Settings" table in **Subject 400**. If the measurement is within the specified range, the forward pinion angle is correct.



1. Forward Axle Pinion Angle vs. Horizontal
2. Engine/Transmission Angle vs. Horizontal
3. Difference Angle
4. Rear Axle Pinion Angle vs. Horizontal
5. Torque Rod
6. Shims

Fig. 2, Tandem Axle Driveshaft Angles

2. Measure the slope of the engine and transmission vs. the horizontal with the same inclinometer resting against a machined surface known to be parallel to the crankshaft (the manufacturing pads on some transmission cases are a suitable surface).
3. Subtract this angle from the forward axle pinion angle to obtain the difference in the angles.
4. Add or remove shims from the forward torque rod bracket to bring the measured forward axle pinion angle within the range specified for the suspension in the chart. Each thick shim (Part No. E4HT–4N002–CA or equivalent, 0.12-in. thick) will subtract approximately 22 minutes from the forward axle pinion angle (reverse for Neway air suspensions). Each thin shim (Part No. E4HT–4N002–BA or equivalent, 0.06-in. thick) will subtract approximately 11 minutes from the

forward pinion angle. Repeat the procedure following any change in the number of shims under the forward torque rod bracket.

5. With the rear torque arm installed, measure the rear axle pinion angle vs. the horizontal to the nearest five minutes, using the same gauge as for the forward axle.

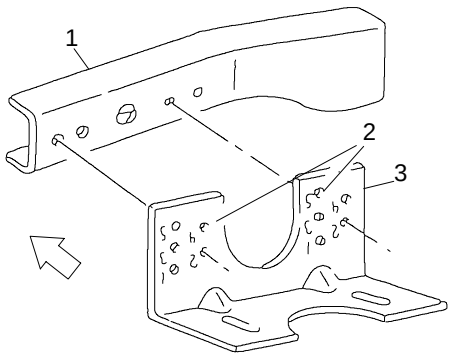
NOTE: Compare the measured rear pinion angle to the range shown for the suspension Refer to the "Tandem Axle Angle Settings" table in **Subject 400**. If the measurement is within the specified range, the rear pinion angle is correct.

6. Add or remove shims from the rear torque rod bracket to bring the measured rear axle pinion angle within the range specified for the suspension in the chart. Each thick (0.12-in.) shim will add approximately 22 minutes to the rear axle pinion angle. Each thin (0.06-in.) shim will add approximately 11 minutes to the rear pinion angle. Repeat the procedure following any change in the number of shims under the rear torque rod bracket.

Adjustable Driveline Support Plate Position Adjustment

Adjustment

NOTE: An adjustable driveline support plate is used on some applications. Although it can be mounted in any one of several positions, only one position is correct for a specific application. See **Fig. 1**.



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1. Crossmember
2. Hole Set Numbers
3. Support Plate

Fig. 1, Adjustable Driveline Support Plate

1. Determine the correct position of the support plate part number shown on the Truck Specification List attached to each vehicle.

   1.1 The numerical digit in the adjustable support plate part number suffix indicates the hole set to be used. For example, FGHT–CA1 requires that the FGHT–4831–CA support plate be bolted to the crossmember (or 4691 bracket — some installations) through support plate hole set number 1.

   1.2 The hole sets are identified by the numbers 1 through 4 or 5 stamped into the support plate.

NOTE: The leg of the support plate must always face the rear of the vehicle.

2. Assemble the support plate to the crossmember through the hole set identified in the support plate part number suffix.

Specifications

Tandem Axle Angle Settings							
Axle Description	**RT40-145**						
Suspension Type	RT2-400 and RTA2-380	RS-400 and RSA-380	RTE2-400 and RTEA2-380	RT2-400	RTE2-400	Neway AD-246	Neway AD-246
Axle Spread, Inches	52.00	52.00	52.00	60.00	60.00	60.00	54.00
"AD" Front Pinion Difference Angle							
Minimum	2° 00 Minutes	1° 00 Minutes	3° 05 Minutes	1° 55 Minutes	3° 00 Minutes	0° 20 Minutes	0° 20 Minutes
Maximum	2° 25 Minutes	1° 30 Minutes	3° 30 Minutes	2° 25 Minutes	3° 25 Minutes	0° 50 Minutes	0° 50 Minutes
(Ref.) Front Shims (0.12 & 0.06 Inch Thick)	6 Thick & 1 Thin	5 Thick & 1 Thin	3 Thick & 1 Thin	8 Thick & 1 Thin	3 Thick & 1 Thin	3 Thick & 1 Thin	3 Thick & 1 Thin
Rear Pinion Angle "DH" to Horizontal							
Minimum	11° 35 Minutes	11° 15 Minutes	11° 15 Minutes	9° 35 Minutes	9° 10 Minutes	9° 50 Minutes	10° 50 Minutes
Maximum	11° 55 Minutes	11° 45 Minutes	11° 45 Minutes	10° 05 Minutes	9° 35 Minutes	10° 10 Minutes	11° 10 Minutes

Table 1, Tandem Axle Angle Settings

Tandem Axle Angle Settings							
Axle Description	**RT34-145 & RT40-145**		**RT46-160**				
Suspension Type	U2-340	UE2-340	RT2-460	RS-460	RT2-460	Neway AD-246	Neway AD-246
Axle Spread, Inches	52.00	52.00	54.00	54.00	60.00	60.00	54.00
"AD" Front Pinion Difference Angle							
Minimum	1° 55 Minutes	3° 10 Minutes	2° 00 Minutes	1° 00 Minutes	1° 55 Minutes	0° 20 Minutes	0° 20 Minutes
Maximum	2° 20 Minutes	3° 30 Minutes	2° 25 Minutes	1° 30 Minutes	2° 25 Minutes	0° 50 Minutes	0° 50 Minutes
(Ref.) Front Shims (0.12 & 0.06 Inch Thick)	6 Thick	5 Thick	6 Thick & 1 Thin	5 Thick & 1 Thin	8 Thick & 1 Thin	3 Thick & 1 Thin	3 Thick & 1 Thin
Rear Pinion Angle "DH" to Horizontal							
Minimum	11° 10 Minutes	11° 15 Minutes	10° 50 Minutes	10° 30 Minutes	9° 35 Minutes	9° 50 Minutes	10° 50 Minutes
Maximum	11° 35 Minutes	11° 45 Minutes	11° 10 Minutes	10° 55 Minutes	10° 05 Minutes	10° 10 Minutes	11° 10 Minutes

Table 2, Tandem Axle Angle Settings

General Information

PARKING BRAKE CONTROL VALVE

(See Fig. 1)

The parking brake control valve is a push-pull operated valve with a square, yellow knob mounted on the instrument panel.

The parking brake control valve:

- Can be pulled out to exhaust air from the spring brake portion of the brake air chambers to apply the spring brakes when parking the vehicle;
- Can be pushed in to supply air to the spring brake chambers to release the spring brakes;
- Will automatically pop out from the release (in) position to the apply (out) position when the primary and secondary air reservoirs are reduced below 25 to 45 psi (241 to 310 kPa).

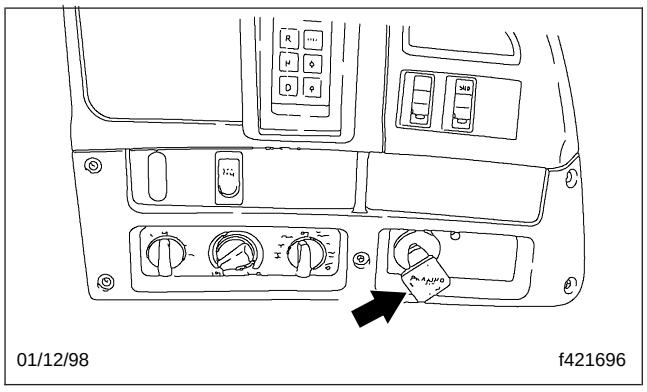

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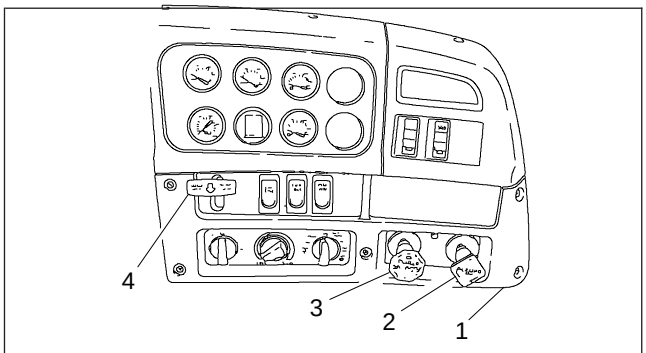
Fig. 1, Parking Brake Control Valve

TRAILER AIR SUPPLY CONTROL VALVE (See Fig. 2)

The trailer air supply control valve has two push-pull knobs, a square yellow parking brake control and an octagonal, red trailer air supply. The trailer air supply control valve is mounted on the instrument panel.

During initial charge, with the system completely discharged, both knobs are out. When system pressure reaches 65 psi (450 kPa), the red knob (trailer supply) can be pushed in and should stay in, charging the trailer system and releasing the trailer spring



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1. Instrument Panel Finish Panel
2. Parking Brake Control
3. Trailer Air Supply
4. Trailer Brake Hand Control Valve

Fig. 2, Trailer Air Supply Control Valve

brakes. The yellow knob can now be pushed in, which will supply air to release the tractor spring brakes.

With both knobs pushed in, air is supplied to the trailer and to the tractor spring brakes; all brakes are released. See **Fig. 3**.

To apply only the trailer brakes, the red knob is pulled out, exhausting the trailer supply line. The trailer spring brakes are now applied. This mode is used to uncouple from the trailer and during bobtail operation. See **Fig. 4**.

With both knobs pushed in for normal run modes, the parking brakes on both the tractor and trailer can be applied by pulling the yellow (parking brake control) knob out, which exhausts the air from the tractor spring brakes and simultaneously causes the red (trailer supply) knob to pop out, applying the trailer spring brakes. See **Fig. 5**. This complies with the federal regulation that one control must apply all the parking brakes on the vehicle.

If both knobs are out when parking the combination vehicle and it is desired to recharge the trailer (leaving the tractor spring brakes applied), the red knob can be pushed in, repressurizing the trailer supply line. See **Fig. 6**. This mode can also be used to park a combination vehicle with air-actuated parking brakes on the trailer to provide demonstrated parking capability with tractor spring brakes only.

With both knobs pushed in, in the normal run configuration, if the supply pressure to the trailer air supply control valve is reduced to approximately 35 to

General Information

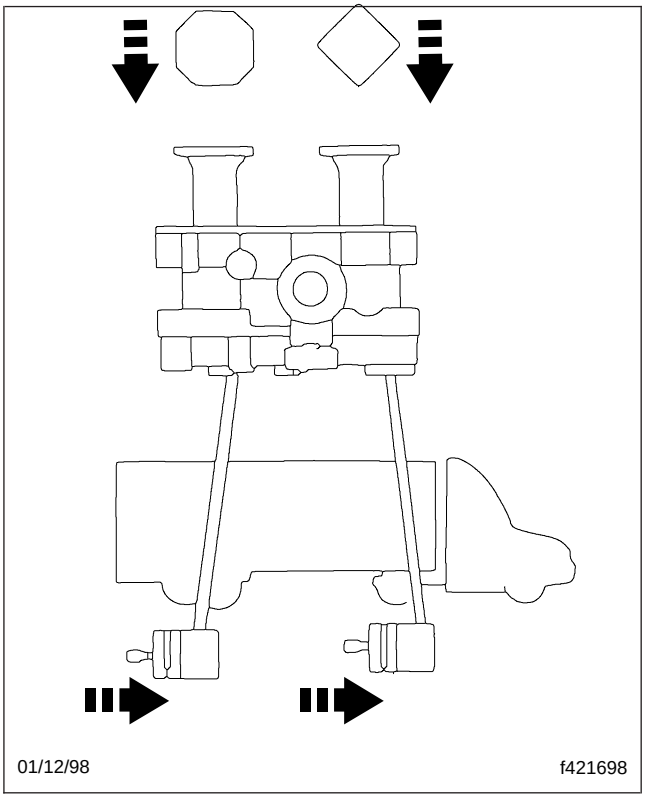


Fig. 3, Normal Operating Position, All Brakes Released

45 psi (241 to 310 kPa), the red knob (trailer supply valve) must pop out, applying the spring brakes on the trailer. If the red knob is held in manually and the pressure decreases to approximately 25 to 35 psi (172 to 241 kPa), a tripper piston within the trailer air supply control valve will move upward, exhausting the trailer supply, effecting the required non-override feature. The yellow (parking brake control) knob will pop out at approximately 20 to 30 psi (138 to 207 kPa).

The No. 1 service reservoir will at all times be selected as the primary supply source for the trailer air supply control valve. This is accomplished automatically by the function of the dual circuit supply valve contained in the body of the trailer air supply control valve. Only in the event of a pressure drop of more than 30 psi (207 kPa) below that of the No. 2 service reservoir will the dual circuit supply valve shuttle and establish the No. 2 service reservoir as the supply.

The spring brake chambers are part of the brake air chambers. See **Fig. 7**. The spring brake chambers contain a powerful spring used instead of air pressure to apply the vehicle brakes. See **Fig. 8**. The spring is kept compressed by air pressure, which is controlled by the parking brake control or the trailer air supply control valve.

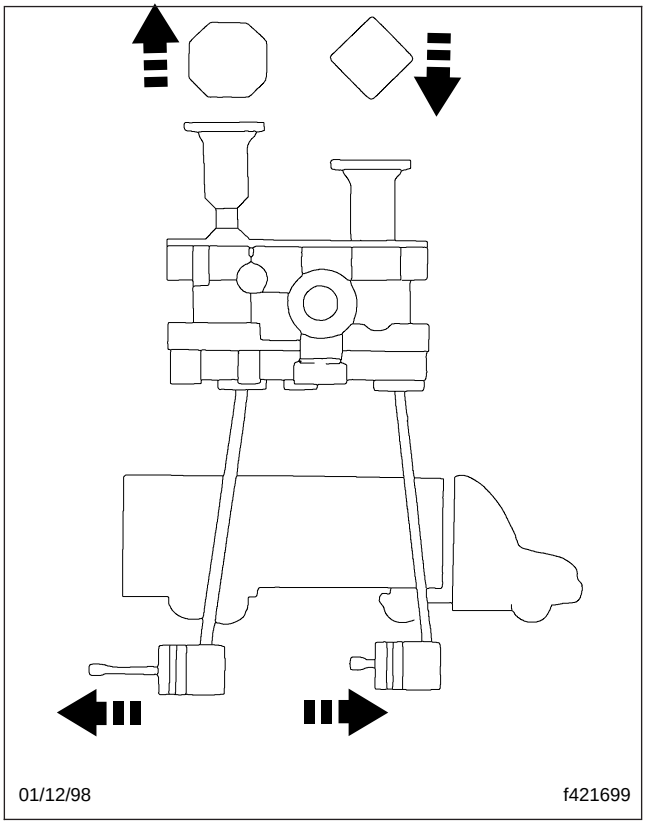


Fig. 4, Trailer Brakes Applied, Tractor Brakes Released

The quick release valve (see **Fig. 9**) controls the exhaust of air from the spring brake chambers. The valve is located near the brake air chambers. The nearer the exhaust port where the air pressure can be released, the more quickly the spring brakes can be applied.

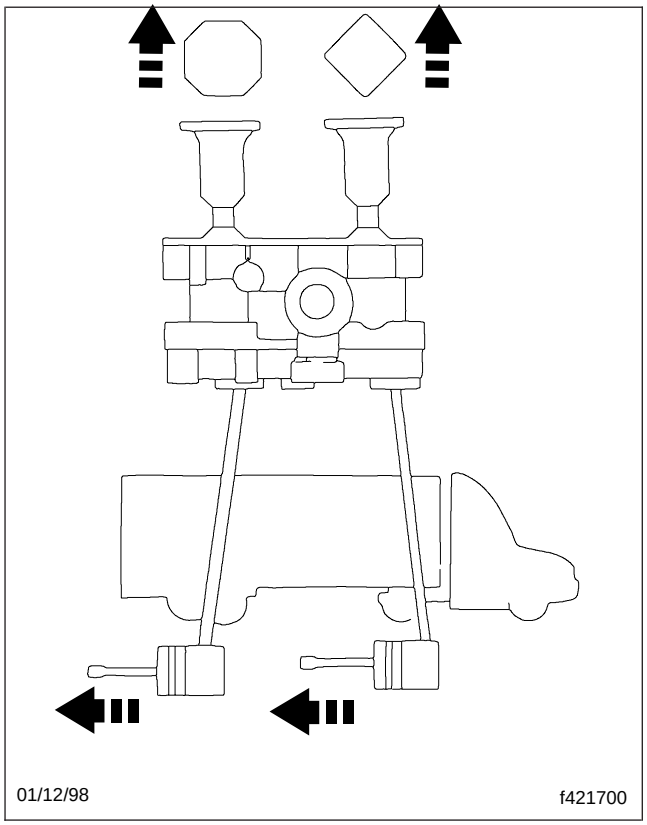


Fig. 5, System Park, Tractor and Trailer Brakes Applied

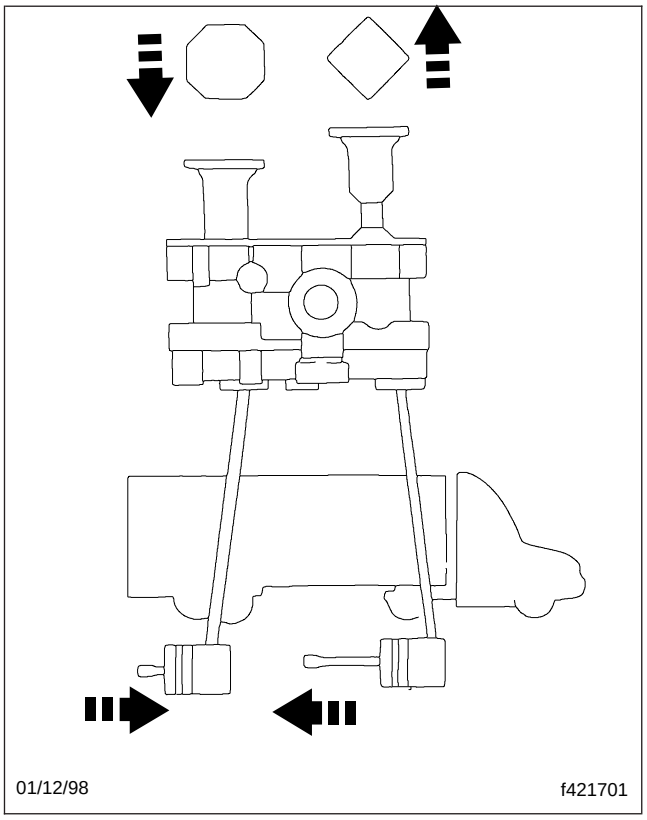


Fig. 6, Trailer Brakes Released, Tractor Brakes Applied

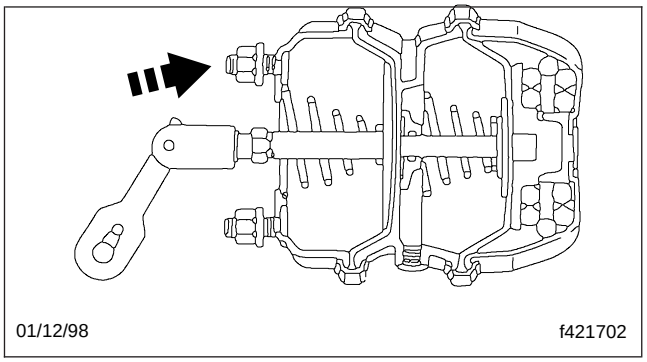


Fig. 7, Brake Air Chamber, Spring Brake Released

General Information

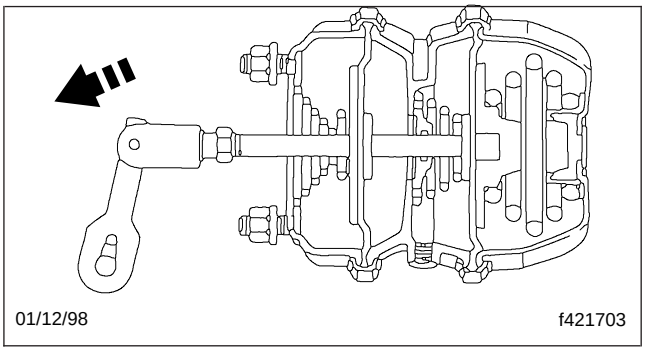
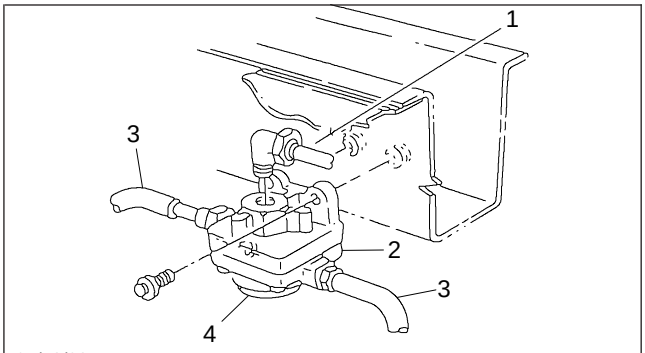


Fig. 8, Brake Air Chamber, Spring Brake Applied



1. Tubing from Relay Valve or Modulator Valve
2. Quick Release Valve
3. Jounce Hose to Spring Brake Chamber
4. Exhaust Port

Fig. 9, Quick Release Valve

Trailer Air Supply Control Valve Removal and Installation

Removal

NOTE: Match-mark the knobs to aid installation.

1. Remove the parking brake control, the trailer air supply and the trailer brake hand control valve knobs. See **Fig. 1**.

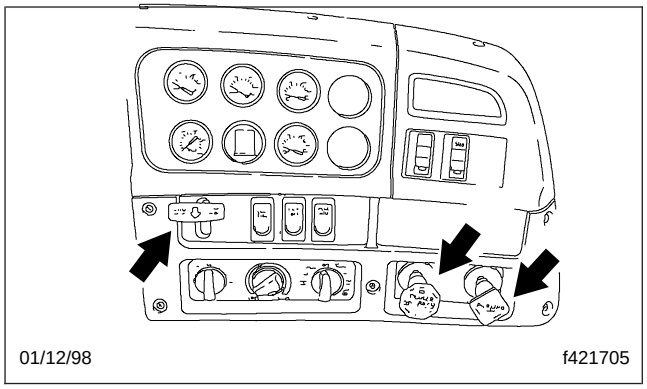


Fig. 1, Parking Brake Control, Trailer Air Supply and Trailer Brake Hand Control

2. Remove the eight screws from the instrument panel finish panel. See **Fig. 2**.

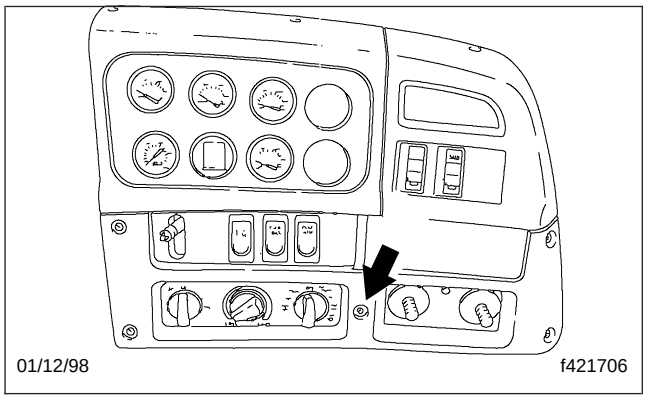


Fig. 2, Instrument Panel Finish Panel Screw

3. Position the instrument panel finish panel out of the way.

NOTE: Match-mark the air lines 1 through 4 to aid installation.

4. Disconnect the air lines from the trailer air supply control valve. See **Fig. 3**.

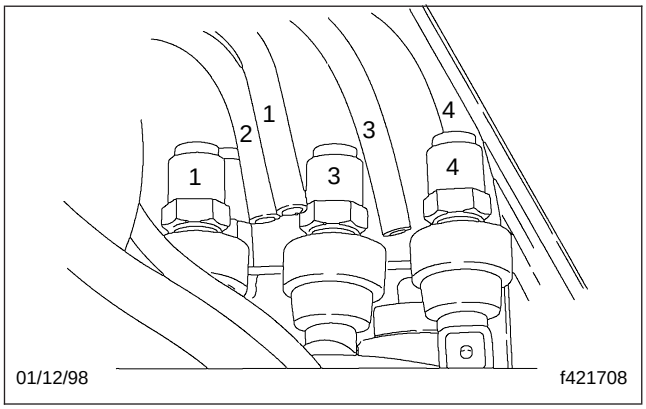


Fig. 3, Numbered Air Lines

5. Remove the two screws retaining the trailer air supply control valve to the finish panel center bracket. See **Fig. 4**.

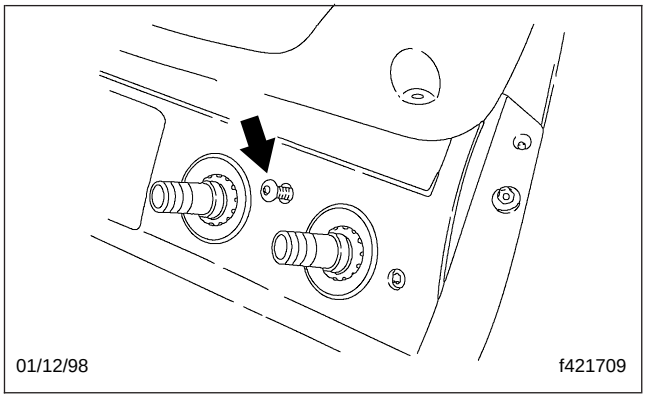


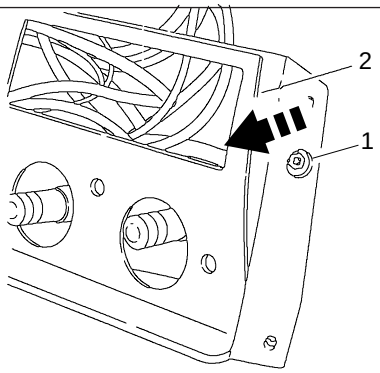
Fig. 4, Trailer Air Supply Control Valve Retaining Screws

6. Make room for valve removal. See **Fig. 5**.
   - 6.1 Remove the two screws retaining the finish panel center bracket to the instrument panel.
   - 6.2 Tilt the finish panel center bracket outward.
7. Remove the trailer air supply control valve. See **Fig. 6**.

Installation

1. Make room for valve installation by tilting the finish panel center bracket inward.

Trailer Air Supply Control Valve Removal and Installation



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1. Retaining Screw
2. Finish Panel

Fig. 5, Accommodate Valve Removal

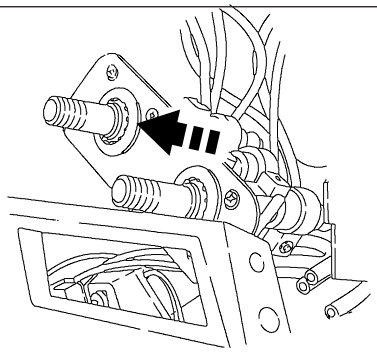

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Fig. 6, Trailer Air Supply Control Valve

2. Install the trailer air supply control valve. See **Fig. 6**.
3. Install the eight screws from the instrument panel finish panel. See **Fig. 2**.
4. Connect the air lines to the trailer air supply control valve.
5. Install the two screws retaining the trailer air supply control valve to the finish panel center bracket. See **Fig. 4**.
6. Install the parking brake control, the trailer air supply and the trailer brake hand control valve knobs. See **Fig. 1**.

Specifications

System Pressures	
Item	**System Pressures psi (kPa)**
Trailer Supply (Red Knob) Will Hold the Release (In) Position	65 (450)
Trailer Supply (Red Knob) Will Pop Out Automatically	35–45 (241–310)
Trailer Air Supply Control Valve Will Automatically Exhaust Spring Brake Chambers if Trailer Supply (Red Knob) Is Held in Manually	25–35 (172–241)
Tractor/Trailer Configuration Parking Brake Control Valve (Yellow Knob) Will Pop Out	20–30 (138–207)
Truck Configuration Parking Brake Control Valve (Yellow Knob) Will Pop Out	35–45 (241–310)

Table 1, System Pressures

Safety Precautions

AIR BRAKE SYSTEM WARNINGS

⚠ WARNING

Before attempting to work on the air brake system, certain precautions must be observed. Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized. The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.

When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.

Hoses will whip dangerously if disconnected under pressure.

Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.

As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber push rods and spring actuators which apply automatically with the loss of pressure. This also applies when checking the service brake system.

Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.

Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.

The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.

Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.

To avoid injury, keep clear of the air chamber push rod when brakes are applied or when air is exhausted from the system.

Observe these warnings while investigating all applicable brake system concerns.

Brake System

INSPECTION AND VERIFICATION

With the engine stopped and the air reservoirs charged to governor pressure (130 psi [897 kPa] maximum), the rate of pressure drop shall not exceed 1 psi (7 kPa) per minute with the service brakes released and spring brakes applied.

For air pressure loss concerns, coat the fittings and exhaust ports of the suspected components with a soap solution and check for air bubble formation. Compare bubble formation to allowable leakage specifications. Tighten, repair or replace as required.

Inspect air lines for kinks, abrasions and correct routing. Repair or reroute as necessary.

For vibration concerns, check the brake drum and foundation brake components at the applicable axle location. Check the brake drum for out-of-round condition. Refinish or replace as necessary. Inspect the foundation brake components for loose mounting, wear, damage and correct installation. Repair or replace as necessary.

Problem—Brakes Pull or Drift

Problem—Brakes Pull or Drift	
Possible Cause	**Remedy**
Vehicle loading	Balance vehicle load.
Base brake components	Check air chamber stroke. Measure the air chamber stroke at all wheels when the brakes are applied. Refer to "DOT Adjusted Air Chamber Stroke Limits" in this section. If the air chamber stroke is not equal and within specification at all wheels, Adjust air chamber stroke. Refer to "Manual Slack Adjuster, Adjustment" in this section. Retest the system. If the air chamber stroke is equal and within specification at all wheels, check for air leaks at the valves, lines and brake air chambers when the brakes are applied. If leaks were found, repair or replace as necessary. Retest the brakes. If leaks were not found, check air chamber pressure. Measure the air pressure at the brake air chambers when the brakes are applied. If the pressure is not equal at all brake air chambers, repair or replace the associated relay valve. Retest the brakes. If the pressure is equal at all brake air chambers, check the brake drums for correct installation, out-of-round condition, cracks or other damage. Repair or replace as necessary. Test the system for normal operation.
Valves or line restriction	Perform "Inspection and Verification" in this section.

Problem—Brakes Do Not Release or Release Too Slowly

Problem—Brakes Do Not Release or Release Too Slowly	
Possible Cause	**Remedy**
Base brake components	Check the base brake components for binding, weak springs and incorrect installation. If the components are OK, repair or replace the associated quick release valve. Retest the brakes. If the components are defective, repair or replace as necessary. Test the system for normal operation.
Valves	Check the foot control valve. Operate and release the foot control valve. Observe the movement of the foot control valve. If the foot control valve does not return to the fully released position when it is released, remove the obstruction. Repair or replace as necessary. Retest the brakes.

Troubleshooting

Problem—Brakes Do Not Release or Release Too Slowly	
Possible Cause	**Remedy**
Line restriction	Check for restrictions. Inspect the air lines and check for a kinked or pinched condition. Correct the kinked or pinched condition. Retest the brakes. If no restrictions are found, check air brake chambers. Check for leaks at the spring brake portion of the brake air chambers. Repair or replace as necessary. Retest the brakes.

Problem—Brakes Insufficient, Do Not Apply or Apply Too Slowly

Problem—Brakes Insufficient, Do Not Apply or Apply Too Slowly	
Possible Cause	**Remedy**
Air chamber free stroke adjustment	Refer to "Air Chamber Free Stroke" under "Inspection and Verification" in this section. Perform slack adjuster manual adjustment.
Water or oil in air supply	Perform air dryer test. Refer to "Component Tests" in this section.
Valves, line restriction or base brake components	Check for vehicle overloading. If the vehicle is overloaded, correct as necessary. Retest the brakes. If the vehicle is not overloaded, check foot control valve. Operate the foot control valve. Check whether the foot control valve can move to the fully operated position. If the foot control valve does not operate OK, remove the obstruction. Repair or replace as necessary. If the foot control valve operates OK, check air brake stroke. Check the air chamber stroke. Refer to "DOT Adjusted Air Chamber Stroke Limits" in this section. If the air chamber stroke is not within specification, perform "Slack Adjuster, Manual Adjustment" in this section. If the air chamber stroke is within specification, check system air pressure. Check air delivery pressure to the brake air chambers. If delivery pressure is not at least 621 kPa (90 psi), perform the "Compressor—Operation and Leakage Tests" and the "Governor" test. Refer to "Component Tests" in this section. Repair or replace as necessary. If the delivery pressure is at least 621 kPa (90 psi), check the base brake components. Check the components for wear, damage or incorrect installation. If the components are OK, inspect the system for air line kinks, restrictions and components leaks. Correct as necessary. Retest brakes. If the components are defective, repair or replace as necessary. Test the system for normal operation.

Problem—Excessive Oil or Water in Brake System

Problem—Excessive Oil or Water in Brake System	
Possible Cause	**Remedy**
Air dryer	Perform the "Air Dryer" test. Refer to "Component Tests" in this section.
Contaminated air source	Drain and repressurize the system with clean, dry air.
Compressor	Perform "Compressor—Operation and Leakage Tests". Refer to "Component Tests" in this section.

Problem—Air Pressure Rises Above Normal

Problem—Air Pressure Rises Above Normal	
Possible Cause	**Remedy**
Governor	Perform the "Governor" test. Refer to "Component Tests" in this section.

Problem—Air Pressure Will Not Rise to Normal or Rises too Slowly

Problem—Air Pressure Will Not Rise to Normal or Rises too Slowly	
Possible Cause	**Remedy**
Compressor	Perform the "Compressor—Operation and Leakage Tests". Refer to "Component Tests" in this section.
Leaks	Perform the "Leakage" tests. Refer to "Component Tests" in this section.

Problem—Low Air Pressure Buzzer Sounding, Air Pressure Gauge Reads OK

Problem—Low Air Pressure Buzzer Sounding, Air Pressure Gauge Reads OK	
Possible Cause	**Remedy**
Low air pressure switch	Check low air pressure switch. Disconnect the electrical connector at the low air pressure switch. If the low air pressure buzzer continues, repair or replace the worn or damaged low air pressure buzzer or circuit. Refer to **Group 54** in this manual. Retest the system.
Air gauge	Check the air gauge. Compare the air gauge to a known good gauge. The original air gauge must be within 48 kPa (7 psi) of the known good gauge. If the air gauge is OK, replace the low air pressure switch. Retest the system. If the air gauge is defective, replace the air gauge, then test the system for normal operation.

Problem—Parking Brake Will Not Apply or Applies too Slowly

Problem—Parking Brake Will Not Apply or Applies too Slowly	
Possible Cause	**Remedy**
Valve	Check the release bolt. Check the brake air chamber to determine if the spring brake is caged with the release bolt. If the spring brake is caged, release the caged spring brake. Retest the system. If the spring brake is not caged, check parking brake control valve. Disconnect the output line at the parking brake control valve. If the parking brake operates, repair or replace the parking brake control valve. Retest the system. If the parking brake does not operate, check the quick release valve. Loosen the input line at the quick release valve.
Brake air chamber	If the quick release valve does not operate, repair or replace the quick release valve. Retest the system. If the quick release valve operates, check the brake air chamber. Disconnect the slack adjuster from the air chamber push rod. Operate the parking brake. If the air chamber push rod fully extends, inspect the base brake components. Repair or replace as necessary. Retest the system. If the air chamber push rod does not fully extend, repair or replace the brake air chamber. Retest the system.

Troubleshooting

Problem—Parking Brake Will Not Release or Releases too Slowly

Problem—Parking Brake Will Not Release or Releases too Slowly	
Possible Cause	**Remedy**
Valve	Check parking brake control. With the parking brake released, loosen the output line fitting at the parking brake control valve and check for air pressure at the fitting. If air pressure is not present at the output line fitting, repair or replace the parking brake control valve. Retest the system. If air pressure is present at the output line fitting, check the air pressure. With the parking brake released, loosen the input fitting at the air chamber spring brake chamber. Check for air pressure at the fitting. If air pressure is not present, correct the obstruction in the air supply path from the parking brake control valve to the brake air chamber. Retest the system. If air pressure is present, check brake air chamber. With the parking brake released, disconnect the slack adjuster from the brake air chamber. If the parking brake releases, repair or replace the brake air chamber. If the parking brake does not release, repair worn or damaged components in the base brake system causing the binding condition. Retest the system for normal operation.
Air supply	

COMPONENT TESTS

Valve—Modulator

1. Chock the wheels. Charge the air brake system to governor cutout pressure.
2. Place the parking brake control valve in the "Park" position. Observe that the spring brakes apply promptly. Remove one line or plug from the delivery port of the valve and install a test gauge known to be accurate. Place the parking brake control valve in the "Release" position. Observe that the spring brakes release fully.
3. With the parking brake control valve in the "Release" position, note the gauge pressure reading. The correct spring brake hold-off pressure setting is 95 to 105 psi (655 to 724 kPa). If the pressure reading is incorrect, replace the modulator valve.
4. Place the parking brake control valve in the "Park" position. The gauge reading should drop to zero promptly. A lag of more than one second in drop of pressure indicates incorrect operation of the single check valve (within the modulator valve).
5. With the parking brake control valve in the park position, fully apply the service brakes with the foot control valve several times and note that a pressure reading increase occurs on the gauge each time the foot control valve is applied. If a pressure reading does not occur, the modulator valve requires repair or replacement.
6. Place the parking brake control valve in the release position. Determine the reservoir which supplies the balance port and drain completely.
7. Apply the foot control valve several times and note that the pressure reading on the gauge decreases each time the foot control valve is applied. After the foot control valve has been applied several times, pressure on the gauge will drop to the point where release of the spring brakes will no longer occur.

LEAKAGE TEST

Place the parking brake control valve in the "Release" position. Using a soap solution, coat the modulator valve exhaust and vent hole in the proximity of the adjusting screw. Slight bubble leakage is permitted.

If the modulator valve does not function as described, or if the leakage is excessive, repair or replace as required.

Valve—Quick Release

1. With the air brake system fully charged, apply the brakes. Observe the brake action on the wheels controlled by the quick release valve or relay valve in question. The brakes should apply promptly.

2. Release the brakes and inspect to make sure the air pressure is exhausted rapidly from the exhaust port. Make sure the exhaust port is not restricted.
3. Disassemble and clean the quick release valve (if required) and retest. If the valve does not seat or operates improperly, replace the quick release valve.
4. With the brakes applied, coat the exhaust port with a soap solution and inspect for leaks. Leakage is not permissible.
5. Disassemble and clean the quick release valve, if required. If the valve does not seat or operates improperly, replace the quick release valve.

Valve—Parking Brake Control

1. Connect a 120 psi (827 kPa) air source to the supply port. An accurate test gauge should be placed in line with the supply line (use a T-fitting to do this). This provides a means of controlling the supply pressure. A small valve with a gauge should be connected to the delivery port.
2. With 120 psi (827 kPa) supply pressure and the button pulled out ("Applied" position), check that leakage at the exhaust port and at the plunger stem does not exceed a 1-inch (25.4 mm) bubble in five seconds. There should be no leakage between the upper and lower body.
3. Push the button in ("Released" position). Leakage at the exhaust port and at the plunger should not exceed a 1-inch (25.4 mm) bubble in three seconds.
4. Reduce the supply pressure. At a pressure of 35 to 45 psi (241 to 310 kPa), the button should pop out automatically, exhausting the delivery volume.

Compressor—Operation and Leakage Tests

NOTE: The tractor must be disconnected from the trailer to run this test.

Bleed both the primary and secondary reservoirs down to 85 psi (586 kPa) as measured with a test gauge.

Run the engine at full governed rpm until the air pressure in the reservoirs reaches 100 psi (689 kPa). If the pressure buildup time exceeds 40 seconds, the compressor is not operating properly and one or more of the following conditions may exist:

- The engine air cleaner or compressor inlet hose, the source of fresh air for the compressor, is clogged;
- Excessive air system leakage;
- The compressor drive gear is slipping;
- Restricted discharge cavity in the compressor or restricted discharge line;
- The discharge valve is stuck or broken;
- The unloader piston inside the compressor is stuck;
- Excessively worn compressor piston rings or cylinder walls;
- Governor out of adjustment or fouled.

The air compressor has three possible sources of leakage: engine coolant, lubricating oil and air. Coolant leakage can be checked by pressurizing the cylinder head water cavity to 60 psi (414 kPa) for five minutes. Make sure there are no leaking fittings by using the soap suds test. If the pressure drops in the system, this leakage is unacceptable and the compressor must be replaced.

Oil leakage can be checked visually at the compressor end caps, crankshaft seal and the base plate. If the leakage cannot be corrected by proper tightening of the end cap and base plate retainer bolts, the compressor or the gasket must be replaced.

The compressor can be checked for air leakage at the discharge and air inlet valves. With the engine stopped and air system pressure at 125 to 135 psi (862 to 931 kPa), discharge valve leakage can be detected by listening at the compressor intake for the sound of escaping air. With 120 psi (827 kPa) of air pressure applied to the unloader cavity and with the air inlet housing removed, check for leaks by squirting oil around the unloader plunger and stem. If leaks are found, replace the compressor or the unloader mechanism through the air inlet cavity.

Governor

The governor for all air compressors used on current Sterling vehicles is mounted on the compressor.

Install a test gauge in the air lines, in the supply or service reservoir. Run the engine to build up air pressure. Note the reading on the test gauge at which

the pressure stops rising. This is the point that the governor shuttles the compressor unloader piston and stops the compression cycle of the compressor. This is the compressor cutout pressure. The compressor cutout pressure must be between 135 psi (931 kPa) maximum. If the instrument panel air gauge is used, the pressure must range between 109 to 131 psi (752 to 903 kPa), allowing for gauge accuracy.

With the engine running, slowly reduce the amount of air pressure in the system by applying and releasing the brakes. Note on the gauge the level at which the pressure starts to build up again. This is the point that the governor releases the compressor unloader piston and starts the compression cycle of the compressor. This is the compressor cut-in pressure. The compressor cut-in pressure must be between 105 psi (724 kPa) minimum.

If the governor does not control the compressor to the above specifications, it must be replaced. Before replacing the governor, check the accuracy of the instrument panel air gauge with a test gauge. With the governor in its unloaded position and approximately 90 to 115 psi (621 to 793 kPa) reservoir pressure, check for leaks at the base of the governor where it mounts to the compressor and repair as required.

All current Sterling governors are nonadjustable and must be replaced if they do not operate as specified.

Air Dryer

NOTE: A small amount of oil in the system is normal and should not, in itself, be considered a reason to replace the desiccant cartridge.

The air dryer must be inspected every 900 operating hours or 25,000 miles (40,000 km), or every three months.

1. Check for moisture in the air brake system by opening reservoir drain cocks, or valves and checking for water. If moisture is found, the air dryer desiccant may need to be replaced; however, consider the following conditions before replacing the desiccant cartridge.
    - 1.1 An outside air source has been used to charge the system. This air did not pass through the air dryer.
    - 1.2 Air use is exceptionally high and not normal for a highway vehicle. This can be due to accessory air demands or some unusual air requirement that does not allow the compressor to load and unload in the usual way. Check for excessive air system leaks.
    - 1.3 The air dryer has been installed in a system that has been previously used without an air dryer. This type of system will be saturated with moisture and it can take several weeks of operation for the system to dry out.
    - 1.4 Location of the air dryer is too close to the air compressor. There must be a minimum of 6 ft (1.8 m) of metal tubing between the compressor discharge port and air dryer supply port.
    - 1.5 Vehicles operating in areas where more than a 30°F (17°C) range of temperature occurs in one day can have small amounts of water accumulating in the air brake system. Under these conditions, small amounts of water should not be considered an indication that the air dryer is not working.
2. Check the retaining bolt torque. Tighten loose bolts to specified torque.
3. Check the operation of the end cover check valve.
    - 3.1 Install an air pressure test gauge in the supply reservoir.
    - 3.2 While observing the test air gauge, start the engine and allow the system air pressure to reach governor cutout. The purge valve will be open when the governor cutout pressure is reached.
    - 3.3 Allow two minutes for completion of the purge cycle before testing the check valve.
    - 3.4 A quick loss of pressure can indicate a worn or damaged check valve. Check the purge valve exhaust to confirm a worn or damaged check valve. Use a soap solution to check air leakage. Air leakage must not exceed a 1-inch (2.5 cm) bubble in 5 seconds. Replace as necessary.

4. While the compressor is loaded, coat the exhaust with soap solution and check for air leaks at the purge valve.
5. Check the operation of the safety valve. While the compressor is loaded, pull the exposed stem. While the stem is held, there must be an exhaust of air. The valve must be re-seated when the stem is released.
6. Check the operation of the end cover heater and thermostat assembly during cold weather operation.

    6.1 With the ignition or engine control on, check for power at the dryer electrical terminal with a voltmeter or test light. On a single terminal air dryer, check between the electrical terminal in the vehicle wiring harness connector and the metal end cover. For dual terminal air dryers, check between the two electrical terminals in the vehicle wiring harness connector. If there is no voltage, look for a blown fuse, broken wires or corrosion in the vehicle wiring harness.

    6.2 Turn off the ignition switch and cool the end cover assembly to below 40°F (4°C).

    6.3 Using an ohmmeter, check resistance of the heater element between the electrical terminal and the metal end cover.

    6.4 On the dual terminal end cover, check the resistance of the heater element between the two terminals. The resistance should be 2.0 to 4.0 ohms for a 12-volt, 60-watt end cover and 4.0 to 7.0 ohms for a 24-volt, 120-watt end cover. These resistance values apply to either single or dual terminal air dryer end covers.

⚠ CAUTION

Do not remove the heater and thermostat assembly unless a replacement is available as it will be damaged during removal.

    6.5 Warm the end cover to over 90°F (32°C) and recheck the resistance of the heater element. The resistance must exceed 1,000 ohms for both single and dual terminal air dryers. If the resistance values are within the given limits, the thermostat and heater are operating properly. If the resistance values are outside the limits, replace the heater and thermostat assembly.

CUMMINS HOLSET E-TYPE COMPRESSOR

Test the Holset E-Compressor unloader system with feedback line and check the valve for proper operation. Make certain Holset ECON is not in use with the AD-IP air dryer; if so, remove and retest.

When the compressor is unloaded, use a soap solution to check for leaks from the turbo cutoff valve. Replace a leaking turbo cutoff valve.

Low Air Pressure Switch

1. Exhaust the brake system pressure and note the pressure at which the warning buzzer sounds. The contacts in the low air pressure switch should close the circuit to the buzzer as the reservoir air pressure approaches 60 psi (414 kPa).
2. If the buzzer does not sound during discharge, or if a sounding buzzer does not stop during buildup when this range is reached, the electrical connections are loose or the low air pressure switch is not operating properly. Check and tighten the electrical connections or replace the low air pressure switch. Retest the system.

Relay Valve

1. Fully charge the air brake system and adjust the brakes.
2. Make several brake applications and check for prompt application and release at all appropriate wheels. If a brake is slow to apply or release, make sure the brake camshaft is properly lubricated and any excessively worn brake parts are replaced before proceeding.
3. With the foot control valve in the released position, coat the relay valve exhaust port with soap solution and check for inlet valve and valve guide O-ring leakage. A 1-inch (25.4 mm) bubble in five seconds leakage is permitted.
4. Make and hold a foot control valve application. Coat the relay valve exhaust port with soap solution and check for leakage. A 1-inch (25.4 mm) bubble in three seconds leakage is permitted.

Troubleshooting

NOTE: If leakage is detected, replacing the inlet/exhaust valve may correct the problem. If leakage still occurs, leakage may be caused by the relay piston O-ring or exhaust valve seat.

5. Make and hold a foot control valve application. Coat the outside of the relay valve body in the area where the cover joins the body to check for cover O-ring leakage. No leakage is permitted. If the relay valve does not function as described above, or if leakage is excessive, it is recommended that the relay valve be repaired or replaced.

Safety Valve

The safety valves are located on the reservoirs and on the air dryer.

With air pressure in the system, pull the exposed end of the safety valve stem which removes the spring load from the ball check valve. Air should exhaust from the valve's exhaust port. Release the stem; the airflow should stop. Repair or replace a safety valve that does not operate as described.

Automatic Moisture Ejector Valve

With the system charged to 100 psi (689 kPa), make several brake applications and note each time an application is made whether or not an exhaust of air occurs at the manual release port of the automatic moisture ejector valve. If no air comes out, push the wire stem. If air still does not come out, the valve is plugged. Remove, disassemble and clean the valve.

The automatic moisture ejector valve functions as reservoir pressure is reduced. Excessive leakage in the air system will cause constant exhausting of the valve. Repair of the air brake system should restore the automatic moisture ejector valve to normal operation.

Foot Control Valve

Check the delivery pressure of both the primary and secondary circuits using test gauges known to be accurate in the appropriate delivery ports of the foot control valve. Depress the treadle to several positions between the fully released and fully applied positions. Then, check the delivered pressure on the test gauges to see that it varies proportionately with the movement of the treadle.

When the treadle is fully depressed, the reading on the test gauge should fall off to zero promptly when the treadle is released. Note that the primary (green) circuit delivery pressure will be about 2 psi (13.7 kPa) greater than the secondary circuit (red) delivery pressure with primary and secondary circuit supply reservoirs at the same pressure. This is normal for the foot control valve.

Any increase in normal stopping distance is a cause for concern and should be investigated. Although the vehicle air brake system may continue to function, the vehicle should not be operated until the necessary repair has been completed and both braking circuits are operating normally.

LEAKAGE TEST

Check leakage as follows:

- Make and hold full brake application.
- Coat the exhaust port and body of the foot control valve with soap solution.
- Leakage must not exceed a 1-inch (25.4 mm) bubble in three seconds in both the applied and released positions.

Trailer Air Supply Control Valve

To perform the following test, an accurate air test gauge is required. The vehicle dash air gauge(s), if used, must be checked for accuracy against the test gauge prior to making these tests.

1. Chock the wheels.
2. Charge the air brake system to 120 psi (827 kPa).
3. Check for leakage between the body of the trailer air supply control valve and the cover plate. Leakage at the exhaust port must not exceed a 1-inch (25.4 mm) bubble in five seconds.
4. With supply pressure still at 120 psi (827 kPa), push the red button in. The button must remain in. Leakage at the exhaust port must not exceed a 1-inch (25.4-mm) bubble in five seconds.

NOTE: The yellow button must not pop out before the red button.

5. Slowly reduce pressure in both service reservoirs. The red button must pop when supply pressure drops to 35 to 45 psi (241 to 310 kPa).

6. Hold the red button in and continue to reduce pressure in all service reservoirs. Air must start to escape from the exhaust port when the trailer supply line pressure reaches 20 to 35 psi (138 to 241 kPa).
7. Release the red button and rebuild the supply pressure to at least 120 psi (827 kPa). Push in the yellow button. The yellow button must remain in. Leakage at the exhaust port must not exceed a 1-inch (25.4 mm) bubble in five seconds.
8. With the red button out, slowly reduce pressure in all service reservoirs. The yellow button must pop at 20 to 30 psi (138 to 207 kPa).
9. Charge the system to 120 psi (827 kPa) and push both buttons in. Pull the red button out. The yellow button must remain in.
10. Push the red button in and pull the yellow button out. The red button must pop out almost instantaneously.
11. Install a gauge to monitor the tractor spring brake delivery pressure. Apply 120 psi (827 kPa) to all service reservoirs (No. 1 and No. 2). Push in the yellow button. Delivery pressure should equal the pressure in the reservoir No. 1. Reduce the pressure in the No. 1 reservoir. Delivery pressure and No. 1 reservoir pressure should descend together to 105 to 90 psi (724 to 620 kPa), at which point the dual circuit supply valve shuttle should switch to the No. 2 reservoir and delivery pressure should increase to No. 2 reservoir pressure. After the No. 1 reservoir pressure is reduced to zero, there should not be audible leakage at the No. 1 reservoir opening. Close the leak created in the No. 1 reservoir.
12. Leaving the yellow button in, recharge the No. 2 reservoir to 120 psi (827 kPa). The delivery pressure should also read 120 psi (827 kPa). Recharge the No. 1 reservoir to 100 psi (689 kPa). Slowly vent the No. 2 reservoir. As the No. 2 reservoir pressure and the delivery line pressure descend, pressure should stabilize at approximately 100 psi (689 kPa).
13. Close all reservoir drain cocks and charge both reservoirs to 120 psi (827 kPa). Position the red button out and the yellow button in. Cause a leak in the spring brake delivery line and hold the yellow button in. The No. 1 reservoir pressure must reduce to zero and No. 2 reservoir pressure to 20 to 30 psi (138 to 207 kPa). The dual circuit supply valve shuttle should cycle several times during this leak-down period.
14. If the trailer air supply control valve fails to operate as described or leakage exceeds the limits stated, repair or replace as required.
15. Close all reservoir drain cocks and deliberately caused leakage points before placing the vehicle in service.

Tractor Protection Valve

1. Charge air brake system to governor cut-out, chock the wheels and place the trailer air supply control valve in the emergency position.
2. Disconnect the trailer service line hose coupling. Make a trailer brake hand control valve application. Hold a finger over the 1/16-inch (1.6 mm) vent hole in the service line shut-off valve area of the tractor protection valve casting. Check for leakage at the hose coupling and at the exhaust port at the tractor protection valve. Excessive leakage at either port indicates a faulty inlet valve.
3. With the trailer brake hand control valve still applied and the key to run, check for stoplight function.
4. Release the trailer brake hand control valve application and place the trailer air supply control valve in normal position.
5. Connect the tractor service hose coupling to a test gauge, reapply the trailer brake hand control valve and note that there is pressure at the service hose coupling.
6. Check for leakage at the service line quick release valve. Excessive leakage indicates a worn or damaged diaphragm.
7. With service line pressure still applied through the trailer brake hand control valve, check for leakage at the foot control valve exhaust. Excessive leakage indicates a worn or damaged double check valve shuttle.
8. Check for leakage at the 1/16-inch (1.60 mm) vent hole. Leakage indicates that one of the two O-rings is worn or damaged.
9. Release the trailer brake hand control valve application and recheck for leakage at the vent

hole. If the leakage continues, it is the large O-ring which is leaking. If the leakage stops, it was the smaller O-ring that was leaking.

10. Make and hold a foot control valve application. Check for leakage at the exhaust of the trailer brake hand control valve. Excessive leakage indicates a worn or damaged double check valve shuttle.
11. Release the foot control valve application, disconnect the line from the primary (green) service brake circuit at the tractor protection valve delivery port and block off the end of the line from the foot control valve. Make a foot control valve application and check for leakage at the protection valve delivery port.
12. Reconnect the primary (green) circuit line and repeat the procedure with the secondary circuit line. Excessive leakage indicates a worn or damaged double check valve shuttle. Restore the secondary (orange) circuit connection to the tractor protection valve.
13. If the tractor protection valve does not function as described above or if leakage is excessive, the tractor protection valve must be replaced.

Trailer Brake Hand Control Valve

Connect an accurate test gauge to the trailer service line hose and leave the trailer emergency or supply hose connected to the trailer. If a trailer is not available, connect the trailer supply hose to an unvented dummy coupling or to a plugged hose fitting. The trailer air supply control valve must be in the normal position.

When the operating lever is moved to the fully applied position, the gauge should register full reservoir pressure. Intermediate positions should deliver proportional intermediate pressures. Upon release, the gauge should immediately register zero.

Locate the open end of the exhaust line from the trailer brake hand control valve in the engine compartment.

With the trailer brake hand control valve in the release position, no pressure should register on the test gauge. Leakage at the end of the exhaust line should not be greater than a 1-inch (25.4 mm) bubble in five seconds. With the trailer brake hand control valve fully applied, leakage at the exhaust line should not be greater than a 1-inch (25.4 mm) bubble in three seconds.

Repair or replace a trailer brake hand control valve that does not function as described.

Bobtail Proportioning Relay Valve

To properly test the function of the bobtail proportioning relay valve, a pair of test gauges or gauges of known accuracy must be used.

1. Park the vehicle on a level surface and chock the wheels.
2. Exhaust the system air pressure.
3. Install a tee at the proportioning valve service port and at one of the delivery ports, then install a gauge in each leg of the tee.
4. Connect the tractor service and emergency "glad hands" (hose couplings) to hose couplings that have been plugged, or alternatively, to a trailer. Build the system air pressure to governor cutout and make four to five full brake applications. Check the air fittings at the bobtail proportioning relay valve for leakage. Tighten as needed.
5. With the trailer air supply control valve (dash control with red octagonal button) and parking brake control valve (dash control with yellow diamond button) activated for tractor trailer operation, apply, hold, then release the brakes several times varying the application pressures while watching the reaction of the gauges installed on the bobtail proportioning relay valve. Note that a prompt application occurs and that it can be held and then promptly released.

NOTE: When performing the following procedure, the measured differential should be approximately 4 psi (28 kPa).

6. Check the proportioning valve differential pressure by applying 10 psi (69 kPa) to the service port and noting the pressure registered at the delivery port. Subtract delivery port pressure from the 10 psi (69 kPa) service pressure to obtain the differential. Compare the measured differential with the pressure specified for the proportioning valve part number.
7. Make and hold a full 100 psi (689 kPa or greater) brake application and note that full pressure is delivered to the brake air chambers.

8. Activate the dash-mounted trailer air supply control valve for bobtail tractor operation. Then make a slow brake application, increasing the pressure at the proportioning valve service port to 20 psi (138 kPa) while watching the reaction at the delivery port gauge. Note that delivery pressure rises to approximately 5 to 10 psi (34 to 69 kPa) and remains constant while service pressure continues to rise to 20 psi (138 kPa). Release the application.
9. Make another brake application and slowly increase the pressure at the proportioning valve service port to between 60 to 70 psi (413 to 482 kPa) while observing the gauge installed at the delivery port. Note that when service port pressure rises to between 20 to 30 psi (138 to 207 kPa), delivery pressure begins to rise above the initial pressure noted previously. The rise of delivery pressure should be at a proportioned rate of approximately 3:1 @70 psi (482 kPa) service pressure, delivered pressure should be 15 to 25 psi (103 to 172 kPa).
10. Make a full brake application and note that both test gauges register the same pressure.
11. Remove the test gauges from the bobtail proportioning relay valve.
12. Build the air system pressure to governor cutout. With the dash-mounted trailer air supply control valve activated for tractor trailer operation, apply a soap solution to all three exhaust ports (two in the cover and one in the body). The leakage noted should not exceed a 1-inch (25.4 mm) bubble in three seconds at any exhaust port.
13. Make and hold a full brake application and apply a soap solution to all three exhaust ports and around the cover where it joins the body. The leakage noted should not exceed a 1-inch (25.4 mm) bubble in three seconds at any exhaust port.

Slack Adjuster

NOTE: A loud clicking sound will be heard when turning the hex extension counterclockwise.

1. Turn the hex extension one-half turn counterclockwise. See **Fig. 1**.

NOTE: Place a box wrench on the hex extension to make rotation easier to verify.

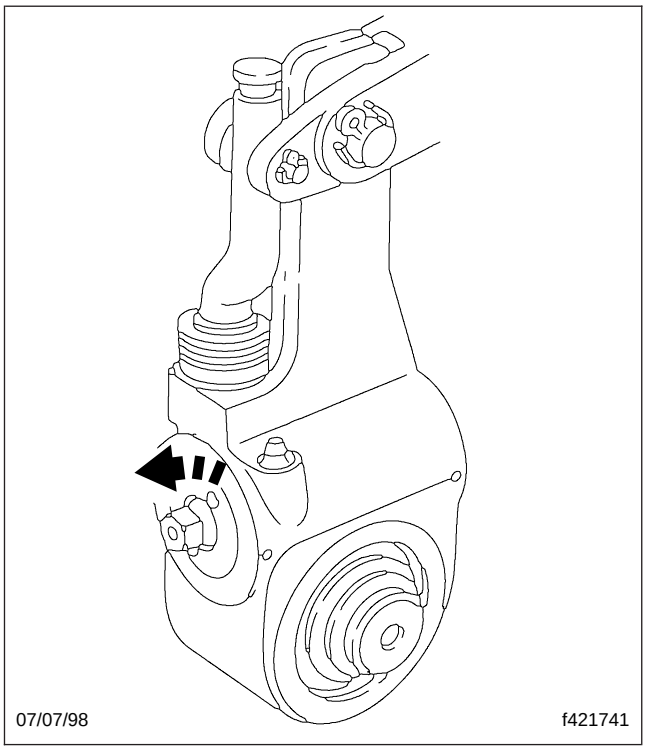


Fig. 1, Turn the Hex Extension Counterclockwise

2. While an assistant makes several service brake applications, check that the hex extension rotates clockwise. See **Fig. 2**. If the slack adjuster arm is rotated by the brake air chamber and there is no hex extension rotation, replace the slack adjuster.

NOTE: To obtain the adjusted air chamber stroke, measure the distance the clevis pin moves from the at-rest position to the brakes-applied position. See **Fig. 3**.

3. Continue to apply the brakes until the brake air chamber is brought within the "DOT Adjusted Air Chamber Stroke Limits". See **Table 1**.

Troubleshooting

DOT Adjusted Air Chamber Stroke Limits	
80 to 90 psi (550 to 620 kPa) Pressure in Air Chamber Clamp-Type Air Chamber	
Chamber Type (Size)	**Adjust the stroke as short as possible without the brakes dragging. The vehicle may be put out of service if the stroke is not:**
9	less than 1.5 ± 0.125 inches (38.1 ± 3.2 mm)
12	less than 1.5 ± 0.125 inches (38.1 ± 3.2 mm)
16	less than 1.5 ± 0.125 inches (38.1 ± 3.2 mm)
20	less than 1.5 ± 0.125 inches (38.1 ± 3.2 mm)
24	less than 1.625 ± 0.125 inches (41.3 ± 3.2 mm)
24 long stroke	less than 1.625 ± 0.125 inches (41.3 ± 3.2 mm)
30	less than 1.625 ± 0.125 inches (41.3 ± 3.2 mm)
36	less than 1.625 ± 0.125 inches (41.3 ± 3.2 mm)

Table 1, DOT Adjusted Air Chamber Stroke Limits

4. Measure the counterclockwise torque of the hex extension. If the counterclockwise torque is less than 15 lbf·ft (20 N·m), the slack adjuster must be replaced. If the slack adjuster cannot be replaced immediately, the brakes must be manually adjusted. See **Fig. 3**.

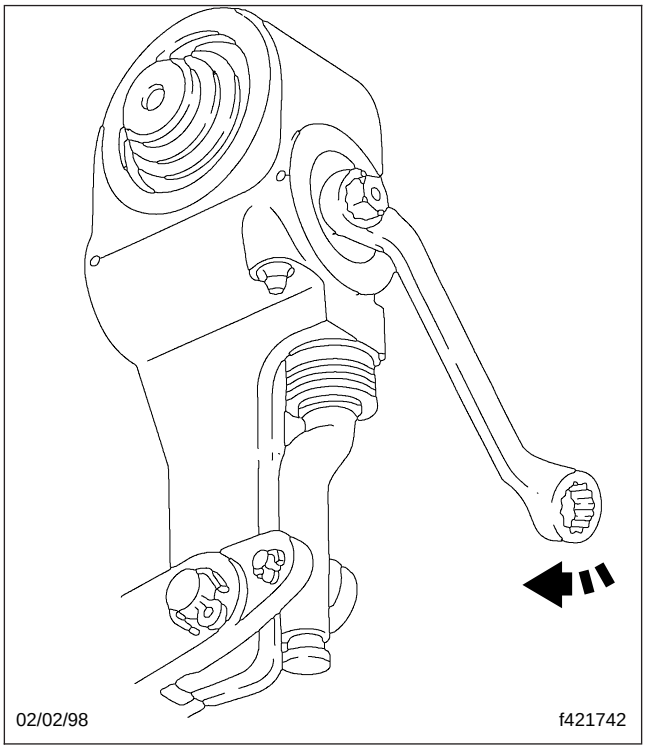


Fig. 2, Use a Boxwrench to Rotate the Hex Extension

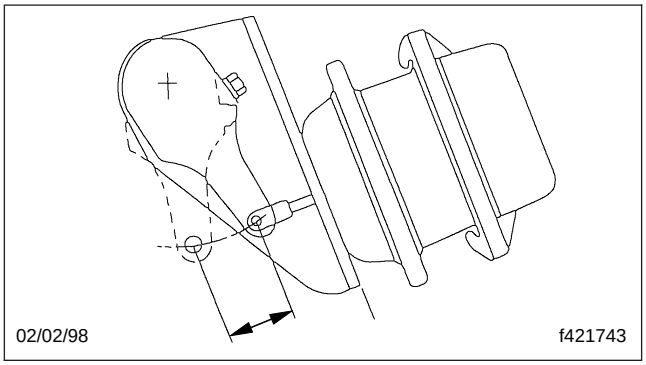


Fig. 3, Measure the Clevis Pin Movement

Specifications

Air Pressure Specifications		
Activation	Pressures	
	psi	kPa
Governor Cut Out, Maximum	135	931
Governor Cut In, Minimum	105	724
Low Air Pressure Switch Trip	60±10	414±69
Safety Valve Releases System Pressure	150±7	1034±48
Safety Valve Re-Seats	135	930
Modulator Relay Spring Brake Hold-Off Pressure	95–105	655–724
Parking Brake Control Valve, Automatic Trip	35–45	241–310
Trailer Air Supply Control Valve, Automatic Trip	35–45	241–310
Trailer Air Supply Control Valve, Red Button Held In, Yellow Button Pops Out	20–30	138–207
Bobtail Proportioning Relay Valve Crack Pressure	4	28
System Pressure for Testing	90–115	621–793

Table 1, Air Pressure Specifications

Allowable Leakage at Approximate System Pressure of 120 psi (827 kPa)			
Component	Test Point	Maximum Bubble Size	Time (Seconds)
Trailer Air Supply Control Valve	Between Body and Cover Plate	1 inch (25.4 mm)	5
Trailer Air Supply Control Valve, Red Button In	Exhaust Port	1 inch (25.4 mm)	5
Trailer Air Supply Control Valve, Yellow Button In	Exhaust Port	1 inch (25.4 mm)	5
Bobtail Proportioning Relay Valve	All Three Exhaust Ports	1 inch (25.4 mm)	3
Bobtail Proportioning Relay Valve, Full Brake Application	All Three Exhaust Ports and Between Body and Cover	1 inch (25.4 mm)	3
Trailer Brake Hand Control Valve	Exhaust Port	1 inch (25.4 mm)	5
Trailer Brake Hand Control Valve, Fully Applied	Exhaust Port	1 inch (25.4 mm)	3
Foot Control Valve, Brakes Applied or Released	Exhaust Port and Valve Body	1 inch (25.4 mm)	3
Relay Valve, Brakes Released	Exhaust Port	1 inch (25.4 mm)	5
Relay Valve, Brakes Applied	Exhaust Port	1 inch (25.4 mm)	3
Relay Valve, Brakes Applied or Released	Valve Body	No Leakage Permitted	—

Table 2, Allowable Leakage at Approximate System Pressure of 120 psi (827 kPa)

Torque Specifications	
Description	lbf·ft (N·m)
Slack Adjuster Collar Nut	40–50 (55–67)

Torque Specifications	
Description	lbf·ft (N·m)
Slack Adjuster Collar Jam Nut	40–50 (55–67)

Table 3, Torque Specifications

Specifications

Plastic Tubing Minimum Bend and Torque Requirements		
Tube Size	**Bend Radius of Nylon Tubing**	**Torque**
1/4 inch O.D.	1.0 inch (25.4 mm)	53–106 lbf·in (6–12 N·m)
3/8 inch O.D.	1.5 inch (38 mm)	9–14 lbf·ft (12–19 N·m)
1/2 inch O.D.	2.0 inch (51 mm)	13–21 lbf·ft (17–29 N·m)

Table 4, Plastic Tubing Minimum Bend and Torque Requirements

Lubricants	Specification
Pipe Sealant with Teflon WSK–N126350–A2	D8AZ–19554–A
Silicone Lubricant COAZ–19553–AA	ESR–M13P4–A
Stud and Bearing Mount EOAZ–19554–BA	WSK–M2G349–A1
Rust Penetrant and Inhibitor F2AZ–19501–A	ESR–M99C56–A

Table 5, Lubricants

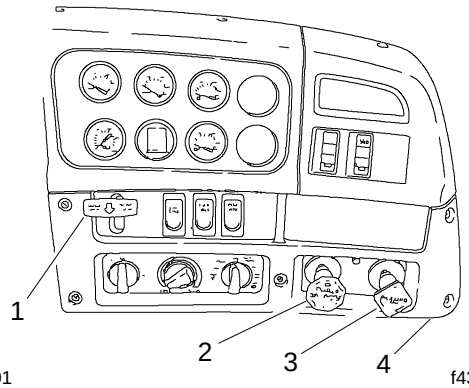
Chamber Type (Size)	DOT Adjusted Maximum Chamber Stroke
9	less than 1.5 ± 0.125 inches (38.1 ± 3.2 mm)
12	less than 1.5 ± 0.125 inches (38.1 ± 3.2 mm)
16	less than 1.5 ± 0.125 inches (38.1 ± 3.2 mm)
20	less than 1.5 ± 0.125 inches (38.1 ± 3.2 mm)
24	less than 1.625 ± 0.125 inches (41.3 ± 3.2 mm)
24 (long stroke)	less than 1.625 ± 0.125 inches (41.3 ± 3.2 mm)
30	less than 1.625 ± 0.125 inches (41.3 ± 3.2 mm)
36	less than 1.625 ± 0.125 inches (41.3 ± 3.2 mm)

Table 6, DOT Maximum Adjusted Brake Chamber Strokes

General Information (See Fig. 1)

The trailer brake hand control valve is a hand-operated, lever-type graduating control valve. The most common use of the trailer control valve is for independent control of trailer service brakes, however, the valve can be used for any application where graduated application pressure is required.

The trailer brake hand control valve is standard with all tractor packages. It can employ a cam, a cam follower, and a graduation spring to control air delivery pressure. Trailer control valves are most often used to snub the trailer brakes when descending grades or on slippery road conditions. They are also often used to hold the vehicle while the vehicle's clutch and accelerator are coordinated. The trailer brake hand control valve should never be used for parking.



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1. Trailer Brake Hand Control Valve
2. Trailer Air Supply
3. Parking Brake Control
4. Auxiliary Instrument Cluster Finish Panel

Fig. 1, Trailer Brake Hand Control Valve Location

Safety Precautions

Air Brake System Warnings

⚠ WARNING

Before attempting to work on the air brake system, certain precautions must be observed. Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized. The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.

When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.

Hoses will whip dangerously if disconnected under pressure.

Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.

As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber push rods and spring actuators which apply automatically with the loss of pressure. This also applies when checking the service brake system.

Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.

Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.

The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.

Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.

To avoid injury, keep clear of the air chamber push rod when brakes are applied or when air is exhausted from the system.

Observe these warnings while investigating all applicable brake system concerns.

Trailer Brake Hand Control Valve Removal and Installation

⚠ CAUTION

Before working on or around air brake systems and components, see "Safety Precautions" in Subject 100.

Removal

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

NOTE: Mark the knobs to aid installation.

2. Remove the knobs. See **Fig. 1**.

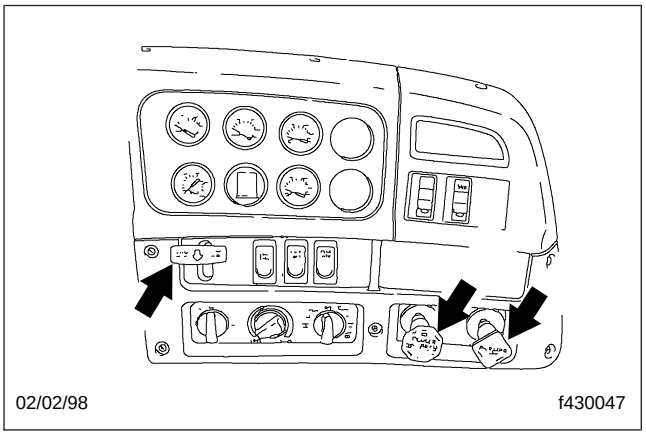


Fig. 1, Brake Control Knobs

3. Remove the eight screws. See **Fig. 2**.

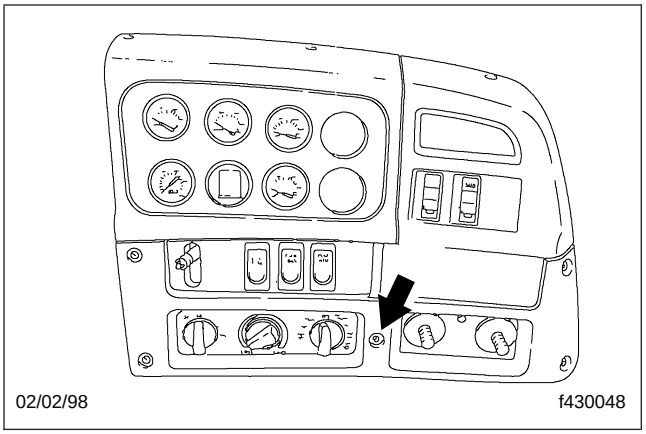


Fig. 2, Instrument Panel Finish Panel Screws

4. Position the instrument panel finish panel out of the way. See **Fig. 3**.

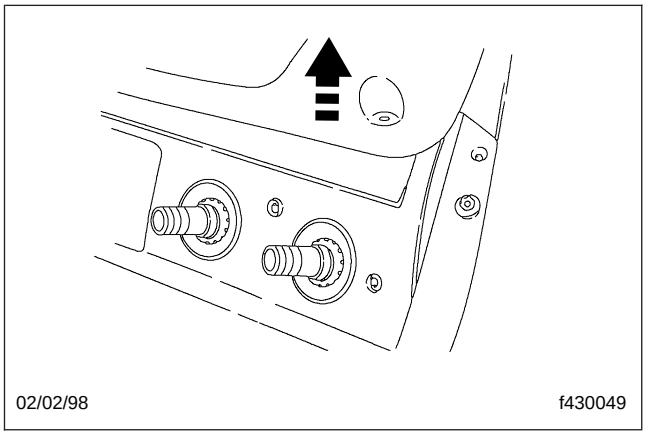


Fig. 3, Positioning the Instrument Panel for Access

5. Remove the three screws. See **Fig. 4**.

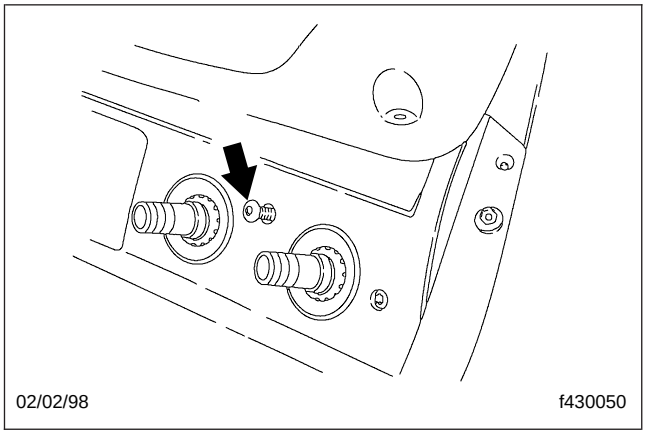
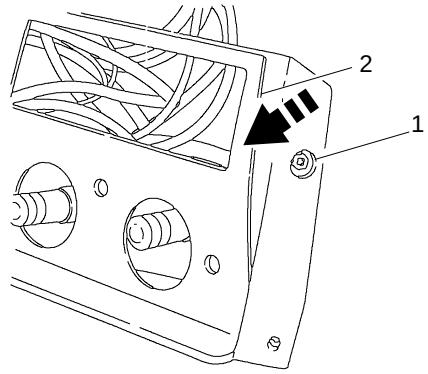


Fig. 4, Three Panel Screws

6. Make room for valve access. See **Fig. 5**.
   - 6.1 Remove the two screws.
   - 6.2 Tilt the finish panel center bracket outward.
7. Tag and disconnect the air lines. See **Fig. 6**.
8. Remove the trailer brake hand control valve retaining screws. See **Fig. 7**.
9. Remove the trailer brake hand control valve. See **Fig. 8**.

Trailer Brake Hand Control Valve Removal and Installation



1. Screw
2. Finish Panel

Fig. 5, Control Valve Access

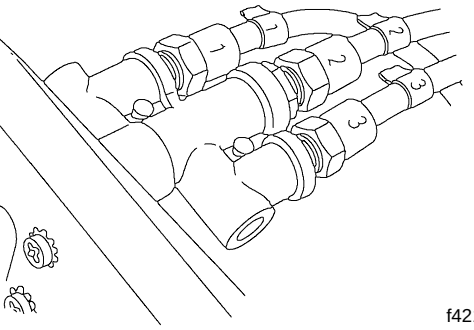


Fig. 6, Tagged Air Lines

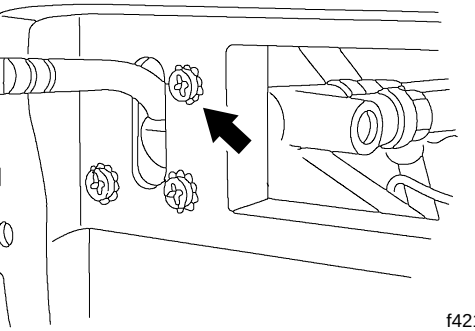


Fig. 7, Trailer Brake Hand Control Valve Retaining Screws

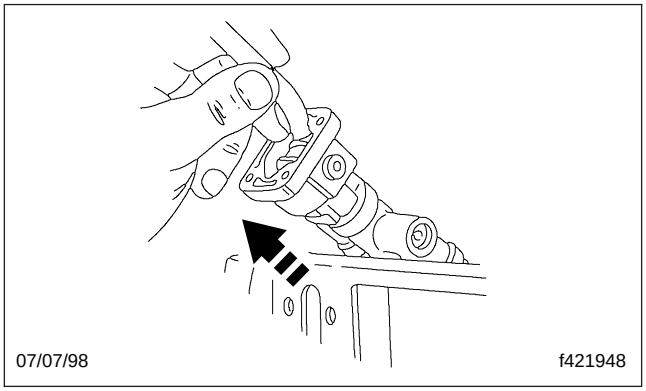


Fig. 8, Trailer Brake Hand Control Valve

Installation

1. Make room for valve access. See **Fig. 5**.
   - 1.1 Install the two screws.
   - 1.2 Tilt the finish panel center bracket outward.
2. Connect the air lines.
3. Install the four screws.
4. Install the trailer brake hand control valve.
5. Install the three screws. See **Fig. 4**.
6. Position the instrument panel finish panel into position. See **Fig. 3**.
7. Install the eight screws. See **Fig. 2**.
8. Install the knobs. See **Fig. 1**.
9. Remove the chocks from the tires.

General Information

The EC–16 is an electronic antilock controller. It is the base component in a family of full-vehicle wheel control antilock systems. See **Fig. 1**. In addition to the antilock function, the control module can be assembled and programmed to provide an optional traction control feature. Refer to **Table 1** for EC–16 mounting configurations.

Mounting Configuration			
Antilock Valve	**Added Function Provided**	**Vehicle Application**	**Designation (Valve+ EC–16)**
AR–1	None	All	CR–17 Controller Relay
AR–2	Bobtail Brake Proportioning	Tractors Only	CR–18 Controller Relay
ATR–1	Traction	All	AT–1 Antilock Traction
ATR–2	Traction and Bobtail Brake Proportioning	Tractors Only	AT–2 Antilock Traction

Table 1, Mounting Configuration

Designed to minimize the potential of brake lock-up on all wheels during aggressive braking, the four channel antilock system provides the vehicle with a high degree of stability and steerability during braking. In most cases, vehicle stopping distance is also reduced. The antilock portion of the four channel system minimizes wheel skid during hard or aggressive braking. By controlling wheel skid at all wheels on the vehicle, optimum steering control and stopping distance is obtained.

Traction control, an optional feature in the full-vehicle wheel control antilock systems, helps improve vehicle traction during acceleration in adverse road conditions. Integrated with antilock logic, the traction control monitors wheel speed information from the sensors during acceleration, as well as braking. The system helps maintain vehicle stability on slippery road surfaces and improves driveability and safety.

In order to provide full-vehicle wheel control antilock, the control module is used in combination with the following components:

- four wheel speed sensors
- two air pressure modulator valves
- one dash-mounted antilock warning lamp
- one service brake modulator relay valve
- two quick release valves (tandem axle only)
- one front modulator assembly (consists of two modulators and one quick release valve)

When programmed to provide traction control in addition to antilock, the following components are added:

- one traction solenoid (incorporated into the relay valve)
- two additional wheel speed sensors (on tandem drive vehicles only)
- one dash-mounted traction condition lamp
- serial connection to engine control module
- traction disable wiring and switch

INPUTS/OUTPUTS

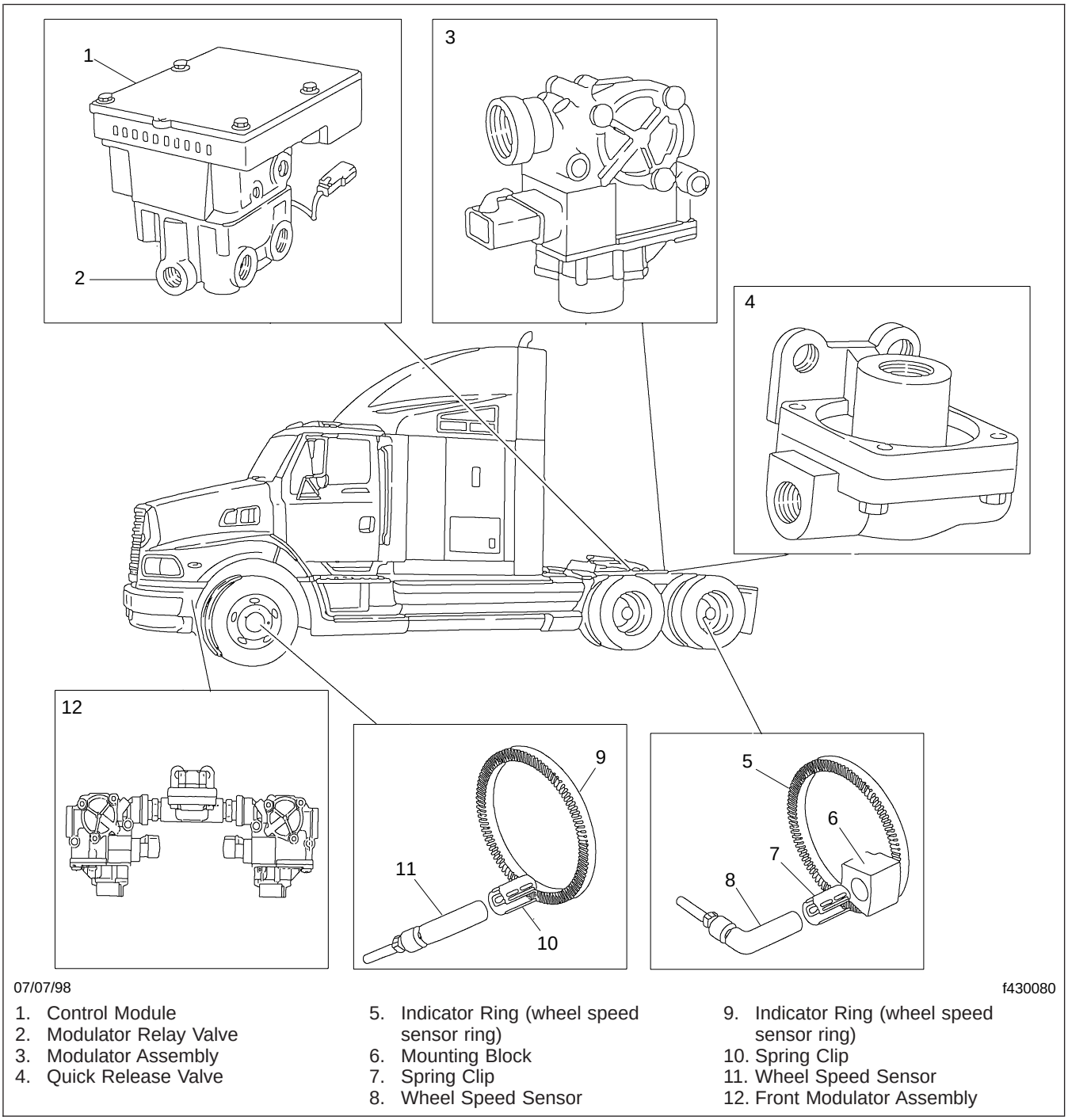
All components in the ABS system either send a signal to or receive a signal from the control module. Components that send signals to the control module are module inputs and components that receive signals are module outputs.

Inputs

Wheel speed sensor information is provided to the control module by a wiring harness from individual wheel speed sensors at or in the vehicle wheels. Working with an indicator ring or wheel speed sensor ring, wheel speed sensors provide information to the control module in the form of an AC signal which varies in voltage and frequency as the speed of the wheel increases or decreases.

The control module is designed to receive wheel speed information, from various wheel speed sensor models. The control module is able to simultaneously receive, and individually interpret, speed signals from six wheel speed sensors. Vehicle drive configuration and whether the traction control feature is in use determines the number of speed sensors that must be used. A vehicle with a single rear axle drive requires four speed sensors for both antilock and traction operation. A vehicle with two rear drive axles (6 x 4) requires four speed sensors for antilock only opera-

General Information



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1. Control Module
2. Modulator Relay Valve
3. Modulator Assembly
4. Quick Release Valve
5. Indicator Ring (wheel speed sensor ring)
6. Mounting Block
7. Spring Clip
8. Wheel Speed Sensor
9. Indicator Ring (wheel speed sensor ring)
10. Spring Clip
11. Wheel Speed Sensor
12. Front Modulator Assembly

Fig. 1, Component Location

tion, but have the option to use six speed sensors for enhanced performance of both antilock and traction operation.

Electrical power is supplied to the control module from the ignition switch through a fuse or a circuit breaker. The electrical ground for the control module is the vehicle chassis.

Outputs

Modulators like the M–22 are the means by which the control module modifies the driver applied air pressure to the service brakes. The modulator is an electrically controlled air valve located near the service actuator(s) it controls. A wiring harness connects the modulator to the control module. Solenoid valves contained in the modulator provide the electrical interface between the control module electronics and the air brake system. The control module is able to simultaneously and independently control four individual modulator assemblies.

An antilock dash lamp and its electrical relay or circuit are connected to, and controlled by, the control module and serve as a means of advising the driver of the condition of the antilock system.

A connection to the engine or transmission retarder and its relay is provided on the control module, which allows the control module to temporarily disable the retarder during certain modes of operation. While the control module is capable of this function, and connections are provided, it is not always used. The use of the retarder disable function is not essential but highly recommended for vehicles equipped with a retarder.

NOTE: The control module can also disable the retarder using the same protocol it uses to control the traction control, engine torque limiting feature. For this redundant retarder disable to function, the control module must be connected to the engine control module (as would be the case if the control module is programmed for the traction control, torque limiting feature).

The data link enables the control module to report its operating condition to a specialized, external computer in response to certain commands it receives. There are two connections to the control module devoted to the data link. While connections are provided for this function, it is not always used. The data link is not essential for the control module to be functional.

If the control module is programmed for traction control, it contains the following outputs:

- a connection to the engine control module allows the control module to reduce engine torque under certain circumstances
- a traction control dash lamp is connected to and controlled by the control module and serves as a means of advising the driver of the condition of the traction control system
- a connection to the traction solenoid (located in the upper portion of the antilock traction relay valve)
- a traction enable switch is provided, but not always used. The switch allows the traction control to be turned on or off manually

ANTILOCK OPERATION

The four-channel antilock system uses individual sensors, modulators and an electronic controller to control the four vehicle wheel ends. By monitoring the deceleration rate during braking, and subsequently adjusting the brake application pressure at each wheel, the control module is able to improve braking between the vehicle tire and the road surface it is on, while maintaining stability.

The rear axle brakes are controlled independently; therefore brake application pressure at an individual wheel is adjusted solely on the basis of its behavior on the road surface on which it is traveling.

While each steering axle brake is under the control of an individual modulator, the control module does not treat these brakes totally independently. The control module uses a modified individual control philosophy for the steering axle brakes. This is done in order to minimize steering wheel pull in the event each wheel is traveling on a different road surface (for example, ice close to the curb and a dry crown). Essentially the control module controls the braking force differences between the two brakes. The wheel on the dry pavement is initially given less braking force and is brought up to optimum during the stop, while the wheel on the ice attempts to maintain optimum braking during the entire stop.

In cases of vehicles equipped with tandem rear axles (6 x 2, 6 x 4), the wheel speed sensors are installed at the wheels on the axle that is most likely to lock first. A single modulator controls both curb side brakes on the tandem, and another modulator con-

trols both brakes on the driver's side of the tandem. With this arrangement of speed sensors and modulators, both brakes on one side of the tandem are treated as one since they will most likely be on the same type of road surface.

Non-Antilock Brake Application

During normal braking, air pressure from the brake valve enters the control port of the service relay valve. The service relay delivers air to, and through, the antilock modulator located near the braked wheel, and into the brake actuator. The service brakes are thus applied. If the wheel speed sensors do not detect an impending wheel lockup, the control module does not initiate any corrective action and the vehicle comes to a stop in a normal fashion.

Antilock Brake Application

If a service brake application is made and the wheel speed sensors detect an impending wheel lockup, the control module will immediately begin modification of the brake application using the antilock modulator(s) at the affected wheel(s). Solenoid valves contained in the modulator are energized and de-energized by the control module in order to modify the brake application.

When a solenoid coil is energized, its shuttle moves. Depending upon the function of the specific solenoid, it either opens or closes, thereby causing the exhaust or re-application of air pressure to the brake actuator. The solenoids in each modulator are controlled independently by the control module. By opening and closing the solenoid valves in the appropriate modulator, the control module is actually simulating what drivers do when they pump the brakes. It must be remembered, however, that unlike the driver, the control module is able to pump each brake on the vehicle independently and with far greater speed and accuracy.

TRACTION CONTROL OPERATION

Traction control is a natural extension of antilock. Just as antilock helps vehicle control and stability during braking, traction control helps during vehicle acceleration. The wheel speed sensors not only detect rapid decreases in wheel speed for antilock but also detect unreasonably high increases for traction control. With traction control, a spinning wheel is instantly detected and compared with the other wheels on the vehicle, both front and rear. Two different methods are used to control wheel spin: "Torque Limiting" and "Differential Braking". Depending upon the vehicle type, speed and road (surface) condition, each method provides a unique and desirable type of wheel spin control. Ideally both methods are used to control vehicle traction. While all new version control modules are capable of providing wheel control antilock and traction control (utilizing both methods of control), not all systems will be configured for both methods. Depending upon the vehicle, either or both traction control methods will be activated during the "Self Configuration Procedure" in this subject.

Torque Limiting

In order for the torque limiting control feature to be used, the vehicle must be equipped with an electronically controlled engine throttle. The torque limiting feature allows the control module to reduce engine torque to a suitable level for the available traction. Torque limiting helps to minimize the amount (or speed) of wheel spin. It is especially useful in helping to minimize a power jackknife when all drive wheels are on an equally slippery surface.

Differential Braking

In order for the differential braking control feature to be used, the vehicle must be equipped with an antilock traction relay valve such as the ATR–1 or 2. The ATR–1 and 2 contain a solenoid assembly which provides this feature. The differential braking feature allows the control module to gently pump the brake on the spinning wheel. Since the vehicle's differential tends to drive the wheel that presents the least resistance (the wheel on the most slippery surface), a slight brake application to this wheel only, forces the differential to drive the stationary or slowly spinning wheel. While a vehicle must be equipped with an electronic throttle to utilize the torque limiting feature of traction control, differential braking can be used on all vehicles. Differential braking can be activated only when the vehicle speed is under 25 mph and one drive wheel is spinning faster than the other(s).

Traction Control at Vehicle Speeds of 0 to 25 Mph (0 to 40 Km/h)

When wheel spin is detected and the vehicle is stopped, or moving at any speed up to 25 mph (40 km/h), the control module simultaneously executes the following operations:

- it instantly blinks the traction dash lamp to advise the driver that a wheel spin is occurring
- if the torque limiting feature is active, the control module uses its link to the engine control module and sends a signal to reduce engine torque to a level suitable for the available traction

If the differential braking feature is configured into the system, the control module energizes the solenoid in the ATR valve which then applies air to each of the rear axle modulators. Because the modulators are controlled by the control module, the solenoid valves in the appropriate modulator are opened and closed to gently pump the brake on the spinning wheel only. This gentle brake application forces the differential to drive the stationary or slowly spinning wheel

Once wheel spin is eliminated, the dash lamp goes out and the traction system disengages control.

Traction Control at Vehicle Speeds Above 25 Mph (40 Km/h)

If wheel spin occurs at any speed above 25 mph (40 km/h), the control module will instantly blink the traction dash lamp to advise the driver that a wheel spin is occurring.

NOTE: The control module will not signal the ATR valve to apply the brakes, even slightly, at any speed above 25 mph (40 km/h).

If the torque limiting feature is programmed in, the control module uses its link to the engine control module and sends a signal to reduce engine torque to a level suitable for the available traction.

COMPONENT FAILURE

Depending upon the type of failure and its position of occurrence, the control module disables all or only a portion of the antilock and traction system. A power or controller failure, however, will result in complete disabling of both systems and reversion to standard braking on all wheels.

Single Failure

The following descriptions and **Table 2** describe how the antilock and traction systems respond to a specific component failure.

NOTE: The right and left, front, mid and rear are determined from the driver seat. Left front is therefore the corner closest to the driver.

For example, if the right mid sensor (RM Sensor on the chart) fails, front and rear antilock will still be operative. Traction will be disabled, and, as always, the system has standard air braking.

Front Modulator

If a front modulator fails, antilock on that wheel is disabled. Antilock and traction on all other wheels remains active.

Rear Modulator

A rear modulator failure disables the traction system. Antilock on that wheel will also be disabled, but antilock on all other wheels remains active.

Front Sensor

The wheel is still modulated using input from the opposite sensor. The traction system is disabled.

Mid or Rear Sensor

Antilock on that wheel is disabled, but antilock on all other wheels remains active. Traction control is disabled.

Control Module

Antilock and traction are disabled. The system reverts to standard air braking.

Traction Solenoid

Traction control is disabled. Antilock remains active.

Engine Control Module

If the engine control module (ECM) or the wiring from the control module to the ECM fails, traction control is disabled. Antilock remains active.

Voltage

If system voltage is out of range, antilock and traction are disabled, and the system reverts to standard air braking.

General Information

Failure Location	System Still Operating (Yes/No)					
	ABS Front		ABS Rear		Traction	Standard Braking
	Left	Right	Left	Right		
RF Sensor	Yes	Yes	Yes	Yes	No	Yes
LF Sensor	Yes	Yes	Yes	Yes	No	Yes
RM Sensor	Yes	Yes	Yes	Yes	No	Yes
LM Sensor	Yes	Yes	Yes	Yes	No	Yes
RR Sensor	Yes	Yes	Yes	No	No	Yes
LR Sensor	Yes	Yes	No	Yes	No	Yes
RF Modulator	Yes	No	Yes	Yes	Yes	Yes
LF Modulator	No	Yes	Yes	Yes	Yes	Yes
RR Modulator	Yes	Yes	Yes	No	No	Yes
LR Modulator	Yes	Yes	No	Yes	No	Yes
Controller	No	No	No	No	No	Yes
Traction Solenoid	Yes	Yes	Yes	Yes	No	Yes
Engine Control Module NOTE: When ECM wiring or voltage corrects itself, the system is restored.	Yes	Yes	Yes	Yes	No	Yes
Voltage	No	No	No	No	No	Yes

Table 2, Failure Location

Multiple Failures

In the event that multiple failures occur, the dash lamp will react as it normally would during a single failure, and the LEDs will show one failure at a time, see **Table 3**. When the first problem is fixed and the system is reset, the next problem area will appear at the LEDs. This way, the driver or mechanic does not lose track of problem areas, and the system is not restored until each and every error is corrected and the control module is reset.

Dash Lamp Conditions					
Antilock Lamp	Lamp On 1st Time	Lamp Off 1st Time	Lamp On 2nd Time	Lamp Off 2nd Time	Lamp On Stays On
Traction Lamp (control module with torque limiting & differential braking)	On	Off	On	Off	Stays Off
Traction Lamp (control module with torque limiting only)	Off	Off	On	Off	Stays Off
Traction Lamp (control module with differential braking only)	On	Off	Off	Off	Stays Off

Table 3, Dash Lamp Conditions

CONTROL MODULE CONFIGURATION

General

All control modules manufactured on or after August 1, 1995 incorporate the self configuring feature. New, replacement control modules will be provided factory preprogrammed for 6 speed sensor inputs and both the differential braking and torque limiting features for traction control.

Identifying the Self Configuring Control Module

The self configuring control module can most easily be identified while installed on the vehicle. Identification can be made by observing the reaction of the diagnostic display when the ignition is switched ON and power is applied to the control module. The current configuration of the control module is displayed via the troubleshooting LEDs and occurs during the normal self test sequence. This configuration review is repeated each time the ignition is turned on. The sequence and manner of LED illumination is described in "Control Module Configuration Display". That section should also be used to confirm that the system is configured as desired.

The diagnostic LEDs on older versions of the control module will only react as described in items 2 and 6 under "Control Module Configuration Display".

Control Module Configuration Display

1. Turn the ignition on.
2. All LEDs will illuminate then go out.
3. The number of active sensors will be displayed by the momentary illumination of the red SEN (sensor) LED and two or more of the red locating LEDs. No other LEDs will be on.
   - 3.1 SEN + FRT (front) + RER (rear) = A four sensor configuration (all systems must have at least a 4 sensor configuration).
   - 3.2 SEN + FRT + MID (middle) + RER = A six sensor configuration.
4. The red TRC LED will momentarily illuminate by itself if traction control torque limiting is active. If not, then the display will go to the condition described previously.
5. The red TRC and MOD LEDs will momentarily illuminate if traction control differential braking is active. If not, then the display will go to the condition described previously. No other LEDs will be on.
6. The diagnostic display will return to its normal operational status. Assuming no problems exist in the antilock or traction system, all red LEDs will be off and the single, green, VLT LED is illuminated.

Control Module Self Configuring Process

1. Three aspects of the antilock and traction system are influenced by the self configuring feature of the control module.
   - 1.1 Speed Sensors—The number of speed sensors connected to the control module will be detected during the self configuration process. The control module will check the MID SEN (mid axle speed sensor) locations on its connector to determine if a sensor is connected to it and will default to a six sensor configuration if it detects even one sensor connected. If no mid axle speed sensor is detected, the control module will default to a four sensor configuration.
   - 1.2 Electronic Engine Control—If the control module is connected to the control module of an electronic engine, the torque limiting feature of traction control will be activated during the self configuring process.
   - 1.3 Antilock Traction Relay Valve—If the solenoid assembly in the ATR valve is connected to the control module, the differential braking feature of traction control will be activated during the self configuring process.
2. No method is available to disable the self-configuration feature.
3. Due to the extended period of time the magnet must be held on "Reset" to initiate the self configuration process (between 10 and 20 seconds),

it is unlikely that a self-configuration would occur accidentally.

4. Basic, four speed sensor, antilock operation can not be removed during the self configuration process. This is a minimum configuration for all control modules.
5. If a speed sensor is connected to either wheel on the mid axle, the control module will configure for six sensors. If no mid axle speed sensor is detected, the control module will configure for four sensors. Any disconnected speed sensor(s) will register as a failure on the diagnostic display at the end of the control module self test.
6. All or part of traction control can be lost during self configuration by:
   - 6.1 Not connecting one of the wire harnesses (engine control module for torque limiting and ATR valve solenoid for differential braking).
   - 6.2 A missing or inoperative traction dash lamp (bulb missing or burned out).
   - 6.3 A missing or inoperative traction control enable/disable switch.
   - 6.4 Not placing the traction control enable/disable switch in the disabled position. The operator can tell that the traction features are lost by noting the absence of the traction lamp flash upon power-up. The operator should note the flashing of the antilock condition lamp, and the traction lamp if traction equipped, upon every power-up. Observing the dash lamps is the only method the operator has to verify the system operation.
7. The control module can be reprogrammed up to 10,000 times.
8. When a replacement control module is installed on a vehicle that does not have one or more of the preprogrammed features, a failure will be registered on the dash lamp(s) and on the control module diagnostic display. For this reason it is necessary to perform the self configuring procedure.
9. Some configuration information is available by observing the reaction of the dash condition lamps on vehicles configured with traction control and equipped with the self configuring control module. When the ignition is switched on, the control module self test is begun. During the self test the dash lamps will flash on and off together as indicated in the chart, depending upon the type and amount of traction control configured into the control module.

Self Configuration Process

In order to successfully complete the self-configuring process follow the steps below.

1. Connect all antilock and traction control wire harnesses. Make certain that all the speed sensors present on the vehicle are connected (H2, H3, J1, J2 on the 30 pin connector and E2, E3, F2, F3, B2, B3, C2, C3 on the 18 pin connector). If the vehicle has an electronic engine and traction control torque limiting is desired the engine control module must be connected (B2 and B3 on the 30 pin connector). If the vehicle is equipped with either an ATR–1 or ATR–2 valve, the solenoid connection must be made to the control module (D2 and D3 on the 18 pin connector) in order to obtain traction control differential braking.
2. If the vehicle is to be configured with traction control, it must have a traction control dash lamp and a traction control enable/disable switch. Both the lamp and switch must be functional. Place the traction control enable/disable switch in the traction control disabled position (traction control inoperative).

NOTE: If the control module is being configured with traction control (either torque limiting, differential braking or both), the traction control condition dash lamp will be illuminated as well as the appropriate LEDs on the control module diagnostic display.

3. Turn the ignition on and hold a magnet on the "Reset" position of the control module diagnostic display until the LEDs begin to randomly flash then remove the magnet. If the magnet is not removed during the random LED flashing, a second self configuration may be initiated. The magnet may have to be held on "Reset" for as long as 20 seconds. When the self-configuration process is complete, the control module will automatically go through a self test. During the self test, the diagnostic display will indicate the new configuration as described under "Control Module

Configuration Display". The traction control dash lamp will be illuminated until the traction control enable/disable switch is placed in the traction control enabled position (traction control operative).

4. Place the traction control enable/disable switch in the traction control enabled position (traction control operative), the traction control dash lamp should be off.
5. Before placing the vehicle in service, verify the configuration and the system condition by turning the ignition off then on while observing the control module diagnostic display. The diagnostic display should indicate the desired configuration as described under "Control Module Configuration Display" in this section and no red LEDs should be illuminated at the end of the self test.
6. If the configuration appears correct but the diagnostic LEDs indicate a failure somewhere in the system, refer to "Inspection and Verification" in **Troubleshooting, 300** to locate and repair the problem.

NOTE: The traction switch must be in the disable position to configure traction, but must be placed in the enable position to allow the traction lamp to flash.

7. If the configuration is incorrect, the process can be repeated as required. One common error is performing the self-configuration with the traction enable/disable switch in the wrong position. This will prevent any traction features from being activated.

Safety Precautions

⚠ WARNING

Where circumstances require that the engine be in operation, extreme caution must be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.

⚠ WARNING

If the vehicle is equipped with traction control, disable the traction system before performing any dynamic driveline maintenance.

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels. Stop the engine when working around the vehicle.
2. Exhaust the air pressure from all reservoirs before beginning any work on the vehicle.
3. Shut the engine off when working in the engine compartment.
4. Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been exhausted.
5. Never exceed recommended pressures and always wear safety glasses.
6. Do not attempt to install, remove, disassemble or assemble a component without reading and thoroughly understanding the recommended procedures. Use only the proper tools and observe all precautions.
7. Replacement hardware, tubing, hose fittings, etc. must be of equivalent size, type and strength as original equipment, and be designed specifically for such applications and systems.
8. Components with stripped threads or damaged parts must be replaced rather than repaired. Repairs requiring machining or welding must not be attempted.
9. Prior to returning the vehicle to service, make sure all components and systems are restored to their proper operating condition. Repeat the initial check-out procedure.

Modulator Relay Valve Removal and Installation

Removal

WARNING

Make sure all the air pressure has been exhausted from the brake system to prevent personal injury or property damage; pressurized hoses may whip out of control.

1. Open the drain valve to exhaust the air pressure. See **Fig. 1**.

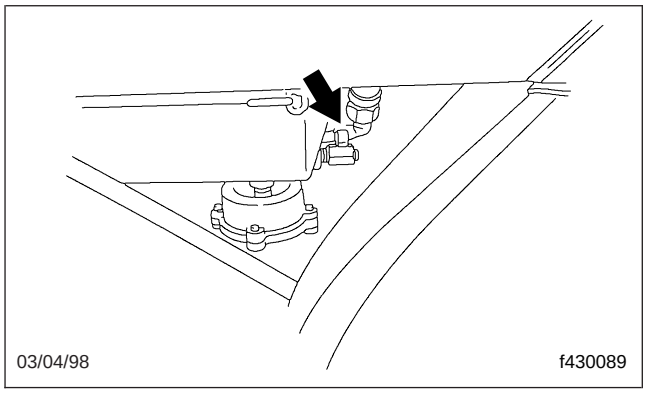

Fig. 1, Air Drain Valve

2. Remove the control module bolts and position the control module aside. See **Fig. 2**.

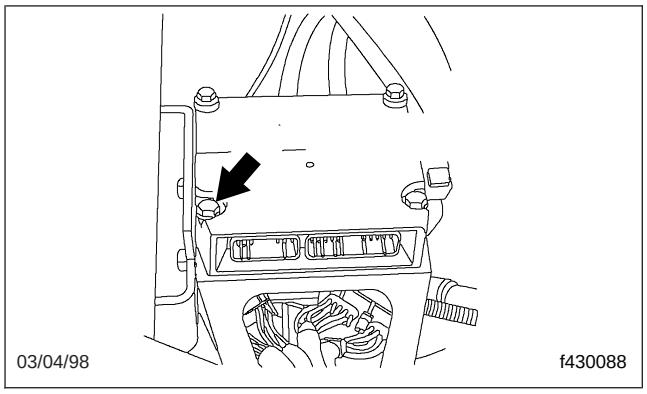

Fig. 2, Control Module Bolts

3. Disconnect the traction control electrical connector. See **Fig. 3**.
4. Cut the wire ties. See **Fig. 4**.
5. Mark and disconnect the air lines from the modulator relay valve. See **Fig. 5**.

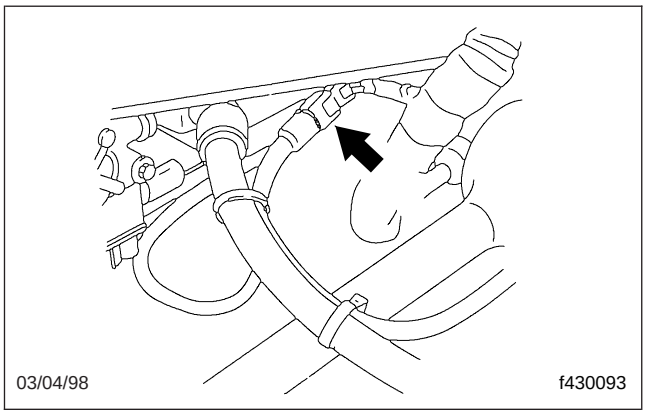

Fig. 3, Traction Control Electrical Connector

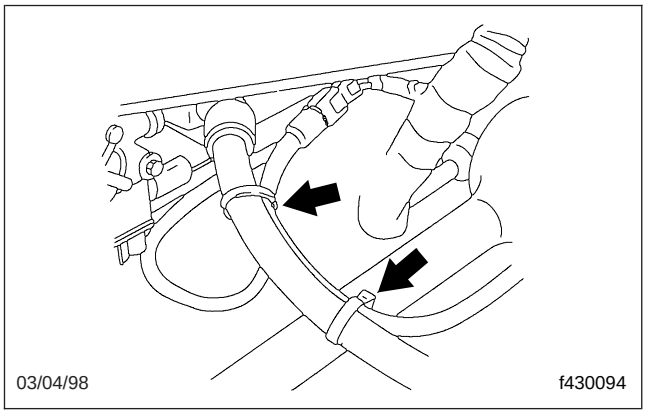

Fig. 4, Wire Ties

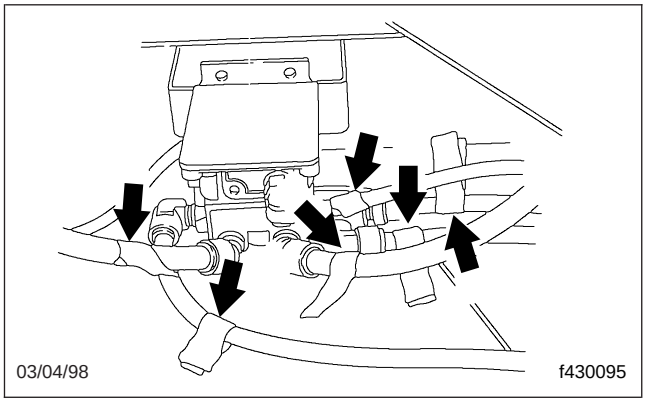

Fig. 5, Modulator Relay Valve Air Line

6. Remove the modulator relay valve bracket nuts.. See **Fig. 6**.
7. Remove the modulator relay valve air line fittings. See **Fig. 7**.

Modulator Relay Valve Removal and Installation

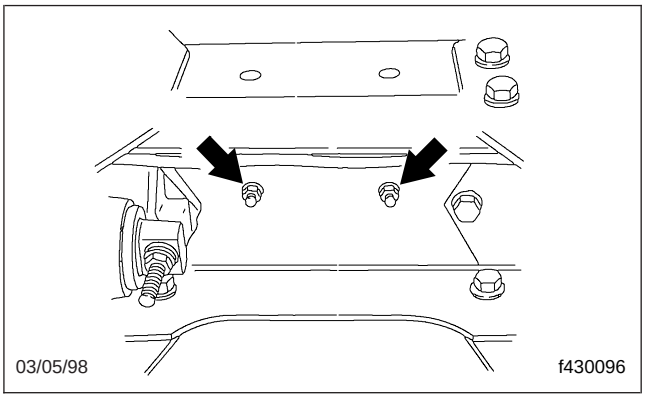

Fig. 6, Modulator Relay Valve Bracket Nuts

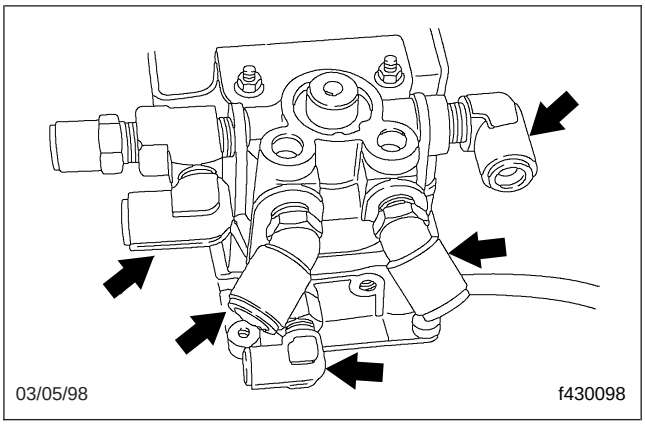

Fig. 7, Modulator Relay Valve Air Line Fittings

8. Remove the modulator relay valve bracket nuts and bolts. See **Fig. 8**.

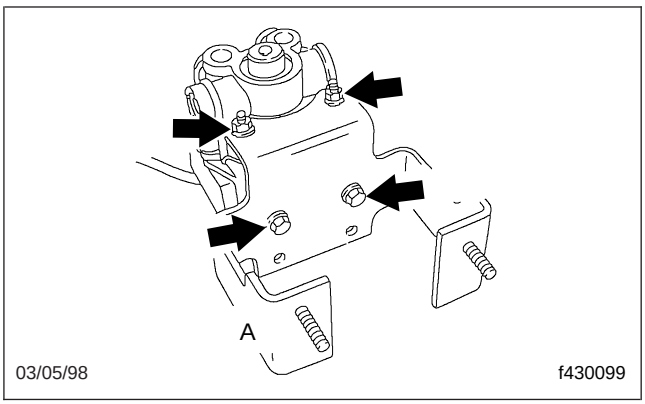

Fig. 8, Modulator Relay Valve Bracket Nuts

Installation

1. Install the modulator relay valve bracket nuts and bolts. Tighten the bolts 15 to 17 lbf·ft (20 to 23 N·m). See **Fig. 8**.
2. Install the modulator relay valve air line fittings. See **Fig. 7**.
3. Install the modulator relay valve bracket nuts. Tighten the nuts 28 to 31 lbf·ft (38 to 42 N·m). See **Fig. 6**.
4. Connect the air lines to the modulator relay valve. See **Fig. 5**.
5. Connect the traction control electrical connector. See **Fig. 3**.
6. Use wire ties to secure the traction control wiring. See **Fig. 4**.
7. Position the control module and Install the control module bolts. Tighten the bolts 50 to 80 lbf·in (56 to 90 N·cm). See **Fig. 2**.

Front Modulator Valve Removal and Installation

Removal

WARNING

Make sure all the air pressure has been exhausted from the brake system to prevent personal injury or property damage; pressurized hoses may whip out of control.

1. Open the drain valve to exhaust the air pressure. See **Fig. 1**.

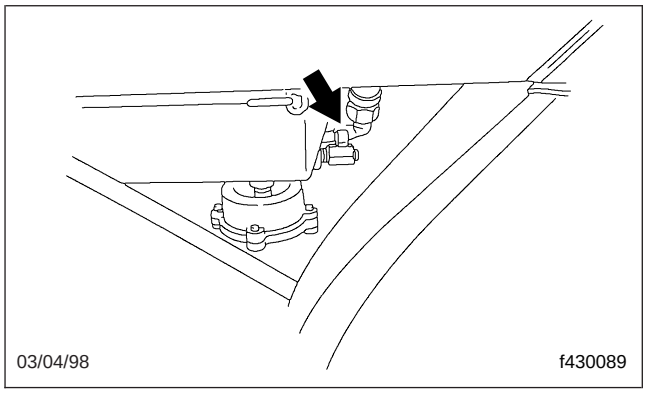

Fig. 1, Air Drain Valve

2. Disconnect the modulator electrical connectors. See **Fig. 2**.

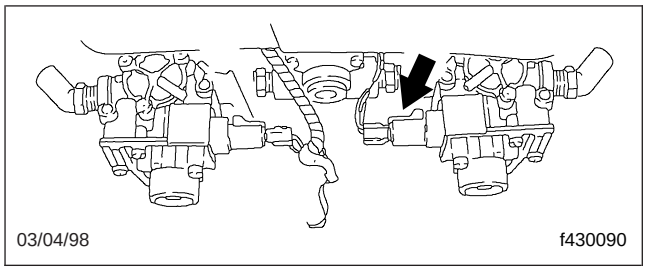

Fig. 2, Modulator Electrical Connectors

3. Disconnect the modulator air lines. See **Fig. 3**.
4. Remove the modulator valve nuts. See **Fig. 4**.
5. Separate the defective modulator valve. Then, remove the modulator valve. See **Fig. 5**.

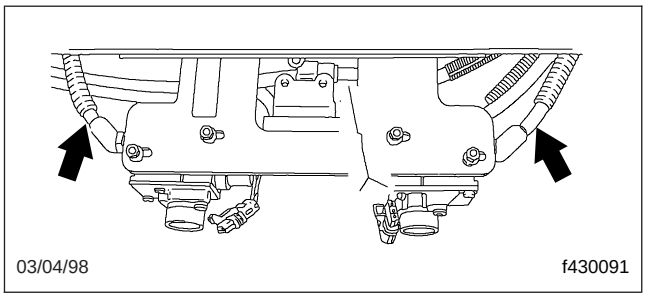

Fig. 3, Modulator Air Lines

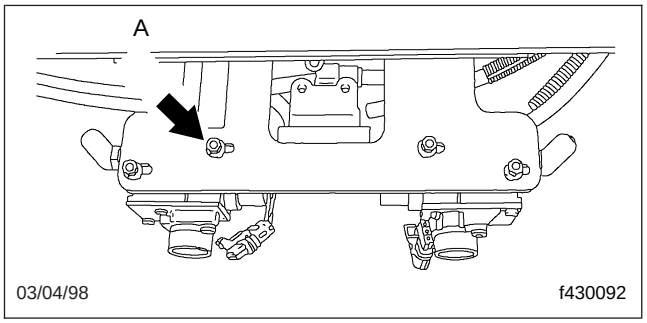

Fig. 4, Modulator Valve Nuts

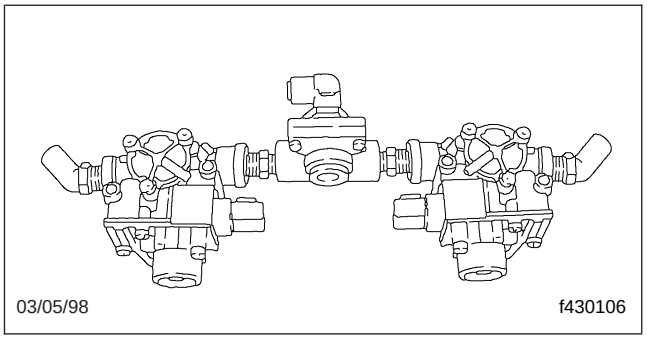

Fig. 5, Modulator Valve

Installation

1. Install the modulator valve and valve nuts. Tighten the modulator valve nuts 15 to 17 lbf·ft (20 to 23 N·m). See **Fig. 4**.
2. Connect the modulator air lines. See **Fig. 3**.
3. Connect the modulator electrical connectors. See **Fig. 2**.

Rear Modulator Valve Removal and Installation

Removal

WARNING

Make sure all the air pressure has been exhausted from the brake system to prevent personal injury or property damage; pressurized hoses may whip out of control.

1. Open the drain valve to exhaust the air pressure. See **Fig. 1**.

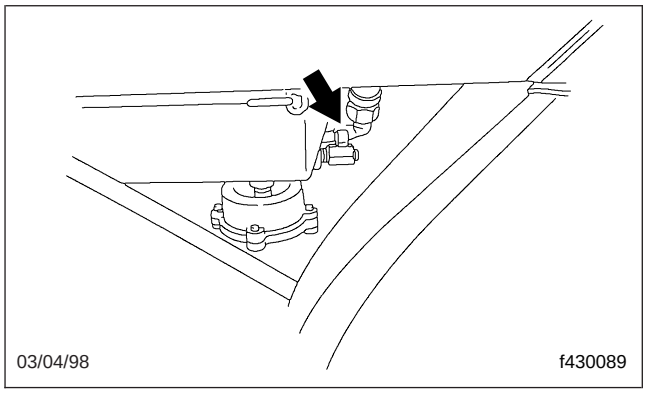

Fig. 1, Air Drain Valve

2. Disconnect the modulator electrical connector. See **Fig. 2**.

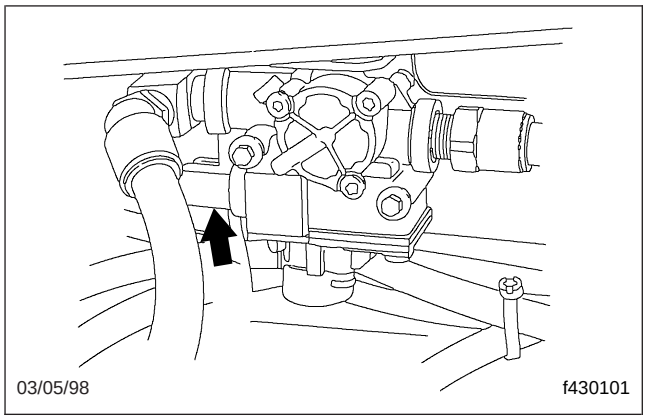

Fig. 2, Modulator Electrical Connector

3. Disconnect the modulator air line. See **Fig. 3**.
4. Remove the modulator valve bolts. See **Fig. 4**.
5. Disconnect the air line and remove the modulator valve. See **Fig. 5**.

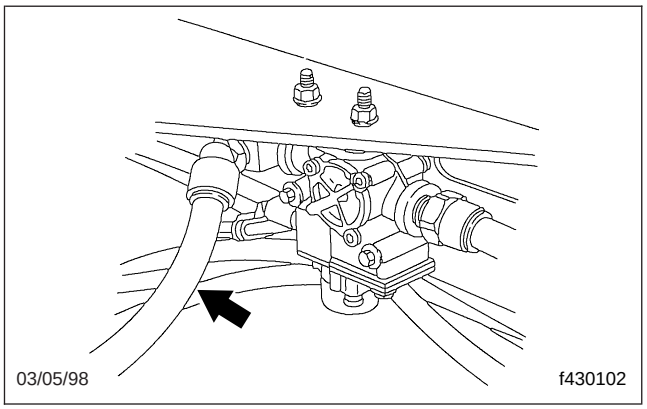

Fig. 3, Modulator Air Line

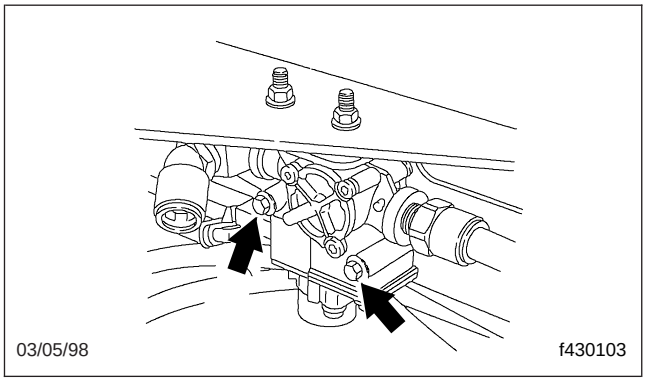

Fig. 4, Modulator Valve Bolts

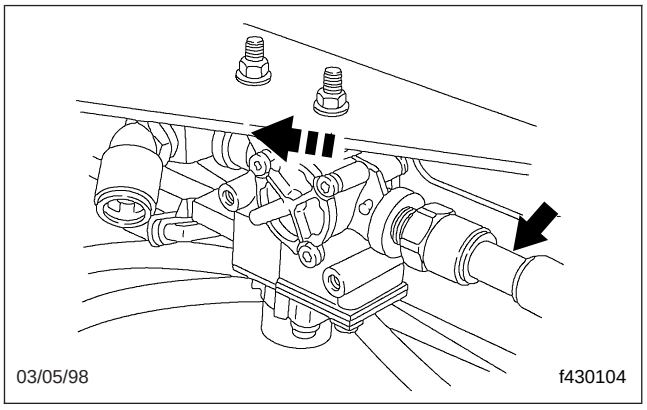

Fig. 5, Modulator Valve Air Line

Installation

1. Install the modulator valve and valve bolts. Tighten the modulator valve bolts 15 to 17 lbf·ft (20 to 23 N·m). See **Fig. 4**.

Rear Modulator Valve Removal and Installation

2. Connect the modulator air line. See **Fig. 3**.
3. Connect the modulator electrical connector. See **Fig. 2**.

Antilock Control Module Removal and Installation

Removal

1. Disconnect the battery ground cable. Refer to **Group 54**.
2. Remove the screws and disconnect the control module electrical connectors. See **Fig. 1**.

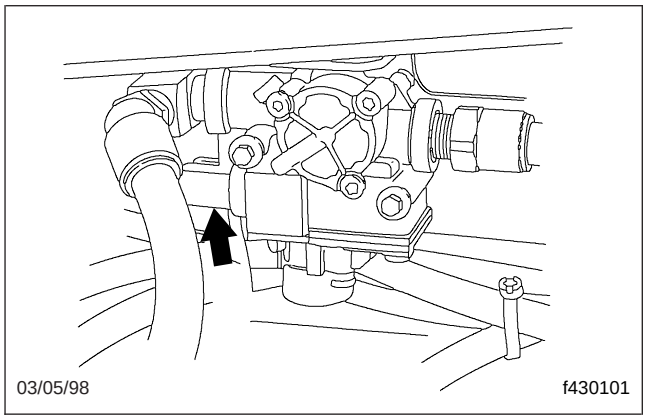

Fig. 1, Antilock Control Module Electrical Connectors

3. Remove the control module bolts and remove the control module. See **Fig. 2**.

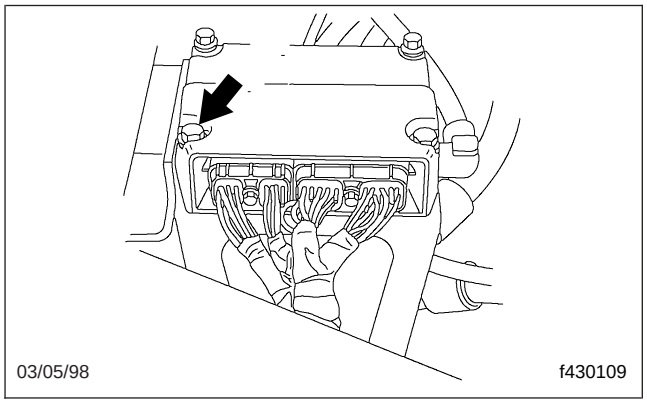

Fig. 2, Control Module Bolts

Installation

1. Install the control module and control module bolts. Tighten the bolts 50 to 80 lbf·in (56 to 90 N·cm). See **Fig. 3**.
2. Connect the control module electrical connectors and install the retaining screws. Tighten the screws 17 to 26 lbf·in (20 to 30 N·cm). See **Fig. 4**.

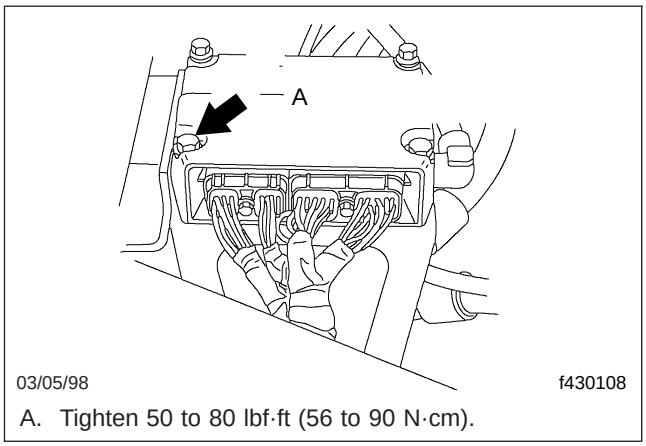

Fig. 3, Antilock Control Module Bolts

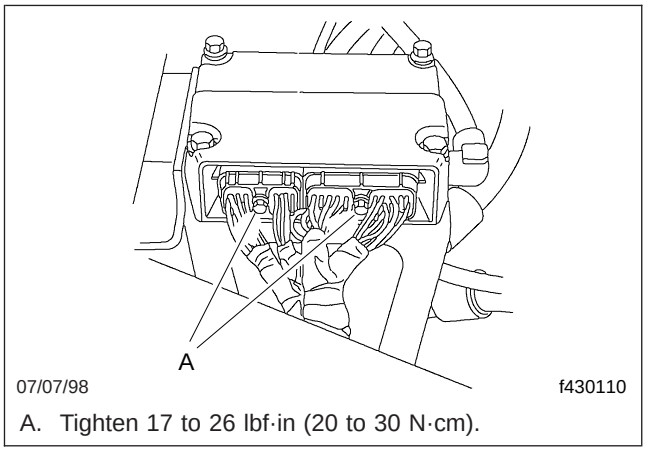

Fig. 4, Antilock Control Module Electrical Connector Screws

Front Wheel Speed Sensor Removal and Installation

Removal

IMPORTANT: Grasp the wheel speed sensor at the base to prevent damage to the component during removal.

1. Open the hood to gain access to the steering knuckle.
2. Remove the wheel speed sensor from the steering knuckle, using a twisting motion. See **Fig. 1**.

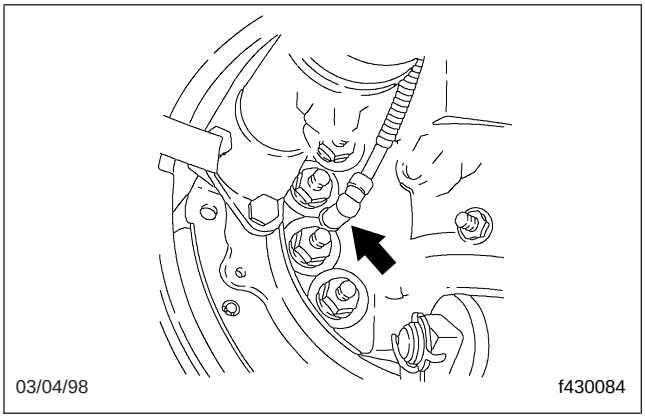

Fig. 1, Wheel Speed Sensor

3. Disconnect the wheel speed sensor electrical connector and remove the sensor. See **Fig. 2**.

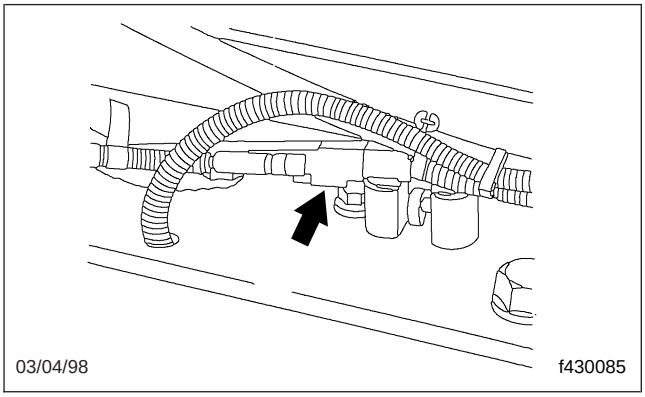

Fig. 2, Wheel Speed Sensor Electrical Connector

Installation

1. Open the hood to gain access to the steering knuckle.
2. Install the wheel speed sensor into the bushing in the steering knuckle until it comes to a stop.
3. Connect the wheel speed sensor electrical connector. See **Fig. 2**.

Rear Wheel Speed Sensor Removal and Installation

Removal

IMPORTANT:Grasp the wheel speed sensor at the base to prevent damage to the component during removal.

1. Remove the wheel and tire assembly; refer to **Group 40**.
2. Manually release the brake air chamber.
3. Remove the brake drum. See **Fig. 1**.

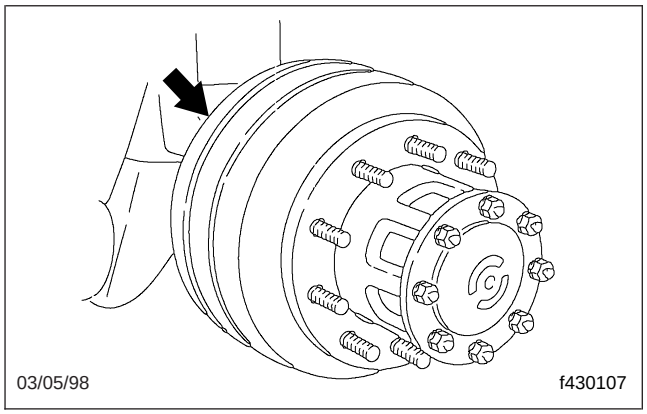

Fig. 1, Brake Drum

4. Remove the wheel speed sensor from the mounting block, using a twisting motion. See **Fig. 2** and **Fig. 3**.

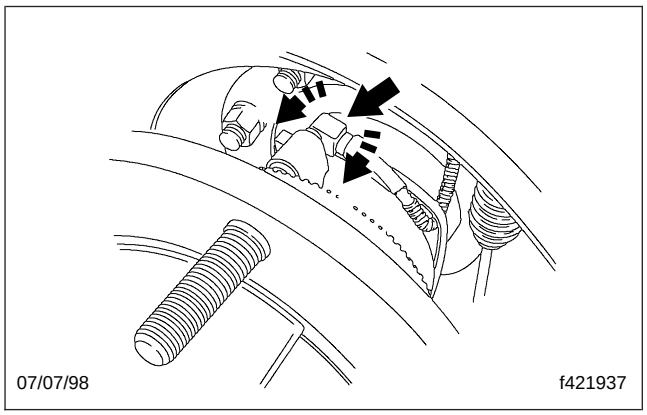

Fig. 2, Twisting the Rear Wheel Speed Sensor

5. Disconnect any fasteners that hold the wheel speed sensor harness, and disconnect the wheel speed sensor connector.

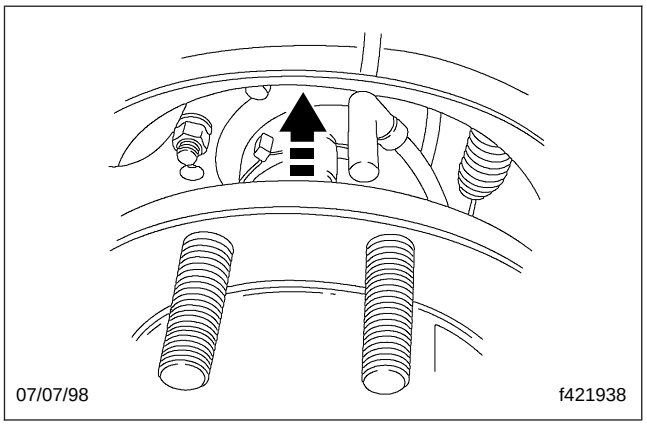

Fig. 3, Rear Wheel Speed Sensor, Removed

6. Pull the harness through the access hole to remove the wheel speed sensor harness.

Installation

1. Install the wheel speed sensor into the bushing until it comes to a stop.
2. Install any fasteners that hold the wheel speed sensor harness.
3. Connect the wheel speed sensor electrical connector.
4. Install the brake drum. See **Fig. 1**.
5. Install the wheel and tire assembly; refer to **Group 40**.

Wheel Speed Sensor Ring/ Sensor Indicator

The wheel speed sensor rings on the front and rear hubs are not serviceable. The hubs must be replaced.

Refer to **Group 35** for removal and installation procedures.

Troubleshooting

Inspection and Verification

General

While the diagnostic display locates a specific area, it is still needed to confirm whether the concern resides in the component itself or the wiring. The following troubleshooting procedure is devoted to narrowing the problem to either the wiring or a specific antilock or traction control component. It should be noted that all troubleshooting begins by observing the antilock and traction control lamps on the dash.

To assist the troubleshooting technician in keeping track of the procedure and also to provide a record of the repairs performed, use a troubleshooting record sheet. See **Fig. 1**. Refer to "Troubleshooting Tips" in this section.

Troubleshooting Tips

1. Determine if the vehicle is equipped with traction control. The presence of a traction control lamp on the dash can be used.
2. Some vehicles are equipped with a traction control disable switch. If so equipped, enable the traction system before beginning the troubleshooting.
3. If the vehicle is equipped with traction control and is a tandem axle unit, note the number of drive axles. The MID diagnostic LED is used only on 6 x 4 vehicles equipped with traction control.
4. It is generally advisable to replace a wire harness rather than repair individual wires in the harness. If a splice repair must be made, it is important that the splice be properly soldered with a rosin flux (not acid based) and made waterproof.
5. While the retarder disable, serial link, and traction on/off connections (4 total) are present on all control modules, they are not always used.

⚠ CAUTION

Use caution when probing the wire harness terminals. Excessive force can cause the terminal to spread, thereby causing a loss of contact with the mating terminal. Record all findings and the actions taken while troubleshooting on a troubleshooting record sheet. The troubleshooting record sheet should be filed in the vehicle maintenance folder for further reference and comparison. See Fig. 1.

No voltage or resistance tests are performed on the control module. All voltage and resistance tests are performed by beginning at the wire harness half of the connector and moving away from the control module toward an antilock traction system component (modulator, wheel speed sensor, etc.).

NOTE: If a failure occurs in a wheel speed sensor, both the antilock and traction control lamps will illuminate. Always begin diagnosis of the antilock lamp first.

Pin Test

When performing checks at the control module connector pins, be careful not to damage the pins. Also, check the pins for corrosion and damage. Make sure the terminals and pins make proper contact.

Ground Tests

Make sure all ground connections are tight and that all ground voltage measurements are zero volts.

Resistance Tests

Make sure the wiring harnesses are tight and in good condition without any damaged insulation or frayed wires. Measure the resistance or continuity at the control module connector to verify the condition of the wiring harness or component.

Component Resistance

If the resistance or continuity tests are not within specifications, measure the resistance of each component at the connector. If the resistance is not correct, check the component and repair or replace the parts as needed.

Checking Continuity, Power and Ground

When checking for continuity, do not pierce the wire insulation. Check for power, ground or continuity by disconnecting the connector and testing the individual pins or sockets in the connector.

Troubleshooting

TROUBLESHOOTING RECORD SHEET

TECHNICIAN'S NAME _____

DATE _____ TIME _____

LOCATION _____

VEHICLE NUMBER _____

VEHICLE MILEAGE _____ MILES _____

CHECK LED'S ILLUMINATED

___ FRT ___ MID ___ RER ___ RHT ___ LFT ___ TRC ___ MOD ___ SEN ___ ECU ___ VLT

STEPS TAKEN, COMMENTS

_____

_____

_____

_____

CHECK LED'S ILLUMINATED

___ FRT ___ MID ___ RER ___ RHT ___ LFT ___ TRC ___ MOD ___ SEN ___ ECU ___ VLT

STEPS TAKEN, COMMENTS

_____

_____

_____

_____

CHECK LED'S ILLUMINATED

___ FRT ___ MID ___ RER ___ RHT ___ LFT ___ TRC ___ MOD ___ SEN ___ ECU ___ VLT

STEPS TAKEN, COMMENTS

_____

_____

_____

_____

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Fig. 1, Troubleshooting Record

Exhaust Brake Disable, Data Link, and Traction "On/Off" Connections

The exhaust disable, data link, and traction on/off connections are on all control modules but are not always used.

Use Rotunda 73 Digital Multimeter or equivalent to perform troubleshooting procedures.

Problem—Initial Start-Up Procedure

Problem—Initial Start-Up Procedure	
Possible Cause	**Remedy**
System is functioning abnormally	Check the vehicle for traction control. Turn the ignition switch to the "On" position. If the vehicle is not equipped with traction control, check the antilock dash lamp. If the antilock dash lamp did not illuminate, blink twice then turn off, refer to "Problem—Antilock Warning Lamp" If the antilock dash lamp illuminated, blinked twice then turned off, check the antilock dash lamp status. Drive the vehicle. Increase vehicle speed to above 10 mph for 20 seconds and observe the antilock dash lamp. If the antilock dash lamp does not illuminate, the system is functioning normally. Note the parts replaced or repaired and the steps taken on the troubleshooting sheet. Test the system for normal operation. If the antilock dash lamp does illuminate, check the SEN LED. If the SEN LED is lit, refer to "Problem—Wheel Speed Sensor Failure" and test the appropriate wheel speed sensor. If the vehicle is equipped with traction control, check the dash lamps. Observe the antilock and traction control dash lamps. If the traction control lamp did not blink twice then turn off, check the traction control enable switch. Make sure the traction control enable switch is turned on. If the traction control dash lamp is illuminated, refer to "Problem—Traction Control Dash Lamp". If the traction control dash lamp is not illuminated, check the antilock dash lamp. If the antilock dash lamp did not illuminate, blink twice then turn off, refer to "Problem—Antilock Warning Lamp". If the antilock dash lamp illuminated, blinked twice then turned off, check the antilock dash lamp status. Drive the vehicle. Increase vehicle speed to above 10 mph for 20 seconds and observe the antilock dash lamp. If the antilock dash lamp does not illuminate, the system is functioning normally. Note the parts replaced or repaired and the steps taken on the troubleshooting sheet. Test the system for normal operation. If the antilock dash lamp does illuminate, check the SEN LED. If the SEN LED is lit, refer to "Problem—Wheel Speed Sensor Failure" and test the appropriate wheel speed sensor.

Problem—Antilock Warning Lamp

Problem—Antilock Warning Lamp	
Possible Cause	**Remedy**
Harness and relay shorts	Check the lamp with the control module disconnected. Turn the ignition switch to the "Off" position. Disconnect control module (30-Pin) electrical connector C409. Turn the ignition switch to the "On" position. Observe the amber antilock warning lamp on the dash. If the antilock dash lamp is lit, check the antilock wiring harness and relay for shorts to ground. Test the system for normal operation. If the antilock dash lamp is off, check the antilock wiring harness and the antilock dash lamp bulb for an open. Test the system for normal operation
Faulty warning lamp components	

Troubleshooting

Problem—Green LED Lit but Not Flashing

Problem—Green LED Lit but Not Flashing (See Fig. 2 and Fig. 3)	
Possible Cause	**Remedy**
Damaged control module	Check the red LEDs. If any red LEDs are lit, note and record the condition of all the red LEDs, then refer to "Problem—Red LED Lit". If no red LEDs are lit, reset the control module. Turn the ignition switch to the "On" position. Place the magnet over the reset portion of the control module and hold the magnet in place. If all the LEDs are not illuminated, replace the control module. Test the system for normal operation. If all the LEDs are illuminated, check the supply voltage to the control module. Turn the ignition switch to the "Off" position. Disconnect the control module 30-Pin connector C409. Measure the voltage between the control module 30-Pin connector C409 Pin E3 and ground. If the voltage is greater than 10 volts, repair or replace the antilock wiring harness, the circuitry to the warning lamp bulb or the bulb. Test the system for normal operation. If the voltage is less than 10 volts, repair or replace the antilock wiring harness or the ABS relays. Test the system for normal operation.
Harness and relay shorts	
False failure codes	

Problem—Green LED Flashing

Problem—Green LED Flashing (See Fig. 2)	
Possible Cause	**Remedy**
Damaged control module	Check the voltage supply to the control module. Turn the ignition switch to the "Off" position. Disconnect the control module 30-Pin electrical connector C409. Turn the ignition switch to the "On" position. Measure the voltage between the control module 30-Pin connector, Pins B1 to A1 and A3. If the voltage is not between 11 and 17 volts, repair the affected circuit(s). Test the system for normal operation. If the voltage is between 11 and 17 volts, check the supply voltage to the control module. Measure the voltage between the control module 30-Pin connector C409, Pins K2 to A1, A2 and A3. If the voltage is not between 11 and 17 volts, repair the affected circuit(s). Test the system for normal operation. If the voltage is between 11 and 17 volts, check the supply voltage.
Harness and relay shorts	
False failure codes	Measure the voltage between the control module 30-Pin connector C409, Pins K3 to A1, A2 and A3. If the voltage is between 11 and 17 volts, replace the control module. Repeat the "Problem—Initial Start-Up Procedure". Test the system for normal operation. If the voltage is not between 11 and 17 volts, repair the affected circuit(s). Test the system for normal operation.

Problem—Red LED Lit

Problem—Red LED Lit (See Fig. 2)	
Possible Cause	**Remedy**
Damaged control module	Check the red ECU LED. If the red ECU LED is lit, check the voltage supply to the control module. Turn the ignition switch to the "Off" position. Disconnect the control module 30-Pin electrical connector C409. Turn the ignition switch to the "On" position. Measure the voltage between the control module 30-Pin connector Pins B1 to A1 and A3. If the voltage is not between 11 and 17 volts, repair the affected circuit(s). Test the system for normal operation. If the voltage is between 11 and 17 volts, check the supply voltage tot the control module.
Harness and relay shorts	Measure the voltage between the control module 30-Pin connector C409, Pins K2 to A1, A2 and A3. If the voltage is not between 11 and 17 volts, repair the affected circuit(s). Test the system for normal operation. If the voltage is between 11 and 17 volts, check the supply voltage. Measure the voltage between the control module 30-Pin connector C409 Pins K3 to A1, A2 and A3. If the voltage is between 11 and 17 volts, replace the control module. Repeat the "Problem—Initial Start-Up Procedure". Test the system for normal operation. If the voltage is not between 11 and 17 volts, repair the affected circuit(s). Test the system for normal operation.
False failure codes	If the red ECU LED is not lit, check the combination of the red LEDs. There should be a minimum of three red LEDs illuminated and, of these three, there must be a RHT, LFT, FRT, RER and a MOD or SEN LED. If this condition does not exist, replace the control module. Test the system for normal operation. If this condition exists, note the illuminated LEDs. If the MOD LED is lit using the two positioning LEDs (RHT/LFT and FRT/RER), refer to "Problem—Modulator Valve" and test the appropriate modulator. If the MOD LED is not lit, and the SEN LED is lit, and the SEN LED is not lit, refer to "Problem—Initial Start-Up Procedure". If the SEN LED is lit using the two positioning LEDs (RHT/LFT and FRT/RER), refer to "Problem—Wheel Speed Sensor Failure", and test the appropriate wheel speed sensor.

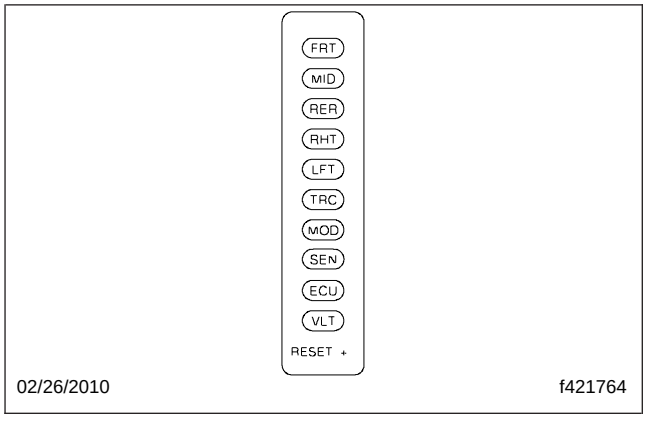


Fig. 2, Diagnostic LEDs

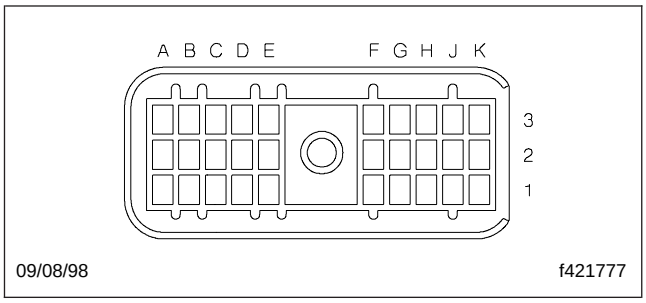


Fig. 3, Control Module 30-Pin Connector

Troubleshooting

Problem—Wheel Speed Sensor Failure

Problem—Wheel Speed Sensor Failure (See Fig. 2 and Fig. 4)	
Possible Cause	**Remedy**
Improper wheel speed sensor resistance	Turn the ignition switch to the "On" position. Reset the control module. Place the magnet over the reset portion of the control module, then remove the magnet. If any red LEDs are illuminated, observe the LEDs on the control diagnostic window. If the same red LEDs are not illuminated, refer to "Problem—Red LED Lit". If the same red LEDs are illuminated, check the wheel speed sensor circuitry. Turn the ignition switch to the "Off" position. Disconnect the control module 18-Pin and 30-Pin connectors C409 and C429. The 30-Pin connector C409 is for the front sensors and the 18-Pin connector C429 is for the rear and middle (tandem axle) sensors. Perform the component test for the appropriate wheel speed sensor at the control module connector. If the resistance values are within the specifications indicated in the component test, replace the control module. Test the system for normal operation. If the resistance values are not within the specifications indicated in the component test, check the wheel speed sensor resistance at the sensor. Disconnect the inoperative wheel speed sensor. Measure the resistance between the inoperative wheel speed sensor terminals (component side). If the resistance is not between 1500 and 2500 ohms, replace the wheel speed sensor. Repeat the "Problem—Initial Start-Up Procedure". Test the system for normal operation. If the resistance is between 1500 and 2500 ohms, connect the control module 18-Pin and 30-Pin connectors C409 and C429. Connect the wheel speed sensor wiring connector. Turn the ignition switch to the "On" position. Reset the control module. Place the magnet over the reset portion of the control module, then remove the magnet. If no red LEDs are illuminated, repeat "Problem—Initial Start-Up Procedure". If any red LEDs are illuminated, check the status of the red LEDs. Observe the LEDs on the control module diagnostic window. If the same red LEDs are illuminated as before, repair and replace the wheel sensor wiring harness. Test the system for normal operation. If the same red LEDs are not illuminated as before, refer to "Problem—Red LED Lit". If no red LEDs are illuminated, check the gap between the wheel speed sensor and the wheel speed sensor ring. Turn the ignition switch to the "Off" position. Check the gap between the inoperative wheel speed sensor and the wheel speed sensor ring. If the wheel speed sensor gap is between 0 and 0.015 inch, check the wheel bearing for proper free play. Adjust as necessary. Refer to **Group 32** for the front and **Group 35** for the rear. Check the wheel speed sensor ring. Visually inspect the wheel speed sensor ring for missing or damaged teeth and that the ring runs true and perpendicular to the sensor face. If the wheel speed sensor ring is not in proper condition, repair or replace as necessary. If the wheel speed sensor ring is in proper condition, check the wheel speed sensor harness. Visually inspect the wheel speed sensor harness and connector for damage. Check the harness for continuity. If the wheel speed sensor harness is not in proper condition, repair or replace as necessary. If the wheel speed sensor harness is in proper condition, check the brakes.
Damaged wheel speed sensor ring	
Circuitry open or shorted	
Damaged control module	
Improper wheel speed sensor resistance	

Problem—Wheel Speed Sensor Failure

Problem—Wheel Speed Sensor Failure (See Fig. 2 and Fig. 4)	
Possible Cause	**Remedy**
Damaged wheel speed sensor ring	Check the dragging brakes (overadjusted, trapped air in actuator, out of round drums, damaged return springs, parking brake system concerns, etc.). If the brakes are not within specification and operating properly, repair as necessary. If the brakes are within specification and operating properly, check the wheel speed sensor mounting tightness. If the wheel speed sensor is not securely mounted, tighten the sensor by replacing the spring sleeve that holds the sensor in the mounting block bore. Test the system for normal operation. If the wheel speed sensor is securely mounted, Inspect the wheel speed sensor for any cracks or physical damage. If the wheel speed sensor does not check OK, replace the wheel speed sensor. Test the system for normal operation. If the wheel speed sensor checks OK, turn the ignition switch to the "On" position. If the wheel speed sensor is OK, reset the control module. Place the magnet over the reset portion of the control module, then remove the magnet. If any red LEDs are illuminated, refer to "Problem—Red LED Lit". If no red LEDs are illuminated, repeat "Problem—Initial Start-Up Procedure". Test the system for normal operation. If the wheel speed sensor gap is not 0 to 0.015 inch, check for loose or worn wheel bearings before regapping the sensor. Refer to **Group 32** for the front and **Group 35** for the rear. Turn the ignition switch to the "On" position. If the wheel speed sensor checks OK, reset the control module. Place the magnet over the reset portion of the control module, then remove the magnet. If any red LEDs are illuminated, refer to "Problem—Red LED Lit". If no red LEDs are illuminated, repeat "Problem—Initial Start-Up Procedure". Test the system for normal operation.
Circuitry open or shorted	
Damaged control module	

Troubleshooting

Problem—Modulator Valve

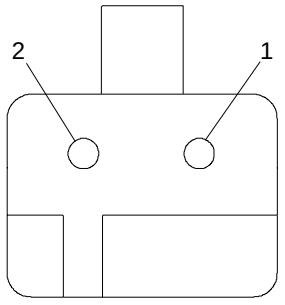
Problem—Modulator Valve (See Fig. 2 and Fig. 5)	
Possible Cause	**Remedy**
Improper modulator valve resistance	Check the modulator valve circuits. Disconnect the control module 30-Pin and 18-Pin connectors C409 and C429. NOTE: The 30-Pin connector C409 is for the front modulators and the 18-Pin connector C429 is for the rear modulators. Perform the component test for the appropriate modulator valve at the control module connector. If the resistance values are within the specification indicated in the component test, connect the inoperative modulator connector. Connect the control module 30-Pin and 18-Pin connectors C409 and C429. Reset the control module. Place the magnet over the reset portion of the control module, then remove the magnet. If any red LEDs are illuminated, repair or replace the inoperative modulator valve wiring harness. Test the system for normal operation. If no red LEDs are illuminated, repeat "Problem—Initial Start-Up Procedure". If testing returns to this point two consecutive times, replace the control module. Test the system for normal operation. If the resistance values are not within the specification indicated in the component test, check the inoperative modulator valve. Disconnect the modulator valve connector. Measure the resistance between the inoperative modulator valve hold terminal and common terminal (component side). If the resistance is not between 3.5 and 5.0 ohms, replace the inoperative modulator valve. Test the system for normal operation. If the resistance is between 3.5 and 5.0 ohms, check the inoperative modulator valve resistance. Measure the resistance between the inoperative modulator valve exhaust terminal and common terminal (component side). If the resistance is not between 3.5 and 5.0 ohms, replace the inoperative modulator valve. Test the system for normal operation. If the resistance is between 3.5 and 5.0 ohms, check the modulator valve. Measure the resistance between the inoperative modulator valve exhaust terminal and hold terminal (component side). If the resistance is not between 7 and 10 ohms, replace the inoperative modulator valve. Test the system for normal operation. If the resistance is between 7 and 10 ohms, connect the inoperative modulator connector. Connect the control module 30-Pin and 18-Pin connectors C409 and C429. Reset the control module. Place the magnet over the reset portion of the control module, then remove the magnet. If any red LEDs are illuminated, repair or replace the inoperative modulator valve wiring harness. Test the system for normal operation. If no red LEDs are illuminated, repeat "Problem—Initial Start-Up Procedure". If testing returns to this point two consecutive times, replace the control module. Test the system for normal operation.
Circuitry open or shorted	
Damaged control module	

Problem—False Indication Caused By Wheel Speed Components

Problem—False Indication Caused By Wheel Speed Components (See Fig. 2)	
Possible Cause	**Remedy**
Harness and relay shorts	Turn the ignition switch to the "On" position. Place the magnet over the reset portion of the control module and hold the magnet in place. If all the LEDs are not illuminated, replace the control module. Test the system for normal operation. If all the LEDs are illuminated, remove the magnet, then check the wheel speed sensors and indicator rings. Turn the ignition switch to the "Off" position. Inspect the axle(s) for the presence of, and for proper installation of, the wheel speed sensors and indicator rings. Inspect the wheel speed sensor gap and the bearing end play. If all the components check OK, drive the vehicle at 10 mph for at least 20 seconds. Repeat the "Problem—Initial Start-Up Procedure". If all the components do not check OK, repair or replace as necessary. Drive the vehicle at 10 mph for at least 20 seconds. Repeat the "Problem—Initial Start-Up Procedure".
Damaged control module	
Faulty wheel speed sensor components	

Problem—Traction Control Dash Lamp

Problem—Traction Control Dash Lamp (See Fig. 3)	
Possible Cause	**Remedy**
Harness and relay shorts	Check the voltage to the control module. Turn the ignition switch to the "Off" position. Disconnect the control module 30-Pin connector C409. Turn the ignition switch to the "On" position. Measure the voltage between the control module 30-Pin connector C409, Pin C2 and ground. If the voltage is greater than 10 volts, replace the dash lamp. If OK, replace the control module. Test the system for normal operation. If the voltage is less than 10 volts, repair or replace the wiring harness. Repeat the "Problem—Initial Start-Up Procedure".
Damaged control module	



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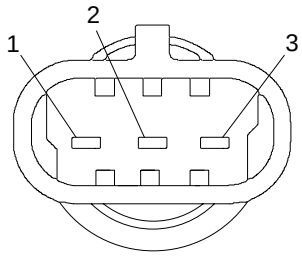
1. Pin 1
2. Pin 2

Fig. 4, Wheel Speed Sensor Connector



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1. Exhaust Terminal
2. Common Terminal
3. Hold Terminal

Fig. 5, Modulator Valve Connector

Problem—Traction Control Solenoid

Problem—Traction Control Solenoid (See Fig. 2, Fig. 3, Fig. 6 and Fig. 7)	
Possible Cause	**Remedy**
Circuitry open or shorted	Check the LEDs on the control module. Turn the ignition switch to the "Off" position. Observe the LEDs on the control module. If only the TRC LED is illuminated, refer to "Problem—Engine Control Module Wiring Harness". If the TRC LED is not the only LED illuminated, check the status of the LEDs on the control module. Observe the LEDs on the control module. If the TRC and MOD LEDs are not illuminated, refer to "Problem—Initial Start-Up Procedure". If the TRC and MOD LEDs are illuminated, check the resistance at the control module. Turn the ignition switch to the "Off" position. Disconnect the control module 18-Pin and 30-Pin connector C429 Pin D2 and Pin D3. If the resistance is not between 10 and 12 ohms, check the resistance of the solenoid. Disconnect the solenoid 2-Pin connector. Measure the resistance between the solenoid 2-Pin connector terminals (component side). If the resistance is not between 10 and 12 ohms, replace the modulator relay valve. Test the system for normal operation. If the resistance is between 10 and 12 ohms, check the solenoid for a short to ground. Measure the resistance between the solenoid 2-Pin connector terminals and ground (component side). If continuity is indicated for each test, replace the modulator relay valve. Test the system for normal operation. If continuity is not indicated for each test, repair or replace the wiring harness. Test the system for normal operation. If the resistance is between 10 and 12 ohms, check for a short to ground.
Improper solenoid resistance	Measure the resistance between the 18-Pin control module connector C429, Pin D2 and the 30-Pin control module connector C409, Pins A1, A2 and A3. If continuity is not indicated on each test, check for a short. Measure the resistance between the 18-Pin control module connector C429, Pin D3 and the 30-Pin control module connector C409, Pins A1, A2 and A3. If continuity is not indicated on each test, check for a poor connection at the control module. Reset the control module. Repeat the "Problem—Initial Start-Up Procedure". If continuity is indicated on each test, check the resistance of the solenoid. Disconnect the solenoid 2-Pin connector. Measure the resistance between the solenoid 2-Pin connector terminals (component side). If the resistance is not between 10 and 12 ohms, replace the modulator relay valve. Test the system for normal operation. If the resistance is between 10 and 12 ohms, check the solenoid for a short to ground. Measure the resistance between the solenoid 2-Pin connector terminals and ground (component side). If continuity is indicated for each test, replace the modulator relay valve. Test the system for normal operation. If continuity is not indicated for each test, repair or replace the wiring harness. Test the system for normal operation.

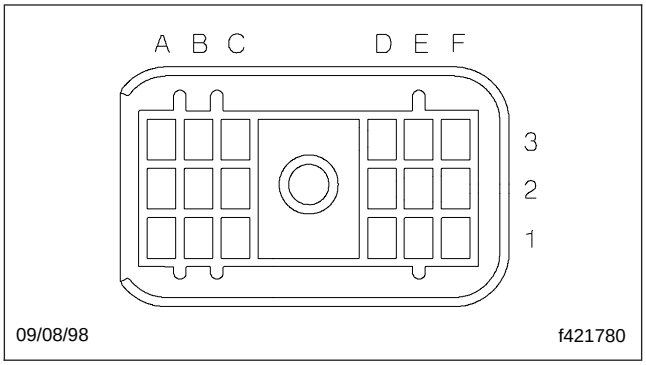


Fig. 6, Control Module 18-Pin Connector

Problem—Engine Control Module Wire Harness

Problem—Engine Control Module Wire Harness (See Fig. 2)	
Possible Cause	**Remedy**
Circuitry open or shorted	Check the control module. Turn the ignition switch to the "On" position. Observe the LEDs on the control module. If the TRC LED is not the only LED illuminated, reset the control module. Repeat the "Problem—Initial Start-Up Procedure". If the only LED illuminated is the TRC LED, check the wiring harness. Turn the ignition switch to the "Off" position. Disconnect the control module 30-Pin connector C409 and ECM connector. Measure the resistance between the control module 30-Pin connector C409, Pin B2 and the corresponding ECM connector pin. If the resistance is more than 5.0 ohms, repair or replace the wiring harness. Repeat the "Problem—Initial Start-Up Procedure". If the resistance is less than 5.0 ohms, check the wiring harness for continuity. Measure the resistance between the control module 30-Pin connector C429, Pin B3 and the corresponding ECM connector pin. If the resistance is less than 5.0 ohms, check the ECM. If the resistance is more than 5.0 ohms, repair or replace the wiring harness. Repeat the "Problem—Initial Start-Up Procedure".
Damaged control module	

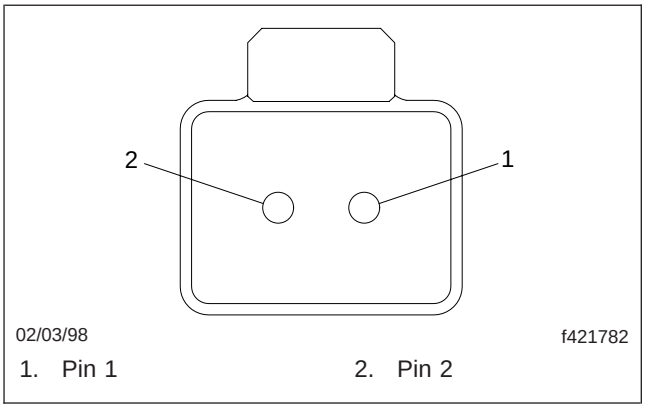


Fig. 7, Traction Control Solenoid Connector

LED Diagnosis

NOTE: Refer to **Table 1** for specific LED descriptions.

FRT (Front) LED

This red LED lights and latches on in order to show the location of the worn or damaged component or its wiring. It will illuminate in conjunction with either the right or left LED and the MOD or SEN LED.

MID (Mid Axle) LED

This red LED is not used in all installations. On those vehicles that have six wheel speed sensors installed, this red LED lights and latches on to show the location of the worn wheel speed sensor or its wiring. The MID LED should not illuminate with the MOD LED.

RER (Rear) LED

This red LED lights and latches on in order to show the location of the worn or damaged component or its wiring. It will illuminate in conjunction with either the right or left LED and the MOD or SEN LED.

LED Description	
LED	**Description**
FRT	Red LED
MID	Red LED (see "NOTE")
RER	Red LED
RHT	Red LED
LFT	Red LED
TRC	Red LED
MOD	Red LED
SEN	Red LED
ECU	Red LED
VLT	Green LED
Reset	No LED

Table 1, LED Description

RHT (Right) LED

This red LED lights and latches on in order to show the location of the worn or damaged component or its wiring. It will illuminate in conjunction with either the front or rear LED and the MOD or SEN LED.

LFT (Left) LED

This red LED lights and latches on in order to show the location of the worn or damaged component or its wiring. It will illuminate in conjunction with either the front or rear LED and the MOD or SEN LED.

TRC (Traction Control) LED

NOTE: If an intermittent concern exists with the wiring to the engine control module, this LED will illuminate. However, it will not latch on. It will go out when the concern corrects itself.

This red LED lights and latches on to show a permanent problem in the traction control system. It may be lit with the MOD LED or it may be lit by itself.

MOD (Modulator) LED

NOTE: The MID positioning LED should not be lit with this LED. This LED is also used to show a concern with a traction control solenoid. When lit for a traction control system concern, the TRC LED will also be lit.

This red LED lights and latches on to show a permanent or intermittent open or short circuit in the solenoids of one of the four modulators or the wiring. When indicating a concern with a modulator, this LED will be lit with two positioning LEDs (RHT/LFT + FRT/RER).

SEN (Wheel Speed Sensor) LED

This red LED lights and latches on to show a permanent or intermittent failure. The failures indicated are open or shorted wheel speed sensor, open or shorted wheel speed sensor wiring, wheel speed signal not present or not to specification. The SEN LED will be lit with two positioning LEDs (RHT/LFT + FRT/MID/RER).

ECU (Electronic Control Unit) LED

This red LED, when lit, shows that the control module itself has failed. It is latched on for all control module failures except low voltage. Before the control module is replaced, always check for battery voltage at the control module connector.

VLT LED

This green LED lights and remains lit during vehicle operation to show that the battery voltage is reaching the control module. If the battery voltage is out of range (below 11 volts or above 17 volts) this LED will flash until the battery voltage is brought into range.

Reset

Beneath the "Reset" area of the display is a magnetically sensitive switch that is used to reset the diagnostic system. The device will respond to a magnet which has the strength sufficient to lift a three ounce weight. Momentarily holding a magnet against the "Reset" will cause all LEDs to illuminate during the time the magnet is held against it. Holding the magnet against "Reset" longer than 10 seconds will cause the newer version of the control module to initiate the self-configuration feature.

Modulator Valve Test

NOTE: Refer to **Table 2** for test information.

Modulator Valve Test			
Modulator	**Pin**	**Control Module Connector**	**Resistance Value**
Left Rear Modulator	E1 to F1	18-Pin C429	3.5–5.0 Ohms
Left Rear Modulator	D1 to F1	18-Pin C429	3.5–5.0 Ohms
Left Rear Modulator	D1 to E1	18-Pin C429	7–10 Ohms
Left Rear Modulator	F1 to Ground	18-Pin C429	No Continuity
Left Rear Modulator	E1 to Ground	18-Pin C429	No Continuity

Modulator Valve Test			
Modulator	**Pin**	**Control Module Connector**	**Resistance Value**
Left Rear Modulator	D1 to Ground	18-Pin C429	No Continuity
Left Rear Modulator	E1 to Voltage	18-Pin C429	No Continuity
Right Rear Modulator	B1 to A1	18-Pin C429	3.5–5.0 Ohms
Right Rear Modulator	C1 to A1	18-Pin C429	3.5–5.0 Ohms
Right Rear Modulator	B1 to C1	18-Pin C429	7–10 Ohms
Right Rear Modulator	A1 to Ground	18-Pin C429	No Continuity
Right Rear Modulator	B1 to Ground	18-Pin C429	No Continuity
Right Rear Modulator	C1 to Ground	18-Pin C429	No Continuity
Right Rear Modulator	B1 to Voltage	18-Pin C429	No Continuity
Left Front Modulator	H1 to G1	30-Pin C409	3.5–5.0 Ohms
Left Front Modulator	F1 to H1	30-Pin C409	3.5–5.0 Ohms
Left Front Modulator	F1 to G1	30-Pin C409	7–10 Ohms
Left Front Modulator	H1 to Ground	30-Pin C409	No Continuity
Left Front Modulator	G1 to Ground	30-Pin C409	No Continuity
Left Front Modulator	F1 to Ground	30-Pin C409	No Continuity
Left Front Modulator	G1 to Voltage	30-Pin C409	No Continuity
Right Front Modulator	D1 to C1	30-Pin C409	3.5–5.0 Ohms
Right Front Modulator	E1 to C1	30-Pin C409	3.5–5.0 Ohms
Right Front Modulator	E1 to D1	30-Pin C409	7–10 Ohms
Right Front Modulator	C1 to Ground	30-Pin C409	No Continuity
Right Front Modulator	D1 to Ground	30-Pin C409	No Continuity
Right Front Modulator	E1 to Ground	30-Pin C409	No Continuity
Right Front Modulator	D1 to Voltage	30-Pin C409	No Continuity

Table 2, Modulator Valve Test

Wheel Speed Sensor Test

NOTE: Refer to **Table 3** for test information.

Wheel Speed Sensor Test			
Wheel Speed	**Pin**	**Control Module Connector**	**Resistance Value**
Left Mid Sensor	C2 to C3	18-Pin C429	1500–2500 Ohms
Left Mid Sensor	C2 to Ground	18-Pin C429	No Continuity
Left Mid Sensor	C2 to Voltage	18-Pin C429	No Continuity
Left Mid Sensor	C3 to Ground	18-Pin C429	No Continuity
Left Mid Sensor	C3 to Voltage	18-Pin C429	No Continuity
Left Rear Sensor	F2 to F3	18-Pin C429	1500–2500 Ohms

Troubleshooting

Wheel Speed Sensor Test			
Wheel Speed	**Pin**	**Control Module Connector**	**Resistance Value**
Left Rear Sensor	F2 to Ground	18-Pin C429	No Continuity
Left Rear Sensor	F2 to Voltage	18-Pin C429	No Continuity
Left Rear Sensor	F3 to Ground	18-Pin C429	No Continuity
Left Rear Sensor	F3 to Voltage	18-Pin C429	No Continuity
Right Mid Sensor	B2 to B3	18-Pin C429	1500–2500 Ohms
Right Mid Sensor	B2 to Ground	18-Pin C429	No Continuity
Right Mid Sensor	B2 to Voltage	18-Pin C429	No Continuity
Right Mid Sensor	B3 to Ground	18-Pin C429	No Continuity
Right Mid Sensor	B3 to Voltage	18-Pin C429	No Continuity
Right Rear Sensor	E2 to E3	18-Pin C429	1500–2500 Ohms
Right Rear Sensor	E2 to Ground	18-Pin C429	No Continuity
Right Rear Sensor	E2 to Voltage	18-Pin C429	No Continuity
Right Rear Sensor	E3 to Ground	18-Pin C429	No Continuity
Right Rear Sensor	E3 to Voltage	18-Pin C429	No Continuity
Left Front Sensor	J1 to J2	30-Pin C409	1500–2500 Ohms
Left Front Sensor	J1 to Ground	30-Pin C409	No Continuity
Left Front Sensor	J1 to Voltage	30-Pin C409	No Continuity
Left Front Sensor	J2 to Ground	30-Pin C409	No Continuity
Left Front Sensor	J2 to Voltage	30-Pin C409	No Continuity
Right Front Sensor	H2 to H3	30-Pin C409	1500–2500 Ohms
Right Front Sensor	H2 to Ground	30-Pin C409	No Continuity
Right Front Sensor	H2 to Voltage	30-Pin C409	No Continuity
Right Front Sensor	H3 to Ground	30-Pin C409	No Continuity
Right Front Sensor	H3 to Voltage	30-Pin C409	No Continuity

Table 3, Wheel Speed Sensor Test

Specifications

Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Control Module Mounting Bolts	—	50–80 (560–900)
Control Module Electrical Connector Screws	—	17–26 (200–300)
Modulator Relay Valve Bracket Nuts	28–31 (38–42)	—
Modulator Relay Valve Bracket Nuts and Bolts	15–17 (20–23)	—
Modulator Valve Bolts	15–17 (20–23)	—
Modulator Valve Nuts	15–17 (20–23)	—

Table 1, Torque Specifications

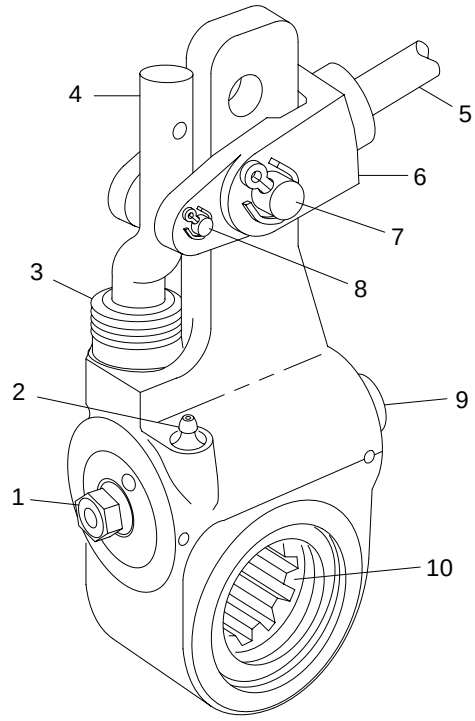
General Information

The Gunite automatic slack adjuster has two main functions:

- As a lever it converts the straight-line force of the brake chamber pushrod to torque on the brake camshaft. Rotation of the camshaft forces the brake shoes against the drum.
- As an automatic slack adjuster, it maintains the lining-to-drum clearance needed for proper brake chamber pushrod stroke.

The slack adjuster is installed between the brake chamber pushrod and the brake camshaft. See **Fig. 1**. A clevis connects the brake chamber pushrod 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 pushrod 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 pushrod. 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 Pushrod
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 Slack Adjuster

Safety Precautions

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 all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices with 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.

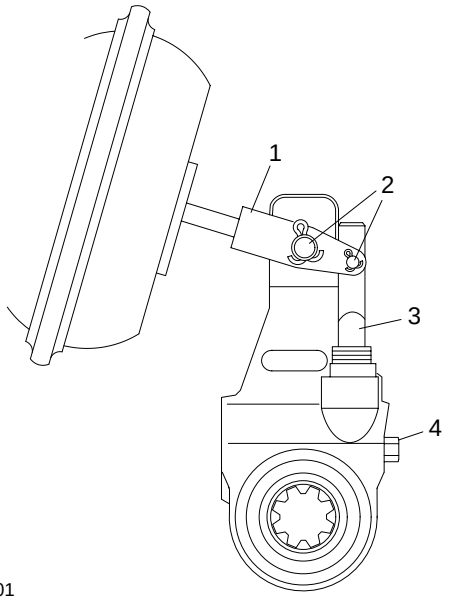
Slack Adjuster Removal and Installation

WARNING

Before working on or around air brake systems and components, see "Safety Precautions" in Subject 100. Failure to do so may result in personal injury.

IMPORTANT: This automatic slack adjuster cannot be rebuilt. If it is damaged or inoperative, replace the unit.

Each factory-installed brake chamber has a clevis welded onto the pushrod. See **Fig. 1**. On a replacement brake chamber, the clevis is threaded onto the pushrod, and has a jam nut installed. See **Fig. 2**.



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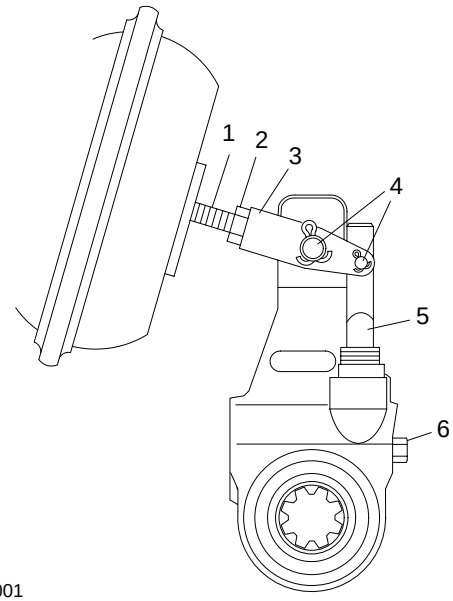
1. Brake Chamber Pushrod and Clevis Assembly
2. Cotter Pins and Clevis Pins
3. Link
4. Adjusting Hexnut

Fig. 1, Slack Adjuster (attached to welded clevis)

Removal

1. With the vehicle parked on a level surface, chock the tires. If you are removing a rear slack adjuster, cage the parking brake power spring. For instructions, refer to the applicable brake chamber section in this group.
2. Remove the cotter pins and clevis pins.



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1. Brake Chamber Pushrod (threaded)
2. Jam Nut
3. Threaded Clevis
4. Cotter Pins and Clevis Pins
5. Link
6. Adjusting Hexnut

Fig. 2, Slack Adjuster (attached to threaded clevis)

3. Rotate the adjusting hexnut counterclockwise until the slack adjuster clears the clevis.
4. Remove the snap ring from the brake camshaft, then slide the slack adjuster off the camshaft.

Installation

NOTE: For brake chambers that have pushrods with threaded clevises, measure the pushrod length before installing the new slack adjuster. With the brakes fully released, and no air pressure to the chamber, check the dimension between the chamber face and the centerline of the 1/2 inch clevis pin hole. It should be 2.25 inches (57 mm) for long stroke chambers, and 2.75 inches (70 mm) for standard stroke chambers.

1. Coat the camshaft splines, and the splines of the slack adjuster gear with an anticorrosion grease.

Slack Adjuster Removal and Installation

2. Using the old snap ring, install the automatic slack adjuster on the brake camshaft.
3. Turn the adjusting hexnut clockwise to rotate the slack adjuster toward the brake chamber until the holes line up.
4. Install the clevis pins and cotter pins.

NOTE: A properly working self-adjusting slack adjuster does not require manual adjustment while in service.

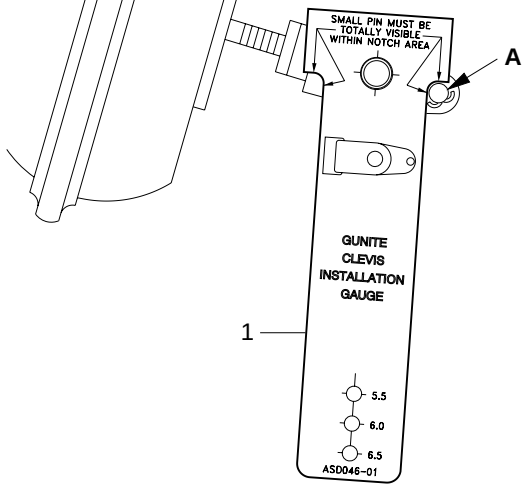
⚠ WARNING

Manually adjusting an automatic slack adjuster to bring the pushrod stroke within legal limits is likely masking a mechanical problem. Adjustment is not repairing. Before adjusting an automatic slack adjuster, troubleshoot the foundation brake system and inspect it for worn or damaged components. Improperly maintaining the vehicle braking system may lead to brake failure, resulting in property damage, personal injury, or death.

5. If the pushrod has a threaded clevis, use the gauge supplied with a new slack adjuster to check the adjustment of the clevis, as follows. See **Fig. 3**.
   - 5.1 Position the 1/2-inch hole in the gauge over the end of the 1/2-inch clevis pin.
   - 5.2 Align the applicable 1/4-inch hole in the bottom of the gauge over the center of the camshaft.
   - 5.3 Check that the 1/4-inch pin is visible in the notched area of the gauge. If the pin is not in the right location, back off the slack adjuster and readjust the pushrod length, then repeat this step.

NOTE: Make sure there is clearance between the slack adjuster and other vehicle components when the brakes are applied and the pushrod travels its maximum stroke.

6. Set the initial free-stroke, as follows.
   - 6.1 Turn the adjusting hexnut clockwise until the brake linings contact the drum.
   - 6.2 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.



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A. Adjust the clevis in or out to position the 1/4-inch clevis pin within the notched area of the gauge.

1. Installation Gauge

Fig. 3, Checking the Clevis Adjustment

7. Measure the brake chamber applied stroke, as follows.
   - 7.1 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**.
   - 7.2 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**. The difference between the measurements is the brake chamber stroke.
   - 7.3 The brake chamber stroke must be within the range shown in **Table 1**. If it is not, 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 applicable brake section in this group. Then, repeat the two previous steps.

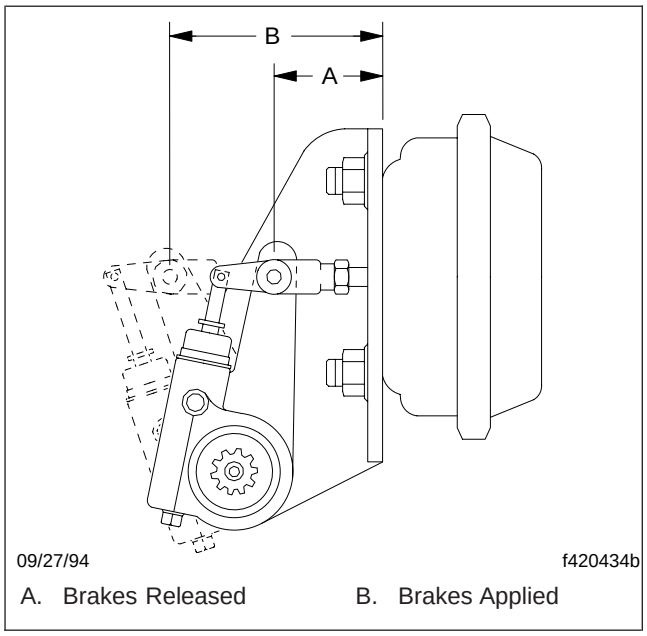


Fig. 4, Brake Stroke Measurements

8. If a rear axle slack adjuster was installed, manually uncage the parking brake. Refer to the applicable brake chamber section in this group for instructions.
9. Apply the parking brakes.
10. Remove the chocks from the tires.
11. In a safe area, check for proper brake operation, as follows.
    - 11.1 Apply and release the brakes several times to check for correct operation of the slack adjusters.
    - 11.2 Perform six low-speed stops to ensure correct parts replacement and full vehicle control.
    - 11.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others show a lack of braking effort on those wheels.

Brake Chamber Stroke Specifications			
Chamber Type (Size)	**Maximum Applied Stroke*: inch (mm)**	**Free-Stroke: inch (mm)**	
		New Brake Installation	**In-Service Brake**
Long Stroke†			
16 and 20	2-1/2 (64)	5/8–3/4 (16–19)	1/2–5/8 (13–16)
24 and 30	3 (76)		

* Specifications are relative to a brake application with 80–90 psi (550–620 kPa) air pressure in the brake chambers.

† Long stroke design is indicated by a tag, or embossing, on the brake chamber.

Table 1, Brake Chamber Stroke Specifications

Specifications

Approved Lubricants	
Lubricant Type	**Temperature**
Lubriplate Aero	Above –40°F (–40°C)
Texaco Multifak EP-2	Above –20°F (–29°C)
Mobil Grease 77	

Table 1, Approved Lubricants

Maximum Adjusted Brake Chamber Stroke		
Chamber Size	**Maximum Chamber Stroke Inch (mm)**	
	Standard Stroke	**Long Stroke**
16	1-3/4 (44)	2 (51)
20		
24	1-3/4 (44)	2 (51) — *2-1/2-Inch rated stroke*
		2-1/4 (63) — *3-Inch rated stroke*
30	2 (51)	2-1/2 (57)

Table 2, Maximum Adjusted Brake Chamber Stroke

Safety Precautions

Before attempting to work on the air brake system, observe the following precautions:

- Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized. The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.
- When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.
- Air lines will whip dangerously if disconnected under pressure. Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.
- As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber pushrods and spring actuators that apply automatically with the loss of pressure. This also applies when checking the service brake system.
- Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.
- Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.
- The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.
- Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.
- To avoid injury, keep clear of the air chamber pushrod when brakes are applied or when air is exhausted from the system.

⚠ WARNING

Make sure the air system has been reduced to 0 psi before attempting to remove an air line. Do not disconnect pressurized air lines as they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

Replacement

⚠ CAUTION

Before working on or around air brake systems and components, see Safety Precautions 100.

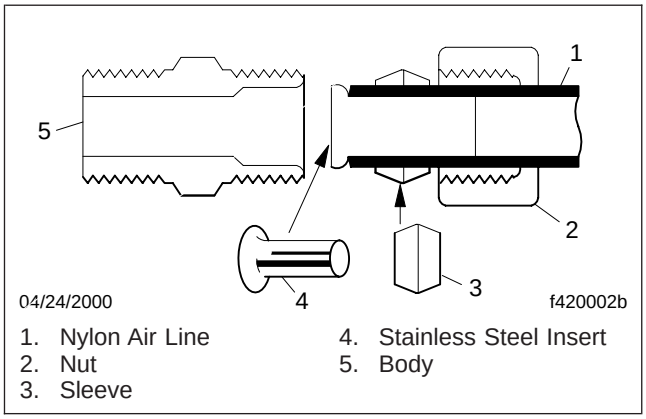
⚠ CAUTION

If the air line is bent to a radius smaller than the specified minimum bend radius, it may kink and shut off normal airflow to the component.

NOTE: When installing a nylon or a wire braid air line, be careful not to bend it past its minimum bend radius. For minimum bend radius values, see **Specifications 400**.

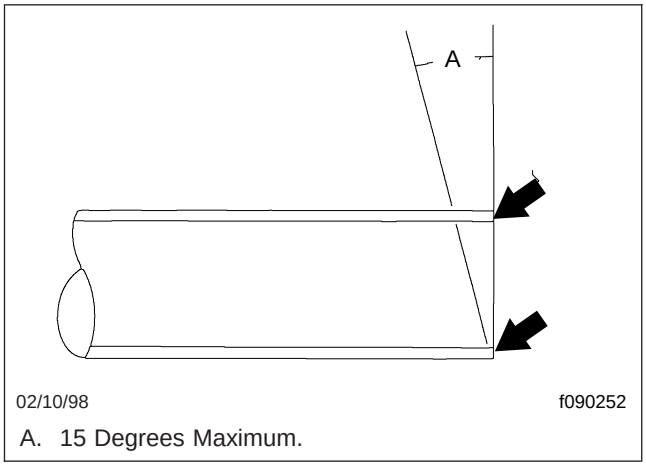
Nylon Air Lines and Compression Fittings

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Remove the air line. See **Fig. 1**.
   - 3.1 Loosen the fitting nut.
   - 3.2 Pull the air line out of the fitting.
4. Use pliers to remove the stainless steel insert from the fitting. Discard the insert.
5. Clean all of the fitting components.
6. Place a new stainless steel insert into the fitting body. Use thumb pressure to press it into position.
7. Check the air line end for a square cut-off that does not exceed a 15-degree angle. Check that the air line is not distorted or damaged. See **Fig. 2**.



1. Nylon Air Line
2. Nut
3. Sleeve
4. Stainless Steel Insert
5. Body

Fig. 1, Nylon Air Line and Compression Fitting



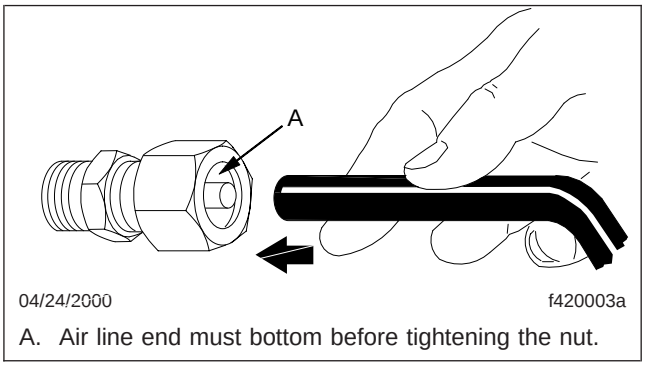
A. 15 Degrees Maximum.

Fig. 2, Check Air Line End Angle

- 7.1 If the angle exceeds the specification, recut the air line.
- 7.2 Use a sharp blade to prevent collapsing the air line or leaving burrs.

8. Make sure the nylon air line ends and fittings are free of grease and debris. If the air line is crimped or otherwise damaged, replace it with a new air line.
9. Install a new sleeve in the nut. Start the threads of the nut on the fitting body.
10. Insert the squared end of the air line in the fitting until it bottoms in the body of the fitting. See **Fig. 3**.
11. Tighten the nut until one thread remains visible.

Air Lines Replacement



A. Air line end must bottom before tightening the nut.

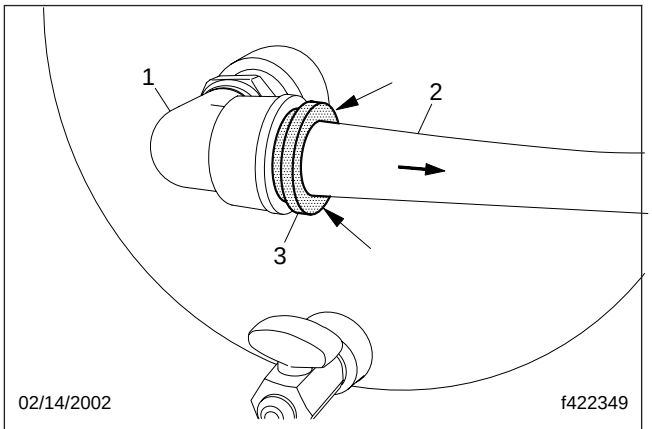
Fig. 3, Installing Nylon Air Line into Compression Fitting

12. Pull back on the air line to make sure it is fully seated.
13. Pressurize the air system. Check the air system for leaks.
14. Remove the chocks from the tires.

Nylon Air Lines and KV2 One-Touch Fittings

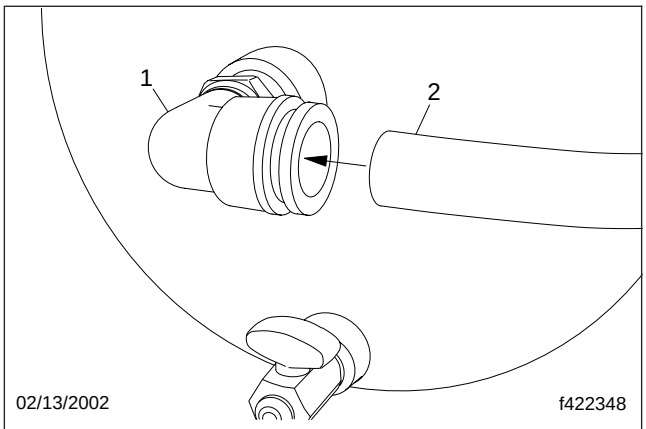
IMPORTANT: The use of a sharp air line cutter is highly recommended. This tool will insure a clean, perpendicular cut of the air line.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Push the air line into the fitting.
4. Press and hold the release button against the body of the fitting and remove the air line. See **Fig. 4**.
5. Remove the air line.
6. Clean any dirt or contamination from the leading edge of the air line.
7. Lubricate the leading end of the air line with light oil, petroleum jelly or silicone lubricant.
8. Insert the end of the air line into the fitting until it bottoms. See **Fig. 5**.
9. Pull on the air line to verify it is properly retained.
10. Pressurize the air system. Check the air system for leaks.



1. Push-to-Connect Fitting
2. Air Line
3. Release Button

Fig. 4, Push on Release Button and Remove Air Line



1. Push-to-Connect Fitting
2. Air Line

Fig. 5, Insert Air Line

11. Remove the chocks from the tires.

Wire Braid Air Lines

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Remove the air line.
   - 3.1 Unthread the swivel fitting nut.
   - 3.2 Remove the air line assembly from the mating fitting.

4. Make sure the wire braid air line assembly is free of grease and dirt. Replace the assembly if the air line or fitting is crimped or otherwise damaged.
5. Install the air line and finger-tighten the nut.
6. Using two wrenches to prevent twisting of the air line, tighten the nut until it seats solidly. Tighten the nut one-sixth turn more.
7. Pressurize the air system. Check the air system for leaks.
8. Remove the chocks from the tires.

WARNING

Make sure the air system has been reduced to 0 psi before attempting to remove an air line. Do not disconnect pressurized air lines as they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

Replacement

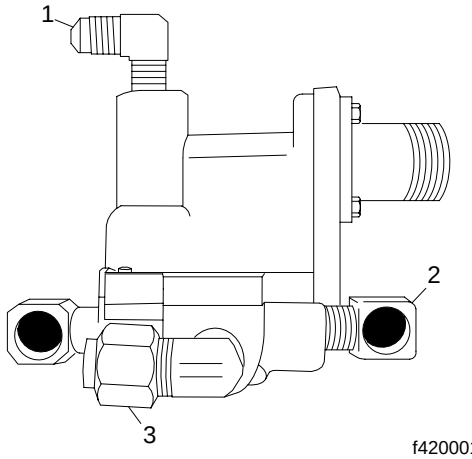
CAUTION

Before working on or around air brake systems and components, see Safety Precautions 100.

CAUTION

Never use diagonal pliers, a razor knife, saw or dull cutting tool to cut nylon air lines. The use of such tools leaves the air line with a sharp edge, burr or out-of-round condition which can damage the seal when the air line is inserted into the fitting. This reduces the sealing ability of the fitting. The use of a sharp air line cutter is highly recommended. This tool will insure a clean, perpendicular cut of the air line.

Brass or Steel Pipe Fittings



1. Wire Braid Hose Fitting
2. Brass or Steel Pipe Fitting
3. Nylon Tube Compression Fitting

Fig. 1, Screw-On Fittings

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Remove the air line from the fitting. For instructions, see **Subject 110**.
4. Using an open-end wrench or similar tool, rotate the fitting counterclockwise until it is completely disengaged from the fitting port. See **Fig. 1**.
5. Make sure the fitting is free of grease, dirt, and old sealant. Apply liquid thread sealant (white) to the threads and finger-tighten securely.

NOTE: Always apply the sealant to the external thread, so that any excess will be scraped off externally rather than internally to the joint.

6. Install the fitting:
   - *For a fitting that must be positioned*, tighten one additional turn from finger-tight using a wrench. Continue to tighten the fitting clockwise until it is correctly positioned. Never turn the fitting counterclockwise to position it.

Fittings Replacement

- *For a fitting that does not require positioning*, tighten 1-1/2 additional turns from finger-tight.

7. Install the air line in the fitting. For instructions, see **Subject 110**.
8. Pressurize the air system. Check the air system for leaks.
9. Remove the chocks from the tires.

Brass or Steel Pipe Fittings on Plastic Components

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Remove the air line from the fitting. For instructions, see **Subject 110**.
4. Remove the fitting.
5. Install the fitting. For tightening specifications, see the applicable table in **Specifications, 400**.
6. Install the air line in the fitting. For instructions, see **Subject 110**.
7. Pressurize the air system. Check the air system for leaks.
8. Remove the chocks from the tires.

Copper Fittings

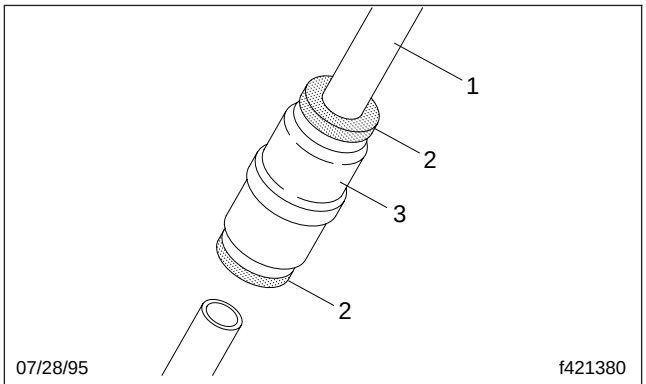
1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Remove the air line from the fitting. For instructions, see **Subject 110**.
4. Loosen the nut and remove the fitting.
5. Position the fitting.
6. Finger-tighten the nut.
7. Using two wrenches to prevent twisting of the air line, tighten the nut the number of turns shown in the applicable table in **Specifications 400**.
8. Install the air line in the fitting. For instructions, see **Subject 110**.
9. Pressurize the air system. Check the air system for leaks.
10. Remove the chocks from the tires.

Quick-Connect Fittings

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Drain the air system.

NOTE: If damaged, quick-connect fittings must be replaced as an assembly.

3. Push in on the fitting collar to release the air line.
4. Pull the air line out of the fitting. See **Fig. 2**.



1. Air Line
2. Collar
3. Fitting

Fig. 2, Nylon Air Line and Quick-Connect Fitting

5. Push the air line into the fitting.
6. Pull the collar away from the fitting to secure the air line.
7. Check and make sure that the air line is seated in the fitting.
8. Pressurize the air system. Check the air system for leaks.
9. Remove the chocks from the tires.

KV2 One-Touch Fittings

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

2. Drain the air system.
3. Remove the air line from the fitting. For instructions, see **Subject 110**.
4. Using an open-end wrench or similar tool, rotate the fitting's hexstud end counterclockwise until it is hand-loose.
5. Continue to rotate the fitting by hand until it is completely disengaged from the fitting port.
6. Clean any dirt or thread sealant from the fitting and fitting port.
7. If required, apply liquid thread sealant (white) to the threads.
8. Insert the fitting into the port and rotate it clockwise until it is hand-tight.
9. Using an open-end wrench or similar tool, tighten the fitting to the manufacturer's recommended torque. For torque specifications, see the applicable table in **Specifications 400**.
10. Rotate the fitting body by hand to the correct position.
11. Install the air line in the fitting. For instructions, see **Subject 110**.
12. Pressurize the air system. Check the air system for leaks.
13. Remove the chocks from the tires.

Specifications

Nylon Air Lines			
Number	Inside Diameter Inch	Outside Diameter Inch	Minimum Bend Radius inches (mm)
4	0.170	1/4	1.00 (25)
6	0.251	3/8	1.50 (38)
8	0.376	1/2	2.00 (51)
10	0.441	5/8	2.50 (64)
12	0.566	3/4	3.00 (76)

Table 1, Nylon Air Lines

211 Wire Braid (Medium Pressure) Air Lines *			
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 air lines are identified by part number and size (for example, part numbers 211-4, 211-5, and so on).

Table 2, 211 Wire Braid (Medium Pressure) Air Lines

213 Wire Braid Air Lines *			
Number	Inside Diameter Inch	Outside Diameter Inch	Minimum Bend Radius inches (mm)
4	3/16	0.49	0.75 (20)
5	1/4	0.55	1.00 (25)
6	5/16	0.62	1.25 (30)
8	13/32	0.74	1.75 (45)
10	1/2	0.83	2.25 (55)
12	5/8	0.96	2.75 (70)
16	7/8	1.21	3.50 (90)
20	1-1/8	1.49	4.50 (115)

* 213 air lines are identified by two green stripes 180 degrees apart, part numbers, and size (for example, part numbers 213-4, 213-5, and so on).

Table 3, 213 Wire Braid Air Lines

KV2 Stud End Torque into Metallic Ports *		
Thread, NPTF Inch	Torque †	
	lbf·in (N·cm)	lbf·ft (N·m)
1/16	62–80 (700–900)	—
1/8	62–80 (700–900)	—
1/4	106–124 (1200–1400)	—
3/8	—	16–18 (22–24)
1/2	—	21–22 (28–30)

* Aluminum, zinc, steel and brass ports.
† The component in which the KV2 One-Touch fitting is being installed may have torque values lower than those listed here. Please see the component supplier's recommended torque specifications.

Table 4, KV2 Stud End Torque into Metallic Ports

Specifications

Brass or Steel Pipe Fittings on Plastic Components			
Description	Port Size Inch	Torque	
		lbf·in (N·cm)	lbf·ft (N·m)
Midland Quick Release Valve	3/8	60–90 (680–1020) *	—
	1/2	—	13–17 (18–23) *
Bendix MV-2/MV-3 Valve	1/4	—	10 (14)

* Tighten to the lower torque value. If needed, turn the fittings to allow for the proper routing of the air lines.

Table 5, Brass or Steel Pipe Fittings on Plastic Components

Copper Fittings			
Number	Outside Diameter Inch	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 6, Copper Fittings

Brake Chamber Removal and Installation

Removal

1. Chock the tires.
2. Release the spring brake.
3. Exhaust the system air pressure.
4. Disconnect the air lines from the brake air chamber. See **Fig. 1**.

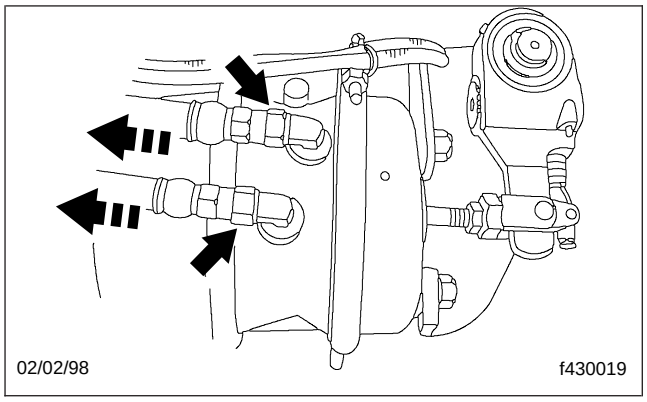


Fig. 1, Air Lines at the Brake Air Chamber

5. Remove and discard the cotter pins from the clevis pin and the adjusting link pin. See **Fig. 2**.

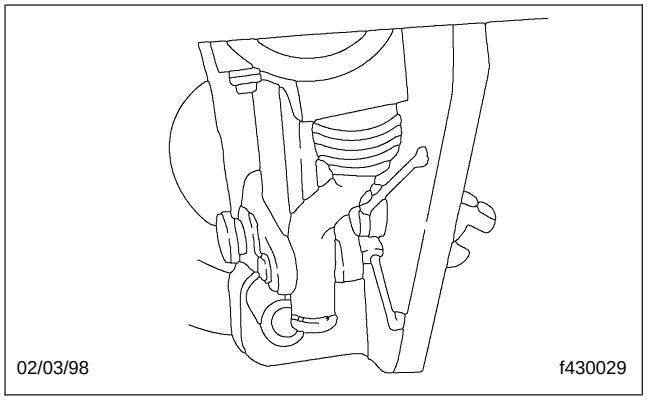


Fig. 2, Cotter Pins

6. Remove the clevis pin and adjusting link pin. See **Fig. 3**.

NOTE: Support the brake air chamber while removing the nuts.

7. Remove the nuts and the brake air chamber. See **Fig. 4**.

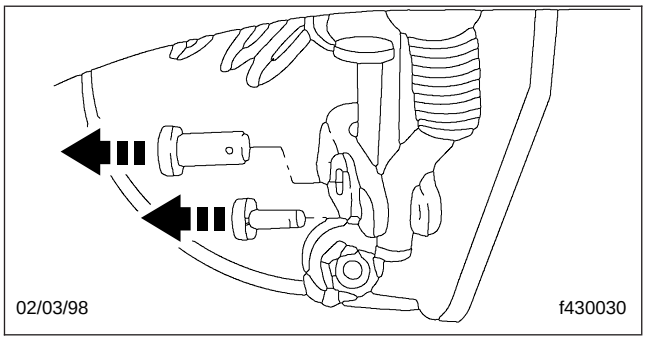


Fig. 3, Clevis Pin and Adjusting Link Pin

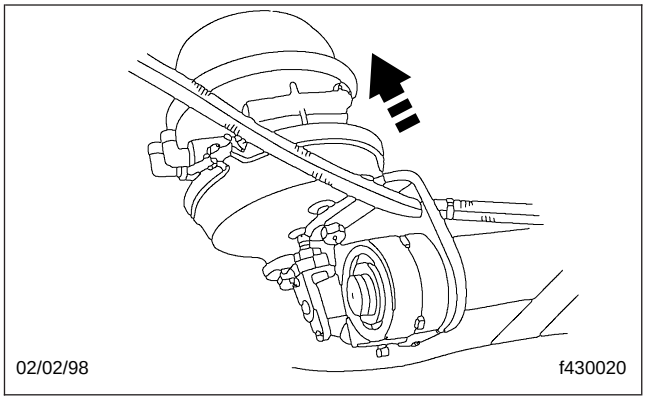


Fig. 4, Brake Air Chamber

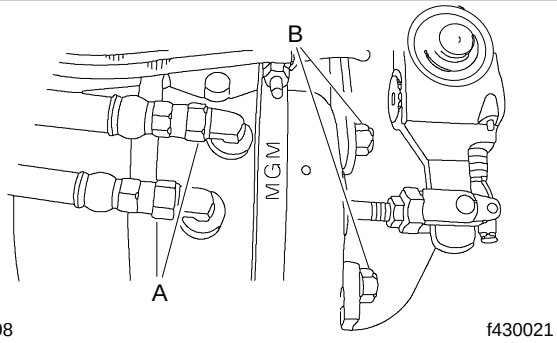
Installation

NOTE: If installing a new brake air chamber, cut the air chamber push rod to the correct length. Refer to "Brake Chamber Push Rod Cutting" in **Subject 120**.

NOTE: Support the brake air chamber while installing the nuts.

1. Install the nuts and the brake air chamber. See **Fig. 4**.
2. Connect the air lines to the brake air chamber. Tighten "A" to: MGM: 24 lbf·ft (33 N·m) and "B" to: MAXI-BRAKE: 12 lbf·ft (16 N·m). See **Fig. 5**.
3. Install the clevis pin and adjusting link pin. See **Fig. 3**.
4. Install new cotter pins to the clevis pin and the adjusting link pin. See **Fig. 2**.
5. Engage the spring brake.
6. Unchock the tires.

Brake Chamber Removal and Installation



A. Tighten 24 lbf·ft (33 N·m).
B. Tighten 12 lbf·ft (16 N·m).

Fig. 5, Tighten the Air Line Fittings

Disassembly

DANGER

Do not attempt to repair the spring brake portion of the brake chamber for any reason. If the power spring were to break loose, it could result in property damage, severe personal injury, or death.

1. Match-mark the service brake end cap, then clamp ring and the bulkhead. See **Fig. 1**.

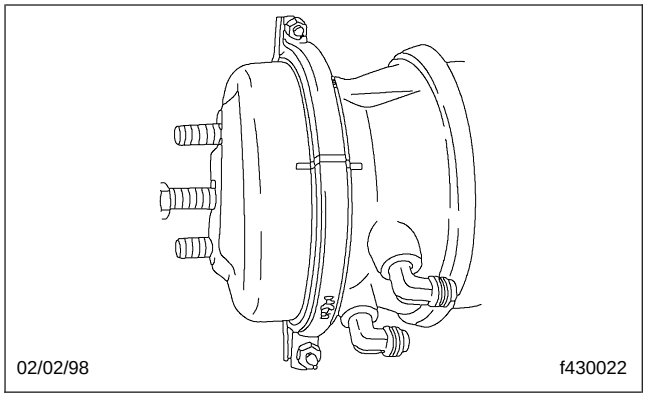


Fig. 1, Service Brake End Cap, Clamp, Ring and Bulkhead

DANGER

The internal return spring can separate parts unexpectedly. Severe personal injury or death can result.

2. Remove the nuts and separate the two-part service chamber clamp ring. See **Fig. 2**.

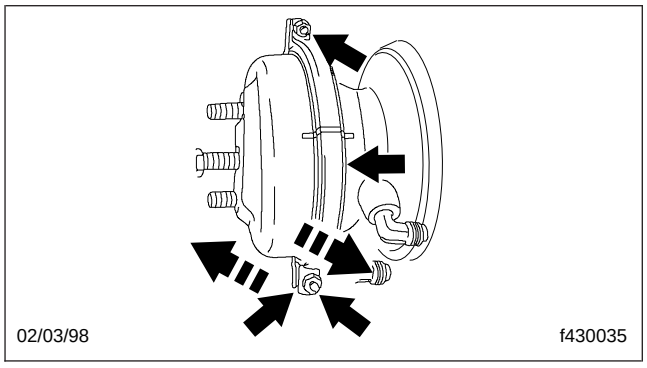


Fig. 2, Two-Part Service Chamber Nuts

3. Separate the service brake chamber end cap assembly from the bulkhead assembly. See **Fig. 3**.

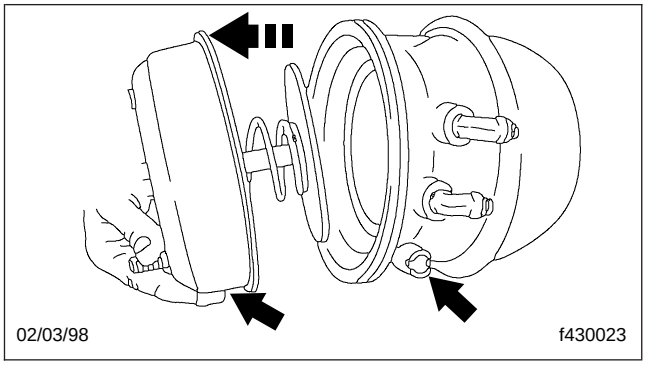


Fig. 3, Service Brake Chamber End Cap/Bulkhead Assembly

4. Remove the service brake diaphragm. See **Fig. 4**.

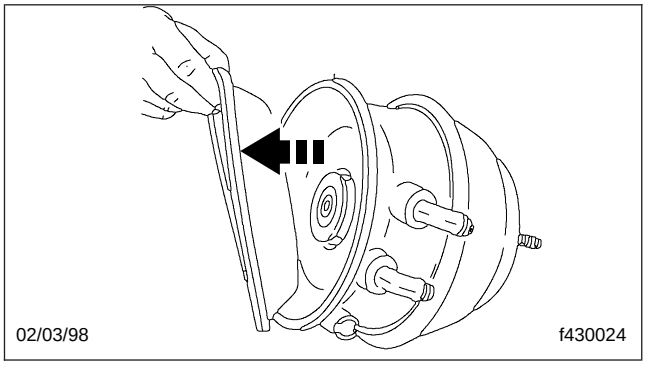


Fig. 4, Brake Diaphragm

Assembly

1. Install a new service brake diaphragm.

DANGER

The internal return spring can separate parts unexpectedly. Severe personal injury or death can result.

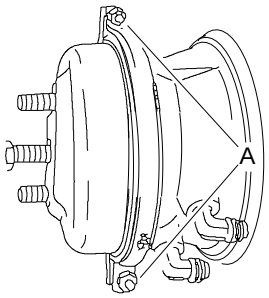
2. Connect the two-part service chamber clamp ring. See **Fig. 2**.
3. Connect the service brake chamber end cap assembly to the bulkhead assembly. See **Fig. 3**.

Brake Chamber Disassembly and Assembly

DANGER

To avoid the risk of injury, do not attempt to repair the spring brake portion of the brake chamber. The spring brake portion is not intended to be serviced. Serious injury or death may result from the sudden release of the spring.

4. Clamp the ring to the bulkhead. See **Fig. 1**.
5. Tighten the diaphragm ring bolts: MGM: 30 to 35 lbf·ft (41 to 47 N·m); MAXI-BRAKE: 16 to 19 lbf·ft (22 to 26 N·m). See **Fig. 5**.



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A. Tighten 16 to 19 lbf·ft (22 to 26 N·m).

Fig. 5, Tighten the Nuts

Brake Chamber, Manual Release

1. Park the vehicle on a level surface and chock the tires.
2. Pull the rubber plug from the hole on the spring brake end cap. See **Fig. 1**.

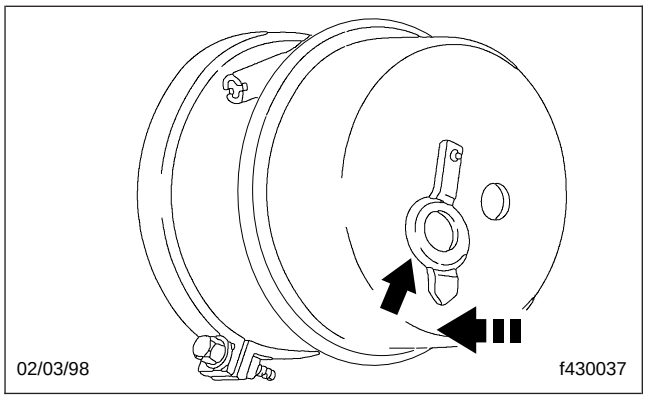


Fig. 1, Spring Brake End Cap Rubber Plug

3. Remove the release bolt, nut and washer from the side of the brake air chamber. See **Fig. 2**.

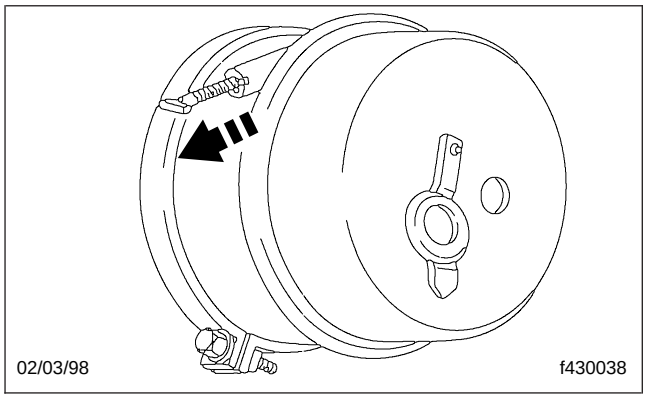


Fig. 2, Bolt, Nut and Washer on the Side of the Air Brake Chamber

4. Insert the release bolt into the spring brake chamber and into the internal T-slot. Turn the release bolt 90 degrees, until it locks and cannot be pulled out. See **Fig. 3**.

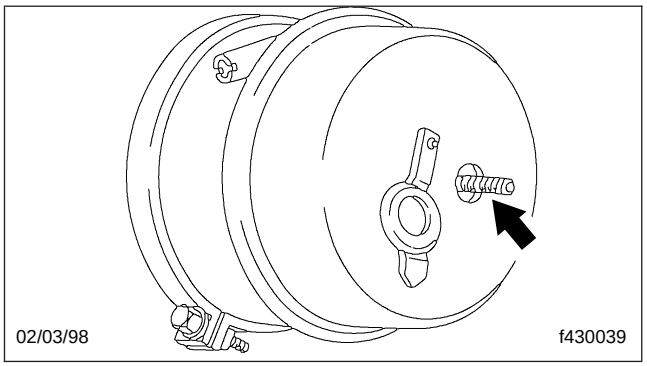


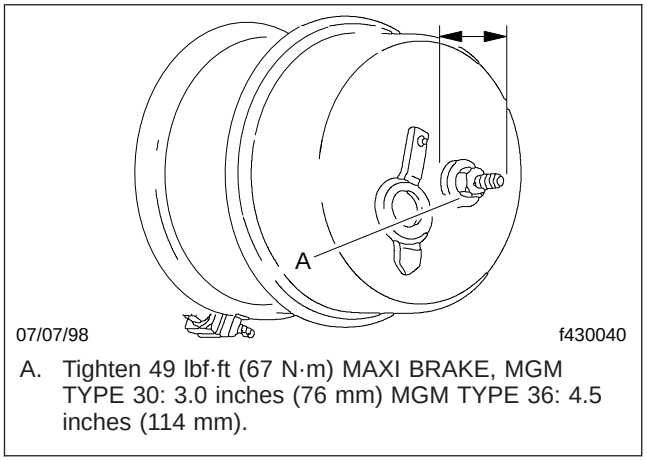
Fig. 3, Brake Chamber Release Bolt

CAUTION

To avoid damage to the spring brake chamber, do not use air-driven tools to tighten the release bolt nut. Do not exceed the torque specification.

NOTE: Charging the brake system with normal air pressure will ease the tightening process.

5. Install the washer and nut on the release bolt and tighten to: 49 lbf·ft (67 N·m) MAXI BRAKE, MGM TYPE 30: 3.0 inches (76 mm), MGM TYPE 36: 4.5 inches (114 mm). See **Fig. 4**.



A. Tighten 49 lbf·ft (67 N·m) MAXI BRAKE, MGM TYPE 30: 3.0 inches (76 mm) MGM TYPE 36: 4.5 inches (114 mm).

Fig. 4, Tighten the Release Bolt and Nut

6. Unchock the tires.

Brake Chamber Push Rod Cutting

1. Park the vehicle on a level surface and chock the tires.

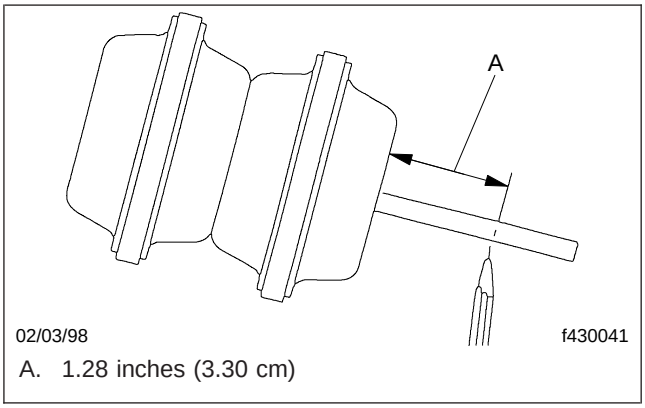
⚠ CAUTION

If the spring brake is not fully released, the air chamber push rod can be cut too short.

2. Release the spring brake. Make sure the air chamber push rod is fully retracted in the brake air chamber.

NOTE: Make sure, when marking the air chamber push rod, that it is centered in the air chamber hole.

3. Measure and mark the specified distance from the face of the brake air chamber. It should be 1¼ inches (3.30 cm). See **Fig. 5**.



A. 1.28 inches (3.30 cm)

Fig. 5, Brake Chamber Face Distance

4. Position the jam nut, clevis nut and collar nut, in that order, above the mark made in the previous step. See **Fig. 6**.
5. Cut the air chamber push rod at the mark made previously. See **Fig. 7**.

⚠ CAUTION

Failure to position the nuts as specified will diminish braking function.

6. Position the nuts for attachment to the slack adjuster. See **Fig. 8**.
   - 6.1 Position the collar nut at the end of the push rod.
   - 6.2 Position the clevis nut against the collar nut.
   - 6.3 Position the jam nut close to the clevis nut.
7. Unchock the tires.

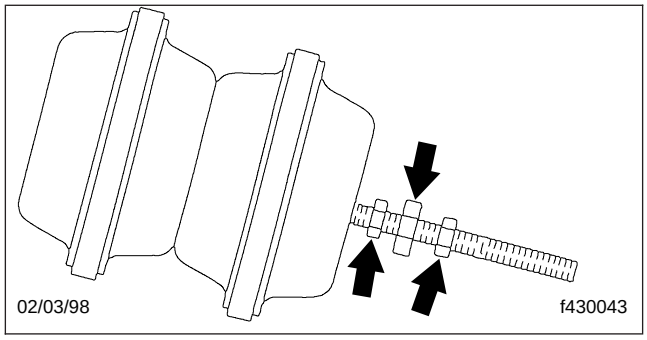


Fig. 6, Jam Nut, Clevis Nut and Collar Nut

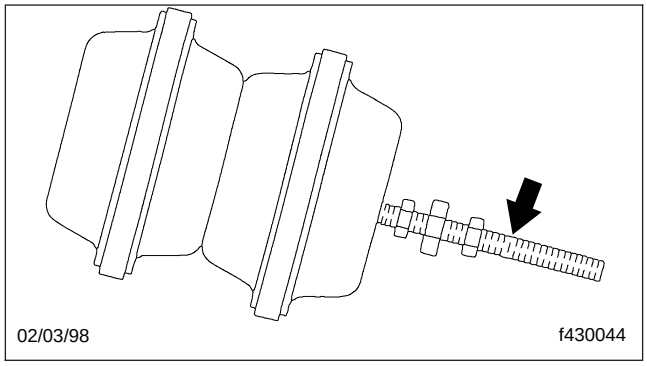
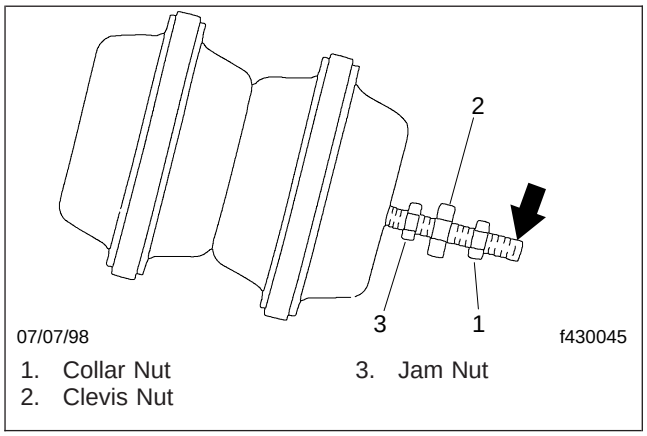


Fig. 7, Brake Chamber Push Rod Cut-off Position



1. Collar Nut
2. Clevis Nut
3. Jam Nut

Fig. 8, Position of Nuts on the Slack Adjuster

Brake Chamber Free Stroke Checking

Free stroke is the amount of slack adjuster movement required to bring the brake shoes and linings into contact with the brake drum. Check the brake chamber free stroke as follows:

1. With the brakes released, measure and record the distance from the brake chamber face to the center of the large clevis pin. See **Fig. 1**.

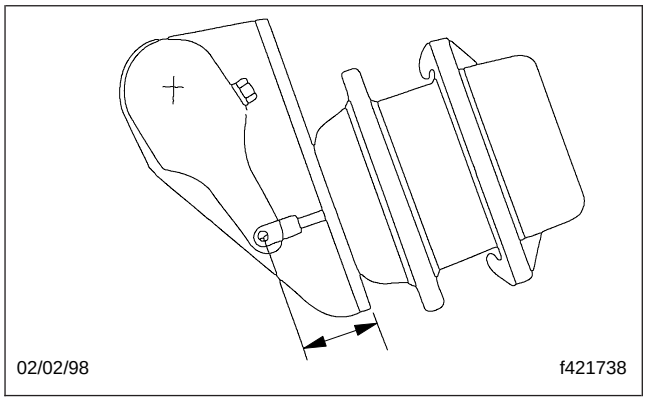


Fig. 1, Brake Chamber Face to Center of Large Clevis Pin Distance

2. Using a lever, extend and hold the brake chamber push rod at the point at which the brake shoe and lining is felt to come into contact with the brake drum.
3. Make the same measurement as in the previous step. See **Fig. 2**.

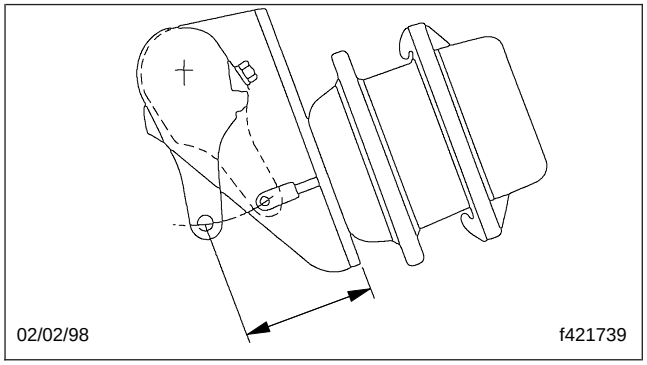


Fig. 2, Measurement with Brake Application

4. Subtract the measurement from the previous step to obtain the free stroke measurement.
5. For a properly installed slack adjuster and properly adjusted brakes, the free stroke must be 3/8 to 5/8 inch (10 to 16 mm). A free stroke that is longer than specified is caused by a worn or damaged slack adjuster. If the slack adjuster is OK, inspect the foundation brakes for proper installation, missing, worn or damaged parts. Correct as necessary. Recheck the brake chamber free stroke.

Specifications

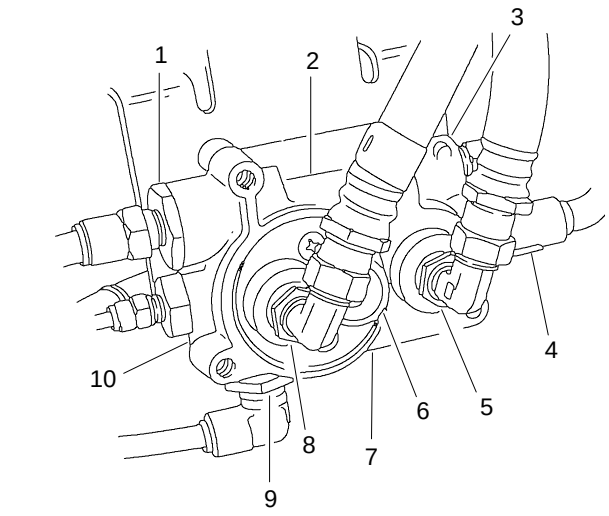
Torque Specifications	
Description	**lbf·ft (N·m)**
Slack Adjuster Hex Extension (Counterclockwise, Maximum)	15 (20)
Air Chamber-to-Camshaft Bracket Nuts, 7/16-inch	31–42 (42–56)
Air Chamber-to-Camshaft Bracket Nuts, 5/8-inch	101–145 (136–196)
Backing Plate-to-Axle Nuts Bolt Size 7/16-20	60–75 (81–102)
Backing Plate-to-Axle Nuts Bolt Size 1/2-20	85–115 (115–156)
Backing Plate-to-Axle Nuts Bolt Size 9/16-18	130–165 (176–224)
Backing Plate-to-Axle Nuts Bolt Size 5/8-18	180–240 (244–325)
Air Chamber Push Rod Jam Nut	40–50 (55–67)
Slack Adjuster Collar Nut	40–50 (55–67)
Camshaft Bracket-to-Backing Plate Nut	
1/2-13 Grade 8	90–120 (122–163)
1/2-13 Grade 5	65–100 (88–136)
5/8-18 Plain Nut	150–190 (203–258)
5/8-18 Plain Lock Nut	130–165 (176–244)
3/4-16 Nut	220–300 (299–406)
Air Chamber Air Line Fittings (Maximum)	
MGM	24 (33)
Maxi-Brake	12 (16)
Cast Spoke Wheel-to-Brake Drum	200–250 (272–338)
Brake Air Chamber Release Bolt Nut (Maximum)	49 (67)
Brake Air Chamber Clamp Ring Nuts, MGM	30–35 (41–47)
Brake Air Chamber Clamp Ring Nuts, Maxi-Brake	16–19 (22–26)

Table 1, Torque Specifications

DOT Maximum Adjusted Brake Chamber Strokes	
Chamber Type (Size)	**Maximum Chamber Stroke**
9	less than 1.5 ± 0.125 inches (38.1 ± 3.2 mm)
12	less than 1.5 ± 0.125 inches (38.1 ± 3.2 mm)
16	less than 1.5 ± 0.125 inches (38.1 ± 3.2 mm)
20	less than 1.5 ± 0.125 inches (38.1 ± 3.2 mm)
24	less than 1.625 ± 0.125 inches (41.3 ± 3.2 mm)
24 (long stroke)	less than 1.625 ± 0.125 inches (41.3 ± 3.2 mm)
30	less than 1.625 ± 0.125 inches (41.3 ± 3.2 mm)
36	less than 1.625 ± 0.125 inches (41.3 ± 3.2 mm)

Table 2, DOT Maximum Adjusted Brake Chamber Strokes

General Information (See Fig. 1)



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1. Primary Circuit Delivery Port
2. Tractor Protection Valve
3. Secondary Delivery Port
4. Trailer Parking Control Port (from trailer air supply control valve)
5. Trailer Parking Supply Port (to trailer parking brakes)
6. Exhaust Port
7. Vent (not shown)
8. Trailer Service Supply Port (to trailer service brakes)
9. Trailer Control Port (from trailer brake hand control valve)
10. Service Line Shut-Off Control Port

Fig. 1, Tractor Protection Valve

The tractor protection valve (TPV), as required by United States Federal law, protects the tractor brakes in the event of trailer breakaway or a severe air system leak. When used with a dash-mounted trailer supply control valve, the trailer protection valve can be used to shut off the trailer control line before the trailer is disconnected.

The TPV also includes an integral single check valve which prevents air from getting trapped in the trailer control line. Trapped air in this line could cause service/spring brake compounding and, if the trailer is parked with air applied, a trailer roll-away situation can occur. See **Fig. 2** for the tractor protection valve and related plumbing.

Initial Charge

Pushing in the red trailer air supply knob on the instrument panel causes air to flow into the tractor protection valve at the tractor supply port. Air flows through the valve housing, exiting via the auxiliary supply port (if used) and the trailer supply port, to pressurize the trailer brake system and release the trailer parking brakes.

As air pressure builds in the trailer supply circuit, the single check valve seats, and the valve plunger begins to move (against spring pressure) toward the guide. When pressure reaches about 45 psi (310 kPa), the plunger bottoms against the guide and the inlet valve is open.

The tractor protection valve is in the "Run" mode, and ready to receive and deliver a service brake application from either the foot brake control valve or the hand valve.

Service Brake Application

When the foot brake control valve is pressed, air flows to the tractor protection valve tractor control primary and secondary ports. If the trailer control valve is also used, the external double check delivers the higher pressure (trailer control or foot control valve secondary) to the TPV tractor control secondary port.

Inside the tractor protection valve, the higher pressure (primary or secondary) moves the diaphragm to seal off the port at the lower pressure.

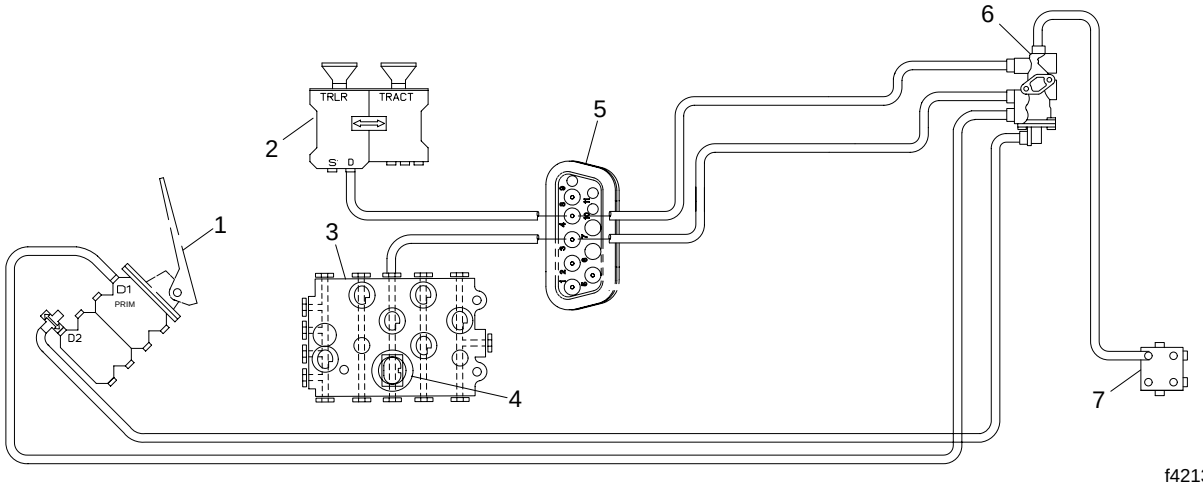
With the plunger bottomed against the guide and the inlet valve open (as described earlier), the higher pressure air flows through the valve to the trailer control port and the stop lamp switch, applying the brakes and activating the stop lamps.

NOTE: While air pressure also reaches the single check valve, the valve stays closed because supply pressure is acting on the other side.

Service Brake Release

When the foot pedal is released, air stops flowing into the tractor protection valve at the tractor control primary or secondary port. At the same time, air in

General Information



1. Foot Brake Control Valve
2. Dash Valves
3. Air Manifold and Pressure Switch
4. Stop Lamp Switch
5. Pass-Thru Grommet
6. Tractor Protection Valve
7. Relay Valve

Fig. 2, Tractor Protection Valve Plumbing Diagram

the trailer control line returns to the valve, flowing back through the open inlet valve.

The air forces the diaphragm to seat, sealing off the tractor control primary port. The air then exits the valve at the tractor control (secondary) port and flows to the foot brake control valve or hand valve where it is exhausted.

Tractor Protection

If the red trailer air supply knob on the instrument panel is pulled out (or if a large leak develops in the trailer supply circuit), pressure in the trailer supply circuit (and the auxiliary supply circuit, if used) is vented. When pressure drops to about 20 to 30 psi (138 to 207 kPa), the pressure can no longer overcome the spring force inside the tractor protection valve and the inlet valve closes.

With the inlet valve closed, air pressure from the brake foot or hand control valves will not reach the trailer control circuit when the brakes are applied.

Anti-Compounding

If the red trailer air supply knob on the instrument panel is pulled out while the service brakes are applied, the single check valve in the tractor protection prevents simultaneous spring and service brake application. As pressure in the trailer supply circuit drops, the spring in the tractor protection valve forces the inlet valve closed (as described above in "Tractor Protection"). Any pressure in the trailer control circuit is relieved by passing first through the single check valve and then exhausting at the trailer supply valve.

If the service brakes (hand or foot) are released and applied again, the closed inlet valve prevents air pressure from reaching the trailer control circuit.

Safety Precautions

AIR BRAKE SYSTEM WARNINGS

⚠ WARNING

Before attempting to work on the air brake system, certain precautions must be observed. Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized. The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.

When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.

Hoses will whip dangerously if disconnected under pressure.

Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.

As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber push rods and spring actuators which apply automatically with the loss of pressure. This also applies when checking the service brake system.

Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.

Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.

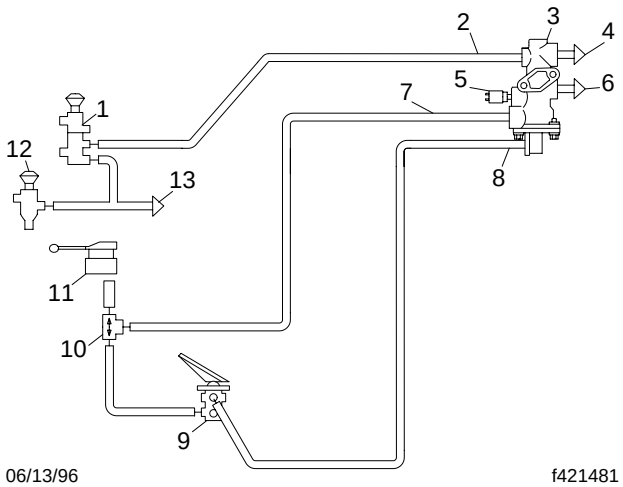
The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.

Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.

To avoid injury, keep clear of the air chamber push rod when brakes are applied or when air is exhausted from the system.

Observe these warnings while investigating all applicable brake system concerns.

Removal (See Fig. 1)



1. Trailer Air Supply Valve
2. Tractor Supply
3. Auxiliary Supply Port
4. Trailer Supply
5. Stop Lamp Switch Port
6. Trailer Control
7. Tractor Control (Secondary)
8. Tractor Control (Primary)
9. Foot Brake Control Valve
10. Double Check Valve
11. Trailer Control Valve
12. Parking Brake Valve
13. To Tractor Spring Brakes

Fig. 1, Tractor Protection Valve Plumbing

CAUTION

Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Drain the air system.
4. Remove the trailer hose assemblies from the TPV. Disconnect the tractor service and supply lines. Mark the lines for later assembly reference. Cap the air lines tightly to keep out contaminants.
5. Remove the fasteners attaching the TPV to the vehicle, then remove the valve.

Installation

1. Install the tractor protection valve on the vehicle, and install the attaching bolts, washers, and nuts. Tighten the fasteners 11 to 15 lbf·ft (15 to 20 N·m).
2. Remove the caps from the air lines, connect the air hoses to the correct valve ports, and tighten the nuts finger-tight. Use a wrench to tighten the nuts at least two turns, or until no threads show on the fitting.
3. Close the drain cocks to the air reservoirs and pressurize the air system.
4. Leak test the valve following the instructions in Subject 120.
5. Connect the batteries.
6. Remove the chocks from the tires.

Leakage Test

CAUTION

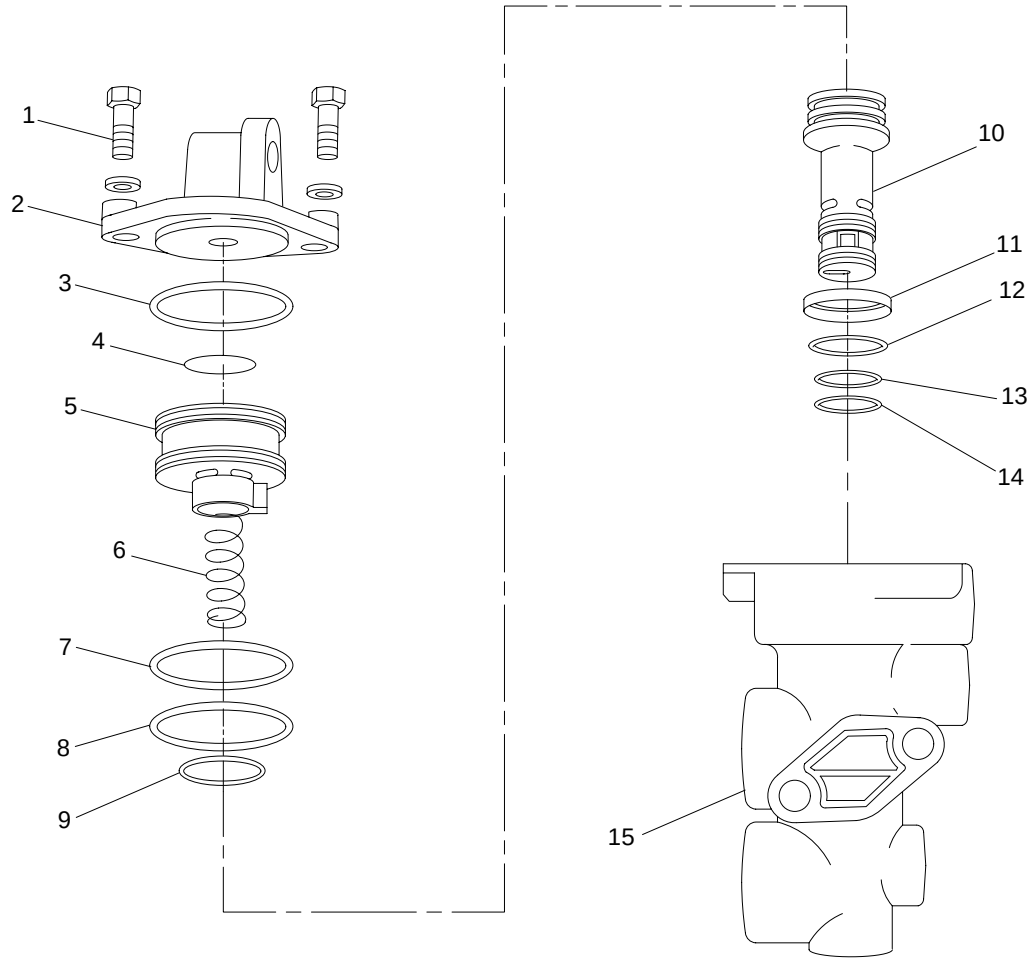
Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

1. Chock the tires, start the engine, and run it until the air system is fully charged.
2. Shut down the engine and place the trailer air supply valve in the emergency position.
3. Disconnect the trailer control line hose coupling and apply a soap-water solution to the coupling.
4. With tractor reservoirs charged to at least 100 psi (689 kPa) make and hold a full service brake application using either the foot valve or the trailer control valve. Leakage at the hose coupling should not exceed a 1-inch (2.5-cm) bubble in five seconds.
5. Release the service brake application and place the trailer supply valve in the "Run" position. Connect the trailer control valve to a test gauge.
6. Make a service brake application and note that service air pressure is present at the trailer control line hose coupling.
7. Disconnect the air line at the TPV tractor control port (primary), plug the line, and apply a soap-water solution to the valve.
8. Make a service brake application and check for leakage at the open tractor control port. Leakage should not exceed a 1-inch (2.5-cm) bubble in five seconds.
9. Reconnect the air line to the tractor control port (primary) and disconnect the air line at the tractor control port (secondary). Then, plug the disconnected line and apply a soap-water solution to the valve.
10. Make and service brake application and check for leakage at the open tractor control port. Leakage should not exceed a 1-inch (2.5-cm) bubble in five seconds.

IMPORTANT: If the valve does not function as described, or if leakage is excessive, repair or replace the valve.

Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)



1. 1/4" Hex/Torx Screw
2. Valve Cover
3. Cover O-Ring
4. Diaphragm
5. Guide
6. Valve Spring
7. Guide O-Ring
8. Guide O-Ring
9. Plunger O-Ring
10. Plunger
11. Collar
12. O-Ring
13. Plunger O-Ring
14. Plunger O-Ring
15. Valve Body

Fig. 1, Tractor Protection Valve

⚠ CAUTION

Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

1. Remove the valve from the vehicle, retaining the mounting hardware. For instructions, see Subject 120.
2. Scribe a line across the valve cover and valve body to ensure proper alignment during assembly.

Disassembly, Cleaning and Inspection, and Assembly

3. Remove the two 1/4-inch screws that secure the valve cover to the valve body and allow the valve spring to expand until the valve cover can be removed.
4. Remove the cover O-ring and discard it.
5. Remove the diaphragm from the valve body and discard it.
6. Remove the guide from the valve body.
7. Remove the O-rings from the guide and discard them.
8. Remove the valve spring from the plunger, then the plunger from the valve body.
9. Remove the O-rings from the plunger and discard them.
10. Remove the collar and the O-ring from the plunger. Discard the O-ring, but keep the collar.

Cleaning and Inspection

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

1. Wash all metal parts of the valve in cleaning solvent, then dry them using compressed air.
2. Examine the cover, body, guide, and plunger for corrosion, excessive wear, cracks, or other damage. If any of these conditions are found on a part, replace the part with a new one.
3. Check the spring for distortion and corrosion. If the spring is distorted or corroded, replace it.
4. Check the valve body bores for deep scratches or gouging.

Assembly

1. Lubricate the O-rings, O-ring grooves, body bores, and all sliding parts with the lubricant provided in the overhaul kit (Bendix silicone lubricant #291126 or equivalent).
2. Install the O-rings on the plunger.
3. Install the O-ring on the plunger and then the collar over the O-ring. Make sure that the collar is fully seated and firmly in place over the O-ring.
4. Install the plunger into the valve body and the spring into the plunger.
5. Install the O-rings in their grooves on the guide.
6. Align the indexing tab on the guide with the notch in the valve body and install the guide in the valve body.
7. Place the diaphragm in its recess on the guide.
8. Place the O-ring on the cover.
9. Place the cover on the guide and press them down, against spring pressure, until the cover is seated against the valve body.
10. Install the two 1/4-inch screws and tighten them 30 to 60 lbf·in (340 to 675 N·cm).
11. Install the valve on the vehicle following the instructions in **Subject 120**.

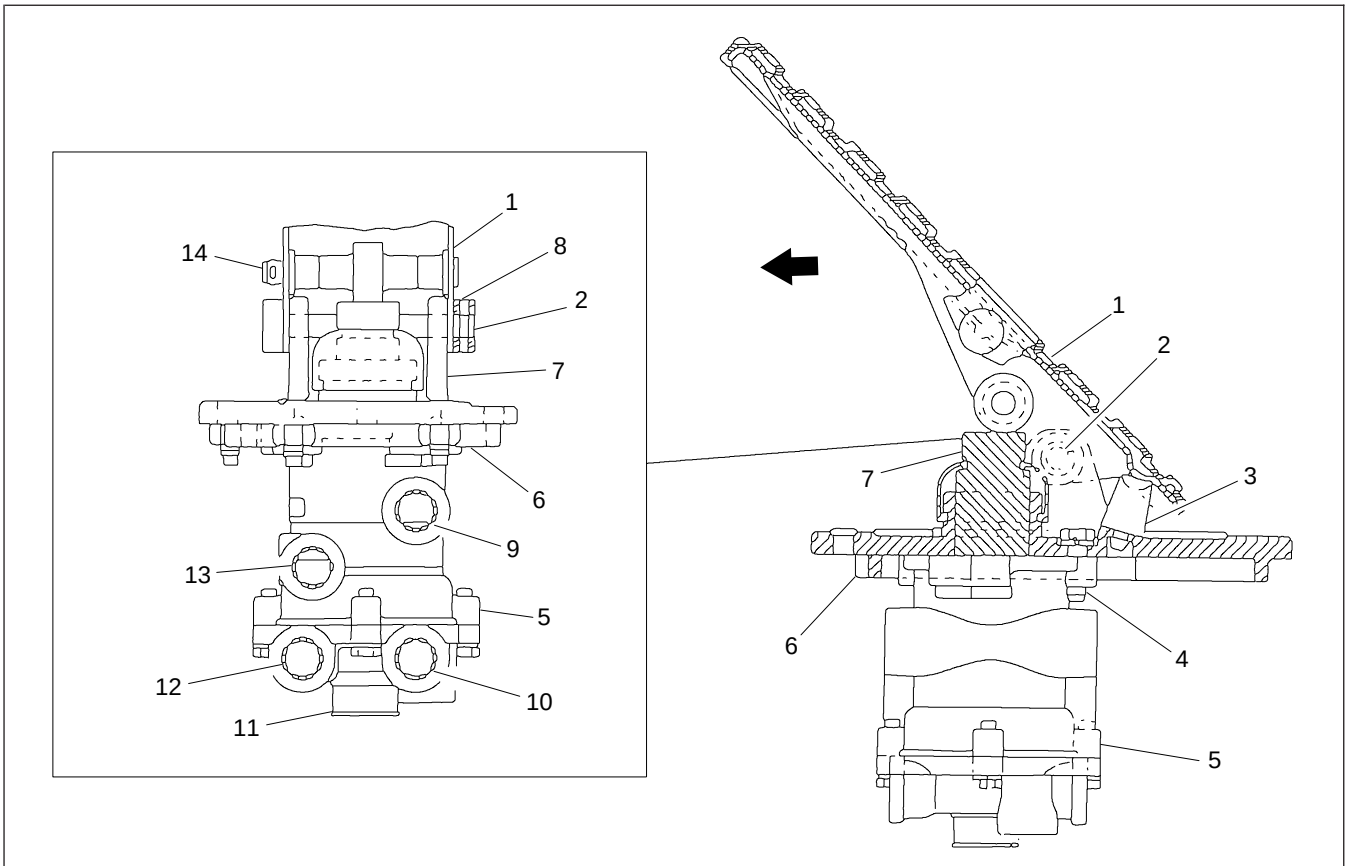
Specifications

Torque Specifications		
Description	**lbf·in (N·cm)**	**lbf·ft (N·m)**
Valve Cover Capscrews	30–60 (340–675)	—
Valve Mounting Capscrews	—	11–15 (15–20)

Table 1, Torque Specifications

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

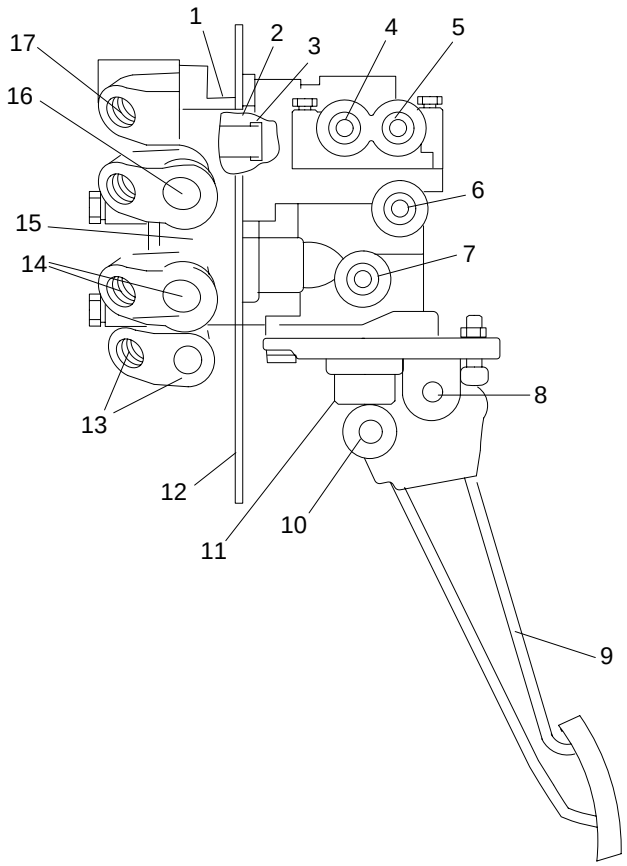
The foot brake control valve assembly controls the application of air pressure from the primary and secondary air reservoirs. The foot brake control valve will vary air pressure delivery in proportion to the amount of foot pressure applied to the pedal.



1. Brake Pedal
2. Fulcrum Shaft
3. Pedal Bumper
4. Pedal Bracket-to-Foot Control Valve Screws
5. Foot Brake Control Valve
6. Reinforcement Plate
7. Pedal Plunger
8. Fulcrum Shaft Pin
9. Primary Supply Port
10. Secondary Supply Port
11. Exhaust Port
12. Secondary Delivery Port
13. Primary Delivery Port
14. Pedal Roller

Fig. 1, Left-Hand-Drive Foot Brake Control Valve Assembly

General Information



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1. Sealing Ring
2. Adaptor Sleeve
3. O-Ring
4. Secondary Supply
5. Secondary Delivery
6. Primary Supply
7. Primary Delivery
8. Pivot Pin
9. Brake Pedal Assembly
10. Pedal Roller
11. Plunger
12. Cab Wall Mounting Plate
13. Primary Delivery
14. Primary Supply
15. Manifold
16. Secondary Supply
17. Secondary Delivery

Fig. 2, Right-Hand-Drive Foot Brake Control Valve Assembly

Safety Precautions

AIR BRAKE SYSTEM WARNINGS

⚠ WARNING

Before attempting to work on the air brake system, certain precautions must be observed. Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized. The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.

When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.

Hoses will whip dangerously if disconnected under pressure.

Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.

As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber push rods and spring actuators which apply automatically with the loss of pressure. This also applies when checking the service brake system.

Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.

Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.

The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.

Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.

To avoid injury, keep clear of the air chamber push rod when brakes are applied or when air is exhausted from the system.

Observe these warnings while investigating all applicable brake system concerns.

Removal and Installation, Left-Hand-Drive Vehicle

Removal

CAUTION

Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Drive out and remove the foot control valve pin. See **Fig. 1**.

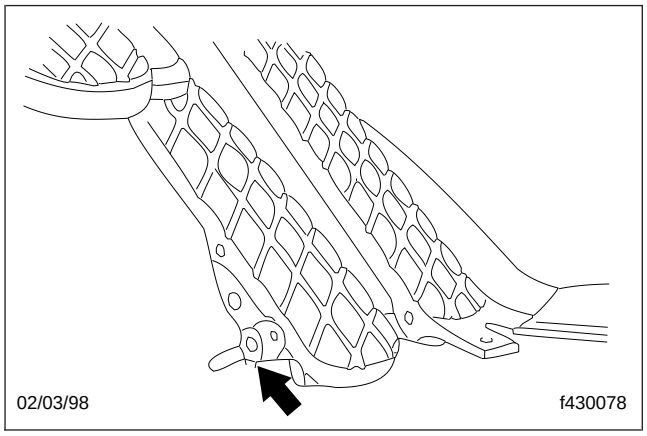


Fig. 1, Foot Control Valve Pin

3. Remove the fulcrum shaft and the brake pedal. See **Fig. 2**.

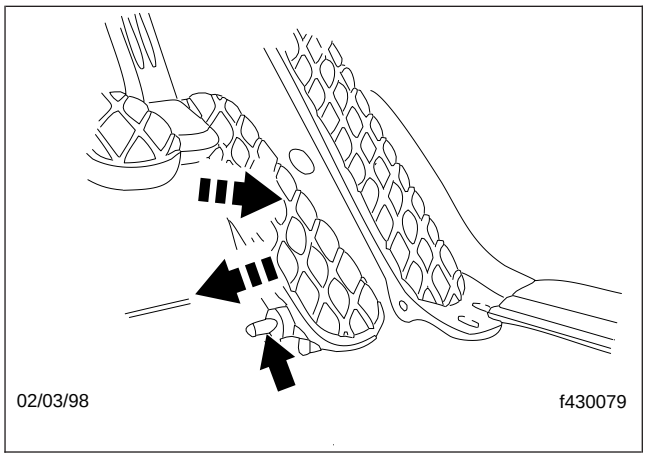


Fig. 2, Fulcrum Shaft and Brake Pedal

4. Remove the screws. See **Fig. 3**.

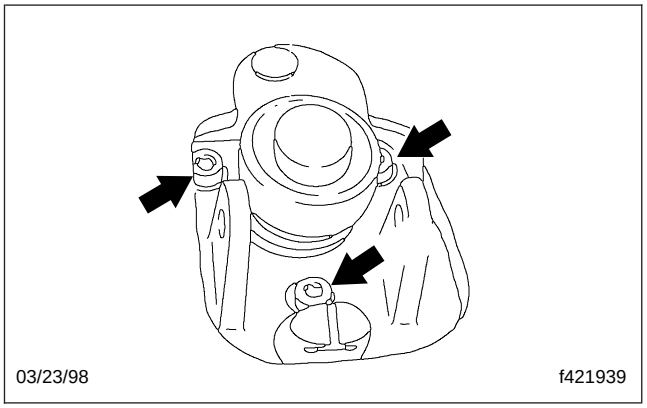


Fig. 3, Foot Valve Footwell

NOTE: Removing the left-side fender well eases access to the foot control valve air lines.

5. Remove the five fender well capscrews. See **Fig. 4**.

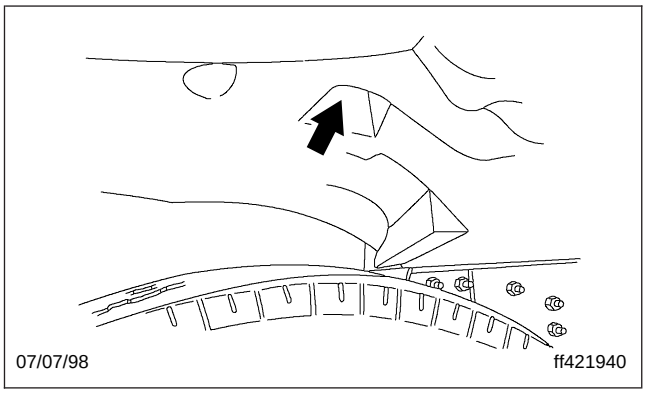


Fig. 4, Fender Well Access

6. Remove the left-side fender well. See **Fig. 5**.

NOTE: The air line fittings are all of the quick-disconnect type.

7. Remove the foot control valve.
   - 7.1 Tag and disconnect the air lines. See **Fig. 6**.
   - 7.2 Remove the foot control valve.
8. Beneath the floor, remove the five nuts. See **Fig. 7**.
9. Remove the reinforcement plate. See **Fig. 8**.

Removal and Installation, Left-Hand-Drive Vehicle

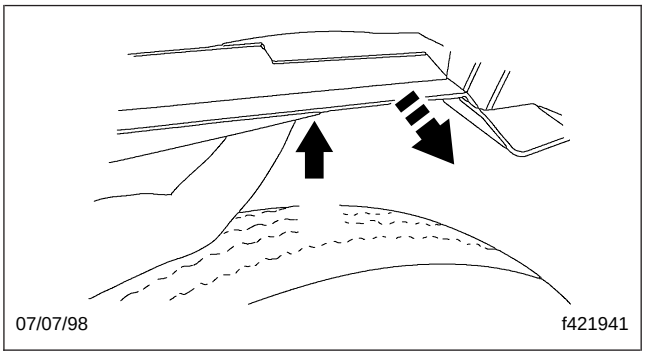
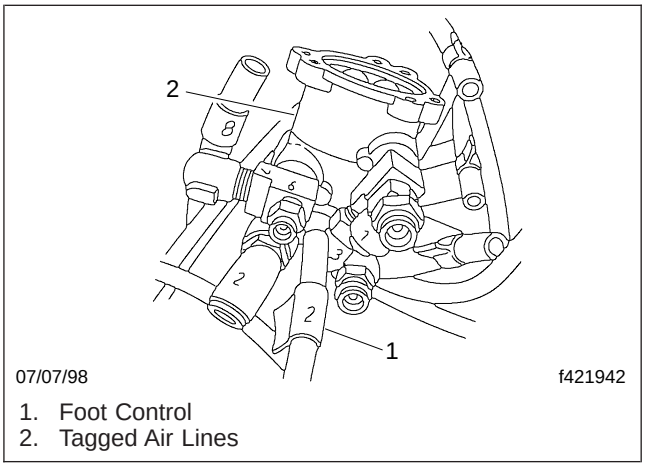


Fig. 5, Fender Well



1. Foot Control
2. Tagged Air Lines

Fig. 6, Air Lines and Fittings

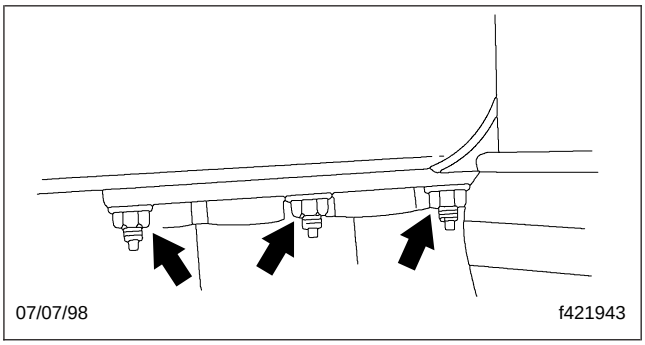


Fig. 7, Foot Control Valve Stud Nuts

10. Remove the pedal bracket. See **Fig. 9**.

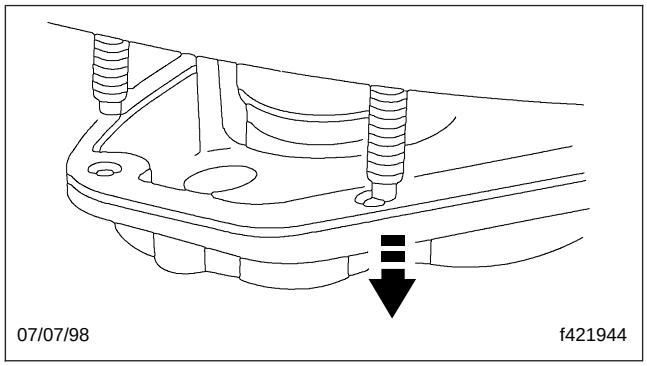


Fig. 8, Reinforcement Plate

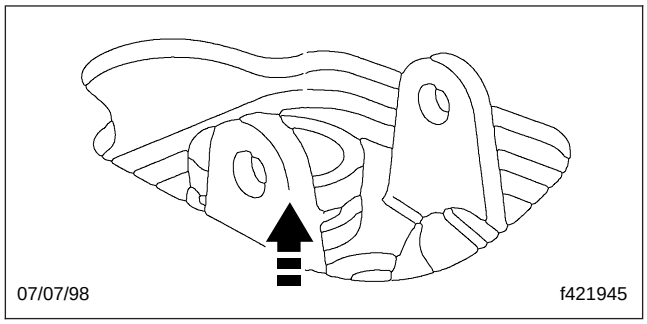


Fig. 9, Pedal Bracket

Installation

NOTE: An assistant is necessary to position the foot control valve while the capscrews are installed from inside the cab.

1. Install the fulcrum shaft and the brake pedal. See **Fig. 2**.
2. Install the left side fender well.
3. Install the five fender well capscrews.
4. Install the foot control valve.
   - 4.1 Connect the air lines.
   - 4.2 Install the foot control valve.
5. Beneath the floor, install the five nuts. See **Fig. 7**.
6. Install the reinforcement plate.
7. Install the pedal bracket.
8. Install the foot control valve pin. See **Fig. 1**.
9. Remove the chocks from the tires.

Removal and Installation, Right-Hand-Drive Vehicle

Removal (See Fig. 1)

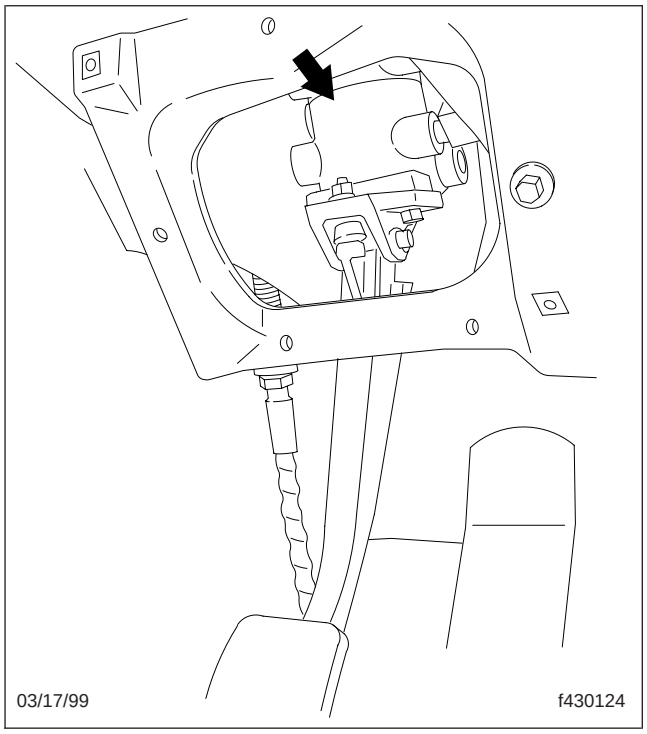


Fig. 1, Foot Brake Control Valve

CAUTION

Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the battery.
3. Drain the air system.
4. Remove the under steering panel.
5. Disconnect the electrical connectors.
6. Disconnect and mark the air lines.
7. Remove the foot brake control valve assembly retaining bolts. See Fig. 2.
8. Remove the foot brake control valve assembly.

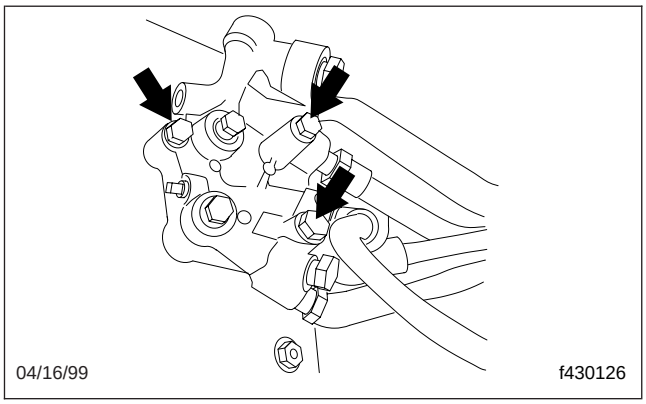


Fig. 2, Brake Control Treadle Valve and Assembly Bolts

Installation

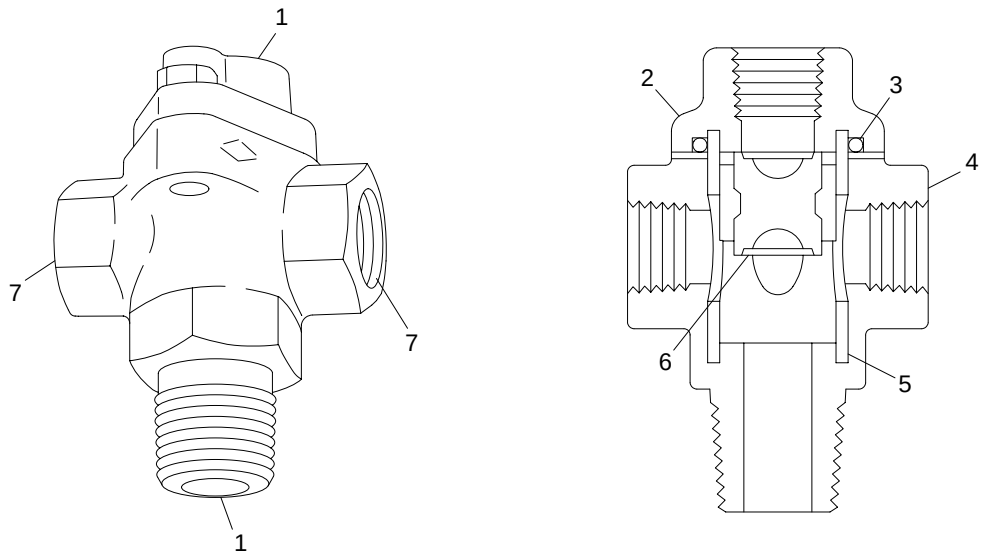
NOTE: An assistant is necessary to position the foot control valve assembly on the three bolts that are installed through the brake control treadle valve and assembly under the hood.

1. Position the foot brake control valve assembly.
2. Install the retaining bolts.
3. Connect the air lines.
4. Connect the electrical connectors.
5. Install the under steering panel.
6. Connect the battery.
7. Remove the chocks from the tires.

General Information (See Fig. 1)

Sterling vehicles use one or two shuttle type double check valves. If a vehicle is equipped with a trailer control valve it has two double check valves. Otherwise, most other vehicles will only have one. A shuttle type valve has a movable shuttle to seal off the lower pressure source. The valves are screwed into the forward side of the foot brake valve.

Double check valves are used in the air brake system to direct a flow of air into a common line from either of two sources, whichever is at the higher pressure.



1. Supply Port
2. End Cap
3. O-Ring
4. Valve Body
5. Shuttle Guide
6. Shuttle Valve
7. Delivery Port

Fig. 1, Double Check Valve

Principles of Operation

As pressurized air enters either end of the double check valve inlet port, the moving shuttle responds to the greater pressure source and seals the opposite port. The air flow continues out the delivery port of the valve. The position of the shuttle will reverse if the pressure levels are reversed. Double check valves are designed so the shuttle cannot interfere with the backflow of air in the exhaust mode.

Safety Precautions

AIR BRAKE SYSTEM WARNINGS

⚠ WARNING

Before attempting to work on the air brake system, certain precautions must be observed. Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized. The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.

When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.

Hoses will whip dangerously if disconnected under pressure.

Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.

As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber push rods and spring actuators which apply automatically with the loss of pressure. This also applies when checking the service brake system.

Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.

Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.

The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.

Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.

To avoid injury, keep clear of the air chamber push rod when brakes are applied or when air is exhausted from the system.

Observe these warnings while investigating all applicable brake system concerns.

Removal

CAUTION

Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Drain the air tanks.
3. Tilt the hood.
4. Remove the ziptie holding the air lines together.

NOTE: To disconnect the air lines, push the hose in, push the retaining ring in and pull out the hose in a swift motion.

5. Mark the air lines and disconnect them.
6. Remove the bolt and remove the valve. See Fig. 1.

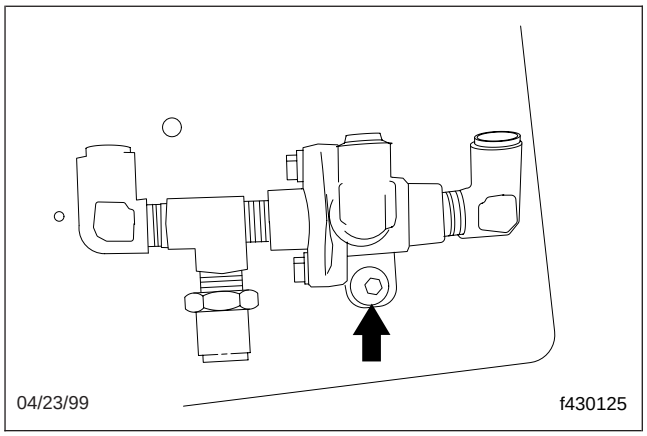


Fig. 1, Double Check Valve Bolt

Installation

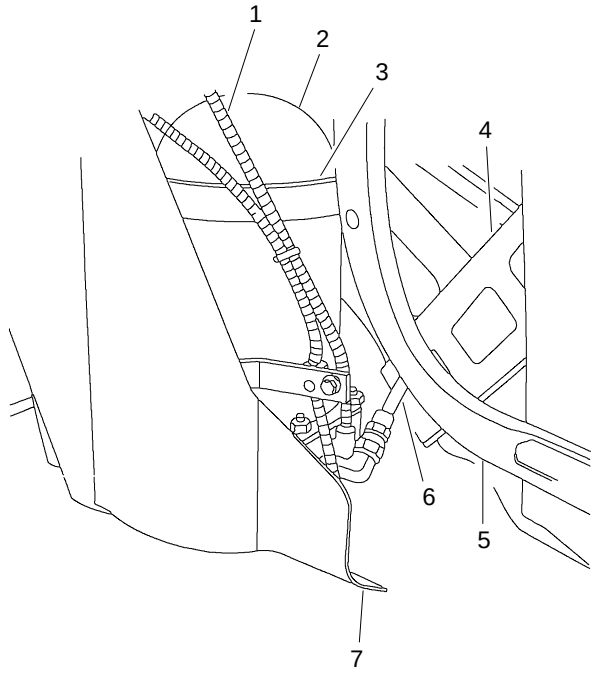
1. Install the double check valve. Tighten the bolt.
2. Connect the air lines.
3. Close the hood.
4. Remove the chocks from the tires.

General Information

The air dryer receives the compressed air from the air compressor and removes excess moisture and contaminants.

Two types of air dryers are available: the Bendix AD–9 and the Bendix AD–IP. The AD–9 air dryer must be removed from the vehicle to change the desiccant cartridge. The AD–IP air dryer desiccant cartridge can be changed on-vehicle. To determine which type is in use, note whether the air dryer is equipped with a clamp around the upper end of the desiccant canister. The AD–9 has a clamp around the upper end of the desiccant canister and the AD–IP does not. See **Fig. 1**.

Follow the manufacturer's instructions when replacing the desiccant cartridge.



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1. Tubing (to governor)
2. Air Dryer
3. Clamp
4. Battery Support Brace
5. Fender Brace (left-side)
6. Braided Shield Tubing (from compressor)
7. Splash Shield

Fig. 1, AD-9 Air Dryer

Removal

WARNING

Before working on, or around, air brake systems and components, read "Safety Precautions" in Section 42.01. Failure to do so can result in personal injury.

NOTE: Air dryer removal is easier with the wheels turned all the way to the right.

This procedure covers the Bendix AD–9 and AD–IP air dryers.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Relieve system air pressure.
3. Release the wiring harness and shield bracket by removing the nut and bolt. See Fig. 1.

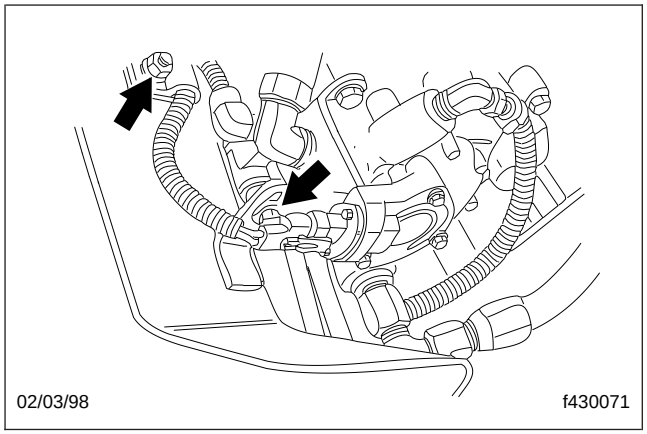


Fig. 1, Wiring Harness and Bracket Nuts

IMPORTANT: A-Line models are equipped with an inner fender splash guard. The splash guard and mounting bracket must be removed to access the air dryer.

4. Remove the nuts and bolts. Remove the air dryer shield. See Fig. 2.

NOTE: The 1/4-inch (6.4-mm) governor signal line is the quick-disconnect type.

Tag the air lines to aid installation, noting their orientation.

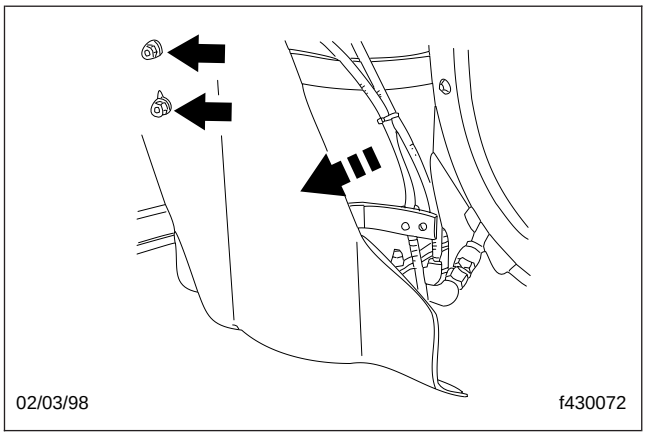


Fig. 2, Air Dryer Shield Nuts and Bolts

Note the orientation of the air dryer ports relative to the vehicle.

5. Disconnect the following (see Fig. 3):

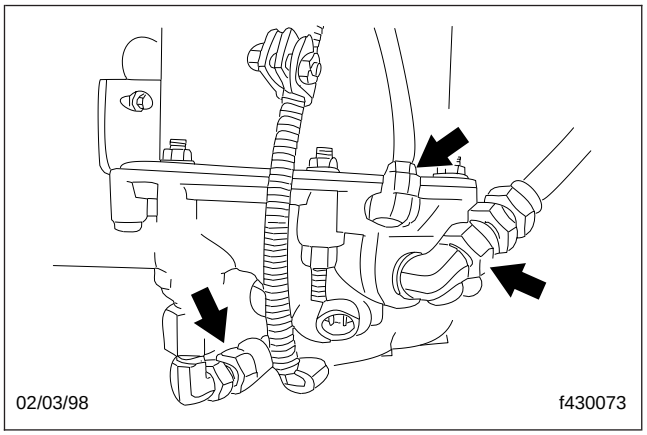


Fig. 3, Electrical Connector and Air Lines

- electrical connector
- governor signal air line
- supply air line from the air compressor
- delivery air line to the reservoir

CAUTION

To avoid breaking the canister-to-base seal, do not remove the canister-to-base nuts.

IMPORTANT: Support the air dryer while removing the bolts.

Air Dryer Removal and Installation

6. Remove the air dryer support bracket nuts and bolts.
7. Remove the clamp bracket nuts and bolts and remove the air dryer.

Installation

NOTE: Air dryer installation is easier with the wheels turned all the way to the right.

Support the air dryer while installing the mounting bolts.

1. Install the air dryer.
2. Tighten the air dryer support bracket nuts and bolts 23 to 29 lbf·ft (31 to 40 N·m). See **Fig. 4**.

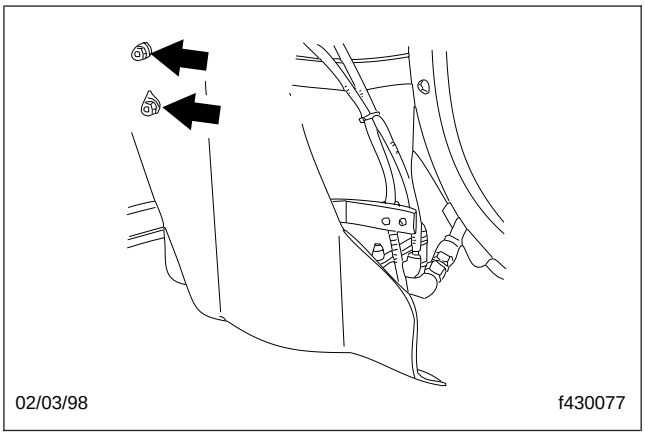


Fig. 4, Air Dryer Shield Nuts and Bolts

3. Install the air dryer clamp bracket nuts and bolts. Tighten them 26 to 33 lbf·in (36 to 45 N·m).
4. Install the air dryer shield, nuts and bolts. See **Fig. 2**.

NOTE: The 1/4-inch (6.4-mm) governor air line is the quick-disconnect type.

5. Connect the following (see **Fig. 3**):
   - electrical connector
   - governor air line
   - supply air line from the air compressor
   - delivery air line to the reservoir
6. Position the wiring harness and install the shield bracket. See **Fig. 1**.
7. Remove the chocks from the tires.
8. Start the vehicle and check for air leaks and proper operation.

Bendix AD–9 Disassembly, Cleaning, Inspection, and Assembly

Disassembly (See Fig. 1)

⚠ WARNING

Before working on, or around, air brake systems and components, read "Safety Precautions" in Section 42.01. Failure to do so could result in personal injury.

⚠ CAUTION

While servicing the air dryer, do not 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.

NOTE: 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.

1. Remove the air dryer from the vehicle. Refer to Subject 100.
2. Remove the check valve assembly and O-ring. Remove the O-ring from the check valve assembly.
3. Remove the purge valve housing assembly.
   - 3.1 Remove the three self-tapping screws 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 and discard the three O-rings from the exterior of the purge valve housing assembly.

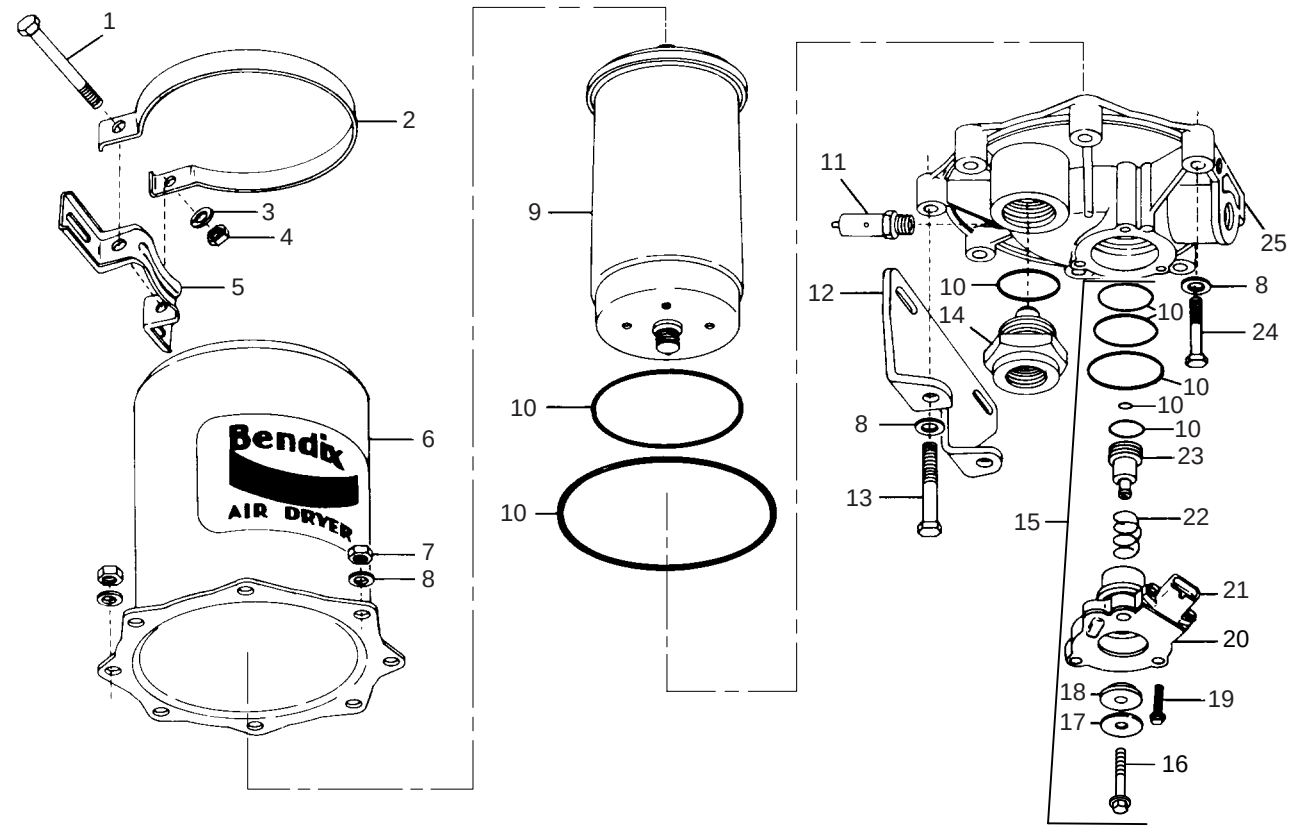
   NOTE: These O-rings may lodge in and have to be removed from the end cover bores.
4. Remove the heater and thermostat assembly.
   - 4.1 Remove and discard the two screws that attach the heater and thermostat assembly to the purge valve housing.
   - 4.2 Gently rotate the electrical connector to the left until the thermostat clears the purge valve housing. Slide the heater element out to the right and up. Discard the assembly.
5. Disassemble the purge valve housing assembly.
   - 5.1 If a flat non-extended exhaust cover 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* separate 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.*
   - 5.2 Remove the bolt from the bottom of the purge valve housing assembly. Remove the diaphragm and the purge valve from the purge valve housing.
   - 5.3 Remove the purge piston, the return spring and two O-rings (one on the outside and the other in the inside of the purge piston).
6. Remove the remaining six capscrews, locknuts, and 12 special washers that secure the end cover to the housing. Separate the end cover and desiccant cartridge from the housing.
7. Remove the end-cover-to-outer-housing O-ring.
8. Do not 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.

NOTE: It may be necessary to apply up to 50 lbf·ft (68 N·m) of torque to separate the desiccant cartridge from the end cover.

9. Place a strap or chain wrench around the desiccant cartridge 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.
10. Remove the desiccant cartridge O-ring from the end cover.

Bendix AD–9 Disassembly, Cleaning, Inspection, and Assembly



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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 Bolt
17. Exhaust Diaphragm
18. Purge Valve
19. 1/4-Inch Tapping Screw
20. Purge Valve Housing
21. Heater and Thermostat Assembly
22. Return Spring
23. Purge Piston
24. 3/8-Inch Capscrew
25. End Cover

Fig. 1, AD-9 Air Dryer (exploded view)

Cleaning and Inspection

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.
10. Replace parts that show any of the conditions described in the previous steps.

Assembly (See Fig. 1)

WARNING

Before working on, or around, air brake systems and components, read "Safety Precautions" in Section 42.01. Failure to do so could result in personal injury.

1. Before and during assembly, coat all O-rings, O-ring grooves, and bores with a generous amount of barium-based lubricant unless otherwise advised.

IMPORTANT: When installing the heater and thermostat assembly, make sure that the seal ring under the electrical connector is not twisted.

2. Install the heater and thermostat assembly.
   - 2.1 Insert the heater element into the slot in the purge valve housing until the connector contacts the housing.
   - 2.2 Gently push the connector and the thermostat to the left until the thermostat clears the cavity in the housing. Turn the connector to the right while pushing the thermostat all the way down into the cavity.

     Make sure that the connector is seated evenly against the housing.
   - 2.3 Install the two mounting screws. Tighten the screws 10 to 20 lbf·in (113 to 226 N·cm).
3. Assemble the purge valve housing.
   - 3.1 Install the O-ring on the purge piston. Place the return spring in the purge valve housing. Place the O-ring in the bore of the purge piston. Insert the purge piston into the spring. Push the piston into the purge valve housing until it bottoms.
   - 3.2 While holding the purge piston in, install the purge valve with its rubber side first, followed by the diaphragm and the bolt. Torque the purge valve bolt 60 to 80 lbf·in (680 to 900 N·cm).
   - 3.3 Install the three O-rings in their correct locations on the purge valve housing.
   - 3.4 If an extended type exhaust cover was removed, install it on the purge valve housing assembly, making sure the "bubble" portion is positioned over the thermostat.
   - 3.5 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.
   - 3.6 Secure the purge valve housing to the end cover using the three self-tapping screws. Start all three screws by hand, then torque them 85 to 125 lbf·in (960 to 1400 N·cm).
4. Install an O-ring on the check-valve assembly. Install the assembly in the end cover using a socket. Tighten it 200 to 250 lbf·in (2260 to 2820 N·cm).
5. Install the desiccant cartridge in the end cover.
   - 5.1 Install the smaller desiccant cartridge O-ring in its groove in the end cover. Using a light coat of barium grease, lubricate the bottom of the desiccant cartridge in the area that will contact the O-ring and end cover.

Bendix AD–9 Disassembly, Cleaning, Inspection, and Assembly

5.2 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 O-ring. Torque should not exceed 50 lbf·ft (68 N·m).

6. Install the housing over the desiccant cartridge.

6.1 Install the large O-ring on the shoulder in the end cover. Place the housing over the desiccant cartridge and align the holes.

6.2 Install the 6 capscrews, locknuts, and the 12 special washers, making sure they are positioned as referenced earlier. The 2 longer capscrews will be used to secure the air dryer to its mounting bracket.

6.3 Tighten the six capscrews and nuts in a star pattern (depending on lower bracket location) 270 to 385 lbf·in (3060 to 4340 N·cm). See **Fig. 2**.

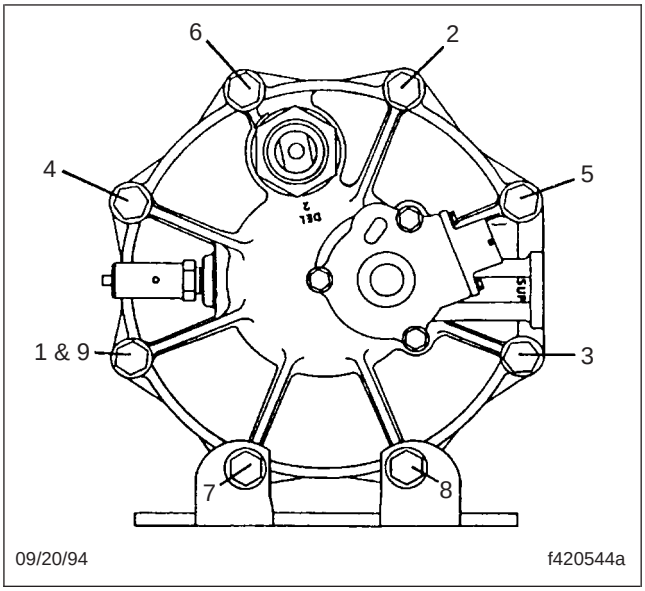


Fig. 2, End Cover-to-Housing Torque Pattern

NOTE: The two remaining bolt holes in the end cover and two 3/8-inch capscrews must be the ones marked during removal to ensure correct orientation of the ports and adequate length of the capscrews.

7. Connect the electrical connector to the heater and thermostat assembly.

Bendix AD–IP Disassembly, Cleaning, Inspection, and Assembly

Disassembly (See Fig. 1)

⚠ WARNING

Before working on, or around, air brake systems and components, read "Safety Precautions" in Section 42.01. 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.

NOTE: 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.

1. Remove the air dryer from the vehicle. Refer to Subject 100.
2. Loosen the cartridge bolt and remove the desiccant cartridge and the cartridge bolt from the end cover.
3. Remove the two O-rings from the cartridge bolt.
4. Remove the purge valve retaining ring.
5. Remove the purge valve assembly from the end cover.

NOTE: The exhaust diaphragm and the purge valve may come out when the purge piston bolt is removed.

6. Hold the purge piston with a large screwdriver and remove the purge piston bolt with a wrench.
7. Remove the exhaust diaphragm and the purge valve from the purge valve assembly.
8. Remove the O-rings from the purge valve assembly.
9. Remove the purge piston and the return spring.
10. Remove the O-ring from the purge piston.
11. Remove the delivery check valve retaining ring.
12. Remove and separate the perforated plate, check valve spring, check valve and O-ring from the end cover.
13. Remove the heater/thermostat retaining ring.
14. Carefully pull the heater and thermostat assembly and the O-ring from the end cover.
15. Remove the safety valve from the end cover.

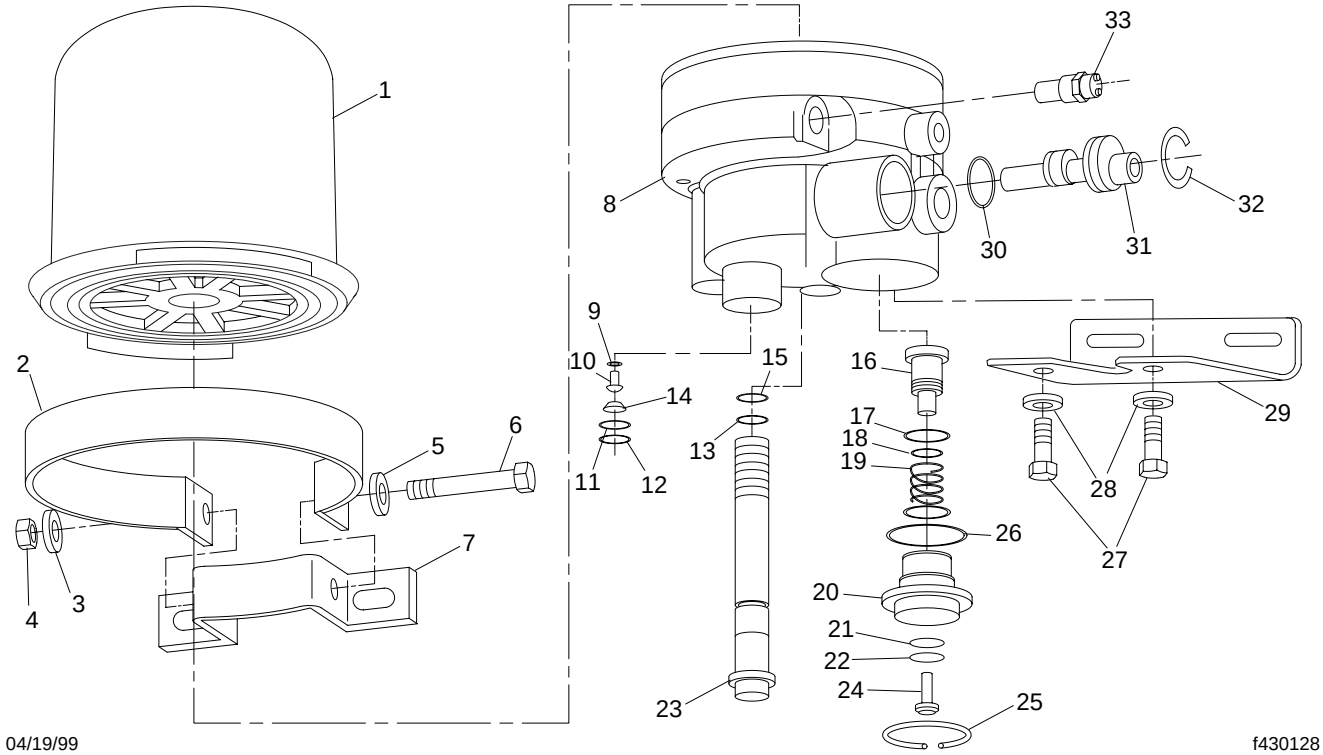
Cleaning and Inspection

1. Wash all metal parts thoroughly, using quality mineral spirits or an equivalent solvent.
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 assembly for deep scuffing or gouges.
4. Make sure that all purge valve assembly 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 assembly 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. Make certain that the purge orifice in the cartridge bolt is open and free of obstructions.
10. Replace all removed O-rings with new ones that are provided in the kits.
11. Replace parts that show any of the conditions described in the previous steps.

Assembly (See Fig. 1)

NOTE: Before assembly, coat all O-rings, O-ring grooves, and bores with a generous amount of silicone grease during assembly unless otherwise advised.

Bendix AD–IP Disassembly, Cleaning, Inspection, and Assembly



1. Desiccant Cartridge
2. Clamp Ring
3. Lockwasher
4. Clamp Ring Nut
5. Washer
6. Clamp Ring Bolt
7. Upper Mounting Bracket
8. End Cover
9. O-Ring
10. Check Valve
11. Perforated Plate
12. Check Valve Retaining Ring
13. O-Ring
14. Check Valve Spring
15. O-Ring
16. Purge Piston
17. O-Ring
18. Piston Return Spring
19. O-Ring
20. Purge Valve Housing
21. Purge Valve
22. Exhaust Diaphragm
23. Cartridge Bolt
24. Purge Piston Bolt
25. Purge Valve Retaining Ring
26. O-Ring
27. End Cover-to-Lower Cover Bracket Capscrews
28. Washers
29. Mounting Bracket
30. O-Ring
31. Heater and Thermostat Assembly
32. Heater/Thermostat Retaining Ring
33. Safety Valve

Fig. 1, AD-IP Air Dryer (exploded view)

1. Position the O-ring in its groove on the O.D. of the purge piston.
2. Position the return spring in the bore of the purge valve assembly.
3. Position the purge piston into the I.D. of the return spring.

NOTE: Make sure the exhaust diaphragm is over the shoulder of the purge piston bolt.

4. Position the exhaust diaphragm on the purge piston bolt.
5. With the metal support side against the exhaust diaphragm, position the purge valve on the purge piston bolt.

Bendix AD–IP Disassembly, Cleaning, Inspection, and Assembly

6. Holding the purge piston with a large screwdriver, position the purge piston bolt assembly into the purge valve assembly. Tighten the purge piston bolt to 60 to 80 lbf·in (70 to 90 N·cm).
7. Position the two O-rings on the purge valve assembly.

NOTE: Make certain that the purge valve retaining ring is fully seated in its groove.

8. Install the purge valve assembly in the end cover and secure with the purge valve retaining ring.
9. Install the safety valve.

IMPORTANT: Install with the vent hole pointing down. Tighten pipe threaded fittings a minimum of two turns past finger-tight. Position directional fittings in the tightening direction only.

10. Position the O-ring on the check valve body and push it down past the three guide lands until it seats in the O-ring groove.
11. Position the check valve spring on the check valve body so that the small coils of the spring slip over the check valve body.
12. Position the check valve assembly in the end cover so that the O-ring is seated and the check valve spring is visible.
13. Position the perforated plate over the check valve and secure with the check valve retaining ring. Make certain that the check valve retaining ring is fully seated.
14. Install the O-ring on the heated thermostat assembly and gently push the heater and thermostat assembly into the end cover.
15. Install the heater/thermostat assembly retaining ring.
16. Position the O-rings on the cartridge bolt.

NOTE: Make certain that the desiccant cartridge is fully seated and flush on the end cover.

17. Align the locking lugs and position the desiccant cartridge on the end cover.

⚠ CAUTION

Overtightening the cartridge bolt can cause it to shear.

18. Tighten the cartridge bolt to 50 lbf·ft (67 N·m).
19. Install the clamp ring, nut and bolt. Tighten the nut 60 to 190 lbf·in (70 to 110 N·cm).

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, and 6.8 to 9.0 ohms for the 24-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, and 4.8 to 7.2 ohms for the 24-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.

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.
The 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 the 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 cutin or cutout 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 cutin 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.
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."

Troubleshooting

Problem—Water in the Vehicle Reservoirs	
Possible Cause	**Remedy**
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 end 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.
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 cutin and cutout pressures, and excessive leakage in both positions. Repair or replace as needed.
Purge control line is connected to the reservoir or exhaust port of the governor	Connect the purge control line to the unloader port of the governor.
Purge valve is frozen open due to an inoperative heater or thermostat, bad wiring, or a blown fuse	Test the heater and thermostat, following instructions in this manual.
Inlet and outlet air connections are reversed; unable to build system pressure	Reconnect the lines properly.
Discharge line is kinked or blocked	See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits.
There are excessive bends in the discharge line; water is collecting and freezing	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure	
Possible Cause	**Remedy**
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 is not working	See if air reaches the purge valve. If it does, repair the purge valve.
The governor is inoperative	Check the governor for proper cutin and cutout pressures, and excessive leakage in both positions. Repair or replace as needed.
Inlet and outlet air connections are reversed; unable to build system pressure	Reconnect the lines properly.
Discharge line is kinked or blocked	See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits.
There are excessive bends in the discharge line; water is collecting and freezing	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.

Problem—Desiccant is Being Expelled from the Air Dryer Purge Valve Exhaust (May Look Like Whitish Liquid, Paste, or Small Beads); or, Unsatisfactory Desiccant Life

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 is not allowing the air dryer to purge during cold weather	Test the heater and thermostat, following instructions in this manual.

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	
Possible Cause	**Remedy**
Desiccant cartridge not attached properly to the end cover	Check the torque and tighten if necessary. Refer to **Specifications, 400**.

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 the 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. If there is no air line from the governor to the compressor, or the line is restricted, repair or replace as needed.

Specifications

AD–9 Torque Specifications		
Description	**Torque lbf·in (N·cm)**	**Torque lbf·ft (N·m)**
Purge Valve Nut and Bolt	60–80 (678–904)	—
Purge Valve Housing Screws	50–80 (565–904)	—
Desiccant Cartridge *	—	50 (68)
End Cover Nut and Bolts	—	23–32 (31–43)

* Tighten 180 to 225 degrees after the cartridge end cover makes contact with the cartridge O-ring (not to exceed 50 lbf·ft [68 N·m]).

Table 1, AD-9 Torque Specifications

AD–IP Torque Specifications		
Description	**Torque lbf·in (N·cm)**	**Torque lbf·ft (N·m)**
Purge Piston Shoulder Bolt	60–80 (678–904)	—
Desiccant Cartridge Bolt	—	50 (68)

Table 2, AD-IP Torque Specifications

General Information

Each vehicle is equipped with two or more air reservoirs, depending on the number of rear axles. On all vehicles, each reservoir is identified as one of three types: supply, primary, and secondary.

A supply reservoir receives compressed air directly from the compressor. Also referred to as the wet air tank, its functions are to collect most of the water and oil condensate from the air, and to supply air to the primary and secondary 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 air reservoir is the air source for the rear brakes. The front brakes are supplied by the secondary air reservoir. The combined volumes of all supply reservoirs are at least 12 times the combined volumes of all service brake chambers at maximum travel of the diaphragms.

The reservoirs are made from steel or aluminum and each reservoir is internally coated for corrosion resistance. Each reservoir is tested at 300 psi (2068 kPa) hydrostatic pressure.

Some reservoirs are of dual chamber configuration, and include an integral check valve between chambers. Dual chamber reservoirs must have a drain valve in each chamber.

The integral-type check valve used in the dual chamber reservoir is a means of providing a one-way passage of air from one chamber of the reservoir to the other chamber. This is to protect against the loss of the whole air supply in the event of a failure in part of the system.

Service involving welding should never be performed on reservoirs. If a reservoir has been damaged so as to be unfit for use, it should be replaced with a new one.

Safety Precautions

AIR BRAKE SYSTEM WARNINGS

⚠ WARNING

Before attempting to work on the air brake system, certain precautions must be observed. Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized. The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.

When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.

Hoses will whip dangerously if disconnected under pressure.

Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.

As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber push rods and spring actuators which apply automatically with the loss of pressure. This also applies when checking the service brake system.

Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.

Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.

The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.

Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.

To avoid injury, keep clear of the air chamber push rod when brakes are applied or when air is exhausted from the system.

Observe these warnings while investigating all applicable brake system concerns.

Replacement

WARNING

Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Mark all of the air lines, couplers, and valves for later assembly, then disconnect the components.
4. Cap the exposed ports tightly to keep out contaminants. If access is limited, remove the air reservoir components after removal.
5. Remove the air reservoir strap fasteners, then remove the air reservoir. See Fig. 1.

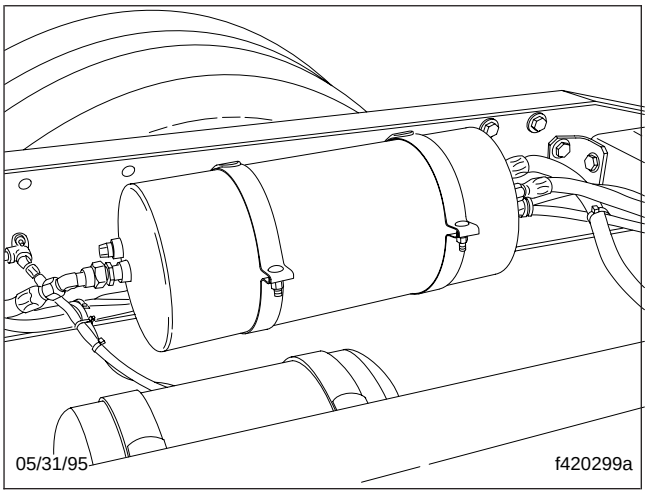


Fig. 1, Frame-Rail-Mounted Air Reservoir with Two-Piece Strap

6. If access is limited, connect the air lines, couplers, and valves first. If not, place a new reservoir in the mount, install the strap fasteners, then connect the components (air lines, couplers, and valves). Tighten the straps 20 to 25 lbf·ft (27 to 34 N·m).
7. Charge the air system and inspect for leaks. Repair as needed.
8. Remove the chocks from the tires.

Wet Air Tank Removal and Installation

Removal

WARNING

Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Drain the air tanks.
3. Disconnect the air lines.
4. Loosen and disconnect the two clamps by removing the nuts.
5. Remove the wet air tank.

Installation

1. Place the wet air tank into the clamps. Support the tank.
2. Connect the clamps by tightening the nuts.
3. Connect the air lines.
4. Charge the air system and inspect for leaks. Repair as needed.
5. Remove the chocks from the tires.

Internal Check Valve Replacement

WARNING

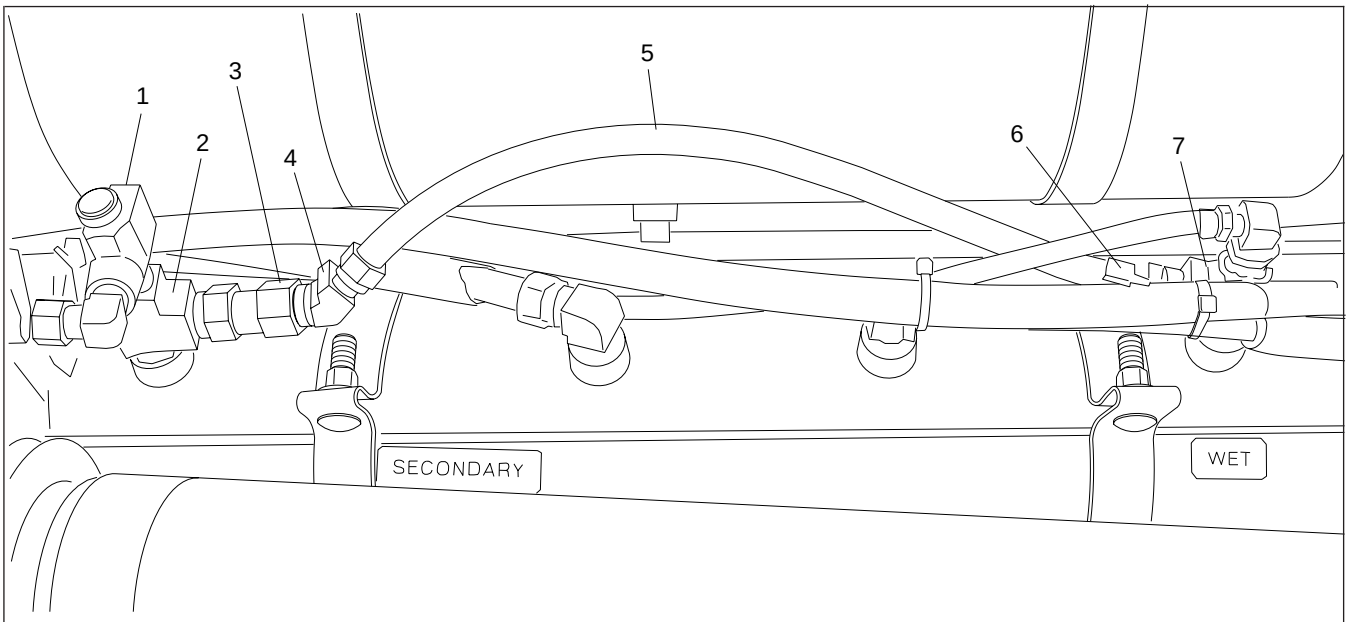
Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

Replacement

Contamination in the two-chamber, wet/secondary, reservoir may cause the inline check valve to become clogged or stuck closed. This can result in insufficient air buildup. Sterling vehicles were built with an internal check valve that is not serviceable. If insufficient air buildup is noted, install an external bypass line. Contact the PDC for the appropriate bypass kit for your vehicle.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain the secondary air reservoir.
3. At the top ports of the reservoir, remove the pressure-protection valve and the 90-degree elbow from the wet reservoir side, and the existing fittings from the secondary side.
4. Install a T-fitting on each side of the reservoir. See **Fig. 1**.
5. On the secondary reservoir side, install the existing plumbing on the top port of the T-fitting. On the side port of the T-fitting, install a check valve, then a 45-degree elbow.
6. On the wet reservoir side, install the existing plumbing onto the top port of the T-fitting. Install a brass fitting on the side port of the T-fitting.
7. Install a 1/2-inch air line between the 45-degree elbow on the secondary side, and the brass fitting on the wet side.
8. Charge the air system and inspect for leaks. Repair as needed.
9. Remove the chocks from the tires.

Internal Check Valve Replacement



1. Pressure-Protection Valve
2. T-Fitting
3. Check Valve
4. 45-Degree Elbow
5. 1/2-Inch Air Line
6. Brass Fitting
7. T-Fitting

Fig. 1, Check Valve Bypass

Safety Precautions

AIR BRAKE SYSTEM WARNINGS

⚠ WARNING

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When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.

Hoses will whip dangerously if disconnected under pressure.

Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.

As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber push rods and spring actuators which apply automatically with the loss of pressure. This also applies when checking the service brake system.

Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.

Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.

The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.

Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.

To avoid injury, keep clear of the air chamber push rod when brakes are applied or when air is exhausted from the system.

Observe these warnings while investigating all applicable brake system concerns.

Removal

CAUTION

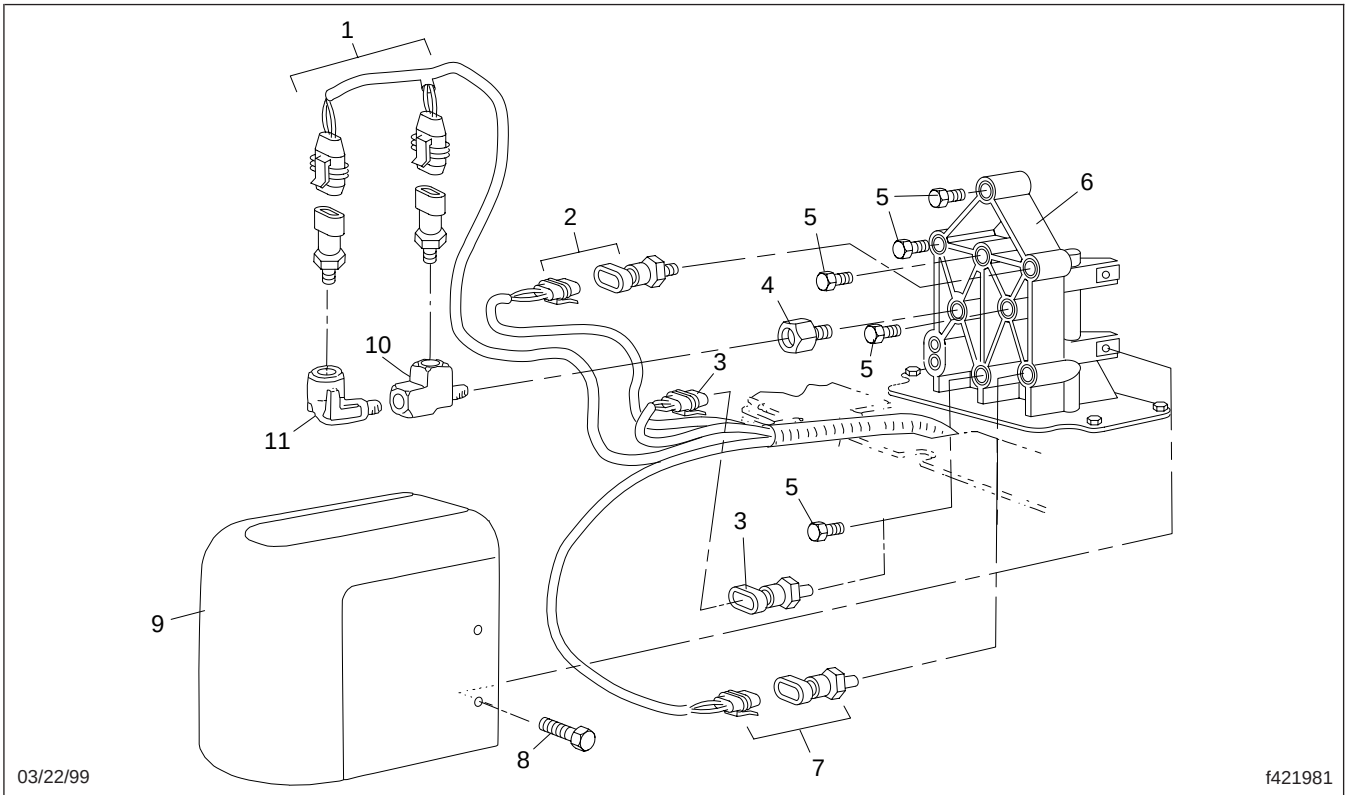
Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Release the system air pressure.
4. Remove the left-side outboard seat belt. For instructions, see **Group 91**.
5. Disconnect the left-side seat from the cab floor and move it forward to access the brake tube manifold. For instructions, see **Group 91**.
6. Remove the brake tube manifold cover retaining screws and remove the cover. See **Fig. 1**.
7. From beneath the cab, mark and disconnect the air lines. See **Fig. 2**.
8. Mark and disconnect the brake tube manifold electrical connectors. See **Fig. 1**.
9. Fold back the cab floor covering to access the brake tube manifold retaining bolts.
10. Remove the retaining bolts, then remove the brake tube manifold.

Installation

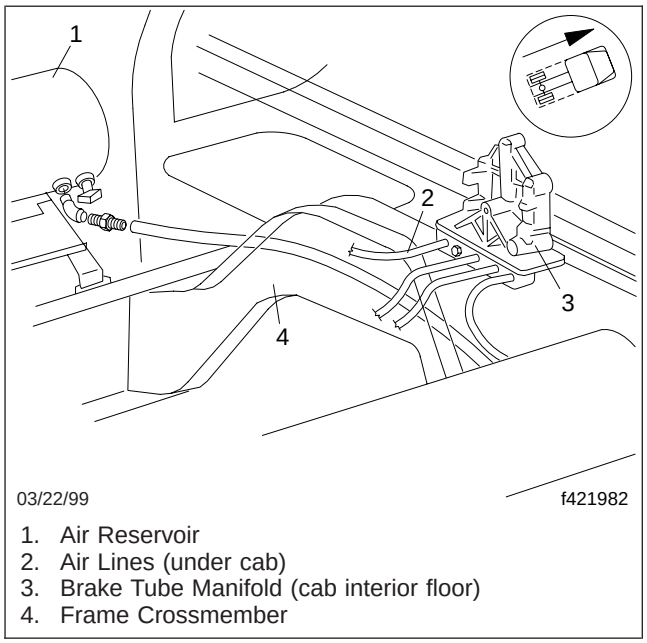
1. Position the brake tube manifold in the cab.
2. Install the retaining bolts. Tighten the bolts 5 to 7 lbf·ft (7 to 9 N·m).
3. From beneath the cab connect the air lines. See **Fig. 2**.
4. Connect the brake tube manifold electrical connectors. See **Fig. 1**.
5. Install the brake tube manifold cover and the four retaining screws. See **Fig. 1**.
6. Replace the cab floor covering to its original location.
7. Install the left-side seat. For instructions, see **Group 91**.
8. Install the left-side outboard seat belt. For instructions, see **Group 91**.
9. Connect the batteries.
10. Remove the chocks from the tires.

Removal and Installation



1. Low Air Pressure Detection Switches and Connectors
2. Cruise Control Brake Dropout Switch and Connector
3. Parking Brake Switch and Connector (DDEC only)
4. Brass Pipe Adaptor
5. Brass Plug
6. Brake Tube Manifold
7. Stop Lamp Switch and Connector
8. Cover Retaining Screw (4 Qty.)
9. Cover
10. T-Fitting
11. Elbow Fitting

Fig. 1, Brake Tube Manifold and Components



1. Air Reservoir
2. Air Lines (under cab)
3. Brake Tube Manifold (cab interior floor)
4. Frame Crossmember

Fig. 2, Brake Tube Manifold and Plumbing Location

Safety Precautions

AIR BRAKE SYSTEM WARNINGS

⚠ WARNING

Before attempting to work on the air brake system, certain precautions must be observed. Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized. The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.

When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.

Hoses will whip dangerously if disconnected under pressure.

Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.

As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber push rods and spring actuators which apply automatically with the loss of pressure. This also applies when checking the service brake system.

Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.

Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.

The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.

Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.

To avoid injury, keep clear of the air chamber push rod when brakes are applied or when air is exhausted from the system.

Observe these warnings while investigating all applicable brake system concerns.

⚠ CAUTION

Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Drain the air tanks.
3. Tilt the hood.
4. Remove the ziptie holding the air lines together.

NOTE: To disconnect the air lines, push the hose in; push the retaining ring in and pull out the hose in a swift motion.

5. Mark and disconnect the air lines.
6. Loosen and remove the three bolts on the treadle valve and assembly. See **Fig. 1**.

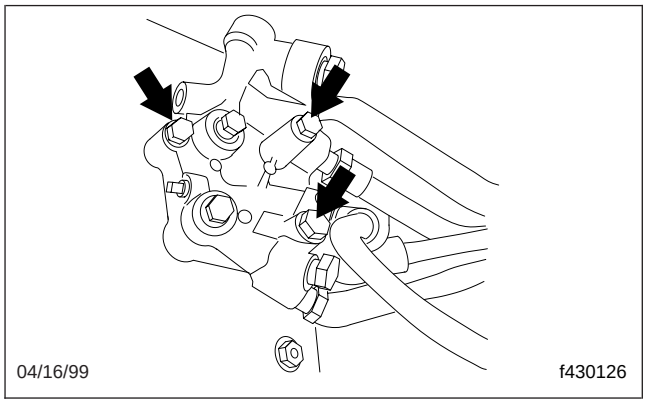


Fig. 1, Brake Control Treadle Valve and Assembly Bolts

7. Remove the treadle valve and assembly.

Installation

1. Remove the under steering panel from inside of the cab by removing the five screws.

NOTE: This is a two-person operation.

2. Install the treadle valve and assembly.

2.1 With one person holding the three brake control treadle valve and assembly bolts in place and the other, from inside of the cab, aligning the foot brake control assembly onto the bolts, install the foot brake control assembly. See **Fig. 2**.

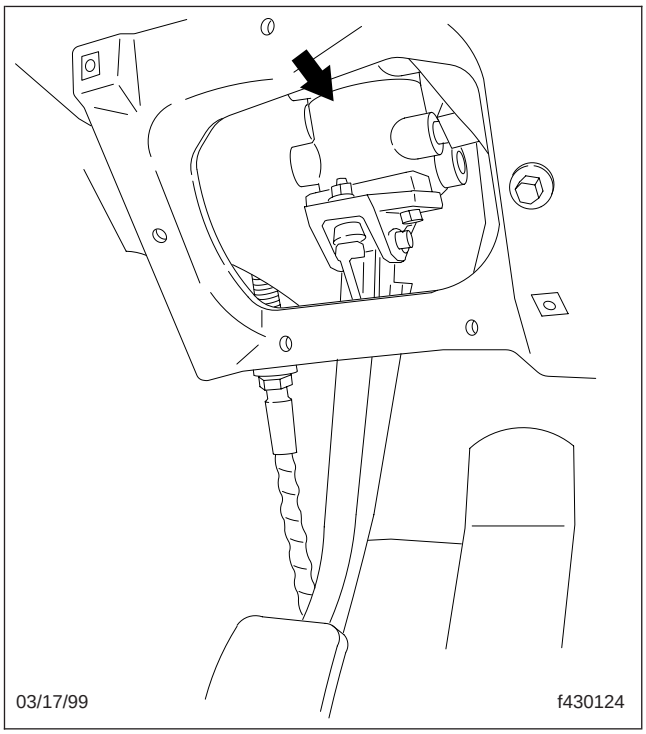


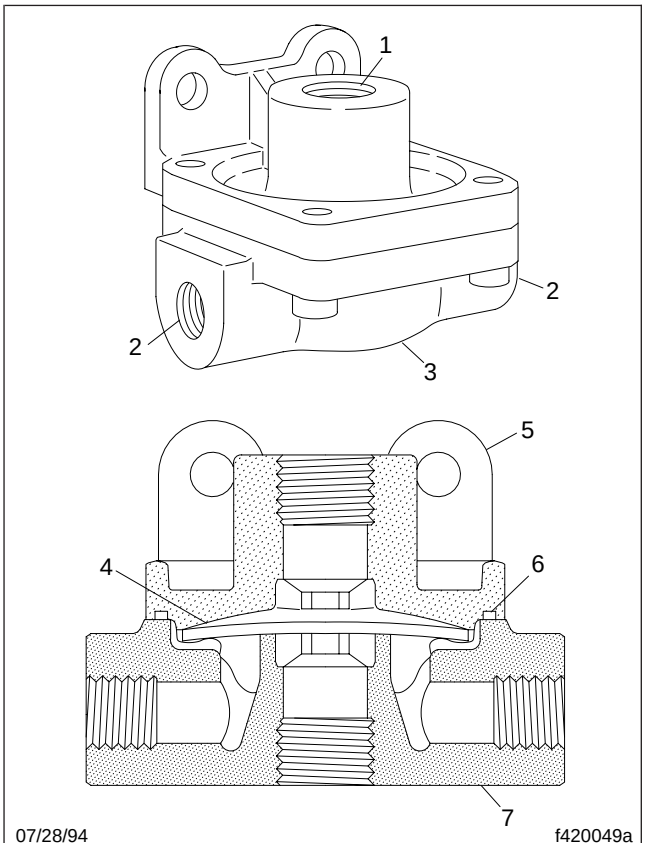
Fig. 2, Foot Brake Control Valve

2.2 Tighten the bolts.

3. Install the under steering panel. Tighten the five capscrews.
4. Connect the air lines.
5. Replace the ziptie.
6. Close the hood.
7. Remove the chocks from the tires.

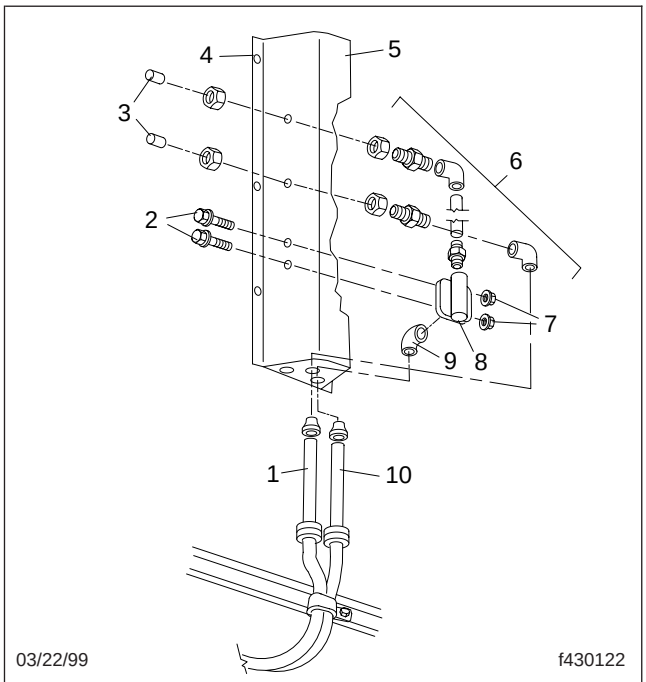
General Information

The function of the QR–1 quick release valve is to speed up the release of air pressure from the brake chambers. If the front brake chambers are equipped with a QR–1 valve and a foot brake application is released, the exhaust port of the quick release valve opens and air from the front brake chambers is exhausted through the quick release valve. See **Fig. 1**. This accelerates the release of the front brakes. When a vehicle is equipped with a tractor protection valve, a quick release valve is fitted on the rear of the cab. See **Fig. 2**. A delivery line from the tractor protection valve is connected to the port on top of the quick release valve; the two side ports are for trailer glad hand connections.



1. Brake Valve Port
2. Brake Chamber Port
3. Exhaust Port
4. Diaphragm
5. Cover
6. O-Ring
7. Valve Body

Fig. 1, QR-1 Quick Release Valve

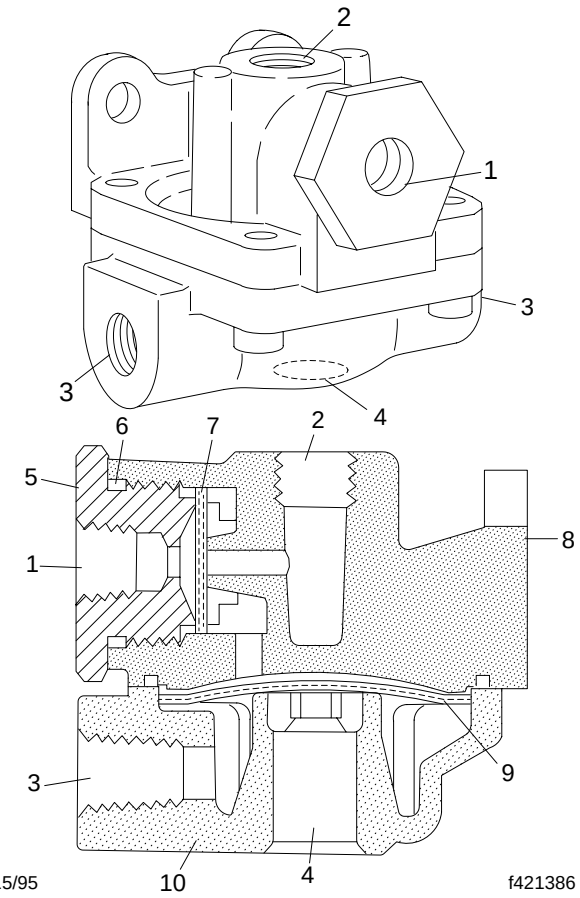


1. Supply Air Line
2. Hexbolts
3. Protective Caps
4. Cover Stud Holes (6 qty.)
5. Cover
6. Plumbing
7. Locknuts
8. Quick Release Valve
9. Elbow
10. Control Air Line

Fig. 2, Back-of-Cab-Mounted Quick Release Valve and Cover

The QR–1C quick release valve is a dual function valve. See **Fig. 3**. Its primary function is to speed up the release of air pressure from the service brake chambers. Additionally, the valve works as an anti-compound device. The double check valve feature prevents a service and parking brake application from occurring at the same time.

General Information



1. Supply Port
2. Balance Port
3. Delivery Port
4. Exhaust
5. Cap Nut
6. Sealing Ring
7. Double Check Diaphragm
8. Body
9. Quick Release Diaphragm
10. Cover

Fig. 3, QR-1C Quick Release Valve

Safety Precautions

AIR BRAKE SYSTEM WARNINGS

⚠ WARNING

Before attempting to work on the air brake system, certain precautions must be observed. Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized.

When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.

Hoses will whip dangerously if disconnected under pressure.

Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.

As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber push rods and spring actuators which apply automatically with the loss of pressure. This also applies when checking the service brake system.

Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.

Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.

The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.

Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.

To avoid injury, keep clear of the air chamber push rod when brakes are applied or when air is exhausted from the system.

The wheels must be chocked to prevent vehicle movement while servicing any component in the brake system.

Observe these warnings while investigating all applicable brake system concerns.

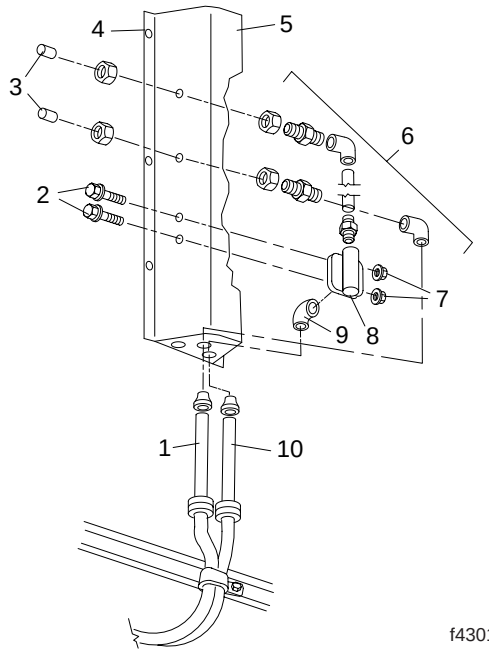
Quick Release Valve Removal and Installation

Removal

CAUTION

Before working on or around air brake systems and components, see "Safety Precautions" in Subject 100.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Drain the air system.
3. If equipped, remove the cover stud nuts and remove the cover. See **Fig. 1**.



1. Supply Air Line
2. Hexbolts
3. Protective Caps
4. Cover Stud Holes (6 qty.)
5. Cover
6. Plumbing
7. Locknuts
8. Quick Release Valve
9. Elbow
10. Control Air Line

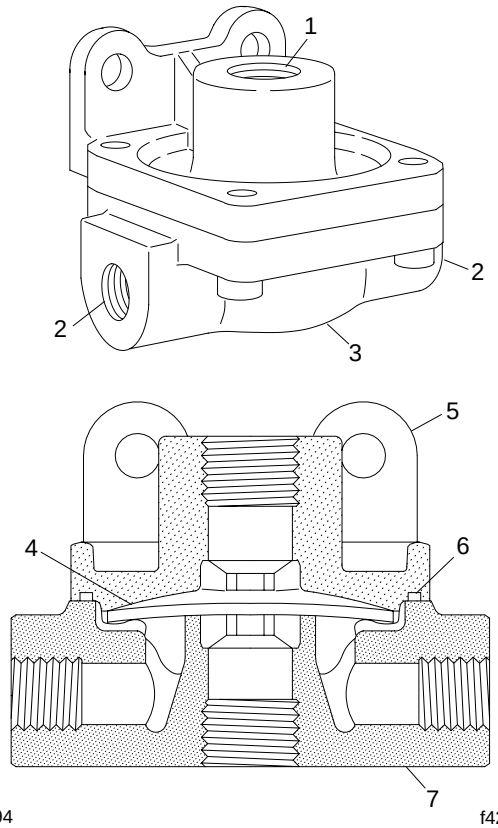
Fig. 1, Trailer Air and Electrical Connections Cover and Components

4. If equipped, disconnect the trailer electrical supply socket. For instructions, see **Section 54.13**.
5. Mark and disconnect the air lines to the quick release valve.
6. Remove the valve mounting fasteners and remove the valve.

Installation

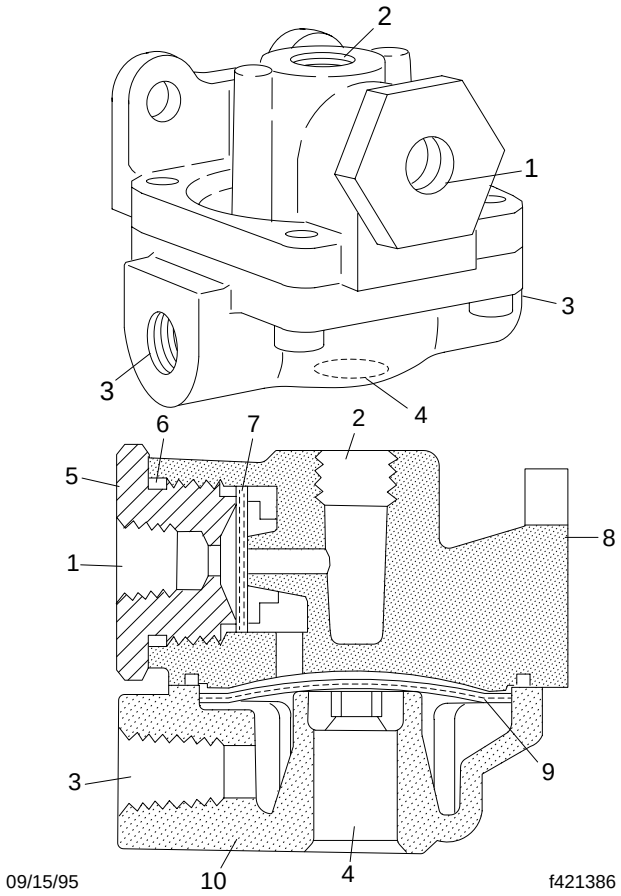
1. Position the valve with the exhaust port facing down. Install and securely tighten the mounting fasteners.
2. Connect the air lines to the valve.
3. If equipped, install the trailer electrical supply socket. For instructions, see **Section 54.13** in this manual.
4. If equipped, position the cover and install cover stud nuts. See **Fig. 1**.
5. Perform the operation and leakage test in **Subject 120**.

Test (See Fig. 1 and Fig. 2)



1. Brake Valve Port
2. Brake Chamber Port
3. Exhaust Port
4. Diaphragm
5. Cover
6. O-Ring
7. Valve Body

Fig. 1, QR-1 Quick Release Valve



1. Supply Port
2. Balance Port
3. Delivery Port
4. Exhaust Port
5. Cap Nut
6. Sealing Ring
7. Double Check Diaphragm
8. Body
9. Quick Release Diaphragm
10. Cover

Fig. 2, QR-1C Quick Release Valve

CAUTION

Before working on or around air brake systems and components, see "Safety Precautions" in Subject 100.

The following test should be performed after repairing or replacing the quick release valve to ensure that it is functioning properly.

1. Chock the tires.
2. Apply the parking brakes.
3. Drain the air system.
4. Remove the air line from the valve balance port. Build system air pressure to 120 psi (827 kPa). Release the parking brakes. Coat the exhaust and balance ports with a soap solution; leakage of a 1-inch (2.5 cm) bubble in 5 seconds at either port is allowable. Install the air line at the balance port.

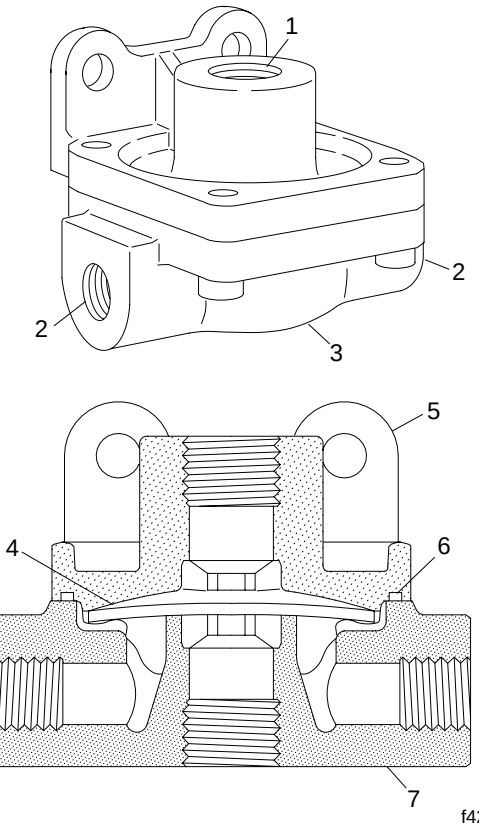
Quick Release Valve Operation and Leakage Test

5. Apply the parking brakes. Step on the foot brake; the quick release valve should exhaust air at the exhaust port.
6. Drain the air system.
7. Remove the air line from the valve supply port. Build system air pressure to 120 psi (827 kPa). With the foot valve depressed, coat the supply port and the seam between the body and cover with a soap solution; leakage of a 1-inch (2.5 cm) bubble in 5 seconds at the supply port is allowable. No leakage between the body and cover is permitted. Install the air line at the supply port.
8. If the valve does not function properly, or if leakage is excessive, repair or replace it following the instructions in this section.
9. Apply the parking brakes.
10. Remove the chocks from the tires.

QR–1 Disassembly, Cleaning and Inspection, and Assembly

Disassembly

1. Remove the quick release valve from the vehicle following the instructions in **Subject 110**.
2. Remove the four screws holding the valve cover on the valve body. See **Fig. 1**.



1. Brake Valve Port
2. Brake Chamber Port
3. Exhaust Port
4. Diaphragm
5. Cover
6. O-Ring
7. Valve Body

Fig. 1, QR-1 Quick Release Valve

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. See **Fig. 1**.

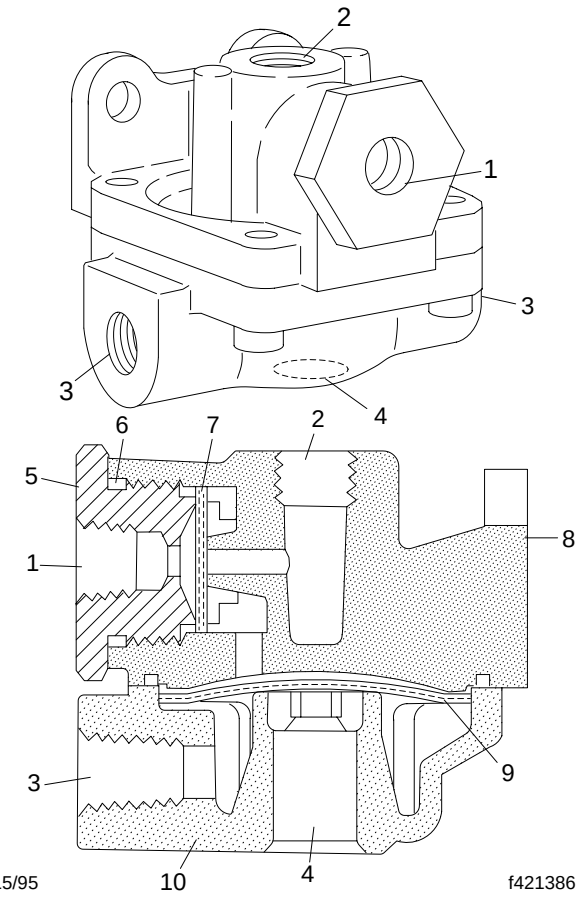
   If the quick release valve is equipped with a spring, position the spring in the valve body. Position the diaphragm over the spring seat.
2. Install the O-ring in the valve cover groove and install the valve cover. Tighten the screws 30 to 60 lbf·in (340 to 680 N·cm) evenly and securely.
3. Install the quick release valve, following the instructions in **Subject 110**.
4. Perform the operation and leakage test as instructed in **Subject 120**.

QR–1C Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)

CAUTION

Before working on or around air brake systems and components, see "Safety Precautions" in Subject 100.



1. Supply Port
2. Balance Port
3. Delivery Port
4. Exhaust Port
5. Cap Nut
6. Sealing Ring
7. Double Check Diaphragm
8. Body
9. Quick Release Diaphragm
10. Cover

Fig. 1, QR-1C Quick Release Valve

1. Remove the quick release valve from the vehicle following the instructions in Subject 110.
2. Mark the valve body and cover for ease of installation.
3. Remove the cap nut at the supply port. Remove the sealing ring from the cap nut.
4. Remove the double check diaphragm.
5. Remove the four screws holding the valve cover on the valve body.
6. Separate the cover from the body and remove the sealing ring and the quick release diaphragm.

Cleaning and Inspection

1. Clean all metal parts in mineral spirits. Wipe all rubber parts clean.
2. It is recommended that all rubber parts and any other part showing signs of wear or deterioration be replaced with genuine Bendix parts.

Assembly

1. Install the sealing ring on the cap nut.
2. Install the double check diaphragm in the valve body.
3. Install the cap nut. Tighten 12 to 33 lbf·ft (17 to 45 N·m).
4. Install the quick release diaphragm in the cover.
5. Install the valve cover on the body. Tighten the screws 30 to 60 lbf·in (340 to 680 N·cm) evenly and securely.
6. Install the quick release valve as instructed in Subject 110.
7. Perform the operation and leakage test as instructed in Subject 120.

Specifications

Torque Specifications		
Description	**Torque lbf·in (N·cm)**	**Torque lbf·ft (N·m)**
Cover Capscrews	30–60 (340–675)	—
Quick Release Valve Mounting Capscrews	—	11–15 (15–20)

Table 1, Torque Specifications

General Information (See Fig. 1)

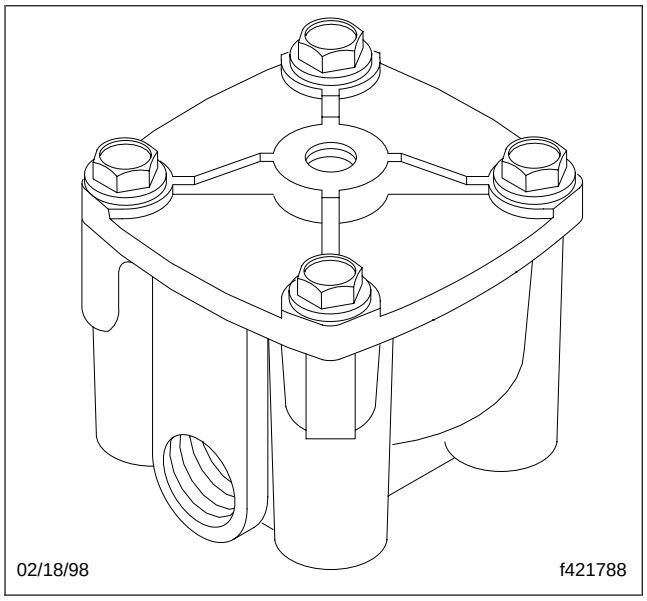


Fig. 1, R–12 Valve

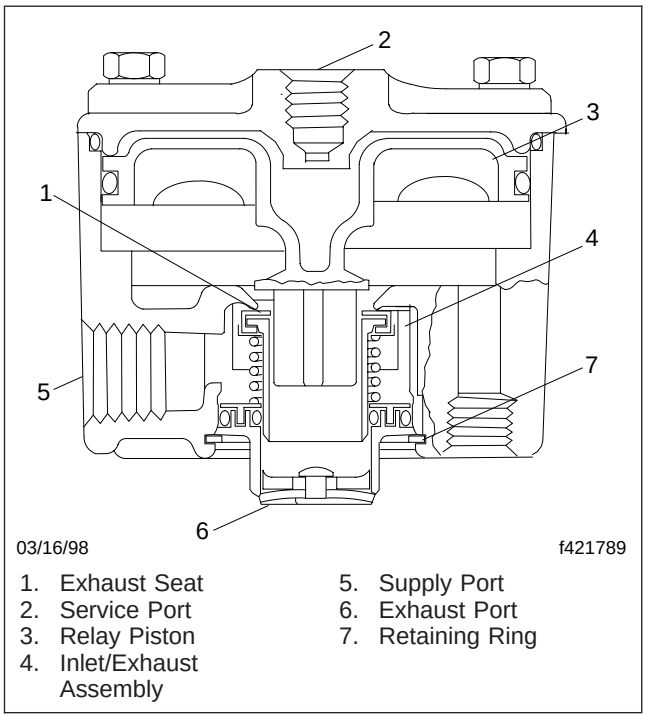
The relay valve is a control relay station in the air brake system used to speed the application and release of the brakes. Mounted at the rear of the vehicle, it is operated by remote control and gives about the same amount of air pressure to the brake chambers as it receives from the service brake foot valve or other source. The valve is piston operated and has an insert-type inlet and exhaust valve that is serviceable.

Application (See Fig. 2)

Air pressure delivered to the service port enters the small cavity above the piston and moves the piston down. The exhaust seat moves down with the piston and seats on the inner or exhaust portion of the inlet/exhaust valve, sealing off the exhaust passage. At the same time, the outer or inlet portion of the inlet/exhaust valve moves off its seat, permitting supply air to flow from the reservoir, past the open inlet valve and into the brake chambers.

Balance (See Fig. 2)

The air pressure being delivered by the open inlet valve also is effective on the bottom area of the relay piston. When air pressure beneath the piston equals



1. Exhaust Seat
2. Service Port
3. Relay Piston
4. Inlet/Exhaust Assembly
5. Supply Port
6. Exhaust Port
7. Retaining Ring

Fig. 2, R-12 Valve (sectional view)

the service air pressure above, the piston lifts slightly and the inlet spring returns the inlet valve to its closed position. The exhaust remains closed as the service line pressure balances the delivery pressure. As delivered air pressure is changed, the valve reacts to the change, holding the brake application at the level.

Exhaust or Release (See Fig. 2)

When air pressure is released from the service port and air pressure in the cavity above the relay piston is exhausted, air pressure beneath the piston lifts the relay piston and the exhaust seat moves away from the exhaust valve, opening the exhaust passage. With the exhaust passage open, the air pressure in the brake chambers is then permitted to exhaust through the exhaust port, releasing the brakes.

Safety Precautions

AIR BRAKE SYSTEM WARNINGS

⚠ WARNING

Before attempting to work on the air brake system, certain precautions must be observed. Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized.

When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.

Hoses will whip dangerously if disconnected under pressure.

Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.

As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber push rods and spring actuators which apply automatically with the loss of pressure. This also applies when checking the service brake system.

Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.

Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.

The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.

Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.

To avoid injury, keep clear of the air chamber push rod when brakes are applied or when air is exhausted from the system.

The wheels must be chocked to prevent vehicle movement while servicing any component in the brake system.

Observe these warnings while investigating all applicable brake system concerns.

Removal

CAUTION

Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Remove all air hoses from the valve. Cap the hoses and mark them for reassembly.
4. Remove the relay valve mounting bolts.
5. Remove the valve.

Installation

1. Attach the valve to the vehicle, using the bolts, washers, and nuts. Tighten the nuts 11 to 15 lbf·ft (15 to 20 N·m).
2. Remove the caps from the air lines and connect the air lines to the valve.
   - 2.1 For nylon tubing, connect the air line fittings to the valve ports, and tighten the nuts finger-tight. Using a wrench, tighten the nuts at least two turns, or until one thread shows on the fittings.
   - 2.2 For wire braid hoses, connect the hose fittings to the valve ports, and hand-tighten the nuts. Using a wrench, tighten the nuts until resistance is felt. Tighten one-sixth turn more. Do not overtighten.
3. Close the air reservoir drain cocks. Start the engine to pressurize the air system.
4. Test the valve following the instructions in **Subject 120**.
5. Remove the chocks from the tires.

⚠ CAUTION

Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

Operation Test

1. Start the vehicle and build the brake system to cut-out pressure, about 130 psi (827 kPa).
2. Using a soap-and-water solution, check all air line fittings on the valve for leakage. If the fittings or air lines are leaking, replace the fittings.
3. Make several service brake applications and check for prompt application and release of the brakes.
4. If brake response is slow, troubleshoot the brake system. For instructions, see **Section 42.01**. If the valve is malfunctioning, repair or replace it.

Leakage Test

1. Start the vehicle and build the brake system to cut-out pressure, about 130 psi (827 kPa).
2. Using a soap-and-water solution, check for inlet valve and O-ring leakage.
   - 2.1 Make this check with the service brakes released when the R–12 or R–14 is used to control the service brakes.
   - 2.2 Make the check with the spring brakes (parking brakes) applied when the R–14 is used to control the spring brakes.
3. While holding a full service brake application, apply a soap-and-water solution to the exhaust port. Leakage at the exhaust port should not exceed a 1-inch (2.5-cm) bubble in 3 seconds.

NOTE: If the anti-compound feature is in use, the line attached to the balance port must be disconnected to perform this test.

4. Coat the outside of the valve where the cover joins the body to check for O-ring leakage; no leakage is permitted.
5. If the R–14 relay valve is used to control the spring brakes, release the parking brake, apply a soap solution to the balance port. Leakage at the balance port should not exceed a 1-inch (2.5-cm) bubble in 3 seconds.

IMPORTANT: If the valves do not function as described in the above test, or if leakage is excessive, replace it. For instructions, see **Subject 110**.

Disassembly, Cleaning and Inspection, and Assembly

Disassembly

CAUTION

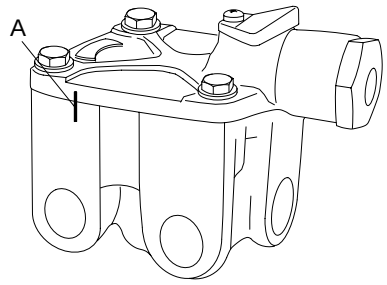
Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

1. Remove the valve from the vehicle. For instructions, see **Subject 110**.

NOTE: Prior to disassembly, draw an alignment mark across the valve cover and body, for reassembly alignment. See **Fig. 1**.

2. Disassemble the valve.

   2.1 Referring to **Fig. 2**, remove the four cover capscrews and integral lockwashers.



A. Mark the valve housing for reassembly alignment.

Fig. 1, R-14 Valve Marked for Reassembly

   2.2 Remove the valve cover and O-ring.

   2.3 Remove the relay piston, and the O-ring.

   2.4 While depressing the exhaust cover, remove the retainer ring; slowly remove the exhaust cover and the valve spring. Remove the O-rings from the exhaust cover.

   2.5 Remove the inlet/exhaust valve. Remove the valve retainer from the inlet/exhaust valve.

3. On the R–14 valves, remove the Phillips-head screw and the exhaust cover. Then, remove the service port cap nut, the O-ring, and the diaphragm located inside the service port.

Cleaning and Inspection

WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

1. Wash all metal parts of the valve in cleaning solvent. Dry the metal parts of the disassembled valve with compressed air.
2. Wipe all rubber parts clean with a clean cloth. Examine all rubber parts for cracks, tears, or other deterioration. If any rubber parts are worn, cracked, torn or otherwise damaged, replace them with new parts.
3. Examine all metal parts for wear, cracks, or other damage. If any metal parts are worn, cracked or otherwise damaged, replace them with new parts.
4. Check the springs for distortion and corrosion. If the springs are distorted or corroded, replace them.
5. Inspect the exhaust seat of the quick release diaphragm in the R–14 cover and make sure all internal air passages in the area are open and clean and free of nicks and scratches.

Assembly

1. Lubricate the O-rings and all sliding parts with Dow Corning 55-M pneumatic grease or equivalent. Assemble the valve. Refer to **Fig. 2**.

   1.1 Install the O-ring on the relay piston.

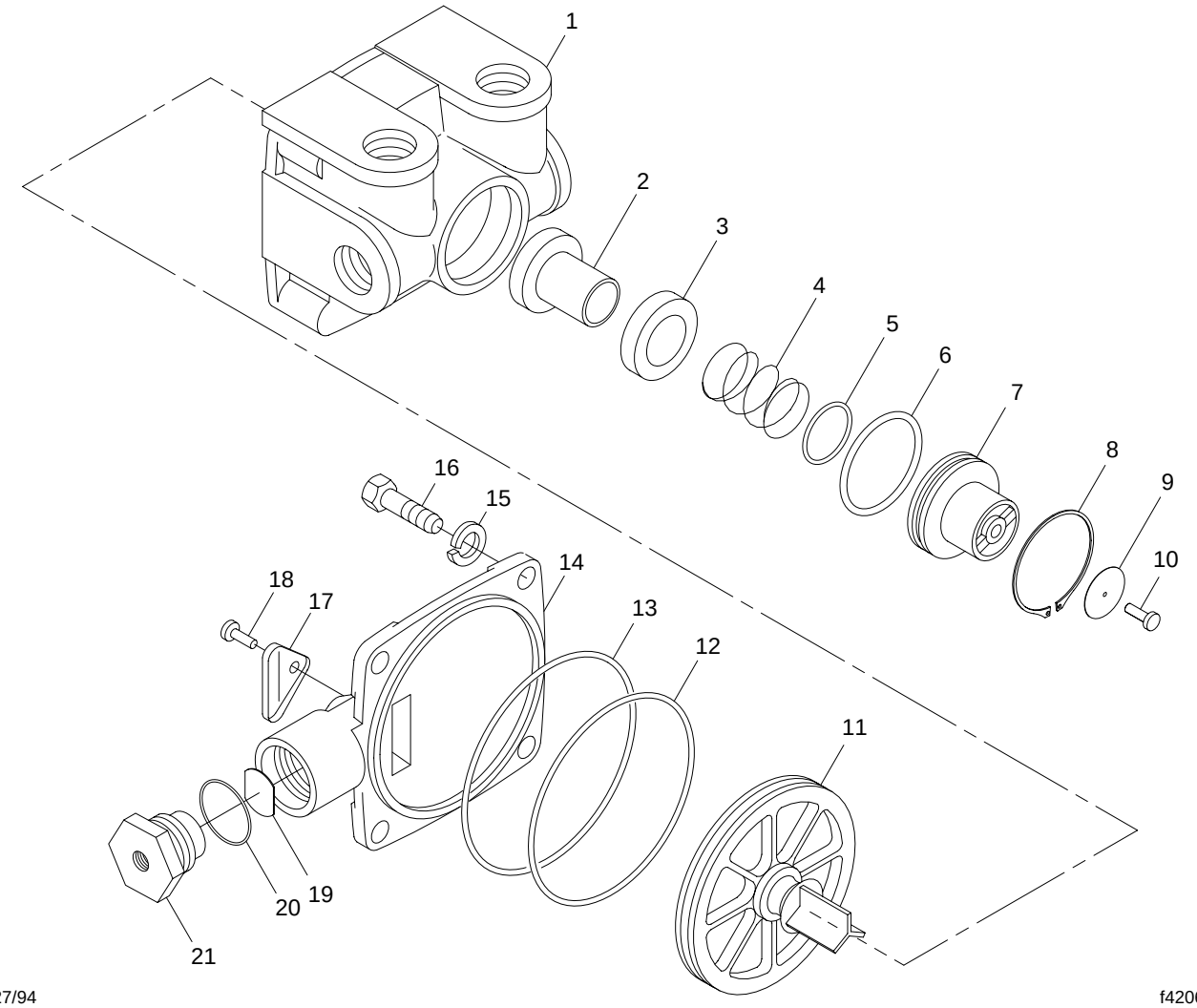
   1.2 Install the inner and outer O-rings on the exhaust cover.

   1.3 Install the O-ring on the valve cover.

   1.4 Install the relay piston in the body, taking care not to damage the piston O-ring.

   1.5 Noting the reference mark made during disassembly, secure the valve cover with four capscrews and lockwashers. Torque the capscrews 7 to 10 lbf·ft (9 to 14 N·m).

Disassembly, Cleaning and Inspection, and Assembly



1. Body
2. Inlet/Exhaust Valve
3. Valve Retainer
4. Valve Spring
5. O-Ring
6. O-Ring
7. Exhaust Cover
8. Retainer Ring
9. Diaphragm
10. Rivet
11. Relay Piston
12. O-Ring
13. O-Ring
14. Valve Cover
15. Lockwasher (4 qty.)
16. Capscrew (4 qty.)
17. Exhaust Cover
18. Phillips Screw, No.10–24
19. Diaphragm
20. O-Ring
21. Cap Nut

Fig. 2, R-14 Relay Valve

1.6 Install the valve retainer and spring on the inlet/exhaust valve assembly. Install the inlet/exhaust valve assembly in the body.

1.7 Install the exhaust cover. While depressing the exhaust cover, install the retaining ring, making sure the retaining ring is completely seated in the groove.

1.8 On R–14 valves, place the diaphragm in the service port making sure it is positioned between the guide ribs. Install the

service port cap nut and O-ring and tighten to 13 lbf·ft (17 N·m).

1.9 Position the exhaust cover, then install the Phillips-head screw. Tighten the screw 25 lbf·in (280 N·cm).

2. Install the relay valve on the vehicle following the instructions in **Subject 110**.

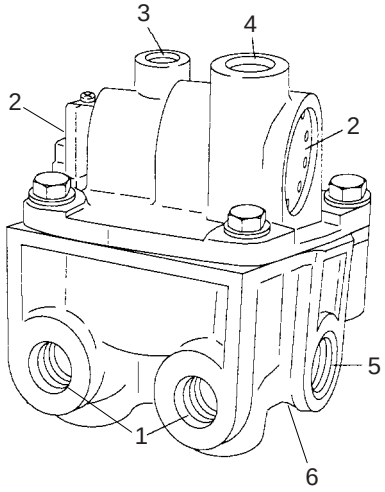
3. Test the valve following the instructions in **Subject 120**.

Specifications

Torque Specifications		
Description	**lbf·in (N·cm)**	**lbf·ft (N·m)**
Valve Cover Capscrews	–	7–10 (9–14)
Valve Mounting Capscrews	–	11–15 (15–20)
Service Port Cap Nut	–	13 (17)
Phillips Screw, No. 10–24	25 (280)	–

Table 1, Torque Specifications

General Information (See Fig. 1)



1. Delivery
2. Exhaust
3. Control
4. Service
5. Supply
6. Exhaust

Fig. 1, BP–R1 Bobtail Proportioning Valve Port Locations

During tractor-trailer operation, the trailer supply valve knob is pushed in to deliver compressed air to the trailer and the bobtail proportioning valve control port.

Upon brake application, air pressure supplied to the control port holds the blend-back piston against the valve cover, and the initial delivery spring forces the proportioning piston to seat in the valve body. This opens the inlet valve, closes the exhaust valve, and allows air pressure to enter the supply port and flow to the front brake chambers. Air pressure delivered to the front brake chambers is also present beneath the proportioning piston. Since the area on the delivery side (brake chamber side) of the proportioning piston is larger than the area on the supply side (brake foot valve side), the delivery side needs less air pressure to apply the same force. After initial brake application, the bobtail proportioning valve delivers less air pressure to the front brake chambers than it receives from the brake foot valve.

During bobtail operation, the trailer supply valve knob is pulled out. Air in the valve flows back to the trailer supply valve and is exhausted to atmosphere. With no pressure at the valve control port, the blendback piston contacts the proportioning piston. The inlet/exhaust valve is held by its spring and seals the exhaust passage. In this position, the bobtail proportioning valve delivers full service brake air pressure to the front brake chambers. When the brakes are released, delivery air pressure flows back through the valve and exhausts at the foot valve. Air from the front brake chambers exhausts through the quick release valve.

Safety Precautions

AIR BRAKE SYSTEM WARNINGS

⚠ WARNING

Before attempting to work on the air brake system, certain precautions must be observed. Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized.

When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.

Hoses will whip dangerously if disconnected under pressure.

Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.

As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber push rods and spring actuators which apply automatically with the loss of pressure. This also applies when checking the service brake system.

Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.

Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.

The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.

Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.

To avoid injury, keep clear of the air chamber push rod when brakes are applied or when air is exhausted from the system.

The wheels must be chocked to prevent vehicle movement while servicing any component in the brake system.

Observe these warnings while investigating all applicable brake system concerns.

Removal

CAUTION

Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Disconnect the air lines from the valve. Cap the lines and mark them for reassembly.
4. Remove the valve mounting bolts.
5. Remove the valve.

Installation

1. Attach the valve to the vehicle, using the bolts, washers, and nuts. Tighten the nuts 11 to 15 lbf·ft (15 to 20 N·m).
2. Remove the caps from the air lines and connect the air lines to the valve.
   - 2.1 For nylon tubing, connect the air line fittings to the valve ports, and finger-tighten the nuts. Using a wrench, tighten the nuts at least two turns, or until one thread shows on the fittings.
   - 2.2 For wire braid hoses, connect the hose fittings to the valve ports, and finger-tighten the nuts. Using a wrench, tighten the nuts until resistance is felt. Tighten one-sixth turn more. Do not overtighten.
3. Close the air reservoir drain cocks. Start the vehicle engine to pressurize the air system.
4. Check for leaks and proper valve function. For instructions, see Subject 120.
5. Remove the chocks from the tires.

Operation Test

1. Park the vehicle on a level surface and chock the tires.
2. Before testing the air brake proportioning system, do the following.
   - 2.1 Check the operation of the air compressor. For instructions, see **Group 13**.
   - 2.2 Check the pressure levels of the air reservoirs.
   - 2.3 Check the operation of the brake chambers. For instructions, see **Section 42.07**.
   - 2.4 Inspect all hoses and tubing for kinks, dents, and other damage. Replace damaged tubing. For instructions, see **Section 42.06**.
   - 2.5 Inspect all air line fittings. Tighten loose connections; replace fittings that are damaged. For instructions, see **Section 42.06**.
3. Drain all air tanks.
4. Install a tee at the service port and at one of the delivery ports, then install an air pressure gauge in each.
5. Connect the tractor service and emergency gladhands to hose couplings that have been plugged or connect them to a trailer. Build the tractor system air pressure to the governor cut-out point.
6. With the dashboard trailer supply valve and system park control valve activated for tractor/trailer operation, apply, hold, and then release the brakes several times, varying the application pressures while watching the reaction of the gauges installed on the valve ports. Note that a prompt application occurs and that it can be held, then promptly released.
7. Check the proportioning valve differential pressure by applying 10 psi (69 kPa) to the service port and noting the pressure registered at the delivery port. Subtract delivery port pressure from the 10 psi (69 kPa) service pressure to obtain the differential.

NOTE: For valves without a relay piston spring (**Fig. 1**), the measured differential should be about 4 psi (28 kPa). When a relay piston spring is used, the differential will be higher.

8. Make and hold a full brake application of 100 psi (689 kPa) or greater, and note that full pressure is delivered to the chambers.
9. Activate the dash-mounted trailer supply valve for bobtail tractor operation. Make a slow brake application and watch the gauges installed previously. Both gauge readings should rise until the delivery pressure is 5 to 10 psi (34 to 69 kPa). Then the service supply pressure should continue rising while delivery pressure remains constant. Hold the brake application at 20 psi (138 kPa) and check that the delivery pressure is 5 to 10 psi (34 to 69 kPa). Release the application.
10. Make another brake application and slowly increase the pressure at the bobtail proportioning valve service port to between 60 to 70 psi (414 to 483 kPa) while observing the gauge installed at the delivery port. Note that when service port pressure rises between 20 and 30 psi (138 to 207 kPa), delivery pressure begins to rise above the initial pressure noted in the previous step. The rise of delivery pressure should be at a proportioned rate of about three-to-one. At 70 psi (483 kPa) service pressure, delivered pressure should be 15 to 25 psi (103 to 172 kPa).
11. Make a full brake application, and note that both test gauges register the same pressure.
12. Remove the test gauges from the valve ports.
13. Remove the chocks from the tires. Test drive the vehicle (without a trailer) in a safe area at slow speed with the trailer supply valve pulled out (bobtail position). Make several brake applications to become familiar with the feel of the system before returning the vehicle back to service.

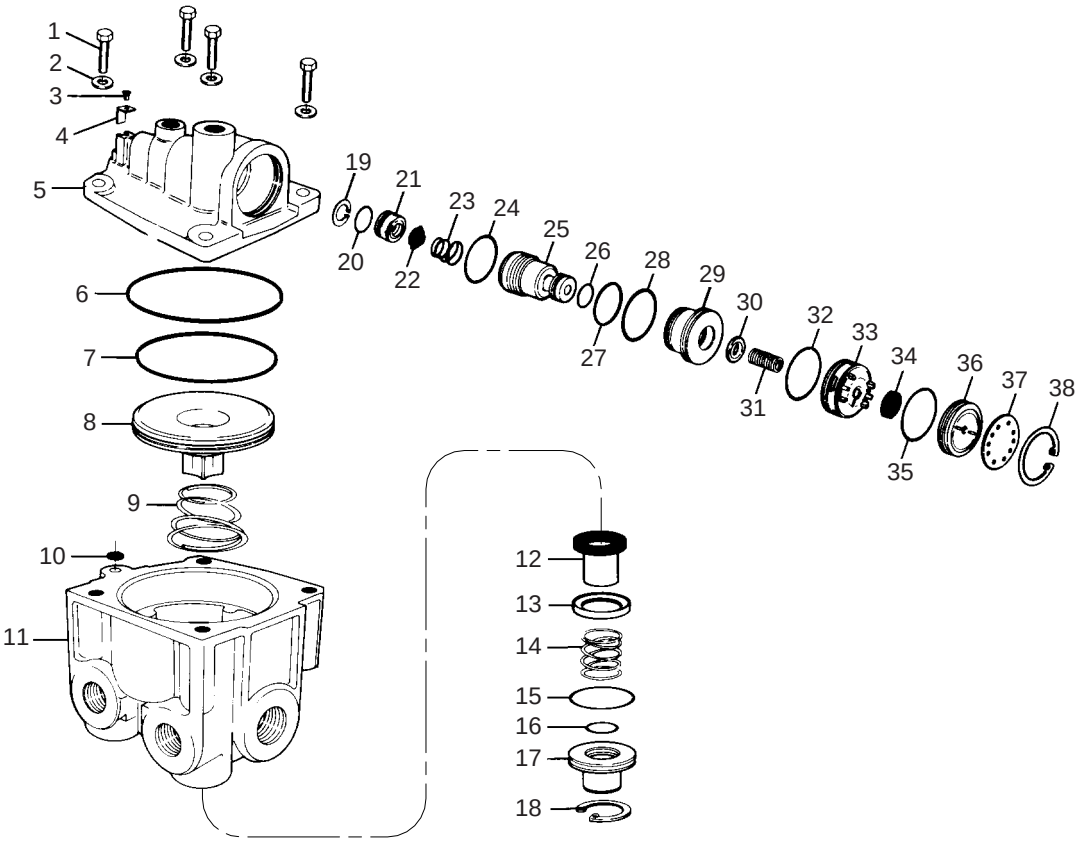
Leakage Tests

CAUTION

Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

NOTE: The following checks should be made with two test gauges or two gauges known to be accurate.

Operation and Leakage Tests



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1. Capscrew
2. Washer
3. Exhaust Cover Screw
4. Exhaust Cover
5. Cover
6. O-Ring
7. O-Ring
8. Relay Piston
9. Relay Piston Spring
10. Sealing Ring
11. Body
12. Valve Assembly
13. Valve Retainer
14. Valve Spring
15. O-Ring
16. O-Ring
17. Exhaust Cover
18. Retaining Ring
19. Retaining Ring
20. O-Ring
21. Inlet Valve Seat
22. Inlet Valve
23. Valve Spring
24. O-Ring
25. Proportioning Piston
26. O-Ring
27. O-Ring
28. O-Ring
29. Blend-Back Piston
30. Spring Cage
31. Spring
32. O-Ring
33. Service Piston
34. Exhaust Diaphragm
35. O-Ring
36. Exhaust Piston
37. Dust Shield
38. Retaining Ring

Fig. 1, BP-R1 Bobtail Proportioning Valve (exploded view)

Depending upon installation, it may be easier or necessary to completely remove the valve to test it properly.

1. Install a test gauge in a control and supply line. Install the other test gauge in the delivery port. Gradually apply pressure to the supply and control line.

   Slowly decrease pressure in the control cavity and note at which pressure delivery is made and

compare this value with the air system requirements in **Section 13.01**.

2. As the pressure rises, note at what pressure exhaust occurs and compare this value with the air system requirements in **Section 13.01**.
3. With air pressure present in the supply and control ports, apply a soap-and-water solution around the supply port cap nut. No leakage is permitted.
4. Apply soap-and-water solution to the delivery and exhaust ports. A slight bubble leakage is permissible. Excessive leakage indicates a faulty O-ring or inlet valve.

Disassembly, Cleaning and Inspecting, and Assembly

Disassembly (See Fig. 1)

CAUTION

The bobtail proportioning valve may be lightly clamped in a bench vise during disassembly, however, over-clamping will cause damage to the valve and result in leakage or malfunction.

If a vise is to be used, position the valve so that the jaws bear on the supply ports on opposing sides of the valve's body.

1. Remove all air fittings and plugs from the valve.
2. Mark the relationship of the valve cover to the body, and if the valve is equipped with a mounting bracket, mark the relationship of the bracket to the cover.
3. While holding the exhaust cover, remove and discard the retaining ring that secures it to the body.
4. Remove and discard the exhaust cover along with both O-rings.
5. Remove and discard the valve spring, valve retainer, and the valve assembly from the body.
6. Remove and retain the four capscrews and washers that secure the cover to the body.
7. Separate the cover from the body. Remove and discard the sealing ring and O-ring.
8. Remove and retain the relay piston and, if present, the relay piston spring from the body.

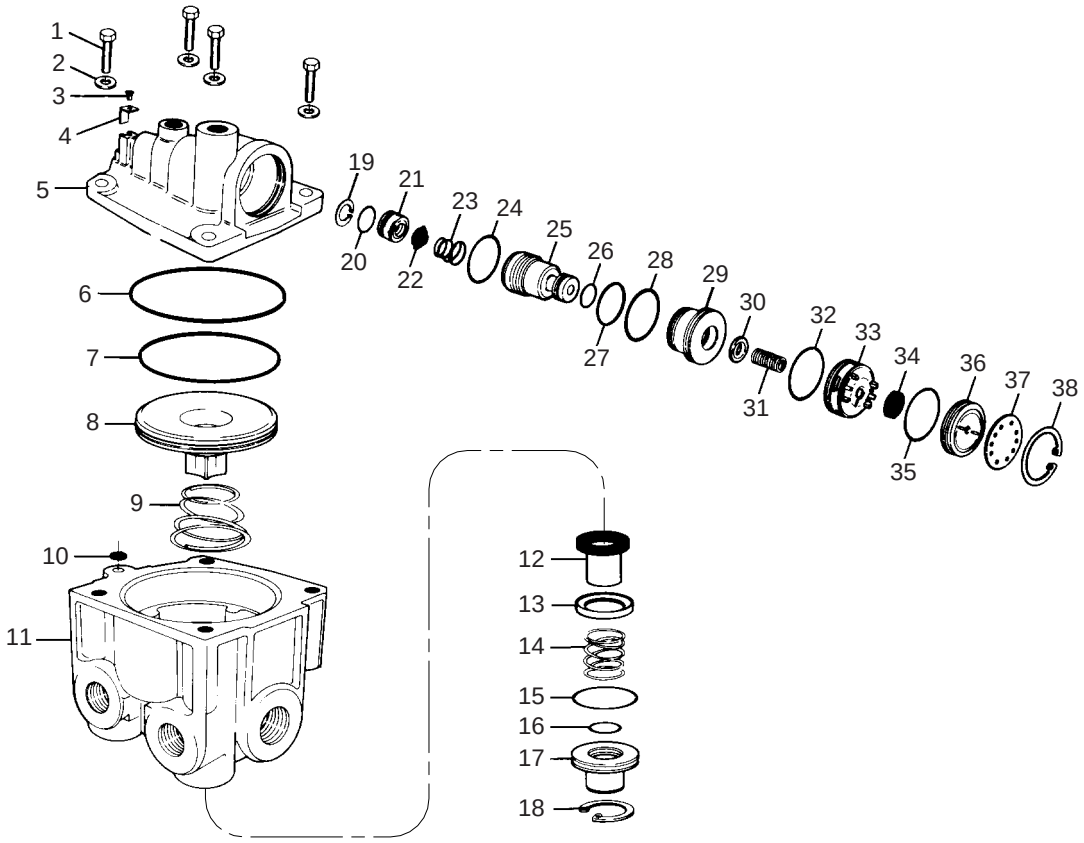
NOTE: The relay piston spring is not used in all valves.

9. Remove and discard the O-ring from the relay piston.
10. Remove and discard the dust shield and the retaining ring from the valve cover. Remove and save the exhaust piston.
11. Remove and discard the exhaust piston O-ring and the exhaust diaphragm.
12. Remove and save the service piston from the valve cover. Remove and discard the service piston O-ring.
13. Remove the spring and spring cage from the valve cover. Discard the spring and retain the spring cage.
14. Remove and retain the blend-back piston from the valve cover. Remove and discard both O-rings.
15. Remove and save the proportioning piston from the valve cover. Remove and discard both O-rings.
16. While holding the inlet valve seat in place, remove and discard the retaining ring from the proportioning piston.
17. Remove the inlet valve seat, the inlet valve, and the valve spring from the proportioning piston. Remove and discard the O-ring from the valve seat. Discard the valve and spring also.
18. Remove and discard the exhaust cover screw and exhaust cover.

Cleaning and Inspection

1. Using mineral spirits or an equivalent solvent, clean and thoroughly dry all metal parts. Do not damage any bores with metal tools.
2. Wash all non-metallic parts in a soap-and-water solution, making certain to rinse and dry thoroughly.
3. Inspect the interior and exterior of all metal parts that will be re-used. Check for severe corrosion, pitting, gouges and cracks. Superficial corrosion or pitting of the exterior portion of the body and cover is acceptable. Replace the entire valve if the interior of the body or cover show signs of corrosion or pitting.
4. Inspect each non-metallic part for cracks, wear or distortion. Replace the entire valve if these conditions exist.
5. Replace all rubber parts.
6. Make certain the air channel running between the top surface of the body and its supply port is clear and free of blockages.
7. Make certain all air channels and exhaust passages in the valve cover are clear and free of blockages.

Disassembly, Cleaning and Inspecting, and Assembly



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1. Capscrew
2. Washer
3. Exhaust Cover Screw
4. Exhaust Cover
5. Cover
6. O-Ring
7. O-Ring
8. Relay Piston
9. Relay Piston Spring (not used in all valves)
10. Sealing Ring
11. Body
12. Valve Assembly
13. Valve Retainer
14. Valve Spring
15. O-Ring
16. O-Ring
17. Exhaust Cover
18. Retaining Ring
19. Retaining Ring
20. O-Ring
21. Inlet Valve Seat
22. Inlet Valve
23. Valve Spring
24. O-Ring
25. Proportioning Piston
26. O-Ring
27. O-Ring
28. O-Ring
29. Blend-Back Piston
30. Spring Cage
31. Spring
32. O-Ring
33. Service Piston
34. Exhaust Diaphragm
35. O-Ring
36. Exhaust Piston
37. Dust Shield
38. Retaining Ring

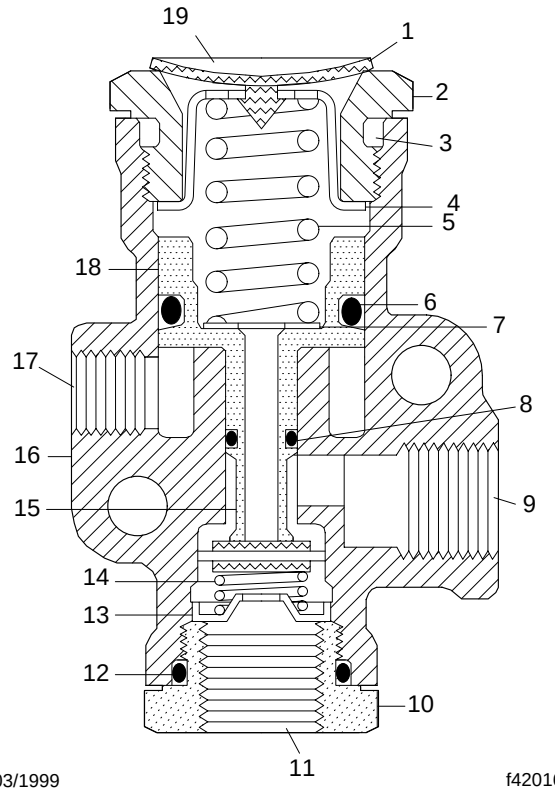
Fig. 1, BP-R1 Bobtail Proportioning Valve (exploded view)

8. Inspect the pipe threads in the body and valve cover. Make certain they are clean and free of thread sealant.
9. If the valve was equipped with a relay piston spring, check it for signs of corrosion, pitting, and cracks. Replace as needed.
10. Inspect all air line fittings for corrosion; replace as needed. Be sure to remove all old thread sealant before re-use.

Assembly (See Fig. 1)

1. Prior to assembly, lubricate all O-rings, seals, and pistons, as well as body and cover bores, using the lubricant provided in the Bendix maintenance kit. Use all of the lubricant, and spread it evenly on the rubbing surfaces.
2. Install the O-ring on the inlet valve seat.
3. Install the small end of the valve spring over the rubber portion of the inlet valve, making sure the spring coils rest on the valve's four tabs.
4. Insert the spring and valve into the valve seat, making sure the four tabs are inside the seat's bore.
5. Insert the valve, seat, and spring assembly into the proportioning piston, large end of the spring first.
6. While holding the seat in place, install the retaining ring to secure it in the piston. Make certain the retaining ring is fully seated in its groove. Make sure the valve is straight against the exhaust seat and free to move.
7. Install both the large and small diameter O-rings on the proportioning piston.
8. Install both the large and small diameter O-rings on the blend-back piston. Insert the small diameter of the proportioning piston into the small diameter end of the blend-back piston.
9. Carefully insert the assembled proportioning and blend-back pistons to the edge of the bore in the cover. Do not cut or pinch the O-rings.
10. With the bore of the cover facing up, install the spring cage in the blend-back piston so that its flat side rests against the blend-back piston (its depressed side out towards spring).
11. Install the O-ring on the service piston. Install the spring in the cage so that its coils are inside the diameter of the cage.
12. Install the O-ring on the exhaust piston, and place the exhaust diaphragm between the six posts of the service piston.
13. Place the exhaust piston on the service piston with its six-ribbed side facing the service piston. Then install both pistons while pushing the proportioning and blend-back pistons all the way into the cover.
14. Install the dust shield in the cover.
15. While holding the dust shield in the cover, install the retaining ring, making certain it is fully seated in its groove.
16. Install the exhaust cover using the screw to retain it. Torque the screw 8 to 15 lbf·in (100 to 160 N·cm).
17. Install the valve retainer on the valve assembly so that the flange of the retainer surrounds the rubber portion of the valve. Install the valve assembly in the body.
18. Install the valve spring in the body.
19. Install the large and small diameter O-rings in the exhaust cover. Install the exhaust cover in the body, taking care not to damage the O-rings. Hold the exhaust cover in place.
20. While depressing the exhaust cover, install the retaining ring in the body. Make sure this ring is fully seated in its groove in the body.
21. If the bobtail proportioning valve was equipped with a relay piston spring, install the spring in the body, large diameter first.
22. Using lubricant to hold them in place, install the large O-ring and small sealing ring on the cover.
23. Install the O-ring on the relay piston. Install the piston in the body.
24. After noting the relationship marks made prior to disassembly, install the mounting bracket (not shown) on the cover. Secure the cover and mounting bracket on the body using the four capscrews and washers. Torque the capscrews 10 to 13 lbf·ft (14 to 17 N·m).

General Information (See Fig. 1)



1. Diaphragm
2. Exhaust Port Cap Nut
3. O-Ring
4. Diaphragm Retainer
5. Piston Spring
6. Piston O-Ring
7. Shim
8. Exhaust Stem O-Ring
9. Delivery Port
10. Supply Port Cap
11. Supply Port
12. O-Ring
13. Valve Stop
14. Valve Spring
15. Inlet/Exhaust Valve
16. Body
17. Control Port
18. Piston
19. Exhaust Port

Fig. 1, TR-3 Inversion Valve (sectional view)

The inversion valve is an on/off, two-way valve. With normal operating pressure at both supply and control ports, the delivery port will be exhausted to the atmosphere. As control pressure is reduced to the point that the piston return spring overcomes the force on the control piston, the valve will deliver full supply pressure at the delivery port.

During brake application, air pressure delivered to the service port enters the small cavity above the piston and moves the piston down. The exhaust seat moves down with the piston and seats on the inner or exhaust portion of the inlet/exhaust valve, sealing off the exhaust passage. At the same time, the outer or inlet portion of the inlet/exhaust valve moves off its seat, permitting supply air to flow from the reservoir, past the open inlet valve and into the brake chambers.

The inversion valve balances when air pressure beneath the piston equals the service air pressure above. The piston lifts slightly and the inlet spring returns the inlet valve to its closed position. The exhaust remains closed as the service line pressure balances the delivery pressure. As delivered air pressure is changed, the valve reacts to the change, holding the brake application at the level.

When air pressure is released from the service port and air pressure in the cavity above the relay piston is exhausted, air pressure beneath the piston lifts the relay piston and the exhaust seat moves away from the exhaust valve, opening the exhaust passage. With the exhaust passage open, the air pressure in the brake chambers is then permitted to exhaust through the exhaust port, releasing the brakes.

Safety Precautions

AIR BRAKE SYSTEM WARNINGS

⚠ WARNING

Before attempting to work on the air brake system, certain precautions must be observed. Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized.

When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.

Hoses will whip dangerously if disconnected under pressure.

Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.

As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber push rods and spring actuators which apply automatically with the loss of pressure. This also applies when checking the service brake system.

Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.

Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.

The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.

Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.

To avoid injury, keep clear of the air chamber push rod when brakes are applied or when air is exhausted from the system.

The wheels must be chocked to prevent vehicle movement while servicing any component in the brake system.

Observe these warnings while investigating all applicable brake system concerns.

CAUTION

Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Drain the air system.

NOTE: To disconnect the air lines, push the hose in; push the retaining ring in and pull out the hose in a swift motion.

3. Mark and disconnect the air lines.
4. Loosen the retaining bolts and remove the inversion valve.

Installation

1. Attach the valve to the vehicle, using the bolts, washers, and nuts. Tighten the nuts 11 to 15 lbf·ft (15 to 20 N·m).
2. Connect the air lines to the valve.
3. Close the air reservoir drain cocks. Start the engine to pressurize the air system.
4. Check for leaks and proper valve function. For instructions, see **Subject 120**.
5. Remove the chocks from the tires.

CAUTION

Before working on or around air brake systems and components, review "Safety Precautions" in Subject 100.

NOTE: The following checks should be made with two test gauges or two gauges known to be accurate.

Depending upon installation, it may be easier or necessary to completely remove the valve to test it properly. For instructions, see **Subject 110**.

Operation and Leakage Tests

(See Fig. 1)

1. Install one test gauge in a common control and supply line; install the other gauge in the delivery port. Gradually apply pressure to the common supply and control line.

   Slowly decrease pressure in the control cavity and note at which pressure delivery is made and compare this value with the air system requirements in **Section 13.01**.

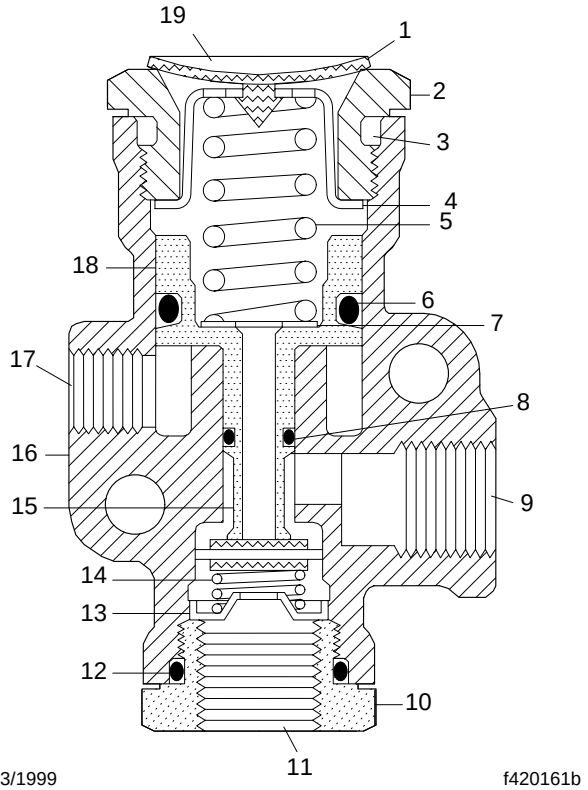
2. As the pressure rises, note at what pressure exhaust occurs and compare this value with the air system requirements in **Section 13.01**.

3. With air pressure present in the supply and control ports, apply a soap solution around the supply port cap nut. No leakage is permitted.

4. Apply soap solution to the delivery and exhaust ports. A slight bubble leakage is permissible. Excessive leakage indicates a faulty O-ring or inlet valve.

5. Operate the manual control of the inverting relay valve and check to insure that delivery and exhaust occurs promptly.

NOTE: If the inversion valve does not function properly or leakage is excessive, replace the valve with a new or remanufactured unit is. If the valve is repaired, use genuine valve manufacturer parts.



1. Diaphragm
2. Exhaust Port Cap Nut
3. O-Ring
4. Diaphragm Retainer
5. Piston Spring
6. Piston O-Ring
7. Shim
8. Exhaust Stem O-Ring
9. Delivery Port
10. Supply Port Cap
11. Supply Port
12. O-Ring
13. Valve Stop
14. Valve Spring
15. Inlet/Exhaust Valve
16. Body
17. Control Port
18. Piston
19. Exhaust Port

Fig. 1, TR–3 Inversion Valve (sectional view)

General Description

CAUTION

The size of the tires installed at the factory is programmed into the electronic control unit (ECU). Installing different size tires could result in a reduced braking force, leading to longer stopping distances and possibly resulting in personal injury or property damage.

The Meritor WABCO Antilock Braking System (ABS) is an electronic wheel speed monitoring and control system that works with the standard air brake system. It passively monitors vehicle wheel speed at all times, then controls wheel speed during emergency stops. As a result, the driver has full control of braking until the electronic control unit senses that a lockup is about to occur.

The ABS includes signal-generating sensors activated by tone (tooth) wheels located on the hubs of the monitored wheels. See **Fig. 1**. The sensors transmit vehicle wheel speed information to the electronic control unit (ECU).

According to programmed specifications, the ECU signals the appropriate modulator valve to increase, reduce, or maintain air pressure in the brake chamber. This prevents front and rear wheel lockup, and enhances steering control during emergency braking situations.

Sterling vehicles with a 4 x 2, 6 x 2, or 6 x 4 wheel configuration normally have the standard four-channel ABS with four wheel speed sensors and four modulator valves (4S/4M). Vehicles with tandem rear axles may be optionally equipped with a 6S/4M or 6S/6M ABS.

During normal braking conditions, the standard air brake system is in effect. If the vehicle is equipped with Automatic Traction Control (ATC), wheel spin is controlled during reduced-traction startup and acceleration.

Principles of Operation

The ABS has an electronic control unit that serves as the information processing and command center for the antilock braking system. The ECU is a digital microcomputer that 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 modulator valves.

The major components of the Meritor WABCO pneumatic ABS system include the following:

- Wheel speed sensors
- An electronic control unit (ECU)
- Modulator valves (solenoid control valves)
- Automatic Traction Control (ATC) valve (optional)
- ABS warning and wheel-spin indicator lights
- Retarder relay

CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power, ground cables, and the electrical harness connectors at the ABS electronic control unit (ECU). Electric currents produced during electric welding can damage various electronic components on the vehicle.

WHEEL SPEED SENSORS

The wheel speed sensor assembly is a signal-generating device. The assembly includes a sensor (coil wrapped around a magnet), a tone wheel, and a sensor clip that holds the sensor in position near the tone wheel. See **Fig. 2**.

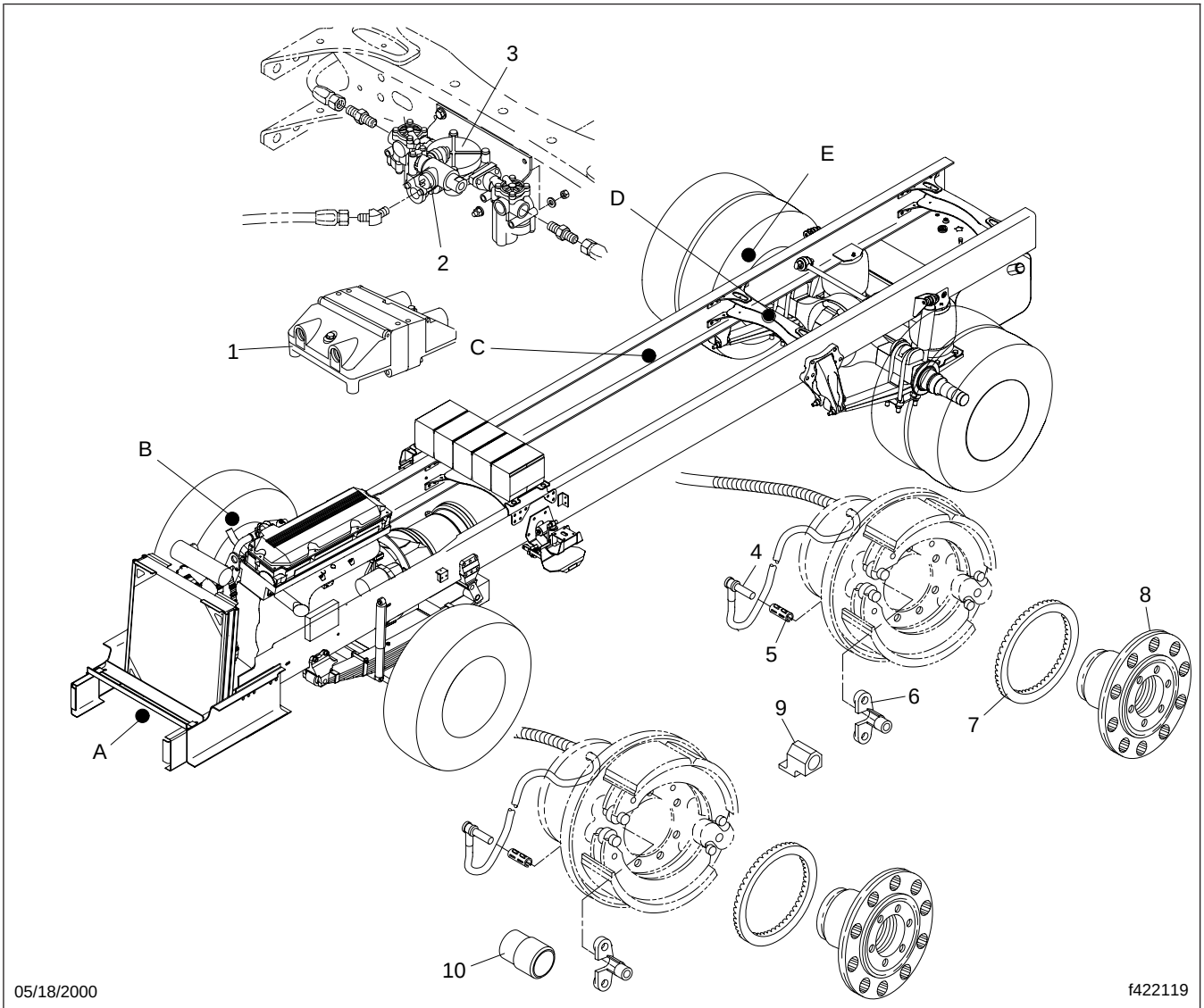
Each ABS-controlled wheel has a wheel speed sensor assembly with a tone wheel mounted on the hub. When the vehicle is moving, the teeth on the tone wheel cause interruptions in the magnetic field created by the sensor. The interruptions create electrical pulses that are sent to the electronic control unit where they are used to determine the wheel speed.

ELECTRONIC CONTROL UNIT (ECU)

Sterling L-Line and A-Line vehicles that are equipped with a Meritor WABCO ABS have a frame-mounted D-version ECU.

The ECU contains microcomputers to monitor the front and rear control channels. See **Fig. 3**. It is mounted on the right-hand frame rail.

General Information

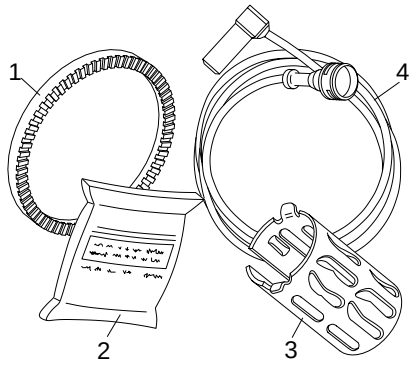


A. Front modulator valve assembly (mounted on the front crossmember).
B. Front wheel speed sensor assemblies.
C. Electronic control unit (ECU).
D. Rear modulator valve assembly (mounted on a crossmember forward of the rear axle).
E. Rear wheel speed sensor assemblies.

1. Electronic Control Unit (ECU)
2. ATC Valve (optional)
3. Rear Modulator Valve Assembly
4. Sensor
5. Sensor Clip
6. Sensor Holder (bolt on)
7. Tone Wheel
8. Hub
9. Sensor Mounting Block (weld on)
10. Sensor Bushing (weld on)

Fig. 1, ABS Component Location (4-channel, 4S/4M system shown)

The ECU receives signals from the wheel speed sensors and uses them to calculate wheel speed and a vehicle reference speed. The unit is programmed to determine whether the wheels are slowing at a nor-

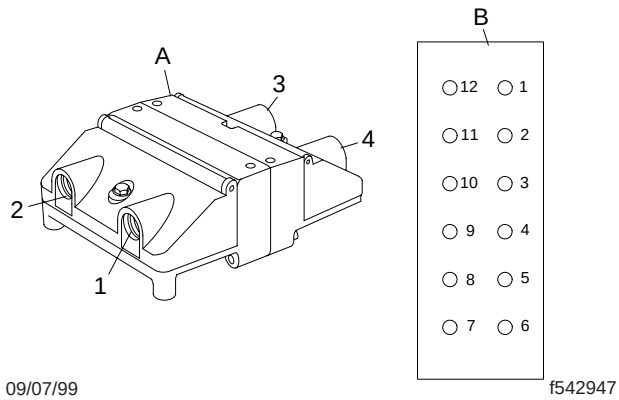


1. Tone Wheel
2. Lubricant
3. Sensor Spring Clip
4. Sensor

Fig. 2, Wheel Speed Sensor Components

mal braking rate or at a higher rate, requiring ABS braking control. If the ECU senses wheel slip or lockup, the appropriate control circuit signals the modulator valve(s) to release, hold, or reapply braking pressure.

The ECU also shuts down the engine brake and the exhaust brake, if equipped, when a wheel approaches a slip or lockup condition. When the wheels return to a normal rate of speed, the engine and exhaust brakes are reactivated automatically.



A. Frame-mounted ECU.
B. ECU connector pin locations.
1. X1 Connector (gray)
2. X2 Connector (black)
3. X3 Connector (green)
4. X4 Connector (brown—6S/4M, 6S/6M only)

Fig. 3, Frame-Mounted ECU and Pin Locations

The ECU constantly monitors the wheel sensors, modulator valves, Automatic Traction Control valve (if equipped), and the electrical circuitry. After the ignition switch is turned on, the ABS warning light (ABS, TRACTOR ABS, or ANTI LOCK) and the ATC wheel spin indicator light (TRAC) on the dash light for about 3 seconds. See **Fig. 4** for a typical instrument cluster for a vehicle without ATC.

During the self-test, the modulator valves and the ATC valve cycle on and off, creating clicking noises that may be heard inside the cab. These clicking noises are normal and do not indicate an ABS problem. After about 3 seconds, the lights go off only if all of the ABS and ATC components are functioning correctly.

On vehicles with Automatic Traction Control, after the self-test the ATC indicator light comes on if a drive wheel spins during startup or acceleration.

IMPORTANT: If the ABS warning light and the ATC indicator light do not work as described above, repair the ABS/ATC system. See **Troubleshooting, 300** for fault diagnosis.

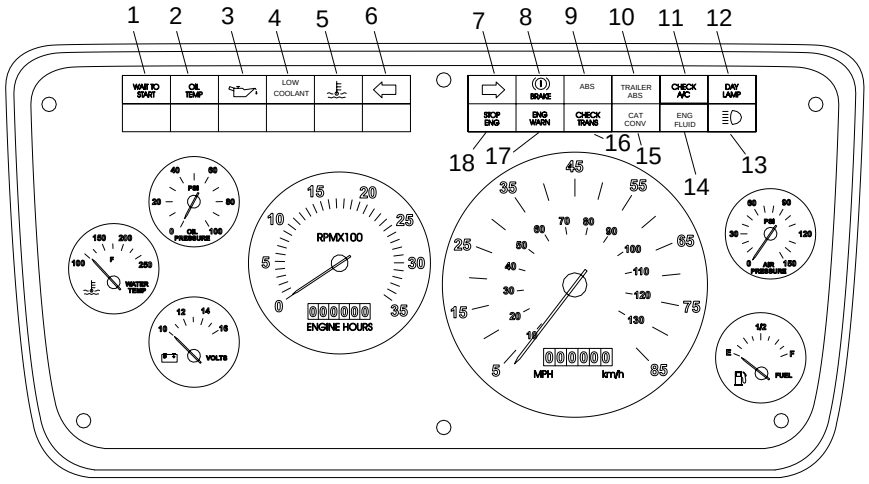
If, during vehicle operation, the safety circuit senses a failure in any part of the ABS system (such as a sensor, modulator valve, wiring connection, or short circuit), the ABS warning light comes on, a fault code is stored in ECU memory, and the control circuit where the failure occurred is switched to normal braking action. The remaining control circuit retains the ABS effect.

Even if the ABS system is completely inoperative, normal braking is maintained. An exception would be if a modulator valve or valve assembly is damaged and inoperative. These components are an integral part of the air brake system so normal braking may be impaired or inoperative.

For troubleshooting purposes, the ECU can communicate with the Meritor WABCO PC Diagnostics (recommended), ServiceLink, or a hand-held Pro-Link electronic diagnostic tool through the J1587 diagnostic datalink connector. The connector is located below the dash on the driver's side. See **Fig. 5**. Fault codes can be retrieved through the datalink connection, when necessary.

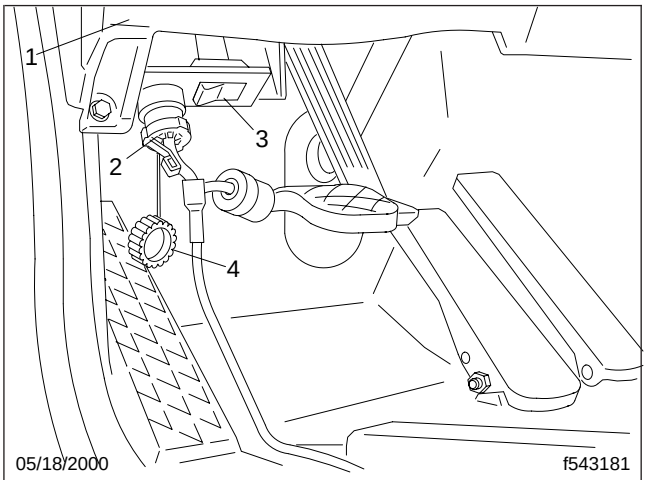
IMPORTANT: Do not open the ECU. Opening the ECU to gain access to the internal components will void the warranty.

General Information



1. Wait-to Start
2. Oil Temperature
3. Oil Pressure
4. Low Coolant Level
5. High Coolant Temperature
6. Left-Turn Signal
7. Right-Turn Signal
8. Brake Low Air Pressure
9. ABS
10. Trailer ABS
11. Check A/C
12. Daytime Running Lights
13. High Beam
14. Engine Fluid
15. Catalytic Converter
16. Transmission Temperature
17. Engine Warning
18. Stop Engine

Fig. 4, Instrument Cluster (typical, without ATC)



1. Lower LH Dash
2. J1587 Datalink Diagnostic Connector
3. Diagnostic Switch
4. Connector Cap (tethered)

Fig. 5, J1587 Datalink Diagnostic Connector

MODULATOR VALVES

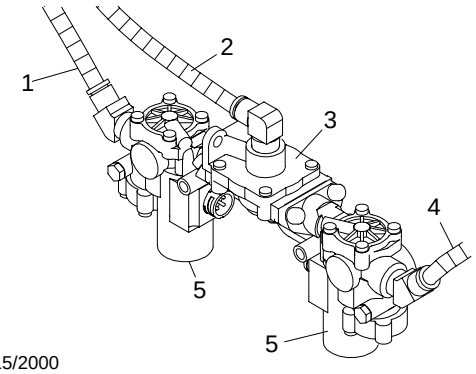
Modulator valves control the air pressure in each affected brake chamber during an ABS operation. Depending on the signal received from the ECU, modulator valves prevent wheel lockup by reducing, maintaining, or increasing brake pressure. During normal braking applications, the ABS system is inactive and compressed air flows freely through the modulator valves to the brake chambers.

Each ABS-monitored wheel has its own modulator valve. The front modulator valve assembly, mounted on the front crossmember, includes two modulator valves connected to a quick-release valve. See **Fig. 6**.

The rear modulator valve assembly is mounted on a crossmember near the rear brake chambers. See **Fig. 1**. The assembly includes two modulator valves, one mounted on each side of a service relay valve. If the vehicle has an ATC system, the ATC valve is mounted on the control port of the service relay valve.

Vehicles with tandem rear axles and a 4S/4M ABS share modulator valves. One wheel is sensed but the modulator valve controls both wheels.

Each modulator valve includes two solenoid control valves (one supply and one exhaust) and two diaphragms. See **Fig. 7**.



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1. Air Line to RH Brake Chamber
2. Supply Air Line
3. Quick-Release Valve
4. Air Line to LH Brake Chamber
5. Modulator Valve

Fig. 6, Front Modulator Valve Assembly

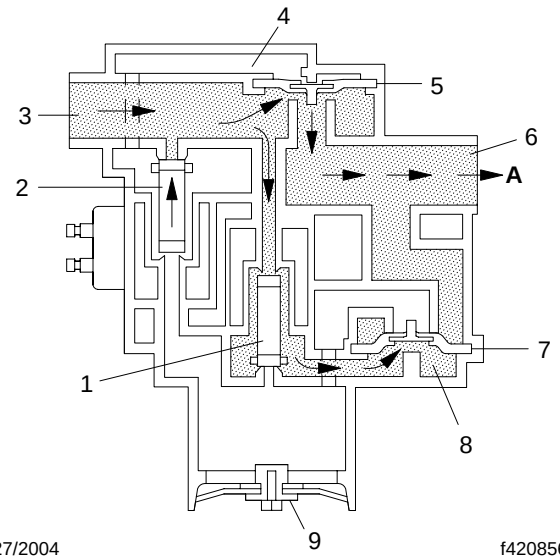
- The supply diaphragm opens and closes an air passage between the supply port and delivery port. It is controlled by the supply solenoid valve.
- The exhaust diaphragm opens and closes an air passage between the exhaust port and the delivery port. It is controlled by the exhaust solenoid valve.

The ECU energizes different combinations of these solenoid valves to perform four functions: normal braking (without ABS control), ABS brake release (exhaust), ABS brake hold, and normal brake reapply.

Normal Brake Control

The normal brake function (without ABS control) operates as follows:

- Before braking, the supply pilot chamber is open to the atmosphere through the exhaust port.
- When the brakes are applied, both solenoid valves in the ABS modulator valve are closed (de-energized). See **Fig. 7**.
- Increased air pressure entering the supply port unseats the supply diaphragm by increasing the pressure under the diaphragm. This opens the passage to the delivery port and allows air to flow directly through the valve and into the brake chamber.



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NOTE: Both solenoid valves are closed. The modulator valve is shown in the braking configuration with increased air pressure at the supply port (supply diaphragm unseated, exhaust diaphragm seated).

A. Air to brake chamber.

1. Exhaust Valve (closed)
2. Supply Valve (closed)
3. Supply Port
4. Supply Diaphragm (unseated)
5. Delivery Port
6. Exhaust Diaphragm (seated)
7. Exhaust Port

Fig. 7, Modulator Valve, Normal Brake Control (brake applied)

- Air also flows through the exhaust valve. The increased pressure under the exhaust diaphragm seats the diaphragm, which closes the passage between the exhaust port and the delivery port.
- When the brake pedal is released, air pressure at the supply port decreases and the higher pressure in the brake chamber reverses the flow of air in the modulator valve. Air now flows from the delivery port to the supply port until the pressure is balanced. This releases the supply diaphragm and closes the passage between the two ports.
- The reduced pressure unseats the exhaust diaphragm and air is vented through the exhaust port to the atmosphere.

Brake Release (ABS Active)

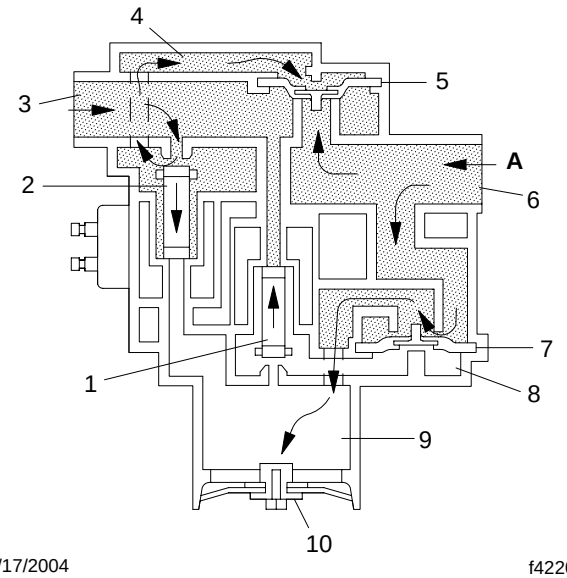
The ABS brake release (exhaust) function is triggered when the ECU determines that the brakes are about to lock.

- When a wheel is going to lock, the ECU opens (energizes) both solenoid valves in the ABS modulator valve. See **Fig. 8**.
- The open supply valve allows compressed air to enter the supply pilot chamber above the supply diaphragm. The increased pressure seats the diaphragm and stops air from entering the brake chamber.
- The open exhaust valve shuts off the supply of air entering the exhaust pilot chamber. It also creates an opening between the pilot and exhaust chambers.
- Air from the brake chamber enters through the delivery port. The pressure unseats the exhaust diaphragm, creating an opening between the delivery and exhaust chambers. Brake-chamber air is then released through the exhaust port.

Brake Hold Control (ABS Active)

The ABS brake hold function takes control during an emergency stop when the pedal control valve delivers more air than the brakes can handle without locking. The hold function occurs after the ABS has started to control the pressure in the brake chamber by releasing some of the air.

- When enough air is released through the exhaust port to stop the wheel from locking (ABS brake release), the exhaust valve is closed and air pressure is allowed to flow into the exhaust pilot chamber. See **Fig. 9**.
- The increased pressure under the exhaust diaphragm seats the diaphragm, which closes the passage between the exhaust port and the delivery port. This stops the flow of air from the brake chamber to the exhaust port.
- The supply valve stays open to maintain pressure in the supply pilot chamber and keep the supply diaphragm seated. This prevents further buildup of pressure in the brake chamber.
- The remaining air pressure in the brake chamber is held and remains constant for stopping the vehicle in the minimum distance.



NOTE: Both solenoid valves are open.

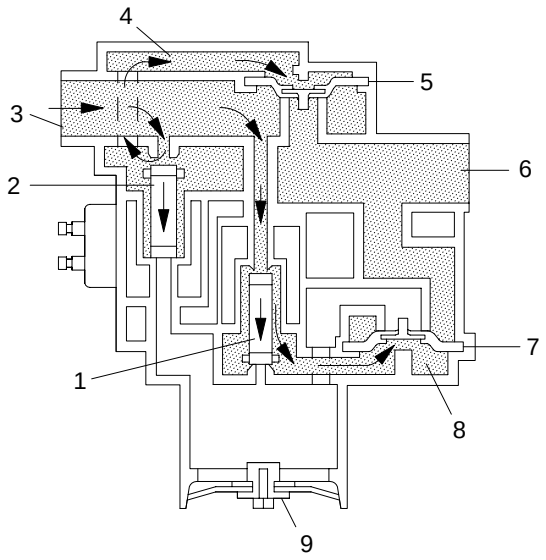
A. Air from brake chamber.
1. Exhaust Valve (open)
2. Supply Valve (open)
3. Supply Port
4. Supply Pilot Chamber
5. Supply Diaphragm (seated)
6. Delivery Port
7. Exhaust Diaphragm (unseated)
8. Exhaust Pilot Chamber
9. Exhaust Chamber
10. Exhaust Port

Fig. 8, Modulator Valve, Brake Release (exhaust)

Reapply Brake Control (ABS Active)

The last ABS function is the reapply brake control. To achieve maximum braking, the ECU determines when to reapply the air pressure that the pedal control valve is delivering. When appropriate, both ABS solenoid valves are closed, which returns the system to the normal brake control state shown in **Fig. 7**.

During an ABS event, the ECU cycles the modulator valve(s) through the sequence of ABS valve states (brake release, hold, and reapply) very rapidly in order to control wheel speed. The effect is similar to manually pumping the brakes on a vehicle without an ABS.



NOTE: The supply valve is open; the exhaust valve is closed.

1. Exhaust Valve (closed)
2. Supply Valve (open)
3. Supply Port
4. Supply Pilot Chamber
5. Supply Diaphragm (seated)
6. Delivery Port
7. Exhaust Diaphragm (seated)
8. Exhaust Port

Fig. 9, Modulator Valve, Brake Hold Control

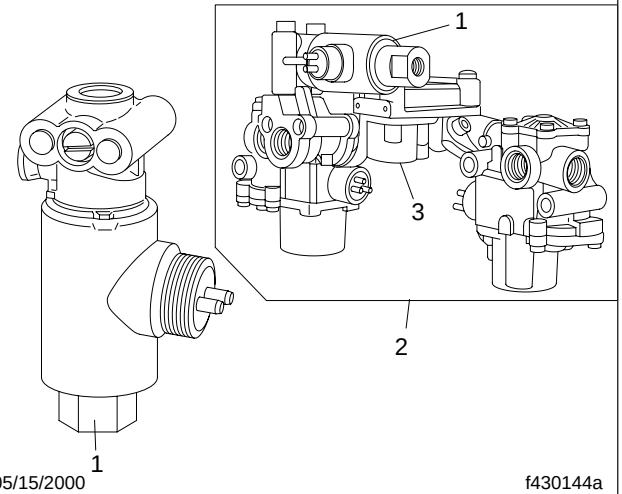
NOTE: The driver always controls the maximum amount of pressure applied to the brakes. Pressure to the brake chamber can never be more than the driver applies with the foot pedal. The ABS can override the pedal pressure to provide less brake pressure but not more.

AUTOMATIC TRACTION CONTROL

If the vehicle is equipped with Automatic Traction Control (ATC), the ABS/ATC system automatically reduces wheel spin during low-traction startup or acceleration.

If a drive wheel starts to spin faster than the steer-axle wheels, the ATC system applies air pressure to brake that drive wheel. This transfers engine torque to the wheel or wheels that have better traction (differential braking). If two or more drive wheels spin, the ATC reduces the engine torque to provide improved traction, overriding the throttle pressure from the driver.

The ATC valve controls only the brake chambers for the drive wheels. It is mounted on the service relay valve (rear modulator valve assembly). See **Fig. 10**. The solenoid in the ATC valve controls an on/off air valve, which allows or prevents air flow to the control side of the service relay valve.



1. ATC Valve
2. Rear Modulator Valve Assembly
3. Service Relay Valve

Fig. 10, ATC Valve

If a wheel spin from one side of the vehicle is detected, the ECU signals the ATC valve to open. This allows compressed air to enter the service relay valve and the normal ABS control system determines which brake to apply.

An ATC function switch on the dash allows the driver to select from two levels of drive-axle traction control (see **Fig. 11**):

- In the default position, the ATC reduces drive-axle wheel spin on icy, wet, or sand-covered roads.
- Pressing the TRAC MUD/SNOW switch increases the available traction on extra soft surfaces like snow, mud, or gravel by slightly increasing the permissible wheel spin. The

General Information

greater wheel spin may also be used to help burn through a thin layer of ice.

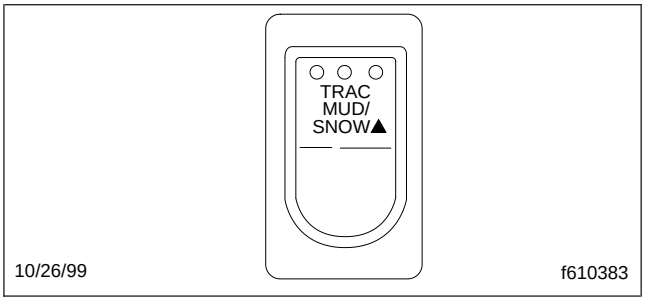


Fig. 11, ATC Switch for Soft Surfaces

The ATC function turns on and off automatically; drivers do not have to select this feature. If a drive wheel spins during startup or acceleration, the ATC indicator lamp comes on, indicating the ATC is active. It goes out when the drive wheel stops spinning.

The TRAC MUD/SNOW mode overrides the ATC function. It must be manually selected by pressing the TRAC MUD/SNOW spring-loaded switch briefly after the vehicle is started. The ECU indicates the activation by a constant flashing of the TRAC lamp. This mode is disengaged by pressing TRAC MUD/SNOW on the switch again or turning the ignition switch off.

ABS WARNING AND ATC INDICATOR LIGHTS

The ABS warning light (ABS, TRACTOR ABS, or ANTI-LOCK) receives power whenever the ignition switch is turned on. The ground paths for this indicator are through the ABS ECU and the blink-code switch. During the self-test, and whenever a malfunction occurs, the ECU completes the ground path and the ABS indicator on the dash comes on. See **Fig. 4**. The light is also used to display blink code diagnostics.

The warning light alerts the driver that the self-test is working or that an ABS system malfunction exists. After a wheel-sensor-related fault has been repaired, if the stored faults are cleared, the ABS warning light remains on until the vehicle is driven above a speed of 4 mph (6 km/h).

The ATC indicator light also receives power whenever the ignition switch is on. If the drive-axle wheels spin, the ATC indicator light turns on.

On vehicles equipped with Automatic Traction Control, if the TRAC MUD/SNOW switch (**Fig. 11**) is activated, the ABS ECU allows more wheel spin than normal and the ATC indicator blinks continuously until the switch is deactivated.

If the ATC wheel-spin indicator light stays on during normal vehicle operation, there is a malfunction in the ATC system.

TIRE SIZE

For proper ABS/ATC operation with the standard ECU, the front and rear tire sizes must be within 14 percent of each other. When the tire-size range is exceeded, system performance can be affected and the warning lamp may come on.

Call Meritor WABCO at 1-800-535-5560 if you plan a tire-size difference greater than 14 percent.

Calculate the percentage difference of the tire sizes with the following equation:

Percentage Difference = {(steer-axle tire RPM ÷ drive-axle tire RPM) – 1} x 100, where RPM equals tire revolutions per mile.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

- Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires before working under the vehicle. Releasing air from the system can cause the vehicle to roll.
- Keep hands away from brake chamber push rods and slack adjusters; they will apply as the air 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 the recommended air pressure.
- Always wear safety glasses when working with compressed air. Never look into air jets or direct them toward anyone.
- 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 they are not correctly disassembled. Use only the correct tools and observe all precautions regarding use of those tools.

Wheel Speed Sensor Replacement

IMPORTANT: Do not attempt to repair the wheel sensor wire (the wire that comes with the sensor). If the wire is damaged, replace the sensor assembly.

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. Refer to **Section 54.13** for information on special terminals and connectors, and on ordering tools for them.

FRONT AXLE

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires to prevent vehicle movement.
2. Twist and pull the sensor to remove it from the steering knuckle. See **Fig. 1**.

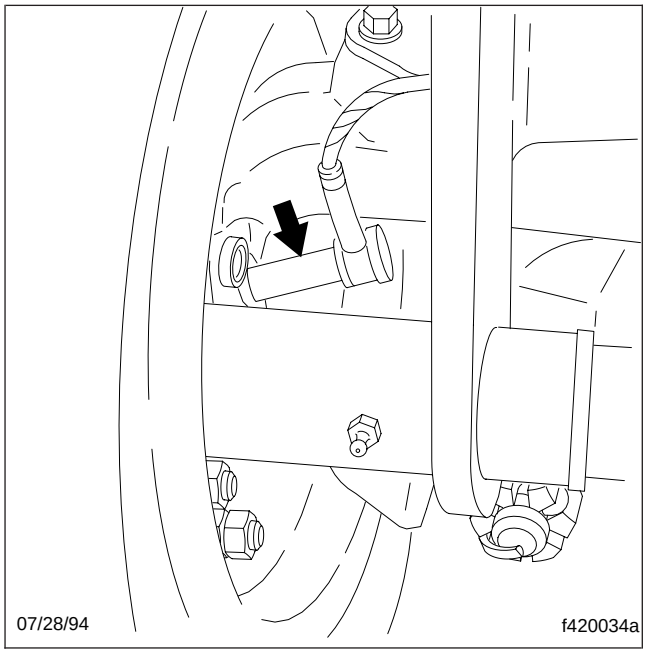


Fig. 1, Front Wheel Speed Sensor Removal

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 new 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, Pennzoil 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. Park the vehicle on a flat surface, set the parking brake, and shut down the engine. Chock the front tires to prevent vehicle movement.
2. Raise the rear of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove the wheel and tire assembly from the rear axle. For instructions, see **Group 40**.
5. Remove the brake drum. For instructions, refer to **Group 35**.
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 new 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, Pennzoil 707L, or an equivalent. Using your

Wheel Speed Sensor Replacement

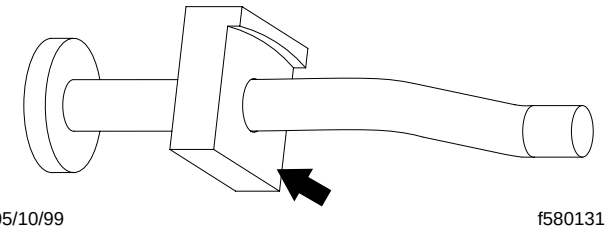
hand, push the sensor into the clamping bushing until it is stopped by the tone wheel.

14. Install the brake drum on the wheel hub. For instructions, refer to **Group 35**.
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**.
17. Remove the safety stands, lower the vehicle, and remove the chocks from the front tires.

Adjustment

NOTE: The following adjustment procedure requires the use of special tool T11-17556-000. Use of this tool, available through the PDCs, eliminates the time-consuming task of removing the wheel and tire assembly, and the brake drum. See **Fig. 1**.

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



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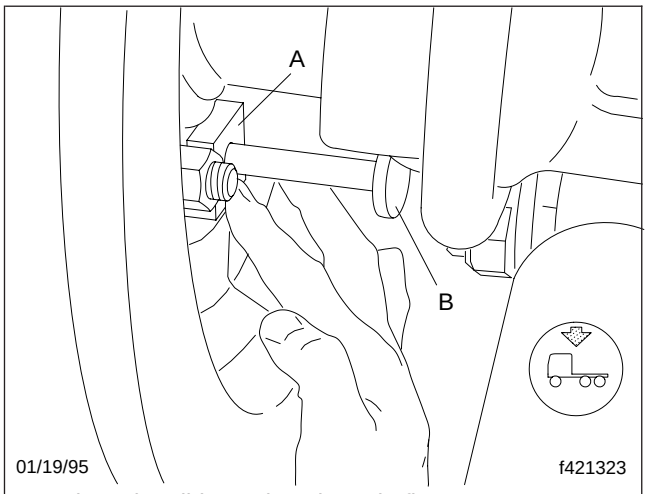
1. Adjustment Tool Slide

Fig. 1, ABS Sensor Adjustment Tool

2. Find the sensor access hole in the rear-axle flange.
   - 2.1 View the inboard side of the brake drum and axle from the rear. The ABS sensor wiring harness should be visible through a hole in the 12 o'clock position.
   - 2.2 Find the S-cam at either the 3 or 9 o'clock position.
   - 2.3 The sensor access hole is opposite the S-cam. The hole is approximately 3/4 inch (19 mm) in diameter.

IMPORTANT: Do not pry or push the sensor with sharp objects.

3. Insert service tool T11-17556-000 in the sensor access hole.
4. Place the slide of the tool on the axle flange to align the tool. See **Fig. 2**.
5. Tap the tool handle lightly with the palm of your hand. This ensures that the sensor is touching the tone wheel.
6. Remove the tool from the wheel and repeat the procedure on the other rear-axle speed sensor.



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A. Place the slide against the axle flange.
B. Tap the handle with your hand.

Fig. 2, Position the Tool

7. Remove the chocks from the tires.

Modulator Valve Removal and Installation

Removal

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Section 54.13** for information on special terminals and connectors, and on ordering tools for them.

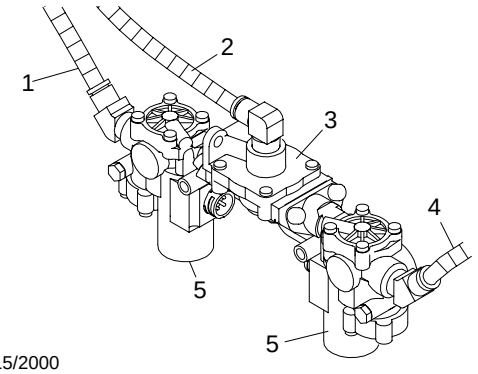
1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the front and rear tires.

⚠ WARNING

Release all the compressed air from the air reservoirs before disconnecting any air hose. Disconnecting air hoses from the modulator valves without first releasing the pressure in the air reservoirs can cause the hoses to swing uncontrollably, possibly resulting in personal injury or property damage. Before starting work on the brake system, read Safety Precautions, 100 in this section.

2. Release the pressure from the air reservoirs.
3. Mark the electrical connectors for ease of installation. Disconnect the wiring from the applicable front or rear modulator valve assembly.
   - The modulator valves for the front-axle brakes are mounted as an assembly on a bracket on the front crossmember (behind the front bumper). See **Fig. 1**. The assembly includes two modulator valves and a quick-release valve.
   - The rear modulator valve assembly is mounted on a bracket on a crossmember near the rear brake chambers. See **Fig. 2**. The assembly includes two modulator valves and a service relay valve.
4. Mark the air lines for ease of installation. Disconnect the air lines.
5. Remove the fasteners attaching the modulator valve assembly to the mounting bracket. Remove the valve assembly.

NOTE: The modulator valve assemblies can be disassembled if replacement of the quick-release valve, service relay valve, automatic traction control valve (if equipped), or one of the modulator valves is needed. For disassembly and assembly instructions, see **Subject 140**.



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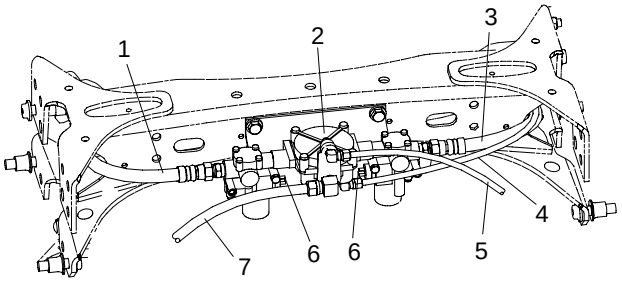
1. Air Line to RH Brake Chamber
2. Supply Air Line
3. Quick-Release Valve
4. Air Line to LH Brake Chamber
5. Modulator Valve

Fig. 1, Front Modulator Valve Assembly



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1. Delivery Air Line (to RH brake chamber)
2. Service Relay Valve
3. Delivery Air Line (to LH brake chamber)
4. Anti-compounding Line (black, to park brake quick-release/relay valve)
5. Control Air Line (green, from foot pedal valve)
6. Modulator Valve Electrical Connection
7. Supply Air Line (green, from primary air reservoir)

Fig. 2, Rear Modulator Valve Assembly

Installation

1. Install the new modulator valve assembly on the bracket on the crossmember. Tighten the fasteners 18 lbf·ft (24 N·m).

Modulator Valve Removal and Installation

2. Connect the air lines to the valves, as marked during removal.
3. Connect the electrical cable connectors to the modulator valves. Tighten only hand-tight.

Installation Checkout

1. Apply the brakes, turn the ignition switch on, and wait for the ABS indicator light to come on.
2. Listen to the modulator valves cycle one by one, then together diagonally as follows:
    - 4-Channel valve cycle: 1, 2, 3, 4; then 1 and 2 together followed by 3 and 4.
    - 6-Channel valve cycle: 1, 2, 3, 4, 5, 6; then 1, 2, and 3 together followed by 4, 5, and 6.
3. If a valve fails to cycle, turn the ignition switch off and make sure the electrical connections are tight. Then, turn the ignition switch on and listen to the valve cycle again.

   If a valve still fails to cycle, check for fault codes. See **Troubleshooting, 300** for fault-code identification.
4. Apply the brakes and check the modulator valve fittings for leaks. No air leakage is permitted.
5. Remove the chocks from the tires.
6. Test drive the vehicle to verify that the ABS warning light is functioning correctly.

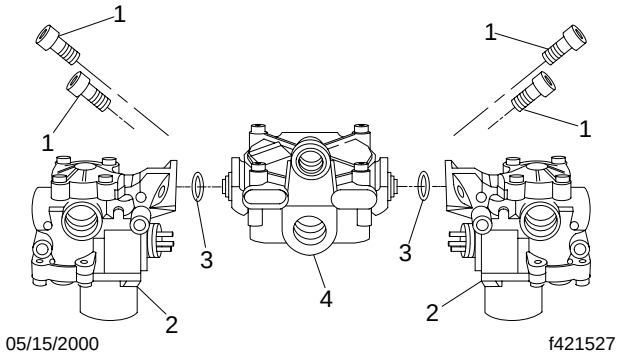
Modulator Valve Assembly, Disassembly and Assembly

Disassembly

NOTE: On vehicles equipped with Automatic Traction Control (ATC), the ATC valve can be replaced without removing the rear modular valve assembly if there is enough room to work.

1. Remove the modulator valve assembly from the crossmember. See **Subject 130** for instructions.
2. Remove the modulator valves from the quick-release or service relay valve.

   2.1 Using a 6-mm Allen wrench, remove two Allen-head capscrews that attach each modulator valve to the quick-release or service relay valve. See **Fig. 1**.



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NOTE: The fasteners are the same for both the front and rear modulator valve assemblies.

1. Capscrew, Allen-Head, M8
2. Modulator Valve
3. O-Ring
4. Service Relay Valve

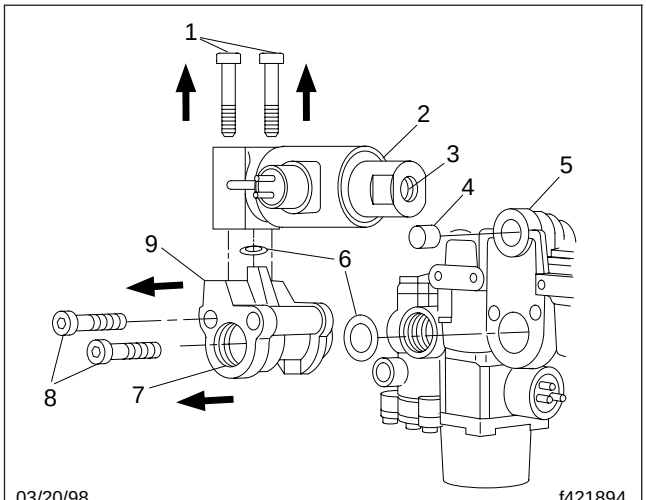
Fig. 1, Rear Modulator Valve Assembly

   2.2 Carefully separate the modulator valves from the quick-release or service relay valve.

   2.3 Remove and discard the O-rings.

3. If the vehicle is equipped with Automatic Traction Control (ATC), remove the ATC valve from the service relay valve. See **Fig. 2**.

   3.1 Using a 5-mm Allen wrench, remove two Allen-head capscrews that attach the adaptor to the service relay valve. Remove the adapter/ATC valve assembly.



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1. Capscrew, Allen-head, M8
2. ATC Valve
3. Control Port
4. Seal
5. Service Relay Valve
6. O-Ring
7. Supply Port
8. Capscrew, Allen-head, M6
9. Adaptor

Fig. 2, ATC Valve Mounting

   3.2 Using a 6-mm Allen wrench, remove two Allen-head capscrews that attach the ATC valve to the adaptor. Separate the valve from the adaptor.

   3.3 Remove and discard the seal and two O-rings.

Assembly

1. If the vehicle is equipped with Automatic Traction Control (ATC), install the ATC valve on the service relay valve.

   1.1 Clean the O-ring grooves on the adaptor. Lubricate the small replacement O-ring and install it in the top port in the adaptor.

   1.2 Using two new M8 Allen-head capscrews, install the ATC valve on the adaptor. Tighten the capscrews 12 to 13 lbf·ft (18 to 20 N·m).

Modulator Valve Assembly, Disassembly and Assembly

1.3 Lubricate the replacement seal and install it in the control port (upper port) of the service relay valve.

1.4 Lubricate the large replacement O-ring and install it in the groove in the supply port (lower port) of the service relay valve.

1.5 Using two new M6 Allen-head capscrews, install the adaptor on the service relay valve. Tighten the capscrews 48 to 60 lbf·in (542 to 678 N·cm).

2. Install the modulator valves on the quick-release or service relay valve.

2.1 Plug any unused ports on the replacement modulator valves.

2.2 Clean the O-ring surfaces on the modulator and quick-release or service relay valves. Lubricate the replacement O-rings and place them in the applicable grooves in the valves.

2.3 Install each modulator valve on the quick-release or service relay valve with two M8 Allen-head capscrews. Tighten the capscrews 13 to 15 lbf·ft (18 to 20 N·m).

3. Install the modulator valve assembly on the bracket on the crossmember. For instructions, see **Subject 130**.

ABS Tone Ring Installation on Service Hubs

Installation

IMPORTANT: Some ABS service hubs do not have a tone (tooth) ring installed on the hub. The tone ring must be ordered separately and installed on the hub before installation of the hub onto the axle. Tone rings are made of a special material and require a specific installation procedure for proper installation.

⚠ WARNING

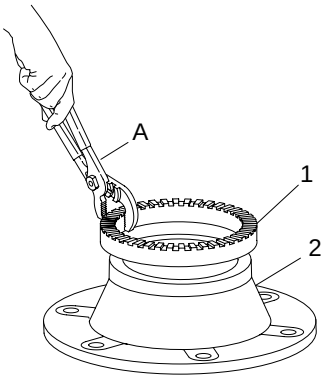
When installing an ABS system, special ABS hubs must be ordered. Machining older hubs to accommodate the installation of tone rings can cause problems due to insufficient hub bore wall thickness. Machining an older hub with insufficient hub bore wall thickness could result in cracking, causing bearing damage and wheel loss. This could cause an accident resulting in personal injury and property damage.

1. Submerge the tone ring in boiling water or place it in an oven at 250°F (121°C) for approximately 15 minutes.

⚠ CAUTION

Do not attempt to heat the tone ring with a torch as this can damage the ring.

2. Using pliers, remove the tone ring from the boiling water or oven and center it on the machined area of the hub bore. See **Fig. 1**.
3. While the tone ring is still hot, make sure it is properly centered on the machined surface. Using a rubber mallet, tap the tone ring until it bottoms out around the machined surface on the hub. See **Fig. 2**.
4. Install the hub on the axle. Place a dial indicator with a magnetic base so the dial indicator is against the tone-ring teeth. See **Fig. 3**.
5. Rotate the hub and check the ring for runout. The runout should be less than 0.005 inch (0.13 mm). See **Fig. 4**.
6. Install the wheel. For instructions, see **Group 40**.



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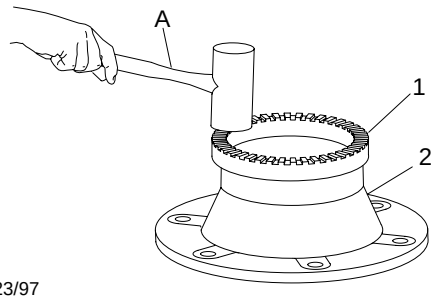
A. Use pliers to apply the ring.
1. Tone Ring 2. Hub

Fig. 1, Install the Ring on the Hub



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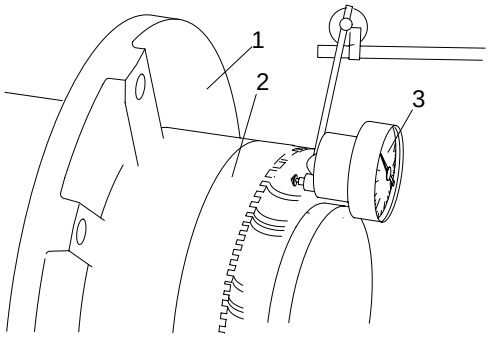
A. Use a rubber mallet.
1. Tone Ring 2. Hub

Fig. 2, Tap the Tone Ring



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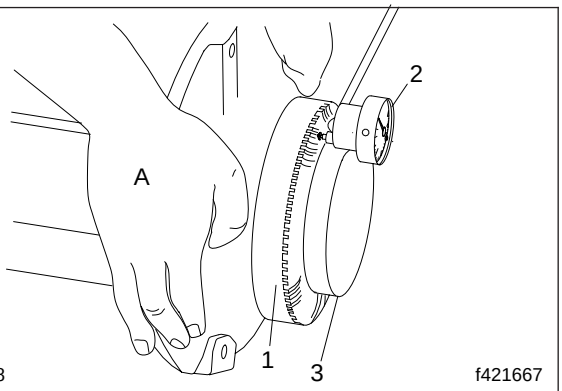
1. Hub 3. Dial Indicator
2. Tone Ring

Fig. 3, Position the Dial Indicator

ABS Tone Ring Installation on Service Hubs



A. Rotate the hub.
1. Tone Ring
2. Dial Indicator
3. Axle

Fig. 4, Check Tone-Ring Runout

Dynamometer Testing Vehicles with ATC

⚠ WARNING

Do not test a vehicle equipped with Automatic Traction Control (ATC) on a dynamometer unless the ATC system is disabled. Activation of the ATC on a dynamometer will cause unequal drive-wheel torque that can result in loss of vehicle control and personal injury or death.

Vehicles with ATC must have the ATC disabled before testing the vehicle on a dynamometer. Use one of the following methods to disable the ATC:

- Use the Meritor PC Diagnostics or the Pro-Link electronic diagnostic tool to disable the ATC.
- Press and hold the blink code switch for a least three seconds. Once the system identification code begins, the ATC system has been disabled. See **Table 1** for system ID codes.
- Removing the ABS circuit breaker or fuse, or removing the ECU power connector will disable both the ABS and ATC.

The ATC light on the dash comes on and stays on when the ATC is disabled.

System Identification Blink Codes *		
Blink Code	**Sensors/ Modulators**	**Wheel Positions**
1 Blink	6S/6M	6 x 2
2 Blinks	4S/4M	4 x 4
4 Blinks	6S/4M	6 x 4
5 Blinks	6S/6M	6 x 4

* The system identification blink code, followed by a 4-second pause, repeats until the ignition switch is turned off.

Table 1, System Identification Blink Codes

General Information

⚠ WARNING

Before testing a vehicle equipped with Automatic Traction Control (ATC) on a dynamometer, the ATC system must be disabled. See Subject 160 for instructions. Activation of the vehicle ATC on a dynamometer will cause unequal drive-wheel torque that can result in loss of vehicle control and personal injury or death.

Before testing a wheel speed sensor, modulator valve, or ATC valve, make sure the supply voltage to the antilock braking system (ABS) electronic control unit (ECU) is sufficient (see "ECU Supply Voltage Test") and check for leaks in the ABS pneumatic system.

The sensor and valve resistance tests are given in two steps. First, disconnect the applicable cable from the ECU and measure the resistance across the terminals in the cable connector. If the resistance is within the specified range, both the cable and the sensor or valve are good.

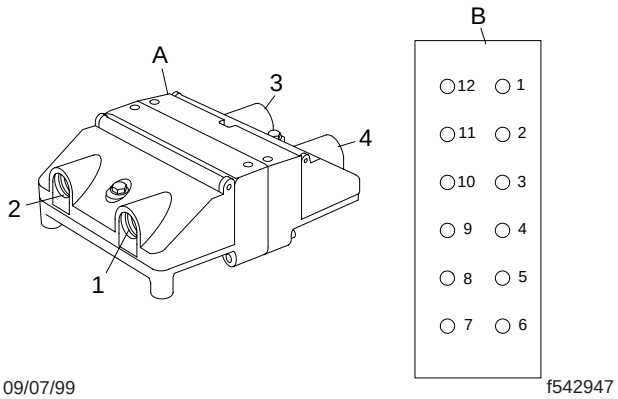
Next, if the resistance reading is not acceptable, disconnect the cable from the sensor or valve and measure the resistance across the sensor or valve terminals. This two-step procedure quickly determines whether the problem is in the cable or the component.

Wire Numbers and Connector Pin Locations

⚠ CAUTION

The ignition switch must be off when connecting or disconnecting connectors from the ECU. Power applied to the ECU during connector installation or removal could damage the pins.

The WABCO D-Version, frame-mounted ECU has several multi-pin connectors that must be disconnected to test the wheel speed sensors, modulator valves, or ATC valve. To disconnect the electrical connectors from the ABS ECU, remove the capscrews and lift the covers. See **Fig. 1** to identify the pin locations on the ECU connector. **Table 1** provides the wire numbers and circuit descriptions for testing the ABS/ATC components.



A. Frame-mounted ECU.
B. ECU connector pin locations.
1. X1 Connector (gray)
2. X2 Connector (black)
3. X3 Connector (green)
4. X4 Connector (brown—6S/4M, 6S/6M only)

Fig. 1, Frame-Mounted ECU and Pin Locations

ECU Supply Voltage Test

Use Meritor WABCO PC Diagnostics system to check the supply voltage to the ABS ECU. If the PC Diagnostics is not available, use the following procedure to check the voltage.

1. Park the vehicle on a level surface, set the parking brake, shut down the engine, and chock the rear tires.
2. Disconnect the X1 (gray) connector at the ABS ECU.
3. Turn the ignition switch on.
4. Connect a voltmeter between pin 1 and a good chassis ground. The voltmeter must indicate 9.5 to 14 volts.
5. Connect a voltmeter between pin 2 and a good chassis ground. The voltmeter must indicate 9.5 to 14 volts.
6. Turn the ignition switch off.
7. If the voltage at the ECU is not within the specified range, check the battery voltage and test the wiring to the ECU and to ground.

Testing

8. Connect the X1 connector to the ECU and remove the chocks from the tires.

ABS/ATC Circuit Pin and Wire Numbers				
Pin Connector	**Pin Number**	**Color**	**Wire Number**	**Circuit Description**
X1 Gray	1	—	16	ECU Ignition Supply
	2	—	16A	ECU #2 Positive 12 Volt Supply
	3	—	171	Wheel Spin Light and Switch
	4	—	716	J1587
	5	—	670	Retarder Interrupt Signal
	6	—	689	J1922–
	7	—	642	J1922+
	9	—	712	J1587–
	10	—	723	ABS Light and Switch
	11	—	57AH	ECU Ground
	12	—	57AG	ECU Ground
X2 Black	1	—	—	Not used
	2	Brown	378LFI	Left Front Modulator Valve, In
	3	Blue	378RF0	Right Front Modulator Valve, Out
	4	Brown	378RFI	Right Front Modulator Valve, In
	5	Brown	377RF+	Right Front Sensor, High
	6	Black	377RF–	Right Front Sensor, Low
	7	Black	377LF–	Left Front Sensor, Low
	8	Brown	377LF+	Left Front Sensor, High
	9	Green-Yellow	378RF–	Right Front Modulator Valve, Ground
	10	Blue	378LF0	Left Front Modulator Valve, Out
	11	Green-Yellow	378LF–	Left Front Modulator Valve, Ground
	12	—	—	Not used

ABS/ATC Circuit Pin and Wire Numbers				
Pin Connector	**Pin Number**	**Color**	**Wire Number**	**Circuit Description**
X3 Green	1	Brown	377RR+	Right Rear Sensor, High
	2	Black	377RR–	Right Rear Sensor, Low
	3	Brown	377LR+	Left Rear Sensor, High
	4	Black	377LR–	Left Rear Sensor, Low
	5	Brown	378T–	ATC Valve, Low
	6	Blue	378T+	ATC Valve, High
	7	Blue	378RR0	Right Rear Modulator Valve, Out
	8	Green-Yellow	378RR–	Right Rear Modulator Valve, Ground
	9	Brown	378RRI	Right Rear Modulator Valve, In
	10	Blue	378LR0	Left Rear Modulator Valve, Out
	11	Green-Yellow	378LR–	Left Rear Modulator Valve, Ground
	12	Brown	378LRI	Left Rear Modulator Valve, In
X4 Brown (third axle)	1	—	—	Not used
	2	—	—	Not used
	3	Brown	377LT+	Left Third-Axle Sensor, High
	4	Black	377LT–	Left Third-Axle Sensor, Low
	5	Brown	377RT+	Left Third-Axle Sensor, High
	6	Black	377RT–	Left Third-Axle Sensor, Low
	7	Blue	378RTO	Right Third-Axle Modulator Valve, In
	8	Green-Yellow	378RT–	Right Third-Axle Modulator Valve, Ground
	9	Brown	378RTI	Right Third-Axle Modulator Valve, Out
	10	Blue	378LTO	Left Third-Axle Modulator Valve, Out
	11	Green-Yellow	378LT–	Left Third-Axle Modulator Valve, Ground
	12	Brown	378LTI	Left Third-Axle Modulator Valve, In

Table 1, ABS/ATC Circuit Pin and Wire Numbers

ABS Pneumatic System Test

To check for air leaks in the ABS pneumatic system, listen for the sound of escaping air at each valve. To confirm a slow air leak, apply a soap-and-water solution to air line fittings and watch for bubbles.

Wheel Speed Sensor Tests

WHEEL SPEED SENSOR AND CIRCUIT RESISTANCE

To check the resistance in a wheel speed sensor circuit, perform the following test:

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Disconnect the sensor cable connector from the ABS ECU. See **Table 1**.

3. Connect ohmmeter probes to the sensor connector terminals and read the resistance.
    - If the resistance is 500 to 2000 ohms, the cable and the sensor circuit are good. Proceed to the "Wheel Speed Sensor Voltage" test.
    - If the resistance is less than 500 ohms or greater than 2000 ohms, perform the next test, "Wheel Speed Sensor Resistance."

WHEEL SPEED SENSOR RESISTANCE

To check the resistance in a wheel speed sensor, perform the following test:

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Disconnect the wheel sensor cable from the chassis harness.
3. Connect ohmmeter probes to the pins on the sensor and read the resistance.
    - If the resistance reading is 500 to 2000 ohms but the resistance noted in the previous test, "Wheel Speed Sensor and Cable Resistance" was not, repair or replace the chassis harness wiring.
    - If the resistance is less than 500 ohms or greater than 2000 ohms, clean the terminals and check the resistance again.
    - If the resistance reading is still not correct, replace the sensor. See **Subject 110** for instructions.
4. Install the connectors and remove the chocks from the tires.

WHEEL SPEED SENSOR VOLTAGE

To check the voltage output of a wheel speed sensor:

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine.
2. Chock the tires of the axle not being tested. Raise the vehicle and put jack stands under the axle so the wheels can rotate.
3. Disconnect the applicable connector from the ABS ECU for the sensor being tested. See **Table 1**.
4. Set a digital multimeter to the AC voltmeter mode. Connect the probes to the cable connector terminals for the sensor being tested.
5. Rotate the wheel by hand at a speed of 30 rpm (one-half revolution per second) and read the voltage output. The wheel speed sensor must generate a minimum of 0.2 volt AC.
    - If the voltage is at least 0.2 volt AC, skip to the next step.
    - If the voltage reading is less than 0.2 volt AC, push the sensor in its holder until the sensor touches the tooth wheel. See **Subject 120** for instructions. Repeat the voltage test.
    - If the sensor output is still less than 0.2 volt AC, replace the sensor.
6. Install the connector on the ECU. Remove the jack stands, lower the vehicle, and remove the chocks from the tires.

Modulator Valve Tests

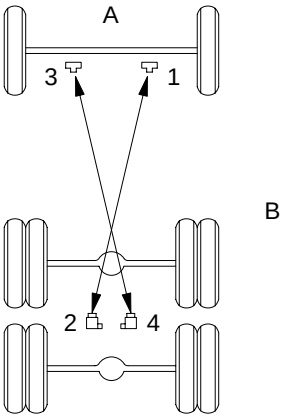
MODULATOR VALVE FUNCTION CHECK

NOTE: Valves can be tested using the Meritor WABCO PC Diagnostics software or the following procedure.

Modulator valves control the air pressure to each affected brake during an ABS function. To make sure the modulator valves are working, listen to them cycle during the ABS self-test.

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Turn the ignition switch on.
3. When the ABS warning light comes on, listen for the modulator valves to cycle one by one, then together diagonally. See **Fig. 2**.
    - 4-Channel valve cycle: 1, 2, 3, 4; then 1 and 2 together followed by 3 and 4.

- 6-Channel valve cycle: 1, 2, 3, 4, 5, 6; then 1, 2, and 3 together followed by 4, 5, and 6.



NOTE: During the self-test, the valves cycle one by one in order (1–2–3–4), then in pairs diagonally (1/2 and 3/4). A 4-channel valve cycle is shown.

A. Cab
B. Curbside
1. Right Front Modulator Valve
2. Left Rear Modulator Valve
3. Left Front Modulator Valve
4. Right Rear Modulator Valve

Fig. 2, Modulator Valve Self-Test Sequence

4. If the valves do not all cycle correctly, turn the ignition off and check the connectors for tightness. Repeat the self-test.
5. If the valves still do not cycle correctly, start the engine and check the air line connections to the valves for leaks. Shut down the engine and tighten the air line fittings. Repeat the self-test.
6. If the valves still do not cycle correctly, perform the next test, "Modulator Valve and Cable Resistance."

MODULATOR VALVE AND CABLE RESISTANCE

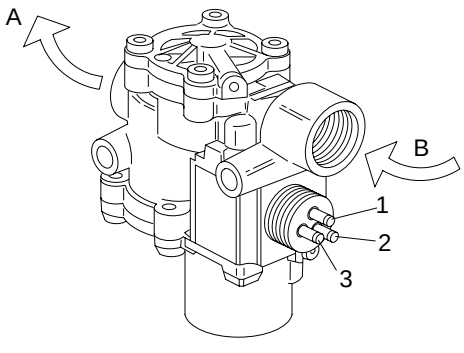
To check the resistance in a modulator valve and cable circuit, perform the following test:

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Disconnect the modulator valve connector from the ABS ECU. See **Table 1**.
3. Connect ohmmeter probes to the cable connector pins for the modulator valve "In" solenoid and "Ground." Read the resistance. Then, move the probes to the "Out" and "Ground" pins and read the resistance.
4. The resistance in each solenoid coil and cable circuit must be 4 to 8 ohms.
   - If the resistance in each solenoid circuit is 4 to 8 ohms, the cable and modulator valve are good. Install the connector on the ECU and remove the chocks from the tires.
   - If the resistance in either solenoid circuit is less than 4 ohms or greater than 8 ohms, go to the next test, "Modulator Valve Resistance."

MODULATOR VALVE RESISTANCE

To check the resistance in the solenoid coils in an ABS modulator valve, perform the following test:

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Disconnect the cable connector from the modulator valve being tested. See **Table 1**.
3. Connect ohmmeter probes to the modulator valve "In" solenoid and "Ground" terminals and read the resistance. Then, move the probes to the "Out" and "Ground" terminals and read the resistance. See **Fig. 3** for the modulator terminal locations.
4. The resistance in each solenoid coil must be 4 to 8 ohms.
   - If the resistance in each solenoid coil is 4 to 8 ohms but the resistance noted in the previous test, "Modulator Valve and Cable Resistance" was not, repair or replace the chassis harness.
   - If the resistance is less than 4 ohms or greater than 8 ohms, clean the terminals on the modulator valve and check the resistance again.



A. Delivery Port B. Supply Port
1. Ground (Common), green-yellow wire
2. Exhaust Solenoid (Out), blue wire
3. Supply Solenoid (In), brown wire

Fig. 3, Modulator Valve Terminals

- If the resistance is still not correct, replace the valve. See **Subject 130** for instructions.

5. Install the cable connectors and remove the chocks from the tires.

ATC Valve Tests

ATC VALVE AND CABLE RESISTANCE

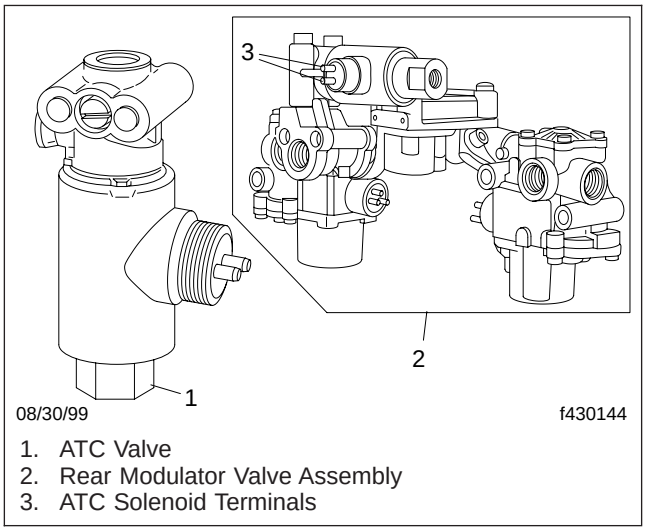
To check the resistance in the ATC valve and cable circuit, perform the following test:

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Disconnect the ATC valve connector from the ABS ECU. See **Table 1**.
3. Connect ohmmeter probes to the cable connector pins for the ATC valve and read the resistance.
4. The resistance in the ATC solenoid coil and cable circuit must be 6.4 to 12 ohms.
   - If the resistance is 6.4 to 12 ohms, the ATC valve and cable are good. Install the cable connector on the ECU and remove the chocks from the tires.
   - If the resistance is less than 6.4 ohms or greater than 12 ohms go to the next test, "ATC Valve Resistance."

ATC VALVE RESISTANCE

To check the resistance in the solenoid coil in the ATC valve, perform the following test:

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Disconnect the cable connector from the ATC valve. See **Table 1**.
3. Connect ohmmeter probes to the ATC valve terminals and read the resistance. See **Fig. 4**.



1. ATC Valve
2. Rear Modulator Valve Assembly
3. ATC Solenoid Terminals

Fig. 4, ATC Valve Terminals

4. The resistance of the ATC solenoid coil and its wiring must be 6.4 to 12 ohms.
   - If the resistance is 6.4 to 12 ohms but the resistance noted in the previous test, "ATC Valve and Cable Resistance" was not, repair or replace the electrical cable.
   - If the resistance is less than 6.4 ohms or greater than 12 ohms, clean the terminals on the ATC valve and check the resistance again.
   - If the resistance is still not correct, replace the valve. See **Subject 140** for instructions.

5. Install the connectors and remove the chocks from the tires.

Troubleshooting

⚠ WARNING

Before testing a vehicle equipped with Automatic Traction Control (ATC) on a dynamometer, the ATC system must be disabled. See Subject 160 for instructions. Activation of the vehicle ATC on a dynamometer will cause unequal drive-wheel torque that can result in loss of vehicle control and personal injury or death.

This subject includes troubleshooting procedures for diagnosing problems indicated by the ABS warning light(s) or the ATC wheel spin indicator light (if equipped) on the instrument panel. If any of these lights come on after the initial self-test, use one of the following methods to identify the problem:

- Troubleshoot using the Meritor WABCO PC Diagnostics software.
- Troubleshoot using J1587 codes viewed on a computer with Freightliner's ServiceLink installed.
- Troubleshoot using the instrument panel blink codes (with or without Pro-Link 9000®).

The J1587-code method provides more information about the specific problem than can be obtained from the blink codes.

The ABS (and ATC, if equipped) system has built-in diagnostics to ensure that all components are operating correctly. The first step is an automatic self-test. Under normal conditions, the ABS warning light(s) (ABS, TRAILER ABS, or ANTI LOCK) and ATC wheel spin indicator light (TRAC) light up on the instrument cluster when the ignition is turned on. After about 3 seconds, these lights should go out if all of the vehicle's ABS/ATC components are working.

If any of the lights stay on, or come back on later, a problem within the ABS/ATC system has occurred. The driver can continue to drive the vehicle, but the ABS system could be partially or completely inoperative.

NOTE: The TRAC indicator stays lit when the ATC is controlling wheel spin and blinks continuously if the ATC switch (TRAC MUD/SNOW) is activated. These are normal conditions and do not indicate a fault.

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 stays on after the 3-second self-test, there is an active system fault that must be repaired to ensure proper system operation.

If the light does not stay on, a stored or intermittent fault (indicating a loose connector or broken wire) has been recorded in the ABS electronic control unit (ECU) memory.

If either light does not come on during the self-test, check the bulb, all related circuit breakers in the electrical panel, or the batteries (the ABS/ATC system requires at least 9.5 volts to function correctly).

If a fault has been corrected since the ABS warning light originally came on, the system must be calibrated by driving the vehicle a short distance at 4 mph (6 km/h) or more before the light will go out.

Using Meritor WABCO PC Diagnostics

Follow the instructions in the Meritor WABCO PC Diagnostics manual for troubleshooting the ABS/ATC system.

Using J1587 Fault Codes

Use Freightliner's ServiceLink to diagnose the ABS/ATC system if detailed fault codes are needed or if the diagnosis must be done remotely. Connect a computer, with ServiceLink installed, to the J1587 datalink connector located under the left-hand dash. Follow the instructions found in the ServiceLink manual.

The J1587 fault codes are eight-digit numbers.

- The first three digits refer to the message identifier (MID) that indicates the ECU reporting the fault. The MID is 136 for the ABS/ATC ECU.
- The next three digits (preceded by a lowercase "s") represents the subsystem identifier (SID), which indicates the component at fault.
- The last two digits, the Failure Mode Identifier (FMI), represent the specific problem with the component.

The tables provided in "Troubleshooting Tables" all have an MID code of 136. Each table lists all the FMI codes for a specific component (SID). See **Table 1**

Troubleshooting for D-Version ABS

for a list of the first six digits of the fault codes with their corresponding components and troubleshooting table references.

Active faults cannot be cleared until they are repaired. A wheel sensor fault that has been repaired will not be cleared from memory until the vehicle has been driven at least 4 mph (6 km/h) to calibrate the system.

To erase all the stored fault codes from the ECU memory, refer to the ServiceLink manual. Make sure to make a note of all the stored fault codes before clearing them. Stored faults cannot be cleared if active faults exist.

J1587 Fault Code Cross-Reference		
Fault Code, First 6 Digits	**Component or Area**	**Troubleshooting Table**
136001	Left Front Wheel Sensor	**Table 4**
136002	Right Front Wheel Sensor	**Table 5**
136003	Left Rear Wheel Sensor	**Table 6**
136004	Right Rear Wheel Sensor	**Table 7**
136005	Left Third Wheel Sensor *	**Table 8**
136006	Right Third Wheel Sensor *	**Table 9**
136007	Left Front Modulator Valve	**Table 10**
136008	Right Front Modulator Valve	**Table 11**
136009	Left Rear Modulator Valve	**Table 12**
136010	Right Rear Modulator Valve	**Table 13**
136011	Left Third Modulator Valve †	**Table 14**
136012	Right Third Modulator Valve	**Table 15**
136013	Retarder	**Table 16**
136014	Ground (diagonal 1)	**Table 17**
136015	Ground (diagonal 2)	**Table 18**
136018	ATC Valve	**Table 19**
136023	Warning Light	**Table 20**
136248	SAE-J1939 Datalink	**Table 21**
136249	SAE-J1922 Datalink	**Table 22**
136251	Voltage	**Table 23**
136253	Configuration	**Table 24**
136254	Miscellaneous	**Table 25**

***** The left or right third wheel sensor is located at the wheel end of the rearmost axle on a 6S/4M or 6S/6M configuration.

† The left or right third modulator valve is located on the chassis near the rearmost axle on a 6S/6M configuration.

Table 1, J1587 Fault Code Cross-Reference

Using The Instrumentation Panel Blink Codes

NOTE: If troubleshooting the system with the Pro-Link 9000, use the instruction booklet that is supplied with the WABCO D-Version ABS cartridge.

Use the ABS CHECK switch and the ABS warning light to:

- Display any active or stored faults (press the ABS CHECK switch 1 second for the Diagnostic mode).
- Erase stored faults from the ECU memory or display the system identification code (press the ABS CHECK switch 3 seconds for the Clear All mode).

NOTE: For simplicity, the ABS warning light will be referred to as the ABS light in this procedure. The warning light(s) on your vehicle may indicate ABS, TRAILER ABS, or ANTI LOCK.

Displaying Fault Codes

Fault codes are displayed as follows:

- With the ignition switch on, press the ABS CHECK switch for about 1 second (Diagnostic mode), then release. The ABS light should go out during the 1-1/2 second pause. See **Fig. 1**.
- The ABS light will blink (flash) a number equal to the first digit of the two-digit fault code. The first digit is a number from one to eight.
- After a 1-1/2 second pause, the light will blink the second digit. The number of blinks for the second digit is from one to six.
- After a 4-second pause, the cycle repeats an active fault code until it is repaired.
- If there are no active faults but one or more stored faults are in the ECU memory, the system will display all recorded faults in sequence starting with the most recent, with a 4-second pause between codes.

For example, after the ABS CHECK switch is pressed 1 second and released, fault code 2–3 is indicated by two blinks, a pause of 1-1/2 seconds, followed by three blinks and a 4-second pause.

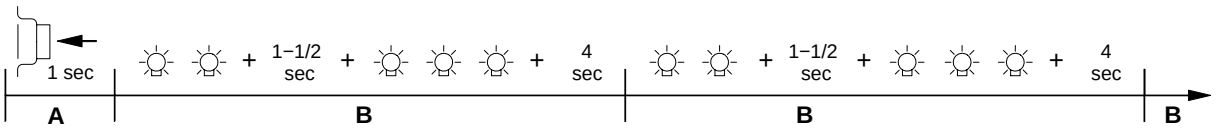
- If it is an active fault, the same fault code will repeat until the ignition switch is turned off. See **Fig. 1**.
- If it is a stored fault, the next fault in the ECU memory will be displayed after the 4-second pause. See **Fig. 2**. The last fault stored in memory is displayed first; each stored fault is displayed only once.
- If there are no fault codes in the ECU memory, blink code 1–1 is displayed, meaning the system is clear. See **Fig. 3**.

Identifying Blink Codes

The first digit in a blink code identifies the type of fault; the second digit indicates the specific location of the fault. See **Table 2** to identify the blink codes.

CAUTION

The ignition switch must be off when connecting or disconnecting connectors from the ECU. Power applied to the ECU during connector installation or removal could damage the pins.



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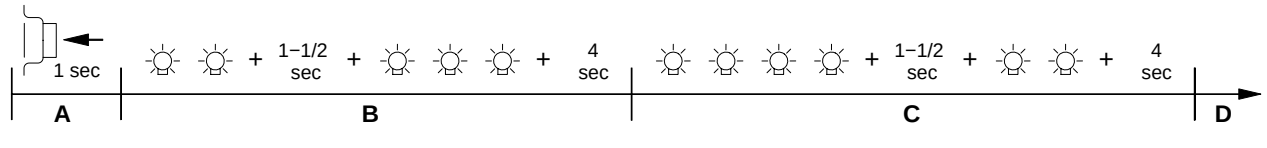
NOTE: An active fault code repeats until the ignition switch is turned off.

A. Press the ABS CHECK switch 1 second. The ABS light goes out during a 1-1/2 second pause.
B. Blink code 2–3: two blinks, a 1-1/2 second pause, three blinks, and a 4-second pause.

Fig. 1, Active Fault Codes Repeat (blink code 2-3 shown)

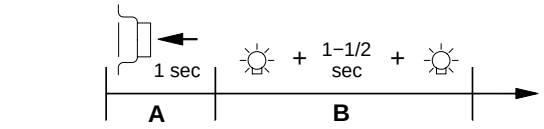
Troubleshooting for D-Version ABS



NOTE: The last fault stored is displayed first; each stored fault is displayed only once.

A. Press the ABS CHECK switch 1 second. The ABS light goes out during a 1-1/2 second pause.
B. The newest stored fault is displayed (blink code 2–3 is shown).
C. The second newest stored fault is displayed if one exists (blink code 3–2 is shown).
D. The third newest stored fault is displayed if one exists.

Fig. 2, Stored Fault Codes Display in Sequence



A. Press the ABS CHECK switch 1 second. The ABS light goes out during a 1-1/2 second pause.
B. Blink code 1–1: one blink, a 1-1/2 second pause, and 1 blink.

Fig. 3, No Faults, System OK

Once a fault code has been identified, use a multimeter to check the electrical harness at the ABS ECU connectors. See **Testing, 200** for wire numbers and connector pin locations on the frame-mounted ECU.

Refer to the applicable table in "Troubleshooting Tables" for fault codes, pins to be tested, and the correct multimeter 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** for information on special terminals and connectors, and ordering tools for them.

Refer to the wiring diagrams in **Specifications, 400** when troubleshooting the ABS system.

After the repair is complete, drive the vehicle at least 4 mph (6km/h) to calibrate the ABS/ATC system. Then, shut down the engine and turn the ignition switch on to verify the fault is no longer active. After pressing the ABS CHECK switch 1 second, a 1–1 "no fault" blink code should be displayed if there are no stored faults in the ECU memory.

Erasing Stored Faults

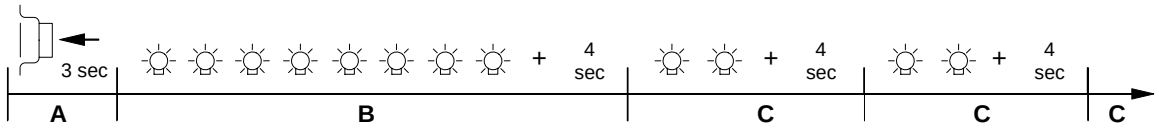
An active fault code cannot be erased from ECU memory but stored faults can be erased all at once without being repaired. Make sure that all stored fault codes are recorded before they are erased because they should be repaired as soon as possible.

Stored faults can be erased from the ECU memory as follows:

- Press the ABS CHECK switch for 3 to 6 seconds (Clear All mode).
- After releasing the switch, the ABS light will go out during the 1-1/2 second pause.
- If there were stored faults but no active faults, the ABS light will blink eight times meaning all stored faults have been cleared. See **Fig. 4**. (If there are active faults, only the system identification code will be displayed. See **Fig. 5**).
- After a 4-second pause, the ABS light will display the system identification code followed by another 4-second pause repeatedly until the ignition switch is turned off.

If there are active faults, only the system identification code will be displayed. See **Fig. 5**.

The system identification code indicates the number of ABS wheel speed sensors (S) and modulator valves (M) installed on the vehicle. See **Table 3** for a list of system identification codes.



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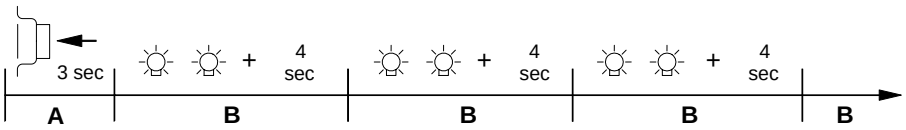
A. Press the ABS CHECK switch 3 seconds. The ABS light goes out during a 1-1/2 second pause.
B. Eight quick blinks followed by a 4-second pause. (Faults cleared.)
C. The system ID code followed by a 4-second pause repeats until the ignition switch is turned off. (The system ID code for a 4 x 4 vehicle is two quick blinks.)

Fig. 4, Stored Faults Cleared



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A. Press the ABS CHECK switch 3 seconds. The ABS light goes out during a 1-1/2 second pause.
B. The system ID code followed by a 4-second pause repeats until the ignition switch is turned off.

Fig. 5, Faults Not Cleared (active faults still exist)

ABS Blink Codes			
1st Digit (blinks)	**Type of Fault**	**2nd Digit (blinks)**	**Specific Location of Fault**
1	No Faults	1	—
2	ABS Modulator Valve	1	Right Front Steer Axle
		2	Left Front Steer Axle
		3	Right Rear Drive Axle
		4	Left Rear Drive Axle
		5	Right Rear Additional Axle
		6	Left Rear Additional Axle
3	Sensor Gap Too Large	See 2nd digit and fault-location list above.	
4	Short or Open Sensor Circuit		
5	Erratic Sensor Signal		
6	Tone Wheel		

Troubleshooting for D-Version ABS

ABS Blink Codes			
1st Digit (blinks)	**Type of Fault**	**2nd Digit (blinks)**	**Specific Location of Fault**
7	System Function *	1	J1922 or J1939 Datalink
		2	ATC Valve
		3	Retarder Relay † (third brake)
		4	ABS Warning Light
		5	ATC Configuration
		6	Reserved for future use
8	ECU	1	Low Power Supply
		2	High Power Supply
		3	Internal Fault
		4	System Configuration
		5	Ground

* Reconfigure the ECU if fault messages appear for components not installed on the vehicle.

† The ECU detects only fault code 136 S013 03, indicating the retarder relay is shorted to power. See "Troubleshooting Tables," **Table 16**. If the retarder relay circuit is open or if it is shorted to ground, the system will not indicate a fault.

Table 2, ABS Blink Codes

System Identification Blink Codes		
Blink Code	**Sensors/ Modulators**	**Vehicle Wheel Positions**
1 Blink	6S/6M	6 x 2
2 Blinks	4S/4M	4 x 4
4 Blinks	6S/4M	6 x 4
5 Blinks	6S/6M	6 x 4

Table 3, System Identification Blink Codes

If a fault cannot be repaired or erased from ECU memory, contact your Meritor district service manager or call Meritor WABCO at 1-800-535-5560.

Troubleshooting Tables

Left Front Wheel Sensor Troubleshooting (SID = s001)					
J1587 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 7 and 8 of the X2 (black) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 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

Left Front Wheel Sensor Troubleshooting (SID = s001)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	001	03	Shorted to power	Measure the voltage across pin 7 of the X2 (black) connector and ground, and pin 8 of the X2 connector and ground. If the measurement indicates a voltage, the sensor is shorted to power.	4–2
136	001	04	Shorted to ground	Check the continuity between pin 7 of the X2 (black) connector and ground, and pin 8 of the X2 connector and ground. If continuity exists in either pin, the sensor is shorted to ground.	
136	001	05	Open circuit	Check the continuity between pins 7 and 8 of the X2 (black) connector. A good resistance measurement will be between 500 and 2000 ohms. If the resistance is not within this range, check the sensor and the chassis wiring.	
136	001	06	Short circuit	Check the continuity between pins 7 and 8 of the X2 (black) connector. A good resistance measurement will be between 500 and 2000 ohms. If the resistance is not within this range, check the sensor and the chassis wiring.	
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 7 and 8 of the X2 (black) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 30 rpm. A fault is triggered if the wheel slips longer than 16 seconds.	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
136	001	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 7 and 8 of the X2 (black) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 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 7 and 8 of the X2 (black) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 30 rpm. *	5–2
136	001	12	Frequency incorrect	Check the sensor wiring and connectors for intermittent contact. The ECU may be at fault if the problem persists.	

* Use Meritor WABCO PC Diagnostics software to view the wheel speed signals. If there is an intermittent loss of the signal, check the connections.

Table 4, Left Front Wheel Sensor Troubleshooting (SID = s001)

Right Front Wheel Sensor Troubleshooting (SID = s002)					
J1587 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 5 and 6 of the X2 (black) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–1

Troubleshooting for D-Version ABS

Right Front Wheel Sensor Troubleshooting (SID = s002)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
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 voltage across pin 4 of the X2 (black) connector and ground, and pin 6 of the X2 connector and ground. If the measurement indicates a voltage, the sensor is shorted to power.	4–1
136	002	04	Shorted to ground	Check the continuity between pin 4 of the X2 (black) connector and ground, and pin 6 of the X2 connector and ground. If continuity exists in either pin, the sensor is shorted to ground.	
136	002	05	Open circuit	Check the continuity between pins 5 and 6 of the X2 (black) connector. A good resistance measurement will be between 500 and 2000 ohms. If the resistance is not within this range, check the sensor and the chassis wiring.	
136	002	06	Short circuit	Check the continuity between pins 5 and 6 of the X2 (black) connector. A good resistance measurement will be between 500 and 2000 ohms. If the resistance is not within this range, check the sensor and the chassis wiring.	
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 5 and 6 of the X2 (black) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 30 rpm. A fault is triggered if the wheel slips longer than 16 seconds.	3–1
136	002	09	Wires mismatched	Check for a mismatch fault of another sensor and correct the problem in the wiring harness.	5–1
136	002	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 5 and 6 of the X2 (black) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 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 5 and 6 of the X2 (black) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 30 rpm. *	5–1
136	002	12	Frequency incorrect	Check the sensor wiring and connectors for intermittent contact. The ECU may be at fault if the problem persists.	

* Use Meritor WABCO PC Diagnostics software to view the wheel speed signals. If there is an intermittent loss of the signal, check the connections.

Table 5, Right Front Wheel Sensor Troubleshooting (SID = s002)

Left Rear Wheel Sensor Troubleshooting (SID = s003)					
J1587 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 1 and 2 of the X3 (green) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 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 voltage across pin 1 of the X3 (green) connector and ground, and pin 2 of the X3 connector and ground. If the measurement indicates a voltage, the sensor is shorted to power.	4–4
136	003	04	Shorted to ground	Check the resistance between pin 11 and 14 of the X3 (green) connector and ground, and pin 2 of the X3 connector and ground. If continuity exists in either pin, the sensor is shorted to ground.	
136	003	05	Open circuit	Check the continuity between pins 1 and 2 of the X3 (green) connector. A good resistance measurement will be between 500 and 2000 ohms. If the resistance is not within this range, check the sensor and the chassis wiring.	
136	003	06	Short circuit	Check the continuity between pins 1 and 2 of the X3 (green) connector. A good resistance measurement will be between 500 and 2000 ohms. If the resistance is not within this range, check the sensor and the chassis wiring.	
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 1 and 2 of the X3 (green) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 30 rpm. A fault is triggered if the wheel slips longer than 16 seconds.	3–4
136	003	09	Wires mismatched	Check for a mismatch fault of another sensor and correct the problem in the wiring harness.	5–4
136	003	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 1 and 2 of the X3 (green) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 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 1 and 2 of the X3 (green) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 30 rpm. *	5–4
136	003	12	Frequency incorrect	Check the sensor wiring and connectors for intermittent contact. The ECU may be at fault if the problem persists.	

* Use Meritor WABCO PC Diagnostics software to view the wheel speed signals. If there is an intermittent loss of the signal, check the connections.

Table 6, Left Rear Wheel Sensor Troubleshooting (SID = s003)

Troubleshooting for D-Version ABS

Right Rear Wheel Sensor Troubleshooting (SID = s004)					
J1587 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 3 and 4 of the X3 (green) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 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 voltage across pin 3 of the X3 (green) connector and ground, and pin 4 of the X3 connector and ground. If the measurement indicates a voltage, the sensor is shorted to power.	4–3
136	004	04	Shorted to ground	Check the continuity between pin 3 of the X3 (green) connector and ground, and pin 4 of the X3 connector and ground. If continuity exists in either pin, the sensor is shorted to ground.	
136	004	05	Open circuit	Check the continuity between pins 3 and 4 of the X3 (green) connector. A good resistance measurement will be between 500 and 2000 ohms. If the resistance is not within this range, check the sensor and the chassis wiring.	
136	004	06	Short circuit	Check the continuity between pins 3 and 4 of the X3 (green) connector. A good resistance measurement will be between 500 and 2000 ohms. If the resistance is not within this range, check the sensor and the chassis wiring.	
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 3 and 4 of the X3 (green) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 30 rpm. A fault is triggered if the wheel slips longer than 16 seconds.	3–3
136	004	09	Wires mismatched	Check for a mismatch fault of another sensor and correct the problem in the wiring harness.	5–3
136	004	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 3 and 4 of the X3 (green) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 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 3 and 4 of the X3 (green) connector. A good measurement should be above 0.2 volt AC when the tire is rotated 30 rpm. *	5–3
136	004	12	Frequency incorrect	Check the sensor wiring and connectors for intermittent contact. The ECU may be at fault if the problem persists.	

* Use Meritor WABCO PC Diagnostics software to view the wheel speed signals. If there is an intermittent loss of the signal, check the connections.

Table 7, Right Rear Wheel Sensor Troubleshooting (SID = s004)

Left Third Wheel Sensor Troubleshooting (SID = s005)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	005	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 3 and 4 of the X4 (brown) connector. A good measurement should be above 0.2 volt AC when the tire is rotated at 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–6
136	005	02	Incorrect tire	Check for correct tire size. Check for correct number of teeth on the tone wheel.	5–6
136	005	03	Shorted to power	Measure the voltage across pin 3 of the X4 (brown) connector and ground, and pin 4 of the X4 connector and ground. If the measurement indicates a voltage, the sensor is shorted to power.	4–6
136	005	04	Shorted to ground	Check the continuity between pin 3 of the X4 (brown) connector and ground, and pin 4 of the X4 connector and ground. If continuity exists in either pin, the sensor is shorted to ground.	4–6
136	005	05	Open circuit	Check the continuity between pins 3 and 4 of the X4 (brown) connector. A good resistance measurement will be between 700 and 3000 ohms.	4–6
136	005	06	Short circuit	Check the continuity between pins 3 and 4 of the X4 (brown) connector. A good resistance measurement will be between 700 and 3000 ohms.	4–6
136	005	07	Damaged tone wheel	Check the tone wheel for damage such as missing teeth.	6–6
136	005	08	Wheel slip	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 3 and 4 of the X4 (brown) connector. A good measurement should be above 0.2 volt AC when the tire is rotated at 30 rpm. A fault is triggered if the wheel slips longer than 16 seconds.	3–6
136	005	09	Wires mismatched	Check for a mismatch fault of another sensor and correct the problem in the wiring harness.	5–6
136	005	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 3 and 4 of the X4 (brown) connector. A good measurement should be above 0.2 volt AC when the tire is rotated at 30 rpm. *	3–6
136	005	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 3 and 4 of the X4 (brown) connector. A good measurement should be above 0.2 volt AC when the tire is rotated at 30 rpm. *	5–6
136	005	12	Frequency incorrect	Check the sensor wiring and connectors for intermittent contact. The ECU may be at fault if the problem persists.	5–6

* Use Meritor WABCO PC Diagnostics software to view the wheel speed signals. If there is an intermittent loss of the signal, check the connections.

Table 8, Left Third Wheel Sensor Troubleshooting (SID = s005)

Troubleshooting for D-Version ABS

Right Third Wheel Sensor Troubleshooting (SID = s006)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	006	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 5 and 6 of the X4 (brown) connector. A good measurement should be above 0.2 volt AC when the tire is rotated at 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–5
136	006	02	Incorrect tire	Check for correct tire size. Check for correct number of teeth on the tone wheel.	5–5
136	006	03	Shorted to power	Measure the voltage across pin 5 of the X4 (brown) connector and ground, and pin 6 of the X4 connector and ground. If the measurement indicates a voltage, the sensor is shorted to power.	4–5
136	006	04	Shorted to ground	Check the continuity between pin 5 of the X4 (brown) connector and ground, and pin 6 of the X4 connector and ground. If continuity exists in either pin, the sensor is shorted to ground.	4–5
136	006	05	Open circuit	Check the continuity between pins 5 and 6 of the X4 (brown) connector. A good resistance measurement will be between 700 and 3000 ohms.	4–5
136	006	06	Short circuit	Check the continuity between pins 5 and 6 of the of the X4 (brown) connector. A good resistance measurement will be between 700 and 3000 ohms.	4–5
136	006	07	Damaged tone wheel	Check the tone wheel for damage such as missing teeth.	6–5
136	006	08	Wheel slip	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 5 and 6 of the X4 (brown) connector. A good measurement should be above 0.2 volt AC when the tire is rotated at 30 rpm. A fault is triggered if the wheel slips longer than 16 seconds.	3–5
136	006	09	Wires mismatched	Check for a mismatch fault of another sensor and correct the problem in the wiring harness.	5–5
136	006	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 5 and 6 of the X4 (brown) connector. A good measurement should be above 0.2 volt AC when the tire is rotated at 30 rpm. *	3–5
136	006	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 5 and 6 of the X4 (brown) connector. A good measurement should be above 0.2 volt AC when the tire is rotated at 30 rpm. *	5–5
136	006	12	Frequency incorrect	Check the sensor wiring and connectors for intermittent contact. The ECU may be at fault if the problem persists.	5–5

* Use Meritor WABCO PC Diagnostics software to view the wheel speed signals. If there is an intermittent loss of the signal, check the connections.

Table 9, Right Third Wheel Sensor Troubleshooting (SID = s006)

Left Front Modulator Valve Troubleshooting (SID = s007)					
J1587 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 modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 10 and 11 of the X2 (black) connector, and between pins 2 and 11. A good measurement should be between 4 and 8 ohms.	2–2
136	007	03	Shorted to power	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the voltage across pins 2, 10, and 11 of the X2 (black) connector and ground. If any of the measurements indicate a voltage, the valve is shorted to power.	
136	007	05	Open circuit	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 10 and 11 of the X2 (black) connector, and between pins 2 and 11 of the X2 connector. A good measurement should be between 4 and 8 ohms.	
136	007	06	Shorted to ground	Check continuity between pin 2 of the X2 (black) connector and ground, and pin 10 of the X2 connector and ground. If continuity exists in either pin, the valve is shorted to ground.	

Table 10, Left Front Modulator Valve Troubleshooting (SID = s007)

Right Front Modulator Valve Troubleshooting (SID = s008)					
J1587 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 modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 3 and 9 of the X2 (black) connector, and between pins 4 and 9. A good measurement should be between 4 and 8 ohms.	2–1
136	008	03	Shorted to power	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the voltage across pins 3, 4, and 9 of the X2 (black) connector and ground. If any of the measurements indicate a voltage, the valve is shorted to power.	
136	008	05	Open circuit	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 3 and 9 of the X2 (black) connector, and between pins 4 and 9 of the X2 connector. A good measurement should be between 4 and 8 ohms.	
136	008	06	Shorted to ground	Check continuity between pin 3 of the X2 (black) connector and ground, and pin 4 of the X2 connector and ground. If continuity exists in either pin, the valve is shorted to ground.	

Table 11, Right Front Modulator Valve Troubleshooting (SID = s008)

Troubleshooting for D-Version ABS

Left Rear Modulator Valve Troubleshooting (SID = s009)					
J1587 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 modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 10 and 11 of the X3 (green) connector, and between pins 12 and 11. A good measurement should be between 4 and 8 ohms.	2–4
136	009	03	Shorted to power	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the voltage across pins 10, 11, and 12 of the X3 (green) connector and ground. If any of the measurements indicate a voltage, the valve is shorted to power.	
136	009	05	Open circuit	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 10 and 11 of the X3 (green) connector, and between pins 12 and 11 of the X3 connector. A good measurement should be between 4 and 8 ohms.	
136	009	06	Shorted to ground	Check continuity between pin 10 of the X3 (green) connector and ground, and pin 12 of the X3 connector and ground. If continuity exists in either pin, the valve is shorted to ground.	

Table 12, Left Rear Modulator Valve Troubleshooting (SID = s009)

Right Rear Modulator Valve Troubleshooting (SID = s010)					
J1587 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 modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 7 and 8 of the X3 (green) connector, and between pins 9 and 8. A good measurement should be between 4 and 8 ohms.	2–3
136	010	03	Shorted to power	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the voltage across pins 7, 8, and 9 of the X3 (green) connector and ground. If any of the measurements indicate a voltage, the valve is shorted to power.	
136	010	05	Open circuit	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 7 and 8 of the X3 (green) connector, and between pins 9 and 8 of the X3 connector. A good measurement should be between 4 and 8 ohms.	
136	010	06	Shorted to ground	Check continuity between pin 7 of the X3 (green) connector and ground, and pin 9 of the X3 connector and ground. If continuity exists in either pin, the valve is shorted to ground.	

Table 13, Right Rear Modulator Valve Troubleshooting (SID = s010)

Left Third Modulator Valve Troubleshooting (SID = s011)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	011	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 10 and 11 of the X4 (brown) connector, and between pins 12 and 11. A good measurement should be between 4 and 8 ohms.	2–6
136	011	03	Shorted to power	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the voltage across pins 10, 11, and 12 of the X4 (brown) connector and ground. If any of the measurements indicate a voltage, the valve is shorted to power.	
136	011	05	Open circuit	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 10 and 11 of the X4 (brown) connector, and between pins 12 and 11 of the X4 connector. A good measurement should be between 4 and 8 ohms.	
136	011	06	Shorted to ground	Check continuity between pin 10 of the X4 (brown) connector and ground, and pin 12 of the X4 connector and ground. If continuity exists in either pin, the valve is shorted to ground.	

Table 14, Left Third Modulator Valve Troubleshooting (SID = s011)

Right Third Modulator Valve Troubleshooting (SID = s012)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	012	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 7 and 8 of the X4 (brown) connector, and between pins 9 and 8. A good measurement should be between 4 and 8 ohms.	2–5
136	012	03	Shorted to power	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the voltage across pins 7, 8, and 9 of the X3 (green) connector and ground. If any of the measurements indicate a voltage, the valve is shorted to power.	
136	012	05	Open circuit	Check the modulator valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 7 and 8 of the X4 (brown) connector, and between pins 9 and 8 of the X4 connector. A good measurement should be between 4 and 8 ohms.	
136	012	06	Shorted to ground	Check continuity between pin 7 of the X4 (brown) connector and ground, and pin 9 of the X4 connector and ground. If continuity exists in either pin, the valve is shorted to ground.	

Table 15, Right Third Modulator Valve Troubleshooting (SID = s012)

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Retarder Troubleshooting (SID = s013)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	013	03	Shorted to power	Measure the voltage between pin 5 of the X1 (gray) connector and ground. If the measurement indicates a voltage, the relay circuit is shorted to power.	7–3
136	013	05	Open circuit	Check continuity of the retarder relay circuit 376R. Replace the wire if continuity does not exist. Reconfigure the ECU if the fault message appears but no retarder is installed.	
136	013	06	Shorted to ground	Check continuity between pin 5 of the X1 (gray) connector and ground. If continuity exists, the retarder relay circuit is shorted to ground.	

Table 16, Retarder Troubleshooting (SID = s013)

Ground (diagonal 1–right front, left rear) Troubleshooting (SID = s014)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	014	04	Voltage, diagonal 1, low voltage/open circuit	Check the 10A circuit breaker F43. Check pin 1 in the X1 (gray) connector for proper contact. Check circuit 16, 16E. Check the vehicle batteries and charging system.	8–1
136	014	07	ABS ECU	Replace ECU if the fault repeats.	8–3

Table 17, Ground (diagonal 1; right front, left rear) Troubleshooting (SID = s014)

Ground (diagonal 2–left front, right rear) Troubleshooting (SID = s015)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	015	04	Voltage, diagonal 2, low voltage/open circuit	Check the 10A circuit breaker. Check pin 1 in the X1 (gray) connector for proper contact. Check circuit 16A,16F.	8–1
136	015	07	ABS ECU	Replace ECU if the fault repeats.	8–3

Table 18, Ground (diagonal 2; left front, right rear) Troubleshooting (SID = s015)

ATC Valve Troubleshooting (SID = s018)					
J1587 Fault Code *			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	018	03	ATC valve, shorted to power	Measure the voltage between pin 5 of the X3 (green) connector and ground, and pin 6 of the X3 connector and ground. If measurements indicate a voltage, the ATC valve is shorted to power.	7–2
136	018	05	ATC valve, open circuit	Check the resistance between pins 5 and 6 of the X3 (green) connector. A good measurement will read between 8 and 14 ohms. Check the wiring and the valve.	
136	018	06	ATC valve, shorted to ground	Check the continuity between pin 6 of the X3 (green) connector and ground. If continuity exists, there is a short to ground.	

* Reconfigure the ECU if the fault message appears but ATC is not installed.

Table 19, ATC Valve Troubleshooting (SID = s018)

Warning Light Troubleshooting (SID = s023)					
J1587 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 20, Warning Light Troubleshooting (SID = s023)

J1939 Datalink Troubleshooting (SID = s231)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	231	02	J1939 plausibility error	Check the speedometer calibration. Check for tire size mismatch.	7–1
136	231	05	The J1939 datalink has an open circuit.	Check J1939 datalink connections. Check for continuity of datalink wires. Reconfigure the ECU if the fault message appears but no J1939 datalink is installed.	
136	231	06	J1939 shorted to ground	Check the continuity between pin 6 of the X1 (gray) connector and ground, and pin 7 of the X1 (gray) connector and ground. If continuity exists, the J1939 datalink is shorted to ground.	
136	231	09	J1939 time-out	Check other J1939 ECUs for incorrect communication.	
136	231	12	J1939, internal error	Cycle the ignition off and on. If the fault detection repeats, replace the ABS ECU.	8–3

Table 21, J1939 Datalink Troubleshooting (SID = s231)

Troubleshooting for D-Version ABS

J1922 Datalink Troubleshooting (SID = s249)					
J1587 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. Reconfigure the ECU if the fault message appears but no J1922 datalink is installed.	7–1
136	249	06	The J1922 datalink is shorted to ground.	Check continuity between pin 6 of the X1 (gray) connector and ground, and pin 7 of the X1 (gray) connector and ground. If continuity exists, the J1922 datalink is shorted to ground.	
136	249	10	The J1922 bus is not free.	Check other J1922 ECUs for incorrect communication.	

Table 22, J1922 Datalink Troubleshooting (SID = s249)

Overvoltage Troubleshooting (SID = s251)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	251	03	Overvoltage, diagonal 1 or 2	Check the alternator output and the battery voltage. Supply voltage is greater than 14 volts for more than 5 seconds.	8–2

Table 23, Overvoltage Troubleshooting (SID = s251)

Configuration Troubleshooting (SID = s253)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	253	01	ATC configuration	Check the wires responsible for parameter setting.	7–5
136	253	02	EEPROM or ABS configuration, wheel parameter incorrect	Cycle the ignition off and on. If the fault detection repeats, replace the ABS ECU.	8–4
136	253	12	EEPROM, checksum	Check the parameter setting. Diagnostic device disconnected during active diagnosis. Cycle the ignition off and on. If the fault detection repeats, replace the ABS ECU.	

Table 24, Configuration Troubleshooting (SID = s253)

Miscellaneous ABS/ATC Troubleshooting (SID = s254)					
J1587 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 ECU.	8–3
136	254	05	ABS/ATC ECU, no loads	No modulators connected. Fault not memorized.	8–4
136	254	08	Excessive slip/ dynamometer	Check the wheel sensor air gaps, one axle is much faster than the other.	7–1

Miscellaneous ABS/ATC Troubleshooting (SID = s254)					
J1587 Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	254	09	Modulator 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 ECU.	8–3

Table 25, Miscellaneous ABS/ATC Troubleshooting (SID = s254)

Wiring Diagrams

Use the following wiring diagrams when troubleshooting the Meritor WABCO D-Version ABS/ATC system with a frame-mounted ECU:

- For systems with the J1922 datalink, see **Fig. 1** for a full view of wiring diagram D06-31049.

  See **Fig. 2** or **Fig. 3** for enlarged partial views.

- For systems with the J1939 datalink, see **Fig. 4** for a full view of wiring diagram D06-31861.

  See **Fig. 5** or **Fig. 6** for enlarged partial views.

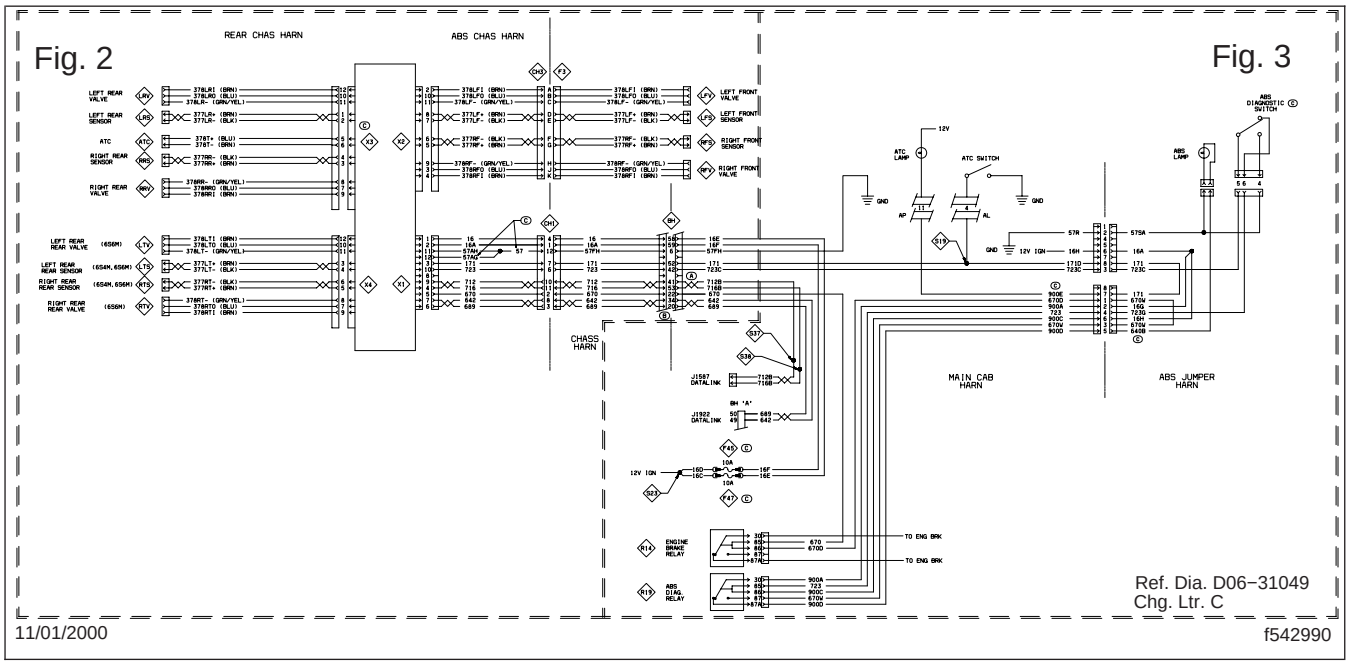


Fig. 1, J1922 Datalink, WABCO ABS D-Version Wiring Diagram (full view)

Specifications

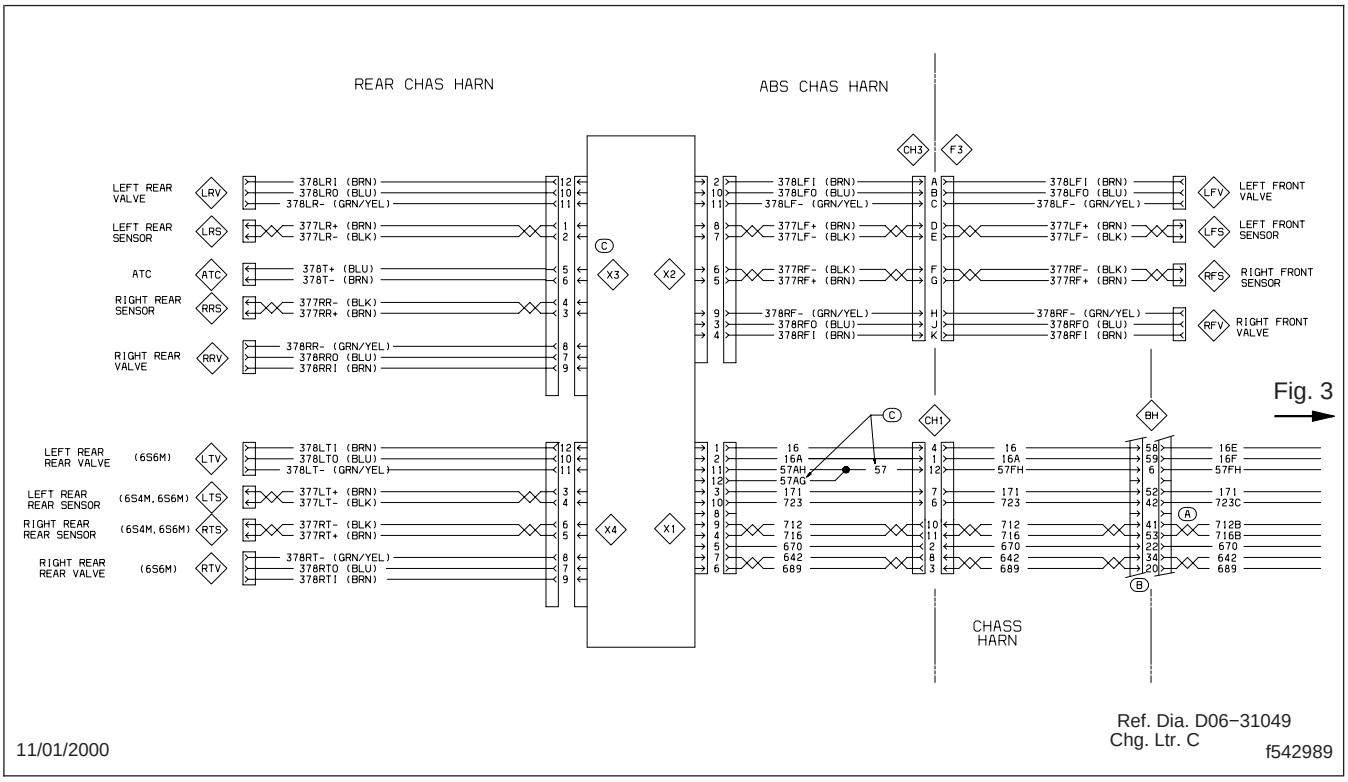


Fig. 2, J1922 Datalink, WABCO ABS D-Version Wiring Diagram (partial view)

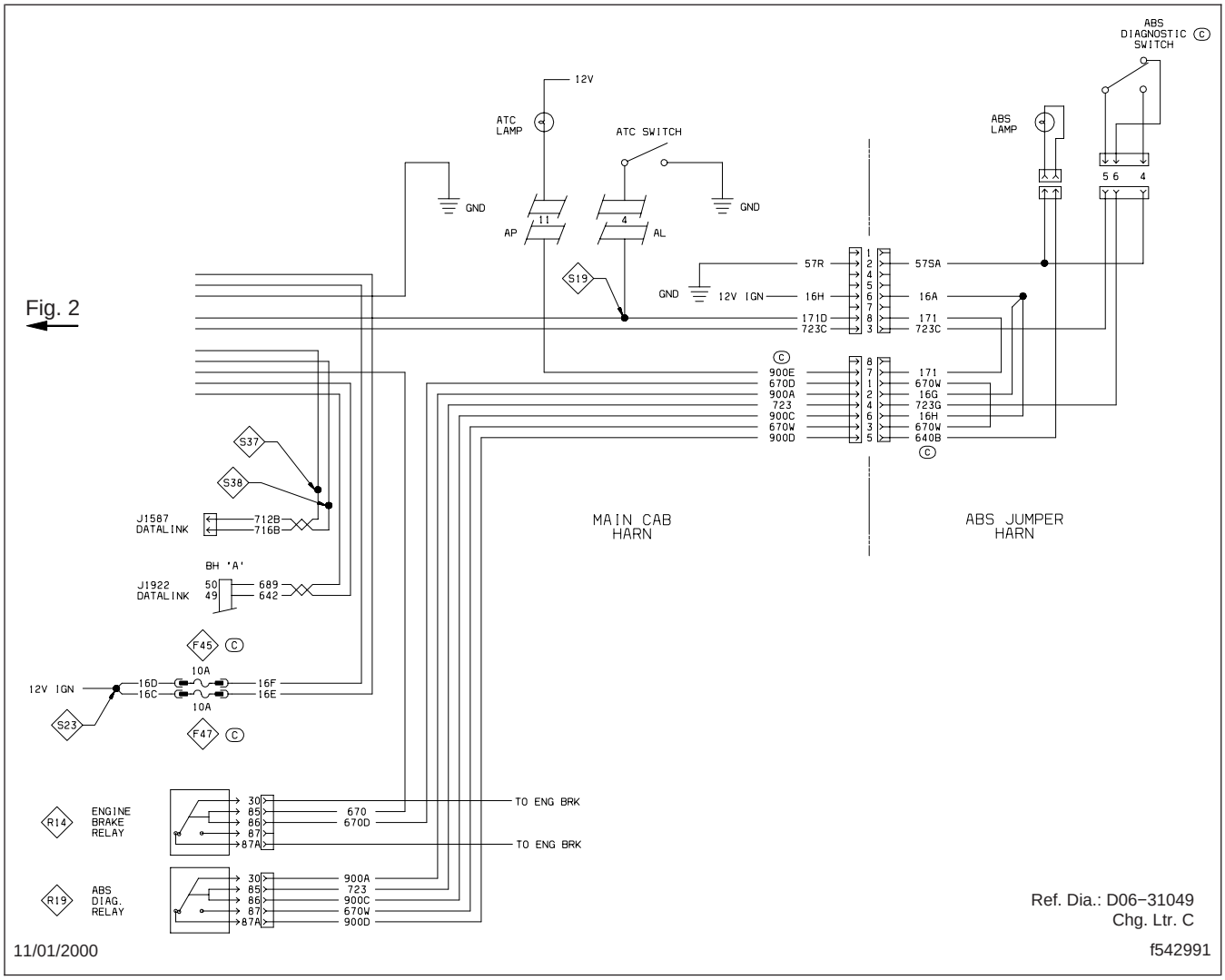


Fig. 3, J1922 Datalink, WABCO ABS D-Version Wiring Diagram (partial view)

Specifications

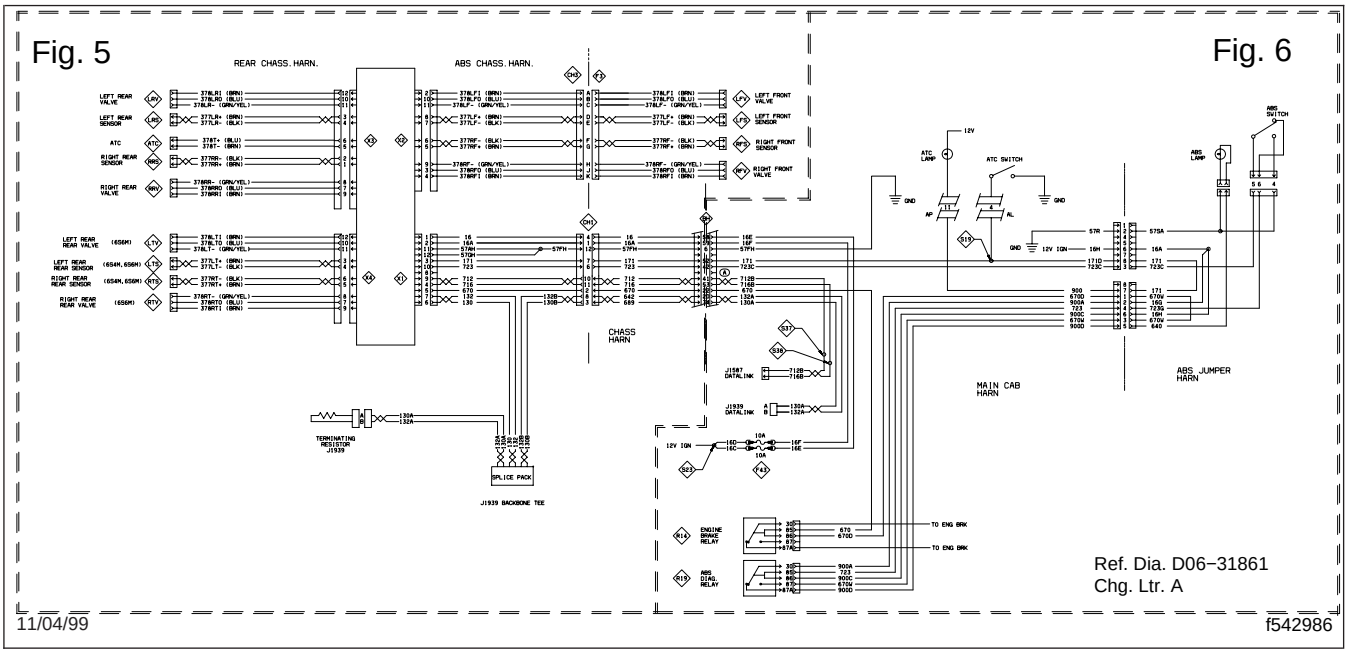


Fig. 4, J1939 Datalink, WABCO ABS D-Version Wiring Diagram (full view)

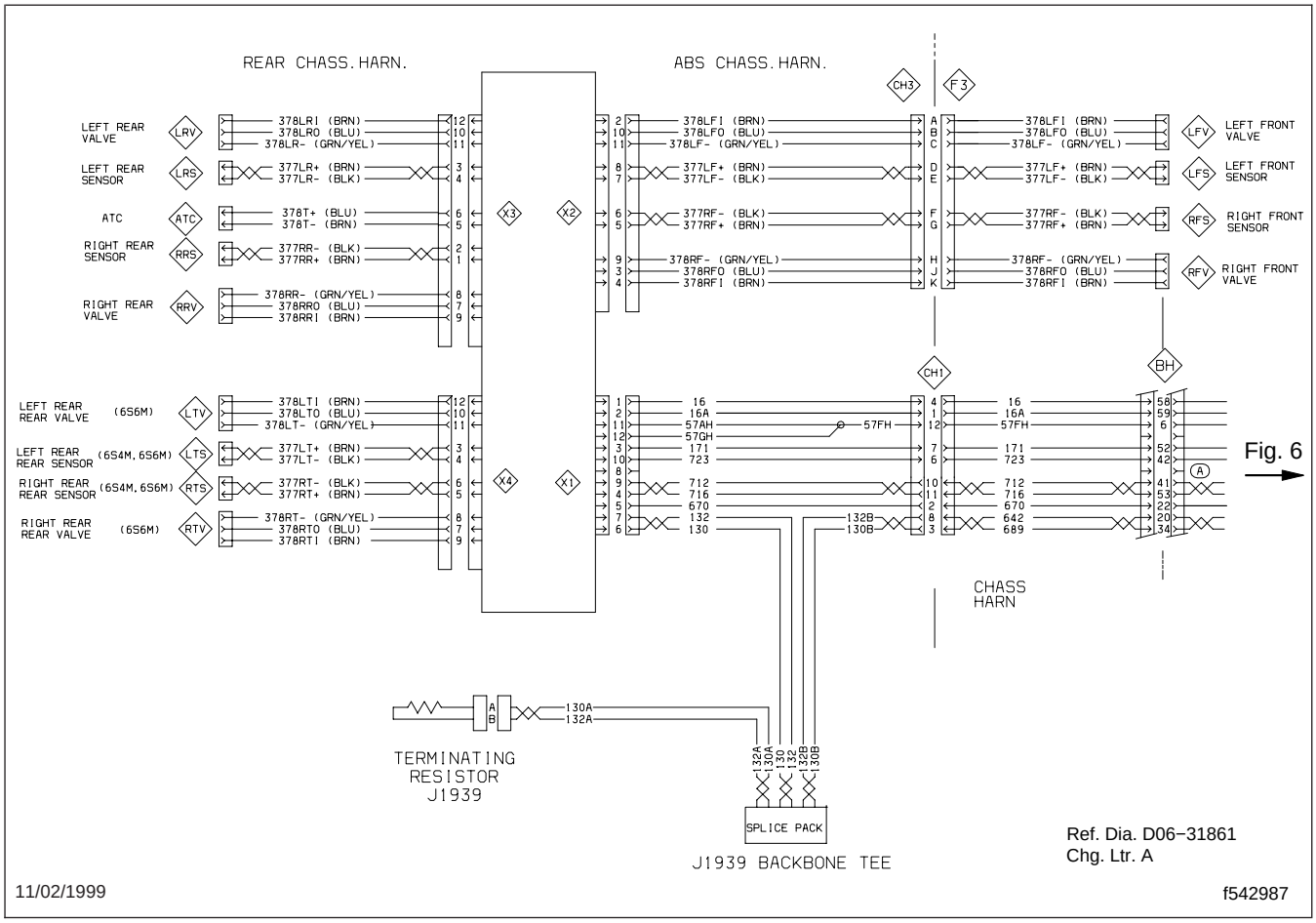


Fig. 5, J1939 Datalink, WABCO ABS D-Version Wiring Diagram (partial view)

Specifications

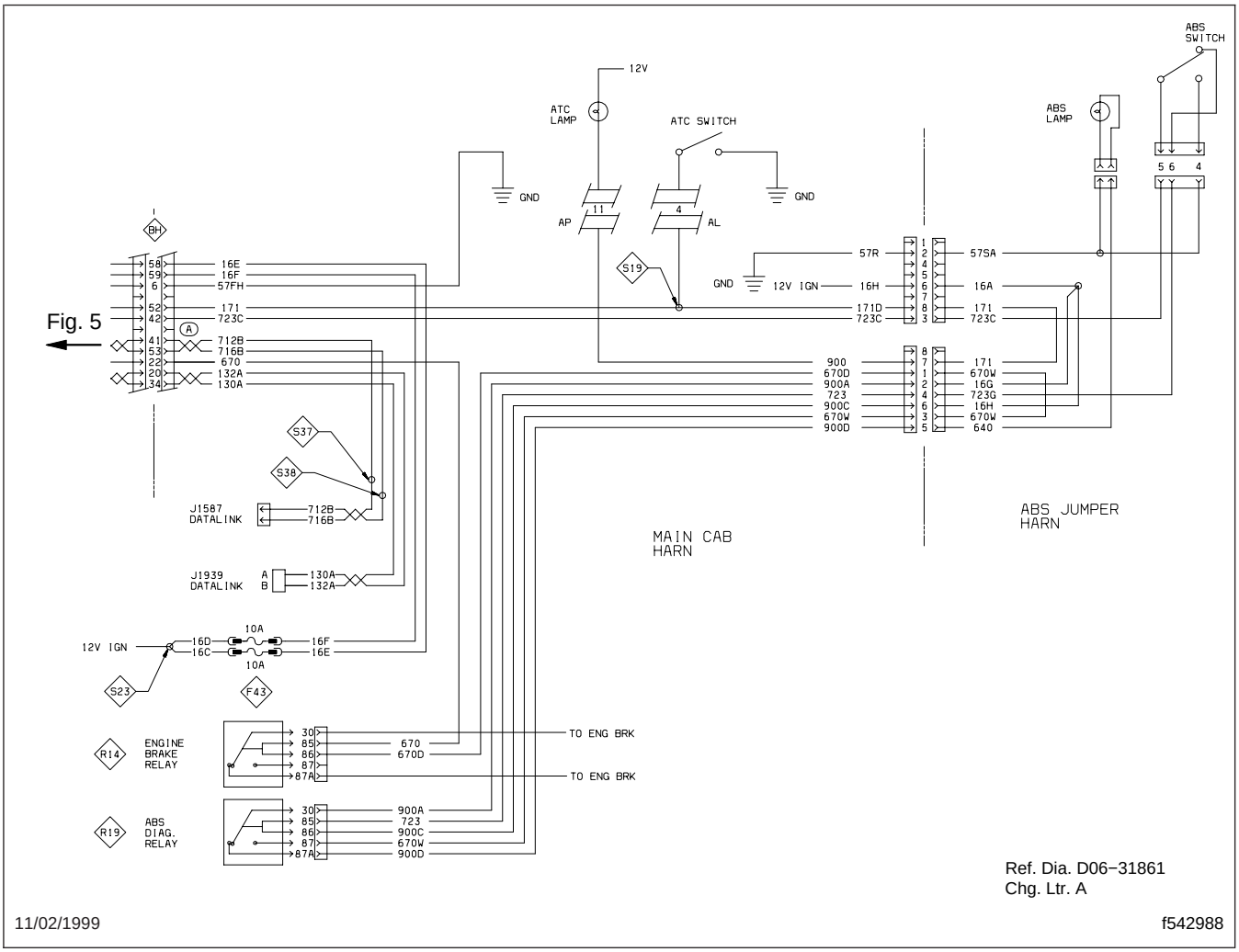


Fig. 6, J1939 Datalink, WABCO ABS D-Version Wiring Diagram (partial view)

General Information

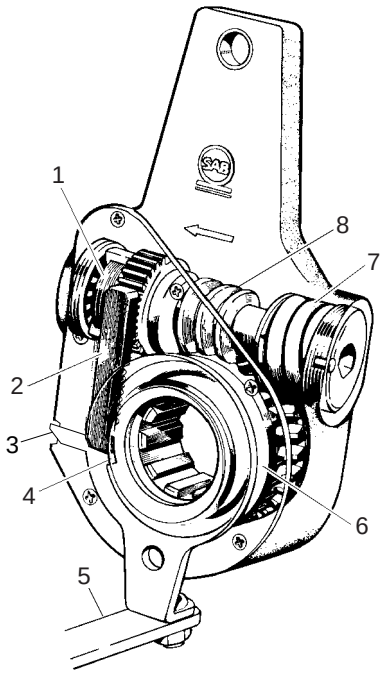
The Haldex automatic slack adjuster serves two main functions:

- As a lever, it converts the straight-line force of the air brake chamber pushrod 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 pushrod stroke and lining-to-drum clearance automatically during normal use.

When the brakes are applied, the slack adjuster rotates and moves the shoes into contact with the drum. The clearance notch corresponds to the normal lining-to-drum clearance. See **Fig. 1**. Different notches are available to meet the requirements of various vehicles and brake duty cycles. As the brake application continues, the rack moves upward and rotates the one-way clutch which slips in this direction.

As the brake torque increases, the coil-spring load is overcome and the wormshaft is displaced axially, releasing 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 wormshaft through the locked cone clutch. The wormshaft then rotates the worm wheel and camshaft, adjusting the brakes.



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NOTE: Older slack adjusters may not have an installation indicator.

1. Clutch Assembly
2. Enclosed Rack
3. Installation Indicator (aligned with indicator notch)
4. Clearance Notch
5. Control Arm Anchor Bracket (design varies depending on the axle)
6. Worm Wheel
7. Coil Spring
8. Wormshaft

Fig. 1, Haldex Slack Adjuster

Safety Precautions

When working on or around a vehicle, observe the following precautions:

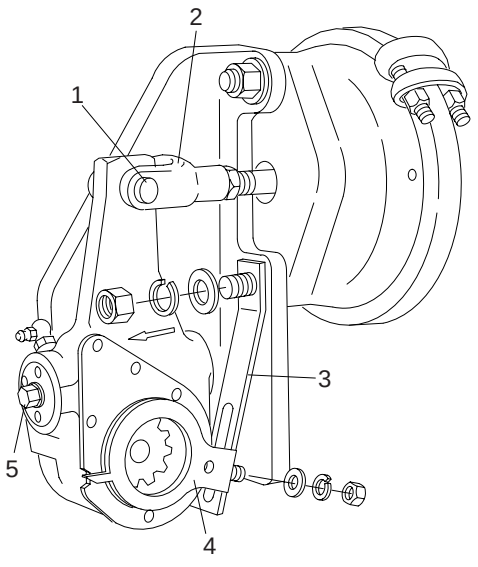
- Park the vehicle on a level surface and apply the parking brakes. Shut down the engine and chock the tires.
- If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle. Depleting air system pressure may cause the 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 all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices with 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.

⚠ WARNING

Before working on or around air brake systems and components, see "Safety Precautions" in Subject 100. Failure to do so may result in personal injury.

Removal

1. With the vehicle parked on a level surface, set the parking brakes, and shut down the engine. Chock the tires.
2. If a rear-axle slack adjuster will be removed, release the parking brakes and cage the power spring of the parking brake chamber. For instructions, refer to the applicable brake chamber section in this group.
3. Remove the anchor bracket fasteners and the anchor bracket. See **Fig. 1**.



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1. Clevis Pin
2. Clevis
3. Anchor Bracket
4. Control Arm
5. Adjusting Hexnut

Fig. 1, Anchor Bracket Removal/Installation

4. Remove the cotter pin from the clevis pin. Remove the clevis pin.
5. Remove the snap ring that secures the slack adjuster on the camshaft.

⚠ CAUTION

Do not use an impact wrench on the adjusting hexnut. To do so may damage the slack adjuster or camshaft.

6. Using a 7/16-inch box wrench, turn the adjusting hexnut counterclockwise to move the adjuster arm out of the clevis. A minimum of 13 lbf·ft (18 N·m) is required to overcome the internal clutch. You will hear a ratcheting sound.
7. Remove the slack adjuster from the camshaft.

Installation

NOTE: For brake chambers that have pushrods with threaded clevises, measure the pushrod length before installing the new slack adjuster. With the brakes fully released, and no air pressure to the chamber, check the dimension between the chamber face and the centerline of the 1/2 inch clevis pin hole. It should be 2.25 inches (57 mm) for long stroke chambers, and 2.75 inches (70 mm) for standard stroke chambers.

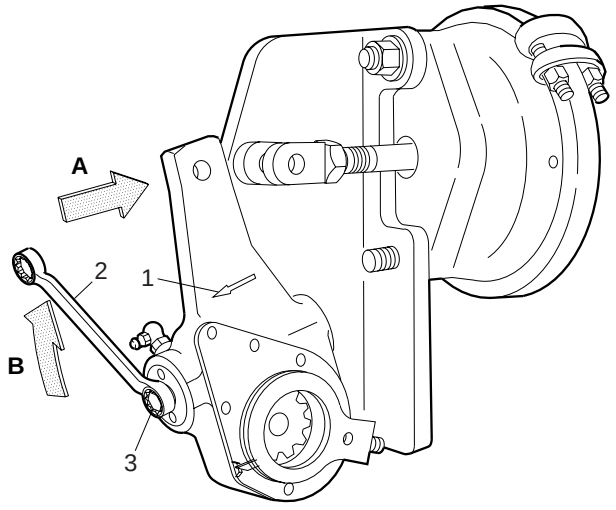
1. Check that the brake-chamber pushrod is fully retracted.
2. Apply antiseize compound to the camshaft splines.

IMPORTANT: When correctly installed, the brake-chamber pushrod pushes in the direction of the arrow on the slack adjuster housing.

3. Install the slack adjuster on the camshaft, with the adjusting hexnut pointing away from the brake chamber. See **Fig. 2**.
4. Using a snap ring, secure the slack adjuster on the camshaft. Use at least one inner washer and enough outer washers to allow no more than 0.060-inch (1.52-mm) movement on the shaft.

IMPORTANT: Never pull the pushrod out to meet the slack adjuster or push the slack adjuster into position. Always turn the adjusting hexnut for positioning.

Slack Adjuster Removal and Installation



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A. Use only the adjusting hexnut to align the slack adjuster with the pushrod clevis.
B. Turn the adjusting hexnut clockwise.

1. Direction of Applied Stroke
2. Box Wrench, 7/16 inch
3. Adjusting Hexnut

Fig. 2, Slack Adjuster Installation

5. Using a 7/16-inch box wrench, turn the adjusting hexnut clockwise until the slack adjuster hole is aligned with the pushrod clevis hole. See **Fig. 2**.
6. Apply antiseize compound to the clevis pin, and insert the pin in the clevis hole. Do not install the cotter pin at this time.

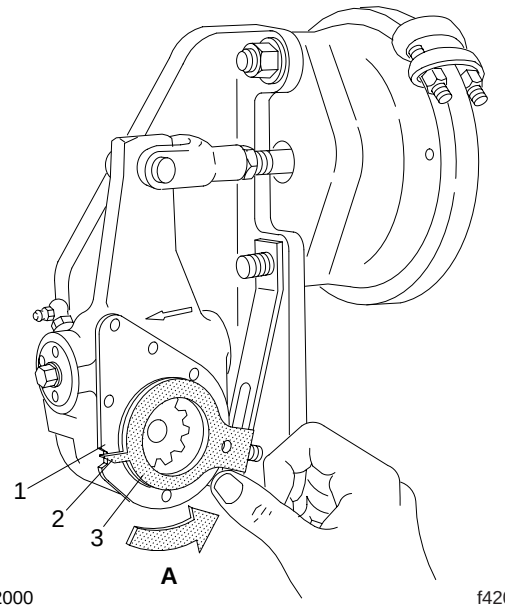
CAUTION

Never hammer the control arm. Hammering may damage the slack adjuster or camshaft splines.

7. Rotate the control arm away from the adjusting hexnut toward the brake chamber until it comes to a definite internal stop. Make sure the installation indicator is in the center of the indicator notch on the slack adjuster. See **Fig. 3**.

IMPORTANT: If the installation indicator is not aligned with the indicator notch, the brakes will be too tight.

NOTE: The anchor bracket and slack adjuster housing design will vary, depending on the axle.



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NOTE: The installation indicator must be aligned with the indicator notch.

A. Rotate the control arm counterclockwise until it stops.

1. Indicator Notch
2. Installation Indicator
3. Control Arm

Fig. 3, Aligning the Control Arm

The anchor bracket mounting location is determined by the length of the control arm.

8. Install the control-arm anchor bracket, as follows. See **Fig. 1**.
   - 8.1 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.
   - 8.2 Tighten the fastener at the brake chamber mounting stud according to the brake chamber manufacturer's specifications.
9. Adjust the brakes. See "Brake Adjustment".

Brake Adjustment

NOTE: A properly working self-adjusting slack adjuster does not require manual adjustment while in service.

⚠ WARNING

Manually adjusting an automatic slack adjuster to bring the pushrod stroke within legal limits is likely masking a mechanical problem. Adjustment is not repairing. Before adjusting an automatic slack adjuster, troubleshoot the foundation brake system and inspect it for worn or damaged components. Improperly maintaining the vehicle braking system may lead to brake failure, resulting in property damage, personal injury, or death.

1. Adjust the brake lining clearance by manually turning the adjusting hexnut clockwise until the brake lining contacts the brake drum, then back off the hexnut counterclockwise 1/2 turn. You will hear a ratcheting sound.

IMPORTANT: Incorrect installation can cause dragging brakes.

2. Make sure the brakes are still fully released, then check the position of the installation indicator on the control arm. It must be within the indicator notch on the slack adjuster.

   If the indicator is out of position, loosen the control arm fasteners and repeat the control-arm adjustment procedure. Then, tighten the bracket fasteners.

⚠ WARNING

Install and lock a new cotter pin in the clevis pin. Failure to do so could allow the pushrod to disengage from the slack adjuster, causing a loss of braking ability that could result in personal injury and property damage.

3. Install and lock a new cotter pin in the clevis pin.

IMPORTANT: Ensure that the air system has at least 100 psi prior to uncaging the brake chamber. This will aid in the uncaging of the parking brake since the parking brake should be fully released.

4. 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.

⚠ WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

IMPORTANT: To check the brake adjustment, measure both the applied and free strokes.

NOTE: The location of the measurements is the same for both strokes but the applied stroke is measured with the brakes applied, while a lever is used to manually move the slack adjuster to measure the free stroke.

5. Measure the free stroke, as follows. The free stroke is the distance the slack adjuster has to travel to move the brake shoes against the drum.

   5.1 With the brakes released, measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement A.

   5.2 Using a lever, move the slack adjuster until the brake shoes contact the drum. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement B.

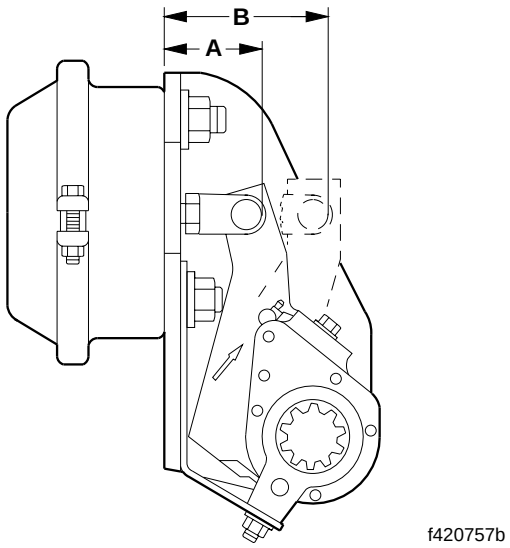
   5.3 Subtract measurement A from measurement B to determine the free stroke. For new brake installations, the free stroke should be 5/8 to 3/4 inch (16 to 19 mm). For in-service brakes, the free stroke should be 1/2 to 5/8 inch (13 to 16 mm). If it is not in this range, refer to **Troubleshooting 300**.

6. Measure the applied stroke, as follows.

   6.1 With the brakes released (pushrod fully retracted), measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. See **Fig. 4**. Record the exact distance as measurement A.

   6.2 Apply and hold an 80 psi (551 kPa) brake application. Measure the distance from the bottom of the brake chamber to the far

Slack Adjuster Removal and Installation



NOTE: Measurements are from the bottom of the brake chamber to the far side of the clevis-pin hole.

A. Measurement with brakes released.
B. Measurement with brakes applied at 80 psi (551 kPa).

Fig. 4, Brake Applied Stroke Check

side of the clevis-pin hole. Record the exact distance as measurement B.

6.3 Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 1**.

6.4 If the stroke varies or is greater than the maximum allowed length, refer to **Troubleshooting 300**.

7. Apply the parking brakes.
8. Remove the chocks from the tires.
9. In a safe area, check for proper brake operation, as follows.

9.1 Apply and release the brakes several times to check for correct operation of the slack adjusters.

9.2 Perform six low-speed stops to ensure correct parts replacement and full vehicle control.

9.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others show a lack of braking effort on those wheels.

Chamber Size	Maximum Applied Stroke: inch (mm)	Free Stroke: inch (mm)	
		New Brake Installation	In-Service Brake Installation
16	1-3/4 (44)	5/8–3/4 (16–19)	1/2–5/8 (13–16)
20			
24	1-7/8 (48)		
30	2 (51)		

Table 1, Brake Chamber Stroke Specifications

Troubleshooting Tables

Problem—Tight or Dragging Brakes

Problem—Tight or Dragging Brakes	
Possible Cause	**Remedy**
Improperly positioned control arm anchor bracket	See instructions in **Subject 110**.
System air pressure too low to fully release spring brake	Check that the air governor cuts out at the recommended setting.
Ruptured spring brake diaphragm or leaking piston seal	Replace the diaphragm or spring brake piston seal.
Broken return spring in brake chamber	Replace the spring brake return spring.
Pushrod binds on chamber housing	Check for correct alignment and correct chamber mounting bracket. Adjust or replace parts as needed.
Air supply does not exhaust completely	Test the air system valves for leakage and correct operation.
Out-of-round brake drums	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, see the brake manufacturer's service manual.
Extreme differences in lining-to-drum clearances between shoes on same wheel	Check for proper operation of the brake mechanism. Lubricate or overhaul as needed.
Out-of-adjustment wheel bearings	Adjust the wheel bearings, or replace them if damaged. For instructions see **Section 33.01** for front axles and **Section 35.00** for rear axles.
Broken brake shoe return spring	Replace the brake shoe return spring.

Problem— Brake Chamber Pushrod Travel Is Excessive

Problem— Brake Chamber Pushrod Travel Is Excessive	
Possible Cause	**Remedy**
Loose, broken, or bent control arm anchor bracket	Tighten or replace the anchor bracket as required.
Excessive wear between anchor bracket bolt and control arm slot	Replace the worn parts.
Damaged or worn control arm assembly, resulting in lateral movement between control arm and cover plate	Replace the slack adjuster.
Worn camshaft bushings	Replace the worn camshaft bushings.
Camshaft binds	Lubricate the camshaft or overhaul the brake mechanism as needed.
Loose brake chamber mounting	Tighten the brake chamber mounting fasteners.
Slack adjuster bound against camshaft housing, 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.
Worn slack adjuster clutch assembly	Replace the slack adjuster.

Specifications

Maximum Applied Stroke	
Chamber Size	**Inch (mm)**
16	1-3/4 (44)
20	1-3/4 (44)
24	1-7/8 (48)
30	2 (51)

Table 1, Maximum Applied Stroke

General Information (See Fig. 1)

The Meritor automatic slack adjuster has two main functions:

- As a lever, it converts the straight-line force of the brake chamber pushrod 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 pushrod stroke, which controls lining-to-drum clearance during operation.

Meritor's automatic slack adjuster automatically adjusts the clearance between the brake lining and the brake drum (rotor). When linings wear, this clearance increases and causes the chamber pushrod to move a greater distance to apply the brakes.

During operation, if the chamber stroke exceeds the design limit, the automatic slack adjuster will automatically adjust the pushrod's return stroke to control clearance between the lining and the drum (rotor) and reset the stroke to the correct length.

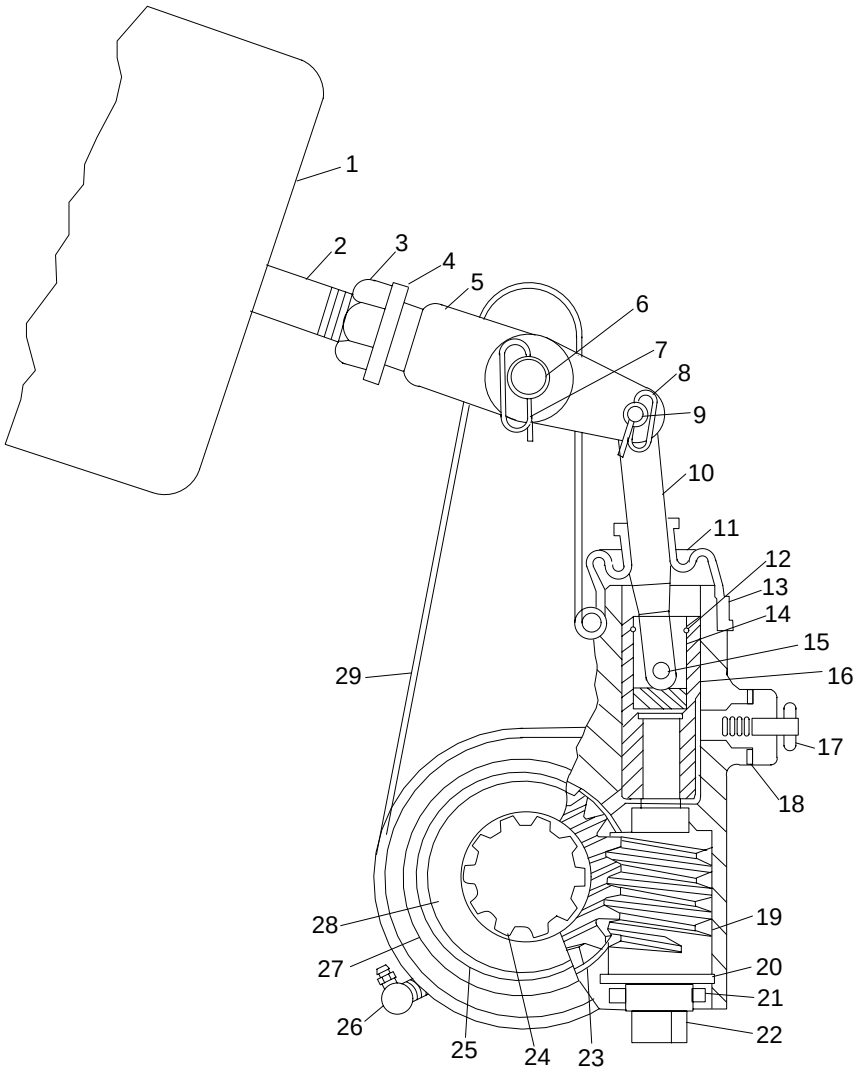
A pressed-in, sealed actuator boot is standard equipment on Meritor slack adjusters. The boot features a metal retaining ring with additional material that extends beyond the base of the retainer. The boot forms a seal once it is pressed into the slack adjuster body.

Meritor's automatic slack adjusters, including the factory-installed slack adjusters on the Q Plus cam brakes, have a one-piece threaded clevis. See **Fig. 2**.

The one-piece threaded clevis:

- Has a threaded hole for the pushrod;
- Can be straight or offset;
- Is used on all service replacement automatic slack adjusters.

General Information



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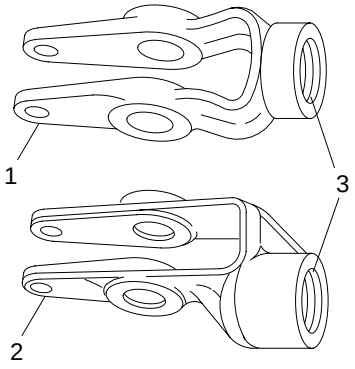
1. Brake Air Chamber
2. Brake Chamber Pushrod
3. Clevis Jam Nut
4. Collar
5. Clevis
6. Large Clevis Pin
7. Large Clevis Pin Retainer Clip
8. Small Clevis Pin Retainer Clip
9. Small Clevis Pin
10. Actuator Rod
11. Boot
12. Piston Retaining Ring
13. Boot Retaining Clamp
14. Actuator Piston
15. Roller (Pin)
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)



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1. Straight Clevis
2. Offset Clevis
3. Threads

Fig. 2, One-Piece Threaded Clevis Configurations

Safety Precautions

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 all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices with 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.

WARNING

Before working on or around air brake systems and components, see "Safety Precautions" in Subject 100. Failure to do so may result in personal injury.

Removal

1. With the vehicle parked on a level surface, set the parking brakes, and shut down the engine. Chock the tires.

WARNING

Manually cage each parking brake chamber power spring in the release (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.

2. If the rear slack adjusters will be removed, release the parking brakes, then cage the power spring of the parking brake chamber.
3. Remove the retainer clips from the large and small clevis pins. Remove the clevis pins. See Fig. 1.

CAUTION

Disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.

4. Using a screwdriver or an equivalent tool, pry the pawl button out about 1/32 inch (0.8 mm). See Fig. 2.

   Wedge the tool in place. Pull-pawls are spring-loaded; when the tool is removed, the pull-pawl will engage the teeth automatically.
5. Using a wrench, manually turn the square adjusting nut clockwise to move the slack adjuster away from the clevis. See Fig. 3.
6. Remove the snap ring, washer(s), and seal (if equipped) that secure the slack adjuster in place on the brake camshaft; 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. Remove the spacers and seal (LX500 and MX500 series only), and save them for later installation.

Installation

NOTE: For brake chambers that have pushrods with threaded clevises, measure the pushrod length before installing the new slack adjuster. With the brakes fully released, and no air pressure to the chamber, check the dimension between the chamber face and the centerline of the 1/2 inch clevis pin hole. It should be 2.25 inches (57 mm) for long stroke chambers, and 2.75 inches (70 mm) for standard stroke chambers.

1. Inspect the parts and prepare the slack adjuster for installation.
2. Check the brake camshaft splines for wear or corrosion.

IMPORTANT: The following lubricants provide corrosion protection. Do not mix them with other types of lubricants.

3. Coat the camshaft splines and the splines of the slack adjuster gear with Meritor 0-637, Meritor 0-695 (LX500 and MX500 only), Southwest SA 8249496, or an equivalent.
4. Apply the service brake several times. Make sure the return spring retracts the pushrod quickly and completely. Replace the return spring or brake chamber, if needed.
5. Slide the spacing washer(s) on the camshaft.

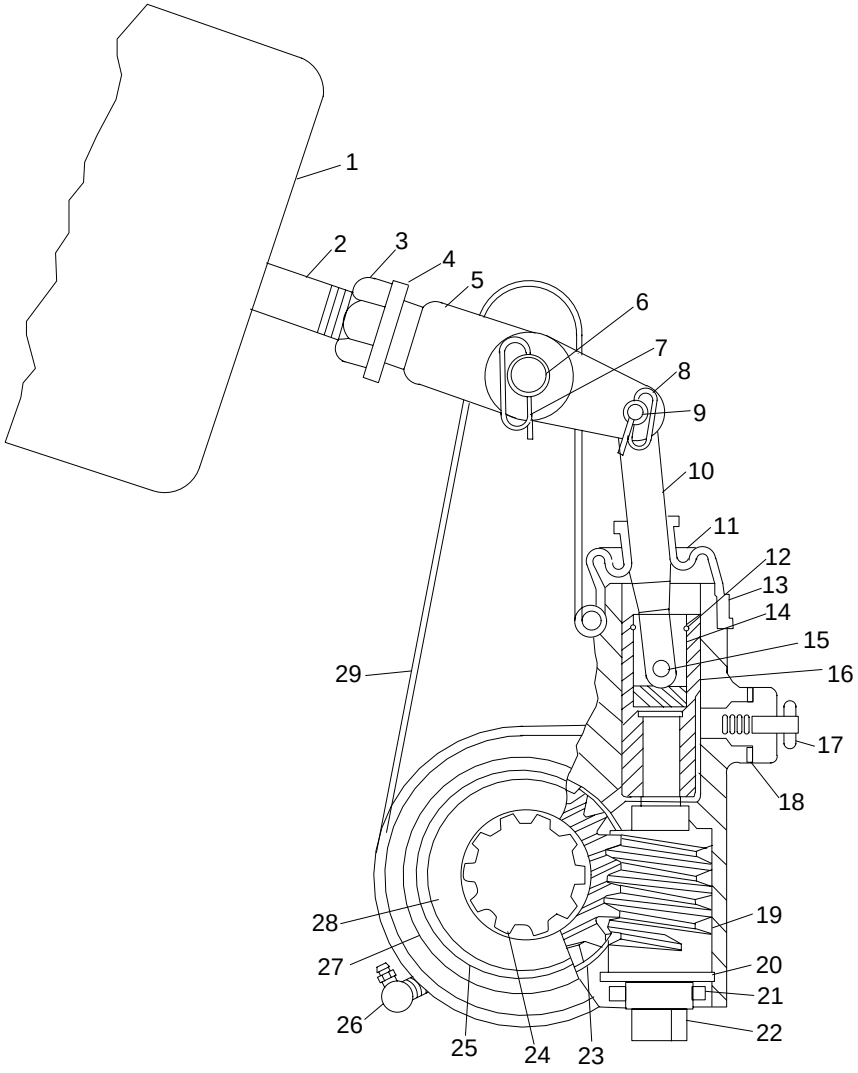
   On LX500 and MX500, install the slack adjuster seal with the lip facing the brake spider.
6. If reinstalling the same slack adjuster:

   6.1 Slide the slack adjuster on the camshaft, with the actuator rod on the side opposite the brake chamber.

   6.2 On LX500 and MX500, install the orange slack adjuster seal on the camshaft. The lip on the seal must face the snap ring.

   6.3 Install the outer washer(s) and snap ring on the camshaft.

Slack Adjuster Removal and Installation



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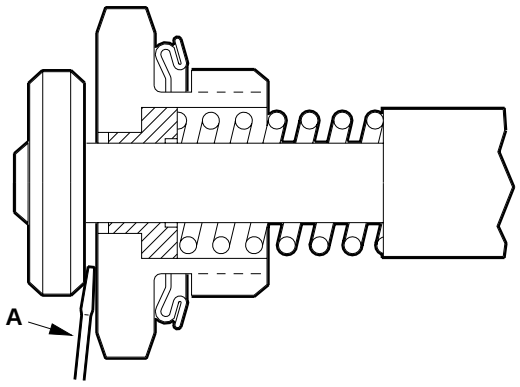
1. Brake Air Chamber
2. Brake Chamber Pushrod
3. Clevis Jam Nut
4. Quick-Connect Collar (if equipped)
5. Clevis
6. Clevis Pin (large)
7. Retainer Clip (large)
8. Retainer Clip (small)
9. Clevis Pin (small)
10. Actuator Rod
11. Boot
12. Piston Retaining Ring
13. Boot Retaining Clamp
14. Actuator Piston
15. Roller (Pin)
16. Actuator (Adjusting Sleeve)
17. Pull-Pawl Assembly (shown 90 degrees out of position)
18. Gasket
19. Worm
20. Worm Retaining Snap Ring
21. Worm Seal
22. Manual Adjusting Nut
23. Gear-to-Body Seal
24. Camshaft Splines
25. Gear Retaining Ring
26. Grease Fitting (if equipped)
27. Gear Thrustwasher
28. Gear
29. Slack Adjuster Housing

Fig. 1, Meritor Automatic Slack Adjuster



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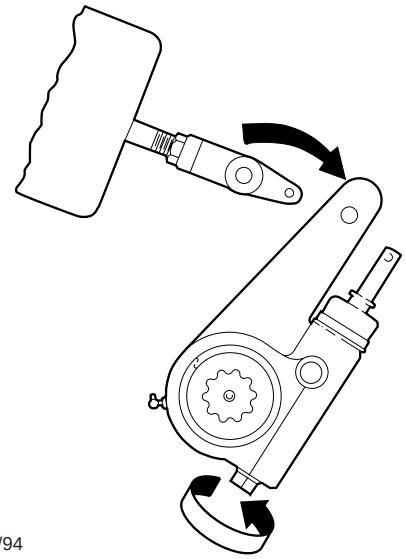
A. Insert a screwdriver here to pry the pull-pawl button out about 1/32 inch (0.8 mm).

Fig. 2, Pull-Pawl Assembly



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Turn the manual adjusting nut clockwise.

Fig. 3, Slack Adjuster Removal

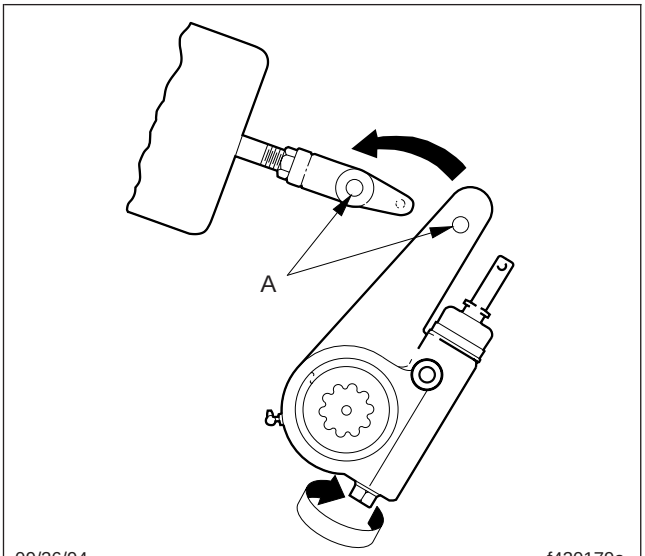
CAUTION

Disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.

6.4 Using a screwdriver or an equivalent tool, pry the pawl button out at least 1/32 inch (0.8 mm). See **Fig. 2**. Wedge the tool in place.

IMPORTANT: Never pull the pushrod out to meet the slack adjuster or push the slack adjuster into position. Always turn the adjusting nut for positioning.

6.5 Using a wrench, turn the manual adjusting nut counterclockwise to align the hole in the slack adjuster housing with the large hole in the clevis. See **Fig. 4**.



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A. Turning the adjusting nut counterclockwise, align the large holes in the slack adjuster and clevis.

Fig. 4, Slack Adjuster Installation

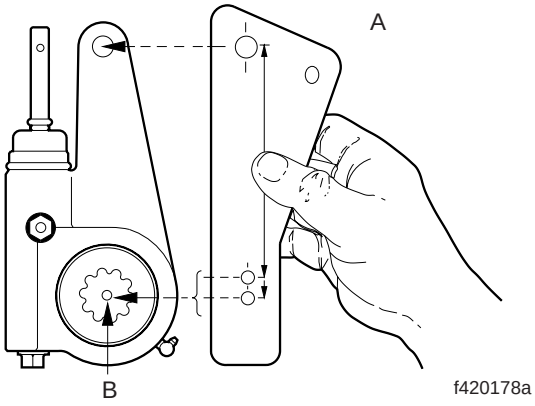
7. If installing a new slack adjuster:

7.1 Using an installation template, measure the old and new slack adjusters. Measure from the center of the large clevis-pin hole to the center of the camshaft opening. See **Fig. 5**.

Make sure the old and new slack adjusters are the same length.

7.2 Slide the slack adjuster on the camshaft, with the actuator rod on the side opposite the brake chamber.

Slack Adjuster Removal and Installation



A. Using a template, measure the slack adjuster arm length.
B. Camshaft Center

Fig. 5, Slack Adjuster Measurement

7.3 On LX500 and MX500 series, install the orange slack adjuster seal on the camshaft. The lip on the seal must face the snap ring.

7.4 Install the outer washer(s) and snap ring on the camshaft.

7.5 Using a dial indicator, measure the in-and-out (axial) end play of the camshaft. If necessary, add the appropriate number of spacing washers to achieve the correct axial end play.

- For all Cam-Master brakes, except LX500 and MX500 series, there should be no more than 0.060 inch (1.52 mm) movement.
- For LX500 and MX500, the axial end play should be no more than 0.020 inch (0.51 mm).

⚠ CAUTION

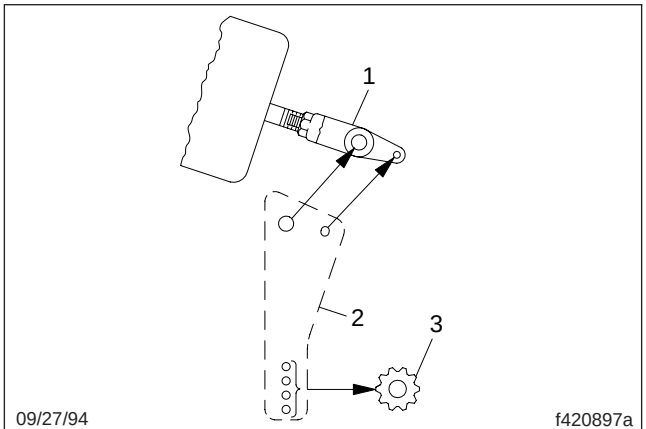
Disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.

7.6 Using a screwdriver or an equivalent tool, pry the pawl button out about 1/32 inch (0.8 mm). See **Fig. 2**. Wedge the tool in place.

IMPORTANT: Never pull the pushrod out to meet the slack adjuster or push the slack adjuster into position. Always turn the adjusting nut for positioning.

7.7 Using a wrench, turn the manual adjusting nut counterclockwise to align the hole in the slack adjuster housing with the large hole in the clevis. See **Fig. 4**.

7.8 With the brakes fully released, place the installation template over the clevis and camshaft end. See **Fig. 6**.



Place the template over the clevis and camshaft end.
1. Clevis
2. Template
3. Camshaft End

Fig. 6, Template Placement

7.9 Temporarily insert the large clevis pin through the large holes in the template and the clevis.

7.10 Select the hole in the lower part of the template that matches the length of the slack adjuster. Hold the template in place on the center of the camshaft with a pencil.

7.11 Make sure the small hole in the clevis is completely visible through the 1/8-inch hole at the top of the template.

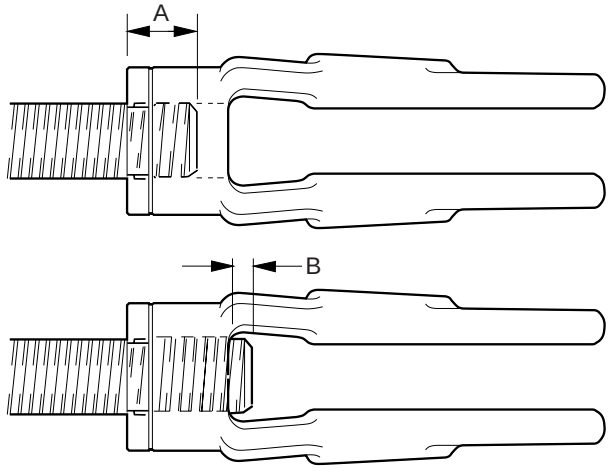
If it is not, loosen the clevis jam nut, and turn the clevis adjusting nut to adjust the position of the clevis on the pushrod until the small clevis hole is completely visible.

IMPORTANT: The pushrod must be installed in the clevis at least 1/2 inch (13 mm) and not extend beyond it more than 1/8-inch (3-mm).

7.12 Make sure there is at least 1/2 inch (13 mm) of thread engagement between the clevis and the pushrod. Also, check that the pushrod does not extend through the clevis more than 1/8-inch (3-mm). See **Fig. 7**.

If necessary, cut the pushrod, install a new pushrod, or install a new brake chamber.

7.13 Temporarily insert the small clevis pin through the template, clevis, and actuator rod to make sure the alignment is correct. Repeat the adjustment, if necessary. When the alignment is correct, remove both clevis pins and the template.



A. Minimum 1/2 inch (13 mm).
B. Maximum 1/8 inch (3 mm).

Fig. 7, Check Pushrod Engagement

8. Apply antiseize compound to the two clevis pins.
9. Insert both clevis pins with their pinheads on the inboard side of the slack adjuster. Be sure the small clevis pin is inserted through the hole in the actuator rod. Install new retaining clips to secure the clevis pins.
10. If it was loosened, tighten the clevis jam nut to the following values.
    - For 1/2–20 threads, tighten the clevis jam nut 20 to 30 lbf·ft (27 to 41 N·m).
    - For 5/8–18 threads, tighten the jam nut 25 to 50 lbf·ft (34 to 68 N·m).
11. Lube the slack adjuster through the grease fitting until the lubricant is forced out through the pawl slot or through the gear splines around the inboard snap ring.
12. Adjust the brakes. See "Brake Adjustment" below.

Brake Adjustment

NOTE: A properly working self-adjusting slack adjuster does not require manual adjustment while in service.

⚠ WARNING

Manually adjusting an automatic slack adjuster to bring the pushrod stroke within legal limits is likely masking a mechanical problem. Adjustment is not repairing. Before adjusting an automatic slack adjuster, troubleshoot the foundation brake system and inspect it for worn or damaged components. Improperly maintaining the vehicle braking system may lead to brake failure, resulting in property damage, personal injury, or death.

1. If a rear axle slack adjuster was installed, manually uncage the parking brake.
2. Fully release the brakes (the air chamber pushrod must be fully retracted).

⚠ CAUTION

Before turning the manual adjusting nut on the slack adjuster, disengage the pull-pawl. Failure to do so could damage the pull-pawl teeth. A damaged pull-pawl will not allow the slack adjuster to automatically adjust the brake clearance.

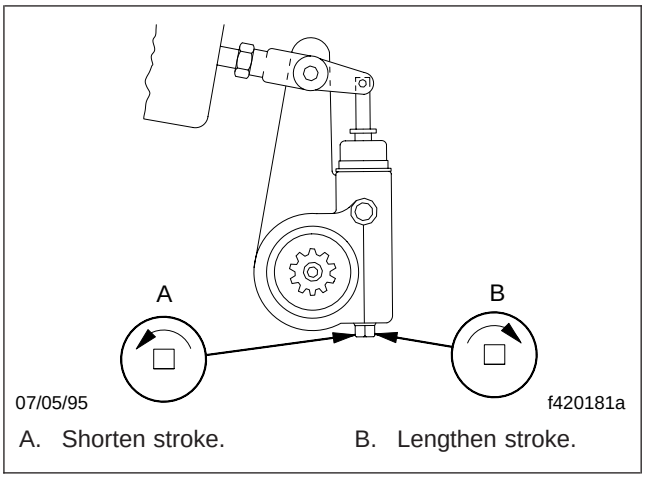
3. Using a screwdriver, pry the pull-pawl button out at least 1/32 inch (0.8 mm) to disengage the pull-pawl teeth from the slack adjuster actuator. See **Fig. 2**. Wedge the screwdriver in place. The pull-pawl will need to be disengaged until the brake adjustment is complete.

Slack Adjuster Removal and Installation

NOTE: When the screwdriver is removed, the pull-pawl will engage automatically.

4. Using the manual adjusting nut on the slack adjuster, adjust the brake chamber stroke (coarse adjustment), as follows. See **Fig. 8**.

   4.1 Turn the adjusting nut counterclockwise until the brake linings touch the brake drum.



A. Shorten stroke. B. Lengthen stroke.

Fig. 8, Adjusting the Stroke

   4.2 Then, turn the adjusting nut clockwise 1/2 turn.

5. Measure and adjust the free-stroke, as follows.

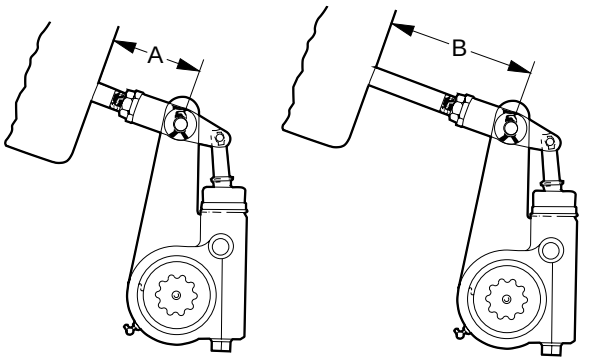
   5.1 With the brakes released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension A. See **Fig. 9**.

   5.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum.

   Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension B. See **Fig. 9**.

   5.3 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.

   5.4 The free-stroke for a new brake installation should be 5/8 to 3/4 inch (16 to 19 mm). For a brake that is in service, the free-stroke should be 1/2 to 5/8 inch (13 to 16 mm). If it is not, turn the adjusting nut 1/8 turn, as shown in **Fig. 8**. Then, measure the free-stroke again; readjust it until it is correct.



NOTE: For either free-stroke or applied chamber stroke, subtract measurement A from B.

A. Measurement with the brakes released.
B. Measurement with the brakes applied by manual lever (free-stroke) or pressurized brake application (applied chamber stroke).

Fig. 9, Measuring the Stroke

6. Measure and adjust the applied chamber stroke (fine adjustment), as follows.

   6.1 If system pressure is not already at 100 psi (689 kPa), start the engine and build air pressure, then shut down the engine.

   6.2 With the brakes released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension A. See **Fig. 9**.

   6.3 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. 9**, Ref. B. Record this measurement as dimension B.

   6.4 Subtract dimension A from dimension B. The difference between these measurements is the true applied chamber stroke.

CAUTION

The adjusted applied chamber stroke should be as short as possible but not so short that the free-stroke is too short and the linings drag. If the linings drag, the brakes could be damaged.

6.5 The applied chamber stroke must not exceed the maximum value specified in **Table 1**.

If the applied chamber stroke is incorrect, turn the adjusting nut 1/8-turn counterclockwise to shorten the stroke, or 1/8-turn clockwise to lengthen it. See **Fig. 8**. Measure the applied stroke again and readjust it until it is correct.

6.6 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes. See **Section 42.29, Subject 150**.

7. Remove the screwdriver from the pull-pawl assembly. This will engage the pull-pawl with the actuator.

WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

8. In a safe area, check for proper brake operation before you put the vehicle in service, as follows.

8.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.

8.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.

8.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than others show a lack of braking effort on those wheels.

Brake Chamber Stroke Specifications			
Chamber Type (Size)	Maximum Applied Stroke*: inch (mm)	Free-Stroke: inch (mm)	
		New Brake Installation	In-Service Brake
Long Stroke†			
16 and 20	2-1/2 (64)	5/8–3/4 (16–19)	1/2–5/8 (13–16)
24 and 30	3 (76)		

* Specifications are relative to a brake application with 80–90 psi (550–620 kPa) air pressure in the brake chambers.

† Long stroke design is indicated by a tag, or embossing, on the brake chamber.

Table 1, Brake Chamber Stroke Specifications

Specifications

Lubricant Specifications	
Lubricant Type	**Temperature**
Amoco Super Permalube No. 2	–40°F (–40°C) or Above
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	
Mobil 28	Below –40°F (–40°C)
Meritor 0-645	

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 Long stroke	Less than 2 (51)

Maximum Adjusted Brake Chamber Strokes	
Chamber Size	**Maximum Chamber Stroke for Cam Brake inches (mm)**
30	Less than 2 (51)

Table 3, Maximum Adjusted Brake Chamber Strokes

Thread Sizes	
Chambers	**Thread Sizes Inch**
9, 12,16	1/2–20
20, 24, 30, 36	5/8–18

Table 4, Thread Sizes

General Information

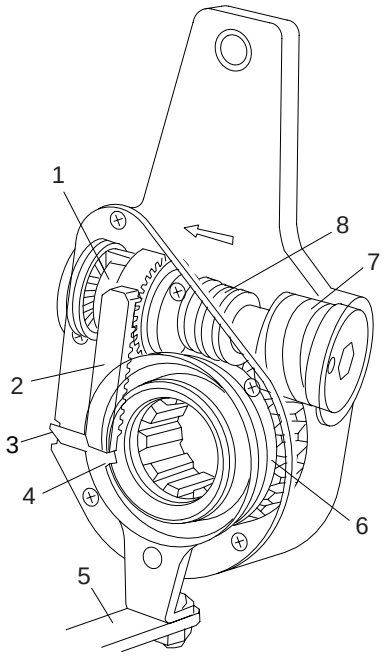
The Dana® Spicer® automatic slack adjuster serves two main functions:

- As a lever, it converts the straight-line force of the air brake chamber pushrod 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 pushrod stroke and lining-to-drum clearance automatically during normal use.

When the brakes are applied, the slack adjuster rotates and moves the shoes into contact with the drum. The clearance notch corresponds to the normal lining-to-drum clearance. See **Fig. 1**. Different notches are available to meet the requirements of various vehicles and brake duty cycles. As the brake application continues, the rack moves upward and rotates the one-way clutch which slips in this direction.

As the brake torque increases, the coil-spring load is overcome and the wormshaft is displaced axially, releasing 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 wormshaft through the locked cone clutch. The wormshaft then rotates the worm wheel and camshaft, adjusting the brakes.



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NOTE: Older slack adjusters may not have an installation indicator.

1. Clutch Assembly
2. Enclosed Rack
3. Installation Indicator (aligned with indicator notch)
4. Clearance Notch
5. Control Arm Anchor Bracket (design varies depending on the axle)
6. Worm Wheel
7. Coil Spring
8. Wormshaft

Fig. 1, Dana Spicer Slack Adjuster

Safety Precautions

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 all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices with 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.

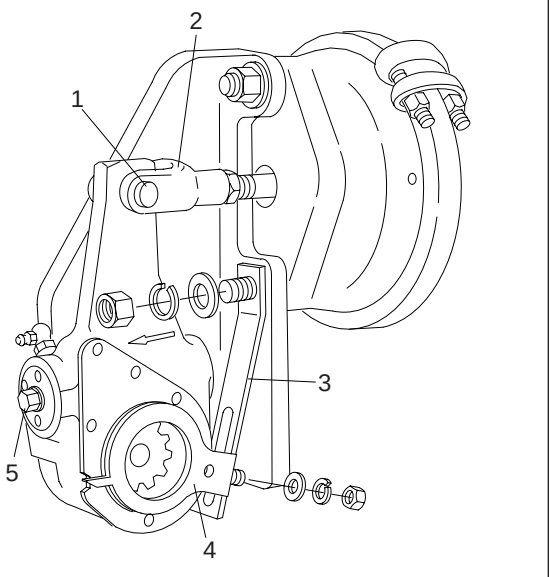
Slack Adjuster Removal and Installation

⚠ WARNING

Before working on or around air brake systems and components, see "Safety Precautions" in Subject 100. Failure to do so may result in personal injury.

Removal

1. With the vehicle parked on a level surface, set the parking brakes, and shut down the engine. Chock the tires.
2. If a rear-axle slack adjuster will be removed, release the parking brakes and cage the power spring of the parking brake chamber. For instructions, refer to the applicable brake chamber section in this group.
3. Remove the anchor bracket fasteners and the anchor bracket. See **Fig. 1**.



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1. Clevis Pin
2. Clevis
3. Anchor Bracket
4. Control Arm
5. Adjusting Hexnut

Fig. 1, Anchor Bracket Removal/Installation

4. Remove the cotter pin from the clevis pin. Remove the clevis pin.
5. Remove the snap ring that secures the slack adjuster on the camshaft.

⚠ CAUTION

Do not use an impact wrench on the adjusting hexnut. To do so may damage the slack adjuster or camshaft.

6. Using a 7/16-inch box wrench, turn the adjusting hexnut counterclockwise to move the adjuster arm out of the clevis. A minimum of 13 lbf·ft (18 N·m) is required to overcome the internal clutch. You will hear a ratcheting sound.
7. Remove the slack adjuster from the camshaft.

Installation

NOTE: For brake chambers that have pushrods with threaded clevises, measure the pushrod length before installing the new slack adjuster. With the brakes fully released, and no air pressure to the chamber, check the dimension between the chamber face and the centerline of the 1/2 inch clevis pin hole. It should be 2.25 inches (57 mm) for long stroke chambers, and 2.75 inches (70 mm) for standard stroke chambers.

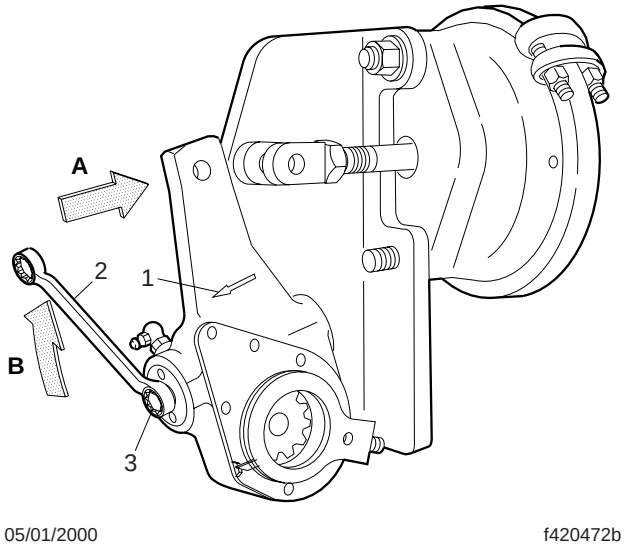
1. Check that the brake-chamber pushrod is fully retracted.
2. Apply antiseize compound to the camshaft splines.

IMPORTANT: When correctly installed, the brake-chamber pushrod pushes in the direction of the arrow on the slack adjuster housing.

3. Install the slack adjuster on the camshaft, with the adjusting hexnut pointing away from the brake chamber. See **Fig. 2**.
4. Using a snap ring, secure the slack adjuster on the camshaft. Use at least one inner washer and enough outer washers to allow no more than 0.060-inch (1.52-mm) movement on the shaft.

IMPORTANT: Never pull the pushrod out to meet the slack adjuster or push the slack adjuster into position. Always turn the adjusting hexnut for positioning.

Slack Adjuster Removal and Installation



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A. Use only the adjusting hexnut to align the slack adjuster with the pushrod clevis.
B. Turn the adjusting hexnut clockwise.

1. Direction of Applied Stroke
2. Box Wrench, 7/16 inch
3. Adjusting Hexnut

Fig. 2, Slack Adjuster Installation

5. Using a 7/16-inch box wrench, turn the adjusting hexnut clockwise until the slack adjuster hole is aligned with the pushrod clevis hole. See **Fig. 2**.
6. Apply antiseize compound to the clevis pin, and insert the pin in the clevis hole. Do not install the cotter pin at this time.

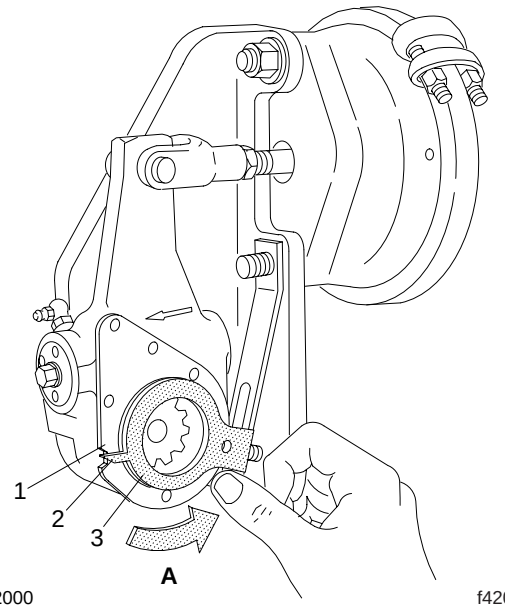
⚠ CAUTION

Never hammer the control arm. Hammering may damage the slack adjuster or camshaft splines.

7. Rotate the control arm away from the adjusting hexnut toward the brake chamber until it comes to a definite internal stop. Make sure the installation indicator is in the center of the indicator notch on the slack adjuster. See **Fig. 3**.

IMPORTANT: If the installation indicator is not aligned with the indicator notch, the brakes will be too tight.

NOTE: The anchor bracket and slack adjuster housing design will vary, depending on the axle.



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NOTE: The installation indicator must be aligned with the indicator notch.

A. Rotate the control arm counterclockwise until it stops.

1. Indicator Notch
2. Installation Indicator
3. Control Arm

Fig. 3, Aligning the Control Arm

The anchor bracket mounting location is determined by the length of the control arm.

8. Install the control-arm anchor bracket, as follows. See **Fig. 1**.
   - 8.1 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.
   - 8.2 Tighten the fastener at the brake chamber mounting stud according to the brake chamber manufacturer's specifications.
9. Adjust the brakes. See "Brake Adjustment".

Brake Adjustment

NOTE: A properly working self-adjusting slack adjuster does not require manual adjustment while in service.

Slack Adjuster Removal and Installation

⚠ WARNING

Manually adjusting an automatic slack adjuster to bring the pushrod stroke within legal limits is likely masking a mechanical problem. Adjustment is not repairing. Before adjusting an automatic slack adjuster, troubleshoot the foundation brake system and inspect it for worn or damaged components. Improperly maintaining the vehicle braking system may lead to brake failure, resulting in property damage, personal injury, or death.

1. Adjust the brake lining clearance by manually turning the adjusting hexnut clockwise until the brake lining contacts the brake drum, then back off the hexnut counterclockwise 1/2 turn. You will hear a ratcheting sound.

IMPORTANT: Incorrect installation can cause dragging brakes.

2. Make sure the brakes are still fully released, then check the position of the installation indicator on the control arm. It must be within the indicator notch on the slack adjuster.

   If the indicator is out of position, loosen the control arm fasteners and repeat the control-arm adjustment procedure. Then, tighten the bracket fasteners.

⚠ WARNING

Install and lock a new cotter pin in the clevis pin. Failure to do so could allow the pushrod to disengage from the slack adjuster, causing a loss of braking ability that could result in personal injury and property damage.

3. Install and lock a new cotter pin in the clevis pin.

IMPORTANT: Ensure that the air system has at least 100 psi prior to uncaging the brake chamber. This will aid in the uncaging of the parking brake since the parking brake should be fully released.

4. 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.

⚠ WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

IMPORTANT: To check the brake adjustment, measure both the applied and free strokes.

NOTE: The location of the measurements is the same for both strokes but the applied stroke is measured with the brakes applied, while a lever is used to manually move the slack adjuster to measure the free stroke.

5. Measure the free stroke, as follows. The free stroke is the distance the slack adjuster has to travel to move the brake shoes against the drum.

   5.1 With the brakes released, measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement A.

   5.2 Using a lever, move the slack adjuster until the brake shoes contact the drum. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement B.

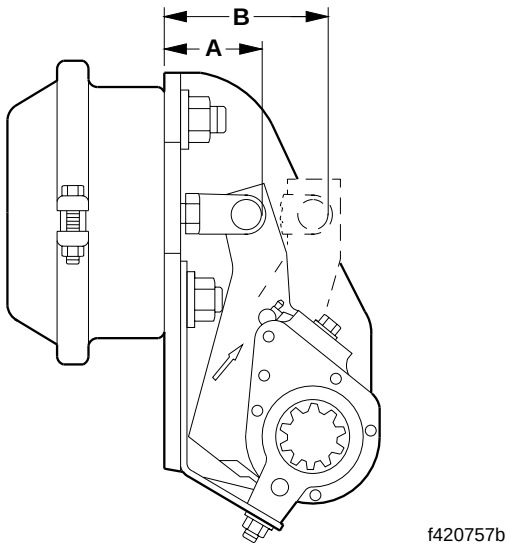
   5.3 Subtract measurement A from measurement B to determine the free stroke. For new brake installations, the free stroke should be 5/8 to 3/4 inch (16 to 19 mm). For in-service brakes, the free stroke should be 1/2 to 5/8 inch (13 to 16 mm). If it is not in this range, refer to **Troubleshooting 300**.

6. Measure the applied stroke, as follows.

   6.1 With the brakes released (pushrod fully retracted), measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. See **Fig. 4**. Record the exact distance as measurement A.

   6.2 Apply and hold an 80 psi (551 kPa) brake application. Measure the distance from the bottom of the brake chamber to the far

Slack Adjuster Removal and Installation



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NOTE: Measurements are from the bottom of the brake chamber to the far side of the clevis-pin hole.

A. Measurement with brakes released.
B. Measurement with brakes applied at 80 psi (551 kPa).

Fig. 4, Brake Applied Stroke Check

side of the clevis-pin hole. Record the exact distance as measurement B.

6.3 Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 1**.

6.4 If the stroke varies or is greater than the maximum allowed length, refer to **Troubleshooting 300**.

7. Apply the parking brakes.
8. Remove the chocks from the tires.
9. In a safe area, check for proper brake operation, as follows.

9.1 Apply and release the brakes several times to check for correct operation of the slack adjusters.

9.2 Perform six low-speed stops to ensure correct parts replacement and full vehicle control.

9.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others show a lack of braking effort on those wheels.

Chamber Size	Maximum Applied Stroke: inch (mm)	Free Stroke: inch (mm)	
		New Brake Installation	In-Service Brake Installation
16	1-3/4 (44)	5/8–3/4 (16–19)	1/2–5/8 (13–16)
20			
24	1-7/8 (48)		
30	2 (51)		

Table 1, Brake Chamber Stroke Specifications

Troubleshooting Tables

Problem—Tight or Dragging Brakes

Problem—Tight or Dragging Brakes	
Possible Cause	**Remedy**
Improperly positioned control arm anchor bracket	See instructions in **Subject 110**.
System air pressure too low to fully release spring brake	Check that the air governor cuts out at the recommended setting.
Loose brake linings	Repair or replace the linings as required.
Pushrod binds on chamber housing	Check for correct alignment and correct chamber mounting bracket. Adjust or replace parts as needed.
Air supply does not exhaust completely	Test the air system valves for leakage and correct operation.
Out-of-round brake drums	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, see the brake manufacturer's service manual.
Extreme differences in lining-to-drum clearances between shoes on same wheel	Check for proper operation of the brake mechanism. Lubricate or overhaul as needed.
Out-of-adjustment wheel bearings	Adjust the wheel bearings, or replace them if damaged. For instructions see **Section 33.01** for front axles and **Section 35.00** for rear axles.
Broken brake shoe return spring	Replace the brake shoe return spring.

Problem— Brake Chamber Pushrod Travel Is Excessive

Problem— Brake Chamber Pushrod Travel Is Excessive	
Possible Cause	**Remedy**
Loose, broken, or bent control arm anchor bracket	Tighten or replace the anchor bracket as required.
Worn camshaft bushings	Replace the worn camshaft bushings.
Camshaft binds	Lubricate the camshaft or overhaul the brake mechanism as needed.
Loose brake chamber mounting	Tighten the brake chamber mounting fasteners.
Worn slack adjuster clutch assembly	Replace the slack adjuster.

Specifications

Approved Lubricants	
Component	**Lubricant Type**
Low Lube	SHC 460 Synthetic
Standard	Standard Chassis Grease

Table 1, Approved Lubricants

Stroke Specifications		
Chamber Size	**Maximum Applied Stroke Inch (mm)**	**Desired Free Stroke Inch (mm)**
12	1-3/8 (35)	3/8–1/2 (10–13)
16 and 20	1-3/4 (44)	
24	1-3/4 (44)	3/8–5/8 (10–16) *
	2 (51) — 2-1/2-Inch Extended Stroke	
	2.5 (64) — 3-Inch Extended Stroke	
30	2 (51)	
	2.5 (64) — Long Stroke	

* Without drag.

Table 2, Stroke Specifications

Brake Pedal Removal and Installation

Removal

See **Fig. 1** for a complete exploded view of the clutch- and brake-pedal assembly.

1. Park the vehicle on a level surface, shut down the engine, apply the parking brakes, and chock the tires.
2. Remove the clutch pedal. For instructions on removal See **Section 25.03**, Subject 100.
3. Remove the clutch stop and neutral safety switch. See **Fig. 2**.
4. Remove the flanged hexnut, washer, and bolt securing the brake plunger to the air brake lever. See **Fig. 3**. Discard the hexnut.
5. Remove the bearing from the air brake lever. The bearing sits horizontally in a U-shaped cutout near the cab end of the brake plunger. See **Fig. 4**.
   - 5.1 Lift the brake pedal up and push the brake plunger in slightly.
   - 5.2 Reach behind the brake lever and remove the bearing from the plunger.
6. Remove the wedge, belleville washers, and capscrew from each end of the brake cross-shaft.
   - 6.1 Remove the capscrews and belleville washers from the wedge at each end of the brake cross-shaft.
   - 6.2 Pry the wedges out from end.
   - 6.3 Discard the wedges, washers, and capscrews. DO NOT REUSE!
7. Remove the two 5/16–18 machine screws and washers securing the rubber seal assembly (rubber boot) to the mounting bracket. See **Fig. 5**. Remove the seal.
8. Slide the brake plunger out of the bore in the center of the mounting bracket. Wipe off the old grease from the plunger, rubber seal, and bracket.
9. Wipe out the old lubricant from the bore, and any bearing dust and using clean shop air.
10. Inspect the brake plunger bearing (in the center bore) and the sliding surface of the plunger. If there is any wear or damage (cracks or chips), replace the part.
11. Inspect the guide bearing and rubber seal assembly; replace the assembly if it is damaged.

NOTE: Removing the brake lever allows the cross-shaft to move far enough to the right for the brake pedal to be removed.

12. Slide the cross-shaft to the left and remove the brake lever.
13. Slide the cross-shaft to the right and remove the brake pedal.

Installation

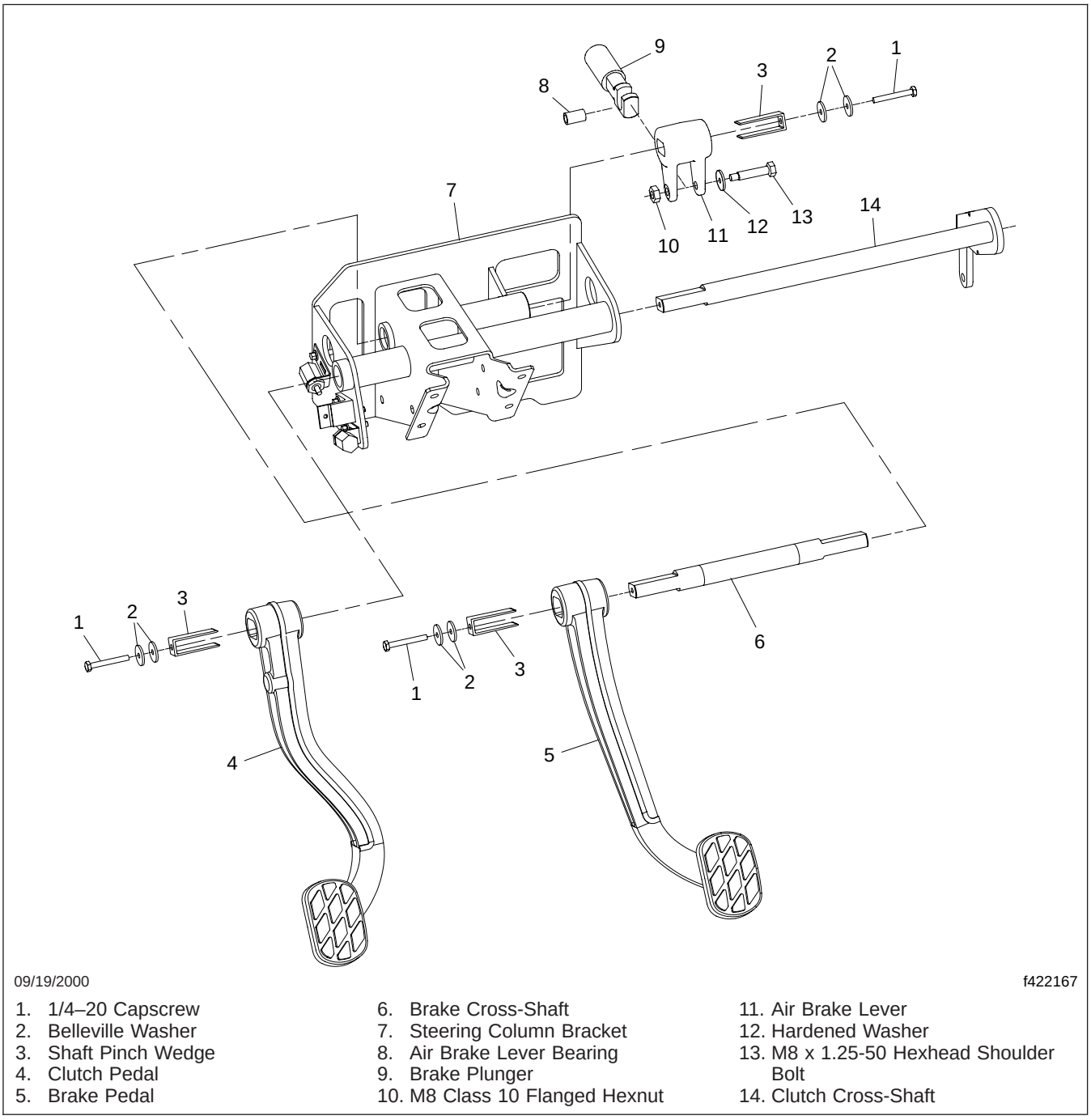
1. Slide the brake cross-shaft to the right and slide the brake pedal onto the shaft.
2. Slide the cross-shaft to the left and install the brake lever.
3. Lightly Lubricate the sliding surface on the brake plunger and the bearing bore with a silicone-based grease such as Dow Corning 55 O-Ring Lubricant or Loctite V-755 O-Ring Lubricant.
4. Carefully slide the brake plunger into the bearing in the mounting bracket. Make sure the plunger is positioned correctly with the U-shaped cutout facing up. See **Fig. 5**.
5. Install the guide bearing and rubber seal assembly on the mounting bracket with the arrow pointing up. Secure the seal with two washers and 5/16–18 machine screws. Tighten the screws 15 lbf·ft (20 N·m).
6. Inside the cab, place the lever bearing in the U-shaped cutout near the end of the brake plunger. See **Fig. 3**.
7. Align the lever bearing with the holes in the brake lever.

IMPORTANT: The shoulder bolt may be reused but the hexnut must be replaced after it is removed for any reason. For part numbers, see **Specifications 400**.

8. Insert a washer and M8 x 1.25-50 shoulder bolt through the holes in the brake lever and bearing. Secure in place with a new M8, class 10 flanged hexnut. Tighten the nut 17 lbf·ft (23 N·m).

IMPORTANT: The wedge, belleville washers and capscrews must be replaced after they are re-

Brake Pedal Removal and Installation

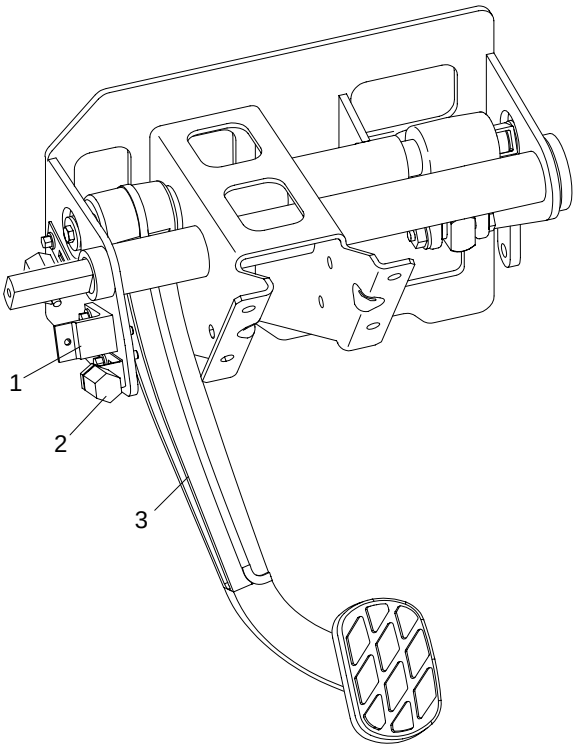


1. 1/4–20 Capscrew
2. Belleville Washer
3. Shaft Pinch Wedge
4. Clutch Pedal
5. Brake Pedal
6. Brake Cross-Shaft
7. Steering Column Bracket
8. Air Brake Lever Bearing
9. Brake Plunger
10. M8 Class 10 Flanged Hexnut
11. Air Brake Lever
12. Hardened Washer
13. M8 x 1.25-50 Hexhead Shoulder Bolt
14. Clutch Cross-Shaft

Fig. 1, Brake- and Clutch-Pedal Assembly

moved for any reason. For part numbers, see **Specifications 400**.

9. Install the wedge, belleville washers, and capscrew from each end of the brake cross-shaft.



1. Clutch Stop
2. Nuetral Safety Switch
3. Clutch Pedal

Fig. 2, Clutch Pedal Removed

IMPORTANT: The belleville washers are concave and must be installed facing each other as shown in **Fig. 6**.

9.1 Install the capscrews and belleville washers at each end of the brake cross-shaft. The belleville washers are concave and must be installed opening away from each other as shown in **Fig. 6**.

9.2 Tighten the capscrews 8 lbf·ft (10.8 N·m).

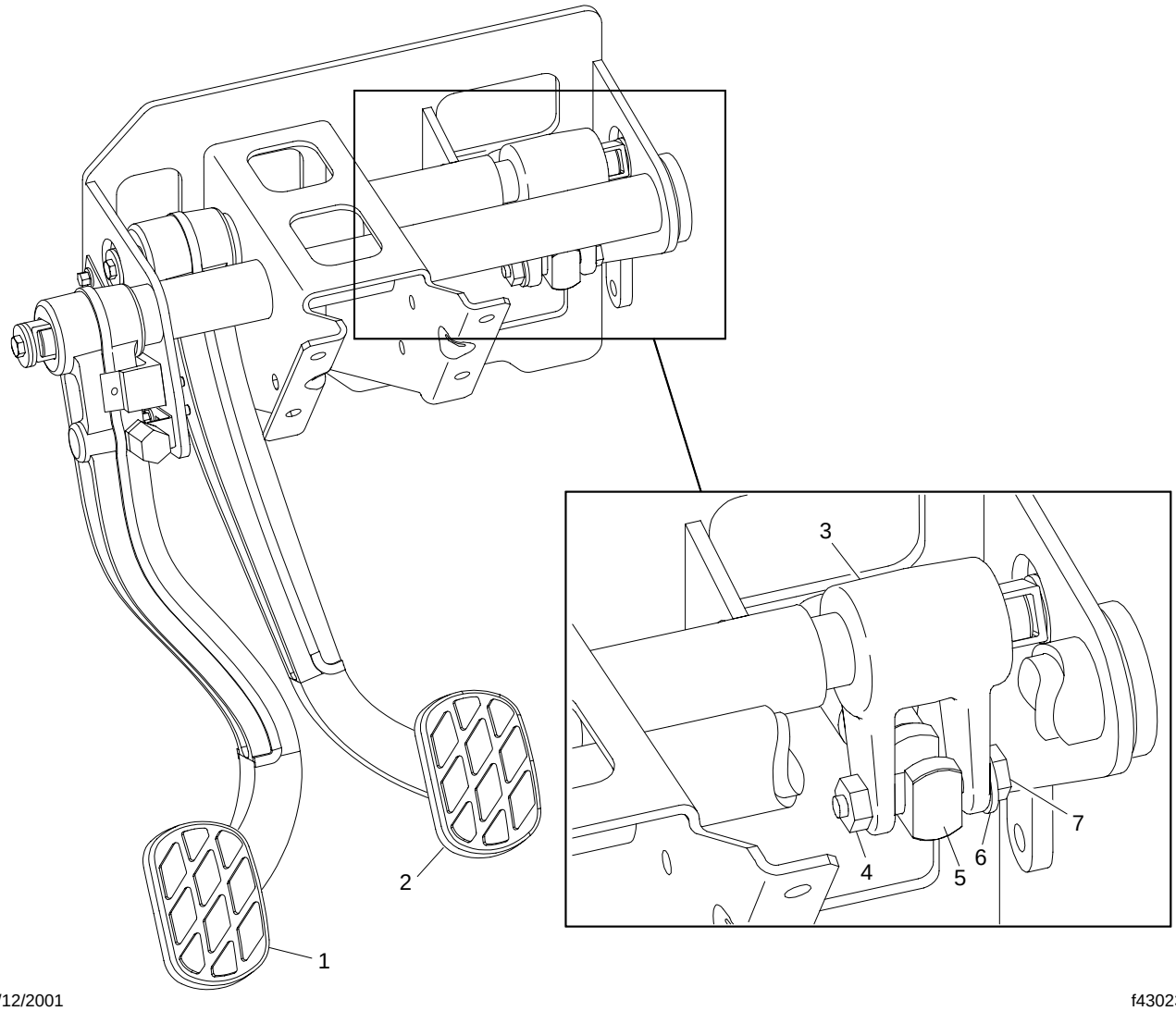
10. Install the clutch stop and neutral safety switch. See **Fig. 2**.
11. Install the Clutch Pedal. For instructions, see **Section 25.03**, Subject 100.
12. Remove the chocks from the tires.

⚠ WARNING

Do not operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

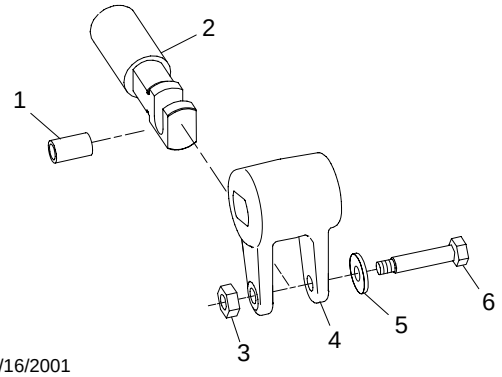
13. Test drive the vehicle in a safe area at low speed. Make several brake applications to be sure the vehicle comes to a stop.

Brake Pedal Removal and Installation



1. Clutch Pedal
2. Brake Pedal
3. Air Brake Lever
4. M8 Class 10 Flanged Hexnut
5. Brake Plunger
6. Hardened Washer
7. M8 x 1.25-50 Hexhead Shoulder Bolt

Fig. 3, Brake- and Clutch-Pedal Assembly



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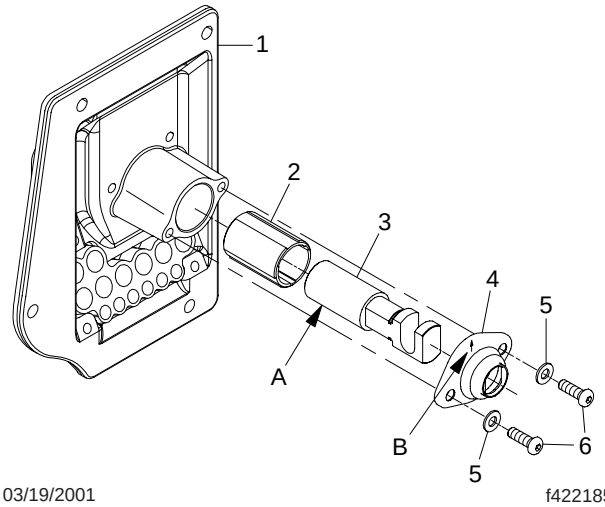
1. Bearing
2. Brake Plunger
3. M8 Class 10 Flanged Hexnut
4. Air Brake Lever
5. Hardened Washer
6. M8 x 1.25-50 Hexhead Socket Shoulder Bolt

Fig. 4, Air Brake Lever Assembly



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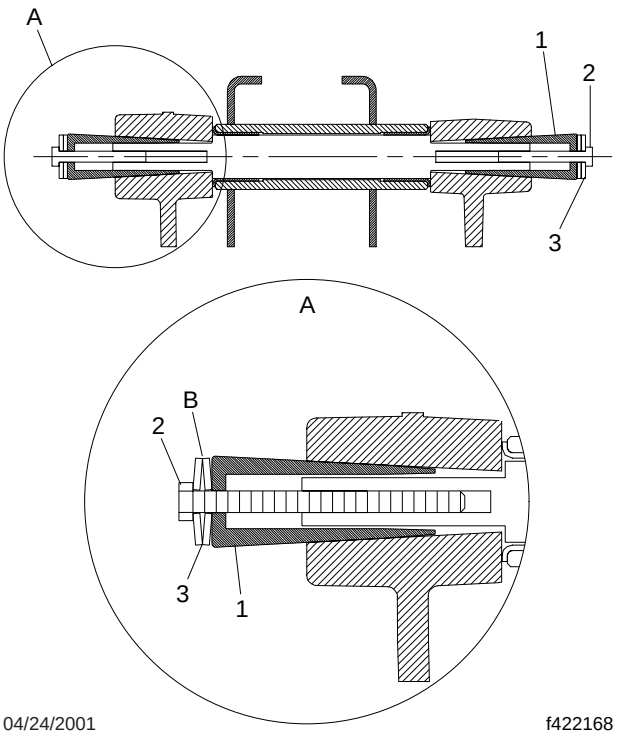
A. Apply a small amount of silicon grease on the contact surface between items 2 and 3.
B. Install the rubber seal assembly with the arrow pointing up.

1. Mounting Bracket
2. Brake Plunger Bearing
3. Brake Plunger
4. Guide Bearing and Rubber Seal Assembly
5. Plated Flatwasher
6. 5/16–18 x 1-Inch Machine Screw

Fig. 5, Brake Plunger Removal



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A. Detailed Area
B. **IMPORTANT: Belleville washers must be installed facing each other.**

1. Wedge
2. 1/4–20 Capscrew
3. Belleville Washers

Fig. 6, Wedge Installation

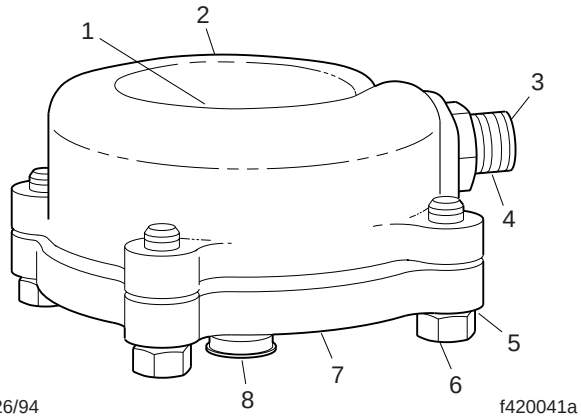
Specifications

Brake Pedal Replacement Parts	
Description	**Part Number**
Shaft Pinch Wedge	12-17561-000
Belleville Washer	23-12105-000
1/4–20 Capscrew	23-12686-250
M8 Class 10 Flanged Hexnut	MBT N210100008000

Table 1, Brake Pedal Replacement Parts

General Information

The DV–2 automatic reservoir drain valve automatically removes contaminants and water from the wet air tank each time the brakes are applied. See **Fig. 1**. The drain valve is attached to a drain cock located on the bottom of either end of the wet air tank. Since the brake application valve is protected by a check valve between the wet and dry air tanks, any leak or failure will not reduce the supply of air that is in the dry part of the system. If the leak is severe, it could prevent the continued resupply of air as it is used when applying the brakes. A failed drain valve will allow moisture to build up in the wet tank which in turn could reach the dry tank, and then travel into the air brake system where it could cause brake failure. A leaking drain valve allows wet tank leakdown which in turn can cause premature wear on the air compressor during vehicle operation as the air compressor continues to run to maintain wet tank air pressure.



1. Top Reservoir Port
2. Valve Body
3. Hexhead Nipple
4. Side Reservoir Port
5. Lockwasher (4 qty.)
6. Capscrew (4 qty.)
7. Valve Cover
8. Exhaust Port

Fig. 1, DV-2 Valve

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 approximately 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 sufficiently to close the exhaust valve. See **Fig. 5**.

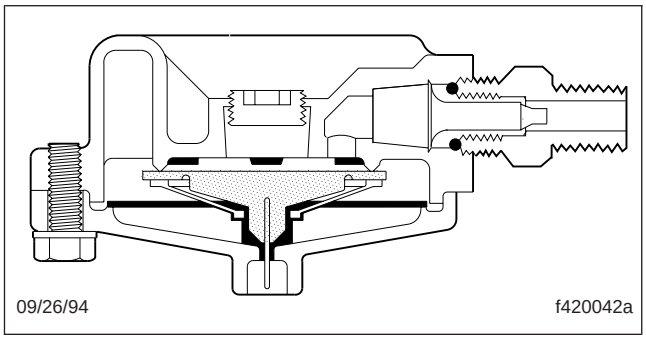


Fig. 2, No System Pressure

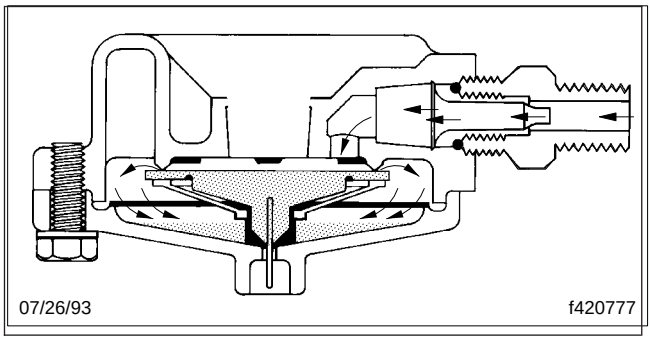


Fig. 3, Start of System Pressure Charging

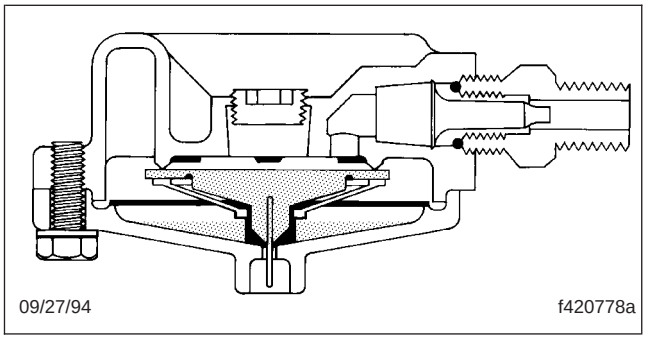


Fig. 4, System Pressure Rising

The length of time the exhaust valve remains open and the amount of moisture and contaminants ejected depends upon the sump pressure and the

General Information

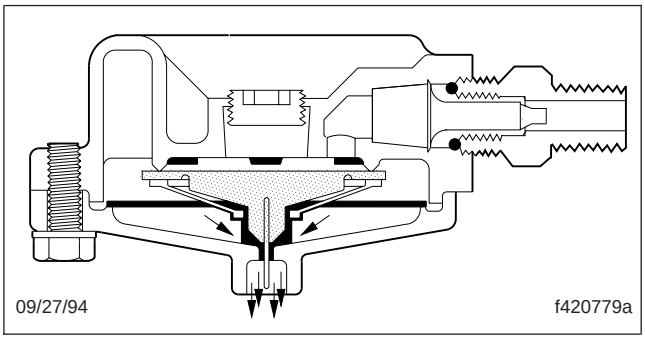


Fig. 5, Exhaust Cycle

wet tank pressure drop that occurs each time air is used from the system.

Safety Precautions

Before attempting to work on the air brake system, observe the following precautions:

- Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized. The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.
- When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.
- Hoses will whip dangerously if disconnected under pressure. Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.
- As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber pushrods and spring actuators that apply automatically with the loss of pressure. This also applies when checking the service brake system.
- Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.
- Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.
- The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.
- Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.
- To avoid injury, keep clear of the air chamber pushrod when brakes are applied or when air is exhausted from the system.

⚠ WARNING

Before working on or around air brake systems and components, see "Safety Precautions" in Subject 100. Failure to do so may result in personal injury.

Operating Test

Perform the following test after repairing or replacing the DV–2 valve to ensure that the valve is functioning properly.

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 properly, repair or replace it following the instructions in this section.

Leakage Test

Perform the following test after repairing or replacing the DV–2 valve to ensure that the valve is functioning properly.

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 the instructions in this section.

⚠ WARNING

Before working on or around air brake systems and components, see "Safety Precautions" in Subject 100. Failure to do so may result in personal injury.

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Remove the drain valve assembly from the end of the wet tank air reservoir.

Installation

1. Using a cleaning solvent, thoroughly flush and clean the wet tank reservoir to avoid early fouling at the drain valve. Aerate the wet tank thoroughly 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 in **Subject 110**.
5. Remove the chocks from the tires.

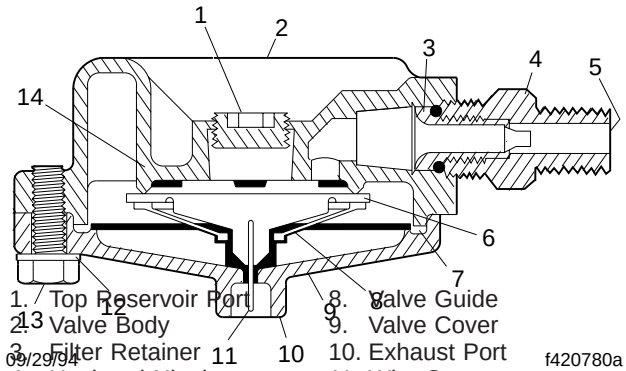
Disassembly, Cleaning and Inspection, and Assembly

⚠ WARNING

Before working on or around air brake systems and components, see "Safety Precautions" in Subject 100. Failure to do so may result in personal injury.

NOTE: For a cutaway view of the DV–2 valve, see **Fig. 1**.

Disassembly



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 (4 qty.)
13. Capscrew (4 qty.)
14. Inlet Valve Seat

Fig. 1, DV-2 Valve (cutaway view)

1. Remove the drain valve following the instructions in **Subject 120**.
2. Remove the four capscrews that hold the valve cover to the valve body.
3. Remove the valve cover and sealing ring.
4. Remove the valve guide, and the inlet and exhaust valve from the valve body.
5. Remove the hexhead nipple from the valve body.

Cleaning and Inspection

⚠ WARNING

Use eye protection when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

1. Wash all metal parts of the drain valve in an approved cleaning solvent. Dry the metal parts of the disassembled moisture ejection valve with compressed air.
2. Wipe all rubber parts with a clean cloth. Examine all rubber parts for wear, cracks, tears, or other deterioration. If any rubber parts are worn, cracked, torn or otherwise deteriorated, replace them with new parts.
3. Examine all metal parts for wear, cracks, or other damage. If any metal parts are worn, cracked, or otherwise damaged, replace them with new parts.
4. 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

Before assembling the drain valve, apply a light film of grease on the inlet valve seat.

⚠ CAUTION

Do not apply oil to the inlet and exhaust valve.

1. Install the valve sealing ring into its groove in the valve cover.
2. Install the valve guide over the inlet and exhaust valve.
3. Install the valve guide, and the inlet and exhaust valve as an assembly into the valve cover. The wire stem will project through the exhaust port.

Disassembly, Cleaning and Inspection, and Assembly

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 in **Subject 120**.

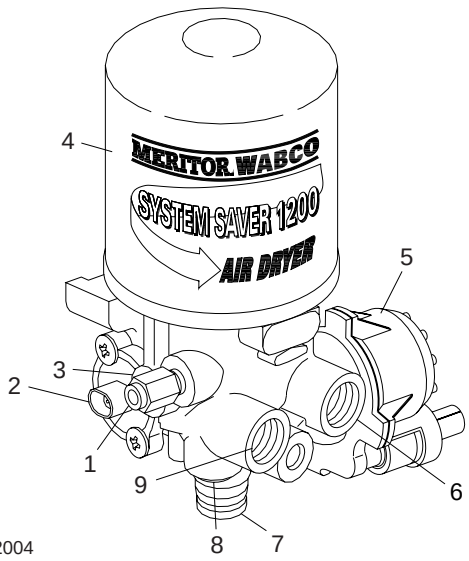
Specifications

Torque Values	
Description	**Torque lbf·in (N·cm)**
Valve Cover Capscrews	72–96 (820–1080)
Hexhead Nipple	48–72 (540–820)

Table 1, Torque Values

General Information

The System Saver 1200 air dryer (see **Fig. 1**) is a desiccant air dryer, mounted vertically between the air compressor and the supply reservoir. The air dryer receives hot compressed air, which it cools and filters before sending it to the supply reservoir, reducing the build-up of dirt and moisture in the vehicle air system.



1. Pressure Relief Valve
2. Heater/Thermostat Assembly
3. Governor Port (to air governor)
4. Desiccant Canister
5. Regeneration Valve Assembly
6. Outlet Port (to air supply reservoir)
7. Exhaust Port (Purge Valve Assembly)
8. Turbocharger Cutoff Valve
9. Inlet Port (from air compressor)

Fig. 1, WABCO System Saver 1200

The air dryer consists of a light-weight aluminum and steel body. The desiccant cartridge is contained in a spinoff canister at the top of the air dryer.

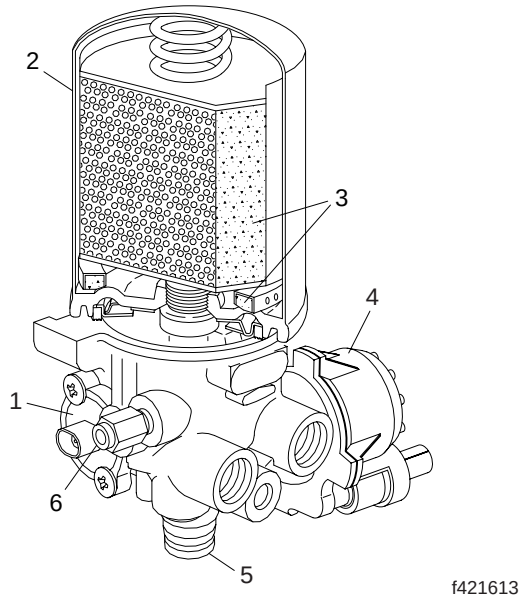
The following components attach to the body of the air dryer:

- Pressure Relief Valve—this valve protects the air dryer from over pressurization. The valve is attached directly to the air dryer.
- Desiccant Canister—a cylindrical steel housing that contains the filter elements and the desiccant needed to filter and dry the air that passes through it.
- Heater/Thermostat Assembly—located in the air dryer base, this assembly is designed to prevent the collected moisture from freezing.
- Outlet Check Valve—this valve prevents air in the system from flowing back through the air dryer and escaping out the purge valve during the compressor unload cycle.
- Pressure-Controlled Check Valve—this valve is separate from the air dryer and is installed on the system air tank. The valve allows air to back flow from the system tank to the supply tank as long as air system pressure remains between the normal cut-in and cut-out range of the air governor.
- Purge Valve—this valve allows the collected moisture and contaminants to be expelled from the air dryer during the purge cycle.
- Regeneration Valve—this valve allows air from the supply and system tanks to bypass the outlet check valve and flow into the regeneration valve. Air then flows through an orifice where the air expands and back flushes moisture off of the desiccant. The air is then exhausted through the purge valve.
- Silencer (Muffler)—an optional component that is attached to the purge valve and used to eliminate most of the noise during the air dryer purge cycle.
- Turbocharger Cut-Off Valve—this valve closes the path between the air compressor and the air dryer purge valve to help maintain boost pressure for maximum engine horsepower during the compressor unload cycle.

Principles of Operation

Hot, compressed air enters the air dryer through the inlet port. As the hot air is forced into the desiccant cartridge, the temperature of the compressed air falls to nearly ambient. Oil and water vapor condense and initially settle into the base of the dryer. The moisture-laden air also passes through the desiccant bed, where any remaining moisture is retained by the desiccant. The clean air then passes through the air dryer outlet port to the supply reservoir. See **Fig. 2 .**

General Information and Principles of Operation



1. Heater/Thermostat Assembly
2. Desiccant Canister
3. Filter
4. Regeneration Valve Assembly
5. Exhaust Port (Purge Valve Assembly)
6. Pressure Relief Valve

Fig. 2, Sectional View

When the compressor reaches about 125 psi (862 kPa), the purge valve opens, allowing the initial decompression of the dryer, and expelling the water and contaminants collected in the base of the dryer. The regeneration valve, along with the pressure-controlled check valve, allows the system air to flow back through the dryer. This back flow dries the desiccant for the next cycle.

Safety Precautions

⚠ WARNING

When draining the air system, do not look into the air jets or direct them toward another person, as dirt or sludge particles may be in the air-stream. Do not disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions during service operations of the air brake system can cause personal injury.

When working on or around air brake systems and components, observe the following precautions.

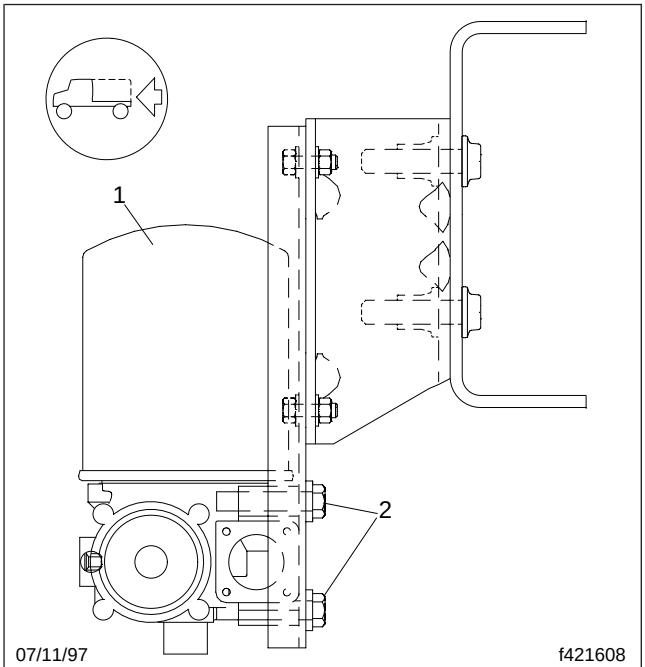
1. Apply the parking brake, chock the tires, and stop the engine when working under the vehicle. Draining the air system may cause the vehicle to roll. Keep hands away from the brake chamber push rods and slack adjusters, which may apply as air system pressure drops.
2. Wear safety goggles.
3. Never connect or disconnect a hose or line containing air under pressure; it may whip as air escapes. Never remove a component or pipe plug unless you are sure all system pressure has been depleted.
4. Don’t disassemble a component before reading and understanding recommended procedures. Use only the correct tools and follow basic tool safety.
5. Replacement hardware, tubing, hose, fittings, etc. should be the same size, type, length, and strength as the original equipment. When replacing tubing or hose, be sure that all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace any components that have stripped threads or damaged parts. Don’t attempt to repair parts by machining.
7. Never exceed recommended air pressure.

WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

Removal

1. Drain the air system.
2. Disconnect the wiring harness from the air dryer.
3. Mark the air lines for later reference, then disconnect them from the air dryer.
4. Remove the capscrews, washers, and spacers that attach the air dryer to the mounting bracket.
5. Remove the air dryer. See **Fig. 1**.



1. Desiccant Canister
2. 1/2" Capscrew, Washer, and Spacer

Fig. 1, Air Dryer Installation (outboard rail mounting shown)

Installation

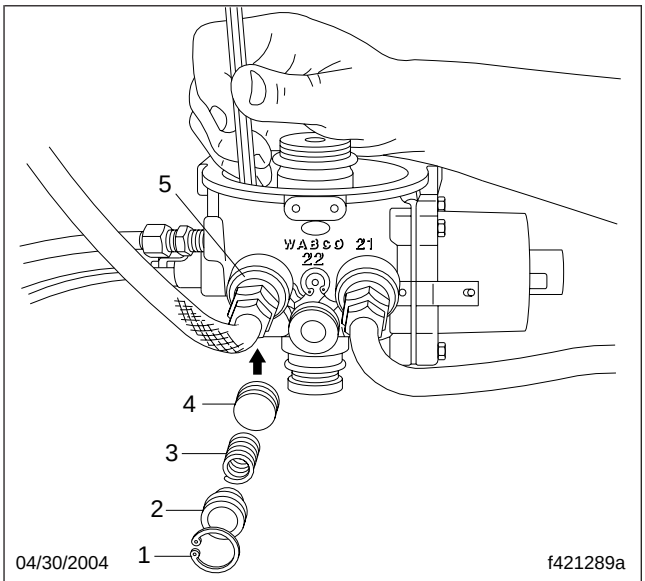
1. Position the air dryer on the mounting bracket. Install the spacers, washers, and capscrews. Tighten them 22 to 30 lbf·ft (30 to 41 N·m). See **Fig. 1** .
2. Make sure the air lines are clean. Replace any line or fitting that is crimped or damaged.
3. Connect the remaining air lines to the air dryer as previously marked. Tighten the nut on each fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance.
4. Connect the air dryer wiring harness.
5. Pressurize the air system and check for leaks. Repair as necessary.

Replacement

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Remove the snap ring at the bottom of the valve assembly. The valve cover and spring may fall out of the cavity when the snap ring is removed. See **Fig. 1**.



1. Snap Ring
2. Cover
3. Spring
4. Piston
5. Inlet Port

Fig. 1, Push the Piston, Spring, and Cover out of the Valve Cavity

3. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it.
4. Using a wooden stick, push the piston, spring, and the cover out of the valve cavity.
5. Clean the valve cavity with a commercial cleaning solvent.
6. Install new O-rings on the piston and the cover.
7. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-rings and the valve cavity.
8. Install the new piston with its hollow side facing out.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

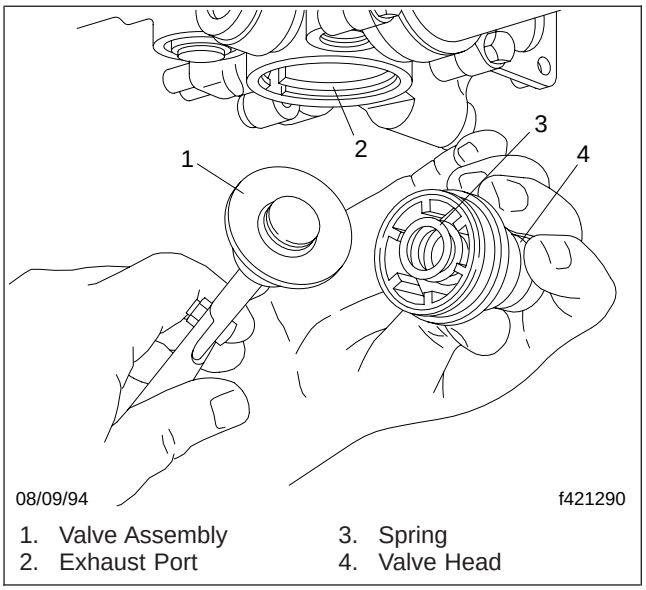
9. Install the new spring, cover, and snap ring to hold the components in place.
10. Thread the desiccant cartridge onto the dryer base (turn clockwise). When the seal contacts the base, tighten the cartridge one complete turn more. Do not over-tighten.

Replacement

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Remove the snap ring, valve head, and the spring from the exhaust port. See **Fig. 1**.



1. Valve Assembly
2. Exhaust Port
3. Spring
4. Valve Head

Fig. 1, Remove the Valve Assembly

3. Pull the valve assembly out of the exhaust port.
4. Remove the O-ring from the base of the exhaust port.
5. Clean the purge valve cavity area with a commercial cleaning solvent.
6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the O-rings and the valve cavity. Install the O-rings in the base of the exhaust port and on the valve head.
7. Position the new valve assembly in the valve cavity.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

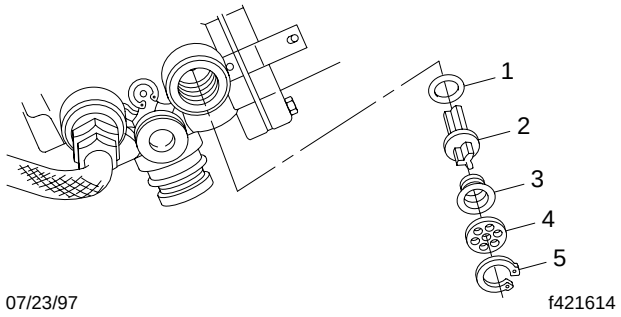
8. Install the spring in the valve head, and position them in the valve cavity.
9. Install the snap ring to secure the valve head in position.

Replacement

WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Disconnect the air line from the outlet port. See **Fig. 1**.



1. O-Ring
2. Valve Body
3. Spring
4. Washer
5. Snap Ring

Fig. 1, Outlet Check Valve Assembly

3. Remove the snap ring, washer, valve body, and the O-ring.
4. Clean the cavity area with a commercial cleaning solvent.
5. Install a new O-ring on the valve body.
6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the valve cavity.
7. Install the new valve body. Make sure that the long end of the body is inserted first into the valve cavity.
8. Install the new spring with its small end around the "Y" shaped fins on the valve body.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

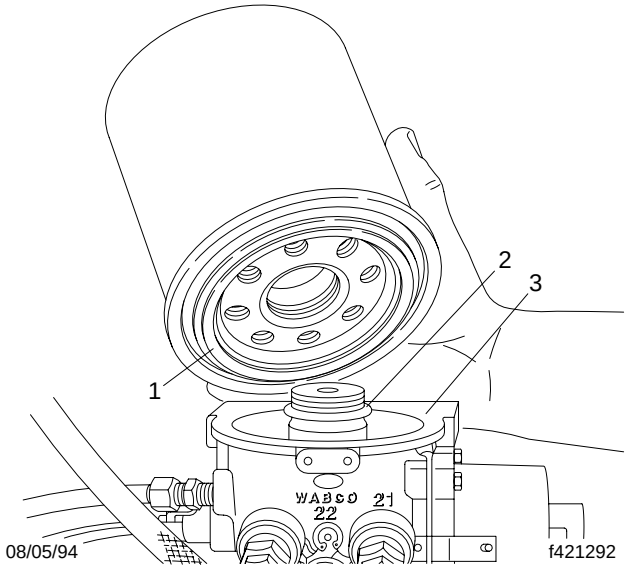
9. Install a new washer and snap ring to secure the assembly in the valve cavity.
10. Connect the air line to the outlet port. Tighten the nut on the fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.

Replacement

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it. See **Fig. 1**.



1. Seal
2. O-Ring
3. Air Dryer Base

Fig. 1, Desicant Cartridge Replacement

3. Remove and discard the O-ring.
4. Clean the top surface of the dryer base with a commercial cleaning solvent.
5. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the dryer base. Install the O-ring.
6. Thread the desiccant cartridge onto the dryer base (turn clockwise). When the seal contacts the base, tighten the cartridge one complete turn more. Do not over-tighten.

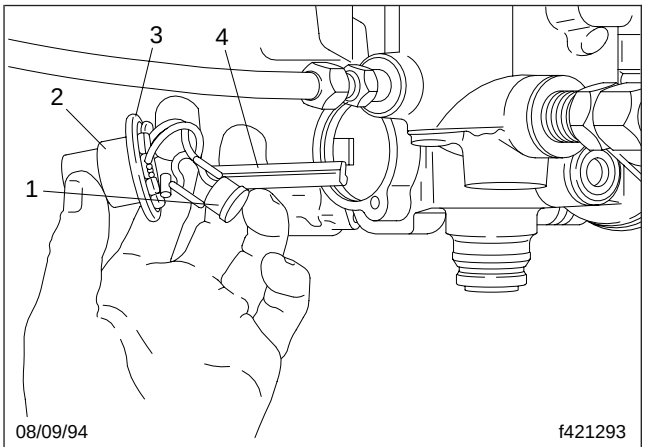
IMPORTANT: If the air dryer base is damaged, preventing a tight seal, replace the air dryer.

Replacement

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Disconnect the wiring harness.
3. Remove the screws that attach the heater/thermostat receptacle. Remove the receptacle and the O-ring.
4. Remove the retaining screw that holds the assembly in place. Remove and discard the heater/thermostat assembly. See **Fig. 1**.



1. Thermostat
2. Receptacle
3. O-Ring
4. Heater Element

Fig. 1, Heater/Thermostat Replacement

5. Clean the heater/thermostat assembly area with a commercial cleaning solvent.
6. Position the new heater/thermostat assembly in the cavity. Install the retaining screw.
7. Position the new receptacle and O-ring, and install the screws. Tighten the screws securely.
8. Connect the wiring harness.

Replacement

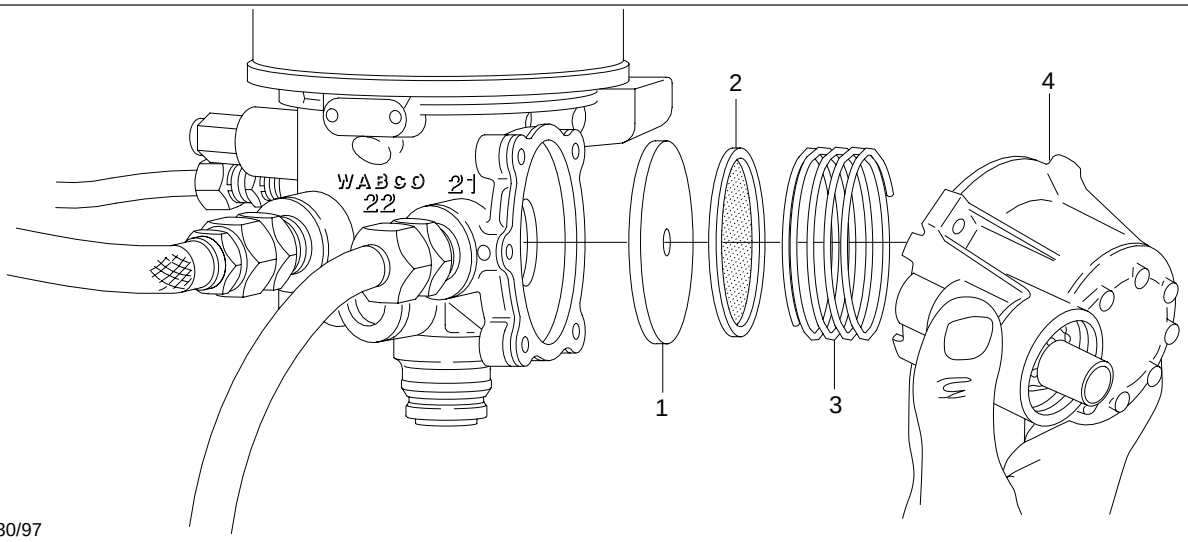
WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.

NOTE: When the valve housing is removed, the spring and the retainer will fall out of the housing. See **Fig. 1**.

2. Remove the four mounting bolts and remove the valve housing assembly.



1. Diaphragm
2. Retainer
3. Spring
4. Valve Housing Assembly

Fig. 1, Regeneration Valve Assembly

3. Remove the rubber diaphragm.
4. Using a commercial cleaning solvent, clean the groove where the diaphragm lip fits.
5. Install a new diaphragm with its lip in the groove.

IMPORTANT: If the groove is damaged, preventing a tight seal, replace the air dryer.

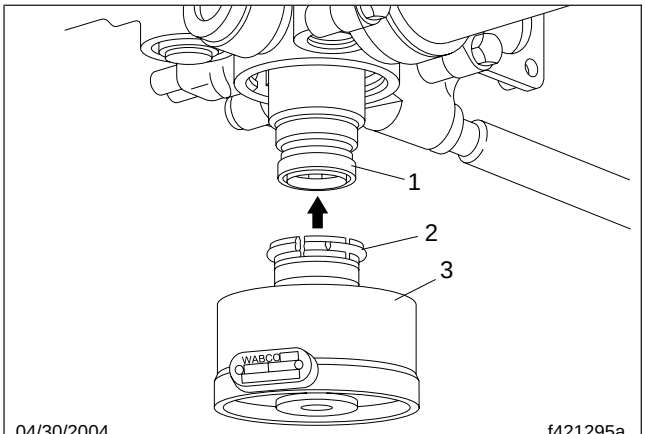
6. Install the new spring and retainer (with the retainer lip facing out).
7. Position the valve housing on the air dryer. Install the bolts and tighten them to 53 lbf·in (600 N·cm).

Replacement

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Using snap ring pliers, expand the snap ring and pull the silencer off of the purge valve head. See **Fig. 1**.



1. Purge Valve Head
2. Snap Ring
3. Silencer

Fig. 1, Silencer Replacement

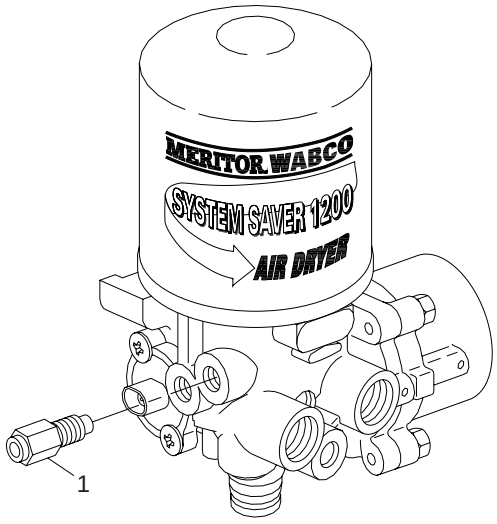
2. Push the new silencer onto the purge valve head until the silencer snaps into place.

Replacement

⚠ WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Unscrew and remove the old valve from the dryer. See **Fig. 1**.



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1. Pressure Relief Valve

Fig. 1, Pressure Relief Valve Replacement

3. Screw the replacement valve into the dryer base. Do not exceed a torque of 30 lbf·ft (41 N·m) for a 3/8-inch thread, or 65 lbf·ft (88 N·m) for a 1/2-inch thread.

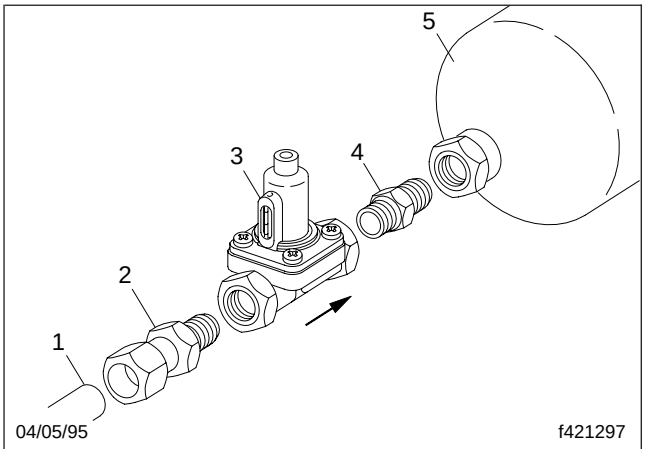
NOTE: The threads on the replacement pressure relief valve provided by Meritor WABCO are coated with sealant. They do not require any additional sealant.

Replacement

WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Disconnect the air line from the fitting on the valve. See **Fig. 1**.



1. Air Line
2. Nylon Tube Connector
3. Pressure-Controlled Check Valve
4. Hex Nipple Pipe Fitting
5. Air Tank

Fig. 1, Check Valve Assembly Replacement

3. Remove the air-line fitting firm the valve.
4. Remove the valve and the hex nipple fitting from the air tank. Then remove the nipple from the valve.

NOTE: Apply liquid Loctite® Hydraulic Sealant (brown), or an equivalent, to the threads of all fittings before installing them. Always apply sealant to the external threads so that any excess will be scraped off externally rather than internally to the joint.

5. Install the pipe fittings on the new valve. Make sure that the arrow on the valve will be pointing towards the tank when installed.
6. Install the new valve on the air tank.
7. Connect the air line to the air-line fitting on the valve. Tighten the air line securely.

Operating Tests

WARNING

Before starting the procedures below, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

Air Dryer Operating Check

1. Drain the air system.
2. Start the engine and build the air pressure to as close to cutout pressure as possible (about 125 psi [862 kPa]).
3. When the compressor reaches the unload cycle, the air dryer purges, beginning regeneration of the air dryer.
4. During the purge cycle, which lasts about 10 to 15 seconds, the wet tank and secondary system tank with pressure-controlled check valve will drop about 10 psi (69 kPa). Check the secondary system air gauge in the cab dash panel.
5. If the secondary gauge needle does not show a pressure drop of about 10 psi (69 kPa), one of the following problems may exist.
    - A pressure-controlled check valve is not installed.
    - The pressure-controlled check valve is installed in the wrong air tank.
    - The pressure-controlled check valve is installed on a one-way check valve, instead of in place of a one-way check valve.
    - There is an extra check valve located somewhere between the air dryer and the secondary air tank (usually at the wet tank).
    - The secondary air gauge is not plumbed to the secondary air system.
6. If system secondary air pressure drops 25 psi (172 kPa) or more during the purge cycle, and there are no other air-operated components in use, then there are air leaks or other system problems. Refer to **Troubleshooting, 300** for other possible causes.

Pressure-Control Check Valve Operating Check

1. Start the engine and build the air pressure to cutout pressure (about 125 psi [862 kPa]).
2. Stop the engine after the air compressor has unloaded.
3. Drain the supply system air tank down to about 80 psi (552 kPa) or lower.
4. Check the secondary air gauge. It should read 95 ±5 psi (655 ±34 kPa).

    If the gauge reading is less that 90 psi (621 kPa), either the pressure-control check valve is installed backwards, it is damaged, or there are air leaks in the secondary air system.

    If the secondary gauge reading does not change, or the reading does not fall below 100 psi (689 kPa):

    - There is no pressure-controlled check valve installed, or it is installed in the wrong tank.
    - The pressure-controlled check valve is installed into a one-way check valve, rather than in place of a one-way check valve.
    - There is another check valve located between the air dryer and the secondary air tank.
    - The secondary air gauge is not plumbed to the secondary air system.

Troubleshooting Table

Meritor WABCO System Saver 1200 Troubleshooting

Meritor WABCO System Saver 1200 Troubleshooting		
Condition	**Possible Cause**	**Solution**
Dryer leaks from purge valve during compressor-loaded cycle. The leak may cause excessive compressor cycling or prevent the system from building air pressure.	Purge valve frozen open (cold weather operation).	Check heater. Repair/replace if necessary. Make sure governor to dryer port 4 line is free of water/oil.
		Remove and inspect purge valve and clean water/oil from top of piston.
	Debris under purge valve seat, such as particles from fittings or air inlet line.	Disassemble and clean purge valve.
	Purge valve washer installed upside-down.	Remove cartridge and clean dryer sump area. Ensure lip on aluminum washer faces DOWN, away from dryer.
	Wrong air-line connected to dryer port 4 (unloader port).	Verify correct air-line installation and correct as needed.
	Purge valve snap-ring not fully seated in groove.	Seat snap-ring fully into groove.
Slight leak from purge valve. After several hours, the supply tank may be empty.	Outlet check valve not seating or regeneration valve not shutting off regeneration airflow.	Remove, inspect, and clean outlet check valve and regeneration valve diaphragms. Replace if worn or damaged.
Regeneration cycle too long (more than 30 seconds), accompanied by loss of pressure in the supply tank.	Outlet check valve not seating.	Inspect and replace outlet check valve as needed.
	Regeneration valve not shutting off regeneration airflow.	Replace regeneration valve.
Regeneration cycle too short (less than 10 seconds).	High air system demands during compressor unloaded cycle.	Increase air system capacity or reduce air demands.
	Pressure-controlled check valve not installed in system or not working properly.	Check and replace pressur-econtrolled check valve as needed.
	One-way check valve installed in system reservoir instead of, or with, pressure-controlled check valve.	Remove one-way check valve. Make sure pressure-controlled check valve is installed correctly.
	Regeneration valve not working.	Remove regeneration valve and clean oil from diaphragm.
		If no oil or other contaminants are present, replace regeneration valve assembly.
	Air governor not working properly.	Inspect per manufacturer's instructions and repair/replace as needed.

Troubleshooting

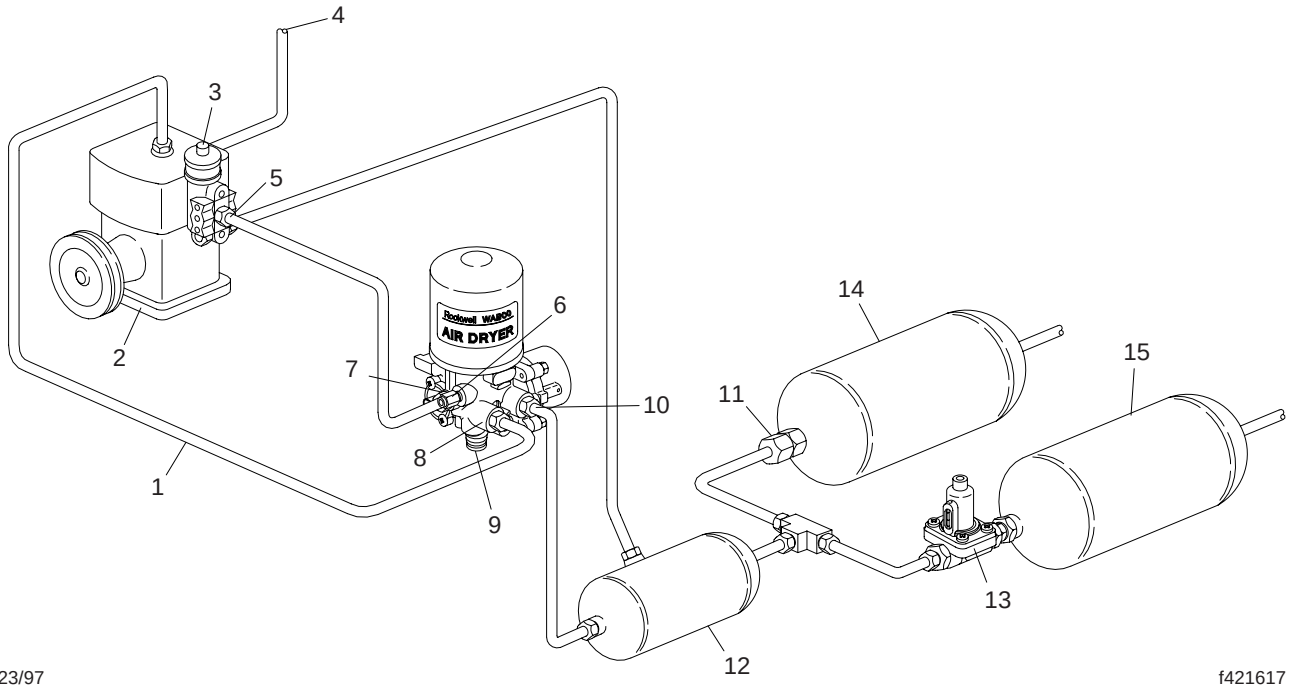
Meritor WABCO System Saver 1200 Troubleshooting		
Condition	**Possible Cause**	**Solution**
No regeneration cycle. No airflow from purge valve after initial purge blast (dryer decompression).	Air dryer not connected to supply tank or connections reversed at dryer.	Verify proper dryer installation per system diagram.
	Regeneration valve not working.	Replace regeneration valve.
	One-way check valve installed in supply tank.	Remove one-way check valve.
	Alcohol evaporator installed between dryer and supply tank.	Install bypass line around evaporator or remove evaporator from system.
Air dryer does not purge when compressor unloads (no blast of air from purge valve).	Air line between governor and air dryer port 4 kinked or plugged.	Repair air line.
	Purge valve stuck closed.	Replace purge valve.
	Air governor not working properly.	Inspect air governor. Repair/replace per manufacturer's instructions.
	Cut-out pressure never achieved by air compressor.	Check for air leaks in system and repair as needed. If no leaks in system, check compressor output. Repair/replace per manufacturer's instructions.
Air dryer purges too often, perhaps as frequently as every 15 seconds, accompanied by excessive cycling of the compressor.	Leak in line between governor and dryer port 4.	Repair air line.
	Leak in line between supply tank and governor.	Repair air line.
	Excessive air system leaks.	Repair leaks.
	Excessive air system demands.	Increase air system capacity or reduce air demand.
	Outlet check valve not seating.	Inspect and replace outlet check valve as needed.
	Regeneration valve not shutting off properly.	Replace regeneration valve.
	Air governor has less than 16 psi range.	Replace air governor.
	Leaking air compressor unloader(s).	Inspect compressor. Repair/replace per manufacturer's instructions.
Air flows out of purge valve entire time compressor is unloaded.	Turbo cut-off valve not sealing. NOTE: With U Series air dryers the compressor unloads through the dryer, so a steady flow of air is normal.	Replace turbo cut-off valve.
Rapid "spitting" of air from purge valve in small amounts. Frequency varies with engine speed.	Holset E-type compressor used, but no Econ valve installed.	Install Econ valve to provide make-up air to compressor.
	Compressor not completely unloading when cut-out pressure is reached.	Inspect compressor. Repair/replace per manufacturer's instructions.

Meritor WABCO System Saver 1200 Troubleshooting		
Condition	**Possible Cause**	**Solution**
Air leak at turbo cut-off valve vent. Hole burned in piston.	Temperature of air coming into dryer is too high—not enough cooling takes place before dryer inlet.	Move dryer farther from compressor. Add additional compressor discharge line before air dryer. Add cooling coil or heat exchanger before air dryer. NOTE: Inlet air temperature must not exceed 175°F (80°C).
Air leak at turbo cut-off valve vent.	Lip seal installed upside-down on piston. Lip must face UP (towards dryer).	Install lip seal correctly.
	Valve bore worn excessively.	Inspect valve bore for wear. If a new turbo cut-off valve does not seal in a clean, lubricated bore, replace the air dryer.
Air dryer frozen (water collecting in base of dryer is freezing).	No electrical power to heater connector.	Check for a blown fuse. Repair heater circuit. NOTE: There must be power to the heater connector the entire time the vehicle's ignition is ON.
	Low voltage to heater connector.	Repair cause of low voltage, such as poor electrical ground, bad connections, corroded wire splices, etc.
	Heater assembly not working.	Replace heater assembly.
	Wrong voltage air dryer used; i.e., 12-volt air dryer used in a 24-volt system.	Replace with correct voltage air dryer.
No air pressure build-up in system.	Air dryer not plumbed correctly (connections reversed).	Ensure compressor discharge line is plumbed to air dryer port 1, and air dryer port 21 is connected to vehicle's supply tank.
	Wrong air line connected to dryer port 4.	Ensure dryer port 4 line is connected to the "UNL" port of the air governor.
	Air governor not working properly.	Inspect governor per manufacturer's instructions. Repair or replace as needed.
	Air system leaks, such as compressor discharge line, air dryer, reservoirs, brake or suspension valves, etc.	Locate leak(s) and repair.
	Air dryer leaks from purge valve.	Refer to purge valve conditions listed in this chart.
Water in tanks; often following aftermarket installation or when dryer is a replacement for a competitive brand.	Pressure-controlled check valve not installed in correct tank or not installed at all.	Install pressure-controlled check valve in secondary tank.
	Pressure-controlled check valve properly installed, but one-way check valve not removed.	Remove one-way check valve so that only the pressure-controlled check valve is installed between the secondary tank and supply tank.

Troubleshooting

Meritor WABCO System Saver 1200 Troubleshooting		
Condition	**Possible Cause**	**Solution**
Water, oil, or sludge in air system tanks.	Desiccant contaminated with oil.	Replace desiccant. Inspect compressor per manufacturer's instructions.
Water in system tanks, everything else checks out okay.	Dryer not suitable for application.	Review application guidelines. For assistance, call Arvin Meritor's Customer Service Center at 800-535-5560.

See **Fig. 1** for the plumbing diagram.



1. Compressor Discharge Line
2. Air Compressor
3. Air Governor
4. Compressor Intake Line
5. Unloader Port
6. Pressure Relief Valve
7. Air Governor Port
8. Air Dryer Inlet
9. Purge Valve
10. Air Dryer Outlet
11. Check Valve
12. Supply Tank
13. Pressure-Controlled Check Valve
14. Primary Reservoir
15. Secondary Reservoir

Fig. 1, Air Dryer Plumbing Diagram

General Description

Dana Spicer extended service (ES) brakes can be installed on both the front and rear axles. See **Table 1** for brake model identification.

The brakes are actuated by an S-type cam head that is forged integrally with the camshaft and supported with nylon bushings. Cam pressure is applied through the cam rollers. **Figure 1** shows a Dana Spicer front axle brake.

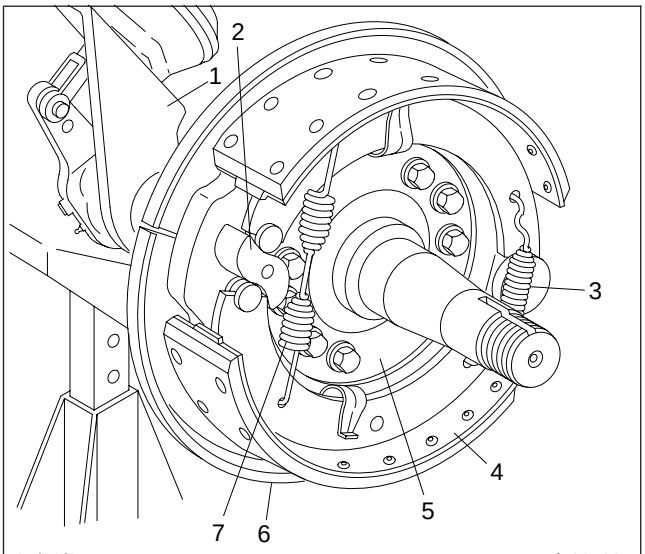
Dana Spicer Brake Model Identification Sample Model Number: ES-150-8D			
Code	**Definition**		
Service			
ES	Extended Service Brake		
Drum Diameter	(inch)	(mm)	
150	15	381	
165	16-1/2	419	
180	18	457	
Shoe Size	(inch)	(mm)	
4	4	102	
7	7	178	
8	8-5/8	219	
Configuration	(Shoe)	(Spider)	(Anchor Pin)
L	Fabricated	Fabricated	Single
D	Fabricated	Cast	Single

Table 1, Dana Spicer Brake Model Identification

Steer axles have seven holes for attaching the spider to the axle flange. An eighth hole is left open on the brake spider, on both left and right sides of the steer axle. See **Fig. 2**.

The seven holes used for attaching the spider to the axle flange are 0.656 inch in diameter. The eighth hole is oversized at 0.687 inch in diameter and is used for the antilock braking system (ABS) speed sensor bushing.

The front- and rear-axle brakes may have significant differences, as shown in **Table 2**.



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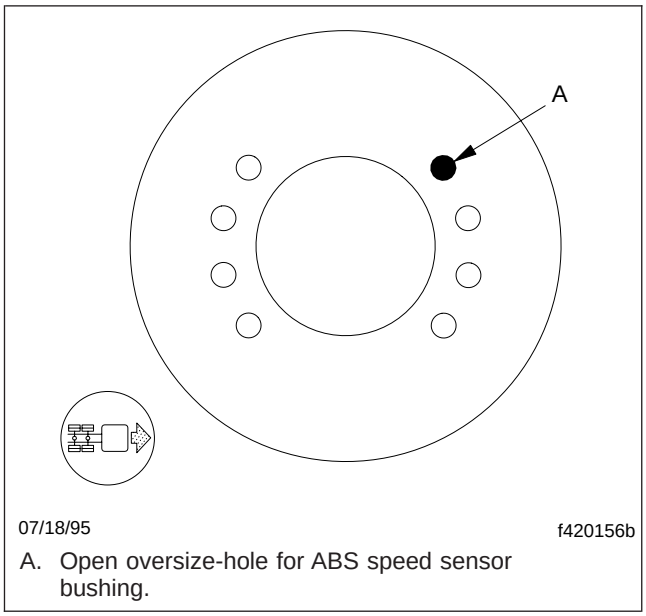
1. Air Chamber Bracket
2. S-Head Camshaft
3. Shoe Retaining Spring
4. Shoe Assembly
5. Spider
6. Dust Shield
7. Shoe Return Spring

Fig. 1, Front Axle Brake



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A. Open oversize-hole for ABS speed sensor bushing.

Fig. 2, Brake Spider Oversize Hole

General Information

Principles of Operation

When the brake pedal is depressed, compressed air enters the brake chamber, causing the diaphragm to move a pushrod assembly.

The pushrod turns the slack adjuster and brake camshaft. As the camshaft turns, the S-head 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 pushrod to their released positions.

Dana Spicer ES Brake Characteristics		
Item	**Front Brakes**	**Rear Brakes**
Brake drums	15 or 16-1/2 in	15 or 16-1/2 in
Brake Shoe Lining	4, 5, or 6 in 1- or 2-piece	7 or 8-5/8 in 2-piece
Brake Shoe Web	Single or Double	Double
Cam Roller	Center groove or Bushing-type	Bushing-type roller with protruding center pin and retainer clip
Hold-down Spring (clip)	Some models	No
Retaining Spring	1	2
Return Spring	1	1

Table 2, Dana Spicer ES Brake Characteristics

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.

Removal

WARNING

Before doing this procedure, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Park the vehicle on a level surface, apply the parking brakes, and shut down the engine. Chock the tires on the axle that is not being repaired.
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.

WARNING

When work is being done on the spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury or death.

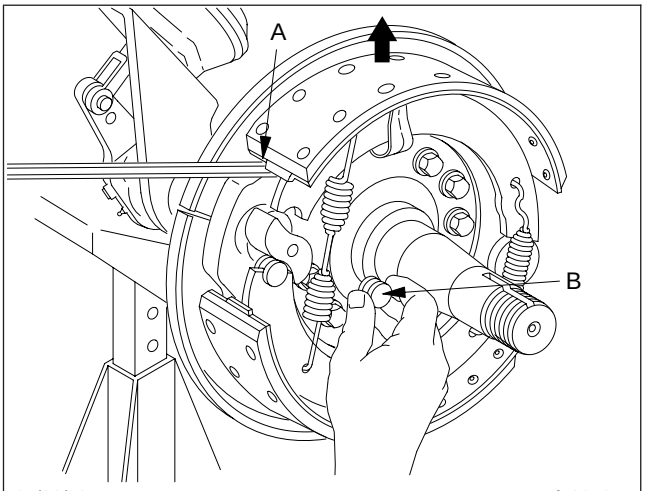
3. If the brake has spring chambers, carefully cage and lock the springs so that the springs cannot actuate during disassembly.
4. Remove the wheels. For instructions, see Section 40.00.
5. Remove the brake drums. For instructions, see Section 33.01, Subject 100, for front axles or Section 35.01, Subject 100, for rear axles.

CAUTION

Before you back off the automatic slack adjuster, refer to the applicable slack adjuster section in this manual or to the manufacturer's service information for instructions. Failure to do so could damage the slack adjusters.

6. Back off the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.
7. To remove the front brake shoes (4-inch shoes with single webs):

   7.1 Using a large screwdriver or lever, raise the upper shoe and remove the upper cam roller. See Fig. 1.

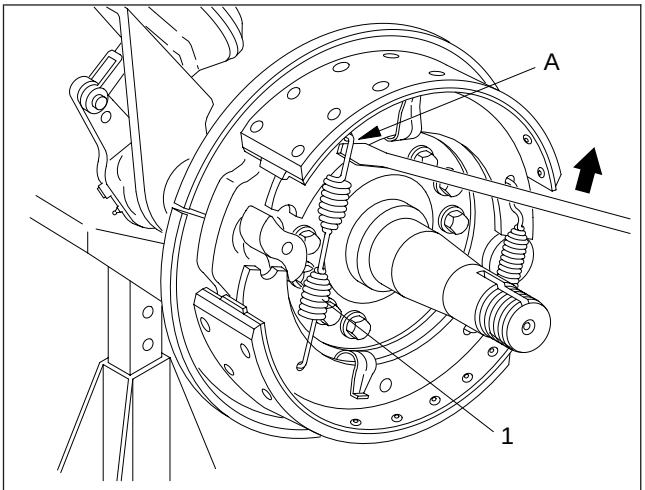


A. Lift the upper shoe to stretch the spring.
B. Remove the cam roller.

Fig. 1, Remove the Upper Cam Roller

   7.2 Reposition the tool and pry the lower shoe downward. Remove the lower cam roller.

   7.3 Using a large screwdriver or lever, stretch the shoe return spring and unhook it from the upper shoe web. See Fig. 2. Remove the spring from the lower web.

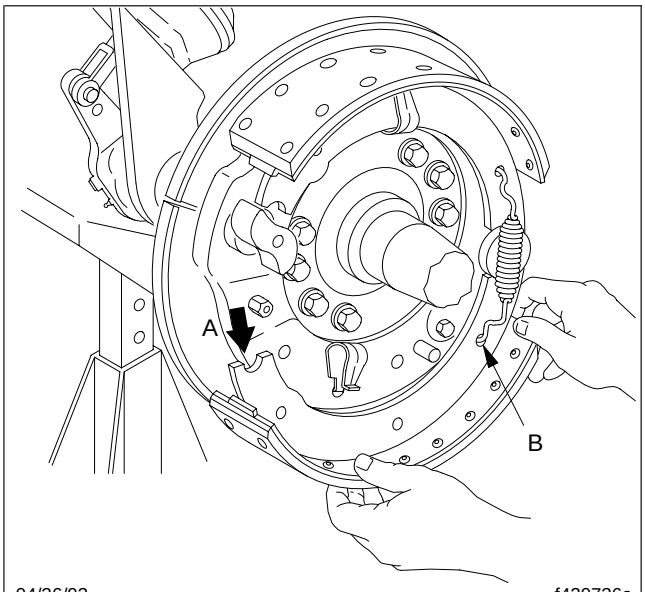


A. Stretch the return spring and unhook it from the shoe web.
1. Shoe Return Spring

Fig. 2, Stretch the Shoe Return Spring

Brake Shoe Removal and Installation

7.4 Rotate the lower shoe downward around the anchor pin to remove the tension on the shoe retaining spring. See **Fig. 3**. Remove the retaining spring from the lower shoe. Remove the lower shoe from the spider.



A. Rotate the lower shoe around the anchor pin.
B. Unhook the retaining spring.

Fig. 3, Rotate the Lower Shoe Downward

7.5 Remove the upper shoe from the spider.

7.6 Discard the cam rollers, shoe return spring, and shoe retaining spring.

8. To remove the rear brake shoes (7- or 8-5/8-inch shoes with dual webs):

8.1 Pry the roller retainer loops out of both shoe web holes. See **Fig. 4**. Pivot the roller retainer to swing the loops clear of the shoe webs.

8.2 Using a large screwdriver or lever, raise the upper shoe, stretching the return spring. See **Fig. 5**. Remove the cam roller and retainer as a unit.

Pry the the lower shoe downward and remove the lower cam roller and retainer.

8.3 Position a suitable lever to engage the return-spring rod. See **Fig. 6**. Force the lever down to release the tension on the upper part of the spring. Remove the upper spring hook.

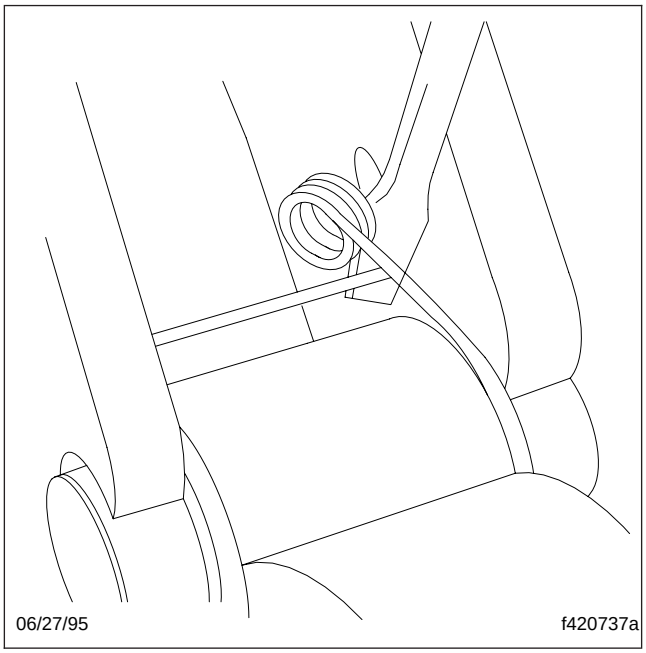
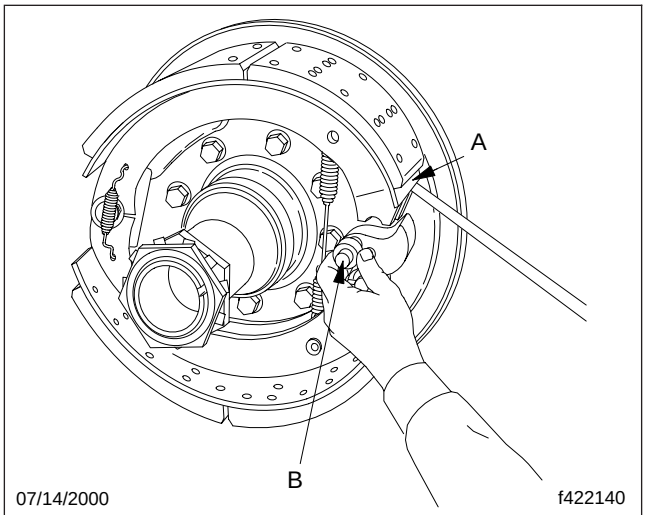
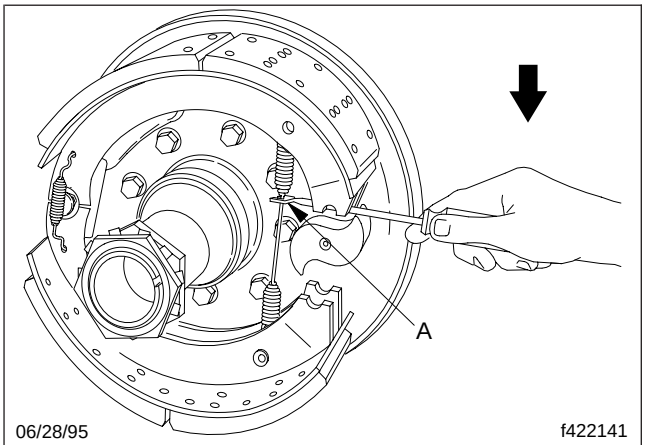


Fig. 4, Pry out the Roller Retainer Loops



A. Lift upper shoe to stretch the return spring.
B. Remove the roller and retainer.

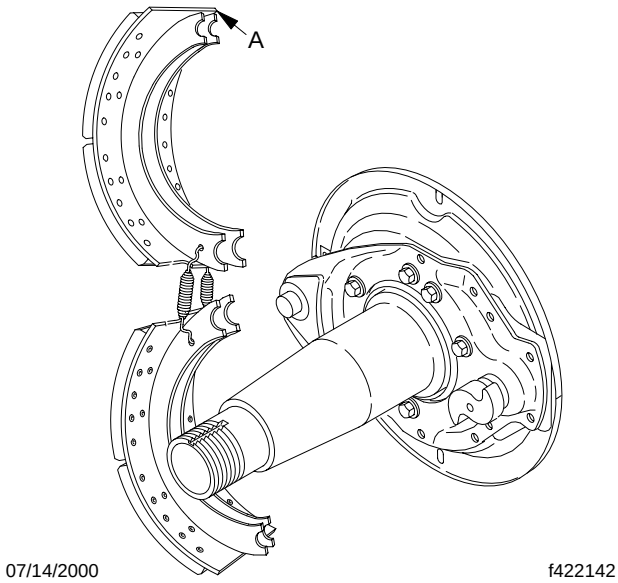
Fig. 5, Remove the Cam Roller



A. Pry up on the return spring for easy removal of the upper hook.

Fig. 6, Remove the Return Spring

8.4 Rotate both shoes around the anchor pin and remove the shoes from the spider. See **Fig. 7**.



A. Rotate both shoes around the anchor pin and remove the brake shoes from the spider.

Fig. 7, Remove the Brake Shoes

8.5 Discard the cam rollers and retainers, and the shoe return spring.

9. Inspect the brake shoes and linings for wear or damage. For instructions, see **Subject 120**.

Installation

IMPORTANT: For best brake performance, do not mix Extended Service brakes with other Dana Spicer series brakes. Use the same brake series on the entire vehicle.

1. Make sure the spider, camshaft, air chamber bracket, and slack adjuster are serviceable and properly installed.

IMPORTANT: Do not lubricate the cam-head surface or the corresponding surface on the cam rollers. For efficient operation, the cam interface must remain free of oil, grease, and other contaminants.

2. Apply a thin film of NLGI grade 1, high-temperature, waterproof grease (Kendall M-621, or an equivalent) to the recesses on the end of each shoe web where the web contacts the cam roller and anchor pin.
3. To install a single-web brake shoe assembly on a 15-inch front brake:

   3.1 Place the upper brake shoe web on the anchor pin and rotate the shoe assembly downward until the web is secured in the shoe hold-down spring (clamp).

   NOTE: The shoe hold-down spring is mounted on the spider between the anchor pin and the S-cam.

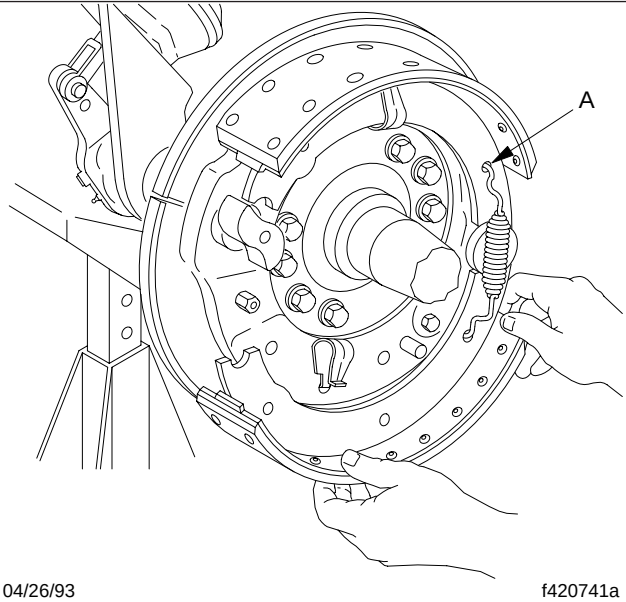
   3.2 Hook one end of a new shoe retaining spring in the hole in the upper shoe web so that the coil lays across the anchor pin. See **Fig. 8**.

   3.3 Hook the lower end of the retaining spring in the hole on the lower shoe web.

   3.4 Place the lower shoe web against the anchor pin and stretch the retaining spring enough to rotate the shoe assembly into place on the spider.

   3.5 Hook one end of a new shoe return spring in the hole in the lower shoe web. Using a large screwdriver, stretch the shoe return spring to hook it in the upper shoe web hole. See **Fig. 2**.

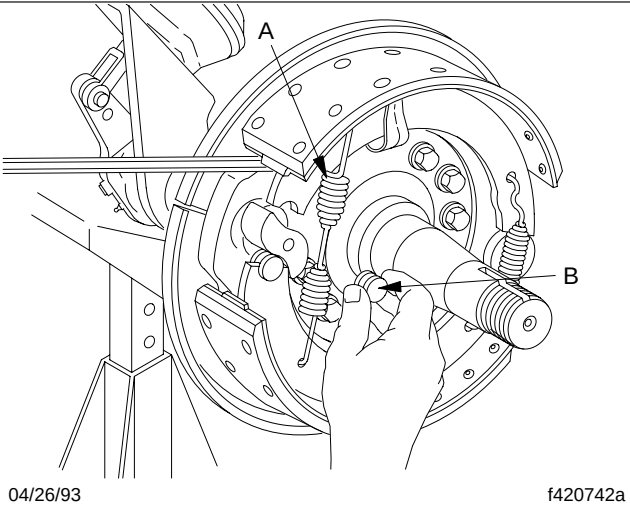
Brake Shoe Removal and Installation



A. Hook the retaining spring in the shoe web hole.

Fig. 8, Install a New Shoe Retaining Spring

3.6 Using a large screwdriver or lever, pry the upper shoe upward and install a new cam roller between the upper shoe web and the S-cam. See **Fig. 9**.



A. Install a new return spring.
B. Install the upper and lower cam rollers.

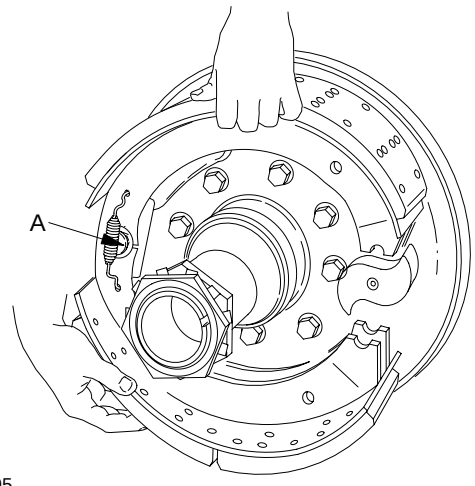
Fig. 9, Install the Cam Rollers

3.7 Pry the lower shoe downward and install a new cam roller between the lower shoe web and the S-cam.

4. To install a dual-web brake shoe assembly on a 15- or 16-1/2-inch rear brake:

4.1 Hook the ends of a new retainer spring in the holes on the upper and lower webs. Install a second retainer spring on the webs on the back side of the brake shoe assembly.

4.2 Place the upper and lower shoes around the anchor pin. See **Fig. 10**.



A. With both retainer springs installed, place the upper and lower shoes around anchor pin.

Fig. 10, Position the Upper and Lower Shoes

4.3 Place a new return spring between the webs and hook the bottom of the spring in the hole in the lower shoe web.

4.4 With a suitable tool placed against the return spring rod, force the tool handle down to stretch the lower half of the spring. See **Fig. 6**. Hook the top of the return spring in the hole in the upper shoe web.

4.5 Assemble the roller retainer on the ends of the roller. See **Fig. 11**.

4.6 Lift the upper shoe assembly and insert the new roller and retainer assembly between the shoe webs and the S-cam. See **Fig. 12**.

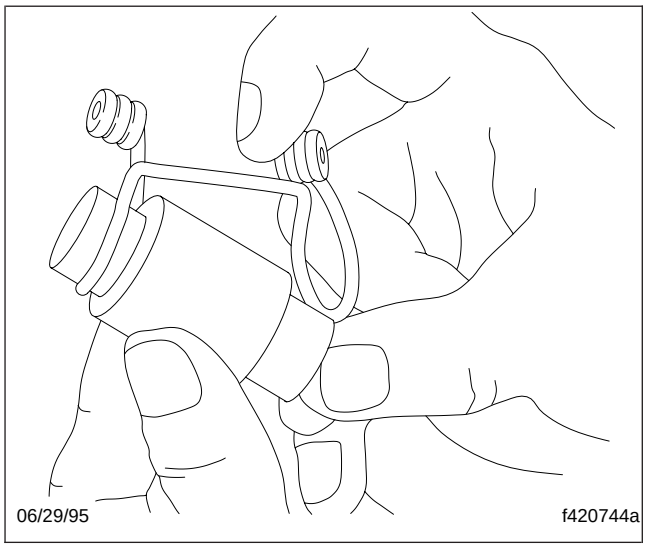
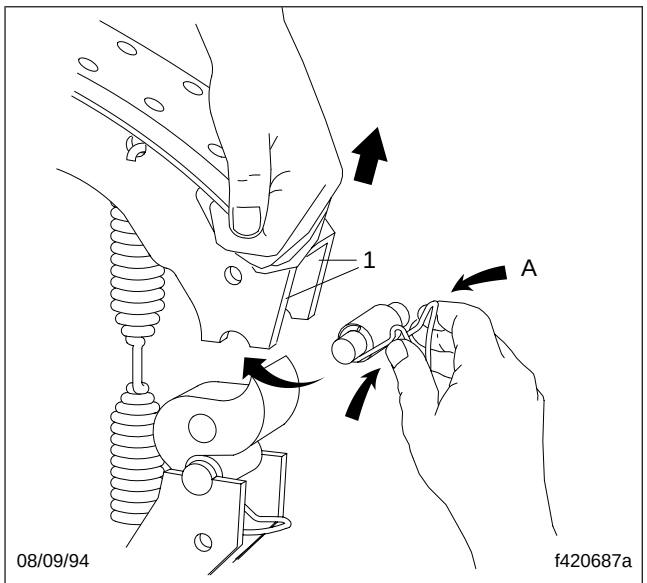


Fig. 11, Assemble the Roller Retainer

Squeeze the retainer loops and swing the retainer assembly into position (see **Fig. 13**), then snap the loops into the web holes. Make sure that both retainer loops are engaged in the web holes.

Repeat on the lower shoe.



A. Squeeze the ears of the retainer together.

1. Brake Shoe Web

Fig. 12, Install the Cam Rollers

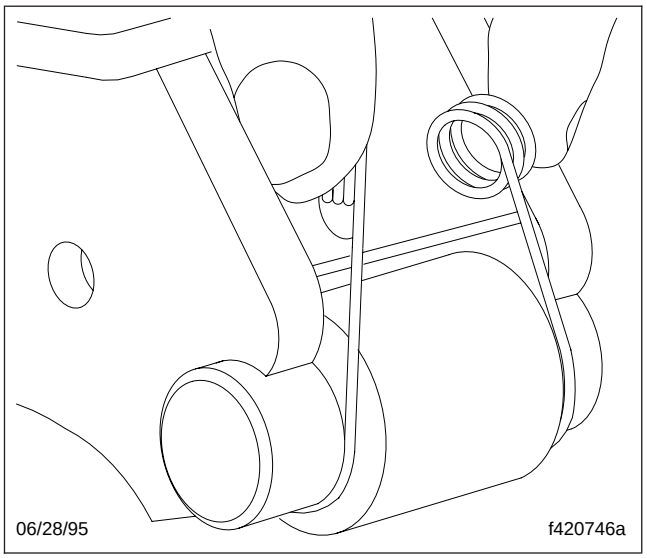


Fig. 13, Position the Retainer Assembly

5. Install the brake drums. For instructions, see **Section 33.01**, Subject 100, for front axles or **Section 35.01**, Subject 100, for rear axles.
6. Install the wheels. For instructions, see **Section 40.00**.
7. If working on the rear axle, manually uncage the power spring of the parking brake chamber. For instructions, refer to the applicable brake chamber section in this manual.
8. Adjust the brakes at the slack adjusters. For instructions, see **Subject 150.**
9. Remove the safety stands, lower the vehicle, and remove the chocks from the tires.

⚠ WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

10. In a safe area, check for proper brake operation before you put the vehicle in service.

    10.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.

Brake Shoe Removal and Installation

10.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.

10.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others indicate a lack of braking effort on those wheels.

Inspection

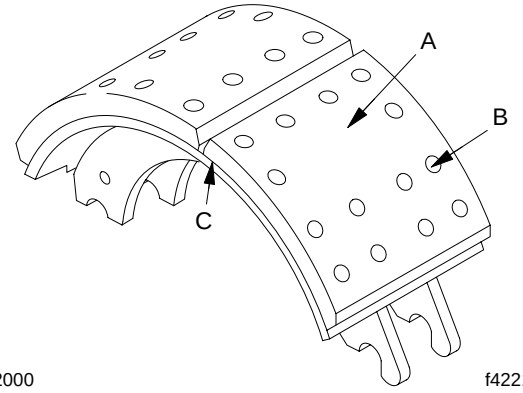
WARNING

Before doing this procedure, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Remove the brake shoes. Refer to **Subject 110** for instructions.
2. Inspect the brake shoe linings.

   On front-axle brakes, if the linings are grease- or oil-soaked, cracked, or worn to less than 3/16 inch (4.5 mm) thickness at any point, replace them. See **Fig. 1**. The lining surface should be no closer than 1/16 inch (1.5 mm) to any rivet head.

   On rear-axle brakes, 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.



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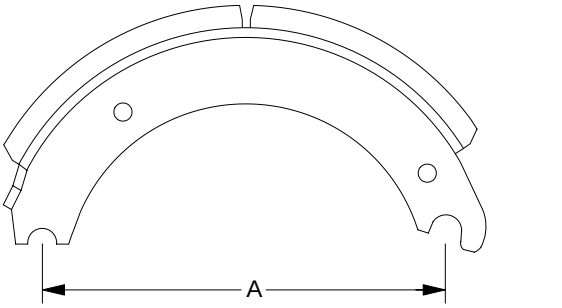
A. Check for cracks or contamination.
B. The lining surface must not be closer than 1/16 inch (1.5 mm) to any rivet head.
C. The minimum lining thickness is 3/16 inch (4.5 mm).

Fig. 1, Inspect the Brake Shoe (15-inch series shown)

3. Check the shoes for bent or cracked webs or tables, broken welds, loose rivets, or out-of-round rivet holes. Replace the shoes if any of these conditions exist.
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 distance between the centerlines of the anchor pin and cam roller recesses in the shoe web. See **Fig. 2**.
   - On 15-inch series brakes, if the measurement is more than 11-3/4 inches (298 mm), replace the shoe.
   - On 16-1/2-inch series brakes, if the measurement is more than 12-9/16 inches (319 mm), replace the shoe.



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A. Measure the distance between recess centers.

Fig. 2, Shoe Span Measurement

Replacement

WARNING

Before doing this procedure, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

IMPORTANT: Vehicle brake systems require the correct lining material to perform as originally designed. The type of lining material that is specified for the vehicle is based on several technical considerations and Department of Transportation (DOT) braking performance regulations. To ensure fewer relines and greater compatibility with the vehicle's brake system, use the same quality of friction lining material that was installed at the factory.

Always reline both wheels of a single axle and all wheels of a tandem axle at the same time.

Always install the same linings and drums on both wheels of a single axle and all four wheels of a tandem axle. It is not necessary for the steering axle brakes to have the same linings as the rear drive axle brakes.

When the minimum thickness is reached for any of the brake linings on an axle, reline both brakes on that axle at the same time.

NOTE: Replace the springs each time the brakes are relined. Dana Spicer recommends replacement of the cam rollers at each reline.

1. Remove the brake shoes. For instructions, see **Subject 110**.

CAUTION

Drilling out rivets or cutting off rivet heads with a chisel can cause the rivet hole to become out-of-round. This could damage the brake shoe.

2. Using a suitable riveting mandrel, push out (do not drill out) the old rivets.
3. Clean the shoe table. For instructions, see **Subject 140**, "Cleaning."

CAUTION

Make sure that the replacement lining material conforms to FMSI 1308, a standard for lining size and shape only. Use of an improper FMSI lining specification or friction material type may cause brake dragging or grabbing, or improper brake performance.

4. Align the brake shoe and lining rivet holes. Using a C-clamp, clamp the lining to the brake shoe.

IMPORTANT: Use rivets that have the correct material, shank diameter, length, head size, and shape. Use tubular rivets that are:

- 1/4-inch (6-mm) diameter by 1/2-inch (13-mm) long,
- SAE no. 10-8, and
- made of zinc- or brass-plated steel.

5. Insert the correct size rivets into all the holes in the new block. Temporarily hold them in place with masking tape.
6. Secure the rivets in the correct sequence.
   - For front brake shoes with one-piece, 4-inch linings, start with the two middle holes and work toward the ends in a criss-cross pattern.
   - For rear brake shoes, follow the sequence shown in **Fig. 1**.
7. Check for a close fit between the lining and shoe table.

   Try to insert a 0.006-inch (0.15-mm) feeler gauge between the lining and shoe table along the edges. See **Fig. 2**. It should not be possible to insert the gauge anywhere along the edge, except at each end beyond the last row of rivets. A larger clearance may exist in these areas.
8. Remove the C-clamp and masking tape.

IMPORTANT: Always adjust the brakes at the slack adjusters after replacing the linings. For instructions, see **Subject 150.**

Brake Shoe and Lining Replacement

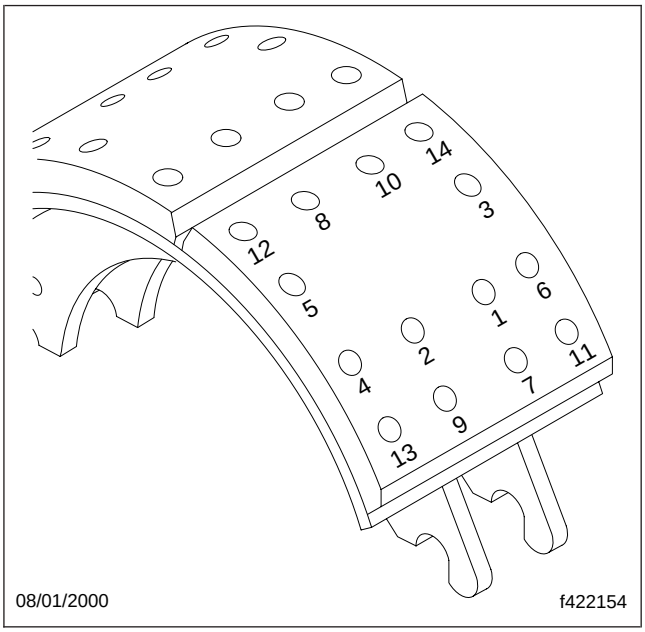
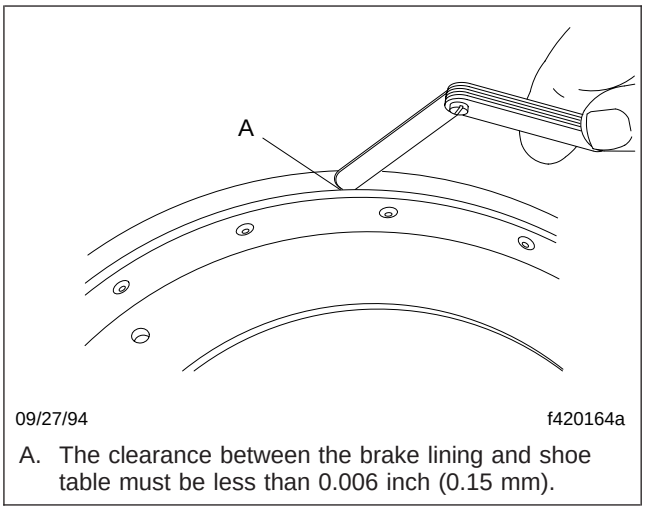


Fig. 1, Rear Lining Rivet Sequence



A. The clearance between the brake lining and shoe table must be less than 0.006 inch (0.15 mm).

Fig. 2, Check Fit Between Lining and Shoe Table

Brake Components Disassembly and Inspection, Cleaning, and Assembly

WARNING

Before doing this procedure, read the information in Safety Precautions, 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

Disassembly and Inspection

On front-axle brakes, the upper and lower brake shoe assemblies have single webs, one-piece brake shoe linings, and a single retaining spring. See **Fig. 1**.

On rear-axle brakes, the brake shoe assemblies have dual webs, two-piece brake shoe linings, and two retaining springs. **Figure 2** is an exploded view of a typical rear-axle brake assembly.

1. Remove the brake shoes. For instructions, see **Subject 110**.
2. Inspect the drum.
   - 2.1 Check the drum for cracks. Replace any cracked drum.
   - 2.2 Using a drum caliper or other measuring device, measure the inside diameter of the drum in several places. Replace the drum if it exceeds the maximum diameter stamped on it.
   - 2.3 Check the drum for heat checks, glazing, grooving, run-out, and out-of-round. See **Fig. 3**. Some drums that are glazed, grooved, or out-of-round can be repaired. For detailed instructions, see **Section 33.01** or **Section 35.01**.

IMPORTANT: Never pull the slack adjuster out of the pushrod clevis. Always turn the adjusting nut for positioning.

3. Disconnect the slack adjuster from the pushrod clevis. For detailed instructions, see the appropriate section in this manual for the automatic slack adjusters installed on the vehicle.
   - 3.1 Remove the cotter pin from the clevis pin; remove the clevis pin. See **Fig. 4**.

CAUTION

For a Meritor automatic slack adjuster, disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.

   - 3.2 For a Meritor automatic slack adjuster, disengage the pull-pawl on the side of the adjuster. Using a screwdriver or an equivalent tool, pry the pawl button out about 1/32 inch (0.8 mm) and wedge the tool in place. See **Fig. 5**. Pull-pawls are spring loaded. When the tool is removed, the pull-pawl will engage the teeth automatically.

IMPORTANT: Never pull the slack adjuster out of the pushrod clevis. Always turn the adjusting nut for positioning.

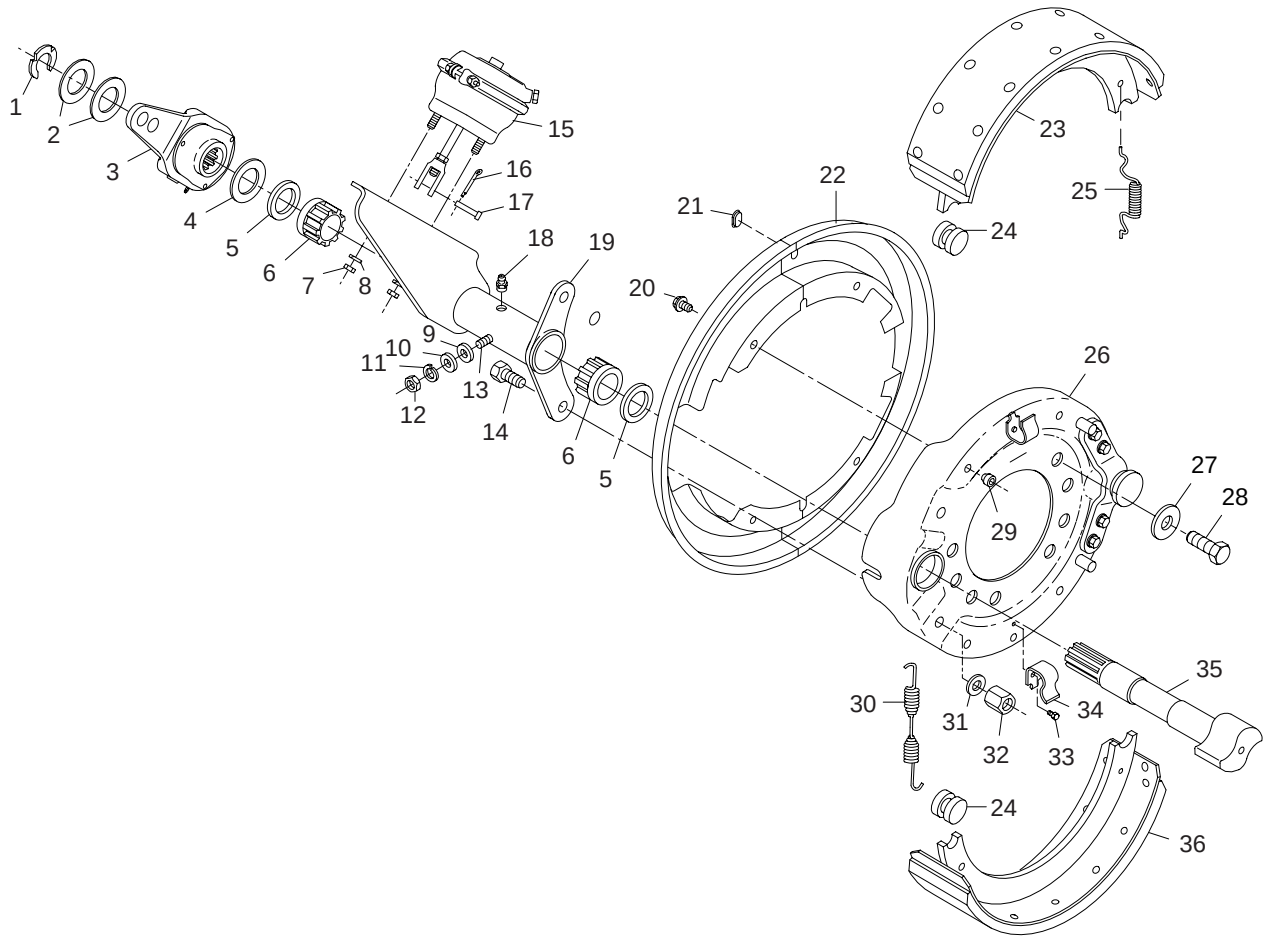
   - 3.3 Using a wrench, turn the manual adjusting nut to back the slack adjuster out of the clevis.
     - On Meritor adjustors, turn the square adjusting nut clockwise.
     - On Haldex or Gunite adjusters, turn the adjusting hexnut counterclockwise. You will hear a ratcheting sound.
4. Using a dial indicator, measure the up-and-down and side-to-side end-play of the camshaft. Replace the bushings if there is more than 0.020-inch (0.5 mm) of movement.

CAUTION

Do not hammer on the slack adjuster to remove it. Damage to the adjuster or camshaft spline may result.

5. Remove the slack adjuster.
   - 5.1 From the slack adjuster side of the camshaft support bracket, remove the snap ring and any washers, spacers, and seals from the camshaft. See **Fig. 1** or **Fig. 2**.
   - 5.2 Remove the slack adjuster from the camshaft.

Brake Components Disassembly and Inspection, Cleaning, and Assembly



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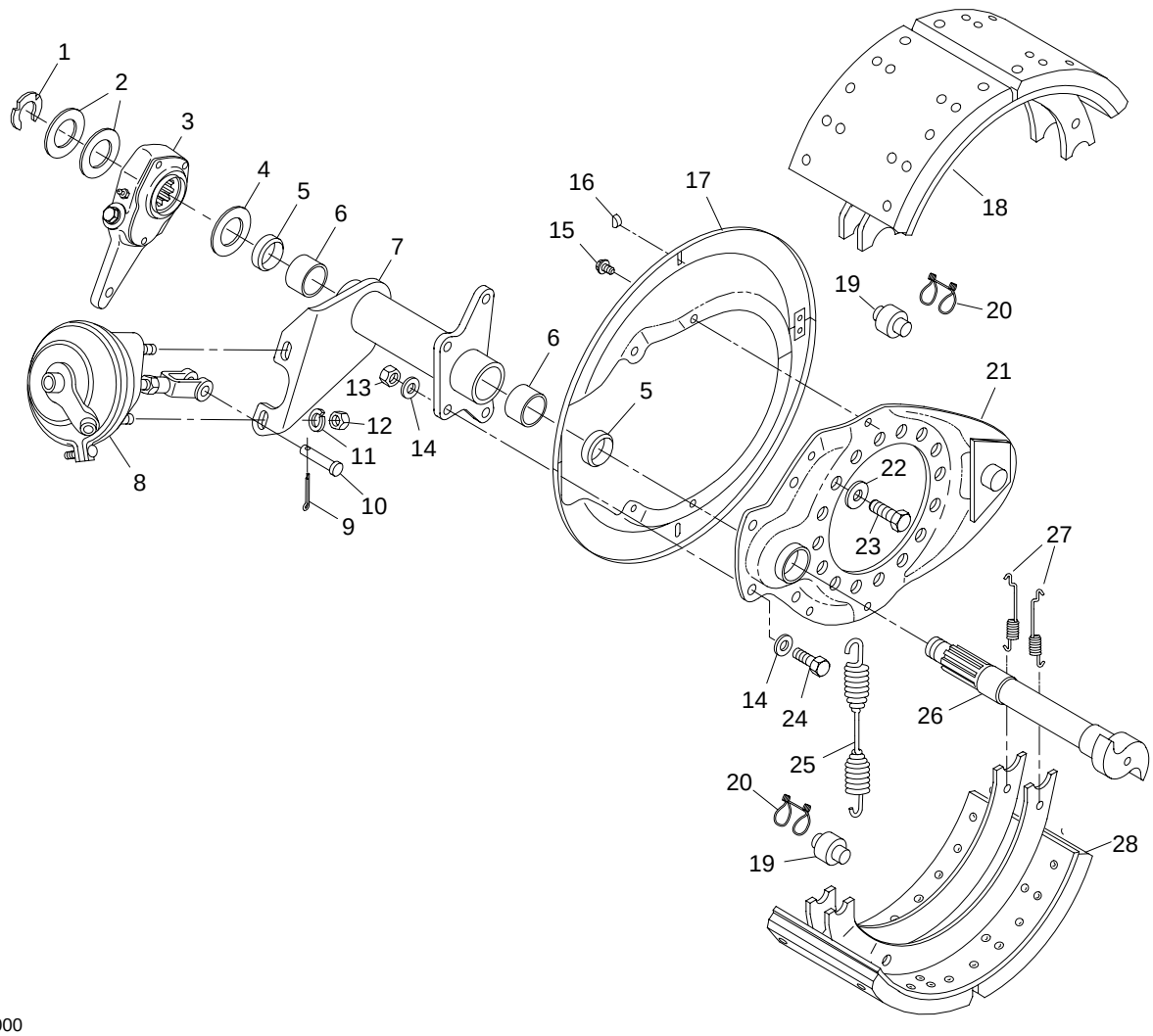
1. Snap Ring
2. Camshaft Outer Washers
3. Slack Adjuster
4. Camshaft Inner Washer
5. Grease Seal
6. Camshaft Bushing
7. Stud Nut
8. Lockwasher
9. Spacer
10. Plain Washer
11. Lockwasher
12. Nut
13. Stabilizing Screw
14. Bracket Mounting Bolt
15. Brake Chamber
16. Cotter Key
17. Clevis Pin
18. Grease Fitting
19. Camshaft Support Bracket
20. Dust Shield Screw
21. Lining Inspection Plug
22. Dust Shield
23. Upper Brake Shoe and Lining
24. Cam Roller
25. Retaining Spring
26. Brake Spider and Anchor Pin Assembly
27. Hardened Washer
28. Spider Mounting Bolt
29. Nutsert
30. Return Spring
31. Lockwasher
32. Barrel Nut
33. Bolt
34. Shoe Hold-Down Spring
35. Camshaft
36. Lower Brake Shoe and Lining

Fig. 1, Front Axle Brake

6. Check the slack adjuster for damage and binding.

6.1 Check the slack adjuster clevis for cracks or bushing wear. Check the splines for chipped teeth and deformation. Replace as needed.

Brake Components Disassembly and Inspection, Cleaning, and Assembly

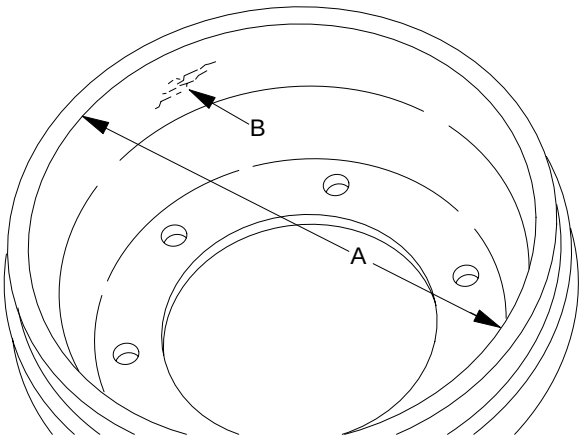


1. Snap Ring
2. Camshaft Outer Washers
3. Slack Adjuster
4. Camshaft Inner Washer(s)
5. Spring-Loaded Lip Seal
6. Camshaft Bushing
7. Camshaft Mounting Bracket
8. Brake Chamber
9. Clevis Pin Cotter Pin
10. Brake Chamber Clevis Pin
11. Lockwasher
12. Stud Nut
13. Locknut
14. Washer
15. Dust Shield Capscrew
16. Dust Shield Plug
17. Dust Shield (2-piece)
18. Upper Brake Shoe and Lining
19. Cam Roller and Pin
20. Retainer Clip
21. Spider (stamped spider shown)
22. Hardened Washer
23. Spider Mounting Bolt
24. Bracket Mounting Bolt
25. Return Spring
26. Camshaft
27. Retaining Springs
28. Lower Brake Shoe and Lining

Fig. 2, Rear Axle Brake (typical)

NOTE: For a Haldex or a Gunite automatic slack adjuster, there is an internal clutch that resists the manual adjusting nut from being turned in the counterclockwise direction. When checking these slack adjusters for

Brake Components Disassembly and Inspection, Cleaning, and Assembly



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A. Measure the diameter and check for out-of-round.
B. Check for cracks, heat checks, glazing, and grooves.

Fig. 3, Check the Drum

binding, only rotate the manual adjusting nut in the clockwise direction.

6.2 Using a torque wrench that measures lbf·in (or N·cm), turn the manual adjusting nut clockwise so that the worm gear rotates a full 360 degrees (typically 22 turns of the wrench).

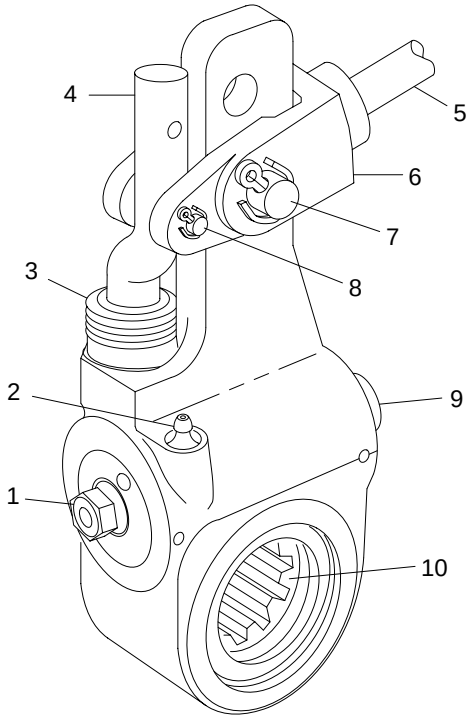
If there is binding, or if more than 25 lbf·in (280 N·cm) is needed to turn the slack adjuster, replace it. For instructions, see the applicable slack adjuster section in this group.

IMPORTANT: If any slack adjuster problem is found, repair or replace the unit, depending on the manufacturer's recommendations.

7. Check to see if a camhead thrustwasher is installed between the S-cam and the spider. If so, note the orientation for later installation. The orientation depends on the brake assembly model.

8. Remove the camshaft by grasping its head and pulling the camshaft outboard from the brake spider and camshaft support bracket.

   Remove the camhead thrustwasher from the camshaft, if one is installed.



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NOTE: A Gunite automatic slack adjuster is shown.

1. Adjusting Hexnut
2. Grease Fitting
3. Boot
4. Link
5. Brake Chamber Pushrod
6. Clevis
7. Clevis Pin, 1/2-in
8. Clevis Pin, 1/4-in
9. Grease Relief Opening
10. Slack Adjuster Spline

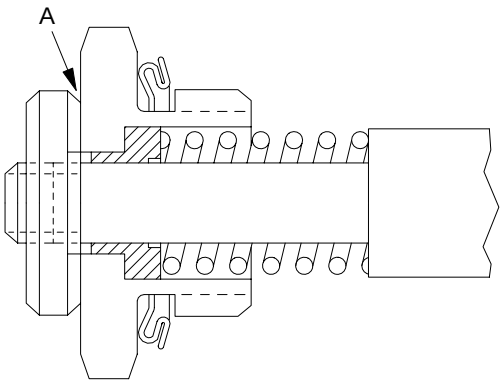
Fig. 4, Disconnect Slack Adjuster from Clevis

9. Check the camshaft spline end for cracks, or worn or deformed splines. Replace the camshaft if damaged.

10. 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.

11. 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 camhead surface.

12. Remove the brake chamber stud nuts and lockwashers that attach the brake chamber to the camshaft support bracket. Check the chamber and parts for problems.



A. Insert a screwdriver here and pry the pull-pall out about 1/32 inch (0.8 mm).

Fig. 5, Disengage the Pull-Pall on Meritor Automatic Slack Adjusters

Check the brake chamber for a cracked housing, bent pushrod, loose clamp ring, loose air fitting, air leaks, or clogged vent holes. Repair or replace parts as needed.

13. Remove and inspect the camshaft support bracket. Remove and discard the gasket. Check the bracket for a bent, broken, or cracked arm, and for cracked welds. Replace the bracket if any of these conditions exist.

⚠ WARNING

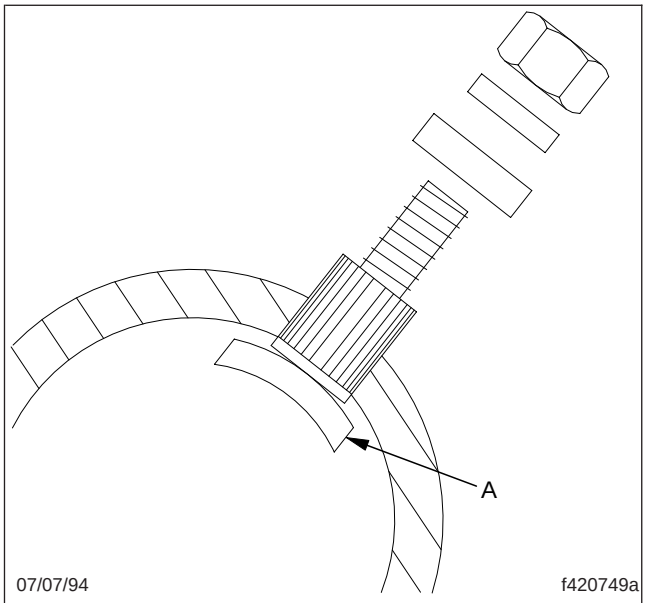
When removing bushings with a driver, wear eye protection. Do not hit steel parts with a steel hammer. To do so could cause steel pieces to break off, which could cause serious eye injury.

14. Remove and inspect the old bushing and the grease seal.
    - 14.1 Check the camshaft bushing for wear. The inner surface must be smooth; if rough or abrasive, replace the bushing.
    - 14.2 Inspect the seal. Replace it if the lip is nicked, cut, or distorted.
15. On front brakes, check the stabilizing screw for bends, looseness, or damaged threads.
16. If necessary, replace the stabilizing screw.

⚠ WARNING

Wear eye protection when driving the screw into the camshaft bracket tube with a pin punch and hammer. Failure to wear eye protection could result in personal injury due to flying metal debris.

- 16.1 Remove the damaged screw by driving it into the camshaft bracket tube with a pin punch and hammer.
- 16.2 Aligning the curvature of the screw head with the curvature of the bracket tube, install the new screw. See **Fig. 6**.



A. Align the curvature of the head with the curvature of the camshaft bracket tube.

Fig. 6, Align the Screw Head

- 16.3 Install the spacer, lockwasher, and nut. Tighten the nut 23 to 27 lbf·ft (31 to 37 N·m) to draw the screw serrations uniformly through the camshaft bracket tube wall.
- 16.4 Remove the nut and washer before assembling the bracket on the spider.

17. Using a suitable piloted driver, install the new bushing or seal.

Brake Components Disassembly and Inspection, Cleaning, and Assembly

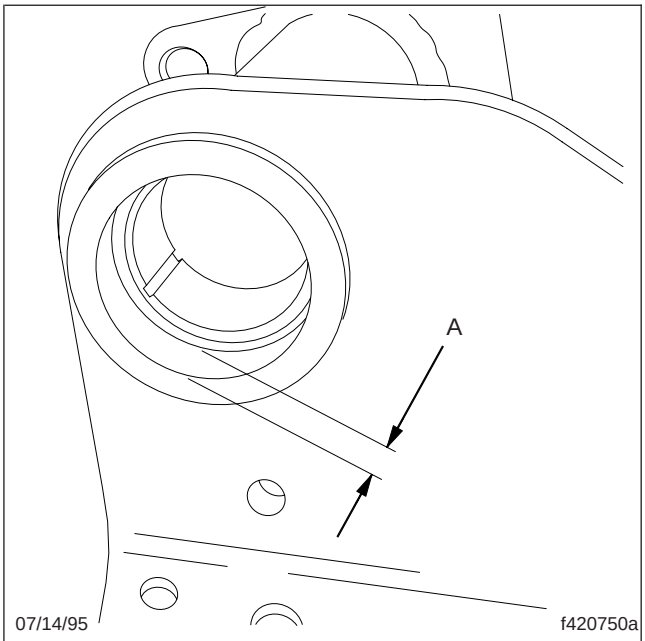
On front brakes, install the new bushing to a depth of 3/8 inch (9.5 mm) from each end of the bracket tube. See **Fig. 7**.

On rear brakes, install the new bushing to a depth of 22/32 inch (17.5 mm) at the slack adjuster end of the bracket tube and to a depth of 9/32 inch (7.1 mm) at the cam head end of the bracket tube.

Install the grease seal flush with the end of the air chamber bracket tube.

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. 8**.

18. Remove the spider-to-axle attaching nuts, hardened washers, and bolts; remove the spider from the axle flange.

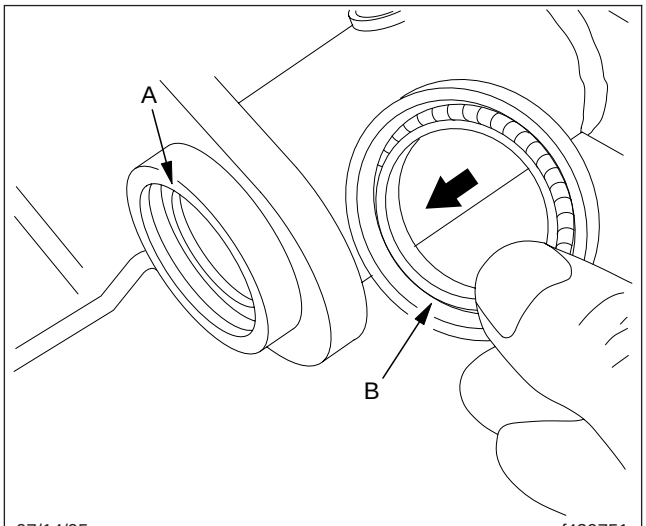


A. Recess the bushing (see text for specifications).

Fig. 7, Install the New Bushing

19. If equipped, remove the capscrews that attach the dust shield to the spider; remove the dust shield.

20. Inspect the spider and parts for damage; replace as needed.



A. Install seals flush with end of tube.
B. Lip side of both seals must face toward slack-adjuster end of the bracket.

Fig. 8, Install the Grease Seals

20.1 Check for cracks at the bolt holes, cam area, and around the anchor pin. Replace if damaged.

20.2 Check the anchor pin. See **Fig. 9**. If the pin is loose, or grooved more than 0.03 inch (0.8 mm) below the original surface, replace the spider assembly.

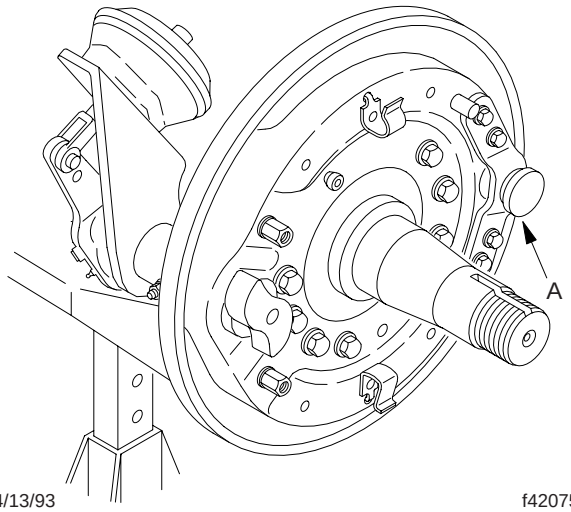
20.3 Check the anchor pin and brake spider bushings for deterioration. The inner surfaces must be smooth. If any surface is rough or abrasive, replace the part.

20.4 On front brakes, check the anchor pin reinforcement plate attaching nuts (see **Fig. 10**) for tightness. If needed, tighten the nuts 35 to 40 lbf·ft (47 to 54 N·m).

Check the anchor pin retaining nut for tightness. See **Fig. 10**. If needed, tighten the nut 475 to 525 lbf·ft (644 to 712 N·m).

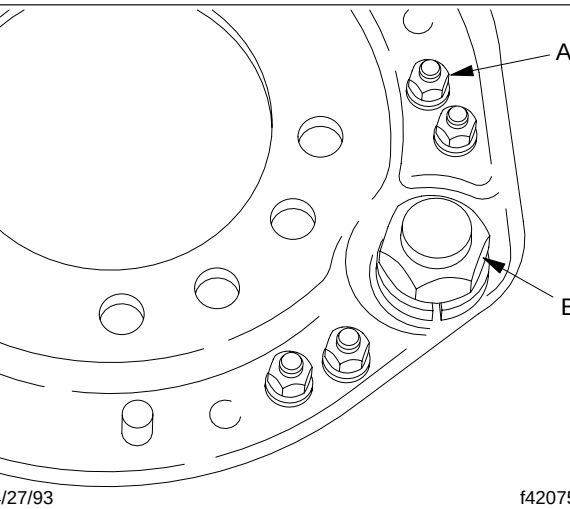
IMPORTANT: If the anchor pin turns while checking the retaining nut torque, replace the spider assembly. Dana Spicer recommends replacing the complete spider and pin assembly. Do not try to repair the spider assembly.

Brake Components Disassembly and Inspection, Cleaning, and Assembly



A. Check for grooving and looseness.

Fig. 9, Check the Anchor Pin



A. Reinforcement Plate Nut
B. Anchor Pin Retaining Nut

Fig. 10, Check the Anchor Pin Nuts

Cleaning

CAUTION

Do not clean ground or polished metal parts in a hot solution tank or with water, steam, or alkaline solutions. These solutions will cause parts to corrode.

IMPORTANT: Do not apply brake grease or corrosion-preventive materials to the brake linings or the brake drum.

After removing the brake parts being serviced, do the following:

1. Clean the camshaft journals with an emery cloth.
2. Wire brush all parts that have been 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 hinder normal heat dissipation. Make sure oxidation and dirt are removed by wire brushing, or damage to brake components could occur.

3. Using an industrial vacuum cleaner with a HEPA filter system, remove any dust accumulation from the brake parts.
4. Wipe the inside of the drums with a damp rag to remove lining dust.
5. Prepare the brake parts for assembly.

   5.1 Thoroughly clean all the brake parts.

   For ground or polished metal parts, use a cleaning solvent to clean the parts and surfaces that are ground or polished.

   For rough metal parts, use a cleaning solvent or a weak alkaline solution in a hot solution tank to clean the parts. If a hot solution tank is used, leave the rough parts in the hot solution tank until they are completely cleaned and heated. Remove the rough parts from the hot solution tank and wash them with water until the alkaline solution is removed.

   5.2 Thoroughly dry all the brake parts with a clean, lint-free cloth or paper towel, or use low-pressure filtered and compressed air.

Brake Components Disassembly and Inspection, Cleaning, and Assembly

WARNING

All worn or damaged brake parts must be replaced. If the brakes are assembled with worn or damaged parts, they may not perform to their capacity and a brake failure could occur, which could cause personal injury and property damage.

5.3 Thoroughly inspect all the brake parts for wear or damage. It is very important that all the parts be carefully inspected before they are assembled. Repair or replace any worn or damaged parts.

5.4 For parts that will be assembled, apply a thin layer of brake grease to the parts after they have been cleaned, dried, and inspected to protect them from corrosion.

If the parts will be stored, apply a special material that prevents corrosion and rust on all surfaces. The parts should be stored in special paper (or other material) that prevents corrosion and rust.

Assembly

1. Install the dust shield (if equipped). See **Fig. 1** or **Fig. 2.**

   If installing a one-piece dust shield, place it against the spider and install the capscrews. Tighten the capscrews to the specifications in **Table 1**.

   If installing a two-piece dust shield, place both halves against the spider and tighten the attaching screws finger-tight. Reposition the dust shield halves to allow a uniform space of 1/8 inch (3 mm) along the mating edges. See **Fig. 11**. Tighten the screws to the specifications in **Table 1**.

NOTE: Because of the interference fit in the upper dust shield-to-brake chamber bracket area (see **Fig. 12**) you may need to deform the upper dust shield slightly by hand to correctly align the upper half with the lower half.

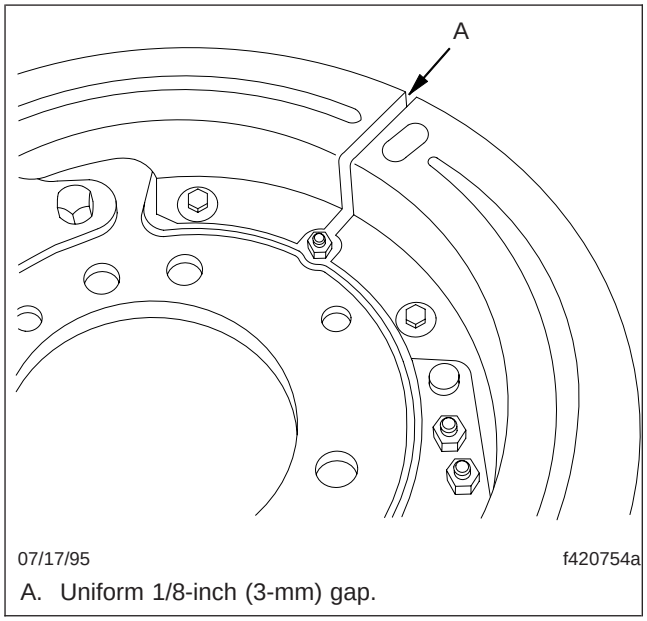
2. Install the spider.

   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 to the specifications in **Table 1** in a cross pattern.

Brake Assembly Torque Specifications		
Description	**lbf·ft**	**N·m**
Dust Shield Fasteners		
One- and Two-Piece Dust Shield	11 to 16	15 to 22
Brake Spider Fasteners		
1/2–13	60 to 80	81 to 108
5/8–11 (hexhead capscrew)	130 to 160	176 to 217
5/8–11 (flanged hexhead capscrew)	160 to 200	217 to 271
Brake Chamber		
Midland 12, 16	30	41
Midland 20, 24, 30, 36	100	136
MGM 24, 30, 36	100 to 115	136 to 156
Camshaft Support Bracket Fasteners, 1/2–13	55 to 65	75 to 88
Stabilizing Screw (front brake)	23 to 27	31 to 37

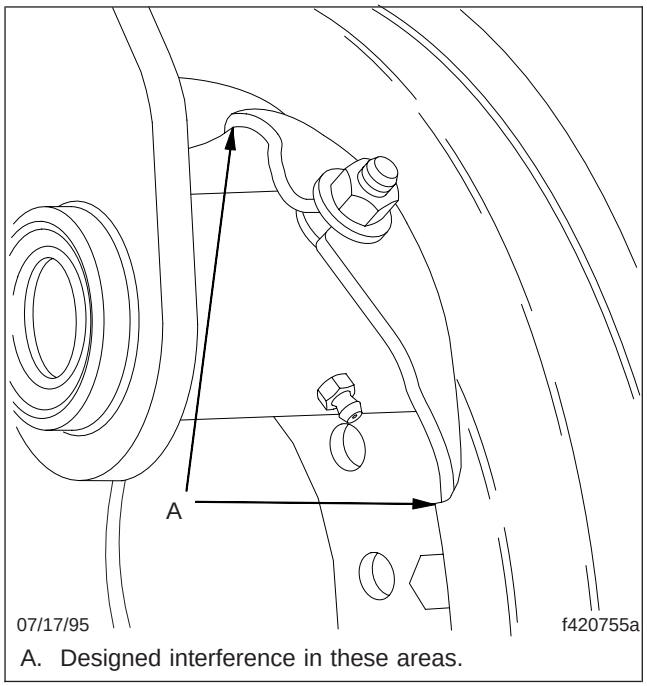
Table 1, Brake Assembly Torque Specifications

3. Install the brake chamber and bracket.



A. Uniform 1/8-inch (3-mm) gap.

Fig. 11, Two-Piece Dust Shield Installation



A. Designed interference in these areas.

Fig. 12, Check the Fit at the Upper Dust Shield-to-Brake Chamber Bracket

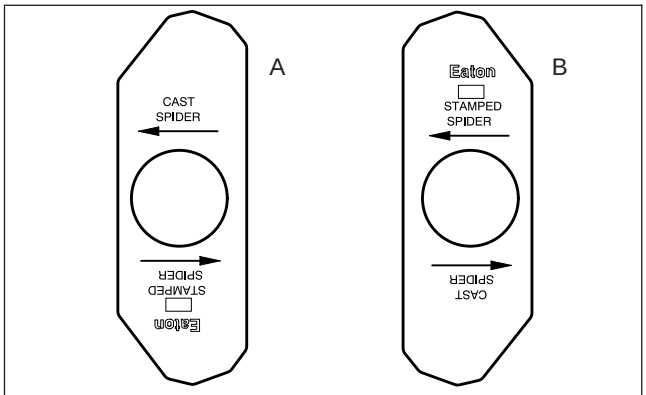
3.1 Place the brake chamber on the mounting bracket with the chamber mounting studs through the bracket holes. Install the lockwashers and stud nuts. Tighten the nuts to the specifications in **Table 1**.

3.2 Place the bracket against the spider, and install the lockwashers and barrel nuts. Tighten the nuts to the specifications in **Table 1**.

3.3 Install the washer, lockwasher, and nut on the stabilizing screw (if equipped). Tighten the nut to the specification in **Table 1**.

4. Install the camshaft in the spider.

4.1 If a camhead thrustwasher was removed during disassembly, reinstall it in the same orientation between the S-cam and the spider. See **Fig. 13**.



A. Cast Spider: Place the camhead thrustwasher under the camhead with the CAST SPIDER arrow pointing toward the center of the spider. Exception: for model ES-150-8D, the arrow points away from the center of the spider.
B. Stamped Spider: Place the camhead thrustwasher under the camhead with the STAMPED SPIDER arrow pointing toward the center of the spider.

Fig. 13, Install Thrustwasher

4.2 Apply a thin film of chassis grease on the inside of the camshaft bushings and journals. Do not grease the camshaft head area.

4.3 Apply a thin film of rust preventive grease (Meritor 0-637 or an equivalent) on the camshaft splines.

Brake Components Disassembly and Inspection, Cleaning, and Assembly

4.4 Carefully slip the camshaft into the spider and the mounting bracket tube.

4.5 Install the thick camshaft washer on the camshaft.

5. Install the slack adjuster on the camshaft, with the adjuster nut on the side opposite the brake chamber.
6. Install the thin outer washer(s) and snap ring.
7. Using a dial indicator, measure the end play of the camshaft.

   7.1 With the slack adjuster centered between the brake chamber bracket and the snap ring groove, pull inboard on the slack-adjuster end of the camshaft to take up the end play.

   7.2 Set the dial indicator to zero.

   7.3 Push outboard on the slack-adjuster end of the camshaft and note the maximum reading.

   7.4 There should be 0.005 to 0.045 inch (0.1 to 1.1 mm) of movement. Add or remove outer washers as needed to adjust the end play.

⚠ WARNING

When lubricating the camshaft bracket bushings, if grease leaks out under the cam head, the camshaft grease seal is worn or damaged. If the seal is not replaced, the brake linings could be contaminated by grease and the vehicles stopping distance could be reduced, which could result in personal injury or property damage.

NOTE: Use meter-type fittings, having a maximum 40 psi (276 kPa) pressure relief at the shutoff.

8. 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 cam head, the camshaft grease seal is worn or damaged, or is installed backwards. Replace the seal.

9. Adjust the brakes at the slack adjusters. For instructions, refer to **Subject 150**.
10. Install the brake shoes. For instructions, see **Subject 110**.

⚠ WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

Pre-Adjustment Checks and General Adjustment Information

Before adjusting the brakes, check and adjust the following:

- Adjust the wheel bearings. For instructions, see **Section 33.01** or **Section 35.01** in this manual.
- Check the slack adjuster and the brake chamber for loose fasteners and tighten as necessary. For torque specifications, see **Specifications, 400**.

  For slack adjuster installation instructions, see the appropriate section in this manual for the type of adjuster installed on the vehicle.

Brakes with automatic slack adjusters should never have to be manually adjusted while in service. The only time automatic slack adjusters should be manually adjusted is during installation or after the brakes have been relined.

For cam brakes, there are two brake chamber stroke measurement specifications: applied chamber stroke and free-stroke.

IMPORTANT: The U.S. Department of Transportation (DOT) Federal Highway Administration has issued the applied chamber stroke specifications for cam brakes. When the applied chamber stroke is checked and adjusted, it must not be greater than the DOT specification. See **Table 1**.

The specific procedure for adjusting the brake chamber stroke at the slack adjuster's manual adjusting nut may vary, depending on which slack adjuster is installed, but there are three basic steps in completing a manual brake chamber stroke adjustment:

1. Adjusting the approximate brake chamber stroke using the manual adjusting nut on the slack adjuster (coarse adjustment).
2. Measuring and adjusting the free-stroke.
3. Measuring and adjusting the applied chamber stroke (fine adjustment).

The stroke (free or applied chamber) is the distance that the large clevis pin moves when the brakes are applied. The type of force used to move the slack adjuster from its released position to its applied position (where the brake linings contact the brake drum) distinguishes the free-stroke from the applied chamber stroke.

- The free-stroke is measured using a lever to move the slack adjuster. The length of the free-stroke equals the clearance between the brake linings and the drum when the brakes are not applied.

Brake Chamber Stroke Specifications		
Chamber Type (Size)	**Maximum Applied Stroke*: inch (mm)**	**Free-Stroke: inch (mm)**
Standard Stroke		5/8 to 3/4 (16 to 19)
16, 20, and 24	1-3/4 (44)	
30	2 (51)	
36	2-1/4 (57)	
Long Stroke†		
16, 20, and 24	2 (51)	
30	2-1/2 (64)	

* Specifications are relative to a brake application with 80 to 90 psi (550 to 620 kPa) air pressure in the brake chambers.

† Long stroke design is indicated by a tag, or embossing, on the brake chamber.

Table 1, Brake Chamber Stroke Specifications

Brake Adjustment

- The applied chamber stroke is measured using an 80 to 90 psi (550 to 620 kPa) brake application to move the slack adjuster.

With the engine off, 100 psi (689 kPa) of air tank pressure will apply the required 80 to 90 psi (550 to 620 kPa) brake application for measuring the applied chamber stroke.

The applied chamber stroke measurement can be used for diagnostic purposes. A stroke that is too long or too short may indicate excessive wear in the cam, cam bushings, return springs, or air chamber.

The applied chamber stroke should always be adjusted (minimized) to within the specified limit, but it should not be reduced to the point where the free-stroke is too short and the brakes drag. To check for brake drag, spin the wheel end, tap the rim lightly with a hammer, and listen for a drag noise (a sharp ringing sound).

Adjustment

Meritor Automatic Slack Adjuster

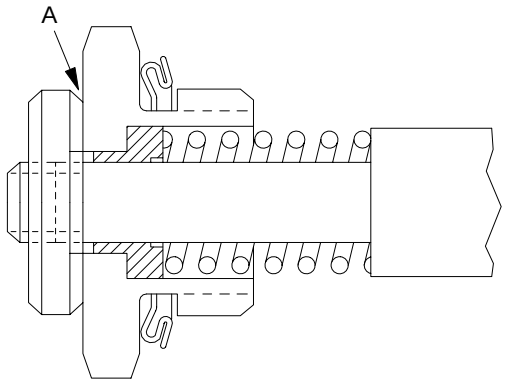
IMPORTANT: Before adjusting the brakes, see the pre-adjustment checks and general adjustment information at the beginning of this subject.

1. Park the vehicle on a level surface, apply the parking brakes, and shut down the engine. Chock the tires on the axle that is not being repaired.
2. Raise the front or rear axle and place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
3. Fully release the brakes (the air chamber push-rod must be fully retracted).
4. Check the condition of the boot on the slack adjuster. It should be held in the correct position with a retaining clip. If the boot is torn or cracked, see the slack adjuster disassembly and inspection procedures for information.

⚠ CAUTION

Before turning the manual adjusting nut on the slack adjuster, disengage the pull-pawl. Failure to do so could damage the pull-pawl teeth. A damaged pull-pawl will not allow the slack adjuster to automatically adjust the brake clearance.

5. Using a screwdriver, pry the pull-pawl button out at least 1/32 inch (0.8 mm) to disengage the pull-pawl teeth from the slack adjuster actuator. See **Fig. 1**. Wedge the screwdriver in place. The pull-pawl will need to be disengaged until the brake adjustment is complete.



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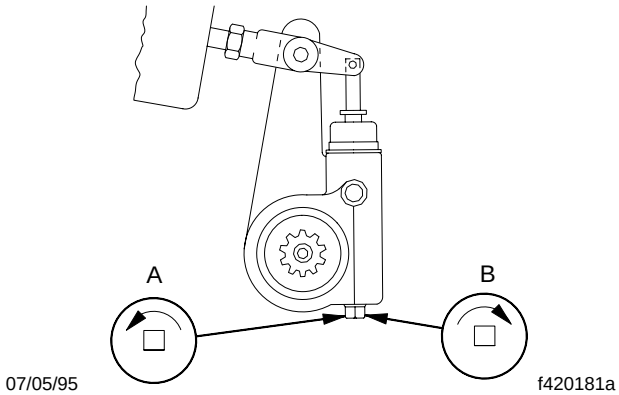
A. Insert screwdriver here.

Fig. 1, Disengage the Pull-Pawl

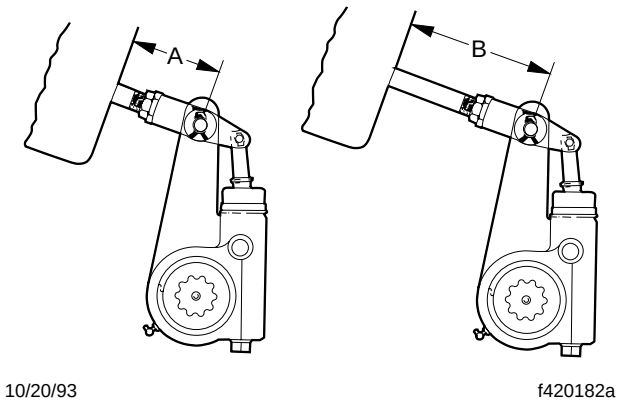
NOTE: When the screwdriver is removed, the pull-pawl will engage automatically.

6. Using the manual adjusting nut on the slack adjuster, adjust the brake chamber stroke (coarse adjustment). See **Fig. 2**.
   - 6.1 Turn the adjusting nut counterclockwise until the brake linings touch the brake drum.
   - 6.2 Then, turn the adjusting nut clockwise one-half turn.
7. Measure and adjust the free-stroke.
   - 7.1 With the brakes released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension A. See **Fig. 3**.
   - 7.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum.



A. Shorten stroke. B. Lengthen stroke.

Fig. 2, Turn the Adjusting Nut



NOTE: For either free-stroke or applied chamber stroke, subtract measurement A from B.

A. Measurement with the brakes released.
B. Measurement with the brakes applied by manual lever (free-stroke) or pressurized brake application (applied chamber stroke).

Fig. 3, Measuring the Stroke

7.3 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension B. See **Fig. 3**.

7.4 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.

7.5 The free-stroke should be 5/8 to 3/4 inch (16 to 19 mm). If it is not, turn the adjusting nut one-eighth turn, as shown in **Fig. 2**. Then, measure the free-stroke again, and readjust it until it is correct.

8. Measure and adjust the applied chamber stroke (fine adjustment).

8.1 Start the engine and build the air pressure to 100 psi (689 kPa). Shut down the engine.

8.2 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. 3**, Ref. B. Record this measurement as dimension C.

8.3 Subtract dimension A from dimension C. The difference between these measurements is the true applied chamber stroke.

8.4 The applied chamber stroke must not exceed the maximum value specified in **Table 1**.

⚠ CAUTION

The adjusted applied chamber stroke should be as short as possible but not so short that the free-stroke is too short and the linings drag. If the linings drag, the brakes could be damaged.

8.5 If the applied chamber stroke is incorrect, turn the adjusting nut one-eighth turn counterclockwise to shorten the stroke, or one-eighth turn clockwise to lengthen it. See **Fig. 2**. Measure the applied stroke again and readjust it until it is correct.

8.6 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes. See **Subject 150**. If necessary, replace the slack adjuster.

9. Remove the screwdriver from the pull-pawl assembly. This will engage the pull-pawl with the actuator.

10. Remove the safety stands, lower the vehicle, and remove the chocks from the tires.

⚠ WARNING

Do not operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability,

Brake Adjustment

which could cause personal injury or death, and property damage.

11. Check for proper brake operation. For instructions, see **Subject 110**.

Haldex Automatic Slack Adjusters

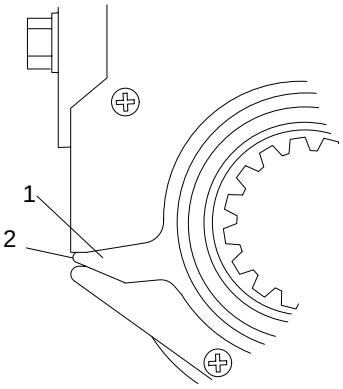
IMPORTANT: Before adjusting the brakes, see the pre-adjustment checks and general adjustment information at the beginning of this subject.

1. Park the vehicle on a level surface, apply the parking brakes, and shut down the engine. Chock the tires on the axle that is not being repaired.
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. Fully release the brakes (the air chamber pushrod must be fully retracted).

⚠ CAUTION

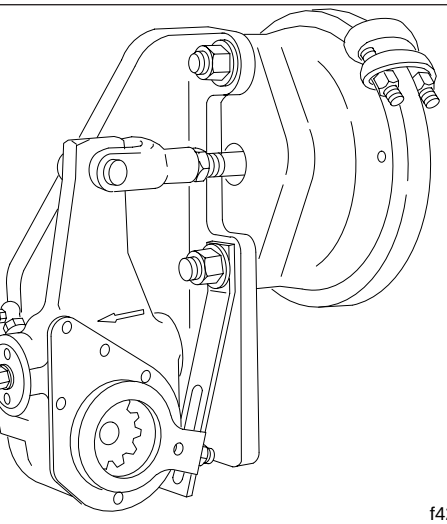
The installation indicator must be aligned with the indicator notch on the slack adjuster. If the indicator is not within the notched area, the control arm is installed in the wrong position. This may result in tight brakes, excessive lining wear, and possible brake damage.

4. Make sure the installation indicator is aligned with the indicator notch on the slack adjuster. See **Fig. 4**. If the indicator is not within the notched area, the control arm is not installed correctly.
5. Measure how much torque is required to overcome the resistance of the internal clutch (internal clutch slippage).
   - 5.1 Using a 7/16-inch torque wrench, turn the adjusting nut counterclockwise. See **Fig. 5**. You will hear a ratcheting sound.
   - 5.2 If the clutch slips with a torque less than 13 lbf·ft (18 N·m), the slack adjuster must be replaced.
6. Using the manual adjusting nut on the slack adjuster, adjust the brake chamber stroke (coarse adjustment).



1. Installation Indicator 2. Indicator Notch

Fig. 4, Installation Indicator



1. Adjusting Hexnut

Fig. 5, Adjusting Hexnut

   - 6.1 Turn the adjusting nut clockwise until the brake linings contact the brake drum.
   - 6.2 Then, turn the adjusting nut counterclockwise one-half turn. You will hear a ratcheting sound.
7. Measure and adjust the free-stroke.
   - 7.1 Measure the distance from the bottom of the brake chamber to the far side of the clevis pin. See **Fig. 6**. Record this measurement as dimension A.

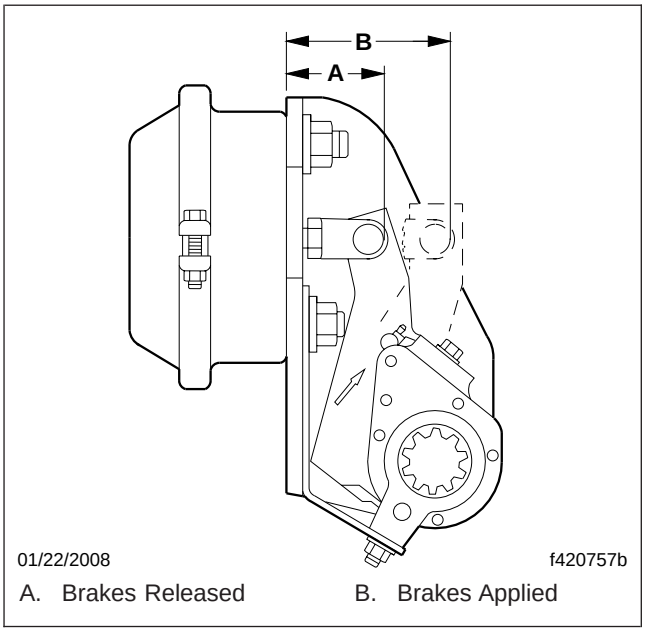


Fig. 6, Measure the Stroke

7.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum. Then, measure the distance from the bottom of the brake chamber to the far side of the clevis pin. See **Fig. 6**. Record this measurement as dimension B.

7.3 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.

7.4 The free-stroke should be 5/8 to 3/4 inch (16 to 19 mm). If it is not, turn the adjusting nut in the required direction. Then, measure the free-stroke again and readjust it until it is correct.

8. Measure and adjust the applied chamber stroke (fine adjustment).

8.1 Start the engine and build the air pressure to 100 psi (689 kPa). Shut down the engine.

8.2 Fully apply the brakes. Then, measure the distance from the bottom of the brake chamber to the far side of the clevis pin hole. See **Fig. 6**, Ref. B. Record this measurement as dimension C.

8.3 Subtract dimension A from dimension C. The difference between these measurements is the applied chamber stroke.

8.4 The applied chamber stroke must not exceed the maximum value specified in **Table 1**. If the stroke is not correct, turn the adjusting nut in the required direction. Then, measure the applied chamber stroke again and readjust it until it is correct.

8.5 If the slack adjuster does not maintain the correct applied chamber stroke, check the condition of the foundation brakes. See **Subject 150**. If necessary, replace the slack adjuster.

9. Remove the safety stands, lower the vehicle, and remove the chocks from the tires.

⚠ WARNING

Do not operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

10. Check for proper brake operation. For instructions, see **Subject 110**.

Gunite Automatic Slack Adjusters

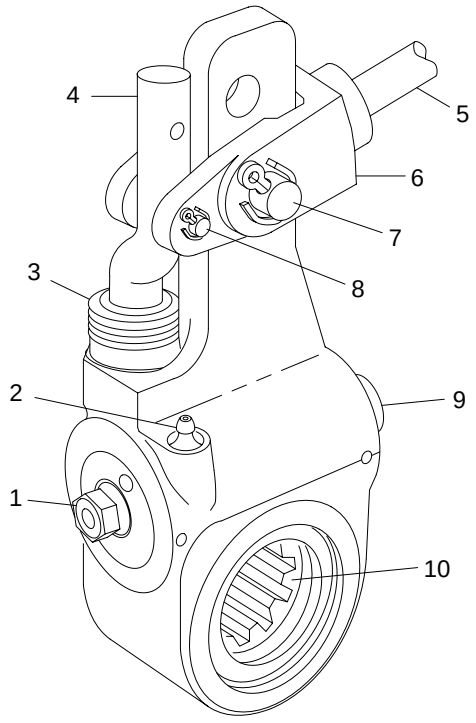
IMPORTANT: Before adjusting the brakes, see the pre-adjustment checks and general adjustment information at the beginning of this subject.

1. Park the vehicle on a level surface, apply the parking brakes, and shut down the engine. Chock the tires on the axle that is not being repaired.
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. Fully release the brakes (the air chamber pushrod must be fully retracted).
4. Measure how much torque is required to overcome the resistance of the internal clutch (internal clutch slippage).

Brake Adjustment

4.1 Using a 7/16-inch torque wrench, turn the adjusting nut counterclockwise. See **Fig. 7**. You will hear a ratcheting sound.

4.2 If the clutch slips with a torque less than 15 lbf·ft (20 N·m), the slack adjuster must be replaced.



1. Adjusting Hexnut
2. Grease Fitting
3. Boot
4. Link
5. Brake Chamber Pushrod
6. Clevis
7. Clevis Pin, 1/2-inch
8. Clevis Pin, 1/4-inch
9. Grease Relief Opening
10. Slack Adjuster Spline

Fig. 7, Gunite Slack Adjuster

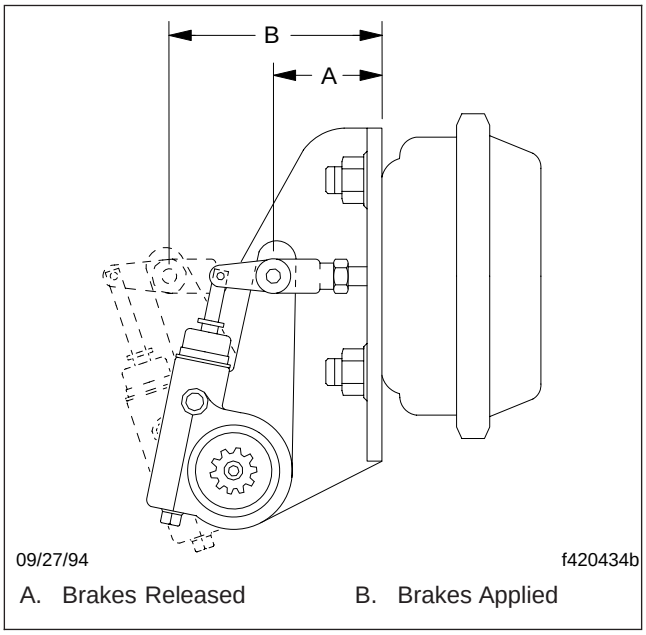
5. Using the manual adjusting nut on the slack adjuster, adjust the brake chamber stroke (coarse adjustment).

5.1 Turn the adjusting nut clockwise until the brake linings contact the brake drum.

5.2 Turn the adjusting nut counterclockwise one-half turn. There should be about 30 lbf·ft (41 N·m) resistance. You will hear a ratcheting sound.

6. Measure and adjust the free-stroke.

6.1 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 8**. Record this measurement as dimension A.



A. Brakes Released B. Brakes Applied

Fig. 8, Measure the Stroke

6.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum.

6.3 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 8**. Record this measurement as dimension B.

6.4 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.

6.5 The free-stroke should be 5/8 to 3/4 inch (16 to 19 mm). If it is not, turn the adjusting nut in the required direction. Then, measure the free-stroke again and readjust it until it is correct.

7. Measure and adjust the applied chamber stroke (fine adjustment).

7.1 Start the engine and build air pressure to 100 psi (689 kPa). Shut down the engine.

7.2 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. 8**, Ref. B. Record this measurement as dimension C.

7.3 Subtract dimension A from dimension C. The difference between these measurements is the applied chamber stroke.

7.4 The applied chamber stroke must not exceed the maximum value specified in **Table 1**. If the stroke is not correct, turn the adjusting nut in the required direction. Then, measure the applied stroke again and readjust it until it is correct.

7.5 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes. See **Subject 150**. If necessary, replace the slack adjuster.

8. Remove the safety stands, lower the vehicle, and remove the chocks from the tires.

⚠ WARNING

Do not operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

9. In a safe area, check for proper brake operation before you put the vehicle in service.

9.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.

9.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.

9.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than others shows a lack of braking effort on those wheels.

Specifications

Dana Spicer ES Brakes Torque Specifications		
Description	**lbf·ft**	**N·m**
Dust Shield Fasteners		
One-Piece Dust Shield	11 to 16	15 to 22
Two-Piece Dust Shield		
Brake Spider Fasteners		
1/2–13	60 to 80	81 to 108
5/8–11 (hexhead capscrew)	130 to 160	176 to 217
5/8–11 (flanged hexhead capscrew)	160 to 200	217 to 271
Camshaft Support Bracket Fasteners		
1/2–13	55 to 65	75 to 88
Stabilizing Screw (front brake)	23 to 27	31 to 37
Anchor Pin		
Reinforcement Plate Nuts	35 to 40	47 to 54
Retaining Nut	475 to 525	644 to 712

Table 1, Dana Spicer E.S. Brakes Torque Specifications

Brake Chamber Mounting Torque		
Manufacturer	**Chamber Size (square inches)**	**Torque lbf·ft (N·m)**
Midland	12, 16	30 (41)
	20, 24, 30, 36	100 (136)
MGM	24, 30, 36	100–115 (136–156)

Table 2, Brake Chamber Mounting Torque

Description

The Bendix SR-7™ spring brake modulating valve (see **Fig. 1** and **Fig. 2**) is used in conjunction with a dual air brake system and spring brake actuator, and performs the following functions:

- Provides a rapid application of the spring brake actuator when parking.
- Modulates the spring brake actuator application using the dual brake valve should a primary failure occur in the service brake system.
- Prevents compounding of service and spring brake forces.

The SR-7 valve has one park control, one service control, one supply, one balance, four delivery NPT ports, and an exhaust port protected by an exhaust diaphragm. The valve incorporates two mounting studs for mounting the valve to the frame rail or crossmember.

⚠ CAUTION

Do not attempt to disassemble the SR-7 valve. The valve contains high spring forces that could result in personal injury if disassembly is attempted.

Operation

The operation guidelines in this subject represent the relay-valve-based SR-7. A quick-release-based valve functions similarly to the relay-valve-based version with the exception that all air delivered to the spring brakes passes through the park control port through the inline single check valve. The SR-7 quick release style can be easily identified by the pipe plug in the supply port of the valve. See **Fig. 1**. For vehicle-specific plumbing diagrams, go to **EZWiring**.

Charging the Spring Brake Actuators Below 107 psi (737 kPa)

With the air brake system charged and the parking brakes released (by pushing in the dash valve button), air enters the park control port. This opens the SR-7 valve, to supply air pressure to the spring brake chambers. As illustrated, air pressure in the chambers is below 107 psi (737 kPa) (nominal). See **Fig. 3**.

Charging the Spring Brake Actuators Above 107 psi (737 kPa)

Once the SR-7 valve delivery pressure reaches 107 psi (nominal), the inlet and exhaust are closed (valve lap position). This maintains the spring brake hold-off pressure at 107 psi (nominal). See **Fig. 4**.

Normal Service Application

During a service brake application, the valve remains in the lap position. The SR-7 valve monitors the presence of air pressure in both primary and secondary delivery circuits. See **Fig. 5**.

Parking

Actuating the park brakes (by pulling out the dash valve button) exhausts spring brake air pressure through the SR-7 valve exhaust port. See **Fig. 6**.

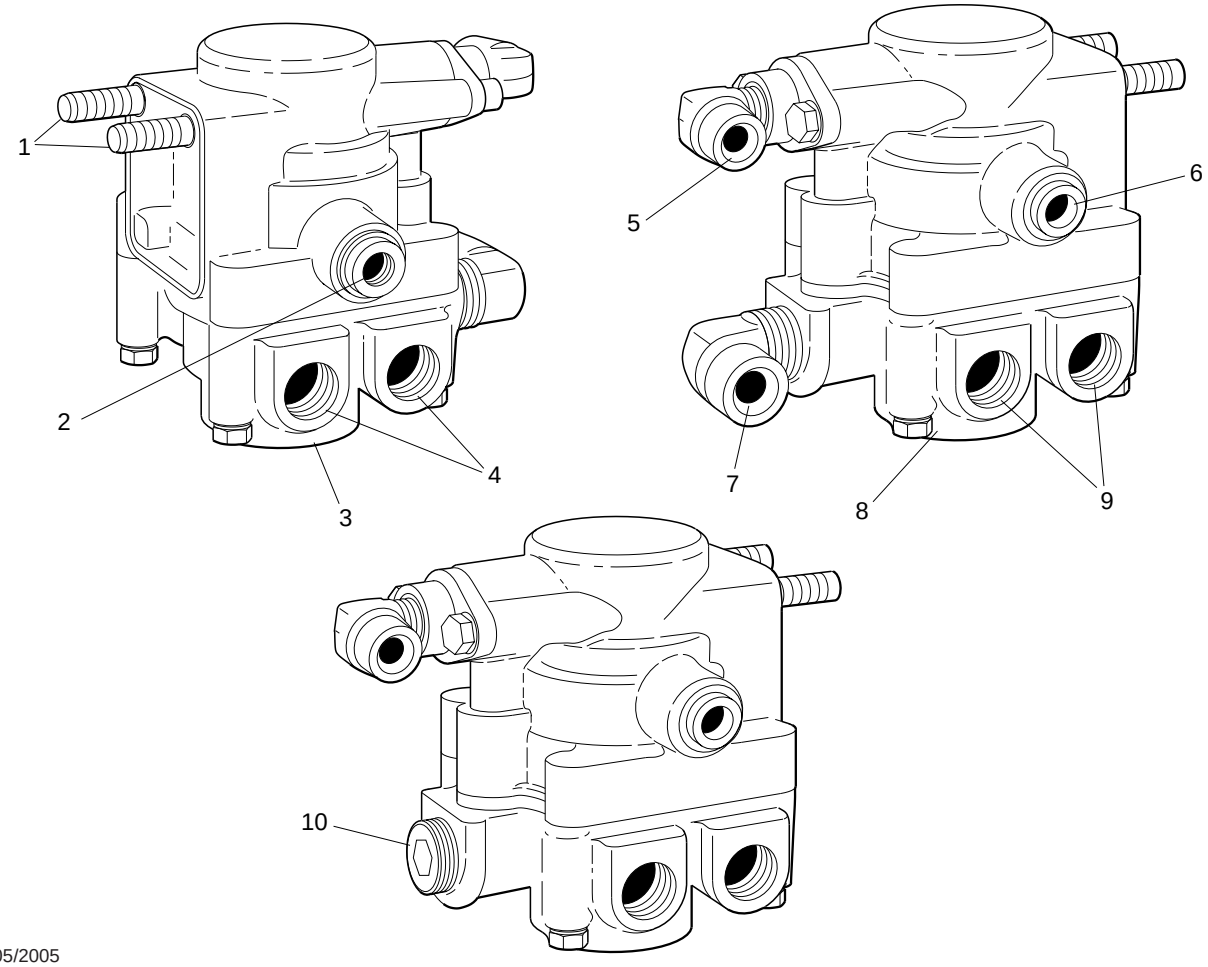
Service Application with Loss of Air in Primary Circuit

With the parking brakes released (dash valve button in) and the absence of air in the primary circuit delivery, a service brake application from the secondary circuit causes the pressure in the spring brakes to be exhausted proportionally to this application. This is known as spring brake modulation. A 30 psi (207 kPa) service brake application will exhaust the spring brake pressure to approximately 60 psi (414 kPa). See **Fig. 7**.

Service Application with Loss of Air in Secondary Circuit

With the parking brakes released (dash valve button in) and the absence of air in the secondary circuit reservoir, the external single check valve in the supply port seals to prevent air leakage to atmosphere from the SR-7 valve. The dash valve delivery air flows through the inline single check valve and becomes SR-7 valve supply air. This air is delivered to maintain at least 107 psi (737 kPa) (nominal) in the spring brake chambers. See **Fig. 8**.

General Information



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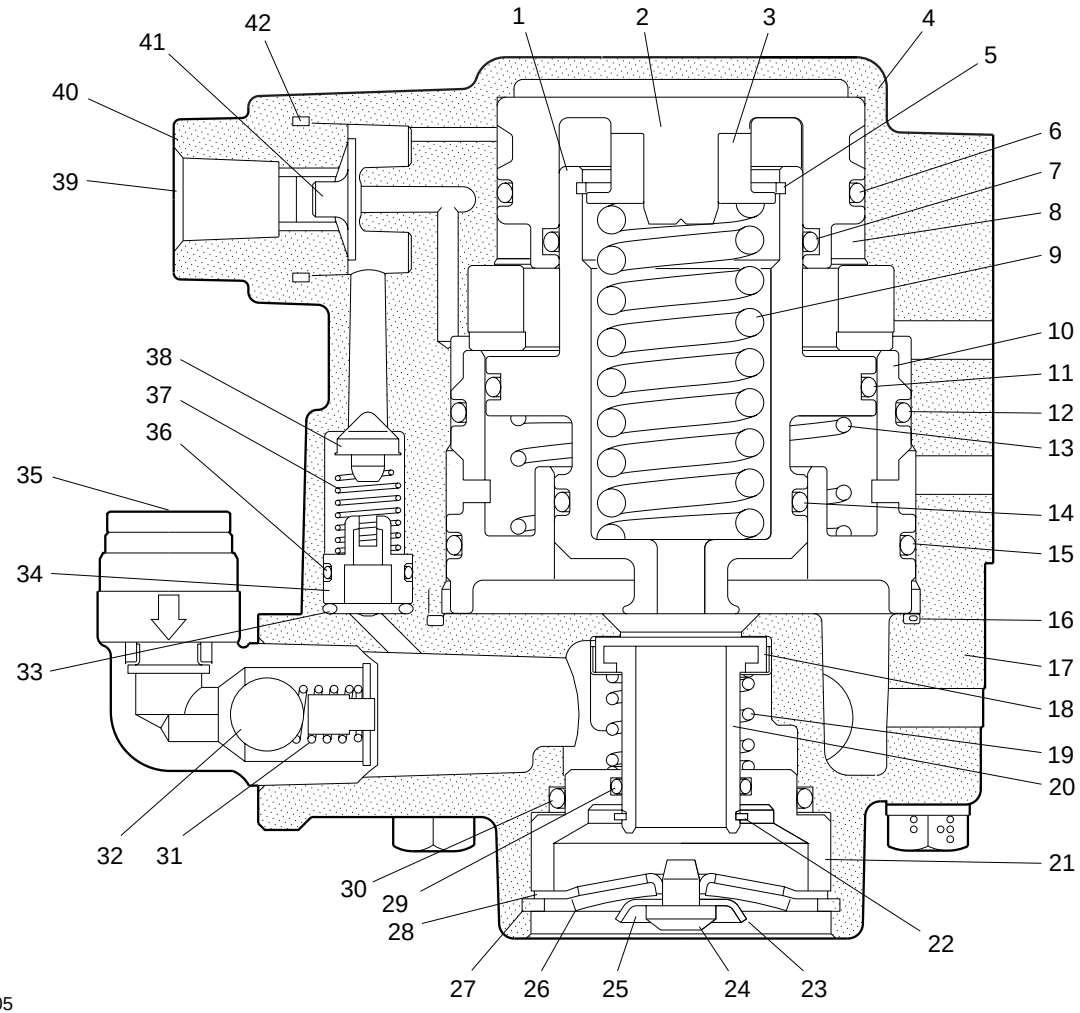
1. Mounting Studs
2. 42 Control Port
3. Exhaust
4. Delivery
5. 41 Park Control (from dash valve)
6. 41 Balance Port
7. Supply Port
8. Exhaust
9. Delivery
10. Pipe Plug (QRV applications only)

Fig. 1, SR-7 Spring Brake Modulating Valve (exterior views)

Anticompounding

The SR-7 valve provides anticompounding of the service and spring brake forces. When the park brakes are actuated (by pulling out the dash valve button), a service brake application will cause the SR-7 valve to deliver air pressure to the spring brake chambers. Thus the vehicle is held stationary using a service brake application. When the service brake application is released, the delivery pressure is exhausted from the spring brake chambers and the vehicle remains parked using the spring brake actuators. See **Fig. 9**.



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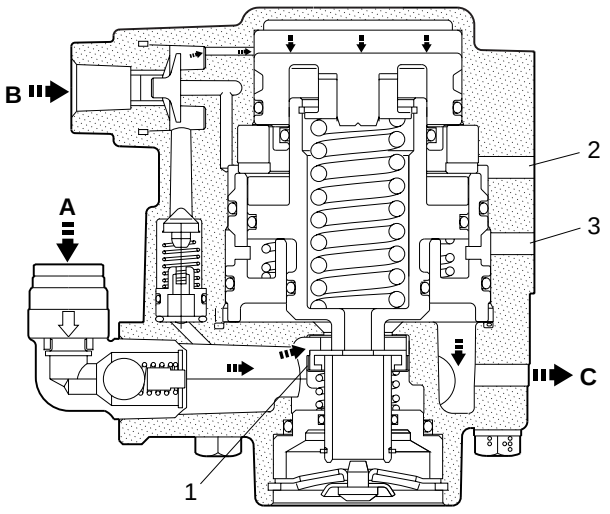
1. Main Piston
2. Control Piston
3. Spring Guide
4. Upper Body
5. Retaining Ring
6. O-Ring
7. O-Ring
8. Spacer
9. Main Piston Spring
10. Static Piston
11. O-Ring
12. O-Ring
13. Static Piston Spring
14. O-Ring
15. O-Ring
16. O-Ring
17. Lower Body
18. Valve Retainer
19. Spring
20. Inlet/Exhaust Valve
21. Lower Valve Guide
22. Retaining Ring
23. Exhaust Port
24. #10 Torx Screw
25. Diaphragm Washer
26. Diaphragm
27. Retaining Ring
28. Valve Seat
29. O-Ring
30. O-Ring
31. Spring
32. Ball Check Valve
33. O-Ring
34. Check Valve Guide
35. Supply Port
36. O-Ring
37. Spring
38. Inline Single Check Valve
39. Park Control Port
40. Check Valve Cover
41. Double Check Valve
42. O-Ring

Fig. 2, SR-7 Spring Brake Modulating Valve (sectional view)

General Information



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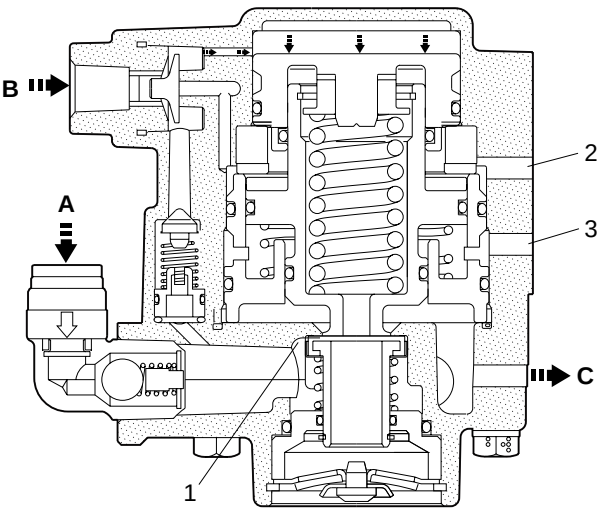
A. Secondary reservoir constant pressure
B. Control line pressure
C. Delivery to spring brakes
1. Inlet/Exhaust Valve Open
2. Balance Port
3. Control Port

Fig. 3, Charging the Spring Brake Actuators Below 107 psi (737 kPa)



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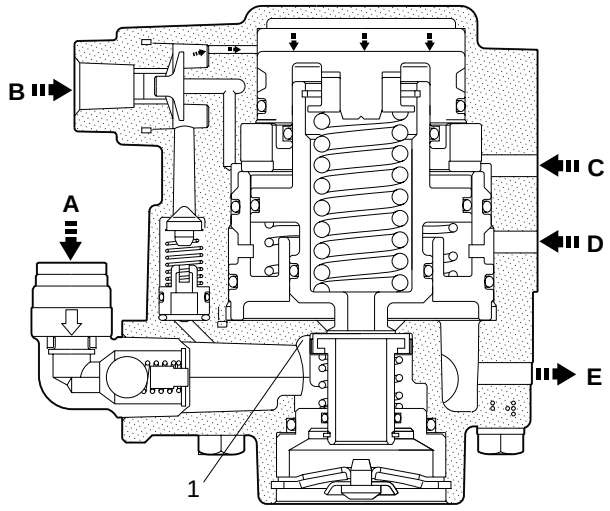
A. Secondary reservoir constant pressure
B. Control line pressure
C. Delivery to spring brakes
1. Inlet/Exhaust Valve Seated
2. Balance Port
3. Control Port

Fig. 4, Charging the Spring Brake Actuators Above 107 psi (737 kPa)



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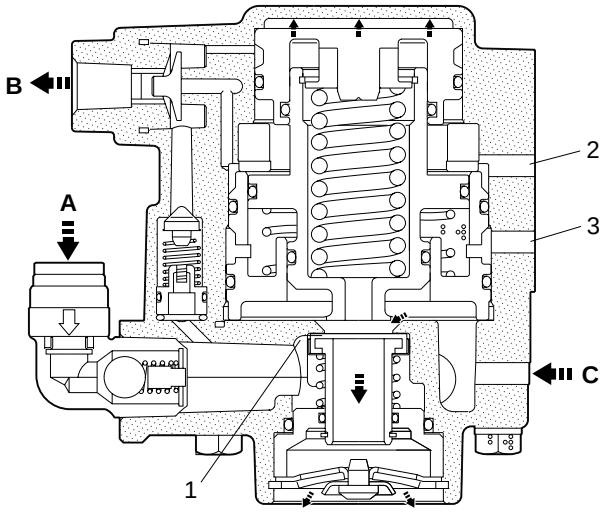
A. Secondary reservoir constant pressure
B. Control line pressure
C. Balance port—primary circuit pressure
D. Control port—secondary circuit pressure
E. Delivery to spring brakes
1. Inlet/Exhaust Valve Seated

Fig. 5, Normal Service Application



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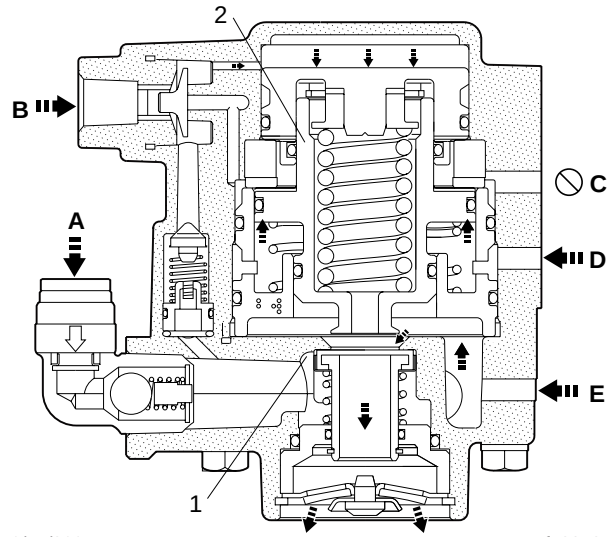
A. Secondary reservoir constant pressure
B. Control line pressure
C. Delivery to spring brakes
1. Inlet/Exhaust Valve Seated
2. Balance Port
3. Control Port

Fig. 6, Parking

General Information



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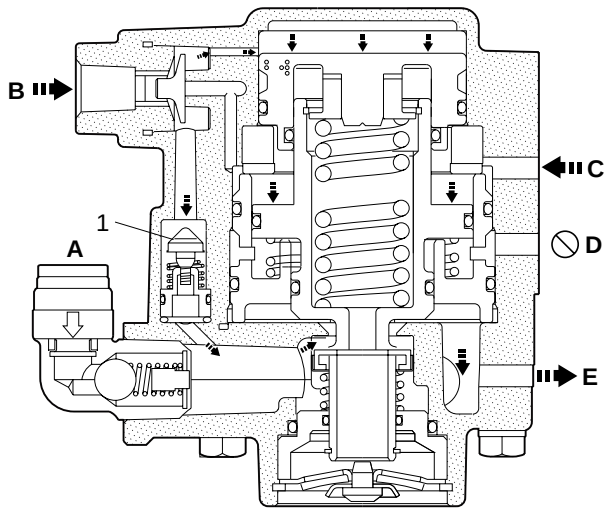
A. Secondary reservoir constant pressure
B. Control line pressure
C. Balance port—loss of primary circuit pressure
D. Control port—secondary circuit pressure
E. Delivery to spring brakes
1. Inlet Valve Seated
2. Main Piston Moves Up

Fig. 7, Service Application with Loss of Air in Primary Circuit



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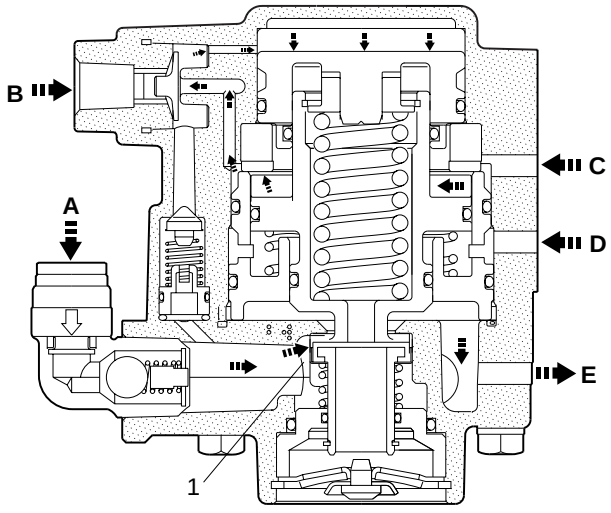
A. Secondary reservoir no pressure
B. Control line pressure
C. Balance port—primary circuit pressure
D. Control port—loss of secondary circuit pressure
E. Delivery to spring brakes
1. Inline Single Check Valve

Fig. 8, Service Application with Loss of Air in Secondary Circuit



A. Secondary reservoir constant pressure
B. Control line pressure
C. Balance port—primary circuit pressure
D. Control port—secondary circuit pressure
E. Delivery to spring brakes
1. Inlet/Exhaust Valve Open

Fig. 9, Anticompounding

Safety Precautions

Before attempting to work on the air brake system, observe the following precautions:

- Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized. The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.
- When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.
- Hoses will whip dangerously if disconnected under pressure. Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.
- As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber pushrods and spring actuators that apply automatically with the loss of pressure. This also applies when checking the service brake system.
- Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.
- Used reservoirs must not be used as replacements, in order to eliminate the possibility of component failure.
- The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured, in order to prevent valve failure.
- Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.
- To avoid injury, keep clear of the air chamber pushrod when brakes are applied or when air is exhausted from the system.

Removal

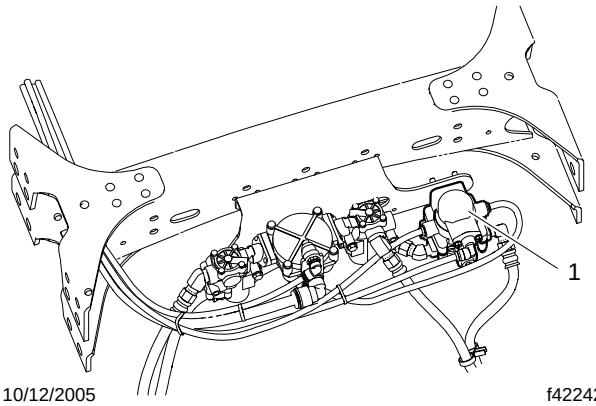
WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so could result in personal injury.

CAUTION

Do not attempt to disassemble the SR-7 valve. The valve contains high spring forces that could result in personal injury if disassembly is attempted.

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the tires.
2. Drain the air system.
3. Identify all the air lines attached to the valve, for reinstallation. See **Fig. 1** for a view of a typical installation, or access EZWiring for vehicle-specific plumbing diagrams.



1. SR-7 Valve

Fig. 1, SR-7 Spring Brake Modulating Valve Installation (typical)

4. Disconnect all the air lines from the valve.
5. Remove the two mounting nuts that secure the valve to the crossmember bracket, and remove the valve.
6. If the valve is being replaced, note the orientation of all fittings, then remove the fittings for use on the new valve.

Installation

1. If a new valve is being installed, install the fittings removed from the old valve.
2. Position the valve on the crossmember bracket and install the mounting nuts. Tighten to 15 to 18 lbf·ft (20 to 24 N·m).
3. Attach all the air lines as noted during removal.
4. Before returning the vehicle to service, perform the operating and leakage tests in **Subject 120**, *Tests*.

Operating Test

⚠ WARNING

Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so could result in personal injury.

⚠ CAUTION

Do not attempt to disassemble the SR-7 valve. The valve contains high spring forces that could result in personal injury if disassembly is attempted.

1. Chock the tires.
2. Charge the air brake system to governor cut-out pressure.
3. Place the parking control valve in the PARK position. Observe that the spring brake actuators apply promptly.
4. Remove one line from a delivery port of the SR-7 valve and install a test gauge that is known to be accurate. See **Fig. 1** for the port locations.
5. Place the parking control valve in the RELEASE position. Observe that the spring brake actuators fully release.
6. With the parking control valve still in the RELEASE position, note the gauge pressure reading. Correct spring brake actuator hold-off pressure is 107 psi (737 kPa) nominal.
7. Place the parking control valve in the PARK position. The gauge reading should drop to zero promptly. A lag (more than 3 seconds) in the drop of pressure would indicate faulty operation.
8. With the parking control valve still in the PARK position, gradually apply the foot brake valve and note a pressure reading increase on the gauge installed in the SR-7 valve delivery port.
9. Place the parking control valve in the RELEASE position.
10. Drain the reservoir that supplies the rear service brake circuit; apply the foot brake valve several times and note that the pressure reading on the gauge decreases each time the foot brake valve is applied (spring brake modulation). After the foot brake valve has been applied several times, the pressure reading on the gauge will drop to the point where release of the spring brake actuators will no longer occur.

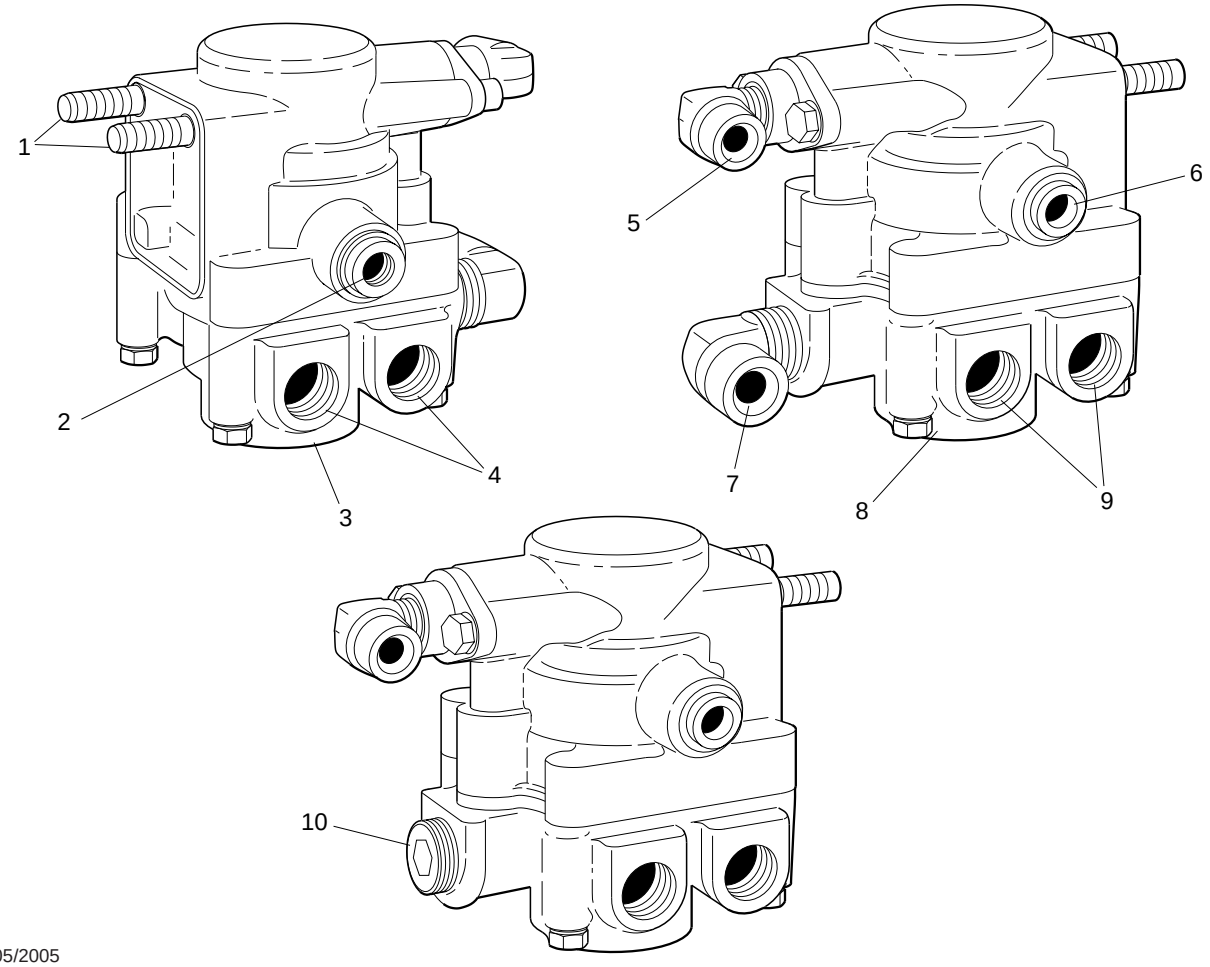
NOTE: The SR-7 valve is not serviceable. If the valve does not function as described, replace it.

Leakage Test

Place the park control valve in the RELEASE position; using a soap solution, coat all ports including the exhaust port. A 1-inch (25-mm) bubble in three seconds is permitted.

NOTE: The SR-7 valve is not serviceable. If the valve does not function as described, or if leakage is excessive, replace it.

Tests



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1. Mounting Studs
2. 42 Control Port
3. Exhaust
4. Delivery
5. 41 Park Control (from dash valve)
6. 41 Balance Port
7. Supply Port
8. Exhaust
9. Delivery
10. Pipe Plug (QRV applications only)

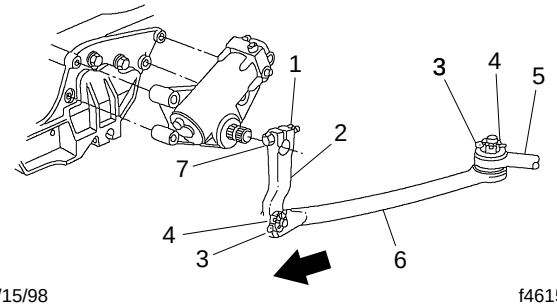
Fig. 1, SR-7 Spring Brake Modulating Valve (exterior views)

General Information

The steering linkage on L-Line and A-Line vehicles consists of left-side and right-side spindle assemblies attached to an I-beam front axle. Separate steering and spindle arms attach to the spindles. A tie rod, adjustable for toe-in, is connected between the left-side and right-side spindle arms. The drag link is connected between the steering arm on the left-side spindle assembly and the pitman arm on the steering gear. See **Fig. 1**.

DUAL-GEAR STEERING LINKAGE

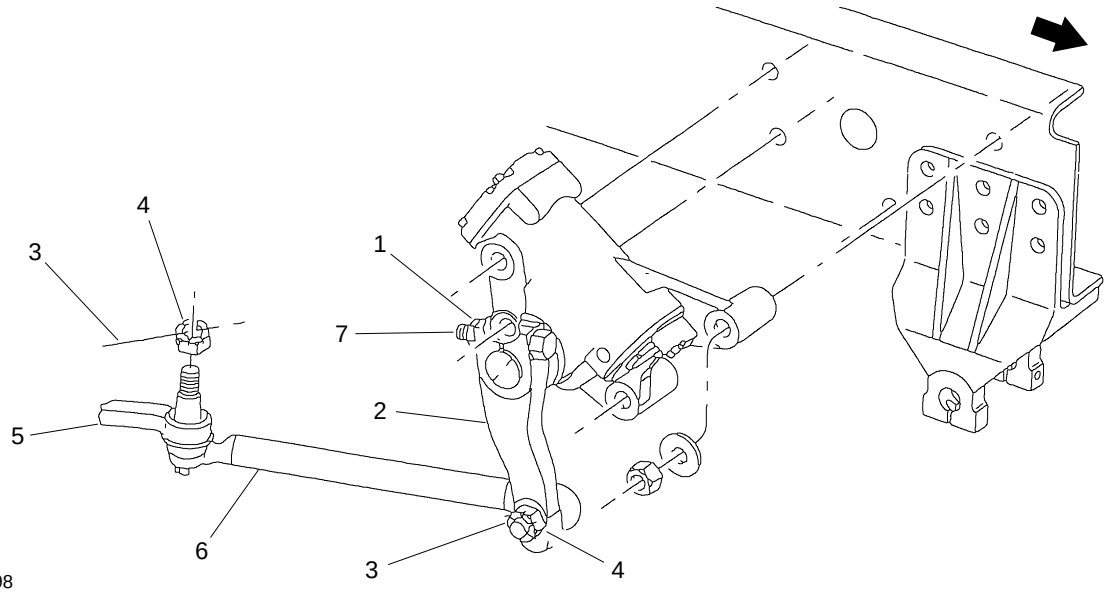
18,000- to 20,000-lb front axles utilize steering gears on both the left- and right-sides to reduce steering efforts normally associated with heavy axles. This is known as a dual-gear system. In a dual-gear system, the steering linkage on the right-side is the mirror image of the linkage on the left-side. See **Fig. 2**.



1. Pitman Arm Pinch Bolt Nut
2. Pitman Arm
3. Cotter Pin
4. Nut
5. Steering Arm
6. Drag Link
7. Pitman Arm Pinch Bolt

Fig. 1, Steering Linkage Drag Link, Typical

General Information



1. Pitman Arm Pinch Bolt Nut
2. Pitman Arm
3. Cotter Pin
4. Nut
5. Steering Arm
6. Drag Link
7. Pitman Arm Pinch Bolt

Fig. 2, Right-Side Dual-Gear Steering Linkage (Left-Hand Drive Shown)

Tie Rod End Removal and Installation

NOTE: All figures show left-hand drive configurations. Right-hand drive configurations are similar.

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the cotter pin and nut from the tie rod end. Discard the cotter pin. See **Fig. 1**.

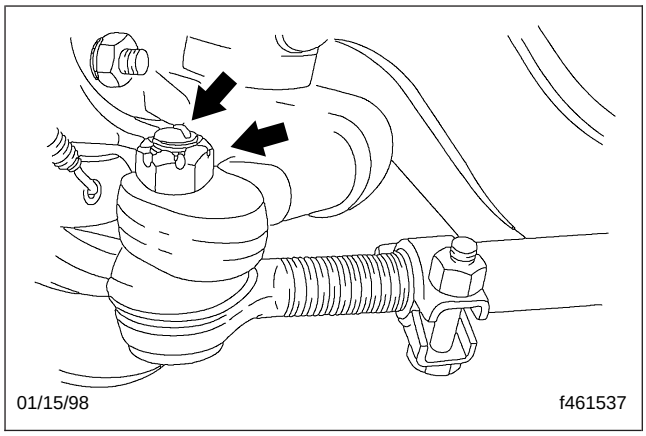


Fig. 1, Remove the Cotter Pin and Nut

3. Remove the tie rod end ball stud from the steering arm using the pitman arm puller. See **Fig. 2**.

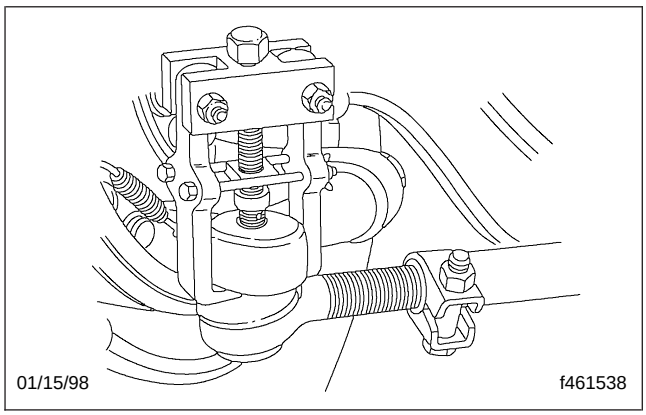


Fig. 2, Remove the Tie Rod End Ball Stud

4. Remove and discard the grease seal from the tie rod end. See **Fig. 3**.

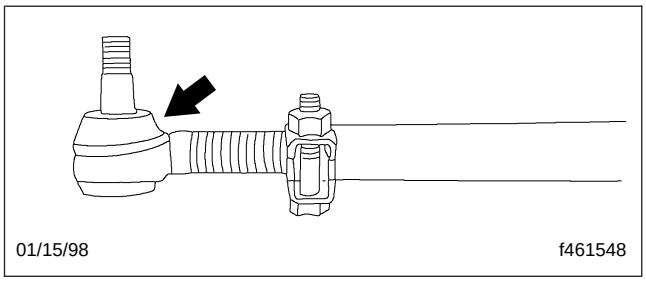


Fig. 3, Grease Seal

5. Loosen the tie rod end clamp bolt, and count the number of turns required to remove the tie rod end. See **Fig. 4**.

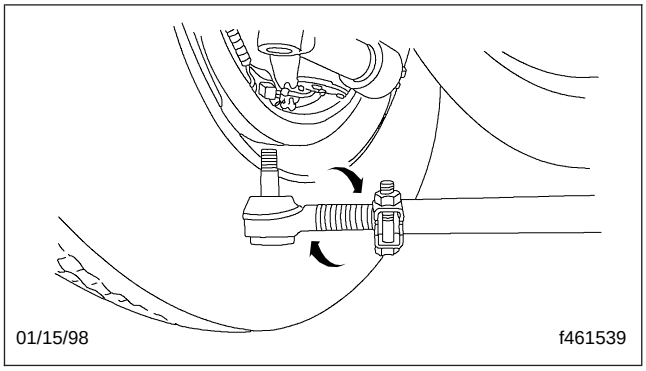


Fig. 4, Unscrew the Tie Rod (Count the Number of Turns)

Installation

1. Install the tie rod end. Turn the tie rod end the same number of turns used to remove the old tie rod end. See **Fig. 5**.
2. Install a new grease seal on the tie rod end. See **Fig. 3**.
3. Install the tie rod end to the steering arm. For 9,000-lb front axles, tighten the nut 75 to 105 lbf·ft (102 to 142 N·m). For 10,000- to 20,000-lb front axles, tighten the nut 110 to 150 lbf·ft (149 to 203 N·m). Advance to the next castlelation, if necessary, to install the cotter pin. See **Fig. 6**.
4. Install a new cotter pin.
5. Tighten the tie rod end clamp bolt 50 to 70 lbf·ft (68 to 95 N·m). See **Fig. 7**.
6. Check the vehicle alignment.
7. Remove the chocks from the tires.

Tie Rod End Removal and Installation

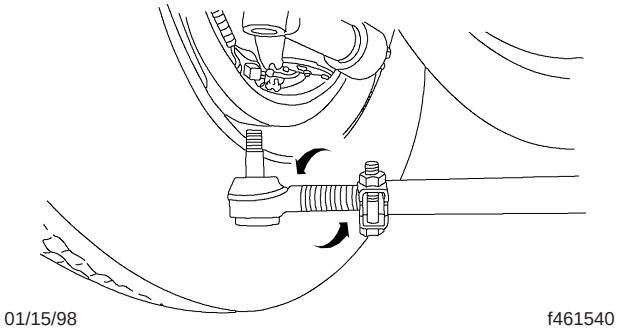
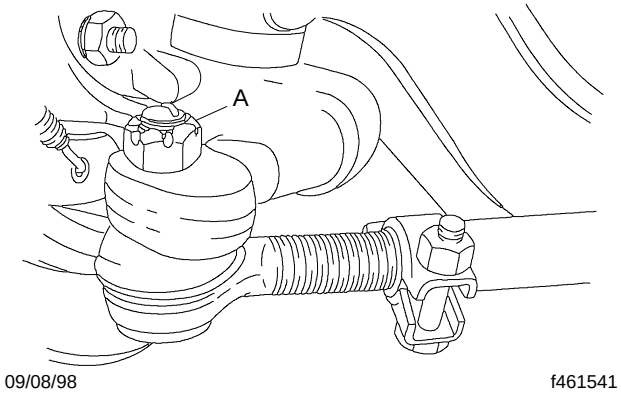
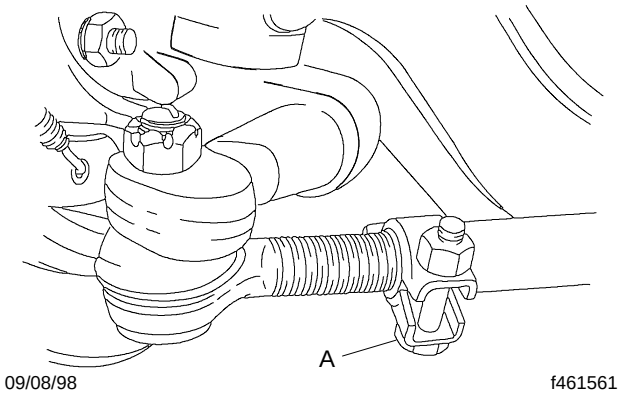


Fig. 5, Screw in the Tie Rod



A. On 9,000-lb front axles, tighten 75 to 105 lbf·ft (102 to 142 N·m). On 10,000- to 20,000-lb front axles, tighten 110 to 150 lbf·ft (149 to 203 N·m).

Fig. 6, Tie Rod End Nut



A. Tighten 50 to 70 lbf·ft (68 to 95 N·m).

Fig. 7, Tie Rod End Clamp

Drag Link Removal and Installation

Removal

WARNING

All steering mechanisms are essential to the safe operation of the vehicle. Follow the instructions in this subject exactly. Failure to do so may result in loss of steering, which could cause personal injury and property damage.

NOTE: All figures show left-hand drive configurations. Right-hand drive configurations are similar.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the cotter pin and nut from the drag link ball stud to the steering arm. Discard the cotter pin. See **Fig. 1**.

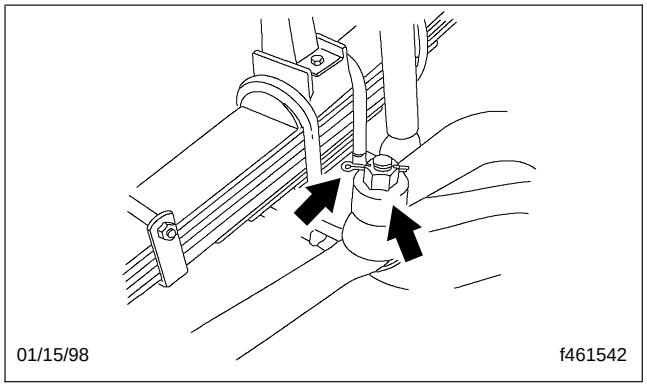


Fig. 1, Remove the Cotter Pin and Nut

3. Using the pitman arm puller, remove the ball stud. See **Fig. 2**.
4. Remove the cotter pin and nut from the drag link ball stud to the pitman arm. Discard the cotter pin. See **Fig. 3**.
5. Using the pitman arm puller, remove the drag link from the pitman arm. See **Fig. 4**.

Installation

1. Attach the drag link to the pitman arm. Tighten the castle nut to the appropriate torque spec:
   - 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. Install a new cotter pin.
3. Install the drag link on the steering arm. Tighten the castle nut to the appropriate torque spec:
   - 5/8–18: 60 to 115 lbf·ft (81 to 156 N·m)
   - 3/4–16: 90 to 170 lbf·ft (122 to 230 N·m)
   - 7/8–14: 160 to 300 lbf·ft (217 to 407 N·m)

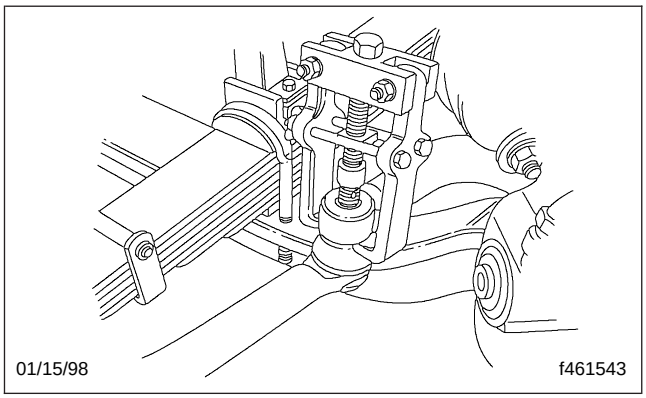


Fig. 2, Remove the Ball Stud

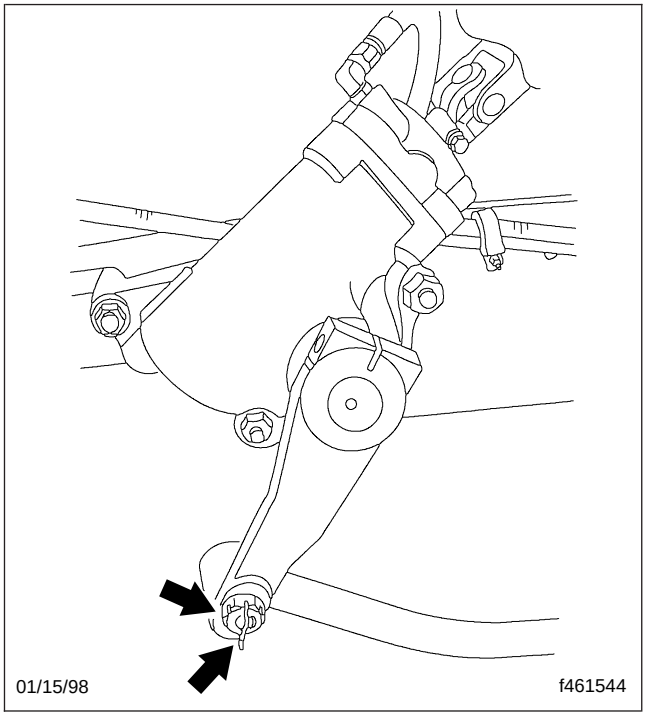


Fig. 3, Remove the Cotter Pin and Nut

Drag Link Removal and Installation

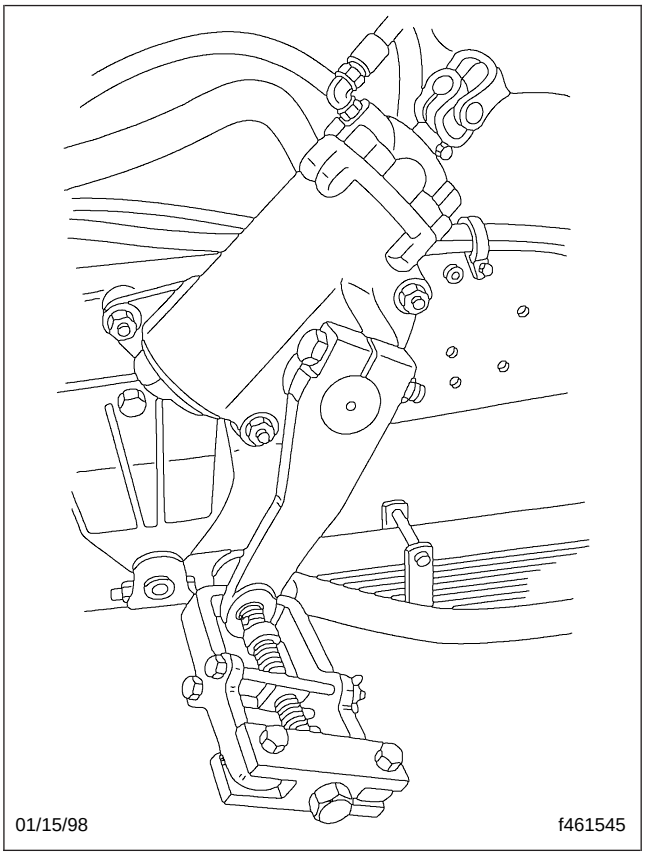


Fig. 4, Remove the Drag Link from the Pitman Arm

4. Install a new cotter pin.

⚠ WARNING

Install and lock new cotter pins in the ball studs and nuts. Failure to do so could result in disengagement of the components, causing loss of steering control, which could result in personal injury and property damage.

5. Check vehicle alignment. See **Group 32** for instructions.
6. Remove the chocks from the tires.

Pitman Arm Removal and Installation

NOTE: All figures show left-hand drive configurations. Right-hand drive configurations are similar.

Removal

NOTE: When parking the vehicle, make sure the tires are in the straight ahead position.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Open the hood.
3. Remove the cotter pin and nut from the drag link ball stud to the pitman arm. Discard the cotter pin. See **Fig. 1**.

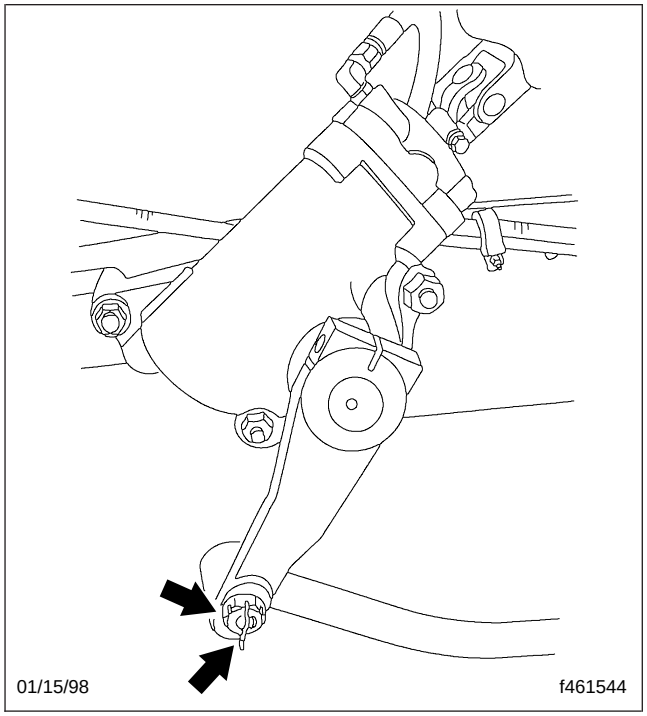


Fig. 1, Remove the Cotter Pin and Nut

4. Remove the drag link ball stud to the pitman arm using the pitman arm puller. See **Fig. 2**.
5. Remove and discard the nut and bolt. See **Fig. 3**.
6. Remove the pitman arm from the steering gear using the pitman arm puller. See **Fig. 4**.

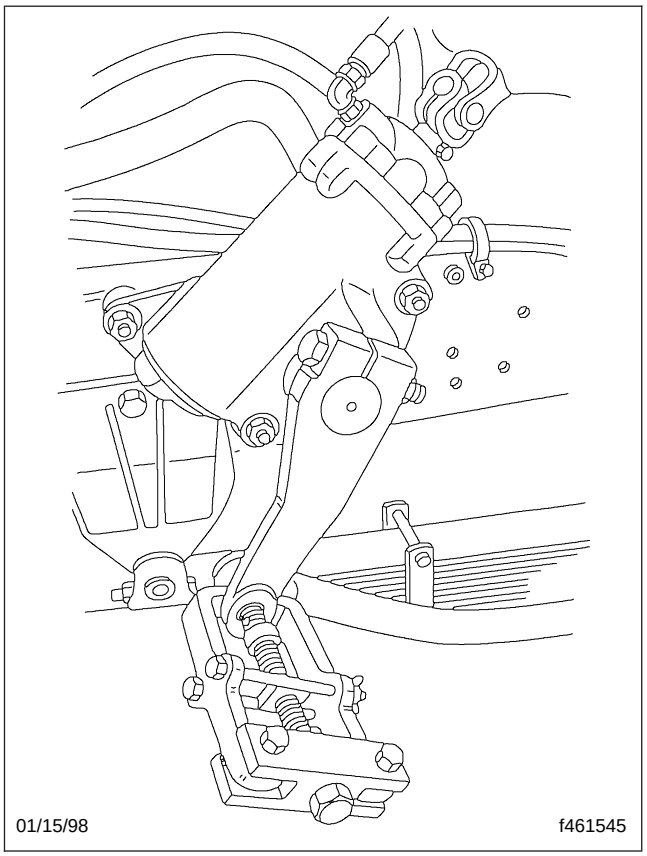


Fig. 2, Remove the Drag Link Ball Stud

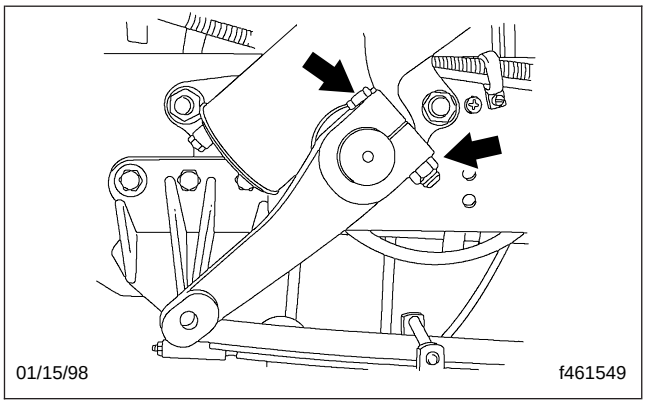


Fig. 3, Remove the Nut and Bolt

Installation

1. Install a new pitman arm on the sector shaft. Be careful to align the index mark on the steering

Pitman Arm Removal and Installation

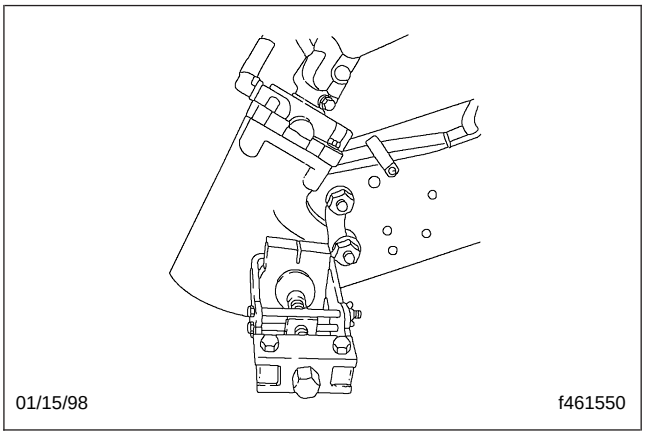


Fig. 4, Remove the Pitman Arm

gear sector shaft with the index mark on the pitman arm. See **Fig. 5**.

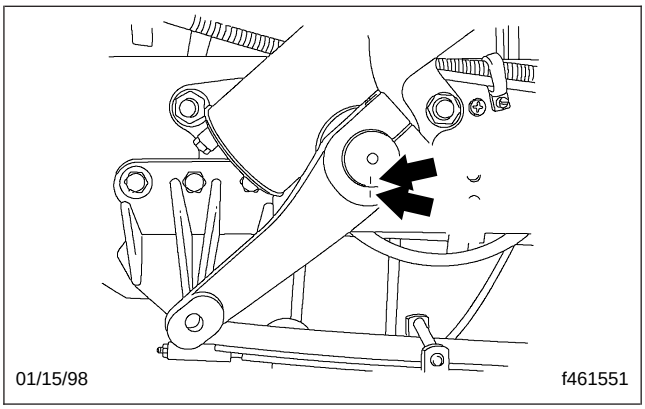


Fig. 5, Align the Index Marks

2. Using a new nut and bolt, install the pitman arm on the steering gear. Tighten the nut to the appropriate torque spec:
    - 5/8–18: 130 to 155 lbf·ft (177 to 211 N·m)
    - 3/4–16: 200 to 230 lbf·ft (272 to 313 N·m)
3. Attach the drag link to the pitman arm. Tighten the nut to the appropriate torque spec:
    - 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)
4. Install a new cotter pin. Advance to the next castlellation, if necessary, to install the cotter pin.
5. Close the hood.
6. Remove the chocks from the tires.

Spindle/Upper Steering Arm Removal and Installation

Removal

1. Raise and support the vehicle. Refer to **Group 00** in this manual for instructions.
2. Remove the cotter pin and castle nut from the drag link. Discard the cotter pin. See **Fig. 1**.

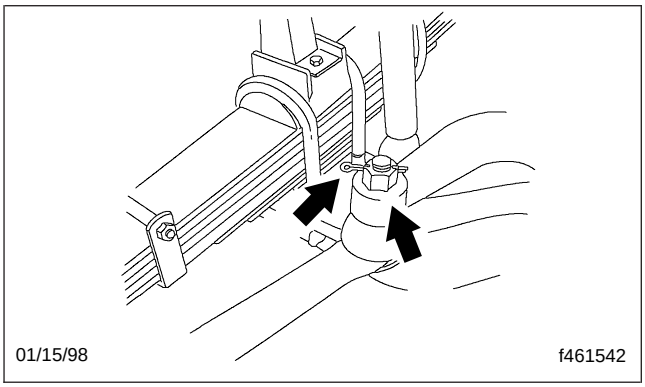


Fig. 1, Remove the Cotter Pin and Nut

3. Remove the brake camshaft. Refer to **Group 42**.
4. Remove the brake air chamber. Refer to **Group 42**.
5. Remove the bolts. See **Fig. 2**.

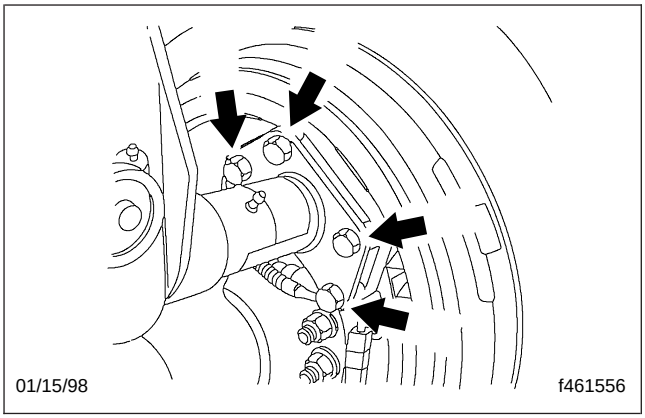


Fig. 2, Remove the Bolts

6. Remove the cotter pin and castle nut from the steering arm. Discard the cotter pin. See **Fig. 3**.
7. Drive the steering arm out of the spindle.

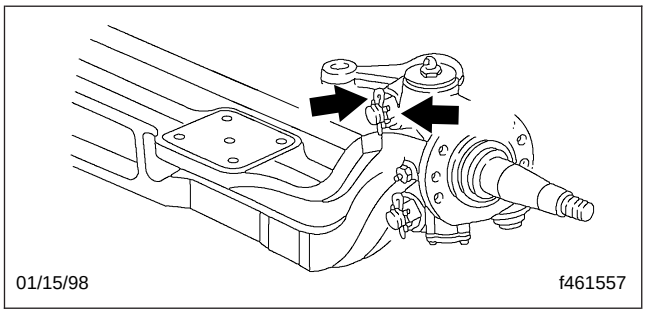


Fig. 3, Remove and Discard the Cotter Pin

Installation

NOTE: The spindle hole is slotted to align the arm with a key.

1. Install a new arm in the spindle.
   - 1.1 Insert the key in the slot from the nut side of the spindle.
   - 1.2 Be sure the key is flush with the slot face of the spindle. See **Fig. 4**.

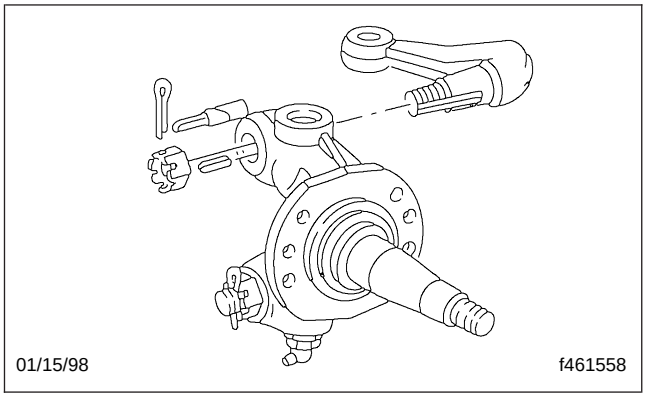
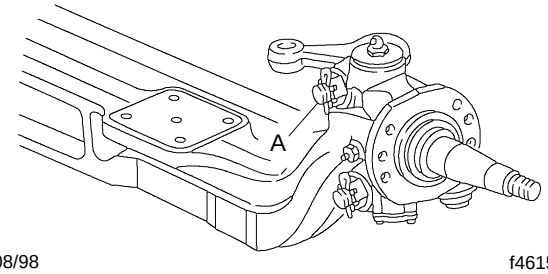


Fig. 4, Align the Key With the Slot Face

2. Install the nut. For 9,000-lb front axles, tighten the nut 360 to 480 lbf·ft (489 to 650 N·m). For 10,000- to 20,000-lb front axles, tighten the nut 540 to 730 lbf·ft (733 to 989 N·m). Advance to the next castellation, if necessary, to install the cotter pin. See **Fig. 5**.
3. Install a new cotter pin. Advance to the next castellation, if necessary, to install the cotter pin.
4. Install the bolts. Tighten the bolts 75 to 105 lbf·ft (102 to 142 N·m). See **Fig. 6**.

Spindle/Upper Steering Arm Removal and Installation



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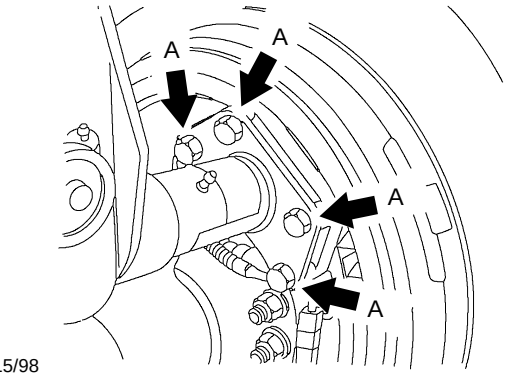
A. On 9,000-lb Front Axles, tighten 360 to 480 lbf·ft (489 to 650 N·m). On 10,000- to 20,000-lb Front Axles, tighten 540 to 730 lbf·ft (733 to 989 N·m).

Fig. 5, Install the Nut



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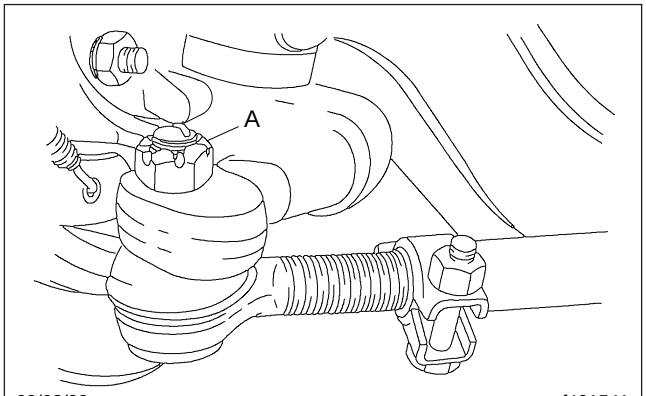
A. Tighten 75 to 105 lbf·ft (102 to 142 N·m).

Fig. 6, Install the Bolts

5. Install the brake air chamber. Refer to **Group 42** in this manual for instructions.
6. Install the brake camshaft. Refer to **Group 42**.
7. Install the drag link to the steering arm. For 9,000-lb front axles, tighten the nut 75 to 105 lbf·ft (102 to 142 N·m). For 10,000- to 20,000-lb front axles, tighten the nut 110 to 150 lbf·ft (149 to 203 N·m). See **Fig. 7**.
8. Install a new cotter pin. Advance to the next castellation, if necessary, to install the cotter pin.
9. Lower the vehicle. Refer to **Group 00** in this manual for instructions.
10. Check vehicle alignment. Refer to **Group 32** in this manual for instructions.



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A. On 9,000-lb Front Axles, tighten 75 to 105 lbf·ft (102 to 142 N·m). On 10,000- to 20,000-lb Front Axles, tighten 110 to 150 lbf·ft (149 to 203 N·m).

Fig. 7, Install the Nut and a New Cotter Pin

Spindle/Lower Steering Arm Removal and Installation

Removal

1. Raise and support the vehicle. Refer to **Group 00** in this manual for instructions.
2. Remove the cotter pin and nut from the tie rod end. Discard the cotter pin. See **Fig. 1**.

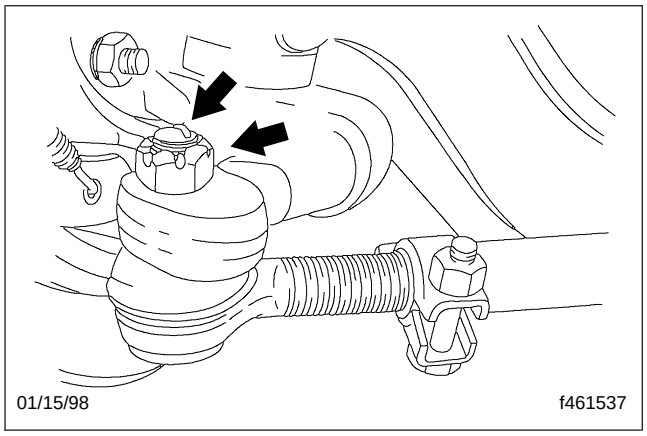


Fig. 1, Remove the Cotter Pin and Nut

3. Using the pitman arm puller, remove the tie rod end ball stud from the steering arm. See **Fig. 2**.

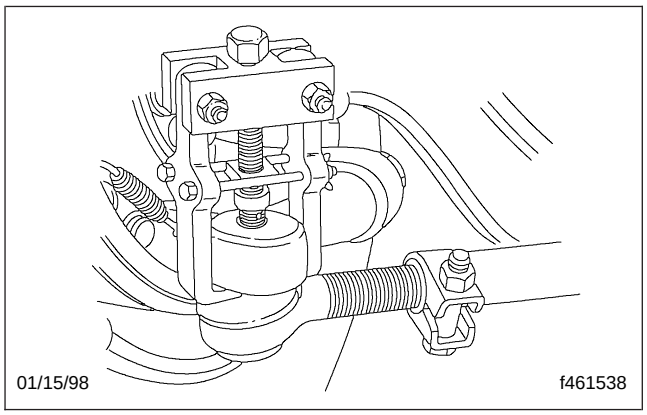


Fig. 2, Remove the Tie Rod End Ball Stud

4. Remove the cotter pin and nut from the steering arm. Discard the cotter pin. See **Fig. 3**.

⚠ CAUTION

Do not use a steel hammer to drive arm out of the spindle. Damage to the arm or threads can result. A brass hammer is recommended for removal.

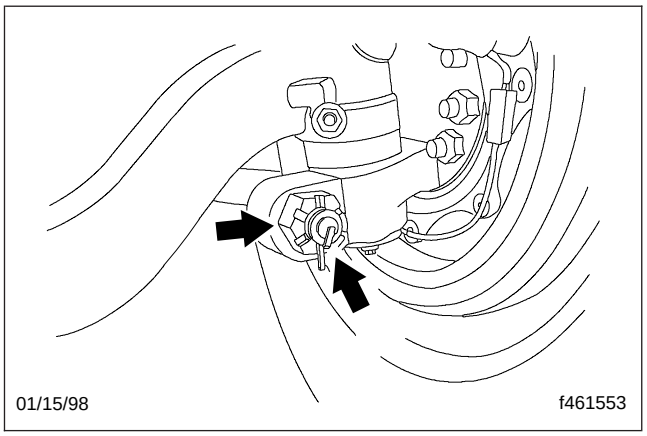


Fig. 3, Remove the Cotter Pin and Nut

5. Drive the arm out of the spindle.

Installation

NOTE: The spindle hole is slotted to align the arm with a key.

1. Install a new arm in the spindle.
   - 1.1 Insert the key in the slot from the nut side of the spindle.
   - 1.2 Be sure the key is flush with the slot face of the spindle. See **Fig. 4**.

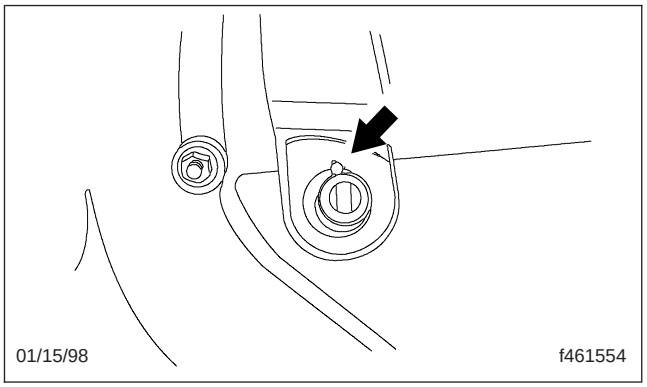
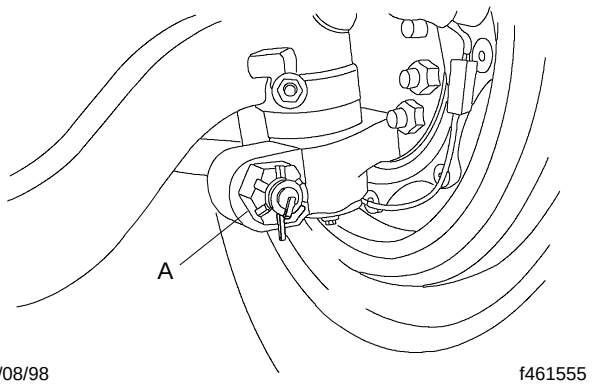


Fig. 4, Check the Key Position

2. Install the nut. For 9,000-lb front axles, tighten the nut 360 to 480 lbf·ft (489 to 650 N·m). For 14,600- to 20,000-lb axles, tighten the nut 540 to 730 lbf·ft (733 to 989 N·m). See **Fig. 5**.
3. Install a new cotter pin. Advance to the next castellation, if necessary, to install the cotter pin.

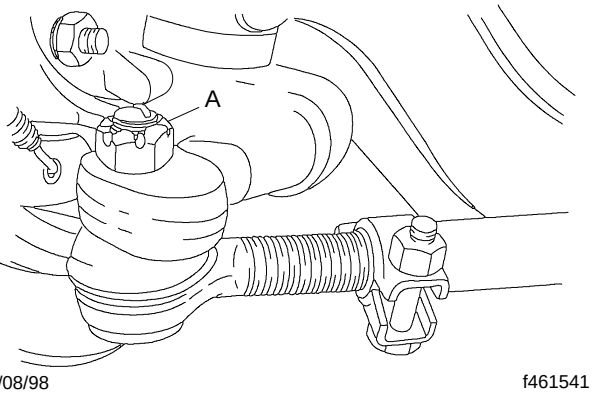
Spindle/Lower Steering Arm Removal and Installation



A. On 9,000-lb Front Axles, tighten 360 to 480 lbf·ft (489 to 650 N·m). On 14,600- to 20,000-lb Front Axles, tighten 540 to 730 lbf·ft (733 to 989 N·m).

Fig. 5, Install the Nut

4. Install the tie rod end to the steering arm. For 9,000-lb front axles, tighten the nut 75 to 105 lbf·ft (102 to 142 N·m). For 10,000- to 20,000-lb front axles, tighten the nut 110 to 150 lbf·ft (149 to 203 N·m). See **Fig. 6**.



A. On 9,000-lb Front Axles, tighten 75 to 105 lbf·ft (102 to 142 N·m). On 10,000- to 20,000-lb Front Axles, tighten 110 to 150 lbf·ft (149 to 203 N·m).

Fig. 6, Install the Nut

5. Install a new cotter pin. Advance to the next castellation, if necessary, to install the cotter pin.
6. Lower the vehicle. Refer to **Group 00** in this manual for instructions.
7. Check vehicle alignment. Refer to **Group 32** in this manual for instructions.

Specifications

Torque Specifications		
Description	**Bolt Size**	**lbf·ft (N·m)**
Drag Link Ball Stud to Pitman Arm Retaining Nut	3/4–16 7/8–14	90–170 (122–230) 160–300 (217–407)
Tie Rod End to Steering Arm Retaining Nut, 9000-lb Front Axles	—	75–105 (102–42)
Tie Rod End to Steering Arm Retaining Nut, 10,000- to 20,000-lb Front Axles	—	110–150 (149–203)
Drag Link Ball Stud to Upper Steering Arm Retaining Nut	—	110–150 (149–203)
Tie Rod End Clamp Bolt	—	50–70 (68–95)
Pitman Arm Pinch Bolt Retaining Nut	5/8–18 3/4–16	130–155 (177–211) 200–130 (272–313)
Steering Arm to Spindle Retaining Nut, 9000- to 13,000-lb Front Axles	—	360–480 (489–650)
Steering Arm to Spindle Retaining Nut, 14,600- to 20,000-lb Front Axles	—	540–730 (733–989)
Brake Camshaft Bracket Retaining Bolt	—	75–105 (102–142)

Table 1, Torque Specifications

System Flushing

To perform system flushing, follow the instructions provided with the Power Steering Analyzer.

System Bleeding

1. If bubbles are visible in the power steering fluid, bleed air from the system.
2. Check the power steering reservoir fluid level and add fluid if necessary.

⚠ CAUTION

Do not hold the steering wheel in the far-left or far-right position for more than five seconds. Doing so causes high steering system temperatures and can cause damage to components.

3. Run the engine until the fluid reaches normal operating temperature.
4. Turn the steering wheel all the way to the left and right several times and return to center.
5. Recheck the fluid level and add Motorcraft Mercon® ATF XT–2–QDX or Mercon® equivalent, if necessary.

Final Fill

NOTE: The fluid level must show between the ADD and FULL markings on the dipstick. If the fluid is below the ADD mark, add Motorcraft Mercon® ATF XT–2–QDX or Mercon® equivalent.

NOTE: After any major power steering system or component overhaul, the system must be purged of old fluid and the oil filter discarded, and new fluid and a new filter installed.

1. Check the fluid level in the power steering reservoir with the engine off. Use the HOT or COLD markings on the dipstick, depending upon the fluid temperature.
   - 1.1 Use COLD for checking at room temperature, 70°F (20°C).
   - 1.2 Use HOT for normal operating temperatures, 175° F (80°C).

IMPORTANT: Do not turn the steering wheel during the initial fill procedure. Place the front wheels in a straight-ahead position and engage the parking brake.

2. Fill the reservoir with fluid and allow the fluid to gravity feed the system.
   - 2.1 Crack the pressure line fittings at the pump and steering gear.
   - 2.2 Tighten the fittings when fluid is visible.
   - 2.3 Keep adding fluid to the reservoir as required.
3. When the fluid level in the reservoir no longer goes down, start the engine. Continue to add fluid to the reservoir as required. Do not exceed the FULL mark.
4. After the fluid level in the reservoir no longer goes down, rotate the steering wheel to full-right and full-left turns, stop to stop. Add fluid as required.
5. Continue the process until the fluid level no longer changes. Fluid level is correct when it is in the FULL range on the dipstick.
6. Place the front wheels in a straight-ahead position and engage the parking brake.

NOTE: Whenever a minor leak is corrected, follow the next four steps.

7. Fill the reservoir to the FULL mark on the dipstick.
   - 7.1 Start the engine and let idle for several minutes.
   - 7.2 Check fluid level and add as required.
8. Rotate the steering wheel to full-right and full-left turns, stop to stop, several times.
9. Stop the engine and check fluid level. Fill the reservoir to FULL range indicated on the dipstick.

Specifications

Approved Power Steering Fluid	
Item	**Specification**
Motorcraft Mercon® ATF XT–2–QDX	Mercon®

Table 1, Approved Power Steering Fluid

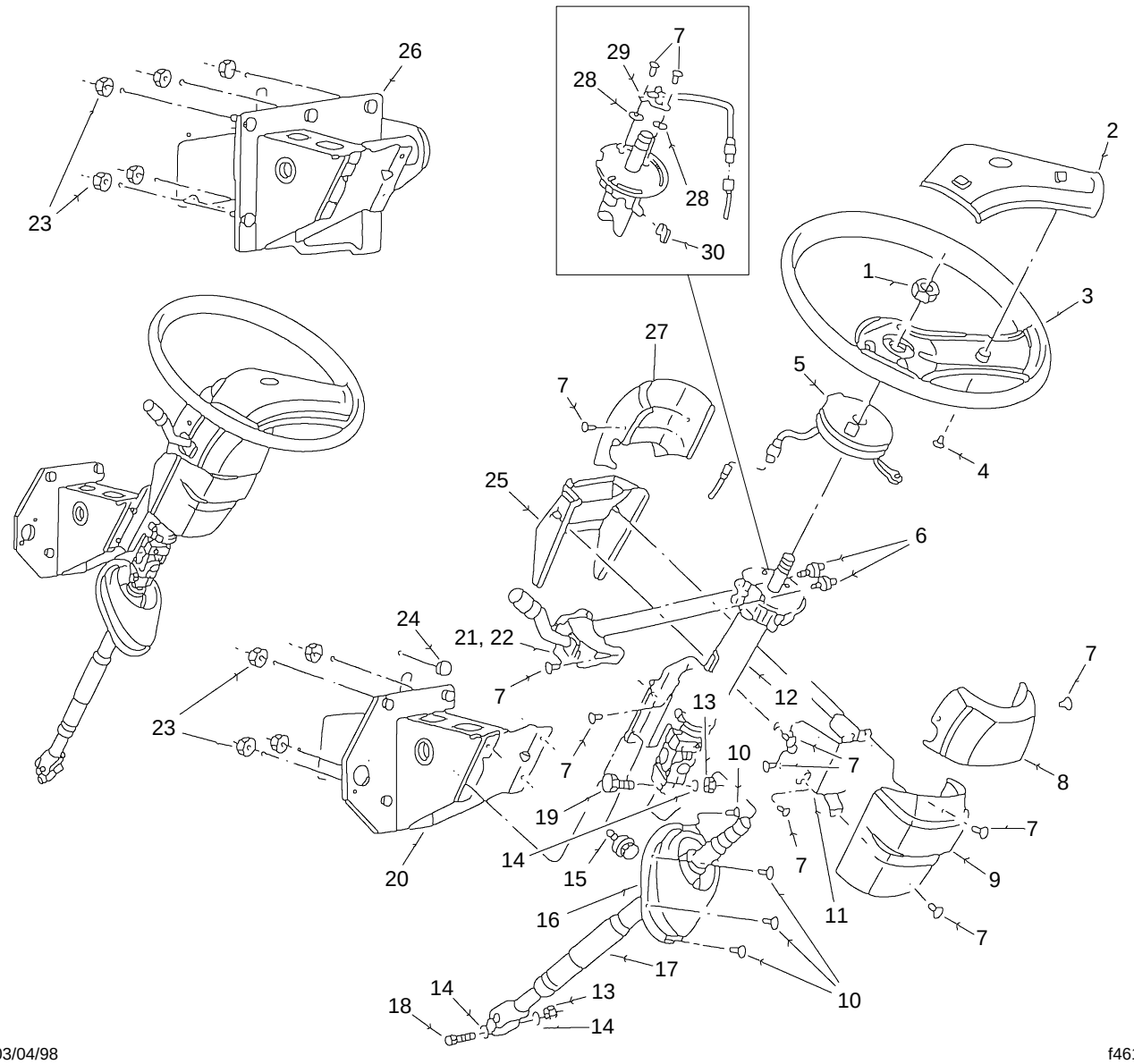
Torque Specifications	
Component	**lbf·ft (N·m)**
Gear/Assist Cylinder Port Adaptor	36 (48)
Stop Bolt Jam Nuts	51–71 (68–95)
Pressure Relief Valve Plug	26–36 (34–48)
Sector Shaft Adjusting Screw Jam Nut	43 (58)

Table 2, Torque Specifications

General Information

L-Line and A-Line vehicles can be equipped with one of three types of steering column assemblies. The fixed column (see **Fig. 1**) is standard equipment. The tilt (**Fig. 2**) and tilt/telescopic (**Fig. 3**) steering columns are optional.

General Information



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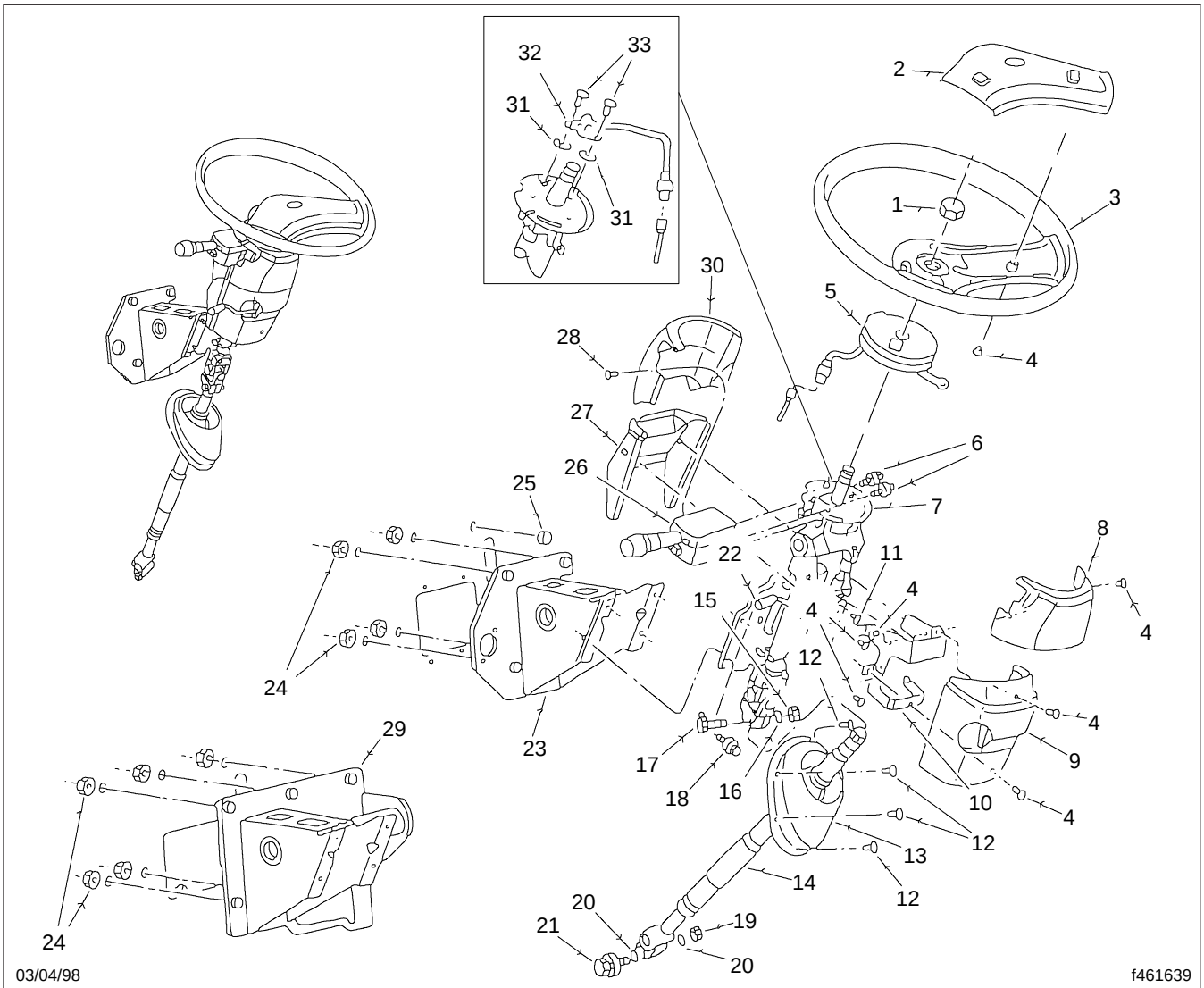
1. Steering Wheel Nut
2. Horn Pad
3. Steering Wheel
4. Screw
5. Clockspring
6. Screw
7. Screw
8. Shroud (upper front)
9. Shroud (lower front)
10. Screw
11. Shroud Bracket (front and back)
12. Steering Column
13. Nut
14. Washer
15. Screw and Washer
16. Steering Column Floor Seal
17. Steering Column Coupling Shaft
18. Bolt
19. Bolt and Retainer
20. Steering Column Support Bracket (automatic transmission)
21. Turn Signal Switch Assembly (with Signal-Stat turn signal)
22. Turn Signal Switch Assembly (with windshield wiper)
23. Nut
24. Button Plug
25. Shroud (lower front)
26. Steering Column Support Bracket (manual transmission)
27. Shroud (upper back)
28. Washer
29. Horn Brush Assembly
30. U-Nut

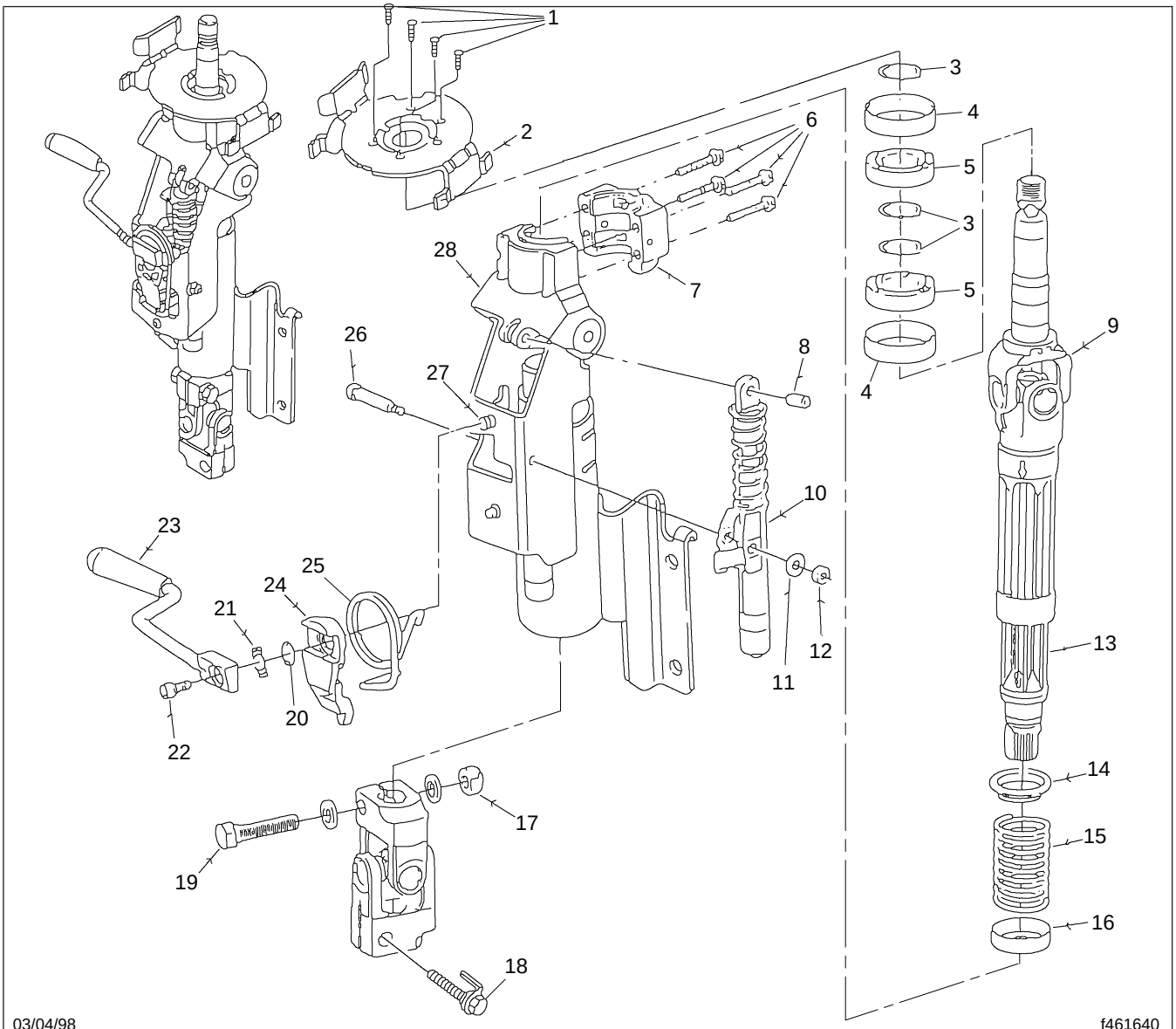
Fig. 1, Fixed Steering Column



1. Steering Wheel Nut
2. Horn Pad
3. Steering Wheel
4. Screw
5. Clockspring
6. Screw
7. Steering Column
8. Shroud (upper front)
9. Shroud (lower front)
10. Shroud Bracket (lower front and back)
11. Screw
12. Screw
13. Steering Column Floor Seal
14. Steering Column Coupling Shaft
15. Nut
16. Washer
17. Bolt and Retainer
18. Screw and Washer
19. Nut
20. Washer
21. Bolt
22. Tilt Lock Actuator Lever
23. Steering Column Support Bracket (automatic transmission)
24. Nut
25. Button Plug
26. Turn Signal Switch Assembly
27. Steering Column Shroud (lower front)
28. Screw
29. Steering Column Support Bracket (manual transmission)
30. Steering Column Shroud (upper back)
31. Washer
32. Horn Brush Assembly
33. Screw

Fig. 2, Tilt Steering Column

General Information



1. Screws
2. Clockspring Adapter Plate
3. Retaining Ring (4)
4. Bearing Gasket
5. Bearing
6. Bolts (4)
7. Bearing Cap
8. Tilt Pivot Pin
9. Upper Rotating Tube
10. Tilt Lock Mechanism
11. Washer
12. Prevailing Torque Lock Nut
13. Lower Rotating Tube
14. Bushing
15. Telescope Spring
16. Dust Cover
17. U-Joint Nut
18. Bolt and Retainer
19. Bolt
20. Retaining Ring
21. Winged O-Ring
22. Socket Head Capscrew
23. Actuator Handle
24. Actuator Cam
25. Torsion Spring
26. Shoulder Screw
27. Actuator Pivot Pin
28. Tilt/Telescope Column

Fig. 3, Tilt/Telescopic Steering Column

Steering Wheel Removal and Installation

Removal

1. Make sure that the vehicle road wheels are in the straight-ahead position. Mark the steering wheel and column with a grease pencil for alignment reference.
2. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
3. Disconnect the battery ground cable(s).
4. Remove two horn pad retaining screws. See **Fig. 1**.

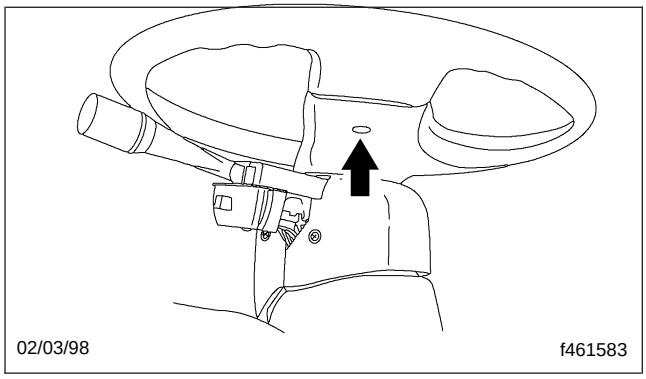


Fig. 1, Horn Pad Retaining Screw

5. Tilt the horn pad upward and disconnect the horn pad/speed control connector (if so equipped). See **Fig. 2**.

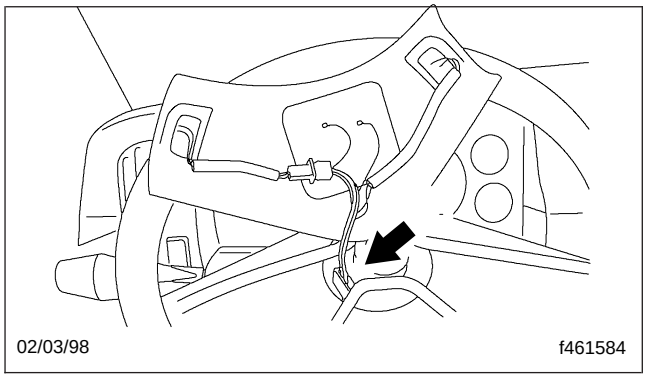


Fig. 2, Horn Pad/Speed Control Connector

6. Remove the steering wheel retaining nut. See **Fig. 3**.
7. Install the steering wheel puller and remove the steering wheel. See **Fig. 4**.

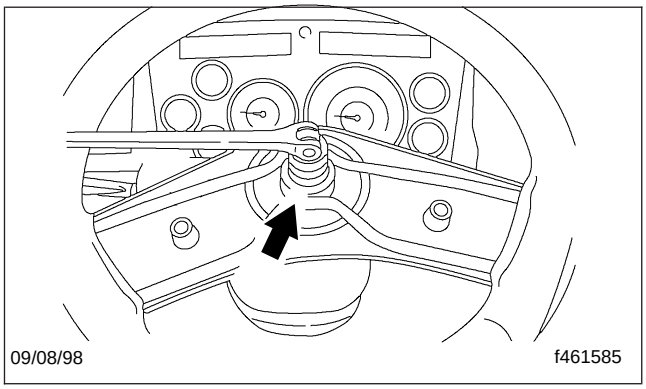


Fig. 3, Remove the Steering Wheel Retaining Nut

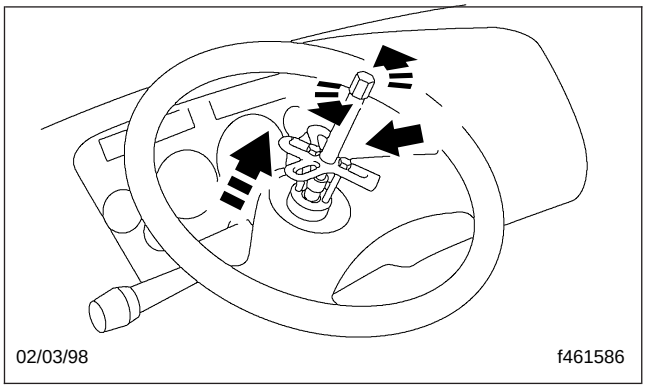
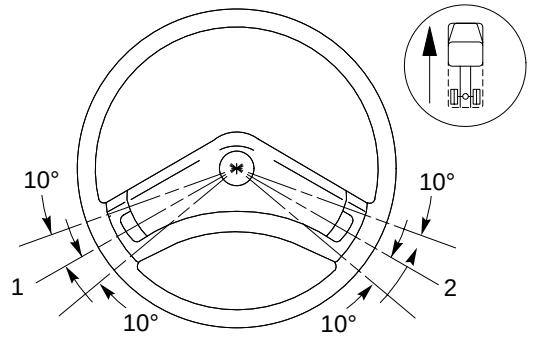


Fig. 4, Install the Steering Wheel Puller

Installation

1. Remove the steering wheel puller and replace the steering wheel.
2. 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. See **Fig. 5**. If not, remove the steering wheel and install it in the correct position.
3. Tighten the steering wheel nut 45 to 65 lbf·ft (61 to 88 N·m). See **Fig. 6**.
4. Apply torque seal OGP F900WHITE to the exposed thread and to the locknut.
5. Connect the horn pad/speed control connector (if so equipped).
6. Install two horn pad retaining screws.
7. Connect the battery ground cable(s).

Steering Wheel Removal and Installation



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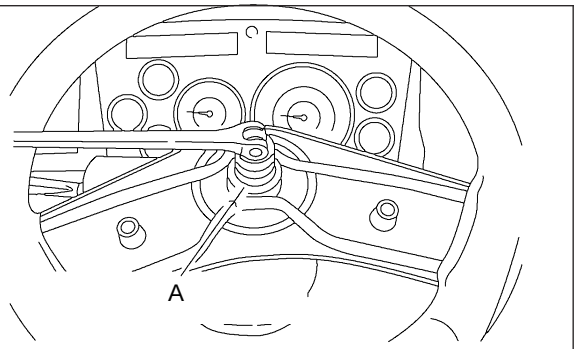
1. 8 o'Clock 2. 4 o'Clock

Fig. 5, Steering Wheel Centered



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A. Tighten 45 to 65 lbf·ft (61 to 88 N·m).

Fig. 6, Tighten the Steering Wheel Nut

8. Remove the chocks from the rear tires.
9. Test drive the vehicle, or take a ride with the driver.

Steering Column Removal and Installation

Removal

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service work will be done. Do not move the tires from the straight-ahead position during removal or at any time while the steering column is removed.
2. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
3. Disconnect the batteries at the negative terminals or at the battery shutoff switch.
4. Remove the steering wheel. For instructions, see **Subject 100**.
5. Remove the clockspring. For instructions, see **Subject 130**.
6. Remove the under steering panel. For instructions, see **Section 60.01**.
7. Remove the SmartShift™ transmission shift control, if equipped. For instructions, see **Section 26.12**.
8. Disconnect the multifunction switch electrical connectors. See **Fig. 1**.
9. Remove the screws that secure the multifunction switch, then remove the switch. See **Fig. 2**.

NOTE: Before disconnecting the steering driveline from the steering column yoke, mark the steering driveline so that it can be installed in the same orientation it was in when removed.

10. Mark the steering driveline/steering column yoke orientation. Remove and discard the steering column pinch bolt and nut. Slide the steering driveline out of the way. See **Fig. 3**.
11. Remove the four bolts that attach the steering column to the support bracket. See **Fig. 4**.
12. Remove the steering column.

Installation

1. Position the steering column on the steering column mounting bracket.
2. Install the four bolts that attach the steering column to the support bracket. Tighten the bolts 32 to 41 lbf·ft (43 to 55 N·m).

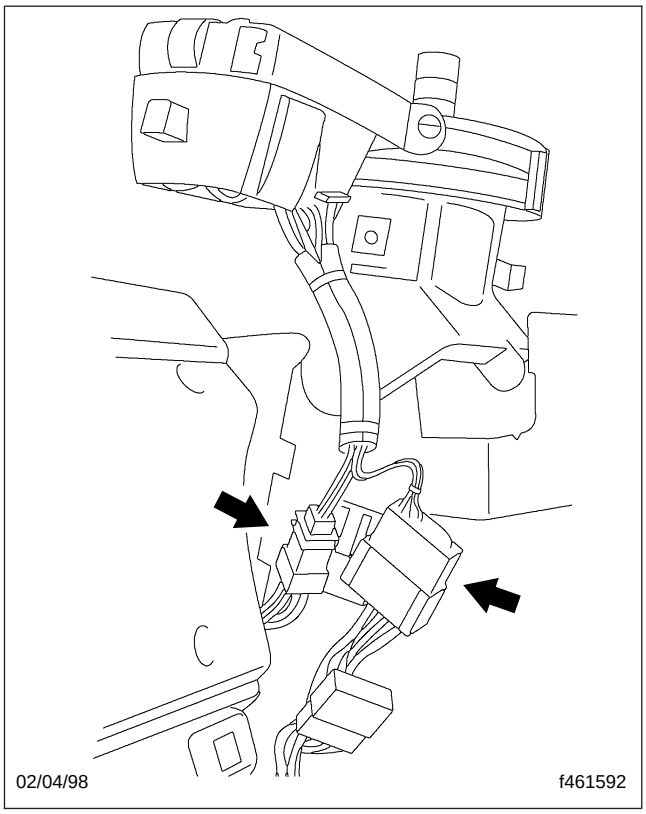
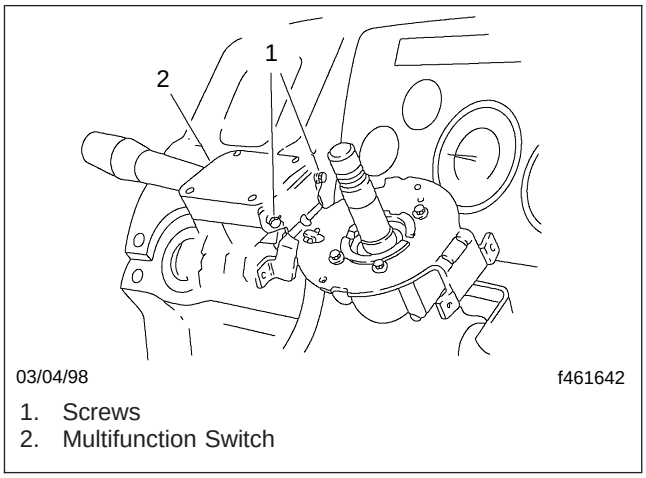


Fig. 1, Multifunction Switch Electrical Connectors



1. Screws
2. Multifunction Switch

Fig. 2, Remove the Multifunction Switch

NOTE: The steering column yoke must be installed in the same orientation it was in when removed.

Steering Column Removal and Installation

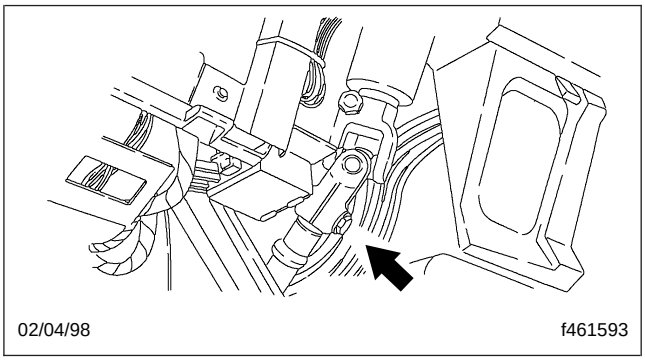


Fig. 3, Steering Column Yoke Pinch Bolt

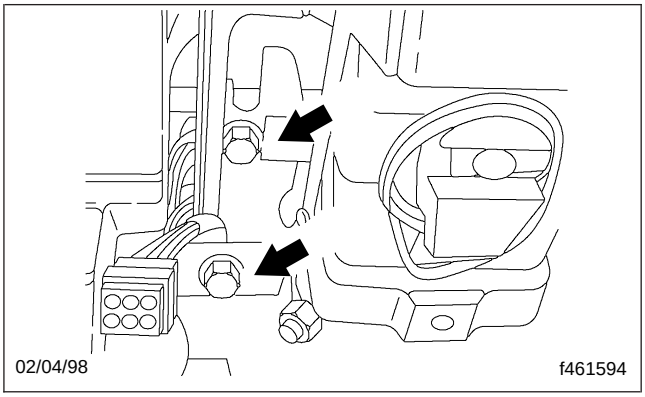


Fig. 4, Support Bracket Bolts

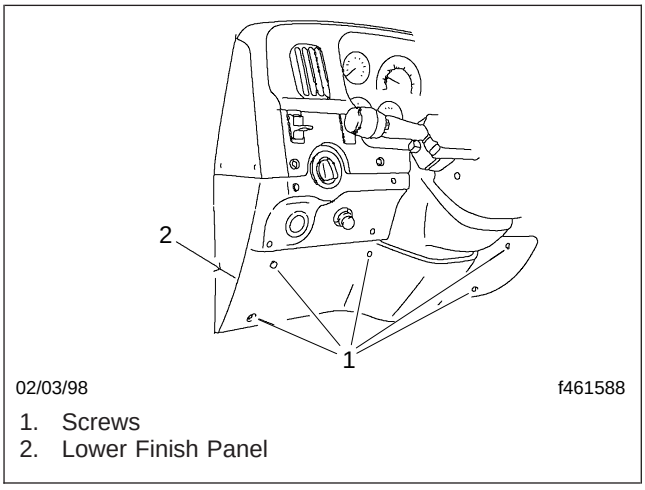
3. Slide the upper end of the steering driveline into the steering column yoke. Install the new pinch bolt. Before installing the nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a new nut and tighten the nut to one of the following torque specs:
   - 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16–20 pinch bolt and nut
   - 30 to 35 lbf·ft (41 to 47 N·m) for an M10 x 1.25 pinch bolt and nut
4. Apply torque seal, OGP F900WHITE, to the exposed bolt thread and to the nut.
5. Install the multifunction switch.
6. Connect the multifunction switch electrical connectors.
7. Install the SmartShift™ transmission shift control, if equipped. For instructions, see **Section 26.12**.
8. Install the under steering panel. For instructions, see **Section 60.01**.
9. Install the clockspring. For instructions, see **Subject 130**.
10. Install the steering wheel. For instructions, see **Subject 100**.
11. Check the position of the steering wheel when the front tires are pointing forward. The steering wheel should be within ±10 degrees of center.
12. Connect the batteries.
13. Remove the chocks from the tires.

U-Joint Removal and Installation

Removal

NOTE: Make sure the front wheels are in the straight-ahead position.

1. Remove the instrument panel lower finish panel. See **Fig. 1**.



1. Screws
2. Lower Finish Panel

Fig. 1, Instrument Panel

1.1 Remove the screws.

1.2 Remove the instrument panel lower finish panel.

NOTE: Before removing the U-joint, mark it in a manner that will allow it to be installed in the same orientation as when removed. The short yoke must be installed on the output shaft of the column.

2. Mark the U-joint/shaft orientation. Remove the coupling shaft-to-steering column pinch bolt, washer and nut and slide the coupling shaft out of the way. See **Fig. 2**.
3. Mark the U-joint/shaft orientation. Remove the pinch bolt, two washers and nut holding the U-joint in place. See **Fig. 3**.
4. Remove the U-joint, then inspect the U-joint and pinch bolts for damage. Replace if necessary. See **Fig. 4**.

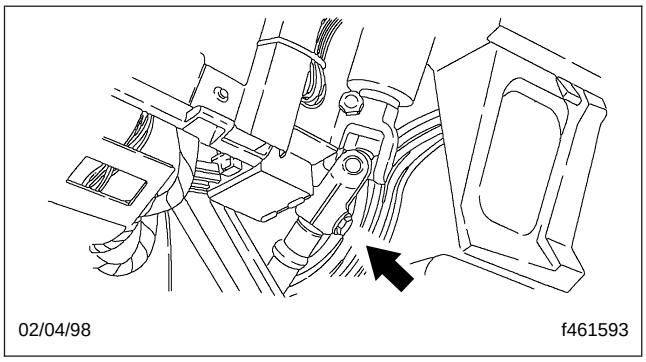


Fig. 2, Coupling Shaft Pinch Bolt

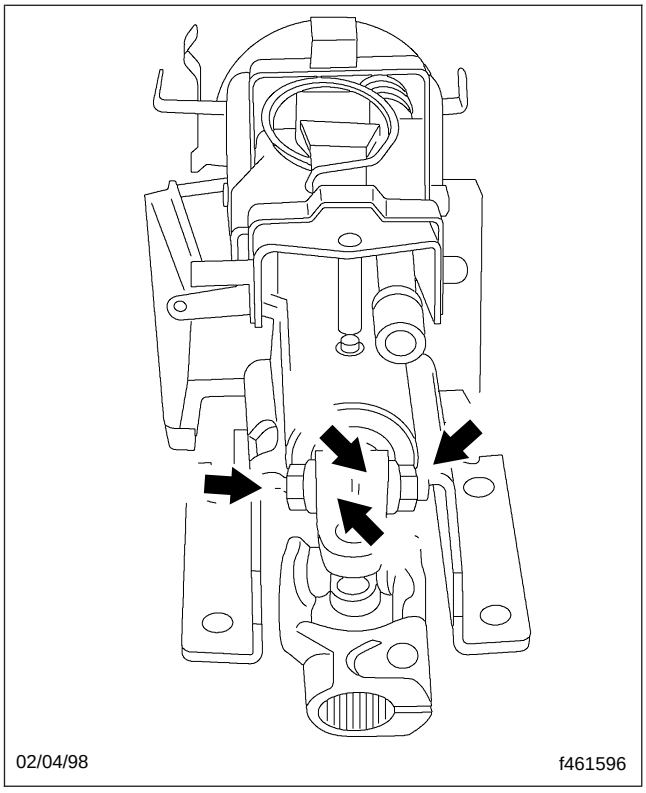


Fig. 3, U-Joint Retaining Points

Installation

NOTE: The U-joint must be installed in the same orientation as when removed. The short yoke must be installed on the output shaft of the column.

1. Position the U-joint and install the pinch bolt, two washers and nut holding the U-joint in place.

U-Joint Removal and Installation

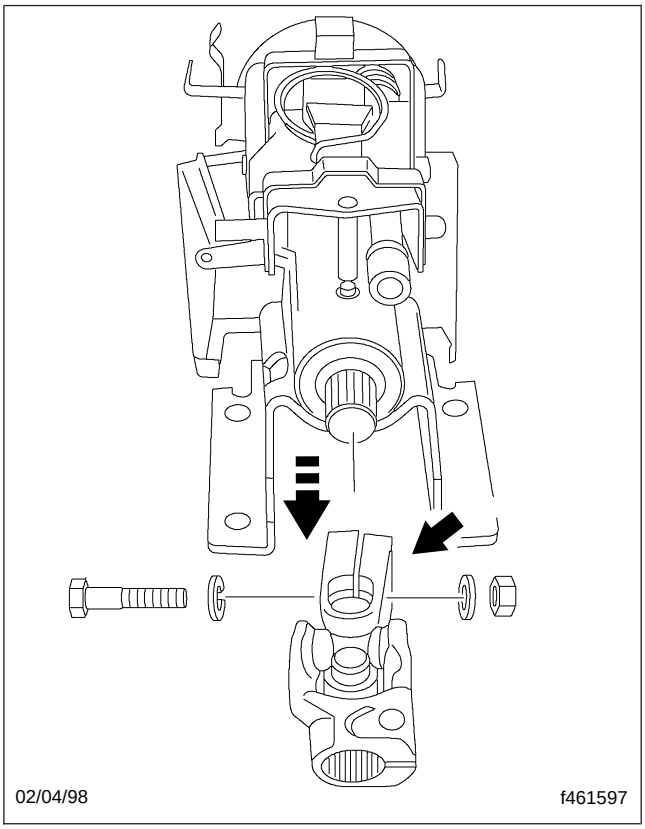
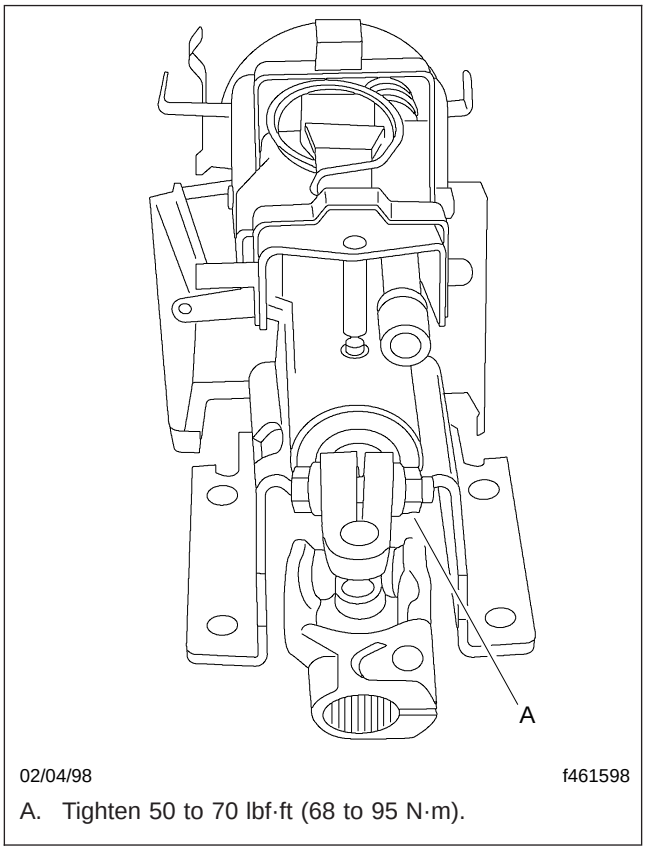


Fig. 4, Remove the U-Joint from the Steering Shaft

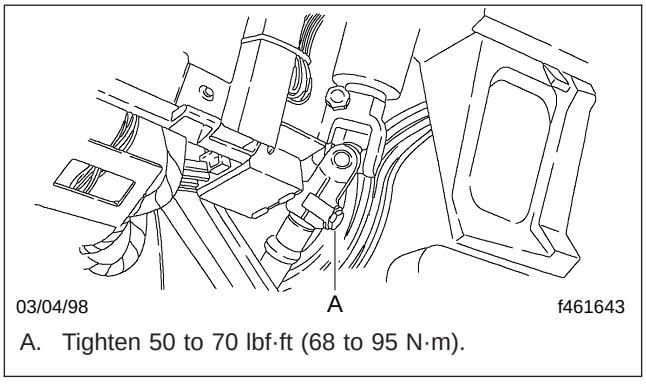
Tighten the nut 50 to 70 lbf·ft (68 to 95 N·m). See **Fig. 5**.

2. Position the coupling shaft and install the coupling shaft-to-steering column pinch bolt, washer and nut. Tighten the nut 50 to 70 lbf·ft (68 to 95 N·m). See **Fig. 6**.
3. Install the instrument panel lower finish panel. See **Fig. 1**.



A. Tighten 50 to 70 lbf·ft (68 to 95 N·m).

Fig. 5, U-Joint Clamp Bolt



A. Tighten 50 to 70 lbf·ft (68 to 95 N·m).

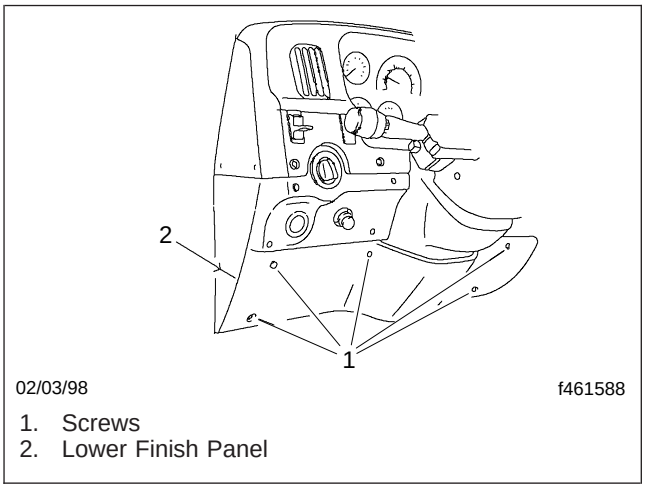
Fig. 6, Tighten the Coupling Shaft Pinch Bolt

Clockspring Removal and Installation

Removal

NOTE: Make sure the front wheels are in the straight-ahead position.

1. Remove the steering wheel; see **Subject 100**.
2. Remove the upper steering column shrouds.
3. Remove the instrument panel lower finish panel. See **Fig. 1**.



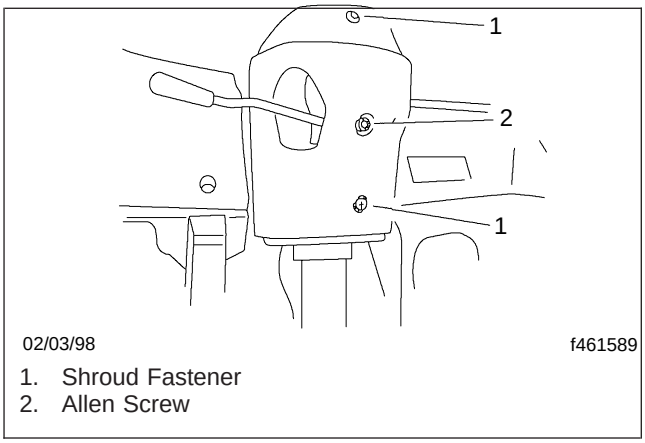
1. Screws
2. Lower Finish Panel

Fig. 1, Instrument Panel

3.1 Remove the screws.

3.2 Remove the instrument panel lower finish panel.

4. Remove the lower shroud. See **Fig. 2**.



1. Shroud Fastener
2. Allen Screw

Fig. 2, Lower Steering Column Cover

4.1 Remove the screws.

4.2 Remove the Allen screw.

5. Disconnect the clockspring electrical connector. See **Fig. 3**.

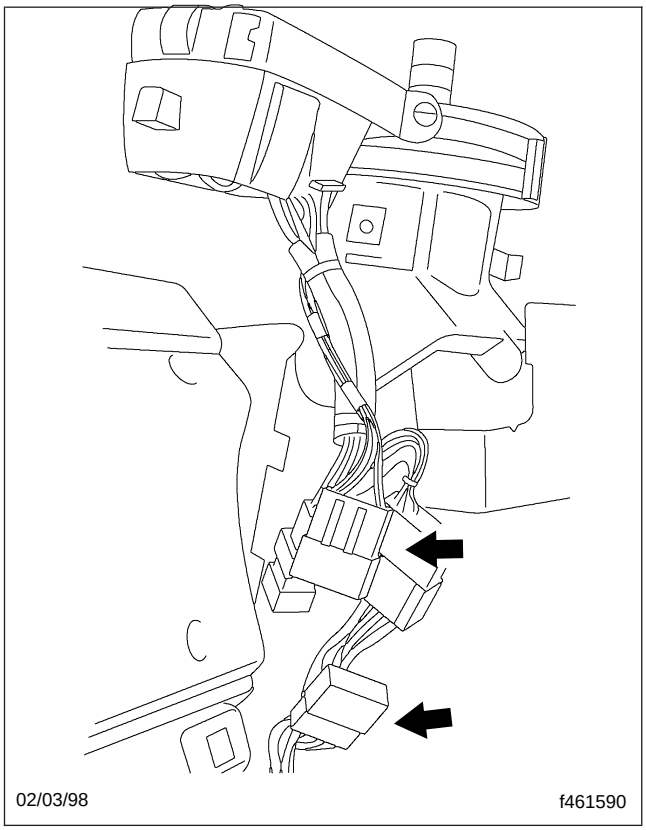


Fig. 3, Clockspring Electrical Connector

NOTE: The clockspring retaining tabs are located at the 12 o'clock, 6 o'clock and the 9 o'clock positions.

6. Depress the three clockspring retaining tabs (located at the bottom of the clockspring adapter plate) while slightly lifting the clockspring off the steering column shaft. See **Fig. 4**.

Installation

NOTE: The clockspring retaining tabs are located at the 12 o'clock, 6 o'clock and the 9 o'clock positions.

Clockspring Removal and Installation

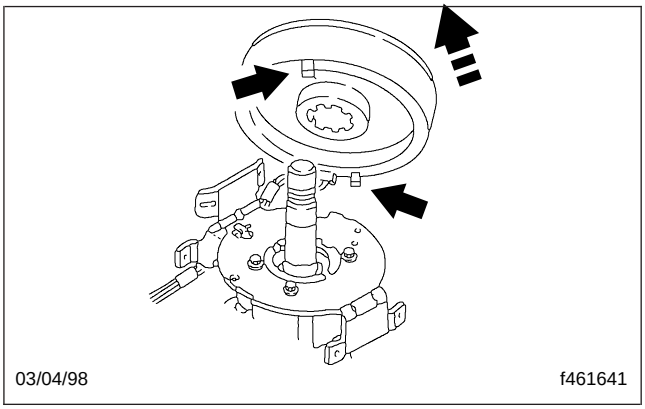
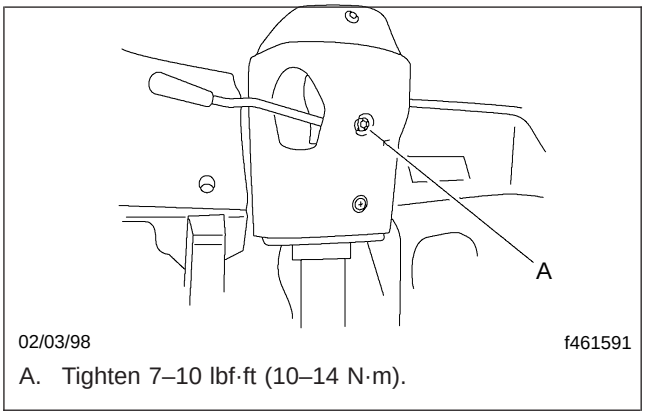


Fig. 4, Clockspring Retaining Tabs

1. Depress the three clockspring retaining tabs (located at the bottom of the clockspring adapter plate) while pushing the clockspring back on the steering column shaft.
2. Connect the clockspring electrical connector.
3. Install the lower shroud.
   - 3.1 Install the Allen screw.

     Tighten the lower shroud Allen screw 7 to 10 lbf·ft (10 to 14 N·m). See **Fig. 5**.



A. Tighten 7–10 lbf·ft (10–14 N·m).

Fig. 5, Tightening the Allen Screw

   - 3.2 Install the screws.
4. Install the instrument panel lower finish panel.
   - 4.1 Position the instrument panel lower finish panel.
   - 4.2 Install the screws.
5. Install the upper steering column shrouds.
6. Install the steering wheel; see **Subject 100**.

Tilt Steering Column Disassembly and Assembly

Disassembly

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Disconnect the battery ground cable(s).
3. Remove the steering wheel. For instructions, see **Subject 100**.
4. Remove the clockspring. For instructions, see **Subject 130**.
5. Remove the steering column. For instructions, see **Subject 110**.
6. Remove the under steering panel brackets.
7. Place the column in a soft-jawed vise, clamping on the mounting bracket flange. See **Fig. 1**.

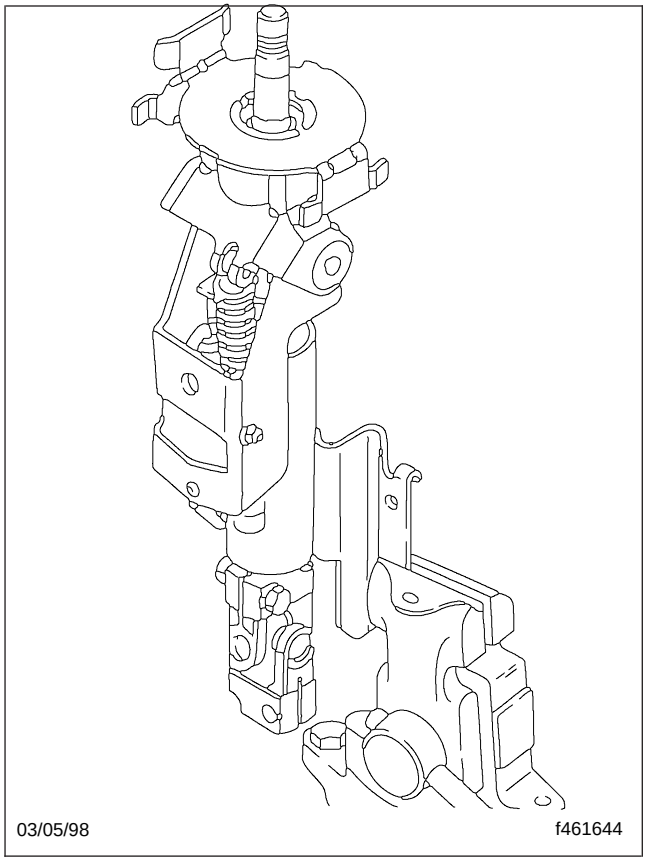


Fig. 1, Soft-Jawed Vise Holding Column

8. Remove the clockspring adaptor plate. See **Fig. 2**.

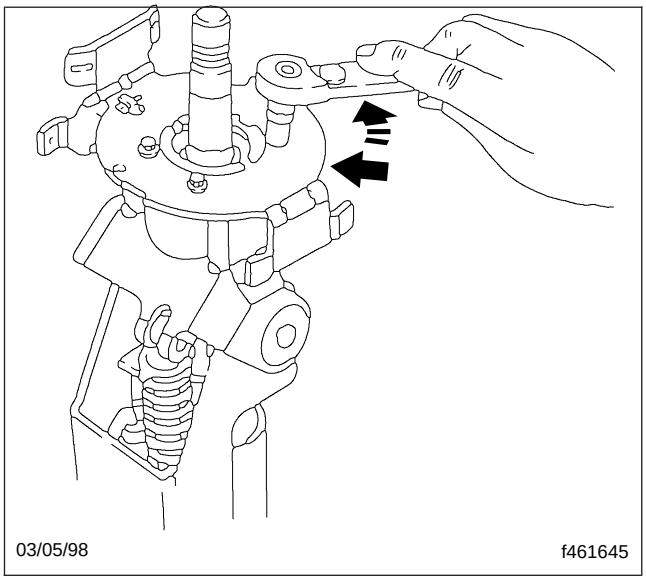


Fig. 2, Clockspring Adaptor Plate

9. Remove four bolts from the steering column and bearing cap. See **Fig. 3**.

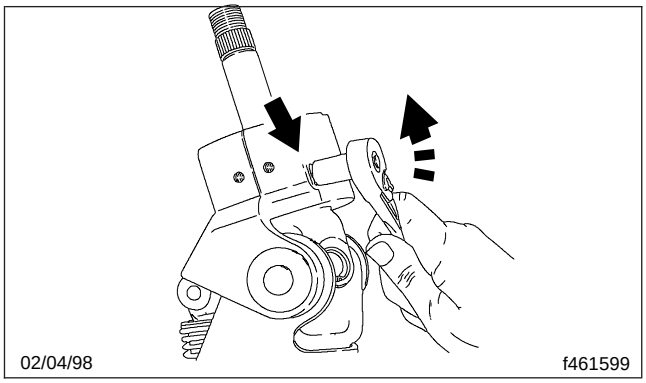


Fig. 3, Remove the Bolts from the Steering Column and Bearing Cap

10. Remove the bearing cap. See **Fig. 4**.

NOTE: Before removing the U-joint, mark it in a manner that will allow it to be reinstalled in the same orientation as when removed. The short yoke must be installed on the output shaft of the column.

11. Mark the U-joint/shaft orientation. Remove the U-joint from the lower end of the rotating shaft. See **Fig. 5**.

Tilt Steering Column Disassembly and Assembly

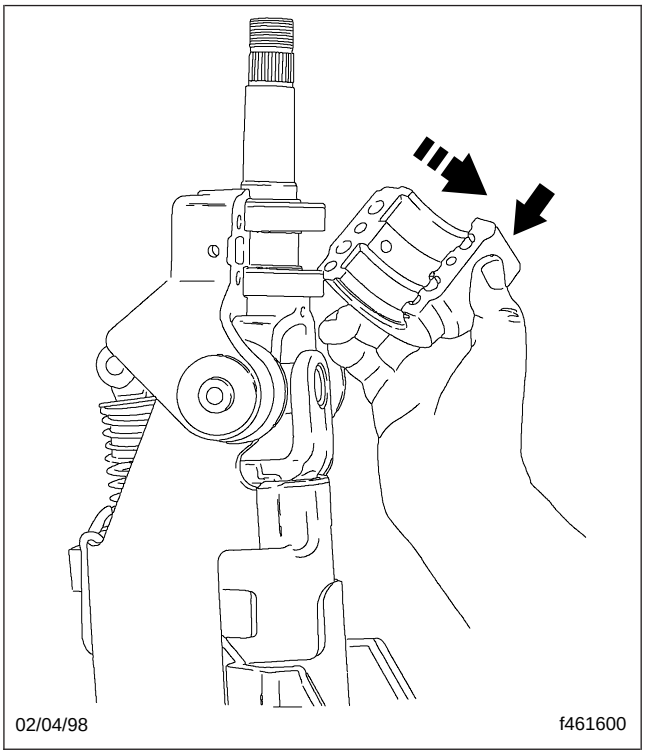


Fig. 4, Remove the Bearing Cap

12. Remove the retaining ring from the lower end of the steering column shaft.
13. Unseat the bearings from their seat in the housing. Tilt the unit rearward, and remove the steering column shaft. Lightly tap with a rubber mallet to start the process, if necessary. See **Fig. 6**.

    13.1 Check for lash in the U-joint. Inspect for twisted or otherwise damaged serrations. If either condition exists, replace the rotating assembly.

    13.2 Inspect the housing thread. Make sure the threads are not stripped. If the housing threads are stripped, the entire unit must be replaced.

    13.3 Remove the bearing gaskets from each bearing and discard.
14. Tilt the steering column forward to relieve spring tension. Remove the socket head capscrew and actuator handle. See **Fig. 7**.
15. Remove the retaining ring, actuator cam and washer.

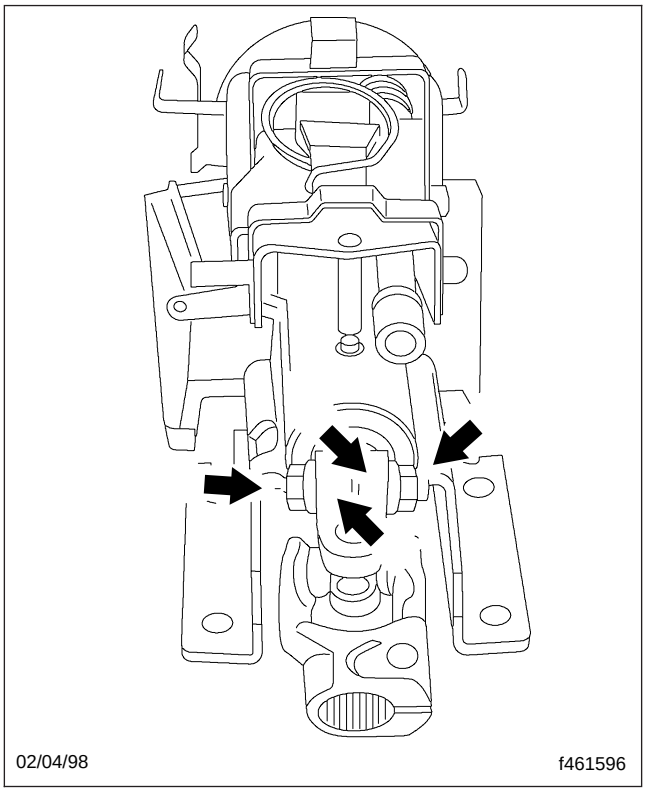


Fig. 5, Mark the U-Joint/Shaft Orientation

Inspect the actuator cam for cracks or breaks. Replace if necessary.

16. Remove the prevailing torque locknut and washer, then use a rubber mallet to lightly tap out the shoulder screw. See **Fig. 8**.

⚠ CAUTION

Handle the tilt lock mechanism carefully. The spring may be loaded.

17. Drive the tilt pivot pin on the other end of the tilt lock mechanism, from the smaller hole toward the larger, with a punch. Remove the tilt lock mechanism. See **Fig. 9**.

    If the tilt function no longer locks, replace the tilt lock mechanism, tilt pivot pin, shoulder screw, washer and locknut.

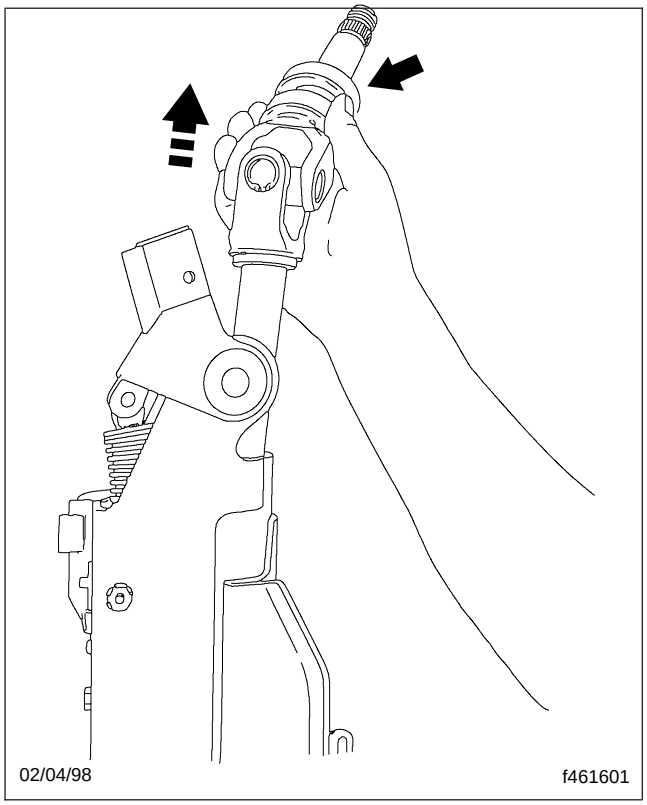


Fig. 6, Remove the Steering Column Shaft

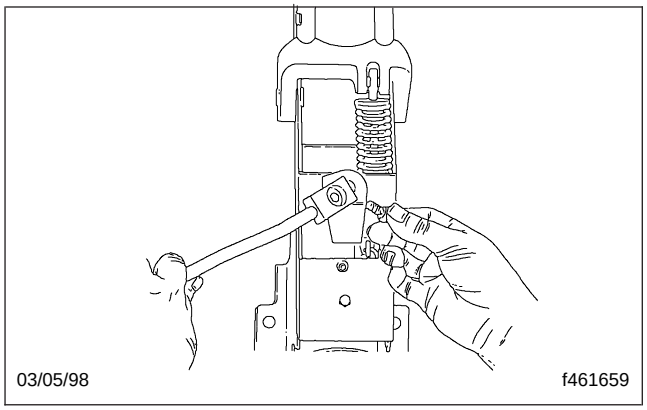


Fig. 7, Actuator Handle

Assembly

1. Position the tilt lock mechanism in the steering column with the spring toward the tilt housing, so the lever is exposed through the window on the steering column.

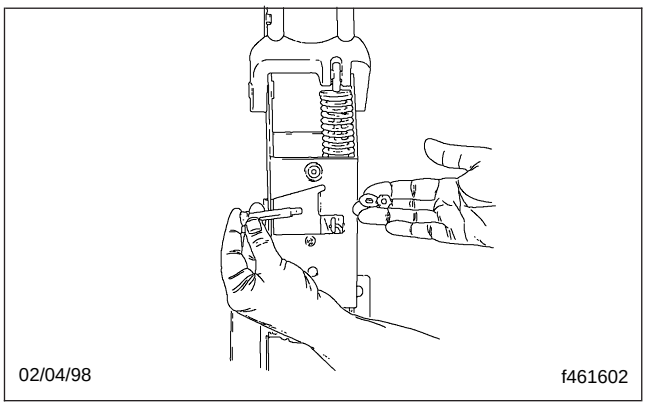


Fig. 8, Remove the Shoulder Screw

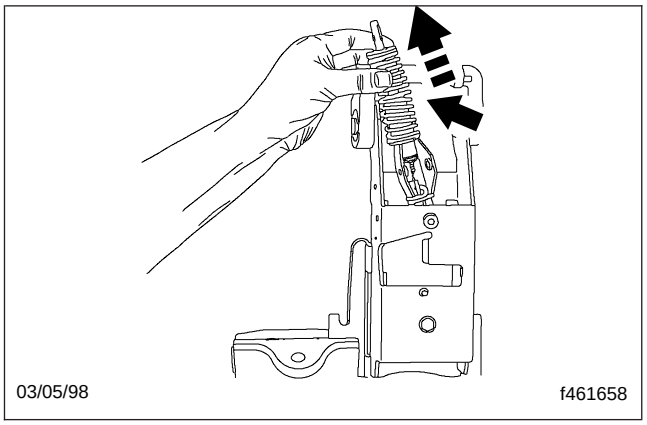


Fig. 9, Tilt Lock Mechanism

2. Align the tilt lock mechanism holes with the hole in the steering column, and replace the shoulder screw with the threads on the outside of the steering column. Replace the washer and the prevailing torque nut. Tighten the nut 72 to 88 lbf·in (813 to 994 N·cm).

⚠ CAUTION

The pin must be fully seated, not just pressed flush with the boss. If the tilt pivot pin is not seated properly, the tilt function can cease to operate.

3. Install the tilt pivot pin through the other end of the tilt mechanism. Carefully line up the tilt pivot pin with the holes, and use a punch to tap the tilt pivot into place until it stops. See **Fig. 10**.
4. Install the actuator cam and washer on the base unit, with the tail end under the bracket and posi-

Tilt Steering Column Disassembly and Assembly

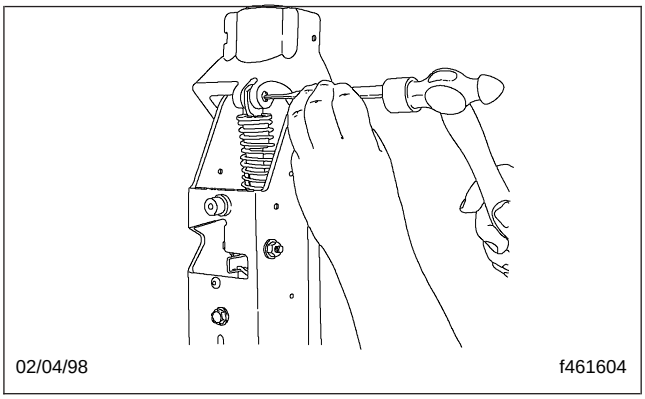


Fig. 10, Tap the Tilt Pivot into Place

tioned between the travel stop and the tilt mechanism lever. See **Fig. 11**.

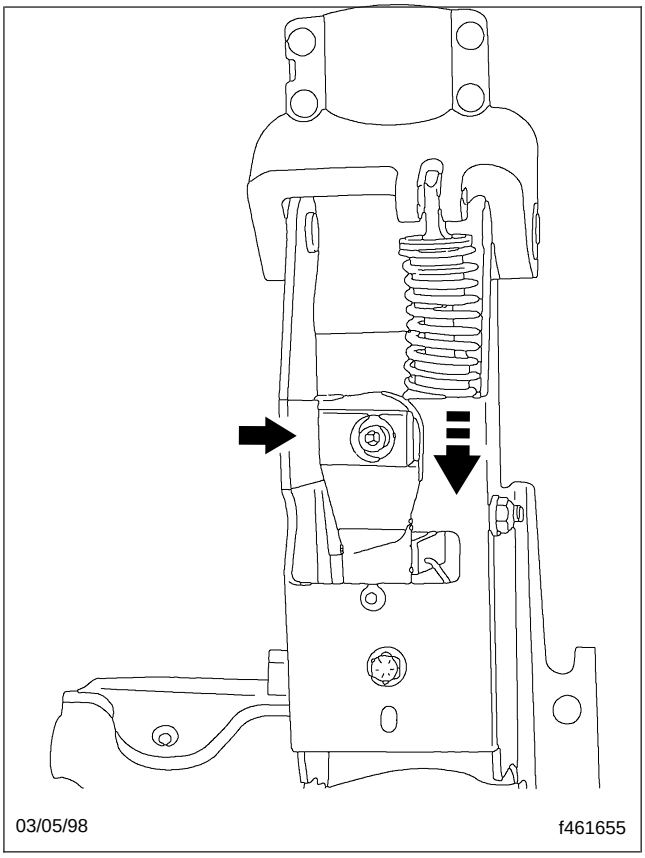


Fig. 11, Actuator Cam and Washer

5. Install the retaining ring, rounded edge toward the actuator cam, making sure it is properly seated in its groove. Install the actuator handle and socket head screw. Tighten to 7 to 10 lbf·ft (10 to 14 N·m). See **Fig. 12**.

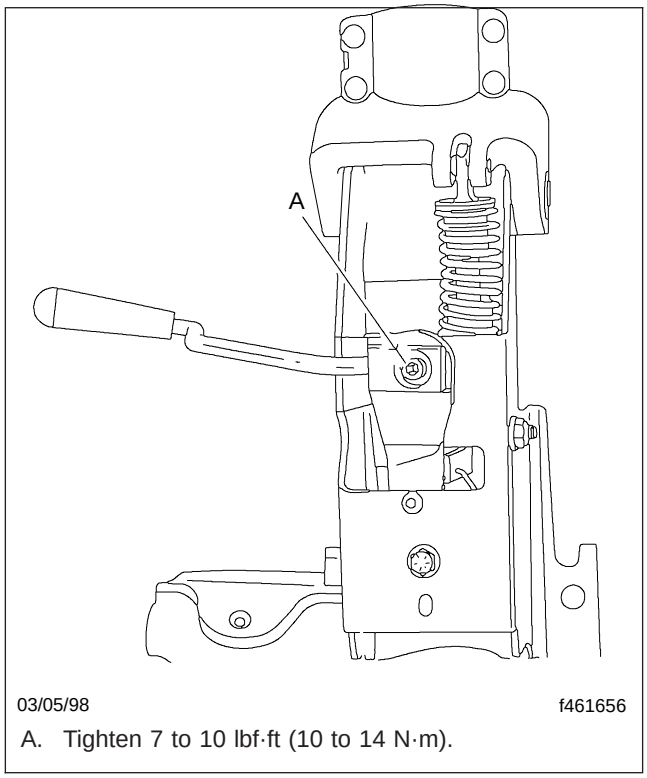


Fig. 12, Actuator Handle

6. Install a new bearing gasket on each bearing. See **Fig. 13**.

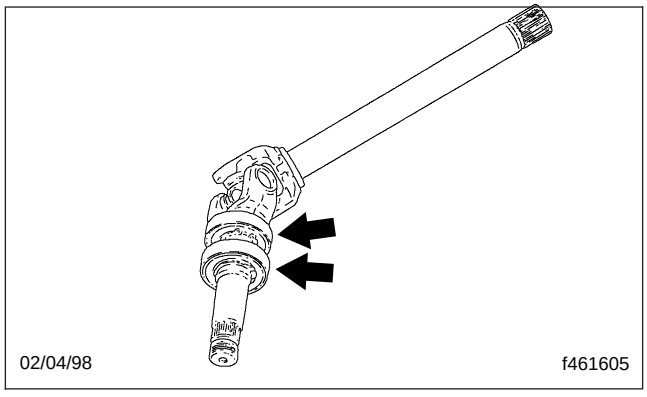


Fig. 13, Location of Bearing Gasket Installation

7. Tilt the unit rearward and insert the steering column shaft into the jacket tube. See **Fig. 14**.

Tilt Steering Column Disassembly and Assembly

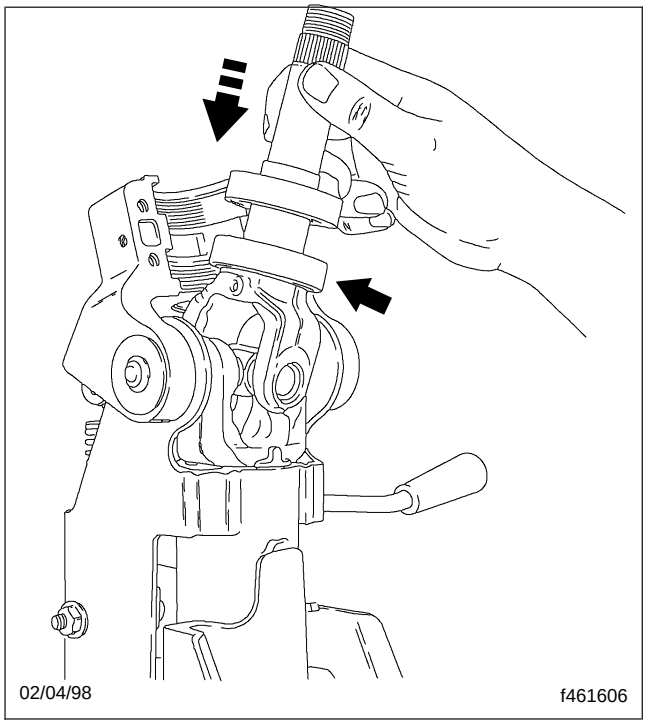


Fig. 14, Insert the Steering Column Shaft into the Jacket Tube

NOTE: Install the U-joint so that the shorter yoke is attached to the column output shaft aligning the marks previously made during disassembly for proper orientation of the U-joint/shaft.

8. Install the U-joint to the column output shaft. Tighten the U-joint bolt 50 to 70 lbf·ft (68 to 95 N·m).
9. Seat the bearings in the tilt housing grooves. Make sure the four gaskets are straight and seated properly. See **Fig. 15**.
10. Install the bearing cap with the pilot lip up, so it matches up with the pilot lip on the housing. Install the four bolts and tighten 75 to 80 lbf·in (840 to 900 N·cm). See **Fig. 16**.
11. Test the tilt lock mechanism. The actuator handle should self-return to a neutral position. See **Fig. 17**.
12. Reinstall the clockspring adaptor plate. Tighten the screws 80 to 115 lbf·in (900 to 1300 N·cm).
13. Install the under steering panel brackets.

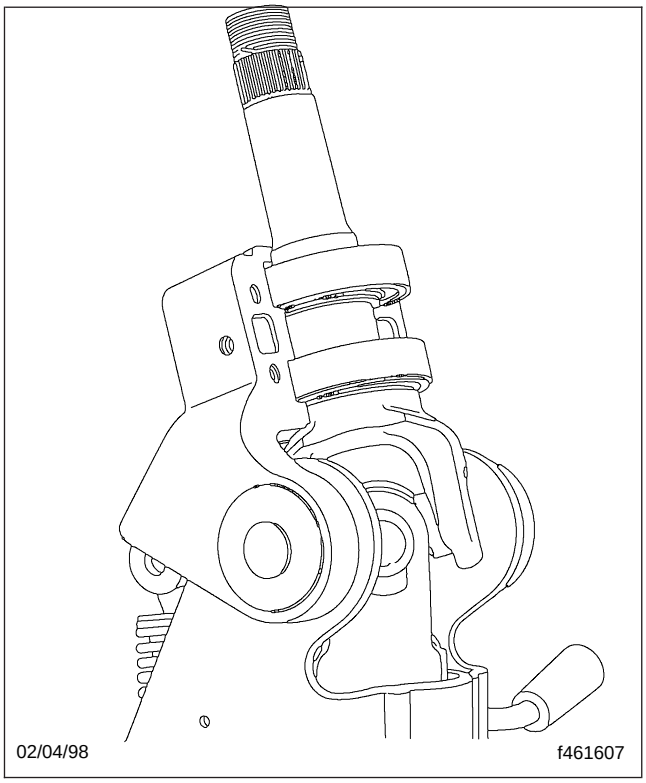
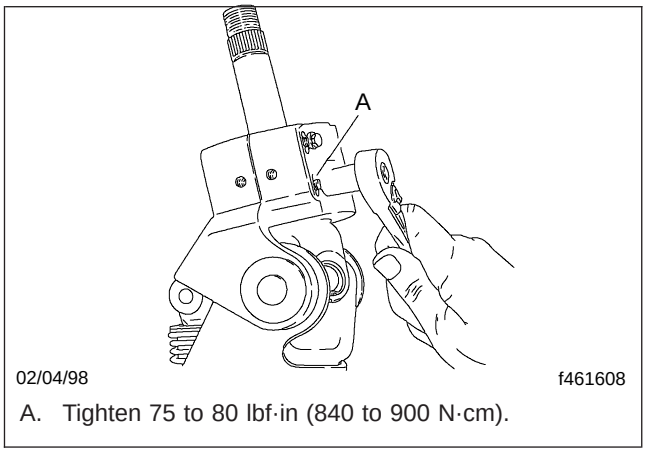


Fig. 15, Seat the Bearings in the Tilt Housing



A. Tighten 75 to 80 lbf·in (840 to 900 N·cm).

Fig. 16, Install the Four Bearing Cap Bolts

14. Install the steering column. For instructions, see **Subject 110**.
15. Install the clockspring. For instructions, see **Subject 130**.
16. Install the steering wheel and check if it is centered (within ±10 degrees). See **Subject 100**.

Tilt Steering Column Disassembly and Assembly

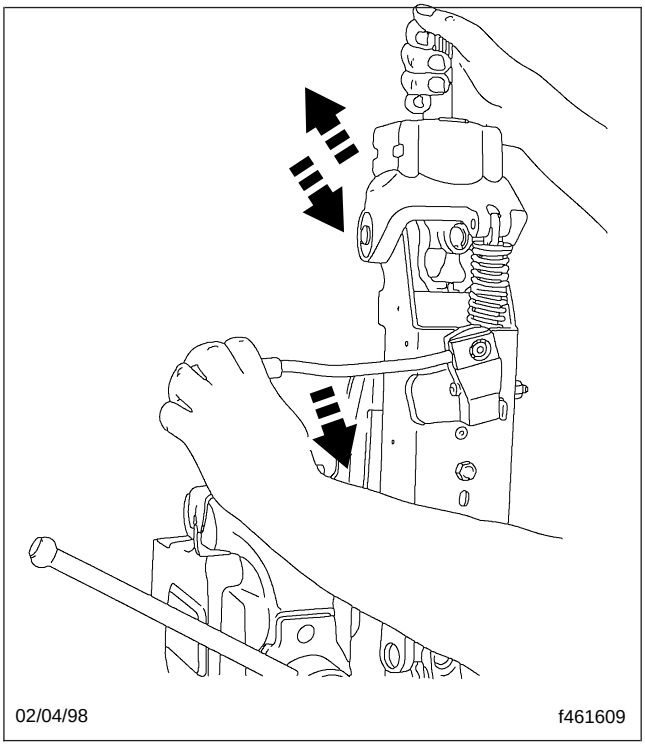


Fig. 17, Test the Tilt Lock Mechanism

17. Connect the battery ground cable(s).
18. Remove the chocks from the rear tires.

Tilt/Telescopic Steering Column Disassembly and Assembly

Disassembly

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Disconnect the battery ground cable(s).
3. Remove the steering wheel. For instructions, see **Subject 100**.
4. Remove the clockspring. For instructions, see **Subject 130**.
5. Remove the steering column. For instructions, see **Subject 110**.
6. Remove the under steering panel brackets.
7. Place the column in a soft-jawed vise, clamping on the mounting bracket flange. See **Fig. 1**.

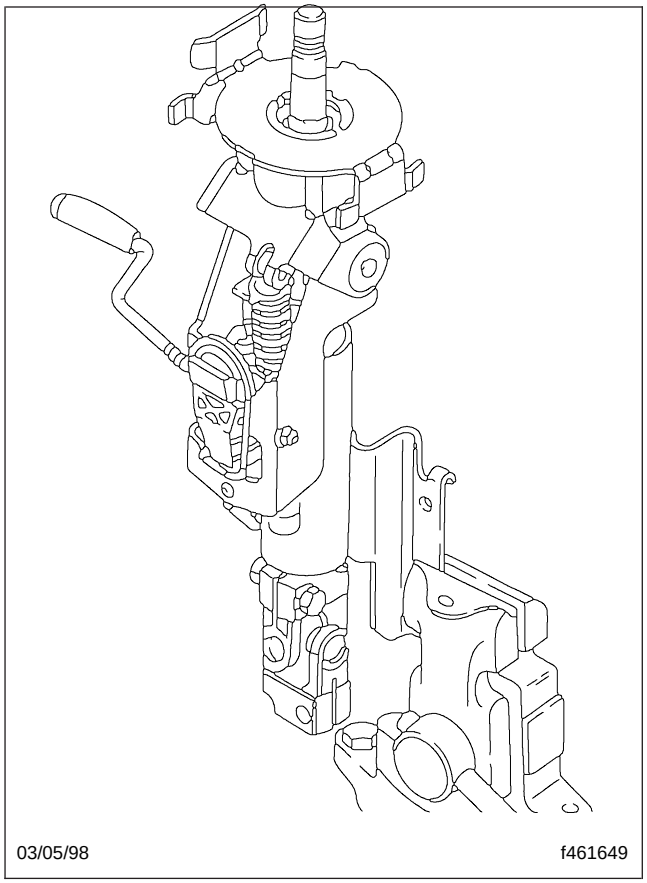


Fig. 1, Soft-Jawed Vise Holding Column

8. Telescope the steering column up to fully unload the telescope spring.
9. Remove the clockspring adaptor plate. See **Fig. 2**.

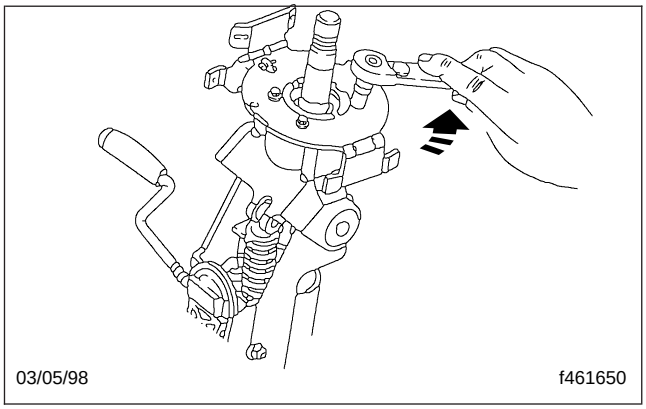


Fig. 2, Clockspring Adaptor Plate

10. Remove four bolts from the steering column and bearing cap. See **Fig. 3**.

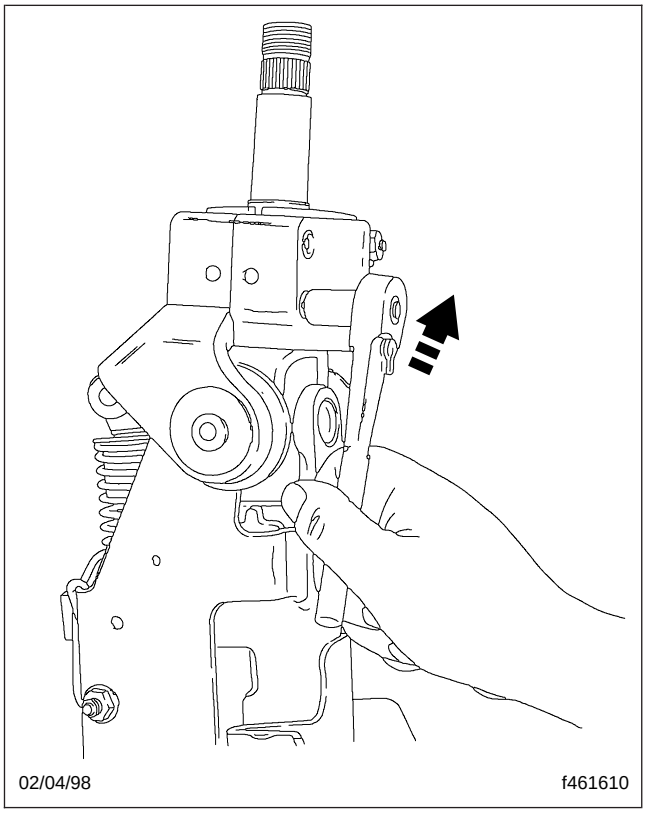


Fig. 3, Remove the Bearing Cap Bolts

Tilt/Telescopic Steering Column Disassembly and Assembly

⚠ WARNING

Wear eye protection during this step. The upper rotating tube is under spring tension. If the column has not been telescoped fully, this assembly will spring upward causing possible eye injury.

11. Remove the bearing cap. See **Fig. 4**.

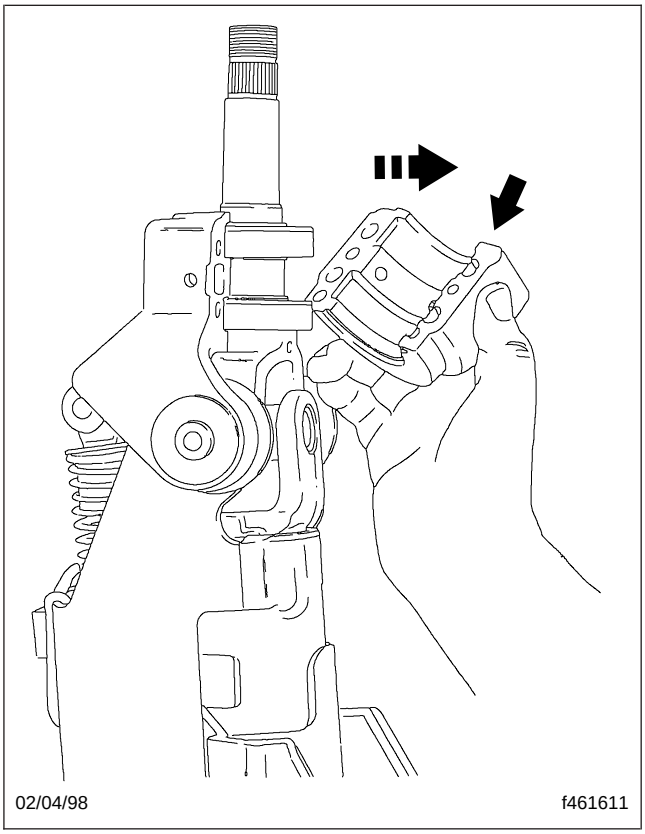


Fig. 4, Remove the Bearing Cap

12. Tilt the unit away from the mounting bracket and remove the upper rotating tube by lifting the bearings out of their seats, rotating the shaft if necessary for U-joint clearance, and pulling on the input shaft. See **Fig. 5**.

    12.1 Inspect the rotating bearings for looseness.

    12.2 Check for lash in the U-joint. Inspect for twisted or otherwise damaged serrations. If either condition exists, replace the rotating assembly.

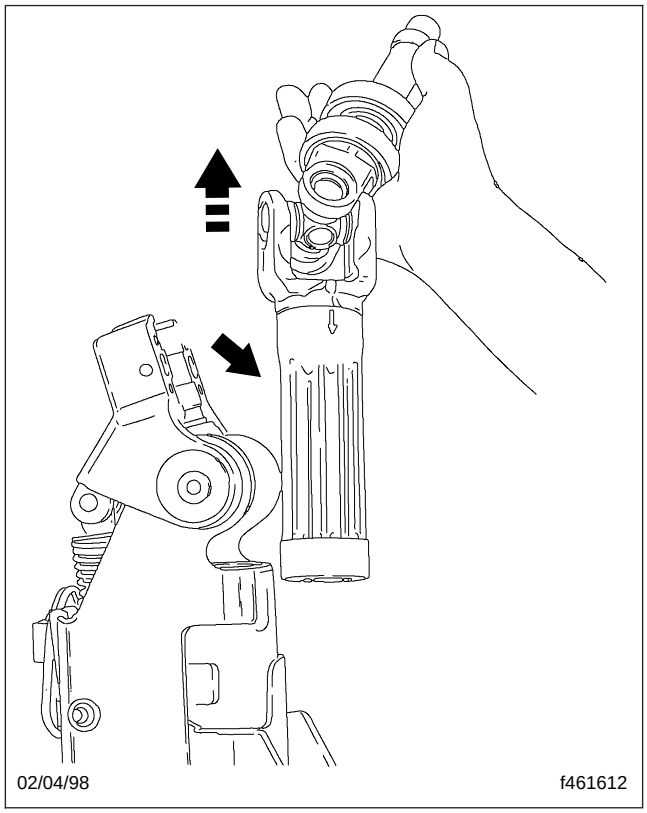


Fig. 5, Remove the Input Shaft and Bearing Assembly

    12.3 Remove the bearing gaskets from both bearings and discard.

NOTE: Before removing the U-joint, mark it in a manner that will allow it to be installed in the same orientation as when removed. The short yoke must be installed on the output shaft of the column.

13. Mark the U-joint/shaft orientation. Remove the pinch bolt, two washers and nut holding the U-joint in place. See **Fig. 6**.
14. Inspect the housing threads; make sure the threads are not stripped. If housing threads are stripped, the entire unit must be replaced. See **Fig. 7**.
15. Remove the retaining ring holding the lower rotating tube.
16. Remove the lower rotating tube and the telescope spring from jacket tube.

Tilt/Telescopic Steering Column Disassembly and Assembly

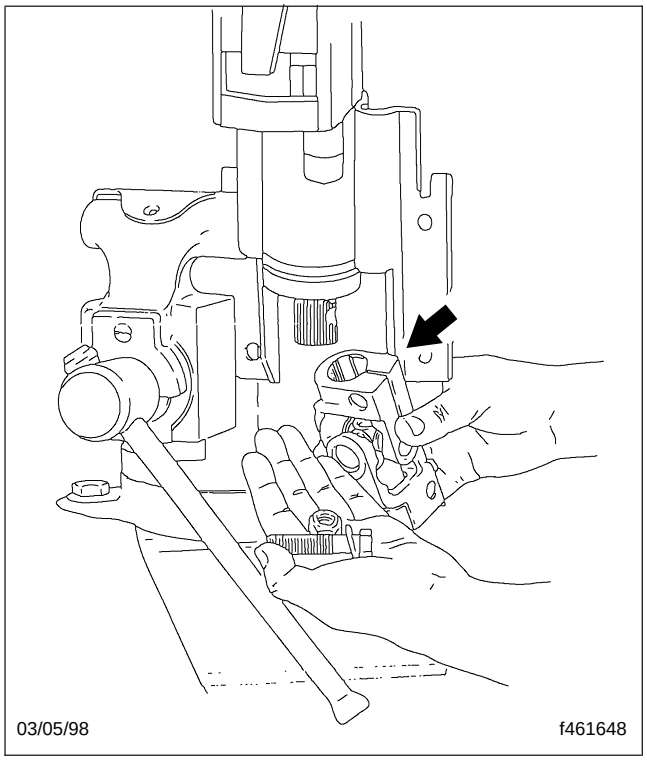


Fig. 6, Remove the U-Joint

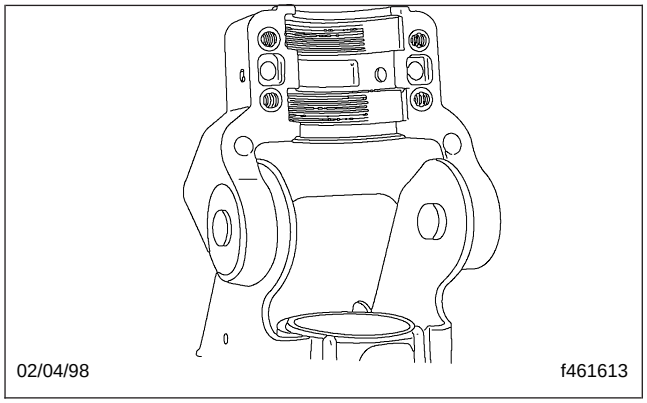


Fig. 7, Inspect the Housing Threads

17. Turn the unit upside down and allow the dust cover to fall out of the unit. See **Fig. 8**.

Assembly

1. Install the dust cover and the telescope spring. See **Fig. 9**.

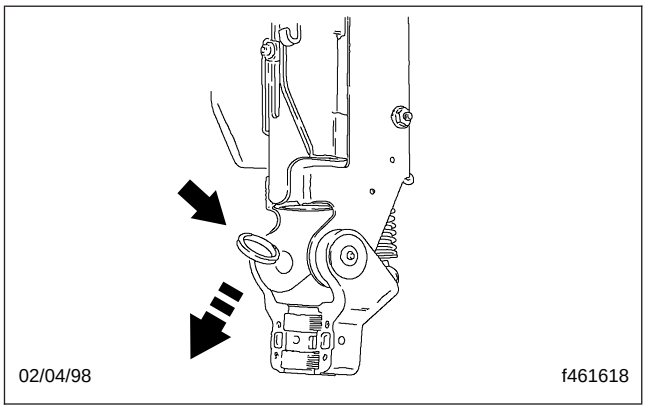


Fig. 8, Release the Dust Cover from the Unit

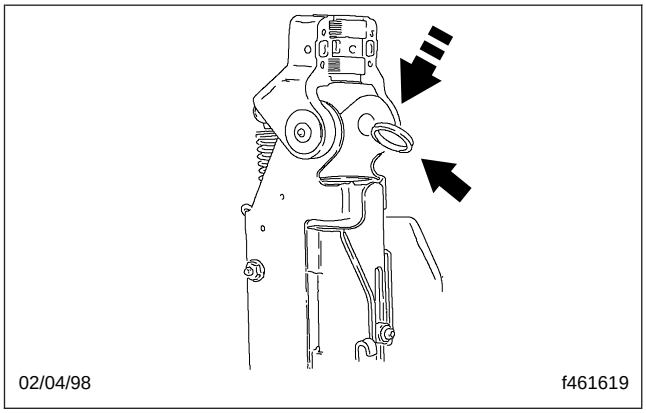


Fig. 9, Install the Dust Cover

NOTE: Note the position of the alignment arrows on the rotating tubes. Alignment arrows must line up for the tubes to fit together and function properly. Mark if necessary to align parts during installation, but not on the formed surfaces.

NOTE: Telescoping the column down may make this procedure easier.

2. Separate the upper and lower rotating tubes, and insert the new lower rotating tube in the jacket tube, inside the spring. See **Fig. 10**.

   2.1 Tap the lower tube with a wooden hammer handle if all components are properly aligned, and if it does not seat easily.

   2.2 If the lower tube still will not seat, clean the I.D. of the lower bearing with a fine grade of emery cloth and retry.

Tilt/Telescopic Steering Column Disassembly and Assembly

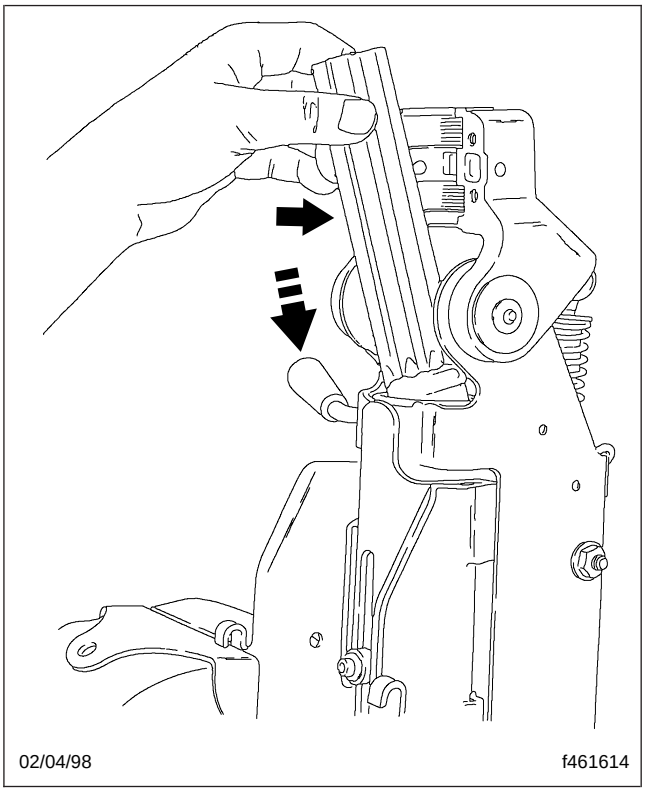
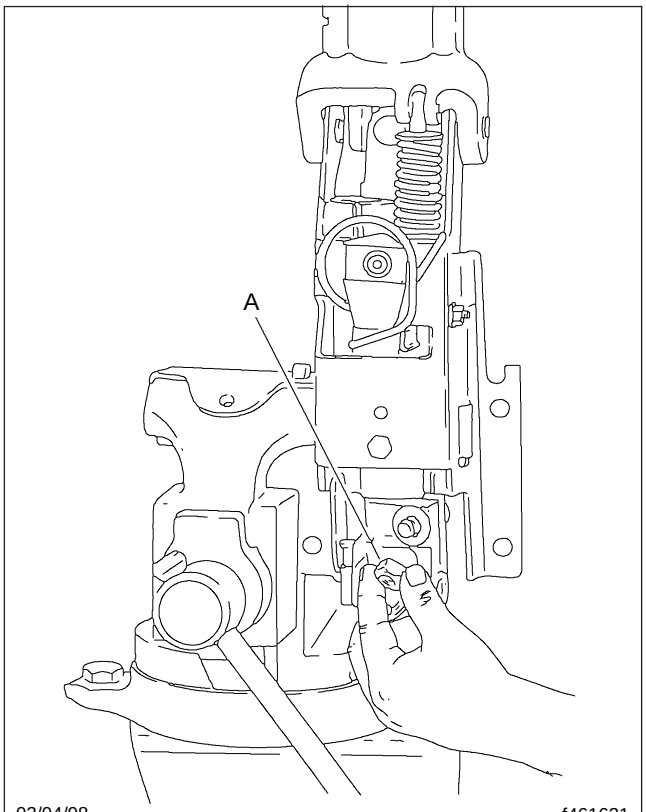


Fig. 10, Insert the Lower Rotating Tube

3. Install new gaskets on both bearings.

NOTE: Install the U-joint so that the shorter yoke is attached to the column output shaft aligning the marks previously made during disassembly for proper orientation of the U-joint/shaft.

4. Install the U-joint to the column output shaft. Tighten 50 to 70 lbf·ft (68 to 95 N·m). See **Fig. 11**.
5. Align the arrows or marks on the upper and lower rotating tubes, and install the upper rotating tube onto the lower rotating tube.
6. Seat the bearings in the tilt housing grooves. Make sure the gaskets are straight and seated properly. See **Fig. 12**.
7. Install the bearing cap with the pilot lip up, so it matches up with the pilot lip on the housing. Install the four bolts and tighten 75 to 80 lbf·in (840 to 900 N·cm). See **Fig. 13**.



A. Tighten 50 to 70 lbf·ft (68 to 95 N·m).

Fig. 11, Install the U-Joint

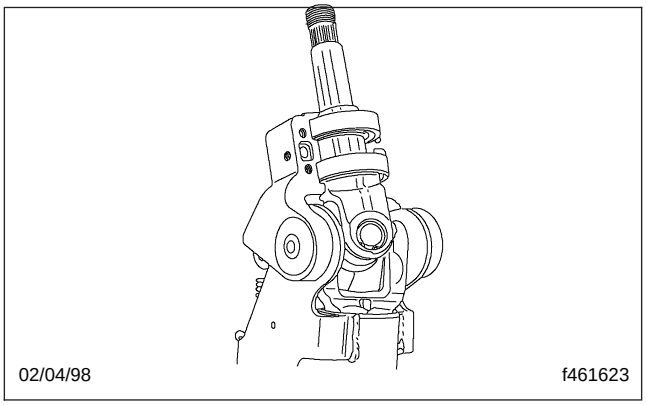
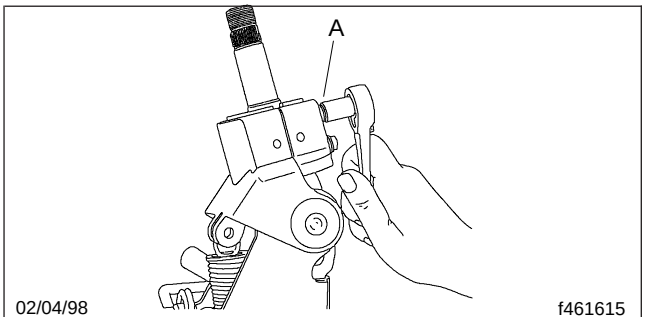


Fig. 12, Bearings Seated in Tilt Housing Grooves

8. Test the tilt and telescope mechanisms. The actuator handle should self-return to a neutral position. See **Fig. 14**.

Tilt/Telescopic Steering Column Disassembly and Assembly



A. Tighten 75 to 80 lbf·in (840 to 900 N·cm).

Fig. 13, Install Bearing Cap Retaining Bolts

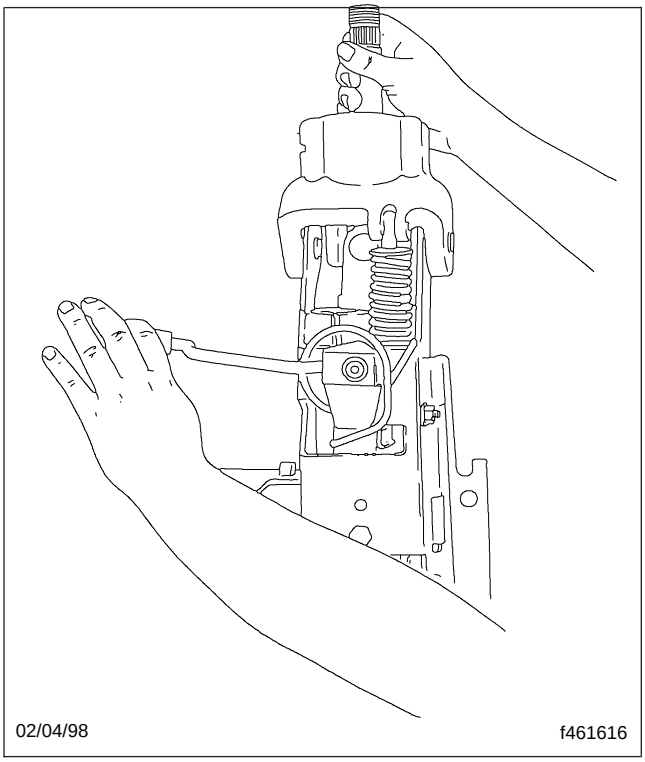


Fig. 14, Test the Tilt and Telescoping Mechanisms

9. Install the clockspring adaptor plate. Tighten the screws 80 to 115 lbf·in (900 to 1300 N·cm).
10. Install the under steering panel brackets.
11. Install the steering column. For instructions, see **Subject 110**.
12. Install the clockspring. For instructions, see **Subject 130**.
13. Install the steering wheel and check if it is centered (within ±10 degrees). See **Subject 100**.
14. Connect the battery ground cable(s).
15. Remove the chocks from the rear tires.

Steering Column Cam Kit Replacement

Replacement

1. Disconnect the battery ground cable(s).
2. Remove the steering wheel. Refer to **Subject 100**.
3. Remove the clockspring. Refer to **Subject 130**.
4. Remove the steering column. Refer to **Subject 110**.
5. Remove the steering column shrouds.

CAUTION

Wear eye protection when working with springs and spring-loaded devices.

6. Remove the steering column shroud brackets.
7. Place the column in a soft-jawed vise, clamping on the mounting bracket flange.

NOTE: The capscrew has a nylon patch.

8. Use a 5/32-inch Allen socket to remove the socket head capscrew and actuator handle.
9. Remove the winged O-ring. See **Fig. 1**.

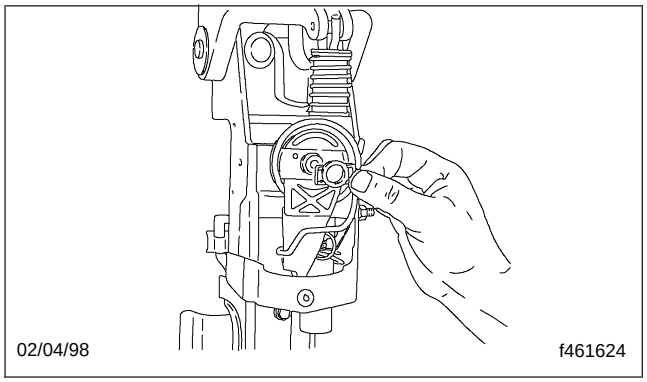


Fig. 1, Remove the Winged O-Ring

10. Use vise grips to release the lower end of the torsion spring from its position over the wire form. Guide the spring end until the spring rests in a non-tension position. See **Fig. 2**.
11. Remove the retaining ring. See **Fig. 3**.
12. Remove the cam and torsion spring.

    Inspect the actuator cam for cracks or breaks. Replace if necessary. See **Fig. 4**.
13. Wipe off the grease from around the pivot pin.

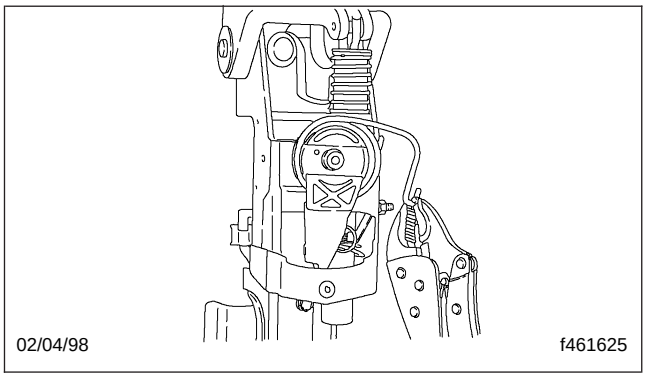


Fig. 2, Guide the Spring to a Rest Position

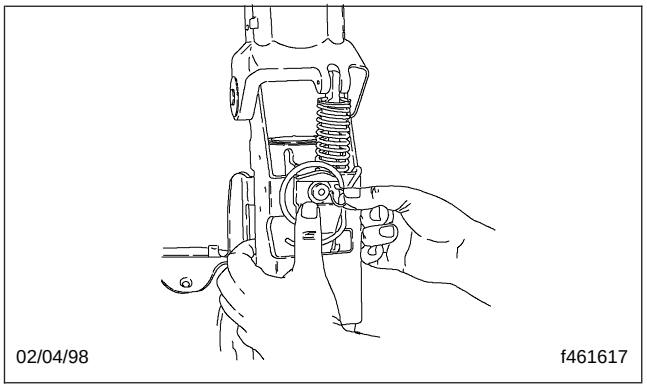


Fig. 3, Remove the Retaining Ring

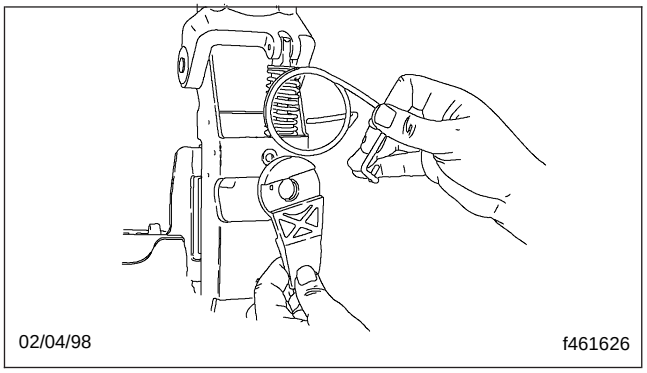


Fig. 4, Remove the Cam and Torsion Spring

14. Grease the area around the pivot pin, and the back of the cam.
15. Install the torsion spring.
16. Position the cam on the pivot pin, and install the retaining ring. Make sure the retaining ring is seated properly. See **Fig. 5**.

Steering Column Cam Kit Replacement

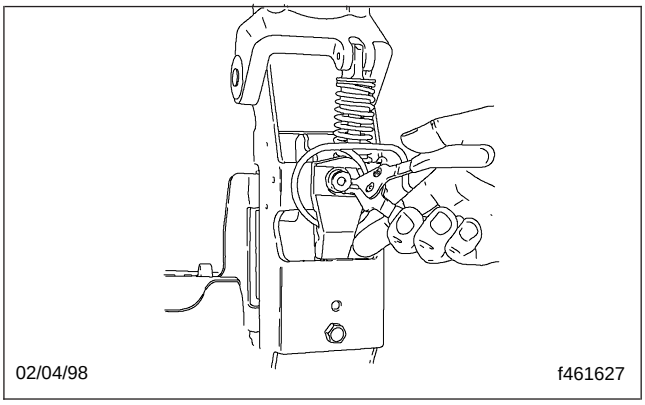


Fig. 5, Install the Retaining Ring

17. Use vise grips to pull the lower end of the torsion spring into place over the wire form. See **Fig. 6**.

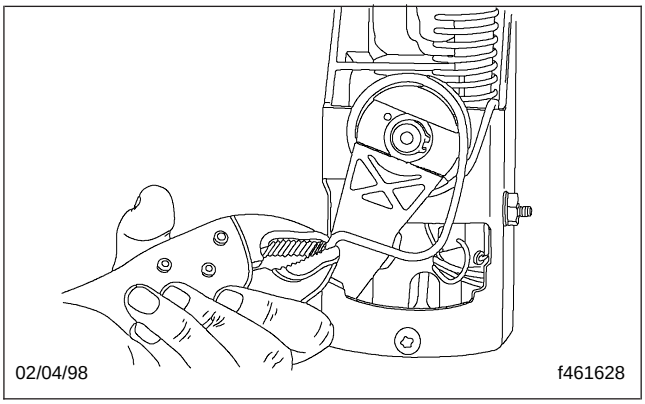


Fig. 6, Pull the Torsion Spring into Place

18. Install the winged O-ring. See **Fig. 7**.

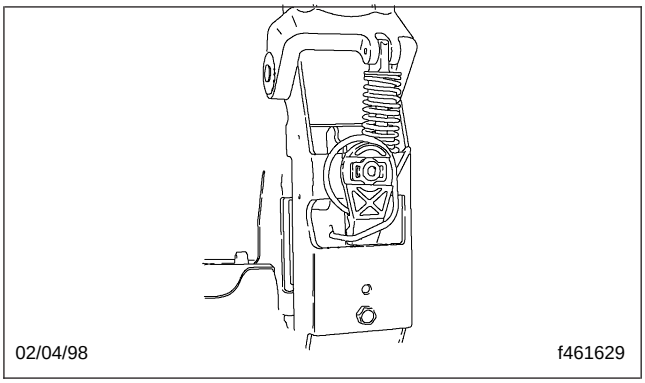


Fig. 7, Install a Winged O-Ring

19. Install the actuator handle on the actuator pivot pin. Test the function of the tilt and telescopic mechanism. See **Fig. 8**.

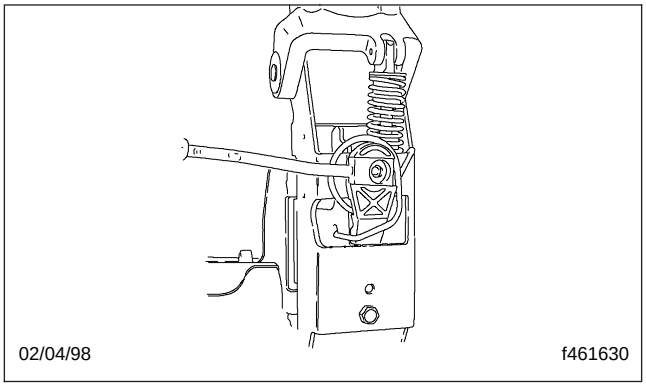


Fig. 8, Test the Tilt/Telescopic Function

20. Install the steering column shroud brackets.
21. Install the steering column. Refer to **Subject 110**.
22. Install the clockspring. Refer to **Subject 130**.
23. Install the steering wheel. Refer to **Subject 100**.
24. Connect the battery ground cable(s).

General Information

Two different multi-function switches are used on the L-Line and A-Line vehicles:

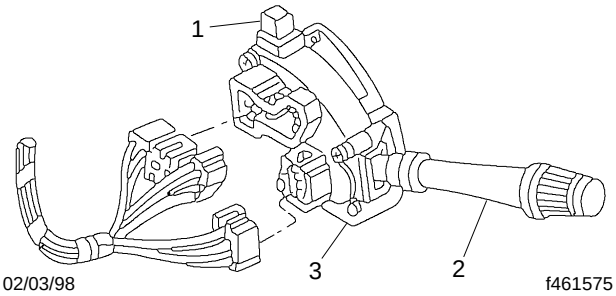
- a UTA self-canceling switch (see **Fig. 1**)
- a Signal-Stat manual cancel switch (see **Fig. 2**)

The multi-function switch combines the following features:

- integral wiper/washer controls
- windshield wiper interval control
- headlamp dimmer (UTA)
- flash-to-pass control
- turn signal "On/Off" switch
- hazard lamp "On/Off" switch

The UTA self-canceling multi-function switch automatically returns the turn signal lever to the "Off" position, upon completion of a turn, by means of a cancel cam located on the steering column shaft.

For more information on exterior lights, refer to **Group 54**.



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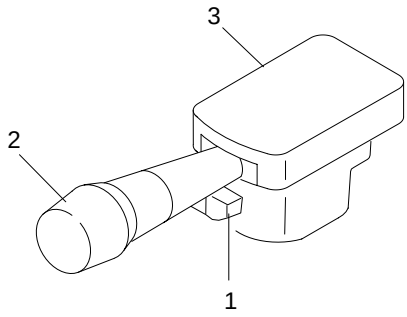
1. Hazard Lamp "On/Off" Switch
2. Turn Signal/Headlamp Dimmer/Wiper/Washer Control Lever
3. Turn Switch and Windshield Wiper Switch Assembly

Fig. 1, UTA Turn Signal and Windshield Wiper Switch Assembly



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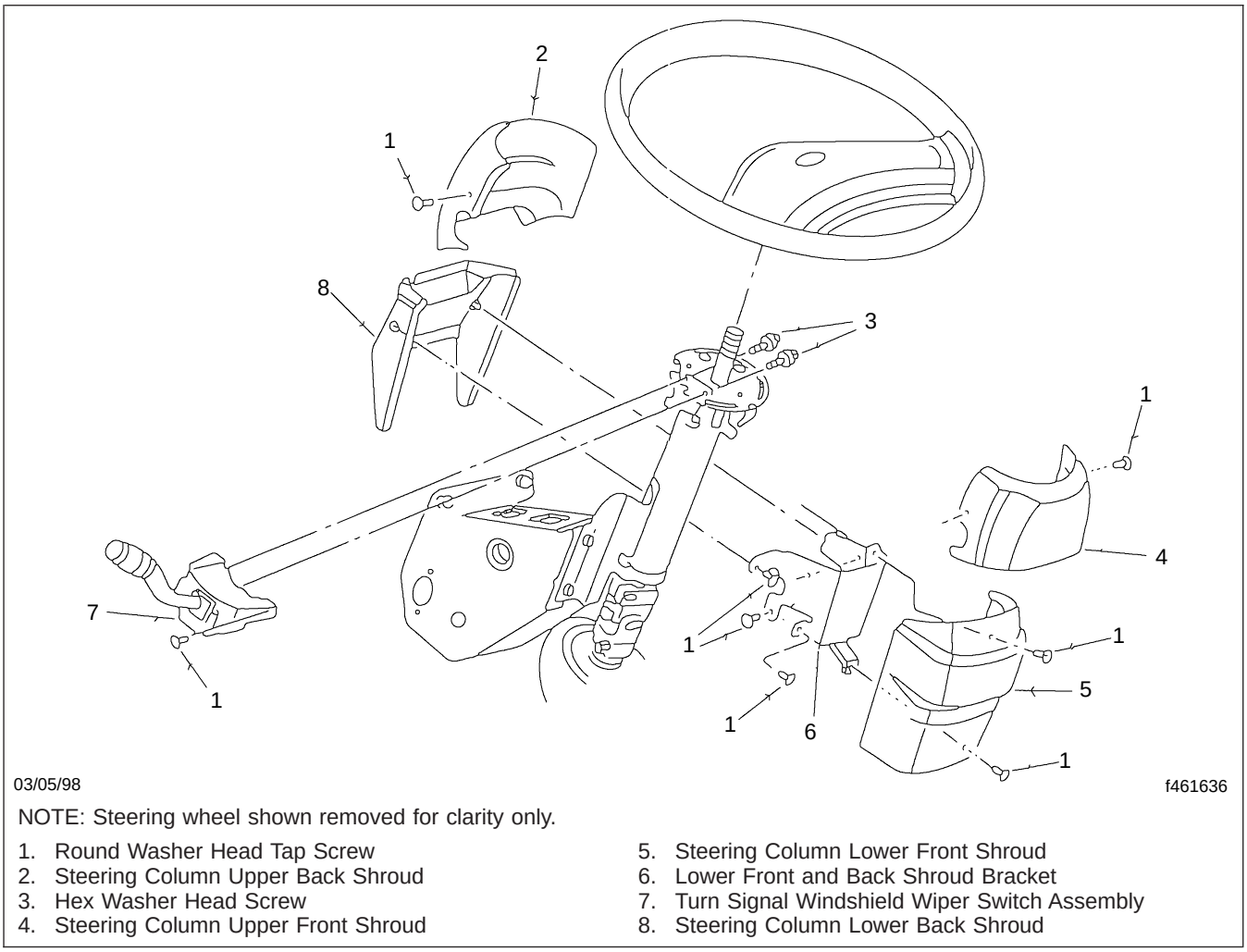
1. Hazard Lamp "On/Off" Switch
2. Turn Signal/Flash-to-Pass/Wiper/Washer Control Lever
3. Turn Signal Switch Assembly

Fig. 2, Signal-Stat Turn Signal Switch Assembly

Replacement (See Fig. 1)



NOTE: Steering wheel shown removed for clarity only.

1. Round Washer Head Tap Screw
2. Steering Column Upper Back Shroud
3. Hex Washer Head Screw
4. Steering Column Upper Front Shroud
5. Steering Column Lower Front Shroud
6. Lower Front and Back Shroud Bracket
7. Turn Signal Windshield Wiper Switch Assembly
8. Steering Column Lower Back Shroud

Fig. 1, UTA Turn Signal and Windshield Wiper Switch Assembly

⚠ CAUTION

Do not drop the screw or the cancel cam down the steering column housing.

1. Remove the screws and the panels from the steering column. See **Fig. 2**.
2. Remove the multi-function switch.
3. Remove the screw and the cancel cam. See **Fig. 3**.
4. Position the cancel cam and install the screw. Tighten the screw 25 to 35 lbf·in (280 to 390 N·cm). See **Fig. 2**.
5. Install the multi-function switch.

Cancel Cam Replacement

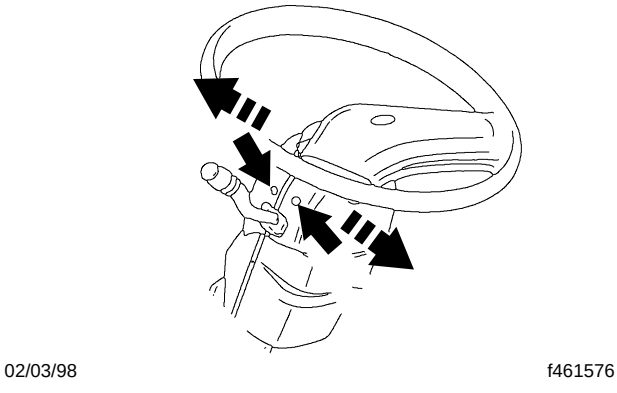
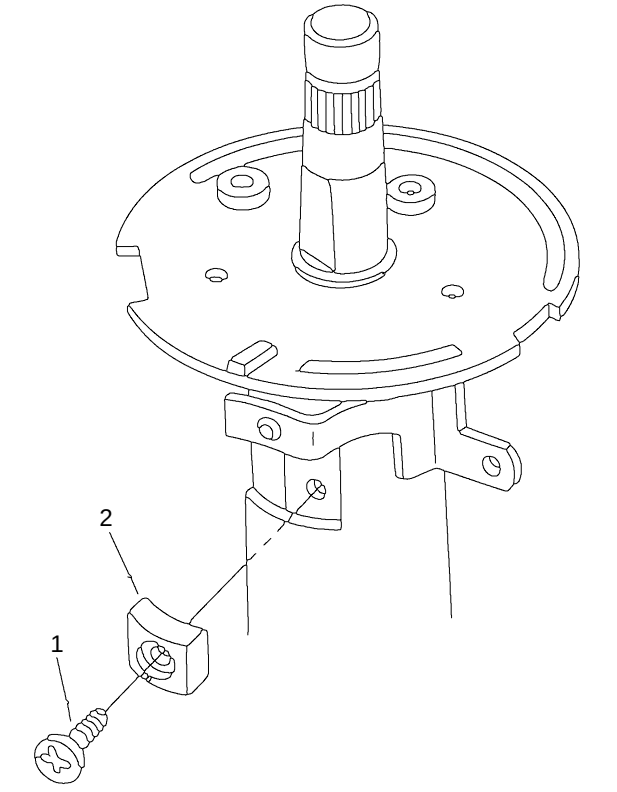


Fig. 2, Remove the Panels from Steering Column



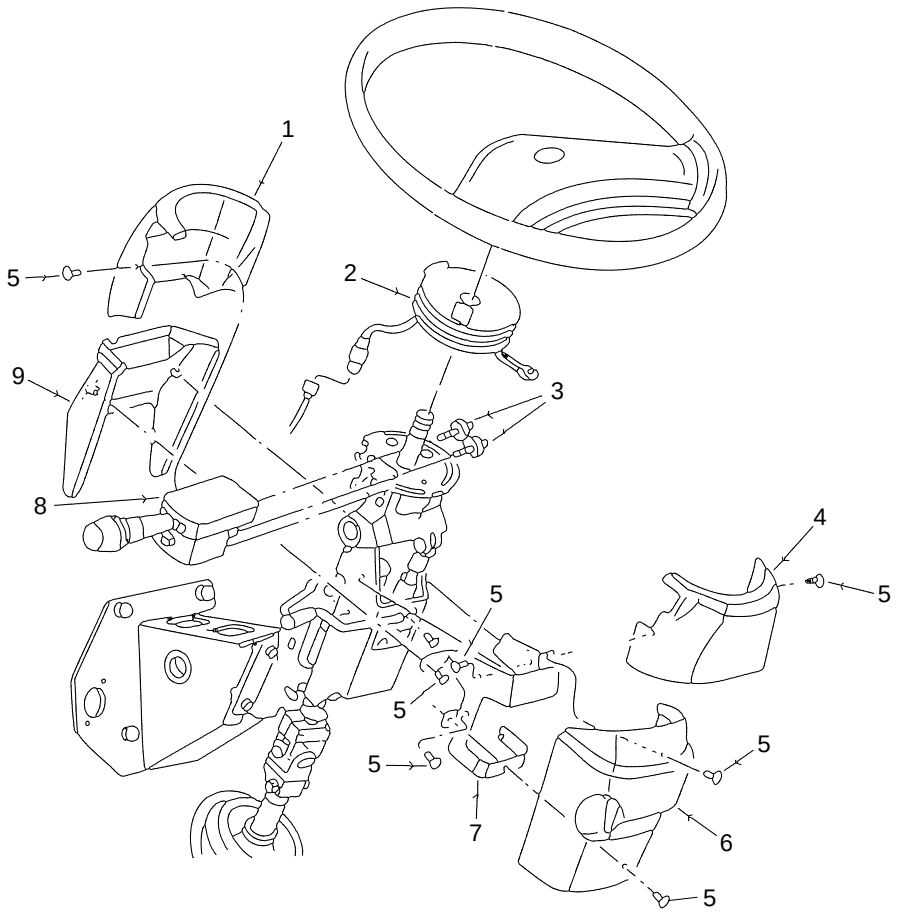
NOTE: The steering wheel is shown removed for clarity.

1. Screw
2. Cancel Cam

Fig. 3, Remove the Cancel Cam

Signal-Stat Multi-Function Switch Replacement

Replacement (See Fig. 1)



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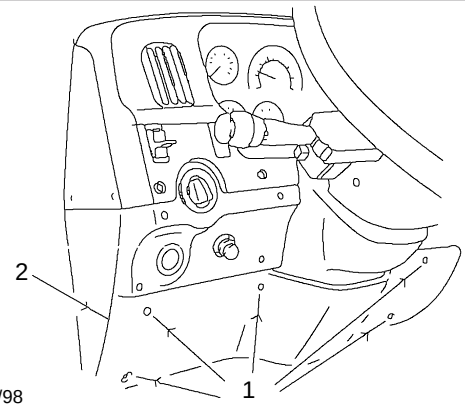
NOTE: Steering wheel and air bag connector assembly shown removed for clarity only.

1. Steering Column Upper Back Shroud
2. Air Bag Contact Assembly
3. Hex Washer Head Screw
4. Steering Column Upper Front Shroud
5. Round Washer Head Tap Screw
6. Steering Column Lower Front Shroud
7. Shroud Lower Front and Back Bracket
8. Turn Signal Switch Assembly
9. Steering Column Lower Back Shroud

Fig. 1, Signal-Stat Turn Signal Switch Assembly

1. Remove the screws and the instrument panel lower finish panel. See **Fig. 2**.
2. Remove the screws and the steering column upper front and upper back shrouds. See **Fig. 3**.
3. Remove the steering column lower front shroud. See **Fig. 4**.
   - 3.1 Remove the steering column lock actuator lever screw.
   - 3.2 Remove the two screws.
   - 3.3 Remove the steering column lower front shroud with the lock actuator lever.
4. Disconnect the turn signal switch assembly electrical connectors.

Signal-Stat Multi-Function Switch Replacement



1. Screws
2. Lower Finish Panel

Fig. 2, Instrument Panel

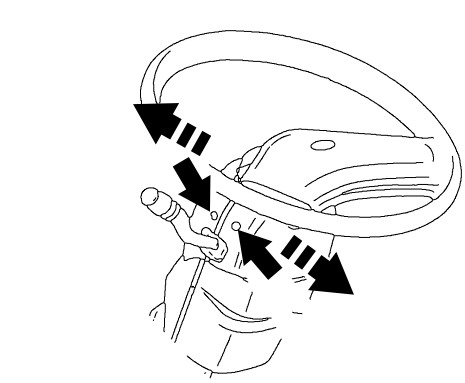
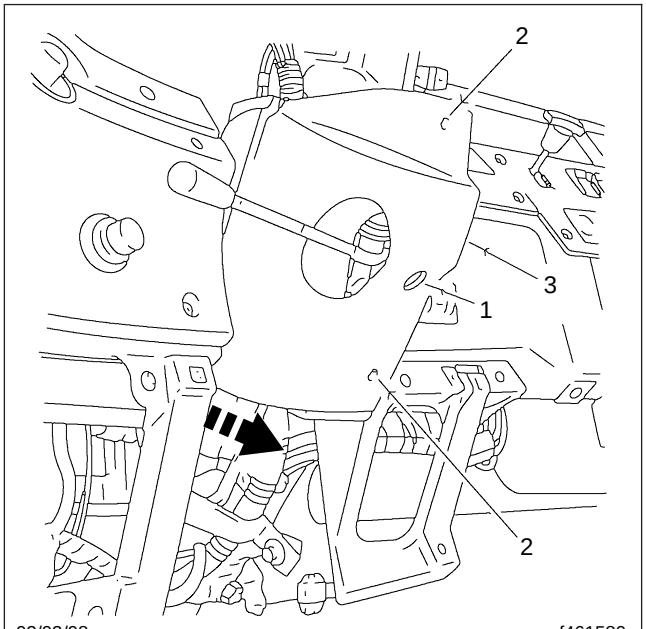


Fig. 3, Remove the Upper Shrouds

5. Remove the screws and the turn signal switch assembly from the steering column. See **Fig. 5**.
6. Position the turn signal switch on the steering column and install the retaining screws.
7. Connect the turn signal switch assembly electrical connectors.
8. Install the steering column lower front shroud.
   - 8.1 Position the steering column lower front shroud with the lock actuator lever.
   - 8.2 Install the two screws.
   - 8.3 Install the steering column lock actuator lever screw.



1. Lock Actuator Lever Screw
2. Shroud Screws
3. Lower Front Shroud

Fig. 4, Removing the Lower Front Shroud

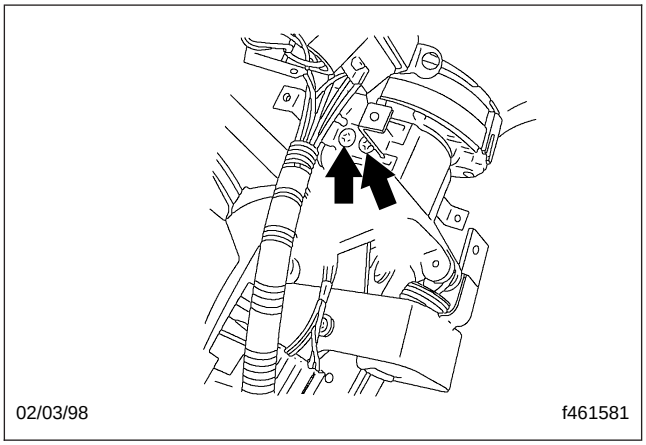


Fig. 5, Screws

9. Install the screws and the steering column upper front and upper back shrouds.
10. Install the instrument panel lower finish panel.
    - 10.1 Position the instrument panel lower finish panel.
    - 10.2 Install the screws.

Troubleshooting

INSPECTION AND VERIFICATION

Inspect the installation of the steering column shroud parts to make sure there is no interference with the operation of the turn signal control or hazard warning switch.

- Remove the steering column shroud to gain access to the multi-function switch mounting screws. Make sure the screws are secure.
- With the steering column shroud and the multi-function switch removed, inspect the cancel cam, if so equipped. Check for wear or damage. Replace as necessary.
- Inspect the multi-function switch connectors. Make sure the connections are tight.
- Operate the multi-function switch controls through all function positions. Check for binding or looseness. Make sure the multi-function switch controls hold in each detent position. Repair or replace as necessary.

Problem—Multi-Function Switch/Controlled Component Will Not Function Properly

Problem—Multi-Function Switch/Controlled Component Will Not Function Properly	
Possible Cause	**Remedy**
Multi-function switch	Refer to **Group 54** in this manual for instructions.
Circuit/controlled component	For exterior lighting concerns, refer to **Group 54** in this manual for instructions. For wiper and washer circuit concerns, refer to **Group 82** in this manual for instructions.
Damaged or missing cancel cam (UTA)	Replace cancel cam.

Specifications

Torque Specifications	
Description	**lbf·in (N·cm)**
Cancel Cam Retaining Screw	25–35 (280–390)
Steering Column Lock Actuator Lever Screw	120 (1400)

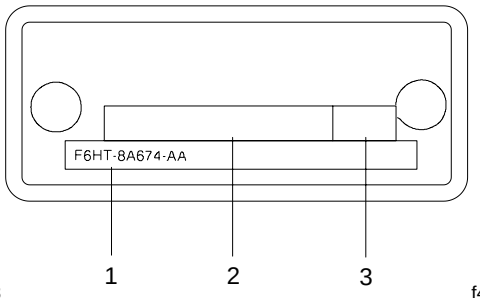
Table 1, Torque Specifications

General Information

The ZF power steering pump has been specially designed to supply pressurized oil to power steering units.

The ZF power steering pump is directly driven by the engine. As the driven shaft rotates the rotor, the slipper vanes inside the power steering pump also move. The centrifugal force and pressurized oil force the slipper vanes against the track of the cam ring. The oil passes from the two pressure chambers to the area between the rear cover and faceplate, thus pressing this plate against the cam ring at operating pressure. The oil then passes through a flow-limiting valve to the pressure line.

ZF power steering pumps are identified by a tag riveted on the pump body. The tag provides the Sterling part number, pump serial number, and date code. See **Fig. 1**.



1. Part Number
2. Pump Serial Number
3. Date Code

Fig. 1, Steering Pump Identification Tag

Cast Iron Power Steering Pump Disassembly and Assembly

Disassembly

1. Remove the helical drive gear. See **Fig. 1**.

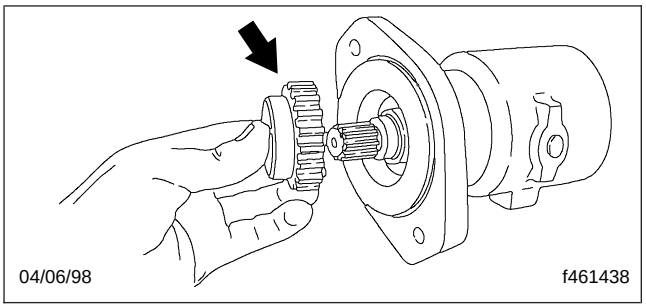


Fig. 1, Helical Drive Gear

2. Remove the hook spring ring from the radial groove in the housing, using pliers. See **Fig. 2**.

NOTE: The O-ring is inboard of the backup ring.

3. Remove the cover and the pressure spring then remove the internal O-ring and backup ring from the rear cover. See **Fig. 3**.
4. Remove the circlip from the groove. See **Fig. 4**.

NOTE: This O-ring is outboard of the backup ring.

NOTE: Check and record the direction of rotation (arrow on the cam ring) and the location of the set pins. The power steering pump cannot be reassembled properly without this information.

5. Turn the housing over and remove the rear faceplate, rotor assembly (rotor, cam ring, vanes and set pin) and front faceplate from the housing.

   Remove the O-ring and backup ring from the rear faceplate. See **Fig. 5**.
6. Clamp the driveshaft in a vise (use soft jaws) and with a soft mallet, tap on the housing to remove the driveshaft from the housing. See **Fig. 6**.
7. If the ball bearing is to be replaced, remove the retaining ring and press the bearing from the driveshaft. See **Fig. 7**.
8. If the shaft seal or the needle bearing needs repair, remove the seal or the bearing from the housing. Discard the seal. See **Fig. 8**.

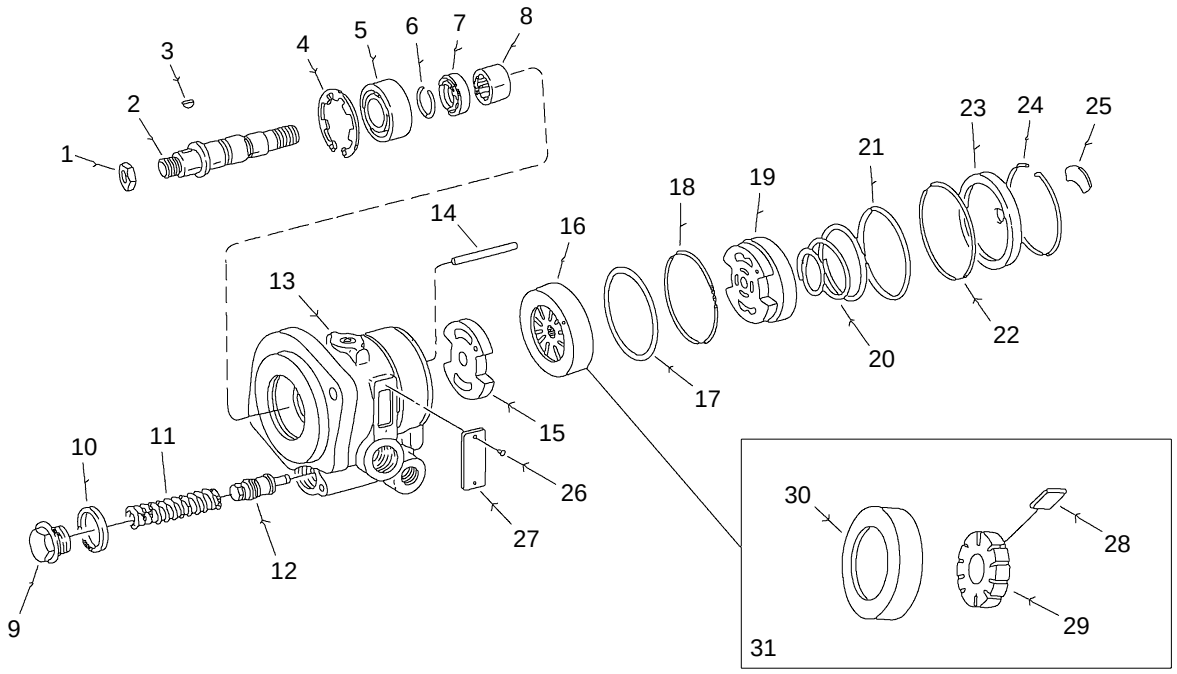
Assembly

1. If removed, press in a new needle bearing.
2. If removed, install a new shaft seal in the housing.
3. If removed, press a new bearing onto the driveshaft and install the retaining ring in the driveshaft groove. See **Fig. 9**.
4. Install the driveshaft and bearing assembly into the housing.
5. Install the bearing circlip in the groove.
6. Install the O-ring and backup ring on the rear faceplate.

NOTE: The cam ring of the rotor assembly must be installed with the arrow pointed in the direction of rotation (DDC 60 counterclockwise, all others clockwise). The set pin is installed in the location recorded during disassembly.

7. Install the set pin, front faceplate and rotor assembly into the housing.
8. Install the rear pressure spring and rear cover.
   - 8.1 Install the O-ring and backup ring in the rear cover housing. See **Fig. 2**.
   - 8.2 Place the rear pressure spring in the rear faceplate.
   - 8.3 Position the rear cover in the housing.
9. Press down on the rear cover plate and install the hook spring ring in the groove in the housing.
10. Install the helical drive gear.

Cast Iron Power Steering Pump Disassembly and Assembly



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1. Nut
2. Driveshaft
3. Woodruff Key
4. Circlip
5. Ball Bearing
6. Retaining Ring
7. Shaft Seal
8. Needle Bearing
9. Screw Plug
10. Seal Ring
11. Pressure Spring
12. Valve Piston
13. Housing
14. Set Pin
15. Front Faceplate (driver side)
16. Power Steering Pump Rotor
17. Backup Ring
18. O-Ring
19. Rear Faceplate (cover side)
20. Pressure Spring
21. O-Ring
22. Backup Ring
23. Cover
24. Hook Spring Ring
25. Label
26. Pin
27. Plate
28. Vanes (10)
29. Rotor
30. Cam Ring
31. Rotary Assembly

Fig. 2, Direct Drive Power Steering Pump

Cast Iron Power Steering Pump Disassembly and Assembly

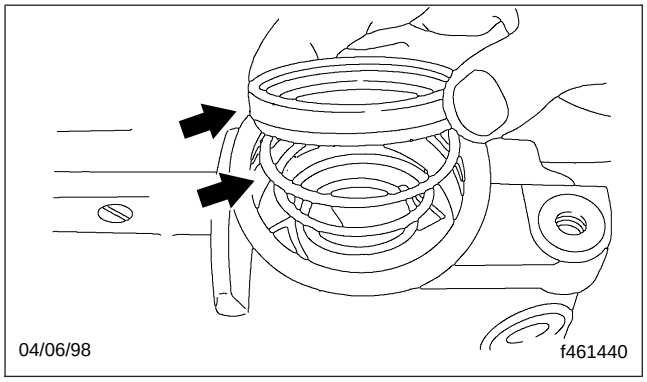


Fig. 3, Internal O-Ring and Back-up Ring

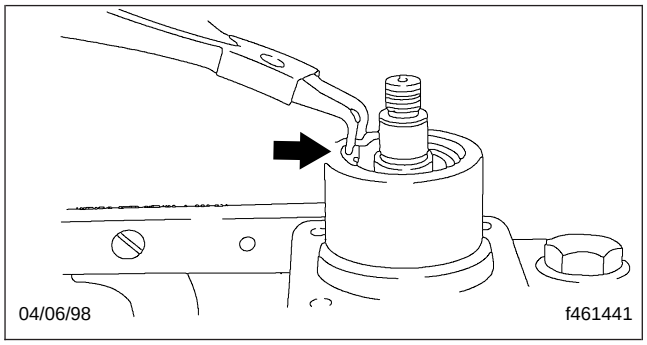


Fig. 4, Circlip

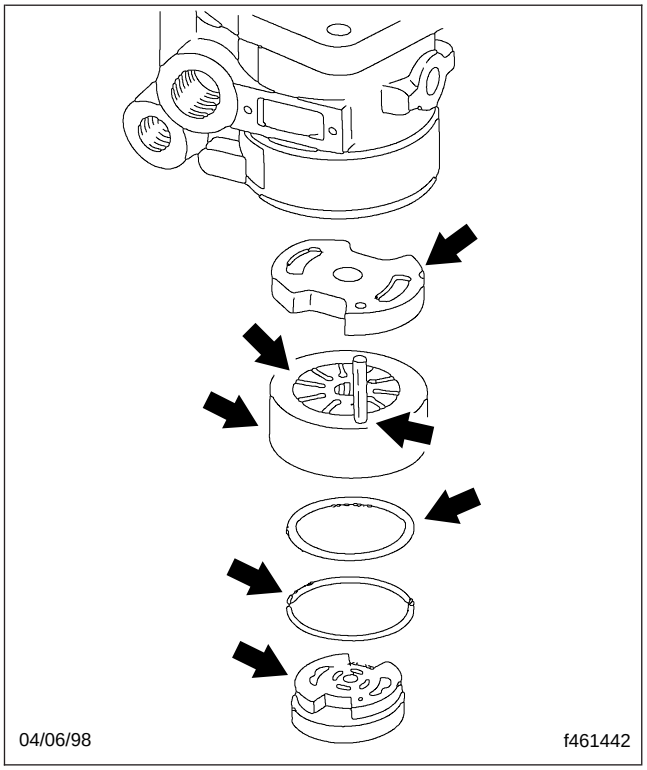


Fig. 5, Faceplate O-Ring and Back-Up Ring

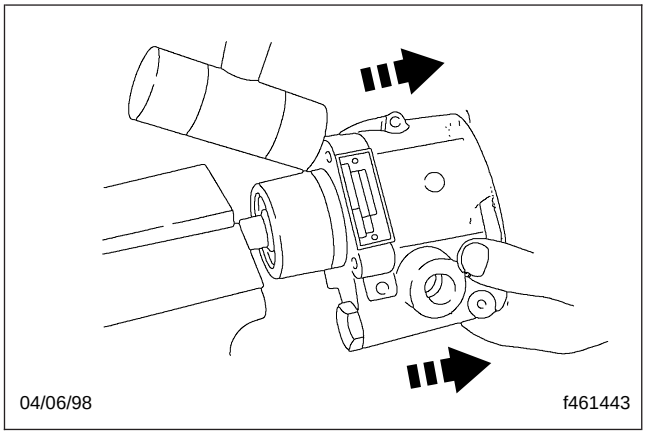


Fig. 6, Remove the Driveshaft from the Housing

Cast Iron Power Steering Pump Disassembly and Assembly

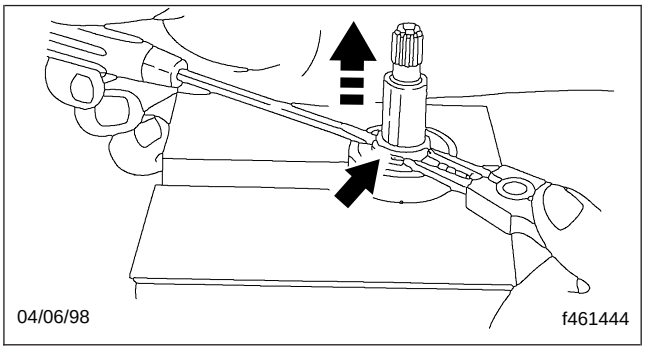


Fig. 7, Press the Bearing Out

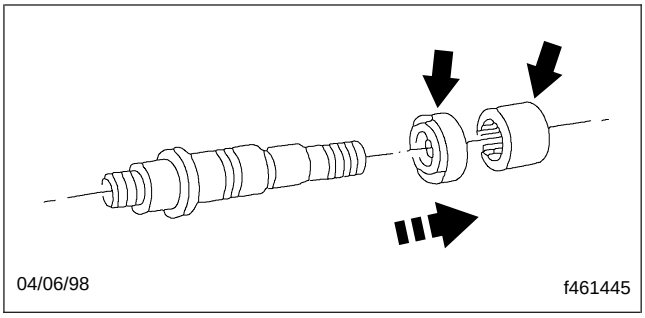


Fig. 8, Remove the Seal

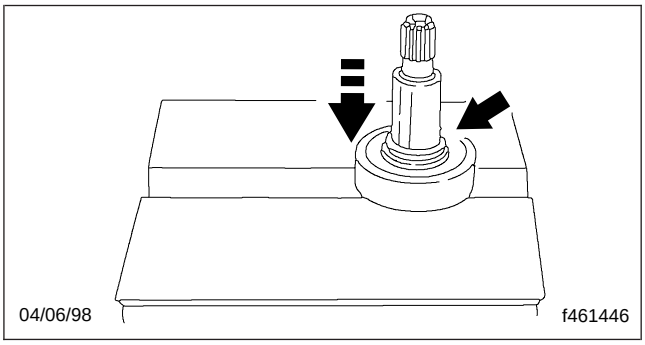
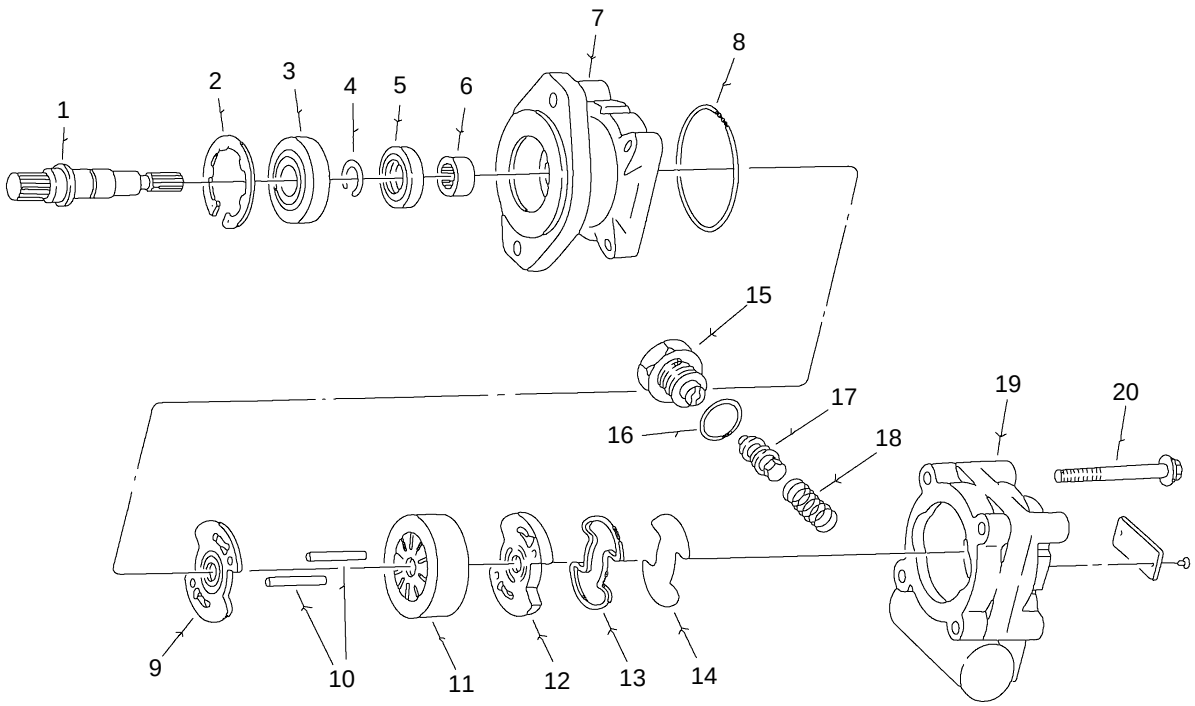


Fig. 9, Press a Bearing onto the Driveshaft

Aluminum Power Steering Pump Disassembly and Assembly

Disassembly

1. Clamp the power steering pump in a soft-jawed vise.
2. Mark the position of the cover and housing, then remove four power steering pump cover retaining bolts. See **Fig. 1**.
3. Remove the protecting screw and O-ring. See **Fig. 2**.
4. Remove the valve spool together with the compression spring. See **Fig. 3**.
5. Lift the pressure plate from the housing. See **Fig. 4**.
6. Remove the sealing ring and the backup ring from the pressure plate. See **Fig. 5**.
7. Remove the rotor set together with the needle rollers. See **Fig. 6**.
8. Remove the needle rollers and the vanes from the rotor.
9. Remove the pressure plate. See **Fig. 7**.
10. Remove the retaining ring. See **Fig. 8**.
11. Press the power steering shaft out of the power steering pump housing together with the ball bearing and snap ring. See **Fig. 9**.



04/07/98 f461522

1. Driveshaft
2. Retaining Ring
3. Ball Bearing
4. Retaining Ring
5. Shaft Seal
6. Needle Bearing
7. Housing
8. O-Ring
9. Pressure Plate
10. Needle Rollers
11. Pump Rotor
12. Pressure Plate
13. Sealing Ring
14. Backup Sealing Ring
15. Protecting Screw
16. O-Ring
17. Valve Spool
18. Compression Spring
19. Pump Cover
20. Bolt

Fig. 1, Aluminum Power Steering Pump

Aluminum Power Steering Pump Disassembly and Assembly

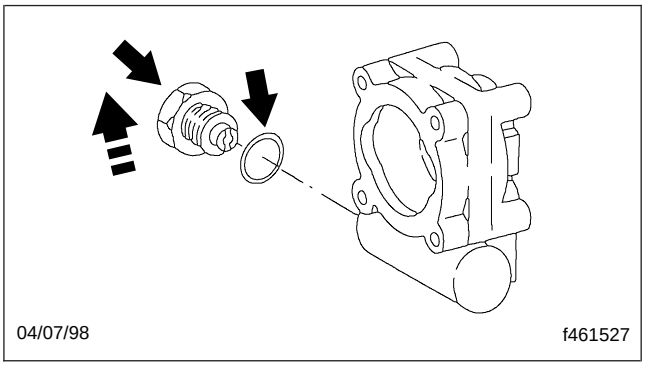


Fig. 2, Protect the Screw and O-Ring

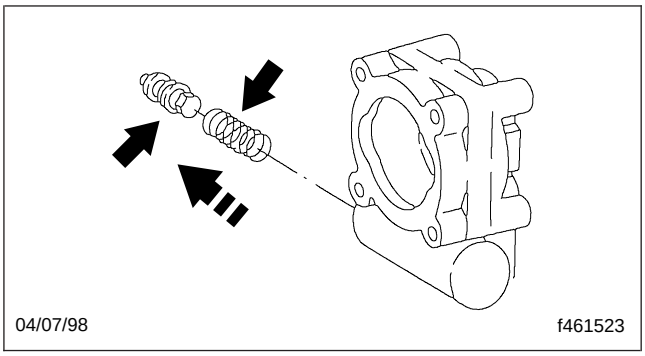


Fig. 3, Remove the Valve Spool and Compression Spring

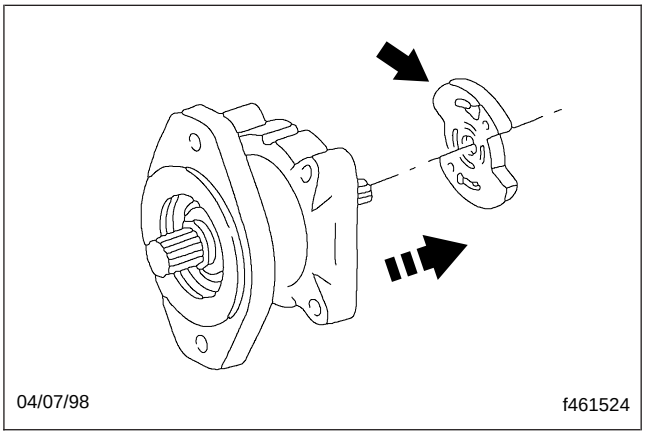


Fig. 4, Lift the Pressure Plate from the Housing

NOTE: Press the ball bearing from the shaft only if it is damaged. Release the bearing from the shaft by removing the snap ring/retaining ring.

12. Press the bearing from the shaft.

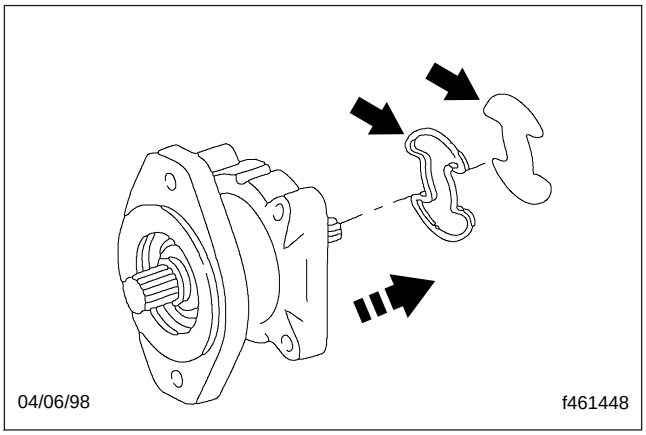


Fig. 5, Remove the Sealing Ring and Back-Up Ring

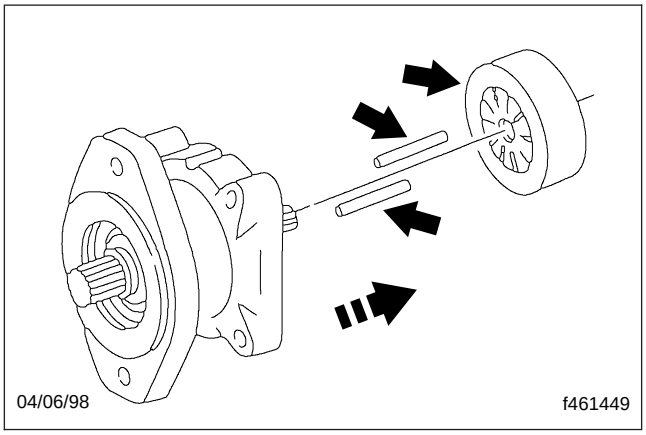


Fig. 6, Remove the Rotor Set and Rollers

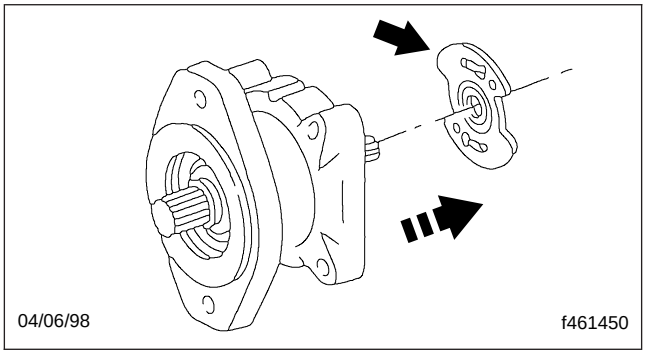


Fig. 7, Remove the Pressure Plate

13. Remove the shaft seal using a seal extractor. See **Fig. 10**.
14. Remove the O-ring from the pump housing. See **Fig. 11**.

Aluminum Power Steering Pump Disassembly and Assembly

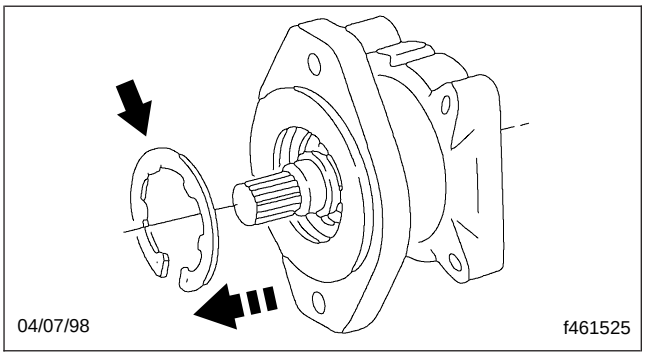


Fig. 8, Remove the Retaining Ring

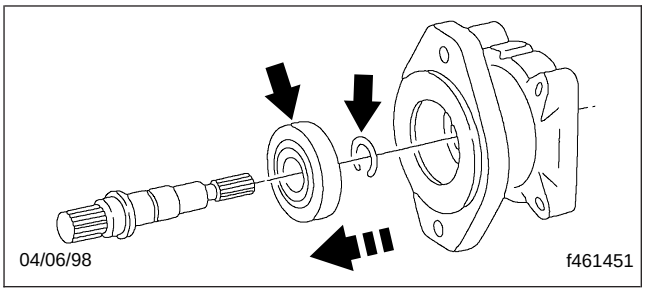


Fig. 9, Shaft, Bearing and Snap Ring

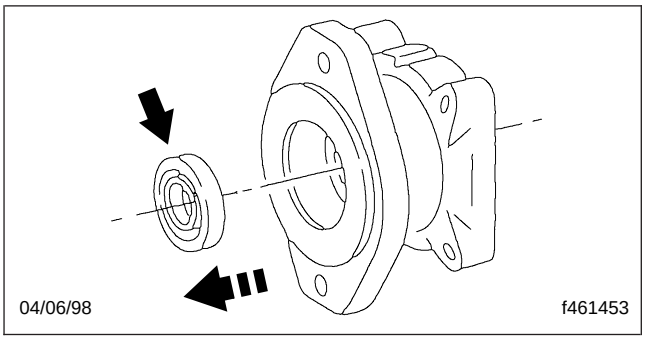


Fig. 10, Remove the Shaft Seal

15. If the shaft is damaged in the area of the needle sleeve bearing surface, remove the needle sleeve using the shaft seal extractor and counter support for shaft seal extractor or equivalents. See **Fig. 12**.

Assembly

1. If removed, press the needle sleeve onto the power steering pump shaft using the mandril tool. See **Fig. 13**.
2. Install the O-ring. See **Fig. 14**.

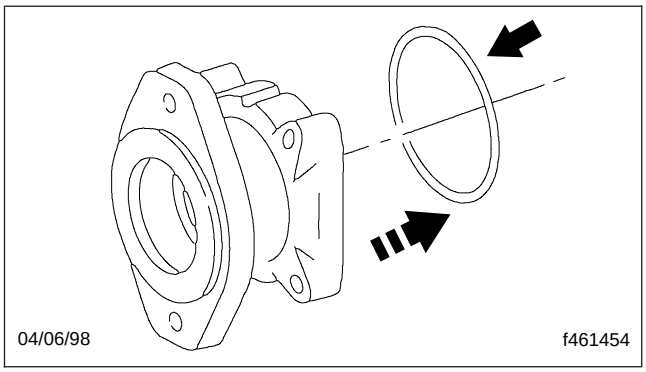


Fig. 11, Remove the O-Ring

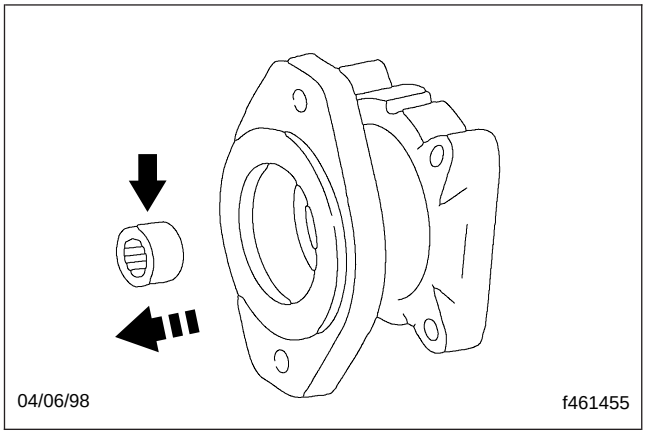


Fig. 12, Remove the Needle Sleeve

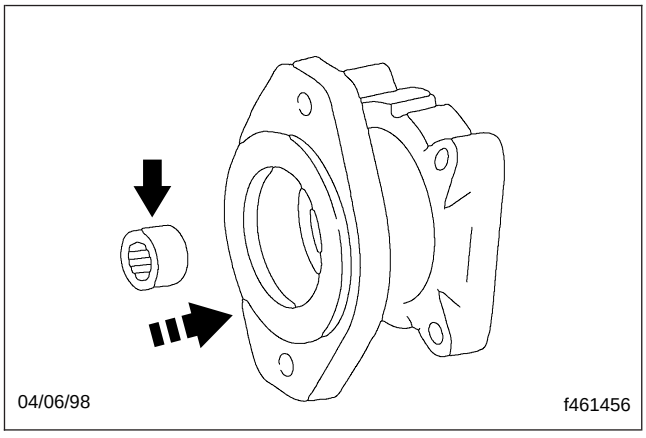


Fig. 13, Press the Needle Sleeve onto the Shaft

3. Install the shaft seal using the mandril tool. See **Fig. 15**.

Aluminum Power Steering Pump Disassembly and Assembly

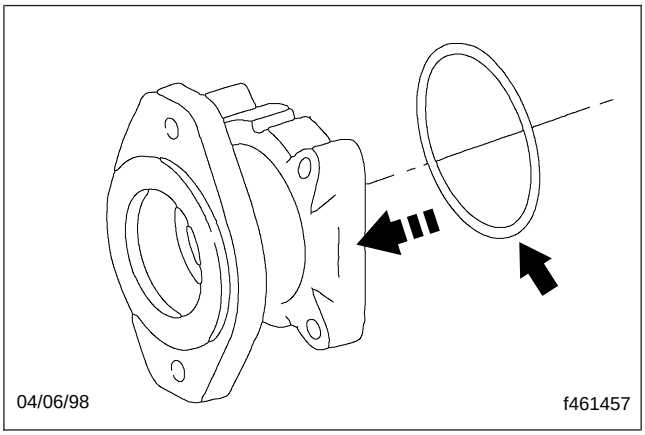


Fig. 14, Install the O-Ring

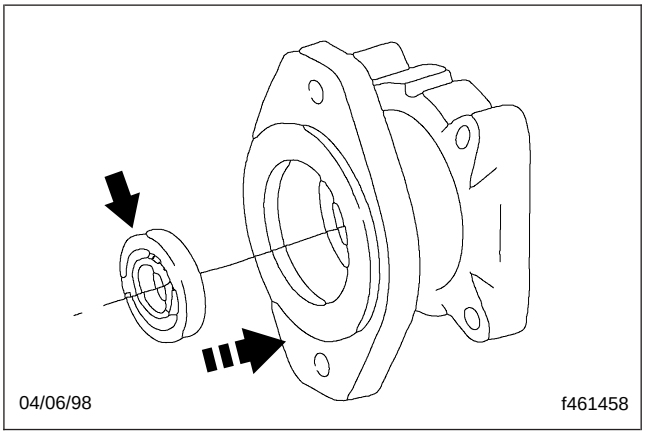


Fig. 15, Install the Seal into the Housing

4. Press the ball bearing onto the power steering pump shaft and secure with the bearing snap ring. See **Fig. 16**.

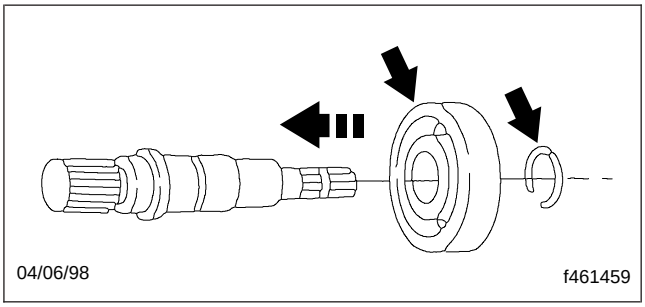


Fig. 16, Press the Bearing onto the Shaft

5. Press the shaft into the housing up to the stop and secure with the retaining ring. See **Fig. 17**.

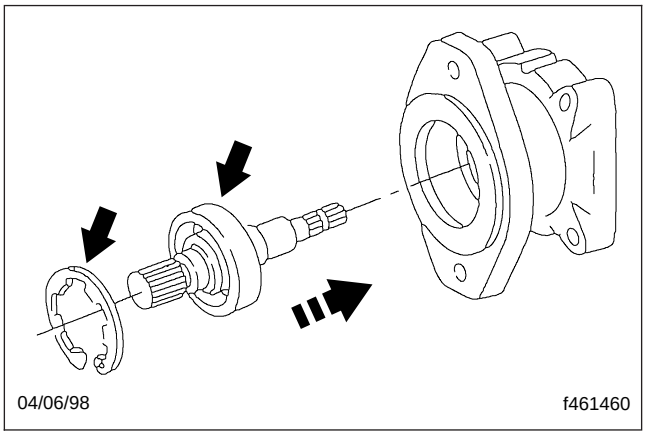


Fig. 17, Press the Shaft into the Pump Housing

6. Install the pressure plate onto the shaft. See **Fig. 18**.

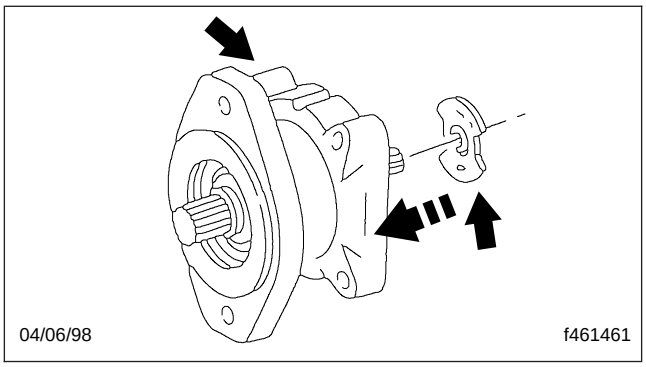


Fig. 18, Install the Pressure Plate

7. Install the 10 vanes into the rotor with the rounded, polished sides aligned to the curved ring.
8. Install the rotor onto the shaft with the internal chamfer toward the housing. See **Fig. 19**.

NOTE: Fit the curved ring so that the direction of the rotation arrows and the assembly markings are aligned.

9. Install the needle rollers in the curved ring, pressure plate and housing. See **Fig. 20**.
10. Install the compression spring and the spool valve into the cover. See **Fig. 21**.
11. Install the protecting screw and the O-ring. Tighten the screw 52 lbf·ft (70 N·m). See **Fig. 22**.

Aluminum Power Steering Pump Disassembly and Assembly

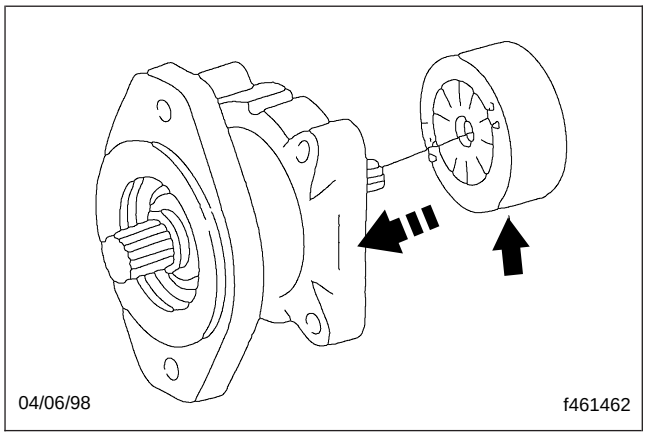


Fig. 19, Install the Rotor

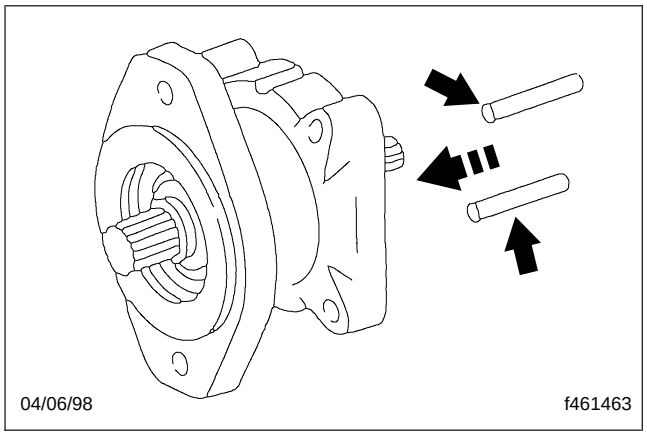


Fig. 20, Install the Needle Rollers

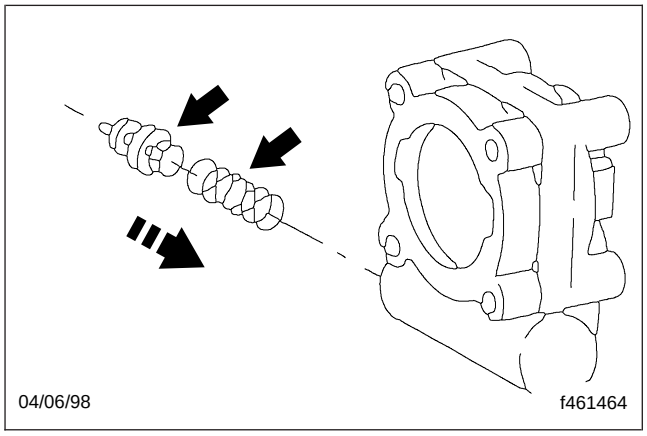


Fig. 21, Install the Compression Ring and Spool Valve

12. Install the power steering pump cover as marked and install the four power steering pump cover retaining bolts. Tighten the bolts 17 to 20 lbf·ft (23 to 27 N·m).

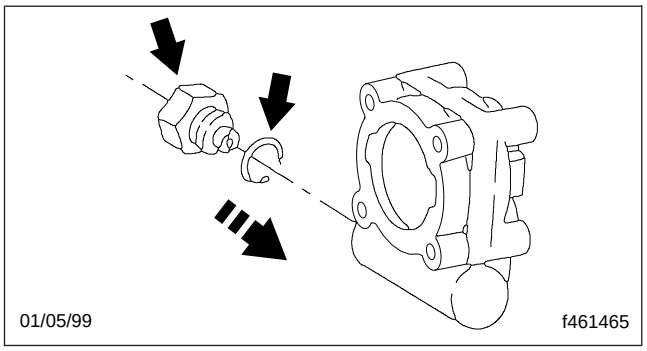


Fig. 22, Install the Protecting Screw

Power Steering Pump Removal and Installation

Removal

1. Turn off the engine, apply the parking brakes, and chock the rear tires.
2. Drain the power steering reservoir using a suction pump.
3. Place a drain pan under the power steering pump, and remove the hoses from the pump.
4. If necessary, remove the starter to access the power steering pump. For instructions, see **Group 15**.
5. Remove the capscrews that attach the power steering pump to the engine, and remove the pump and gasket.
6. If replacing the power steering pump, remove the fittings from the pump.

Installation

1. If necessary, install the fittings on the power steering pump. Torque the fittings 31 to 41 lbf·ft (42 to 56 N·m).
2. Using capscrews, install the gasket and pump on the engine. Torque the capscrews 27 to 32 lbf·ft (37 to 43 N·m).
3. Attach the power steering hoses to the pump, and torque the lines 31 to 42 lbf·ft (42 to 57 N·m).
4. Fill the power steering reservoir with Dexron® III automatic transmission fluid.
5. Bleed the air from the power steering system. For instructions, see **Section 46.02, Subject 100**.
6. Remove the chocks from the tires.

Power Steering Plumbing Components Removal and Installation

Power Steering Reservoir

Removal

1. Remove the filler cap and, using a suction gun, remove power steering fluid from the filler opening.
2. With the container nearby, disconnect the return hoses from the power steering reservoir and drain the reservoir into the container.
3. Loosen fasteners and remove the power steering reservoir from the bracket.

Installation

1. Position the power steering reservoir into the bracket. See **Fig. 1**.

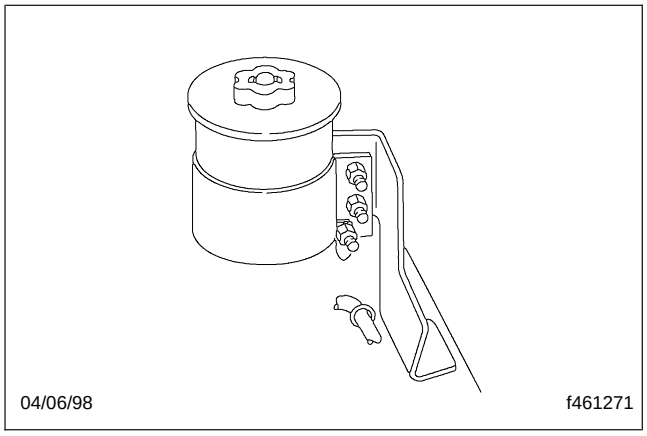


Fig. 1, Power Steering Fluid Reservoir

2. Fill the system with the recommended hydraulic oil. Then, bleed the air from the power steering hydraulic system.
3. Tighten the bolts.

Power Steering Fluid Filter Element

Removal

1. Drain the power steering reservoir using a suction pump.
2. Loosen the worm screw of the band clamp, then remove the cover and spring from the reservoir. See **Fig. 2**.

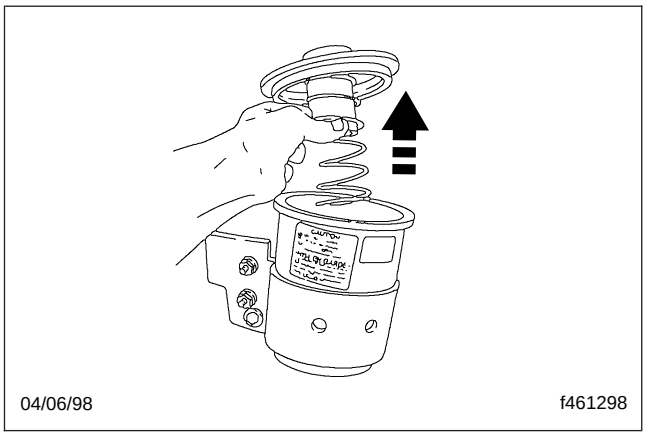


Fig. 2, Removing the Cover and Spring from the Reservoir

3. Remove the filter from the power steering reservoir. See **Fig. 3**.

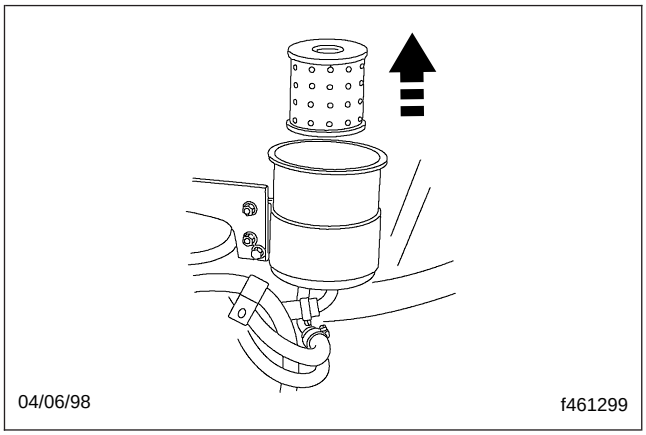


Fig. 3, Removing the Filter from the Reservoir

Installation

1. Install the new filter into the power steering reservoir.
2. Install the worm screw of the band clamp. Then install the cover and spring into the reservoir.
3. Fill the system with the recommended hydraulic oil. Then bleed the air from the power steering hydraulic system.

Power Steering Plumbing Components Removal and Installation

Power Steering Cooler

Removal

1. Position a suitable container below the power steering cooler connections.
2. Loosen the worm screw of the band clamps and disconnect the hoses.
3. Remove the two bolts and the power steering cooler assembly. See **Fig. 4**.

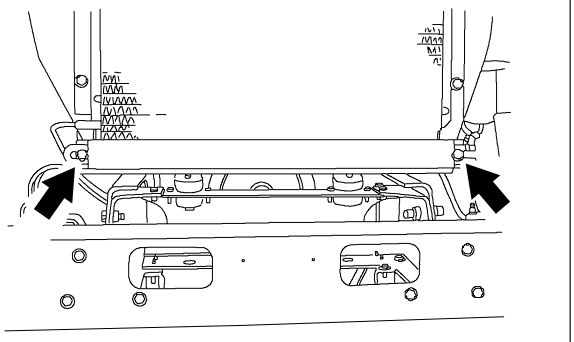


Fig. 4, Power Steering Cooler Bolts

Installation

1. Install the two power steering cooler assembly bolts. Tighten bolts to 31 lbf·ft (42 N·m). See **Fig. 4**.
2. Connect the hoses and install the worm clamps.
3. Fill the system with the recommended hydraulic oil. Then bleed the air from the power steering hydraulic system.

System Flushing

To flush the power steering system, follow the instructions provided with the Power Steering Analyzer.

System Bleeding

1. If bubbles are visible in the power steering fluid, bleed the air from the system.
2. Check the power steering reservoir fluid level and add Dexron® III automatic transmission fluid (ATF) if necessary.

⚠ WARNING

Do not hold the steering wheel in the far-left or far-right position for more than five seconds to avoid high temperature and possible damage to components.

3. Run the engine until the fluid reaches normal operating temperature.
4. Turn the steering wheel to the left and right completely (but not lock to lock), several times and return to center.
5. Check the fluid level and add Dexron® III ATF if necessary.

Final Fill

NOTE: The fluid level must show between the ADD and FULL mark on the dipstick or reservoir. If the fluid is below the ADD mark, add Dexron® III ATF.

NOTE: After any major power steering system or component overhaul, the system must be purged of hydraulic fluid and the oil filter discarded. Add clean ATF and install a new filter.

1. Check the fluid level in the power steering reservoir with the engine off. Use the HOT or COLD marks on the dipstick or reservoir, depending upon the fluid temperature.
   - 1.1 Use COLD for checking at 70°F (21°C).
   - 1.2 Use HOT for normal operating temperatures of 175°F (80°C).

⚠ CAUTION

Do not turn the steering wheel during the initial fill procedure.

Place the front wheels in a straight-ahead position and engage the parking brake.

2. Fill the reservoir with fluid and allow the fluid to gravity feed the system.
   - 2.1 Crack the pressure line fittings at the pump and steering gear.
   - 2.2 Tighten the fittings when fluid is visible.
   - 2.3 Keep adding fluid to the reservoir as required.
3. When the fluid level in the reservoir no longer goes down, start the engine. Continue to add fluid to the reservoir as required.

IMPORTANT: Do not exceed the FULL mark on the dipstick or reservoir.

4. After the fluid level in the reservoir no longer goes down, rotate the steering wheel to full-right and full-left turns, stop to stop. Add fluid as required.
5. Continue the process until the fluid level no longer changes. Fluid level is correct when it is in the FULL range on the dipstick or reservoir.
6. Place the front wheels in a straight-ahead position and set the parking brake.

NOTE: When a minor leak is corrected, follow the next steps.

7. Fill the reservoir to the FULL mark on the dipstick or reservoir.
   - 7.1 Start the engine and let idle for several minutes.
   - 7.2 Check fluid level and add as required.
8. Rotate the steering wheel to full-right and full-left turns, stop to stop, several times.
9. Stop the engine and check fluid level. Fill the reservoir to FULL range indicated on the dipstick or reservoir.

General Information

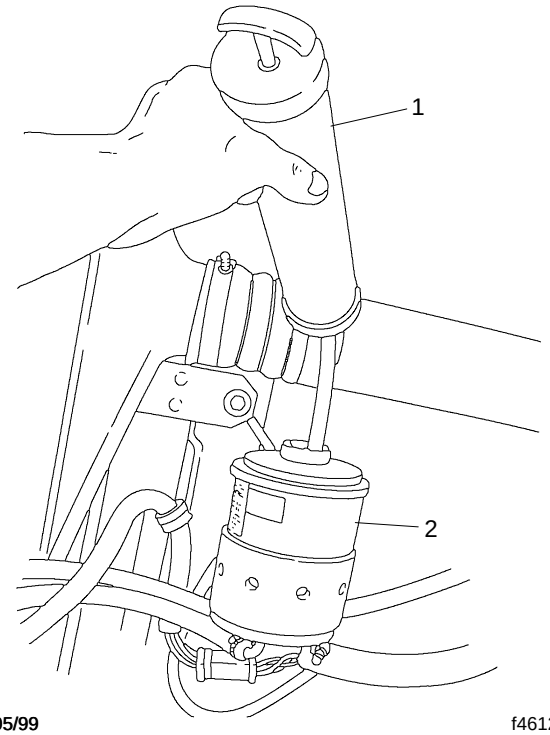
Some heavy-truck power steering systems are equipped with a rotary assist cylinder to increase power steering forces. The rotary assist cylinder is similar in design to the power steering gear but without the worm gear and valve components that attach to the steering wheel.

The rotary assist cylinder consists of a combined cylinder and gear box that contains a piston with an integral rack. The rack meshes with a gear sector that connects to a pitman arm and steering linkage similar to the integral power steering gear.

The piston operates from pressure supplied from and controlled by the integral power steering gear. When the integral gear supplies pressure to the top of its own piston, it supplies pressure to the top of the auxiliary cylinder piston. When it supplies pressure to the bottom of its own piston, it supplies pressure to the bottom of the auxiliary cylinder piston.

Removal

1. Drain the power steering system using a suction pump. See **Fig. 1**.



1. Suction Pump 2. Reservoir

Fig. 1, Drain the Power Steering Fluid Reservoir

NOTE: Plug all port holes immediately after removing the hoses and before removing the gear from the vehicle to prevent foreign matter from entering.

2. Disconnect the hydraulic fluid lines at the rotary assist cylinder. Plug all port and line openings. See **Fig. 2**.
3. Remove the pitman arm. For instructions, see **Section 46.01, Subject 120**.
4. If replacing the rotary assist cylinder, remove the power steering hose fittings from the rotary assist cylinder. See **Fig. 3**.
5. Remove the four nuts and bolts, then remove the cylinder. See **Fig. 4**.

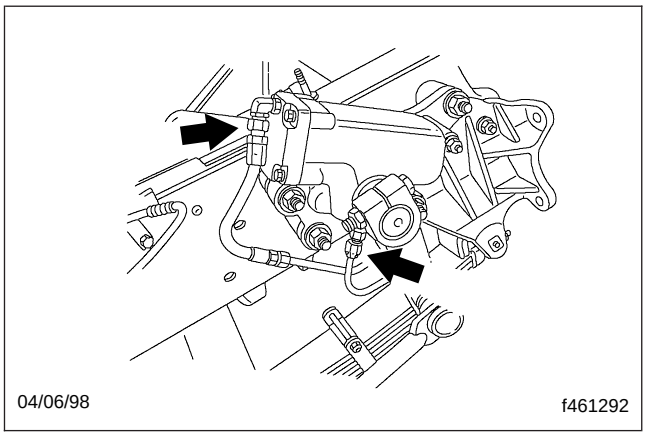


Fig. 2, Hydraulic Fluid Lines

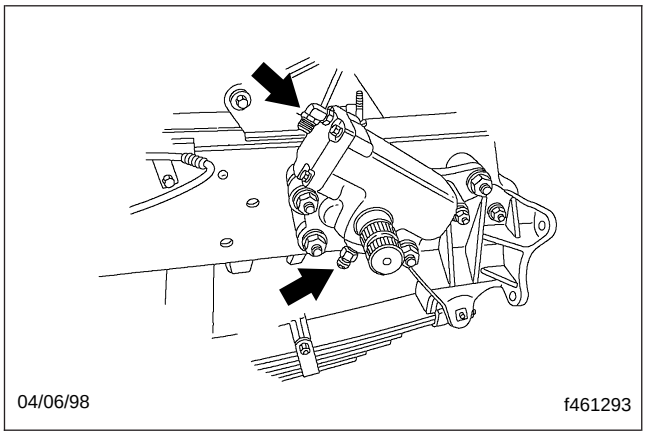


Fig. 3, Hose Fittings

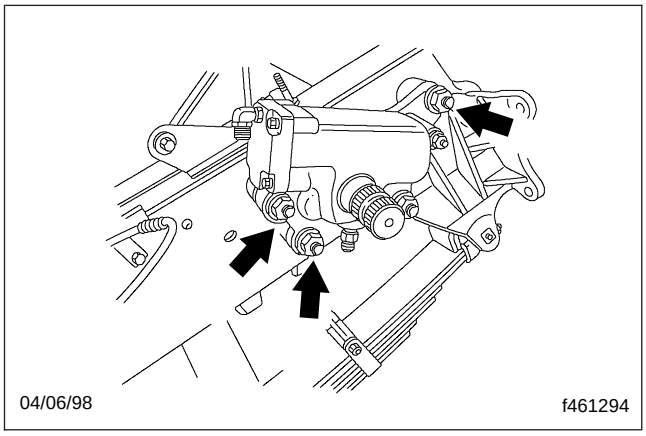


Fig. 4, Nuts and Bolts

Removal and Installation

Installation

1. Position the rotary assist cylinder and install the four retaining nuts and bolts. Tighten 360 to 480 lbf·ft (488 to 650 N·m). See **Fig. 4**.
2. Install the pitman arm. For instructions, see **Section 46.01, Subject 120**.
3. Install the power steering hose fittings and tighten 31 to 42 lbf·ft (42 to 57 N·m). See **Fig. 3**.
4. Connect the hydraulic fluid lines to the rotary assist cylinder. Tighten 31 to 42 lbf·ft (42 to 57 N·m). See **Fig. 2**.
5. Fill the system with the recommended hydraulic oil. See **Specifications 400** for approved power steering fluids. Bleed the air from the power steering hydraulic system.

Disassembly

⚠ WARNING

Wear eye protection and be sure to comply with OSHA or other maximum air pressure requirements.

⚠ CAUTION

Never steam clean or high-pressure wash hydraulic steering components. Do not force or abuse closely fitted parts, or component damage can result.

NOTE: The special tools used in this procedure are available from SPX Kent-Moore, Warren, MI 48092, 800-328-6657.

NOTE: Thoroughly clean and dry the rotary assist cylinder before disassembly. During disassembly of the rotary assist cylinder, clean all parts in fresh, petroleum base solvent, and blow dry. Keep each part separate to avoid nicks and burrs.

See **Fig. 1** for an exploded view of the rotary assist cylinder gear.

1. Put the cylinder in a vise, clamping firmly against the housing mounting flange or boss.

   The piston bore should be horizontal and the side cover and end cover are accessible for disassembly. See **Fig. 2**.

2. Place a suitable container under the gear, then unplug the hydraulic ports. See **Fig. 3**.
3. Rotate the sector 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.

   This will position the sector shaft for removal (rotary cylinder is now in its center of travel). See **Fig. 4**.

4. Remove and discard the dirt and water seal from the housing trunnion. See **Fig. 5**.
5. Remove any paint or corrosion from the exposed area of the sector shaft, using a fine grade emery cloth. See **Fig. 6**.
6. Tape the serrations and bolt groove of the sector shaft with one layer of masking tape.

   The tape should not extend onto the sector shaft bearing diameter. See **Fig. 7**.

7. Remove the sector shaft adjusting screw jam nut. See **Fig. 8**.
8. Remove the six special bolts from the side cover. See **Fig. 9**.
9. Remove the side cover and sector shaft assembly from the cylinder.

   Start the shaft and cover assembly removal by tapping the end of the shaft lightly with a soft mallet or wooden hammer handle. See **Fig. 10**.

10. Remove and discard the side cover gasket. See **Fig. 11**.
11. Remove and discard the vent plug. See **Fig. 12** .
12. Turn the sector shaft adjusting screw clockwise through the side cover and pull the sector shaft out of the side cover. See **Fig. 13**.

IMPORTANT: Do not damage the bore or DU bushing when removing the seal.

13. Remove the seal.

    13.1 Clamp the side cover in a vise.

    13.2 Place a standard 5/8-inch or 11/16-inch, 3/8-inch drive socket in the center of the side cover.

    13.3 Pry the seal out with a rolling head pry bar, using the socket for support.

    13.4 Discard the seal and remove the socket.

NOTE: The retainer must be securely staked in place. The adjusting screw must rotate by hand with no perceptible end play (lash).

14. Inspect the sector shaft assembly for damaged adjusting screw threads. See **Fig. 14**.

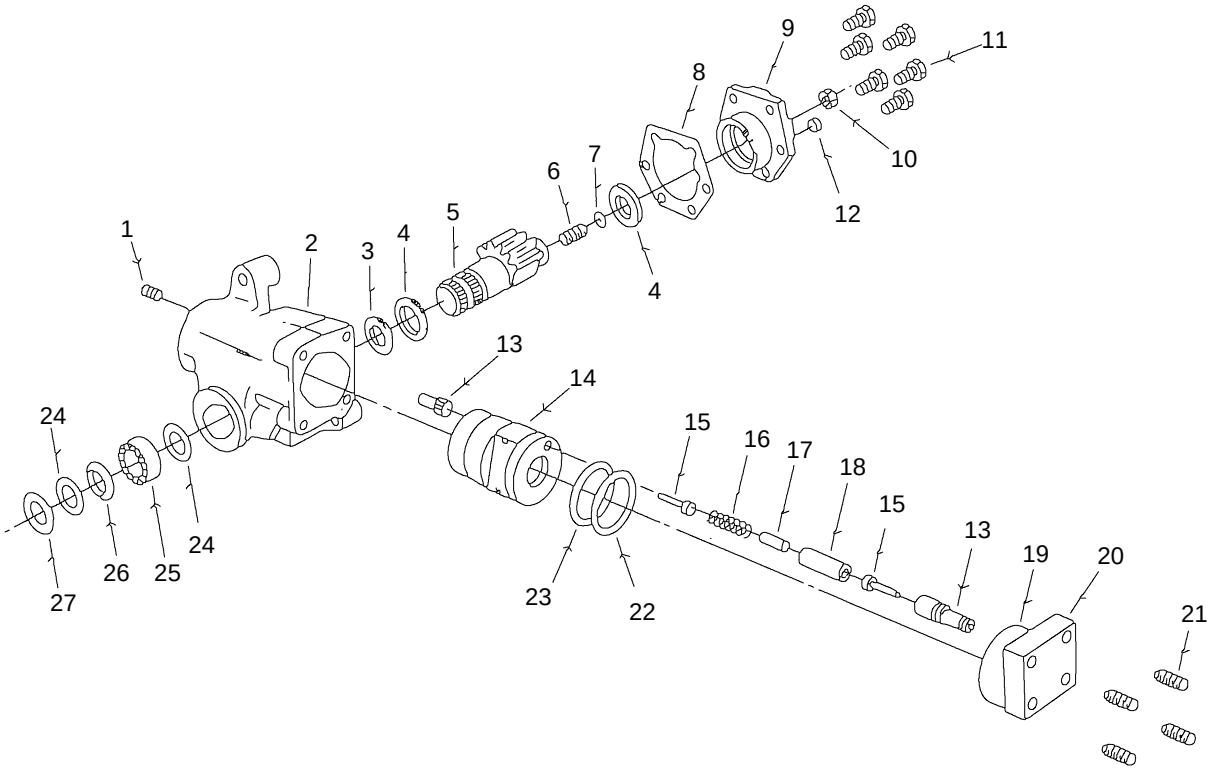
NOTE: Mark the orientation of the end cover to the housing prior to removal of the end cover.

15. Remove the four Torx® head end cover bolts and the end cover. See **Fig. 15**.

IMPORTANT: The set position of poppet seat and sleeve assemblies must not be disturbed if the poppets are not going to be replaced or reset during disassembly.

16. Remove the piston subassembly and place it on a clean cloth. See **Fig. 16**.

Disassembly and Assembly



04/06/98 f461372

1. Fixed Poppet Stop Screw
2. Housing
3. Washer (spacer)
4. Seal (output)
5. Sector Shaft
6. Sector Shaft Adjusting Screw
7. Adjusting Screw Retainer
8. Side Cover Gasket
9. Side Cover Assembly
10. Jam Nut
11. Side Cover Bolts (6)
12. Vent Plug
13. Poppet Seat and Sleeve Assembly
14. Piston (rack)
15. Poppet
16. Poppet Spring
17. Spacer Rod
18. Push Tube
19. Valve Housing Seal Ring
20. End Cover
21. End Cover Bolts (4)
22. Teflon® Seal Ring
23. Backup Piston O-Ring
24. Retaining Ring
25. Roller Bearing
26. Dirt Seal
27. Trunnion Dirt and Water Seal

Fig. 1, Rotary Assist Cylinder Gear

17. Remove and discard the end cover seal ring. See **Fig. 17**.
18. Cut and remove the Teflon® seal ring and O-ring from the piston. See **Fig. 18**.

NOTE: TRW recommends that the poppet adjuster seat and sleeve assemblies not be removed unless replacement of the poppet components is required.

19. Push the poppet stems and the poppet seat. The poppet stems should spring back and the poppet seats should not move by hand. See **Fig. 19**.

NOTE: If components are bent or broken, the poppet stems do not spring back, or the poppet seat moves by hand, proceed to the next step. If poppet component replacement is not necessary, skip the next nine steps.

20. Place the piston in a soft-jawed vise. See **Fig. 20**.

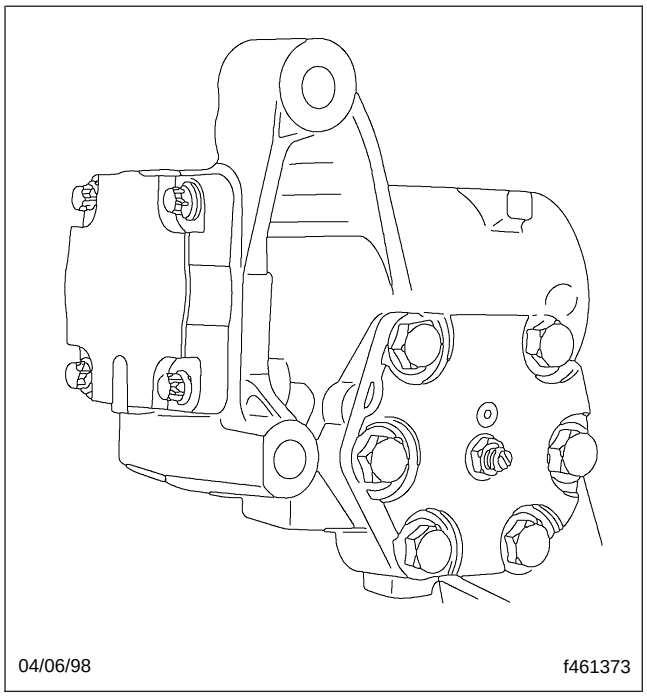


Fig. 2, Correct Position of the Steering Gear

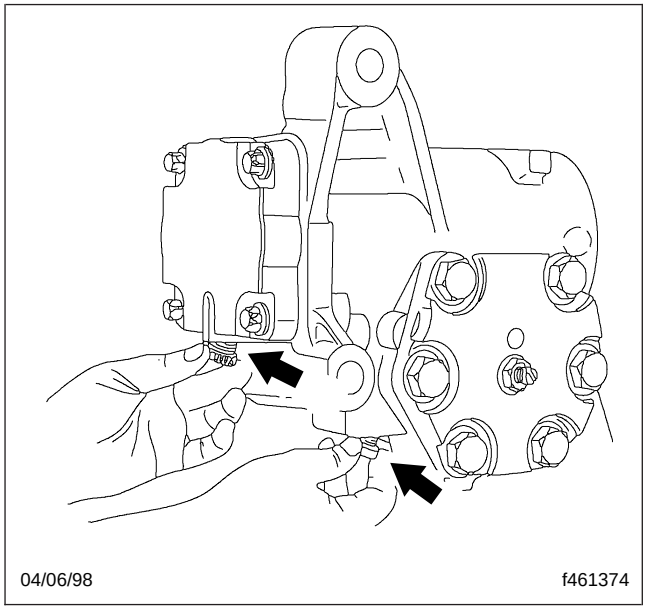


Fig. 3, Unplug the Hydraulic Ports

NOTE: Poppet adjuster seat and sleeve assemblies are retained by Loctite® applied to the threads, which makes the assemblies difficult to remove.

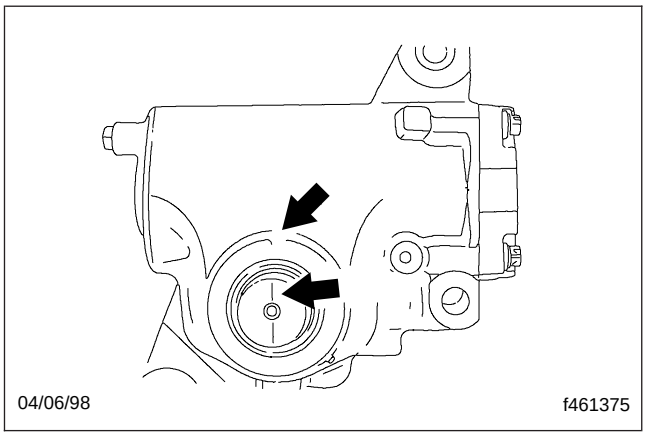


Fig. 4, Line Up the Timing Marks

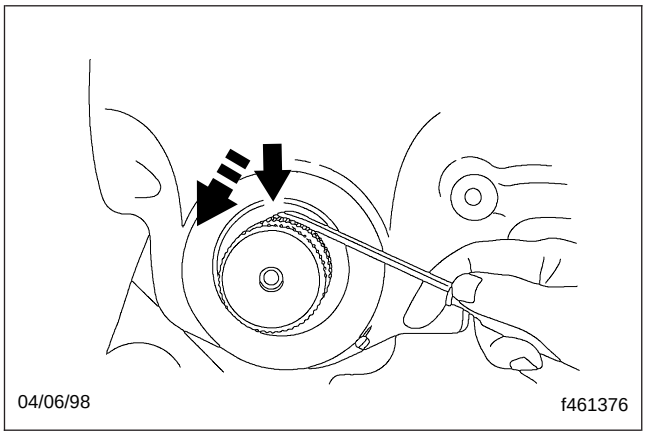


Fig. 5, Remove the Dirt and Water Seal

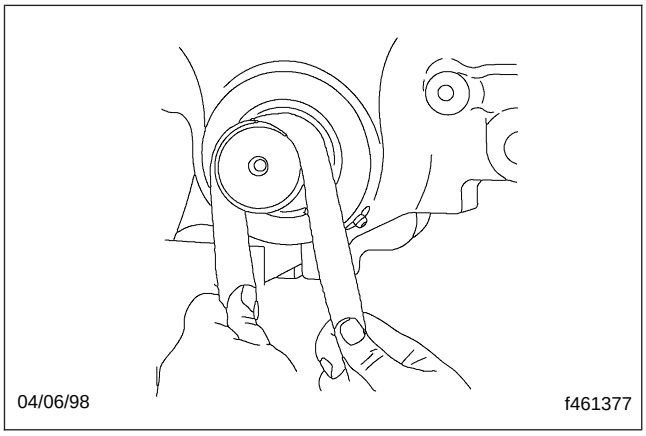


Fig. 6, Remove the Paint and Corrosion

Disassembly and Assembly

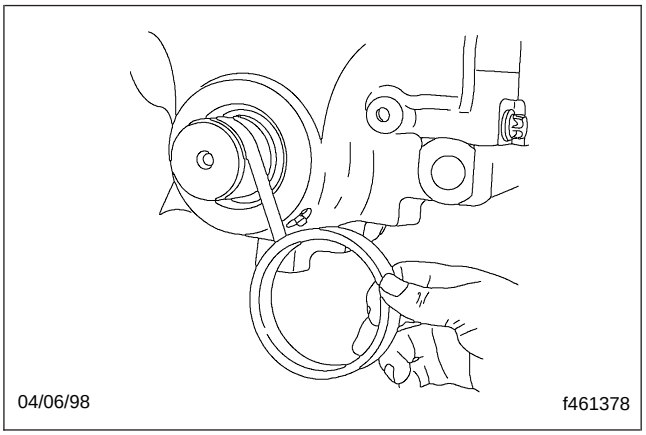


Fig. 7, Tape the Sector Shaft

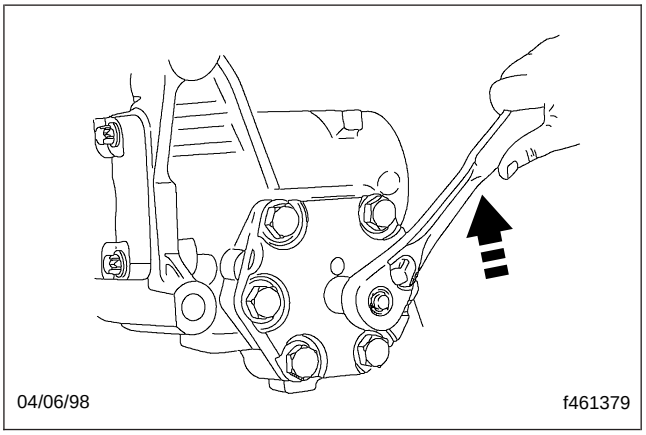


Fig. 8, Remove the Sector Shaft Screw Jam Nut

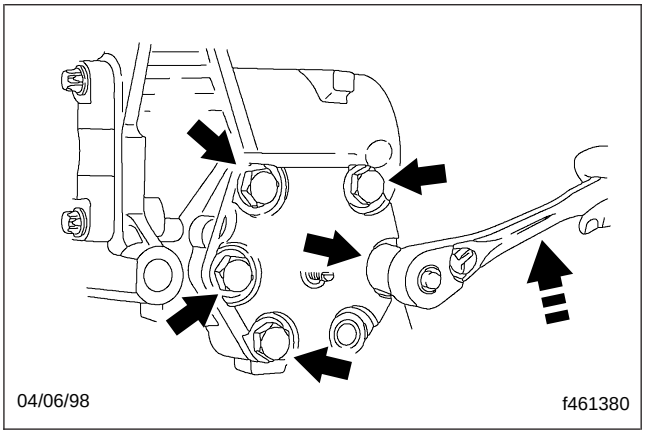


Fig. 9, Remove the Six Side Cover Bolts

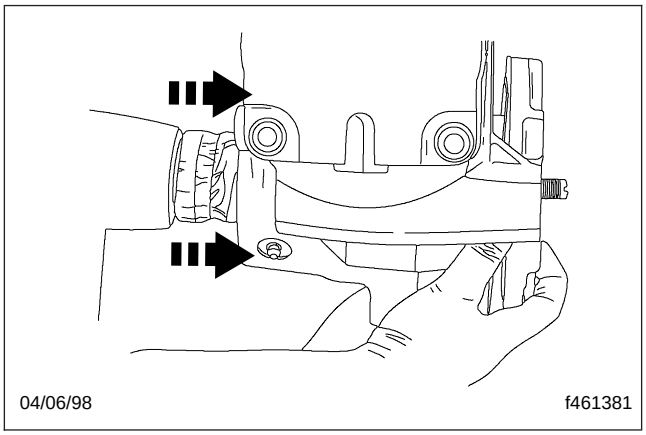


Fig. 10, Remove the Side Cover and Sector Shaft

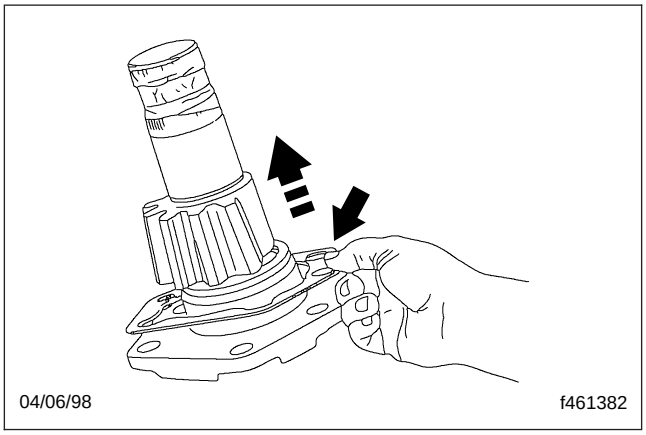


Fig. 11, Remove the Side Cover Gasket

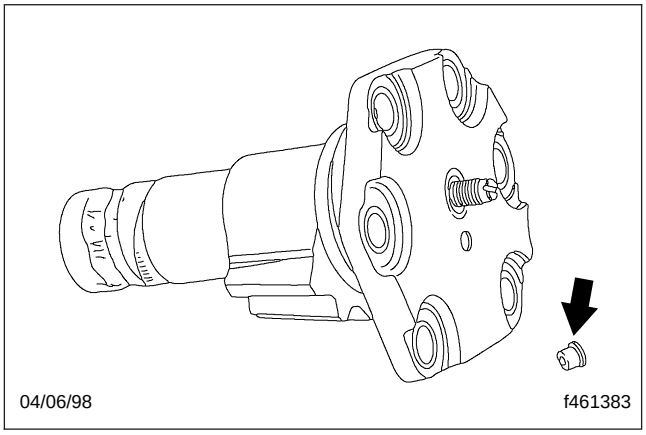


Fig. 12, Remove the Vent Plug

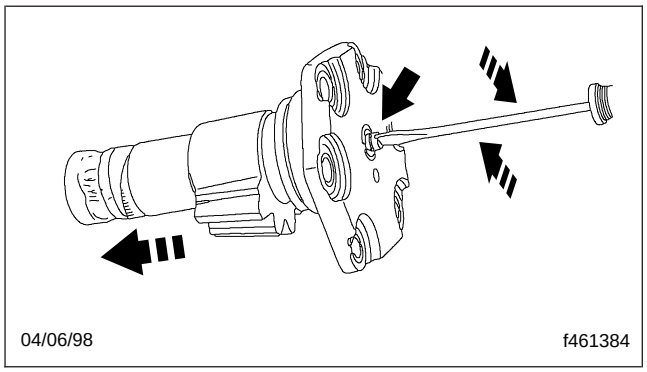


Fig. 13, Remove the Sector Shaft

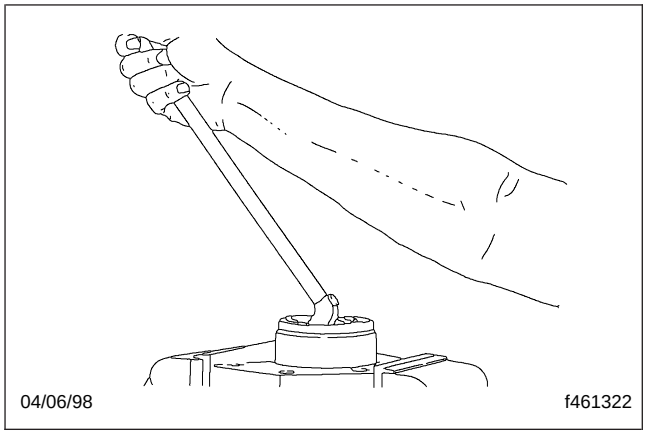


Fig. 14, Inspect the Sector Shaft Assembly

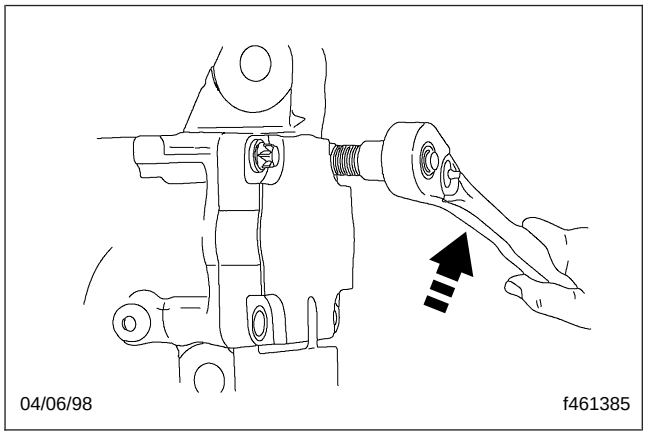


Fig. 15, Remove the End Cover

21. Slide the poppet adjusting seat tool over the seat of the poppet adjuster seat and sleeve assembly and engage the tool in the slots in the threaded sleeve.

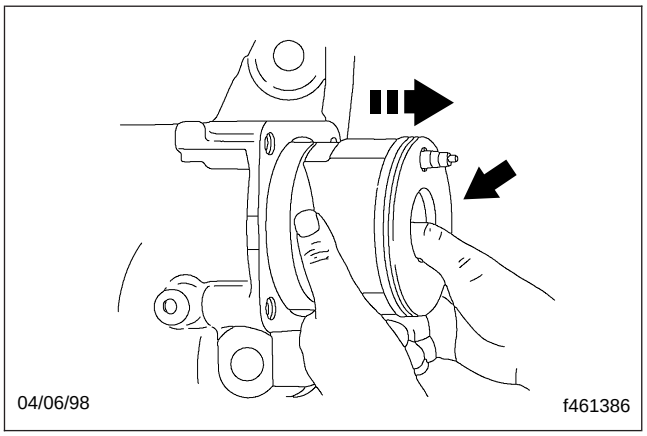


Fig. 16, Remove the Piston Subassembly

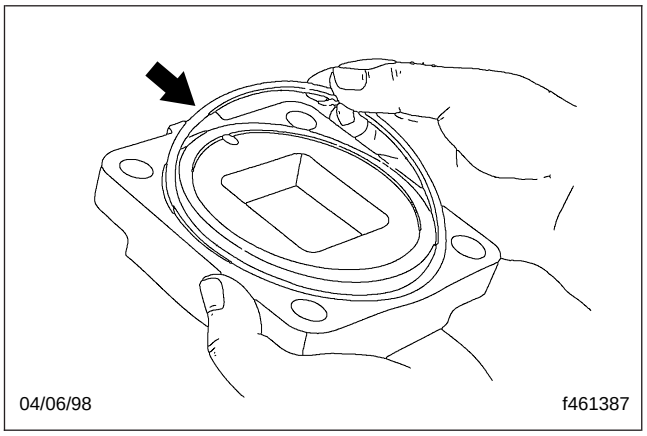


Fig. 17, Remove the End Cover Seal Ring

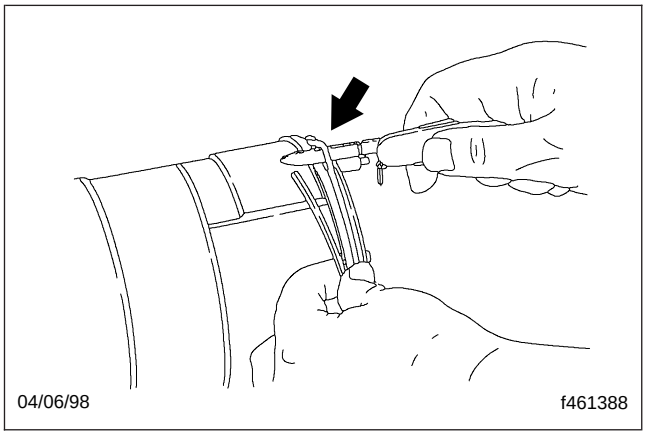


Fig. 18, Remove the O-Ring

Disassembly and Assembly

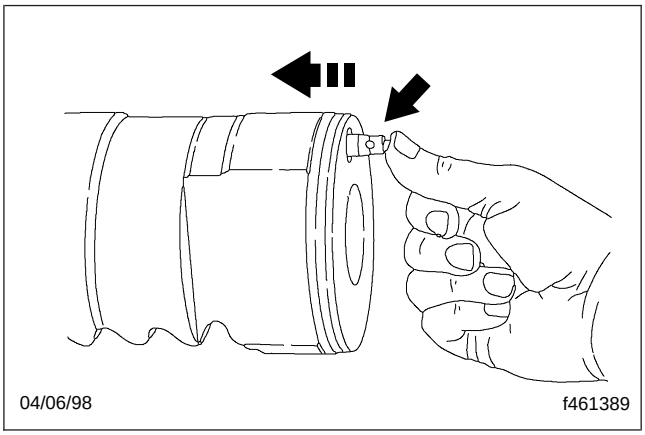


Fig. 19, Push the Poppet Stems and Seat

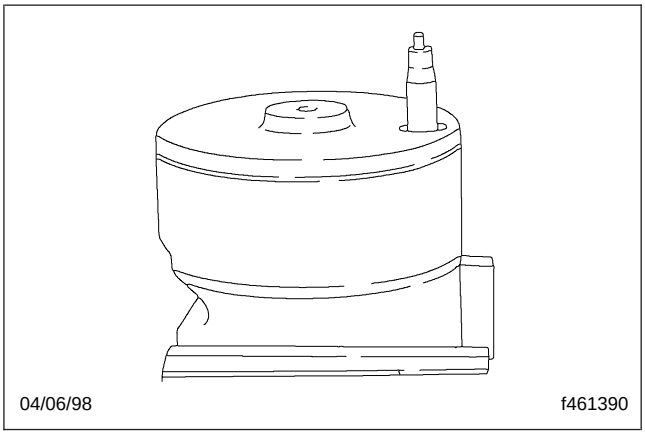


Fig. 20, Piston in a Soft-Jawed Vice

Hit the end of the tool firmly, four or five times with a 2-pound sledge hammer, to loosen the Loctite®. See **Fig. 21**.

22. With a ratchet applied to the tool, turn one adjuster seat and sleeve assembly out of the piston. See **Fig. 22**.

    22.1 If the ratchet does not turn easily, strike the adjuster removal tool again with a hammer.

    22.2 If the engaging tangs will not stay in place while loosening, it might be necessary to hold in place with an arbor press while applying loosening torque.

    22.3 Discard the poppet seat and sleeve assembly.

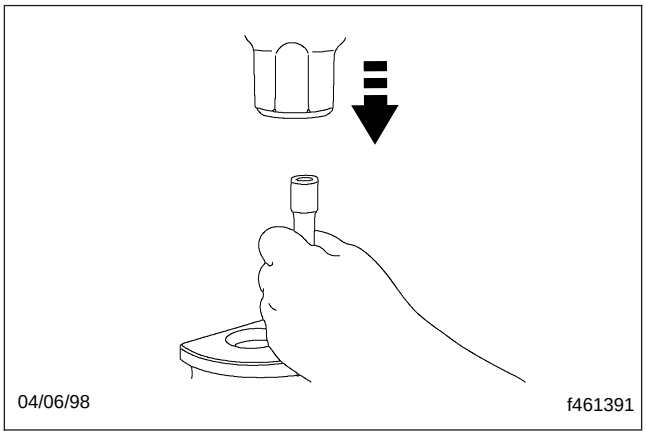


Fig. 21, Loosen the Poppet Adjuster Seat and Sleeve Assembly

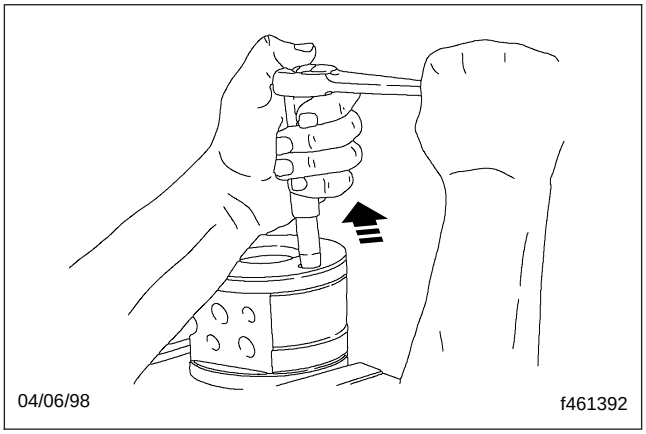


Fig. 22, Remove Seat and Sleeve Assembly from Piston

23. Remove the two poppets, spring, spacer rod, and push tube. See **Fig. 23**.

NOTE: It is possible to reset one poppet adjuster seat and sleeve assembly for automatic poppet adjustment while it is in the piston, if one adjuster seat and sleeve assembly and poppets, spring, spacer rod, and push tube are removed.

24. Remove and discard the remaining poppet seat and sleeve assembly only if required. See **Fig. 24**.

25. If one poppet seat and sleeve assembly was left in the piston, it can be reset for automatic poppet adjustment by inserting a 3/8-inch diameter x 6-inch (9.52 x 152.4 mm) drill rod down through the poppet seat hole at the opposite end of the

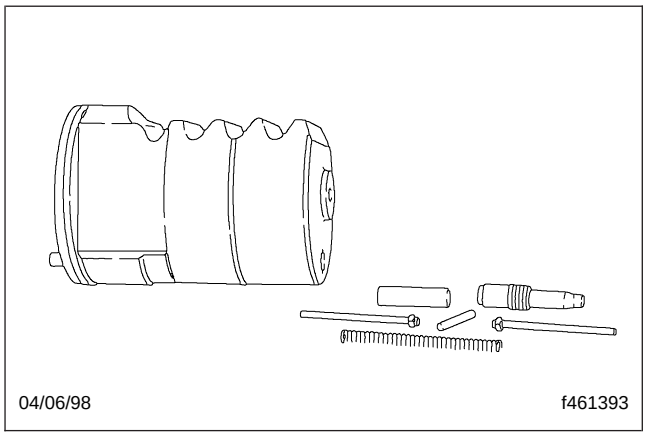


Fig. 23, Poppet Assembly Removed

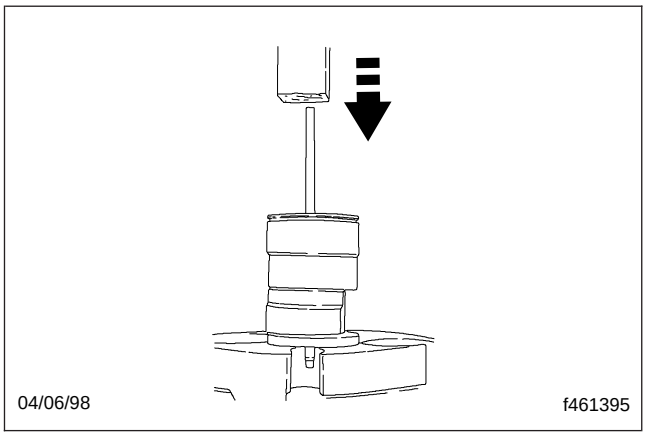


Fig. 25, Reset Poppet Assembly

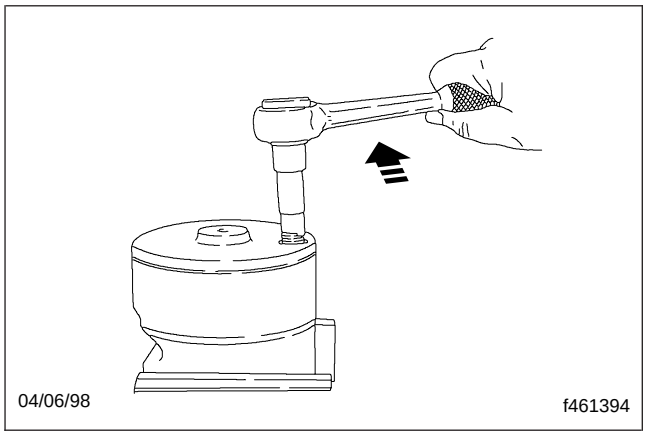


Fig. 24, Remove Remaining Poppet Assembly

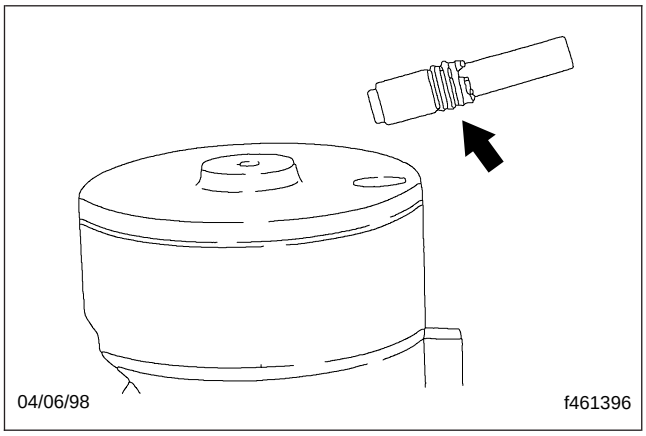


Fig. 26, Poppet Threads

piston and against the adjuster seat, to press the seat in until it bottoms against the adjuster sleeve. See **Fig. 25**.

CAUTION

Do not allow Loctite® or Locquic® to get on the adjuster seat and sleeve assembly. The poppets will not function properly.

26. Carefully apply Locquic® T primer or equivalent to the threads in poppet holes and threads on the new seat and sleeve assemblies. Allow to dry for 10 minutes, then carefully apply Loctite® RC680 or equivalent to same threads. See **Fig. 26**.

WARNING

Wear eye protection while assembling poppets. Spring-loaded poppets could eject and cause eye injury.

27. Place the piston in a soft-jawed vise and turn one new poppet adjuster seat and sleeve assembly, with slotted end out, into the poppet hole in one end of the piston. See **Fig. 27**.
28. From the other end of the poppet hole in the piston, install one poppet, poppet spring, nylon spacer rod, push tube, the other poppet, and the other new poppet adjuster seat and sleeve assembly.

Disassembly and Assembly

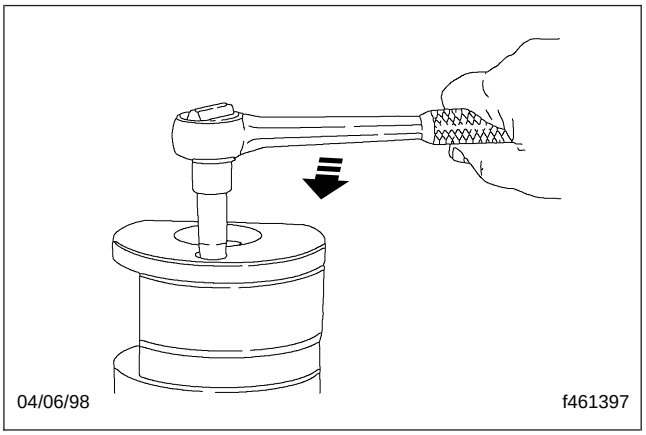


Fig. 27, Install the Poppet Assembly

Using the poppet adjusting seat tool and a torque wrench, tighten both the poppet adjuster seat and the sleeve assemblies to 18 lbf·ft (25 N·m).

29. Remove the retaining ring that is closest to the output end of the housing trunnion. See **Fig. 28**.

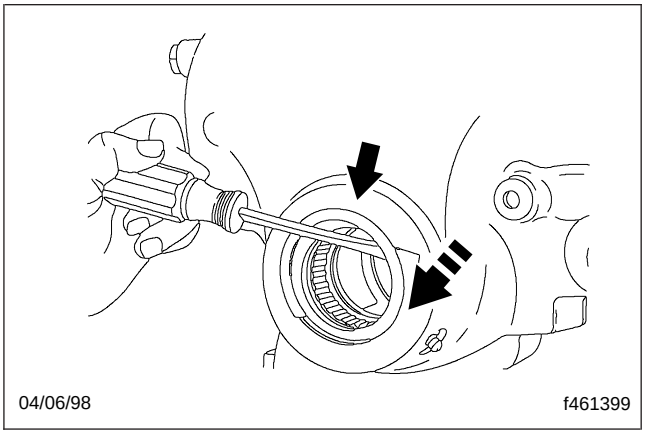


Fig. 28, Remove the Retaining Ring

30. Remove and discard the dirt seal. See **Fig. 29**.

NOTE: Be careful not to damage the sealing area of the bore or the spacer washer when performing this step.

31. Insert a screwdriver into the housing bearing bore from the trunnion end and carefully push the seal and spacer washer out of the other end of the bearing bore. Discard the seal. See **Fig. 30**.

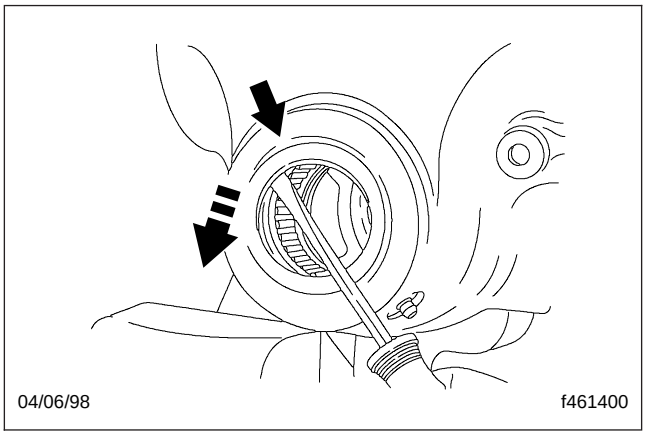


Fig. 29, Remove the Dirt Seal

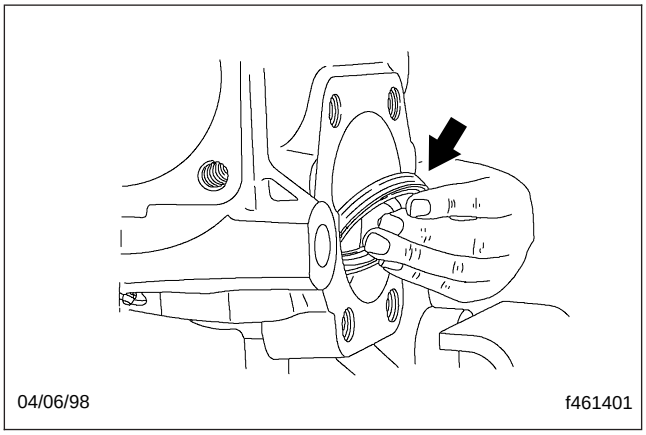


Fig. 30, Remove the Seal and Spacer Washer

32. Inspect the roller bearing in the housing for brinelling or spalling and the retaining ring for damage.

⚠ CAUTION

The bearing must be pressed out from the side cover side to protect the seal counterbore. Be sure to use a bearing removal tool that will clear the retaining ring.

33. If the roller bearing in the housing needs to be replaced, place the bearing removal end of the bearing and seal tool against the side cover end of the bearing and press it out of the trunnion end of the bearing bore. Discard the bearing. See **Fig. 31**.

34. If the retaining ring that is still in the housing bore needs to be replaced, remove it through the

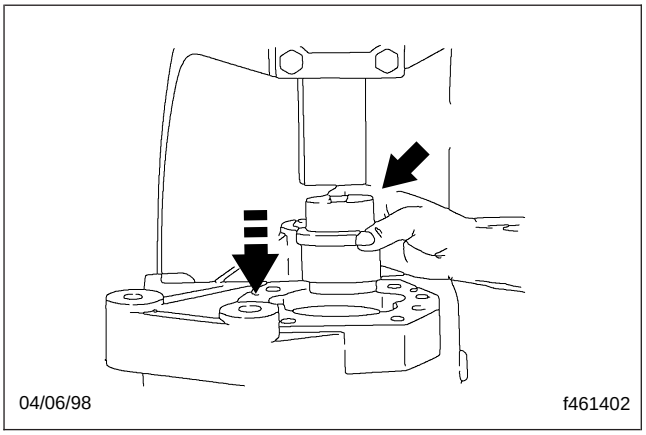


Fig. 31, Remove the Roller Bearing

trunnion end of the bearing bore, to protect the pressure seal bore area from being damaged. See **Fig. 32**.

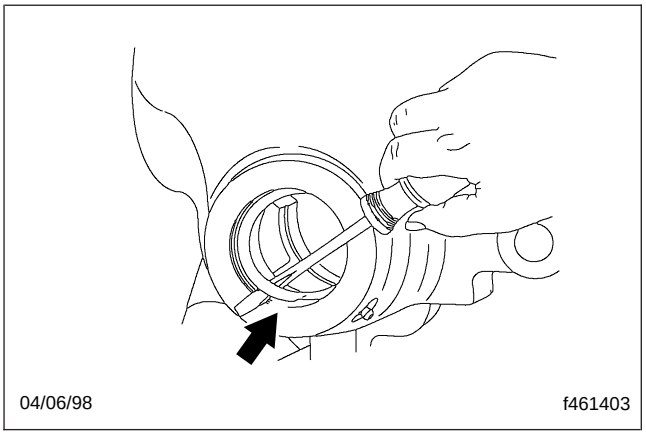


Fig. 32, Remove the Retaining Ring

Assembly

1. Insert the retaining ring, if it was removed, into the housing bore from the trunnion end, to protect the sealing area.

   Verify that the retaining ring is seated in the retaining ring groove closest to the side cover end of the bearing bore.

   Lubricate the bearing bore. See **Fig. 33**.

⚠ CAUTION

Use the bearing installation end of the tool. If the bearing removal end of the bearing and seal tool

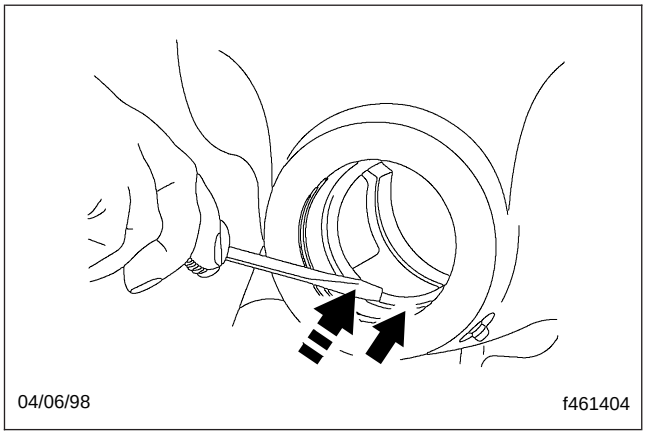


Fig. 33, Install the Retaining Ring

is used to press in the bearing, the cage on the new bearing can be damaged.

2. Press the roller bearing into the housing from the trunnion end of bearing bore, using the installation end of the bearing and seal tool, until it is seated against the retaining ring.

   Verify the housing is square with the press base and the bearing is not cocked. See **Fig. 34**.

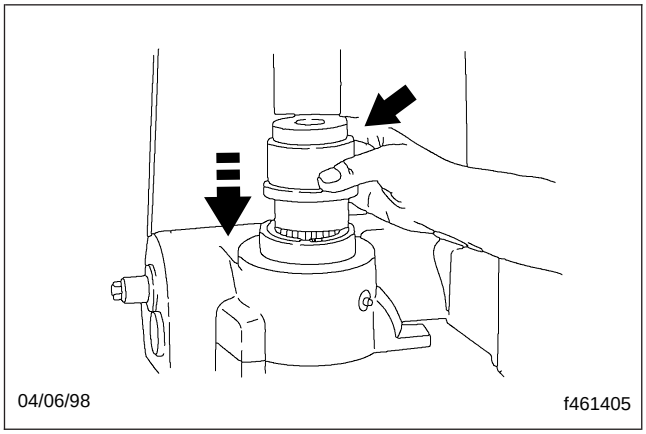


Fig. 34, Install the Roller Bearing

NOTE: Perform an inspection of the components prior to assembling the rotary steering gear.

3. Inspect the poppet fixed stop screw or poppet adjusting screw for damage.

NOTE: If damaged, remove the fixed poppet stop screw and sealing nut without allowing the nut to change its position on the screw.

Disassembly and Assembly

4. Assemble the new nut onto the adjusting screw, matching its position to the nut and screw removed. Tighten the sealing nut to 35 lbf·ft (47 N·m).
5. Install a new dirt seal into the trunnion end of the housing sector shaft bore and against the bearing, with the seal lip out. See **Fig. 35**.

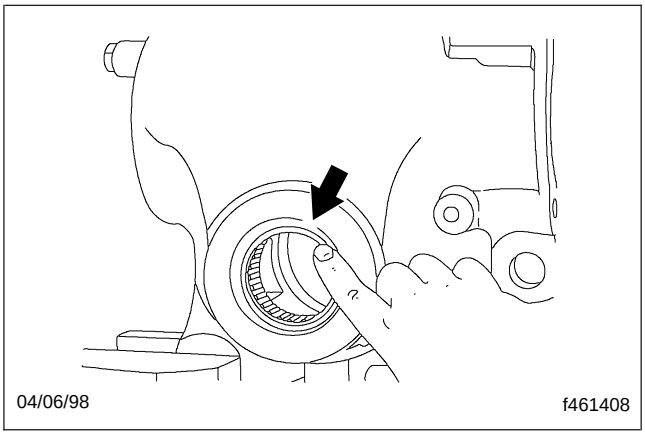


Fig. 35, Install the Dirt Seal

6. Install the second retaining ring, seating it firmly in the housing retaining ring groove. See **Fig. 36**.

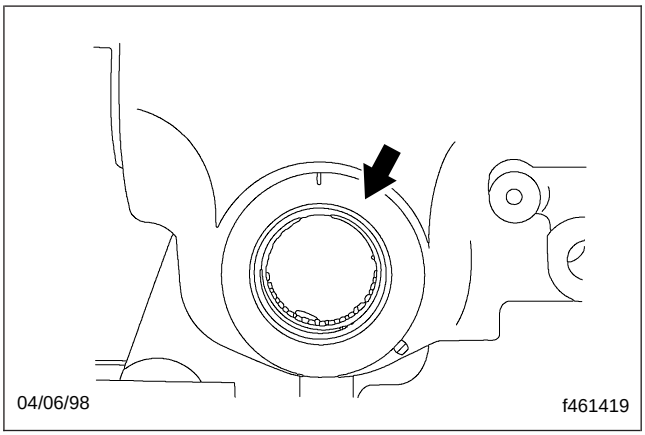


Fig. 36, Install the Second Retaining Ring

7. Install the washer into the side cover side of the housing seal bore, with the small diameter piloted into the retaining ring. See **Fig. 37**.
8. Liberally pack the area between the dirt seal and the pressure seal, including the roller bearing, with clean high temperature front axle and wheel bearing grease E8TZ–19590–A or equivalent meeting specification ESA–M1C198–A. See **Fig. 38**.

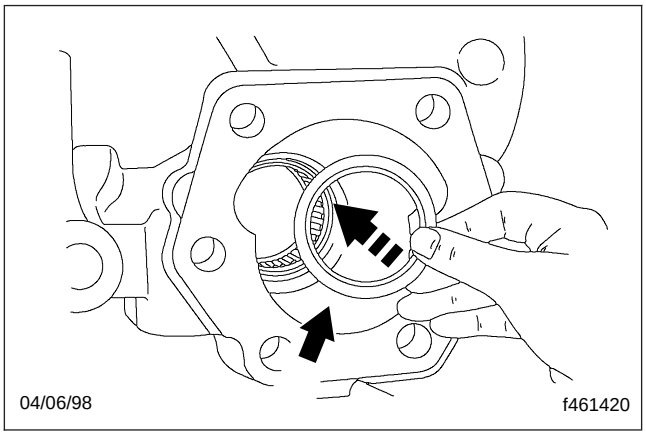


Fig. 37, Install the Washer

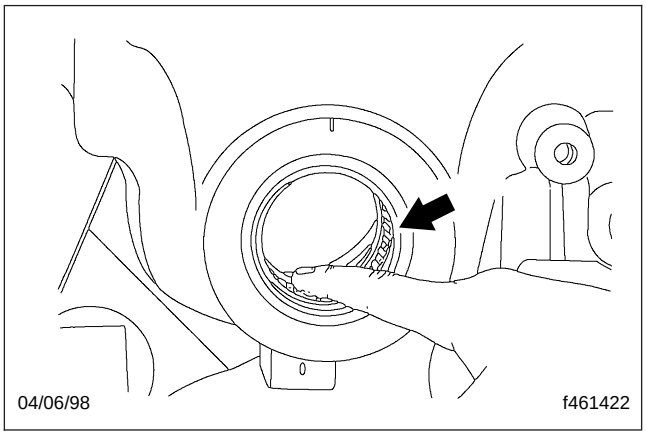


Fig. 38, Grease the Dirt Seal and the Pressure Seal

9. Oil a new seal ring and assemble in the end cover mounting face groove. See **Fig. 39**.

NOTE: Do not overstretch these rings as you install them. Do not allow the Teflon® seal ring to become twisted.

10. Install a new backup O-ring and then a new Teflon® seal ring on the piston. See **Fig. 40**.

NOTE: Do not damage the seal ring while installing the piston into the housing.

NOTE: The poppet seat and sleeve assemblies must not bottom out against the internal poppet stops in the steering gear until the gear is in-

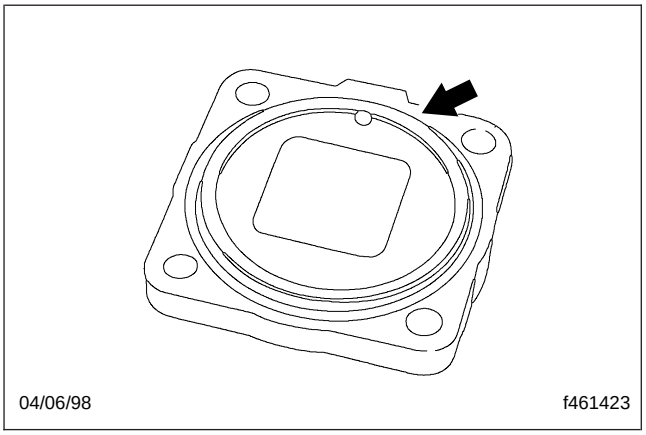


Fig. 39, Seal Ring

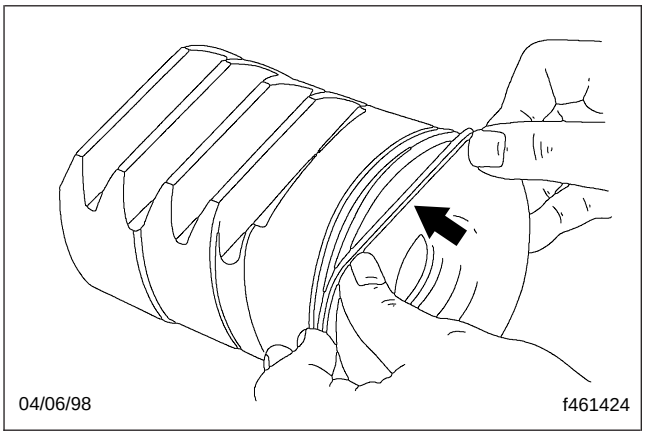


Fig. 40, Install the New Rings

stalled on the vehicle and the poppet adjustment procedures are performed.

11. Apply clean oil to the housing cylinder bore and Teflon® seal ring on the piston. Place the piston in the housing piston bore with piston teeth toward the sector shaft opening. See **Fig. 41**.
12. Lubricate and install the four end cover bolts in the housing. Tighten the bolts to 80 lbf·ft (108 N·m). See **Fig. 42**.

NOTE: Do not use grease.

13. Lightly oil the DU bushing. See **Fig. 43**.

NOTE: Assemble a new seal on the bearing and seal tool so that the lip with the garter spring is toward the shoulder of the tool.

14. Working from the side cover side of the housing, pilot the seal tool into the washer and bearing

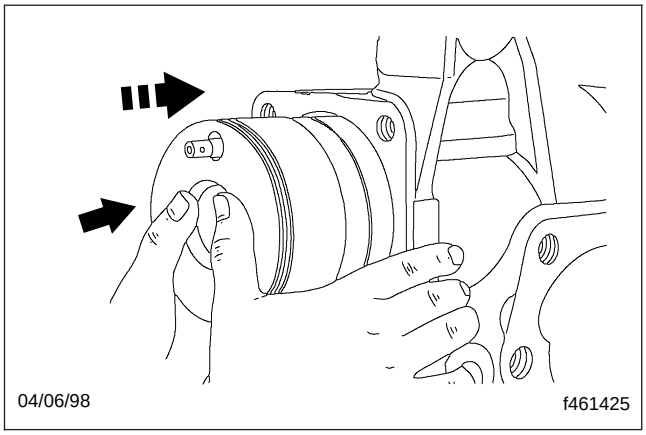
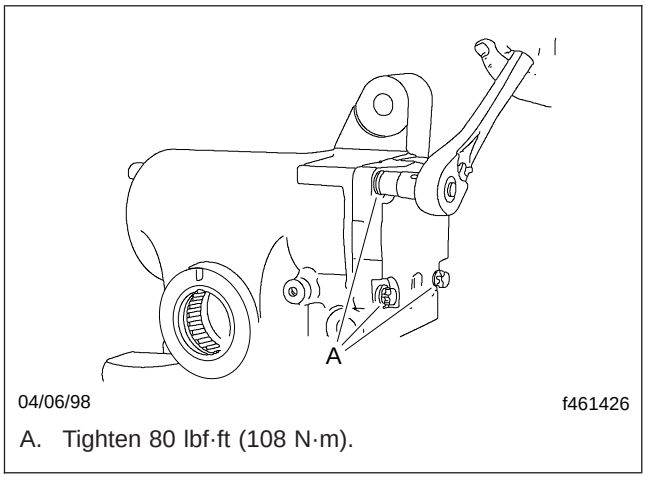


Fig. 41, Install the Piston



A. Tighten 80 lbf·ft (108 N·m).

Fig. 42, Install the End Cover Bolts

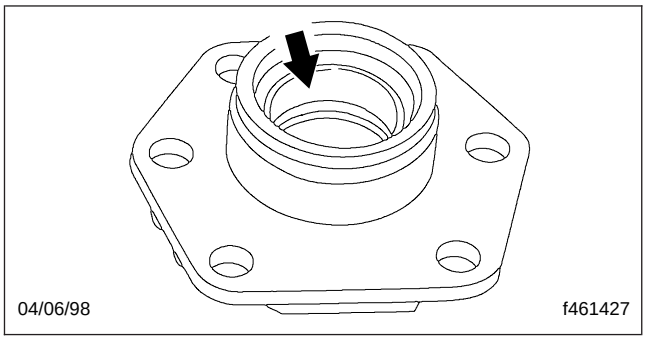


Fig. 43, DU Bushing

and press with a force of 100 to 800 lbf (445 to 3500 N) until seated against the washer. See **Fig. 44**.

Disassembly and Assembly

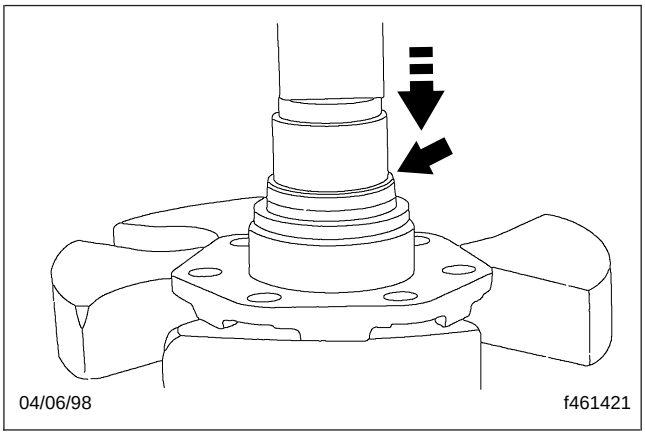


Fig. 44, Press the Seal Tool into the Washer and Bearing

15. Lightly oil the short bearing area of the sector shaft. See **Fig. 45**.

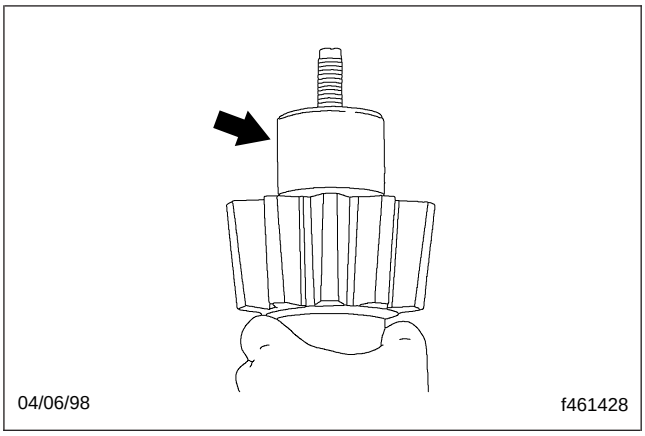


Fig. 45, Short Bearing Area of the Sector Shaft

16. Insert the sector shaft into the side cover subassembly and screw the sector shaft adjusting screw counterclockwise into the side cover, until the screw reaches solid height. See **Fig. 46**.
17. Install the sector shaft adjusting screw jam nut onto the sector shaft adjusting screw a few threads. The final adjustment will be made later. See **Fig. 47**.

⚠ WARNING

Do not weld or otherwise plug the vent in any permanent manner. This is a safety vent which functions only if the side cover fails. If the seal

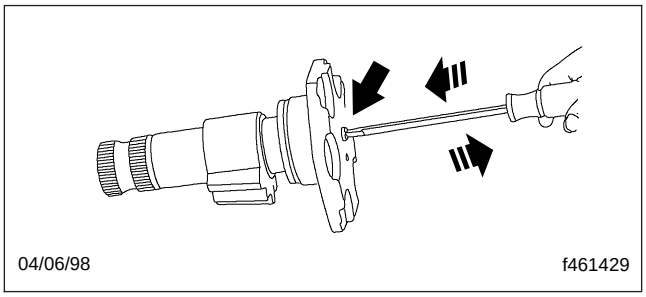


Fig. 46, Insert the Sector Shaft

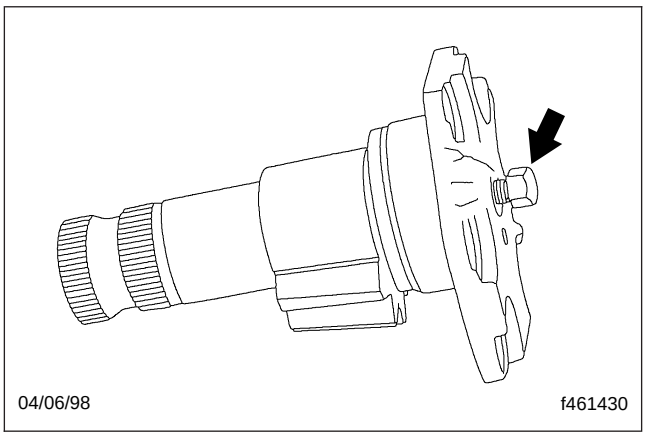


Fig. 47, Sector Shaft Adjusting Screw Jam Nut

fails and the plug cannot vent, the cylinder may lock up or otherwise function improperly.

18. Press the new vent plug into the hole provided in the side cover until the plug is bottomed. See **Fig. 48**.

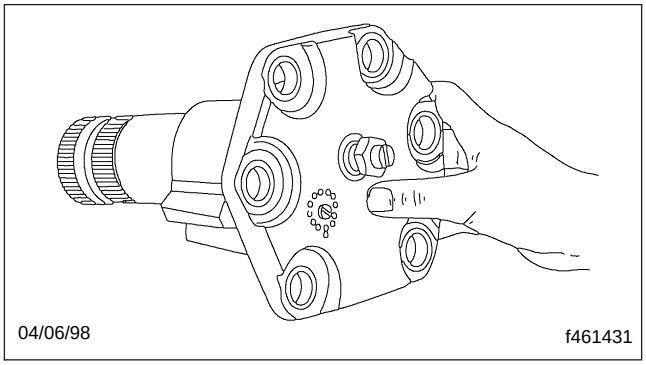


Fig. 48, Install the New Vent Plug

19. Apply clean grease to the new side cover gasket to hold it in place and assemble it onto the side cover. See **Fig. 49**.

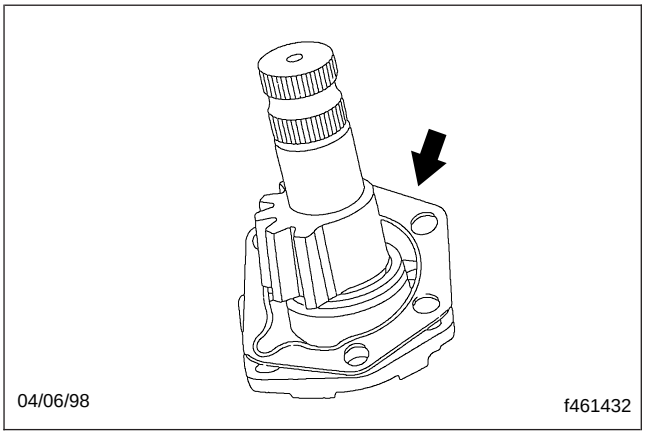


Fig. 49, New Side Cover Gasket

WARNING

If the piston is not centered when the sector shaft is installed, gear travel will be severely limited in one direction, which could result in an accident.

NOTE: There are four teeth on the piston.

20. Position the piston so the space between the second and third teeth is in the center of the sector shaft opening.

    This will center the piston for assembly of the sector shaft. See **Fig. 50**.

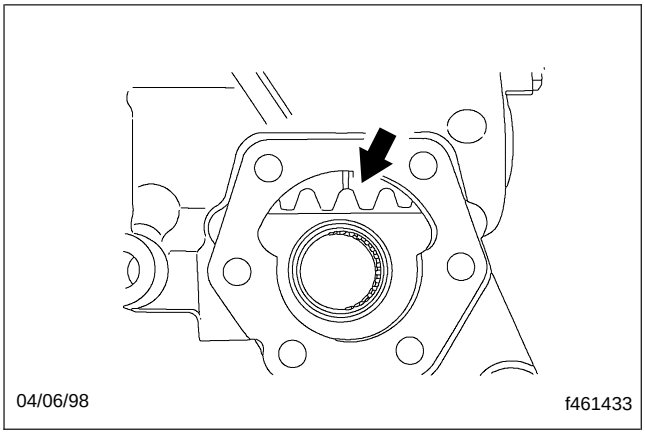


Fig. 50, Position the Piston

CAUTION

If the serrations are not properly taped, they will damage the output seal in the housing, causing the seal to leak.

NOTE: The center tooth of the sector shaft must engage the center space between the second and third teeth of the piston, with the side cover gasket in place.

21. Install the sector shaft assembly into the housing.

    Clean off any old tape on the serrations and reapply one layer of masking tape.

    Rock the sector shaft for ease of assembly, if necessary. See **Fig. 51**.

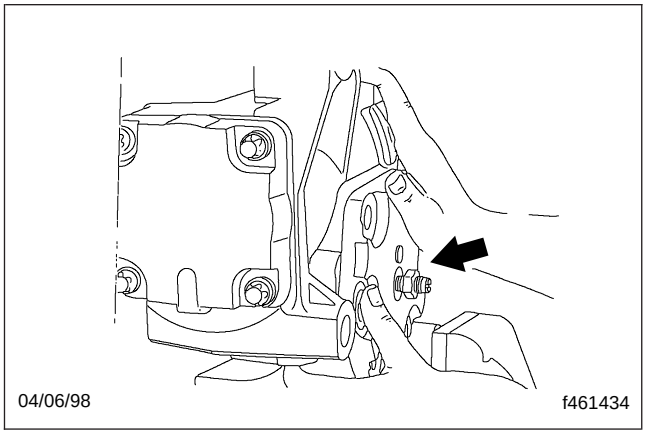


Fig. 51, Install the Sector Shaft Assembly

NOTE: If bolts must be replaced, use bolts of the same design, type and length as those removed. Do not use a substitute.

22. Lubricate and install the special side cover bolts into the side cover and tighten them in sequence, as shown. Tighten bolts to 170 lbf·ft (230 N·m). See **Fig. 52**.

NOTE: Remove tape from the sector shaft and pack the end of the housing trunnion area at the sector shaft with clean, high-temperature industrial grease, Mobil® Temp 1 or 2 or equivalent.

23. Apply the grease to the inside of the new trunnion dirt seal and assemble it over the sector shaft and into the trunnion. See **Fig. 53**.

Disassembly and Assembly

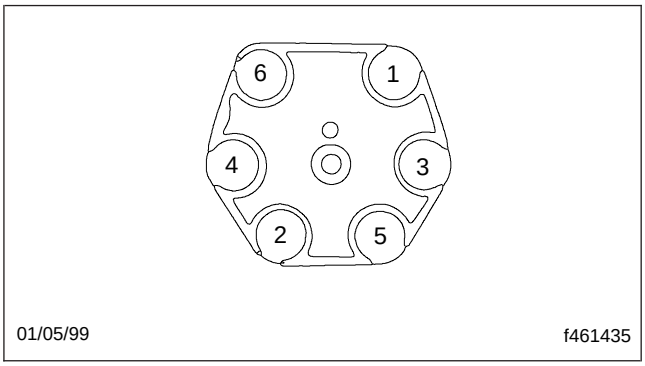


Fig. 52, Tightening Sequence

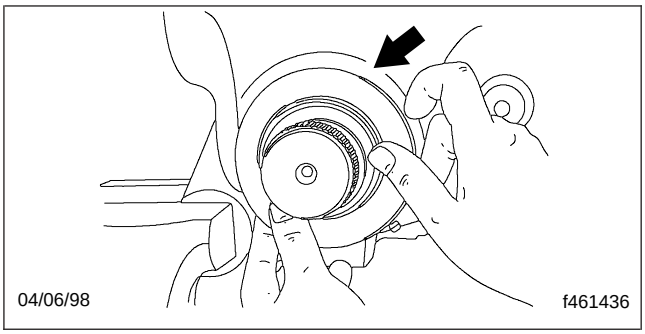


Fig. 53, Install the New Trunnion Dirt Seal

Adjustments

1. To center the steering gear, rotate the sector 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. 1**.

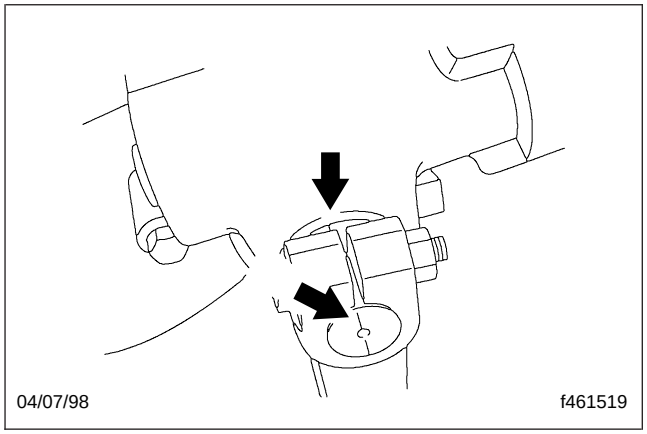


Fig. 1, Center the Steering Gear

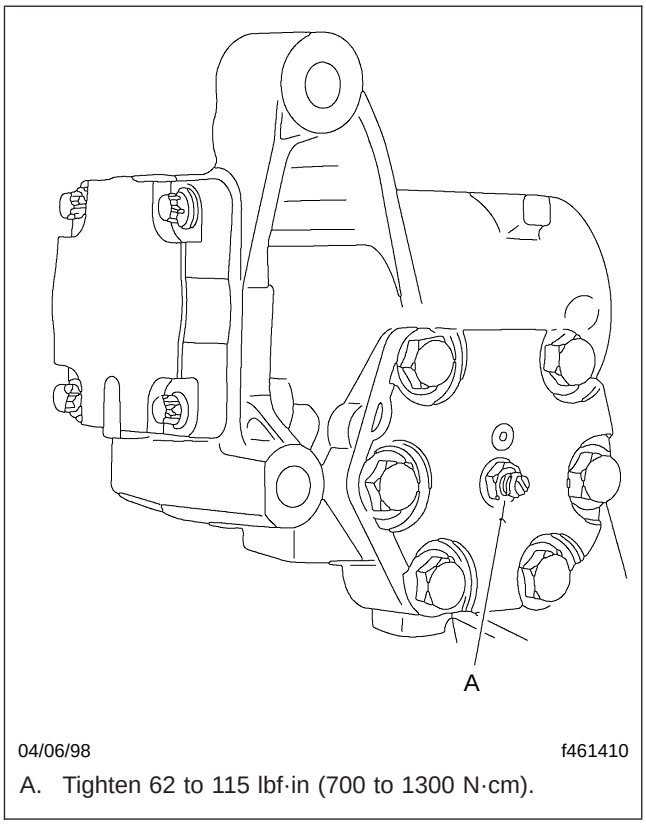
2. Tighten the side cover adjusting screw to 62 to 115 lbf·in (700 to 1300 N·cm), then back the screw out one-half turn. See **Fig. 2**.
3. Check the torque to rotate sector shaft through approximately 20 degrees each side of center.
4. Screw in the adjusting screw to provide a torque as specified over the previously established torque as the sector shaft passes through center. See **Fig. 3**.
5. Tighten the jam nut to 40 to 80 lbf·in (450 to 900 N·cm). See **Fig. 4**.

NOTE: The torque to rotate the sector shaft must not exceed 30 lbf·ft (41 N·m) at any point during travel of the cylinder.

6. Using a suitable spring scale, measure the sector shaft travel.

Poppet Valve Manual Adjustment, 9000-lb (4082-kg) Front Axles Only

NOTE: The adjuster tool (J37070) and the adjuster locknut tool (J37464) are available from SPX Kent-Moore, Warren, MI, 48092 800-328-6657.



A. Tighten 62 to 115 lbf·in (700 to 1300 N·cm).

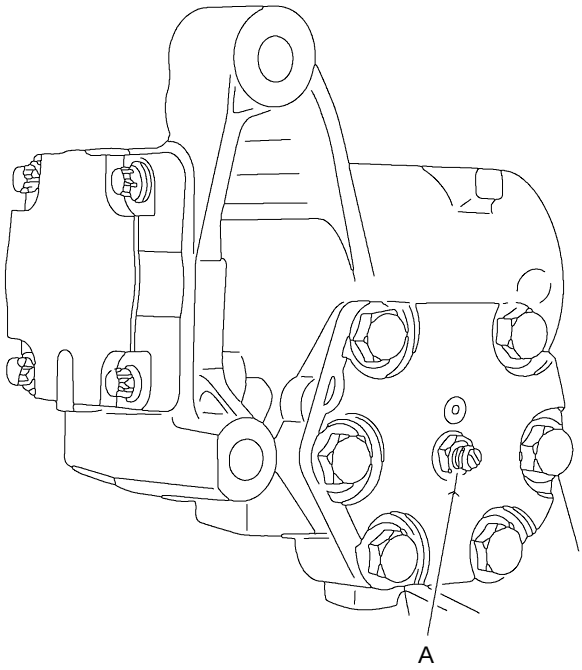
Fig. 2, Adjusting Screw

NOTE: This resetting procedure will work in most cases with at least 1-3/4 hand wheel turns from side to side of center. If making a large reduction in wheel cut and this procedure does not work, the poppets may need to be internally reset.

NOTE: The steering gear is equipped with two hydraulic pressure-relieving poppet valves that were automatically set to trip, relieving pressure just before reaching the axle stops. This was achieved after initial installation into the vehicle at the first full right and left turns. The pressure-relieving poppet valves will automatically reset themselves within the poppet adjustment limits if the axle stops are reset for increased steering gear travel based on acceptable equipment revisions from original factory installations.

1. To determine if the poppets require readjustment or if they are performing properly, install a Power Steering System Analyzer (PSSA) between the

Adjustments



04/06/98 f461411

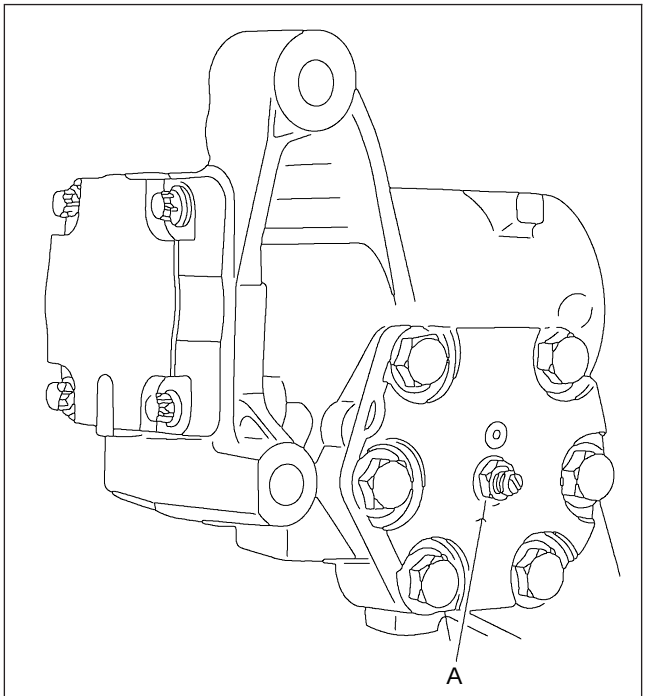
A. Tighten 62 to 115 lbf·in (700 to 1300 N·cm).

Fig. 3, Screw In the Adjusting Screw

power steering pump and the steering gear. If poppet readjustment is necessary, you can leave the PSSA in the system to verify that the following procedure is completed properly.

2. Poppets might need to be readjusted if the following conditions exist:
   - changing to larger tires
   - reduced vehicle wheelcut
   - pitman arm mistimed, condition corrected
   - steering gear being installed on a different truck
   - steer axle stop bolt(s) were bent or broken
   - steer axle U-bolt(s) were bent or broken

NOTE: The steering gear will have either a fixed stop screw or an adjusting screw. If the adjusting screw is already part of the steering gear,



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A. Tighten 40 to 80 lbf·in (450 to 900 N·cm).

Fig. 4, Jam Nut

back the nut off the adjusting screw until it is flush with the end of the adjusting screw. See **Fig. 5**.

NOTE: Only perform the following step with the wheels in the straight-ahead position, the steering gear in its center position and only when the timing marks on the end of the sector shaft and the housing trunnion are aligned.

NOTE: An alternate method of manually resetting the poppet valves with the steering gear installed in the vehicle is done by using TRW special service tools, poppet adjuster tool and adjuster locknut tool.

3. Check the maximum turn angle of the front wheels. Refer to **Group 32** in this manual for the correct specifications.
4. Turn adjusting tool into the nonsealing end of adjuster locknut tool until the drive end of the screw is flush with the nut. See **Fig. 6**.

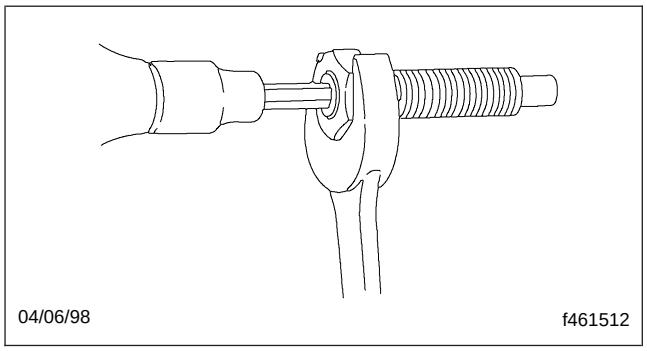


Fig. 5, Back the Nut Off of the Adjusting Screw

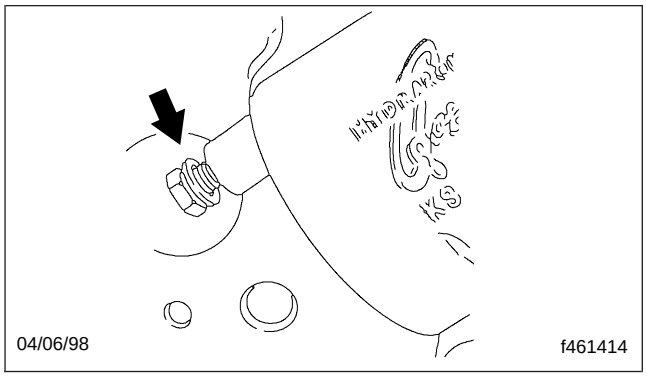


Fig. 6, Turn the Adjuster Locknut

NOTE: If the unit has a poppet adjusting screw and sealing nut that need to be replaced, remove and discard them.

5. With the vehicle unloaded, the engine off and the wheels in the straight-ahead position, remove and discard the fixed stop screw, if so equipped, and the washer from the lower end of the housing.
6. Install the adjusting screw and the sealing nut assembly (without moving the nut on the screw) into the housing until the nut is firmly against the housing. Tighten the sealing nut against the housing. See **Fig. 7**.

⚠ CAUTION

Do not mix fluid types. Mixing transmission fluid, motor oil, or other hydraulic fluids will cause seals to deteriorate faster.

7. Fill the power steering reservoir with the specified fluid, Motorcraft Mercon® ATF XT–2–QDX or Mercon® equivalent.

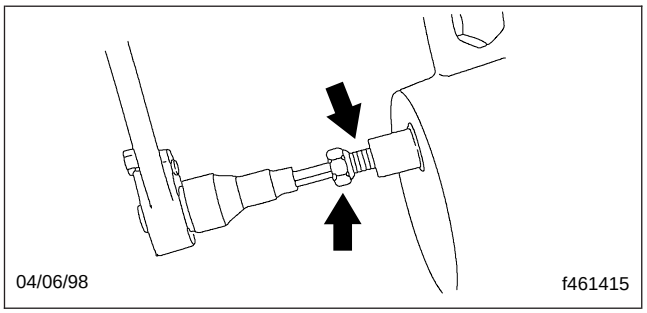


Fig. 7, Tighten the Sealing Nut Against the Housing

8. Place a jack under the center of the front axle and jack up the front end of the vehicle so the steering axle tires are off the ground.
9. Start the engine and let it run at idle speed.
10. Note which output shaft timing mark is nearest the housing piston bore.
11. Turn the steering wheel to make right-hand turn (which makes the pitman arm turn in a counterclockwise direction toward the poppet adjusting screw). Turn in this direction until axle stop contact is made.
12. Pull hard on the steering wheel (put 30 pounds of rim pull on a 20-inch diameter steering wheel) after the axle stop is contacted.
13. Turn the steering wheel in the opposite direction (end of timing mark away from the adjusting screw) until the other axle stop is contacted.
14. Pull hard on the steering wheel. Put 44 pounds of rim pull on an 18-inch diameter steering wheel.
15. Release the steering wheel and shut off the engine. Do not steer again until instructed to do so.
16. Loosen the sealing nut and back out the adjusting screw until it is past the nut. Tighten the sealing nut against the housing.
17. Start the engine and let it idle.

⚠ CAUTION

Do not hold the steering wheel in this position for more than 10 seconds at a time. Excessive heat buildup can damage components.

18. Turn the steering wheel in the original direction (end of timing mark toward adjusting screw), until axle stop contact is made.

Adjustments

19. Hold the steering wheel in this position (with 30 pounds rim pull) for 10 seconds, then release. Repeat this hold and release process as many times as necessary.
20. With the steering wheel held at full-lock position, loosen the jam nut and hold it in place with a wrench.

NOTE: Do not attempt to turn further.

NOTE: Pause the turning of the adjusting screw each time the driver releases the steering wheel. Continue turning only while the wheel is held at full turn.

21. Turn the adjusting screw clockwise using finger pressure only until the Allen wrench comes to a stop. Do not use a ratchet. See **Fig. 8**.

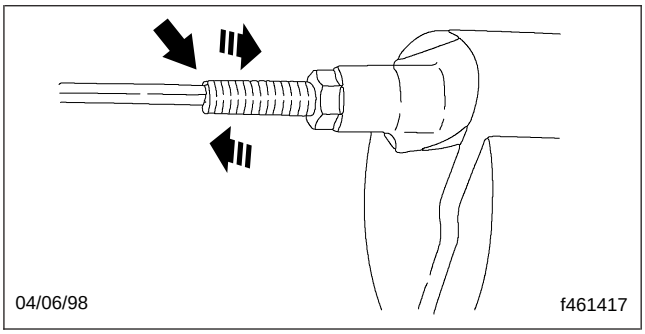


Fig. 8, Turn the Adjusting Screw Clockwise

22. Back off the adjusting screw 1-1/2 turns and tighten the sealing nut. Tighten the sealing nut 30 to 37 lbf·ft (40 to 50 N·m). See **Fig. 9**.

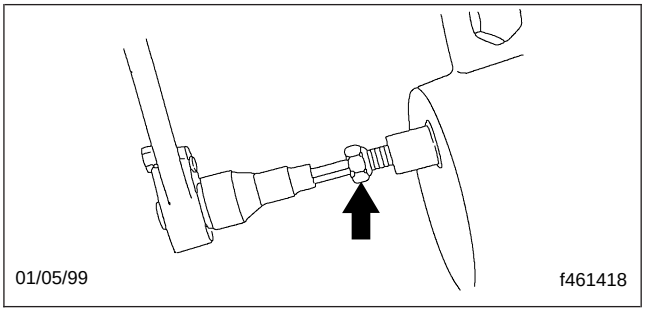


Fig. 9, Sealing Nut

23. Check the reservoir and fill if required.

IMPORTANT: The length of the adjusting screw beyond the nut must be on more than 1-1/16 inch for proper thread engagement.

NOTE: The length of the adjusting screw beyond the sealing nut may be different for each vehicle.

24. For vehicles equipped with a dual system, use the following procedure to set the poppets.

    TAS gear with slave gear—back out the poppet screws on the slave gear (RCS slave) so that 1 to 1-1/16 inch of poppet adjusting screw is protruding beyond the nut.
25. Set the main TAS gear using the procedures described above. Leave the adjusting screws on the rotary cylinders in place as described above after the poppets on the main gear have been reset.
26. Lower the vehicle.

Specifications

Approved Power Steering Fluids	
Fluid	**Specification**
Mercon® Dexron II EATF	ESP–M1C138–CJ or ESP–M2C166–H
Motorcraft Mercon® ATF XT–2–QDX	Mercon®

Table 1, Approved Power Steering Fluids

General Specifications	
Item	**Specification**
Locquic® T Primer	—
Loctite® RC680	—
High Temperature Front Axle and Wheel Bearing Grease	ESA–M1C198–A
Mobile Temp 1 or 2 High Temperature Front Axle and Wheel Bearing Grease	—

Table 2, General Specifications

SPX Kent-Moore Tools, Warren, MI 48092, 1-800-328-6657		
Part Number		**Tool**
TAS65	**TAS85**	
J37070	J37070	Adjuster Tool
J37464	J37464	Adjuster Locknut Tool
J37071	J38779	Bearing and Seal Tool
J37073	J37073	Input Seal Installer
J38713	J38713	Poppet Adjuster Seat Tool, Heavy-Duty (preferred)
J36452	J36452	Poppet Adjuster Seat Tool
J37130	J37130	Relief Valve Plug
J8092	J8092	Tool Handle

Table 3, SPX Kent-Moore Tools, Warren, MI 48092, 1-800-328-6657

General Information[1]

NOTE: Procedures contained in this section have been slightly modified from the original component manufacturer's service manual. If you are not clear on how to perform an operation, consult the component manufacturer's service literature before continuing a specific procedure.

The TRW THP60 power steering gear is an integral hydraulic power steering gear. An integral hydraulic power steering gear contains a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder.

The rotary control valve controls the flow of hydraulic fluid through the steering gear. The speed at which the driver can turn the steering wheel with power assist is dependent on the pump flow directed to a cylinder cavity.

The pressure required for the steering gear to steer the vehicle is created by the power steering pump to overcome resistance at the steered wheels. The control valve senses these requirements and directs fluid to the appropriate cylinder cavity in the steering gear (and in the auxiliary cylinder if it is a dual steering system) at the proper flow rate and pressure.

The higher the pressure a steering gear can withstand, the more work it can perform. The maximum operating pressure for the THP60 gear is 2685 psi (18 512 kPa). The maximum flow rate is 8 gpm (30.3 L/min).

The THP60 power steering gear can steer a vehicle within its front axle weight rating through a turn at low speed and engine idle. As the steering wheel is turned faster or slower, more or less fluid will be required by the gear. The recommended minimum flow at 1.5 steering wheel turns per second is 2.6 gpm (9.8 L/min). The THP60 power steering gear is used for front axle capacities up to 13,300 pounds (6032 kg).

If the rotary control valve is controlling an auxiliary cylinder, increased minimum flow is required (generally at least 75 percent) based on the size of the auxiliary cylinder and the steering geometry of the vehicle.

Maximum internal leakage for the THP60 gear is 1.2 gpm (4.5 L/min).

Principles of Operation

When the steering wheel is turned, force is transmitted from the steering wheel to the steering gear input shaft. A torsion bar, pinned at one end to the input shaft and at the other end to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response, the worm shaft, acting through the recirculating ball mechanism, tries to move the rack piston on or along the axis through the gear housing cylinder bore.

The axial movement of the rack piston is resisted by its engagement to the sector shaft, which is connected by linkage to the steered wheels. Because of this resistance, the torsion bar is twisted by the input shaft, thereby actuating the control valve. Pressurized fluid, directed by the control valve, assists in moving the rack piston on or along the axis through the cylinder bore. The rack piston then turns the sector shaft to steer the vehicle.

If the steered wheels receive a shock load, the shock forces are transmitted through the sector shaft to the rack piston and on to the worm shaft. The internal construction of the steering gear causes the control valve to send high-pressure fluid to the correct cylinder cavity to resist the shock forces. By absorbing the shock forces hydraulically, the steering gear prevents kickback at the steering wheel.

Most THP steering gears are equipped with two poppet (unloading) valves, one at each end of the rack piston. One valve or the other, depending on the direction of the turn, will trip as the steered wheels approach the axle stops, which must be set to the manufacturer's specifications. The tripped valve reduces pressure in the gear and helps to reduce heat generated by the pump. At the same time, the valves also reduce forces on the steering linkage. These valves are automatically set to axle stops after installation in the vehicle at first full-right and first full-left turns.

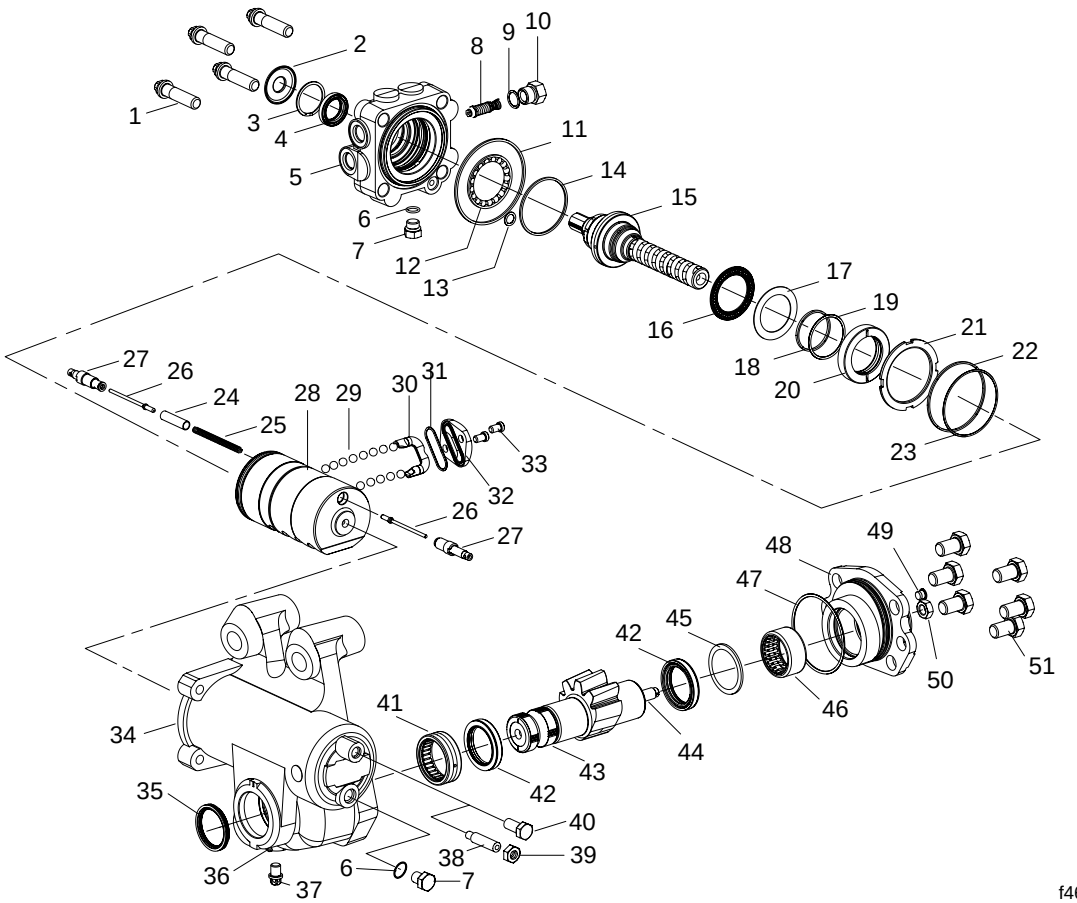
Some THP steering gears with or without poppets are supplied with a relief valve. The relief valve limits maximum supply pressure to protect the power steering gear, but it does not reduce pressure as the steered wheels approach the axle stops.

[1] The illustrations in this section are provided by TRW Commercial Steering Systems and are used with permission.

General Information

Some THP steering gears that are mounted with the output shaft above the rack piston bore are equipped with either an automatic bleed system or a manual bleed screw. Most L-Line and A-Line vehicles have an automatic bleed system.

See **Fig. 1** for an exploded view of the THP steering gear.



10/21/2003 f461925

1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft Assembly
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover Assembly
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

Fig. 1, THP Steering Gear

Replacement

1. Verify that the axle stops are adjusted to the specifications in **Section 33.00**, Subject 110. Ensuring correct axle stop adjustment now will eliminate the possibility of resetting the steering gear poppets after the steering gear is replaced.
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.
3. Turn off the engine, apply the parking brakes, chock the tires, and open the hood.
4. Disconnect the batteries at the negative terminals or at the battery shutoff switch.
5. Clean all the fittings and hose connections on the steering gear until they are free of dirt.
6. Drain the hydraulic fluid from the power steering system. Disconnect the hydraulic lines from the steering gear, marking the lines for later reference. Plug the lines and the fittings to keep out dirt.
7. Remove the bolts, nuts, and washers that attach the power steering reservoir to the mounting bracket. Remove the power steering reservoir.

CAUTION

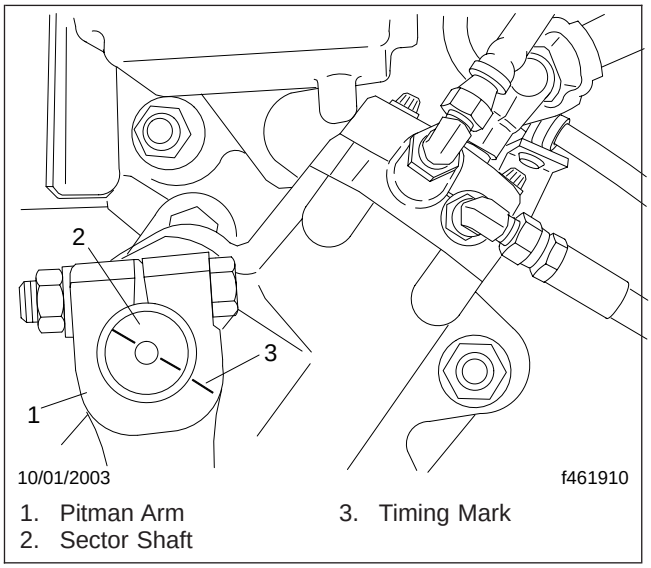
Do not pound the U-joint or lower end yoke on or off the steering gear input shaft. Internal damage to the steering gear can result.

8. Remove and discard the pinch bolt and nut that attach the steering driveline to the steering gear. Remove the lower end yoke from the steering gear.
9. Remove and discard the pinch bolt and nut that attach the pitman arm to the steering gear. Remove the pitman arm from the steering gear.

WARNING

The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.

10. Remove the bolts, nuts, and washers that attach the steering gear to the frame rail. Remove the steering gear.
11. Using bolts, nuts, and washers, attach the steering gear to the frame rail. Torque the nuts 342 to 434 lbf·ft (464 to 588 N·m).
12. Match the mark on the pitman arm to the timing mark on the steering gear sector shaft and attach the pitman arm to the steering gear. See **Fig. 1**. Using a new pinch bolt and nut, secure the pitman arm to the steering gear.
    - For a 5/8–18 pinch bolt, torque the nut 130 to 155 lbf·ft (176 to 210 N·m).
    - For a 3/4–16 pinch bolt, torque the nut 200 to 230 lbf·ft (271 to 312 N·m).



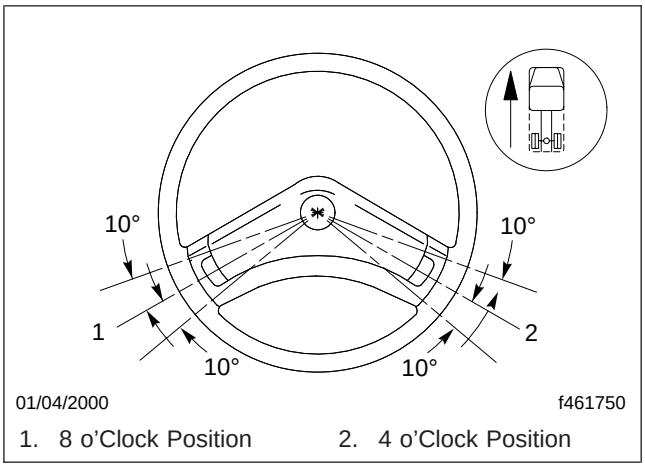
1. Pitman Arm
2. Sector Shaft
3. Timing Mark

Fig. 1, Pitman Arm Timing Mark

13. Match the mark made on the lower end yoke to the mark made on the input shaft and attach the lower end yoke to the steering gear. Using a new pinch bolt and nut, secure the lower end yoke to the input shaft. Tighten the nut to one of the following torque specs:
    - 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16–20 pinch bolt and nut
    - 30 to 35 lbf·ft (41 to 47 N·m) for an M10 x 1.25 pinch bolt and nut
14. Unplug the hydraulic lines and fittings and connect the lines to the power steering reservoir.

Power Steering Gear Replacement

15. Using bolts, nuts, and washers, attach the power steering reservoir to the mounting bracket.
16. Connect the batteries at the negative terminals or at the battery switch.
17. Fill the power steering reservoir to the full line on the reservoir or dipstick. For approved power steering fluids, see **Specifications 400**.
18. Start the engine and turn the steering wheel from full right to full left two or three times to remove air from the lines.
19. Check the power steering reservoir again and add fluid if needed.
20. Check the hydraulic lines for leaks.
21. Remove the chocks from the tires and close the hood.
22. Test drive the vehicle.
    - 22.1 With the front tires pointing straight ahead, check the position of the steering wheel spokes. The spokes on the steering wheel should be within ±10 degrees of the 4 o'clock and 8 o'clock positions. See **Fig. 2**.
    - 22.2 If the steering wheel is not in the correct position, remove the steering wheel and install it in the correct position. For instructions, see **Group 46**.



1. 8 o'Clock Position 2. 4 o'Clock Position

Fig. 2, Steering Wheel Centered

Filling and Air Bleeding the System

IMPORTANT: Make sure the poppets are set correctly before beginning this procedure. If the poppets are not set correctly, see **Subject 160**.

1. Fill the power steering reservoir nearly full. Do not steer.
2. Start the engine and run it for 10 seconds, then shut it off. Check and fill the reservoir. Repeat this step at least three times checking the fluid level in the reservoir each time.

IMPORTANT: Do not let the fluid level drop significantly or allow the reservoir to empty. Doing so may introduce air into the system.

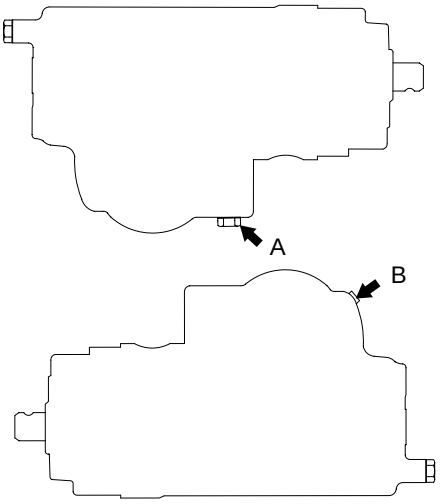
3. Start the engine and let it idle for two minutes. Do not steer. Shut off the engine and check the fluid level in the reservoir. If needed, add more fluid.
4. Start the engine again. Turn the steering wheel from full left to full right several times. If needed, add fluid to the reservoir.

   Automatic bleed systems should now be free of trapped air. If the vehicle has a manual bleed system, proceed to the next step. See **Fig. 1**.

IMPORTANT: Do not turn the steering wheel while the bleed screw is loosened.

5. With the engine idling, turn the steering wheel from full left to full right several times. Stop steering and loosen the manual bleed screw about one turn. Allow air and aerated fluid to bleed out until only clear fluid is seen. Close the bleed screw and add fluid to the reservoir if needed.

   Repeat this step until all the air is out of the system. Torque the bleed screw 40 to 50 lbf·in (452 to 565 N·cm).



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A. Steering gear with automatic bleed plug. Do not remove the bleed plug.
B. Steering gear with manual bleed plug.

Fig. 1, Steering Gears With Bleed Systems

Replacement

The power steering pump is used in this procedure to force out the input shaft seal. To use this procedure, the power steering pump should have a minimum of 1500 psi (10 342 kPa) available.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the return line from the steering gear and plug the line. Cap the return port of the steering gear with a high pressure fitting.
3. Remove the steering driveline from the steering gear input shaft.
4. Remove the dirt and water seal, item 2 in **Fig. 1**, from the steering gear. Save this seal to determine the correct size of the new seal.
5. Using a clean cloth, remove the grease from around the input shaft.
6. Using a screwdriver inserted into the notch formed in the end of the retaining ring, item 3 in **Fig. 1**, remove the retaining ring. Be careful not to scratch the bore with the screwdriver.
7. Using a pinch bolt and nut, attach the steering driveline to the input shaft but do not tighten the nut.
8. Tie or wrap a shop towel around the input shaft and place a drain pan under the steering gear to catch the oil.

⚠ WARNING

Do not mix hydraulic fluid types or use unapproved fluids. Doing so could cause seal deterioration, leaks, and a loss of steering assist, which could result in serious personal injury or death.

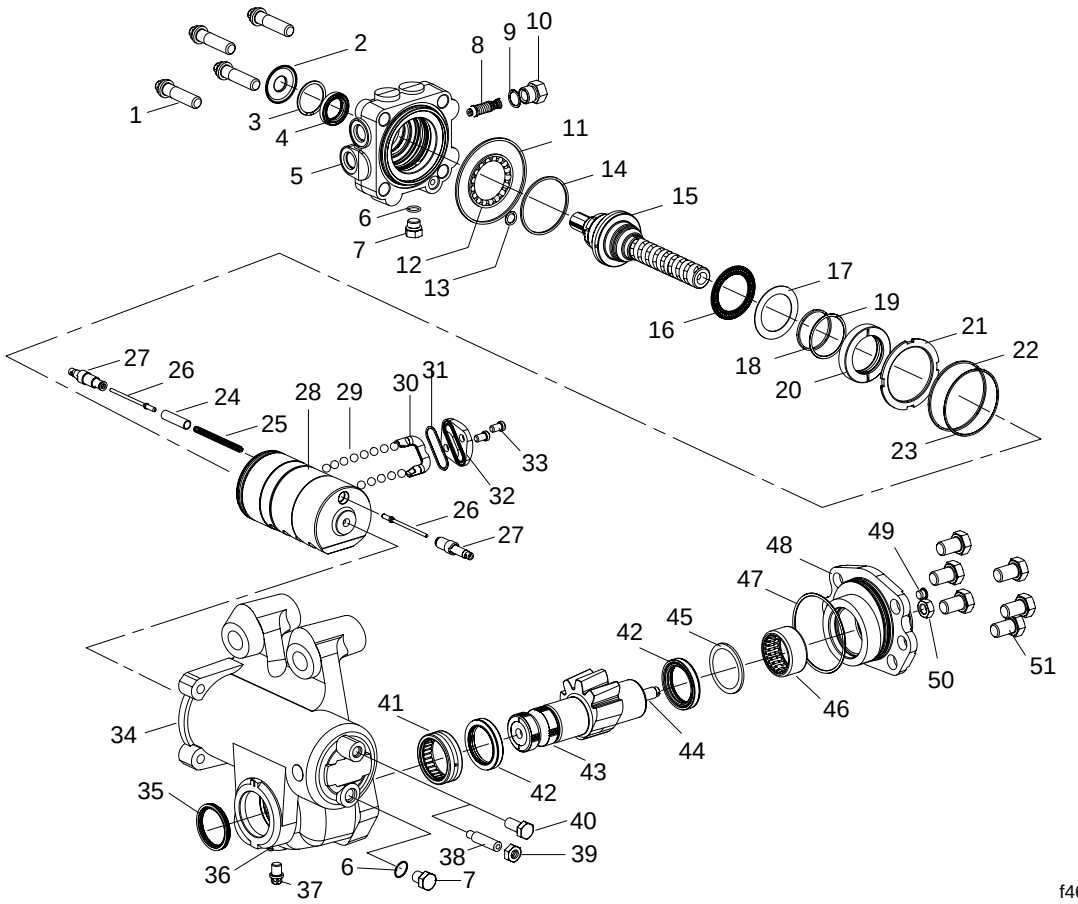
9. If needed, add hydraulic fluid to the power steering reservoir to the full line on the reservoir dipstick. Do not mix fluid types. See **Specifications 400** for a list of approved hydraulic fluids.
10. With the vehicle in neutral, momentarily turn the starter. If the engine starts, quickly turn it off. This should force out the input shaft seal.
11. Remove the shop towel. Disconnect the steering driveline from the steering gear and remove the input shaft seal, item 4 in **Fig. 1**.
12. Inspect the seal area of the valve housing for seal fragments. Remove all seal fragments.
13. Check the input shaft seal for heat damage. If the seal is stiff and brittle, it is probably heat damaged. Determine and fix the cause of excessive heat in the vehicle.

⚠ WARNING

Do not use a socket to install the input shaft seal. You will not be able to control the seal installation depth with a socket and this could lead to leaks. Leaks could result in loss of steering assist which could result in serious personal injury or death.

14. Install a new input shaft seal.
    - 14.1 Using Exxon Polyrex® EP2 grease (045422), lubricate the inside diameter of the new input shaft seal and install it on the input shaft.
    - 14.2 Using a hammer and seal driver (J37073), tap the driver until the shoulder of the driver is square against the valve housing. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.
15. Install a new retaining ring in the groove.
16. Using Exxon Polyrex EP2 grease (045422), pack the end of the valve housing bore.
17. Install a new dirt and water seal.
    - 17.1 Choose the correct size dirt and water seal by comparing the replacement seals to the old seal, or by measuring the major diameter of the input shaft serrations. See **Table 1** for the major serration diameter and the corresponding seal part number.
    - 17.2 Apply Exxon Polyrex EP2 grease (045422) to the new dirt and water seal and install it on the input shaft. Seat it in the groove behind the serrations and against the valve housing.
18. Using a new pinch bolt and nut, attach the steering driveline to the input shaft. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).
19. Attach the return line to the steering gear return port.

Input Shaft Seal Replacement



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1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
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9. O-Ring
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13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
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17. Thrust Washer
18. Seal Ring
19. O-Ring
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23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

Fig. 1, THP Steering Gear

Major Serration Diameters and Corresponding Seal Part Numbers		
Major Serration Diameter inch (mm)	**Serration Size**	**Part Number**
0.807/0.799 (20)	13/16 inch (21 mm) x 36	478044
0.866/0.857 (22)	7/8 inch (22 mm) x 36	478060
0.987/0.977 (25)	1 inch (25 mm) x 36	478050
1.008/1.000 (25)	1 inch (25 mm) x 79	478050

Table 1, Major Serration Diameters and Corresponding Seal Part Numbers

20. Bleed the air from the system. For instructions, see **Subject 110**.
21. Remove the chocks from the tires.

Sector Shaft Adjustment

The sector shaft adjustment can only be completed if the adjusting screw jam nut is accessible when the steering gear is attached to the frame rail. The jam nut is located on the side cover. If the jam nut is not accessible, the adjustment can be made by removing the steering gear and placing it in a vise. See **Subject 100** for removal instructions.

1. Apply the parking brakes and chock the rear tires.
2. With the engine on, turn the steering wheel until the timing mark on the sector shaft lines up with the timing mark on the housing. The line on the sector shaft should be at a 90-degree angle from the input shaft. The sector shaft is now on its center of travel. Turn the engine off.
3. Remove the cotter pin and castle nut that attach the drag link to the pitman arm. Remove the drag link from the pitman arm.

IMPORTANT: To avoid resetting the poppets, do not turn the input shaft more than 1-1/2 turns from the center-of-travel position while the drag link is disconnected.

4. From the center-of-travel position, grasp the pitman arm at the lower end of the arm and gently try to move the arm back and forth. If the pitman arm is loose or lash (free play) is detected, the sector shaft is out of adjustment.
5. Loosen the adjusting screw jam nut.

NOTE: If the steering gear is removed from the frame rail to correct the lash, leave the pitman arm attached to the steering gear and follow the instructions under the "Final Adjustments" heading in **Subject 150**.

6. If no lash is detected, use a screwdriver to turn the shaft adjusting screw counterclockwise until you feel lash at the sector shaft.
7. Slowly turn the shaft adjusting screw clockwise until you feel no lash at the sector shaft without using more than 10 lbf·ft (14 N·m) of torque. See **Fig. 1**. From this position, turn the screw clockwise 1/8 to 3/16 of a turn more. Hold the adjusting screw in place and tighten the jam nut 43 lbf·ft (58 N·m).

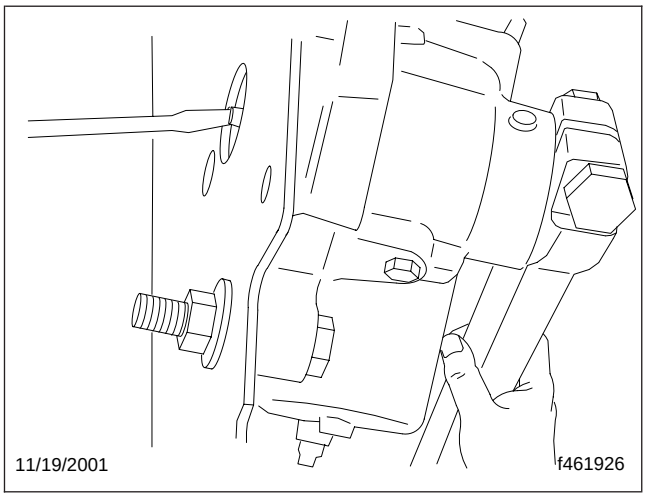

Fig. 1, Adjusting the Sector Shaft

8. Turn the steering wheel one-quarter turn each side of center then back to center and check the pitman arm for lash. There should be no lash. If lash is detected, loosen the jam nut and repeat the previous step as well as this step.
9. If the steering gear was removed from the frame rail, install the steering gear on the frame rail. For instructions, see **Subject 100**.
10. Using a castle nut, attach the drag link to the pitman arm. Torque the castle nut using the appropriate torque value.
    - 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)
11. If required, continue to tighten the castle nut until a slot on the nut aligns with the hole in the ball stud. Do **not** reverse the tightening direction of the nut when locating the cotter pin hole. Install a new cotter pin in the ball stud and nut, then lock the cotter pin in place.

⚠ WARNING

Failure to install and lock a new cotter pin in the ball stud and nut could result in disengagement of the parts and loss of steering control.

⚠ CAUTION

Do not use a power grease gun to add grease to the sector shaft bearing. Doing so could damage

Sector Shaft Adjustment

the high pressure seal and contaminate the hydraulic fluid.

12. Using only a hand-operated grease gun, add grease to the sector shaft bearing through the grease fitting in the housing until grease begins to extrude past the dirt and water seal.
13. Remove the chocks from the tires.

Poppet Adjustment

Poppet adjustment will work in most cases with at least 1-3/4 turns of the steering wheel from each side of center. If a large reduction in wheel cut is being made and this procedure does not work, you may have to replace or reset the poppets, using the "Poppet Component Replacement" procedure in **Subject 160**.

1. Check that the axle stops are adjusted to the specifications in **Section 33.00, Subject 110**.
2. Start the engine, and allow it to idle for 5 to 10 minutes to warm the hydraulic fluid.
3. Shut down the engine, apply the parking brakes, and chock the rear tires.
4. If a new poppet adjusting screw and nut (**Fig. 1**, Items 38 and 39) are being used, turn the screw into the nonsealing end of the nut until the drive end of the screw is flush with the nut.

NOTE: The steering gear will have either a poppet fixed stop screw or a poppet adjusting screw. See **Fig. 1**. If the adjusting screw is already part of the steering gear, back the nut off of the adjusting screw until it is flush with the end of the adjusting screw.

5. Make sure that the engine is off and the wheels are in the straight-ahead position.
6. If equipped with a poppet fixed stop screw and washer, remove and discard both items from the lower end of the housing.

   If equipped with a poppet adjusting screw and nut that need to be replaced, remove and discard both items.
7. Using a wrench, turn the adjusting screw and nut assembly (without turning the nut on the screw) into the housing until the nut is firmly against the housing. Tighten the nut against the housing.

CAUTION

Make sure the drive end of the adjusting screw is not below the face of the nut. If the drive end of the adjusting screw is below the face of the nut, the poppet seat flange will break when the upper poppet is prepared for setting.

WARNING

Fill the power steering reservoir with approved, clean fluid only. Do not mix automatic transmission fluid types. If you are changing fluid types, completely flush the steering system with the fluid type being added. Any mixture or any unapproved fluid could lead to seal deterioration and leaks. Any fluid leak could eventually cause loss of power steering assist, which could cause personal injury and property damage.

8. Fill the power steering reservoir to the full line on the reservoir dipstick. For approved hydraulic fluids, see **Specifications 400**.
9. Place a jack under the center of the front axle and jack up the front of the vehicle so the steer axle tires are off the ground.

CAUTION

Do not hold the steering wheel at full turn for more than 10 seconds at a time. The heat buildup at pump relief pressure may damage components.

10. Push the upper poppet out to prepare it for setting, as follows.
    - 10.1 Start the engine and let it run at idle speed.
    - 10.2 Note which sector shaft timing mark is nearest the housing piston bore.
    - 10.3 Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screw just installed. Turn the steering wheel in this direction until axle stop contact is made.
    - 10.4 Pull hard on the steering wheel. Put up to 40-lbf (178-N) pull on a 20-inch diameter steering wheel after the axle stop is contacted.
11. Set the upper poppet, as follows.
    - 11.1 Turn the steering wheel in the opposite direction (the end of the timing mark away from the adjusting screw) until the other axle stop is contacted.
    - 11.2 Pull hard on the steering wheel. Put up to 40-lbf (178-N) pull on a 20-inch diameter steering wheel.

Poppet Adjustment on a Single Gear

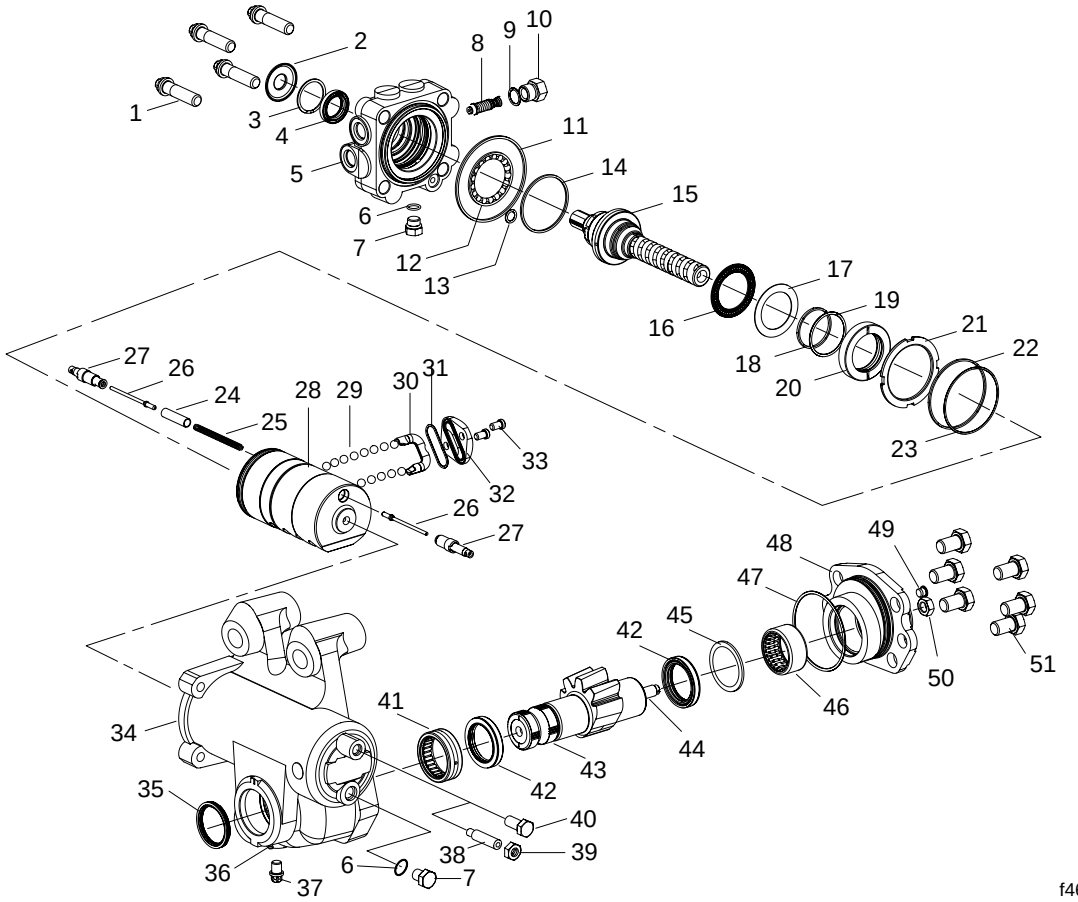

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Fig. 1, THP Steering Gear

11.3 Release the steering wheel and shut off the engine.

12. Loosen the nut and back out the adjusting screw until the adjusting screw is 1 inch (2.5 cm) past the nut. Tighten the nut against the housing.
13. Set the lower poppet, as follows.

    13.1 Start the engine and let it idle.

    13.2 Turn the steering wheel in the original direction (the end of the timing mark is toward the adjusting screw) until axle stop contact is made.

    13.3 Hold the steering wheel in this position with up to 40-lbf (178-N) pull for 10 seconds, then release. Repeat this hold-and-release process as many times as necessary while completing the next step.

14. Position the adjusting screw, as follows.

    14.1 With the steering wheel held tightly at full turn, loosen the nut and hold it in place with a wrench.

    14.2 Using a wrench and finger pressure only, turn the adjusting screw clockwise until the wrench stops. Do not attempt to turn the adjusting screw any farther. Pause the turning-in process each time the driver releases the steering wheel. Continue turning only while the steering wheel is held at full turn.

    14.3 Back off the adjusting screw 3-1/4 turns and tighten the nut 35 lbf·ft (47 N·m).

⚠ 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 procedures must be repeated if steering travel is increased or decreased in the future.

NOTE: The length of the adjusting screw beyond the nut may be different for each vehicle, but must not exceed 1-1/16 inches (27 mm).

15. The poppets have now been completely reset. Check the power steering reservoir and fill it if necessary.
16. Lower the vehicle and remove the chocks.

Disassembly, Inspection, Assembly, and Final Adjustments

Disassembly

NOTE: Replace all seals, seal rings, and gaskets each time the gear is disassembled.

1. 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, disconnect the batteries, and open the hood.
2. Remove all dirt from around the fittings and hose connections before removing the steering gear.

IMPORTANT: To avoid resetting the poppets, do not turn the input shaft more than 1-1/2 turns from the center-of-travel position while the drag link is disconnected.

3. Remove the power steering gear. For instructions, see **Subject 100**.

⚠ CAUTION

Never steam clean or high-pressure wash hydraulic steering components. Do not force or abuse closely fitted parts. Use care that the bearing and sealing surfaces are not damaged by the disassembly and assembly procedures. Failure to follow these precautions could result in damage to the components.

4. Clean and dry the steering gear before beginning to disassemble it.
5. As you disassemble the gear, clean all parts in clean, OSHA-approved solvent and use only air to blow dry the parts.
6. With the input shaft horizontal and the side cover and valve housing accessible, put the steering gear in a vise with the clamps firmly against the housing mounting flange or boss.

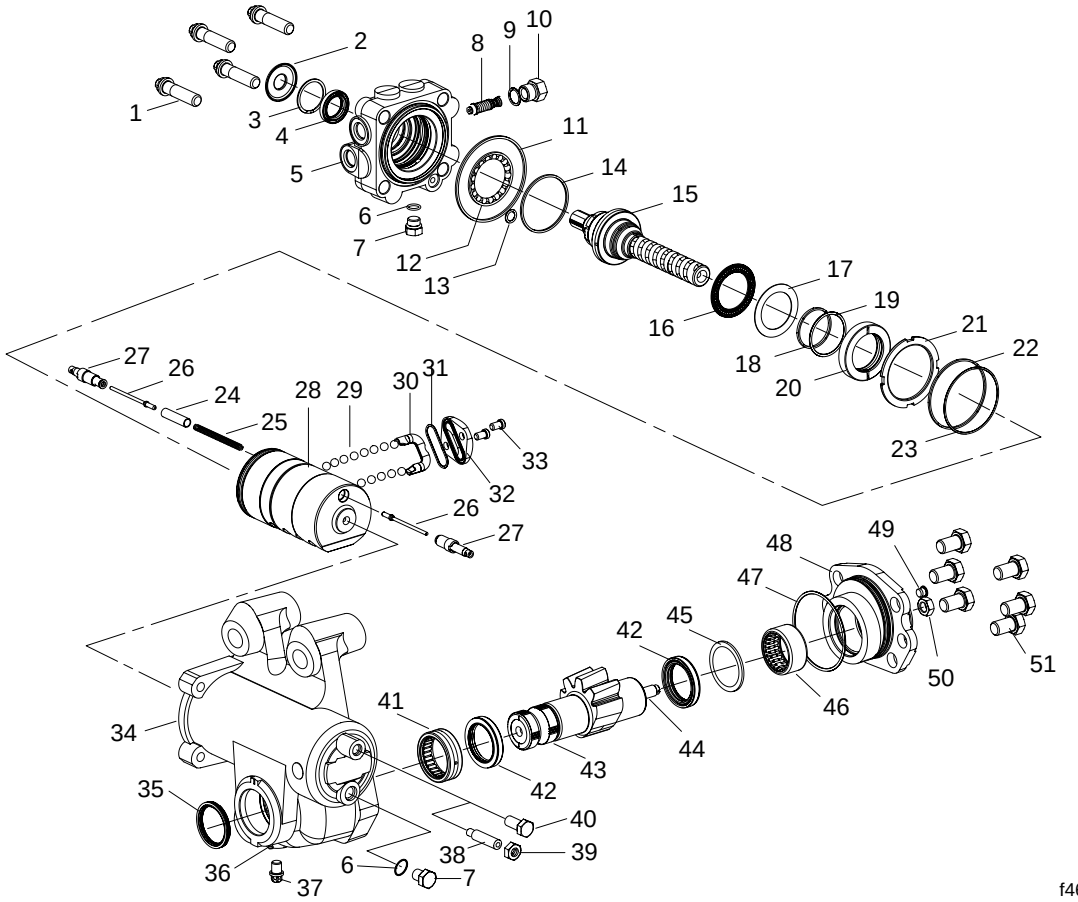
IMPORTANT: Do not clamp against the body of the housing. If the mounting boss or flange is not accessible, fabricate and attach a mounting plate to the housing mounting bosses.

7. Place a drain pan under the gear and remove the plugs from the hydraulic ports.
8. Rotate 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. The sector shaft is now positioned for removal.
9. Remove any paint or corrosion from the exposed area of the sector shaft.
10. Tape the serrations and bolt groove of the sector shaft with one layer of masking tape. The tape should not extend on to the sector shaft bearing diameter.
11. Remove the adjusting screw jam nut, item 50 in **Fig. 1**.
12. Remove the capscrews that attach the side cover to the housing.
13. Remove the side cover and sector shaft assembly from the gear. Start the cover and sector shaft assembly removal by lightly tapping the end of the shaft with a soft mallet.
14. Remove and discard the vent plug, item 49 in **Fig. 1**.
15. Remove and discard the side cover O-ring, item 47 in **Fig. 1**.
16. Turn the sector shaft adjusting screw, item 44 in **Fig. 1**, clockwise through the side cover and pull the sector shaft out of the side cover.

IMPORTANT: Take care not to damage the bore or bearing when removing the output seal.

17. Clamp the side cover in a vise. Place a 3/8-inch drive socket in the center of the side cover. Using the socket for support, pry out the output seal with a rolling head pry bar. Discard the seal and remove the socket. Remove the washer.
18. Inspect the sector shaft assembly for damaged adjusting screw threads. The retainer must be securely staked in place. The adjusting screw must rotate by hand with no perceptible end play.
19. If equipped with a relief valve, remove the relief valve cap, the O-ring, and the relief valve from the valve housing. Discard the O-ring.
20. Remove the dirt and water seal, item 2 in **Fig. 1**, from the input shaft assembly. Save this seal to determine the correct size of the new seal.
21. Clean any paint or corrosion from the exposed area of the input shaft

Disassembly, Inspection, Assembly, and Final Adjustments



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1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

Fig. 1, THP Steering Gear

22. Remove the four valve housing capscrews and remove the rack piston. Place the rack piston on a clean cloth.

IMPORTANT: The set position of the poppet seat and sleeve assembly must not be disturbed if the poppets are not going to be replaced or reset during disassembly.

23. Remove and discard the O-ring and the valve housing O-ring, items 13 and 11 in **Fig. 1**.

CAUTION

Do not remove the input shaft assembly or the balls from the rack piston until the ball return guides are removed. If this precaution is not followed, the ball return guides will be damaged.

24. Remove and discard the two Torx® capscrews, item 33 in **Fig. 1**. Remove the ball return guide cap and the cap seal. Discard the cap seal.

25. Remove the ball return guide by carefully inserting a screwdriver between the rack piston and guide.

NOTE: Left-hand ball return guide halves are plated with copper or zinc chromate for identification. Right-hand guide halves are not plated.

26. Remove the balls from the rack piston by rotating the input shaft assembly until the balls fall out. Place the balls and return guide in a container. Count the balls and make sure all have been removed. There are 31 balls in the THP60 steering gear.

IMPORTANT: The balls are a matched set. If any are lost, the set must be replaced.

27. Remove the valve housing and input shaft assembly from the rack piston.

28. Cut and remove the seal ring and O-ring, items 23 and 22 in **Fig. 1**, from the rack piston.

29. Inspect the poppet seat and sleeve assembly.

    29.1 Push on the poppet stem; it should spring back.

    29.2 Push on the poppet seat; it should not move by hand.

    29.3 If the components are bent or broken, if the poppet stems don't spring back, or if the poppet seat moves by hand, replace the poppet seat and sleeve assembly. For instructions, see **Subject 160**.

NOTE: TRW recommends that the poppet seat and sleeve assemblies not be removed unless replacement of the poppet is required.

30. Inspect the valve housing and input shaft assembly for heat damage or bearing roughness. If these conditions are present, if there is excessive internal leakage, or if preload adjustment is required, see the instructions in **Subject 170**.

31. Remove and discard the dirt and water seal, item 35 in **Fig. 1**.

32. Insert a screwdriver through the trunnion opening and carefully push the output seal out without damaging the sealing area of the bore. Discard the output seal.

NOTE: A special hook groove has been machined into the bore to hold the seal in position. Clean out the rubber from the groove prior to installing a new seal.

33. Inspect the roller bearing for brinelling or spalling. If the roller bearing needs to be replaced, see the instructions in **Subject 180**.

34. Inspect the following components for damage. If they are damaged, see the instructions in **Subject 190**.
    - poppet fixed stop screw
    - poppet adjusting screw and nut
    - automatic bleed plug
    - manual bleed screw
    - auxiliary port plug and O-ring

Inspection

WARNING

If one of the conditions in Table 1 is found in one component of the steering gear, inspect all components carefully for signs of impact damage. Replace the components if you suspect impact damage. Failure to replace all damaged components could result in a serious vehicle accident.

Disassembly, Inspection, Assembly, and Final Adjustments

Conditions in the Steering Gear That Indicate Impact Damage	
Condition	**Area**
Brinelling	Ball track grooves of rack piston
	Ball track grooves of worm screw
	Bearing area of sector shaft
	Thrust washer and bearing in valve housing
	Ball cup and bearing in valve housing
Cracks or Breaks	Bearing area of sector shaft
	Sector shaft teeth
	Rack piston teeth
	Housing
	Thrust washer and bearing in valve housing
	Worm screw
	Ball cup and bearing in valve housing
Twisted Serrations	Output shaft serrations

Table 1, Conditions in the Steering Gear That Indicate Impact Damage

1. Make sure all sealing surfaces and seal cavities are free of nicks and corrosion. Any nicked or corroded surface requires part replacement to ensure proper sealing.
2. Inspect the rack piston teeth for cracks or damage. If teeth are damaged, replace the rack piston, the sector shaft, and the set of balls.
3. Inspect the rack piston ball track grooves for brinelling or spalling. If either condition exists, replace the input shaft assembly, the valve housing, the rack piston, and the balls.
4. Inspect the sealing area of the input shaft assembly for nicks and damage. Inspect for discoloration from excess heat. Inspect the input shaft ball track grooves for brinelling or spalling. If any of these conditions exist, replace the:
   - input shaft
   - worm/valve assembly
   - valve housing
   - balls
   - rack piston
5. Inspect the gear housing cylinder bore. Some scoring marks are normal. If there was internal leakage greater than 1.2 gpm (4.5 L/min), make sure there are no damaged seals before replacing the housing.
6. Inspect the valve housing mating surface for nicks that would prevent proper sealing. Replace the gear housing if these nicks are present and cannot be easily removed with a fine-tooth flat file without changing the dimensional characteristics.
7. Inspect the roller bearing in the side cover assembly for brinelling or spalling. If either condition exists, replace the side cover assembly.
8. Inspect the sector shaft bearing and sealing areas and sector teeth contact surfaces for brinelling, spalling, or cracks. Run the end of your fingernail across these areas to detect steps. Remove the masking tape from the shaft and inspect the shaft for twisted or damaged serrations. If any of these conditions exist, replace the sector shaft.

NOTE: A replacement sector shaft comes with the adjusting screw and retainer.

Assembly

NOTE: Use the bearing and seal tool, J37071, in the following two steps.

1. Install a new output seal on the short end of the bearing and seal tool so that the lip with the garter spring is toward the shoulder of the tool. Working from the side cover side of the housing, pilot the bearing and seal tool into the washer and bearing, then press with 100 to 800 lbf (445 to 3560 N) until the seal is seated firmly.
2. Using the long end of the bearing and seal tool, install the dirt and water seal, item 35 in **Fig. 1**, making sure it is not distorted or twisted.

IMPORTANT: Press the seal only until it seats against the bearing; do not press it in farther.

3. Pack the roller bearing seal, the output seal, and the dirt and water seal liberally with clean, high-temperature industrial grease, Exxon Polyrex® EP2 grease (045422).

4. Lightly oil the valve housing O-ring, item 11 in **Fig. 1**, and install the O-ring in the mounting face groove of the valve housing.
5. Lightly oil a new seal ring, item 14 in **Fig. 1**, and install the seal ring in the valve housing mounting face groove.
6. Install a new O-ring, item 22 in **Fig. 1**, and then a seal ring, item 23, on the rack piston. Do not overstretch the rings as they are being installed. Do not allow the seal ring to become twisted.
7. Apply clean oil to the gear housing cylinder bore. Place the rack piston in the housing with the ball return guide holes up.
8. Install the input shaft assembly in the rack piston close to maximum depth without the valve housing making contact with the poppet stem. Insert two 14 mm x 2.0 mm All Threads through the lower valve housing mounting holes and tighten them to support the worm and valve assembly. Line up the rack piston ball guide holes with the worm ball track grooves by rotating the input shaft.
9. Install the ball return guide in the rack piston until seated. Rotate the input shaft slightly if necessary.

⚠ WARNING

Do not seat the ball return guide with a hammer. Damage to the guide can result in subsequent lockup or loss of steering, resulting in personal injury or property damage.

IMPORTANT: If a new rack piston, input shaft, or input shaft assembly is being installed, the balls must be replaced. The balls in a service ball kit are sized to function in the ball track guide path as altered by component replacement.

When using a service ball kit, use the correct quantity of balls. There are 31 balls in the THP60 steering gear.

NOTE: Hold the ball return guide firmly in place while performing the following step.

10. Insert as many balls as you can through the hole in the top of the ball return guide. Rotate the input shaft to pull the balls down and around the ball track guide path. Continue until the correct number of balls is in the ball track guide path.

    If the ball guide becomes unseated (raised) at any time, start the procedure again beginning with the previous step.

⚠ WARNING

Hold down the ball return guide until the ball return guide cap is installed. Failure to hold the guide will result in a trapped ball or balls, which could cause a vehicle accident resulting in personal injury or property damage.

⚠ CAUTION

Do not allow the valve housing to contact the poppet stem or move more than 2.5 inches (64 mm) from the upper end of the rack piston during these procedures. This could incorrectly reset the poppet or back out the input shaft assembly beyond the closed ball loop, trapping the balls.

⚠ CAUTION

Remove any fluid present in the two screw holes. Fluid in these holes could cause improper clamp load when torquing the ball return guide cap.

11. Install a new cap seal in the groove of the ball return guide cap. Make sure the seal makes full contact with the rack piston surface. Install two new Torx capscrews and torque each capscrew alternately until a final torque of 18 lbf·ft (24 N·m) is reached.

IMPORTANT: The cap seal is greased to hold the seal in the groove while it is assembled. Be sure not to trap the seal outside of the groove during assembly.

12. Rotate the input shaft from one end of travel to the other without contacting the poppet stem to the valve housing and without moving the valve housing face more than 2.5 inches (64 mm) from the input end (upper end) of the rack piston. If you cannot rotate the input shaft, remove the balls and install them again.

Disassembly, Inspection, Assembly, and Final Adjustments

WARNING

If a gear is installed on a vehicle when the input shaft is not able to be rotated, the gear will not function correctly. Steering and gear failure may result, possibly causing personal injury or property damage.

13. Apply clean oil to the seal ring, item 23 in **Fig. 1**, on the rack piston. Make sure there is a space of 3/8 to 1/2 inch (10 to 13 mm) between the valve housing and the poppet stem to prevent poppet contact at either end. Remove the All Threads and push the rack piston into the housing with the rack piston teeth toward the sector shaft cavity. Line up the valve housing cylinder feed hole with the gear housing feed hole. Make sure both O-rings in the valve housing remain in position.

IMPORTANT: Do not damage the seal ring while installing the rack piston in the housing.

IMPORTANT: The poppet seat and sleeve assembly must not bottom against the internal poppet stops in the steering gear until the gear is installed on the vehicle and the poppet adjustment procedures are performed.

14. Lubricate and install the four valve housing capscrews in the housing. Torque the capscrews 118 to 138 lbf·ft (160 to 187 N·m).

15. If the gear is equipped with a relief valve, install a new O-ring on the relief valve cap. Install the small end of the tapered spring on the pin on the relief valve cartridge and install the relief valve with the large end of the tapered spring end first in the relief valve cap cavity. Turn the relief valve cap into the valve housing and torque 30 lbf·ft (41 N·m).

CAUTION

The caged bearing assembly is sealed and will not receive lubrication from the hydraulic fluid in the gear. Failure to use the proper grease could result in premature bearing wear.

16. Apply a generous amount of Exxon Polyrex EP2 grease (045422), and **only** this type of grease, to the caged bearing assembly in the side cover. Then install the washer, item 45 in **Fig. 1**, on top of the bearing.

NOTE: Use bearing and seal tool, J37071, on the THP60 steering gear.

17. Grease and install a new output seal on the installation tool so that the side with the garter spring is against the shoulder of the tool. Pilot the tool into the side cover with a force of 100 to 800 lbf (445 to 3560 N) until it is seated against the bearing or bushing.

IMPORTANT: Make sure the outside diameter of the seal and the inside diameter of the bore are free from grease and dust for proper engagement of the seal.

18. Apply a generous amount of Exxon Polyrex EP2 grease (045422) to the short bearing area of the sector shaft.

19. Install the sector shaft in the side cover and turn the sector shaft adjusting screw counterclockwise until the screw reaches solid height.

    Rotate the adjusting screw clockwise one-half turn so that the side cover will rotate freely on the sector shaft.

20. Install the sector shaft adjusting screw jam nut, item 50 in **Fig. 1**, on the sector shaft adjusting screw a few threads. Final adjustment will be made later.

21. Press the new vent plug into the hole provided in the side cover until the plug has bottomed.

WARNING

Hold down the ball return guide until the ball return guide cap is installed. Failure to hold the guide will result in a trapped ball or balls, which could cause a vehicle accident resulting in personal injury or property damage.

22. Apply clean oil to the new side cover O-ring, item 47 in **Fig. 1**, and install it on the side cover.

WARNING

If the rack piston is not centered when the sector shaft is installed, gear travel will be severely limited in one direction. This could cause an accident possibly resulting in personal injury or property damage.

23. There are four teeth on the rack piston. Rotate the input shaft to position the rack piston so that the space between the second and third tooth is in the center of the sector shaft opening. This will center the rack piston for installation of the sector shaft.

⚠ CAUTION

If the serrations are not properly taped, they will damage the output seal in the housing and cause the seal to leak.

24. Remove all tape on the serrations. Apply one layer of masking tape on the serrations and bolt groove of the sector shaft. Install the sector shaft in the housing. The center tooth of the sector shaft must engage the center space (between the second and third tooth) of the rack piston. Lightly tap on the side cover with a rubber mallet to seat the cover against the housing face.
25. Install the capscrews in positions 3 and 4 on the side cover by hand. Then install the remaining capscrews in the side cover and tighten them in the sequence shown in **Fig. 2**. Lubricate the capscrews and torque 180 to 220 lbf·ft (244 to 298 N·m).

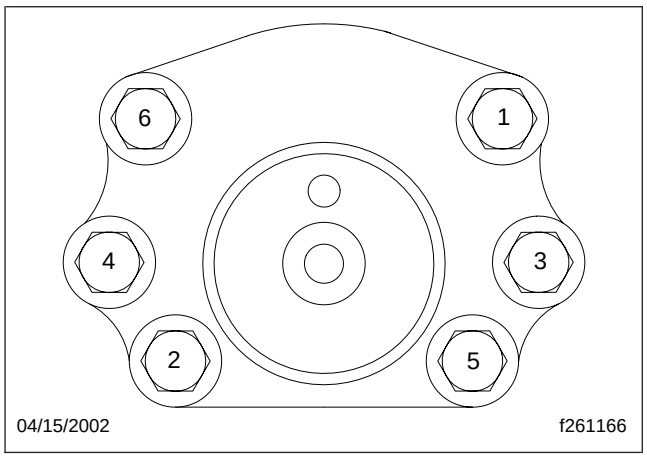


Fig. 2, Capscrew Tightening Sequence

IMPORTANT: If the capscrews must be replaced, use capscrews of the same design, type, and length as those removed.

26. Remove the tape from the sector shaft.
27. Pack the end of the valve housing bore with Exxon Polyrex EP2 grease (045422). Apply more grease to the inside of a new dirt and water seal, and install it on the input shaft. Seat the seal in the groove behind the serrations and against the valve housing.

NOTE: This step may have already been completed if the valve housing and input shaft assembly were disassembled for repair.

Final Adjustments

Before installing the steering gear on the vehicle, make the following adjustments.

NOTE: Worm shaft preload adjustment was done when the input shaft was installed in the valve housing during the assembly procedure.

IMPORTANT: When the steering gear is not connected to the steering system, don't 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 disassembling the gear to position the poppet seat and sleeve assemblies.

1. Using a 3/4- or 11/16-inch socket or box end wrench, center the steering gear by rotating 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.

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.

2. With the adjusting screw jam nut loose, turn the sector shaft adjusting screw clockwise to provide 45 to 50 lbf·in (508 to 565 N·cm) of torque to rotate the input shaft through one-half turn each side of center.

NOTE: This step will properly mesh and seat the rack piston and sector shaft for final adjustments.

3. Turn the sector shaft adjusting screw counterclockwise one-half turn and note the maximum

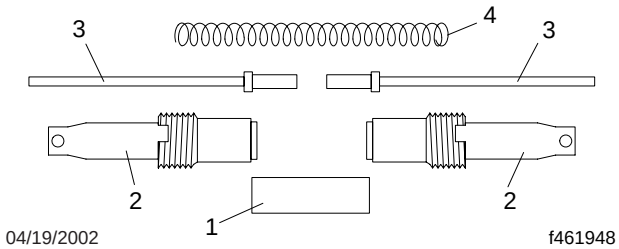
Disassembly, Inspection, Assembly, and Final Adjustments

torque required to rotate the input shaft through one-half turn each side of center.

4. Turn the sector shaft adjusting screw clockwise to increase the maximum torque noted in the previous step by 7 lbf·in (79 N·cm). Tighten the jam nut firmly against the side cover while holding the adjusting screw in position.
5. Torque the jam nut 43 lbf·ft (58 N·m) and check the input shaft torque again. Adjust the sector shaft adjusting screw if the input shaft torque exceeds 40 lbf·in (452 N·cm).
6. Install the steering gear on the vehicle. For instructions, see **Subject 100**.
7. Remove the chocks from the tires.

Replacement

1. Remove the rack piston from the steering gear. For instructions, see **Subject 150**.
2. Place the rack piston in a soft-jawed vise.
3. Place special tool, J36452-A, over the seat of the poppet seat and sleeve assembly and engage the special tool in the slots of the threaded sleeve. Hit the end of the tool firmly four or five times with a two-pound sledge hammer to loosen the Loctite®.
4. Place a ratchet on the special tool and remove the seat and sleeve assembly from the rack piston. If the ratchet does not turn easily, strike the special tool again with a hammer. If the engaging tangs won't stay in place while torquing, it may be necessary to hold the tool in place with an arbor press while applying loosening torque.
5. Discard the poppet seat and sleeve assembly. See **Fig. 1**.



1. Push Tube
2. Poppet Seat and Sleeve Assembly
3. Poppet
4. Spring

Fig. 1, Poppet Components

6. Remove the two poppets, the spring, and the push tube. See **Fig. 1**.
7. If necessary, remove and discard the second poppet seat and sleeve assembly.

NOTE: It is possible to reset one poppet seat and sleeve assembly for automatic poppet adjustment while it is in the rack piston if one poppet seat and sleeve assembly and the poppets, spring, spacer rod, and push tube are removed.

8. To reset the automatic poppet adjustment when one poppet seat and sleeve assembly has been left in the rack piston, insert a 3/8-inch (9.5-mm) diameter x 6-inch (152-mm) drill rod down through the poppet seat hole at the opposite end of the rack piston and against the adjuster seat to press the seat in until it bottoms against the adjuster sleeve.

CAUTION

Do not allow Loctite or Locquic to get on the adjuster seat component of the poppet seat and sleeve assembly. Failure to follow this precaution will prevent the poppets from functioning properly.

9. Carefully apply Locquic® T primer to the threads in the poppet holes and to the threads on the new seat and sleeve assemblies. Allow the primer to dry for 10 minutes, then carefully apply Loctite RC680 to the same threads.

WARNING

Wear eye protection when assembling the poppets since the spring-loaded poppets could eject and cause personal injury.

10. Place the rack piston in a soft-jawed vise. If the second poppet seat and valve assembly was removed, install a new poppet seat and sleeve assembly, with the slotted end out, into the poppet hole in one end of the rack piston.
11. From the other end of the poppet hole in the rack piston, install one poppet, the poppet spring, push tube, the other poppet, and a new poppet seat and sleeve assembly. The new components will fit together as shown in **Fig. 2**.

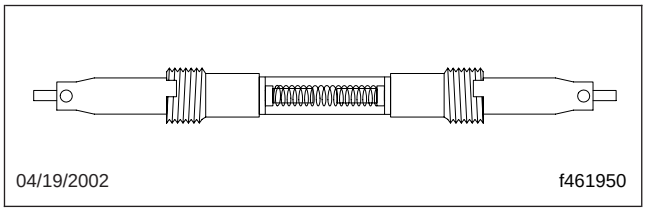


Fig. 2, Poppet Components Assembled

12. Torque the poppet seat and sleeve assemblies 18 lbf·ft (24 N·m).
13. Install the rack piston in the steering gear. For instructions, see **Subject 150**.

Valve Housing/Input Shaft Disassembly, Inspection, and Assembly

Disassembly

1. Remove the valve housing and the input shaft assembly from the steering gear. For instructions, see **Subject 150**.
2. Place the valve housing, with the input shaft in the upright position, in a soft-jawed vise.
3. Unstake the valve housing where the material was moved into the adjuster locknut slot.
4. Using a roll pin punch and hammer, unstake the adjuster locknut from the bearing adjuster. See **Fig. 1**.
5. Using the adjuster locknut tool (J37464), remove the adjuster locknut from the valve housing.
6. Using the bearing adjuster tool (J37070), remove the bearing adjuster from the valve housing.
7. Remove and discard the seal ring and O-ring, items 18 and 19 in **Fig. 1**, from the bearing adjuster.
8. Remove the input shaft from the valve housing.
9. Remove the thrust washer and thrust bearing, items 17 and 16 in **Fig. 1**, from the input shaft.

CAUTION

The input shaft assembly must not be disassembled any further. The components are a select fit at assembly and are available only as part of this subassembly. If disassembled further, the subassembly must be replaced.

10. Remove the bearing assembly, item 12 in **Fig. 1**, from the valve housing.

IMPORTANT: Do not remove the ball cup that the bearing assembly rides on. Do not remove the special spacer seal behind the ball cup.

11. Remove and discard the seal ring, item 14 in **Fig. 1**, from the valve housing.
12. Remove the valve housing from the vise. Turn the valve housing over and remove the retaining ring, item 3 in **Fig. 1**.

CAUTION

Be careful when removing the input shaft seal to prevent damage to the valve housing seal bore.

13. Using a 1-1/8-inch socket and hammer, remove the input shaft seal, item 4 in **Fig. 1**, from the valve housing. Discard the input shaft seal.

NOTE: The valve housing also utilizes a ball plug for manufacturing purposes that must not be removed.

Inspection

1. Inspect the sealing areas of the input shaft and valve housing for nicks. Run the edge of your fingernail over the sealing surfaces to detect steps. Inspect for discoloration from excess heat. Inspect the input shaft ball track grooves for brinelling or spalling. If any of these conditions exist, the input shaft assembly, valve housing, and balls must be replaced. Replace the rack piston if brinelling or spalling is found.
2. Inspect the rollers in the thrust bearing and the bearing assembly for deterioration. Inspect the thrust washer and ball bearing race in the valve housing for brinelling, spalling, or cracks. Replace all parts that exhibit these conditions.

Assembly

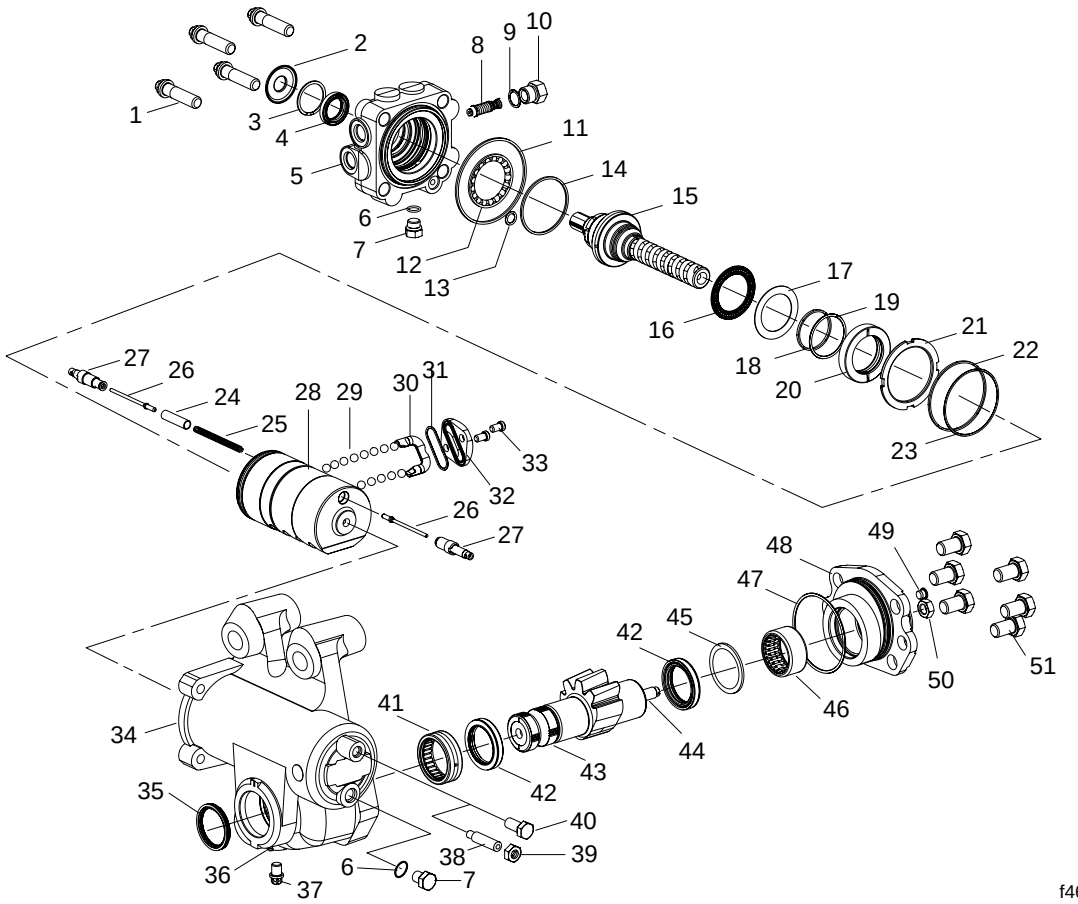
IMPORTANT: Do not clamp the valve housing against the threaded port hole or relief valve hole sealing faces when placing the valve in the vise.

1. Place the valve housing in a vise so the input shaft can be assembled with the worm screw up.
2. Lightly oil a new seal ring and install the seal ring in the large diameter groove in the valve housing. It may be necessary to bend and work the seal ring into the groove. Smooth out the seal ring.

IMPORTANT: The seal ring must be smoothed out to prevent it from damage when the worm screw is installed.

3. Install the bearing assembly in the valve housing. See **Fig. 2** for correct orientation of the bearing assembly.
4. Dip the input end of the input shaft assembly in oil up to the worm lead. Install the input shaft

Valve Housing/Input Shaft Disassembly, Inspection, and Assembly



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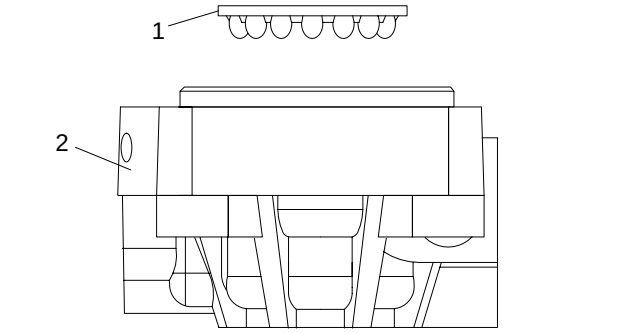
1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft Assembly
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover Assembly
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

Fig. 1, THP Steering Gear

Valve Housing/Input Shaft Disassembly, Inspection, and Assembly



1. Bearing Assembly 2. Valve Housing

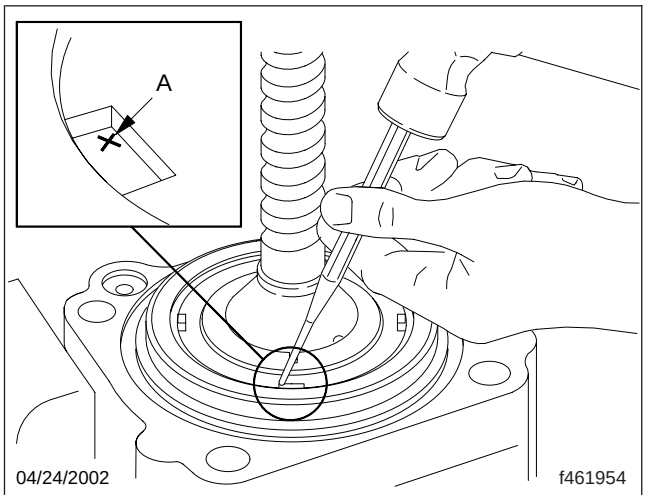
Fig. 2, Correct Orientation of Bearing Assembly

end of the assembly in the valve housing until it is firmly seated.

5. Apply oil to the thrust bearing and thrust washer, then install the bearing and washer over the ball groove end of the worm screw and seat them against the shoulder of the input shaft assembly.
6. Lightly oil a new O-ring and install it in the bearing adjuster seal groove. Lightly oil a new seal ring and install it in the same bearing adjuster seal groove. Smooth out the seal ring.

NOTE: Be sure the valve housing, the adjuster locknut, and the bearing adjuster threads are clean and free of any staking burrs that would impede the locknut from turning freely in the valve housing.

7. Lightly oil a new bearing adjuster and install it in the valve housing. Using a torque wrench inserted in the bearing adjuster tool (J37070), torque the bearing adjuster 13 lbf·ft (18 N·m). This will seat the components. Back off the adjuster one-quarter to one-half of a turn.
8. Lightly oil a new adjuster locknut and install it on the bearing adjuster with the slightly rounded side down. Tighten slightly to keep the bearing adjuster in place.
9. Reverse the valve housing in the vise so that the worm screw is down. With a pound-force-per-inch torque wrench on the input shaft, note the torque required to rotate the input shaft 360 degrees in each direction. Tighten the bearing adjuster to increase the maximum torque at the input shaft 5 to 10 lbf·in (56 to 113 N·cm) over that which was previously noted.
10. Reverse the valve housing in the vise so that the worm screw is up. Torque the adjuster locknut while holding the bearing adjuster in the position established in the previous step with the adjuster locknut tool (J37464). When using a torque wrench in the adjuster locknut tool, the torque wrench reading should be 112 lbf·ft (152 N·m).
11. Check the input shaft torque. It should match the torque measured previously. If the torque readings do not match, repeat the previous two steps.
12. Stake the valve housing in the clockwise-most corner of two opposing slots in the adjuster locknut. See **Fig. 3**. Stake the locknut into the bearing adjuster in two places, 180 degrees apart, at the threaded area. Choose areas that have not been previously staked.



A. Stake the valve housing in the clockwise-most corner of the slot in the adjuster locknut.

Fig. 3, Stake the Valve Housing

13. After staking, the torque required to rotate the input shaft must be between 5 to 10 lbf·in (56 to 113 N·cm) greater than the torque noted previously. The torque value must not exceed 22 lbf·in (249 N·cm). If necessary, unstake and readjust.
14. Place the valve housing/worm screw assembly in the vise so that the worm screw is down.

Valve Housing/Input Shaft Disassembly, Inspection, and Assembly

IMPORTANT: Remove any seal material that may have sheared off and is in the seal bore and retaining groove ring.

15. Apply Exxon Polyrex® EP2 grease (045422) to the outside and inside diameters (fill cavity between the lips) of the new input shaft seal and install it, garter spring side first, on the input shaft. Align the seal in the valve housing seal bore.

IMPORTANT: The input shaft seal must be square in the seal bore and installed to the correct depth.

16. Place the seal driver tool (J37073) with the smaller end first, on the input shaft and against the seal. Tap the seal installer tool until the tool shoulder is squarely against the valve housing. This will correctly position the seal in the housing bore just beyond the retaining ring groove.
17. Insert the new retaining ring, item 3 in **Fig. 1**, into the retaining ring groove in the valve housing.
18. Pack the end of the valve housing bore around the input shaft with Exxon Polyrex EP2 grease (045422). Apply more of the grease to the inside of a new dirt and water seal and install it on the input shaft. Seat the seal in the groove behind the serrations and against the valve housing.
19. Install the valve housing/input shaft assembly in the steering gear. For instructions, see **Subject 150**.

Replacement

1. Remove the side cover assembly in order to access the roller bearing, item 41 in **Fig. 1**. For instructions, see **Subject 150**.
2. Place the long end of the bearing and seal tool, J37071–A, against the trunnion end of the bearing and press it out of the side-cover end of the bearing bore. Discard the roller bearing.

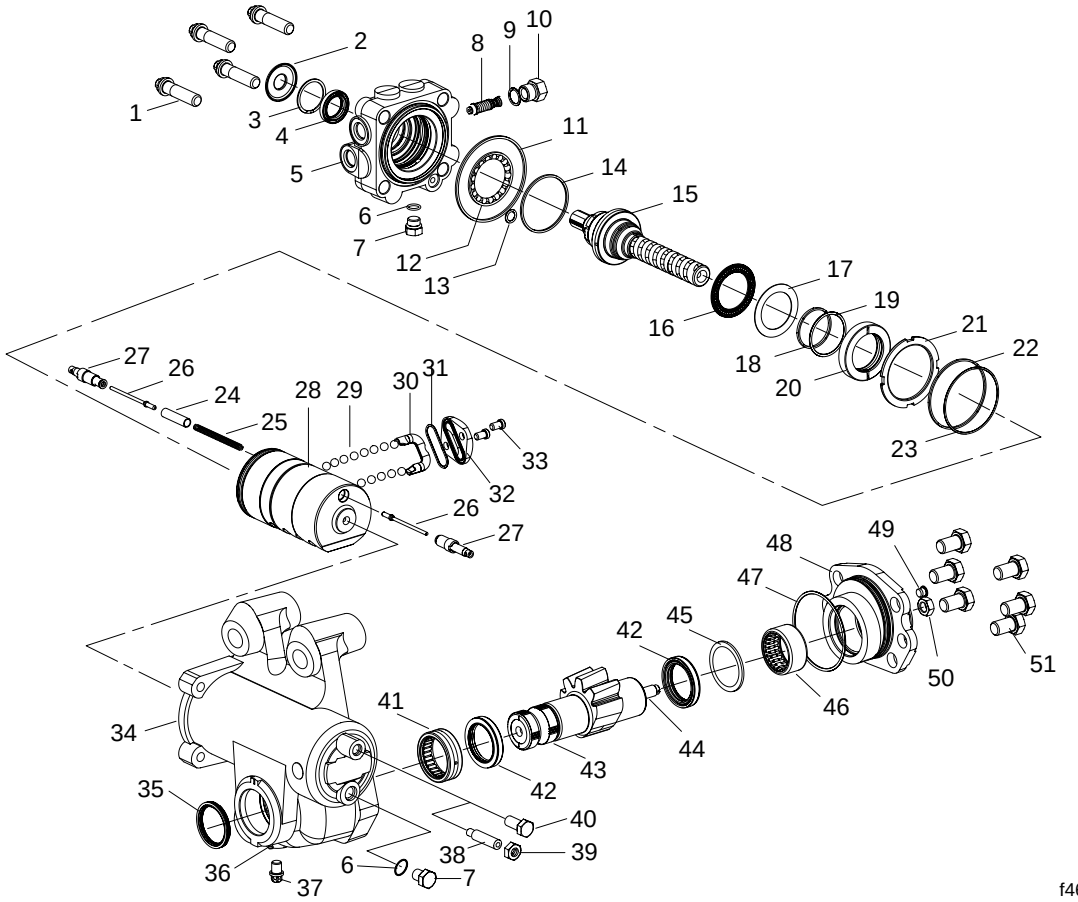
⚠ CAUTION

Use the short end of the bearing and seal tool to press in the roller bearing. If the long end of the bearing and seal tool is used to press in the bearing, the cage on the roller bearing may be damaged.

NOTE: If the unmachined trunnion face is not square, use shims to square it before pressing in the bearing.

3. Using the short end of the bearing and seal tool, press the new roller bearing into the gear housing from the side-cover end of the bearing bore until it is seated against the step bore. Be sure the housing is square with the press base and the bearing is not cocked.
4. Install the side cover on the gear housing. For instructions, see **Subject 150**.

Roller Bearing Replacement



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1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft Assembly
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover Assembly
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

Fig. 1, THP Steering Gear

Housing Port Plugs, Screws, and Fittings Replacement

Poppet Fixed Stop Screw Replacement

1. If the poppet fixed stop screw is damaged, remove the stop screw, item 40 in **Fig. 1**, and the washer. Discard the washer.
2. Install a new poppet fixed stop screw and torque 48 lbf·ft (65 N·m).

Poppet Adjusting Screw Replacement

1. If the poppet adjusting screw and poppet adjusting screw nut are damaged, remove the adjusting screw and nut, items 38 and 39 in **Fig. 1**, without allowing the nut to change its position on the screw.
2. Install a new nut on the new poppet adjusting screw matching its position to the nut and screw removed. Torque the nut 35 lbf·ft (47 N·m).

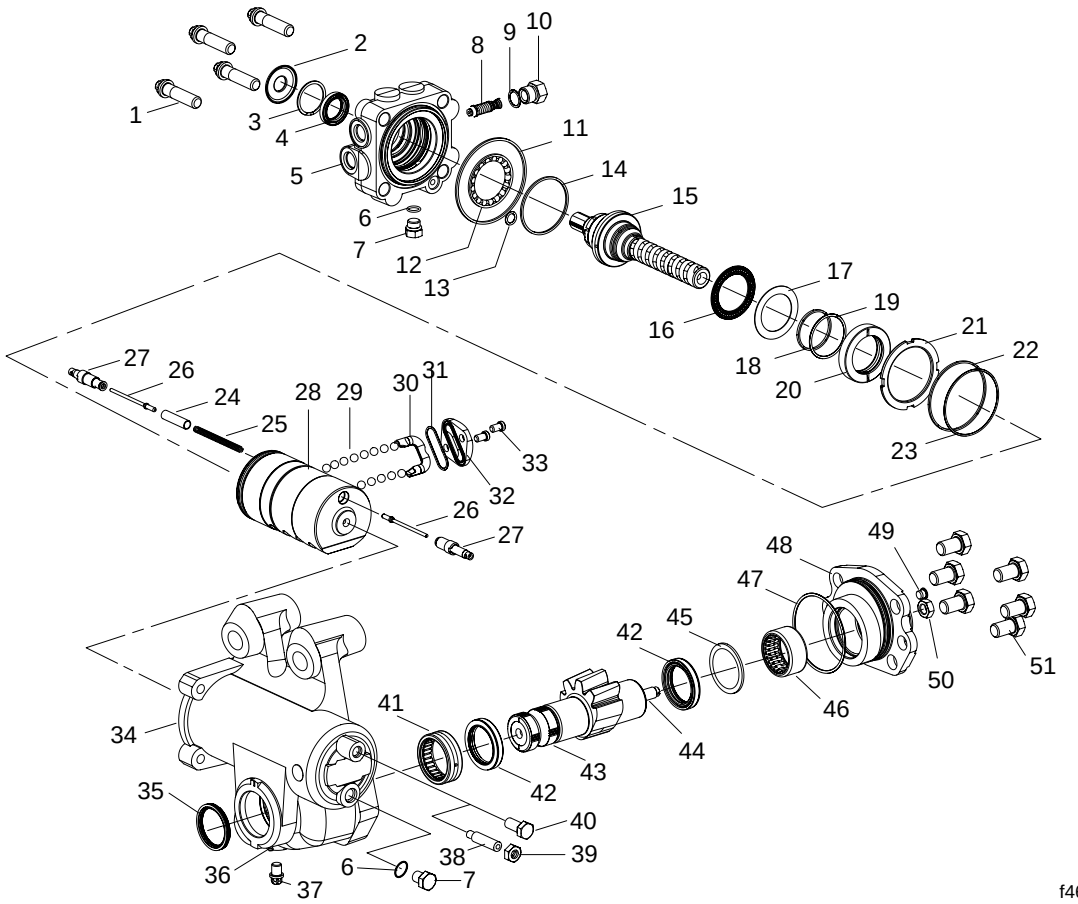
Automatic Bleed Plug and Auxiliary Port Plug Replacement

1. If the automatic bleed plug is damaged, remove the plug, item 37 in **Fig. 1**.
2. Install a new automatic bleed plug and torque the plug 48 lbf·ft (65 N·m).
3. If the auxiliary port plug and the auxiliary port O-ring are damaged, remove the plug and the O-ring, items 7 and 6 in **Fig. 1**.
4. Install a new auxiliary port plug and auxiliary port O-ring in the gear housing or valve housing and torque the plug 30 lbf·ft (41 N·m).

Manual Bleed Screw Replacement

1. If the manual bleed screw is damaged, remove the bleed screw. For possible manual bleed screw locations, see **Fig. 2**.
2. Install a new manual bleed screw and torque the screw 45 lbf·in (508 N·cm).

Housing Port Plugs, Screws, and Fittings Replacement



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1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft Assembly
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover Assembly
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

Fig. 1, THP Steering Gear

Housing Port Plugs, Screws, and Fittings Replacement

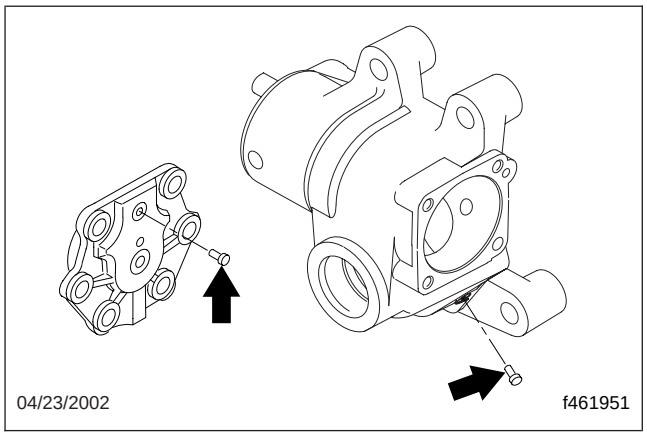


Fig. 2, Possible Manual Bleed Screw Locations

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. Operate the engine at low idle while turning the steering wheel through several full-left and full-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 **Group 46** of the *L-Line and A-Line 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 poppets are set correctly. If needed, adjust them. For instructions, see **Subject 140**.
5. If there are still problems with the power steering system, see **Section 46.10, Subject 300** and perform the troubleshooting procedures; otherwise, go to the next step.
6. Test drive the vehicle. 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 8 o'clock and 4 o'clock positions, remove the steering wheel and reposition it. See **Fig. 1**.

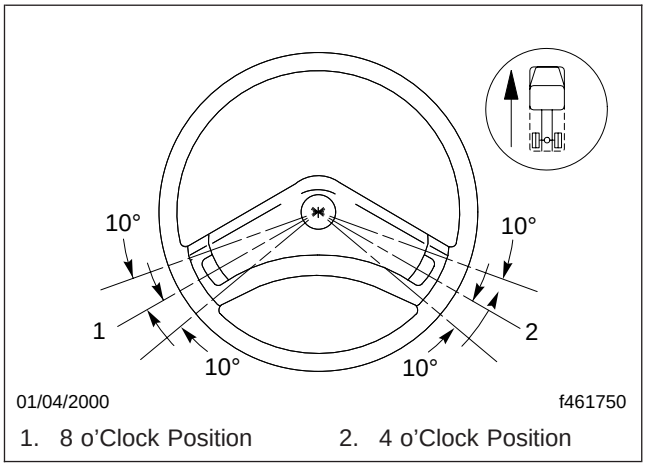


Fig. 1, Steering Wheel Centered

⚠ WARNING

Fill the power steering system only with approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. A fluid leak could eventually cause loss of power steering assist.

The following hydraulic fluids are approved for use in the steering system:

- Automatic Transmission Fluid (ATF), Dexron® II
- Automatic Transmission Fluid (ATF), Dexron® III

The following type of grease is approved for use on the steering gear components:

- Exxon Polyrex® EP2 (045422)

Special tools can be ordered from:

SPX Kent-Moore
28635 Mound Road
Warren, Michigan 48092-3499
1-800-328-6657

SPX Kent-Moore Tools	
Tool Name	**Part Number**
Bearing and Seal Tool	J37071 and J37071–A
Special Tool	J36452–A
Bearing Adjuster Tool	J37070
Seal Driver Tool	J37073
Adjuster Locknut Tool	J37464

Table 1, SPX Kent-Moore Tools

General Information

The TRW TAS power steering gear uses pressurized hydraulic fluid to help the driver turn the front wheels. The steering gear incorporates a manual steering mechanism, hydraulic control valve, and a hydraulic power cylinder. The control valve is a rotary design that directs oil flow from the power steering pump to the upper or lower cylinder cavity. The TAS65 power steering gear is used for front axle capacities of up to 14,000 pounds (6350 kg). The TAS85 power steering gear is used for front axle capacities of up to 18,000 pounds (8164 kg).

⚠ CAUTION

Never steam clean or pressure wash the steering gear. Damage to the gear seals can result, ultimately causing internal damage to the steering gear.

Principles of Operation

When the steering wheel is turned, force is transmitted from the steering wheel to the steering gear input shaft. A torsion bar, pinned at one end to the input shaft, and at the other to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response, the worm shaft, acting through the recirculating ball mechanism, tries to move the rack piston up or down (as applicable) in the gear housing cylinder bore.

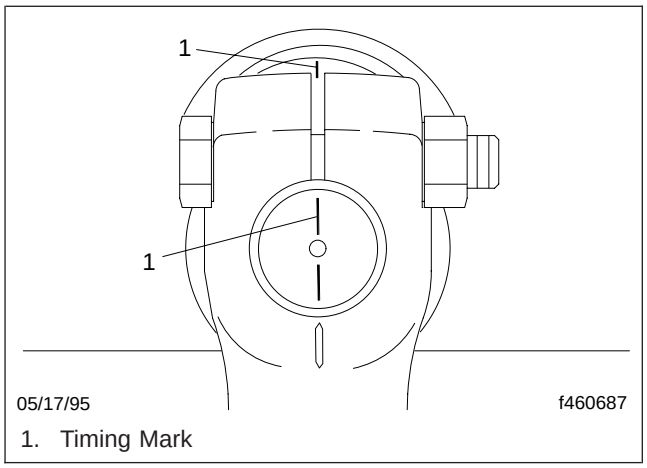
The movement of the rack piston is resisted by its engagement to the sector shaft, which is linked to the steered wheels. Because of this resistance, the torsion bar is twisted by the input shaft, thereby actuating the control valve. Pressurized fluid, directed by the control valve to the upper or lower cylinder cavity (depending on the direction of turn), assists in moving the rack piston up or down (as applicable) in the cylinder bore. The rack piston then turns the sector shaft to steer the vehicle.

If the steered wheels receive a shock load, the shock forces are transmitted through the sector shaft to the rack piston, and on to the worm shaft. The internal construction of the steering gear causes the control valve to send high-pressure fluid to the correct cylinder cavity to resist the shock forces. By absorbing the shock forces hydraulically, the steering gear prevents kickback at the steering wheel.

On each end of the rack piston is a poppet (unloading valve). The appropriate poppet will trip as the steered wheels approach the axle stop for that direction of turn. The tripped poppet reduces pressure in the gear, heat generated by the pump, and outside forces acting on the steering linkage.

Sector Shaft Adjustment

1. Position the sector (output) shaft at its center of travel by turning the steering wheel until the alignment mark on the sector shaft is at a right angle to the input shaft centerline, and in line with the timing mark on the end of the housing trunnion. See **Fig. 1**.



1. Timing Mark

Fig. 1, Position the Sector Shaft

2. Disconnect the drag link from the pitman arm.

   The input shaft/valve/worm assembly must not be turned more than 1-1/2 turns in either direction from its center of travel while the drag link is disconnected from the pitman arm. Turning the input shaft more than 1-1/2 turns from center will cause misadjustment of the automatic poppets. This may require the installation of a service poppet adjustment tool to manually reset the poppets.

3. With the sector shaft in the center position, grasp the pitman arm and gently try to move it back and forth. Fingertip force is adequate to detect lash (free play) of a loose sector shaft. See **Fig. 2**. There must be no movement of the input shaft or sector shaft. If no lash is detected, no adjustment is needed.

   If lash is detected, find the sector shaft adjusting screw, in the center of the sector shaft cover, on the inboard side of the gear housing. Loosen the adjusting screw jam nut, and move the adjusting screw clockwise until the sector shaft and rack piston are in contact. Use no more than 10 lbf·ft (14 N·m) of torque. Then turn the adjusting screw counterclockwise one turn. At this point, there should be lash at the pitman arm.

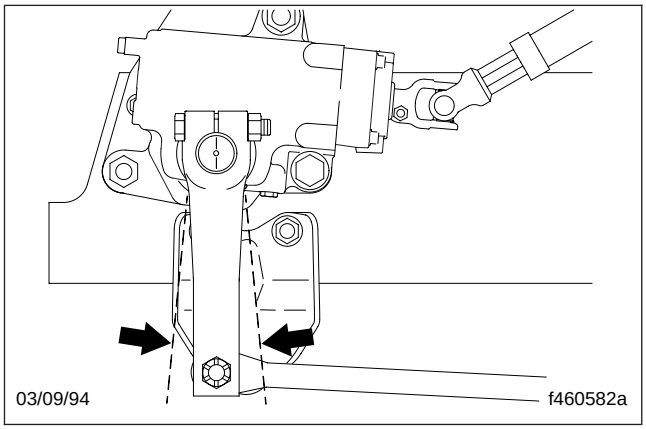


Fig. 2, Checking Sector Shaft Free Play

4. To adjust, slowly turn the adjusting screw clockwise until no lash is felt at the pitman arm, then turn it 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).

5. 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, see **Subject 110**.

Poppet Valves Adjustments

The TRW TAS power steering gear has 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 adjusted manually, through the use of a special service poppet adjusting screw and sealing jam nut kit, unless they were reset 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**.

   If both axle stops were set for increased travel, the steering gear poppets have reset automatically and gear adjustments are complete. No further action is required.

In-Vehicle Adjustments

If either axle stop was set for decreased travel, the steering gear poppets must be set manually. Continue to the next step.

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 turn and a full-right turn; otherwise the poppet valves will not work.

2. Install the steering gear manual poppet adjusting screw.

   2.1 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**.

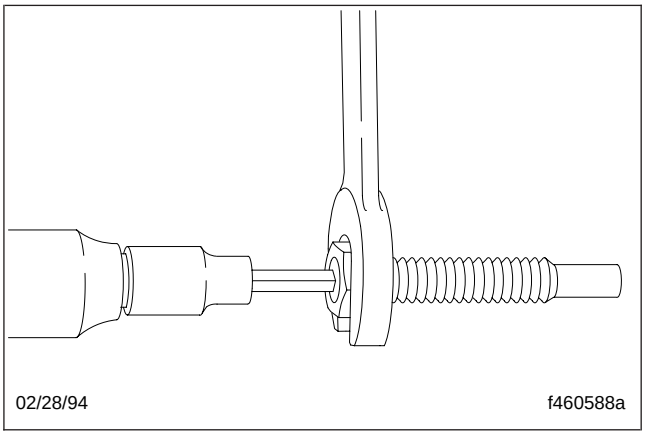


Fig. 3, Screw in the Poppet Adjusting Screw

   2.2 With the vehicle unloaded, the engine off, and the front wheels in the straight-ahead position, remove and discard the poppet fixed stopscrew and washer from the lower end of the steering gear housing. See **Fig. 4**.

   NOTE: With the wheels in the straight-ahead position and the timing marks on the sector shaft and gear housing aligned, the steering gear is centered. See **Fig. 1**.

   2.3 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. Tighten the nut 38 to 42 lbf·ft (52 to 57 N·m). See **Fig. 5**.

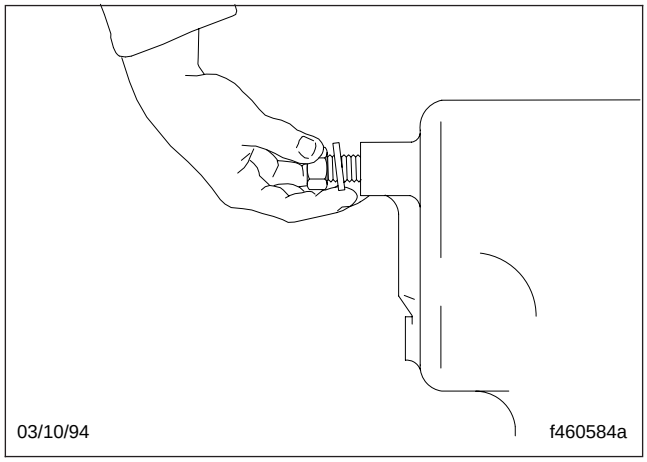


Fig. 4, Remove the Poppet Fixed Stopscrew and Washer

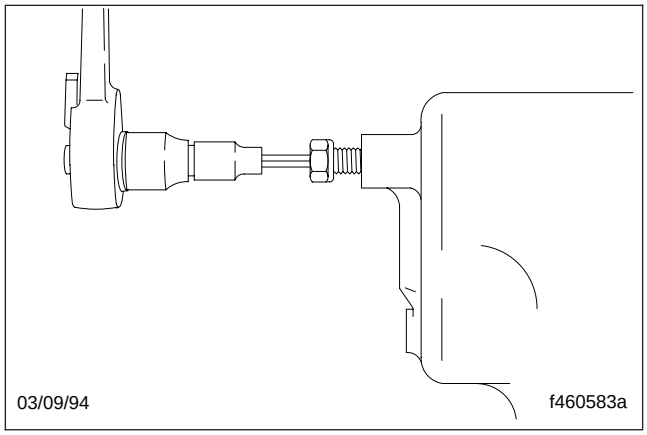


Fig. 5, Turn the Adjusting Screw

   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 the straight-ahead position.

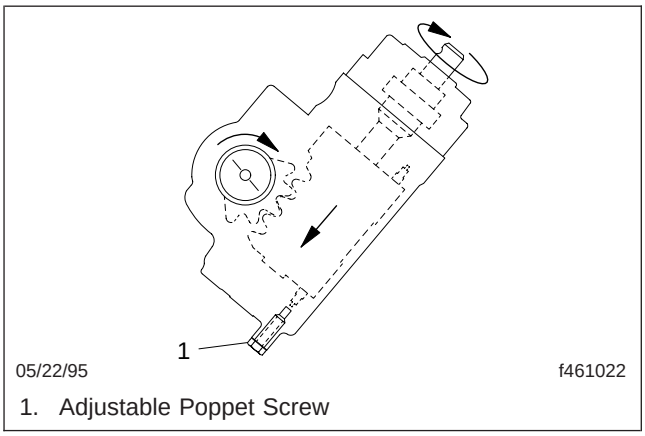
3. Adjust the poppets manually.

   3.1 Check the fluid level and fill the power steering reservoir with Dexron® II or Dexron® III automatic transmission fluid if required.

   3.2 Make sure the engine is off.

   3.3 Place a jack under the center of the front axle, and raise the steer tires off the ground.

3.4 Turn the steering wheel to the right until the axle stopscrew contacts the axle stop, or the end of the gear travel is reached. This pushes out the left-hand turn poppet to prepare it for setting. See **Fig. 6**.



1. Adjustable Poppet Screw

Fig. 6, Preparing the Poppet for Setting

3.5 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 after the adjusting nut has been backed out and the sealing nut tightened.

3.6 Loosen the sealing nut on the gear housing, and back out the adjusting screw until it is 1 to 1-1/16 inches (25 to 27 mm) beyond the sealing nut. See **Fig. 7**. Tighten the sealing nut 38 to 42 lbf·ft (52 to 57 N·m).

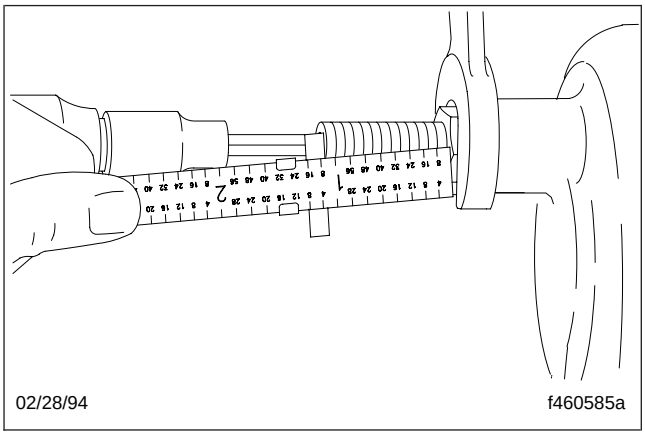


Fig. 7, Back Out the Adjusting Screw and Measure

IMPORTANT: Make sure the adjusting screw does not protrude more than 1-1/16 inches (27 mm) beyond the sealing nut.

3.7 Have someone turn the steering wheel all the way to the right, and hold it in place when the axle stops are contacted.

3.8 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 four complete turns. Have the steering wheel released at this time.

3.9 While holding the adjusting screw in place, tighten the sealing nut firmly against the gear housing. See **Fig. 8**. Tighten it 38 to 42 lbf·ft (52 to 57 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 38 to 42 lbf·ft (52 to 57 N·m). See **Fig. 7** and **Fig. 8**.

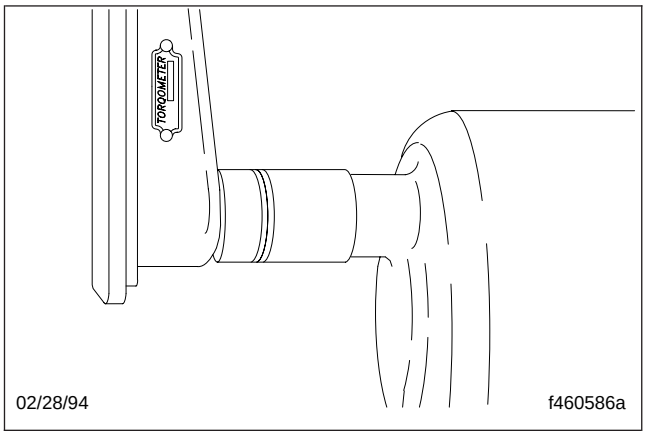


Fig. 8, Tightening the Sealing Nut

⚠ 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

In-Vehicle Adjustments

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

1. Verify correct axle stop adjustment. For instructions, see **Section 33.00**, Subject 110. Ensuring correct axle stop adjustment now will eliminate the possibility of resetting steering gear poppet valves after the gear is installed.
2. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where the work is to be done. Apply the parking brakes and chock the tires.

CAUTION

Do not turn the steering wheel or the steering shaft more than a half turn (except for alignment purposes) during the removal and installation procedures. Doing so may damage the clockspring in a vehicle equipped with an air bag.

3. Clean all outside dirt from around the fittings and hose connections.
4. Drain the power steering system. Disconnect all hydraulic lines from the gear, marking the lines for later assembly reference. Seal the lines and the fittings to keep out dirt.
5. Remove the drag link.
6. Disconnect the steering driveline from the steering gear input shaft as follows.

   6.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

CAUTION

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

   6.2 Remove the end yoke from the input shaft.

7. Clean the entire assembly before removing the gear.

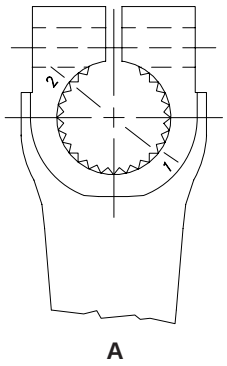
WARNING

The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.

8. Remove the fasteners that attach the steering gear to the frame rail and frame rail extension. Remove the spacers and the steering gear.

Installation

1. Install the steering gear and mounting fasteners. Torque the fasteners 427 lbf·ft (579 N·m).
2. If not previously done, center the steering gear. The sector (output) shaft alignment mark must be at a right angle to the steering gear input shaft center line. Make sure the steering gear remains centralized as the service work continues.
3. If the pitman arm was removed, install the pitman arm on the steering gear, aligning the timing marks as shown in **Fig. 1**.



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A. Timing Mark No. 2 Aligned

Fig. 1, Typical Pitman Arm and Timing

NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. To wedge the slot open, clamp the pitman arm in a vise with the slot at the top. Use a ball-peen hammer to drive a chisel into the slot. Hold the chisel in place, remove the

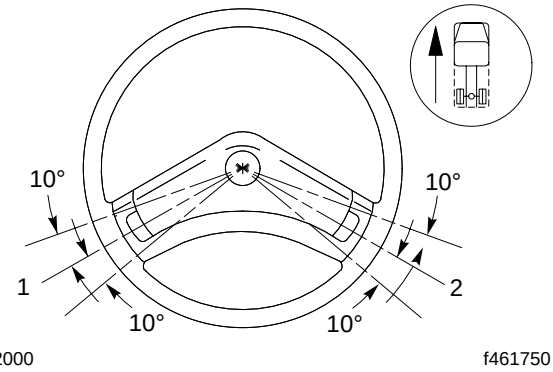
Steering Gear Removal and Installation

pitman arm from the vise, and install the pitman arm on the sector shaft. Remove the chisel from the slot.

⚠ 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.

4. Install a new pitman arm pinch bolt, washer (if applicable), and a new nut. Tighten the nut 230 lbf·ft (312 N·m).
5. Connect the steering driveline to the steering gear input shaft.
   - 5.1 Clean the input shaft and the inside of the driveline yoke.
   - 5.2 Position the steering wheel so that it is within ±10 degrees of center as shown in **Fig. 2**.



1. 8 o'Clock Position 2. 4 o'Clock Position

Fig. 2, Steering Wheel Centered

   - 5.3 Slide the yoke on the input shaft, and install a new pinch bolt and nut. Tighten the nut to one of the following torque specs:
     - 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16–20 pinch bolt and nut
     - 30 to 35 lbf·ft (41 to 47 N·m) for an M10 x 1.25 pinch bolt and nut
6. Connect the drag link to the pitman arm.
   - 6.1 Connect the pitman arm end of the drag link to the pitman arm, and install the castle nut.
   - 6.2 Tighten the castle nut 160 to 300 lbf·ft (217 to 407 N·m). If necessary, continue tightening the castle nut until a slot on the nut aligns with a hole in the ball stud. **Do not back off the nut.**
   - 6.3 Install a new cotter pin through the ball stud and the castle nut, then lock the cotter pin in place.
   - 6.4 Wipe the grease fittings clean at both ball stud sockets, then fill the sockets with Exxon Polyrex® EP2 grease using a pressure gun.
7. If they were removed, attach the hydraulic line elbow fittings to the steering gear. Tighten the fittings 37 lbf·ft (50 N·m). Tighten the pressure-line fitting jam nut 41 lbf·ft (56 N·m) maximum.
8. Remove the plugs from the hydraulic lines. Connect the hydraulic 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.
9. Fill and bleed the steering system.

   IMPORTANT: For the next two substeps, do not turn the steering wheel. Doing so can cause air to enter the system, which can make it more difficult and time-consuming to bleed air from the system.

   - 9.1 Fill the power steering reservoir nearly full. See **Specifications 400** for approved hydraulic fluids.

     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.
   - 9.2 Start the engine and let it idle for two minutes. Shut down the engine and check the fluid level in the reservoir.
   - 9.3 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 under **Subject 100**.

10. Go to **Subject 140** and do the checks as instructed.
11. 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 8 o'clock and 4 o'clock positions, remove the steering wheel and reposition it.

Replacement

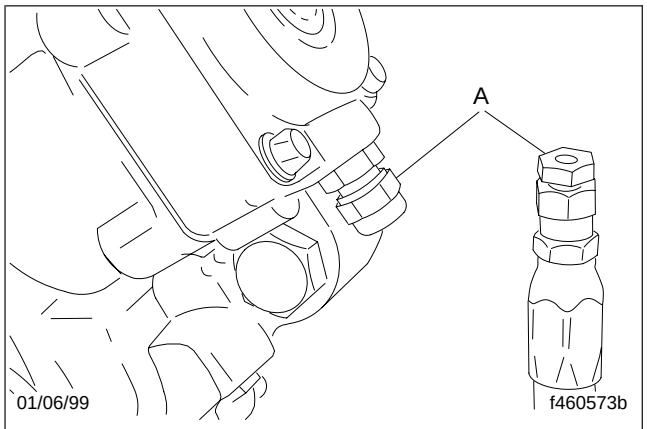
⚠ WARNING

All steering mechanisms are safety items. Because of this, follow the instructions in this subject exactly. Failure to do so may result in loss of steering, which could cause an accident resulting in personal injury or property damage.

Be sure that the required tools are available before beginning the service procedures described here. See the special tools table in **Specifications 400**. The special tool required for replacing the seal is available from SPX Kent-Moore or an affiliated dealer.

If the input shaft seal is causing an external leak, use the following procedure to replace it. This procedure does not require removing and disassembling the steering gear.

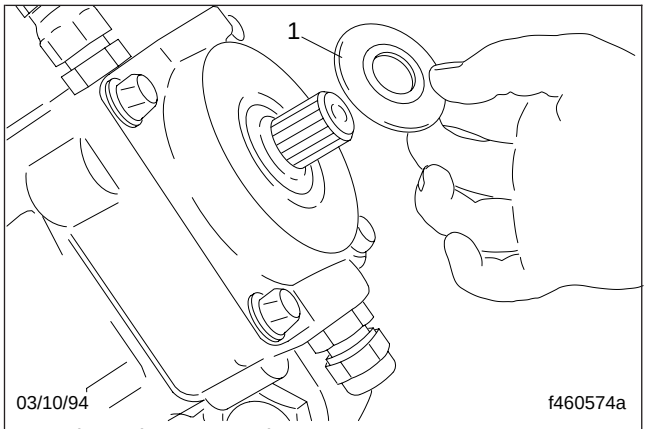
1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Clean all dirt from the area around the return line fitting and input shaft.
3. Disconnect the return line from the steering gear, and cap the line. See **Fig. 1**. Cap the return port of the gear with a 3/4–16 O-ring-type high pressure fitting.



A. Cap the return line and the return port.

Fig. 1, Disconnect the Return Line

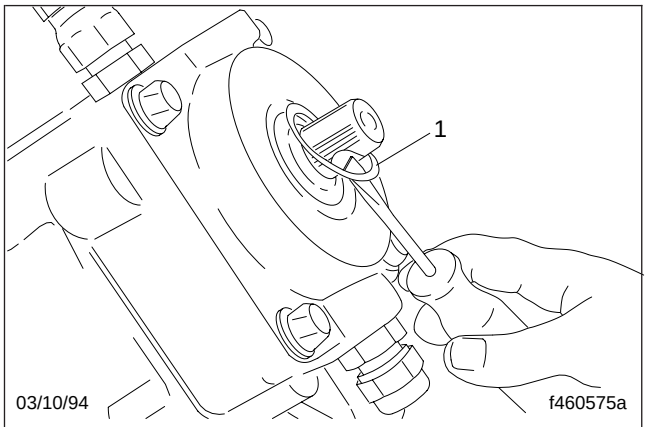
4. Disconnect the steering driveline from the steering gear input shaft. For instructions, refer to **Subject 110**.
5. Remove the dirt and water seal from the input shaft. See **Fig. 2**.



1. Dirt and Water Seal

Fig. 2, Remove the Dirt and Water Seal

6. Wipe off the grease from around the input shaft, then remove the spiral retaining ring by inserting a screwdriver into the notch in the end of the ring. See **Fig. 3**.

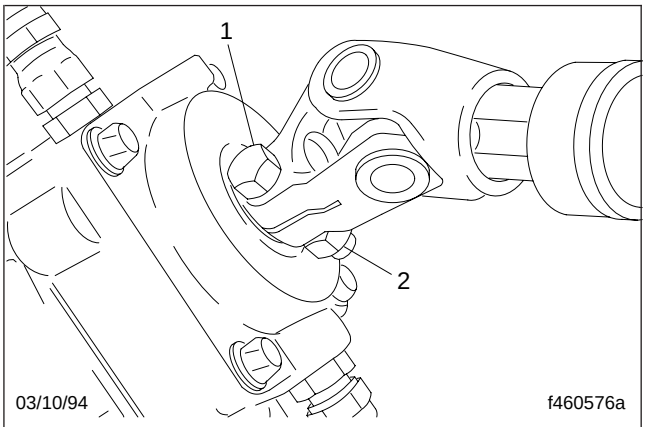


1. Retaining Ring

Fig. 3, Remove the Retaining Ring

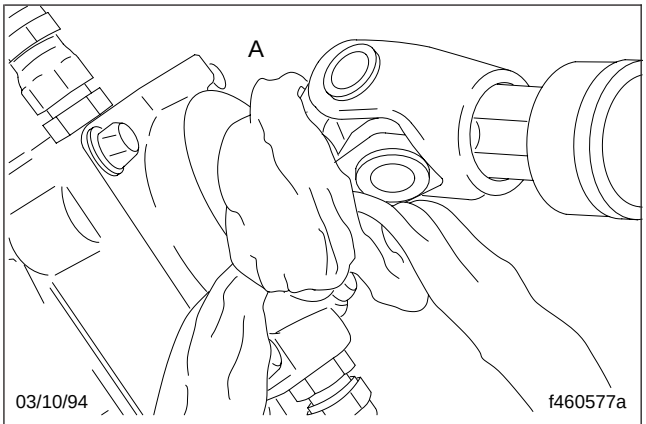
7. Slip the input yoke back onto the input shaft. Install the pinch bolt, but do not tighten it. See **Fig. 4**.
8. Tie or wrap a shop towel around the input shaft area, and place a drip pan under the gear to catch any spilled oil. See **Fig. 5**.
9. If needed, fill the power steering reservoir with Dexron® II or III automatic transmission fluid.

Input Shaft Seal Replacement



1. Pinch Bolt 2. Pinch Bolt Nut

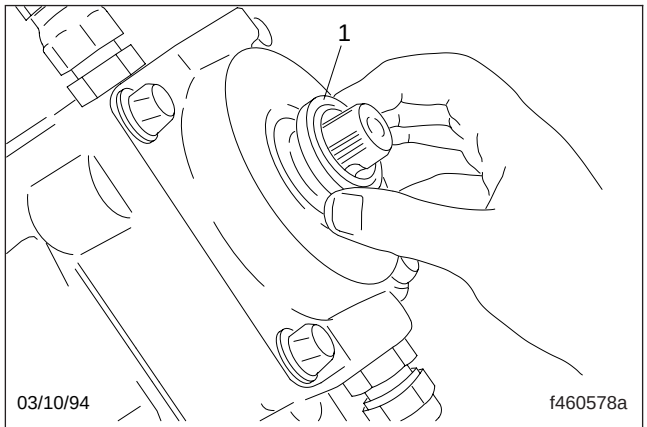
Fig. 4, Install the Pinch Bolt



A. Cover the input shaft area.

Fig. 5, Shop Towel Covering the Input Shaft

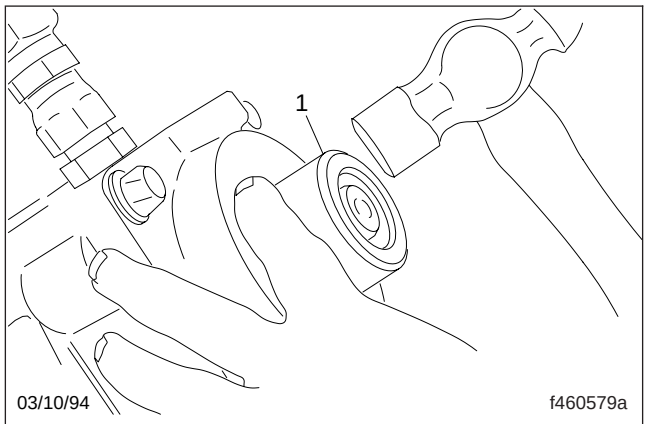
10. With the transmission in neutral, momentarily crank the starter. Quickly turn off the engine if it starts.
11. Remove the shop towel and disconnect the steering driveline from the input shaft.
12. Remove the input shaft seal. See **Fig. 6**.
13. Check the seal area of the valve housing for any seal fragments. Remove any that are found.
14. Check the seal for heat damage. If the seal is stiff and brittle, and not pliable like the new seal, it is probably heat damaged. Determine and fix the cause of excessive heat. For instructions, see **Troubleshooting 300**.



1. Input Shaft Seal

Fig. 6, Remove the Input Shaft Seal

15. Put clean grease on the new input shaft seal, and place it over the input shaft, garter spring side first. Place the input 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.

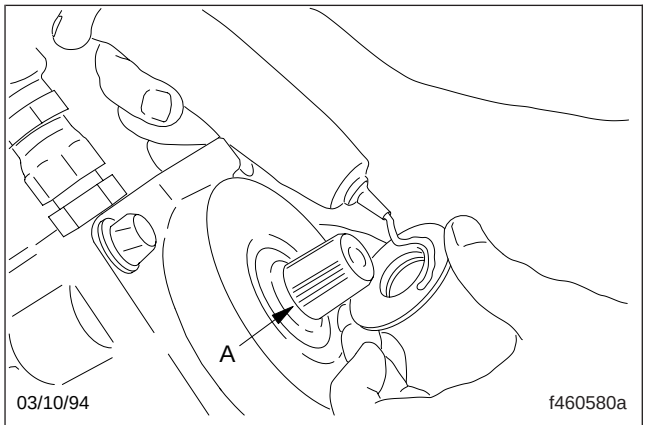


1. Seal Installer Tool

Fig. 7, Position the Seal Installer Tool

16. Insert the new retaining ring into the groove.
17. Pack the end of the valve housing bore around the input shaft with Exxon Polyrex® EP2 grease. Also apply grease to a new dirt and water seal. Install the seal over the input shaft, seating it in

the groove behind the serrations and against the valve housing. See **Fig. 8**.



A. Seat the seal here.

Fig. 8, Install the Dirt and Water Seal

18. Connect the steering driveline to the steering gear input shaft. For instructions, see **Subject 110**.
19. Connect the return line to the steering gear return port.
20. Fill and bleed the steering system.

    IMPORTANT: For the next two substeps, do not turn the steering wheel. Doing so can cause air to enter the system, which can make it more difficult and time-consuming to bleed air from the system.

    20.1 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.

    20.2 Start the engine and let it idle for two minutes. Shut down the engine, and check the fluid level in the reservoir.

    20.3 Start the engine again. Turn the steering wheel from full left to full right, several times. As needed, add fluid to the full line on the reservoir dipstick.

21. With the engine running, check for leaks in the steering system. Eliminate leaks as needed.
22. Lower the hood and remove the chocks from the tires.

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 (52 to 57°C) by operating the engine at low idle while turning the steering wheel through several full-left and full-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. For instructions, see **Group 46** in the*L-Line and A-Line 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, go to **Section 46.10, Subject 300** and perform the troubleshooting procedures. Otherwise, go to the next step.
6. Test drive the vehicle. 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 8 o'clock and 4 o'clock positions, remove the steering wheel and reposition it.

⚠ WARNING

Fill the power steering system only with approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. A fluid leak could eventually cause loss of power steering assist.

The following hydraulic fluids are approved for use in the steering system:

- Automatic Transmission Fluid (ATF), Dexron® II
- Automatic Transmission Fluid (ATF), Dexron® III

The following type of grease is approved for use on the steering gear components:

- Exxon Polyrex® EP2 (PN 045422)

Special tools can be ordered from SPX Kent-Moore.

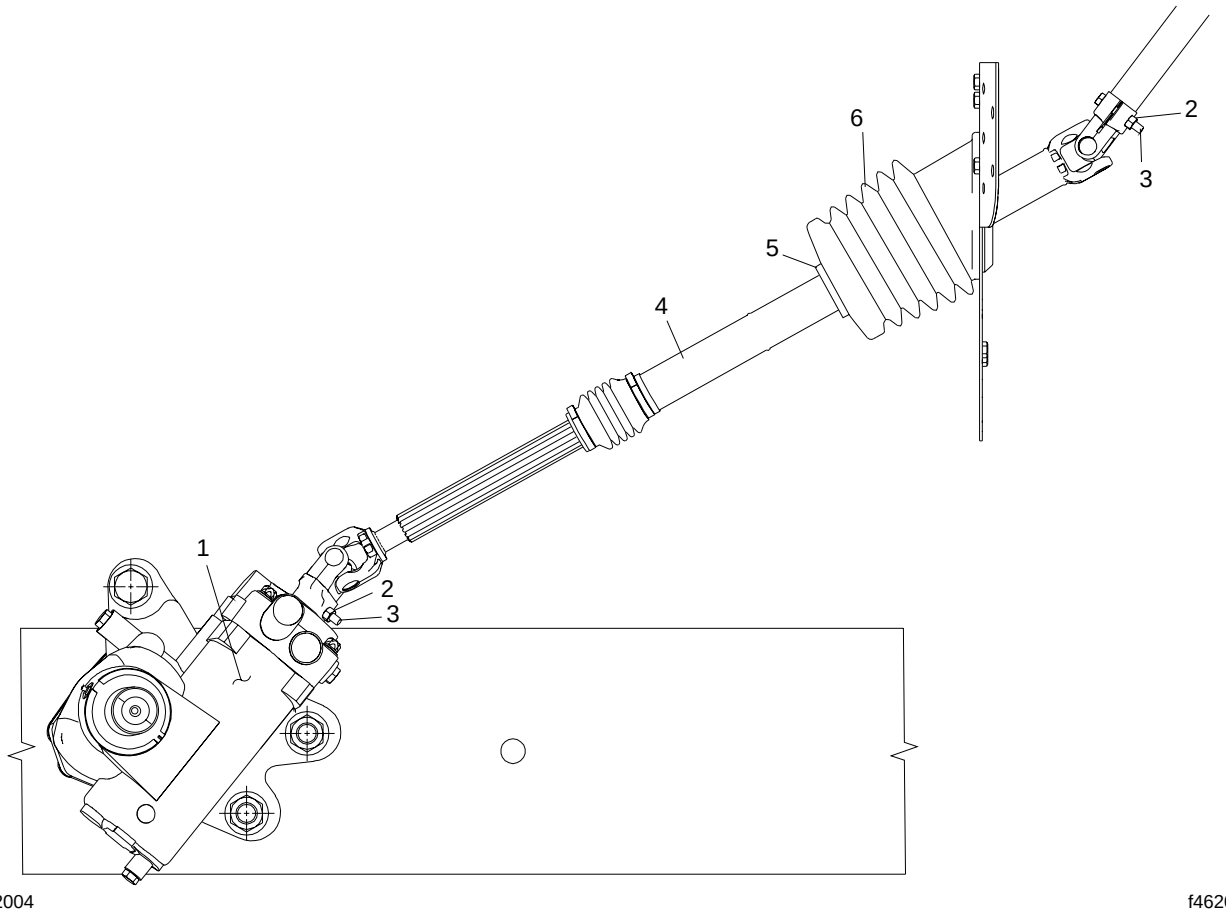
SPX Kent-Moore
28635 Mound Road
Warren, Michigan 48092-3499
(800) 328-6657

Steering Driveline Replacement

Replacement

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be done.
2. Shut down the engine, apply the parking brakes, chock the tires, and open the hood.
3. Remove and discard the pinch bolt and nut that attach the steering column to the steering driveline, then remove the steering driveline from the steering column. See **Fig. 1**.
4. From inside the cab, push the steering driveline boot into the engine compartment.
5. Remove and discard the pinch bolt and nut that attach the steering driveline to the steering gear, then remove the steering driveline.
6. Remove the boot and boot bushing from the steering driveline.
7. Install the boot and boot bushing on the new steering driveline.
8. Install the steering driveline.

   8.1 Using a new pinch bolt and nut, attach the steering driveline to the steering gear.



1. Steering Gear
2. Nut
3. Pinch Bolt
4. Steering Driveline
5. Boot Bushing
6. Boot

Fig. 1, Steering Driveline Installation, TRW Model Shown

Steering Driveline Replacement

Tighten the nut to one of the following torque specs:

- 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16–20 pinch bolt and nut
- 30 to 35 lbf·ft (41 to 47 N·m) for an M10 x 1.25 pinch bolt and nut

8.2 Apply torque seal, OGP F900WHITE, to the exposed threads of the pinch bolt and to the nut.

8.3 Place the driveline through the frontwall.

8.4 Using a new pinch bolt and nut, attach the steering driveline to the steering column. Tighten the nut to one of the following torque specs:

- 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16–20 pinch bolt and nut
- 30 to 35 lbf·ft (41 to 47 N·m) for an M10 x 1.25 pinch bolt and nut

9. Apply torque seal, OGP F900WHITE, to the exposed threads of the pinch bolt and to the nut.
10. Make sure the steering wheel is centered.
11. Put the boot in place on the frontwall.
12. Close the hood and remove the chocks from the tires.

General Information

A *Checklist for Troubleshooting Power Steering Problems*, form STI-492, has been developed to accompany the procedures below. Form STI-492 can be downloaded or printed **here** after logging into **www.AccessFreightliner.com**.

Each step and substep in these troubleshooting procedures corresponds to a step or substep on form STI-492. Use **Table 1** to determine which steps should be completed, based on the customer's complaint. It is very important that the information provided by the driver is communicated accurately to prevent wasting of diagnostic time. For example, if complaints include "Pulling to one side" and "Noisy steering," steps 1, 3, 4, 5, and 6 will be the tests for the most likely failure modes.

Start with the lowest test number and work up to the highest. For example, when completing steps 1, 3, and 6 to determine the cause of a vehicle pulling to one side, start with step 1 and finish with step 6.

Troubleshooting Steps

NOTE: Some of these inspections and procedures can be found in the Pretrip and Post-Trip Inspections and Maintenance chapter in the vehicle driver's/operator's manual.

Steps 1 through 4 may have been performed by the customer. Verify the vehicle service history with the customer to prevent redundant testing.

All measurements and readings must be recorded on STI-492.

Refer to the applicable section in this manual to repair or replace steering system components.

1. Check the tire pressure and load.

   1.1 Check the tires for damage.

   1.2 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.

Steering Complaint and Troubleshooting Steps Checklist												
LH	RH	Both	Complaint	Troubleshooting Steps								
				1	2	3	4	5	6	7	8	9
			Hard or heavy steering	•	•		•	•	•	•	•	•
			Low assist									
			Binding									
			Locking									
			Occasional loss of assist									
			Reduced wheel cut								•	
			Pulling to one side*	•		•			•			
			Darting/oversteering	•	•	•	•		•			
			Wandering									
			Noisy steering				•	•	•			
			External seals leaking					•	•			•
			Excessive heat									

* If there is consistent pull to one side, a braking issue could feel like a steering assist problem. Refer to **Group 42** in this manual to ensure the brake system is functioning properly.

Table 1, Steering Complaint and Troubleshooting Steps Checklist

Troubleshooting Procedures

1.3 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.

1.4 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 may need to be adjusted.

1.5 Communicate with the driver or operator to 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 fifth wheel lubrication and condition.

A dry fifth wheel plate makes it difficult to change direction. Check the plate surface for burrs, gouges, and irregularities.

3. Check vehicle alignment and wheel bearing adjustment.

3.1 Check the vehicle service history for the last known alignment, and inspect tire wear for indications that an alignment needs to be completed.

3.2 Check front axle caster and camber measurements.

3.3 Ensure wheel bearings and rear axle are in good condition, and that toe is set correctly.

3.4 Ensure the rear axle is properly aligned.

4. Check for loose and binding components. Check whether any steering components need maintenance or adjustment.

4.1 Check for proper lubrication of the drag link, tie rods, and knuckle pins. Apply lubrication as needed.

4.2 Check the COE steering column, if equipped. 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.

4.3 Check the steering driveline U-joints for looseness or binding. Lubricate them if needed.

4.4 Check the sector shaft adjustment.

- With the vehicle on the ground, the engine idling, 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, with the engine running, 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.

4.5 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 one tire to the axle stop and release. The tire should self-return to almost straight ahead.
- Repeat with the opposite tire.

If a tire does not return to near straight ahead, check for binding or 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.

4.6 Inspect all suspension fasteners and components for wear or looseness.

5. Check the steering system for leaks and restrictions, and test the system back pressure.

5.1 Inspect hoses, fittings, and seals for damage or leaks.

- With the engine idling, inspect for kinked or collapsed hoses. Repair or replace any collapsed or kinked hoses. If collapsed hoses are found, ensure the steering system is filled with the correct automatic transmission fluid.
- Inspect fittings for leaks. Repair leaking fittings; replace parts as needed.
- Inspect all external seals. Replace leaking seals.

  Inspect the seal bores and sealing surfaces for scrapes or burrs. Make sure the seals are installed correctly using the recommended tools.
- If you replaced the steering gear input shaft seal and found it to be excessively hard, test the system operating temperature in step 6.

5.2 Inspect the steering gear for external leakage.

- Clean the area around the input shaft and inspect the input shaft for signs of leakage after operating the vehicle under normal conditions through steering maneuvers.
- Inspect the sector shaft for signs of leakage. A well greased or heavily used steering gear may weep oil from the grease seal, but a confirmed leak will be evidenced by fluid collecting while the vehicle is being operated under normal conditions.
- Inspect the vent plug in the trunnion housing for signs of leakage. Any fluid in or around the rubber vent plug indicates leakage from an internal steering gear seal.

NOTICE

Do not turn the steering wheel or allow system pressure to exceed the rating of the gauge during the following test. Damage to the gauge could occur.

5.3 Check total steering system back pressure.

- Install a low pressure gauge—300 psi (2068 kPa) maximum—between the steering pump and the steering gear.
- Check for correct fluid level. If necessary, add fluid. If bubbles or foam appear in the reservoir, check hose fittings for looseness or leaks.
- With the engine idling, read the total system back pressure on the pressure gauge.
- If the total system back pressure is greater than 100 psi (689 kPa), or 140 psi (965 kPa) for a vehicle with hydraulic brakes, replace the steering fluid filter and re-test the system. If the system back pressure is still excessive, go to the next substep.

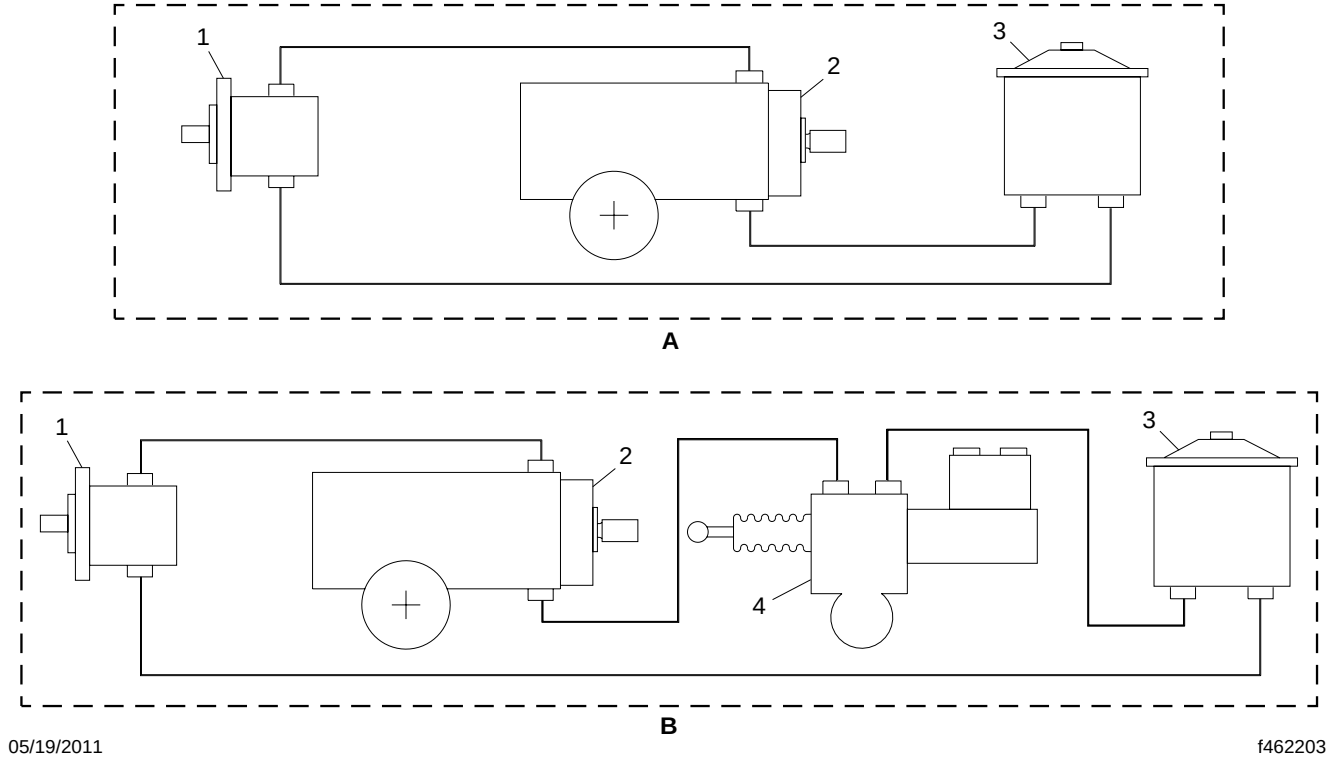
  If the total system back pressure is less than 100 psi (689 kPa), or 140 psi (965 kPa) for a vehicle with hydraulic brakes, restriction is not a problem—go to step 6.

5.4 Leave the low pressure gauge in place and check individual steering system components for excessive restriction. See **Fig. 1** for a plumbing diagram.

- Bypass the steering gear by disconnecting the steering gear input and output lines from the gear and coupling them together. See **Fig. 2** for an example.

  If the drop in system pressure from the value found in substep 5.3 is greater than 55 psi (379 kPa), the steering gear has excessive restriction. If the drop in pressure is less than 55 psi (379 kPa), reconnect the

Troubleshooting Procedures



A. Vehicles With Air Brakes
1. Steering Pump
2. Steering Gear

B. Vehicles With Hydraulic Brakes
3. Reservoir
4. Brake Booster

Fig. 1, Plumbing Diagrams

gear input and output lines to the gear and continue with this substep.

- If the vehicle is equipped with hydraulic brakes, bypass the brake booster by disconnecting the booster input and output lines and coupling them together.

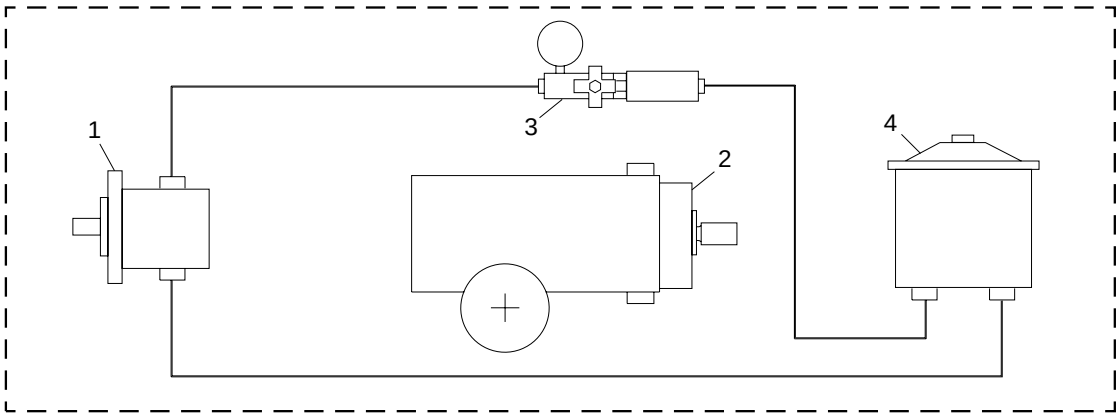
  If the drop in system pressure from the value found in substep 5.3 is greater than 40 psi (276 kPa), the brake booster has excessive restriction. If the drop in pressure is less than 40 psi (276 kPa), reconnect the booster input and output lines and continue with this substep.

- Test each hydraulic line in the power steering system individually by bypassing them one at a time, as was done with the steering gear and brake booster, if equipped.

  If the drop in system pressure from the value found in substep 5.3 is greater than 12 psi (83 kPa) for any one line, replace the line and test total system back pressure again.

6. Check steering pump performance. Power steering fluid temperature should be approximately 180°F (82°C) to best replicate fluid temperatures under normal driving conditions.

   If the system fails the tests in the following substeps, replace the pressure relief valve (PRV) and complete the tests in the substeps below again. If the system fails again, replace the pump.



1. Steering Pump
2. Steering Gear
3. Low Pressure Gauge
4. Reservoir

Fig. 2, Testing Steering Gear Restriction

Install the PSSA between the steering pump and the gear for the following substeps. See the following heading, **Power Steering System Analyzer Setup**, for instructions on PSSA installation.

NOTICE

Do not leave the load valve closed for longer than five seconds during the following test. Doing so could damage the power steering system.

6.1 Check for erratic pump response.

- Slowly close the load valve and watch the pressure and flow readings as the valve closes, then open the valve immediately.
- If the pressure rises rapidly or appears uncontrolled, open the load valve immediately.
- If the response was erratic, replace the PRV or pump, as required. If the response was smooth and controlled, go to the next substep.

6.2 Check the pump relief pressure.

- Slowly close the load valve. When the valve is completely closed, read the pressure gauge, then open the valve.
- If the pump relief pressure does not exceed the relief pressure in **Table 2** or **Table 3**, refer to the pump manufacturer's service literature to verify the exact relief pressure for the pump.
- If the pump relief pressure does not exceed the relief pressure in **Table 2**, **Table 3**, or the pump manufacturer's specifications, replace the PRV or pump, as required.
- If the pump relief pressure exceeds the relief pressure in **Table 2** or **Table 3**, it is acceptable. Go to the next substep.

6.3 Test the pump relief valve reaction at idle.

- Run the engine at idle and note the flow rate with the load valve open.

Troubleshooting Procedures

Minimum Measured Pump Flow and Relief Pressure at Engine Idle				
Power Steering Gear	**Flow at 1500 rpm, No Load: gpm (L/min)**	**Flow at 1000 psi (6900 kPa): gpm (L/min)**	**Flow at 1800 psi (12 400 kPa): gpm (L/min)**	**Typical Relief Pressure: psi (kPa)**
Sheppard M100	3.7 (14.0)	2.8 (10.6)	2.3 (8.7)	2175 ± 100 (15 000 ± 700)*
TRW TAS40	3.7 (14.0)	2.1 (7.9)†	1.6 (6.1)	
TRW TAS55		2.4 (9.1)†	1.9 (7.2)	
TRW TAS65		2.8 (10.6)†	2.3 (8.7)	
TRW TAS85		3.3 (12.5)	2.8 (10.6)	
TRW TAS65 With C28 or C32 Linear Cylinder	5.8 (22.0)	4.9 (18.5)	4.4 (16.7)	
TRW TAS65 With RCS65				
TRW TAS85 With C28 or C32 Linear Cylinder		5.4 (20.4)†	4.9 (18.5)	
TRW TAS85 With RCS65				
ThyssenKrupp LZS5 Rack and Pinion	3.7 (14.0)	3.3 (12.5)	2.8 (10.6)	2300 ± 116 (15 500 ± 800)

* On vehicles with TRW TAS steering gears and hydraulic brakes, typical relief pressure is 2375 ± 100 psi (16 375 ± 690 kPa).

† Approximate value based on flow at 1800 psi (12 400 kPa).

Table 2, Minimum Measured Pump Flow and Relief Pressure at Engine Idle

Minimum Measured Pump Flow and Relief Pressure for High-Pressure Gears at Engine Idle				
Power Steering Gear	**Flow at 1500 rpm, No Load: gpm (L/min)**	**Flow at 1000 psi (6900 kPa): gpm (L/min)**	**Flow at 2300 psi (15 860 kPa): gpm (L/min)**	**Typical Relief Pressure: psi (kPa)**
Sheppard HD94	3.7 (14.0)	2.6 (9.8)	1.8 (6.8)	2683 ± 100 (18 500 ± 700)
TRW THP45		2.2 (8.3)	1.4 (5.3)	
TRW THP60 or PCF60		2.6 (9.8)	1.8 (6.8)	
TRW THP60 With Linear Cylinder	5.8 (22.0)	4.1 (15.5)	3.3 (12.5)	
TRW THP60 With RCH45				

Table 3, Minimum Measured Pump Flow and Relief Pressure for High-Pressure Gears at Engine Idle

- 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. The flow rate should return to the flow rate first noted with the load valve open.
- If the flow rate does not return smoothly and quickly, the pump relief valve is not working correctly. Replace the replace the PRV or pump, as required.
- If the flow rate returns smoothly and quickly, the pump relief valve is acceptable. Go to the next substep.

6.4 Test the pump relief valve reaction at 1500 rpm.

- Run the engine at 1500 rpm and 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 ac-

tion three times. The flow rate should return to the flow rate first noted with the load valve open.

- If the flow rate does not return smoothly and quickly, replace the PRV or pump, as required.
- If the flow rate returns smoothly and quickly, the pump relief valve is acceptable. Go to the next substep.

6.5 Test the flow of the pump at idle with a load applied.

For vehicles with low-pressure steering gears, run the engine at idle and slowly close the load valve until the pressure gauge reads 1000 psi (6900 kPa). Read the flow rate on the gauge, then set the pressure to 1800 psi (12 400 kPa). Read the flow gauge, then open the load valve. Compare the values to those in **Table 2**.

For vehicles with high-pressure steering gears, use 1000 psi (6900 kPa) and 2300 psi (15 860 kPa) as the test load pressures. See **Table 3** for minimum flow rate.

6.6 Test the maximum flow of the pump with no load applied.

- Run the engine at 1500 rpm, make sure the load valve is completely open, and read the flow gauge.
- If the flow rate is below the minimum indicated in **Table 2** or **Table 3**, replace the PRV or pump, as required.
- If the flow rate is above 5.5 gpm (20.8 L/min) on a vehicle with a single steering gear, or 7.7 gpm (28.8 L/min) on a vehicle with an assist cylinder installed, replace the pump.

7. Test the steering gear internal leakage.

Select TRW integral steering gears and all ThyssenKrupp rack and pinion steering gears are equipped with an internal PRV that significantly limits maximum supply pressure to protect the steering gear. These gears, unlike gears on vehicles fitted with hydraulic brake boosters, cannot be tested for internal leakage by plugging the internal PRV in the gear. The pump output must be limited to prevent excessive pressure from damaging the gear, and the internal PRV passage must be blocked to direct oil flow through the gear.

Use PartsPro® for the specific VIN to determine if the steering gear is equipped with an internal PRV, which will be listed as a serviceable part under module 536.

If a TRW steering gear has an internal PRV but no hydraulic brake booster, see the following heading, **Internal Leakage Test Setup, TRW Steering Gears With an Internal PRV**, for instructions on setting up the necessary test components before proceeding with the following substeps.

ThyssenKrupp rack and pinion steering gears are also equipped with an internal PRV, but cannot be tested for internal leakage.

IMPORTANT: Make sure the fluid temperature is approximately 180°F (82°C) and the vehicle is stationary with the front wheels pointing forward.

7.1 Run the engine at idle with the load valve open.

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.

7.2 Place an unhardened steel spacer, 1-inch (25-mm) thick, between the axle and the stop bolt on one side of the axle.

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.

NOTICE

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.

Troubleshooting Procedures

7.3 Have someone turn the steering wheel, applying enough force to completely close the rotary valve.

Complete closure of the rotary valve requires approximately 20 lbf (27 N) pull on the steering wheel, and will be indicated by a pressure reading nearly equal to the system relief pressure (tested in substep 6.2).

7.4 Hold the steering wheel in the full-turn position. Note the steering gear internal leakage on the PSSA.

7.5 Repeat the previous substeps 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 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. Maximum internal leakage on a dual-gear system 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 using the substeps that follow.

7.6 Disconnect the auxiliary cylinder hydraulic lines at the main gear auxiliary ports.

7.7 Plug the main steering gear ports with suitable steel or high-pressure plugs or caps.

7.8 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.

8. 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 cause loss of assist, as the steering wheel approaches either full-left or full-right turn.

8.1 Check the steering system for stop bolt adjustment.

Make sure the stop bolt settings limit the steering travel so there is ½-inch (13-mm) clearance from all stationary components, and 3/4-inch (19-mm) clearance from all moving components.

8.2 Make sure the pitman arm is situated on the steering gear sector shaft correctly. Check that the pitman arm and sector shaft timing marks are aligned.

NOTICE

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.

8.3 Check the poppet relief pressure.

- Install the PSSA between the steering pump and the steering gear. See the following heading, **Power Steering System Analyzer Setup**, for instructions on PSSA installation.
- Run the engine at idle with the load valve open. Turn the steering wheel to either full-lock position. Note the pressure gauge reading, then repeat for the opposite turn.
- The pressure should drop slightly before the stop bolts are contacted. If the pressure increases (from contact with the stop bolts), the poppets must be manually reset.

  If the pressure is relieved and assist is lost when the wheel is too far from the axle stop bolts, refer to the applicable section in this manual for gear-specific information.
- After poppet replacement or adjustment, test again for correct poppet relief function and record the new pressure.

8.4 Check for normal hissing sound at full turn.

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.

See **Table 4** for possible causes and remedies for common noises associated with the power steering system and power steering pump.

8.5 Check for abnormal power steering noise.

Listen for a hissing sound at less than full turn. If a hissing sound is heard, check the steering gear poppet and the axle stop adjustment.

NOTICE

If the temperature exceeds 250°F (121°C), damage to hoses, seals, and other components may result if the vehicle continues to operate at excessive steering system temperatures. If this temperature is exceeded, stop the test and record the last noted temperature on STI-492.

9. Test the system operating temperature.

- Run the engine at governed speed.
- Observe the power steering fluid temperature until it stabilizes.
- Record the power steering fluid temperature in 10-minute intervals until 40 minutes have passed.
- If the temperature does not exceed 250°F (121°C) during the test, excessive heat due to system components is probably not the cause of the complaint. The system may still experience overheating due to driving and load conditions.

  If the temperature exceeds 250°F (121°C), excessive steering system back pressure or excessive pump flow may be the cause of the high temperature problem. If system back pressure or restriction values found in substeps 5.3 and 5.4 above were close to the maximum allowable, complete step 5 again. If steering pump flow and relief pressures found in step 6 above were close to the maximum allowable, complete step 6 again.
- If excessive heat continues to be a problem, a cooler may need to be added to the system.

Power Steering System Noise	
Noise	**Remedy**
Growling or other abnormal steering noise	Check the fluid level. Check for air bubbles and foam. Check for hose and fitting leaks. 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 steering fluid reservoir for air bubbles and foam. 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. Tighten any loose steering components. Check the front suspension for insufficient spring pin shims. Add front spring pin shims if needed.
Hissing when the steering wheel is at or near full turn	This is normal; no action is needed.
Steering Pump intake line is plugged	Drain the system. Clear the intake line if needed. Fill the system.
Air leak at the pump or reservoir connections, fittings, or shaft seal	Check all the connections by pouring power steering fluid over them, and listening for a reduction in sound. Tighten all connections as needed.
Pump input shaft is misaligned	Replace the pump.

Table 4, Power Steering System Noise

Troubleshooting Procedures

Power Steering System Analyzer Setup

The hydraulic power steering system is tested with a Power Steering System Analyzer (PSSA), and with the hydraulic fluid at operating temperature. The PSSA and adaptor kit are available from SPX Kent-Moore.

A PSSA is a combination of a flow meter, a shutoff valve, and a high-pressure gauge. See **Fig. 3**. 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.

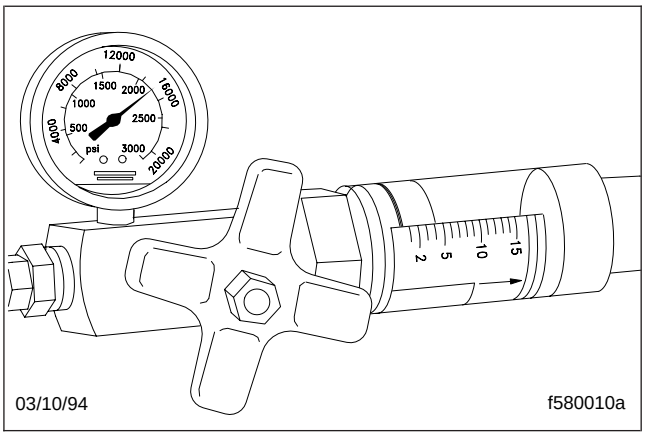


Fig. 3, Power Steering System Analyzer

1. Install a PSSA between the pump high-pressure line and the steering gear.
2. Fill and bleed the steering system as needed.

NOTICE

Do not leave the load valve fully closed for longer than five seconds. Doing so could damage the power steering system.

3. Run the engine at idle.
4. Partially close the load valve on the PSSA until the pressure gauge reads 1000 psi (6895 kPa).
5. Open the valve when the fluid temperature reaches about 180°F (82°C).

Internal Leakage Test Setup, TRW Steering Gears With an Internal PRV

Select TRW steering gears are equipped with an internal PRV that limits maximum supply pressure to protect the steering gear. These gears cannot be tested for internal leakage using the standard procedure. The pump output must be limited to prevent excessive pressure from damaging the gear, and the internal PRV passage must be blocked to direct oil flow through the gear.

Use PartsPro® to determine if a specific TRW steering gear is equipped with an internal PRV, which will be listed as a serviceable part under module 536.

If your TRW steering gear has an internal PRV, complete the following steps to set up the necessary internal leakage test components. See **Table 5** for a list of required leakage test components. The plumbing fittings and hose part numbers are recommended, but may be replaced with identical parts from other suppliers, if necessary.

The ThyssenKrupp rack and pinion steering gear is also equipped with an internal PRV, but cannot currently be tested for internal leakage.

IMPORTANT: The front wheels must be raised or on turnplates during this procedure.

1. Turn the engine off. Remove the relief valve cap, O-ring, and relief valve from the steering gear. See **Fig. 4**.
2. Install the relief valve plug, J-37130, in the internal PRV hole. Install the relief valve cap and O-ring over the plug.
3. Assemble the relief valve cartridge body, relief valve, and tee fittings as shown in **Fig. 4**.
4. Install the PSSA and other test components as shown in **Fig. 4**.
5. Open the external relief valve (**Fig. 4**, Item 15) on the relief valve cartridge. Ensure the PSSA shutoff valve is fully open.
6. Raise the front wheels off the ground and turn the steering wheel to the right and left full-lock positions five times to bleed air from the system.
7. Start the engine and bleed the remaining air out of the system by continuing to turn the wheel from side to side.

NOTICE

Do not leave the PSSA shutoff valve fully closed for longer than five seconds. Doing so could damage the power steering system.

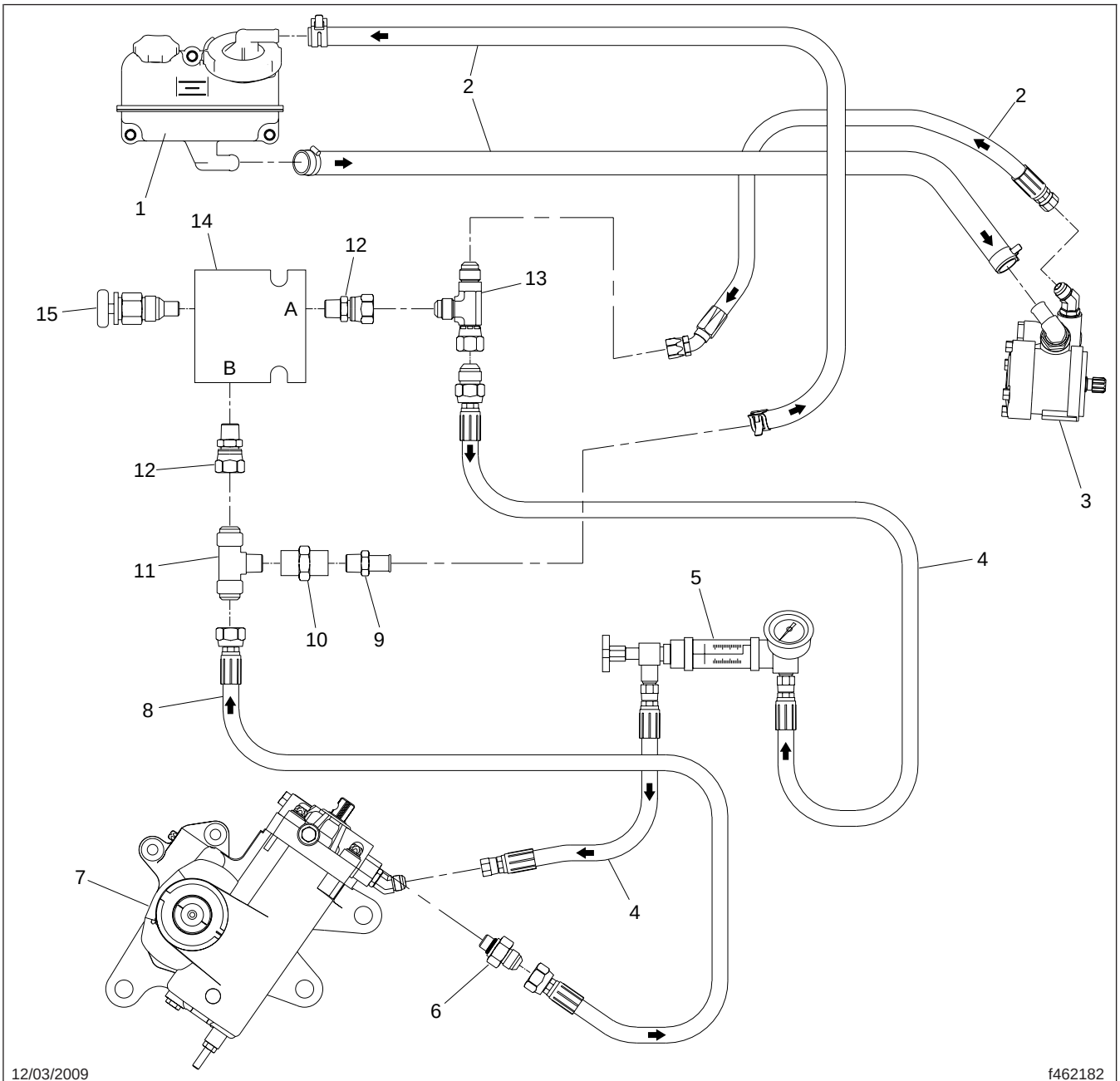
8. With the engine on, close the shutoff valve on the PSSA.
9. Set the system relief pressure by closing the external relief valve (**Fig. 4**, Item 15) until the gauge on the PSSA reaches 2,000 psi (13 790 kPa), then fully open the shutoff valve on the PSSA.
10. Continue with the steering gear internal leakage test (step 9 of the **Troubleshooting Steps** heading above).

Internal Leakage Test Components			
Part	**Available From**	**Part Number (Vendor P/N)**	**Item #, Fig. 4**
Power Steering System Analyzer (PSSA)	SPX Kent-Moore	J-26487	5
PSSA Adaptor Kit	SPX Kent-Moore	J-28593	—
Relief Valve Plug	SPX Kent-Moore	J-37130	—
Connector, Straight Thread with O-Ring	Daimler Trucks PDC	23-11470-088	6
Power Steering Hose, 42"	Daimler Trucks PDC	14-12694-042	8
Connector, 3/8" Male NPT to 5/8" Beaded Hose Barb	Daimler Trucks PDC	23-11321-001	9
Pipe Coupling, 3/8" NPT	Parker Hannifin	PH 3/8 GG S (3/8 GG-S)	10
Tee, Male JIC with Male NPT Branch*	Parker Hannifin	PH 8STXS (8 STX-S)	11
Swivel Adaptor, 3/8" Male NPT to Female 37 degree JIC (qty 2)	Weatherhead	WH 9100X8X6 (9100x8x6)	12
Swivel Nut Run Tee	Parker Hannifin	PH 8 R6X S (8 R6X-S)	13
3/8" Female NPT Aluminum Relief Valve Threaded Cartridge Body	Parker Hannifin	B10-2-A6P (PH B102A6P)	14
Aluminum Hydraulic Threaded Cartridge Relief Valve with Knob	Parker Hannifin	PH RAH101K30 (RAH101K30)	15

* Use steel 37 degree JIC fittings only.

Table 5, Internal Leakage Test Components

Troubleshooting Procedures



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A. High-Pressure Input Port
B. Low-Pressure Output Port

1. Power Steering Fluid Reservoir
2. Existing Power Steering Fluid Lines (Qty 3)
3. Power Steering Pump
4. PSSA Fluid Lines (Qty 2)
5. PSSA
6. Connector, Straight Thread with O-Ring
7. Power Steering Gear (TAS85 shown)
8. Power Steering Hose, 42"
9. Connector, Male NPT to Beaded Hose Barb
10. Pipe Coupling
11. Tee, Male JIC with Male NPT Branch
12. Swivel Adaptor (Qty 2)
13. Swivel Nut Run Tee
14. Relief Valve Threaded Cartridge Body
15. External Relief Valve, Threaded Cartridge Type

Fig. 4, Internal Leakage Test Component Installation

General Information

The system consists of the following:

- fuel tanks
- fuel lines
- fuel filter/water separator
- fuel cooler
- fuel flow splitter valve
- fuel level sensor
- fuel heater

Fuel drawn from the fuel tank under suction is routed to the pre-filter and then to the transfer pump (integral to the fuel injection pump). After leaving the transfer pump, fuel is pumped under pressure to the primary fuel filter/water separator. After leaving the fuel filter/water separator, clean fuel enters the fuel injection pump, then, under high pressure, is routed to the fuel injectors. Unused fuel is routed through a fuel cooler unit (if equipped) back into the fuel tank.

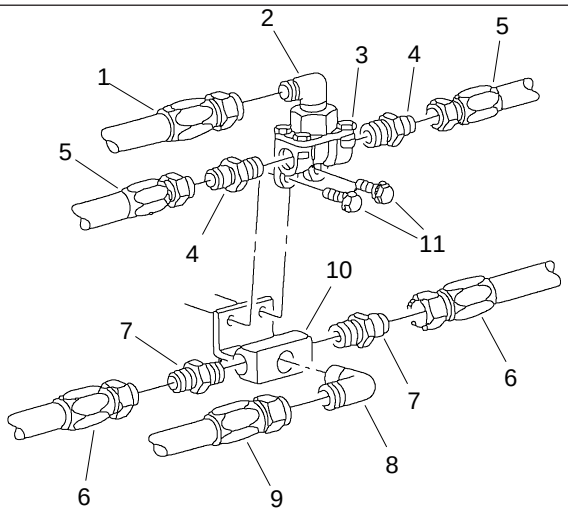
All heavy truck fuel tanks are of the outside frame-mounted type and are made of steel or aluminum. Some vehicles are equipped with dual fuel tanks.

A single draw/return system is simply a system that uses a single fuel pickup and return line. This system is found on single fuel tank applications.

Some vehicles are equipped with a dual draw/dual return fuel system. The dual draw/dual return fuel system is designed to provide accurate and reliable equalization of fuel levels in dual tanks without using a fuel crossover tube and to dissipate the heat added to the fuel by the electronic engines to both tanks. The supply tubes and fittings are designed to ensure right-hand and left-hand symmetry and smooth, upward flow paths throughout the fuel system.

A dual draw/return with crossover system is the same as the dual draw/dual return without crossover except that a crossover tube has been added to aid in balancing the levels between the dual fuel tanks.

Two fuel splitter valves are located in the fuel lines. See **Fig. 1**. The return splitter valve splits a single fuel return line into two lines providing balanced fuel return to each of the two fuel tanks. The supply splitter valve channels two fuel lines from the fuel tanks into one delivery fuel line.



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1. Fuel Return Hose
2. Elbow Fitting
3. Fuel Splitter (return) Valve
4. Connector
5. Fuel Return Hose (to fuel tank from splitter valve)
6. Fuel Supply Hose (from fuel tanks to splitter valve)
7. Connector
8. Elbow Fitting
9. Fuel Supply Hose (from splitter valve to engine)
10. Fuel Splitter (supply) Valve
11. Bolts

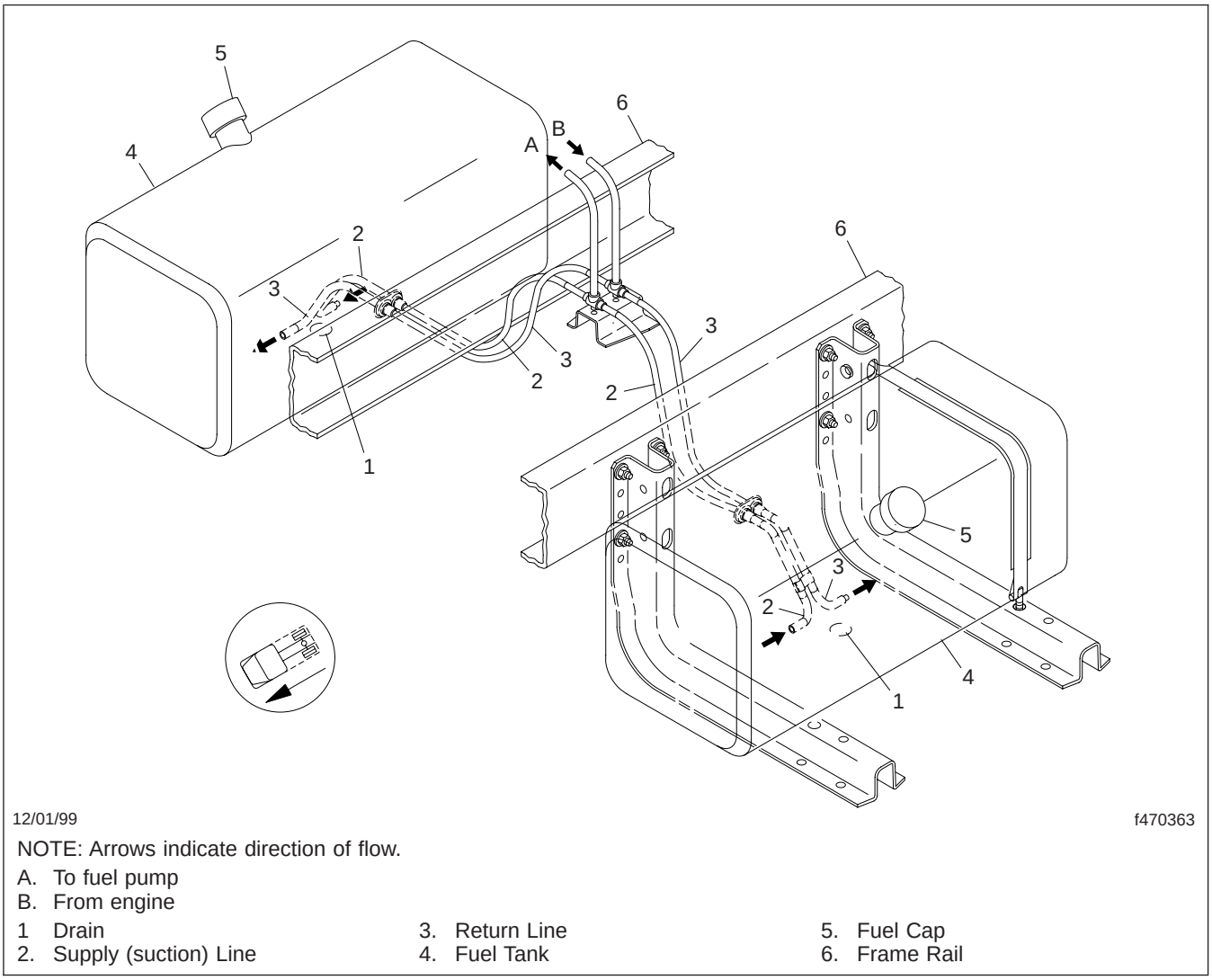
Fig. 1, Fuel Splitter Valve

The EquiFlo® inboard fuel system consists of inboard-routed fuel lines, with the suction and return lines installed in a common opening of the fuel tank(s), and a quarter-turn non-vented fuel cap. See **Fig. 2**. The fuel tank vent and line are located on the top of the tank.

Fuel is drawn equally from, and returned to, each tank, so that their levels stay equal. The suction and return fuel lines, although entering the fuel tank via the same opening, are designed to direct the fuel flow to the bottom of the tank. This ensures thorough mixing of the fuel before it is drawn up by the suction line, so that vapor can disperse, and (electronic engines only) warm fuel is not recirculated.

The fuel cooler is available only on vehicles with an electronic engine and a single fuel tank application. See **Fig. 3**. The fuel cooler is in-line on the return side of the fuel lines and cools the fuel before it is returned to the fuel tank.

General Information



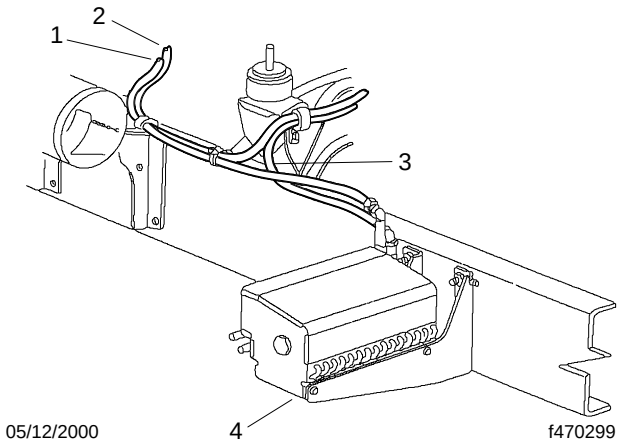
NOTE: Arrows indicate direction of flow.

A. To fuel pump
B. From engine

1 Drain
2. Supply (suction) Line
3. Return Line
4. Fuel Tank
5. Fuel Cap
6. Frame Rail

Fig. 2, EquiFlo Inboard Fuel System

The fuel level sensor is located inside the fuel tank and consists of a variable resistor (potentiometer) attached to a float and varies according to fuel levels in the fuel tank. When the fuel level is low, resistance in the sensor unit is high and allows only a low current to flow through the indicator gauge windings, causing the indicator to move a short distance. When the fuel level is high, the resistance in the sensor unit is low and allows a higher current flow causing the indicator to move a greater distance.



1. Fuel Return Hose (engine-to-cooler)
2. Fuel Supply Hose
3. Fuel Return Hose (cooler-to-fuel tank)
4. Fuel Cooler

Fig. 3, Fuel Cooler

Fuel Tank Removal and Installation

Removal

NOTE: The following procedure is a typical fuel tank removal and installation procedure. See **Subject 050** for component locations.

1. Disconnect the battery negative cables.
2. Drain the fuel from the fuel tank.
3. Disconnect the fuel supply and return lines from the fuel tank.

NOTE: On dual tank systems, close the shutoff valves on the crossover tube.

4. Disconnect the crossover tube from the shutoff valve on the fuel tank to be removed.
5. Position a suitable jack under the fuel tank.
6. Remove the retaining nuts from the fuel tank support straps.
7. Remove the support straps from the fuel tanks.
8. Lower the jack, then slide the fuel tank away from the vehicle.

Installation

1. Position the fuel tank onto a suitable jack.
2. Position the fuel tank onto the fuel tank support brackets.
3. Position the fuel tank support straps over the fuel tank.
4. Install the nuts onto the fuel tank support straps.
5. Remove the jack.

NOTE: On dual tank systems, open the shutoff valves on the crossover tube.

6. Connect the crossover tube onto the shutoff valve on the fuel tank being installed.
7. Connect the fuel supply and return lines onto the fuel tank.
8. Fill the fuel tank.
9. Connect the battery negative cables.
10. Run the engine and check for leaks.

Fuel Level Sensor Removal and Installation

Removal

1. Disconnect the negative battery cables.
2. Disconnect the electrical connector. See **Fig. 1**.

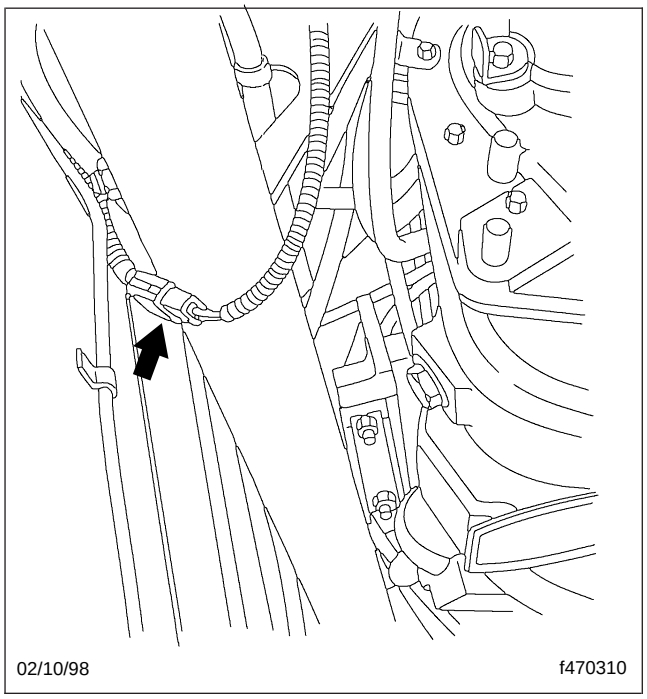


Fig. 1, Electrical Connector

3. Remove the retaining bolts. See **Fig. 2**.

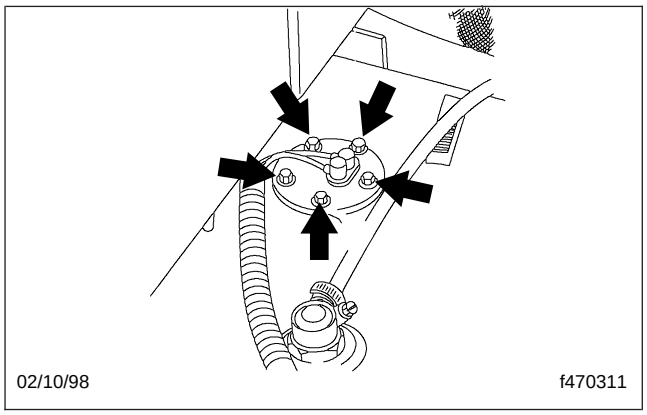


Fig. 2, Retaining Bolts

4. Remove the fuel level sensor and gasket. See **Fig. 3** .
5. Remove and discard the gasket.

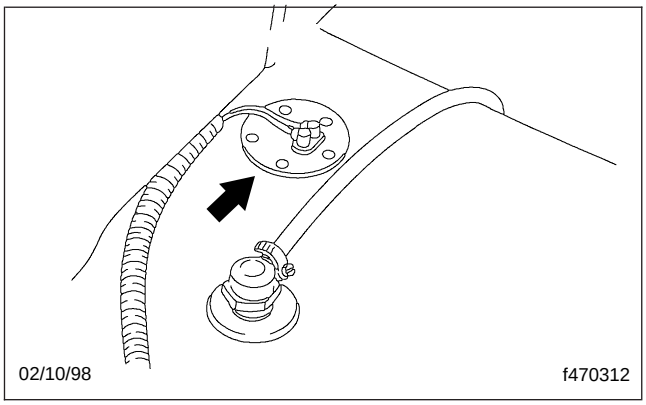


Fig. 3, Fuel Level Sensor

Installation

1. Position the new gasket on the fuel level sensor.
2. Position the fuel level sensor on the fuel tank and align the bolt holes with the holes in the fuel tank. See **Fig. 3**.
3. Install the fuel level sensor retaining bolts. See **Fig. 2**.
4. Connect the electrical connector. See **Fig. 1**.
5. Connect the negative battery cables.
6. Run the vehicle and check for leaks.

Behr Fuel Cooler Removal and Installation

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Place a drain pan under the fuel cooler.
3. Using a 1-1/4-inch box wrench, remove the drain plug from the fuel cooler and drain the fuel from the cooler. See **Fig. 1**.

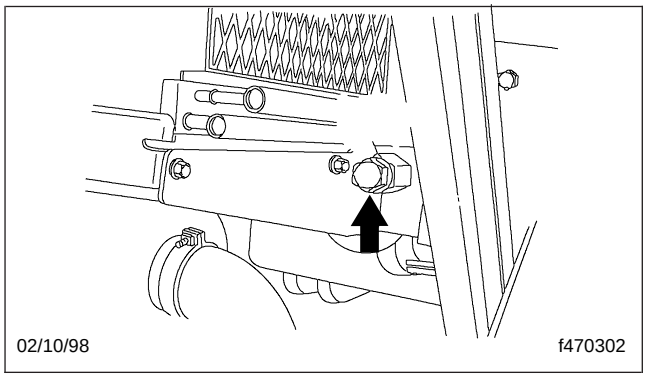


Fig. 1, Drain Plug

4. Install the drain plug into the fuel cooler. See **Fig. 1**.
5. Using a 15/16-inch wrench, disconnect the fuel lines. See **Fig. 2**.

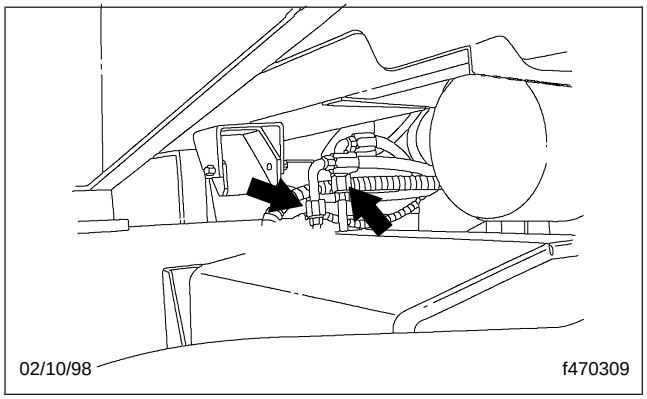


Fig. 2, Fuel Line Connections

6. Remove the four 1/2-inch hexhead mounting bolts from the fuel cooler assembly. See **Fig. 3** and **Fig. 4**.
7. Remove the fuel cooler from the vehicle.

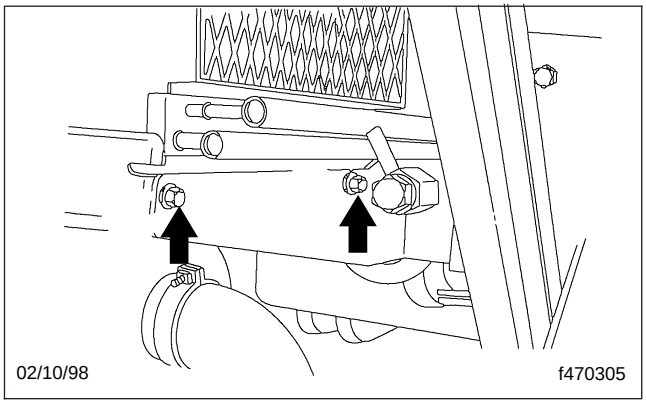


Fig. 3, Fuel Cooler Mounting Bolts

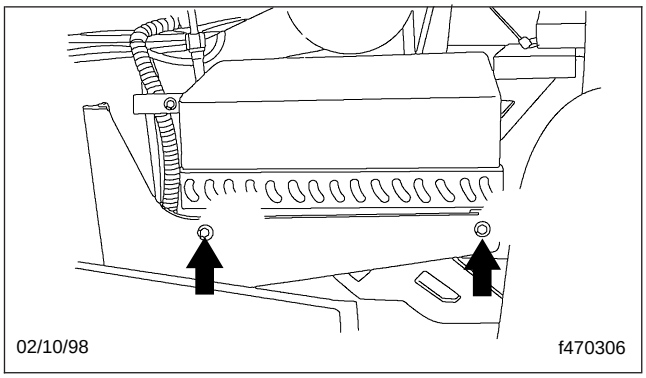


Fig. 4, Fuel Cooler Mounting Bolts

Installation

1. Position the fuel cooler on the mounting bracket.
2. Install the four 1/2-inch hexhead mounting bolts to the fuel cooler assembly. See **Fig. 3** and **Fig. 4**.
3. Connect the two fuel lines to the fuel cooler. See **Fig. 2**.
4. Run the engine and check for leaks.
5. Remove the chocks from the tires.

Specifications

Fuel Tubes		
Tube OD inch (mm)	**Minimum Bend Radius inch (mm)**	**Tube Nut Torque lbf·ft (N·m)**
1/4 (6.4)	1 (25.4)	7–10 (10–14)
3/8 (9.5)	1-1/4 (31.7)	12–17 (16–23)
1/2 (12.7)	2 (50.8)	12–17 (16–23)

Table 1, Fuel Tubes

Fuel/water separators are mounted between the fuel tank and the fuel pump. Fuel drawn to the engine travels through the fuel/water separator, which removes water and impurities.

At the fuel/water separator inlet port, a check valve (**Fig. 1**, Item 12) prevents the fuel from draining back to the fuel tank. Large pieces of dirt and water separate from the fuel in the lower housing, and collect in the bottom to be drained out when the drain valve (**Fig. 1**, Item 1) is opened. From the lower housing, the fuel level rises into the clear cover, which contains the replaceable filter. In the clear cover, the fuel passes through the filter element into the center of the filter, and to the outlet port.

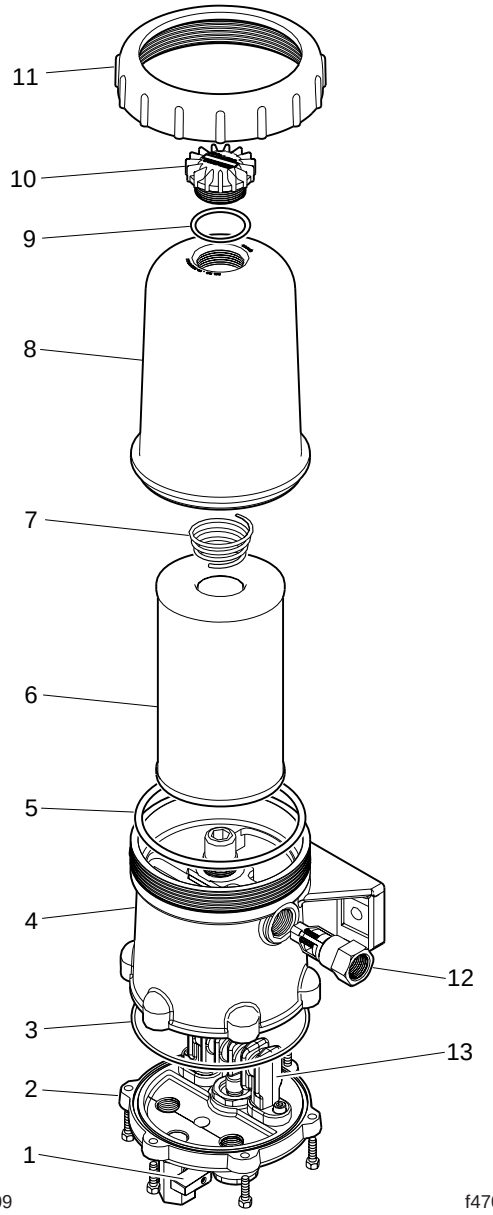
When the filter is new, the fuel is able to pass through the lower part of the filter element. As the element's lower portion clogs, the fuel level rises in order to pass through the filter. This process continues until the filter element is clogged all the way to the top.

For efficiency, the filter should be changed only when the fuel level has reached the top of the filter element. There is no significant restriction to fuel flow until the element is completely clogged.

DAVCO fuel/water separators come in a number of different configurations. The lower housing may be screw-assembled or locking-collar-assembled. There may be an electric heating element installed in the lower housing or there may be fluid heating in the lower housing.

If there is fluid heat, the warming fluid may be fuel returning from the engine or engine coolant. **Fig. 2** shows the patterns that fuel and heating fluids follow in fluid-heated units.

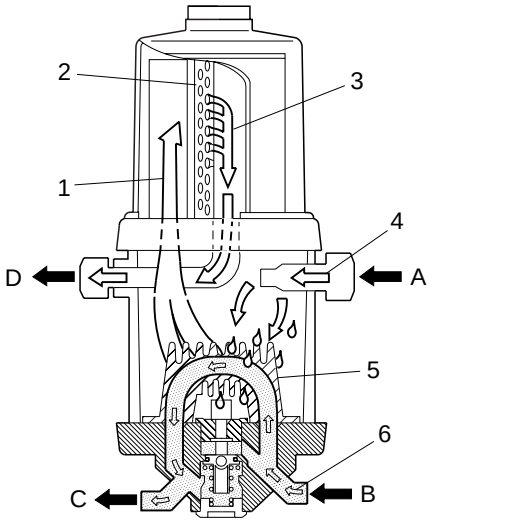
NOTE: The Daimler Trucks North America Learning Center (accessible through **www.AccessFreightliner.com**) and DAVCO (**www.DavcoTec.com**) offer excellent online resources for understanding, testing, and diagnosing fuel/water separator problems.



1. Drain Valve
2. Bottom Plate Assembly
3. Bottom Plate O-Ring
4. Lower Housing
5. Cover O-Ring
6. Filter Element
7. Spring
8. Clear Cover
9. Vent Cap O-Ring
10. Vent Cap
11. Collar
12. Inlet Port/Check Valve
13. Heat Exchanger

Fig. 1, DAVCO Fuel Pro 382 (shown with fluid heat configuration)

General Information



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A. Fuel Inlet Flow
B. Heating Fluid Inlet Flow
C. Heating Fluid Outlet Flow
D. Fuel Outlet Flow

1. Unfiltered, Heated Fuel
2. Filter Element
3. Filtered Fuel
4. Fuel From Fuel Tank
5. Heat Exchanger
6. Heating Fluid From Engine

Fig. 2, DAVCO Fluid Circulation, Fluid-Heated Units

Removal

⚠ WARNING

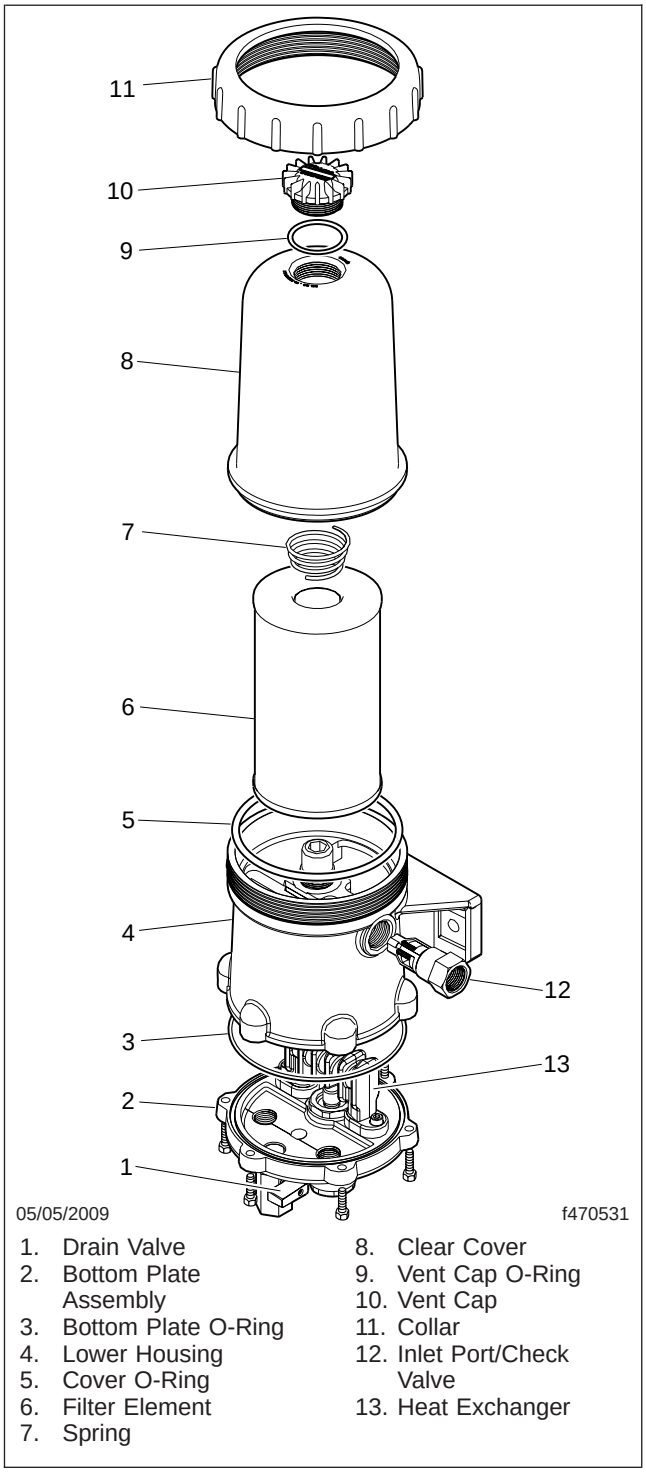
Fluid circulated through the fuel/water separator to heat the fuel may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. 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.

Most service procedures are done with the fuel/water separator in place, but some procedures, such as pressure testing, require that the fuel/water separator be removed from the vehicle.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

   The drain valve (**Fig. 1**, Item 1) has a 1/2-inch (12.7-mm) pipe; use a hose with a 1/2-inch pipe thread to fit correctly.
3. Remove the vent cap (**Fig. 1**, Item 10) and open the drain valve to drain the fuel completely, then close the drain valve.
4. Unplug the electric heating element, if equipped, or disconnect the heating fluid lines.
5. Disconnect the fuel outlet line.
6. Disconnect the fuel inlet line. If the inlet line is difficult to reach, loosen the connection, then fully disconnect it after the fuel/water separator is removed from the frame rail.
7. Remove the fuel/water separator mounting fasteners and remove the fuel/water separator from the frame rail. If the fuel inlet line was not completely disconnected in the previous step, disconnect it.



1. Drain Valve
2. Bottom Plate Assembly
3. Bottom Plate O-Ring
4. Lower Housing
5. Cover O-Ring
6. Filter Element
7. Spring
8. Clear Cover
9. Vent Cap O-Ring
10. Vent Cap
11. Collar
12. Inlet Port/Check Valve
13. Heat Exchanger

Fig. 1, DAVCO Fuel Pro 382 (shown with fluid heat configuration)

Removal and Installation

Installation

IMPORTANT: All fittings, including the locking collars, must be very clean as they are installed. A piece of grit or a damaged surface on a sealing face or in threads can cause air leaks.

Use teflon pipe thread sealant to ensure that the tapered thread fuel line fittings will not leak. Do not use sealer on compression fittings and do not seal the fittings with tape, which may eventually leak.

1. If the inlet fuel line is inaccessible when the fuel/water separator is mounted on the vehicle, loosely connect the inlet fuel line before mounting the fuel/water separator on the frame rail.

   To minimize restrictions, keep fuel line routing as smooth as possible, with no low-hanging loops that could trap water. If the fuel line is being made to length on the job, be sure that the inner liner of the hose is not cut by the fitting. Be certain the interior of all fuel lines is clean and free of debris before connecting them, and confirm that all fittings are clean.

2. Mount the fuel/water separator on the frame rail and install the mounting fasteners.

NOTICE

The lower housings on DAVCO fuel/water separators are made of aluminum. To avoid damaging threads, be careful not to overtighten fasteners or fittings on the fuel/water separator.

3. If the fuel inlet line was loosely connected previously, tighten it. If it was not connected, connect and tighten it.
4. Connect the fuel outlet line.
5. Install the electric heating element, if equipped, and connect the wiring harness, or connect the fluid heater lines. It does not matter which direction the heating fluid flows through the housing; the lines can be reversed.
6. Prime the system
   - 6.1 Ensure that the drain valve is closed.
   - 6.2 Remove the vent cap from the cover, and fill the housing to the top with clean diesel fuel.
   - 6.3 Install and hand-tighten the vent cap.
   - 6.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
   - 6.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.
   - 6.6 Check for leaks and shut down the engine.

Filter Replacement

⚠ WARNING

Fluid circulated through the fuel/water separator to heat the fuel may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

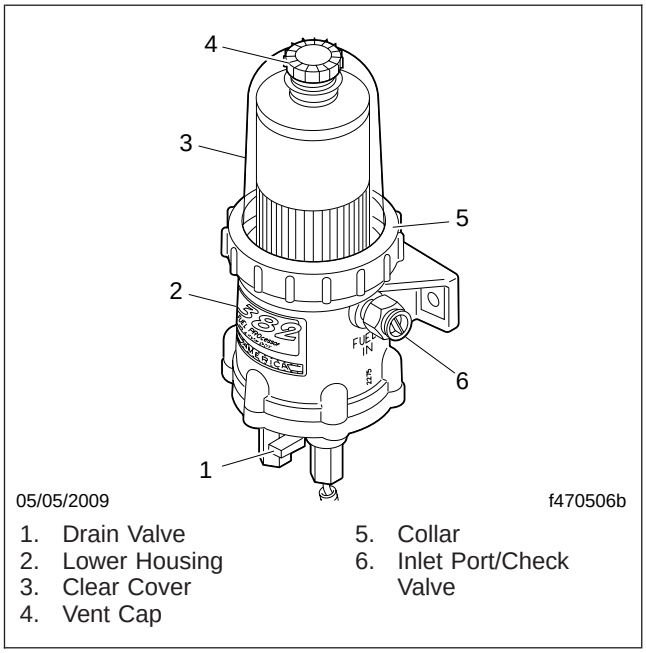
If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

   The drain valve (**Fig. 1**, Item 1) has a 1/2-inch (12.7-mm) pipe; use a hose with a 1/2-inch pipe thread to fit correctly.
3. Remove the vent cap (**Fig. 1**, Item 4) and open the drain valve to drain the fuel completely, then close the drain valve.
4. Using a DAVCO Collar Wrench (**Fig. 2**), remove the clear cover and collar.

NOTE: Broken vent cap and collar warranty claims will not be accepted if any tool other than a DAVCO Collar Wrench, part number 380134, is used for removal. During installation, the vent cap and collar are to be **hand-tightened only**, not tightened with a wrench.

5. Remove the filter, cover O-ring, and vent cap O-ring. Dispose of them in an environmentally acceptable manner.
6. Clean all threads and sealing surfaces very thoroughly. Even a small amount of dirt will prevent the fuel/water separator from sealing, and an air leak may result.
7. Install the grommet on the bottom of the new filter.



1. Drain Valve
2. Lower Housing
3. Clear Cover
4. Vent Cap
5. Collar
6. Inlet Port/Check Valve

Fig. 1, DAVCO Fuel/Water Separator

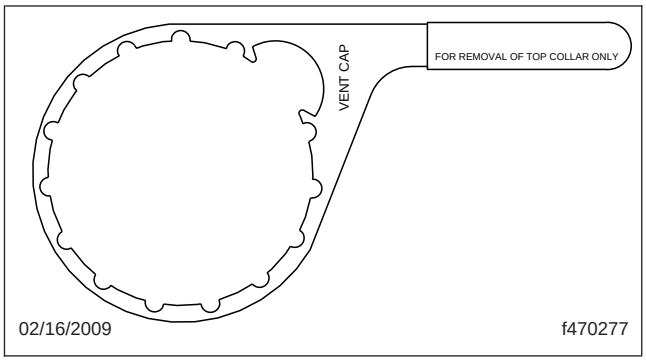


Fig. 2, DAVCO Collar Wrench

8. Install the new filter and grommet assembly and cover O-ring on the housing.
9. Install the clear cover and the collar. Hand-tighten the collar.
10. Prime the system

    10.1 Ensure that the drain valve is closed.

    10.2 Fill the housing to the top with clean diesel fuel.

    10.3 Install and hand-tighten the vent cap O-ring and vent cap.

Filter and Check Valve Replacement

10.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.

10.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.

10.6 Check for leaks and shut down the engine.

Emergency Temporary Filter Replacement

⚠ WARNING

Fluid circulated through the fuel/water separator to heat the fuel may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. 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.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

   The drain valve has a 1/2-inch (12.7-mm) pipe; use a hose with a 1/2-inch pipe thread to fit correctly.
3. Remove the vent cap (**Fig. 1**, Item 4) and open the drain valve (**Fig. 1**, Item 1) to drain the fuel completely, then close the drain valve.
4. Using a DAVCO Collar Wrench (**Fig. 2**), remove the clear cover and collar.

NOTE: Broken vent cap and collar warranty claims will not be accepted if any tool other than a DAVCO Collar Wrench, part number 380134, is used for removal. During installation, the vent cap and collar are to be **hand-tightened only**, not tightened with a wrench.

5. Remove the filter and dispose of it in an environmentally acceptable manner.
6. Clean all threads and sealing surfaces very thoroughly. Even a small amount of dirt will prevent the fuel/water separator from sealing, and an air leak may result.
7. Ensure that the drain valve is closed.
8. Remove the filter grommet from the filter stud, if equipped.
9. Install a standard engine spin-on filter (part number FF105 or equivalent) on the filter stud.
10. Install the cover O-ring, clear cover, and the collar. Hand-tighten the collar.
11. Fill the housing to the top with clean diesel fuel.
12. Install and hand-tighten the vent cap O-ring and vent cap.
13. Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
14. Check for leaks and shut down the engine.

Check Valve Replacement

⚠ WARNING

Fluid circulated through the fuel/water separator to heat the fuel may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. 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.

1. Shut down the engine, apply the parking brake, and chock the tires.

2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

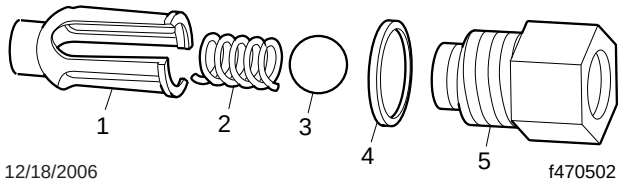
   The drain valve has a 1/2-inch (12.7-mm) pipe; use a hose with a 1/2-inch pipe thread to fit correctly.

3. Remove the vent cap (**Fig. 1**, Item 4) and open the drain valve (**Fig. 1**, Item 1) to drain the fuel completely. Close the drain valve.

4. Place a shop towel under the fuel inlet fitting. Hold the check valve body in place with an open-end wrench and remove the fuel inlet hose from the fitting. Continue holding the check valve body in place and, using a flare-nut wrench, carefully remove the fuel inlet fitting. Drain any residual fuel into the container.

5. Remove the check valve assembly from the fuel/water separator housing.

6. Remove and discard the check ball, spring, and plastic retainer. See **Fig. 3**.



1. Plastic Spring Retainer
2. Retaining Spring
3. Check Ball
4. Seal (Diesel Pro® units only)
5. Check Valve Body

Fig. 3, Check Valve Assembly

7. Carefully clean the threads on the check valve body. Install the new check ball, spring, and plastic retainer on the check valve body.

   The plastic retainer snaps into a groove in the check valve body.

8. Clean the threads on the fuel inlet fitting and fuel/water separator housing. Apply a teflon pipe thread sealant to the check valve body threads.

9. Install the check valve body in the fuel/water separator housing. Do not use tape to seal the fuel fittings; it may eventually leak.

   Tighten the check valve body 44 to 60 lbf·ft (60 to 81 N·m).

10. Install the fuel inlet fitting and connect the fuel inlet line.

11. Prime the system

    11.1 Ensure that the drain valve is closed.

    11.2 Remove the vent cap from the clear cover, and fill the housing to the top with clean diesel fuel.

    11.3 Install and hand-tighten the vent cap.

    11.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.

    11.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.

    11.6 Check for leaks and shut down the engine.

Electric Pre-Heater, Thermoswitch, and Fluid Heat Tests

Any one of several types of pre-heaters and thermoswitches may be fitted to DAVCO fuel/water separators. They include 12 VDC pre-heaters, 120 VAC pre-heaters, combination pre-heater thermoswitches, and fluid heaters. The voltage and wattage ratings are stamped on the hex or the sheath of each component.

Test procedures under these headings apply to the following pre-heater types, as specified:

- Electric Pre-Heater
- 12 VDC Thermoswitch
- Combination Pre-Heater Thermoswitch
- Fluid Heat

The following equipment is recommended to test DAVCO pre-heaters and thermoswitches:

- A precision low-resistance ohmmeter capable of measuring 0.1 ohm or less
- A clamp-on DC current-flow meter
- A means of chilling a thermoswitch, such as ice, dry ice, or compressed carbon dioxide
- A flameless source of heat, such as an infrared heat lamp
- A vortex tube to heat and cool a thermoswitch

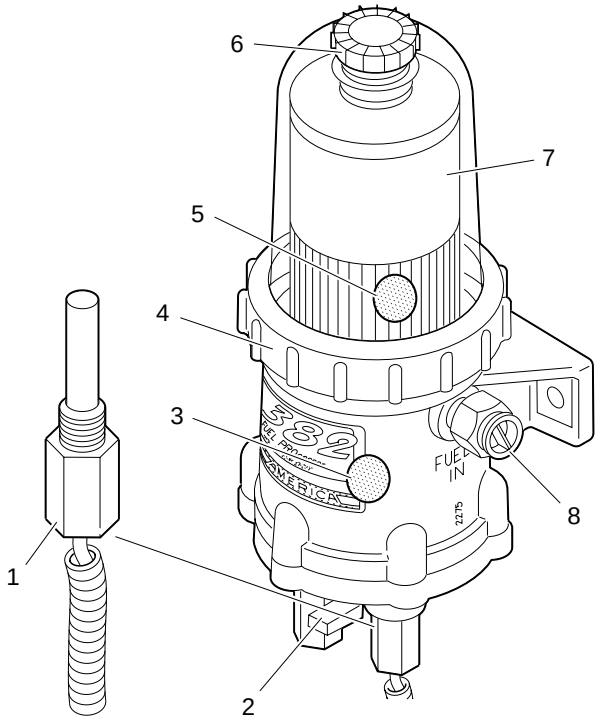
⚠ WARNING

Fluid circulated through the fuel/water separator to heat the fuel may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. 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.

Electric Pre-Heater

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the pre-heater from the wiring harness, see **Fig. 1**.
3. Connect the ohmmeter leads to the pins of the pre-heater (for pre-heaters with one pin, connect to the pin and the bushing).
4. Read the resistance and use **Table 1** to determine whether the pre-heater is within the acceptable resistance range.
5. Connect the pre-heater wiring harness.



1. Electric Heating Element
2. Drain Valve
3. Housing
4. Collar
5. Filter Element
6. Vent Cap
7. Clear Cover
8. Inlet Port/Check Valve

Fig. 1, Fuel Pro 382 With Electric Heating Element

Electric Pre-Heater Test Paramaters		
Electric Pre-Heater	**Watts**	**Resistance Range: Ohms**
12 VDC (two pin)	250	0.6–0.8
12 VDC (single pin)	250	0.6–0.8

Electric Pre-Heater, Thermoswitch, and Fluid Heat Tests

Electric Pre-Heater Test Paramaters		
Electric Pre-Heater	**Watts**	**Resistance Range: Ohms**
12 VDC (single pin)	150	0.9–1.1
120 VAC	75	173–203
120 VAC	37	369–411

Table 1, Electric Pre-Heater Test Parameters

12 VDC Thermoswitch

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

   The drain valve has a 1/2-inch (12.7-mm) pipe use a hose with a 1/2-inch pipe thread to fit correctly.
3. Remove the vent cap and open the drain valve to drain the fuel completely, then close the drain valve.
4. Disconnect the thermoswitch wiring harness, see **Fig. 2**. Remove the thermoswitch from the fuel/water separator.

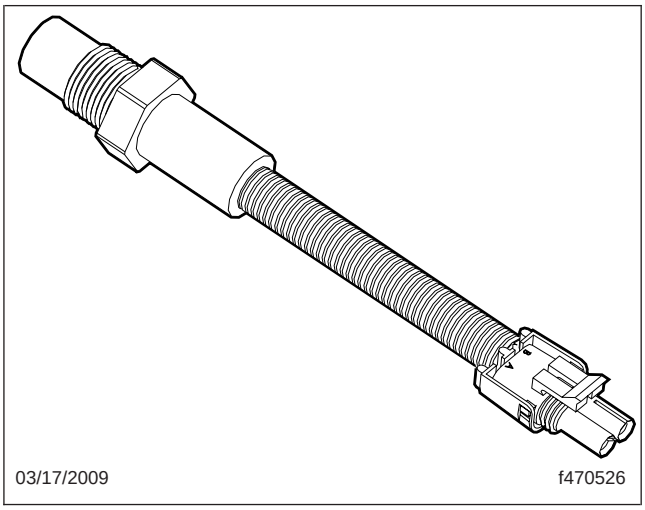


Fig. 2, 12 VDC Thermoswitch

5. Connect the ohmmeter leads to the pins of the thermoswitch.
6. Lower the thermoswitch temperature to below 40°F (4.4°C). The resistance shown on the ohmmeter should be less than or equal to 0.1 ohm.
7. Raise the thermoswitch temperature to above 60°F (15.5°C). The resistance should be more than 10 megohms.
8. Install the thermoswitch in the fuel/water separator. Connect the thermoswitch wiring harness.
9. Prime the system

   9.1 Ensure that the drain valve is closed.

   9.2 Remove the vent cap from the clear cover, and fill the housing to the top with clean diesel fuel.

   9.3 Install and hand-tighten the vent cap.

   9.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.

   9.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.

   9.6 Check for leaks and shut down the engine.

Combination Pre-Heater Thermoswitch

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

   The drain valve has a 1/2-inch (12.7-mm) pipe use a hose with a 1/2-inch pipe thread to fit correctly.
3. Remove the vent cap and open the drain valve to drain the fuel completely, then close the drain valve.
4. Disconnect the pre-heater/thermoswitch unit from the wiring harness, see **Fig. 3**.

Electric Pre-Heater, Thermoswitch, and Fluid Heat Tests

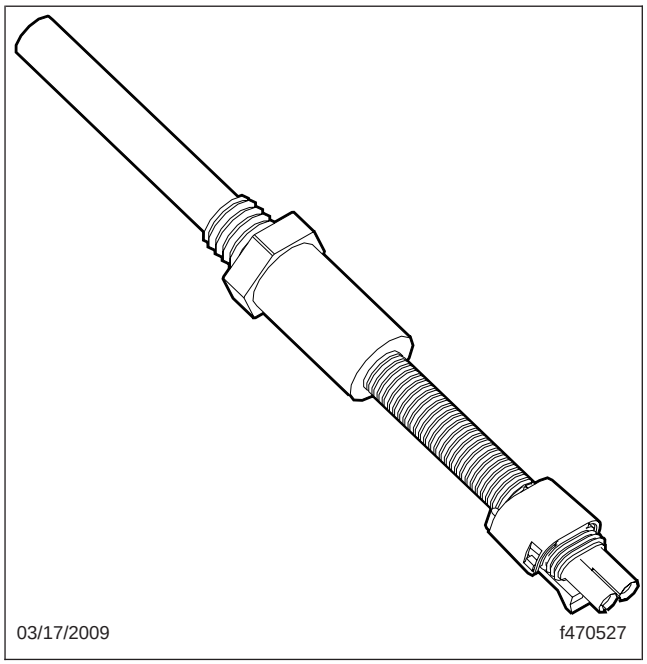


Fig. 3, Combination Pre-Heater Thermoswitch

5. Connect the ohmmeter leads to the pre-heater/thermoswitch pins.
6. Lower the pre-heater/thermoswitch unit temperature to below 40°F (4.4°C).

   The resistance shown on the ohmmeter should be:

   - 0.9 to 1.1 ohms for a 12 VDC 150 W unit
   - 0.6 to 0.8 ohms for a 12 VDC 250 W unit

7. Raise the pre-heater/thermoswitch unit temperature to above 70°F (21°C). The pre-heater/thermoswitch unit should show an open circuit.
8. Install the pre-heater/thermoswitch in the fuel/water separator. Connect the pre-heater/thermoswitch wiring harness.
9. Prime the system

   9.1 Ensure that the drain valve is closed.

   9.2 Remove the vent cap from the clear cover, and fill the housing to the top with clean diesel fuel.

   9.3 Install and hand-tighten the vent cap.

   9.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.

   9.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.

   9.6 Check for leaks and shut down the engine.

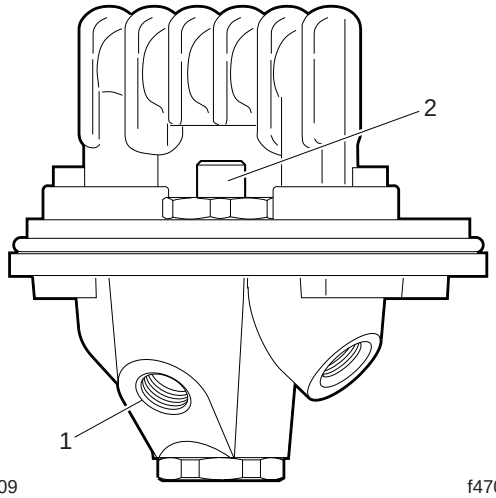
Fluid Heater

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the heating fluid lines from the bottom plate. These will be either engine coolant lines or return fuel lines. Plug engine coolant lines after removing them from the bottom plate of the housing.
3. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

   The drain valve has a 1/2-inch (12.7-mm) pipe use a hose with a 1/2-inch pipe thread to fit correctly.
4. Remove the vent cap and open the drain valve to drain the fuel completely, then close the drain valve.
5. Remove the bottom plate and lower housing O-ring.
6. While looking into the fluid port of the bottom plate (**Fig. 4**), flow cold water over the thermovalve for 30 seconds, then run hot water over the thermovalve to determine whether the thermovalve spool is opening and closing.

   When the fuel entering the fuel/water separator is cold, the thermovalve moves up, allowing warming fluid to enter the heater loop in the heat exchanger. When the fuel is warm, the thermovalve moves down, causing the warming fluid to bypass the heater loop and return directly to the tank. See **Fig. 5**.
7. Replace the lower housing O-ring, and install the bottom plate on the fuel/water separator. There are two types of bottom plates: locking-collar-assembled and screw-assembled.

Electric Pre-Heater, Thermoswitch, and Fluid Heat Tests



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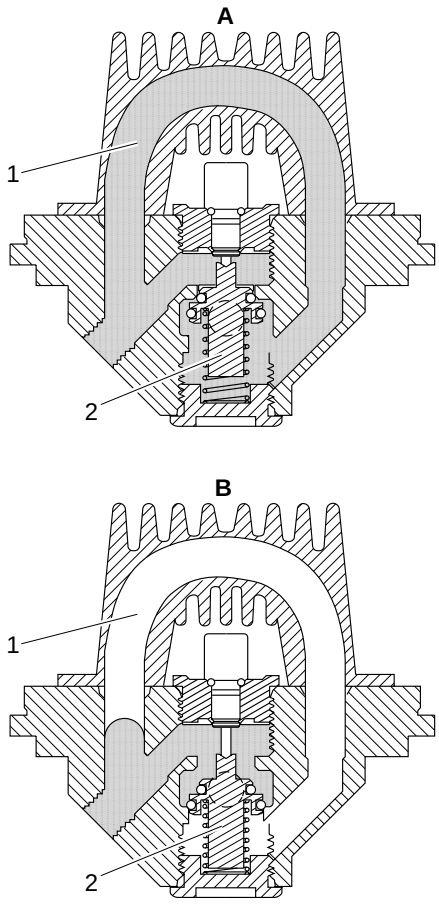
1. Fluid Port
2. Top of Thermovalve Spool

Fig. 4, Fluid Pre-Heater Thermovalve Test

- Locking-collar-assembled: Apply 2 to 3 drops of Loctite 406 to the bottom collar threads, then tighten 50 to 60 lbf·ft (68 to 81 N·m).
- Screw-assembled: Install the screws on the bottom plate and tighten them 8 to 10 lbf·ft (11 to 14 N·m).

8. Connect the heating fluid lines.
9. Prime the system
   - 9.1 Ensure that the drain valve is closed.
   - 9.2 Remove the vent cap from the clear cover, and fill the housing to the top with clean diesel fuel.
   - 9.3 Install and hand-tighten the vent cap.
   - 9.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
   - 9.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.



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A. Fuel is Cold, Thermovalve Is Up
B. Fuel is Warm, Thermovalve is Down

1. Pre-Heater Loop 2. Thermovalve

Fig. 5, Heat Exchanger Fluid Flow

   - 9.6 Check for leaks and shut down the engine.

The Daimler Trucks North America Learning Center (accessible through **www.AccessFreightliner.com**) and DAVCO (**www.DavcoTec.com**) offer excellent online resources for understanding, testing, and diagnosing fuel/water separator problems.

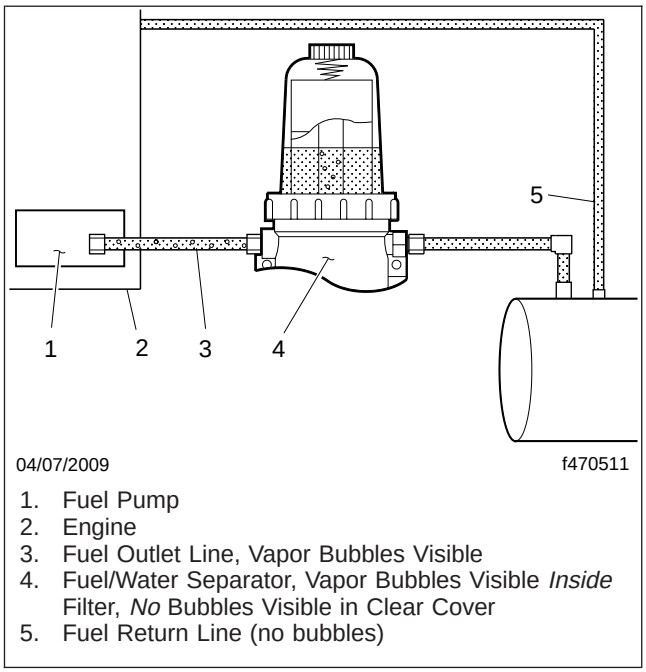
Identifying Bubble Types

Vapor Bubbles

Vapor bubbles are harmless and are present in all diesel fuel systems. Vapor bubbles are often mistaken for air bubbles, but *do not affect engine performance.*

Vapor bubbles (see **Fig. 1**) may be visible in a diagnostic sight tube installed between the fuel/water separator and the fuel pump. They consist of harmless fuel vapor and trapped air, may vary from champagne-size to 1/4-inch (6-mm) diameter, and may increase in volume or size as the engine rpm increases. The lower pressure inside a fuel/water separator filter, caused by the suction of the fuel pump pulling fuel through the fuel/water separator, creates vapor bubbles. These vapor bubbles are normal and harmless to engine operation. In the fuel pump, the fuel is pressurized and the vapor bubbles dissolve. Vapor bubbles do not appear on the fuel return side of the system.

There is no troubleshooting or repair procedure required for vapor bubbles. Vapor bubbles do not cause performance issues and will not be present downstream of the fuel pump.



1. Fuel Pump
2. Engine
3. Fuel Outlet Line, Vapor Bubbles Visible
4. Fuel/Water Separator, Vapor Bubbles Visible *Inside* Filter, *No* Bubbles Visible in Clear Cover
5. Fuel Return Line (no bubbles)

Fig. 1, Harmless Vapor Bubbles

Air and Gas Bubbles

Air or gas bubbles indicate harmful leaks, and can cause hard starting and impaired engine performance. All diesel fuel holds some trapped air, caused by the natural splashing that occurs in the fuel tank. But excessive air bubbles, severe enough to degrade engine performance, indicate an air leak on the suction side of the fuel system, from the fuel tank into the fuel pump.

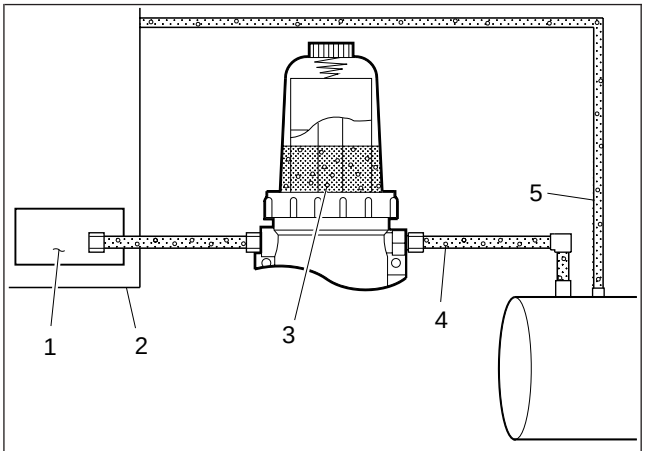
Air bubbles visible in the clear cover of a DAVCO fuel/water separator may indicate an air leak in the fuel system upstream of the bubbles, or in the fuel/water separator; see **Fig. 2**. If there are no bubbles visible in the clear cover but the engine runs rough, there may be an air leak at or between the fuel/water separator outlet port and the fuel pump inlet. These bubbles will be visible in a diagnostic sight tube installed between the fuel pump and the fuel/water separator, and in a diagnostic sight tube installed in the fuel return hose.

Exhaust gas bubbles may also be visible in the clear filter cover. They are the result of leaking fuel injector seals, which can allow combustion gases to enter the fuel system, pass through the fuel return line into the fuel tank, and be drawn into the fuel/water separator. They may be visible in a diagnostic sight tube installed in the fuel return line. To test for combustion gas in the fuel, disconnect the return line at the tank, submerge the end in a bucket of fuel, run the engine, and watch for bubbles. As they pop, these bubbles may smell like exhaust fumes.

In extreme cases, these combustion gas bubbles cause enough aeration in the fuel tank to create visible bubbles in the clear cover of the fuel/water separator and impair engine performance. See the engine manufacturer's documentation for diagnosis and repair of injector seal leakage.

Use the following procedures to determine which bubbles are present in the fuel system, and whether repair is necessary.

Troubleshooting



1. Fuel Pump
2. Engine
3. Fuel/Water Separator, Bubbles Visible in Clear Cover
4. Fuel Inlet Line, Bubbles Visible
5. Fuel Return Line, Bubbles Visible

Fig. 2, Air Bubbles Indicating a Leak

Initial Diagnostic Procedure

1. Apply the parking brake, chock the tires, and turn on the engine.
2. Check for air bubbles in the fuel/water separator clear cover.
3. If no bubbles are visible in the clear cover, but the engine continues to run rough, lopes, or has loss of power, there may be an air leak between the fuel/water separator outlet and the fuel pump inlet.

   If so, bubbles should be visible in a diagnostic sight tube installed at the fuel pump inlet. Air bubbles may also be visible in a diagnostic sight tube installed in the fuel return line to the fuel tank.
4. Replace fuel lines and tighten fittings as needed.
5. A DAVCO fuel/water separator, properly assembled with the rubber grommet in the bottom of the fuel filter, does not restrict fuel flow until the fuel level has risen to the top of the filter. If the fuel level has risen to the top of the filter, replace the filter.

Testing Procedures

Air Leak in the Fuel System

Air leaks are sometimes caused by:

- loose fittings;
- a faulty inlet check valve;
- faulty O-rings;
- leakage elsewhere in the fuel system;
- or dirt on threads and sealing surfaces.

Air leaks originating between the fuel tank and the fuel/water separator cause air bubbles visible in the clear cover, as shown in **Fig. 2**.

If there are symptoms of sucking air and there are no bubbles in the clear cover, look for the air leak at:

- the outlet fitting;
- the fuel pump inlet connection;
- the fuel hose connections;
- or at the vent cap O-ring.

1. Shut down the engine, apply the parking brake, and chock the tires.

⚠ WARNING

Fluid circulated through the fuel/water separator to heat the fuel may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. 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.

2. Remove the fuel hose from the fuel pump inlet port.
3. Install a jumper hose from the inlet port into the fuel tank through the fill cap, or into a container of fuel.
4. Start the engine and look for bubbles in the clear filter cover. If the air bubbles are eliminated, the

air source (and the leak) is at either the fuel tank fittings, or the hose connections.

If air bubbles persist after the tank fittings and hose connections are secured, the leak may be in the fuel/water separator.

5. If the leak is suspected to be in the fuel/water separator, disconnect all fuel connections, coat the threads with teflon pipe thread sealant, and reconnect the fuel connections and tighten them securely.

Air Pressure Testing

⚠ WARNING

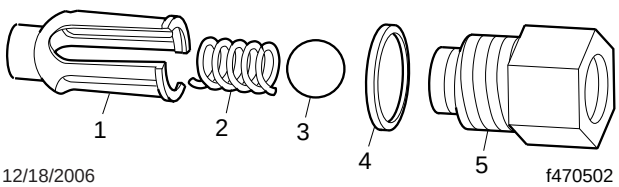
Wear goggles and skin protection when pressure-testing a fuel/water separator, and be careful not to perform this test near a source of possible ignition, such as an open flame. Never exceed the maximum pressure stipulated for the test, and do not perform this test if the clear cover appears to be damaged.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

   The drain valve has a 1/2-inch (12.7-mm) pipe; use a hose with a 1/2-inch pipe thread to fit correctly.
3. Remove the vent cap and open the drain valve to drain the fuel completely, then close the drain valve.
4. Remove the fuel/water separator from the chassis. For instructions, see **Subject 100**.
5. Plug the fuel outlet port. Do not remove the filter, filter cover, collar, vent cap, drain valve, or check valve. Do not remove the electric heating element (if equipped), and do not plug the fluid heat ports (if equipped).
6. Apply 15 psi (207 kPa) air pressure at the fuel inlet. Immerse the unit in a tank of water and look for air bubbles.
7. If a leak is found, repair the fuel/water separator as needed.
8. Install the fuel/water separator onto the chassis frame rail. For instructions, see **Subject 100**.
9. Prime the system
   - 9.1 Ensure that the drain valve is closed.
   - 9.2 Remove the vent cap from the cover, and fill the housing to the top with clean diesel fuel.
   - 9.3 Install and hand-tighten the vent cap.
   - 9.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
   - 9.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.
10. If no bubbles appear, the air leak is not in the fuel/water separator.

Check Valve Operation Test

When air is introduced into the fuel system, (e.g. when draining fluid or when replacing the fuel filter), the check valve (**Fig. 3**) works to keep the fuel system primed from the fuel tank to the fuel/water separator.



1. Plastic Spring Retainer
2. Retaining Spring
3. Check Ball
4. Seal (Diesel Pro units only)
5. Check Valve Body

Fig. 3, Check Valve Assembly

To test for proper check valve operation, remove the fuel inlet line, then open the vent cap. Fuel should not flow out of the check valve, although a slight seepage of fuel is normal. If fuel drains back out of the check valve, complete the following procedure.

1. Shut down the engine, apply the parking brake, and chock the tires.

Troubleshooting

⚠ WARNING

Fluid circulated through the fuel/water separator to heat the fuel may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.

If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. 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.

2. Put a clean receptacle under the fuel/water separator and attach a piece of hose to the drain valve, to direct fuel into the receptacle.

   The drain valve has a 1/2-inch (12.7-mm) pipe; use a hose with a 1/2-inch pipe thread to fit correctly.

3. Remove the vent cap and open the drain valve to drain the fuel completely, then close the drain valve.
4. Place a shop towel under the fuel inlet fitting. Hold the check valve body in place with an open-end wrench and, using a flare-nut wrench, carefully remove the fuel inlet fitting. Drain any residual fuel into the container.
5. Remove the check valve assembly from the fuel/water separator housing, see **Fig. 3**.
6. Clean and inspect the check valve body. If the valve body is damaged, or if the ball seat is not smooth, replace the valve. For instructions, see **Subject 110**.
7. If the valve body and ball seat are not damaged, clean the threads on the check valve body, fuel inlet fitting, and the water separator housing.
8. Apply a teflon pipe thread sealant to the check valve body threads. Install the check valve body in the fuel/water separator housing. Do not use tape to seal the fuel fittings; it may eventually leak.

   Tighten the check valve body 44 to 60 lbf·ft (60 to 81 N·m).

9. Prime the system
   - 9.1 Ensure that the drain valve is closed.
   - 9.2 Remove the vent cap from the clear cover, and fill the housing to the top with clean diesel fuel.
   - 9.3 Install and hand-tighten the vent cap O-ring and vent cap.
   - 9.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
   - 9.5 While the engine is running, and after the air is purged from the system, loosen the vent cap until the fuel level falls to just above the collar, then hand-tighten the vent cap.
   - 9.6 Check for leaks and shut down the engine.

Other Conditions Visible Inside the Cover

The clear filter covers fitted to DAVCO fuel/water separators provide the opportunity to monitor several aspects of fuel condition and engine status, as described in **Table 1**.

Conditions Visible Inside DAVCO Clear Filter Covers

If You See:	What to Do:	Comments:
Amber-colored fuel below the top of the filter element	Nothing, the filter is doing its job	Do not change the filter.
Amber-colored fuel with dark patches in places on the filter element	Dark patches indicate bacteria or algae may be present. Use Fleetguard Monitor Kit CC2650 to test for microbiological activity.	It may be necessary to use a microbicide, and suggest vehicle operator carry extra filters.

Conditions Visible Inside DAVCO Clear Filter Covers		
If You See:	**What to Do:**	**Comments:**
Extremely dark or cloudy fuel with thick black film or sludge collecting on the filter element	Black film or sludge on the filter media indicates the presence of asphaltenes. It may be necessary to use an asphaltene conditioner.	Do not assume this is oil from the engine. Monitor the vehicle for oil consumption. Refer to engine manufacturer's service literature for more information.
Bubbles inside the clear cover	Check for air leaks anywhere in the fuel system. Any leak in any fitting will cause bubbles to appear in the clear cover.	This problem will lead to power complaints; it must be remedied.
No bubbles in the cover, but the engine is running rough	Check for air leaks between the fuel/water separator outlet port and the fuel pump inlet. Check and tighten all fuel fittings in the area of the leak.	—
Coolant in the fluid drained from the fuel/water separator	Check for leaks in the engine, where fuel and coolant are near each other. The most common problem place is the injector cup.	Do not allow the equipment to be operated until the problem is found and repaired.
Anything not listed here	Call DAVCO at 1-800-328-2611, or email: customerservice@DavcoTec.com	—

Table 1, Conditions Visible Inside DAVCO Clear Filter Covers

Specifications

Torque Values		
Component	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Inlet Check Valve	44–60 (60–81)	—
Water in Fuel Sensor	—	20–24 (226–271)
Electric Heating Element	15–30 (20–41)	—
Drain Valve	25 (34)	—
Housing Assembly Screws	8–10 (11–14)	—

Table 1, Torque Values

General Description

The fuel/water separator is mounted on the frame rail, between the fuel tank and the fuel pump. Fuel drawn to the engine travels through the fuel/water separator, which removes water and solid contaminants. The fuel/water separator includes a spin-on filter element and a sight bowl. See **Fig. 1**. The fuel/water separator may also be equipped with the following optional components:

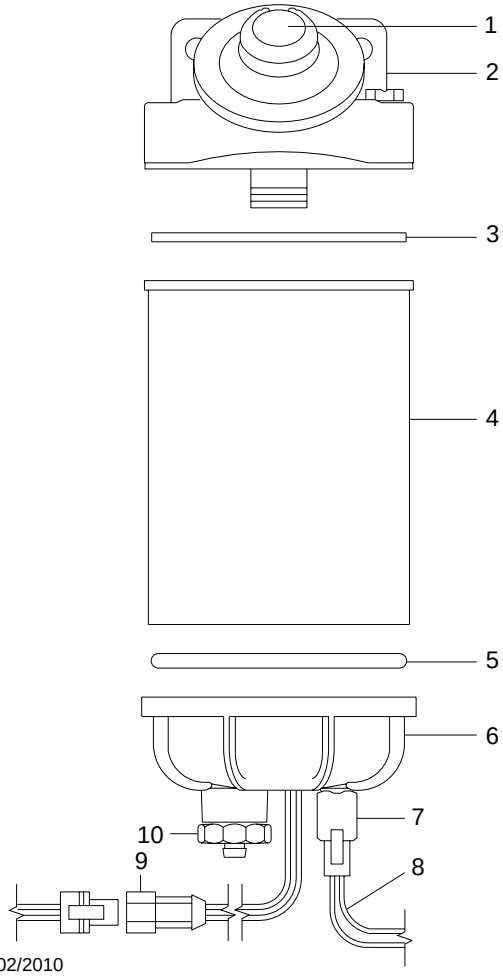
- Ignition-controlled heater to melt ice and wax in the fuel
- Water sensor probe to alert the operator to drain the sight bowl
- Manual priming pump to easily prime the fuel/water separator

Principles of Operation

Diesel fuel enters at the top of the separator and flows down past the heater element, if equipped, to the top of the filter element. As the fuel flows down the sides of the element, the heavier contaminants fall directly to the collection bowl. The filter element itself contains a resin that repels water and forces it to bead and fall to the collection bowl.

Filtered fuel is drawn out through the top of the separator, and the water and solid contaminants remain in the collection bowl. As water collects, it completes the circuit between the two prongs of the water sensor probe, if equipped, and a warning light on the dash alerts the operator to drain the bowl.

The heater is operated by turning on the ignition switch for 5 minutes before starting the engine.



1. Priming Pump
2. Mounting Head
3. Gasket
4. Filter Element
5. O-Ring
6. Sight Bowl
7. Water Sensor Probe
8. Water Sensor Probe Wiring Harness
9. Heater Wiring Harness
10. Drain Plug

Fig. 1, Fuel/Water Separator Assembly

Removal

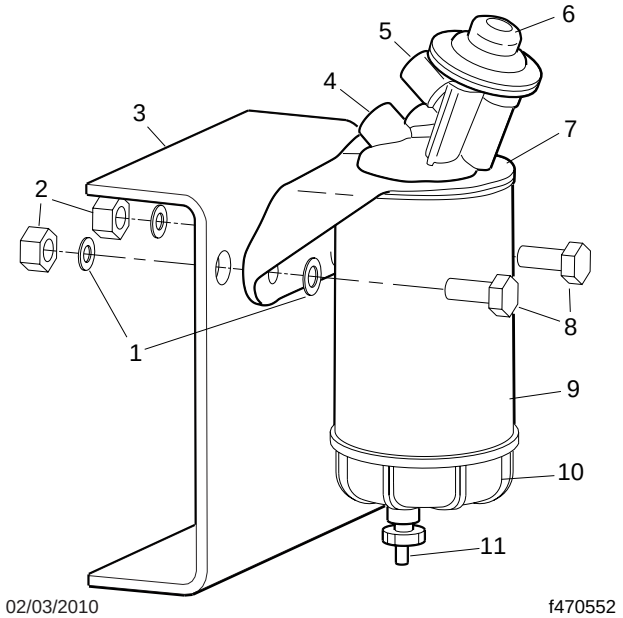
1. Shut down the engine, apply the parking brake, and chock the tires.

   Open the hood.

2. Place a suitable container under the fuel/water separator.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

3. Turn the drain plug counterclockwise to open it. If equipped, operate the priming pump. See **Fig. 1**.



1. Washers (qty 2)
2. Nuts (qty 2)
3. Frame Rail
4. Fuel Outlet Port
5. Fuel Inlet Port
6. Priming Pump
7. Mounting Head
8. Mounting Bolts (qty 2)
9. Filter Element
10. Sight Bowl
11. Drain Plug

Fig. 1, Fuel/Water Separator Assembly and Installation

4. When the fuel/water separator is completely drained, turn the drain plug clockwise to close it.

⚠ WARNING

Do not expose the fuel to open fire. Do not 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.

5. Disconnect the fuel lines from the fuel/water separator.
6. If equipped, disconnect the wiring harnesses from the water sensor probe and the heater element.
7. Remove the fuel/water separator mounting bolts, and remove the fuel/water separator from its mounting bracket.

Installation

1. Mount the fuel/water separator on the frame rail mounting bracket, and install the mounting bolts. Tighten the bolts 40 lbf·ft (55 N·m).
2. Remove the sight bowl and the filter element as a unit from the new fuel/water separator.
3. Using clean motor oil or diesel fuel, lubricate the gasket in the top of the filter element.
4. Make sure the drain in the sight bowl is closed, then fill the filter element and bowl assembly with clean fuel.
5. Install the element and bowl assembly on the mounting head and hand-tighten it until snug.
6. If equipped, connect the wiring harnesses to the water sensor probe and the heater.
7. Connect the fuel lines to the fuel/water separator. Tighten all fittings finger-tight plus 1/4 turn.
8. Prime the fuel/water separator.

   If equipped with a priming pump, loosen the drain plug and operate the priming pump until fuel comes out at the drain.

   If not equipped with a priming pump, fill the filter element and sight bowl with clean fuel and crank the engine until it starts.
9. Start the engine and check for leaks.
10. Shut down the engine and repair any leaks.

Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.

   Open the hood.

2. Place a suitable container under the fuel/water separator.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

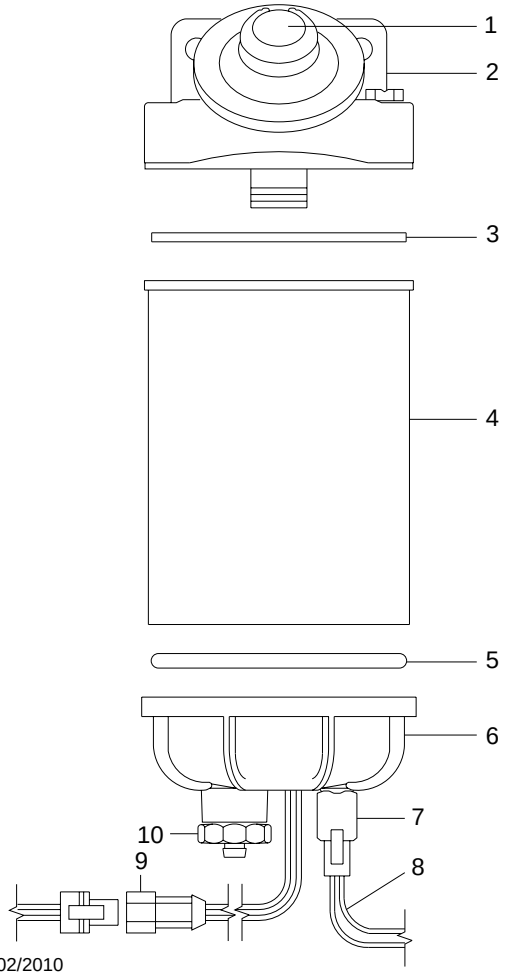
3. Turn the drain plug counterclockwise to open it. If equipped, operate the pump.
4. When the fuel/water separator is completely drained, turn the drain plug clockwise to close it.

⚠ WARNING

Do not expose the fuel to open fire. Do not 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.

5. If equipped, disconnect the wiring harnesses from the water sensor probe and the heater. See **Fig. 1**.
6. Spin off the sight bowl and the filter element as a unit. Remove the gasket from the top of the filter element.
7. Remove the sight bowl from the filter element. Clean the O-ring seating surface.
8. Apply a thin coating of clean diesel fuel or engine oil to the O-ring and the new gasket.
9. Spin the sight bowl onto the new filter element and then fill the filter element and sight bowl assembly with clean diesel fuel.
10. Spin the entire assembly onto the mounting head and tighten by hand until snug.
11. Connect the heater and water sensor wiring harnesses, if equipped.
12. Prime the fuel/water separator.

    If equipped with a priming pump, loosen the drain plug and operate the priming pump until fuel comes out at the drain.



1. Priming Pump
2. Mounting Head
3. Gasket
4. Filter Element
5. O-Ring
6. Sight Bowl
7. Water Sensor Probe
8. Water Sensor Probe Wiring Harness
9. Heater Wiring Harness
10. Drain Plug

Fig. 1, Fuel/Water Separator Assembly

   If not equipped with a priming pump, fill the filter element and sight bowl with clean fuel and crank the engine until it starts.

13. Start the engine and check for leaks.
14. Shut down the engine and repair any leaks.

Replacement

1. Shut down the engine, apply the parking brake, and chock the tires.

   Open the hood.

2. Place a suitable container under the fuel/water separator.

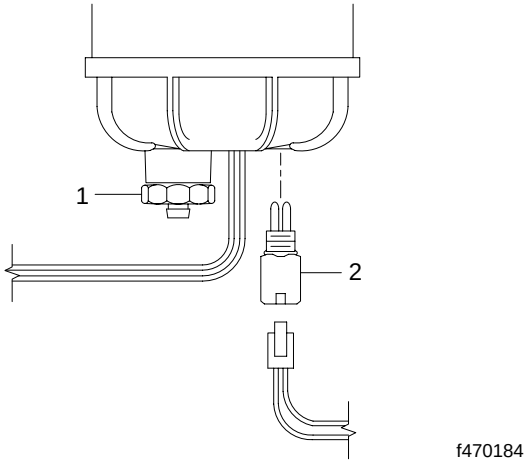
IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

3. Turn the drain plug counterclockwise to open it. If equipped, operate the priming pump.
4. When the fuel/water separator is completely drained, turn the drain plug clockwise to close it.

⚠ WARNING

Do not expose the fuel to open fire. Do not 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.

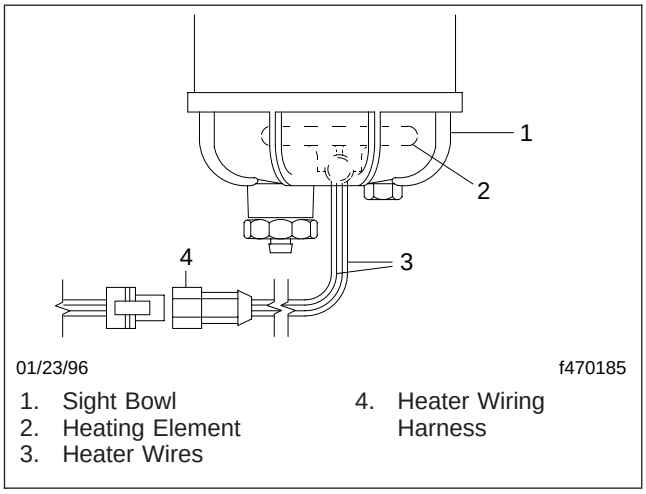
5. If equipped, disconnect the wiring harness from the water sensor probe. See **Fig. 1**.



1. Drain Plug
2. Water Sensor Probe

Fig. 1, Water Sensor Probe

6. Disconnect the heater wiring harness. See **Fig. 2**.



1. Sight Bowl
2. Heating Element
3. Heater Wires
4. Heater Wiring Harness

Fig. 2, In-Bowl Heater

7. Spin off the sight bowl and the filter element as a unit.
8. Remove the sight bowl from the filter element.
9. Remove the O-ring from the lip of the new sight bowl. Lubricate the O-ring with a thin film of clean engine oil or diesel fuel and put it back in the sight bowl.
10. Install the sight bowl on the bottom of the filter element and hand-tighten until it is snug.
11. Make sure the drain in the sight bowl is closed, then fill the filter element and bowl assembly with clean fuel.
12. Install the element and bowl assembly on the mounting head and hand-tighten it until snug.
13. Connect the heater wiring harness.

    If equipped, connect the water sensor wiring harness to the water sensor probe.

14. Prime the fuel/water separator.

    If equipped with a priming pump, loosen the drain plug and operate the priming pump until fuel comes out at the drain.

    If not equipped with a priming pump, fill the filter element and sight bowl with clean fuel and crank the engine until it starts.

15. Start the engine and check for leaks.
16. Shut down the engine and repair any leaks.

Replacement

1. Apply the parking brakes, shut down the engine, and chock the tires.

   Open the hood.

2. Place a suitable container under the fuel/water separator.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

3. Turn the drain plug counterclockwise to open it. If equipped, operate the priming pump.
4. When the fuel/water separator is completely drained, turn the drain plug clockwise to close it.

⚠ WARNING

Do not expose the fuel to open fire. Do not 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.

5. Disconnect the water sensor wiring harness from the water sensor probe. See **Fig. 1**.

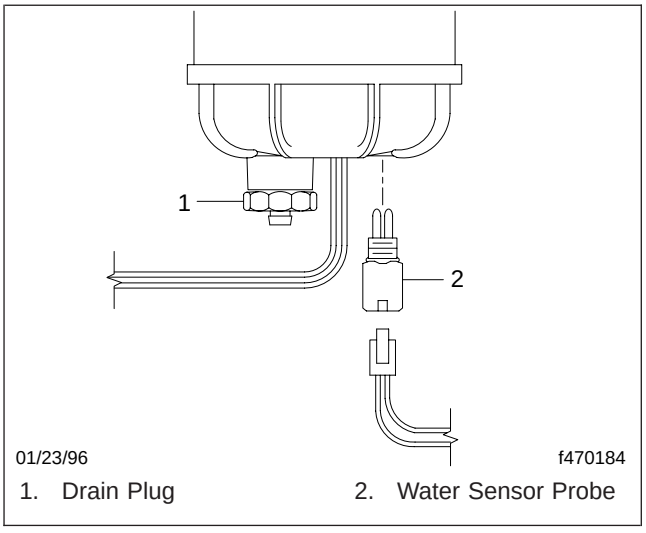


Fig. 1, Water Sensor Probe

6. Spin off the sight bowl and filter element as a unit.
7. Unscrew the water sensor probe from the base of the sight bowl.
8. Install a new water sensor probe in the base of the sight bowl.
9. Make sure the drain plug in the base of the sight bowl is closed snugly.
10. Fill the filter element and sight bowl assembly with clean diesel fuel.
11. Install the element and bowl assembly on the mounting head and hand-tighten it until snug.
12. Connect the water sensor wiring harness to the water sensor probe.
13. Prime the fuel/water separator.

    If equipped with a priming pump, loosen the drain plug and operate the priming pump until fuel comes out at the drain.

    If not equipped with a priming pump, fill the filter element and sight bowl with clean fuel and crank the engine until it starts.

14. Start the engine and check for leaks.
15. Shut down the engine and repair any leaks..

Troubleshooting

Problem—Air Leaking into the Fuel System

Problem—Air Leaking into the Fuel System	
Possible Cause	**Remedy**
The drain is not closed.	Tighten the drain valve.
The sight bowl or filter element is loose.	Hand-tighten the sight bowl or filter element until snug.
There are loose, broken, or clogged fuel fittings, valves, or filters.	Tighten, clean, or repair the fuel fittings, valves, or filters as needed.

Problem—High Water Light Does Not Illuminate For 2 to 5 Seconds When Ignition is Turned to ACCESSORY

Problem—High Water Light Does Not Illuminate For 2 to 5 Seconds When Ignition is Turned to ACCESSORY	
Possible Cause	**Remedy**
Wiring connections are loose.	Tighten connections as needed.
Fuel/water separator is not grounded.	Check that power is on, and the fuel/water separator is grounded.
Wiring is damaged.	Check for damaged wiring and replace as needed. See EZWiring for a diagram of the sensor circuit.
Water sensor probe is damaged.	Replace the water sensor probe. See **Subject 130** for instructions.

General Information

The exhaust system routes hot exhaust gas away from the cab and reduces engine exhaust noise. The exhaust system consists of the following:

- exhaust manifold (part of engine)
- turbocharger (part of engine)
- engine outlet exhaust pipe
- flex pipes
- clamps
- muffler
- inlet pipe
- outlet pipe
- exhaust stack (vertical exhaust systems only)
- exhaust brake

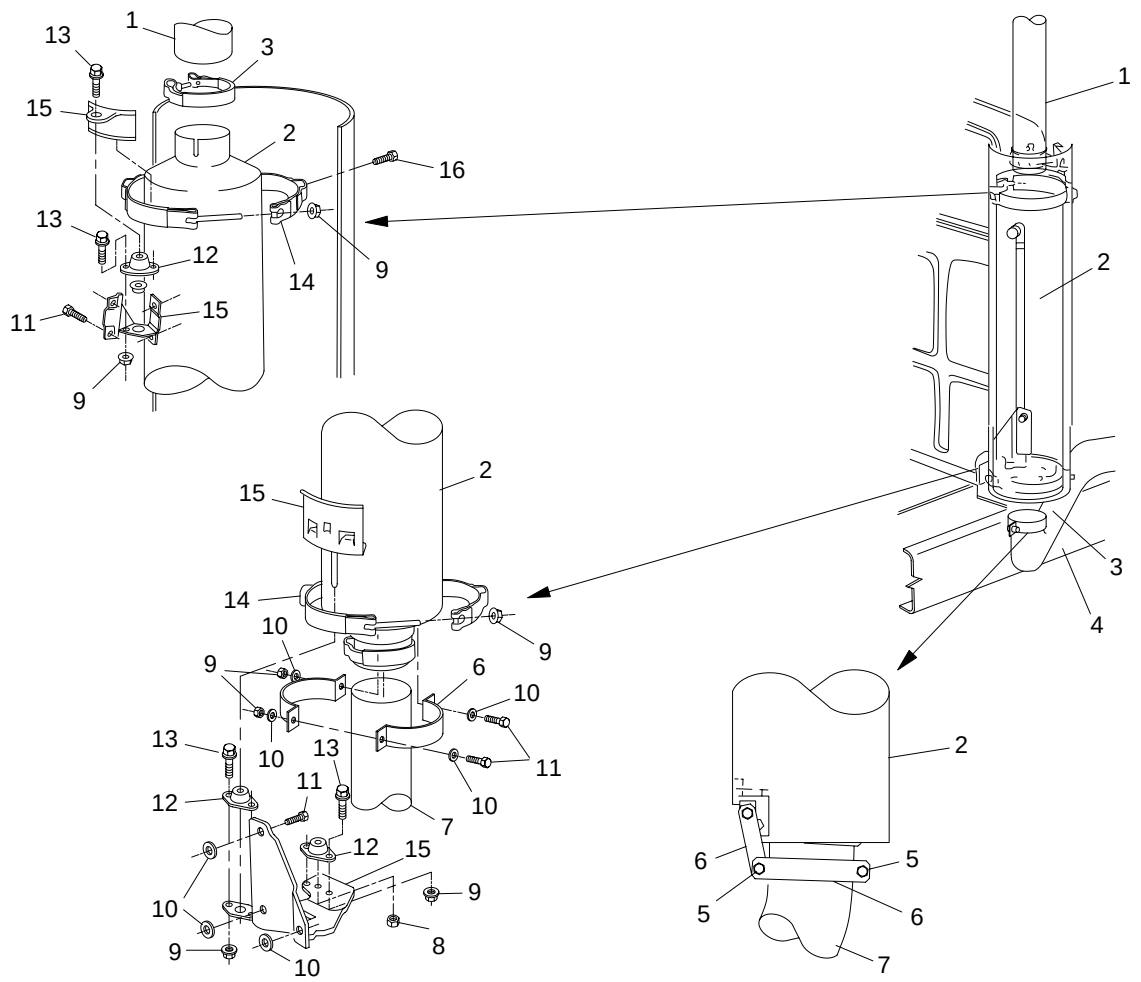
Mufflers can be either cab-mounted or frame-mounted. See **Fig. 1**.

Frame-mounted mufflers can be vertically-mounted or horizontally-mounted. See **Fig. 2** or **Fig. 3**.

Horizontally-mounted mufflers can be equipped with a cab-mounted exhaust stack or a frame-mounted exhaust stack. See **Fig. 4** or **Fig. 5**.

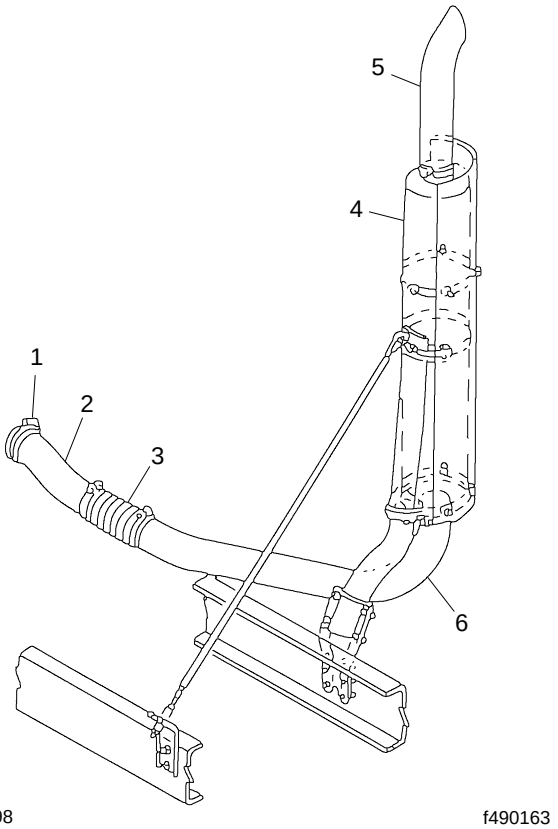
A transverse horizontally-mounted muffler is also available. See **Fig. 6**.

General Information



1. Exhaust Pipe
2. Muffler
3. Exhaust Clamp
4. Frame
5. Bolt (3/8–16 x 2.65)
6. Elbow Bracket
7. Elbow
8. Bushing
9. Locknut (3/8 x 16)
10. Washer
11. Bolt (5/16–1.5 x 33.5)
12. Bushing
13. Hexhead Flange Bolt (5/16–18 x 0.88)
14. Heat Shield Bracket
15. Cab-to-Muffler Bracket

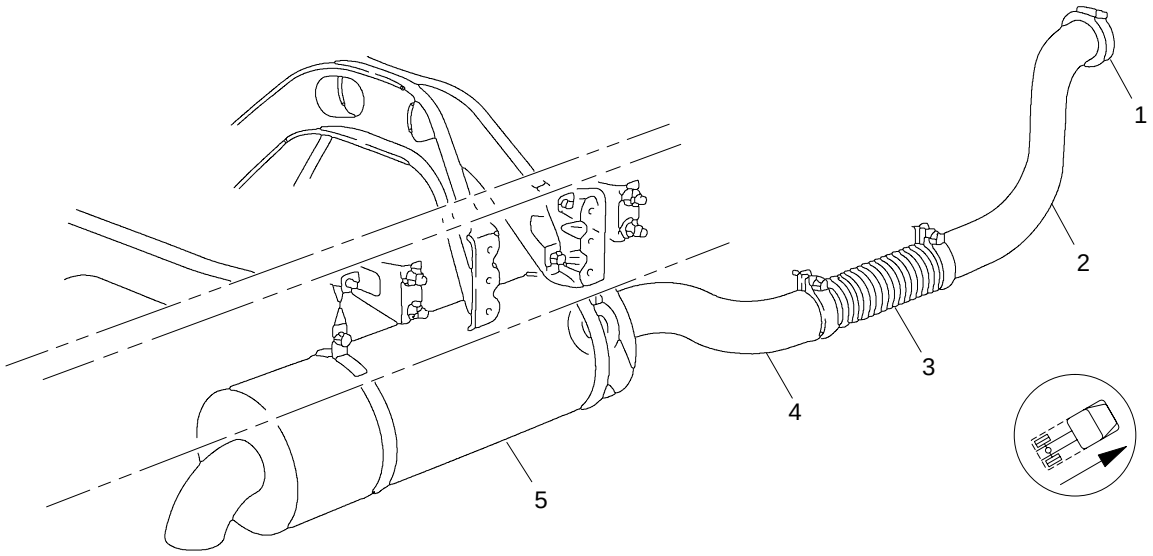
Fig. 1, Vertical Cab-Mounted Muffler



1. Clamp
2. Engine Outlet Exhaust Pipe
3. Flex Pipe
4. Muffler
5. Exhaust Stack Pipe
6. Muffler (inlet extension pipe)

Fig. 2, Vertical Frame-Mounted Muffler

General Information



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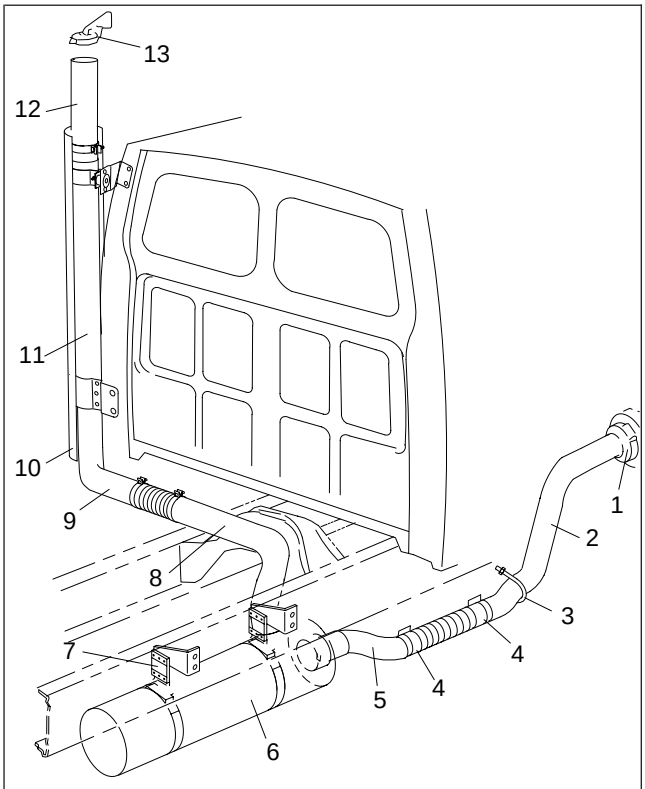
1. Clamp
2. Engine Outlet Exhaust Pipe
3. Flex Pipe
4. Muffler Inlet Pipe
5. Muffler Assembly

Fig. 3, Horizontal Frame-Mounted Muffler



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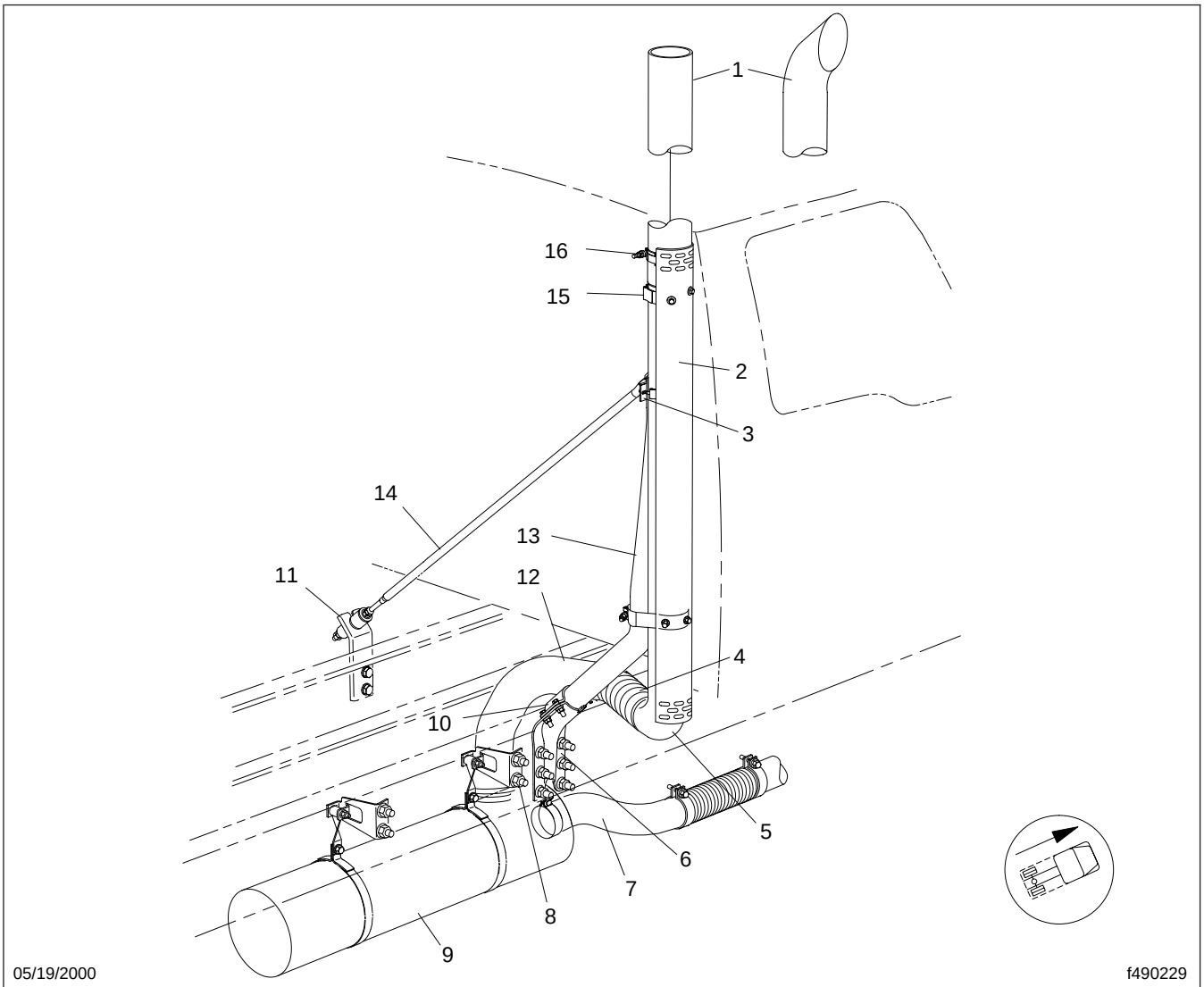
1. Turbocharger
2. Engine Outlet Exhaust Pipe
3. U-Bolt
4. Flex Pipe and Clamps
5. Muffler Inlet Pipe
6. Muffler
7. Muffler Support Bracket
8. Crossover Pipe
9. Exhaust Pipe Elbow
10. Exhaust Stack Shield
11. Lower Exhaust Stack Pipe
12. Upper Exhaust Stack Pipe
13. Rain Cap

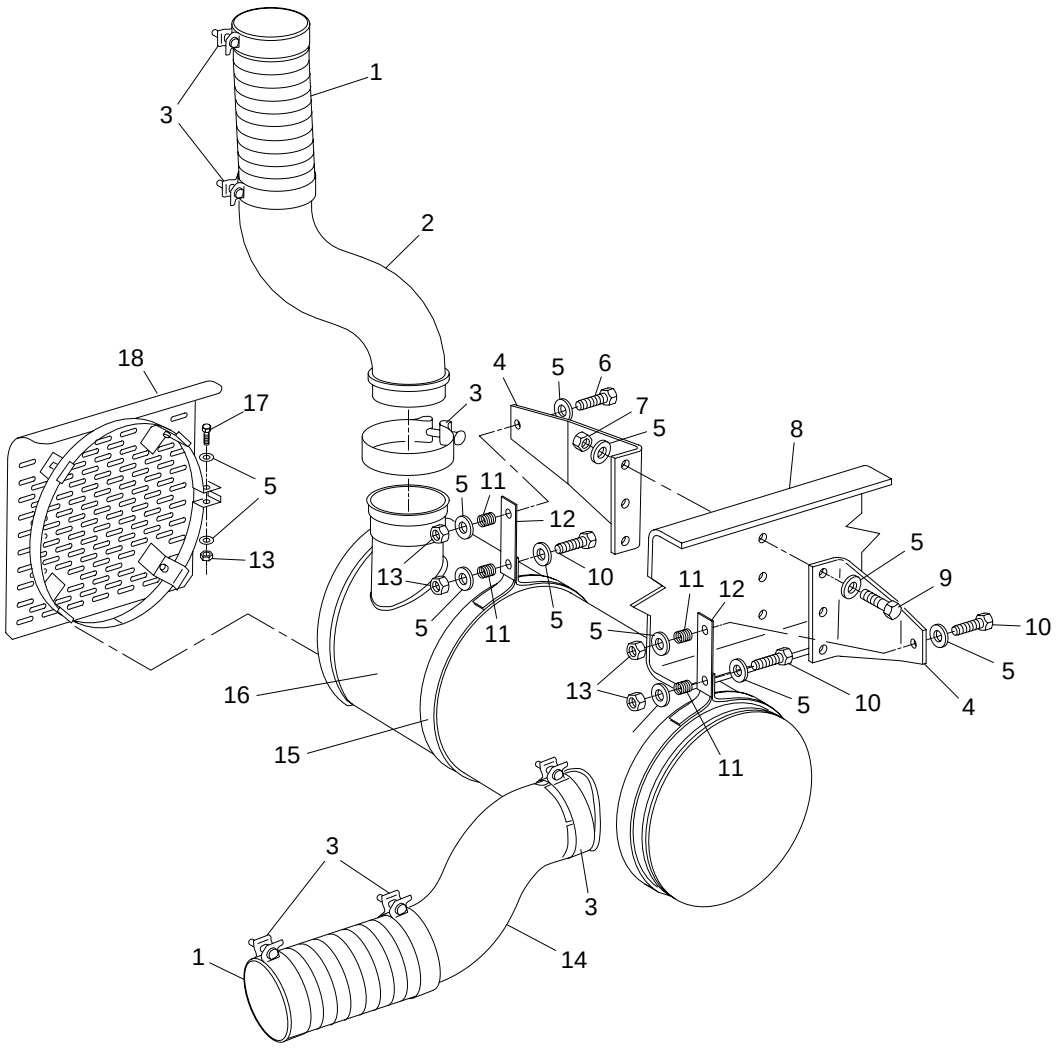
Fig. 4, Horizontal Muffler With Cab-Mounted Exhaust Stack (Right-Hand-Drive Shown)

General Information



1. Exhaust Stack
2. Heat Shield
3. Heat Shield Clamp
4. Flex Pipe
5. Muffler Upper Outlet Pipe
6. Exhaust Stack Support Bracket
7. Muffler Inlet Extension
8. Muffler Mounting Bracket and Fasteners
9. Muffler
10. Exhaust Stack Support Bracket Cap
11. Support Brace Bracket
12. Muffler Lower Outlet Pipe
13. Exhaust Stack Support
14. Exhaust Stack Support Brace
15. Heat Shield Clamp
16. Exhaust Stack Clamp

Fig. 5, Horizontal Muffler With Frame-Mounted Exhaust Stack



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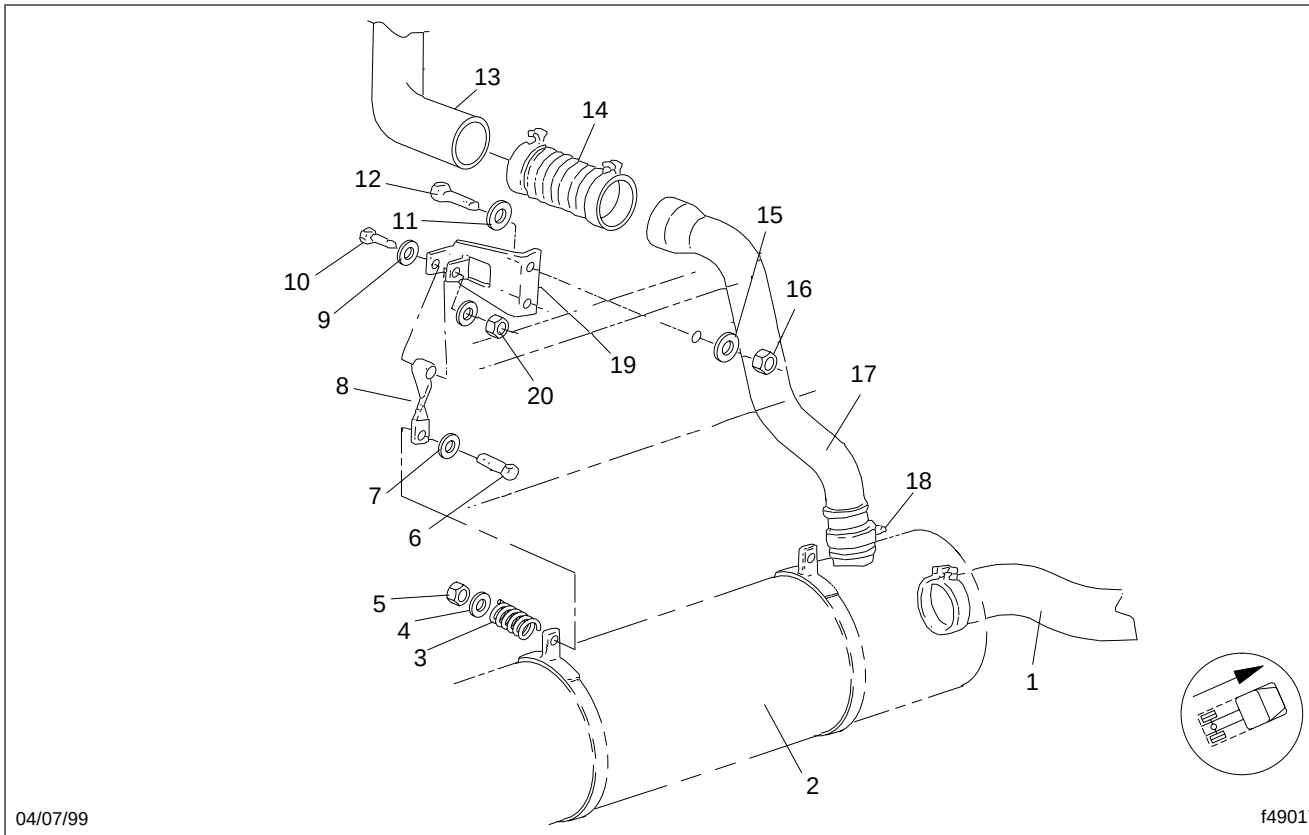
1. Flex Pipe
2. Muffler Outlet Pipe
3. Exhaust Clamp
4. Frame Bracket
5. Washer
6. Bolt (3/8–16 x 2.73)
7. Locknut (5/8 x 11)
8. Frame
9. Bolt (5/8–11 x 2.5)
10. Bolt (3/8–16 x 2.73
11. Spring
12. Muffler Support Bracket
13. Locknut (3/8 x 16)
14. Muffler Inlet Pipe
15. Clamp
16. Muffler
17. Bolt (3/8–16 x 1.25)
18. Heat Shield

Fig. 6, Transverse Horizontally-Mounted Muffler

Horizontal Frame-Mounted

(See Fig. 1)



1. Muffler Inlet Pipe
2. Muffler
3. Spring
4. Flatwasher
5. Locknut
6. Bolt
7. Flatwasher
8. Muffler Support Bracket
9. Flatwasher
10. Bolt
11. Flatwasher
12. Bolt
13. Exhaust Elbow
14. Flex Pipe
15. Hardened Washer
16. Locknut
17. Muffler Outlet Crossover Pipe
18. Clamp
19. Muffler Support Bracket
20. Locknut

Fig. 1, Horizontal Frame-Mounted Muffler

REMOVAL

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Loosen the muffler inlet clamp.
3. Disconnect the muffler inlet pipe.
4. Loosen the muffler outlet clamp.
5. Disconnect the muffler outlet crossover pipe.
6. Remove the front and rear muffler support clamps.
7. Remove the muffler.

Muffler Removal and Installation

INSTALLATION

1. Position the muffler and insert the muffler inlet pipe. Tighten the clamp 45 to 60 lbf·ft (61 to 81 N·m).
2. Insert the muffler into the rear muffler support bracket and tighten 26 lbf·ft (35 N·m).
3. Insert the muffler into the front muffler support bracket and tighten 26 lbf·ft (35 N·m).
4. Install the crossover to the muffler outlet (including the muffler elbow). Tighten the clamp 108 to 144 lbf·in (1220 to 1620 N·cm).
5. Remove the chocks from the tires.

Vertical Frame-Mounted

(See Fig. 2)

REMOVAL

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Loosen the muffler outlet-to-tailpipe clamp. Remove the exhaust tailpipe.
3. Remove the two-piece elbow support clamps and loosen the muffler-to-elbow clamp. Remove the elbow from the muffler inlet.
4. Loosen the lower muffler-to-frame support clamp.
5. Loosen the upper muffler-to-frame support clamp.

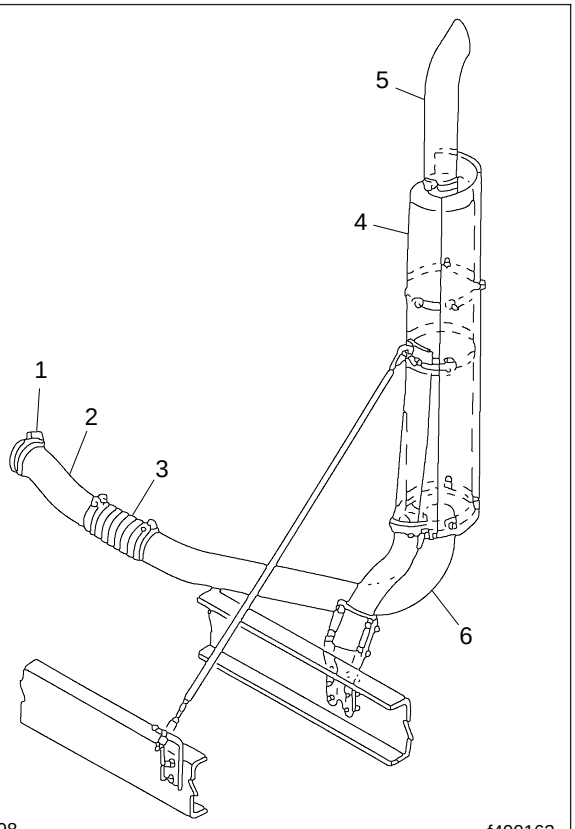
NOTE: The following step must be performed by two people.

6. With the help of an assistant, remove the muffler.

INSTALLATION

NOTE: The following step must be performed by two people.

1. With the help of an assistant, position the muffler and insert the elbow into the muffler inlet.
2. Install the muffler inlet-to-elbow clamp. Tighten the clamp 45 to 60 lbf·ft (61 to 81 N·m).
3. Install the upper muffler-to-frame support clamp and tighten 12 to 17 lbf·ft (17 to 23 N·m).

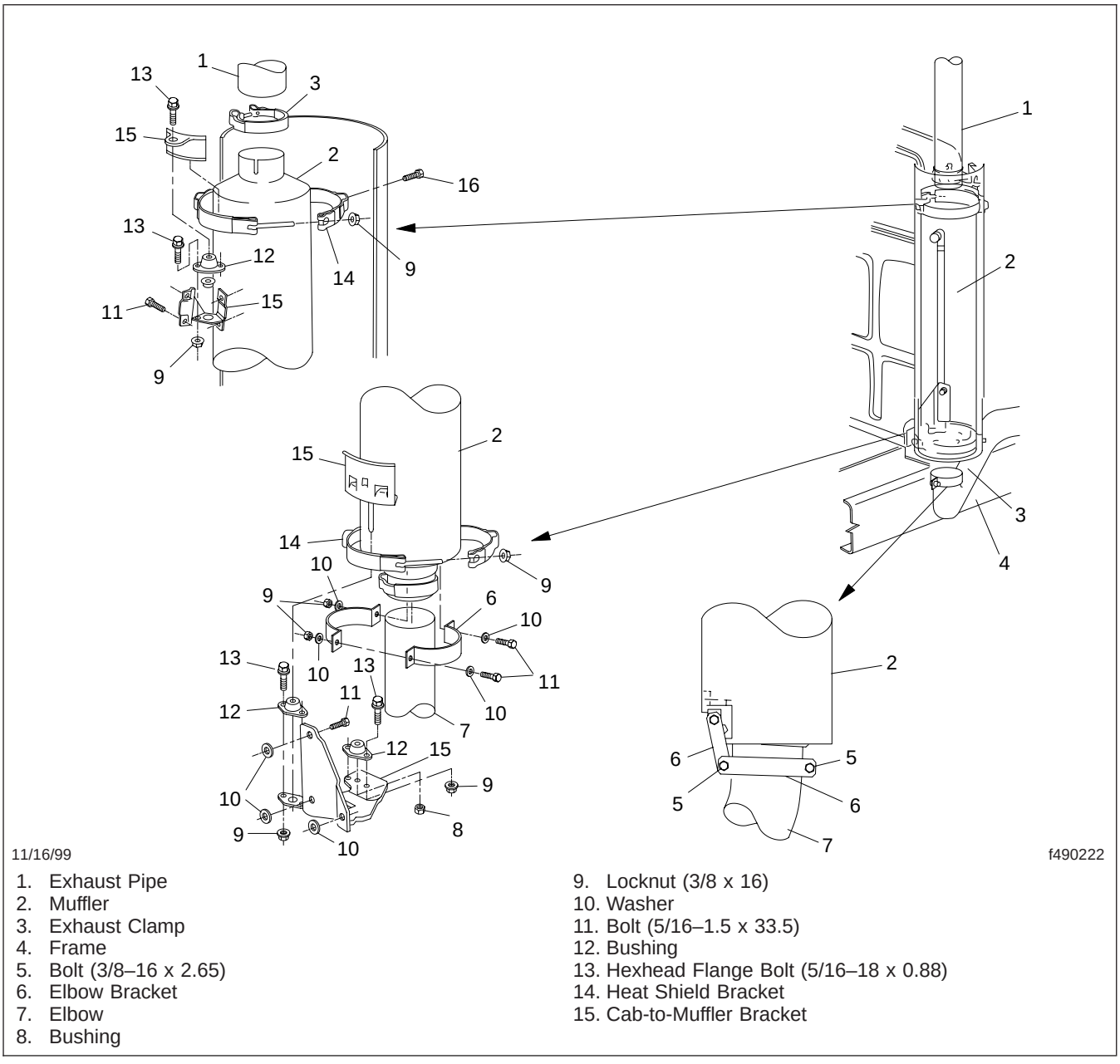


1. Clamp
2. Engine Outlet Exhaust Pipe
3. Flex Pipe
4. Muffler
5. Exhaust Tailpipe
6. Elbow

Fig. 2, Vertical Frame-Mounted Muffler

4. Install the lower muffler-to-frame support clamp and tighten 12 to 17 lbf·ft (17 to 23 N·m).
5. Insert the muffler tailpipe into the muffler outlet.
6. Install the muffler outlet-to-tailpipe clamp and tighten 12 to 17 lbf·ft (17 to 23 N·m).
7. Remove the chocks from the tires.

Vertical Cab-Mounted (See Fig. 3)



1. Exhaust Pipe
2. Muffler
3. Exhaust Clamp
4. Frame
5. Bolt (3/8–16 x 2.65)
6. Elbow Bracket
7. Elbow
8. Bushing
9. Locknut (3/8 x 16)
10. Washer
11. Bolt (5/16–1.5 x 33.5)
12. Bushing
13. Hexhead Flange Bolt (5/16–18 x 0.88)
14. Heat Shield Bracket
15. Cab-to-Muffler Bracket

Fig. 3, Vertical Cab-Mounted Muffler

REMOVAL

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Loosen the muffler outlet-to-tailpipe clamp. Remove the exhaust tailpipe.
3. Remove the two-piece elbow support clamps and loosen the muffler-to-elbow clamp. Remove the elbow from the muffler inlet.

Muffler Removal and Installation

4. Loosen the lower muffler-to-cab bracket clamp.
5. Loosen the upper muffler-to-cab bracket clamp.

NOTE: The following step must be performed by two people.

6. With the help of an assistant, remove the muffler.

INSTALLATION

NOTE: The following step must be performed by two people.

1. With the help of an assistant, position the muffler and insert the elbow into the muffler inlet.
2. Install the muffler inlet-to-elbow clamp. Tighten the clamp 45 to 60 lbf·ft (61 to 81 N·m).
3. Install the upper muffler-to-cab bracket clamp and tighten 12 to 17 lbf·ft (17 to 23 N·m).
4. Install the lower muffler-to-cab bracket clamp and tighten 12 to 17 lbf·ft (17 to 23 N·m).
5. Insert the muffler tailpipe into the muffler outlet.
6. Install the muffler outlet-to-tailpipe clamp and tighten 12 to 17 lbf·ft (17 to 23 N·m).
7. Remove the chocks from the tires.

Transverse Frame-Mounted

(See Fig. 4)

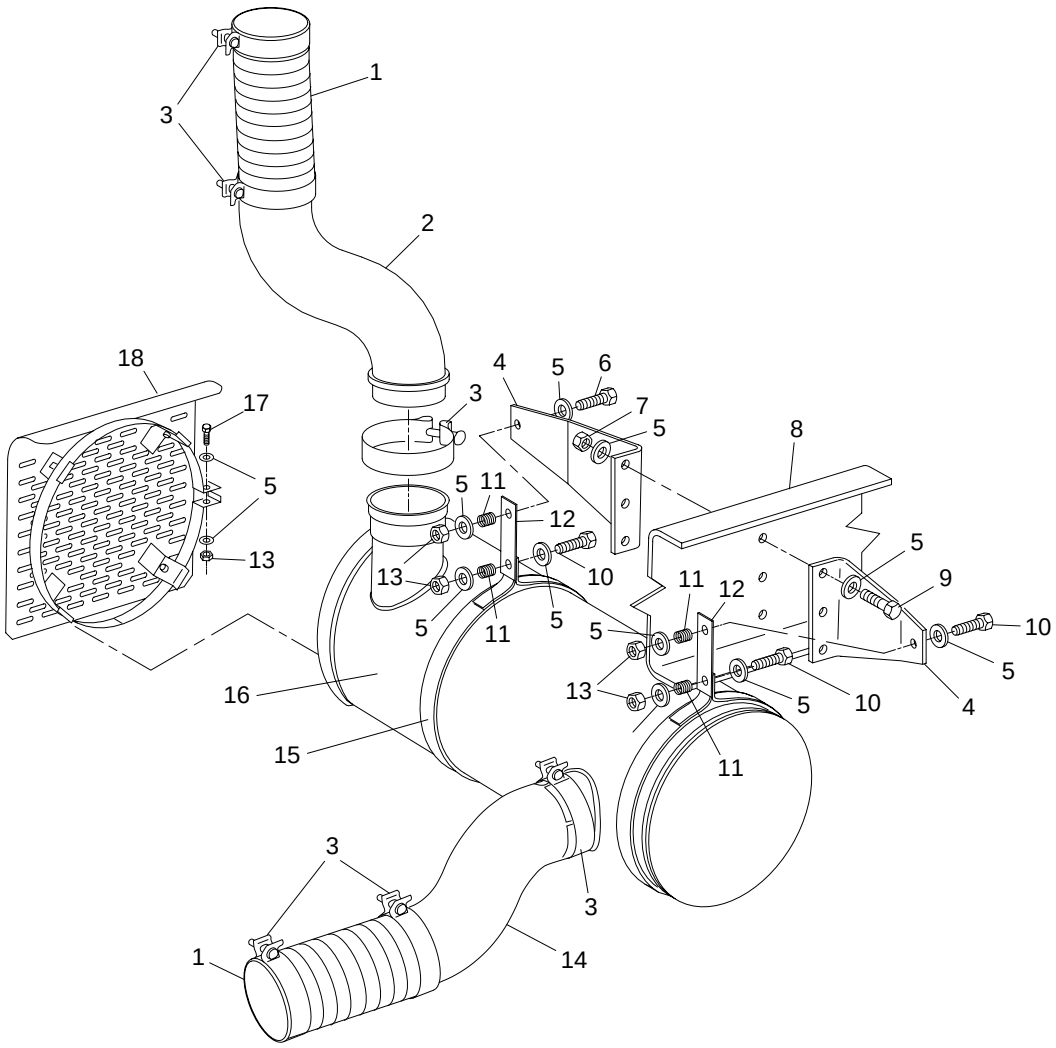
REMOVAL

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the muffler heat shield.
3. Loosen the muffler outlet pipe exhaust clamps.
4. Remove the muffler outlet pipe.
5. Loosen the muffler inlet pipe exhaust clamps.
6. Remove the muffler inlet pipe.
7. Remove the spring bolts from the muffler support brackets.
8. Remove the muffler.

INSTALLATION

1. Position the muffler.
2. Install the spring bolts in the muffler support brackets. Tighten 26 lbf·ft (35 N·m).
3. Install the muffler inlet pipe.
4. Tighten the muffler inlet pipe exhaust clamps 45 to 60 lbf·ft (61 to 81 N·m).
5. Install the muffler outlet pipe.
6. Tighten the muffler outlet pipe exhaust clamps 45 to 60 lbf·ft (61 to 81 N·m).
7. Install the muffler heat shield. Tighten the fasteners 26 lbf·ft (35 N·m).
8. Remove the chocks from the tires.

Muffler Removal and Installation



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1. Flex Pipe
2. Muffler Outlet Pipe
3. Exhaust Clamp
4. Frame Bracket
5. Washer
6. Bolt (3/8–16 x 2.73)
7. Locknut (5/8 x 11)
8. Frame
9. Bolt (5/8–11 x 2.5)
10. Bolt (3/8–16 x 2.73
11. Spring
12. Muffler Support Bracket
13. Locknut (3/8 x 16)
14. Muffler Inlet Pipe
15. Clamp
16. Muffler
17. Bolt (3/8–16 x 1.25)
18. Heat Shield

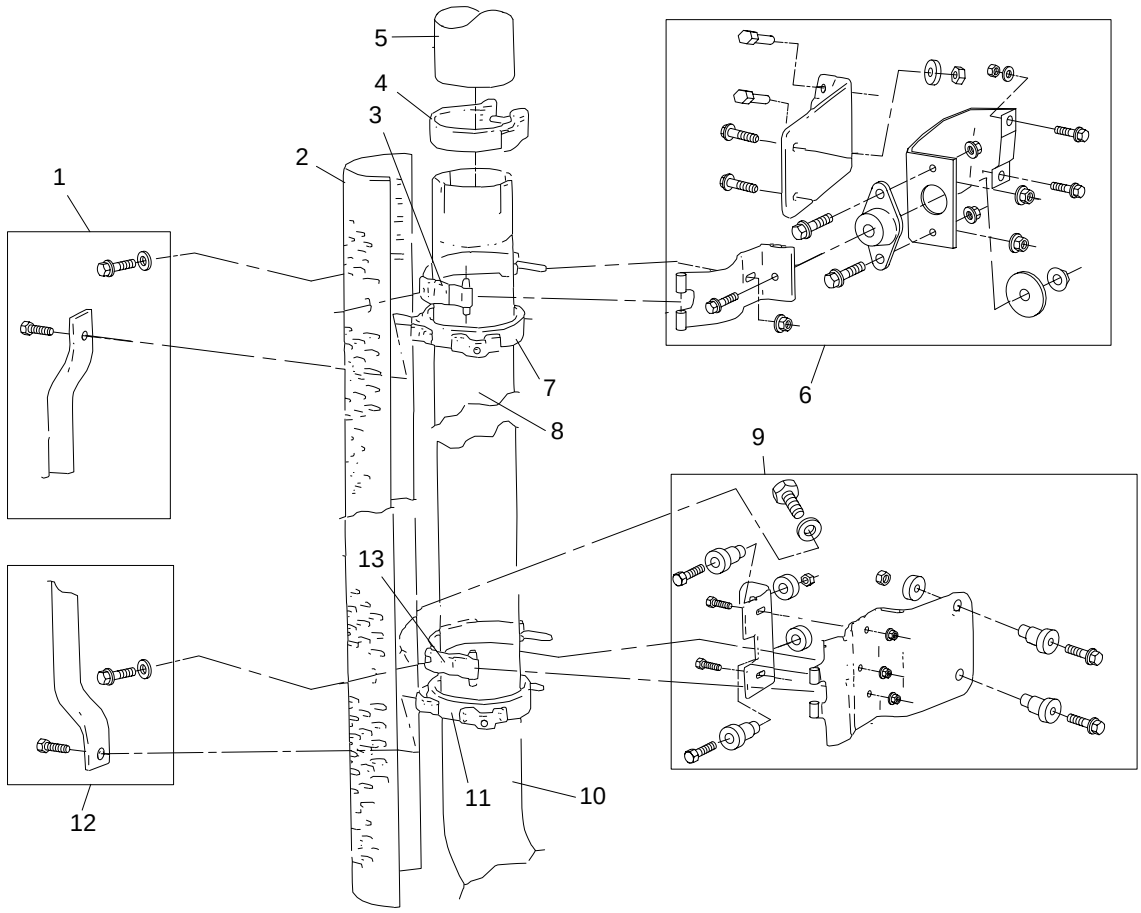
Fig. 4, Transverse Frame-Mounted Muffler

Exhaust Stack and Heat Shield Removal and Installation

Cab-Mounted

REMOVAL (See Fig. 1)

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.



1. Upper Grab Handle and Fasteners
2. Exhaust Shield
3. Upper Exhaust Stack Bracket
4. Clamp
5. Exhaust Stack Outlet Extension
6. Upper Cab-to-Exhaust Stack Bracket and Fasteners
7. Upper Exhaust Shield Clamp
8. Upper Exhaust Stack
9. Lower Cab-to-Exhaust Stack Bracket and Fasteners
10. Lower Exhaust Stack
11. Lower Exhaust Shield Clamp
12. Lower Grab Handle and Fasteners
13. Lower Exhaust Stack Bracket

Fig. 1, Cab-Mounted Exhaust Stack

NOTE: The exhaust stack has an upper and lower pipe. However, it is not necessary to separate them for this procedure.

2. Loosen the clamp between the flex pipe and the lower exhaust stack.
3. Disconnect the upper and lower clamps from the exhaust stack brackets.

Exhaust Stack and Heat Shield Removal and Installation

4. Remove the upper and lower cab-to-exhaust stack bracket nuts.

IMPORTANT: Be sure to support the exhaust stack while removing it from the cab.

5. With the help of an assistant, separate the exhaust stack from the flex pipe and remove the exhaust stack.
6. Remove the grab handle upper and lower retaining bolts and remove the grab handle.
7. Remove the heat shield retaining bolts and remove the heat shield.

INSTALLATION (See Fig. 1)

1. Install the heat shield and the retaining bolts. Tighten the bolts 12 to 17 lbf·ft (17 to 23 N·m).
2. Install the grab handle and the upper and lower retaining bolts. Tighten the bolts 12 to 17 lbf·ft (17 to 23 N·m).

IMPORTANT: Be sure to support the exhaust stack while installing it to the cab.

3. With the help of an assistant, connect the exhaust stack to the flex pipe.
4. Attach the upper and lower clamps to the exhaust stack brackets.
5. Install and tighten the upper and lower cab-to-exhaust stack bracket bolts 26 to 37 lbf·ft (35 to 50 N·m).
6. Tighten the flex pipe-to-exhaust stack clamp to 45 to 60 lbf·ft (61 to 81 N·m).
7. Remove the chocks from the tires.

Frame-Mounted

REMOVAL (See Fig. 2)

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Loosen the muffler lower outlet pipe band clamp.
3. Loosen the lower band clamp from the flex pipe.
4. Remove the muffler lower outlet pipe.
5. Loosen the upper band clamp from the flex pipe.
6. Remove the flex pipe.
7. Loosen the heat shield band clamps.

IMPORTANT: Be sure to support the exhaust stack while removing it from the support bracket.

8. With the help of an assistant, remove the exhaust stack.
9. If equipped, remove the grab handle upper and lower retaining bolts and remove the grab handle.
10. Remove the heat shield bolts.
11. Remove the heat shield from the exhaust stack.

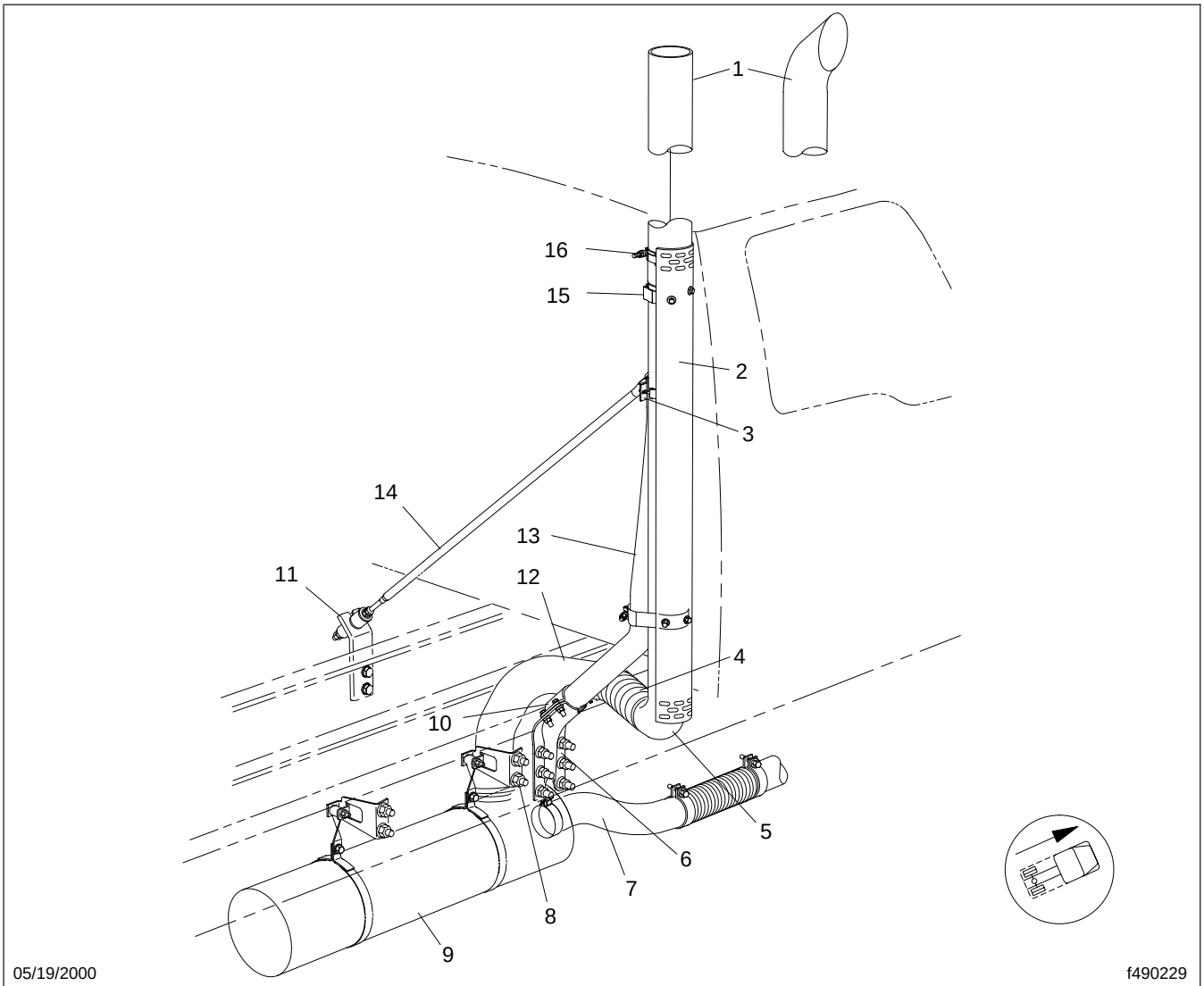
INSTALLATION (See Fig. 2)

1. Position the heat shield on the exhaust stack.
2. Install the heat shield bolts. Tighten 12 to 17 lbf·ft (17 to 23 N·m).
3. If equipped, install the grab handle and the upper and lower retaining bolts. Tighten the bolts 12 to 17 lbf·ft (17 to 23 N·m).

IMPORTANT: Be sure to support the exhaust stack while installing it on the support bracket.

4. With the help of an assistant, position the exhaust stack.
5. Install the heat shield band clamps. Tighten 45 to 60 lbf·ft (61 to 81 N·m).
6. Position the flex pipe.
7. Install the flex pipe upper band clamp. Tighten 45 to 60 lbf·ft (61 to 81 N·m).
8. Position the lower muffler outlet pipe.
9. Install the flex pipe lower band clamp. Tighten 45 to 60 lbf·ft (61 to 81 N·m).
10. Install the lower muffler outlet pipe band clamp. Tighten 45 to 60 lbf·ft (61 to 81 N·m).
11. Remove the chocks from the tires.

Exhaust Stack and Heat Shield Removal and Installation



1. Exhaust Stack
2. Heat Shield
3. Heat Shield Clamp
4. Flex Pipe
5. Muffler Upper Outlet Pipe
6. Exhaust Stack Support Bracket
7. Muffler Inlet Extension
8. Muffler Mounting Bracket and Fasteners
9. Muffler
10. Exhaust Stack Support Bracket Cap
11. Support Brace Bracket
12. Muffler Lower Outlet Pipe
13. Exhaust Stack Support
14. Exhaust Stack Support Brace
15. Heat Shield Clamp
16. Exhaust Stack Clamp

Fig. 2, Frame-Mounted Exhaust Stack

Exhaust Support Brackets Removal and Installation

Vertical Frame-Mounted Exhaust Stack

REMOVAL (See Fig. 1)

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the tires.
2. Remove the exhaust stack. For instructions, see **Subject 110**.
3. Loosen the nut and bolt holding the support brace to the exhaust stack support.
4. Loosen the nuts surrounding the bushings on the support brace bracket and remove the support brace.
5. Remove the nut and bolt from the support brace at the exhaust stack support and remove the support brace.
6. Loosen the four nuts, washers and bolts holding the exhaust stack support bracket cap to the exhaust stack support bracket.
7. Remove the exhaust stack support from the bracket.
8. Remove the mounting brackets from the frame rail.

INSTALLATION (See Fig. 1)

1. Install the mounting brackets on the frame rail. Tighten 128 lbf·ft (173 N·m).
2. Install the exhaust stack support into the bracket.
3. Tighten the four nuts, washers and bolts holding the exhaust stack support bracket cap to the exhaust stack support bracket 26 lbf·ft (35 N·m).
4. Position the support brace and loosely install the nut and bolt in the support brace at the exhaust stack support.
5. Position the support brace in the support brace bracket and tighten the nuts surrounding the bushings on the support brace bracket 35 to 48 lbf·ft (47 to 65 lbf·ft).
6. Tighten the nut and bolt holding the support brace to the exhaust stack support 12 to 17 lbf·ft (17 to 23 N·m).
7. Install the exhaust stack. For instructions, see **Subject 110**.
8. Remove the chocks from the tires.

Vertical Cab-Mounted Muffler

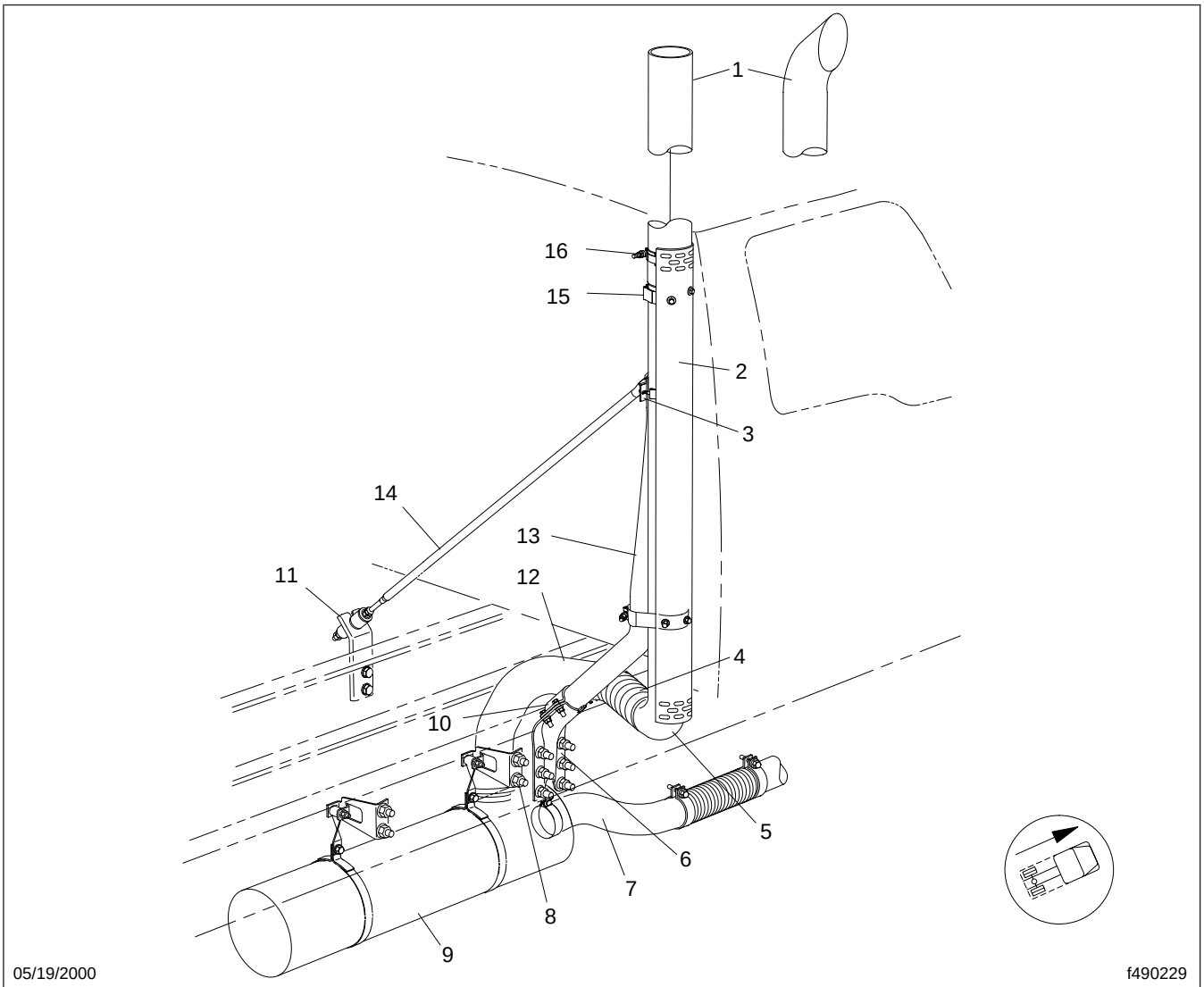
REMOVAL (See Fig. 2)

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the tires.
2. Remove the muffler. For instructions, see **Subject 100**.
3. Remove the three mounting bolts and remove the lower bracket.
4. Remove the four mounting bolts and remove the upper bracket.

INSTALLATION (See Fig. 2)

1. Apply sealant around all bolt holes on the cab.
2. Position the upper bracket and install the four mounting bolts. Tighten 12 to 17 lbf·ft (17 to 23 N·m).
3. Position the lower bracket and install the three mounting bolts. Tighten 12 to 17 lbf·ft (17 to 23 N·m).
4. Install the muffler. For instructions, see **Subject 100**.
5. Remove the chocks from the tires.

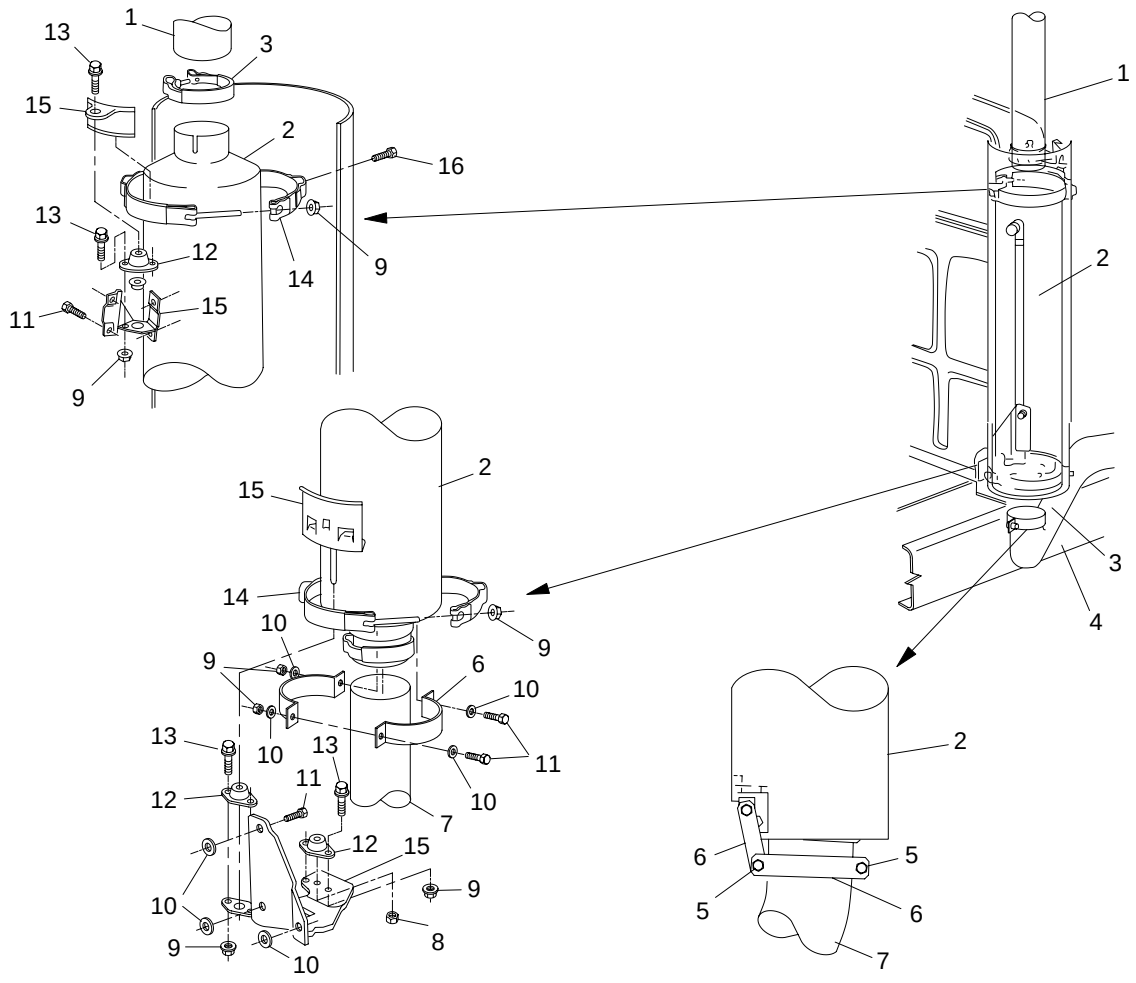
Exhaust Support Brackets Removal and Installation



1. Exhaust Stack
2. Heat Shield
3. Heat Shield Clamp
4. Flex Pipe
5. Upper Muffler Outlet Pipe
6. Exhaust Stack Support Bracket
7. Muffler Inlet Extension
8. Muffler Mounting Bracket and Fasteners
9. Muffler
10. Exhaust Stack Support Bracket Cap
11. Support Brace Bracket
12. Lower Muffler Outlet Pipe
13. Exhaust Stack Support
14. Exhaust Stack Support Brace
15. Heat Shield Clamp
16. Exhaust Stack Clamp

Fig. 1, Vertical Frame-Mounted Exhaust Stack

Exhaust Support Brackets Removal and Installation



1. Exhaust Pipe
2. Muffler
3. Exhaust Clamp
4. Frame
5. Bolt (3/8–16 x 2.65)
6. Elbow Bracket
7. Elbow
8. Bushing
9. Locknut (3/8 x 16)
10. Washer
11. Bolt (5/16–1.5 x 33.5)
12. Bushing
13. Hexhead Flange Bolt (5/16–18 x 0.88)
14. Heat Shield Bracket
15. Cab-to-Muffler Bracket

Fig. 2, Vertical Cab-Mounted Muffler

Troubleshooting

INSPECTION AND VERIFICATION

Exhaust system performance complaints such as excessive back-pressure are usually noticeable by their effect on engine performance. Other worn or damaged components can have the same effect on engine performance and be characterized by the same symptoms or complaints. Refer to the applicable engine manufacturer's service literature when attempting to diagnose this type of problem.

Exhaust Leakage or Noise

Noise can be caused by exhaust leaks. Inspect the exhaust system for the following:

- holes, cracks or gaps
- loose or missing clamps
- black soot residue (indicates leakage) on the exhaust pipes or the muffler

COMPONENT TESTS

Exhaust Back-Pressure Test—Full Load

NOTE: The chassis dynamometer or "Full Load" test is the preferred method for testing exhaust back pressure. However, if a chassis dynamometer is not available, the "No Load" test is the only other authorized method for testing the exhaust back-pressure.

NOTE: Follow the setup procedures supplied by the chassis dynamometer manufacturer.

1. Install the pressure gauge in the test port. The test port is located on the muffler inlet pipe, either near the turbocharger or the muffler assembly.
2. Start and run the engine until the temperature gauge indicates normal operating temperature.
3. Select a transmission gear range where acceleration to full throttle can be accomplished safely.
4. Accelerate to full throttle and peak engine power.
5. When the engine reaches maximum rpm and load, record the maximum exhaust back-pressure reading.
6. The reading should be less than 6 inHg (20 kPa). If the reading is higher than this, replace the muffler assembly.

   If the reading is acceptable, then the muffler assembly is not plugged. Refer to the applicable engine manufacturer's service literature for engine related components.

Exhaust Back-Pressure Test—No Load

⚠ WARNING

Make sure the vehicle parking brake is set, the wheels are blocked, the transmission is in NEUTRAL, and the area around the vehicle is clear before performing this test. Failure to take all necessary precautions could result in personal injury due to unexpected vehicle movement.

1. Install the pressure gauge in the pressure test port.
2. Start and run the engine until the temperature gauge indicates normal operating temperature.

NOTE: Engine rpm will exceed the rated rpm range by 10 to 17 percent under full throttle, no-load conditions. This is normal and no cause for concern.

NOTE: If the engine is unable to reach maximum rpm rating plus 10 percent, it will be necessary to repair this problem before the back-pressure test can be performed.

3. Accelerate to full throttle. Record the maximum engine rpm and the maximum exhaust back-pressure reading.
4. The maximum back-pressure reading under a no load condition is 3 inHg (10.2 kPa). If the reading exceeds this, replace the muffler assembly.

   If the reading is acceptable, then the muffler assembly is not plugged. Refer to the applicable engine manufacturer's service literature for engine related components.

Troubleshooting

Problem—Exhaust Fumes in the Cab

Problem—Exhaust Fumes in the Cab	
Possible Cause	**Remedy**
Leaking gaskets.	Replace the gaskets.
Loose mounting bolts.	Tighten the mounting bolts. Check the gaskets for damage.
Leaking exhaust system.	Repair or replace worn or damaged exhaust components.

Problem—Insufficient Exhaust Back-Pressure

Problem—Insufficient Exhaust Back-Pressure	
Possible Cause	**Remedy**
Leaking exhaust system.	Repair or replace damaged exhaust components.
Insufficient air supply.	Check for air leaks or low system air pressure.
Damaged exhaust brake actuating cylinder.	Repair or replace the actuating cylinder or seal.
Leaking gasket.	Replace the gasket.

Problem—Excessive Exhaust Back-Pressure

Problem—Excessive Exhaust Back-Pressure	
Possible Cause	**Remedy**
Plugged catalyst converter/muffler.	Perform the exhaust back-pressure test. Refer to "Component Tests" in this subject.
Restricted exhaust system.	Check the exhaust system for damage or plugged pipes.

Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Turbocharger Outlet Pipe Clamps	7–9 (9–12)
Exhaust Pipe Clamps	45–60 (61–81)
Heat Shield Clamps	12–17 (17–23)
Exhaust System-to-Frame Rail U-Bolt Nuts, 1/2–20	72 (98)
3/8–16 Hexnut	26 (35)
5/8–11 Hexnut	128 (173)
5/16 Fasteners	12–17 (17–23)

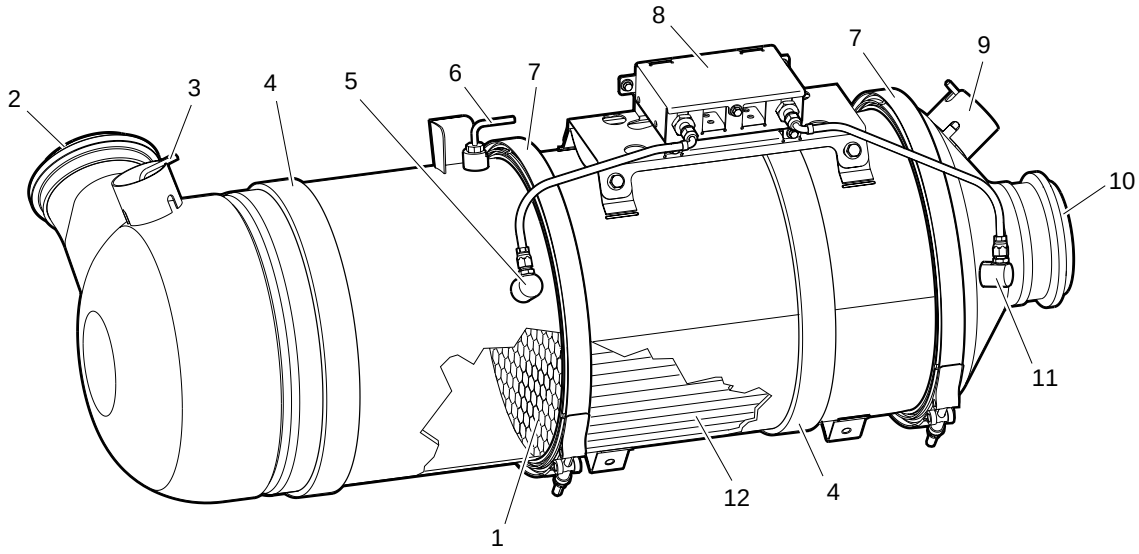
Table 1, Torque Specifications

General Information

The aftertreatment system (ATS), introduced to meet the requirements of the EPA07 emission control regulations, includes all the piping and equipment between the turbocharger outlet and the tip of the exhaust pipe. It resembles the exhaust system on pre-EPA07 vehicles, but includes an aftertreatment device (ATD) instead of a muffler (see **Fig. 1**), and other equipment. Monitoring and operation of the ATS is controlled by an electronic control module (ECM).

ways chassis-mounted, but can be mounted either vertically or horizontally. ATS exhaust piping is stainless steel.

Inside the ATD, the exhaust first passes through the diesel oxidation catalyst (DOC) where combustion gases are chemically broken down to water and carbon dioxide, then through the (DPF), where solid particles are trapped. The trapped particles are almost completely vaporized in the DPF in regeneration, sometimes shortened to the term, "regen." The soot from engine oil additives which cannot be vaporized is burned to ash and held in the DPF until it eventu-



1. Diesel Particulate Filter (DPF) Ceramic Honeycomb Substrate Openings
2. Marmon Fitting at Inlet from Turbocharger
3. Diesel Oxidation Catalyst (DOC) Intake Temperature Sensor
4. ATD Mounting Band
5. DPF Intake Pressure Sensor
6. DOC Outlet Temperature Sensor (connection to sensor housing not shown)
7. DPF V-Band Mounting Clamps
8. Sensor Housing
9. DPF Outlet Temperature Sensor (connection to sensor housing not shown)
10. Exhaust Outlet Marmon Fitting
11. DPF Outlet Pressure Sensor
12. DPF Substrate Tubes

Fig. 1, ATD Components (typical)

EPA07 emissions regulations limit NOx to just over 1 gram per brake horsepower hour (g/bhp-hr) and particulate matter cannot exceed 0.01 g/bhp-hr. EPA07 engines require ultralow sulphur diesel (ULSD) fuel, for low emissions and long life of the diesel particulate filter (DPF), a honeycomb soot filter inside the ATD.

Engine manufacturers use different methods and equipment to reduce emissions from their engines, but an ATD is used on all of them. The ATD is al-

ally builds up, and the DPF must be removed and physically cleaned.

IMPORTANT: To minimize soot buildup on the DPF, low-ash oil is necessary for maximum service between physical cleanings. Only low-ash oil should be used in EPA07 engines.

NOTE: Sterling documentation deals only with removal and installation of the components of the ATS. Refer to the engine manufacturer's ser-

vice literature for all testing, disassembly, cleaning, and repair of the ATD and other components.

IMPORTANT: The ATS is part of an integrated engine and emissions management system, controlled by the ECM. Follow the engine manufacturer's procedures, and use the correct equipment when diagnosing or working on any part of the ATS.

Regeneration

There are two types of regeneration; passive and active.

Passive regeneration happens whenever the ATD internal temperature is 572°F (300°C) or higher. This happens during normal loaded vehicle operation, and exhaust gas temperature is no higher than normal. Under load and at highway speeds, passive regeneration may be all that is necessary to keep the DPF clear. But running light loads, or at low speeds, does not generate enough heat in the ATD for passive regeneration, and soot builds up in the DPF.

As soot builds up in the DPF, it creates back pressure and decreases engine efficiency. So at intervals determined by the ECM, which keeps track of measurements such as engine hours, fuel consumed, and mileage, the ATS raises the temperature inside the ATD to burn the built-up soot to ash. This reduces the back pressure and allows the DPF to continue operating efficiently for tens of thousands of miles.

During active regeneration, engine rpm rise to fast-idle speed and extra fuel is injected into the ATD to raise its interior temperature very high, over 1112°F (600°C), and turn the trapped soot to harmless ash. There are two types of active regeneration; at-speed and parked.

- When conditions permit, the ECM automatically initiates at-speed regeneration. The exact conditions for regeneration vary, according to the engine manufacturer's design. Generally, it can happen only when the vehicle speed is above 7.5 mph, and active regeneration stops when the vehicle slows to 5 mph or below.
- Parked regeneration is initiated by a driver or technician when the vehicle is safely parked with the exhaust outlet well away from any flammable substance, a specific sequence of procedures is followed, and the driver pushes the regeneration button on the dashboard. The parked regeneration sequence varies according to engine and vehicle configuration, but it must be exactly followed or regeneration cannot happen. Follow the exact sequence prescribed for the vehicle, according to the engine manufacturer's literature.

EPA07 Aftertreatment Device Removal and Installation

Removal

These instructions are generalized, because vehicle configurations vary widely. The basic procedures apply to all aftertreatment systems. For service and repair beyond removal and installation, refer to the engine manufacturer's service literature.

NOTE: For test or service procedures on components of the ATS, consult the engine manufacturer's service literature.

NOTICE

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

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

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

The aftertreatment device (ATD) is constructed so that its exterior operating temperature is comparable to that of a standard muffler, but during active regeneration, when a fuel mist is injected to raise its temperature and destroy soot deposits, its interior (see **Fig. 1**) and the outlet become hot enough to melt or ignite many common materials.

⚠ WARNING

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

To avoid potentially serious burns or material damage:

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

1. Set the parking brake and chock the tires.

NOTE: Never attempt to start the vehicle with the ATD removed or with the ATD sensors disconnected, unless the engine manufacturer's documentation allows it for a diagnostic procedure.

2. Disconnect the connections at the sensor housing and the diesel oxidation catalyst (DOC) inlet temperature sensor. See **Fig. 1**.
3. Mark the Marmon fitting joints and mounting bracket orientation to the ATD, so that it can be installed exactly as it was removed. See **Fig. 2**.

NOTE: There are guide pins (see **Fig. 3**) to position the ATD during vehicle manufacture, but they are designed to break off if they are stressed. The most important thing about ATD mounting is that the other ATS components, particularly the bellows, must align correctly.

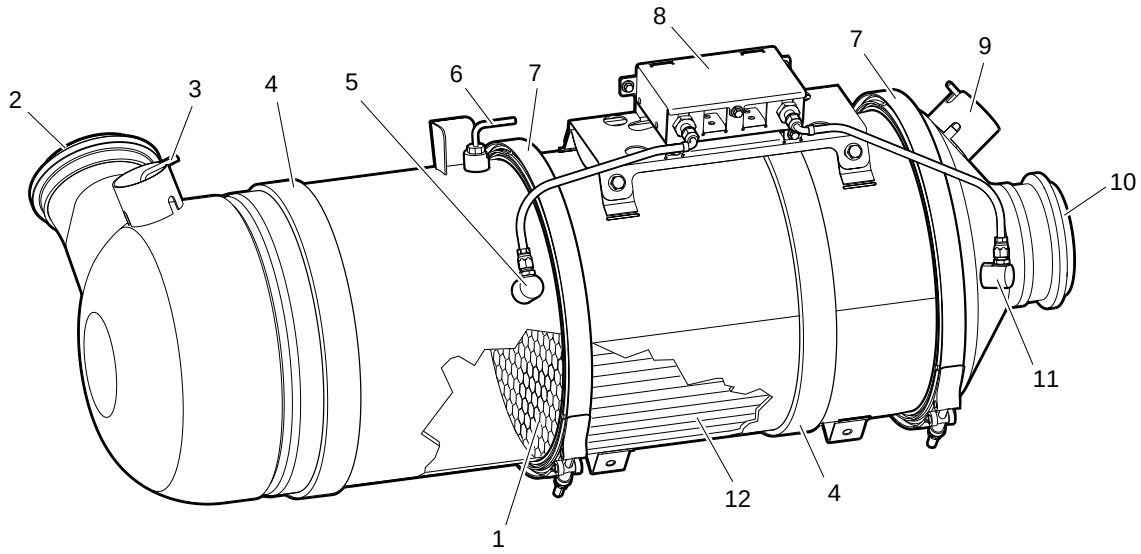
4. If the ATD is horizontally mounted, raise the ATD-handling device into place against it, so that the ATD is supported securely. If the ATD is vertically mounted, attach a shop crane or similar device to the lifting ears and take up the slack so that the lifting device is beginning to take the weight of the ATD.
5. The exhaust pipe may require support, such as a rope sling, to support it when the ATD is removed. If such support is required, install it now.

NOTICE

Be careful not to stress or twist the bellows as the ATD is manipulated. The bellows is not designed to support weight or withstand undue stress and can easily be damaged, requiring expensive replacement.

6. Remove the clamps from the Marmon fittings at the ATD inlet and outlet.
7. Remove the two mounting bands that hold the ATD to its mounting brackets, so that the ATD is held by the ATD handling device.

EPA07 Aftertreatment Device Removal and Installation



1. Diesel Particulate Filter (DPF) Front End Honeycomb
2. Marmon Fitting at Inlet from Turbocharger
3. Diesel Oxidation Catalyst (DOC) Intake Temperature Sensor
4. ATD Mounting Band
5. DPF Intake Pressure Sensor
6. DOC Outlet Temperature Sensor (connection to sensor housing not shown)
7. DPF V-Band Mounting Clamp
8. Sensor Housing
9. DPF Outlet Temperature Sensor (connection to sensor housing not shown)
10. Exhaust Outlet Marmon Fitting
11. DPF Outlet Pressure Sensor
12. DPF Ceramic Substrate

Fig. 1, Typical ATD

NOTE: It may be necessary to raise the vehicle, or remove heat shields or body panels, to remove the ATD.

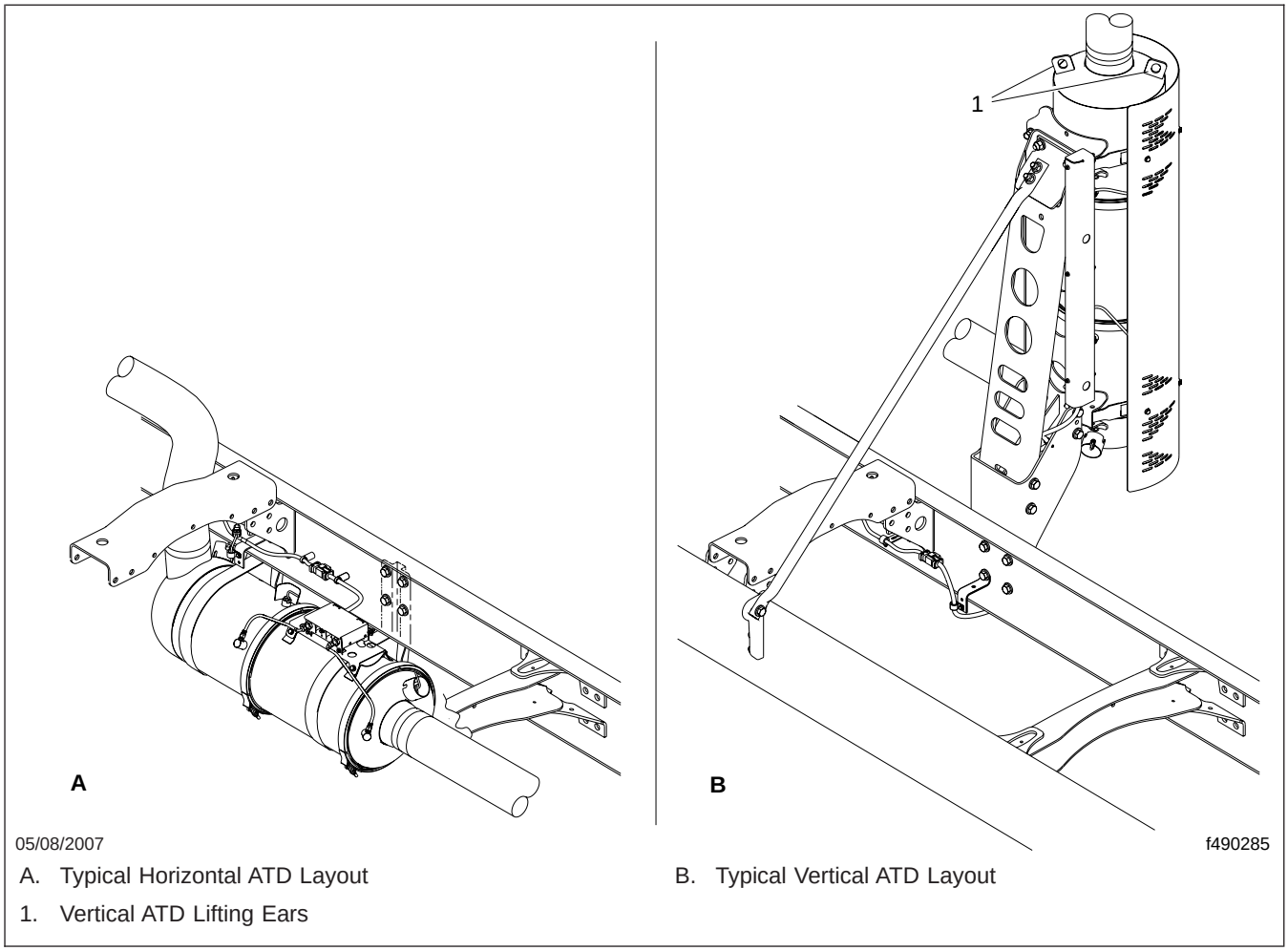
8. Move the ATD handling device slightly, so that the ATD positioning pin (see **Fig. 4**) clears its hole in the mounting bracket. Carefully remove the ATD from the vehicle.

NOTE: ATD component service procedures, such as cleaning the DPF or servicing the sensors, are documented in the engine manufacturers' service literature.

Installation

1. Use the ATD handling device to move the ATD into position, so the inlet and exhaust align with the inlet and exhaust piping. Be sure the ATD positioning pin engages its hole in the ATD mounting bracket, or that the positioning marks align.
2. Install the ATD mounting bands, but do not tighten them yet.
3. Position the V-band clamps on the Marmon fittings and tighten them to the value shown in **Table 1**.
4. Tighten the ATD mounting bands to the value shown in **Table 1**.
5. Connect the harness to the sensor housing and the front temperature sensor.
6. Remove the ATD handling device.
7. If a support was fastened around the exhaust pipe, remove it.
8. Operate the vehicle and check for leaks.

EPA07 Aftertreatment Device Removal and Installation



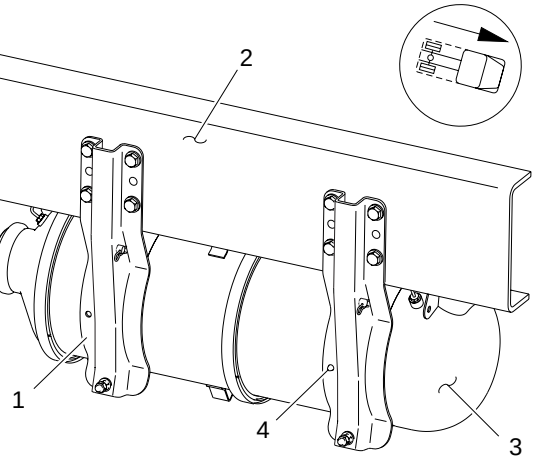
A. Typical Horizontal ATD Layout

B. Typical Vertical ATD Layout

1. Vertical ATD Lifting Ears

Fig. 2, ATD Mounting Options

EPA07 Aftertreatment Device Removal and Installation



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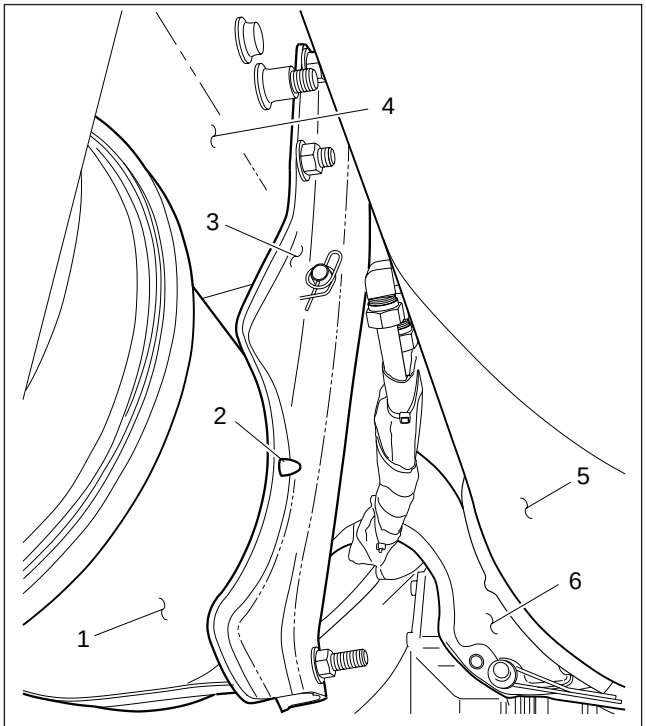
1. ATD Mounting Bracket
2. Chassis Frame Rail
3. ATD Inlet End
4. ATD Positioning Pin

Fig. 3, ATD Mounting on Frame Rail

ATD Torque Values	
Fitting	**Torque: lbf·ft (N·m)**
Mounting Bands	Initial: 15 (20) Final: 30 (41)
Temperature Sensor Nuts	26–29 (35–39)
Pressure Line Tube Nuts	11–13 (15–17)
Pressure Sensor Jam Nuts	15–18 (20–25)
Marmon V-Band Clamps	12–13 (16–17)
Compression Fittings	15–18 (20–25)
Bellows Torco Clamps	Target: 41 (56) Range: 35–48 (48–64)

Table 1, ATD Torque Values



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1. ATD
2. ATD Positioning Pin
3. ATD Mounting Bracket
4. Chassis Frame Rail
5. Fuel Tank
6. Fuel Tank Mounting Bracket

Fig. 4, ATD Mounting Bracket

EPA07 Aftertreatment System Bellows Replacement

Replacement

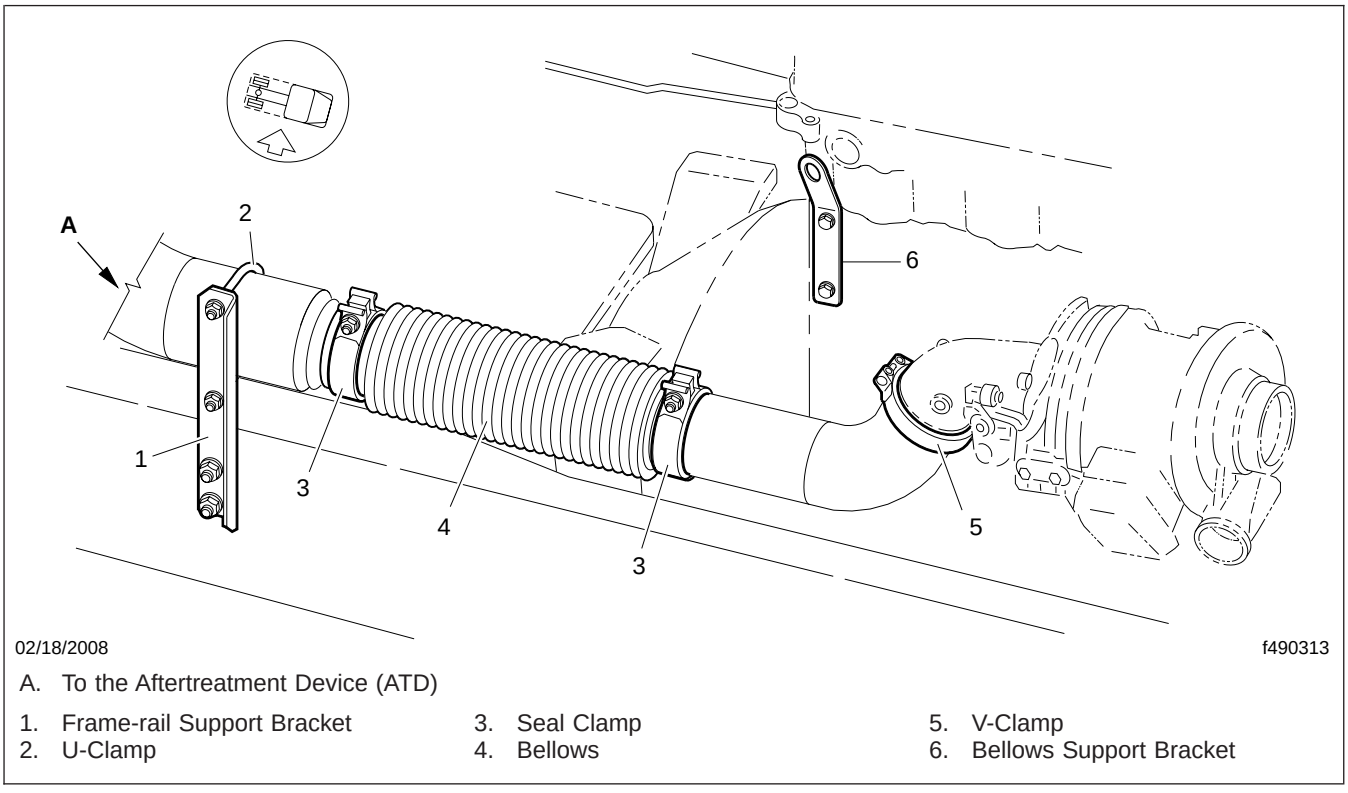
1. Open the hood.
2. Open the tool box under the passenger-side door, and remove the cover.
3. Remove the right quarter fender and mud flap. For instructions, see **Group 88**.
4. Remove the V-clamp (**Fig. 1**, Item 5) that holds the turbo outlet pipe to the turbocharger.
5. Remove the U-clamp that holds the aftertreatment device (ATD) inlet pipe to the support bracket on the frame rail (**Fig. 1**, Item 2).
6. Remove the clamp that holds the exhaust pipe to the front of the ATD, then disconnect the exhaust pipe from the ATD.
7. Remove the bellows and exhaust pipes as a unit from under the vehicle. If the vehicle is equipped with side fairings, remove the parts from the rear of the vehicle.
8. Place the assembly on a work bench. Loosen and spread the seal clamps on the ends of the bellows. Pry the ends of the bellows off the exhaust pipes, being careful not to damage the exhaust pipe ends. If it is not possible to remove the bellows this way, proceed as follows:

⚠ WARNING

Always wear a face shield and other appropriate protection when using a cutting wheel.

The cut edges of the bellows are extremely sharp, and can cause serious injury. Wear appropriate protective gear, including heavy gloves and a face shield, when removing the bellows from the exhaust pipes.

9. If you cannot remove the bellows by prying, use a cutoff wheel to cut through each end of the bellows between the exhaust pipe ends. Be careful not to cut the exhaust pipes. Discard the center section of the bellows when it is cut loose.



A. To the Aftertreatment Device (ATD)

1. Frame-rail Support Bracket
2. U-Clamp
3. Seal Clamp
4. Bellows
5. V-Clamp
6. Bellows Support Bracket

Fig. 1, Bellows Installation

EPA07 Aftertreatment System Bellows Replacement

10. Carefully remove the bellows ends and clamps from the exhaust pipes, either by prying them off, or by driving them off with a soft drift. Be careful not to damage the exhaust pipes.

IMPORTANT: Take the following measurements *before* installing the bellows.

The main section of the ATD inlet pipe is a larger diameter than the turbo outlet pipe. Make sure you measure at the **end** of the pipe, where it inserts into the bellows. The two measurements should be identical. If they are not, loosen the U-clamp nuts that hold the ATD inlet pipe to the frame-rail support bracket, and move the pipe up or down as needed.

NOTICE

The ends of the ATD inlet pipe and the turbo outlet pipe must be in exact vertical and horizontal alignment before installing the new bellows. If they are not aligned the bellows will be twisted, and will fail after a short time.

11. Attach the turbo outlet pipe to the turbocharger, then to the bellows support bracket. Tighten the clamps enough to hold the pipe in place.
12. Attach the ATD inlet pipe to the ATD and the frame-rail support bracket. Tighten the clamps enough to hold the pipes in place.
13. Using a ruler or tape measure, measure the vertical distance between the end of the ATD inlet pipe and the frame rail. See **Fig. 2**. Do the same for the end of the turbo outlet pipe. The two measurements must be the same. If the measurements are different, loosen the U-clamp nuts on the frame-rail support bracket, and raise or lower the ATD inlet pipe as needed. Tighten the U-clamp nuts enough to hold the pipe in place.
14. Using a ruler (or a T-square) and a tape measure, measure the distance between each pipe end and the frame rail. See **Fig. 3**. If these two measurements are different, do one or more of the following adjustments (see **Fig. 4**):
    - Check that the U-clamp on the bellows support bracket is installed correctly, and is not crooked.
    - Rotate the turbo outlet pipe at the turbocharger.
    - Support the ATD with a suitable jack, then loosen the ATD straps and rotate the ATD.
    - Rotate the ATD inlet pipe at the Marmon flange on the ATD.
15. With the two pipe ends in horizontal and vertical alignment and the bellows not installed, measure the distance between them. See **Fig. 5**.

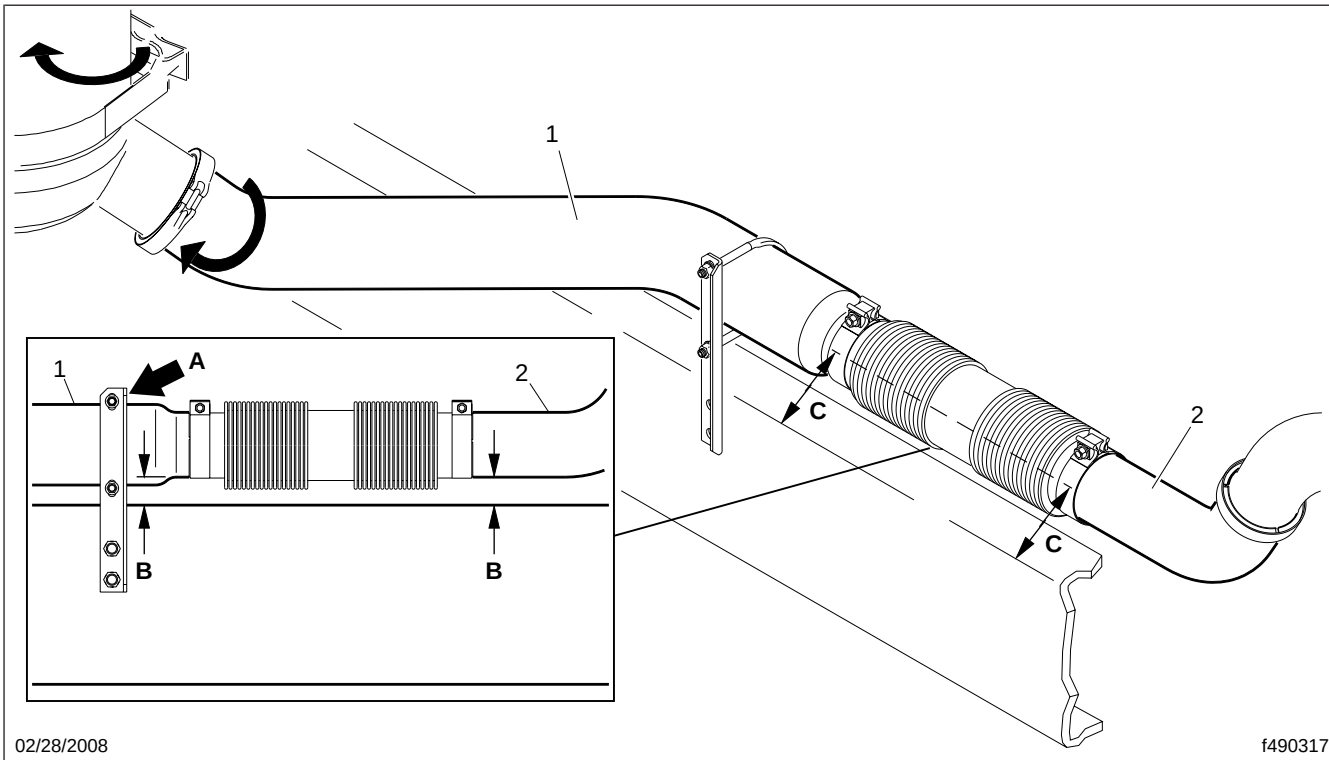
    The distance between the pipe ends is to be at least 14 inches (35.5 cm), but not more than 14-3/8 inches (36.5 cm).

    If the distance is less than the above, remove the turbo outlet pipe and the ATD inlet pipe, and cut off an equal amount from each pipe end, as needed; otherwise, go to the next step. Make sure you remove all burrs from the cut ends of the pipes.

IMPORTANT: If they were loosened, do not tighten the ATD mounting straps until the U-clamp nuts on the frame-rail support bracket are tightened to their final torque. To do otherwise will affect the alignment of the exhaust pipes.

16. When the horizontal and vertical alignment is the same for both exhaust pipes and the distances between the pipe ends is correct, tighten the U-clamp nuts on the frame-rail support bracket that holds the ATD inlet pipe in place. See **Subject 100** for torque values.
17. Tighten the V-clamp that holds the inlet pipe to the ATD. See **Subject 100** for torque values.
18. If applicable, tighten the mounting straps on the ATD, then remove the jack.
19. Remove the turbo outlet pipe from the turbocharger.
20. Remove any dirt or soot from the outer surface of the exhaust pipe ends to ease the installation of the new bellows.
21. Install the new bellows on the ATD inlet pipe, with the clamp nuts on top and facing outboard (**Fig. 2**).
22. Insert the end of the turbo outlet pipe into the bellows, then connect the pipe to the turbocharger and to the new bellows support bracket. See **Subject 100** for torque values.
23. Tighten the bellows seal clamps; see **Subject 100** for torque values.

EPA07 Aftertreatment System Bellows Replacement



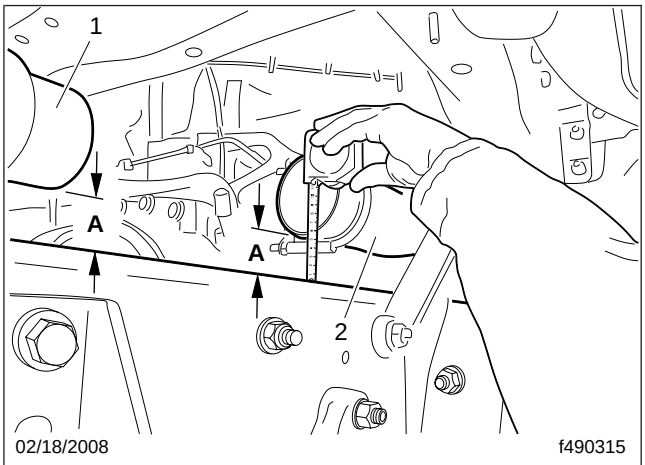
A. Up-and-down adjustment to be done at this bracket.
B. Vertical measurements to be the same.
C. Horizontal (in-and-out) measurements to be the same.

1. ATD Inlet Pipe
2. Turbo Outlet Pipe (support bracket not shown)

Fig. 2, Rotation and Adjustment Areas for Exhaust Pipe alignment (vertical ATD installation shown)

24. Start the engine and check for leaks. Shut down the engine, and tighten any clamps as needed.

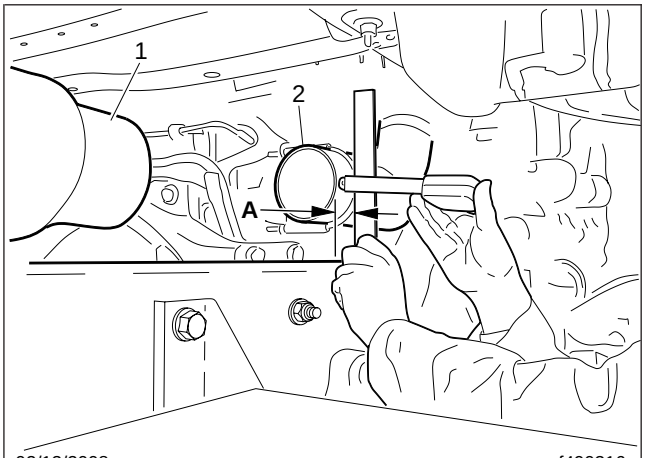
EPA07 Aftertreatment System Bellows Replacement



A. This distance must be the same at both exhaust-pipe ends.

1. ATD Inlet Pipe 2. Turbo Outlet Pipe

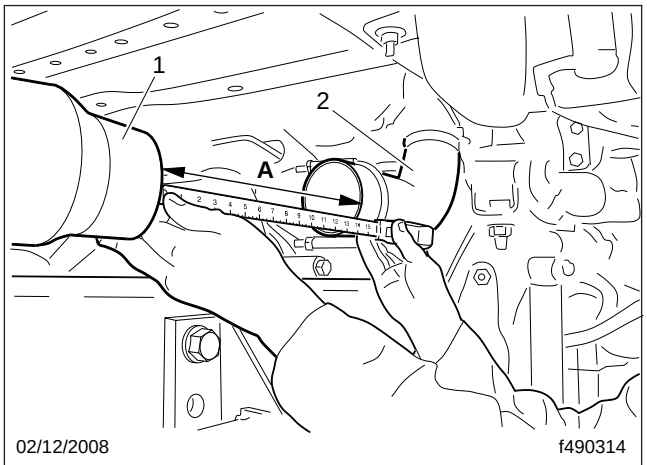
Fig. 3, Measuring the Vertical Distance



A. This distance must be the same at both exhaust-pipe ends.

1. ATD Inlet Pipe 2. Turbo Outlet Pipe

Fig. 4, Measuring the Horizontal Distance



A. This distance should be a minimum of 14 inches (35.5 cm) and a maximum of 14-3/8 inches (36.5 cm).

1. ATD Inlet Pipe 2. Turbo Outlet Pipe

Fig. 5, Measuring the Distance Between Pipe Ends

General Information

WARNING

Do not use the cruise control in heavy traffic or when road conditions are wet or slippery. Improper use of cruise control can result in loss of vehicle control and possible property damage or personal injury.

The cruise control system consists of the following components:

- control switch (ON/OFF, see **Fig. 1**)
- speed control switch (SET/CST and RSM/ACCL, see **Fig. 2**)
- clutch pedal switch
- brake cutoff switch
- engine electronic control module (ECM)

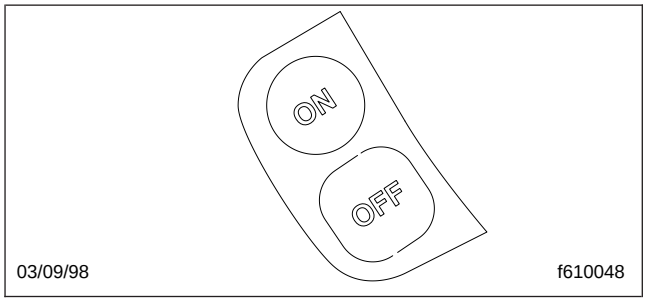


Fig. 1, Control Switch

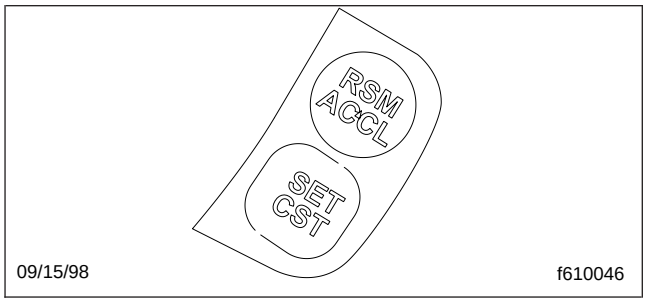


Fig. 2, Speed Control Switch

The ECM (see **Fig. 3** for Caterpillar, **Fig. 4** for Cummins, or **Fig. 5** for DDC) stores the last set speed until either the cruise control system is turned off or the engine is turned off. The ECM is also programmed with the minimum and maximum operational speeds. These settings do not erase when the system is turned off.

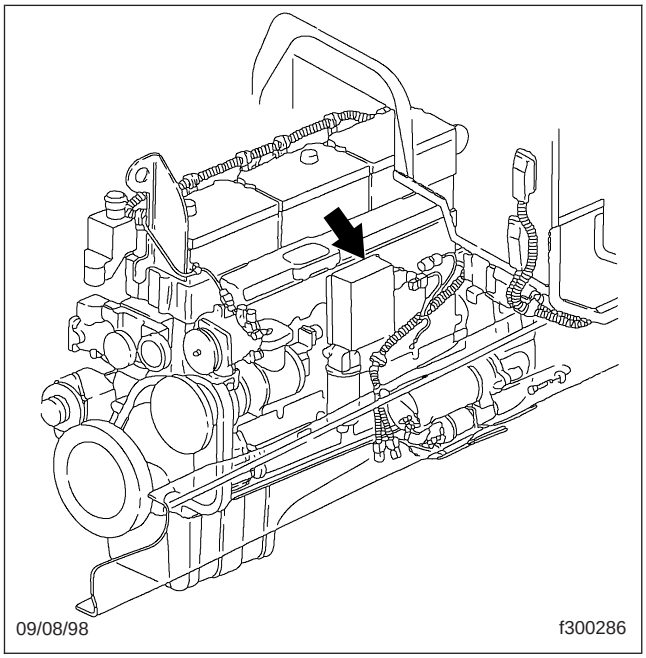


Fig. 3, Caterpillar Engine ECM

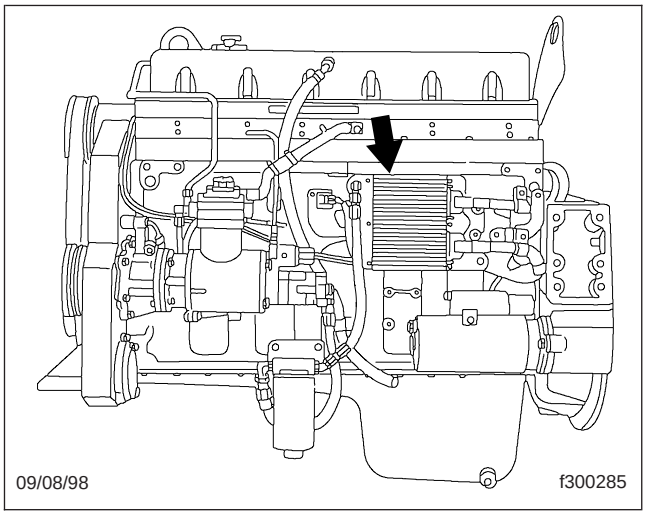


Fig. 4, Cummins Engine ECM

The accelerator pedal can be used to exceed the last set speed if the maximum engine governed speed is greater than the cruise control maximum speed. Releasing the accelerator pedal returns the vehicle to the cruise control set speed.

General Information

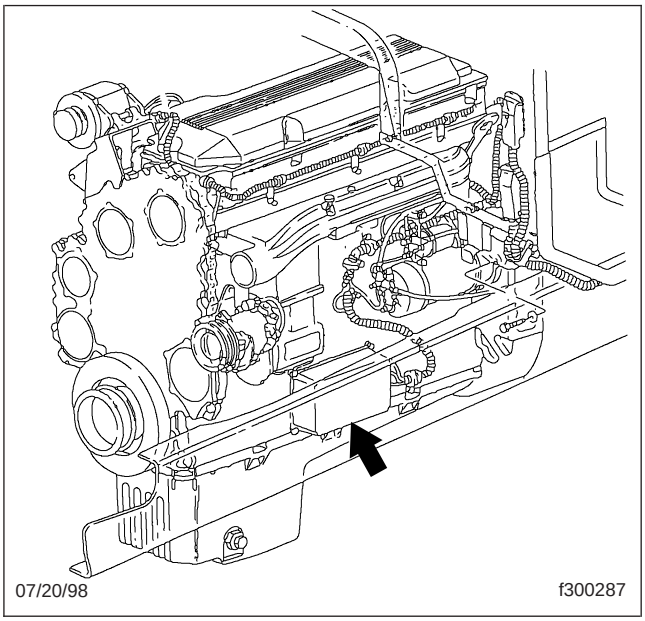


Fig. 5, DDC Engine ECM

When the vehicle has reached 30 mph (48 km/h) perform the following steps to activate the cruise control system:

1. Press the ON button on the control switch.
2. Accelerate to the desired road speed.
3. Press the SET/CST button on the speed control switch.

NOTE: If the SET/CST button is pressed for more than one second, the vehicle will continue to increase in speed until either the SET/CST switch is released or the vehicle reaches the maximum programmed speed.

To disengage the cruise control, perform one of the following steps:

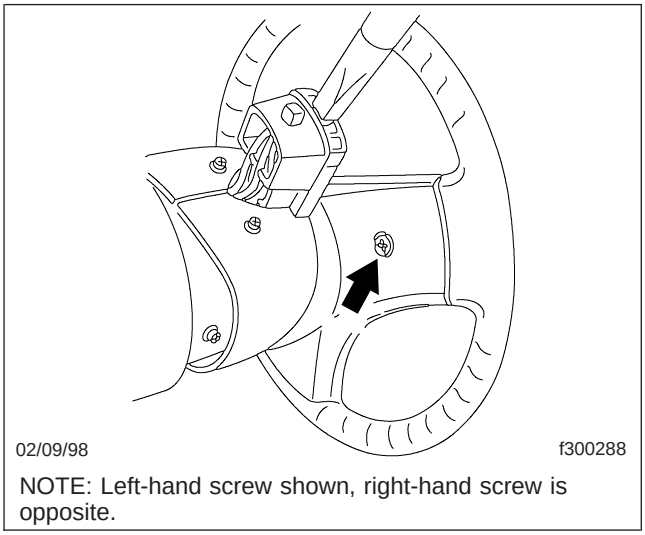
1. Press the OFF button on the control switch, or
2. Press the clutch pedal, or
3. Press the brake pedal.

Control Switches Removal and Installation

NOTE: The following procedures should be used to replace either the control switch (ON/OFF) or the speed control switch (RSM/ACCL and SET/CST).

Removal

1. Remove the horn pad. See **Fig. 1**.



NOTE: Left-hand screw shown, right-hand screw is opposite.

Fig. 1, Horn Pad Screw

1.1 Remove the two screws retaining the horn pad to the steering wheel.

1.2 Lift the horn pad away from the steering wheel.

2. Disconnect the horn pad wiring retainers. See **Fig. 2**.
3. Disconnect the wiring connector. See **Fig. 3**.
4. Disconnect the electrical connector. See **Fig. 4**.
5. Press the lock tabs, and remove the switch from the horn pad. See **Fig. 5**.

Installation

1. Install the switch into the horn pad. See **Fig. 5**.
2. Connect the electrical connector. See **Fig. 4**.
3. Connect the wiring connector. See **Fig. 3**.
4. Connect the wiring to the horn pad. See **Fig. 2**.

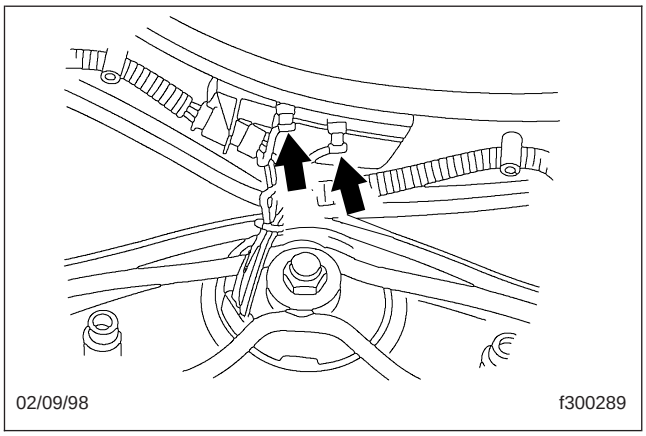


Fig. 2, Horn Pad Wiring Retainers

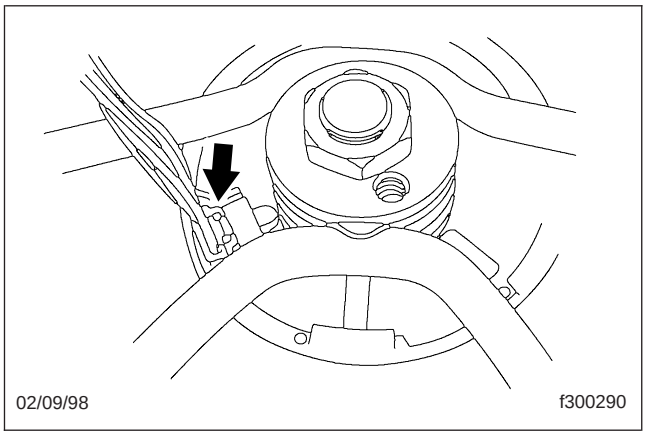


Fig. 3, Horn Pad Wiring Electrical Connector

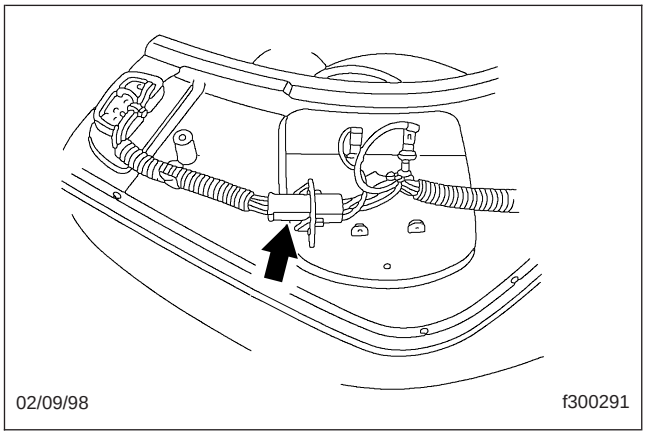


Fig. 4, Electrical Connector

5. Install the horn pad.

Control Switches Removal and Installation

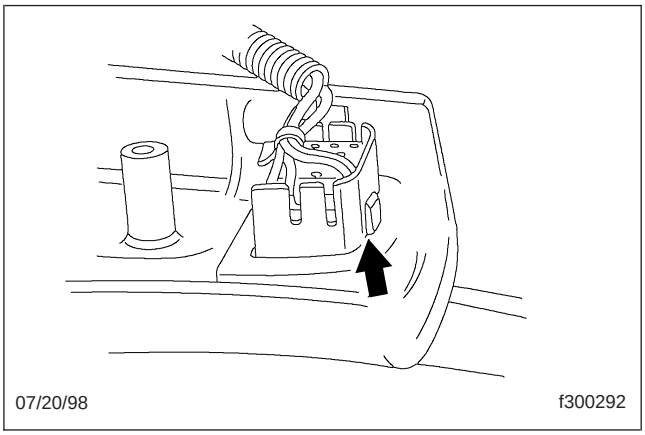


Fig. 5, Switch

5.1 Position the horn pad onto the steering wheel.

5.2 Install the two screws retaining the horn pad to the steering wheel. See **Fig. 1**.

Clutch Pedal Position Switch Removal and Installation

Removal

1. Remove the lower left-hand instrument panel finish panel. See **Fig. 1**.

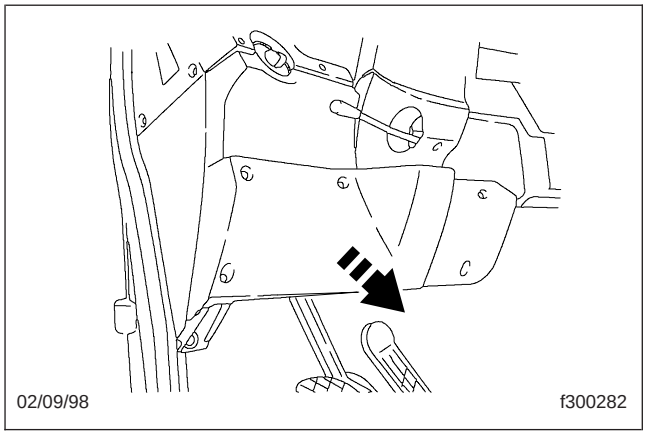


Fig. 1, Instrument Panel Finish Panel

NOTE: Slide the wiper module forward to disengage it from the mounting bracket.

2. Disconnect the wiring, and remove the windshield wiper control module. See **Fig. 2**.

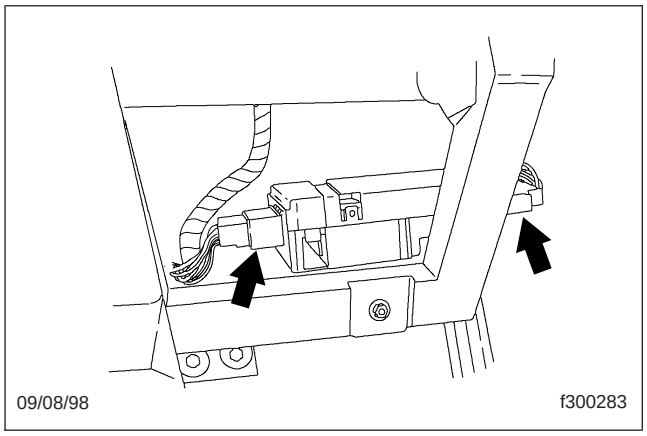


Fig. 2, Windshield Wiper Control Module Wiring

3. Remove the screw and the clutch pedal position switch. See **Fig. 3**.

Installation

1. Install the clutch pedal position switch and the screw. See **Fig. 3**.

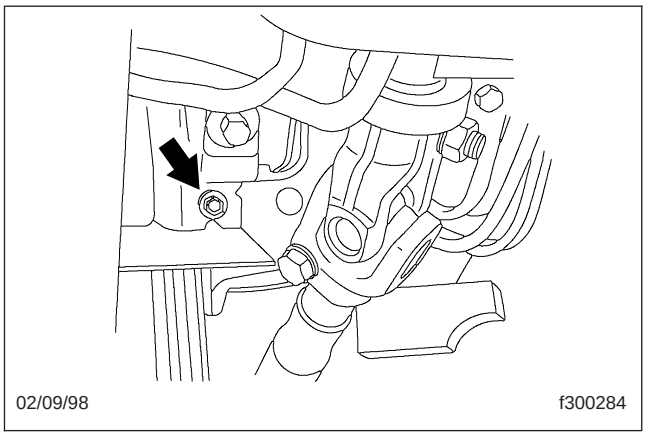


Fig. 3, Remove Clutch Pedal Position Switch Screw

2. Connect the windshield wiper control module wiring. See **Fig. 2**.
3. Slide the windshield wiper control module onto the mounting bracket until it locks in place.
4. Install the lower left-hand instrument panel finish panel. See **Fig. 1**.

Brake Cutoff Switch Removal and Installation

Removal

1. Set the parking brake and chock the wheels.
2. Exhaust air from the air brake system.
3. Remove the screws and the air manifold cover.
4. Disconnect the wiring at the brake switch.
5. Remove the brake switch. See **Fig. 1**.

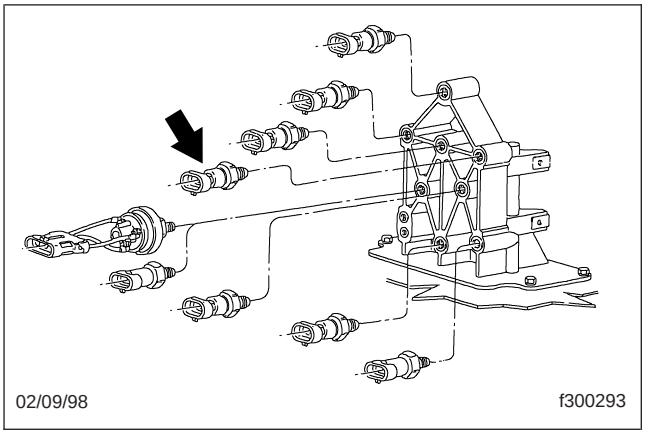


Fig. 1, Brake Switch

Installation

1. Install the brake switch. See **Fig. 1**.
2. Connect the wiring at the brake switch.
3. Install the air manifold cover and the screws.
4. Remove the wheel chocks.

Troubleshooting

Inspection and Verification

NOTE: Diagnosis and testing procedures for Sterling-installed components are covered in this section. For all other components, see the appropriate engine manufacturer's service literature.

1. Verify the customer's concern by operating the speed control system to duplicate the condition.
2. Inspect to determine if one of the following mechanical or electrical concerns apply (see **Table 1**):

Inspection and Verification Chart	
Mechanical	**Electrical**
Inspect and verify that system switches are not damaged.	Verify proper horn operation
	Verify stoplamp operation
	Check Fuse 22
	Inspect and verify that: • connections are complete with no loose wires or terminals • wiring is not broken, shorted or corroded • wiring is not misrouted

Table 1, Inspection and Verification Chart

3. If inspection reveals obvious concerns, correct the concerns before proceeding.

Troubleshooting

Problem—Cruise Control is Inoperative

Problem—Cruise Control is Inoperative	
Possible Cause	**Remedy**
Function switches	Check for battery feed to the clockspring connector. Disconnect the clockspring to harness connector. Turn the ignition switch to the "On" position. Measure the voltage at connector C250, pin 1, Circuit 976 (BK/GN). If the voltage is not greater than 10 volts, repair the open in Circuit 976 (BK/GN). Test the system for normal operation. If the voltage is greater than 10 volts, check "On/Off" switch function. Connect the clockspring-to-harness connector. Connect the positive lead of an ohmmeter to connector C250, pin 591 (BK/O). Connect the ohmmeter negative lead to a clean chassis ground. Press the speed control "On" switch. If the ohmmeter does not show continuity when the "On" switch is pressed, check continuity at the clutch switch. Connect the brake cutoff switch connector. Disconnect the clutch switch connector. Measure the resistance across the clutch switch terminals. If the resistance is less than 5 ohms, replace the switch. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of clockspring Circuit 591 (BK/O). Measure the resistance between connector C250, terminal 5, Circuit 591 (BK/O) and the seventh terminal in the clockspring connector. If the resistance is more than 5 ohms, replace the clockspring. Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of clockspring Circuit 937 (BK). Measure the resistance between connector C250, terminal 1, Circuit 937 (BK) and the seventh terminal in the clockspring connector. If the resistance is more than 5 ohms, replace the clockspring. Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of clockspring Circuit 57 (BK). Measure the resistance between connector C250, terminal 8, Circuit 860 (P/W) and the fifth terminal in the clockspring connector. If the resistance is more than 5 ohms, replace the clockspring. Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of clockspring Circuit 976 (BK/GN). Disconnect the clockspring-to-horn pad. Turn the steering wheel as necessary to position the wheels in the straight-ahead position. Remove the steering wheel. Measure the resistance between connector C250, terminal 1, Circuit 976 (BK/GN) and the sixth terminal in the clockspring connector. If the resistance is less than 5 ohms, replace the on/off switch. Test the system for normal operation. If the resistance is more than 5 ohms, replace the clockspring. Test the system for normal operation. If the ohmmeter shows continuity when the "On" switch is pressed check Circuit 57 (BK) for continuity. Disconnect the clockspring-to-harness connector. Connect the positive lead of an ohmmeter to connector C250, pin 6, Circuit 57. Connect the ohmmeter negative lead to a clean chassis ground. If the ohmmeter does not show continuity, repair the open in Circuit 57 (BK). Test the system for normal operation.
Clutch switch	
Brake cutoff switch wiring	
Clockspring	

Problem—Cruise Control is Inoperative	
Possible Cause	**Remedy**
Function switches	If the ohmmeter does show continuity, check Circuit 591 (BK/O) for continuity. Disconnect the ECM connector. Measure the resistance between connector C250, pin 5, Circuit 591 (BK/O) and one of the following connectors: • Cummins electronic engine—ECM connector C170, pin 2 • Caterpillar electronic engine—ECM connector C110, pin 20 • Caterpillar 3126 engine—ECM connector C118, pin 59 • DDC engine—ECM connector C136, pin F2 • Cummins Encore engine—ECM connector C118, pin 14 If the resistance is more than 5 ohms repair the open in Circuit 591 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check sensor common at clockspring connector—Circuit 937 (BK). Measure the resistance between connector C250, pin 9, Circuit 937 (BK) and ground. If the resistance is more than 5 ohms, repair the open in Circuit 937 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check continuity of Circuit 937 (BK). Measure the resistance between connector C250, terminal 9, Circuit 937 (BK) and one of the following connectors: • Cummins electronic engine—ECM connector C170, pin 10 • Caterpillar electronic engine—ECM connector C110, pin 27 • Caterpillar 3126 engine—ECM connector C118, pin 10 • DDC engine—Ground • Cummins Encore engine—Ground If the resistance is more than 5 ohms, repair the open in Circuit 937 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check continuity at the brake cutoff switch. Disconnect the brake cutoff switch. Measure the resistance across the brake cutoff switch terminals. If the resistance is less than 5 ohms replace the switch. Test the system for normal operation.
Clutch switch	
Brake cutoff switch wiring	
Clockspring	

Troubleshooting

Problem—Cruise Control is Inoperative	
Possible Cause	**Remedy**
Function switches Clutch switch Brake cutoff switch wiring Clockspring	If the resistance is more than 5 ohms, check continuity at the clutch switch. Connect the brake cutoff switch connector. Disconnect the clutch switch connector. Measure the resistance across the clutch switch terminals. If the resistance is less than 5 ohms, replace the switch. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of clockspring Circuit 591 (BK/O). Measure the resistance between connector C250, terminal 5, Circuit 591 (BK/O) and the seventh terminal in the clockspring connector. If the resistance is more than 5 ohms, replace the clockspring. Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of clockspring Circuit 937 (BK). Measure the resistance between connector C250, terminal 1, Circuit 937 (BK) and the seventh terminal in the clockspring connector. If the resistance is more than 5 ohms, replace the clockspring. Test the system for normal operation. If the resistance is less than 5 ohms check the continuity of clockspring Circuit 57 (BK). Measure the resistance between connector C250, terminal 8, Circuit 860 (P/W) and the fifth terminal in the clockspring connector. If the resistance is more than 5 ohms, replace the clockspring. Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of clockspring Circuit 976 (Y). Disconnect the clockspring-to-horn pad. Turn the steering wheel as necessary to position the wheels in the straight-ahead position. Remove the steering wheel. Measure the resistance between connector C250, terminal 1, Circuit 976 (BK/GN) and the sixth terminal in the clockspring connector. If the resistance is less than 5 ohms, replace the on/off switch. Test the system for normal operation. If the resistance is more than 5 ohms, replace the clockspring. Test the system for normal operation.

Problem—Resume/Accel is Inoperative

Problem—Resume/Accel is Inoperative	
Possible Cause	**Remedy**
Function switches	Check sensor common at clockspring connector—Circuit 937 (BK). Measure the resistance between connector C250, Pin 9, Circuit 937 (BK) and ground. If the resistance is more than 5 ohms, repair the open in Circuit 937 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check continuity of Circuit 937 (BK). Disconnect the ECM connector. Measure the resistance between connector C250, terminal 9, Circuit 937 (BK) and one of the following connectors: • Cummins electronic engine—ECM connector C170, pin 10 • Caterpillar electronic engine—ECM connector C110, pin 27 • Caterpillar 3126 engine—ECM connector C118, pin 10 • DDC engine—Ground • Cummins Encore engine—Ground If the resistance is more than 5 ohms, repair the open in Circuit 937 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of clockspring Circuit 862 (W/BL). Turn the steering wheel as necessary to position the wheels in the straight-ahead position. Remove the steering wheel. Measure the resistance between connector C250, terminal 7, Circuit 862 (W/BL) and the first terminal in the clockspring connector. If the resistance is more than 5 ohms, repair the clockspring. Test the system for normal operation. If the resistance is less than 5 ohms, check continuity of Circuit 862 (W/BL). Disconnect the ECM harness connector. Measure the resistance between connector C250, terminal 7, Circuit 862 (W/BL) and one of the following connectors: • Cummins electronic engine—ECM connector C170, pin 22 • Caterpillar electronic engine—ECM connector C110, pin 15 • Caterpillar 3126 engine—ECM connector C118, pin 44 • DDC engine—ECM connector C136, pin 63 • Cummins Encore engine—ECM connector C118, pin 17 If the resistance is less than 5 ohms, see the engine manufacturer's service literature for test procedures related to the ECM. If the resistance is more than 5 ohms, repair the open in Circuit 862 (W/BL). Test the system for normal operation.
Wiring	
Clockspring	

Troubleshooting

Problem—Set/Coast is Inoperative

Problem—Set/Coast is Inoperative	
Possible Cause	**Remedy**
Function switches	Check sensor common at clockspring connector—Circuit 937 (BK). Measure the resistance between connector C250, pin 9, Circuit 937 (BK) and ground. If the resistance is more than 5 ohms, repair the open in Circuit 937 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check continuity of Circuit 937 (BK). Measure the resistance between connector C250, terminal 9, Circuit 937 (BK) and one of the following connectors: • Cummins electronic engine—ECM connector C170, pin 10 • Caterpillar electronic engine—ECM connector C110, pin 27 • Caterpillar 3126 engine—ECM connector C118, pin 10 • DDC engine—Ground • Cummins Encore engine—Ground If the resistance is more than 5 ohms, repair the open in Circuit 937 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of clockspring Circuit 862 (P/W). Turn the steering wheel as necessary to position the wheels in the straight-ahead position. Remove the steering wheel. Measure the resistance between connector C250, terminal 8, Circuit 862 (P/W) and the third terminal in the clockspring connector. If the resistance is more than 5 ohms, replace the clockspring. Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 860 (P/W) for an open. Disconnect the ECM harness connector. Measure the resistance between connector C250, terminal 8, Circuit 860 (P/W) and one of the following connectors: • Cummins electronic engine—ECM connector C170, pin 12 • Caterpillar electronic engine—ECM connector C110, pin 25 • Caterpillar 3126/3406 engine—ECM connector C118, pin 35/25 • DDC engine—ECM connector C136, pin J1 • Cummins Encore engine—ECM connector C118, pin 13 If the resistance is less than 5 ohms, see the engine manufacturer's service literature for test procedures related to the ECM. If the resistance is more than 5 ohms, repair the open in Circuit 860 (P/W). Test the system for normal operation.
Wiring	
Clockspring	

Specifications

See **Fig. 1** for a full view of the cruise control wiring with a Detroit Diesel engine.

See **Fig. 2** for a full view of the cruise control wiring with a Cummins engine.

See **Fig. 3** for a full view of the cruise control wiring with a Caterpillar C10 engine.

See **Fig. 4** for a full view of the cruise control wiring with a Caterpillar 3126 engine.

Specifications

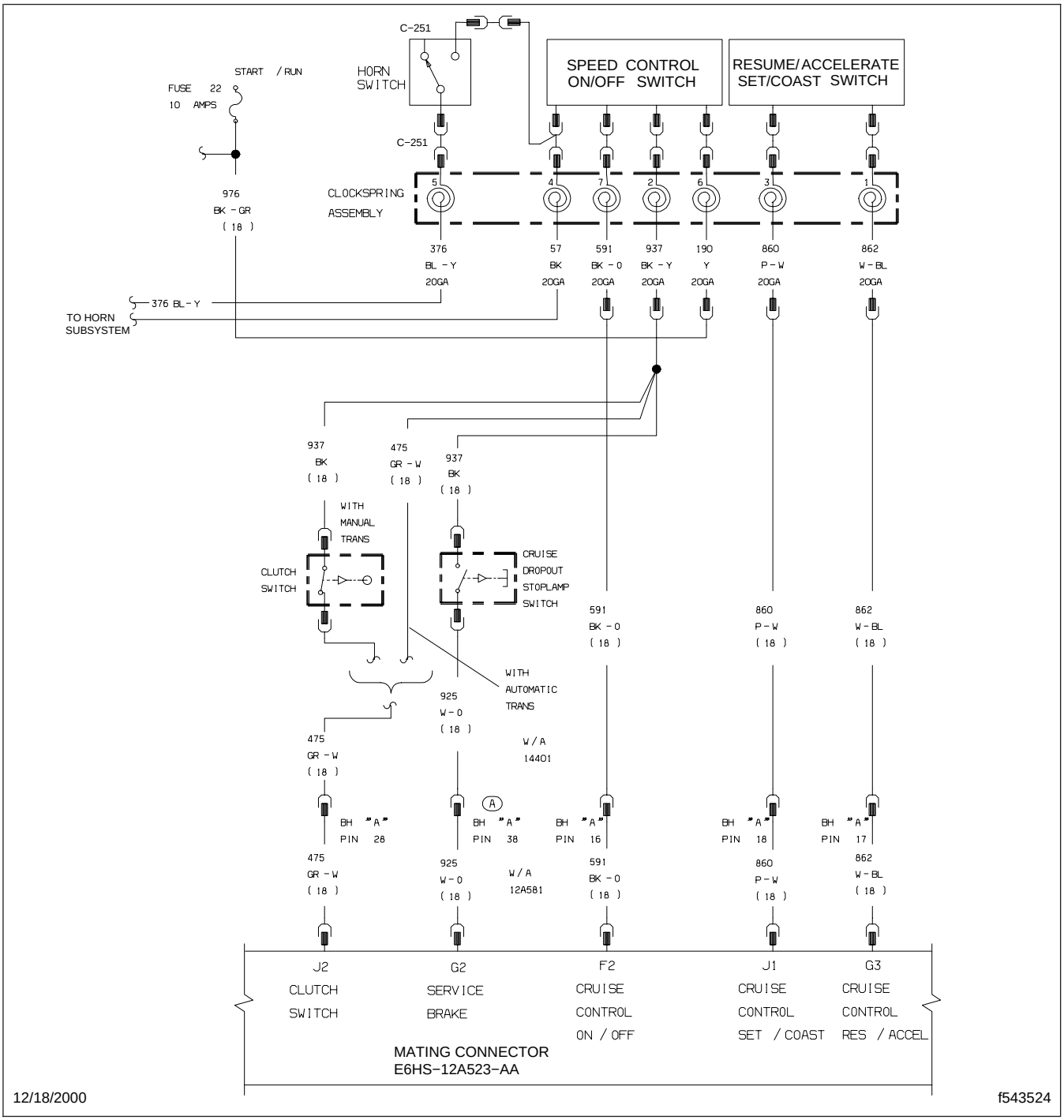


Fig. 1, Cruise Control Wiring with Detroit Diesel Engine

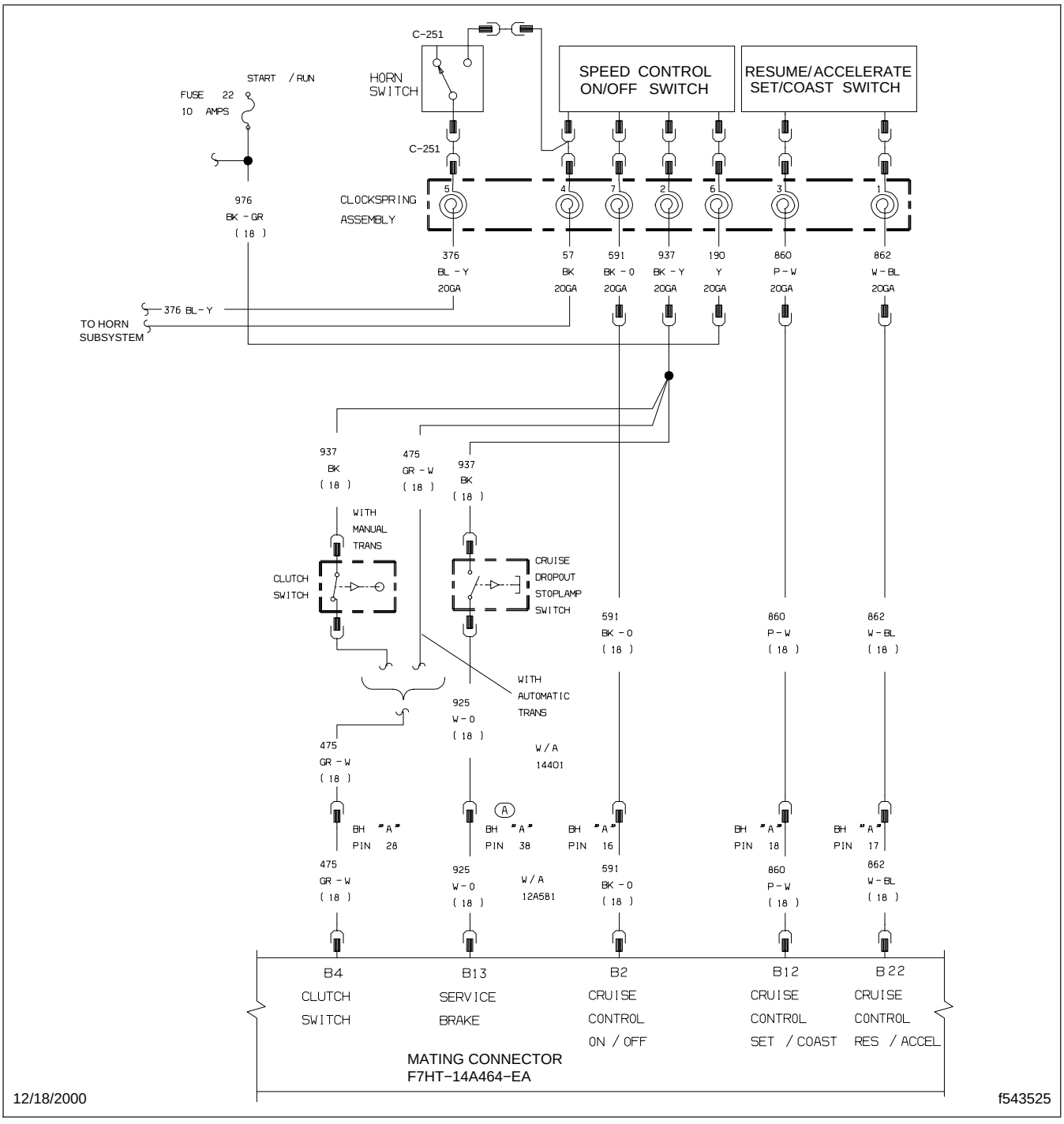


Fig. 2, Cruise Control Wiring with Cummins Engine

Specifications

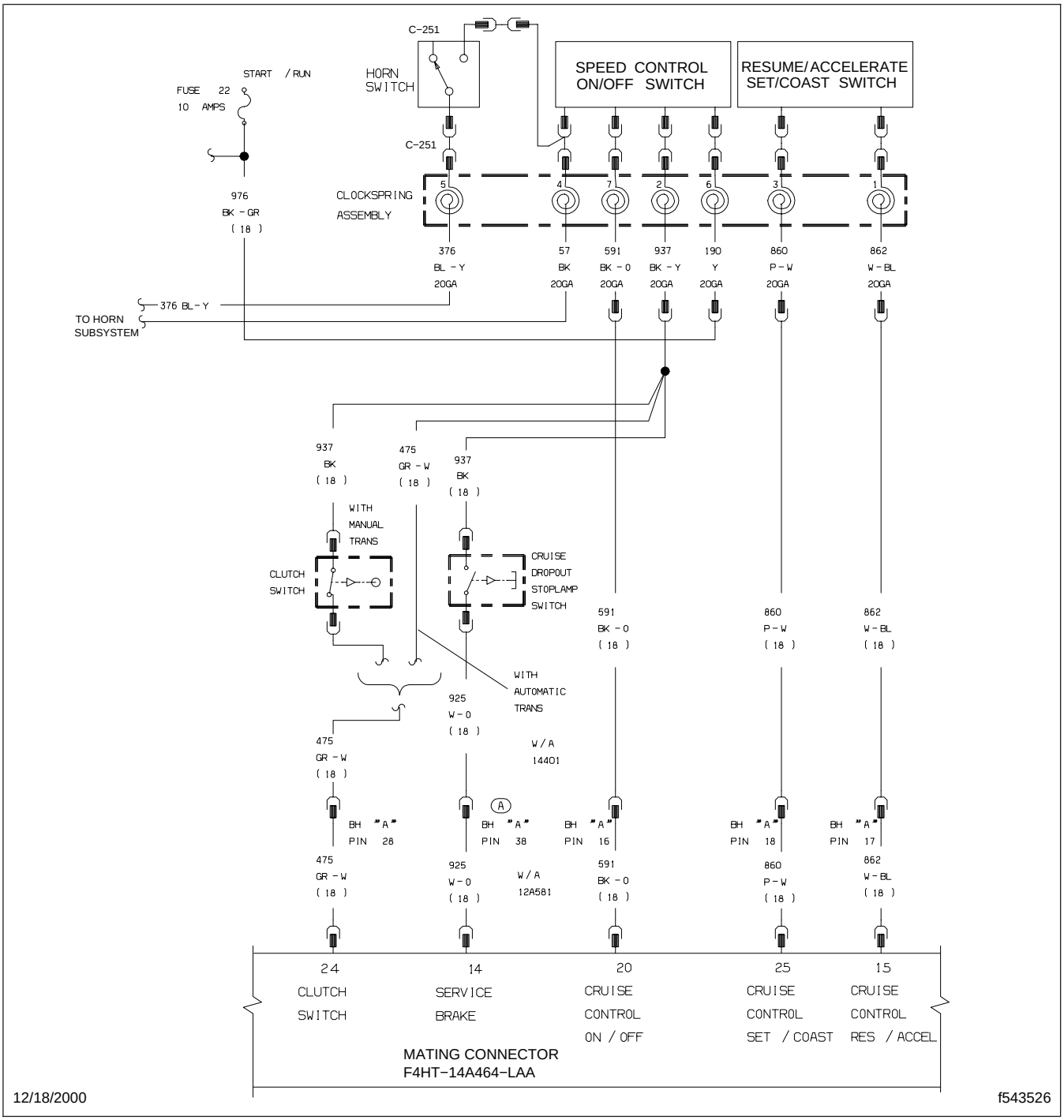


Fig. 3, Cruise Control Wiring with Caterpillar C10 Engine

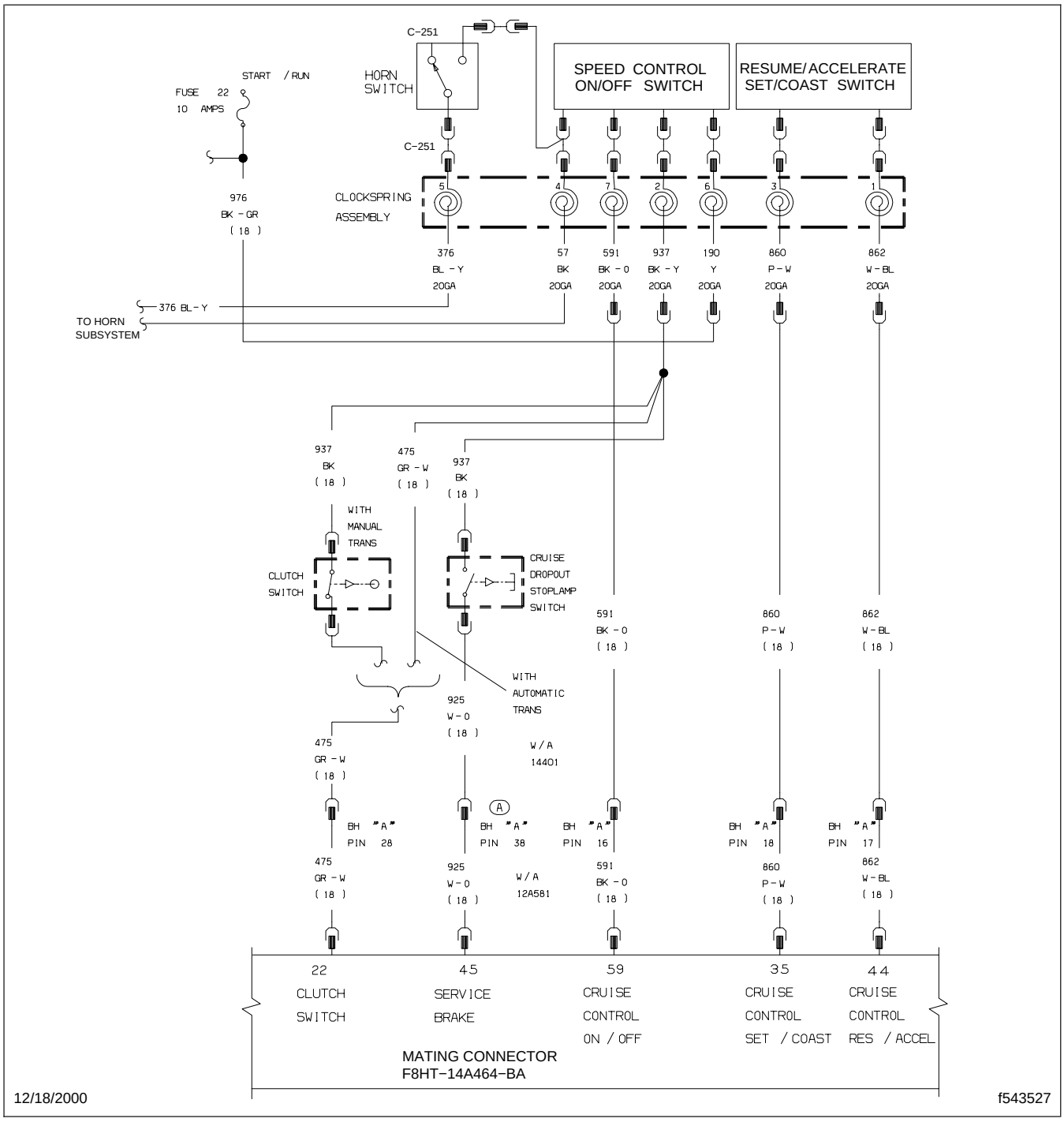


Fig. 4, Cruise Control Wiring with Caterpillar 3126 Engine

General Information (See Fig. 1)

DAYTIME RUNNING LIGHTS (DRL), UNITED STATES

The daytime running light (DRL) system is designed to turn on the low beam headlights with a reduced light intensity output when the following conditions are met:

- the vehicle is running
- the parking brake is fully released
- the headlight switch is in the "Off" or "Park" position

When the necessary conditions are present, the daytime running light (DRL) system is engaged and the DAY LAMPS indicator in the instrument cluster will be illuminated.

NOTE: The low beam headlights and high beam headlights should be working properly.

NOTE: The daytime running lights control module is grounded through the high beam headlights. The pulsed voltage to the low beam headlights cannot be accurately measured.

If the headlight switch is turned to the "Head" position (DRL disabled) with the low beam filaments illuminated, there will be voltage present at Pin 1, Circuit 41 (BK/Y) allowing the illumination of the fog or road lights.

The system senses the manual actuation of the headlight high beams at Pin 6 of the DRL module, through Circuit 12 (GN/BK). Under this condition, the DRL module will be disabled and a pulsed voltage output on Pin 8, Circuit 13 (R/BK) will not be present. The high beam indicator will be illuminated by the high beam Circuit 12 (GN/BK).

Pin 8, Circuit 13 (R/BK) is used as an input to sense the manual actuation of the low beams and as an output to drive the low beams with a pulsed voltage.

The parking brake switch is a closed circuit when the parking brake is engaged. The system senses the parking brake release when the ground is no longer present at Pin 4, Circuit 162 (GN/R).

DAYTIME RUNNING LIGHTS (DRL), CANADA

The daytime running light (DRL) system is designed to turn on the high beam headlights with a reduced light intensity output without illuminating the high beam indicator light in the instrument cluster when the following conditions are met:

- the vehicle is running
- the parking brake is fully released
- the headlight switch is in the "Off" or "Park" position

When the necessary conditions are present, the daytime running lights (DRL) system is engaged and the DAY LAMPS indicator in the instrument cluster will be illuminated.

NOTE: The low beam headlights and high beam headlights should be working properly.

NOTE: The daytime running lights control module is grounded through the low beam headlights. The pulsed voltage to the high beam headlights cannot be accurately measured.

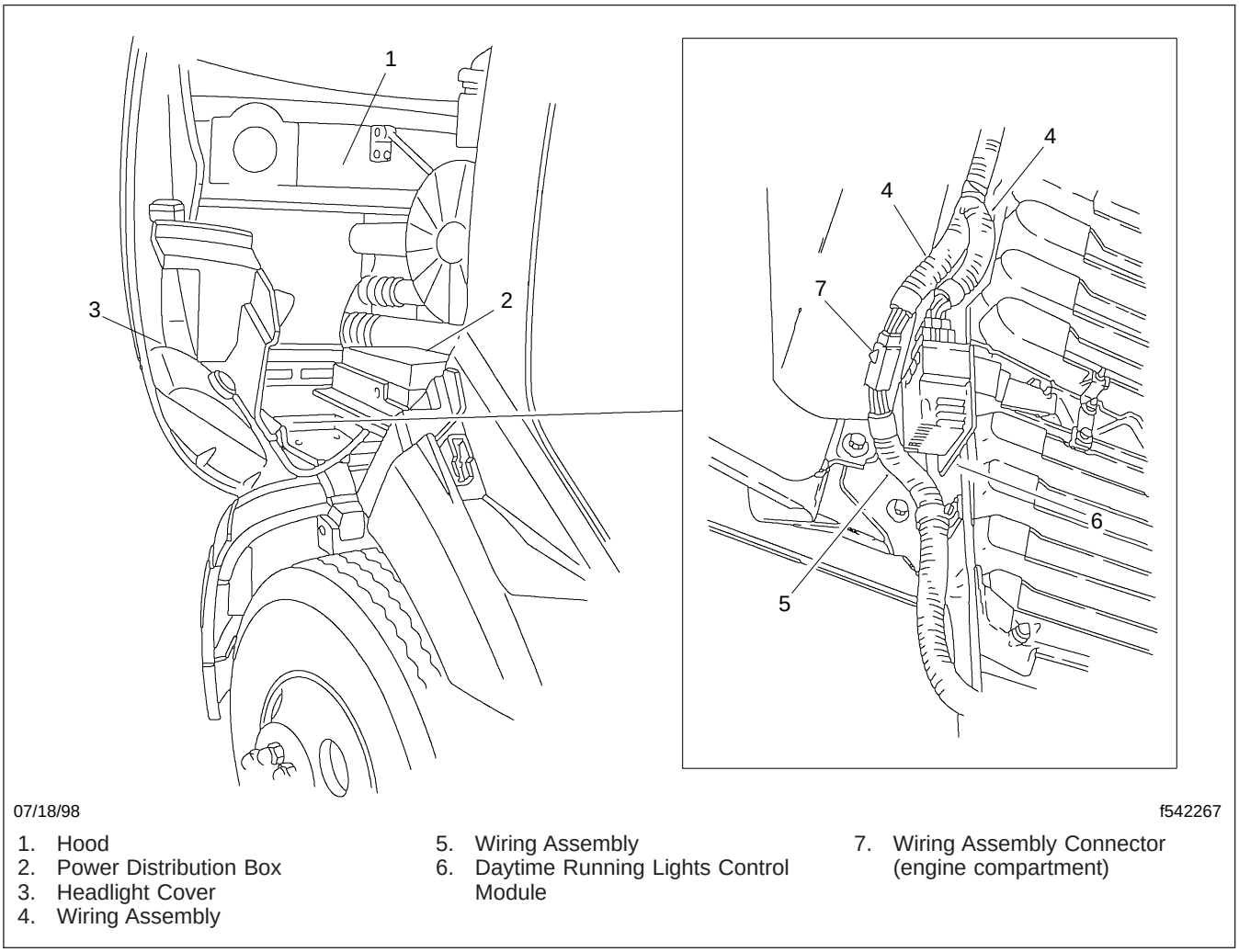
If the headlight switch is turned to the "Head" position (DRL disabled) with the high beam filaments illuminated, voltage will be present at Pin 1, Circuit 41 (BK/Y), illuminating the high beam indicator. The voltage at Pin 1, Circuit 41 (BK/Y) under any other condition will equal zero, disabling the high beam indicator.

The system senses the manual actuation of the headlight low beams at Pin 6 of the DRL module, through Circuit 13 (R/BK). Under this condition, the DRL module will be disabled and a pulsed voltage output on Pin 8, Circuit 12 (GN/BK) will not be present.

Pin 8, Circuit 12 (GN/BK) is used as an input to sense the manual actuation of the high beams and as an output to drive the high beams with a pulsed voltage.

The parking brake switch is a closed circuit when the parking brake is engaged. The system senses the parking brake release when the ground is no longer present at Pin 4, Circuit 162 (GN/R).

General Information



1. Hood
2. Power Distribution Box
3. Headlight Cover
4. Wiring Assembly
5. Wiring Assembly
6. Daytime Running Lights Control Module
7. Wiring Assembly Connector (engine compartment)

Fig. 1, Daytime Running Lights Components

Troubleshooting

1. Before performing any lighting systems test, check that the battery is fully charged, battery connections are clean and tight, and burned-out fuses and bulbs have been replaced. See **Table 1** and **Table 2** for normal operating conditions.
2. See **Table 3** to inspect and determine if one of the electrical concerns applies.
3. If the concern(s) remains after the inspection, determine the symptoms and proceed to the problem charts. See **Table 4** and **Table 5**.

Normal Operating Conditions, DRL System, USA	
Condition	**Results In**
Headlight switch off. DRL operating.	Voltage at Pins 3 and 7 (DRL module power). Zero voltage at Pin 6 (high beams not turned on) (DRL ground). Pulsed voltage output at Pin 8 (cannot be accurately measured). No ground at Pin 4 (parking brake released). Voltage at Pin 2 (DRL indicator illuminated).
Headlight switch manually turned to the "Head" position and headlights in low beam.	Voltage at Pins 3 and 7 (DRL module power). No voltage at Pin 6 (high beams not turned on). Steady voltage input at Pin 8. Parking brake actuated. No voltage at Pin 2 (DRL indicator not illuminated). Voltage at Pin 1 (fog or road lights can be turned on).
Headlight switch manually turned to the "Head" position and headlights in high beam.	Voltage at Pins 3 and 7 (DRL module power). Voltage at Pin 6 (high beams turned on). No voltage at Pin 8. Parking brake actuated. No voltage at Pin 2 (DRL indicator not illuminated). No voltage at Pin 1 (fog or road lights cannot be turned on).

Table 1, Normal Operating Conditions, DRL System, USA

Troubleshooting

Normal Operating Conditions, DRL System, Canada	
Condition	**Results In**
Headlight switch off. DRL operating.	Voltage at Pins 3 and 7 (DRL module power). Zero voltage at Pin 6 (low beams not turned on) (DRL ground). Pulsed voltage output at Pin 8 (cannot be accurately measured) (fog or road lights cannot be turned on). No ground at Pin 4 (parking brake released). Voltage at Pin 2 (DRL indicator illuminated). No voltage at Pin 1 (high beam indicator off).
Headlight switch manually turned to the "Head" position and headlights in low beam.	Voltage at Pins 3 and 7 (DRL module power). Voltage at Pin 6 (low beams turned on). No voltage at Pin 8 (fog or road lights can be turned on). Parking brake actuated to any state. No voltage at Pin 2 (DRL indicator not illuminated). No voltage at Pin 1 (high beam indicator off).
Headlight switch manually turned to the "Head" position and headlights in high beam.	Voltage at Pins 3 and 7 (DRL module power). No voltage at Pin 6 (low beams not turned on). Steady voltage input at Pin 8 (fog or road lights cannot be turned on). Parking brake actuated to any state. No voltage at Pin 2 (DRL indicator not illuminated). Voltage at Pin 1 (high beam indicator illuminated).

Table 2, Normal Operating Conditions, DRL System, Canada

Visual Inspection Chart
Electrical
Power distribution box Fuse L (40 A)
Run power relay No. 1
Instrument panel fuse junction panel Fuse 5 (15 A)
Instrument panel fuse junction panel Fuse 38 (5 A)

Table 3, Visual Inspection Chart

Troubleshooting

Problem—The Daytime Running Lights are Inoperative (See Fig. 1)	
Possible Cause	**Remedy**
Daytime running light control module	Check the high (low USA) beam operation. Turn the ignition switch to the "On" position, fully release the parking brake and position the headlight switch in the "Off" or "Park" position. If the high beams (low beams USA) are on, check the high (low USA) beam intensity. If not, check the daytime running lights control module installation. Check the high (low USA) beam intensity. If the high (low USA) beams are on at reduced intensity, the system is functioning properly. No repair required. If not, replace the daytime running lights control module. Test the system for normal operation. Check the daytime running lights control module installation. Turn the ignition switch and headlight switch to the "Off" position. Check the installation of the daytime running lights control module connector C145. If the daytime running lights control module installed and the connector fully seated, check the daytime running lamps control module power. If not, reinstall the daytime running lights control module. Test the system for normal operation. Check the daytime running lights control module power. Disconnect the daytime running lights control module connector C145 harness connector. Turn the ignition switch to the "On" position. Fully release the parking brake. The headlight switch should be in the "Off" or in the "Park" position. The multi-function switch should be in the LO beam (HI beam USA) position. Measure the voltage between the daytime running lights control module connector C145 Pins 2 and 4, Circuit 34 (GN/BK) and ground. If the voltage is less than 10 volts, repair Circuit 34 (GN/BK) for an open circuit. Test the system for normal operation. If the voltage is more than 10 volts, check the daytime running lights control module Pin 8. Place the headlight switch in the "Head" position, and the multi-function switch in the HI beam (LO beam USA) position. Measure the voltage between the daytime running lights control module connector C145 Pin 8, Circuit 13 (R/BK) (USA) or Circuit 12 (GN/BK) (Canadian) and ground. If the voltage is less than 6 volts, repair the open on Circuit 13 (R/BK) (USA) or Circuit 12 (GN/BK) (Canadian) between the headlights and the daytime running lights control module connector C145. Test the system for normal operation. If the voltage is more than 6 volts, check the module ground. Measure the resistance between the daytime running lights control module connector C145 Pin 7, Circuit 12 (GN/BK) (USA) or Circuit 13 (R/BK) (Canadian) and ground. If the resistance is more than 5 ohms, repair the open on Circuit 12 (GN/BK) (USA) or Circuit 13 (R/BK) (Canadian) between the headlights and daytime running lights control module connector C145. Test the system for normal operation. If the resistance is less than 5 ohms, check the high beam indicator (Canadian). Place the multi-function switch in the HI beam position. Measure the voltage between the control module connector C145 Pin 1 and ground. If the voltage is less than 10 volts, replace the illumination bulb or repair Circuit 41 (BK/Y) feeding the bulb or Circuit 57 (BK) for an open. Test the system for normal operation. If the voltage is more than 10 volts, check the parking brake switch.

Troubleshooting

Problem—The Daytime Running Lights are Inoperative (See Fig. 1)	
Possible Cause	**Remedy**
Daytime running light control module	Turn the ignition switch to the "Off" position. Measure the resistance between the daytime running lights control module connector C145 Pin 6, Circuit 162 (GN/R) and ground. Apply and release the parking brake switch. If the resistance is less than 5 ohms with the parking brake applied and greater than 10,000 ohms with the parking brake released, replace the daytime running lights control module. Test the system for normal operation. If not, repair Circuit 57 (BK) between the parking brake switch and ground, or repair Circuit 162 (GN/R) for an open or a short, or replace the parking brake switch. Test the system for normal operation.

Table 4, Problem: The Daytime Running Lights are Inoperative

Problem—The Daytime Running Lights are On With Parking Brake Set (See Fig. 1)	
Possible Cause	**Remedy**
Parking brake switch	Measure the resistance between the daytime running lights control module connector C145 Pin 6, Circuit 162 (GN/R) and ground. If the resistance is less than 5 ohms with the parking brake applied and greater than 10,000 ohms with the parking brake released, replace the daytime running lights control module. Test the system for normal operation. If not, repair Circuit 57 (BK) between the parking brake switch and ground, or repair Circuit 162 (GN/R) for an open or a short, or replace the parking brake switch. Test the system for normal operation.

Table 5, Problem: The Daytime Running Lights are On With Parking Brake Set

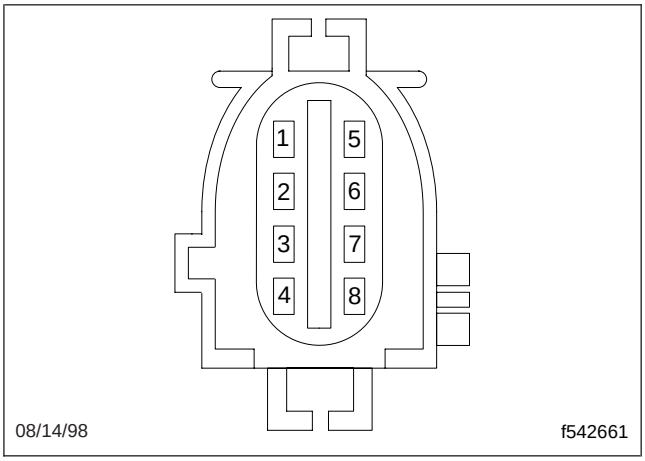


Fig. 1, Connector C145 Pin Identification

See **Fig. 1** for a full view of the daytime running lights wiring.

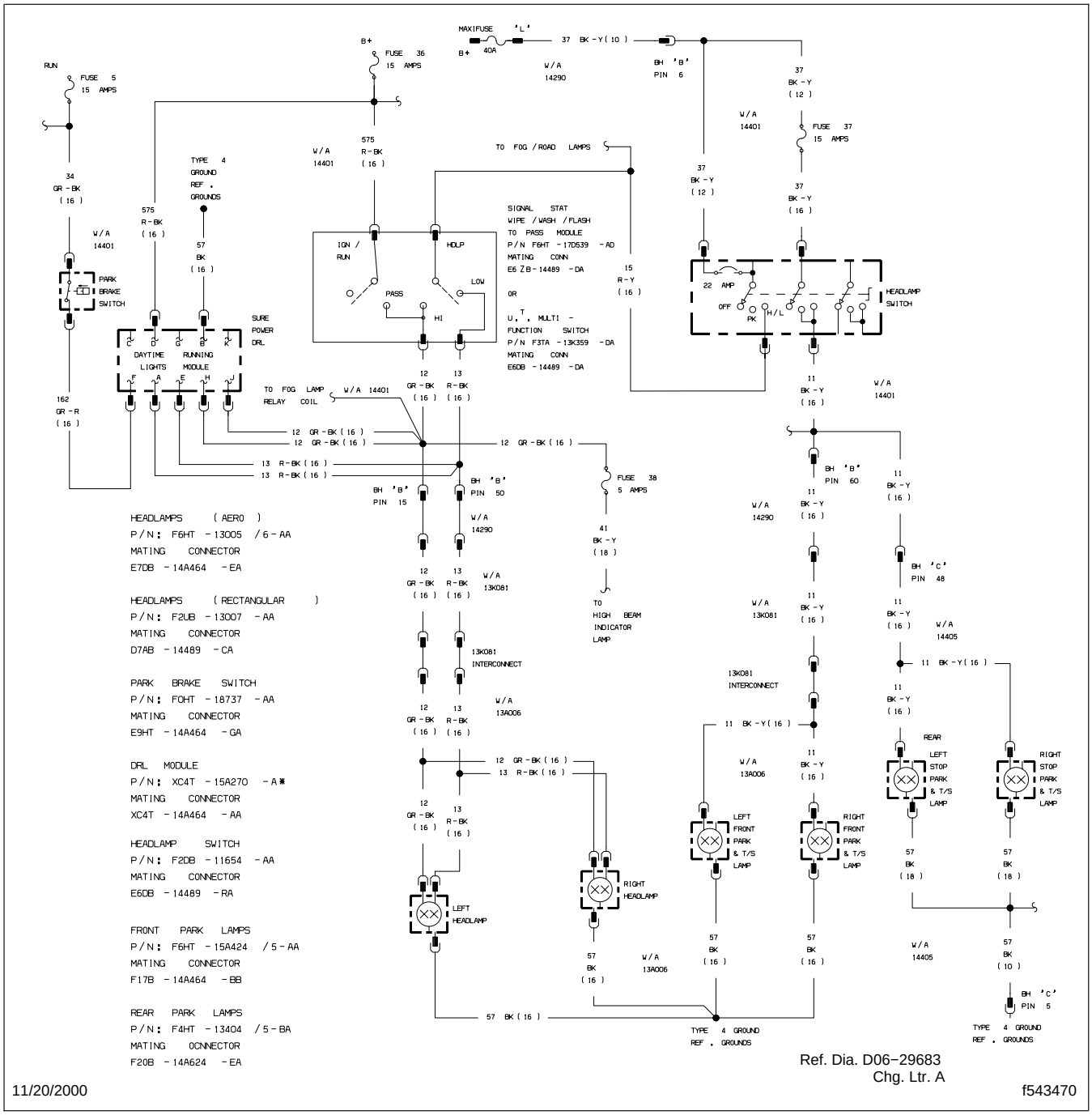


Fig. 1, Daytime Running Lights Wiring

Troubleshooting

Audio System

1. Verify the concern by operating the vehicle. Inspect to determine if one of the following electrical concerns applies:
   - instrument panel fuse junction panel fuses 15 and 16
   - SilverStar sleeper fuse panel fuse 3
   - damaged audio shields
2. Check for damaged components, open fuses, and loose or corroded connections. Check the wiring harness for obvious signs of shorts, opens, bad connections or damage. Verify the circuit operation. See **Table 1**, **Table 2** and **Table 3** for the SilverStar sleeper premium sound circuit types and functions.

Wiring Shields		
Name	**Shielded Circuits**	**Termination Points**
Radio Line Level Audio Output (to the amplifier and the rear radio control)	857 (W), 853 (R/GN), 855 (P), 854 (BR), 851 (GN), 850 (BL/W), 856 (O) and 857 (W)	Radio connector C216 and junction above and right of the dash air manifold
Line Level Audio to the Amplifier	857 (W), 853 (R/GN), 855 (P), 854 (BR), 851 (GN), 850 (BL/W), 856 (O) and 857 (W)	Junction above and right of the dash air manifold and the amplifier connector C208
Line Level Audio (to the rear radio control) and the Audio Control Protocol Lines (to the rear radio control and CD changer) to the Sleeper Accessory Harness	851 (GN), 850 (BL/W), 856 (O), 857 (W), 832 (Y/BK) and 833 (GN)	Junction above and right of the dash air manifold and the sleeper accessory harness connector C309
Line Level Audio to the Rear Radio Control	851 (GN), 850 (BL/W), 856 (O) and 857 (W)	Sleeper accessory harness connector C309 and the rear radio control connector C762
Radio Line Level Audio Input (from the CD changer) and the ACC-ON Conditioned Ignition Power Output (to the CD changer and the rear radio control)	876 (Y), 868 (R/BR), 865 (BK), 866 (BK) and 867 (R)	Radio connector C216 and the sleeper accessory harness connector C311
CD Changer Line Level Audio Output (to radio) and the ACC-ON Conditioned Ignition Power (to the CD changer and the rear radio control)	876 (Y), 868 (R/BR), 865 (BK), 866 (BK) and 867 (R)	Sleeper accessory harness connector C311 and the CD changer connector C764
Amplifier Line Level Audio Output and the Subwoofer Enable to the Sleeper Accessory Harness (to the subwoofer)	915 (BK/O), 916 (R) and 830 (GN/W)	Amplifier connector C207 and sleeper accessory harness connector C311
Amplifier Line Level Audio and the Subwoofer Enable to the Subwoofer	915 (BK/O), 916 (R) and 830 (GN/W)	Sleeper accessory harness connector C311 and the subwoofer connector C751

Table 1, Wiring Shields

Troubleshooting

Twisted Wires	
Name	**Twisted Circuits**
Radio Connector C216 to the Amplifier Connector C208, Twisted Pairs	857 (W) and 853 (R/GN) 855 (P) and 854 (BR) 851 (GN) and 850 (BL/W) 856 (O) and 857 (W)
Radio Connector C216 to the Rear Radio Control Connector C762, Twisted Pairs	832 (Y/BK) and 833 (GN) 851 (GN) and 850 (BL/W) 856 (O) and 857 (W)
Radio Connector C216 to the CD Changer Connector C764, Twisted Quad	876 (Y), 868 (R/BR), 865 (BK) and 866 (BK)
Amplifier Connector C207 to the Subwoofer Connector C751, Twisted Triplet	830 (GN/W), 915 (BK/O) and 916 (R)

Table 2, Twisted Wires

Logic Circuits			
Circuit	**State**	**Source**	**Function**
Circuit 689 (P) is triggered by the power button on the radio and by Circuit 690 (GN/W).	Ground	Radio	System "On" (amplifier and rear radio control "On").
	5 Volts		System "Off" (amplifier and rear radio control "Off").
Circuit 690 (GN/W) is used to trigger a mute on the audio system.	Open Circuit	Speaker Interrupt Module	No call is being received.
	Ground		A call is being received or is in progress.
Circuit 830 (GN/W) is triggered by Circuit 689 (P).	5 Volts	Amplifier	System "On" (rear radio control "On").
	Ground		System "Off" (rear radio control "Off").
Circuit 867 (R) is regulated ignition power through the radio.	2 Volts	Radio	Key in "Run" (ignition power present at CD changer and rear radio control).
	0 Volts		Key not in "Run" (ignition power not present at CD changer and rear radio control).

Table 3, Logic Circuits

3. If the fault is not visually evident, determine the symptom and proceed to the appropriate trouble-shooting table.

Problem—Radio Chassis Is Inoperative, Weatherband Radio

Problem—Radio Chassis is Inoperative, Weatherband Radio (See Fig. 1 and Fig. 2)	
Possible Cause	**Remedy**
Radio	Substitute a known good radio. If the symptom is not present have the radio serviced by an authorized service center. Test the system for normal operation.

Problem—Radio Chassis is Inoperative, Weatherband Radio (See Fig. 1 and Fig. 2)	
Possible Cause	**Remedy**
Missing power or ground	Turn the ignition switch to the "Off" position. Disconnect the radio harness connector C217. Measure the voltage between the radio connector C217 Pin 7, Circuit 54 (GN/Y) and ground. Turn the ignition switch to the ACC position. Measure the voltage between the radio connector C217 Pin 1, Circuit 137 (Y/BK) and ground. If the voltage is less than 10 volts, check for opens on the power feeds to the radio. Turn the ignition switch to the "Off" position. Disconnect the battery ground cable. Disconnect the instrument panel fuse junction panel Fuses 15 and 16. Measure the resistance between the bottom pin of the instrument panel fuse junction panel Fuse 15, Circuit 54 (GN/Y) and the radio connector C217 Pin 7, Circuit 54 (GN/Y). Measure the resistance between the bottom pin of the instrument panel fuse junction panel Fuse 16, Circuit 137 (Y/BK) and the radio connector C217 Pin 1, Circuit 137 (Y/BK). If the resistance is less than 5 ohms, repair Circuit 37 (BK/Y) feeding Fuse 15 or repair Circuit 297 (BK/R) feeding Fuse 16. Test the system for normal operation. If the resistance is greater than 5 ohms, repair the open in the affected circuit(s) between the instrument panel fuse junction panel and the radio. Test the system for normal operation. If the voltage is greater than 10 volts, check for opens on the ground to the radio. Turn the ignition switch to the "Off" position. Disconnect the battery ground cable. Measure the resistance between the radio connector C217 Pin 2, Circuit 18 (BK/BL) and ground. If the resistance is less than 5 ohms, have the radio serviced by an authorized service center. Test the system for normal operation. If the resistance is more than 5 ohms, repair Circuit 18 (BK/BL) for an open. Make sure that all ground connections are clean and tight. Test the system for normal operation.

Troubleshooting

Problem—Radio Chassis is Inoperative, Standard Radio

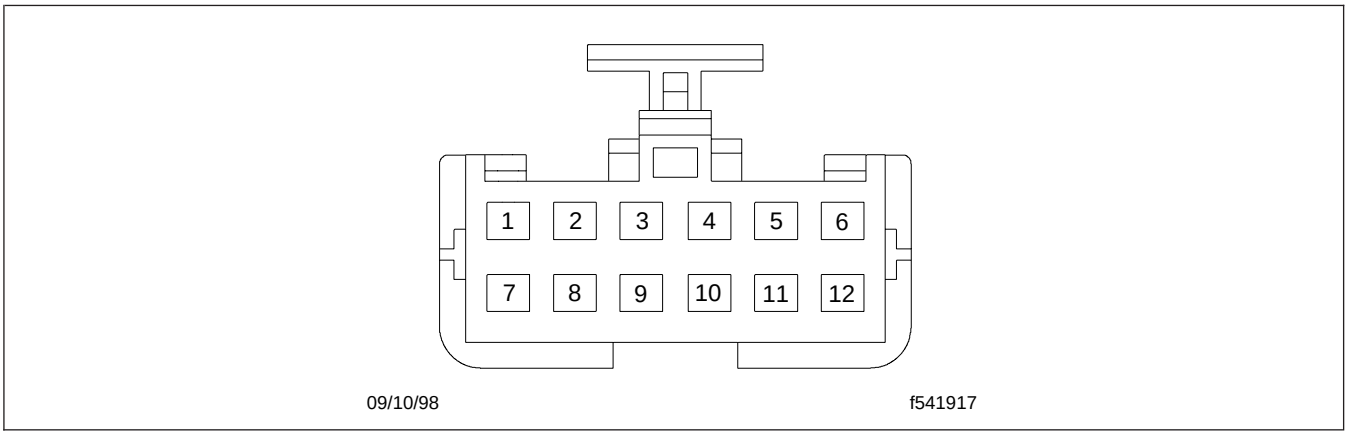


Fig. 1, C217 Radio Connector

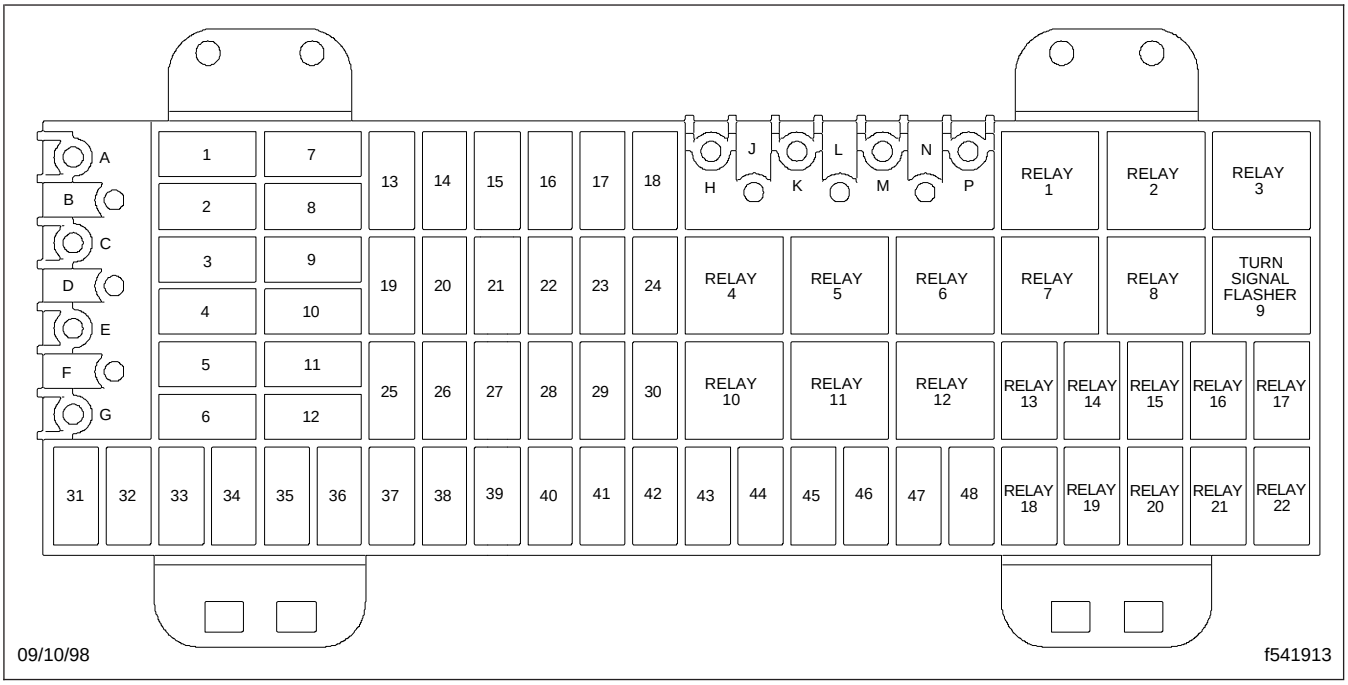


Fig. 2, Instrument Panel Fuse Junction Panel

Problem—Radio Chassis is Inoperative, Standard Radio (See Fig. 2 and Fig. 3)	
Possible Cause	**Remedy**
Radio	Substitute a known good radio. If the symptom is not present have the radio serviced by an authorized service center. Test the system for normal operation.

Problem—Radio Chassis is Inoperative, Standard Radio (See Fig. 2 and Fig. 3)	
Possible Cause	**Remedy**
Missing power or ground	Check the power feeds to the radio. Turn the ignition switch to the "Off" position. Disconnect the radio connector C219. Measure the voltage between the radio connector C219 Pin 8, Circuit 54 (GN/Y) and ground. Turn the ignition to the ACC position. Measure the voltage between the radio connector C219 Pin 6, Circuit 137 (Y/BK) and ground. If the voltage is less than 10 volts, check opens on the power feeds to the radio. Disconnect the battery ground. Turn the ignition switch to the "Off" position. Disconnect the instrument panel fuse junction panel Fuses 15 and 16. Measure the resistance between the bottom pin of the instrument panel fuse junction panel Fuse 15, Circuit 54 (GN/Y) and the radio connector C219 Pin 8, Circuit 54 (GN/Y). Measure the resistance between the bottom pin of the instrument panel fuse junction panel Fuse 16, Circuit 137 (Y/BK) and the radio connector C219 Pin 6, Circuit 137 (Y/BK). If the resistance is less than 5 ohms, repair Circuit 37 (BK/Y) feeding Fuse 15 or repair Circuit 297 (BK/R) feeding Fuse 16. Test the system for normal operation. If the resistance is more than 5 ohms, repair the open in the affected circuit(s) between the instrument panel fuse junction panel and the radio. Test the system for normal operation. If the voltage is greater than 10 volts, check the grounds to the radio for opens. Turn the ignition switch to the "Off" position. Disconnect the battery ground cable(s). Measure the resistance between the radio connector C219 Pin 3, Circuit 18 (BK/BL) and ground. Measure the resistance between the radio connector C219 Pin 7, Circuit 57 (BK) and ground. If the resistance is less than 5 ohms, have the radio serviced by an authorized service center. Test the system for normal operation. If the resistance is more than 5 ohms, repair the affected circuit(s). Make sure that all ground connections are clean and tight. Test the system for normal operation.

Troubleshooting

Problem—Radio Chassis is Inoperative, Premium Radio

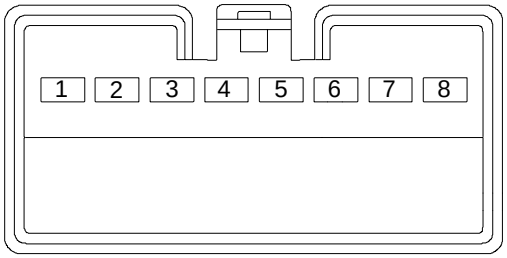


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Fig. 3, C219 Radio Connector

Problem—Radio Chassis is Inoperative, Premium Radio (See Fig. 2, Fig. 3 and Fig. 4)	
Possible Cause	**Remedy**
Radio	Substitute a known good radio. If the symptom is not present have the radio serviced by an authorized service center. Test the system for normal operation.

Problem—Radio Chassis is Inoperative, Premium Radio (See Fig. 2, Fig. 3 and Fig. 4)	
Possible Cause	**Remedy**
Missing power or ground	Check the power feeds to the radio. Turn the ignition switch to the "Off" position. Disconnect the radio connector C219. Measure the voltage between the radio connector C219 Pin 8, Circuit 54 (GN/Y) and ground. Measure the voltage between the amplifier connector C209 Pin 14, Circuit 54 (GN/Y) and ground. Turn the ignition to the ACC position. Measure the voltage between the radio connector C219 Pin 6, Circuit 137 (Y/BK) and ground. If the voltage in the circuits is less than 10 volts, check opens on the power feeds to the radio. Disconnect the battery ground. Turn the ignition switch to the "Off" position. Disconnect the instrument panel fuse junction panel Fuse 15. Measure the resistance between the bottom pin of the instrument panel fuse junction panel Fuse 15, Circuit 54 (GN/Y) and the radio connector C219 Pin 8, Circuit 54 (GN/Y). Measure the resistance between the bottom pin of the instrument panel fuse junction panel Fuse 15, Circuit 54 (GN/Y) and the amplifier connector C209 Pin 14, Circuit 54 (GN/Y). Measure the resistance between the bottom pin of the instrument panel fuse junction panel Fuse 16, Circuit 137 (Y/BK) and the radio connector C219 Pin 6, Circuit 137 (Y/BK). If the resistance is less than 5 ohms, repair Circuit 37 (BK/Y) feeding Fuse 15 or repair Circuit 297 (BK/R) feeding Fuse 16. Test the system for normal operation. If the resistance is more than 5 ohms, repair the affected circuit(s) for an open. Make sure all ground connections are clean and tight. Test the system for normal operation. If the voltage in the circuits is less than 10 volts, check for opens between the grounds to the radio and the amplifier. Turn the ignition switch to the "Off" position. Disconnect the battery ground cable(s). Measure the resistance between the radio connector C219 Pin 3, Circuit 18 (BK/BL) and ground. Measure the resistance between the radio connector C219 Pin 7, Circuit 57 (BK) and ground. Measure the resistance between the amplifier connector C209 Pin 13, Circuit 18 (BK/BL) and ground. If the resistance is less than 5 ohms, have the radio serviced by an authorized service center. Test the system for normal operation. If the resistance is more than 5 ohms, repair the affected circuit(s) for an open. Make sure all ground connections are clean and tight. Test the system for normal operation.

Troubleshooting

Problem—CD Changer is Inoperative

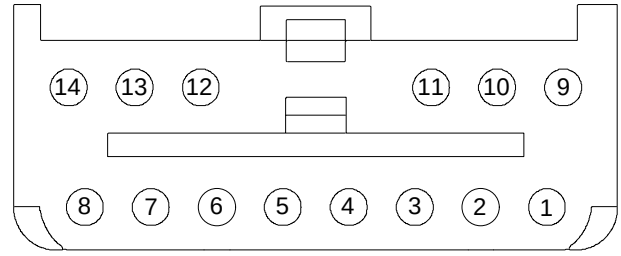

Fig. 4, C209 Radio Connector

Problem—CD Changer is Inoperative (See Fig. 4, Fig. 5, Fig. 6, Fig. 7 and Fig. 8)	
Possible Cause	**Remedy**
CD changer	Substitute a known good radio. If the symptom is not present replace the CD changer. Test the system for normal operation

Problem—CD Changer is Inoperative (See Fig. 4, Fig. 5, Fig. 6, Fig. 7 and Fig. 8)	
Possible Cause	**Remedy**
Missing power or ground	Check the power feeds to the CD changer. Turn the ignition switch to the "Off" position. Disconnect the CD changer connector C764. Measure the voltage between the CD changer connector C764 Pin 10, Circuit 37 (BK/Y) and ground. If the voltage is less than 10 volts, check an open on the power feed. Turn the ignition switch to the "Off" position. Disconnect the battery ground cable(s). Disconnect the sleeper fuse panel Fuse 3 connector. Measure the resistance between the bottom of the sleeper fuse panel Fuse 3, Circuit 37 (BK/Y) and the CD changer connector C764 Pin 10, Circuit 37 (BK/Y). If the resistance is less than 5 ohms, repair Circuit 150 (R) feeding Fuse 3. Test the system for normal operation. If the resistance is more than 5 ohms, repair the open in Circuit 37 (BK/Y) between the sleeper fuse panel and the CD changer. Test the system for normal operation. If the voltage is greater than 10 volts, check the ACC-ON power feed. Turn the ignition switch to the ACC position. Turn the radio on. Measure the voltage between the CD changer connector C764 Pin 11, Circuit 867 (R) and ground. If the voltage is less than 10 volts, check the ACC-ON power. Turn the ignition switch to the "Off" position. Disconnect the sleeper accessory harness connector C311. Turn the ignition switch to the ACC position. Turn the radio on. Measure the voltage between the cab side of the sleeper accessory harness connector C311 Pin 7, Circuit 867 (R) and ground. If the voltage is greater than 10 volts repair the open circuit in the sleeper accessory harness, Circuit 867 (R). Test the system for normal operation. If the voltage is less than 10 volts check the radio ACC-ON power output. Turn the ignition switch to the "Off" position. Disconnect the radio connector C216. Remove the Circuit 867 (R) wire from the radio connector C216. Reconnect the radio connector C216. Turn the ignition switch to the ACC position. Turn the radio on. Measure the voltage between the open Terminal 16 and ground. If the voltage is greater than 10 volts, repair the open circuit in the sleeper accessory harness, Circuit 867 (R). Test the system for normal operation. If the voltage is less than 10 volts have the radio serviced by an authorized service center. Test the system for normal operation.
No audio system "On" power	If the voltage is greater than 10 volts, check the CD changer ground. Turn the ignition switch to the "Off" position. Disconnect the battery ground cable(s). Measure the resistance between the CD changer connector C764 Pin 4, Circuit 57 (BK) and ground. If the resistance is less than 5 ohms, repair Circuit 57 (BK) open circuit between the CD changer and ground. Test the system for normal operation. If the resistance is greater than 5 ohms, check the power output to the radio. Turn the ignition switch to the "Off" position. Disconnect the radio connector C216 and CD changer connector C764. Measure the resistance between the radio connector C216 Pins 16, 15, 8 and 7, Circuits 868 (R/BR), 865 (BK) and 866 (BK), and the CD changer connector Pins 2, 8, 1 and 7 Circuits 876 (Y), 868 (R/BR), 865 (BK) and 866 (BK). If the resistance is greater than 5 ohms, see troubleshooting table "Problem—CD Changer Display is Blank, Does Not Operate Properly." If the resistance is less than 5 ohms, repair the open in the affected circuit(s) between the radio and CD changer. Test the system for normal operation.

Troubleshooting

Problem—CD Changer Display is Blank, Does Not Operate Properly

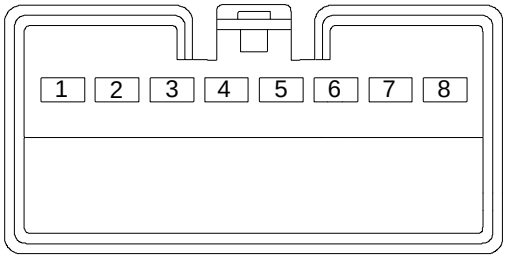

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Fig. 5, C219 Radio Connector

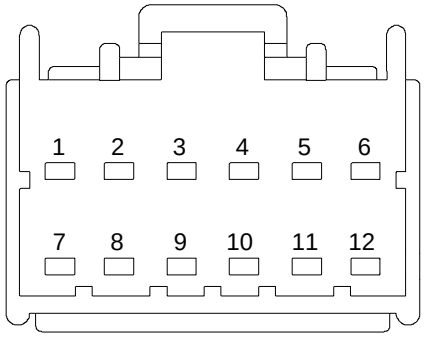

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Fig. 6, C764 CD Changer Connector

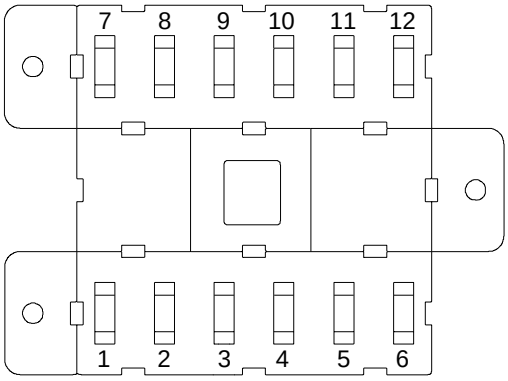

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Fig. 7, Sleeper Fuse Panel

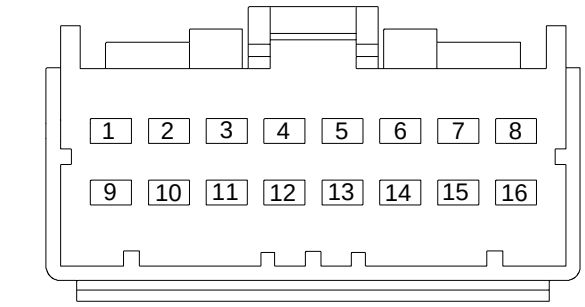


Fig. 8, C216 Radio Connector

Problem—CD Changer Display is Blank, Does Not Operate Properly (See Fig. 6, Fig. 8 and Fig. 9)	
Possible Cause	**Remedy**
NOTE: Circuits 832 (Y/BK) and 833 (GN) are the audio control protocol lines that allow the radio to control the CD changer. These circuits are a twisted pair at 7.3 turns per foot (24 turns per meter). If a repair is necessary, use 20 gauge wire and preserve the twisted pair specification.	
Audio control protocol lines	Check the audio control protocol lines. Disconnect the battery ground cable(s). Disconnect the radio connector C216 and the sleeper accessory harness connector C309. Measure the resistance between the radio connector C216 Pin 9, Circuit 832 (Y/BK) and the cab side of the sleeper accessory harness connector C309 Pin 15, Circuit 832 (Y/BK). Measure the resistance between the radio connector C216 Pin 1, Circuit 833 (GN) and the cab side of the sleeper accessory harness connector C309 Pin 14, Circuit 833 (GN). If the resistance is less than 5 ohms, substitute a known good system, one component at a time. If the known good system functions, have the radio serviced by an authorized service center and replace the CD changer if necessary. Test the system for normal operation. If the resistance is more than 5 ohms, repair the open in the affected circuit(s) in the sleeper accessory harness. Test the system for normal operation.
Audio control protocol to the CD changer	Check the audio control protocol to the CD changer. Measure the resistance between the sleeper side of the accessory harness connector C309 Pin 15, Circuit 832 (Y/BK) and the CD changer connector C764 Pin 6, Circuit 832 (Y/BK). Measure the resistance between the sleeper side of the sleeper accessory harness connector C309 Pin 14, Circuit 833 (GN) and the CD changer connector C764 Pin 12, Circuit 833 (GN). If the resistance is less than 5 ohms, substitute a known good system, one component at a time. If the known good system functions, have the radio serviced by an authorized service center and replace the CD changer if necessary. Test the system for normal operation. If the resistance is more than 5 ohms, repair the open in the affected circuit(s) in the sleeper accessory harness. Test the system for normal operation.

Troubleshooting

Problem—Noisy Reception

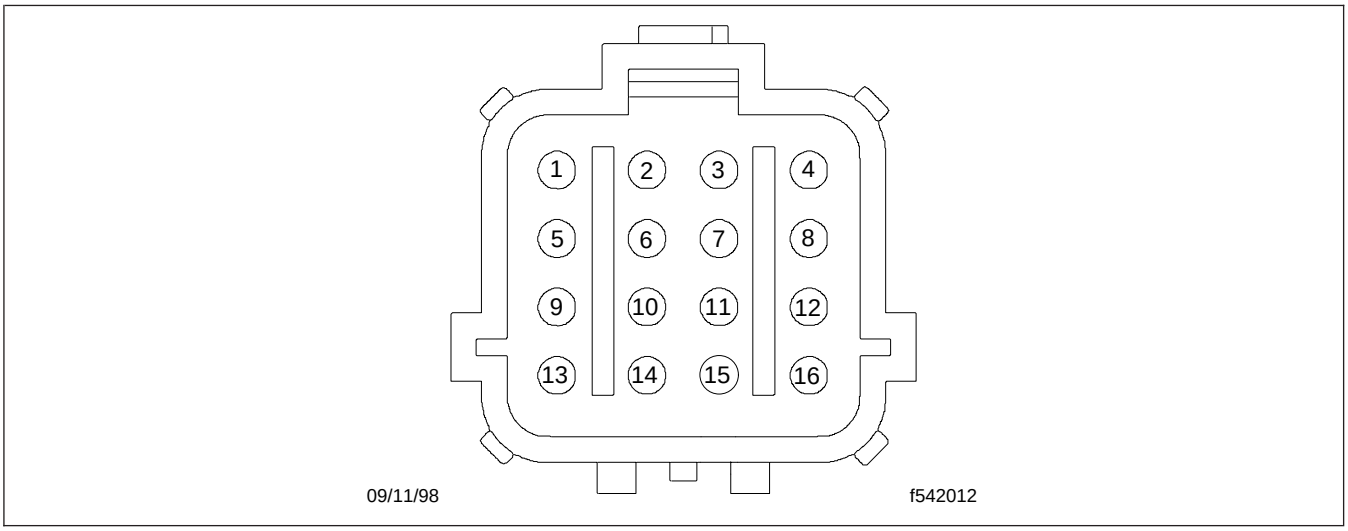


Fig. 9, C309 Sleeper Accessory Harness Connector

Problem—Noisy Reception	
Possible Cause	**Remedy**
Radio	Substitute a known good radio. If the symptom is not present have the radio serviced by an authorized service center. Test the system for normal operation.
Antenna system	If the symptom is present check the antenna. Remove the antenna mast. Check the mast connection to make sure the threads are clean. Tighten the mast. Remove the antenna base. Check the antenna lead-in-cable to make sure that the connection is tight. Then install the antenna base. Remove the radio. Check the antenna lead-in-cable connection to the radio. Reconnect the lead-in-cable. Tune the radio to the strongest signal in the region. If the noisy reception is not present, the system is repaired.
Generator	If the noisy reception is present, check for generator interference. Disconnect the battery ground cable(s). Disconnect the generator connectors. Cover any battery (hot) wires. Connect the battery ground cable(s). Turn the ignition switch to the ACC position. Tune the radio to the strongest signal in the region. If the noisy reception is not present, replace the generator voltage regulator.

Problem—Noisy Reception	
Possible Cause	**Remedy**
Antenna Connections	If the noisy reception is present, check the antenna lead-in cable at the radio. Measure the resistance between the antenna base outside the vehicle and the tip of the antenna lead-in cable at the radio. Measure the resistance between the antenna base outside the vehicle and the metal shield on the antenna lead-in cable at the radio. If the resistance is less than 5 ohms, check the antenna and the lead-in cable for a short. Disconnect the antenna base from the lead-in cable. Measure the resistance between the antenna lead-in cable shield and tip. If the resistance is greater than 10,000 ohms secure the antenna base to the vehicle. Test the system for normal operation. If the resistance is less than 10,000 ohms replace the antenna lead-in cable or the antenna base. Test the system for normal operation. If the resistance is greater than 5 ohms, check the antenna lead-in cable. Disconnect the antenna base from the lead-in cable. Measure the resistance between the antenna lead-in cable center terminals and between the antenna lead-in cable shield (outside) terminals. If the resistance is greater than 5 ohms, replace the antenna lead-in cable. Test the system for normal operation. If the resistance is less than 5 ohms, check the antenna base. Measure the resistance between the antenna mast and the antenna base center terminal. If the resistance is greater than 5 ohms, replace the antenna base. Test the system for normal operation. If the resistance is less than 5 ohms, check the antenna and the antenna lead-in cable for a short. Measure the resistance between the antenna lead-in cable shield and tip. If the resistance is greater than 10,000 ohms, secure the antenna base to the vehicle. Test the system for normal operation. If the resistance is less than 10,000 ohms replace the antenna lead-in cable or the antenna base. Test the system for normal operation.

Problem—Poor Quality/Distorted Sound from One or More Speakers, Weatherband Radio

Problem—Poor Quality/Distorted Sound from One or More Speakers, Weatherband Radio (See Fig. 1, Fig. 10, Fig. 11, Fig. 12 and Fig. 13)	
Possible Cause	**Remedy**
Speaker	Check the suspect speaker(s). Connect the suspect speaker(s) to a bench test audio amplifier. If the speaker is not functioning properly, replace the speaker(s). Test the system for normal operation.
Radio	Check the system with a known good radio. If the symptom is corrected have the radio serviced by an authorized service center. Test the system for normal operation.

Troubleshooting

Problem—Poor Quality/Distorted Sound from One or More Speakers, Weatherband Radio (See Fig. 1, Fig. 10, Fig. 11, Fig. 12 and Fig. 13)	
Possible Cause	**Remedy**
Intermittent connection	Check for a short to ground on the right front speaker feed. Turn the ignition switch to the "Off" position. Disconnect radio connector C217. Measure the resistance between the radio connector C217 Pin 12, Circuit 803 (R/Y) and ground. If the resistance is less than 5 ohms, repair Circuit 803 (R/Y) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the right front speaker feeds. Measure the resistance between the radio connector C217 Pins 12 and 11, Circuits 803 (R/Y) and 287 (BK) and the speaker feed connector C918, Circuits 803 (R/Y) and 287 (BK). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If the resistance is less than 5 ohms, the right front system is OK. If more speakers are distorted, check for a short to ground on the left front speaker feed. Measure the resistance between the radio connector C217 Pin 6, Circuits 802 (BL/Y) and ground. If the resistance is less than 5 ohms, repair Circuit 802 (BL/Y) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the left front speaker feeds. Disconnect the left front speaker connector C919. Measure the resistance between the radio connector C217 Pins 6 and 5, Circuits 802 (BL/Y) and 287 (BK) and the speaker feed connector C919, Circuits 802 (BL/Y) and 287 (BK). If the resistance is less than 5 ohms, the left front system is OK. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation.

Problem—Poor Quality/Distorted Sound from One or More Speakers, Weatherband Radio (See Fig. 1, Fig. 10, Fig. 11, Fig. 12 and Fig. 13)	
Possible Cause	**Remedy**
Able Body sleeper speaker feeds (in-cab wiring)	If more speakers are distorted check for short to ground on the Able Body rear speaker feeds. Measure the resistance between the radio connector C217 Pins 4 and 10, Circuits 807 (O) and 806 (W) and ground. If the resistance is less than 5 ohms, repair the affected circuit(s) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the Able Body sleeper speaker feeds (in-cab wiring). Disconnect the sleeper accessory harness connector C310. Measure the resistance between the radio connector C217 Pins 4, 3, 10 and 9 Circuits 807 (O), 287 (BK), 806 (W) and 287 (BK) and the cab side of the sleeper accessory harness connector C310 Pins 3, 4, 2 and 1 Circuits 807 (O), 287 (BK), 806 (W) and 287 (BK). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of the Able Body sleeper speaker ground feeds. Disconnect the left speaker connector C727 and right sleeper speaker connector C728. Measure the resistance between the sleeper side of the sleeper accessory harness connector C310 Pins 4 and 1, Circuits 410 (P) and 430 (P) and the speaker feed connectors C727 and C728, Circuits 410 (P) and 430 (P). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of the Able Body sleeper speaker positive feeds to the rear radio control (in-sleeper wiring). Disconnect the rear radio control connector C729. Measure the resistance between the sleeper side of the sleeper accessory harness connector C310 Pins 3 and 2, Circuits 400 (O) and 420 (W) and the rear radio control connector C729, Circuits 400 (O) and 420 (W). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of the Able Body sleeper speaker positive feeds to the speakers (in-sleeper wiring). Measure the resistance between the rear radio control connector C729, Circuits 400 (O) and 450 (W) and the speaker feed connectors C727 and C728, Circuits 400 (O) and 450 (W). If the resistance is less than 5 ohms, replace the rear radio control. Test the system for normal operation. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation.

Problem—Poor Quality/Distorted Sound from One or More Speakers, Standard Radio

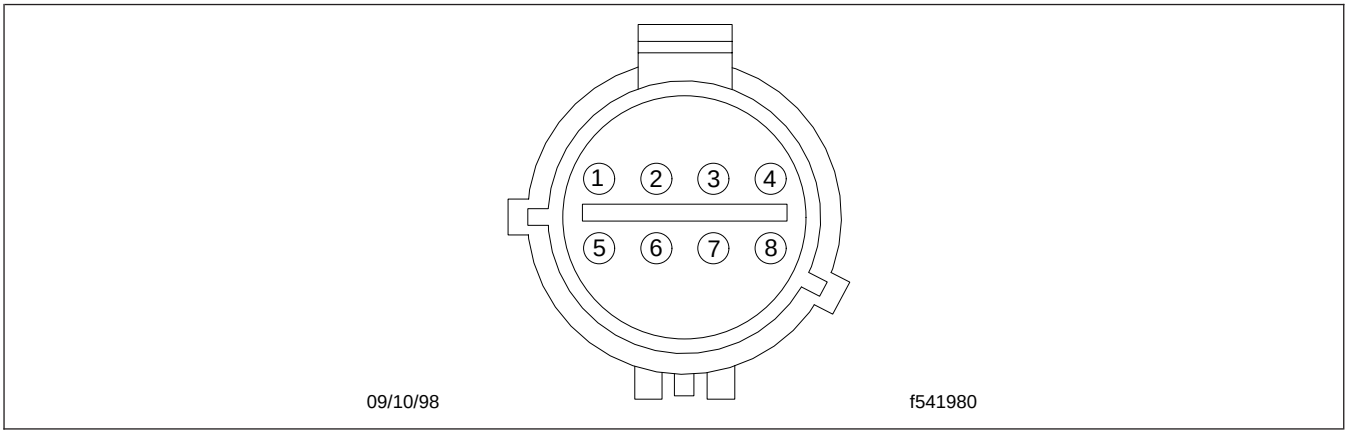


Fig. 10, C246 Interrupt Module Connector

Troubleshooting

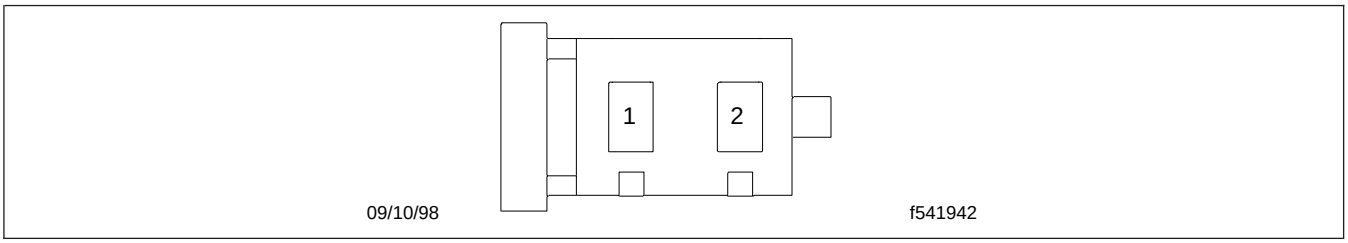


Fig. 11, C918 Speaker Feed Connector

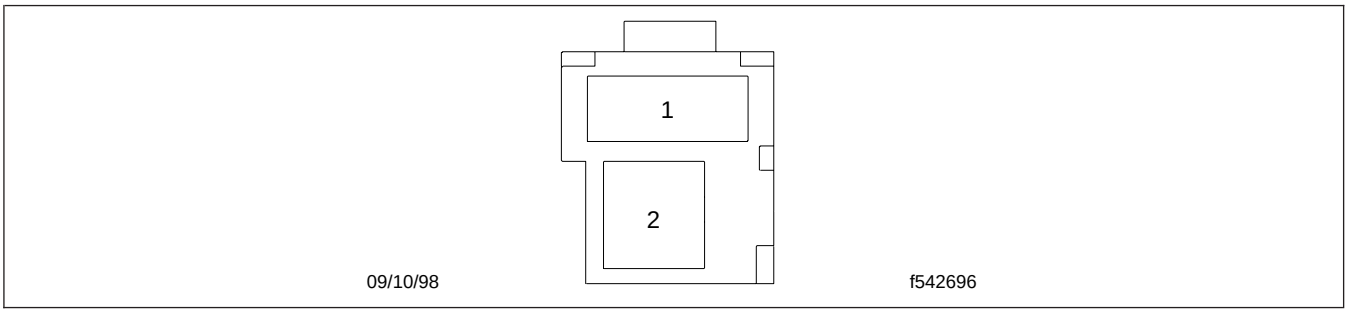


Fig. 12, C727 Speaker Feed Connector

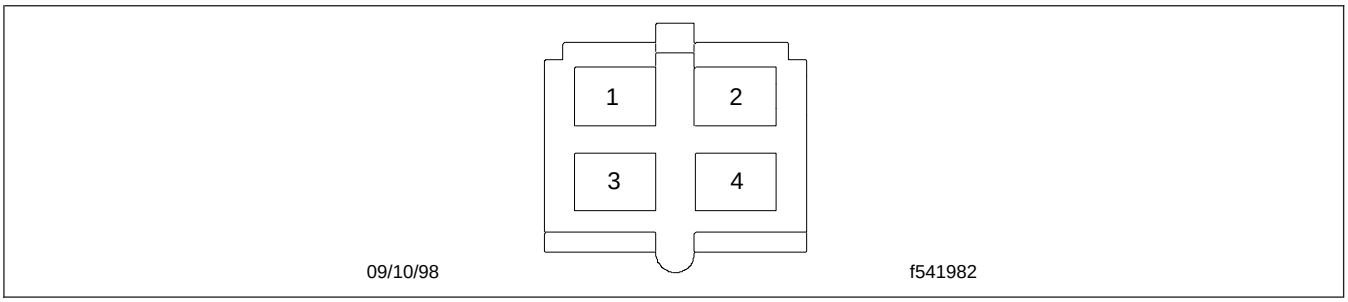


Fig. 13, C310 Sleeper Accessory Harness Connector

Problem—Poor Quality/Distorted Sound from One or More Speakers, Standard Radio (See Fig. 3, Fig. 10, Fig. 11, Fig. 12 and Fig. 13)	
Possible Cause	**Remedy**
Speaker	Check the suspect speaker(s). Connect the suspect speaker(s) to a bench test audio amplifier. If the speaker is not functioning properly replace the speaker(s). Test the system for normal operation.
Radio	Check the system with a known good radio. If the symptom is corrected have the radio serviced by an authorized service center. Test the system for normal operation.

Problem—Poor Quality/Distorted Sound from One or More Speakers, Standard Radio (See Fig. 3, Fig. 10, Fig. 11, Fig. 12 and Fig. 13)	
Possible Cause	**Remedy**
Short to Ground	Check for a short to ground on the right front speaker feed. Turn the ignition switch to the "Off" position. Disconnect radio connector C220. Measure the resistance between the radio connector C220 Pin 4, Circuit 803 (R/Y) and ground. If the resistance is less than 5 ohms, repair Circuit 803 (R/Y) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the right front speaker feeds. Measure the resistance between the radio connector C220 Pins 4 and 3, Circuits 803 (R/Y) and 287 (BK) and the speaker feed connector C918, Circuits 803 (R/Y) and 287 (BK). If the resistance is less than 5 ohms, the right front system is OK. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If more speakers are distorted, check for a short to ground on the left front speaker feed. Measure the resistance between the radio connector C220 Pin 8, Circuits 802 (BL/Y) and ground. If the resistance is less than 5 ohms, repair Circuit 802 (BL/Y) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the left front speaker feeds. Disconnect the left front speaker connector C919. Measure the resistance between the radio connector C220 Pins 8 and 7, Circuits 802 (BL/Y) and 287 (BK) and the speaker feed connector C919, Circuits 802 (BL/Y) and 287 (BK). If the resistance is less than 5 ohms, the left front system is OK. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If more speakers are distorted, check for short to ground on the Able Body rear speaker feeds. Measure the resistance between the radio connector C220 Pins 6 and 2, Circuits 807 (O) and 806 (W) and ground. If the resistance is less than 5 ohms, repair the affected circuit(s) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the Able Body sleeper speaker feeds (in-cab wiring). Disconnect the sleeper accessory harness connector C310. Measure the resistance between the radio connector C220 Pins 6, 5, 2 and 1 Circuits 807 (O), 287 (BK), 806 (W) and 287 (BK) and the cab side of the sleeper accessory harness connector C310 Pins 3, 4, 2 and 1 Circuits 807 (O), 287 (BK), 806 (W) and 287 (BK). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of the Able Body sleeper speaker ground feeds. Disconnect the left speaker connector C727 and right sleeper speaker connector C728. Measure the resistance between the sleeper side of the sleeper accessory harness connector C310 Pins 4 and 1, Circuits 410 (P) and 430 (P) and the speaker feed connectors C727 and C728, Circuits 410 (P) and 430 (P). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation.

Troubleshooting

Problem—Poor Quality/Distorted Sound from One or More Speakers, Standard Radio	
Possible Cause	**Remedy**
Short to Ground	If the resistance is less than 5 ohms, check the continuity of the Able Body sleeper speaker positive feeds to the rear radio control (in-sleeper wiring), disconnect the rear radio control connector C729. Measure the resistance between the sleeper side of the sleeper accessory harness connector C310 Pins 3 and 2, Circuits 400 (O) and 420 (W) and the speaker feed connectors C727 and C728, Circuits 400 (O) and 420 (W). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of the Able Body sleeper speaker positive feeds to the rear radio control (in-sleeper wiring). Measure the resistance between the rear radio control connector C729, Circuits 400 (O) and 450 (W) and the speaker feed connectors C727 and C728, Circuits 400 (O) and 450 (W). If the resistance is less than 5 ohms, replace the rear radio control. Test the system for normal operation. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation.

Problem—Poor Quality/Distorted Sound from One or More Speakers, Premium Radio

Problem—Poor Quality/Distorted Sound from One or More Speakers, Premium Radio (See Fig. 4, Fig. 8, Fig. 9, Fig. 10, Fig. 11 and Fig. 14)	
Possible Cause	**Remedy**
NOTE: Circuits 857 (W) and 853 (R/GN), 855 (P) and 854 (BR), 851 (GN) and 850 (BL/W), 856 (O) and 857 (W) are twisted pairs at 24 turns/meter (7.3 turns/foot). These circuits are the radio output circuits to the premium amplifier. The twisted pairs are shielded by Pin 14 of the radio connector C216. The shield is spirally wrapped aluminum with a 50% overlap per turn. If a repair of a signal line is necessary, use 20 gauge wire and preserve the twisted pair specification. If the shield is damaged, it must be replaced and must conform to the above specification. Test only the suspect speaker circuits. Shake the wire harness while testing the circuit to expose an intermittent condition which may be causing the distorted sound.	
Speaker	Check the suspect speaker(s). Connect the suspect speaker(s) to a bench test audio amplifier.
Radio	Check the audio system with a known good radio. If the symptom is corrected have the radio serviced by an authorized service center. Test the system for normal operation. If the symptom is not corrected check the audio system with a known good amplifier. If the symptom is corrected replace the amplifier. Test the system for normal operation.

Problem—Poor Quality/Distorted Sound from One or More Speakers, Premium Radio (See Fig. 4, Fig. 8, Fig. 9, Fig. 10, Fig. 11 and Fig. 14)	
Possible Cause	**Remedy**
NOTE: Circuits 857 (W) and 853 (R/GN), 855 (P) and 854 (BR), 851 (GN) and 850 (BL/W), 856 (O) and 857 (W) are twisted pairs at 24 turns/meter (7.3 turns/foot). These circuits are the radio output circuits to the premium amplifier. The twisted pairs are shielded by Pin 14 of the radio connector C216. The shield is spirally wrapped aluminum with a 50% overlap per turn. If a repair of a signal line is necessary, use 20 gauge wire and preserve the twisted pair specification. If the shield is damaged, it must be replaced and must conform to the above specification. Test only the suspect speaker circuits. Shake the wire harness while testing the circuit to expose an intermittent condition which may be causing the distorted sound.	
Intermittent connection	Check the shield wire ground feed from the radio. Turn the ignition to the "Off" position. Disconnect the radio connector C216. Remove the Circuit 57 (BK) wire from the radio connector C216. Re-connect the radio connector C216. Measure the resistance between the open terminal 14 and ground. If the resistance is more than 5 ohms, verify a good ground at the radio connector C219 Pin 7. Have the radio serviced by an authorized service center. Test the system for normal operation. If the resistance is less than 5 ohms, check the shields for a good ground. Install the Circuit 57 (BK) wire to the radio connector C216. Disconnect the radio connector C216. Measure the resistance between the shield terminating near the amplifier connector C208 and ground. Measure the resistance between the shield terminating near the radio connector C216 and ground. Measure the resistance between the shields terminating in the harness takeout/splice region above and to the right of the dash air manifold and ground. If the resistance is more than 5 ohms, replace the entire affected shield wire. Test the system for normal operation. If the resistance is less than 5 ohms, check for a short to ground on the amplifier input feeds. Disconnect the radio connector C216. Measure the resistance between the radio connector C216 Pins 13, 5, 11 and 3, Circuits 857 (W), 855 (P), 851 (GN) and 856 (O) and ground. If the resistance is less than 5 ohms, repair the affected circuit(s) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity between the radio and the amplifier. Disconnect the amplifier connector C208. Measure the resistance between the radio connector C216 Pins 13, 12, 5, 4, 11, 10, 3 and 2, Circuits 857 (W), 853 (R/GN), 855 (P), 854 (BR), 851 (GN), 850 (BL/W), 856 (O) and 857 (W) and the amplifier connector C208 Pins 8, 4, 6, 2, 7, 3, 5 and 1, Circuits 857 (W), 853 (R/GN), 855 (P), 854 (BR), 851 (GN), 850 (BL/W), 856 (O) and 857 (W). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If the resistance is less than 5 ohms, check for a short to ground on the right front speaker feed. Disconnect the right speaker front speaker connector C918. Measure the resistance between the amplifier connector C209 Pin 4 Circuit 803 (R/Y) and ground.

Troubleshooting

Problem—Poor Quality/Distorted Sound from One or More Speakers, Premium Radio	
Possible Cause	**Remedy**
NOTE: Circuits 857 (W) and 853 (R/GN), 855 (P) and 854 (BR), 851 (GN) and 850 (BL/W), 856 (O) and 857 (W) are twisted pairs at 24 turns/meter (7.3 turns/foot). These circuits are the radio output circuits to the premium amplifier. The twisted pairs are shielded by Pin 14 of the radio connector C216. The shield is spirally wrapped aluminum with a 50% overlap per turn. If a repair of a signal line is necessary, use 20 gauge wire and preserve the twisted pair specification. If the shield is damaged, it must be replaced and must conform to the above specification. Test only the suspect speaker circuits. Shake the wire harness while testing the circuit to expose an intermittent condition which may be causing the distorted sound.	
Intermittent connection	If the resistance is less than 5 ohms, repair Circuit 803 (R/Y) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the right front speaker feeds. Disconnect the right front speaker connector C918. Measure the resistance between the amplifier connector C209 Pin 4 and 3, Circuits 803 (R/Y) and 287 (BK) and the speaker feed connector C918, Circuits 803 (R/Y) and 287 (BK). If the resistance is less than 5 ohms, the right front system is OK. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If more speakers are distorted, check for a short to ground on the left front speaker feed. Measure the resistance between the amplifier connector C209 Pin 8 Circuit 802 (BL/Y) and ground. If the resistance is less than 5 ohms, repair Circuit 802 (BL/Y) for a short to ground. Test the system for normal operation.

Problem—Poor Quality/Distorted Sound from One or More Speakers, Premium Radio

Problem—Poor Quality/Distorted Sound from One or More Speakers, Premium Radio	
Possible Cause	**Remedy**
NOTE: Circuits 857 (W) and 853 (R/GN), 855 (P) and 854 (BR), 851 (GN) and 850 (BL/W), 856 (O) and 857 (W) are twisted pairs at 24 turns/meter (7.3 turns/foot). These circuits are the radio output circuits to the premium amplifier. The twisted pairs are shielded by Pin 14 of the radio connector C216. The shield is spirally wrapped aluminum with a 50% overlap per turn. If a repair of a signal line is necessary, use 20 gauge wire and preserve the twisted pair specification. If the shield is damaged, it must be replaced and must conform to the above specification. Test only the suspect speaker circuits. Shake the wire harness while testing the circuit to expose an intermittent condition which may be causing the distorted sound.	
Intermittent connection	If the resistance is more than 5 ohms check the continuity of the left front speaker feeds Disconnect the left front speaker connector C919. Measure the resistance between the amplifier connector C209 Pins 8 and 7, Circuits 802 (BL/Y) and 287 (BK) and the speaker feed connector C919, Circuits 802 (BL/Y) and 287 (BK). If the resistance is less than 5 ohms, the right front system is OK. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If more speakers are distorted, check for a short to ground on the rear speaker feeds (in-cab wiring). NOTE: The short to ground may be present in the SilverStar sleeper wiring. Measure the resistance between the amplifier connector C209 Pins 6 and 2, Circuits 807 (O) and 806 (W) and ground. If the resistance is less than 5 ohms, repair the affected circuit(s) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the rear speaker feeds (in-cab wiring). Disconnect the left rear speaker connector C302 and the right rear speaker connector C306. Measure the resistance between the amplifier connector C209 Pins 6, 5, 2 and 1, Circuits 807 (O), 806 (W) and 287 (BK) and the speaker feed connectors C302, C306, Circuits 807 (O), 287 (BK), 806 (W) and 287 (BK). If the resistance is less than 5 ohms, the rear system is OK. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If more speakers are distorted, check the continuity of the SilverStar sleeper speaker feeds (in-cab wiring). Disconnect the sleeper accessory harness connector C309. Measure the resistance between the amplifier connector C209 Pins 6, 5, 2 and 1, Circuits 807 (O), 287 (BK), 806 (W), and 287 (BK) and cab side of the sleeper accessory harness connector C309 Pins 12, 4, 5, and 3, Circuits 807 (O), 287 (BK), 806 (W) and 287 (BK). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If the resistance is less than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If more speakers are distorted, check the continuity of the SilverStar sleeper rear speaker feeds (in-cab Wiring). Disconnect the left and right rear speaker connectors C735 and C734. Measure the resistance between the sleeper side of the sleeper accessory harness connector C309 Pins 12, 4, 5 and 3, Circuits 807 (O), 287 (BK), 806 (W), and 287 (BK) and the speaker feed connectors C735 and C734, Circuits 807 (O), 287 (BK), 806 (W) and 287 (BK). If the resistance is less than 5 ohms, the rear system is OK. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation.

Troubleshooting

Problem—No Sound from One or More of the Speakers, Weatherband Radio

Problem—No Sound from One or More of the Speakers, Weatherband Radio (See Fig. 1, Fig. 10, Fig. 11, Fig. 12 and Fig. 13)	
Possible Cause	**Remedy**
Speaker	Check the suspect speaker(s). Connect the suspect speaker(s) to a bench test audio amplifier. If the speaker is not OK replace the speaker(s). Test the system for normal operation.
Radio	Check the audio system with a known good radio. If the symptom is corrected have the radio serviced by an authorized service center. Test the system for normal operation. If the symptom is not corrected, check for a short to ground on the right front speaker feed. Disconnect the radio connector C217. Measure the resistance between the radio connector C217 Pin 12, Circuit 803 (R/Y) and ground. If the resistance is less than 5 ohms, repair Circuit 803 (R/Y) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the right front speaker feeds. Disconnect the radio connector C918. Measure the resistance between the radio connector C217 Pins 12, and 11, Circuits 803 (R/Y), 287 (BK) and the speaker feed connector C918, Circuits 803 (R/Y) and 287 (BK). If the resistance is less than 5 ohms, the right front system is OK. If the resistance is less than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If more speakers are inoperative, check for a short to ground on the left front speaker feed. Measure the resistance between the radio connector C217 Pin 6 Circuit 802 (BL/Y) and ground. If the resistance is less than 5 ohms, repair Circuit 802 (BL/Y) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the left front speaker feeds. Disconnect the left front speaker connector C919. Measure the resistance between the radio connector C217 Pins 6 and 5, Circuits 802 (BL/Y) and 287 (BK) and the speaker feed connector C919, Circuits 802 (BL/Y) and 287 (BK). If the resistance is less than 5 ohms, the left front system is OK. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If more speakers are inoperative, check for a short to ground on the Able Body rear speaker feeds. Measure the resistance between the radio connector C217 Pins 4 and 10, Circuits 807 (O) and 806 (W) and ground. If the resistance is less than 5 ohms, repair the affected circuit(s). Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the Able Body sleeper feeds (in-cab wiring). Disconnect the sleeper accessory harness connector C310.

Problem—No Sound from One or More of the Speakers, Weatherband Radio	
Possible Cause	**Remedy**
Radio	Measure the resistance between the radio connector C217 Pins 4, 3, 10 and 9, Circuits 807 (O), 287 (BK), 806 (W) and 287 (BK) and the cab side of the sleeper accessory harness connector C310 Pins 3, 4, 2 and 1, Circuits 807 (O), 287 (BK), 806 (W) and 287 (BK). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of the Able Body sleeper speaker ground feeds. Disconnect the left sleeper speaker connector C727 and the right sleeper speaker connector C728. Measure the resistance between the sleeper side of the sleeper accessory harness connector C310 Pins 4 and 1, Circuits 410 (P) and 430 (P) and the speaker feed connectors C727 and C728, Circuits 410 (P) and 430 (P). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of the Able Body sleeper speaker positive feeds to the rear radio control (in-sleeper wiring). Measure the resistance between the sleeper side of the sleeper accessory harness connector C310 Pins 3 and 2, Circuits 400 (O) and 420 (W) and the rear radio control connector C729 Pins 3 and 4, Circuits 400 (O) and 420 (W). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of the Able Body sleeper speaker positive feeds to the speakers (in-sleeper wiring). Measure the resistance between the rear radio control connector C729 Pins 1 and 2, Circuits 400 (O) and 450 (W) and the speaker feed connectors C727 Pin 2 and C728 Pin 2, Circuits 400 (O) and 450 (W). If the resistance is less than 5 ohms, replace the rear radio control. Test the system for normal operation. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation.

Problem—No Sound from One or More of the Speakers, Standard Radio

Problem—No Sound from One or More of the Speakers, Standard Radio (See Fig. 1, Fig. 3, Fig. 10, Fig. 11, Fig. 12 and Fig. 13)	
Possible Cause	**Remedy**
NOTE: Test only the suspect speaker circuits.	
Speaker	Check the suspect speaker(s). Connect the suspect speaker(s) to a bench test audio amplifier. If the speaker is not OK, replace the speaker(s). Test the system for normal operation.

Troubleshooting

Problem—No Sound from One or More of the Speakers, Standard Radio (See Fig. 1, Fig. 3, Fig. 10, Fig. 11, Fig. 12 and Fig. 13)	
Possible Cause	**Remedy**
Radio	Check the audio system with a known good radio. If the symptom is corrected have the radio serviced by an authorized service center. Test the system for normal operation. If the symptom is not corrected check for a short to ground on the right front speaker feed. Disconnect the radio connector C220. Measure the resistance between the radio connector C220 Pin 4, Circuit 803 (R/Y) and ground. If the resistance is less than 5 ohms, repair Circuit 803 (R/Y) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the right front speaker feeds. Disconnect the radio connector C918. Measure the resistance between the radio connector C220 Pins 4, and 3, Circuits 803 (R/Y), 287 (BK) and the speaker feed connector C918, Circuits 803 (R/Y) and 287 (BK). If the resistance is less than 5 ohms, the right front system is OK. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If more speakers are inoperative, check for a short to ground on the left front speaker feed. Measure the resistance between the radio connector C220 Pin 8 Circuit 802 (BL/Y) and ground. If the resistance is less than 5 ohms, repair Circuit 802 (BL/Y) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the left front speaker feeds. Disconnect the left front speaker connector C919. Measure the resistance between the radio connector C220 Pins 8 and 7, Circuits 802 (BL/Y) and 287 (BK) and the speaker feed connector C919, Circuits 802 (BL/Y) and 287 (BK). If the resistance is less than 5 ohms, the left front system is OK. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If more speakers are inoperative, check for a short to ground on the Able Body rear speaker feeds. Measure the resistance between the radio connector C220 Pins 6 and 2, Circuits 807 (O) and 806 (W) and ground. If the resistance is less than 5 ohms, repair the affected circuit(s). If the resistance is more than 5 ohms, check the continuity of the Able Body sleeper feeds (in-cab wiring), disconnect the sleeper accessory harness connector C310. Measure the resistance between the radio connector C220 Pins 6, 5, 2 and 1, Circuits 807 (O), 287 (BK), 806 (W) and 287 (BK) and the cab side of the sleeper accessory harness connector C310 Pins 3, 4, 2 and 1, Circuits 807 (O), 287 (BK), 806 (W) and 287 (BK). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation.

Problem—No Sound from One or More of the Speakers, Standard Radio	
Possible Cause	**Remedy**
NOTE: Test only the suspect speaker circuits.	

Problem—No Sound from One or More of the Speakers, Standard Radio	
Possible Cause	**Remedy**
Radio	If the resistance is less than 5 ohms, check the continuity of the Able Body sleeper speaker ground feeds. Disconnect the left sleeper speaker connector C727 and the right sleeper speaker connector C728. Measure the resistance between the sleeper side of the sleeper accessory harness connector C310 Pins 4 and 1, Circuits 410 (P) and 430 (P) and the speaker feed connectors C727 and C728, Circuits 410 (P) and 430 (P). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the Able Body sleeper speaker positive feeds to the rear radio control (in-sleeper wiring). Disconnect the rear radio connector C729. Measure the resistance between the sleeper side of the sleeper accessory harness connector C310 Pins 3 and 2, Circuits 400 (O) and 420 (W) and the rear radio control connector C729, Circuits 400 (O) and 420 (W). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of the Able Body sleeper speaker positive feeds to the speakers (in-sleeper wiring). Measure the resistance between the rear radio control connector C729, Circuits 400 (O) and 450 (W) and the speaker feed connectors C727 and C728, Circuits 400 (O) and 450 (W). If the resistance is less than 5 ohms, replace the rear radio control. Test the system for normal operation. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation.

Problem—No Sound From One or More of the Speakers, Premium Radio

Problem—No Sound From One or More of the Speakers, Premium Radio (See Fig. 3, Fig. 4, Fig. 8, Fig. 9, Fig. 10 and Fig. 11)	
Possible Cause	**Remedy**
NOTE: Test only the suspect speaker circuits. Circuits 857 (W) and 853 (R/GN), 855 (P) and 854 (BR), 851 (GN) and 850 (BL/W), 856 (O) and 857 (W) are twisted pairs at 24 turns/meter (7.3 turns/foot). These circuits are the radio output circuits to the premium amplifier. The twisted pairs are shielded by Pin 14 of the radio connector C216. If a repair of a signal line is necessary, use 20 gauge wire and preserve the twisted pair specification.	
Speaker	Check the suspect speaker(s). Connect the suspect speaker(s) to a bench test audio amplifier. If the speaker is not OK, replace the speaker(s). Test the system for normal operation.

Troubleshooting

Problem—No Sound From One or More of the Speakers, Premium Radio (See Fig. 3, Fig. 4, Fig. 8, Fig. 9, Fig. 10 and Fig. 11)	
Possible Cause	**Remedy**
NOTE: Test only the suspect speaker circuits. Circuits 857 (W) and 853 (R/GN), 855 (P) and 854 (BR), 851 (GN) and 850 (BL/W), 856 (O) and 857 (W) are twisted pairs at 24 turns/meter (7.3 turns/foot). These circuits are the radio output circuits to the premium amplifier. The twisted pairs are shielded by Pin 14 of the radio connector C216. If a repair of a signal line is necessary, use 20 gauge wire and preserve the twisted pair specification.	
Radio	Check the audio system with a known good radio. If the symptom is corrected have the radio serviced by an authorized service center. Test the system for normal operation. If the symptom is not corrected check the audio system with a known good amplifier. If the symptom is corrected replace the amplifier. Test the system for normal operation. Check the radio output-to-amplifier and output-to-rear radio control for a normal ground condition. Disconnect the amplifier connector C209 and rear radio control connector C762. Remove the Circuit 689 (P) wires from the amplifier connector C209, Pin 12 and from the rear radio control module connector C762, Pin 8. Do not let the Circuit 689 (P) wires touch ground and cover the wire terminations until ready to probe. Disconnect the amplifier connector C209 and rear radio control connector C762. Turn the ignition to the ACC position. Turn the radio on and make sure that no calls on the cellular phone are received during this test step. Measure the voltage between the Circuit 689 (P) wire terminations at the amplifier connector and at the rear radio control connector and ground. If voltage is present, do not proceed. Repair Circuit 689 (P) for a short to power. Measure the resistance between the Circuit 689 (P) wire terminations at the amplifier connector and at the rear radio control connector and ground. If the resistance is more than 5 ohms, repair Circuit 689 (P) for an open circuit. Test the system for normal operation. If the resistance is less than 5 ohms, check for a short to ground on the amplifier input feeds. Disconnect the radio connector C216. Measure the resistance between the radio connector C216 Pins 13, 5, 11 and 3, Circuits 857 (W), 855 (P), 851 (GN) and 856 (O) and ground. If the resistance is less than 5 ohms, repair the affected circuit(s) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity between the radio and the amplifier. Measure the resistance between the radio connector C216 Pins 13, 12, 5, 4, 11, 10, 3 and 2, Circuits 857 (W), 853 (R/GN), 855 (P), 854 (BR), 851 (GN), 850 (BL/W), 856 (O), and 857 (W) and the amplifier connector C208 Pins 8, 4, 6, 2, 7, 3, 5 and 1, Circuits 857 (W), 853 (R/GN), 855 (P), 854 (BR), 851 (GN), 850 (BL/W), 856 (O), and 857 (W). If the resistance is less than 5 ohms, check for a short to ground in the right front speaker leads. Disconnect the amplifier connector C209. Measure the resistance between the amplifier connector C209 Pins 4, Circuit 803 (R/Y) and ground. If the resistance is less than 5 ohms, repair Circuit 803 (R/Y) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the right front speaker feeds. Disconnect the right front speaker connector C918. Measure the resistance between the amplifier connector C209 Pins 4 and 3, Circuits 803 (R/Y) and 287 (BK) and the speaker feed connector C918, Circuits 803 (R/Y) and 287 (BK). If the resistance is less than 5 ohms, the right front system is OK. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation.

Problem—No Sound From One or More of the Speakers, Premium Radio	
Possible Cause	**Remedy**
NOTE: Test only the suspect speaker circuits. Circuits 857 (W) and 853 (R/GN), 855 (P) and 854 (BR), 851 (GN) and 850 (BL/W), 856 (O) and 857 (W) are twisted pairs at 24 turns/meter (7.3 turns/foot). These circuits are the radio output circuits to the premium amplifier. The twisted pairs are shielded by Pin 14 of the radio connector C216. If a repair of a signal line is necessary, use 20 gauge wire and preserve the twisted pair specification.	
Radio	If more speakers are inoperative, check for a short to ground on the left front speaker feed. Measure the resistance between the amplifier connector C209 Pin 8, circuit 802 (BK/Y) and ground. If the resistance is less than 5 ohms, repair Circuit 802 (BL/Y) for a short to ground. Test the system for normal operation. If the resistance is more than 5 ohms, check the continuity of the left-front speaker feeds. Disconnect the left front speaker connector C919. Measure the resistance between the amplifier connector C209 Pin 8, Circuit 802 (BL/Y) and ground. If the resistance is less than 5 ohms, the front speaker system is OK. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). If more speakers are inoperative check for a short to ground on the rear speaker feeds (in-cab wiring). Disconnect the left front speaker connector C919. Measure the resistance between the amplifier connector C209 Pins 6 and 2, Circuits 807 (O) and 806 (W) and ground. If the resistance is less than 5 ohms, repair the affected circuit(s) for a short to ground. Test the system for normal operation. NOTE: The short to ground may be present in the SilverStar sleeper wiring. If the resistance is more than 5 ohms, check the continuity of the rear speaker feeds (in-cab wiring). Disconnect the left front speaker connector C919. Measure the resistance between the amplifier connector C209 Pins 6, 5, 2 and 1, Circuits 807 (O), 287 (BK), 806 (W), and 287 (BK) and the speaker feed connectors C302 and C306, Circuits 807 (O), 287 (BK), 806 (W), and 287 (BK). If the resistance is less than 5 ohms, the rear system is OK. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If more speakers are inoperative, check the continuity of the SilverStar sleeper feeds (in-cab wiring) disconnect the sleeper accessory harness connector C309. Measure the resistance between the sleeper side of the sleeper accessory harness connector C309 Pins 12, 4, 5 and 3, Circuits 807 (O), 287 (BK), 806 (W), and 287 (BK) and the speaker feed connectors C735 and C734, Circuits 807 (O), 287 (BK), 806 (W) and 287 (BK). If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation. If the resistance is less than 5 ohms, check the continuity of the SilverStar sleeper feeds (in-sleeper wiring). Disconnect the left and right rear speaker connectors C735 and C734. Measure the resistance between the sleeper side of the sleeper accessory harness connector C309 Pins 12, 4, 5 and 3, Circuits 807 (O), 287 (BK), 806 (W), and 287 (BK) and the speaker feed connectors C735 and C734, Circuits 807 (O), 287 (BK), 806 (W) and 287 (BK). If the resistance is less than 5 ohms, the rear speaker system is OK. If the resistance is more than 5 ohms, repair the open in the affected circuit(s). Test the system for normal operation.

Troubleshooting

Problem—Subwoofer Speaker Inoperative, SilverStar Sleeper

Problem—Subwoofer Speaker Inoperative, SilverStar Sleeper (See Fig. 8, Fig. 11, Fig. 14, Fig. 15 and Fig. 16)	
Possible Cause	**Remedy**
NOTE: Circuits 851 (GN) and 850 (BL/W), 856 (O) and 857 (W) are line level inputs to the rear radio control module and are twisted pairs at 24 turns/meter (7.3 turns/foot). The twisted pairs are shielded by Pin 14 of the radio connector C216. The shield is spirally wrapped aluminum with a 50% overlap per turn. If a repair of a signal line is necessary, use 20 gauge wire and preserve the twisted configuration specification. If the shield is damaged, it must be replaced and must conform to this specification.	
Subwoofer	Check the system with a known good subwoofer. If the symptom is corrected, replace the subwoofer. Test the system for normal operation. If the symptom is not corrected, check the subwoofer speaker. Connect the subwoofer speaker to a bench Test audio amplifier. If the speaker is not OK replace the subwoofer speaker. Test the system for normal operation.
Missing power	Check the power feeds to the subwoofer. Turn the ignition to the "Off" position. Disconnect the subwoofer connector C752. Measure the voltage between the subwoofer connector C752 Pins 4, 5 and 6, Circuit 37 (BK/Y) and ground. If the voltage is less than 10 volts, check for an open on the power feed. Disconnect the battery ground cable(s). Measure the resistance between the bottom pin of the sleeper fuse panel Fuse 3, Circuit 37 (BK/Y) and the subwoofer connector C752 Pins 4, 5 and 6, Circuit 37 (BK/Y). If the voltage is less than 10 volts, repair Circuit 150 (R) feeding Fuse 3. Test the system for normal operation. If the voltage is greater than 10 volts, check the subwoofer grounds.
Missing ground	Check the subwoofer grounds. Disconnect the battery ground cable(s). Measure the resistance between the subwoofer connector C752 Pins 1, 2 and 3, Circuit 57 (BK) and ground. If the resistance is more than 5 ohms, repair Circuit 57 (BK) for an open circuit. Test the system for normal operation. If the resistance is less than 5 ohms, check the subwoofer speaker wiring.
Subwoofer speaker wiring	Disconnect the subwoofer speaker connector C750. Measure the resistance between the subwoofer connector C752 Pins 7 and 8, Circuits 822 (BR) and 287 (BK) and the subwoofer speaker connector C750, Circuits 822 (BR) and 287 (BK). If the resistance is more than 5 ohms, repair the affected circuit(s) for an open. Test the system for normal operation. If the resistance is less than 5 ohms, check the subwoofer enable circuit for voltage.

Problem—Subwoofer Speaker Inoperative, SilverStar Sleeper (See Fig. 8, Fig. 11, Fig. 14, Fig. 15 and Fig. 16)	
Possible Cause	**Remedy**
Subwoofer enable circuit	Disconnect the subwoofer connector C751. Connect the battery ground cable(s). Turn the ignition key to the ACC position. Turn the radio on. Measure the voltage between the subwoofer connector C751 Pin 2, Circuit 830 (GN/W) and ground. If the voltage is not equal to 5 volts, check the subwoofer enable output at the amplifier. Turn the ignition to the "Off" position. Disconnect the amplifier connector C207. Remove the Circuit 830 (GN/W) wire from the amplifier connector C207. Reconnect the amplifier connector C207. Turn the ignition to the ACC position. Turn the radio on. Measure the voltage between the open terminal 10 and ground. If the voltage is equal to 5 volts, repair Circuit 830 (GN/W) for an open between the subwoofer and the amplifier. Test the system for normal operation. If the voltage is not equal to 5 volts, replace the amplifier. Test the system for normal operation. If the subwoofer enable circuit voltage was equal to 5 volts, check the continuity of the line level audio feeds. Turn the ignition to the "Off" position. Disconnect the amplifier connector C207. Measure the resistance between the amplifier connector C207 Pins 9 and 3, Circuits 915 (BK/O) and 916 (R) and the subwoofer connector C751 Pins 5 and 6, Circuits 915 (BK/O) and 916 (R). If the resistance is less than 5 ohms, replace the amplifier. Test the system for normal operation. If the resistance is more than 5 ohms, repair the affected circuit(s) for an open. Test the system for normal operation.

Troubleshooting

Problem—No Auxiliary Headphone Audio, SilverStar Sleeper

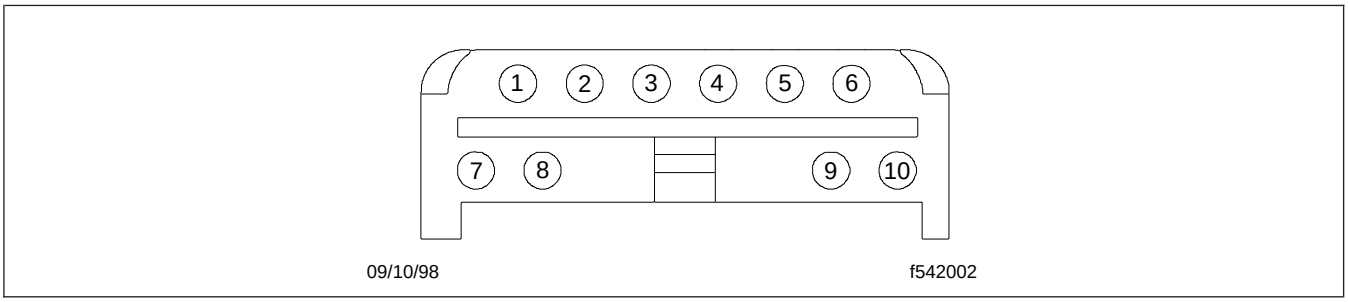


Fig. 15, C750 Subwoofer Speaker Connector

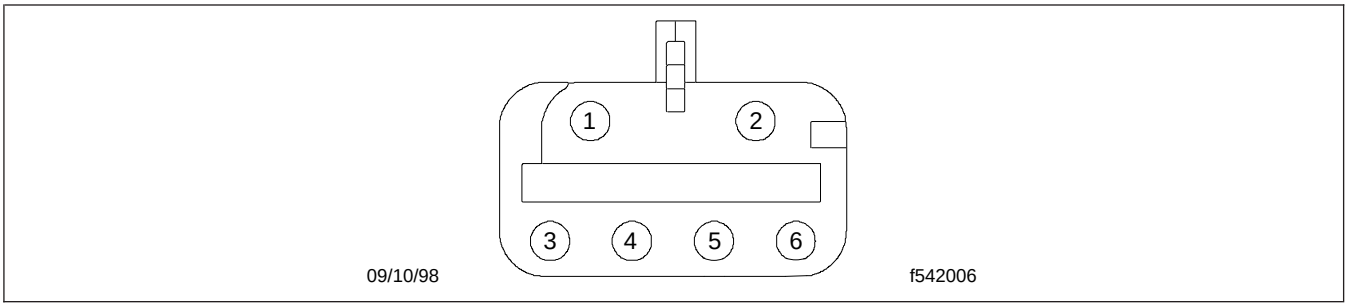


Fig. 16, C751 Subwoofer Connector

Problem—No Auxiliary Headphone Audio, SilverStar Sleeper (See Fig. 2, Fig. 8, Fig. 9, Fig. 11, Fig. 14, Fig. 15 and Fig. 17)	
Possible Cause	**Remedy**
NOTE: Circuits 851 (GN) and 850 (BL/W), 856 (O) and 857 (W) are line level inputs to the rear radio control module and are twisted pairs at 7.3 turns/foot (24 turns/meter). The twisted pairs are shielded by Pin 14 of the radio connector C216. The shield is spirally wrapped aluminum with a 50% overlap per turn. If a repair of a signal line is necessary, use a 20-gauge wire and preserve the twisted configuration specification. If the shield is damaged, it must be replaced and must conform to this specification.	

Problem—No Auxiliary Headphone Audio, SilverStar Sleeper (See Fig. 2, Fig. 8, Fig. 9, Fig. 11, Fig. 14, Fig. 15 and Fig. 17)	
Possible Cause	**Remedy**
Rear radio control	Check the system with a known good rear radio control. If the symptom is corrected replace the rear radio control. Test the system for normal operation. If the symptom is not corrected. Check Circuit 137 (Y/BK) at the rear radio control. Disconnect the rear radio control connector C762. Turn the ignition to the ACC position. Measure the voltage between the rear radio control connector C762 Pin 1, Circuit 137 (Y/BK) and ground. If the voltage is less than 10 volts, check Circuit 137 (Y/BK) at the cab side of the sleeper accessory harness. Turn the ignition to the "Off" position. Disconnect the sleeper accessory harness connector. Turn the ignition switch to the ACC position. Measure the voltage between the cab side of the sleeper accessory connector C309 Pin 7, Circuit 137 (Y/BK) and ground. If the voltage is greater than 10 volts repair the open circuit in the sleeper accessory harness, Circuit 137 (Y/BK) and ground. Test the system for normal operation. If the voltage is less than 10 volts, check the continuity between the instrument panel fuse junction panel Fuse 16 and the cab side of the sleeper accessory harness. Turn the ignition switch to the "Off" position. Disconnect the instrument panel fuse junction panel Fuse 16. Disconnect the battery ground cable(s). Measure the resistance between the bottom pin of the instrument panel fuse junction panel Fuse 16, Circuit 137 (Y/BK) and the cab side of the sleeper accessory harness connector C309 Pin 7, Circuit 137 (Y/BK). If the resistance is less than 5 ohms, repair Circuit 297 (BK/R) feeding Fuse 16. Test the system for normal operation. If the resistance is less than 5 ohms, repair Circuit 137 (Y/BK) for an open circuit. Test the system for normal operation.
Sleeper accessory harness voltage	
Sleeper accessory harness continuity	
Circuit 867 (R) at the rear radio control	If the voltage is more than 10 volts, check Circuit 867 (R) at the rear radio control. Turn the radio on. Measure the voltage between the rear radio control connector C762 Pin 2, Circuit 867 (R) and ground. If the voltage is less than 10 volts, check Circuit 867 (R) at the cab side of the sleeper accessory harness. Turn the ignition to the "Off" position. Disconnect the sleeper accessory harness connector C311. Turn the ignition to the ACC position. Turn the radio on. Measure the voltage between the cab side of the sleeper accessory connector C311 Pin 7, Circuit 867 (R) and ground. If the voltage is greater than 10 volts, repair the open circuit in the sleeper accessory harness, Circuit 867 (R). Test the system for normal operation. If the voltage is less than 10 volts check the Circuit 867 (R) output at the radio. Turn the ignition to the "Off" position. Disconnect the radio connector C216. Remove the Circuit 867 (R) wire from the radio connector C216. Re-connect the radio connector C216. Turn the ignition to the ACC position. Turn the radio on. Measure the voltage between the open terminal 16 and ground. If the voltage is greater than 10 volts, repair Circuit 867 (R) for an open circuit between the radio and the sleeper accessory harness. Test the system for normal operation. If the voltage is less than 10 volts, have the radio serviced by an authorized service center. Test the system for normal operation.

Troubleshooting

Problem—No Auxiliary Headphone Audio, SilverStar Sleeper (See Fig. 2, Fig. 8, Fig. 9, Fig. 11, Fig. 14, Fig. 15 and Fig. 17)	
Possible Cause	**Remedy**
Output-to-rear radio control ground	If the voltage is more than 10 volts, check the Circuit 689 (P) for output-to-rear radio control for a normal ground condition. Turn the ignition to the "Off" position. Remove the Circuit 689 (P) wire from the rear radio control connector C762, Pin 8. Do not let the Circuit 689 (P) touch ground and cover the wire termination until ready to probe. Re-connect the rear radio control connector C762. Turn the ignition to the ACC position. Turn the radio on. Measure the voltage between Circuit 689 (P) wire termination at the rear radio control connector and ground. If voltage is present, do not proceed, repair Circuit 689 (P) for a short to power. Measure the resistance between the Circuit 689 (P) wire termination at the rear radio control connector and ground. If the resistance is more than 5 ohms, repair Circuit 689 (P) for an open circuit if the radio is providing the correct output. Test the system for normal operation. If the resistance is less than 5 ohms, check the rear radio control ground.
Rear radio control ground	Turn the ignition to the "Off" position. Disconnect the rear radio control connector C762. Disconnect the battery ground cable(s). Measure the resistance between the rear radio control connector C762 Pin 11, Circuit 57 (BK) and ground. If the resistance is more than 5 ohms, repair the Circuit 57 (BK) for an open circuit. Test the system for normal operation. If the resistance is less than 5 ohms, check the rear radio control audio ground. Measure the resistance between the rear radio control connector C762 Pin 10, Circuit 18 (BK/BL) and ground. If the resistance is more than 5 ohms, check the rear radio control audio ground at the sleeper accessory harness. Measure the resistance between the cab side of the sleeper accessory harness connector C309 Pin 13, Circuit 18 (BK/BL) and ground. If the resistance is less than 5 ohms, repair Circuit 18 (BK/BL) for an open circuit in the sleeper accessory harness. Test the system for normal operation. If the resistance is more than 5 ohms, repair Circuit 18 (BK/BL) for an open circuit in the cab harness. Test the system for normal operation.
Audio control protocol lines	Check the audio control protocol lines. Disconnect the radio connector C216. Measure the resistance between the radio connector C216 Pin 9, Circuit 832 (Y/BK) and the cab side of the sleeper accessory harness connector C309 Pin 15, 832 (Y/BK). Measure the resistance between the radio connector C216 Pin 1, Circuit 833 (GN) and the cab side of the sleeper accessory harness connector C309 Pin 14, Circuit 833 (GN). If the resistance is more than 5 ohms, repair the affected circuit(s) for an open. Test the system for normal operation. If the resistance is less than 5 ohms, check the audio control protocol lines in the sleeper. Measure the resistance between the sleeper side of the sleeper accessory harness connector C309 Pin 15, Circuit 832 (Y/BK) and the rear radio control connector C762 Pin 5, Circuit 832 (Y/BK). Measure the resistance between the sleeper side of the sleeper accessory harness connector C309 Pin 14, Circuit 833 (GN and the rear radio control connector C762 Pin 4, Circuit 833 (GN). If the resistance is more than 5 ohms, repair the affected circuit(s) for an open. Test the system for normal operation.

Problem—No Auxiliary Headphone Audio, SilverStar Sleeper (See Fig. 2, Fig. 8, Fig. 9, Fig. 11, Fig. 14, Fig. 15 and Fig. 17)	
Possible Cause	**Remedy**
Line level audio input to the rear radio control	Check the continuity of the line level audio input to the rear radio control. Measure the resistance between the radio connector C216 Pins 11, 10, 3 and 2, Circuits 851 (GN), 850 BL/W), 856 (O) and 857 (W) and the rear radio control connector C762 Pins 15, 16, 13 and 14, Circuits 851 (GN), 850 (BL/W), 856 (O) and 857 (W). If the resistance is less than 5 ohms, rear radio control is OK. Check the radio line level outputs. Test the system for normal operation. If the resistance is more than 5 ohms, repair the affected circuit(s) for an open. Test the system for normal operation.

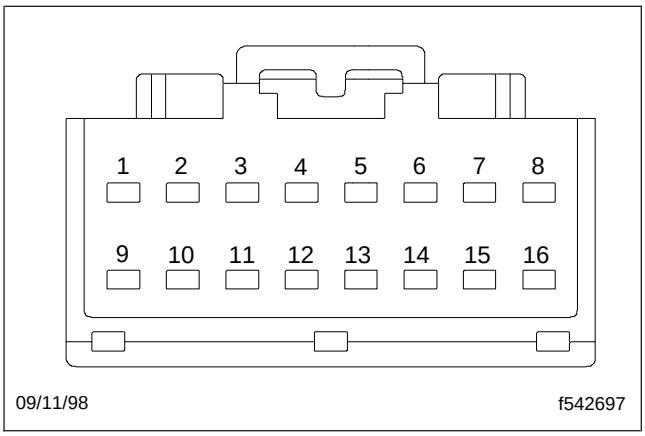


Fig. 17

Specifications

Specifications	
Item	**Specification**
Shields	Spirally Wrapped Aluminum With a 50% Overlap Per Turn
Twisted Wires	7.3 Turns/Foot (24 Turns/ Meter)

Table 1, Specifications

Audio System

Rear Radio Control, SilverStar Sleeper (See Fig. 1)

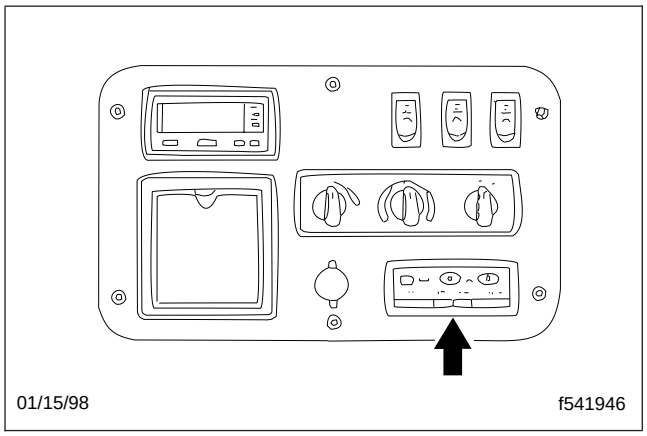


Fig. 1, Rear Radio Control, SilverStar Sleeper

The rear radio control is located on the back wall of the sleeper. The rear radio control includes volume, band selection, memory, seek, speaker toggle knobs and headphone jacks.

Rear Radio Control, Able Body Sleeper (See Fig. 2)

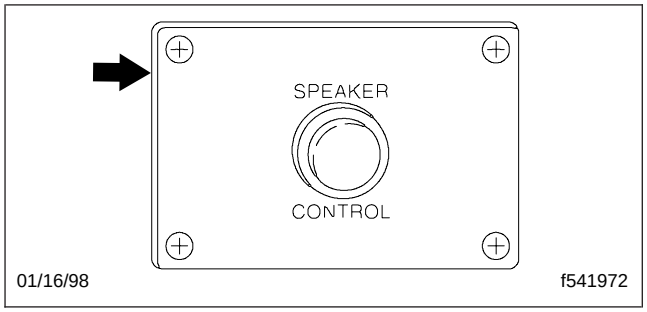


Fig. 2, Rear Radio Control, Able Body Sleeper

The rear radio control is located on the back wall of the sleeper. The rear radio control includes a volume and a balance control.

AM/FM Radio Removal and Installation

Removal

1. Disconnect the battery ground cable(s).
2. Insert the tools into the access holes provided in the bezel until a click is heard. See **Fig. 1**.

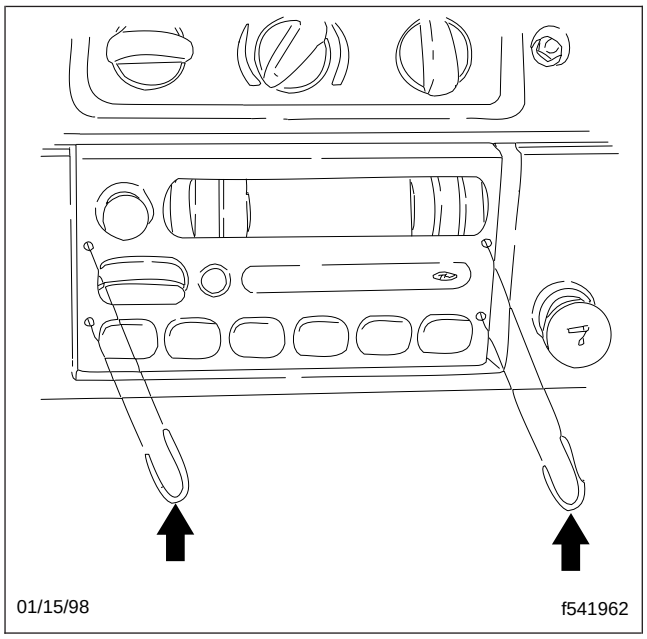


Fig. 1, Radio Chassis Removal Tools

3. Apply outward pressure on the radio chassis removal tools to release the locking tangs, then slide the radio out from the dash. See **Fig. 2**.

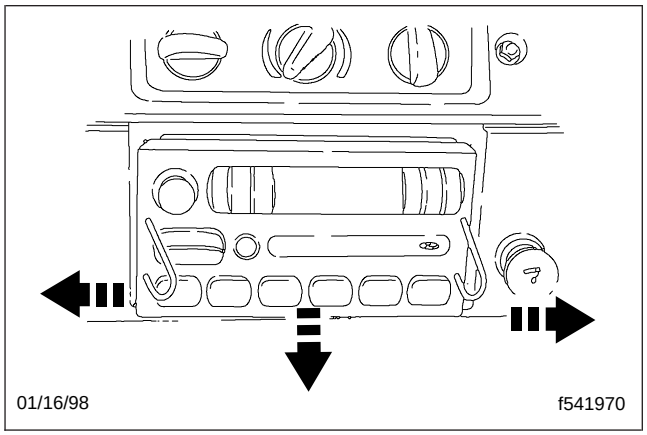


Fig. 2, Radio Chassis Movement

4. Disconnect the radio electrical connectors and the antenna lead-in cable. See **Fig. 3**.

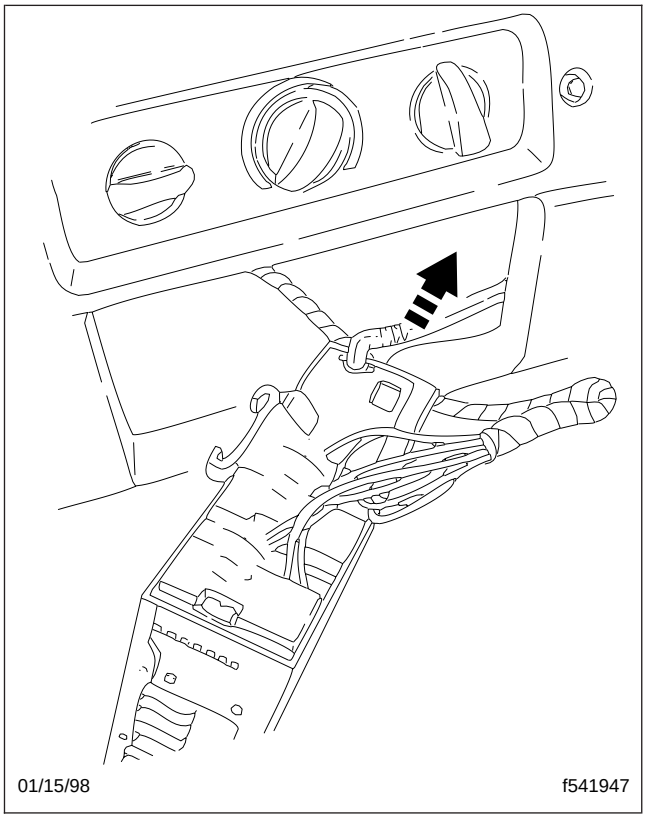


Fig. 3, Radio Electrical Connectors and Antenna Lead-In

5. Remove the radio chassis removal tools from the radio by pressing on the locking tangs on the side of the radio and pulling outward.

Installation

1. Connect the radio electrical connectors and the antenna lead-in cable (see **Fig. 4**). Push the air line harness located behind the instrument panel upward to provide space for the radio.
2. Slide the radio into the dash until the locking tangs engage. See **Fig. 5**.
3. Connect the battery ground cable(s).
4. Refer to the driver's manual to reset the station presets and the clock.

AM/FM Radio Removal and Installation

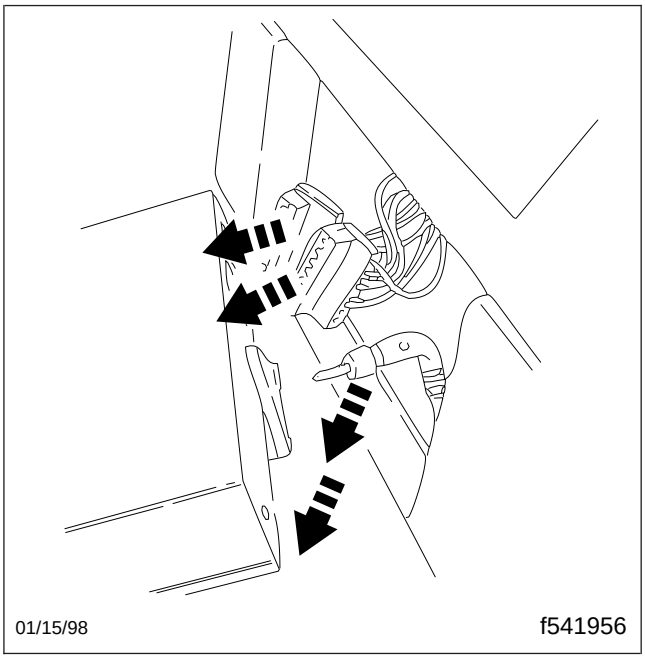


Fig. 4, Radio Electrical Connectors and Antenna Lead-In

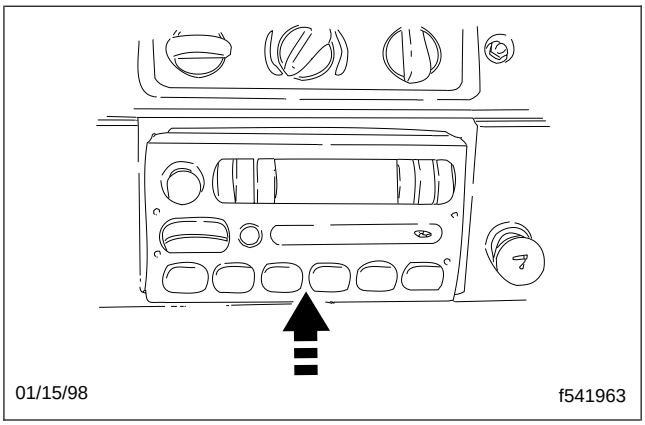


Fig. 5, Slide the Radio into Position

AM/FM Cassette Weather Band Electronic Stereo Radio Removal and Installation

Removal

1. Disconnect the battery ground cable(s).
2. Insert the tools into the access holes provided in the bezel until a click is heard. See **Fig. 1**.

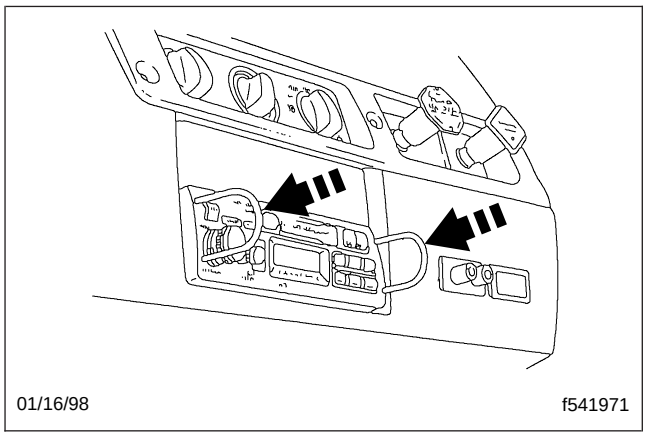


Fig. 1, Insert the Removal Tools

3. Apply outward pressure on the tools to release the locking tangs, then slide the radio partially out from the dash. See **Fig. 2**.

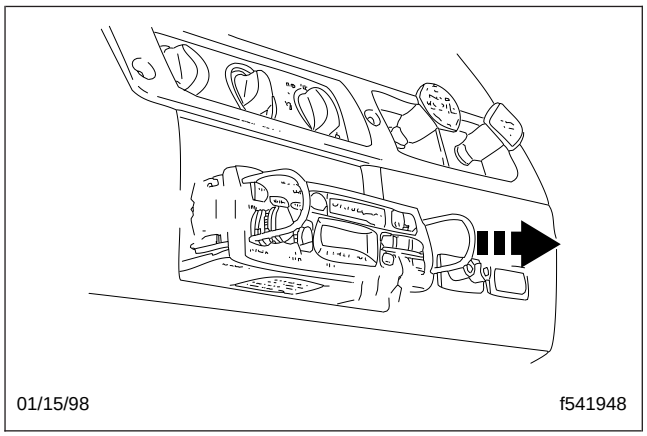


Fig. 2, Slide the Radio Partially Out of the Dash

4. Reach under the dash from the right side and turn the radio chassis support 90 degrees, then slide the radio from the dash. See **Fig. 3**.
5. Disconnect the radio electrical connector and the antenna lead-in cable, then remove the radio. See **Fig. 4**.

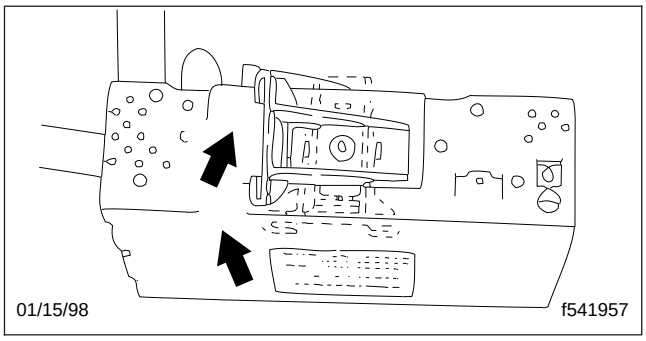


Fig. 3, Radio Chassis Support

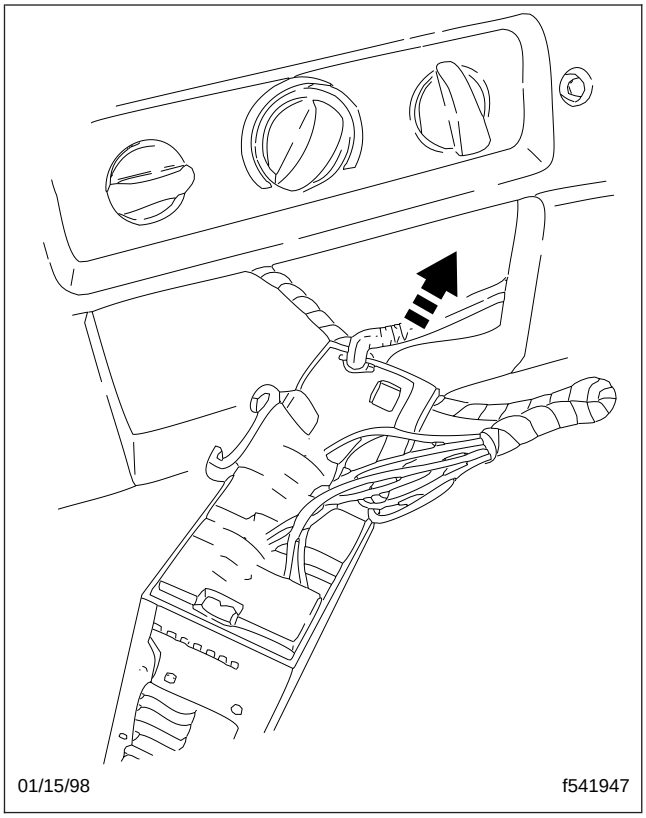


Fig. 4, Radio Electrical Connector and Antenna Lead-In Cable

6. Remove the tools from the radio by pressing on the locking tangs on the sides of the radio and pulling the tools out.

Installation

1. Connect the radio electrical connector and the antenna lead-in cable (see **Fig. 5**). Push the air

AM/FM Cassette Weather Band Electronic Stereo Radio Removal and Installation

line harness located behind the instrument panel upward to provide space for the radio.

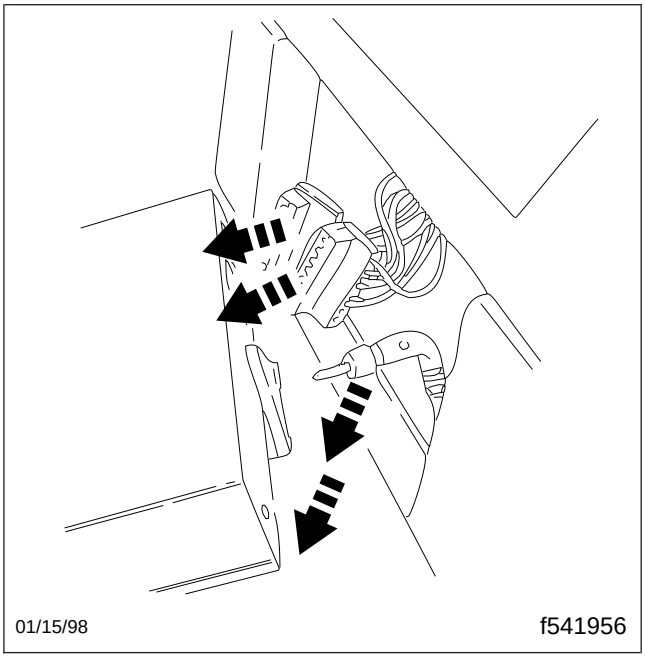


Fig. 5, Radio Electrical Connector and Antenna Lead-In Cable

2. Slide the radio partially into the dash, then reach below the dash from the right side and turn the radio chassis support 90 degrees. See **Fig. 6**.

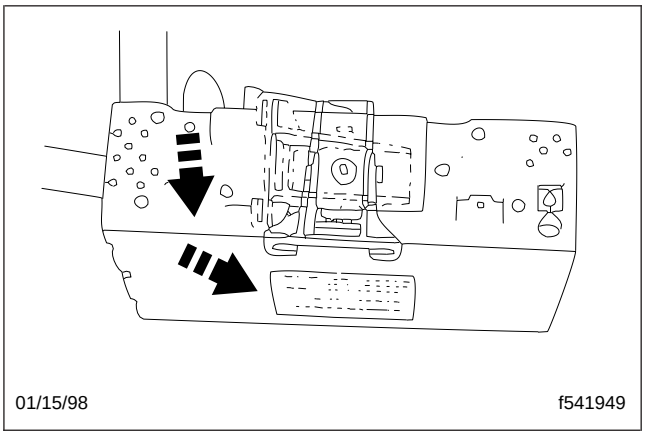


Fig. 6, Radio Chassis Support

3. Make sure that the chassis support is aligned on the metal bracket slide.
4. Slide the radio into the dash until the locking tangs engage. See **Fig. 7**.

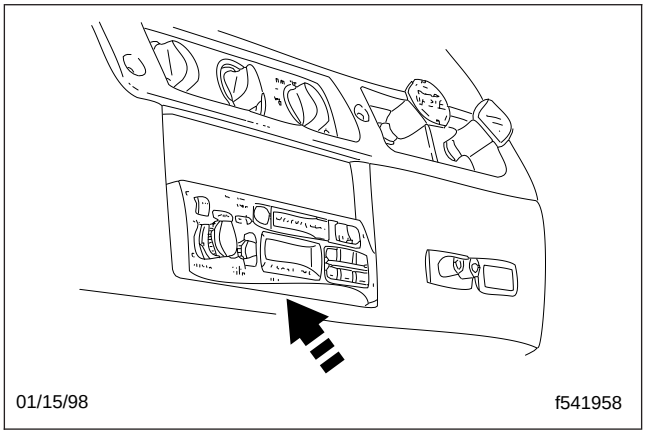


Fig. 7, Install the Radio into the Dash

5. Connect the battery ground cable(s).
6. Refer to the driver's manual to reset the station presets and the clock.

Replacement

1. Make sure the CD changer door is closed. See **Fig. 1**.

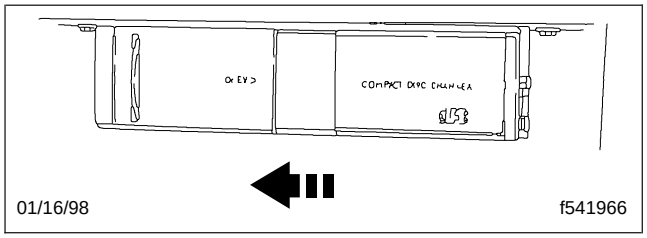


Fig. 1, CD Changer Door

2. Disconnect the battery ground cable(s).
3. Remove the right retaining screws, and support the CD changer. See **Fig. 2**.

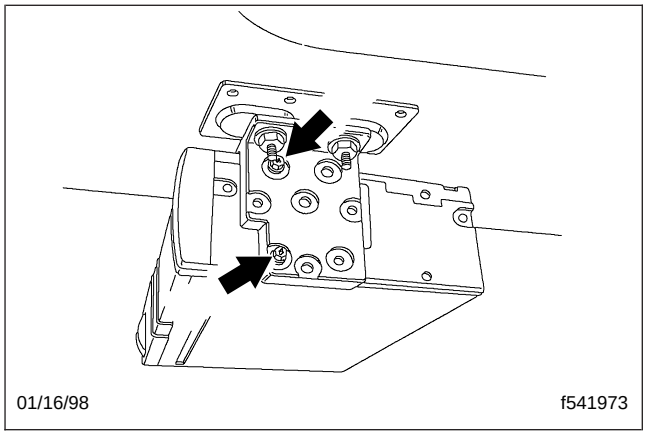


Fig. 2, CD Changer Right Retaining Screws

4. Remove the left retaining screws. See **Fig. 3**.
5. Disconnect the electrical connector. See **Fig. 4**.
6. Connect the electrical connector.
7. Hold the CD changer in the correct position. Then, install the left and right CD changer retaining screws.
8. Connect the battery ground cable(s).

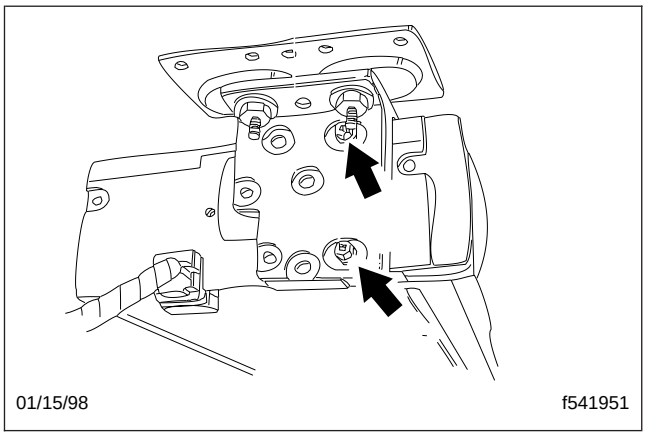


Fig. 3, CD Changer Left Retaining Screws

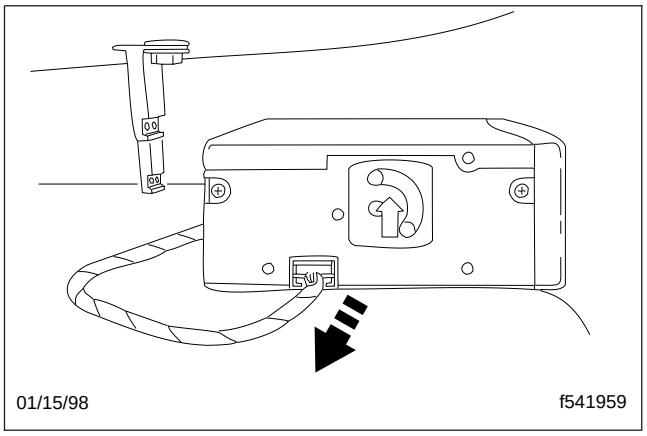


Fig. 4, CD Changer Electrical Connector

Replacement

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Disconnect the battery ground cable(s).
3. Disengage the quarter-turn fasteners and remove the PDM trim panel. See **Fig. 1**.

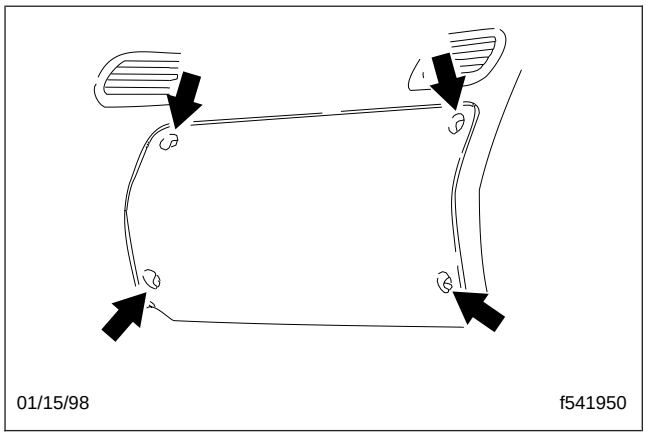


Fig. 1, PDM Trim Panel

4. Remove the lower panel screws and remove the panel. See **Fig. 2**.

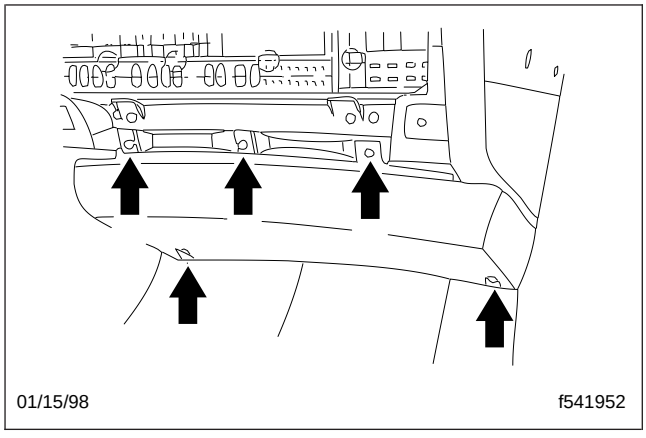
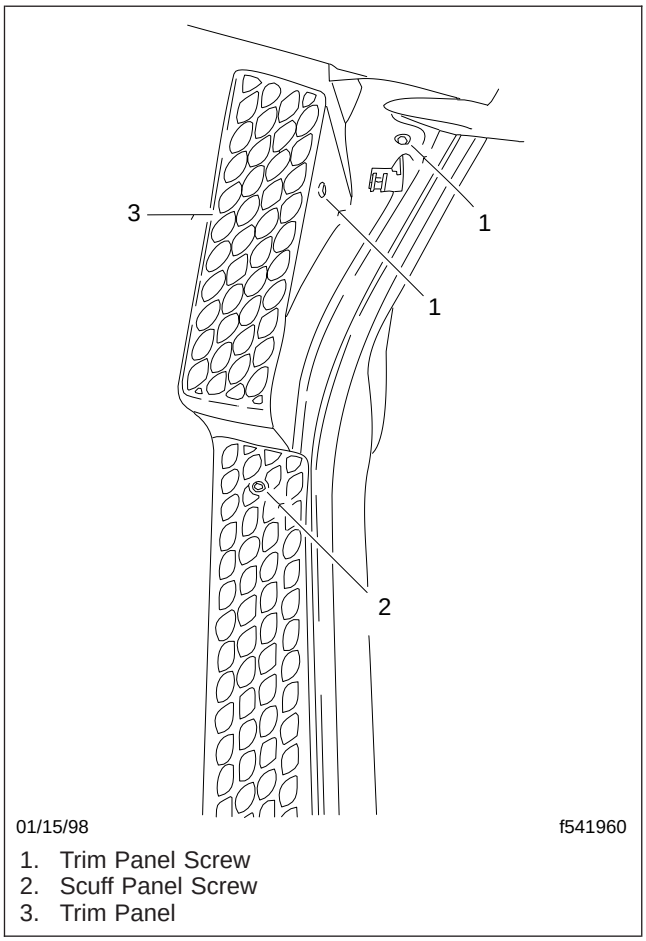


Fig. 2, Instrument Panel Lower Panel

5. Remove the cowl side trim panel. See **Fig. 3**.
   - 5.1 Remove the cowl side trim panel screws.
   - 5.2 Remove the first scuff panel screw.
   - 5.3 Remove the cowl side trim panel.



1. Trim Panel Screw
2. Scuff Panel Screw
3. Trim Panel

Fig. 3, Cowl Side Trim Panel

6. Remove the heater outlet floor duct screws and remove the duct. See **Fig. 4**.

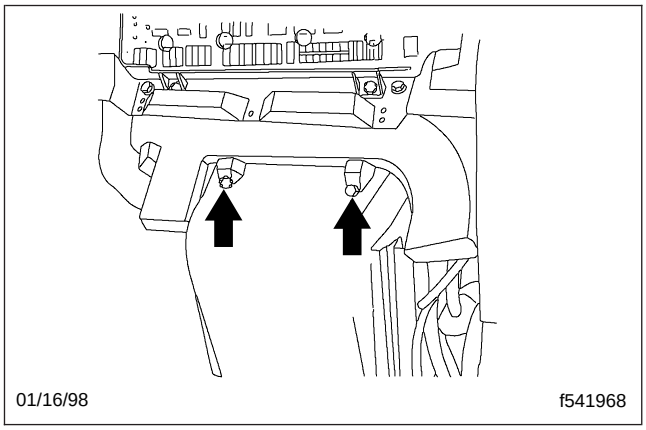
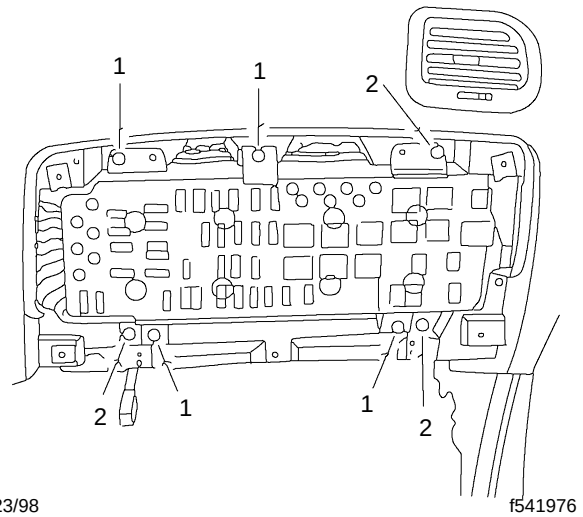


Fig. 4, Heater Outlet Floor Duct

Radio Amplifier Replacement

7. Unfasten the PDM. See **Fig. 5**.



1. PDM Mask Screws
2. PDM Retaining Screws

Fig. 5, PDM

7.1 Remove the PDM mask screws and the mask.

7.2 Remove the PDM retaining screws.

8. Pull the PDM out of the seated position, and support the PDM. See **Fig. 6**.
9. Remove the wiring bracket screw and drop the bracket out of the way.
10. Disconnect the two radio amplifier electrical connectors. See **Fig. 7**.
11. Remove the lower two bolts retaining the radio amplifier. See **Fig. 8**.
12. Remove the radio amplifier. See **Fig. 9**.

12.1 Swing the lower edge of the radio amplifier upward.

12.2 Remove the last radio amplifier retaining bolt.

12.3 Remove the radio amplifier.

13. Install the radio amplifier.

13.1 Position the amplifier.

13.2 Install the radio amplifier retaining bolts.

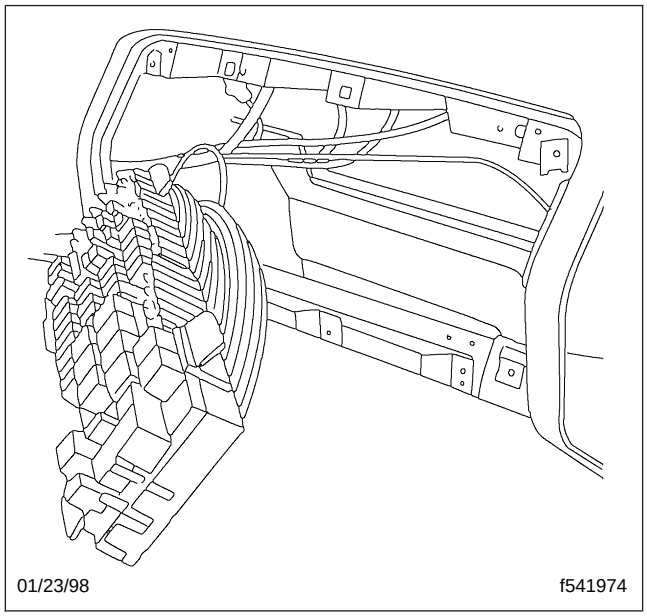


Fig. 6, Pull Out PDM

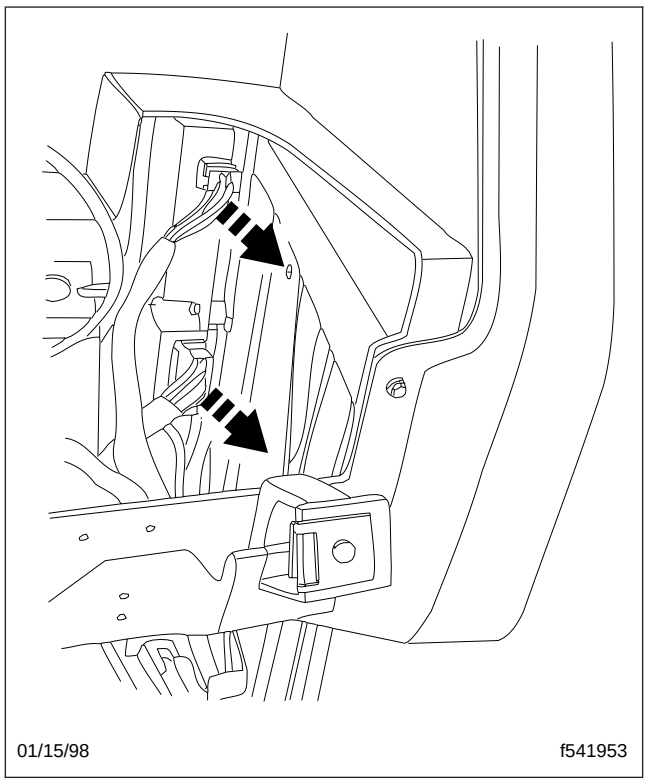


Fig. 7, Radio Amplifier Electrical Connectors

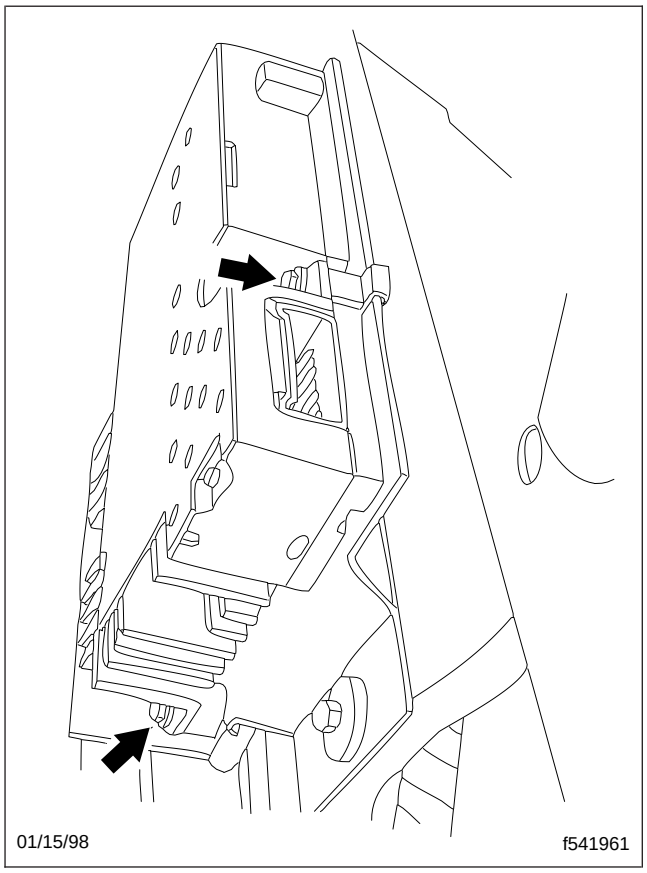


Fig. 8, Radio Amplifier Retaining Bolts

14. Connect the two radio amplifier electrical connectors.
15. Position the wiring bracket and install the wiring bracket screw.
16. Install the PDM.
    - 16.1 Position the PDM.
    - 16.2 Install the PDM mask and the screws.
    - 16.3 Install the PDM retaining screws.
17. Install the cowl side trim panel.
    - 17.1 Position the cowl side trim panel.
    - 17.2 Install the cowl side trim panel screws.
18. Position the lower panel and install the panel screws.
19. Position the PDM trim panel and engage the quarter-turn fasteners.

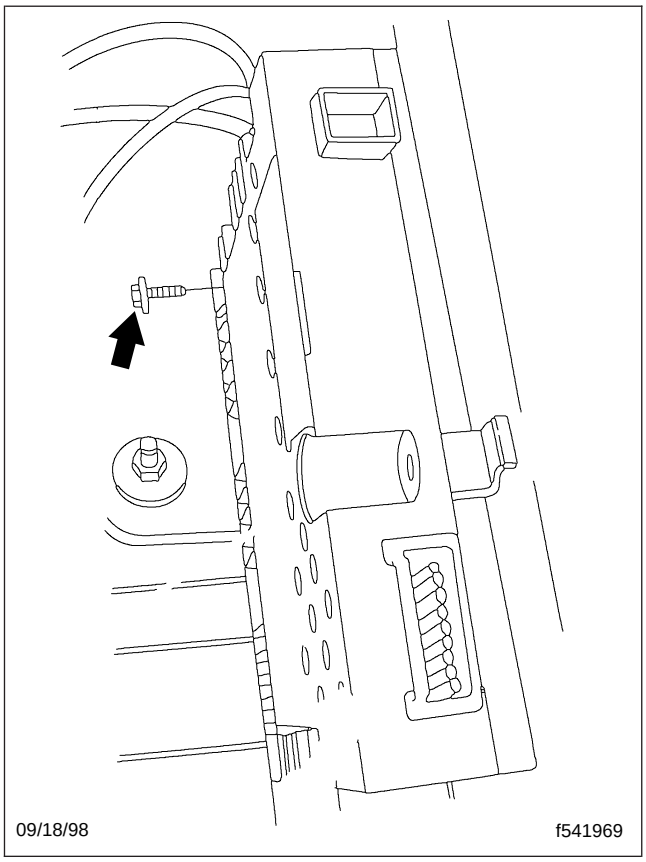


Fig. 9, Radio Amplifier Retaining Bolt

20. Connect the battery ground cable(s).
21. Remove the chocks from the tires.

Rear Radio Control Replacement, SilverStar Sleeper

Replacement

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Carefully pry outward at the top of the rear radio control panel with a small screwdriver. See **Fig. 1**.

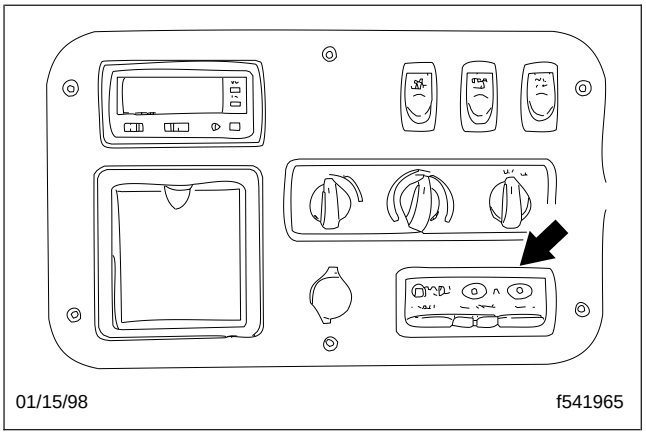


Fig. 1, Rear Radio Control

3. Pull the rear radio control from the control panel until the electrical connector is visible.
4. Disconnect the rear radio control electrical connector.
5. Remove the rear radio control.
6. Connect the rear radio control electrical connector.
7. Install the rear radio control into the control panel.
8. Remove the chocks from the tires.

Rear Radio Control Replacement, Able Body Sleeper

Replacement

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Remove the rear radio control retaining screws. See **Fig. 1**.

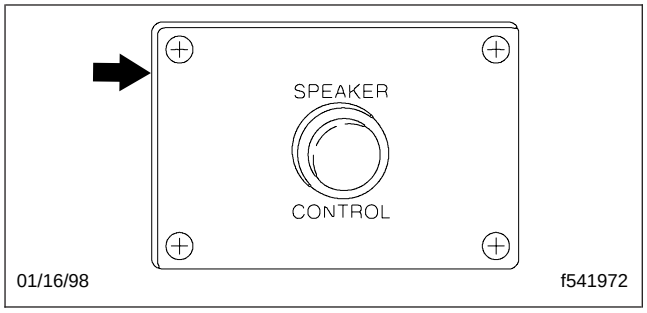


Fig. 1, Rear Radio Control Retaining Screws

3. Separate the rear radio control from the sleeper wall.
4. Disconnect the electrical connector and remove the rear radio control. See **Fig. 2**.

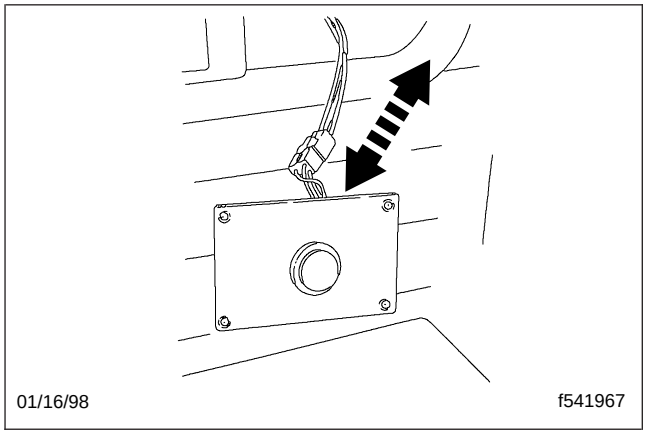


Fig. 2, Rear Radio Control Electrical Connector

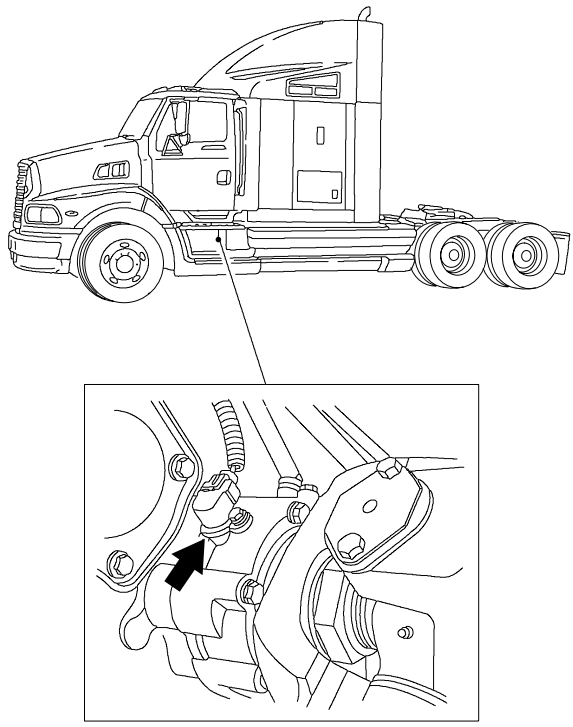
5. Connect the electrical connector and position the rear radio control.
6. Install the rear radio control retaining screws.
7. Remove the chocks from the tires.

General Information

Vehicle Speed Sensor (VSS)

The transmission-mounted vehicle speed sensor (VSS) (see **Fig. 1**) transmits a signal to the speedometer/odometer that is dependent on:

- Rear axle ratio;



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NOTE: The sensor is located at the rear of the transmission, next to the driveshaft.

Fig. 1, Vehicle Speed Sensor (VSS) Location

- Tire revolutions per mile, which is based on tire height.

Two instrument clusters are available on these vehicles. The electronic instrument cluster uses push-in gauges, which can be removed after removing the instrument cluster lens and mask. The non-electronic instrument cluster uses round clamp-mount gauges. The non-electronic instrument cluster must be removed to replace these gauges. The instrument cluster has been designed to clearly indicate the most important vehicle information to the driver. All auxiliary vehicle information is located on the auxiliary instrument cluster. Refer to the driver's manual for both instrument cluster configurations.

Instrument Cluster Display Proveout

NOTE: The brake indicator and buzzer will remain on until enough pressure is built up in the tanks. If the engine is started with enough pressure in the tanks, the brake indicator will proveout normally.

When the ignition switch lock cylinder is turned to the "Run" position, the following warning lamps will proveout by momentarily lighting:

- brake (BRAKE)
- antilock brakes (ABS)
- engine warning (ENG WARN)

Electronic Instrument Cluster Printed Circuit

The instrument cluster printed circuit, which supplies current to the instrument cluster indicators and gauges on the electronic instrument cluster, is made of copper foil bonded to a polyester base film (usually referred to as Mylar®).

The instrument cluster printed circuit is mounted to the back of the cluster housing and, due to its location, cannot be easily inspected or tested in the vehicle. This makes the instrument cluster printed circuit vulnerable to damage when a probe is used for in-vehicle testing, as the probe can pierce the instrument cluster printed circuit or, in some cases, burn the copper conductor.

NOTE: A diode is a polarized electronic device that totally blocks current flow in one direction and passes current flow with a small voltage drop in the other direction.

When testing a printed circuit path when a diode is present, check the resistance across the diode terminals first. Attach the positive terminal of the ohmmeter to the anode and attach the negative terminal to the cathode. The resistance should be in the 1 kohm range. Reverse the ohmmeter terminals and a near infinite resistance should be measured.

Test the printed circuit path in the same manner as the diode was tested. If an infinite resistance is measured in both directions or if a very small resistance

General Information

is measured in both directions, the diode or printed circuit is bad and the printed circuit needs to be replaced.

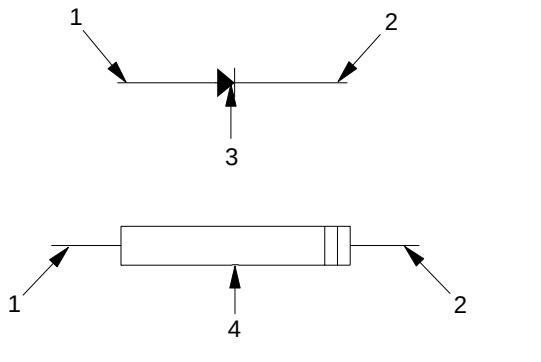
Since there is no approved procedure for in-vehicle testing of the instrument cluster printed circuit, it must be removed for visual inspection. If no visual damage is evident, test each circuit with an ohmmeter. If an open circuit or short between non-linked traces is detected, the instrument cluster printed circuit must be replaced.

Non-Electronic Instrument Cluster Printed Circuit

Two printed circuits supply current to the warning indicators on the non-electronic instrument cluster, and are made of copper foil bonded to a polyester base film.

The right-side and left-side warning lamp module printed circuits are mounted to the back of the cluster housing and, due to their location, cannot be easily inspected or tested in the vehicle. This makes the printed circuits vulnerable to damage when a probe is used for in-vehicle testing, as the probe can pierce the printed circuits or, in some cases, burn the copper conductors.

NOTE: A diode is a polarized electronic device that totally blocks current flow in one direction and passes current flow with a small voltage drop in the other direction. See **Fig. 2**.



1. (+) Anode
2. (-) Cathode
3. Circuit Representation
4. Physical Representation

Fig. 2, Diode

When testing a printed circuit path when a diode is present, check the resistance across the diode terminals first. Attach the positive terminal of the ohmmeter to the anode and attach the negative terminal to the cathode. The resistance should be in the 1000 ohm range. Reverse the ohmmeter terminals and a near infinite resistance should be measured.

Test the printed circuit path in the same manner as the diode was tested. If an infinite resistance is measured in both directions or if a very small resistance is measured in both directions, the diode or printed circuit is bad and the printed circuit needs to be replaced.

Since there is no approved procedure for in-vehicle testing of the instrument cluster printed circuit, it must be removed for visual inspection. If no visual damage is evident, test each circuit with an ohmmeter. If an open circuit or short between non-linked traces is detected, the instrument cluster printed circuit must be replaced.

Fuel Level Indication System

The fuel indicating system is an electromagnetic system and consists of a fuel indicator gauge mounted in the instrument cluster 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. See the driver's manual for a description of the fuel gauge.

Fuel Level Sensor

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.

The fuel level sensor should vary in resistance between 15 and 280 ohms. When the fuel level is low (empty), the resistance of the fuel level sensor will be high. When the fuel level is high (full), the resistance of the fuel level sensor will be low.

Coolant Temperature Indication System

The engine coolant temperature indication system is a magnetic gauge system. It consists of a magnetic engine coolant temperature gauge mounted in the instrument cluster and an engine coolant temperature

sensor. See the driver's manual for a description of the coolant temperature gauge.

High Coolant Temperature Warning Lamp

See the driver's manual for a description of the high coolant temperature warning lamp.

See **Group 20** of this manual for cooling system service.

Coolant Temperature Sensor

The coolant temperature sensor varies in resistance according to the engine coolant temperature. The coolant temperature sensor should vary in resistance between 1 and 1.5 kohms. When the engine coolant temperature is cold, the resistance of the engine coolant temperature sensor will be high. When the engine coolant temperature is hot, the resistance of the engine coolant temperature will be low.

Oil Pressure Indication System

The oil pressure indication system consists of the:

- Oil pressure gauge;
- Low oil pressure warning indicator;
- Oil pressure switch;
- Necessary circuitry.

Oil Pressure Sensor/Switch

The oil pressure sensor consists of a pressure tube connected to the engine.

The oil pressure switch will become a closed circuit when a low pressure exists.

Charge Indication System

The voltmeter is a gauge that 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. See the driver's manual for a description of the voltmeter gauge.

Air Pressure Gauge

Refer to the driver's manual for a description of the air pressure gauge.

Speedometer/Odometer

The speedometer uses an air-core meter to indicate the speed at which the vehicle is moving. This air core meter receives input internally from the electronic buffer circuit, which receives its input from the vehicle speed sensor (VSS). The speedometer is equipped with dip switches necessary to calibrate the electronic buffer circuit to different tire sizes and axle ratios.

NOTE: The speedometer pointer will not return to zero with the ignition switch lock cylinder in the "Off" position. This should not be interpreted as an inoperative condition.

See the driver's manual for a description of the odometer.

Odometer Replacement

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 door jam.

Tachometer

NOTE: The tachometer pointer will not return to zero with the ignition lock cylinder in the "Off" position. This should not be interpreted as an inoperative condition.

NOTE: The tachometer has a 1 to 1-1/2 second delay time in response with the engine rpm. This condition is considered normal.

The tachometer uses an air-core meter to indicate engine speed in revolutions per minute (rpm). This air core meter receives input internally from the electronic buffer circuit, which receives its input from the tachometer sensor. The tachometer is equipped with dip switches necessary to calibrate the electronic buffer circuit to electronic engines or mechanical engines that use a variable reluctance sensor.

Warning Indicators

Brake System

The brake system warning lamp should illuminate when the ignition switch lock cylinder is turned to the "Start" position. If the air pressure in the dual air

tanks is low, the brake lamp and buzzer will stay on until enough pressure is built up for normal application of the vehicle brakes. If air pressure is lost during normal operation of the vehicle, the brake lamp and buzzer will actuate to the "On" state.

Antilock Brakes

See the driver's manual for a description of the antilock lamp.

See **Group 42** of this manual for diagnosis and testing of the ABS system.

Engine Warning

The check engine warning indicator comes on when the engine control system is not working properly.

NOTE: If the vehicle is equipped with dual fuel tanks, the ENG WARN lamp may come on if fuel is restricted to the engine. This condition is normal and the ENG WARN lamp should turn off sometime after fuel flow is restored.

The check engine warning indicator comes on briefly when the ignition switch lock cylinder is turned to the "Start" position, and should turn off when the engine starts. If the check engine warning indicator does not come on when the ignition switch lock cylinder is turned to the "Run" position or if it comes on while the vehicle is moving, the system is malfunctioning.

Low Coolant

See the driver's manual for a description of the low coolant warning lamp.

See **Group 20** of this manual for cooling system service.

Instrument Cluster and Panel Lighting

The electronic instrument cluster and the non-electronic instrument cluster both contain the following gauges:

- speedometer
- tachometer
- voltmeter
- fuel
- coolant temperature
- oil pressure
- air pressure (brake pressure)

The driver side instrument panel contains the following switches:

- ignition switch
- engine start button
- headlamp switch
- marker lamp blink switch
- dome lamp and instrument panel dimmer switch
- two auxiliary rocker switches

The auxiliary instrument panel can have a maximum of eight gauges, nine rocker switches and three rocker-type air controls. Six of the eight gauges are factory equipped while the seventh and eighth gauges are a dealer-installed option.

The three rocker-type air controls are governed by the following in left to right order:

- axle lock valve (priority 1—leftmost valve)
- air dump suspension valve (priority 2)
- wheel lock valve (priority 3)
- fifth wheel slide valve, tractor (priority 4)

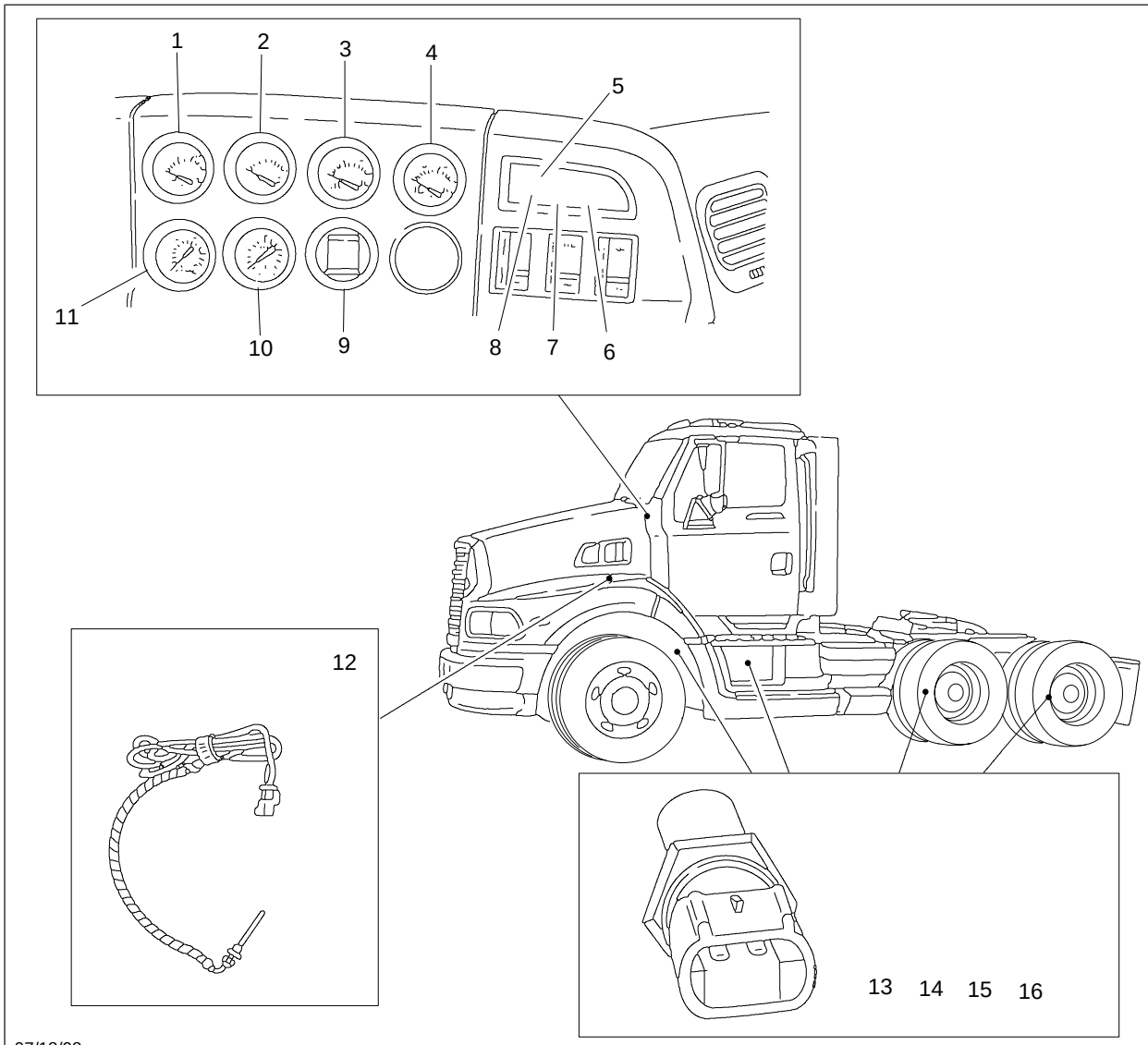
Gauges with priorities 3 and 4 are mutually exclusive (one or the other, not both).

The headlamp switch controls the instrument cluster and panel lighting. When the headlamp switch is in the PARK or HEAD position, the battery supplies voltage through the headlamp switch and through the dome lamp and instrument panel dimmer switch to the instrument cluster and panel illumination lamps. The lamps can be dimmed manually with the dome lamp and instrument panel dimmer switch. Actuating the dome lamp and instrument panel dimmer switch to its highest vertical position will illuminate the dome lamp. Circuit 19 (BL/R) feeds the instrument cluster and panel lighting.

Auxiliary Gauges and Warning Devices **(See Fig. 3)**

Air Restriction Gauge

The air restriction gauge allows the operator to monitor the ability of the engine to receive air through the air filter. As the filter retains more dirt and debris, the vacuum it creates will begin to register on the gauge.



1. Engine Oil Temperature Gauge
2. Transmission Oil Temperature Gauge
3. Forward Drive Axle Oil Temperature Gauge
4. Rear Drive Axle Oil Temperature Gauge
5. Traction Control Warning Lamp (TRAC)
6. Service Soon Warning Lamp (SERVICE SOON)
7. Air Suspension Dump Warning Lamp (SUSP DUMP)
8. Do Not Shift Warning Lamp (DO NOT SHIFT)
9. Air Restriction Gauge
10. Exhaust Gas Temperature Gauge
11. Brake Application Air Pressure Gauge
12. Engine Oil Temperature Gauge
13. Exhaust Gas Pyrometer
14. Transmission Oil Temperature Sensor
15. Forward Drive Axle Oil Temperature Sensor
16. Rear Drive Axle Oil Temperature Sensor

Fig. 3, Gauge and Warning Device Component Location (Left-Hand-Drive Shown, Right-Hand-Drive Similar)

When the gauge reading reaches a predetermined point, the air filter must be replaced and the gauge reset.

General Information

Brake Application Air Pressure Gauge

The brake application air pressure gauge allows the operator to monitor the amount of assist air pressure being applied to the brakes by the operator through the brake pedal. As brake pedal effort is increased, the indicator shows an increase in the amount of pressure being applied to the brakes.

Exhaust Gas Temperature Gauge

The exhaust gas temperature gauge uses a pyrometer sensor to generate the signal for the gauge. The sensor is located in the exhaust outlet pipe from the turbocharger. It allows the operator to monitor the temperature of the exhaust. It works in conjunction with the CAT CONV warning lamp, giving the operator the opportunity to prevent engine or turbocharger damage due to an overtemp condition.

Engine Oil Temperature Gauge

The engine oil temperature gauge uses a thermistor sensor located in the oil pan to provide a signal to the gauge. This allows the operator to monitor the temperature of the engine oil. It works in conjunction with the OIL TEMP warning lamp, giving the operator the opportunity to prevent engine damage due to an engine oil overtemp condition.

Forward Drive Axle Oil Temperature Gauge

The forward drive axle oil temperature gauge uses a thermistor sensor located in the back of the forward drive axle housing to provide a signal to the gauge. This allows the operator to monitor the temperature of the forward drive axle oil. It works in conjunction with the OIL TEMP warning lamp, giving the operator the opportunity to prevent damage to the forward drive axle due to an axle oil overtemp condition.

Rear Drive Axle Oil Temperature Gauge

The rear drive axle oil temperature gauge uses a thermistor sensor located in the back of the rear drive axle housing to provide a signal to the gauge. This allows the operator to monitor the temperature of the rear drive axle oil. It works in conjunction with the OIL TEMP warning lamp, giving the operator the opportunity to prevent damage to the rear drive axle due to an axle oil overtemp condition.

Transmission Oil Temperature Gauge

The transmission oil temperature gauge uses a thermistor sensor located in the transmission case to provide a signal to the gauge. This allows the operator to monitor the temperature of the transmission oil. It works in conjunction with the OIL TEMP warning lamp, giving the operator the opportunity to prevent transmission damage due to a transmission oil overtemp condition.

Air Suspension Dump Warning Lamp

The air suspension dump warning lamp illuminates whenever the dump control valve is in the UP (exhaust) position.

⚠ CAUTION

This control must not be operated during normal vehicle operation because damage to the system or vehicle can occur.

The SUSP DUMP warning lamp is used in conjunction with the red status light on the dump valve switch to alert the operator that the air suspension system is in the exhaust position.

DO NOT SHIFT Warning Lamp (Electronic Allison Transmissions Only)

The DO NOT SHIFT warning lamp will illuminate (accompanied by eight seconds of short beeps from the shifter selector) when the transmission control unit (TCU) has detected the transmission operating parameters have been exceeded and the upshifts and downshifts are being restricted.

SERVICE SOON Warning Lamp (DDC 60 Engine Only)

The SERVICE SOON warning lamp illuminates whenever there is an engine sensor problem. It is activated by the engine control module (ECM) and will stay illuminated until the key is turned to the "Off" position or the problem is no longer present.

Traction Control Warning Lamp

The traction control warning lamp illuminates whenever there is wheel spin and stays on until the wheel spin is eliminated. It will also illuminate whenever there is a problem with the traction control system. During the time a system problem is occurring, the TRAC lamp will illuminate and stay on until the problem is either corrected or the key is turned to the "Off" position. If the problem is there only temporarily, the lamp will be extinguished when the problem is no longer present.

Proveout

When the key is turned to "Run", the DO NOT SHIFT lamp illuminates and stays lit until the engine is started, the TRAC lamp illuminates and stays lit until the traction control system completes a self test, and the SERVICE SOON lamp, for Detroit Diesel engine applications, illuminates for approximately five seconds and extinguishes if no diagnostic trouble codes are set.

When the key is turned to "Start", the SUSP DUMP lamp illuminates for as long as the key stays in "Start".

Engine Protection System (See Fig. 4)

The engine protection system (or engine alarm/shutdown system) is designed to prevent engine damage resulting from operation of the engine during prolonged periods of low oil pressure, high engine oil temperature, high coolant temperature or low coolant level.

The system includes a visual indicator and an audible indicator to alert the operator of each condition. In vehicles equipped with the engine shutdown option, these indicators are accompanied by a delay of 30 to 40 seconds before the engine shuts down. This 30 to 40 second delay is provided to allow the operator to safely remove the vehicle from the road.

⚠ CAUTION

Any attempt to use the override feature to drive the vehicle very far will result in serious engine damage.

This delay feature can be overridden by pressing the engine shutdown override switch if more time is required to remove the vehicle from the road.

On vehicles with mechanical engines (Cummins ISB, ISC and Caterpillar 3306), the engine shutdown system uses a multi-function type module that incorporates the engine shutdown control, brake low air pressure warning and buzzer functions into one module. On electronic engines (Caterpillar 3176, 3406, Cummins M11, N14 and Detroit Diesel Series 60), the engine shutdown system is controlled by the electronic engine control module (ECM).

Engine Alarm/Shutdown Activation

When the engine alarm/shutdown control is grounded at any of the temperature related switches or opened through the coolant level switch, it immediately sounds the audible warning. After approximately 30 to 40 seconds, it opens the circuit that provides power to the fuel shutoff relay and the engine shuts down.

The fuel shutoff solenoid is used to allow the engine to run or be shutdown. This solenoid moves the fuel rack into the fuel "On" or fuel "Off" positions. Power for the solenoid is controlled by the ignition switch and fuel shutoff relay for Cummins ISB and ISC engines or the fuel shutoff relay only for the Caterpillar 3306 engine.

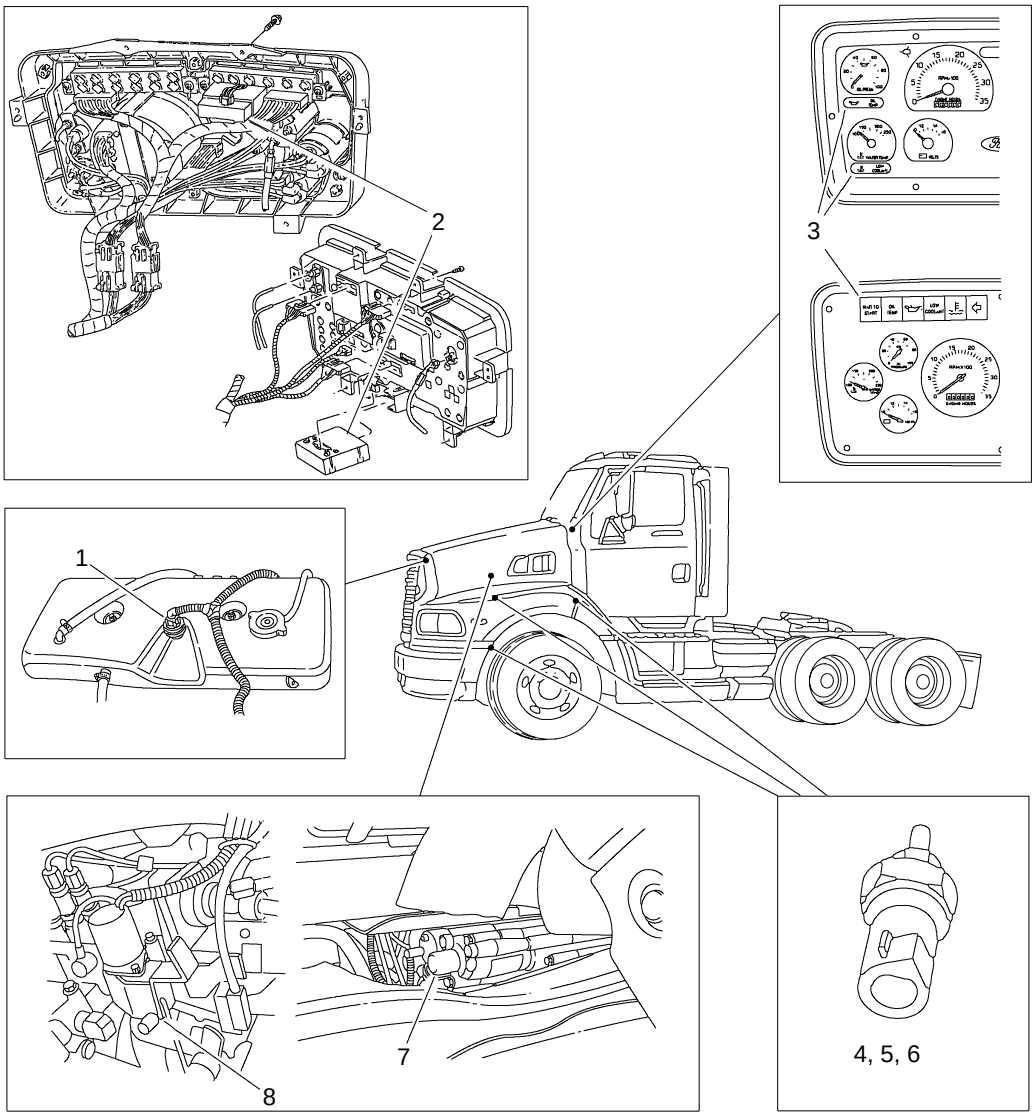
On the Cummins ISB and ISC engines, the fuel shutoff solenoid encompasses two coils within one housing. A powerful pull coil is used to pull the fuel shutoff lever to the open position, allowing fuel to flow. The pull coil is fed from the switched side of the starter motor relay, so it is energized only when the key is in the "Start" position. At the same time, a much less powerful hold coil is fed from the fuel shutoff relay output circuit. When the key is released to the "Run" position, the pull coil de-energizes and the hold coil remains energized to keep the fuel shutoff lever in the open position.

⚠ CAUTION

The pull coil draws a considerable amount of current while it is energized. Do not allow it to remain energized for longer than 30 seconds or it can cause damage to the solenoid.

On the Caterpillar 3306 engine, a single coil solenoid is used for both pull and hold functions of the fuel shutoff solenoid.

General Information



1. Low Coolant Level Sensor
2. Brake Low Air Pressure Buzzer, Engine Warning Chime, Engine Alarm/Shutdown Module
3. Indicator Warning Lamps
4. High Oil Temperature Switch
5. High Coolant Temperature Switch
6. Low Oil Pressure Switch
7. Fuel Shutoff Solenoid, Cummins 3306 (part of engine assembly)
8. Fuel Shutoff Solenoid, Cummins ISB and ISC (part of engine assembly)

Fig. 4, Engine Protection System Components (Left-Hand-Drive Shown, Right-Hand-Drive Similar)

Start

With the key in the "Start" position, the fuel shutoff solenoid is energized by circuit 669 (R/BL) from the starter relay on vehicles equipped with the Cummins ISB or ISC engines. On vehicles equipped with the Caterpillar 3306 engine, the fuel shutoff solenoid is energized by circuit 932 (BL) when the engine alarm/shutdown module activates the fuel shutoff relay coil through circuit 720 (BL), allowing circuit 932 (BL) to

close through the relay contacts to circuit 69 (R/GN). The solenoid pulls the shutoff lever to the open position and the engine receives fuel through the fuel distributor.

Run

When the key returns to the "Run" position, the starter relay and circuit 669 (R/BL) are de-energized on the Cummins ISB and ISC engines. The fuel shutoff solenoid remains energized through circuit 932 (BL) in the same manner that the Caterpillar 3306 engine is energized and held activated. The engine alarm/shutdown module activates the fuel shutoff relay by applying battery voltage to circuit 720 (BL). This activates the fuel shutoff relay, allowing battery voltage to be applied to circuit 932 (BL) through circuit 69 (R/GN) when the relay contacts close.

Shutoff

NOTE: Turning off power to the engine alarm/shutdown system (key off) resets the system, and the sequence of events can be repeated.

When the key is turned to the "Off" position, current to the fuel shutoff relay coil is cut off, the relay is de-energized and the relay contacts open. This de-energizes the fuel shutoff solenoid, the fuel shutoff lever returns to the "Off" position, fuel flow is cut off and the engine stops.

Automatic Shutoff With the Engine Shutdown System

If the engine alarm/shutdown module receives a low oil pressure, high oil temperature, high coolant temperature or low coolant level input, the module will immediately sound the audible warning and, after a 30 to 40 second delay, interrupt the voltage supply to circuit 720 (BL). This de-energizes the fuel shutoff relay, cutting off current to the fuel shutoff solenoid. The shutoff lever moves to the "Off" position and the engine stops running.

Prove-Out Mode

All four engine protection warning lamps will illuminate when the starter is engaged.

Low Oil Pressure Detection

NOTE: At extremely cold temperatures, with a high viscosity oil, the engine shutdown system can activate the engine alarm/shutdown module before the engine has a chance to start.

The oil pressure switch is normally closed. The presence of adequate oil pressure opens the switch, thereby turning off the oil pressure warning indicator lamp and the audible warning. When oil pressure is insufficient, the oil pressure switch remains closed, grounding the oil pressure warning indicator lamp circuit and the engine alarm/shutdown circuit. The indicator lamp illuminates and the audible warning sounds. If the circuit is grounded for 30 to 40 seconds, the engine alarm/shutdown module opens the power circuit for the fuel shutoff relay coil and the engine shuts down.

High Oil Temperature Detection

The oil temperature switch is normally open. If the oil temperature exceeds the design parameter, the switch closes, grounding the oil temperature warning indicator lamp circuit and the engine alarm/shutdown circuit. The indicator lamp illuminates and the engine alarm/shutdown module sounds the audible warning. If the circuit is activated (grounded) for 30 to 40 seconds, the engine alarm/shutdown module opens the power circuit for the fuel shutoff relay coil and the engine shuts down.

High Coolant Temperature Detection

The coolant temperature switch is normally open. If the coolant temperature exceeds the design parameter, the switch closes, grounding the coolant temperature warning indicator lamp circuit and the engine alarm/shutdown circuit. The indicator lamp illuminates and the engine alarm/shutdown module sounds the audible warning. If the circuit is activated (grounded) for 30 to 40 seconds, the engine alarm/shutdown module opens the power circuit for the fuel shutoff relay coil and the engine shuts down.

Low Coolant Level Detection

NOTE: The resistance value of pure antifreeze (without water mix) is high and the sensor can indicate a low level if it is submerged in pure antifreeze. During a system refill, mix the antifreeze with water in the proper ratio before adding it to the coolant reservoir. See **Group 20** of this manual for information on refilling the cool-

General Information

ing system and for information on antifreeze mixture ratios.

The engine alarm/shutdown module monitors the resistance between the tip of the low coolant sensor and the threaded base of the sensor. If the coolant level drops far enough so that the sensor is no longer submerged in coolant mixture, the engine alarm/shutdown module registers the increase in resistance (air has a much higher resistance than coolant). After a short delay of one to three seconds, the engine alarm/shutdown module grounds the coolant level warning indicator lamp circuit and the engine alarm/shutdown module circuit. The coolant level warning indicator lamp is illuminated and the engine alarm/shutdown module sounds the audible warning. If the low coolant level sensor circuit remains at a high resistance for 30 to 40 seconds, the engine alarm/shutdown module opens the power circuit to the fuel shutoff relay coil and the engine shuts down.

Electronic Instrument Cluster Removal and Installation

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.

⚠ WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the air system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

2. Drain the air system.
3. Remove the driver side finish panel. see **Section 60.01** for instructions.
4. Remove the screws from the instrument cluster. See **Fig. 1**.

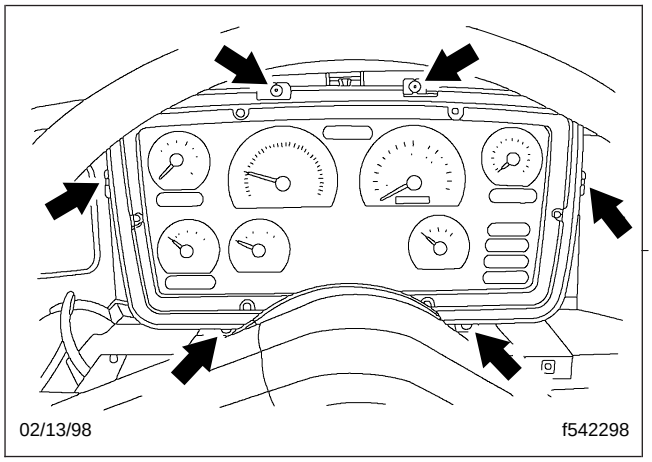


Fig. 1, Instrument Cluster Screws

NOTE: The pneumatic lines are of the quick-release type.

5. Tilt the cluster outward and disconnect the electrical connectors. See **Fig. 2**.
6. Disconnect the air pressure lines. See **Fig. 3**.
7. Remove the oil pressure line and remove the cluster. See **Fig. 4**.

Installation

1. Install the oil pressure line. See **Fig. 4**.

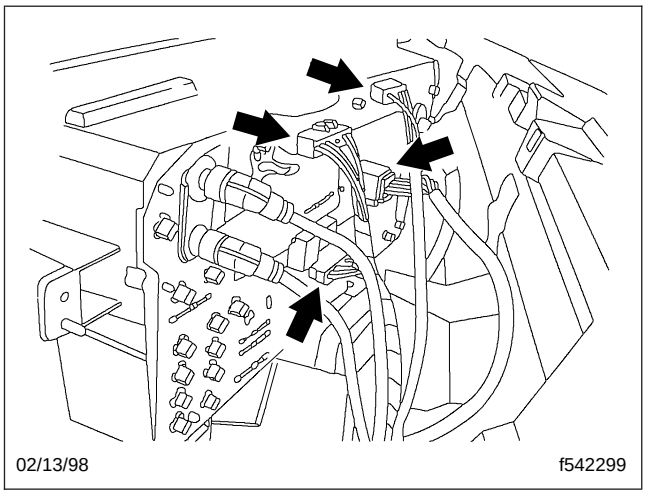


Fig. 2, Instrument Cluster Electrical Connectors

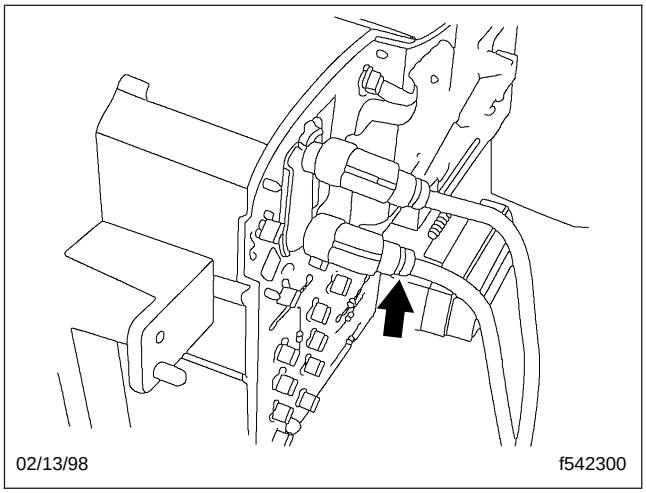


Fig. 3, Air Pressure Lines

2. Connect the air pressure lines. See **Fig. 3**.
3. Connect the electrical connectors. See **Fig. 2**.
4. Install the instrument cluster and tighten the screws. See **Fig. 1**.
5. Install the driver side finish panel. See **Section 60.01** for instructions.
6. Remove the chocks from the tires.

Electronic Instrument Cluster Removal and Installation

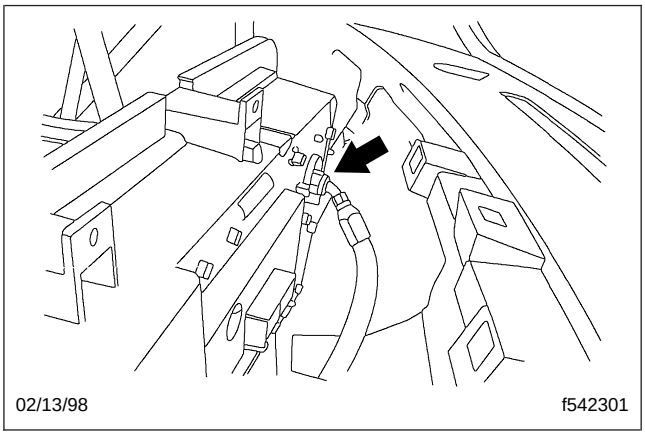


Fig. 4, Oil Pressure Line

Non-Electronic Instrument Cluster Removal and Installation

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the driver side finish panel. See **Section 60.01** for instructions.

⚠ WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the air system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

3. Drain the air system.
4. Remove the screws from the instrument cluster housing. See **Fig. 1**.

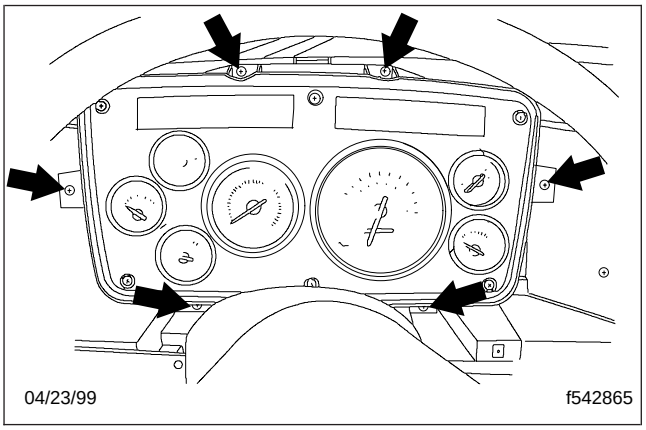


Fig. 1, Instrument Cluster Housing Screws

NOTE: The pneumatic lines are of the quick-release type.

5. Tilt the cluster outward and disconnect the electrical connectors. See **Fig. 2**.
6. Disconnect the air pressure lines. See **Fig. 3**.
7. Disconnect the oil pressure line and remove the cluster. See **Fig. 4**.

Installation

1. Connect the oil pressure line. See **Fig. 4**.
2. Connect the air pressure lines. See **Fig. 3**.

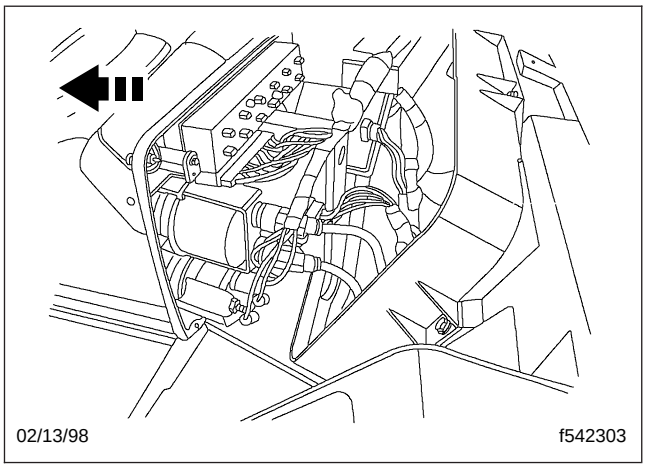


Fig. 2, Instrument Cluster Electrical Connectors

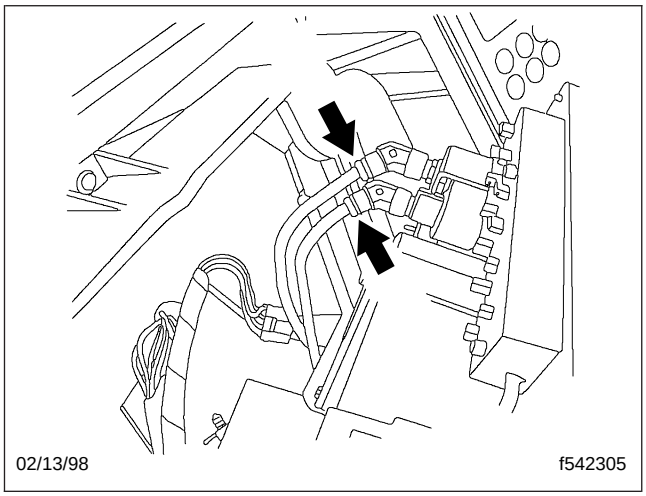


Fig. 3, Air Pressure Lines

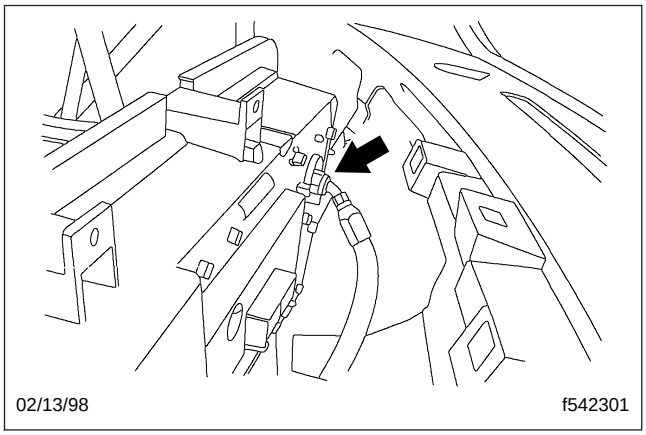


Fig. 4, Oil Pressure Line

Non-Electronic Instrument Cluster Removal and Installation

3. Connect the electrical connectors. See **Fig. 2**.
4. Install the instrument cluster and tighten the housing screws. See **Fig. 1**.
5. Install the driver side finish panel. See **Section 60.01** for instructions.
6. Remove the chocks from the tires.

Electronic Instrument Cluster Gauges Removal and Installation

Oil Pressure and Air Pressure Gauges

REMOVAL

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.

⚠ WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the air system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

3. Drain the air system.
4. Remove the instrument cluster. For instructions, see **Subject 100**.
5. Disconnect the oil and air lines.
6. Remove the instrument cluster lens and mask assembly.
7. Remove the gauge.

INSTALLATION

1. Connect the electrical connector.
2. Connect the air lines.
3. Install the gauge.

⚠ CAUTION

Before replacing the lens/mask assembly, carefully move the speedometer and tachometer pointers above zero to avoid pointer damage.

4. Install the instrument cluster, then install the instrument cluster lens and mask assembly. For instructions, see **Subject 100**.
5. Engage the quarter-turn fasteners. See **Fig. 1**.
6. Connect the batteries.
7. Remove the chocks from the tires.

Speedometer, Tachometer, Coolant Temperature, Voltmeter, and Fuel Gauges

REMOVAL

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Release the quarter-turn fasteners from the instrument cluster. See **Fig. 1**.

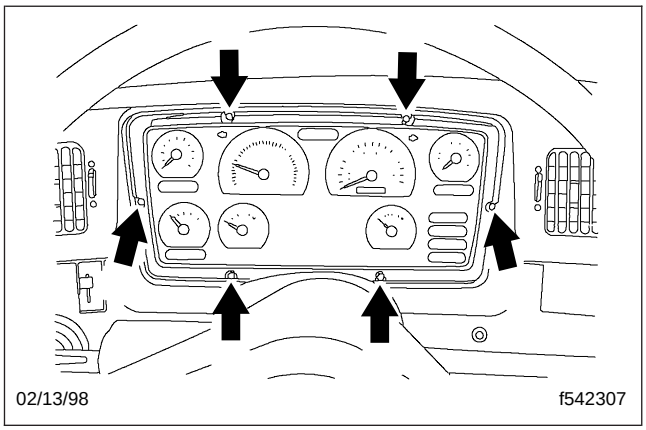


Fig. 1, Quarter-Turn Fasteners

4. Remove the instrument cluster lens and mask assembly. See **Fig. 2**.

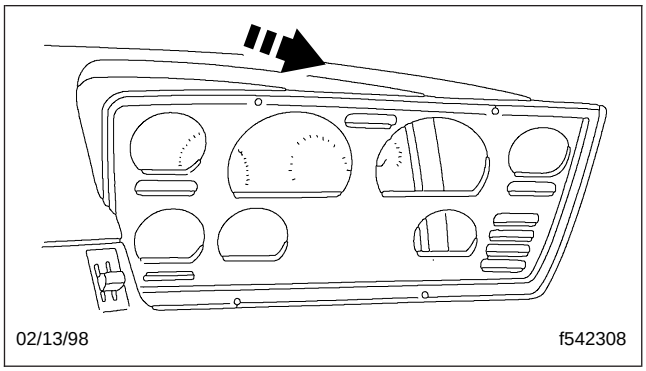


Fig. 2, Instrument Cluster Lens and Mask Assembly

5. Pull the gauge outward. See **Fig. 3**.

Electronic Instrument Cluster Gauges Removal and Installation

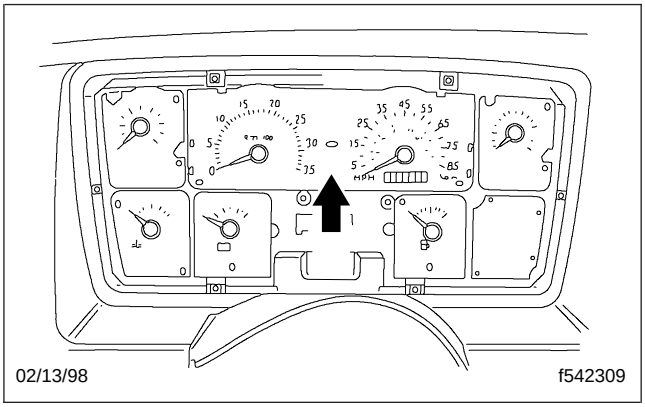


Fig. 3, Speedometer/Tachometer Assembly

6. Disconnect the electrical connector and remove the speedometer/tachometer assembly. See **Fig. 4**.

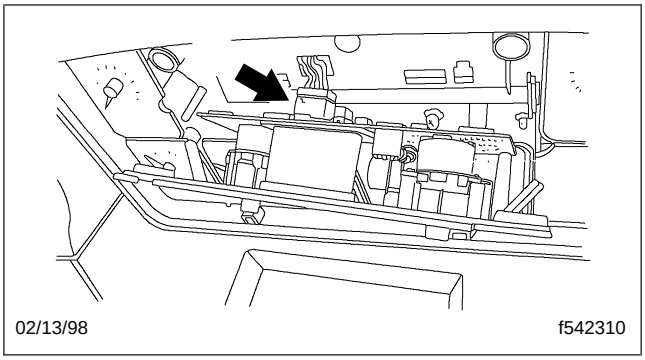


Fig. 4, Speedometer/Tachometer Electrical Connector

INSTALLATION

1. Connect the electrical connector and install the speedometer/tachometer assembly. See **Fig. 4**.

NOTE: Make sure the warning indicator lamp tubes are properly aligned when inserting the gauges.

⚠ CAUTION

Before replacing the lens/mask assembly, carefully move the speedometer and tachometer pointers above zero to avoid pointer damage.

2. Install the instrument cluster lens and mask assembly. See **Fig. 2**.
3. Engage the quarter-turn fasteners. See **Fig. 1**.
4. Connect the batteries.
5. Remove the chocks from the tires.

Non-Electronic Instrument Cluster Gauges Removal and Installation

Fuel Gauge

REMOVAL

NOTE: This procedure is typical and covers left-hand-drive and right-hand-drive vehicles.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.

⚠ WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the air system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

2. Drain the air system.
3. Disconnect the battery.
4. Loosen the six quarter-turn screws and pull the instrument cluster forward. See **Fig. 1**.

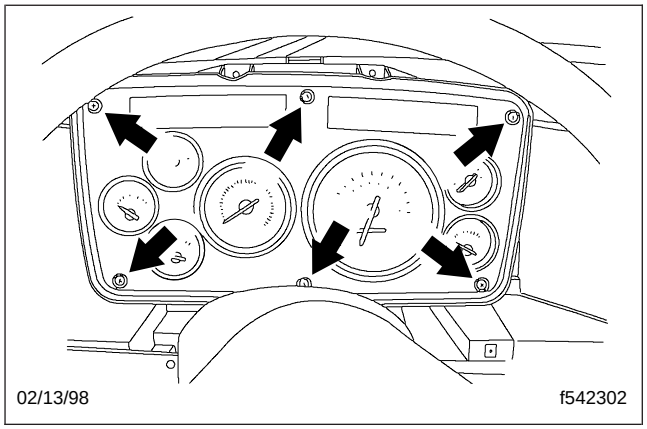


Fig. 1, Quarter-Turn Fasteners

5. Disconnect the air lines from the air pressure gauge. See **Fig. 2**.
6. Disconnect the electrical to the fuel gauge.
7. Disconnect the bracket nuts and the fasteners. See **Fig. 3**.
8. Remove the fuel gauge through the front of the instrument cluster. See **Fig. 4**.

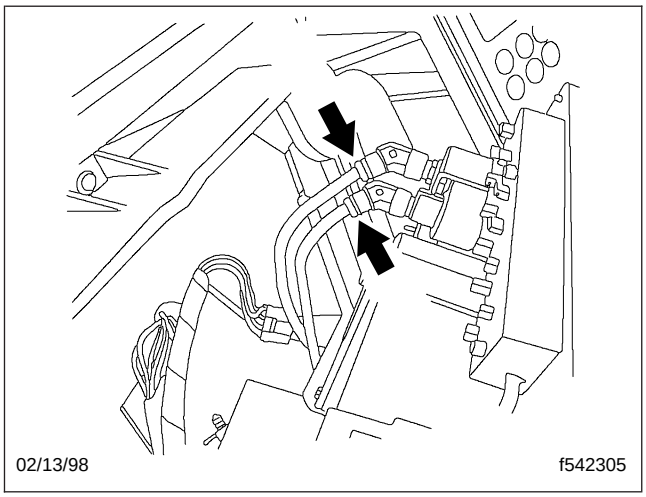


Fig. 2, Air Pressure Gauge Air Lines

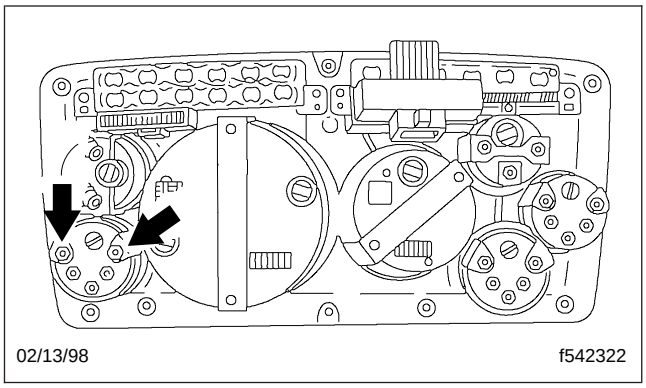


Fig. 3, Fuel Gauge Fasteners

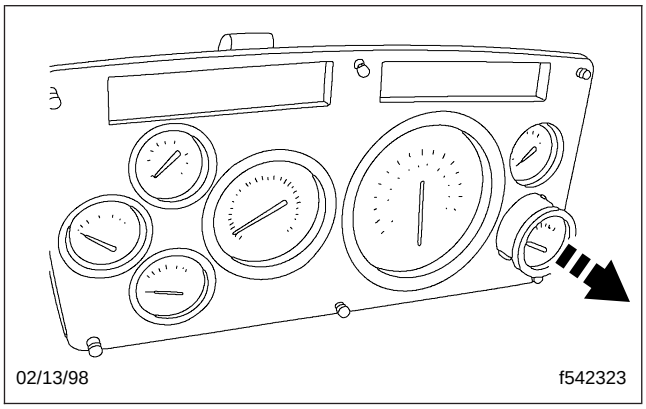


Fig. 4, Fuel Gauge

Non-Electronic Instrument Cluster Gauges Removal and Installation

INSTALLATION

NOTE: Align the fuel gauge locating key to the instrument cluster slot.

1. Install the fuel gauge through the front of the instrument cluster.
2. Install and tighten the bracket nuts.
3. Connect the electrical.
4. Connect the air lines.
5. Insert the instrument cluster and tighten the quarter-turn screws. See **Fig. 1**.
6. Connect the battery.
7. Remove the chocks from the tires.

Voltmeter Gauge

REMOVAL

NOTE: This procedure is typical and covers left-hand-drive and right-hand-drive vehicles.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.

⚠ WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the seating system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

2. Drain the vehicle air reservoirs.
3. Disconnect the battery.
4. Loosen the six quarter-turn screws and pull the instrument cluster forward. See **Fig. 1**.
5. Disconnect the air lines from the air pressure gauge. See **Fig. 2**.
6. Disconnect the electrical to the voltmeter gauge.
7. Disconnect the bracket nuts and remove the fasteners. See **Fig. 5**.
8. Remove the voltmeter gauge through the front of the instrument cluster. See **Fig. 6**.

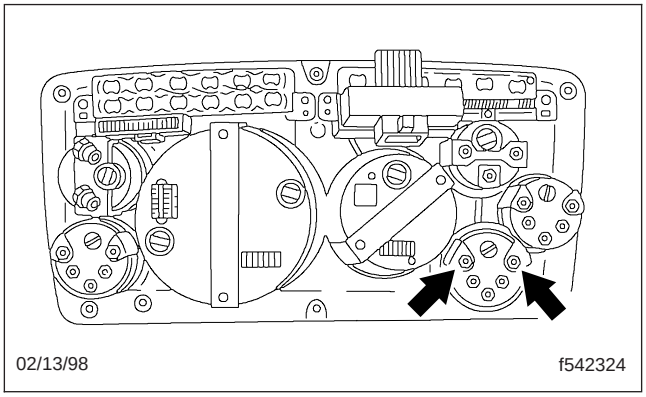


Fig. 5, Voltmeter Fasteners

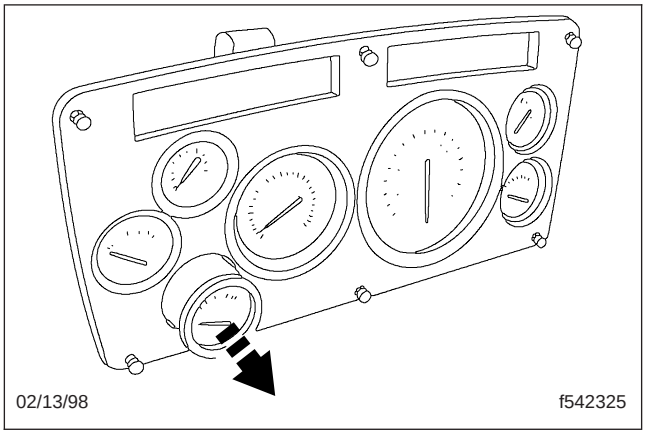


Fig. 6, Voltmeter Gauge

INSTALLATION

NOTE: Align the voltmeter gauge locating key to the instrument cluster slot.

1. Install the voltmeter gauge.
2. Install and tighten the bracket nuts.
3. Connect the electrical.
4. Connect the air lines.
5. Insert the instrument cluster and tighten the quarter-turn screws. See **Fig. 1**.
6. Connect the battery.
7. Remove the chocks from the tires.

Non-Electronic Instrument Cluster Gauges Removal and Installation

Coolant Temperature Gauge

REMOVAL

NOTE: This procedure is typical and covers left-hand-drive and right-hand-drive vehicles.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.

⚠ WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the seating system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

2. Drain the vehicle air reservoirs.
3. Disconnect the battery.
4. Loosen the six quarter-turn screws and pull the instrument cluster forward. See **Fig. 1**.
5. Disconnect the air lines from the air pressure gauge. See **Fig. 2**.
6. Disconnect the electrical to the coolant temperature gauge.
7. Disconnect the bracket nuts and fasteners. See **Fig. 7**.

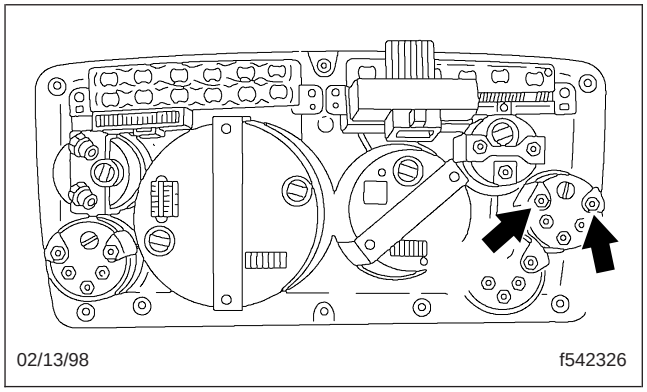


Fig. 7, Coolant Temperature Gauge Fasteners

8. Remove the coolant temperature gauge through the front of the instrument cluster. See **Fig. 8**.

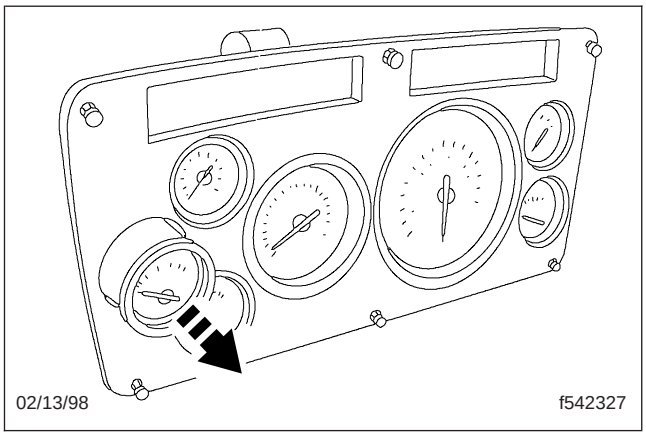


Fig. 8, Coolant Temperature Gauge

INSTALLATION

NOTE: Align the coolant temperature gauge locating key to the instrument cluster slot.

1. Install the coolant temperature gauge.
2. Install and tighten the bracket nuts.
3. Connect the electrical.
4. Connect the air lines.
5. Insert the instrument cluster and tighten the quarter-turn screws. See **Fig. 1**.
6. Connect the battery.
7. Remove the chocks from the tires.

Oil Pressure Gauge

REMOVAL

NOTE: This procedure is typical and covers left-hand-drive and right-hand-drive vehicles.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.

⚠ WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the seating system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

Non-Electronic Instrument Cluster Gauges Removal and Installation

2. Drain the vehicle air reservoirs.
3. Disconnect the battery.
4. Loosen the six quarter-turn screws and pull the instrument cluster forward. See **Fig. 1**.
5. Disconnect the air lines from the air pressure gauge. See **Fig. 2**.
6. Disconnect the electrical to the oil pressure gauge.
7. Disconnect the oil pressure line. See **Fig. 9**.

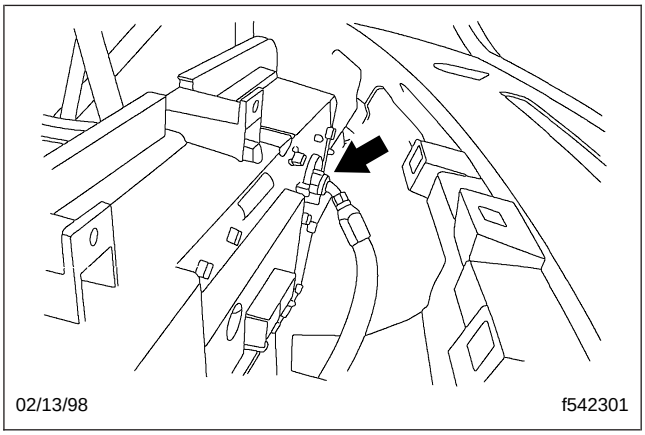


Fig. 9, Oil Pressure Line

8. Disconnect the bracket nuts and remove the fasteners. See **Fig. 10**.

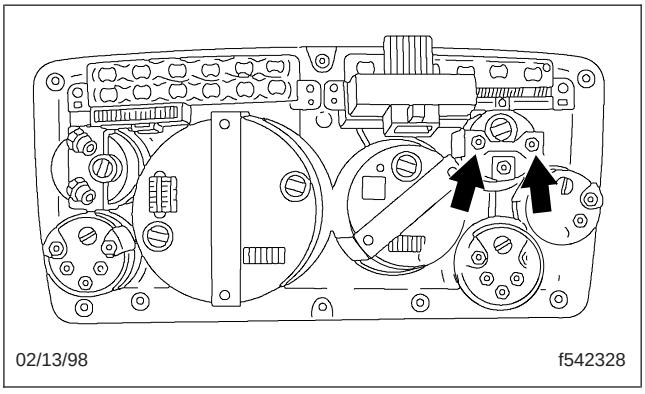


Fig. 10, Oil Pressure Gauge Fasteners

9. Remove the oil pressure gauge through the front of the instrument cluster. See **Fig. 11**.

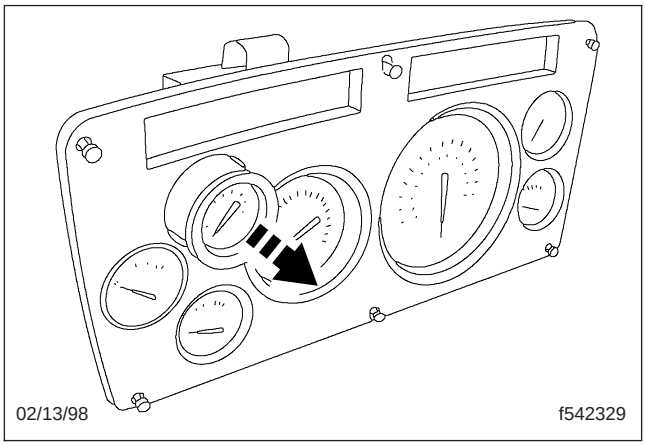


Fig. 11, Oil Pressure Gauge

INSTALLATION

NOTE: Align the oil pressure gauge locating key to the instrument cluster slot.

1. Install the oil pressure gauge.
2. Install and tighten the bracket nuts.
3. Connect the electrical.
4. Connect the air lines.
5. Connect the oil pressure line. See **Fig. 9**.
6. Insert the instrument cluster and tighten the quarter-turn screws. See **Fig. 1**.
7. Connect the battery.
8. Remove the chocks from the tires.

Air Pressure Gauge

REMOVAL

NOTE: This procedure is typical and covers left-hand-drive and right-hand-drive vehicles.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.

⚠ WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the seating system. Failure to re-

Non-Electronic Instrument Cluster Gauges Removal and Installation

lieve air pressure could cause the lines to whip, resulting in personal injury.

2. Drain the vehicle air reservoirs.
3. Disconnect the battery.
4. Loosen the six quarter-turn screws and pull the instrument cluster forward. See **Fig. 1**.
5. Disconnect the air lines from the air pressure gauge. See **Fig. 2**.
6. Disconnect the air fittings from the air pressure gauge. See **Fig. 12**.

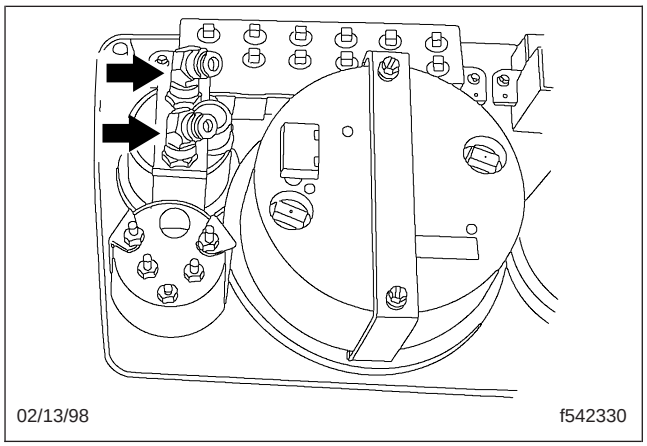


Fig. 12, Air Pressure Fittings

7. Disconnect the electrical to the air pressure gauge.
8. Remove the fasteners. See **Fig. 13**.

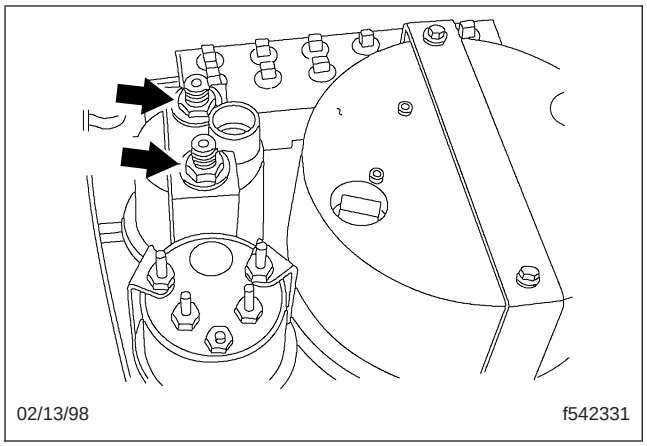


Fig. 13, Air Pressure Gauge Fasteners

9. Remove the air pressure gauge through the front of the instrument cluster. See **Fig. 14**.

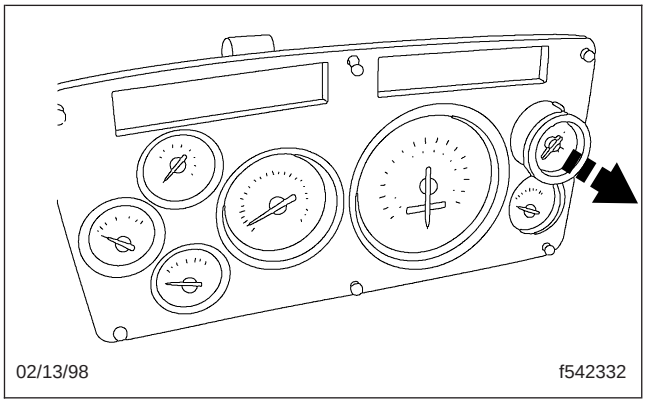


Fig. 14, Air Pressure Gauge

INSTALLATION

NOTE: Align the air pressure gauge locating key to the instrument cluster slot.

1. Install the air pressure gauge.
2. Slide the bracket over the bottom of the gauge.
3. Install the bracket nuts and fasteners. See **Fig. 13**.
4. Install the air pressure fittings. See **Fig. 12**.
5. Connect the electrical.
6. Connect the air lines.
7. Insert the instrument cluster and tighten the quarter-turn screws. See **Fig. 1**.
8. Connect the battery.
9. Remove the chocks from the tires.

Speedometer

REMOVAL

NOTE: This procedure is typical and covers left-hand-drive and right-hand-drive vehicles.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.

Non-Electronic Instrument Cluster Gauges Removal and Installation

WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the seating system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

2. Drain the vehicle air reservoirs.
3. Disconnect the battery.
4. Loosen the six quarter-turn screws and pull the instrument cluster forward. See **Fig. 1**.
5. Disconnect the air lines from the air pressure gauge. See **Fig. 2**.
6. Disconnect the electrical to the speedometer.
7. Remove the two screws from the bracket and remove the bracket. See **Fig. 15**.

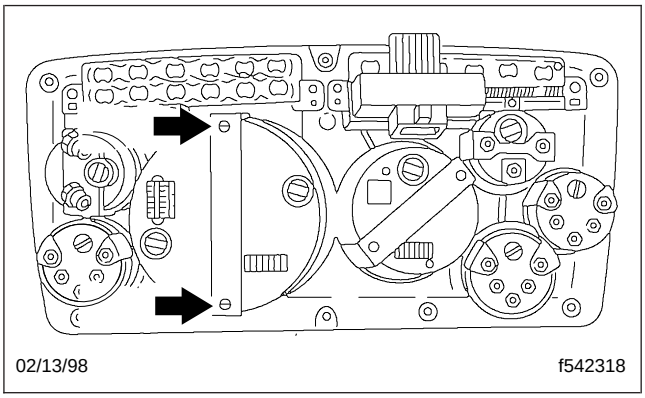


Fig. 15, Speedometer Fasteners

8. Remove the speedometer through the front of the instrument cluster. See **Fig. 16**.
9. Calibrate the speedometer. Refer to **Subject 170** for instructions.

INSTALLATION

NOTE: Align the speedometer locating key to the instrument cluster slot.

1. Install the speedometer through the front of the instrument cluster.
2. Install and tighten the bracket screws. See **Fig. 15**.
3. Connect the electrical.

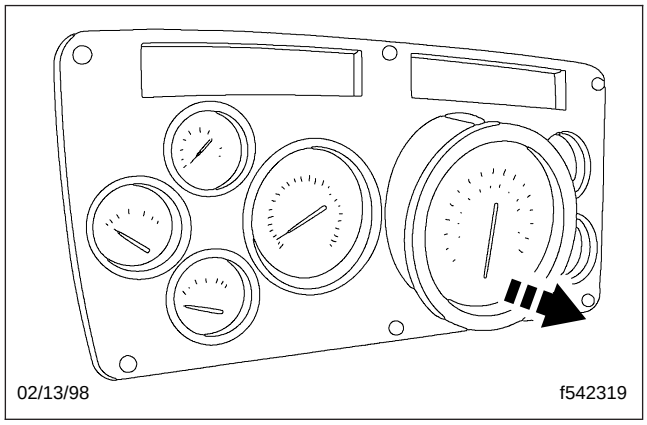


Fig. 16, Speedometer

4. Connect the air lines.
5. Insert the instrument cluster and tighten the quarter-turn screws. See **Fig. 1**.
6. Connect the battery.
7. Remove the chocks from the tires.

Tachometer Gauge

REMOVAL

NOTE: This procedure is typical and covers left-hand-drive and right-hand-drive vehicles.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.

WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the seating system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

2. Drain the vehicle air reservoirs.
3. Disconnect the battery.
4. Loosen the six quarter-turn screws and pull the instrument cluster forward. See **Fig. 1**.
5. Disconnect the air lines from the air pressure gauge. See **Fig. 2**.
6. Disconnect the electrical to the tachometer.

7. Remove the two screws from the bracket and remove the bracket. See **Fig. 17**.

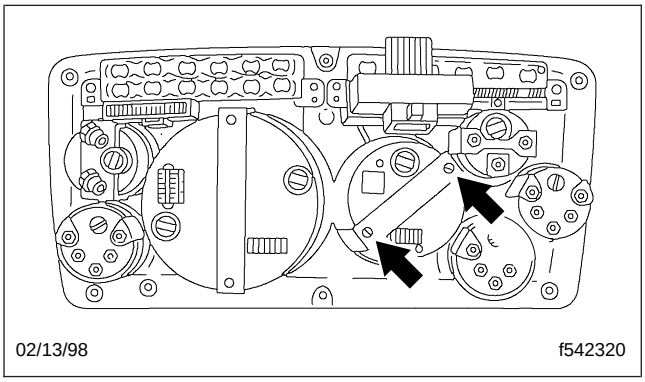


Fig. 17, Tachometer Fasteners

8. Remove the speedometer through the front of the instrument cluster. See **Fig. 18**.

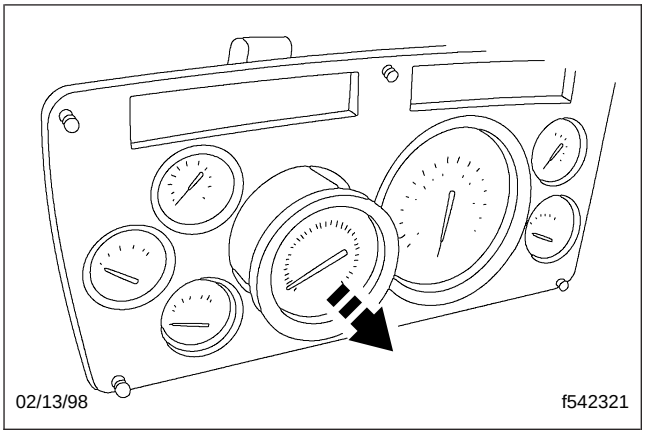


Fig. 18, Tachometer

9. Calibrate the tachometer. See **Subject 170** for instructions.

INSTALLATION

NOTE: Align the tachometer locating key to the instrument cluster slot.

1. Install the tachometer through the front of the instrument cluster.
2. Install and tighten the bracket screws. See **Fig. 17**.
3. Connect the electrical.
4. Connect the air lines.
5. Insert the instrument cluster and tighten the quarter-turn screws. See **Fig. 1**.
6. Connect the battery.
7. Remove the chocks from the tires.

Electronic Instrument Cluster Printed Circuit Removal and Installation

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the battery.

⚠ WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the air system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

3. Drain the air system.
4. Remove the instrument cluster. See **Subject 100** for instructions.
5. Remove the lens and mask assembly. See **Fig. 1**.

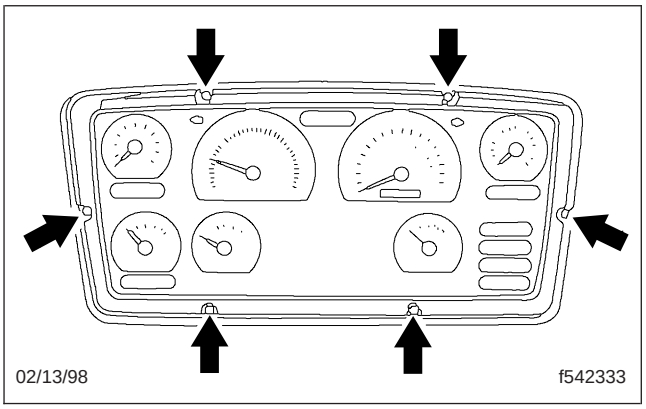


Fig. 1, Lens and Mask Assembly

6. Remove the coolant temperature gauge, the voltmeter gauge, the speedometer/tachometer assembly, and the fuel gauge by pulling the gauges outward. See **Subject 120** for instructions. See **Fig. 2**.
7. Remove the miniature bulbs (maximum of 27). See **Fig. 3**.
8. Disconnect the electrical connector. See **Fig. 4**.
9. Push the gauge terminals through the back of the cluster and remove the instrument cluster printed circuit. See **Fig. 5**.

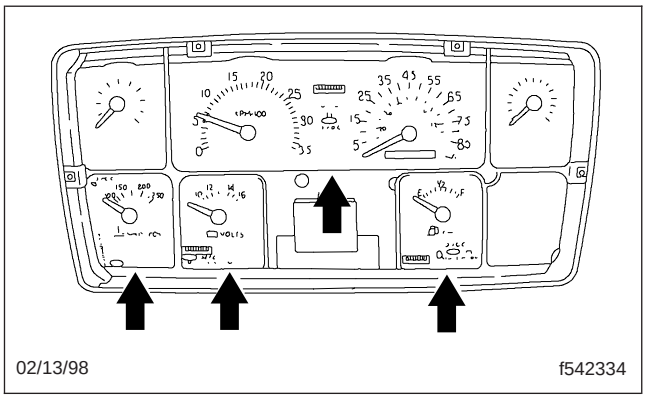


Fig. 2, Gauges

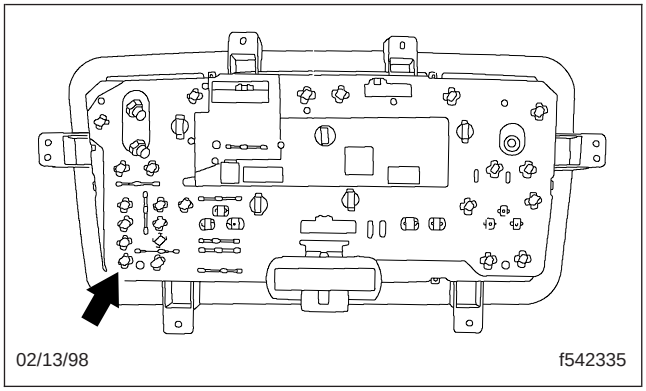


Fig. 3, Miniature Bulbs

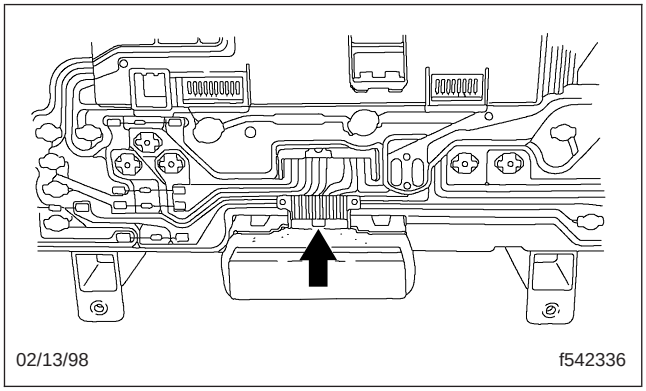


Fig. 4, Instrument Cluster Printed Circuit Electrical Connector

Installation

1. Install the instrument cluster printed circuit. See **Fig. 5**.

Electronic Instrument Cluster Printed Circuit Removal and Installation

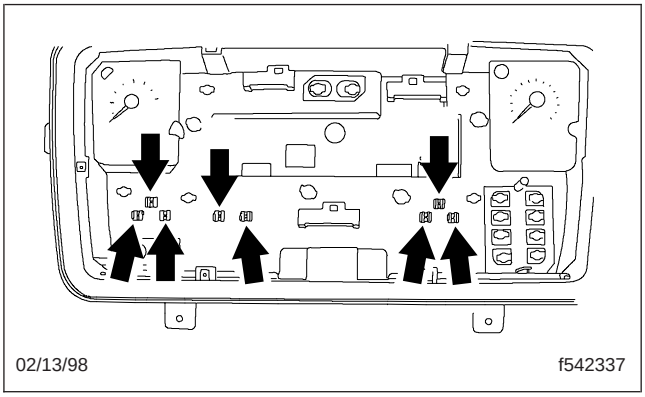


Fig. 5, Gauge Terminals

2. Connect the electrical connector. See **Fig. 4**.
3. Install the miniature bulbs. See **Fig. 3**.

NOTE: Make sure the warning indicator lamp tubes are properly aligned when inserting the gauges.

4. Install the speedometer/tachometer assembly, the fuel gauge, the voltmeter gauge and the coolant temperature gauge. See **Fig. 2**.

⚠ CAUTION

Before replacing the lens/mask assembly, carefully move the speedometer and tachometer pointers above zero to avoid pointer damage.

5. Install the lens and mask assembly. See **Fig. 1**.
6. Install the instrument cluster. See **Subject 100** for instructions.
7. Connect the battery.
8. Remove the chocks from the tires.

Warning Lamp Module Bulb Replacement

Electronic Instrument Cluster

REPLACEMENT

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the battery.
3. Loosen the quarter-turn fasteners.
4. Remove the instrument cluster lens and mask assembly.

NOTE: The warning indicator panel, in the lower right corner of the instrument cluster, is removed in a manner similar to the gauge removal.

NOTE: For replacement of the bulb socket, the instrument cluster must be removed.

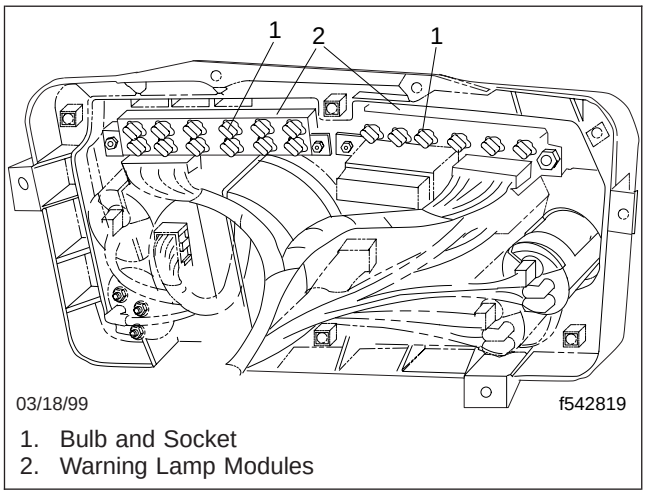
5. It may be necessary to remove more than one gauge to gain access to the desired bulb.

   Grasp the bulb(s) and pull it straight out of the socket.
6. Install the bulb.
7. Install the instrument cluster lens and mask assembly.
8. Tighten the quarter-turn fasteners.

Non-Electronic Instrument Cluster

REPLACEMENT **(See Fig. 1)**

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the battery.
3. Loosen the six quarter-turn screws and pull the instrument cluster forward to reveal the warning lamp modules.
4. Twist the socket counterclockwise approximately a quarter-turn. Pull the bulb out of the warning lamp module. See **Fig. 1**.
5. Twist the socket clockwise a quarter-turn. Insert the bulb into the warning lamp module.



1. Bulb and Socket
2. Warning Lamp Modules

Fig. 1, Bulb and Socket and Warning Lamp Modules

6. Install the instrument cluster and tighten the six quarter-turn screws.
7. Connect the battery.
8. Remove the chocks from the tires.

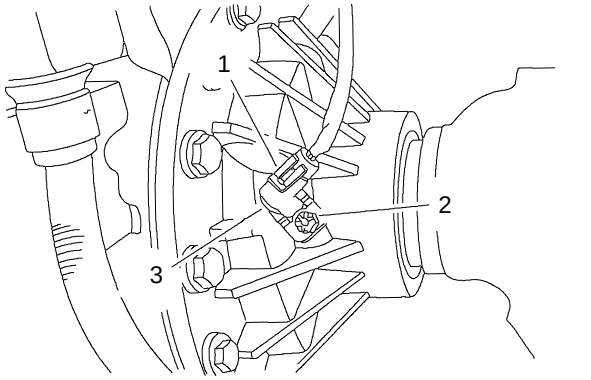
Speedometer Vehicle Speed Sensor (VSS) Replacement

Replacement

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the battery.

NOTE: The vehicle speed sensor (VSS) is located in the transmission housing. Its position in the housing varies depending on the transmission model.

3. Remove the VSS. See **Fig. 1**.



1. Electrical Connector
2. Bolt
3. Vehicle Speed Sensor (VSS)

Fig. 1, Vehicle Speed Sensor (VSS)

3.1 Disconnect the electrical connector.

3.2 Remove the bolt.

3.3 Remove the sensor.

4. Install the VSS.

4.1 Position the sensor.

4.2 Install the bolt.

4.3 Connect the electrical connector.

5. Connect the battery.
6. Remove the chocks from the tires.

Tachometer Calibration

NOTE: The tachometer is calibrated according to the engine type and the number of flywheel teeth. The tachometer can be calibrated by setting the eight dip switches on the back of the tachometer. See **Fig. 1** for the electronic instrument cluster, and **Fig. 2** for the individual gauge instrument cluster. Embossed on the switch are the numbers 1 through 8.

NOTE: A switch is in the "On" position when the switch is pressed towards the number on the top of the switch (settings are listed on the tachometer case label).

1. Determine the number of flywheel teeth from **Table 1**.

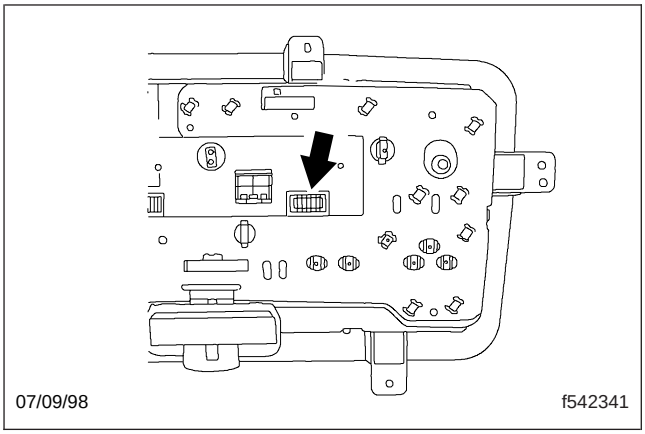


Fig. 1, Electronic Instrument Cluster Eight-Pin Tachometer Dip Switch

Flywheel Teeth	
Engine Type	**Flywheel Teeth**
Cummins M11, N14	103
Caterpillar 3306	156
Caterpillar C10, C12, 3406 (electronic speed output present)	113
Detroit Diesel	118

Table 1, Flywheel Teeth

2. Determine the test frequency required to produce any rpm by using the following equation:

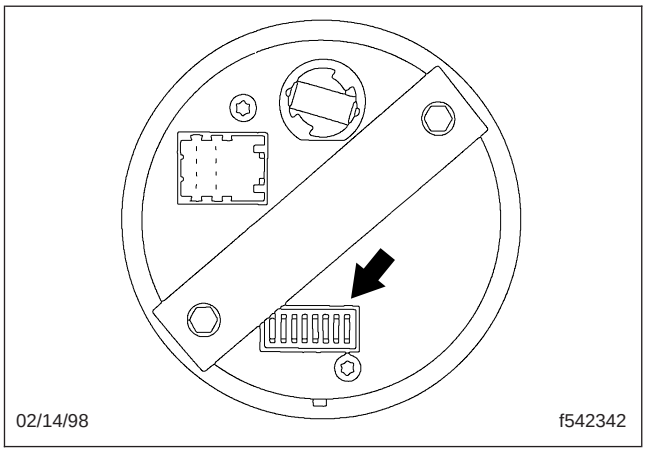


Fig. 2, Non-Electronic Instrument Cluster Eight-Pin Tachometer Dip Switch

Test Frequency = rpm x (Flywheel Teeth/60).

3. Place the switches in either the "On" or "Off" position, depending on the engine type.

NOTE: Electronic engines usually have a separate engine speed output. This output provides 12 pulses per revolution:

4. Refer to the following list for switch settings for the 12 pulse per revolution signal:
   - S1, Off
   - S2, Off
   - S3, Off
   - S4, Off
   - S5, On
   - S6, On
   - S7, Off
   - S8, Off
   - Frequency at 1/2 scale (Hz.), 300
5. Refer to the "Tachometer Dip Switch Setting Chart" in **Specifications, 400** for correct calibration given the number of flywheel teeth and the test frequency at half-scale in hertz.

Speedometer Calibration

NOTE: Periodic inspection of the vehicle speed sensor (VSS) is necessary to ensure the electronic speedometer system operates accurately. The intervals at which to check the speed sensor in mileage (kilometers) are: 500 (800), 12,500 (20 000), 25,000 (40 000), 37,500 (60 000), 50,000 (80 000). Scheduled maintenance beyond 50,000 miles (80 000 kilometers) is every 50,000 miles (80 000 kilometers).

1. Inspect the vehicle speed sensor (VSS) for metal filings accumulating on the sensor pole face.

   Metal filings that have developed on the sensor pole face must be removed.

NOTE: If the vehicle has a two-speed differential (e.g., 4.15/5.72:1), use the smaller number (4.15 in this case) in all calculations.

2. Determine the rear axle differential ratio by referring to the information delivered with the vehicle or finding the metal tag attached to the differential.

NOTE: Measure to the nearest 1/8 inch, then use **Table 1** to convert eighths to a decimal (if the measurement is done in centimeters, divide the tire height by 2.54 to convert to inches).

NOTE: Example: If the tire height is 36-1/8 inches, use 36.125 in the revolutions per mile calculation.

3. Calculate the revolutions per mile by first measuring the tire height (ground to the top of the tire) in inches with the vehicle on level ground, loaded, with the tires cold and inflated to the recommended pressure.

Eighths to Decimal Conversion	
Fraction	**Decimal**
1/8	0.125
1/4	0.25
3/8	0.375
1/2	0.5
5/8	0.625
3/4	0.75
7/8	0.875

Table 1, Eighths to Decimal Conversion

4. Divide 20,168 (constant) by the tire height to get the revolutions per mile.

   Example: 20,168/36.125 = 558.28

5. Calculate the calibration frequency by multiplying the axle ratio times the revolutions per mile times 0.267 (constant).

   Example: 4.15 x 558.28 x 0.267 = 611.14

6. Refer to the "Speedometer Dip Switch Setting Chart" in **Specifications, 400**, find the "Test Frequency" column and determine the switch settings.

   6.1 A number means the switch is to be placed in the On or closed position and a period (.) means that the switch is to be placed in the Off or open position.

   6.2 Example: If the test frequency is calculated at 358, the chart gives the switch settings as (..34..7.90). This means that switches 3, 4, 7, 9, 10 are On and switches 1, 2, 5, 6, 8 are Off.

7. Calibrate the electronic or individual gauge speedometer, using the dip switches located on the back of the speedometer. See **Fig. 1** for the electronic speedometer. See **Fig. 2** for the individual gauge speedometer.

Speedometer Calibration

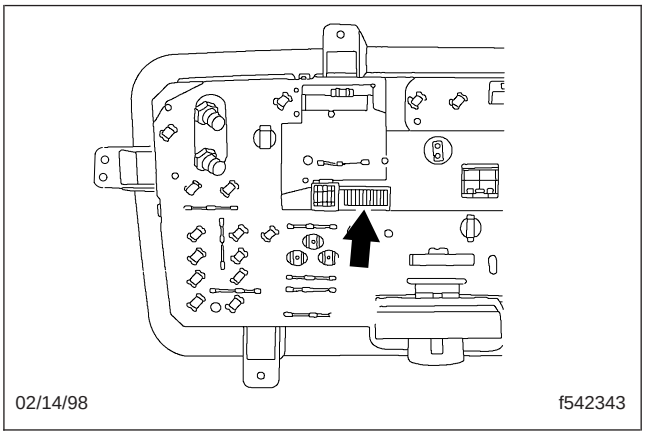


Fig. 1, Electronic Instrument Cluster Speedometer Dip Switch

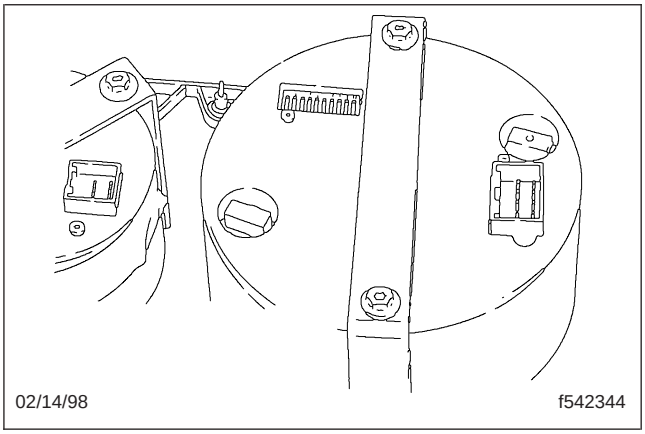


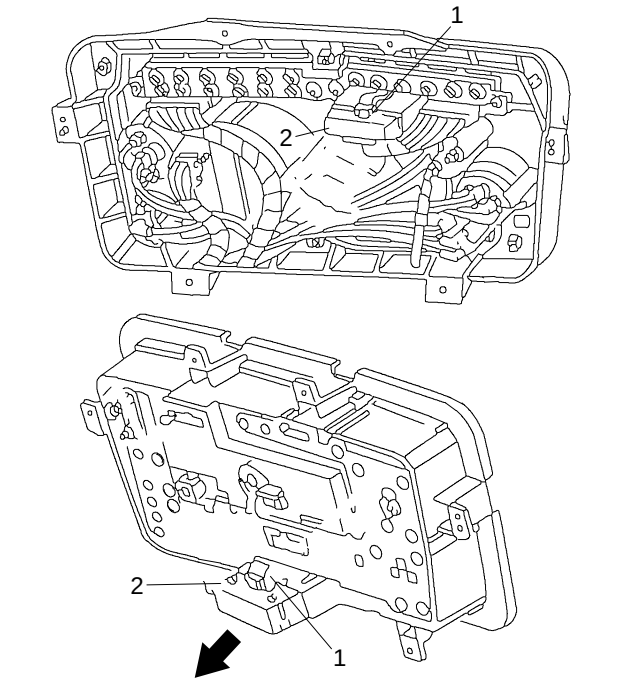
Fig. 2, Non-Electronic Instrument Cluster Speedometer Dip Switch

Brake Low Air Pressure Buzzer/Engine Warning Chime/Engine Alarm/Shutdown Module Replacement

Replacement

NOTE: All three types of warning modules are mounted in the same place in the instrument cluster and have the same replacement procedure.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the instrument cluster. For electronic instrument cluster removal instructions, see **Subject 100**. For non-electronic instrument cluster removal instructions, see **Subject 110**.
3. Disconnect the electrical.
4. Remove the module. See **Fig. 1**.



1. Connector
2. Module

Fig. 1, Warning Module

4.1 For the electronic instrument cluster, disconnect the printed circuit electrical connector.

4.2 Remove the module.

5. Install the module.
6. For the electronic instrument cluster, connect the printed circuit connector.
7. Connect the electrical.
8. Install the instrument cluster.
9. Connect the battery.
10. Remove the chocks from the tires.

Auxiliary Instrument Cluster Gauge Replacement

Replacement

NOTE: This procedure is typical and covers left-hand-drive and right-hand-drive vehicles.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the battery.
3. Remove the trailer brake control valve knob. See **Fig. 1**.

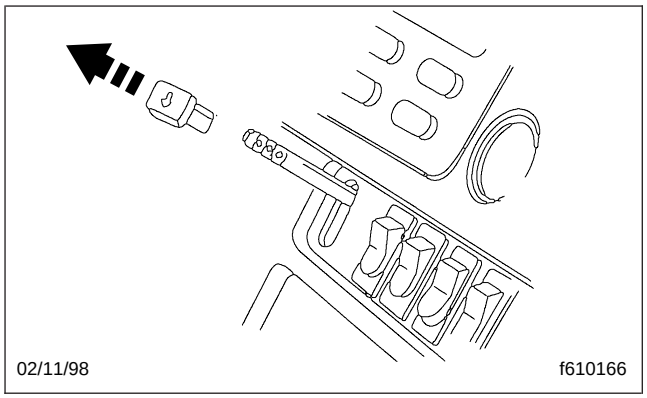


Fig. 1, Trailer Brake Control Valve Knob

4. Remove the screws. See **Fig. 2**.

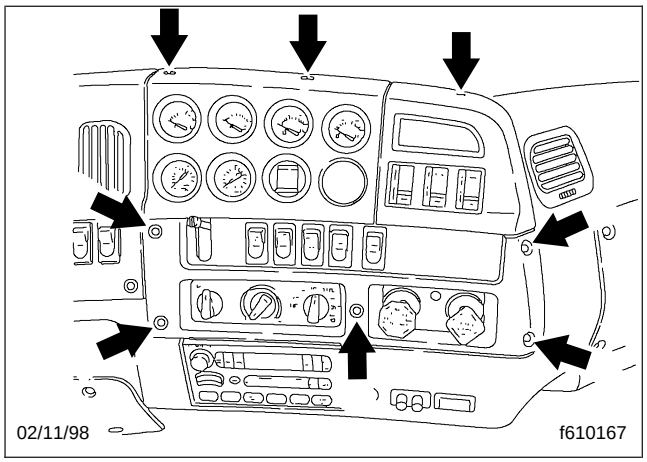


Fig. 2, Auxiliary Finish Panel Screws

5. Tilt the top of the auxiliary finish panel away from the instrument panel cluster to gain access to the gauge retaining bracket and nuts. See **Fig. 3**.
6. Remove the gauge. See **Fig. 4**.

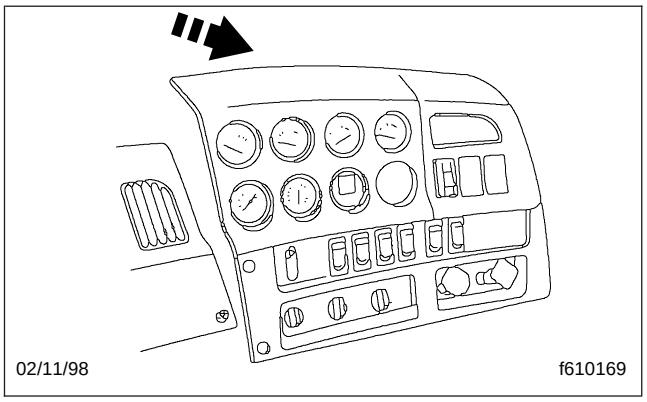
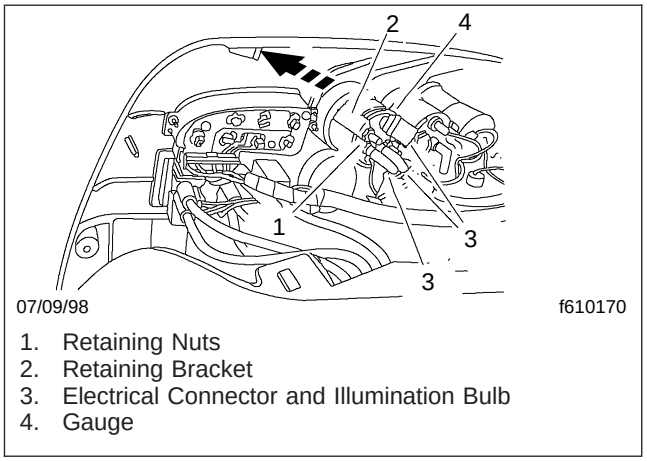


Fig. 3, Auxiliary Finish Panel



1. Retaining Nuts
2. Retaining Bracket
3. Electrical Connector and Illumination Bulb
4. Gauge

Fig. 4, Auxiliary Instrument Cluster Gauge

6.1 Remove the two retaining nuts.

6.2 Remove the gauge retaining bracket.

6.3 Disconnect the electrical connectors and illumination bulb.

6.4 Pull the gauge out of the auxiliary instrument cluster from the front.

7. Position the gauge.
8. Connect the electrical connector and illumination bulb.
9. Install the gauge retaining bracket and nuts.
10. Install the auxiliary finish panel screws.
11. Install the trailer brake control valve knob.
12. Connect the battery.
13. Remove the chocks from the tires.

Electronic and Non-Electronic Instrument Cluster Illumination Bulb Replacement

Electronic Gauge Instrument Cluster Illumination Bulb Replacement

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Release the quarter-turn fasteners. See **Fig. 1**.

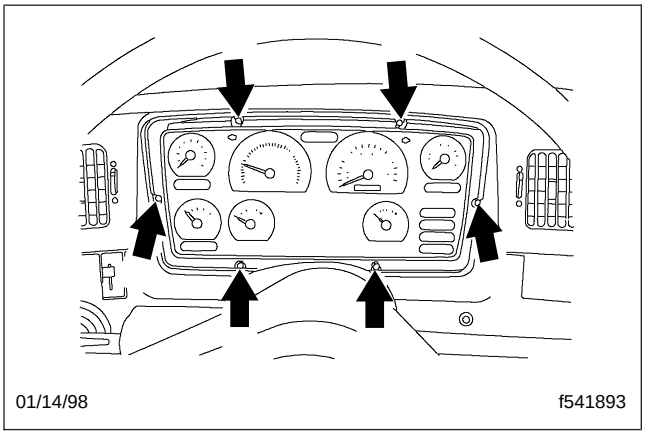


Fig. 1, Quarter-Turn Fasteners

3. Remove the instrument cluster lens and mask assembly. See **Fig. 2**.

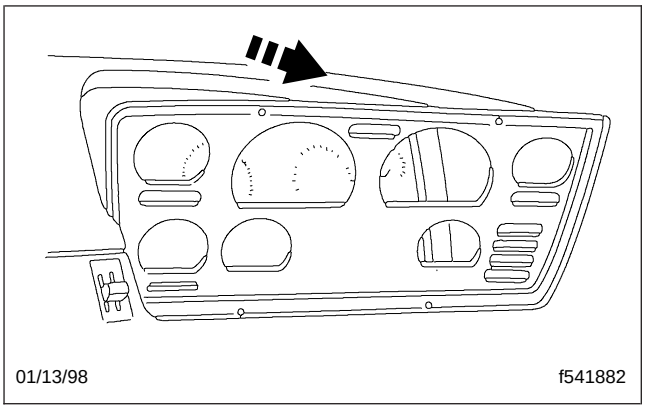


Fig. 2, Instrument Cluster Lens and Mask Assembly

NOTE: If the bulb socket is to be replaced, the instrument cluster must be removed.

4. Pull the gauge outward where the illumination bulb is located.
5. Remove the illumination bulb by twisting and pulling outward.
6. Install the new bulb.
7. Install the gauge.
8. Install the instrument cluster lens and mask assembly.
9. Engage the quarter-turn fasteners.
10. Remove the chocks from the tires.

Non-Electronic Instrument Cluster Illumination Bulb Replacement

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Release the quarter-turn fasteners. See **Fig. 3**.

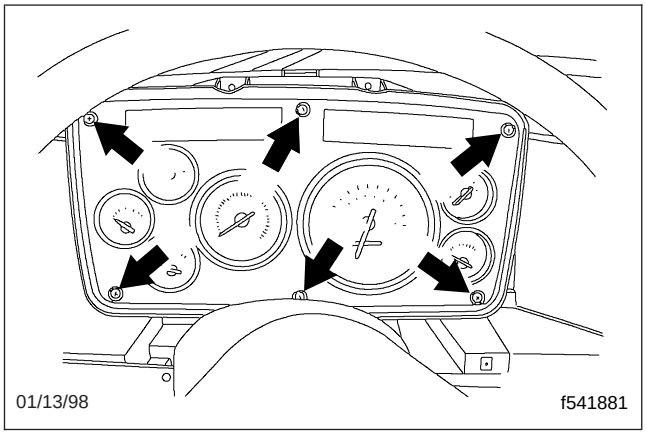


Fig. 3, Quarter-Turn Fasteners

NOTE: Each gauge has its own illumination bulb.

3. Tilt the instrument cluster outward to gain access to the bulb(s).
4. Remove the burned out bulb.
5. Install the new bulb.
6. Install the instrument cluster.
7. Engage the quarter-turn fasteners.
8. Remove the chocks from the tires.

Electronic and Non-Electronic Instrument Cluster Illumination Bulb Replacement

Auxiliary Instrument Cluster Illumination Bulb Replacement

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the trailer brake control valve knob by pulling it straight out. See **Fig. 4**.

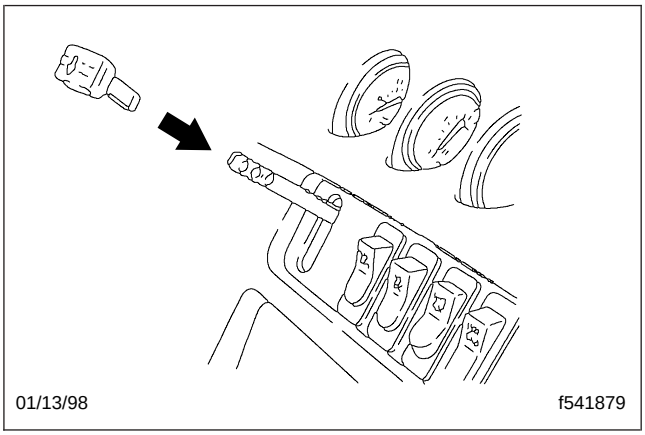


Fig. 4, Trailer Brake Control Valve Knob

3. Remove the screws. See **Fig. 5**.

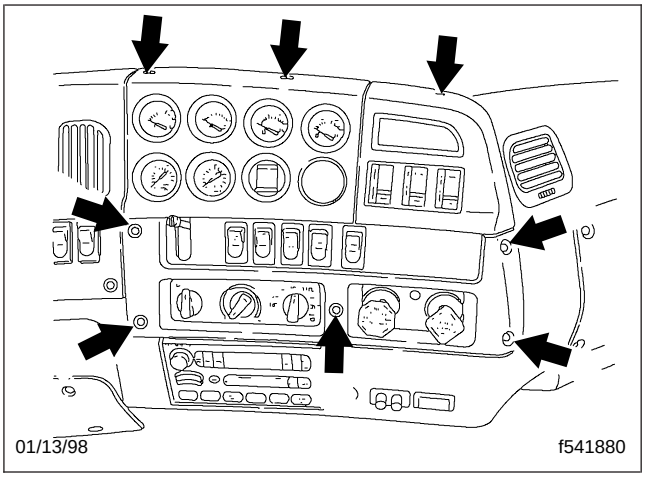


Fig. 5, Auxiliary Finish Panel Screws

NOTE: Each gauge has its own illumination bulb.

4. Tilt the auxiliary instrument cluster outward to gain access to the bulb(s).
5. Remove the burned out bulb.
6. Install the new bulb.
7. Install the auxiliary finish panel.
8. Install the trailer brake control valve knob.
9. Remove the chocks from the tires.

Troubleshooting

Inspection and Verification

1. Verify the vehicle owner's concern by duplicating the original concern. Verify speedometer/ odometer operation by road testing the vehicle.
2. Verify the components or systems related to the fuse for proper operation. If the components or systems are not operating properly, the fuse(s), fuse feed circuit(s) or fuse load side circuit(s) may be the cause.
3. If the concern(s) remains after the inspection, determine the possible causes and proceed to the following problem charts.

Troubleshooting

Problem—Incorrect Fuel Gauge Indication (Electronic Instrument Cluster)

Problem—Incorrect Fuel Gauge Indication (Electronic Instrument Cluster)	
Possible Cause	**Remedy**
Fuse	See **Fig. 1, Fig. 2, Fig. 3, and Fig. 4**. Check Circuit 976 (BL/GN). Turn the ignition switch to the "Off" position and disconnect the electronic instrument cluster connector. Turn the ignition switch to the "On" position and measure the voltage between the electronic instrument cluster connector C231 Pin 12, Circuit 976 (BK/GN) and ground. If the voltage is not greater than 10 volts, repair Circuit 976 (BK/GN) between the splice and the electronic instrument cluster connector. Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 25 (BK/O).
Circuitry open or shorted	Turn the ignition switch to the "Off" position. Measure the resistance between the electronic instrument cluster connector C231 Pin 9, Circuit 25 (BK/O) and ground. If the resistance is more than 5 ohms, repair Circuit 25 (BK/O). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 286 (O) for an open.
Fuel level sensor arm is damaged	Disconnect the fuel level sensor connector. Measure the resistance between the fuel level sensor connector C413 Circuit 286 (O) and the electronic instrument cluster connector C231 Pin 10, Circuit 286 (O). If the resistance is more than 5 ohms, repair Circuit 286 (O) between the electronic instrument cluster connector C231 and the fuel level sensor connector C413. Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 286 (O) for a short to ground.
Damaged gauge	Measure the resistance between the fuel level sensor connector C413 Circuit 286 (O) and ground. If the resistance is less than 10,000 ohms, repair Circuit 286 (O) between the electronic instrument cluster connector C231 and the fuel level sensor connector C413. Test the system for normal operation. If the resistance is more than 10,000 ohms, check the ground for the fuel level sensor.
Resistor element worn or damaged	Measure the resistance between the fuel level sensor connector C413 Circuit 25 (BK/O) and ground. If the resistance is more than 5 ohms, repair Circuit 25 (BK/O) between the fuel level sensor connector C413 and ground. Test the system for normal operation. If the resistance is less than 5 ohms, check the instrument cluster printed circuit voltage supply.
Leaking fuel level sensor float	Connect the electronic instrument cluster connector C231. Remove the fuel gauge. See **Subject 130** for instructions. Turn the ignition switch to the "On" position. Measure the voltage between the voltage supply terminal to the fuel gauge (top terminal) and ground. If the voltage is less than 10 volts, replace the electronic instrument cluster printed circuit (flex circuit assembly). Test the system for normal operation. If the voltage is more than 10 volts, check the instrument cluster printed circuit ground supply.
	Turn the ignition switch to the "Off" position. Measure the resistance between the fuel gauge ground terminal (right terminal) and ground. If the resistance is more than 5 ohms, replace the electronic instrument cluster printed circuit (flex circuit assembly). Test the system for normal operation. If the resistance is less than 5 ohms, check the printed circuit.

Problem—Incorrect Fuel Gauge Indication (Electronic Instrument Cluster)	
Possible Cause	**Remedy**
Fuse	Disconnect the electronic instrument cluster connector. Taking care not to damage the printed circuit, measure the resistance between the printed circuit connection to the electronic instrument cluster connector C231 Pin 10 and the fuel gauge signal return terminal (left terminal). If the resistance is more than 5 ohms, replace the electronic instrument cluster printed circuit (flex circuit assembly). Test the system for normal operation. If the resistance is less than 5 ohms, install the fuel gauge and test the fuel gauge. Connect the electronic instrument cluster connector C231. Using the instrument gauge system tester, connect one lead of the tester to the fuel level sensor connector C413 Circuit 286 (O) and connect the other lead to ground. Set the tester to the 270-ohm scale and wait one minute. The fuel gauge should read E (empty). Set the tester to the 18-ohm scale and wait one minute. The fuel gauge should read F (full). If the fuel gauge does not perform as specified, replace the fuel gauge. Test the system for normal operation. If the fuel gauge performs as specified, inspect the fuel tank for any signs of distortion or damage. If the fuel tank is damaged, replace the fuel tank. See **Group 47**. If the fuel tank is not damaged, replace the fuel level sensor. See **Group 47**.
Circuitry open or shorted	
Fuel level sensor arm is damaged	
Damaged gauge	
Resistor element worn or damaged	
Leaking fuel level sensor float	

Problem—Incorrect Voltage Gauge Indication (Electronic Instrument Cluster)

Problem—Incorrect Voltage Gauge Indication (Electronic Instrument Cluster) **(See Fig. 5 and Fig. 6)**	
Possible Cause	**Remedy**
Fuse	Check Circuit 976 (BK/GN). Turn the ignition switch to the "Off" position. Disconnect the electronic instrument cluster connector. Turn the ignition switch to the "On" position and measure the voltage between the electronic instrument cluster connector C232 Pin 7, Circuit 976 (BK/GN) and ground. If the voltage is less than 10 volts, repair Circuit 976 (BK/GN) between the splice and the electronic instrument cluster connector. Test the system for normal operation. If the voltage is more than 10 volts, check Circuit 25 (BK/O). Turn the ignition switch to the "Off" position. Measure the resistance between the electronic instrument cluster connector C232 Pin 8, Circuit (BK/O) and ground. If the resistance is more than 5 ohms, repair Circuit 25 (BK/O). Test the system for normal operation. If the resistance is less than 5 ohms, check the voltage supply to the voltmeter. Connect the electronic instrument cluster connector C232. Remove the voltmeter gauge. See **Subject 130** for instructions. Turn the ignition switch to the "Off" position. Measure the voltage between the left voltmeter terminal (instrument cluster side) and ground. If the voltage is less than 10 volts, replace the electronic instrument cluster printed circuit (flex circuit assembly). Test the system for normal operation. If the voltage is more than 10 volts, check the ground for the voltmeter gauge. Turn the ignition switch to the "Off" position. Measure the resistance between the right voltmeter terminal (instrument cluster side) and ground. If the resistance is less than 5 ohms, replace the voltmeter gauge. Test the system for normal operation. If the resistance is more than 5 ohms, replace the electronic instrument cluster printed circuit (flex circuit assembly). Test the system for normal operation.
Circuitry open or shorted	
Incorrect battery voltage	
Damaged gauge	

Troubleshooting

Problem—Incorrect Oil Pressure Gauge Indication (Electronic Instrument Cluster)

Problem—Incorrect Oil Pressure Gauge Indication (Electronic Instrument Cluster)	
Possible Cause	**Remedy**
Plugged or kinked oil pressure line	Check the oil pressure line. Verify the oil pressure line is not plugged, broken or kinked. If the oil pressure line is OK, replace the oil pressure gauge. Test the system for normal operation. If the oil pressure line is not OK, replace the oil pressure line. Test the system for normal operation.
Damaged gauge	

Problem—Incorrect Coolant Temperature Gauge Indication (Electronic Instrument Cluster)

Problem—Incorrect Coolant Temperature Gauge Indication (Electronic Instrument Cluster) (See Fig. 5, Fig. 7, Fig. 8, and Fig. 9)	
Possible Cause	**Remedy**
Fuse	Check Circuit 976 (BK/GN). Turn the ignition switch to the "Off" position. Disconnect the electronic instrument cluster connector. Turn the ignition switch to the "On" position. Measure the voltage between the electronic instrument cluster connector C232 Pin 7, Circuit 976 (BK/GN) and ground. If the voltage is less than 10 volts, repair Circuit 976 (BK/GN) between the splice and the electronic instrument cluster connector. Test the system for normal operation. If the voltage is more than 10 volts, check Circuit 25 (BK/O). Turn the ignition switch to the "Off" position. Measure the resistance between the electronic instrument cluster connector C232 Pin 8, Circuit 25 (BK/O) and ground. If the resistance is more than 5 ohms, repair Circuit 25 (BK/O). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 39 (R/W) for an open. Disconnect the engine coolant temperature sensor connector. Measure the resistance between the engine coolant temperature sensor connector C126 Circuit 39 (R/W) and the electronic instrument cluster connector C232 Pin 6, Circuit 39 (R/W). If the resistance is more than 5 ohms, repair Circuit 39 (R/W) between the electronic instrument cluster connector C232 and the engine coolant temperature sensor connector C126. Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 39 (R/W) for a short to ground. Measure the resistance between the engine coolant temperature sensor connector C126 Circuit 39 (R/W) and ground. If the resistance is less than 10,000 ohms, repair Circuit 39 (R/W) between the electronic instrument cluster connector C232 and the engine coolant temperature sensor connector C126. Test the system for normal operation. If the resistance is more than 10,000 ohms, check the ground circuit for the engine coolant temperature sensor. Measure the resistance between the engine coolant temperature sensor connector C126 Circuit 25 (BK/O) and ground. If the resistance is more than 5 ohms, repair Circuit 25 (BK/O) between the engine coolant temperature sensor connector C126 and ground. Test the system for normal operation. If the resistance is less than 5 ohms, check the instrument cluster printed circuit voltage supply. Connect the electronic instrument cluster connector C232. Remove the coolant temperature gauge. See **Subject 130** for instructions. Turn the ignition switch to the "On" position. Measure the voltage between the voltage supply terminal of the coolant temperature gauge (top terminal) and ground. If the voltage is less than 10 volts, replace the electronic instrument cluster printed circuit (flex circuit assembly). Test the system for normal operation. If the voltage is more than 10 volts, check the instrument cluster printed circuit ground supply.
Circuitry open or shorted	
Worn or damaged coolant temperature sensor	
Damaged gauge	

Problem—Incorrect Coolant Temperature Gauge Indication (Electronic Instrument Cluster) (See Fig. 5, Fig. 7, Fig. 8, and Fig. 9)	
Possible Cause	**Remedy**
Fuse	Turn the ignition switch to the "Off" position. Measure the resistance between the coolant temperature gauge ground terminal (right terminal) and ground. If the resistance is more than 5 ohms, replace the electronic instrument cluster printed circuit (flex circuit assembly). Test the system for normal operation. If the resistance is less than 5 ohms, check the printed circuit.
Circuitry open or shorted	Disconnect the electronic instrument cluster connector. Taking care not to damage the printed circuit, measure the resistance between the printed circuit connection to the electronic instrument cluster connector C232 Pin 6 and the coolant temperature gauge signal return terminal (left terminal). If the resistance is more than 5 ohms, replace the electronic instrument cluster printed circuit (flex circuit assembly). Test the system for normal operation. If the resistance is less than 5 ohms, Install the coolant temperature gauge and test.
Worn or damaged coolant temperature sensor	Test the coolant temperature gauge. Connect the electronic instrument cluster connector C232. Turn the ignition switch to the "Off" position. Using the instrument gauge system tester, connect one lead of the tester to the engine coolant temperature sensor connector C126 Circuit 39 (R/W) and connect the other lead to ground. Set the tester to the 1.35-kohm scale and wait one minute. Coolant temperature gauge should read C (cold). Set the tester to the 2-ohm scale and wait one minute. Coolant temperature gauge should read H (hot). If the coolant temperature gauge performs as specified, replace the engine coolant temperature sensor. Test the system for normal operation. If the coolant temperature gauge does not perform as specified, replace the coolant temperature gauge. Test the system for normal operation.
Damaged gauge	

Problem—Incorrect Tachometer Indication (Electronic Instrument Cluster)

Problem—Incorrect Tachometer Indication (Electronic Instrument Cluster)	
Possible Cause	**Remedy**
Damaged gauge	Check the tachometer. NOTE: The tachometer has a 1 to 1-1/2 second delay time in response with the engine rpm. This condition is considered normal.
Worn or damaged tachometer sensor	Perform the "Tachometer Gauge Test". Refer to "Component Tests" in this subject. If the tachometer and the tachometer sensor do not check OK, replace the tachometer or tachometer sensor. Test the system for normal operation. If the tachometer and the tachometer sensor check OK, check the calibration of the tachometer. See **Subject 180** for instructions. If the tachometer is calibrated properly, check for an intermittent malfunction. Test the system for normal operation. If the tachometer is not calibrated properly, calibrate the tachometer. Test the system for normal operation.
Improperly calibrated gauge	

Troubleshooting

Problem—Inaccurate Speedometer Reading (Electronic Instrument Cluster)

Problem—Inaccurate Speedometer Reading (Electronic Instrument Cluster)	
Possible Cause	**Remedy**
Damaged gauge	Check the speedometer. Perform the "Speedometer Gauge Test". Refer to "Component Tests" in this subject. If the speedometer and the vehicle speed sensor (VSS) do not check OK, replace the speedometer or the VSS. Test the system for normal operation. If the speedometer and the VSS check OK, check the speedometer calibration. See **Subject 190** for instructions. If the speedometer is calibrated properly, check for an intermittent malfunction. Test the system for normal operation. If the speedometer is not calibrated properly, calibrate the speedometer. Test the system for normal operation.
Worn or damaged vehicle speed sensor (VSS)	
Improperly calibrated gauge	

Problem—Tachometer Inoperative (Electronic Instrument Cluster) (Vehicles Equipped With ECM)

Problem—Tachometer Inoperative (Electronic Instrument Cluster) (Vehicles Equipped With ECM) **(See Fig. 10, Fig. 11, Fig. 12, and Fig. 13)**	
Possible Cause	**Remedy**
Fuse	Check the voltage supply to the tachometer. Disconnect the electronic instrument cluster connector. Turn the ignition switch to the "Off" position. Measure the voltage between the electronic instrument cluster connector C279 Pin 9, Circuit 976 (BK/GN) and ground. If the voltage is less than 10 volts, repair Circuit 976 (BK/GN) between the splice and the electronic instrument cluster connector. Test the system for normal operation. If the voltage is more than 10 volts, check Circuit 713 (W) for an open. Turn the ignition switch to the "Off" position. Disconnect the ECM connector. Measure the resistance between the electronic instrument cluster connector Pin 1, Circuit 713 (W) and the ECM connector Pin 17 (Caterpillar engine) or Pin K1 (Cummins and Detroit Diesel engines), Circuit 713 (W). If the resistance is more than 5 ohms, repair Circuit 713 (W). Test the system for normal operation. If the resistance is less than 5 ohms, perform the "Tachometer Gauge Test". Refer to "Component Tests" in this subject. If the tachometer checks OK, perform powertrain control diagnostics. If the tachometer does not check OK, replace the tachometer. Test the system for normal operation.
Circuitry open or shorted	
Damaged gauge	
Improperly calibrated gauge	
Worn or damaged tachometer sensor	

Problem—Tachometer Inoperative (Electronic Instrument Cluster) (Vehicles Without ECM)

Problem—Tachometer Inoperative (Electronic Instrument Cluster) (Vehicles Without ECM) (See Fig. 10, Fig. 11, Fig. 12, and Fig. 13)	
Possible Cause	**Remedy**
Fuse	Check Circuit 976 (BK/GN). Disconnect the electronic instrument cluster connector. Turn the ignition switch to the "On" position. Measure the voltage between the electronic instrument cluster connector C279 Pin 9, Circuit 976 (BK/GN) and ground. If the voltage is less than 10 volts, repair Circuit 976 (BK/GN) between the splice and the electronic instrument cluster connector. Test the system for normal operation. If the voltage is more than 10 volts, check Circuit 855 (P).
Circuitry open or shorted	Turn the ignition switch to the "Off" position. Measure the resistance between the electronic instrument cluster connector C279 Pin 8, Circuit 855 (P) and ground. If the resistance is more than 5 ohms, repair Circuit 855 (P). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 713 (W) for an open.
Damaged gauge	Disconnect the tachometer sensor connector. Measure the resistance between the electronic instrument cluster connector C279 Pin 1, Circuit 713 (W) and the tachometer sensor connector C172 Circuit 713 (W). If the resistance is more than 5 ohms, repair Circuit 713 (W). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 713 (W) for a short to ground.
Improperly calibrated gauge	Measure the resistance between the electronic instrument cluster connector C279 Pin 1, Circuit 713 (W) and ground. If the resistance is less than 10,000 ohms, repair Circuit 713 (W). Test the system for normal operation. If the resistance is more than 10,000 ohms, check Circuits 826 (W/PK) and 232 (GN/Y) for an open.
	Measure the resistance between the electronic instrument cluster connector C279 Pin 15, Circuit 826 (W/PK) and the tachometer sensor connector C172 Circuit 232 (GN/Y). If the resistance is more than 5 ohms, repair Circuit 826 (W/PK) or Circuit 232 (GN/Y). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuits 826 (W/PK) and 232 (GN/Y) for a short to ground.
Worn or damaged tachometer sensor	Measure the resistance between the electronic instrument cluster connector C279 Pin 15, Circuit 826 (W/PK) and ground. If the resistance is greater than 10,000 ohms, perform the "Tachometer Gauge Test". Refer to "Component Tests" in this subject. Replace as necessary. Test the system for normal operation. If the resistance is less than 10,000 ohms, repair Circuits 826 (W/PK) or Circuit 232 (GN/Y). Test the system for normal operation.

Troubleshooting

Problem—Speedometer/Odometer Inoperative (Electronic Instrument Cluster)

Problem—Speedometer/Odometer Inoperative (Electronic Instrument Cluster) (See Fig. 10 and Fig. 14)	
Possible Cause	**Remedy**
Fuse	Check Circuit 976 (BK/GN). Disconnect the electronic instrument cluster connector. Turn the ignition switch to the "On" position. Measure the voltage between the electronic instrument cluster connector C279 Pin 9, Circuit 976 (BK/GN) and ground. If the voltage is less than 10 volts, repair Circuit 976 (BK/GN) between the splice and the electronic instrument cluster connector. Test the system for normal operation. If the voltage is more than 10 volts, check Circuit 855 (P).
Circuitry open or shorted	Turn the ignition switch to the "Off" position. Measure the resistance between the electronic instrument cluster connector C279 Pin 8, Circuit 855 (P) and ground. If the resistance is more than 5 ohms, repair Circuit 855 (P). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 614 (GN) for an open. Disconnect the vehicle speed sensor (VSS) connector. Measure the resistance between the electronic instrument cluster connector C279 Pin 10, Circuit 614 (GN) and the VSS connector C115 or C122 Circuit 614 (GN). If the resistance is more than 5 ohms, repair Circuit 614 (GN). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 614 (GN) for a short to ground.
Damaged gauge	Measure the resistance between the electronic instrument cluster connector C279 Pin 10, Circuit 614 (GN) and ground. If the resistance is less than 10,000 ohms, repair Circuit 614 (GN). Test the system for normal operation. If the resistance is more than 10,000 ohms, check Circuit 826 (W/PK) for an open.
Worn or damaged vehicle speed sensor (VSS)	Measure the resistance between the electronic instrument cluster connector C279 Pin 15, Circuit 826 (W/PK) and the VSS connector C115 or C122 Circuit 826 (W/PK). If the resistance is more than 5 ohms, repair Circuit 826 (W/PK). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 826 (W/PK) for a short to ground. Measure the resistance between the electronic instrument cluster connector C279 Pin 15, Circuit 826 (W/PK) and ground. If the resistance is greater than 10,000 ohms, perform the "Speedometer Gauge Test". Refer to "Component Tests" in this subject. Replace as necessary. Test the system for normal operation. If the resistance is less than 10,000 ohms, repair Circuit 826 (W/PK). Test the system for normal operation.

Problem—Incorrect Fuel Gauge Indication (Non-Electronic Instrument Cluster)

Problem—Incorrect Fuel Gauge Indication (Non-Electronic Instrument Cluster)

Problem—Incorrect Fuel Gauge Indication (Non-Electronic Instrument Cluster) (See Fig. 15 and Fig. 16)	
Possible Cause	**Remedy**
Fuse	Check Circuit 976 (BK/GN). Turn the ignition switch to the "Off" position. Disconnect the fuel gauge connector. Turn the ignition switch to the "On" position. Measure the voltage between the fuel gauge connector C2059 Circuit 976 (BK/GN) and ground. If the voltage is less than 10 volts, repair Circuit 976 (BK/GN) between the splice and the fuel gauge. Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 25 (BK/O).
Circuitry open or shorted	Turn the ignition switch to the "Off" position. Disconnect the fuel gauge connector. Measure the resistance between the fuel gauge connector C287 Circuit 25 (BK/O) and ground. If the resistance is more than 5 ohms, repair Circuit 25 (BK/O) between the splice and the fuel gauge. Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 286 (O) for an open.
Fuel level sensor arm is damaged	Disconnect the fuel gauge connector and fuel level sensor. Measure the resistance between the fuel gauge connector C2058 Circuit 286 (O) and the fuel level sensor connector C413 Circuit 286 (O). If the resistance is more than 5 ohms, repair Circuit 286 (O) between the fuel gauge and the fuel level sensor. Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 286 (O) for a short to ground.
Damaged gauge	Measure the resistance between the fuel level sensor connector C413 Circuit 286 (O) and ground. If the resistance is less than 10,000 ohms, repair Circuit 286 (O) between the fuel gauge and the fuel level sensor. Test the system for normal operation. If the resistance is more than 10,000 ohms, check the ground for the fuel level sensor.
Resistor element worn or damaged	Measure the resistance between the fuel level sensor connector C413 Circuit 25 (BK/O) and ground. If the resistance is more than 5 ohms, repair Circuit 25 (BK/O) between the fuel level sensor and ground. Test the system for normal operation. If the resistance is less than 5 ohms, test the fuel gauge.
Leaking fuel level sensor float	Connect the fuel gauge connectors. Using the instrument gauge system tester, connect one lead of the tester to the fuel level sensor connector C413 Circuit 286 (O) and connect the other lead to ground. Turn the ignition switch to the "On" position. Set the tester to the 270-ohm scale and wait 1 minute. The fuel gauge should read E (empty). Set the tester to the 18-ohm scale and wait 1 minute. The fuel gauge should read F (full). If the fuel gauge does not perform as specified, replace the fuel gauge. Test the system for normal operation. If the fuel gauge performs as specified, Inspect the fuel tank for any signs of distortion or damage. If the fuel tank is damaged, replace the fuel tank. See **Group 47**. If the fuel tank is not damaged, replace the fuel level sensor. See **Group 47**.

Troubleshooting

Problem—Incorrect Voltage Gauge Indication (Non-Electronic Instrument Cluster)

Problem—Incorrect Voltage Gauge Indication (Non-Electronic Instrument Cluster) (See Fig. 15)	
Possible Cause	**Remedy**
Fuse	Check Circuit 976 (BK/GN). Turn the ignition switch to the "Off" position. Disconnect the voltmeter gauge connector. Turn the ignition switch to the "On" position. Measure the voltage between the voltmeter connector C284 Circuit 976 (BK/GN) and ground. If the voltage is less than 10 volts, repair Circuit 976 (BK/GN) between the splice and the voltmeter. Test the system for normal operation. If the voltage is more than 10 volts, check Circuit 25 (BK/O).
Circuitry open or shorted	
Incorrect battery voltage	Turn the ignition switch to the "Off" position. Disconnect the voltmeter connector. Measure the resistance between the voltmeter connector C2062 Circuit 25 (BK/O) and ground. If the resistance is less than 5 ohms, replace the voltmeter. Test the system for normal operation. If the resistance is more than 5 ohms, repair Circuit 25 (BK/O) between the splice and the voltmeter. Test the system for normal operation.
Damaged gauge	

Problem—Incorrect Oil Pressure Gauge Indication (Non-Electronic Instrument Cluster)

Problem—Incorrect Oil Pressure Gauge Indication (Non-Electronic Instrument Cluster)	
Possible Cause	**Remedy**
Plugged or kinked oil pressure line	Verify the oil pressure line is not plugged, broken or kinked. If the oil pressure line is OK, replace the oil pressure gauge. Test the system for normal operation. If the oil pressure line is not OK, replace the oil pressure line. Test the system for normal operation.
Damaged gauge	

Problem—Incorrect Coolant Temperature Gauge Indication (Non-Electronic Instrument Cluster)

Problem—Incorrect Coolant Temperature Gauge Indication (Non-Electronic Instrument Cluster) (See Fig. 15 and Fig. 17)	
Possible Cause	**Remedy**
Fuse	Check Circuit 976 (BK/GN). Turn the ignition switch to the "Off" position. Disconnect the coolant temperature gauge connector. Turn the ignition switch to the "On" position. Measure the voltage between the coolant temperature gauge connector C280 Circuit 976 (BK/GN) and ground. If the voltage is less than 10 volts, repair Circuit 976 (BK/GN) between the splice and the coolant temperature gauge. Test the system for normal operation. If the voltage is more than 10 volts, check Circuit 25 (BK/O). Turn the ignition switch to the "Off" position. Disconnect the coolant temperature gauge connector. Measure the resistance between the coolant temperature gauge connector C2061 Circuit 25 (BK/O) and ground. If the resistance is more than 5 ohms, repair Circuit 25 (BK/O) between the splice and the coolant temperature gauge. Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 39 (R/W) for an open.
Circuitry open or shorted	Disconnect the coolant temperature gauge connector and engine coolant temperature sensor connector. Measure the resistance between the coolant temperature gauge connector C2060 Circuit 39 (R/W) and the engine coolant temperature sensor connector C126 Circuit 39 (R/W). If the resistance is more than 5 ohms, repair Circuit 39 (R/W) between the coolant temperature gauge and the engine coolant temperature sensor. Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 39 (R/W) for a short to ground.
Worn or damaged coolant temperature sensor	Measure the resistance between the engine coolant temperature sensor connector C126 Circuit 39 (R/W) and ground. If the resistance is less than 10,000 ohms, repair Circuit 39 (R/W) between the coolant temperature gauge and the engine coolant temperature sensor. Test the system for normal operation. If the resistance is more than 10,000 ohms, check the ground circuit for the engine coolant temperature sensor. Measure the resistance between the engine coolant temperature sensor connector C126 Circuit 25 (BK/O) and ground. If the resistance is more than 5 ohms, repair Circuit 25 (BK/O) between the engine coolant temperature sensor and ground. Test the system for normal operation. If the resistance is less than 5 ohms, test the coolant temperature gauge.
Damaged gauge	Connect the coolant temperature gauge connector. Using the instrument gauge system tester, connect one lead of the tester to the engine coolant temperature sensor connector C126 Circuit 39 (R/W) and connect the other lead to ground. Set the tester to the 1.35-kohm scale and wait 1 minute. Coolant temperature gauge should read C (cold). Set the tester to the 2-ohm scale and wait 1 minute. Coolant temperature gauge should read H (hot). If the coolant temperature gauge performs as specified, replace the engine coolant temperature sensor. Test the system for normal operation. If the coolant temperature gauge does not perform as specified, replace the coolant temperature gauge. Test the system for normal operation.

Troubleshooting

Problem—Incorrect Tachometer Indication (Non-Electronic Instrument Cluster)

Problem—Incorrect Tachometer Indication (Non-Electronic Instrument Cluster)	
Possible Cause	**Remedy**
Damaged gauge	NOTE: The tachometer has a 1 to 1-1/2 second delay time in response with the engine rpm. This condition is considered normal. Perform the "Tachometer Gauge Test". Refer to "Component Tests" in this subject. If the tachometer and the tachometer sensor do not check OK, replace the tachometer or tachometer sensor. Test the system for normal operation. If the tachometer and the tachometer sensor check OK, check the tachometer calibration. See **Subject 180** for instructions.
Worn or damaged tachometer sensor	
Improperly calibrated gauge	If the tachometer is calibrated properly, check for an intermittent malfunction. Test the system for normal operation. If the tachometer is not calibrated properly, calibrate the tachometer. Test the system for normal operation.

Problem—Inaccurate Speedometer Reading (Non-Electronic Instrument Cluster)

Problem—Inaccurate Speedometer Reading (Non-Electronic Instrument Cluster)	
Possible Cause	**Remedy**
Fuse	Perform the "Speedometer Gauge Test". Refer to "Component Tests" in this subject. If the speedometer and the vehicle speed sensor (VSS) do not check OK, replace the speedometer or the VSS. Test the system for normal operation. If the speedometer and the VSS check OK, check the speedometer calibration. See **Subject 190** for instructions. If the speedometer is calibrated properly, check for an intermittent malfunction. Test the system for normal operation. If the speedometer is not calibrated properly, calibrate the speedometer. Test the system for normal operation.
Damaged gauge	
Worn or damaged vehicle speed sensor (VSS)	
Improperly calibrated gauge	

Problem—Tachometer Inoperative (Non-Electronic Instrument Cluster) (Vehicles With ECM)

Problem—Tachometer Inoperative (Non-Electronic Instrument Cluster) (Vehicles With ECM) **(See Fig. 11, Fig. 12, Fig. 13, Fig. 18, and Fig. 19)**	
Possible Cause	**Remedy**
Fuse	Check the supply voltage to the tachometer. Disconnect the tachometer connector. Turn the ignition switch to the "On" position. Measure the voltage between the tachometer connector C233 Pin 5, Circuit 976 (BK/GN) and ground. If the voltage is less than 10 volts, repair Circuit 976 (BK/GN) between the splice and the tachometer. Test the system for normal operation. If the voltage is more than 10 volts, check Circuit 713 (W) for an open. Turn the ignition switch to the "Off" position. Disconnect the ECM connector. Measure the resistance between the tachometer connector Pin 6, Circuit 713 (W) and the ECM connector Pin 17 (Caterpillar and Cummins engine) or Pin K1 (Detroit Diesel engine), Circuit 713 (W). If the resistance is more than 5 ohms, repair Circuit 713 (W). Test the system for normal operation. If the resistance is less than 5 ohms, perform the "Tachometer Gauge Test". Refer to "Component Tests" in this subject. If the tachometer checks OK, perform diagnosis and testing of the ECM. If the tachometer does not check OK, replace the tachometer. Test the system for normal operation.
Circuitry open or shorted	
Damaged gauge	
Worn or damaged tachometer sensor	

Problem—Tachometer Inoperative (Non-Electronic Instrument Cluster) (Vehicles Without ECM)

Problem—Tachometer Inoperative (Non-Electronic Instrument Cluster) (Vehicles Without ECM)

Problem—Tachometer Inoperative (Non-Electronic Instrument Cluster) (Vehicles Without ECM) (See Fig. 11, Fig. 12, Fig. 13, Fig. 18, and Fig. 19)	
Possible Cause	**Remedy**
Fuse	Check Circuit 976 (BK/GN). Disconnect the tachometer connector. Turn the ignition switch to the "On" position. Measure the voltage between the tachometer connector C233 Pin 5, Circuit 976 (BK/GN) and ground. If the voltage is less than 10 volts, repair Circuit 976 (BK/GN) between the splice and the tachometer. Test the system for normal operation. If the voltage is more than 10 volts, check Circuit 855 (P).
Circuitry open or shorted	Measure the resistance between the tachometer connector C233 Pin 4, Circuit 855 (P) and ground. If the resistance is more than 5 ohms, repair Circuit 855 (P). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 713 (W) for an open. Measure the resistance between the tachometer connector C233 Pin 6, Circuit 713 (W) and the tachometer sensor connector C172 Circuit 713 (W). If the resistance is more than 5 ohms, repair Circuit 713 (W). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 713 (W) for a short to ground.
Damaged gauge	Measure the resistance between the tachometer connector C233 Pin 6, Circuit 713 (W) and ground. If the resistance is less than 10,000 ohms, repair Circuit 713 (W). Test the system for normal operation. If the resistance is more than 10,000 ohms, check Circuit 232 (GN/Y) for an open. Measure the resistance between the tachometer connector C233 Pin 7, Circuit 232 (GN/Y) and the tachometer sensor connector C172 Circuit 232 (GN/Y). If the resistance is more than 5 ohms, repair Circuit 232 (GN/Y). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 232 (GN/Y) for a short to ground.
Worn or damaged tachometer sensor	Measure the resistance between the tachometer connector C233 Pin 7, Circuit 232 (GN/Y) and ground. If the resistance is less than 10,000 ohms, perform the "Tachometer Gauge Test". Refer to "Component Tests" in this subject. Replace as necessary. Test the system for normal operation. If the resistance is more than 10,000 ohms, repair Circuit 232 (GN/Y). Test the system for normal operation.

Troubleshooting

Problem—Speedometer Inoperative (Non-Electronic Instrument Cluster)

Problem—Speedometer/Odometer Inoperative (Non-Electronic Instrument Cluster) (See Fig. 10 and Fig. 14)	
Possible Cause	**Remedy**
Fuse	Check Circuit 976 (BK/GN). Disconnect the speedometer connector. Turn the ignition switch to the "On" position. Measure the voltage between the speedometer connector C234 Pin 9, Circuit 976 (BK/GN) and ground. If the voltage is less than 10 volts, repair Circuit 976 (BK/GN) between the splice and the speedometer. Test the system for normal operation. If the voltage is more than 10 volts, check Circuit 614 (GN) for an Open.
Circuitry open or shorted	Turn the ignition switch to the "Off" position. Disconnect the vehicle speed sensor (VSS) connector. Measure the resistance between the speedometer connector C234 Pin 10, Circuit 614 (GN) and the VSS connector C115 or C122 Circuit 614 (GN). If the resistance is more than 5 ohms, repair Circuit 614 (GN). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 614 (GN) for a short to ground.
Damaged gauge	Measure the resistance between the speedometer connector C234 Pin 10, Circuit 614 (GN) and ground. If the resistance is less than 10,000 ohms, repair Circuit 614 (GN). Test the system for normal operation. If the resistance is more than 10,000 ohms, check Circuit 826 (W/PK) for an open. Measure the resistance between the speedometer connector C234 Pin 15, Circuit 826 (W/PK) and the vehicle speed sensor (VSS) connector C115 or C122 Circuit 826 (W/PK). If the resistance is more than 5 ohms, repair Circuit 826 (W/PK). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 826 (W/PK) for a short to ground.
Worn or damaged vehicle speed sensor (VSS)	Measure the resistance between the speedometer connector C234 Pin 15, Circuit 826 (W/PK) and ground. If the resistance is greater than 10,000 ohms, perform the "Speedometer Gauge Test". Refer to "Component Tests" in this subject. Replace as necessary. Test the system for normal operation. If the resistance is less than 10,000 ohms, repair Circuit 826 (W/PK). Test the system for normal operation.

Component Tests

Speedometer and Tachometer Gauge Test

The electronic instrument cluster gauge pointers may hang up on the stop if Pin 3 is left connected to ground when the ignition switch is actuated to the "Off" position. Actuate the ignition switch to the "On" position.

The tachometer has a 1 to 1-1/2 second delay time in response with the engine rpm. This condition is considered normal.

Disconnect Pin 3, then actuate the ignition switch to "Off" or, bring the engine speed up to 1800 rpm, and bring the vehicle speed up to 50 mph (80 km/h).

Speedometer and Tachometer Gauge Test		
Setup	**Tachometer**	**Speedometer**
Electronic instrument cluster, access the instrument cluster connector C279 Pin 3, Circuit 724 (GN/W). Non-electronic instrument cluster, access tachometer connector C233 Pin 1, Circuit 724 (GN/W). Access speedometer connector C234 Pin 3, Circuit 724 (GN/W). Turn the ignition switch "On". Back probe to ground Pin 3 (electronic instrument cluster), Pin 1 (non-electronic instrument cluster, tachometer), Pin 3 (non-electronic instrument cluster, speedometer).	Pointer sweeps to 2000 rpm for 18 seconds and returns to zero.	Pointer sweeps to 60 mph (96 km/h) for 6 seconds and returns to zero. Odometer increments 1/10 mile.
Sensor resistance check.	Magnetic sensor: 100-3200 ohms Electronic sensor: 1-kohm	Magnetic sensor: 100-3200 ohms Electronic sensor: 1-kohm or greater

Table 1, Speedometer and Tachometer Gauge Test

Instrument Cluster and Panel Lighting

Inspection and Verification

1. Verify the vehicle owner's concern by duplicating the original concern.
2. Verify the components or systems related to the fuse for proper operation. If the components or systems are not operating properly, the fuse(s), fuse feed circuits or fuse load side circuit(s) may be at fault.
3. Visually inspect for the following conditions:
   - blown fuse(s)
   - faulty bulb(s)
   - loose or corroded connections
   - circuitry open or shorted
   - bad instrument cluster printed circuit (electronic cluster only)
   - damaged dome lamp and I/P dimmer switch
4. Make sure the vehicle lighting systems are functioning properly.
5. If the concern(s) remains after the inspection, determine the possible causes and proceed to the following problem charts.

Troubleshooting

Problem—Control Illumination is Inoperative

Problem—Control Illumination is Inoperative (See Fig. 20)	
Possible Cause	**Remedy**
Fuse	Check Circuit 11 (BK/Y). Turn the ignition switch to the "Off" position. Disconnect the dome lamp and I/P dimmer switch connector C272. Turn the headlamp switch to the "Park" position. Measure the voltage between the dome lamp and the I/P dimmer switch connector C272 Pin A, Circuit 11 (BK/Y) and ground. If the voltage is less than 10 volts, repair Circuit 11 (BK/Y) between the dome lamp and the I/P dimmer switch and the headlamp switch. Test the system for normal operation. If the voltage is more than 10 volts, check Circuit 57 (BK). Measure the resistance between the dome lamp and I/P dimmer switch connector C272 Pin E, Circuit 57 (BK) and ground. If the resistance is more than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 19 (BL/R). Make sure the dome lamp and the I/P dimmer switch is in the uppermost vertical position. Connect the dome lamp and I/P dimmer switch connector C272. Measure the voltage by backprobing the dome lamp and I/P dimmer switch connector C272 Pin C, Circuit 19 (BL/R) and ground. If the voltage is greater than 10 volts, repair Circuit 19 (BL/R) between the splice and the dome lamp and I/P dimmer switch. Test the system for normal operation. If the voltage is less than 10 volts, replace the dome lamp and I/P dimmer switch. Test the system for normal operation.
Circuitry open or shorted	
Dome lamp and I/P dimmer switch	
Headlamp switch	

Problem—Instrument Cluster Illumination is Inoperative

Problem—Instrument Cluster Illumination is Inoperative (See Fig. 20, Fig. 21, and Fig. 22)	
Possible Cause	**Remedy**
Damaged circuitry	Check Circuit 19 (BL/R). NOTE: This test applies to the electronic instrument cluster only. NOTE: Make sure the dome lamp and the I/P dimmer switch is in the upmost vertical position. NOTE: The tachometer and speedometer use Circuit 855 (P) for the illumination bulb ground circuit. Therefore the tachometer and speedometer bulb may be illuminated with the rest of the instrument cluster inoperative.
I/P printed circuit (electronic cluster only)	Disconnect the electronic instrument cluster connector C232. Turn the headlamp switch to the "Park" position. Measure the voltage between the electronic instrument cluster connector C232 Pin 5, Circuit 19 (BL/R) and ground. If the voltage is less than 10 volts, repair Circuit 19 (BL/R). Test the system for normal operation. If the voltage is more than 10 volts, check Circuit 57 (BK). Measure the resistance between the electronic instrument cluster connector C230 Pin 1, Circuit 57 (BK) and ground. If the resistance is less than 5 ohms, check the I/P printed circuit for damage. Replace as necessary. Test the system for normal operation. If the resistance is more than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation.

Problem—Climate Control Illumination is Inoperative, Front

Problem—Climate Control Illumination is Inoperative, Front	
Possible Cause	**Remedy**
Bulb(s)	Check circuit 19 (BL/R). NOTE: Make sure the dome lamp and the I/P dimmer switch is in the upmost vertical position. Disconnect wiring harness connector C227 or C2068. Turn the headlamp switch to the "Park" position. Measure the voltage between connector C227 (with A/C) or connector C2068 (without A/C) circuit 19 (BL/R) and ground. If the voltage is less than 10 volts, repair circuit 19 (BL/R). Test the system for normal operation. If the voltage is more than 10 volts, check circuit 57 (BK). Turn the headlamp switch off. Measure the resistance between connector C227 (with A/C) or connector C2068 (without A/C) circuit 57 (BK) and ground. If the resistance is more than 5 ohms, repair circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check the bulb for continuity. Measure for continuity between the terminals of the bulb. If continuity exists, replace the climate control assembly. Test the system for normal operation. If continuity does not exist, replace the bulb(s). Test the system for normal operation.
Damaged circuitry	
Climate control assembly	

Problem—Audio System Illumination is Inoperative

Problem—Audio System Illumination is Inoperative (See Fig. 23)	
Possible Cause	**Remedy**
Damaged circuitry	Check Circuit 886 (BL). NOTE: Make sure the dome lamp and the I/P dimmer switch is in the upmost vertical position. Disconnect radio wiring harness connector C219. Turn the ignition switch to the "On" position. Turn the headlamp switch to the "Park" position. Measure the voltage between the radio connector C219 Pin 5, Circuit 886 (BL) and ground. If the voltage is greater than 10 volts, remove the radio chassis for repair. Test the system for normal operation. If the voltage is less than 10 volts, repair Circuit 886 (BL). If OK, replace the dome lamp and I/P dimmer switch. Test the system for normal operation.
Radio chassis	

Troubleshooting

Problem—Single Illumination Source is Inoperative

Problem—Single Illumination Source is Inoperative	
Possible Cause	**Remedy**
Bulb	Check Circuit 19 (BL/R). NOTE: Make sure the dome lamp and the I/P dimmer switch is in the upmost vertical position. Disconnect the inoperative lamp connector. Turn the headlamp switch to the "Park" position. Measure the voltage between the inoperative lamp connector Circuit 19 (BL/R) and ground. If the voltage is less than 10 volts, repair Circuit 19 (BL/R). Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 57 (BK).
Damaged circuitry	NOTE: The tachometer and speedometer use Circuit 855 (P) for the illumination bulb ground circuit. Measure the resistance between the inoperative lamp connector Circuit 57 (BK) or Circuit 855 (P) and ground. If the resistance is less than 5 ohms, replace the bulb. Test the system for normal operation. If the resistance is more than 5 ohms, repair Circuit 57 (BK) or Circuit 855 (P). Test the system for normal operation.

Problem—Instrument Panel Illumination Does Not Dim

Problem—Instrument Panel Illumination Does Not Dim (See Fig. 20)	
Possible Cause	**Remedy**
Circuitry shorted	Check Circuit 19 (BL/R) for a short to power. Disconnect the dome lamp and I/P dimmer switch connector C272. Turn the ignition to the "On" position. Measure the voltage between the dome lamp and the I/P dimmer switch connector C272 Pin C, Circuit 19 (BL/R) and ground. If the voltage reading is 0 volts, replace the dome lamp and the I/P dimmer switch. Test the system for normal operation. If the voltage reading is not 0 volts, repair Circuit 19 (BL/R). Test the system for normal operation.
Dome lamp and I/P dimmer switch	

Gauges and Warning Devices

Inspection and Verification

1. Verify the owner's original concern by operating the system to duplicate the concern.
2. Verify that other components and systems related to the gauge or warning indicator fuse(s) operate properly. If the other components and systems are not operating properly, the fuse(s), fuse feed circuit(s) or load side circuit(s) may be at fault.
3. Visually inspect for obvious signs of mechanical and electrical damage. Refer to the following chart.

Mechanical	Electrical
Damaged gauge Damaged sensor Bent, kinked, plugged or damaged hoses	Open fuse: instrument panel fuse junction panel Fuse 11 (20 A), 21 (10 A) or 46 (20 A) Damaged circuitry Corroded connectors

Table 2, Inspection Chart

Engine Protection System

Inspection and Verification

1. Verify the vehicle owner's original concern by operating the system to duplicate the concern.

2. Inspect to determine if one of the mechanical or electrical concerns in the following chart applies.

Mechanical	Electrical
Low coolant Low oil	Open fuse: instrument panel fuse junction panel Fuse 1 (10 A) Open/shorted circuits Damaged connectors

Table 3, Inspection Chart

3. If the concern remains after the inspection, determine the possible causes and proceed to the following problem charts.

Problem—Low Oil Pressure Warning Lamp Illuminates, Audible Warning Activates and the Engine Shuts Down, No Mechanical Concern

Problem—Low Oil Pressure Warning Lamp Illuminates, Audible Warning Activates and the Engine Shuts Down, No Mechanical Concern (See Fig. 24)	
Possible Cause	**Remedy**
Circuitry	Check the oil pressure switch. With the ignition switch in the "Off" position, disconnect the low oil pressure switch connector. Turn the ignition switch to the "On" position. If the symptom does not continue, replace the oil pressure switch. Test the system for normal operation. If the symptom continues, check Circuit 17 (W) for a short to ground.
Low oil pressure switch	Turn the ignition switch to the "Off" position. Disconnect instrument cluster connector C232 for vehicles equipped with an electronic instrument cluster, or connector C285 for vehicles equipped with the non-electronic instrument cluster. Measure the resistance between oil pressure switch connector C168, Pin 2, Circuit 17 (W) and chassis ground. If the resistance is less than 10k ohms, repair Circuit 17 (W). Test the system for normal operation. If the resistance is more than 10k ohms, check the engine alarm/shutdown module. Reconnect instrument cluster connector C232 for vehicles equipped with an electronic instrument cluster, or connector C285 for vehicles equipped with the non-electronic instrument cluster.
Instrument cluster printed circuit	
Engine alarm/shutdown module	Disconnect the engine alarm/shutdown module connector and turn the ignition switch to the "On" position. Observe the low oil pressure warning indicator lamp. If the lamp illuminates, replace the printed circuit. Test the system for normal operation. If the lamp does not illuminate, replace the engine alarm/shutdown module. Test the system for normal operation.

Problem—High Oil Temperature Warning Indicator Lamp Illuminates, Audible Warning Activates and the Engine Shuts Down, No Mechanical Concern

Troubleshooting

Problem—High Oil Temperature Warning Indicator Lamp Illuminates, Audible Warning Activates and the Engine Shuts Down, No Mechanical Concern

Problem—High Oil Temperature Warning Indicator Lamp Illuminates, Audible Warning Activates and the Engine Shuts Down, No Mechanical Concern (See Fig. 25)	
Possible Cause	**Remedy**
Circuitry	Check the oil temperature switch. Turn the ignition switch to the "Off" position. Disconnect the engine oil temperature switch. Turn the ignition switch to the "On" position. If the symptom does not continue, replace the engine oil temperature switch. Test the system for normal operation. If the symptom continues, check Circuit 635 (GN) for a short to ground.
Engine oil temperature switch	Turn the ignition switch to the "Off" position. Disconnect instrument cluster connector C232 for vehicles equipped with an electronic instrument cluster, or connector C285 for vehicles equipped with the non-electronic instrument cluster. Measure the resistance between oil temperature switch connector C174, Pin 2, Circuit 635 (GN) and chassis ground. If the resistance is less than 10k ohms, repair Circuit 635 (GN). Test the system for normal operation. If the resistance is less than 10k ohms, check the engine alarm/shutdown module.
Instrument cluster printed circuit	Reconnect instrument cluster connector C232 for vehicles equipped with an electronic instrument cluster or connector C285 for vehicles equipped with the non-electronic instrument cluster. Disconnect the engine alarm/shutdown module connector and turn the ignition switch to the "On" position. Observe the engine oil temperature warning indicator lamp. If the lamp illuminates, replace the printed circuit. Test the system for normal operation. If the lamp does not illuminate, replace the engine alarm/shutdown module. Test the system for normal operation.
Engine alarm/shutdown module	

Problem—Coolant Temperature Warning Indicator Lamp Illuminates, Audible Warning Activates and the Engine Shuts Down, No Mechanical Concern

Problem—Coolant Temperature Warning Indicator Lamp Illuminates, Audible Warning Activates and the Engine Shuts Down, No Mechanical Concern

Problem—Coolant Temperature Warning Indicator Lamp Illuminates, Audible Warning Activates and the Engine Shuts Down, No Mechanical Concern (See Fig. 25)	
Possible Cause	**Remedy**
Circuitry	Check the coolant temperature switch. Turn the ignition switch to the "Off" position and disconnect the coolant temperature switch connector. Turn the ignition switch to the "On" position. If the symptom does not continue, replace the coolant temperature switch. Test the system for normal operation. If the symptom continues, check Circuit 45 (Y/R) for a short to ground.
Coolant temperature switch	Turn the ignition switch to the "Off" position. Disconnect instrument cluster connector C231 for vehicles equipped with an electronic instrument cluster, or connector C285 for vehicles equipped with the non-electronic instrument cluster. Measure the resistance between coolant temperature switch connector C175, Pin 2, Circuit 45 (Y/R) and chassis ground. If the resistance is less than 10k ohms, repair Circuit 45 (Y/R). Test the system for normal operation. If the resistance is more than 10k ohms, check the engine alarm/shutdown module.
Instrument cluster printed circuit	Reconnect instrument cluster connector C231 for vehicles equipped with an electronic instrument cluster, or connector C285 for vehicles equipped with the non-electronic instrument cluster. Disconnect the engine alarm/shutdown module connector. Turn the ignition switch to the "On" position. Observe the coolant temperature warning indicator lamp. If the lamp illuminates, replace the printed circuit. Test the system for normal operation. If the lamp does not illuminate, replace the engine alarm/shutdown module. Test the system for normal operation.
Engine alarm/shutdown module	

Troubleshooting

Problem—Low Coolant Warning Indicator Lamp Illuminates, Audible Warning Activates and the Engine Shuts Down, No Mechanical Concern

Problem—Low Coolant Warning Indicator Lamp Illuminates, Audible Warning Activates and the Engine Shuts Down, No Mechanical Concern (See Fig. 1, Fig. 25, and Fig. 26)	
Possible Cause	**Remedy**
Circuitry	Check the low coolant level sensor. Turn the ignition switch to the "Off" position. Disconnect the low coolant level sensor connector. Turn the ignition switch to the "On" position. Connect a jumper between the coolant level sensor connector terminals. If the symptom does not continue, replace the low coolant level sensor. Test the system for normal operation.
Low coolant level sensor	If the symptom continues, disconnect the jumper, then check the sensor ground circuit. With the key in the "Off" position, measure the resistance between low coolant level sensor connector C103, Pin 1, Circuit 57 (BK) and chassis ground. If the resistance is more than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 670 (PK) for an open.
Instrument cluster printed circuit	Disconnect instrument cluster connector C231 for vehicles equipped with an electronic instrument cluster or connector C285 for vehicles equipped with the non-electronic instrument cluster. Measure the resistance between instrument cluster connector C231, Pin 4, Circuit 670 (PK) for vehicles equipped with an electronic instrument cluster, or connector C285, Pin 11, Circuit 670 (PK) for vehicles equipped with the non-electronic instrument cluster and coolant level sensor connector C103, Pin 2, Circuit 670 (PK). If the resistance is more than 5 ohms, repair Circuit 670 (PK). Test the system for normal operation. If the resistance is less than 5 ohms, check the engine alarm/shutdown module.
Engine alarm/shutdown module	Reconnect instrument cluster connector C231 for vehicles equipped with an electronic instrument cluster, or connector C285 for vehicles equipped with the non-electronic instrument cluster. Turn the ignition switch to the "On" position. Observe the low coolant lamp. If the lamp extinguishes, replace the engine alarm/shutdown module. Test the system for normal operation. If the lamp does not extinguish, replace the printed circuit. Test the system for normal operation.

Problem—Audible Warning Activates, but the Engine Does Not Shut Down, No Mechanical Concern

Problem—Audible Warning Activates, but the Engine Does Not Shut Down, No Mechanical Concern (See Fig. 15, Fig. 27, and Fig. 28)	
Possible Cause	**Remedy**
Engine alarm/shutdown module	Replace the engine alarm/shutdown module.

Problem—Audible Warning Activates, but the Engine Does Not Shut Down, With a Mechanical Concern

Problem—Audible Warning Activates, but the Engine Does Not Shut Down, With a Mechanical Concern	
Possible Cause	**Remedy**
Circuitry	Check for power at the fuel shutoff solenoid. NOTE: Perform this test only after correcting the engine mechanical concern. Turn the ignition switch to the "Off" position. Disconnect fuel shutoff solenoid connector C173 for vehicles equipped with a Caterpillar 3306 engine, or connector C1026 for vehicles equipped with a Cummins B5.9 or C8.3 engine. Measure the voltage between fuel shutoff solenoid connector C173, Circuit 932 (BL) and chassis ground for vehicles equipped with an electronic instrument cluster, or connector C1026, Pin 1, Circuit 932 (BL), Pin 2, Circuit 669 (R/BL) and chassis ground for vehicles equipped with the non-electronic instrument cluster. If the voltage is less than 10 volts on either circuit, replace the fuel shutoff solenoid. Test the system for normal operation. If voltage was read on Circuit 669 (R/BL), check Circuit 669 (R/BL) for a short to battery. With the ignition switch in the "Off" position, disconnect Circuit 669 (R/BL) from the starter motor relay and starter motor. Turn the ignition switch to the "On" position and measure the voltage between fuel shutoff solenoid connector C1026, Pin 2, Circuit 669 (R/BL) and chassis ground. If the voltage is less than 10 volts, see **Group 15** for troubleshooting of the starter motor and starter motor relay. If the voltage is more than 10 volts, repair Circuit 669 (R/BL). Test the system for normal operation. If voltage was read on Circuit 932 (BL), check Circuit 932 (BL) for a short to battery. With the ignition switch in the "Off" position, disconnect the fuel shutoff relay connector C2044. With the ignition switch in the "On" position, measure the voltage between fuel shutoff relay connector C2044, Pin 5, Circuit 932 (BL) and chassis ground. If the voltage is greater than 10 volts, repair Circuit 932 (BL). Test the system for normal operation. If the voltage is less than 10 volts, check Circuit 720 (BL) for power. Measure the voltage between fuel shutoff relay connector C2044, Pin 2, Circuit 720 (BL) and chassis ground. If the voltage is less than 10 volts, replace the fuel shutoff relay. Test the system for normal operation. If the voltage is more than 10 volts, check the engine alarm/shutdown module. With the ignition switch in the "Off" position, disconnect the engine alarm/shutdown module connector. With the ignition switch in the "On" position, measure the voltage between fuel shutoff relay connector C2044, Pin 2, Circuit 720 (BL) and chassis ground. If the voltage is less than 10 volts, replace the engine alarm/shutdown module. Test the system for normal operation. If the voltage is more than 10 volts, check the instrument cluster printed circuit. Turn the ignition switch to the "Off" position. Disconnect instrument cluster connector C231 for vehicles equipped with an electronic instrument cluster or connector C285 for vehicles equipped with the non-electronic instrument cluster. Turn the ignition switch to the "On" position. Measure the voltage between fuel shutoff relay connector C2044, Pin 2, Circuit 720 (BL) and chassis ground. If the voltage is greater than 10 volts, repair Circuit 720 (BL). Test the system for normal operation. If the voltage is less than 10 volts, replace the instrument cluster printed circuit. Test the system for normal operation.
Fuel shutoff relay	
Fuel shutoff solenoid	
Instrument cluster printed circuit	
Engine alarm/shutdown module	

Troubleshooting

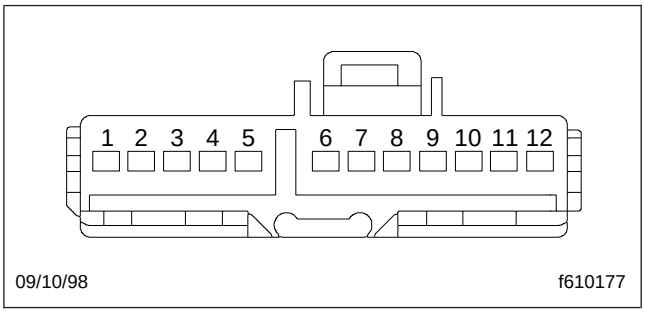


Fig. 1, Electronic Instrument Cluster Connector

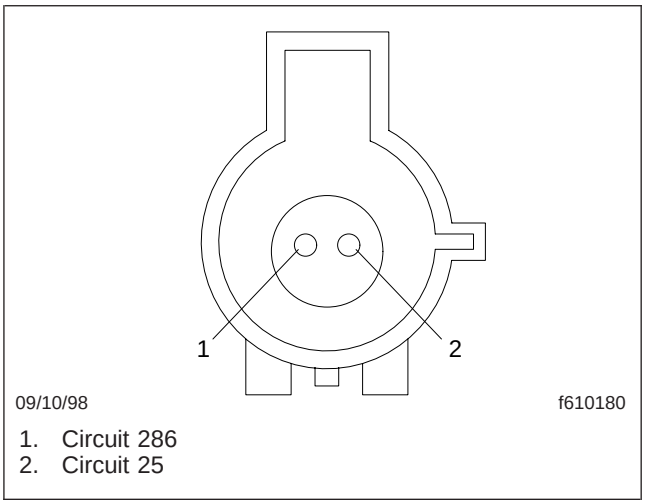


Fig. 2, Fuel Level Sensor Connector

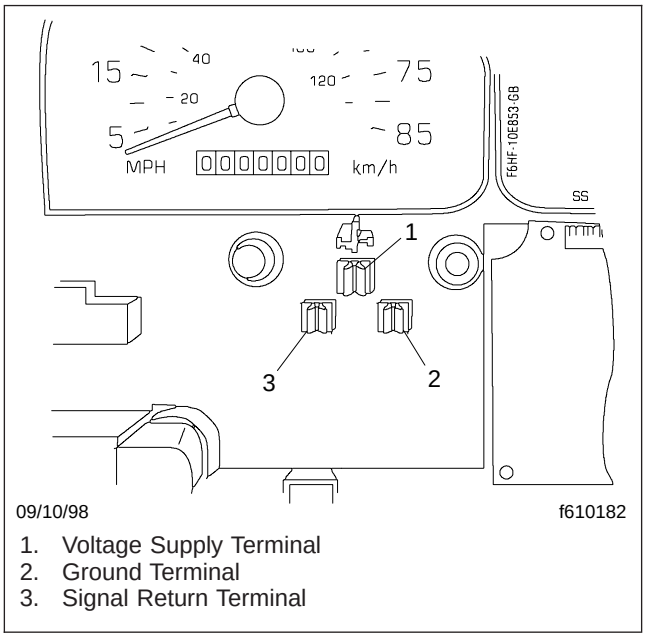


Fig. 3, Fuel Gauge Terminals

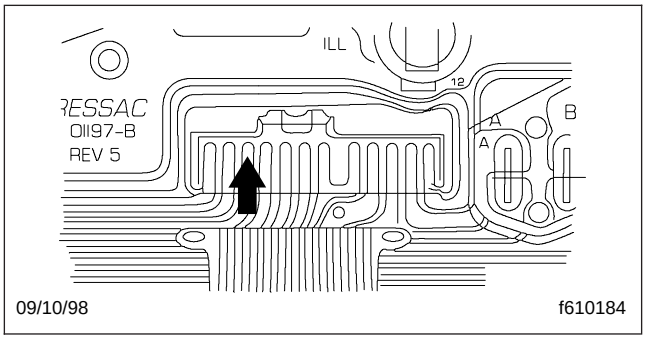


Fig. 4, Instrument Cluster Printed Circuit Connector

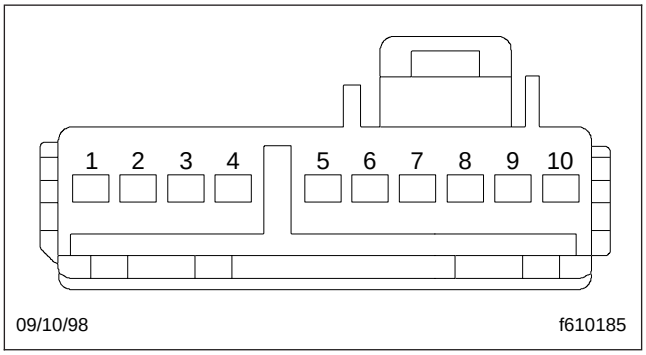
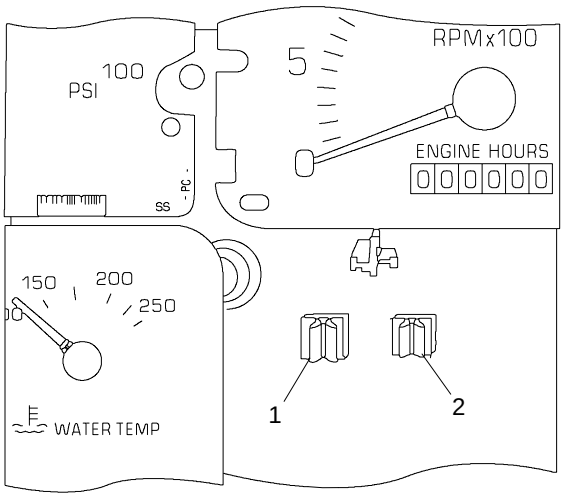


Fig. 5, Electronic Instrument Cluster Connector



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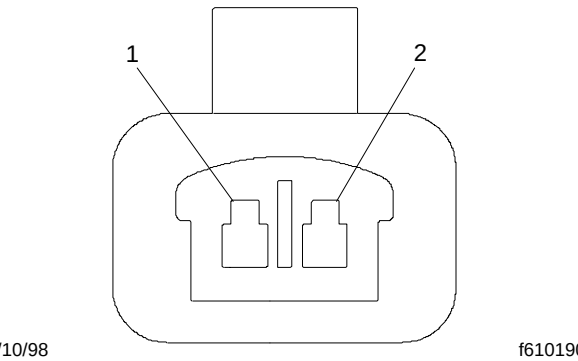
1. Left Terminal
2. Right Terminal

Fig. 6, Voltmeter Terminals



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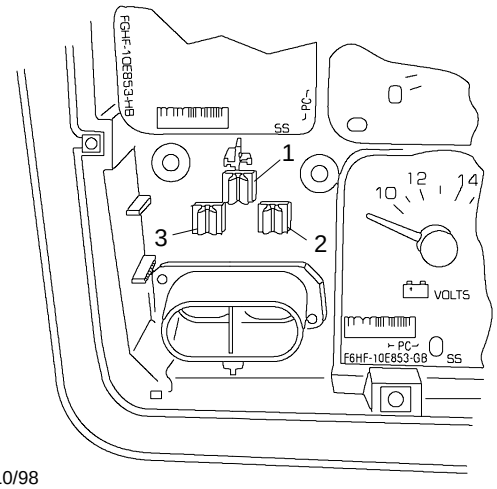
1. Circuit 39
2. Circuit 25

Fig. 7, Coolant Temperature Sensor Connector



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1. Voltage Supply Terminal
2. Ground Terminal
3. Signal Return Terminal

Fig. 8, Coolant Temperature Gauge Terminals

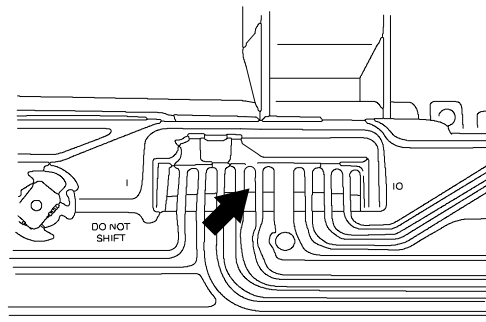

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Fig. 9, Instrument Cluster Printed Circuit Connector

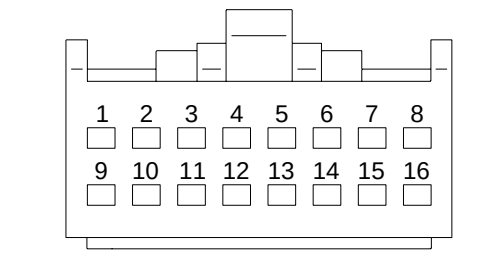

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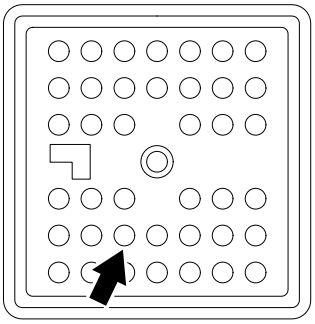
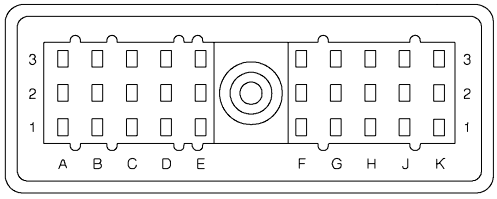
Fig. 10, Electronic Instrument Cluster Connector

Troubleshooting



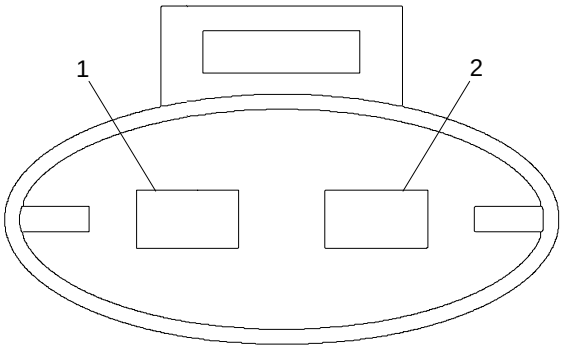
09/10/98 f610196

Fig. 11, ECM Connector (Caterpillar)



09/10/98 f610197

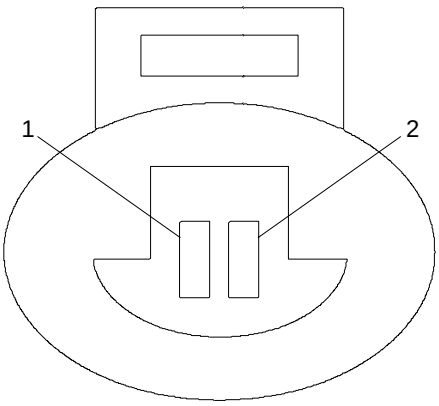
Fig. 12, ECM Connector (Cummins and Detroit Diesel)



09/10/98 f542270

1. Circuit 172
2. Circuit 232

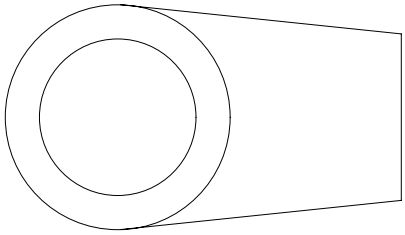
Fig. 13, Tachometer Sensor Connector



09/10/98 f542276

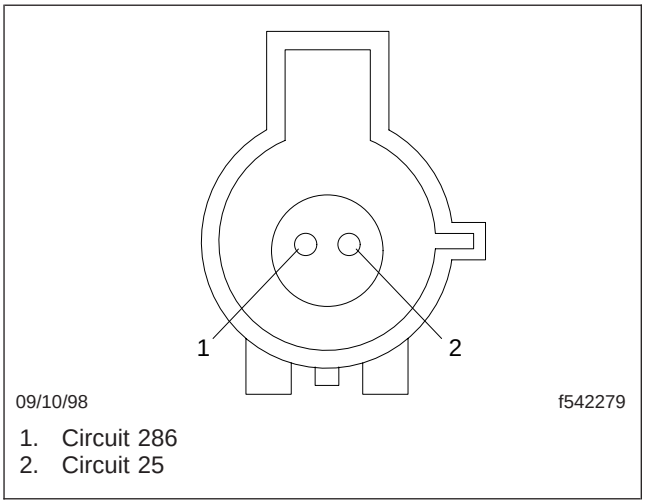
1. Circuit 614
2. Circuit 826

Fig. 14, Vehicle Speed Sensor Connector



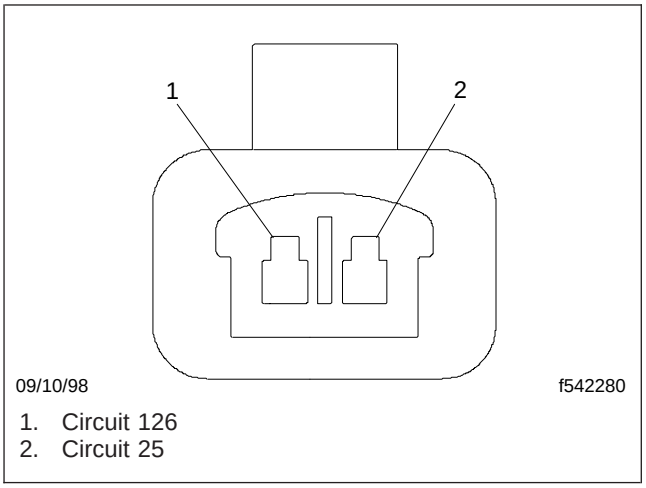
09/10/98 f542277

Fig. 15, Fuel Gauge Connector



1. Circuit 286
2. Circuit 25

Fig. 16, Fuel Level Sensor Connector



1. Circuit 126
2. Circuit 25

Fig. 17, Engine Coolant Temperature Sensor Connector

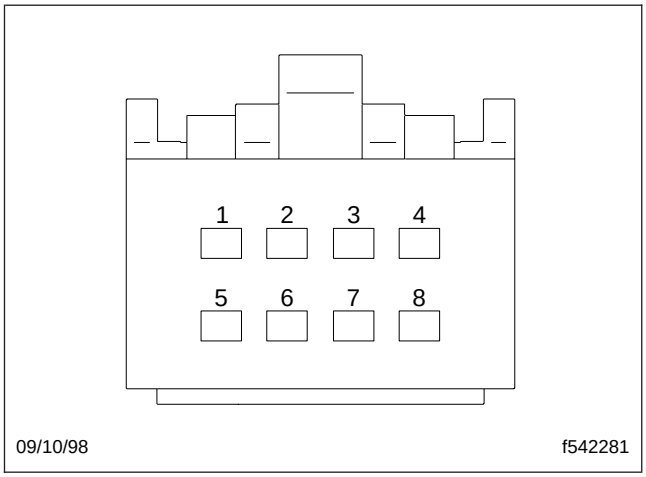


Fig. 18, Tachometer Connector

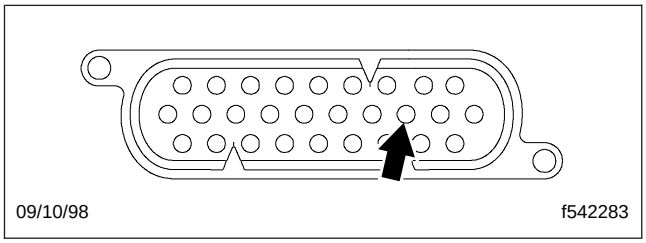


Fig. 19, ECM Connector (Cummins Engine)

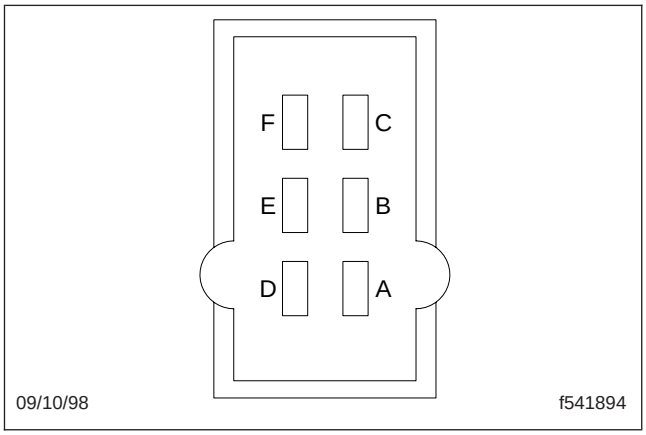


Fig. 20, Dimmer Switch Connector

Troubleshooting

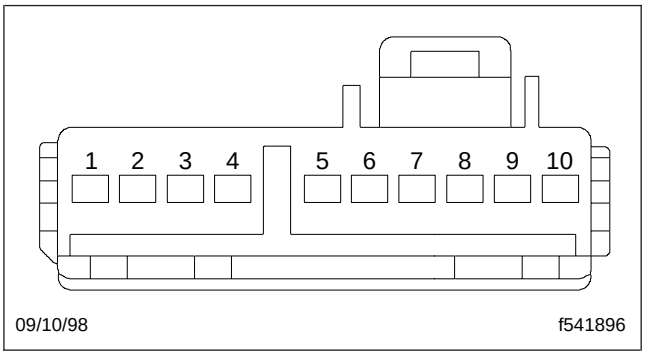


Fig. 21, Electronic Instrument Cluster Connector C232

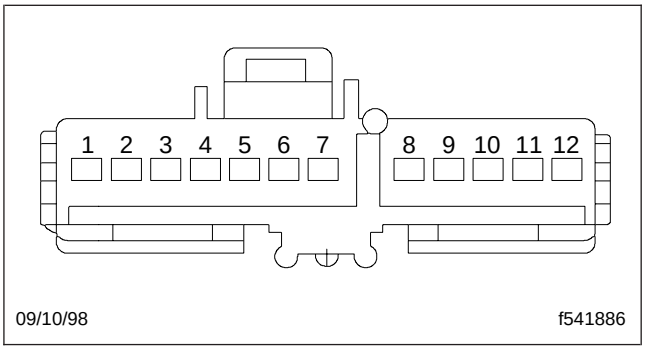


Fig. 22, Electronic Instrument Cluster Connector C230

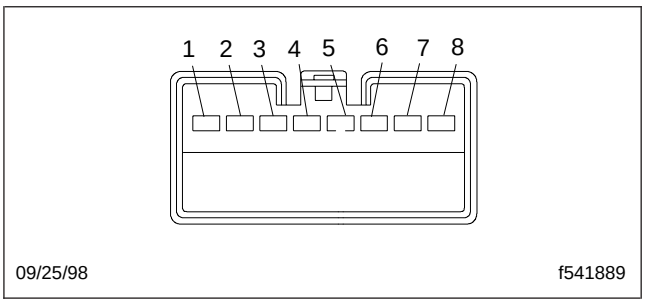


Fig. 23, Radio Connector

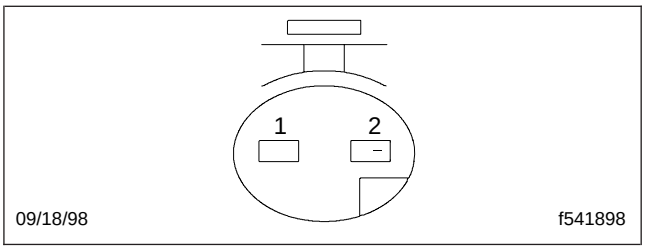


Fig. 24, Oil Pressure Switch Connector

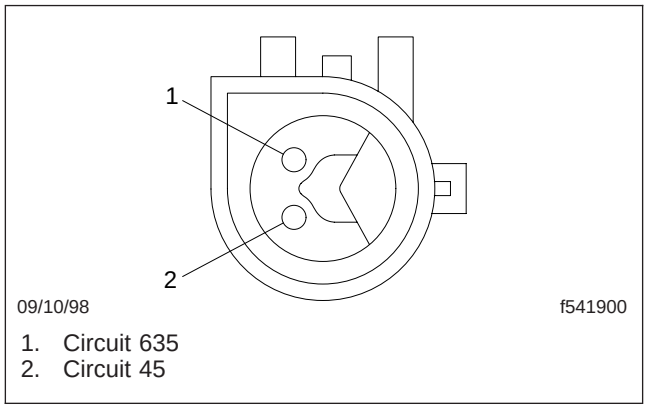


Fig. 25, Oil Temperature Switch Connector

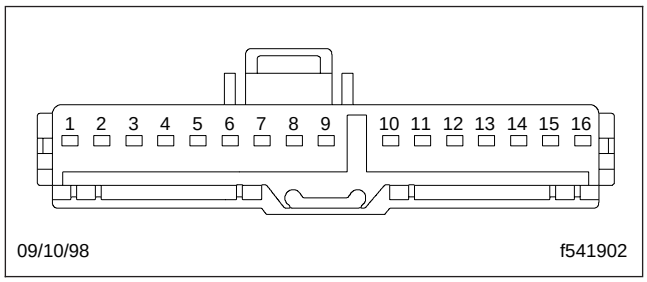


Fig. 26, Instrument Cluster Connector, Optional Cluster

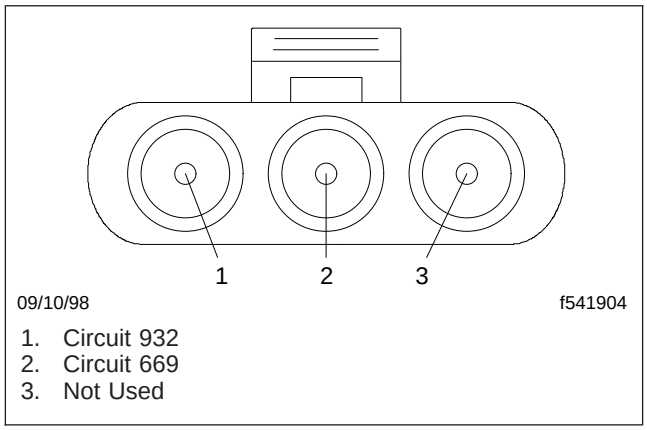
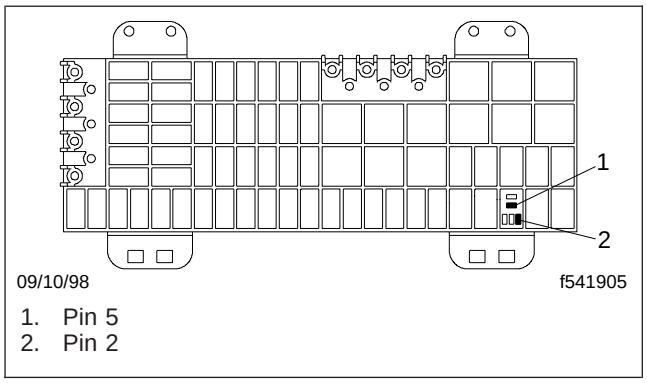


Fig. 27, Fuel Shutoff Solenoid Connector



1. Pin 5
2. Pin 2

Fig. 28, Fuel Shutoff Relay Connector

See **Fig. 1** for a full view of the auxiliary gauges wiring.

See **Fig. 2** for a full view of the electronic cluster gauges wiring.

See **Fig. 3**, **Fig. 4** and **Fig. 5** for partial views of the electronic cluster gauges wiring.

See **Fig. 6** for a full view of the individual gauges wiring.

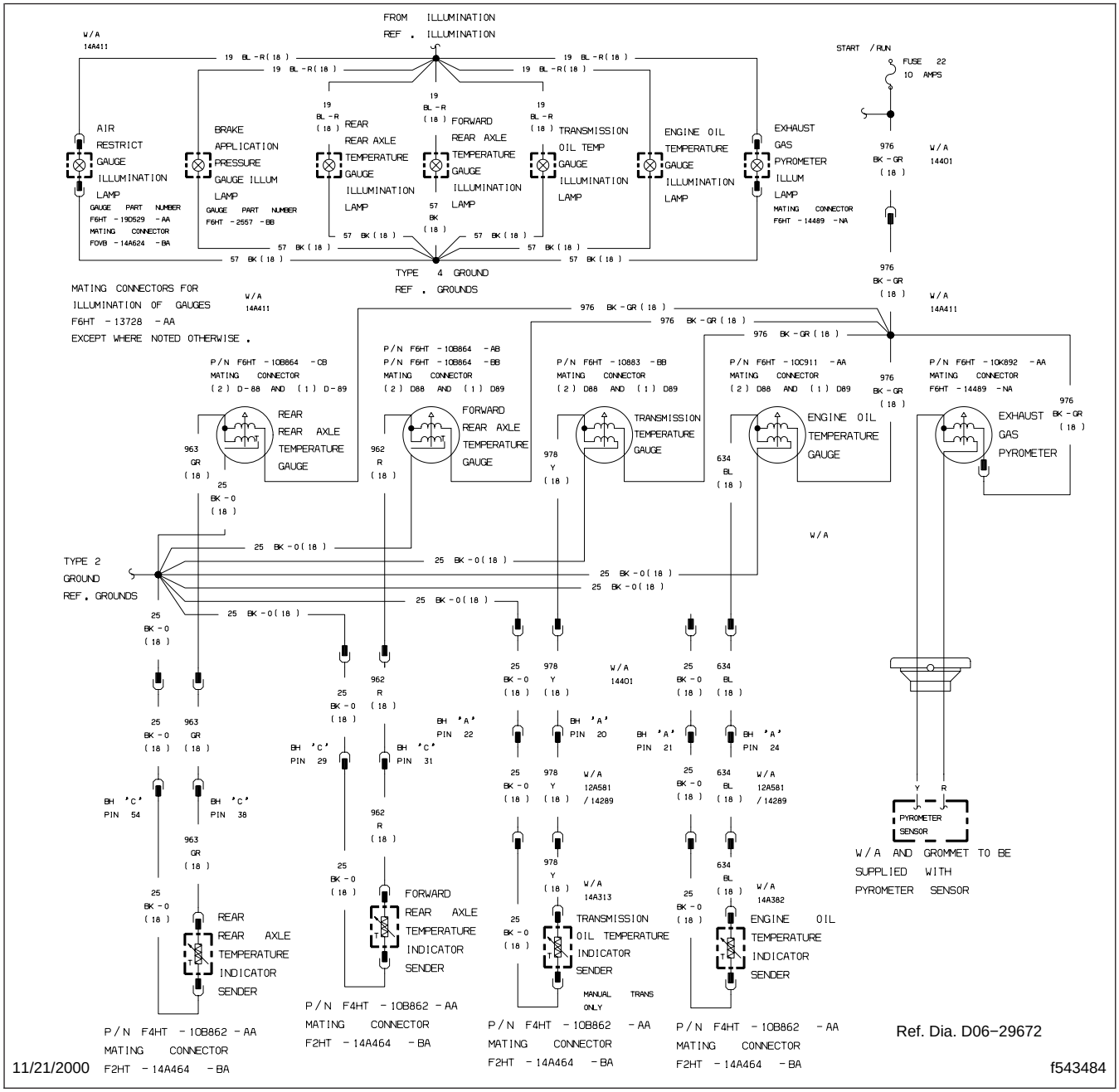


Fig. 1, Auxiliary Gauges Wiring (full view)

Specifications

See **Fig. 7** and **Fig. 8** for partial views of the individual gauges wiring.

See **Fig. 9** for a full view of the illumination summary.

See **Fig. 10** and **Fig. 11** for partial views of the illumination summary.

See **Fig. 12** for a full view of the warning lights wiring.

See **Fig. 13**, **Fig. 14** and **Fig. 15** for partial views of the warning lights wiring.

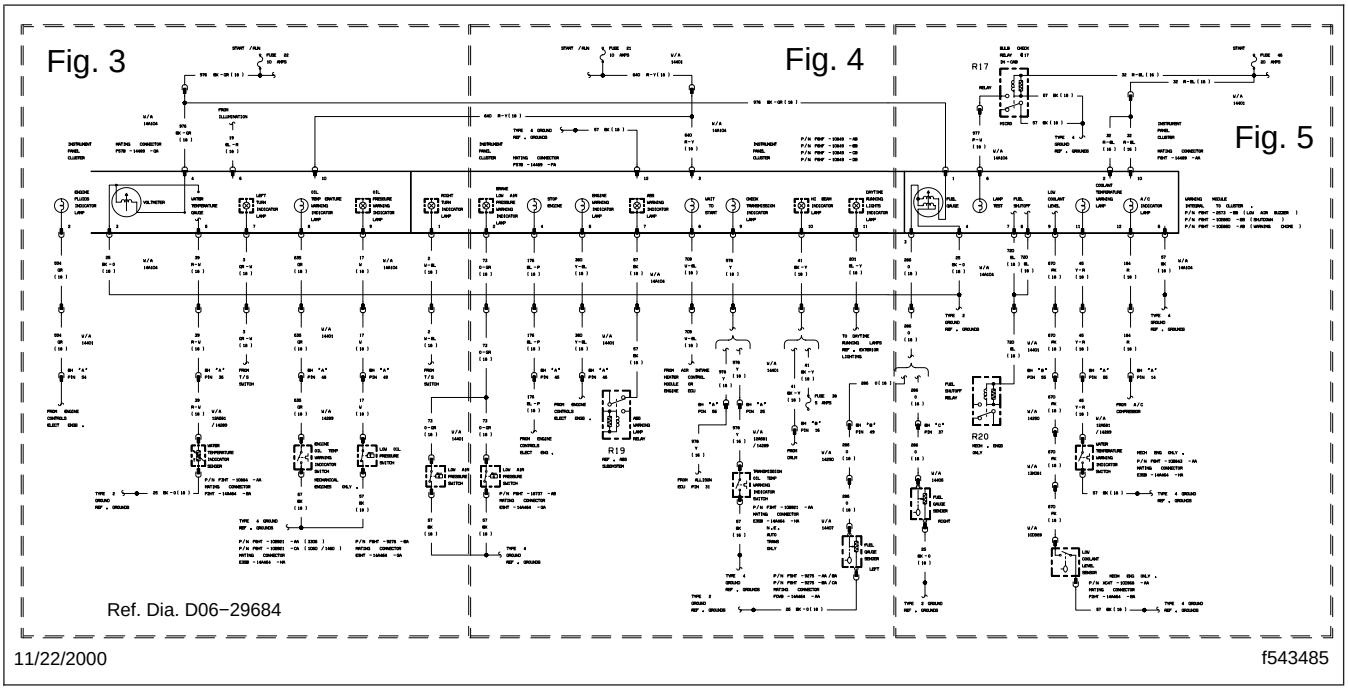


Fig. 2, Electronic Cluster Gauges Wiring (full view)

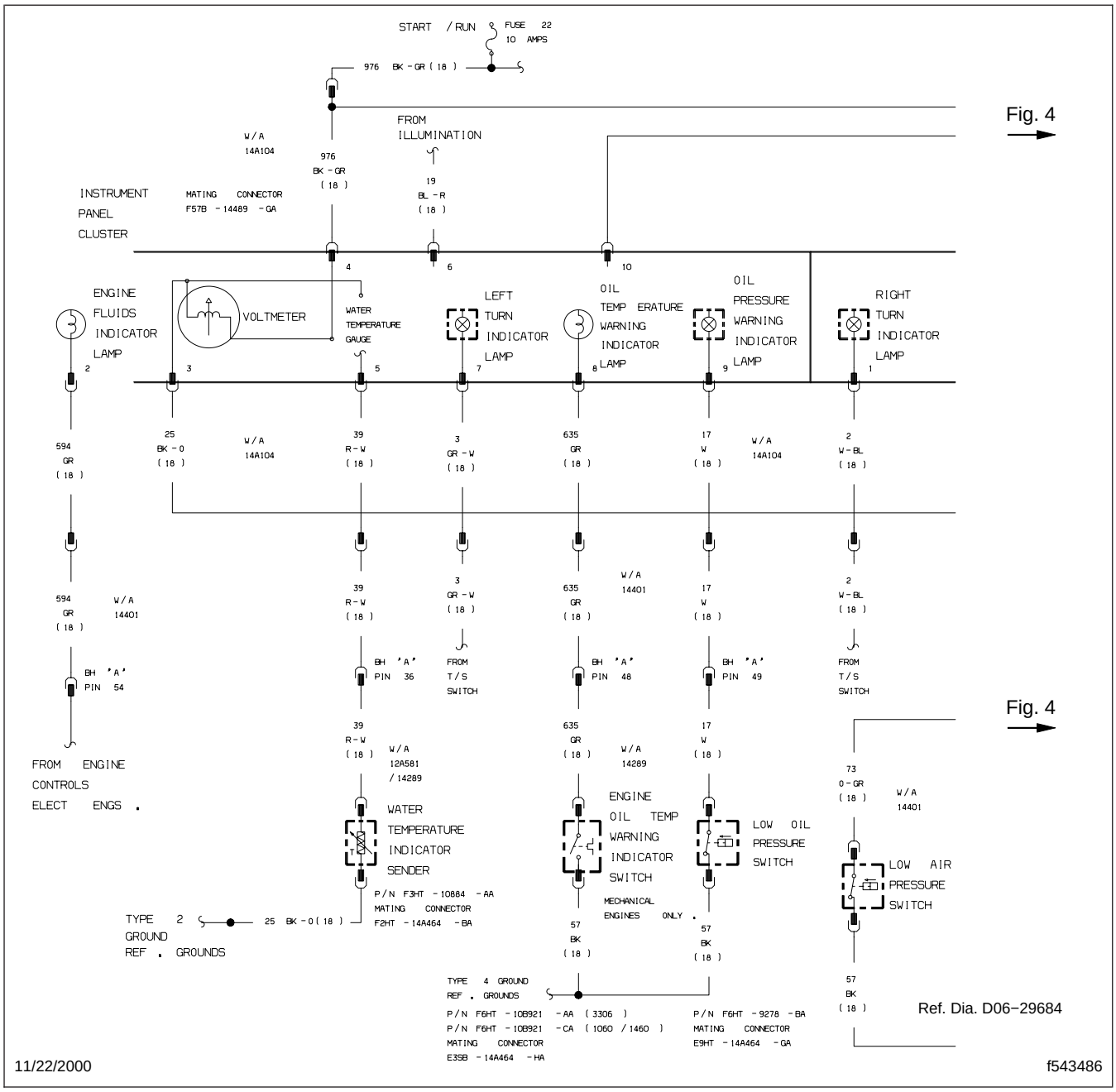


Fig. 3, Electronic Cluster Gauges Wiring (partial view)

Specifications

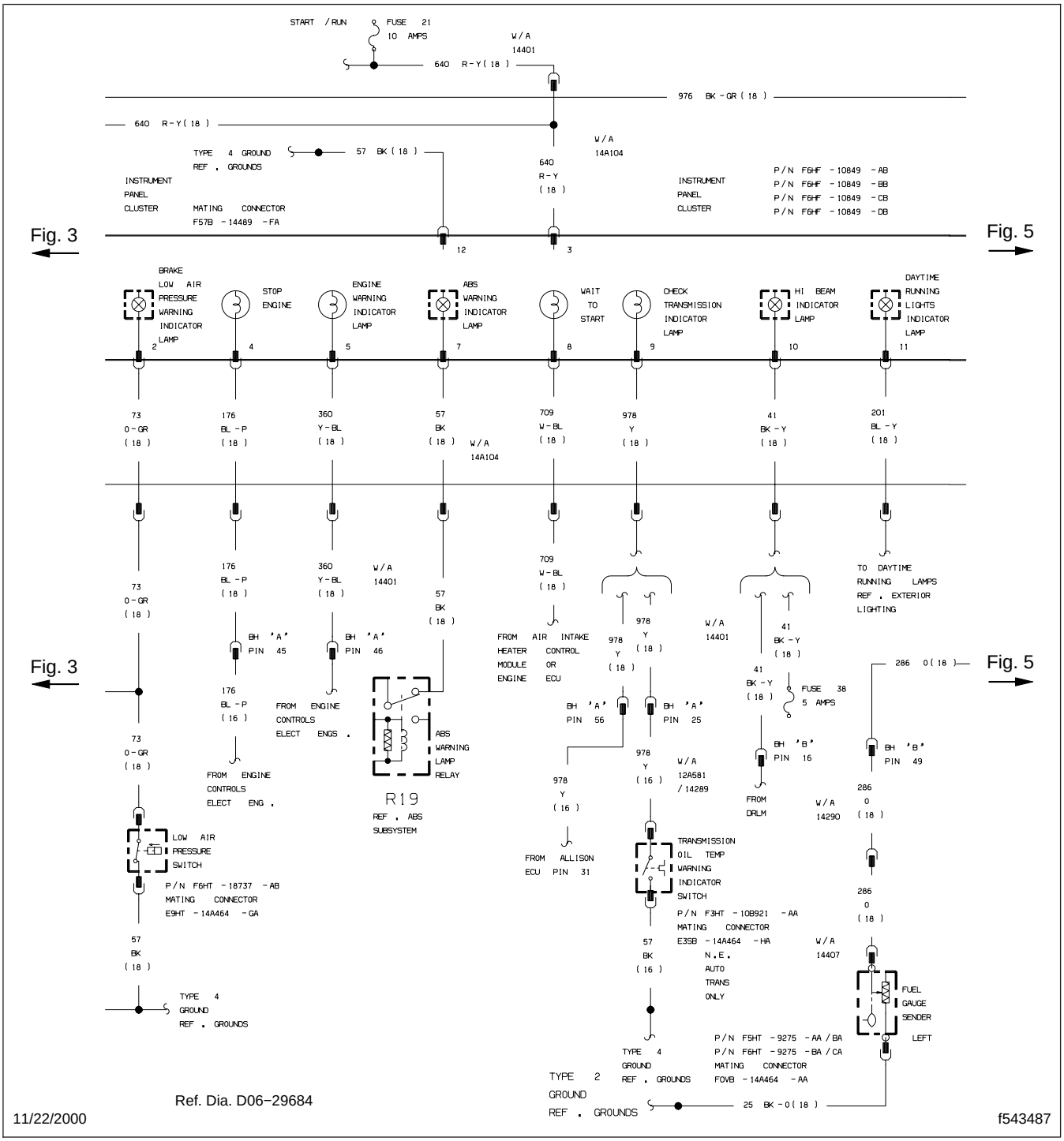


Fig. 4, Electronic Cluster Gauges Wiring (partial view)

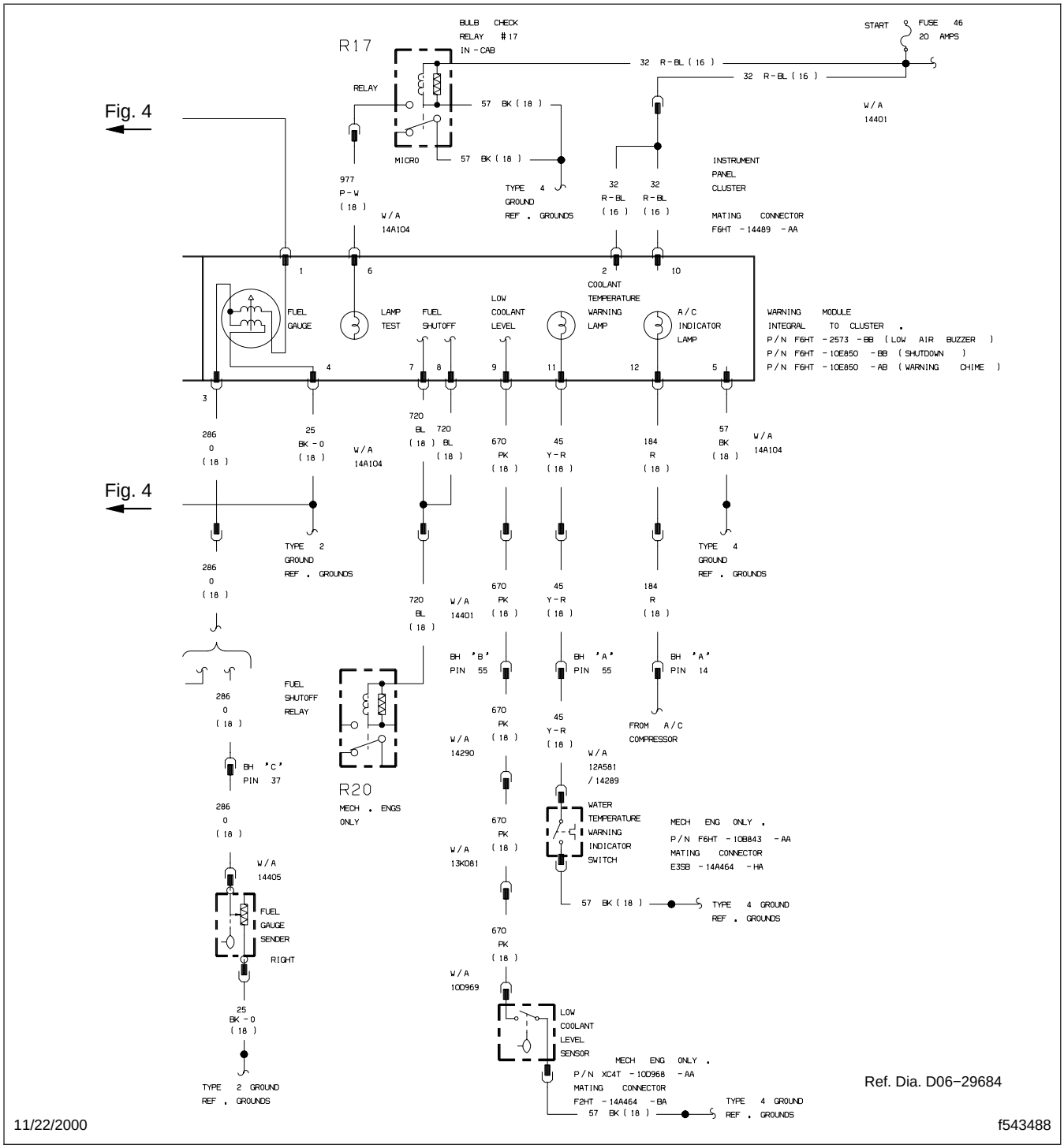


Fig. 5, Electronic Cluster Gauges Wiring (partial view)

Specifications

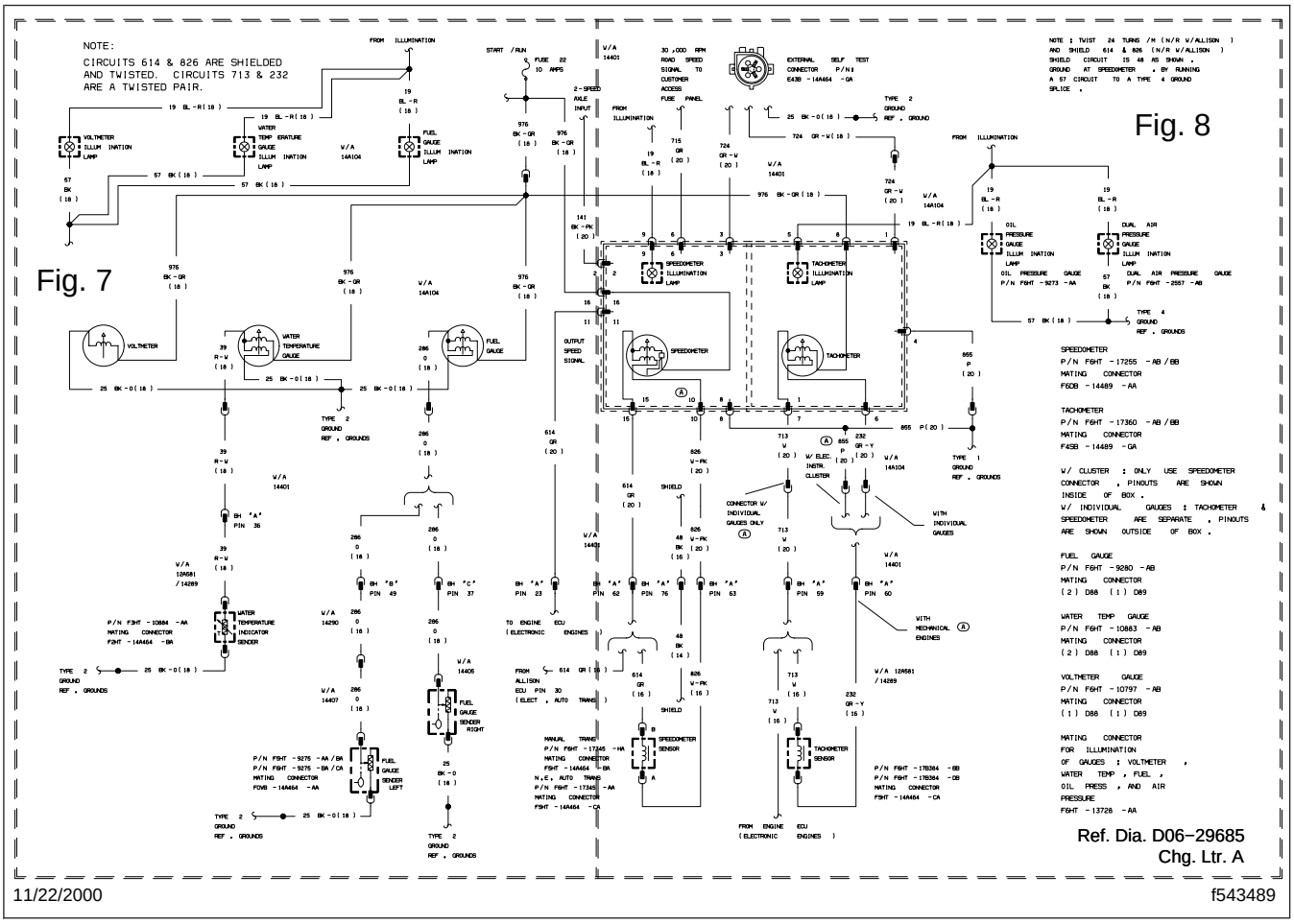


Fig. 6, Individual Gauges Wiring (full view)

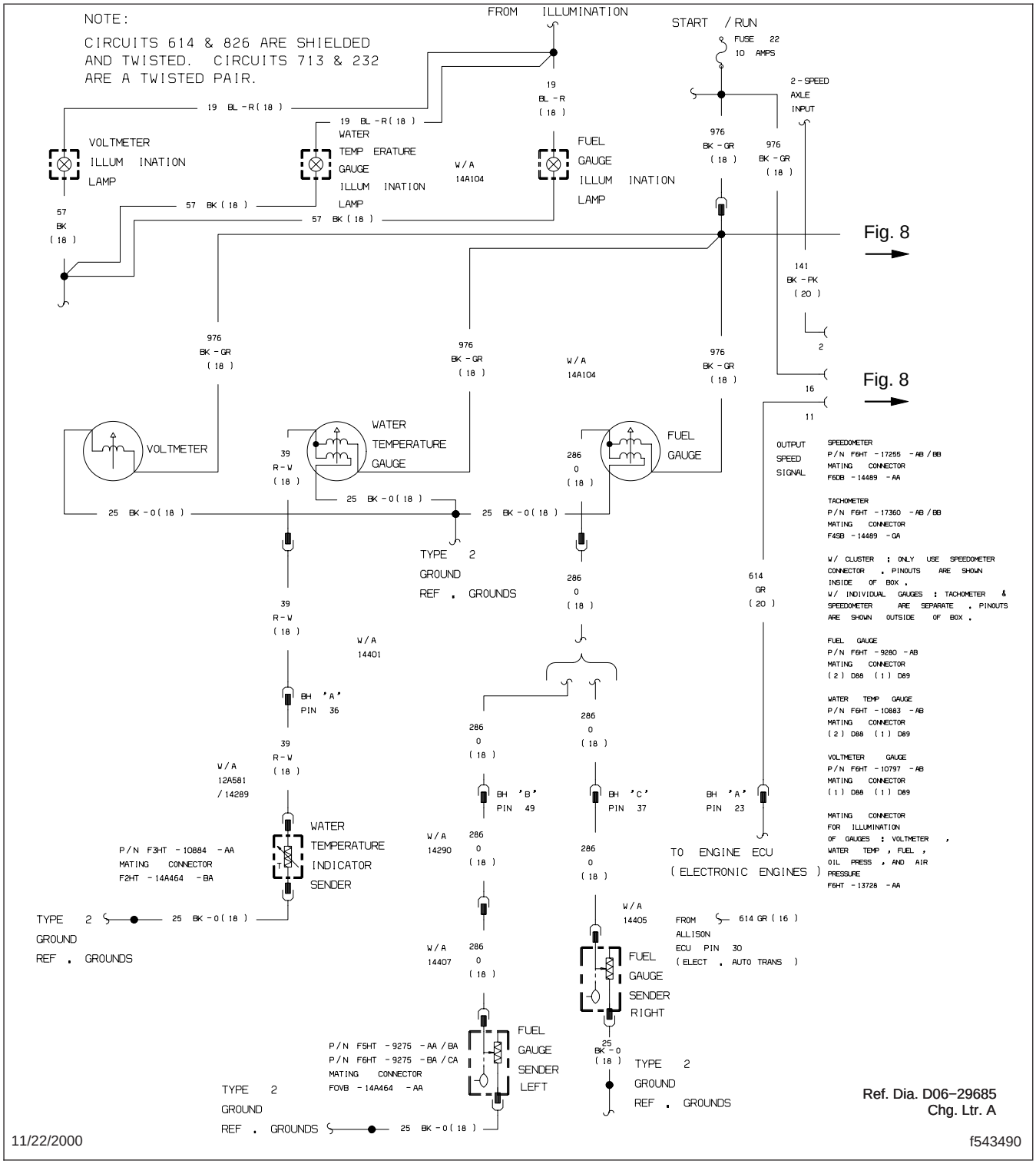


Fig. 7, Individual Gauges Wiring (partial view)

Specifications

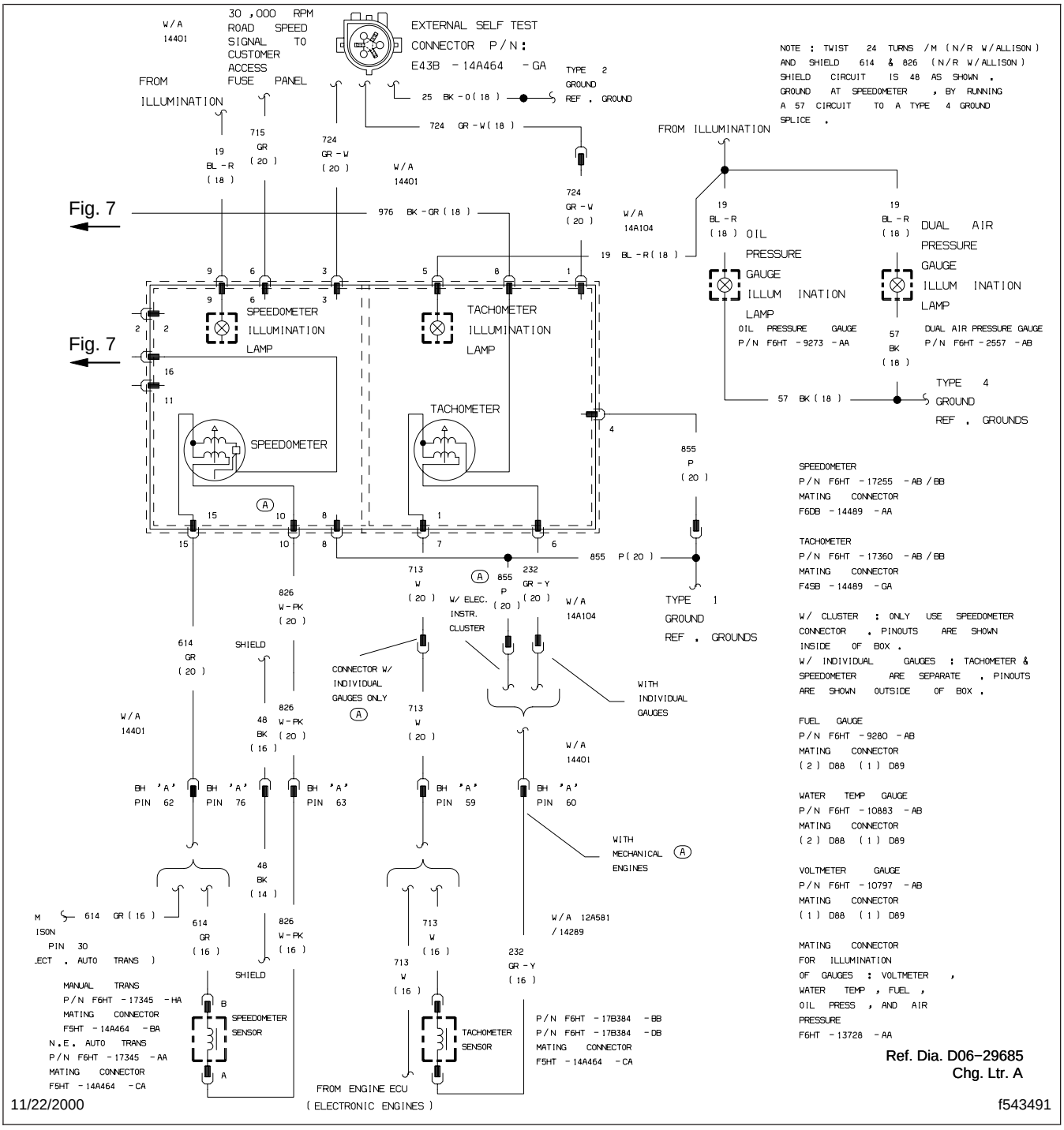


Fig. 8, Individual Gauges Wiring (partial view)

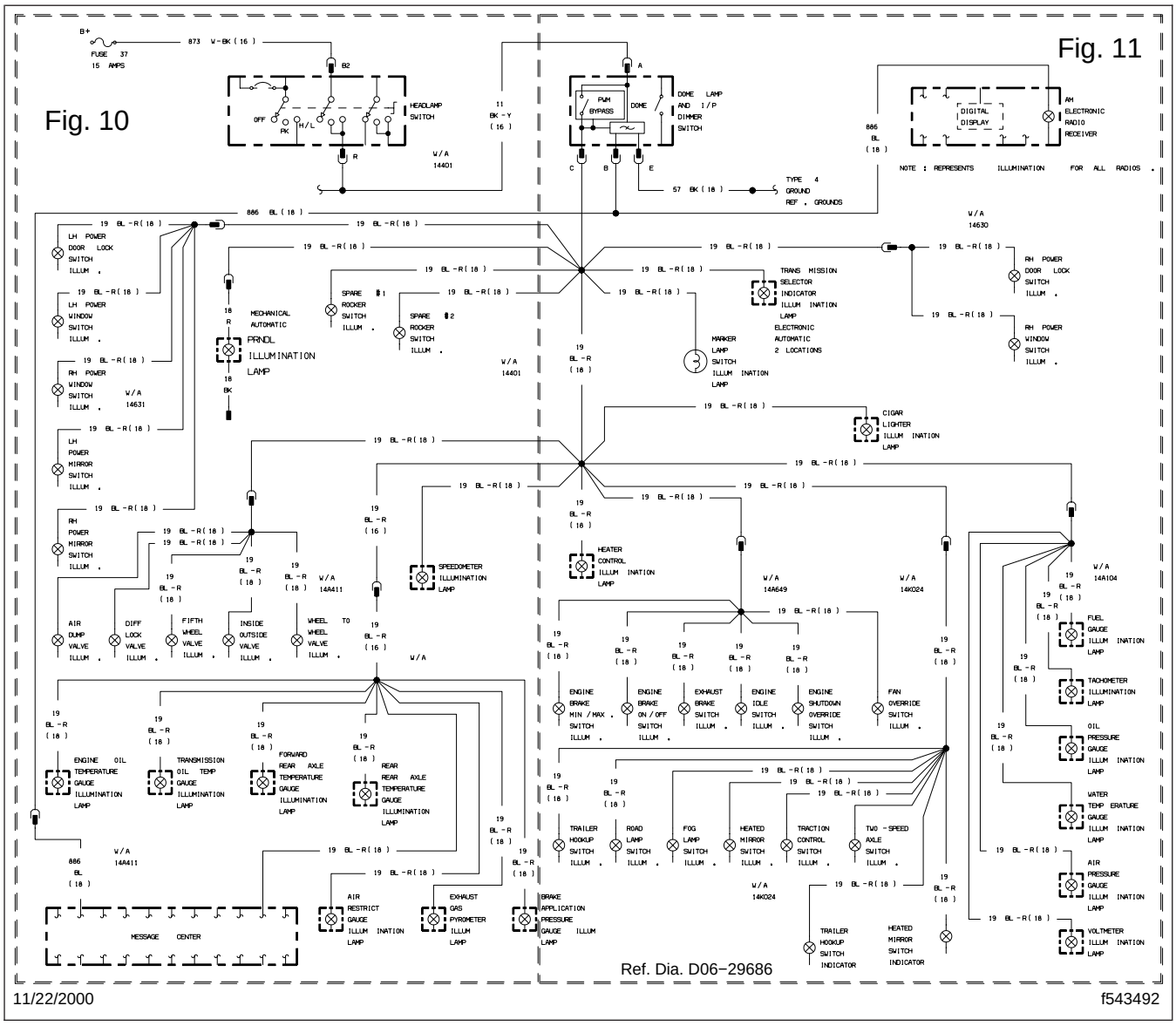


Fig. 9, Illumination Summary (full view)

Specifications

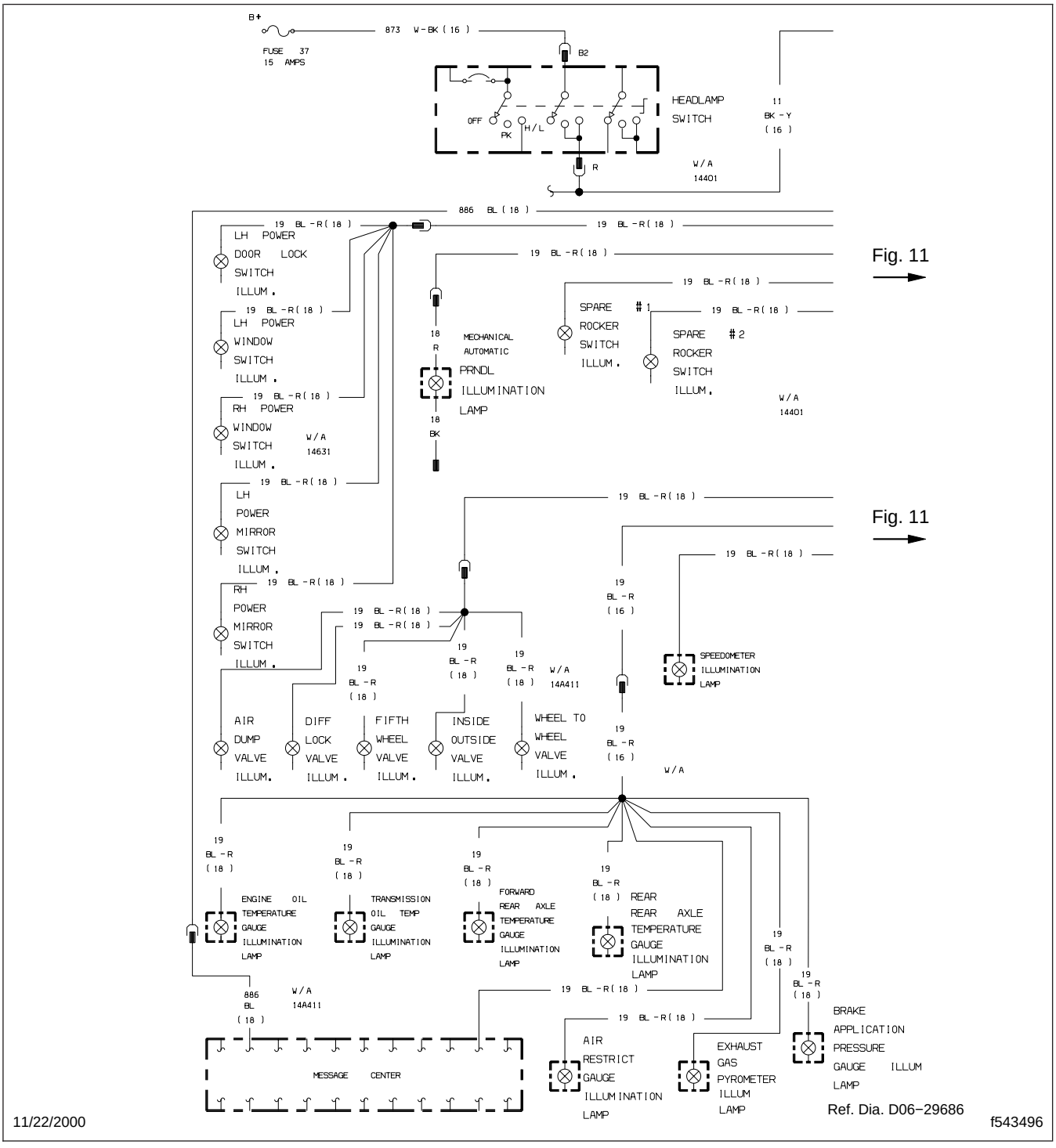


Fig. 10, Illumination Summary (partial view)

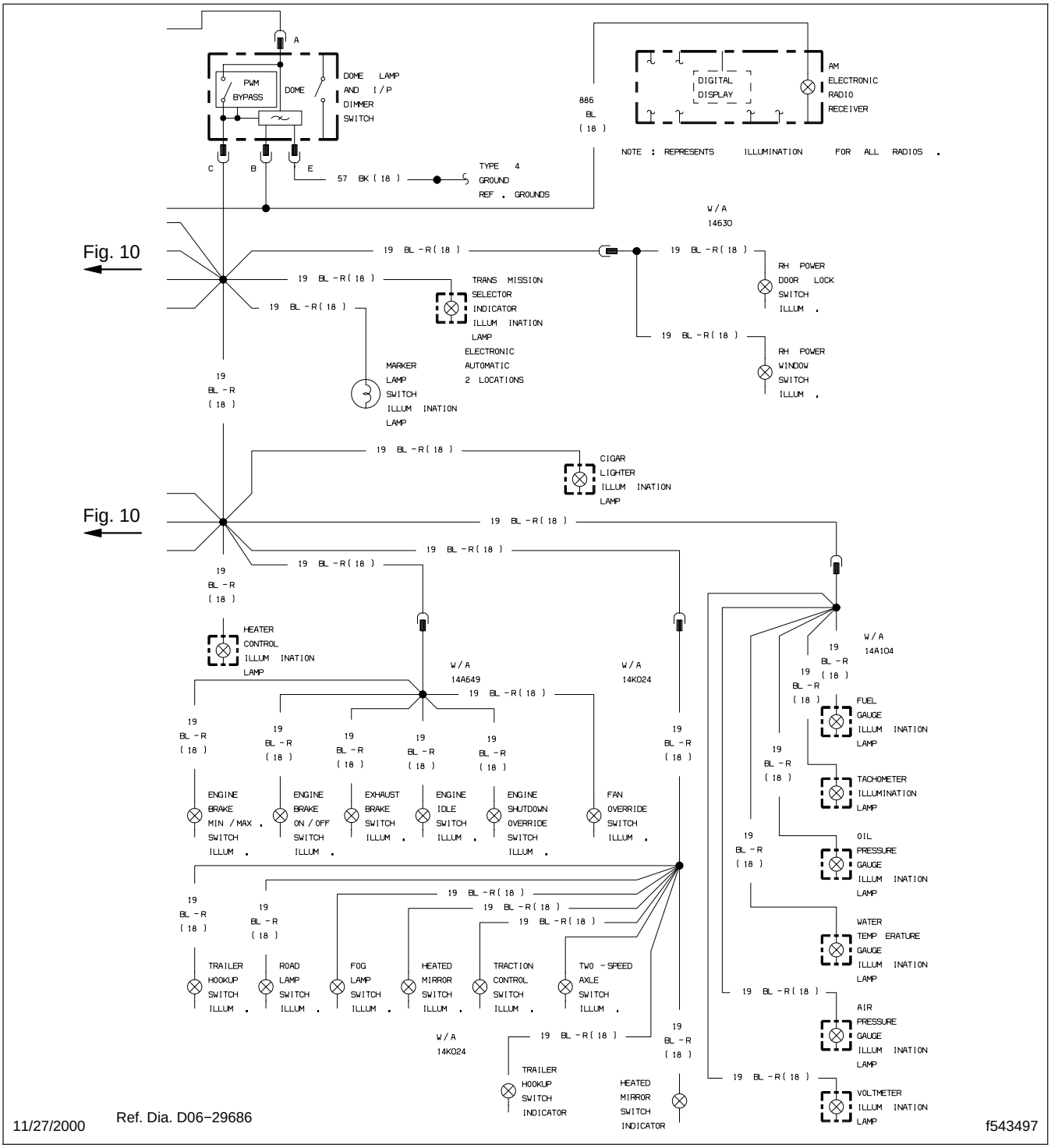


Fig. 11, Illumination Summary (partial view)

Specifications

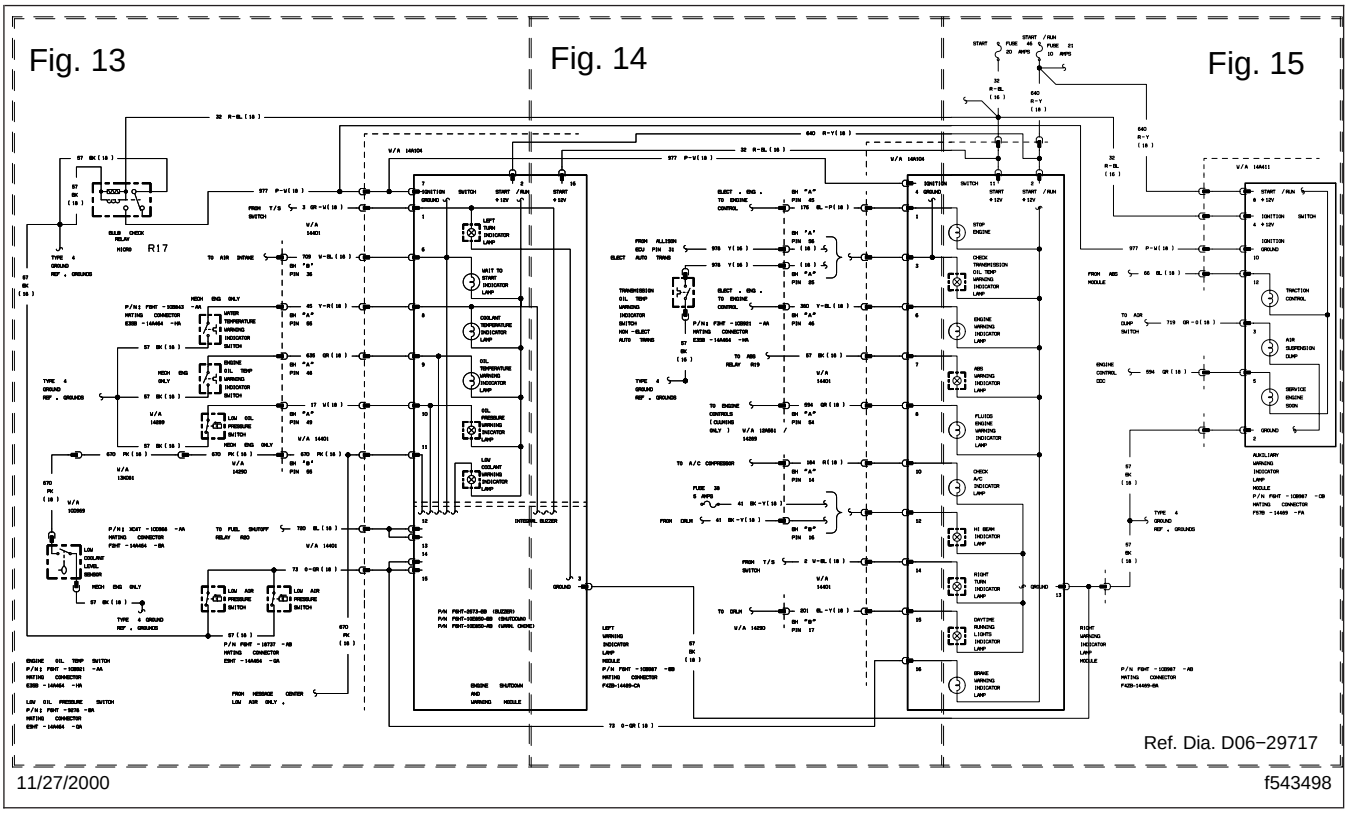


Fig. 12, Warning Lights Wiring (full view)

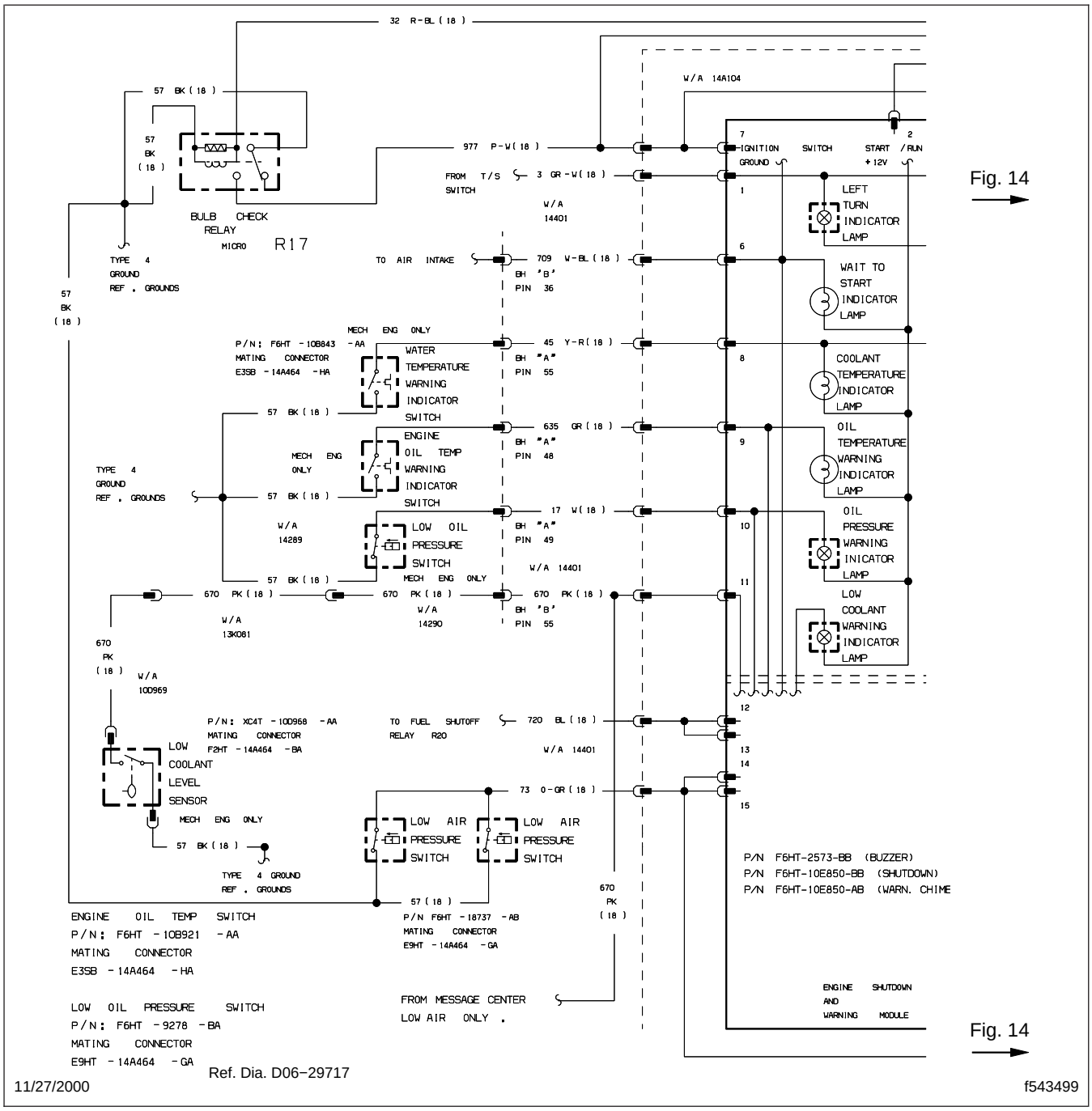


Fig. 13, Warning Lights Wiring (partial view)

Specifications

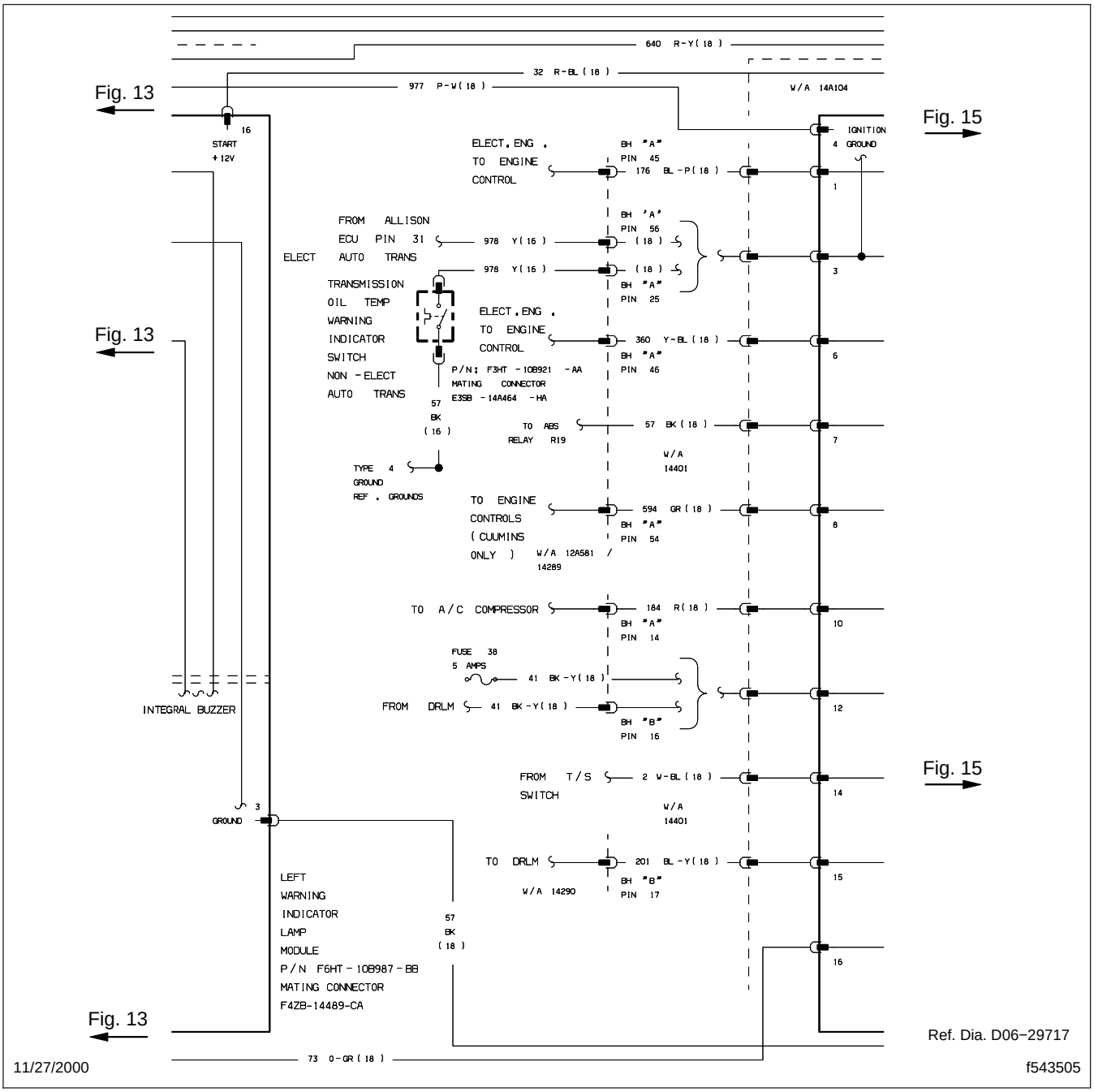


Fig. 14, Warning Lights Wiring (partial view)

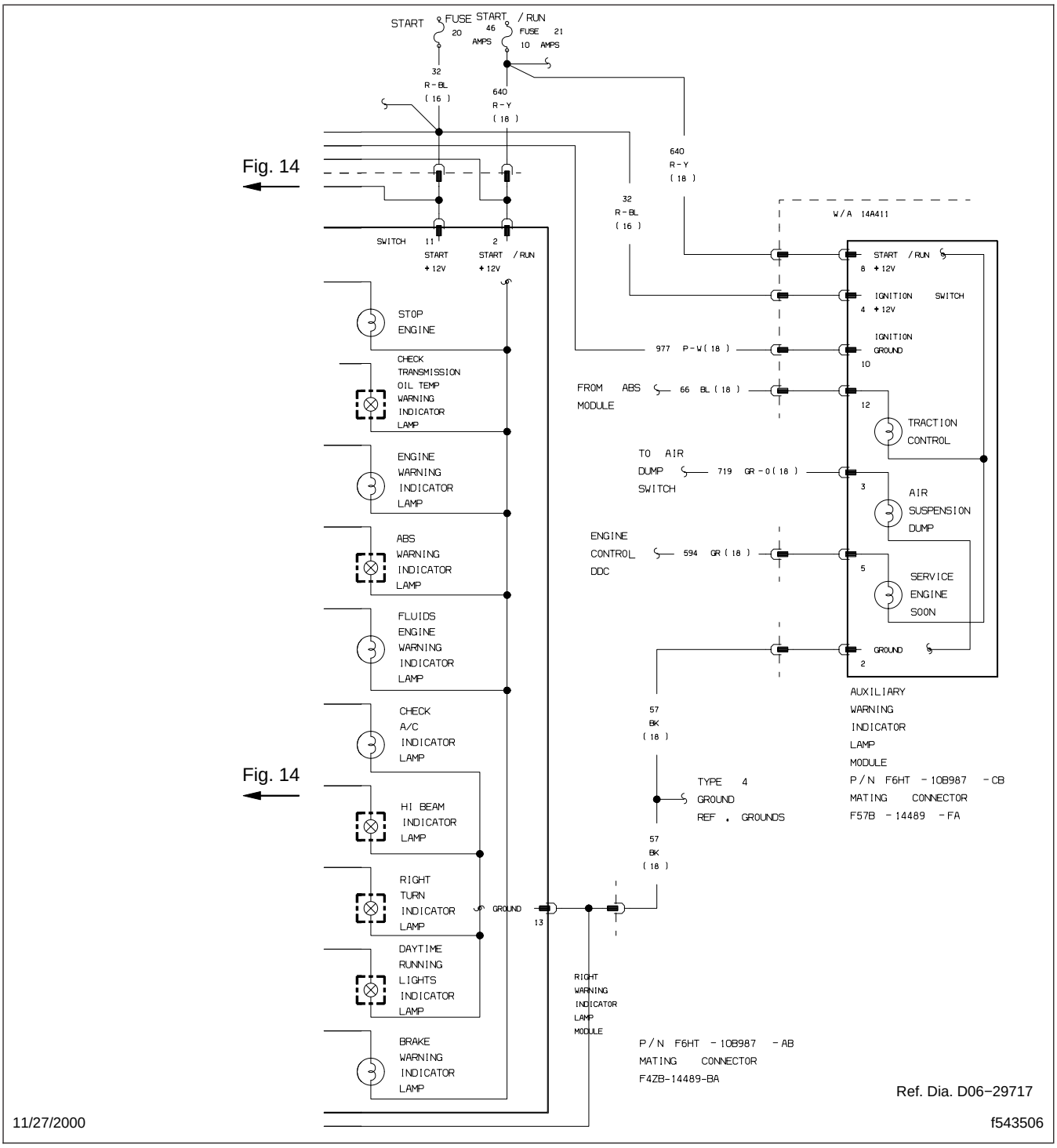


Fig. 15, Warning Lights Wiring (partial view)

Specifications

Tachometer Dip Switch Setting Chart									
Flywheel Teeth	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**Test at 1/2 Frequency Scale**
12	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	300
Electronic Engine Speed Output									
75	OFF	ON	OFF	OFF	ON	OFF	ON	ON	1875
76	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	1900
77	OFF	ON	OFF	OFF	ON	ON	OFF	ON	1925
78	OFF	ON	OFF	OFF	ON	ON	ON	OFF	1950
79	OFF	ON	OFF	OFF	ON	ON	ON	ON	1975
80	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	2000
81	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	2025
82	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	2050
83	OFF	ON	OFF	ON	OFF	OFF	ON	ON	2075
84	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	2100
85	OFF	ON	OFF	ON	OFF	ON	OFF	ON	2125
86	OFF	ON	OFF	ON	OFF	ON	ON	OFF	2150
87	OFF	ON	OFF	ON	OFF	ON	ON	ON	2175
88	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	2200
89	OFF	ON	OFF	ON	ON	OFF	OFF	ON	2225
90	OFF	ON	OFF	ON	ON	OFF	ON	OFF	2250
91	OFF	ON	OFF	ON	ON	OFF	ON	ON	2275
92	OFF	ON	OFF	ON	ON	ON	OFF	OFF	2300
93	OFF	ON	OFF	ON	ON	ON	OFF	ON	2325
94	OFF	ON	OFF	ON	ON	ON	ON	OFF	2350
95	OFF	ON	OFF	ON	ON	ON	ON	ON	2375
96	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	2400
97	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	2425
98	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	2450
99	OFF	ON	ON	OFF	OFF	OFF	ON	ON	2475
100	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	2500
101	OFF	ON	ON	OFF	OFF	ON	OFF	ON	2525
102	OFF	ON	ON	OFF	OFF	ON	ON	OFF	2550
103	OFF	ON	ON	OFF	OFF	ON	ON	ON	2575
104	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	2600
105	OFF	ON	ON	OFF	ON	OFF	OFF	ON	2625
106	OFF	ON	ON	OFF	ON	OFF	ON	OFF	2650
107	OFF	ON	ON	OFF	ON	OFF	ON	ON	2675

Tachometer Dip Switch Setting Chart									
Flywheel Teeth	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**Test at 1/2 Frequency Scale**
108	OFF	ON	ON	OFF	ON	ON	OFF	OFF	2700
109	OFF	ON	ON	OFF	ON	ON	OFF	ON	2725
110	OFF	ON	ON	OFF	ON	ON	ON	OFF	2750
111	OFF	ON	ON	OFF	ON	ON	ON	ON	2775
112	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	2800
113	OFF	ON	ON	ON	OFF	OFF	OFF	ON	2825
114	OFF	ON	ON	ON	OFF	OFF	ON	OFF	2850
115	OFF	ON	ON	ON	OFF	OFF	ON	ON	2875
116	OFF	ON	ON	ON	OFF	ON	OFF	OFF	2900
117	OFF	ON	ON	ON	OFF	ON	OFF	ON	2925
118	OFF	ON	ON	ON	OFF	ON	ON	OFF	2950
119	OFF	ON	ON	ON	OFF	ON	ON	ON	2975
120	OFF	ON	ON	ON	ON	OFF	OFF	OFF	3000
121	OFF	ON	ON	ON	ON	OFF	OFF	ON	3025
122	OFF	ON	ON	ON	ON	OFF	ON	OFF	3050
123	OFF	ON	ON	ON	ON	OFF	ON	ON	3075
124	OFF	ON	ON	ON	ON	ON	OFF	OFF	3100
125	OFF	ON	ON	ON	ON	ON	OFF	ON	3125
126	OFF	ON	ON	ON	ON	ON	ON	OFF	3150
127	OFF	ON	ON	ON	ON	ON	ON	ON	3175
128	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	3200
129	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	3225
130	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	3250
131	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	3275
132	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	3300
133	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	3325
134	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	3350
135	ON	OFF	OFF	OFF	OFF	ON	ON	ON	3375
136	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	3400
137	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	3425
138	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	3450
139	ON	OFF	OFF	OFF	ON	OFF	ON	ON	3475
140	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	3500
141	ON	OFF	OFF	OFF	ON	ON	OFF	ON	3525
142	ON	OFF	OFF	OFF	ON	ON	ON	OFF	3550

Specifications

Tachometer Dip Switch Setting Chart									
Flywheel Teeth	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**Test at 1/2 Frequency Scale**
143	ON	OFF	OFF	OFF	ON	ON	ON	ON	3575
144	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	3600
145	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	3625
146	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	3650
147	ON	OFF	OFF	ON	OFF	OFF	ON	ON	3675
148	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	3700
149	ON	OFF	OFF	ON	OFF	ON	OFF	ON	3725
150	ON	OFF	OFF	ON	OFF	ON	ON	OFF	3750
151	ON	OFF	OFF	ON	OFF	ON	ON	ON	3775
152	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	3800
153	ON	OFF	OFF	ON	ON	OFF	OFF	ON	3825
154	ON	OFF	OFF	ON	ON	OFF	ON	OFF	3850
155	ON	OFF	OFF	ON	ON	OFF	ON	ON	3875
156	ON	OFF	OFF	ON	ON	ON	OFF	OFF	3900
157	ON	OFF	OFF	ON	ON	ON	OFF	ON	3925
158	ON	OFF	OFF	ON	ON	ON	ON	OFF	3950
159	ON	OFF	OFF	ON	ON	ON	ON	ON	3975
160	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	4000
161	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	4025
162	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	4050
163	ON	OFF	ON	OFF	OFF	OFF	ON	ON	4075
164	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	4100
165	ON	OFF	ON	OFF	OFF	ON	OFF	ON	4125
166	ON	OFF	ON	OFF	OFF	ON	ON	OFF	4150
167	ON	OFF	ON	OFF	OFF	ON	ON	ON	4175
168	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	4200
169	ON	OFF	ON	OFF	ON	OFF	OFF	ON	4225
170	ON	OFF	ON	OFF	ON	OFF	ON	OFF	4250

Table 1, Tachometer Dip Switch Setting Chart

Speedometer Dip Switch Setting Chart							
Test Frequency	**Switch Setting**	**Test Frequency**	**Switch Setting**	**Test Frequency**	**Switch Setting**	**Test Frequency**	**Switch Setting**
120	12....7890	122	.2....7890	124	1.....7890	126	7890
128	123456.89	130	.23456.890	132	1.3456.890	134	..3456.890
136	12.456.890	138	.2.456.890	140	1..456.890	142	...456.890

Speedometer Dip Switch Setting Chart							
Test Frequency	**Switch Setting**	**Test Frequency**	**Switch Setting**	**Test Frequency**	**Switch Setting**	**Test Frequency**	**Switch Setting**
144	123.56.890	146	.23.56.890	148	1.3.56.890	150	..3.56.890
152	12..56.890	154	.2..56.890	156	1...56.890	158	....56.890
160	1234.6.890	162	.234.6.890	164	1.34.6.890	166	..34.6.890
168	12.4.6.890	170	.2.4.6.890	172	1..4.6.890	174	...4.6.890
176	123..6.890	178	.23..6.890	180	1.3..6.890	182	..3..6.890
184	12...6.890	186	.2...6.890	188	1....6.890	190	.....6.890
192	12345..890	194	.2345..890	196	1.345..890	198	..345..890
200	12.45..890	202	.2.45..890	204	1..45..890	206	...45..890
208	123.5..890	210	.23.5..890	212	1.3.5..890	214	..3.5..890
216	12..5..890	218	.2..5..890	220	1...5..890	222	....5..890
224	1234...890	226	.234...890	228	1.34...890	230	..34...890
232	12.4...890	234	.2.4...890	236	1..4...890	238	...4...890
240	123....890	242	.23....890	244	1.3....890	246	..3....890
248	12.....890	250	.2.....890	252	1......890	254	890
256	1234567.9	258	.234567.90	260	1.34567.90	262	..34567.90
264	12.4567.90	266	.2.4567.90	268	1..4567.90	270	...4567.90
272	123.567.90	274	.23.567.90	276	1.3.567.90	278	..3.567.90
280	12..567.90	282	.2..567.90	284	1...567.90	286	....567.90
288	1234.67.90	290	.234.67.90	292	1.34.67.90	294	..34.67.90
296	12.4.67.90	298	.2.4.67.90	300	1..4.67.90	302	...4.67.90
304	123..67.90	306	.23..67.90	308	1.3..67.90	310	..3..67.90
312	12...67.90	314	.2...67.90	316	1....67.90	318	.....67.90
320	12345.7.90	322	.2345.7.90	324	1.345.7.90	326	..345.7.90
328	12.45.7.90	330	.2.45.7.90	332	1..45.7.90	334	...45.7.90
336	123.5.7.90	338	.23.5.7.90	340	1.3.5.7.90	342	..3.5.7.90
344	12..5.7.90	346	.2..5.7.90	348	1...5.7.90	350	....5.7.90
352	1234..7.90	354	.234..7.90	356	1.34..7.90	358	..34..7.90
360	12.4..7.90	362	.2.4..7.90	364	1..4..7.90	366	...4..7.90
368	123...7.90	370	.23...7.90	372	1.3...7.90	374	..3...7.90
376	12....7.90	378	.2....7.90	380	1.....7.90	382	......7.90
384	123456..90	386	.23456..90	388	1.3456..90	390	..3456..90
392	12.456..90	394	.2.456..90	396	1..456..90	398	...456..90
400	123.56..90	402	.23.56..90	404	1.3.56..90	406	..3.56..90
408	12..56..90	410	.2..56..90	412	1...56..90	414	....56..90
416	1234.6..90	418	.234.6..90	420	1.34.6..90	422	..34.6..90

Specifications

Speedometer Dip Switch Setting Chart							
Test Frequency	**Switch Setting**	**Test Frequency**	**Switch Setting**	**Test Frequency**	**Switch Setting**	**Test Frequency**	**Switch Setting**
424	12.4.6..90	426	.2.4.6..90	428	1..4.6..90	430	...4.6..90
432	123..6..90	434	.23..6..90	436	1.3..6..90	438	..3..6..90
440	12...6..90	442	.2...6..90	444	1....6..90	446	.....6..90
448	12345...90	450	.2345...90	452	1.345...90	454	..345...90
456	12.45...90	458	.2.45...90	460	1..45...90	462	...45...90
464	123.5...90	466	.23.5...90	468	1.3.5...90	470	..3.5...90
472	12..5...90	474	.2..5...90	476	1...5...90	478	....5...90
480	1234....90	482	.234....90	484	1.34....90	486	..34....90
488	12.4....90	490	.2.4....90	492	1..4....90	494	...4....90
496	123.....90	498	.23.....90	500	1.3.....90	502	..3.....90
504	12......90	506	.2......90	508	1.......90	510	90
512	12345678	514	.2345678.0	516	1.345678.0	518	..345678.0
520	12.45678.0	522	.2.45678.0	524	1..45678.0	526	...45678.0
528	123.5678.0	530	.23.5678.0	532	1.3.5678.0	534	..3.5678.0
536	12..5678.0	538	.2..5678.0	540	1...5678.0	542	....5678.0
544	1234.678.0	546	.234.678.0	548	1.34.678.0	550	..34.678.0
552	12.4.678.0	554	.2.4.678.0	556	1..4.678.0	558	...4.678.0
560	123..678.0	562	.23..678.0	564	1.3..678.0	566	..3..678.0
568	12...678.0	570	.2...678.0	572	1....678.0	574	.....678.0
576	12345.78.0	578	.2345.78.0	580	1.345.78.0	582	..345.78.0
584	12.45.78.0	586	.2.45.78.0	588	1..45.78.0	590	...45.78.0
592	123.5.78.0	594	.23.5.78.0	596	1.3.5.78.0	598	..3.5.78.0
600	12..5.78.0	602	.2..5.78.0	604	1...5.78.0	606	....5.78.0
608	1234..78.0	610	.234..78.0	612	1.34..78.0	614	..34..78.0
616	12.4..78.0	618	.2.4..78.0	620	1..4..78.0	622	...4..78.0
624	123...78.0	626	.23...78.0	628	1.3...78.0	630	..3...78.0
632	12....78.0	634	.2....78.0	636	1.....78.0	638	......78.0
640	123456.8.0	642	.23456.8.0	644	1.3456.8.0	646	..3456.8.0
648	12.456.8.0	650	.2.456.8.0	652	1..456.8.0	654	...456.8.0
656	123.56.8.0	658	.23.56.8.0	660	1.3.56.8.0	662	..3.56.8.0
664	12..56.8.0	666	.2..56.8.0	668	1...56.8.0	670	....56.8.0
672	1234.6.8.0	674	.234.6.8.0	676	1.34.6.8.0	678	..34.6.8.0
680	12.4.6.8.0	682	.2.4.6.8.0	684	1..4.6.8.0	686	...4.6.8.0
688	123..6.8.0	690	.23..6.8.0	692	1.3..6.8.0	694	..3..6.8.0
696	12...6.8.0	698	.2...6.8.0	700	1....6.8.0	702	.....6.8.0

Speedometer Dip Switch Setting Chart							
Test Frequency	**Switch Setting**	**Test Frequency**	**Switch Setting**	**Test Frequency**	**Switch Setting**	**Test Frequency**	**Switch Setting**
704	12345..8.0	706	.2345..8.0	708	1.345..8.0	710	..345..8.0
712	12.45..8.0	714	.2.45..8.0	716	1..45..8.0	718	...45..8.0
720	123.5..8.0	722	.23.5..8.0	724	1.3.5..8.0	726	..3.5..8.0
728	12..5..8.0	730	.2..5..8.0	732	1...5..8.0	734	....5..8.0
736	1234...8.0	738	.234...8.0	740	1.34...8.0	742	..34...8.0
744	12.4...8.0	746	.2.4...8.0	748	1..4...8.0	750	...4...8.0
752	123....8.0	754	.23....8.0	756	1.3....8.0	758	..3....8.0
760	12.....8.0	762	.2.....8.0	764	1......8.0	766	.......8.0
768	1234567..0	770	.234567..0	772	1.34567..0	774	..34567..0
776	12.4567..0	778	.2.4567..0	780	1..4567..0	782	...4567..0
784	123.567..0	786	.23.567..0	788	1.3.567..0	790	..3.567..0
792	12..567..0	794	.2..567..0	796	1...567..0	798	....567..0
800	1234.67..0	802	.234.67..0	804	1.34.67..0	806	..34.67..0
808	12.4.67..0	810	.2.4.67..0	812	1..4.67..0	814	...4.67..0
816	123..67..0	818	.23..67..0	820	1.3..67..0	822	..3..67..0
824	12...67..0	826	.2...67..0	828	1....67..0	830	.....67..0
832	12345.7..0	834	.2345.7..0	836	1.345.7..0	838	..345.7..0
840	12.45.7..0	842	.2.45.7..0	844	1..45.7..0	846	...45.7..0
848	123.5.7..0	850	.23.5.7..0	852	1.3.5.7..0	854	..3.5.7..0
856	12..5.7..0	858	.2..5.7..0	860	1...5.7..0	862	....5.7..0
864	1234..7..0	866	.234..7..0	868	1.34..7..0	870	..34..7..0
872	12.4..7..0	874	.2.4..7..0	876	1..4..7..0	878	...4..7..0
880	123...7..0	882	.23...7..0	884	1.3...7..0	886	..3...7..0
888	12....7..0	890	.2....7..0	892	1.....7..0	894	.....7..0
896	123456...0	898	.23456...0	900	1.3456...0	902	..3456...0
904	12.456...0	906	.2.456...0	908	1..456...0	910	...456...0
912	123.56...0	914	.23.56...0	916	1.3.56...0	918	..3.56...0
920	12..56...0	922	.2..56...0	924	1...56...0	926	....56...0
928	1234.6...0	930	.234.6...0	932	1.34.6...0	934	..34.6...0
936	12.4.6...0	938	.2.4.6...0	940	1..4.6...0	942	...4.6...0
944	123..6...0	946	.23..6...0	948	1.3..6...0	950	..3..6...0
952	12...6...0	954	.2...6...0	956	1....6...0	958	.....6...0
960	12345....0	962	.2345....0	964	1.345....0	966	..345....0
968	12.45....0	970	.2.45....0	972	1..45....0	974	...45....0
976	123.5....0	978	.23.5....0	980	1.3.5....0	982	..3.5....0

Specifications

Speedometer Dip Switch Setting Chart							
Test Frequency	**Switch Setting**	**Test Frequency**	**Switch Setting**	**Test Frequency**	**Switch Setting**	**Test Frequency**	**Switch Setting**
984	12..5....0	986	.2..5....0	988	1...5....0	990	....5....0
992	1234.....0	994	.234.....0	996	1.34.....0	998	..34.....0
1000	12.4.....0	1002	.2.4.....0	1004	1..4.....0	1006	...4.....0
1008	123......0	1010	.23......0	1012	1.3......0	1014	..3......0
1016	12.......0	1018	.2.......0	1020	1........0	1022	0
1024	123456789.	1026	.23456789.	1028	1.3456789.	1030	..3456789.
1032	12.456789.	1034	.2.456789.	1036	1..456789.	1038	...456789.
1040	123.56789.	1042	.23.56789.	1044	1.3.56789.	1046	..3.56789.
1048	12..56789.	1050	.2..56789.	1052	1...56789.	1054	....56789.
1056	1234.6789.	1058	.234.6789.	1060	1.34.6789.	1062	..34.6789.
1064	12.4.6789.	1066	.2.4.6789.	1068	1..4.6789.	1070	...4.6789.
1072	123..6789.	1074	.23..6789.	1076	1.3..6789.	1078	..3..6789.
1080	12...6789.	1082	.2...6789.	1084	1....6789.	1086	.....6789.
1088	12345.789.	1090	.2345.789.	1092	1.345.789.	1094	..345.789.
1096	12.45.789.	1098	.2.45.789.	1100	1..45.789.	-	-

Table 2, Speedometer Dip Switch Setting Chart

Torque Specifications	
Description	**lbf·in (N·cm)**
Auxiliary Finish Panel Screws	27–35 (300–400)
Warning Lamp Module Bolts	8–10 (90–110)
Auxiliary Gauge Retaining Bolts	8–10 (90–110)

Table 3, Torque Specifications

Replacement

NOTE: The horn is located in the right front core support area and can be accessed by opening the vehicle hood.

1. Open the hood.
2. Disconnect the battery ground cable(s).
3. Press the locking tabs and remove the horn electrical connector. See **Fig. 1**.

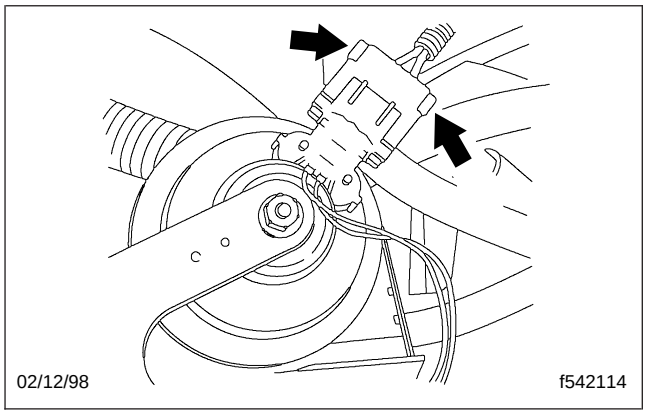


Fig. 1, Horn, Electrical Connector

4. Remove the horn retaining bolt and remove the horn(s). See **Fig. 2**.

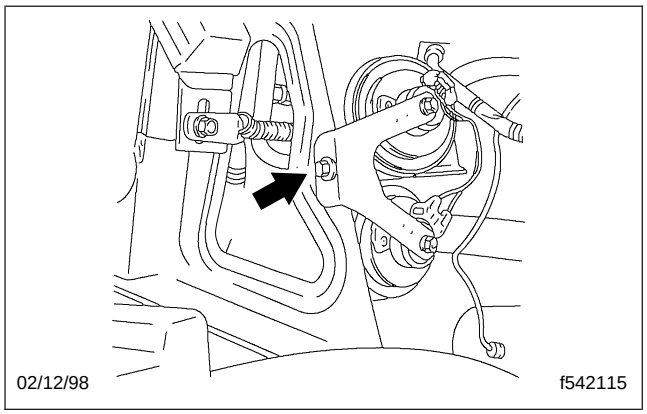


Fig. 2, Horn, Retaining Bolt

5. Position the horn and install the horn retaining bolt.
6. Connect the horn electrical connector.
7. Connect the battery ground cable(s).
8. Close the hood.

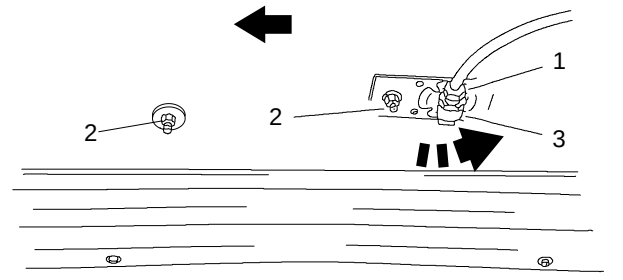
Single Base Dual Trumpet Air Horn Replacement

Replacement

WARNING

Unless the air system is bled, use care not to pull on the air horn lanyard during the removal or installation of the air horn, this could result in personal injury.

1. Remove the vehicle headliner; refer to **Group 60**.
2. Disconnect the air horn. See **Fig. 1**.



1. Air Line
2. Retaining Nuts
3. Air Line Elbow

Fig. 1, Air Horn Air Line Under Headliner

2.1 Remove the air line.

2.2 Remove the retaining nuts and washers.

2.3 Remove (unscrew) the air line elbow and washer.

3. Remove the air horn. See **Fig. 2**.

NOTE: All threaded air line connections should be sealed using Sterling Pipe Sealant with Teflon® D8AZ–19554–A or equivalent meeting Sterling specification WSK–M2G350–A2 or ESR–M18P7–A.

4. Position the air horn and install the airline washer and elbow.
5. Install the air horn retaining nuts and washers.
6. Install the air line.
7. Install the vehicle headliner; refer to **Group 60**.

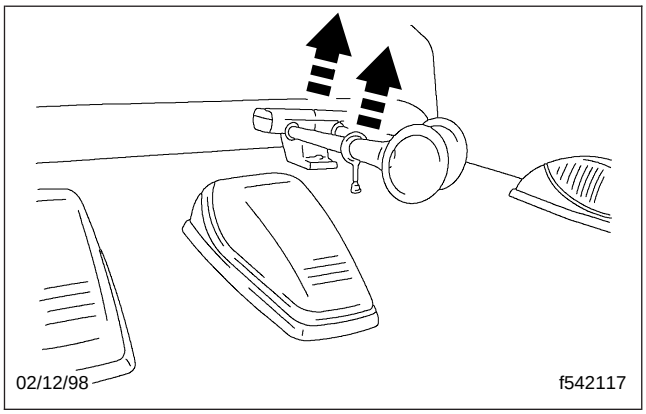


Fig. 2, Air Horn

Replacement

1. Remove one screw and four bolts from the left-hand body rocker panel, and remove the left-hand body rocker panel. See **Fig. 1**.

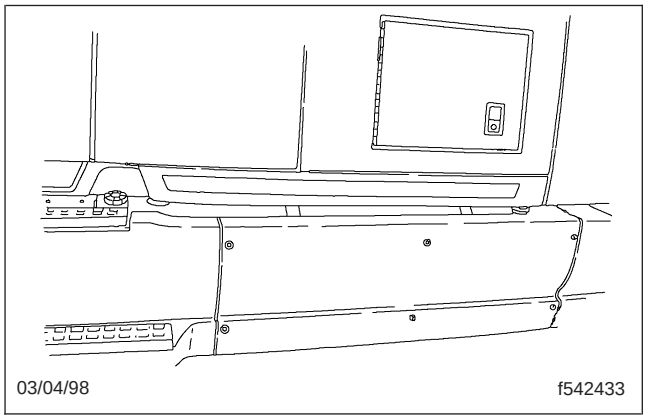


Fig. 1, Left-Hand Body Rocker Panel

2. Remove the air horn bolts. See **Fig. 2**.

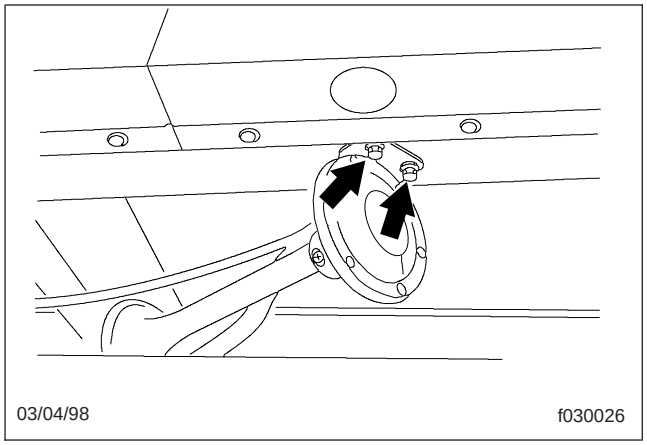


Fig. 2, Air Horn Bolts

3. Disconnect the air line, and remove the air horn. See **Fig. 3**.
4. Connect the air line and position the air horn.
5. Install the air horn bolts.
6. Install the left-hand body rocker panel.

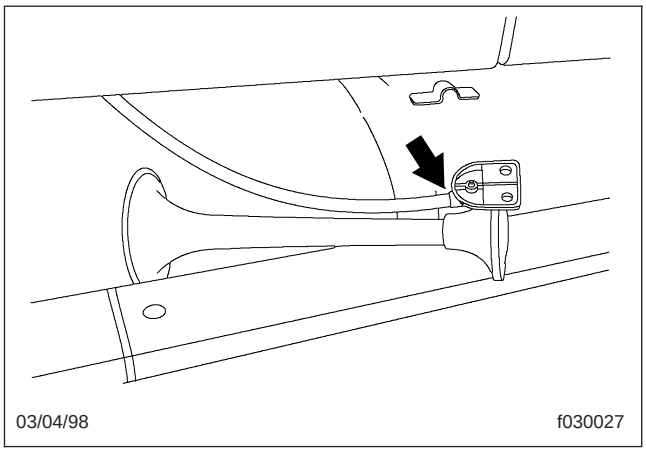
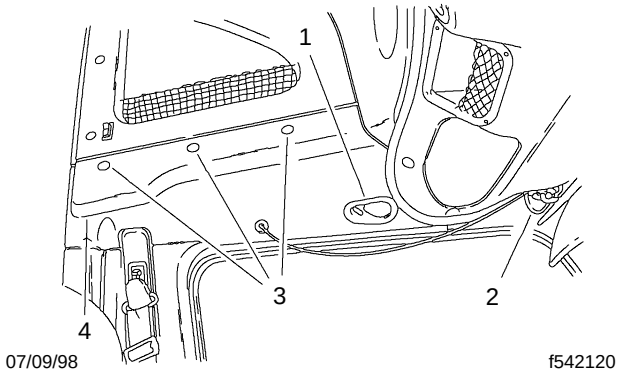


Fig. 3, Air Horn Air Line

SilverStar Horn Air Line, Inside Cab Replacement

Replacement

1. Remove the trim panel over the left-hand door. See **Fig. 1**.



1. Reading Lamp
2. Trim Panel Screw
3. Trim Panel Pushpins
4. Trim Panel

Fig. 1, Trim Panel Over the Left-Hand Door

1.1 Remove the reading lamp.

1.2 Remove the screw.

1.3 Remove the pushpins.

1.4 Remove the trim panel.

2. Remove the pushpin, and remove the trim panel behind the left-hand door. See **Fig. 2**.
3. Remove the refrigerator; refer to **Group 60**.
4. Disconnect the air line from the air horn elbow. See **Fig. 3**.
5. Disconnect the air line from the air compressor. See **Fig. 4**.
6. Remove the air line.
7. Position and connect both sides of the air line.
8. Install the refrigerator; refer to **Group 60**.
9. Install the trim panel over the left-hand door.

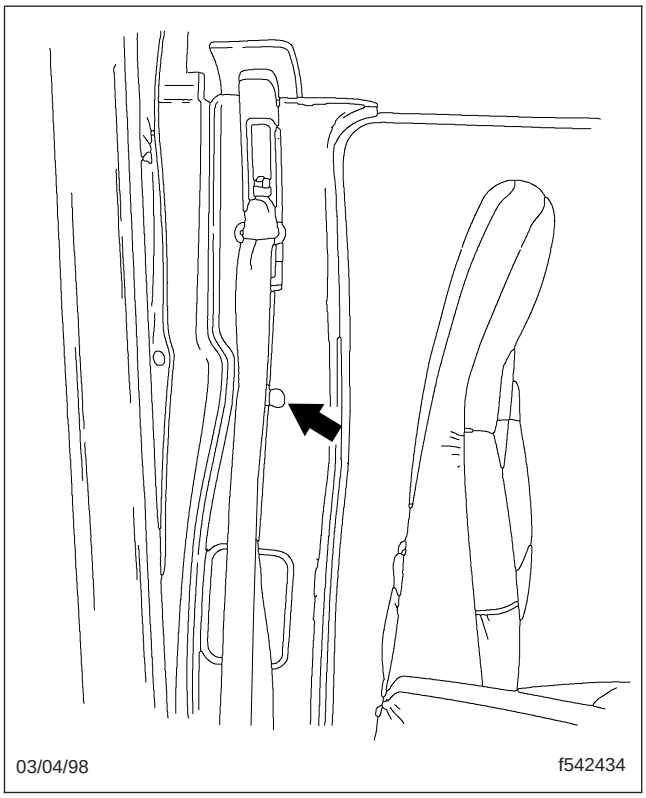


Fig. 2, Trim Panel Behind the Left-Hand Door

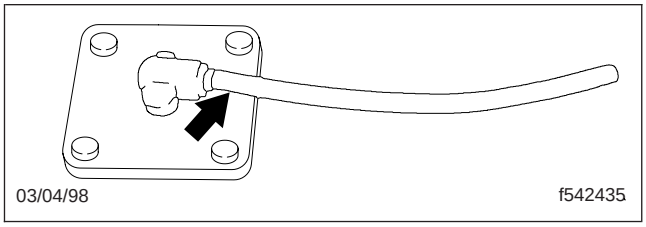


Fig. 3, Air Horn Air Line at Air Horn Elbow

SilverStar Horn Air Line, Inside Cab Replacement

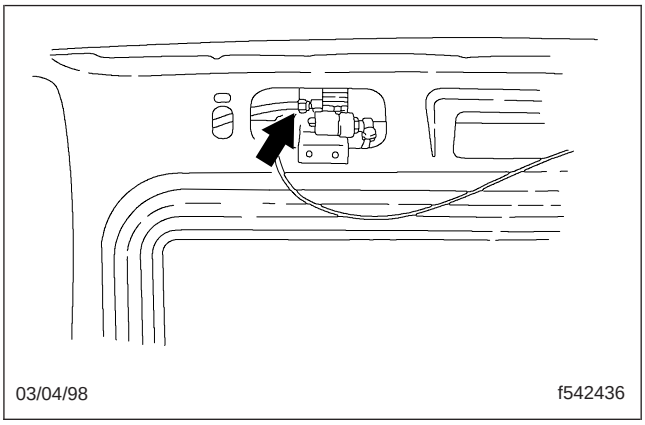


Fig. 4, Air Horn Air Line at Air Horn Compressor

SilverStar Horn Air Line, Outside Cab Replacement

Replacement

1. Remove the air horn. Refer to "SilverStar Air Horn Replacement" in this section.
2. Disconnect the air line, and remove the air line. See **Fig. 1**.

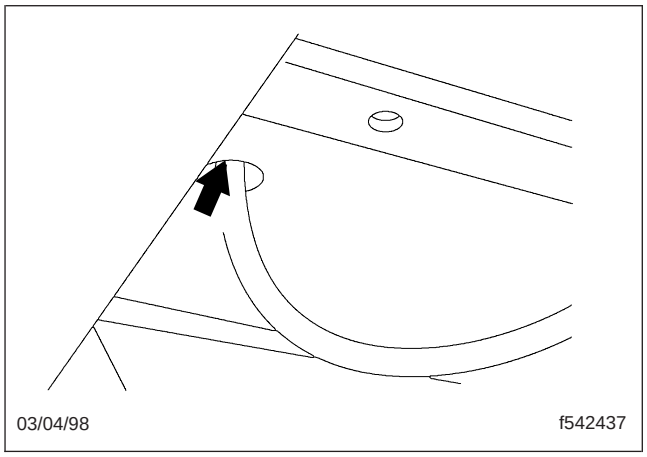


Fig. 1, Air Line

3. Position and connect the air line.

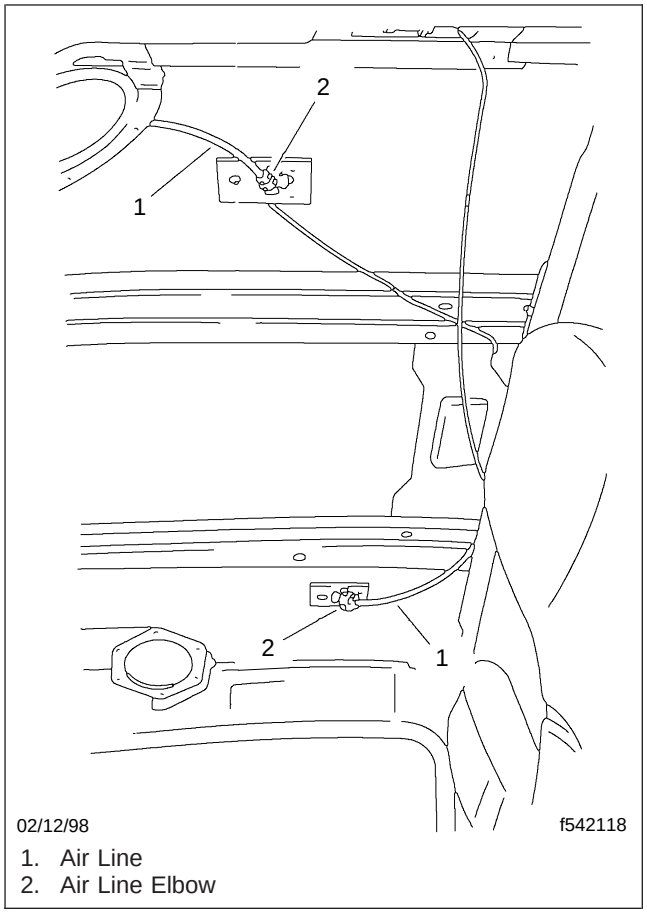
Dual Hadley Air Horn Replacement

Replacement

WARNING

Unless the air system is bled, use care not to pull on the air horn lanyard during the removal or installation of the air horn, this could result in personal injury.

1. Remove the vehicle headliner; refer to **Group 60**.
2. Disconnect the air horns. See **Fig. 1**.



1. Air Line
2. Air Line Elbow

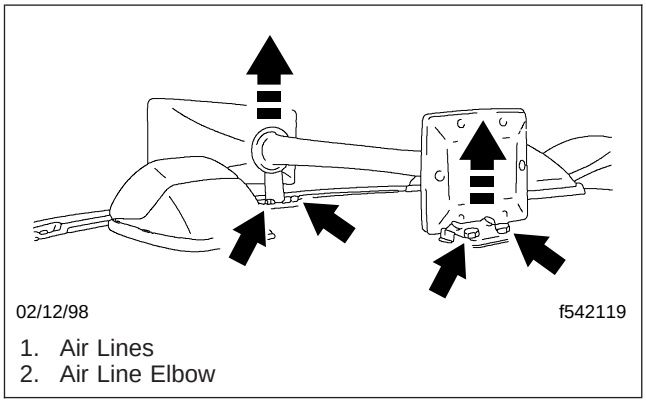
Fig. 1, Air Horn Air Lines Under Headliner

2.1 Remove the air lines.

2.2 Remove (unscrew) the air line elbows and washers.

NOTE: A backup wrench may be required on the underside of the roof to remove the air horn retaining bolts.

3. Remove the air horn retaining bolts and remove the air horn from the roof. See **Fig. 2**.



1. Air Lines
2. Air Line Elbow

Fig. 2, Air Horn Retaining Bolts

4. Repeat the previous step for the second air horn.

NOTE: All threaded air line connections should be sealed using Sterling Pipe Sealant with Teflon® D8AZ–19554–A or equivalent meeting Sterling specification WSK–M2G350–A2 or ESR–M18P7–A.

5. Position the air horn and install the bolts.
6. Install the air horn elbow and washers.
7. Install the air horn air lines.
8. Install the vehicle headliner; refer to **Group 60**.

Troubleshooting

Inspection and Verification

1. Verify customer concern by operating the horn.
2. Visually inspect for obvious signs of mechanical and electrical damage using the chart below.

Component Test

Horn Relay

Remove the horn relay and use the following procedure for testing:

1. Measure the resistance of the horn relay between Terminal 2 and all other terminals. If the resistance is 5 ohms or less between Terminal 2 and any other terminal, replace the relay. If the resistance measures greater than 5 ohms, proceed to the following step. See **Fig. 1.**

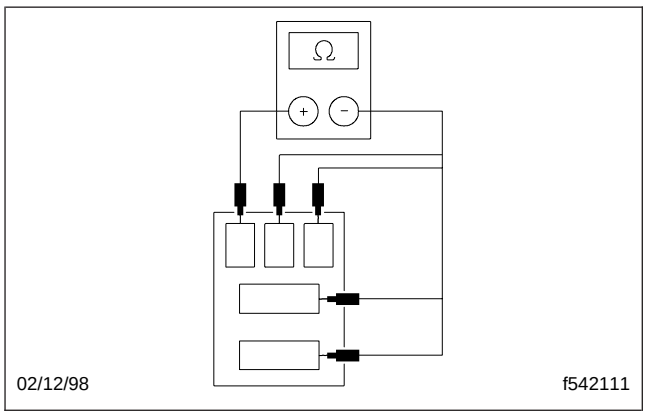


Fig. 1, Measuring Resistance

2. Connect terminals 1 and 3 directly to the positive battery terminal and measure the voltage at Terminal 4. If battery voltage is not indicated, replace the relay. If battery voltage is indicated, proceed to the following step. See **Fig. 2**.
3. Connect a third jumper wire to Terminal 2 and a known good ground, and check for voltage at Terminal 5. If battery voltage is not indicated, replace the relay. See **Fig. 3**.

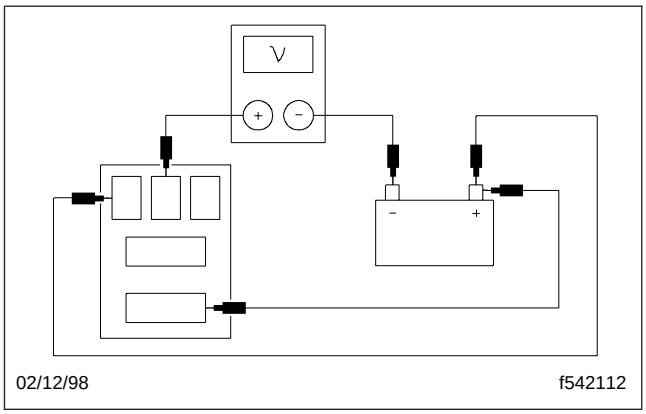


Fig. 2, Measuring Voltage

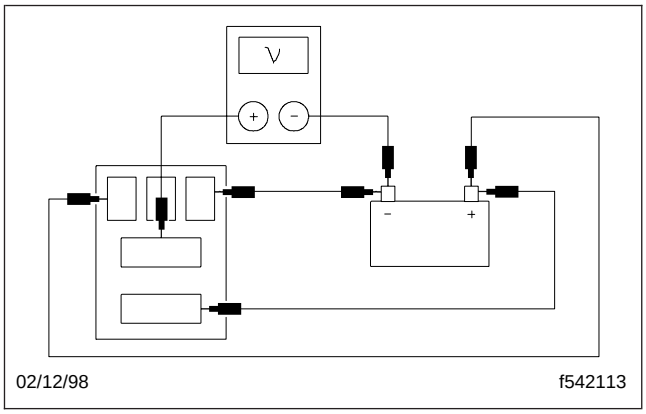


Fig. 3, Testing Ground

Visual Inspection Chart	
Mechanical	**Pneumatic**
Damaged horns	Blown fuse Damaged wiring harness Loose or corroded connections

Table 1, Visual Inspection Chart

Troubleshooting

Problem—The Horn Does Not Sound

Problem—The Horn Does Not Sound	
Possible Cause	**Remedy**
Fuse	Test the horn(s). For each horn, disconnect the horn connector harness. Connect a jumper wire from the battery positive post to the horn positive terminal. Connect a second jumper wire from the battery negative post to the horn negative terminal. If the horn(s) does not sound, replace the horn(s). Test the system for normal operation. If the horn(s) does sound, remove and test the horn relay. For instructions, see "Horn Relay" under "Component test" in this section. Replace the horn relay if it does not test OK. If the horn relay does test OK reinstall and check Circuit 33 (Y). Disconnect the instrument panel fuse junction panel fuse 32 (15 A). Disconnect the instrument panel fuse junction panel horn relay. Measure the resistance of Circuit 33 (Y) between the instrument panel fuse junction panel, fuse cavity 32 and the horn relay cavity, Pin 2. If the resistance is more than 5 ohms, repair Circuit 33 (Y). Test the system for normal operation. If the resistance is less than 5 ohms, disconnect the instrument panel fuse junction panel fuse 3 (10 A). Measure the resistance of circuit 460 (Y) between the instrument panel fuse junction panel, fuse cavity 3 and the horn relay cavity, Pin 3. If the resistance is more than 5 ohms, repair Circuit 460 (Y). Test the system for normal operation. If the resistance is less than 5 ohms, check the horn switch. Remove the horn pad switch; refer to **Group 46**. Connect an ohmmeter between the two horn switch electrical contacts. Press the horn pad switch and measure the resistance between the electrical connectors. If the resistance is more than 5 ohms, replace the horn pad switch; refer to **Group 46**. Test the system for normal operation. If the resistance is less than 5 ohms (with speed control), check the clockspring. If the resistance is less than 5 ohms (without speed control), check circuit 376. Check the clockspring. Remove the clockspring assembly; refer to **Group 46**. Measure the resistance of the clockspring between Pin 10 and Pin 5 and between Pin 4 and 6. If the resistance is more than 5 ohms, replace the clockspring assembly. Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 376 (BL/Y). Check Circuit 376 (BL/Y). Measure the resistance of Circuit 376 (BL/Y) between the horn relay cavity Pin 1 and the clockspring assembly Pin 10 (with speed control) or the horn switch (without speed control). If the resistance is more than 5 ohms repair Circuit 376 (BL/Y). Test the system for normal operation. If the resistance is less than 5 ohms check the horn switch ground. Measure the resistance of Circuit 57 (BK) between the horn switch connector and a known good ground. If the resistance is more than 5 ohms repair Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms check Circuit 482 (BK/Y). Disconnect the horn connector(s). Disconnect the horn relay. Measure the resistance of Circuit 482 (BK/Y) between the horn switch relay Pin 5 and the horn(s). If the resistance is less than 5 ohms repair the horn Circuit 57 (BK). Test the system for normal operation. If the resistance is more than 5 ohms, repair Circuit 482 (BK/Y). Test the system for normal operation.
Circuit	
Horn Relay	
Switch	

Problem—The Horn Sounds Continuously

Problem—The Horn Sounds Continuously	
Possible Cause	**Remedy**
Circuit	Test the horn relay. Disconnect the horn relay connector harness. Test the horn relay. For instructions, see "Horn Relay" under "Component Test" in this section. If the horn(s) does not sound, replace the horn relay. Test the system for normal operation. If the horn(s) sound (with speed control), check the clockspring. If the horn(s) sound (without speed control) check the horn switch.
Horn Relay	Check the clockspring. Remove the horn pad switch; for instructions, see **Group 46**. Disconnect the clockspring connector. Measure the resistance of the clockspring between Pin 6 and Pin 10. If the resistance is less than 5 ohms, replace the clockspring; for instructions, see **Group 46**. Test the system for normal operation. If the resistance is more than 5 ohms, test the horn switch. NOTE: Do not press the switch while performing this test.
Switch	Test the horn switch. Remove the horn pad. Disconnect the horn pad switch. Measure the resistance of the horn switch. If the resistance is greater than 10,000 ohms, check the associated horn circuitry for signs of wear or exposed wiring. Repair as necessary. Test the system for normal operation. If the resistance is less than 10,000 ohms replace the horn pad. Test the system for normal operation.

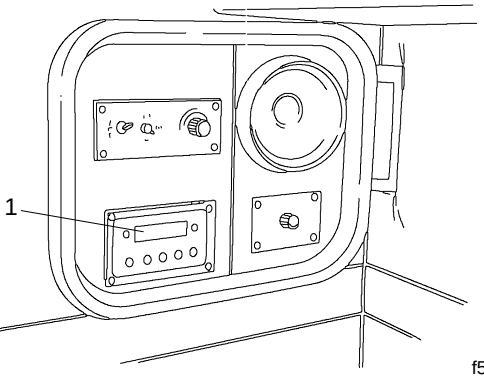
Specifications

General Specifications	
Item	**Specification**
Sterling Pipe Sealant with Teflon® D8AZ–19554–A	WSK–M2G350–A2, ESR–M18P7–A

Table 1, General Specifications

General Information

ABLE BODY CLOCK (See Fig. 1)



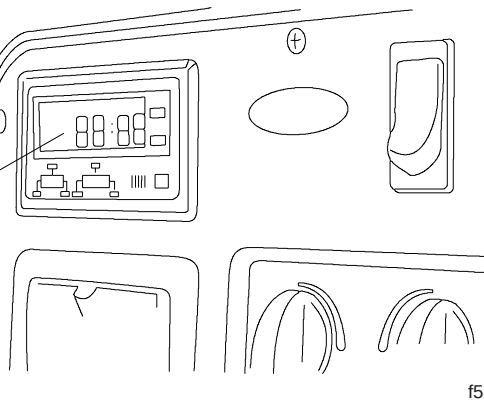
1. Electronic Clock

Fig. 1, Able Body Clock Location

The electronic clock in the Able Body sleeper is located on the left rear sleeper wall in the accessory panel.

The electronic clock control buttons are located along the bottom of the clock display. Pressing the DISPLAY ON button toggles the illumination "On" and "Off".

SILVERSTAR CLOCK (See Fig. 2)



1. Electronic Clock

Fig. 2, SilverStar Clock Location

The electronic clock in the SilverStar sleeper is located on the left sleeper wall in the accessory panel.

For information on the operation of the clock, refer to the driver's manual.

Replacement

ABLE BODY

1. Remove the Phillips screws. See **Fig. 1.**

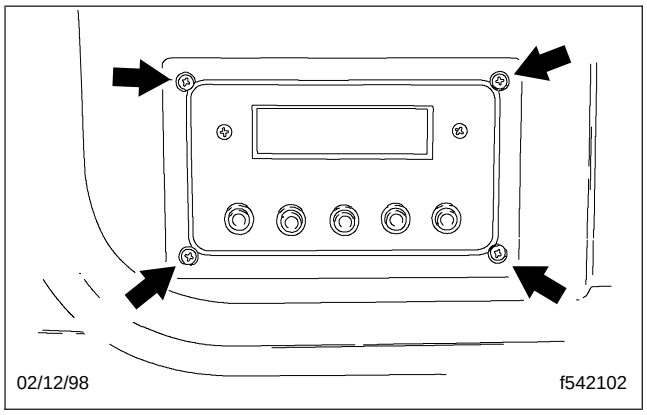


Fig. 1, Clock Screws

2. Disconnect the electrical connector and remove the clock from the accessory panel. See **Fig. 2.**

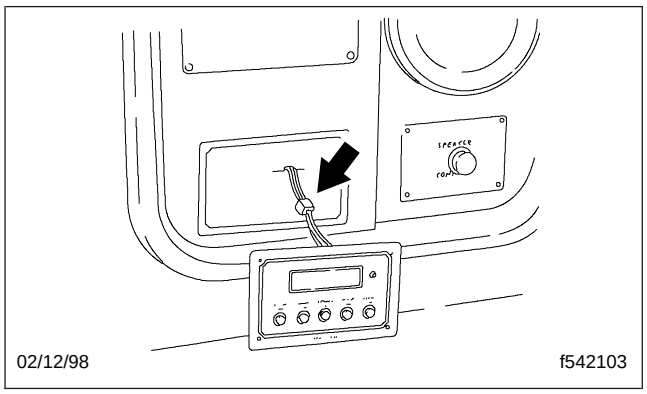


Fig. 2, Clock Electrical Connector

3. Connect the electrical connector and position the clock into the accessory panel.
4. Install the Phillips screws and tighten until firm.

SILVERSTAR

1. Pry the clock outward from the accessory panel. See **Fig. 3.**
2. Disconnect the electrical connector, then remove the clock from the accessory panel.

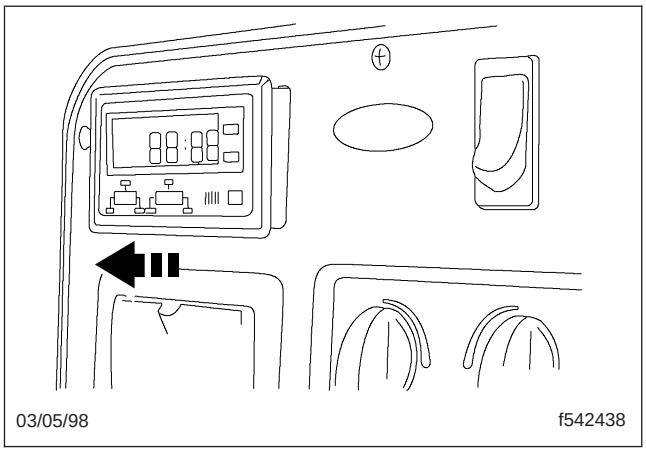


Fig. 3, Clock

3. Connect the electrical connector and install the clock into the accessory panel.

Troubleshooting

Inspection and Verification

1. Verify the vehicle owner's concern by operating the electronic clock to duplicate the original concern.
2. Verify components or systems related to the fuse for proper operation. If the components or systems are not operating properly, the fuse(s), fuse feed circuits or fuse load side circuits(s) may be at fault.
3. If the concern(s) remains after the inspection, determine the problem and proceed to the problem charts.

Problem—The Clock is Erratic or Inoperative, Able Body

Problem—The Clock is Erratic or Inoperative, Able Body (See Fig. 1 and Fig. 2)	
Possible Cause	**Remedy**
Circuitry open or shorted	Check the supply voltage to the clock. Disconnect the clock connector C717. Measure the voltage between the clock connector C717 Circuit 130 (Y) and ground. If the voltage is more than 10 volts repair Circuit 139 (Y). Test the system for normal operation. If not, check the ground circuit. Measure the resistance between the clock connector C717 Circuit 239 (BK) and ground. If the resistance is less than 5 ohms, replace the clock assembly. Test the system for normal operation. If not, repair Circuit 239 (BK). Test the system for normal operation.
Blown fuse	
Damaged electronic clock	

Problem—The Clock is Erratic or Inoperative, SilverStar

Problem—The Clock is Erratic or Inoperative, SilverStar (See Fig. 3 and Fig. 4)	
Possible Cause	**Remedy**
Circuitry open or shorted	Check the supply voltage to the clock. Disconnect the clock connector C765. Measure the voltage between the clock connector C765 Circuit 45 (Y/R) and ground. If the voltage is more than 10 volts repair Circuit 45 (Y/R). Test the system for normal operation. If not, check the ground circuit. Measure the resistance between the clock connector C765 Circuit 57 (BK) and ground. If the resistance is less than 5 ohms, replace the clock assembly. Test the system for normal operation. If not, repair Circuit 57 (BK). Test the system for normal operation.
Blown fuse	
Damaged electronic clock	

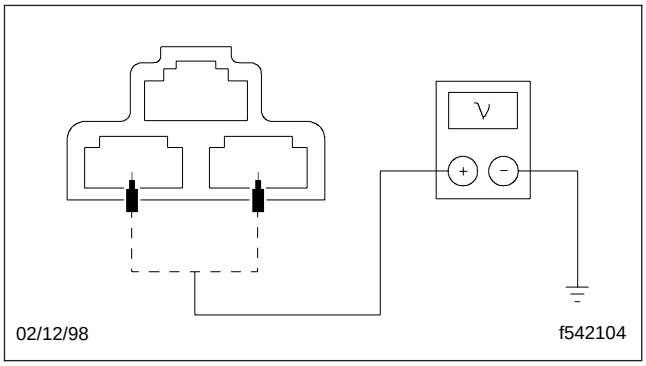


Fig. 1, Circuit 130, Clock Connector C717

Troubleshooting

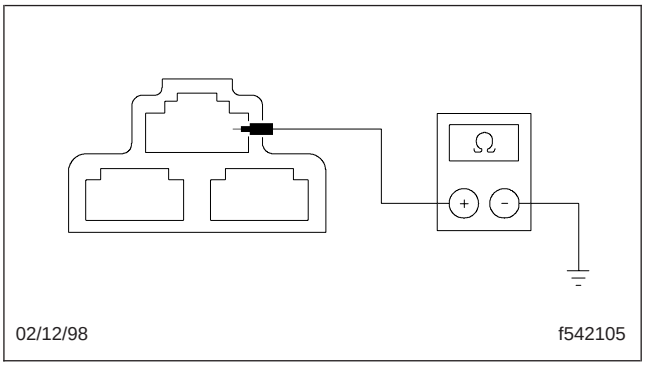


Fig. 2, Circuit 239, Clock Connector C717

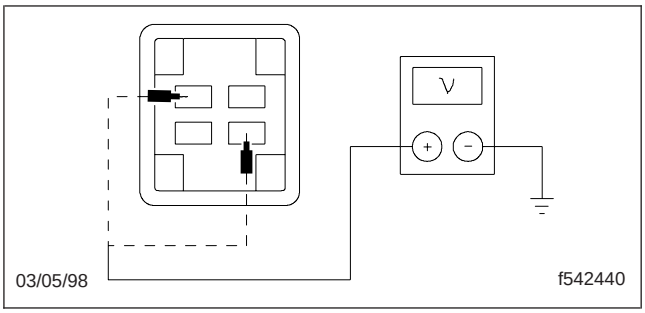


Fig. 3, Circuit 45, Clock Connector C765

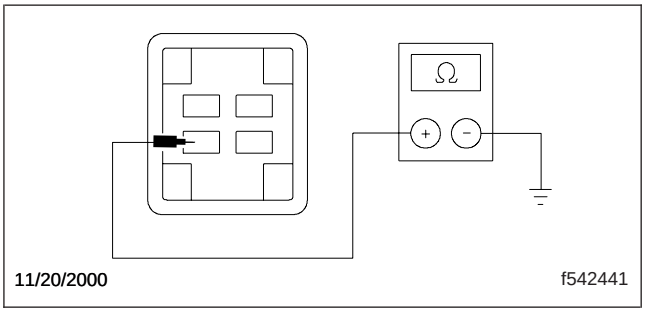


Fig. 4

General Information

MESSAGE CENTER

The message center is a microprocessor-controlled module providing service diagnostics and vehicle information to the operator with a two-line display. The message center is capable of receiving direct sensor inputs for oil temperature, transmission oil temperature, exhaust gas temperature, forward drive axle oil temperature and rear drive axle temperature. In addition, it allows the operator to view current and average fuel economy and active faults, and can alert the operator to vehicle operating conditions that are beyond normal operating range by providing an output to an audible alarm. The message center also has the capability of displaying current time and four independent odometer readings.

The message center system components are shown in **Fig. 1**.

The message center includes the following features:

- TRIP: trip odometer, trip 1, trip 2, driver 1, driver 2, display units and blank screen
- STATUS: fuel economy, engine oil temperature, transmission oil temperature, forward drive axle oil temperature, rear drive axle oil temperature, exhaust gas temperature and diagnostics
- TIME: current time, time zone, date and alarm

The features are activated by the operator via the six buttons on the face of the message center module.

MESSAGE CENTER CALIBRATION

(See Fig. 2)

The message center is calibrated for the vehicle by setting the dip switches on the back of the message center. Switch 1 must be placed in the "On" position if the vehicle is equipped with a Caterpillar engine, switch 2 must be placed in the "On" position if the vehicle is equipped with a Cummins engine, and switch 3 must be placed in the "On" position if the vehicle is equipped with a Detroit Diesel engine. If more than one of the first three switches are placed in the "On" position at the same time, a calibration error will be set. Switch 4 must be placed in the "On" position if the vehicle is equipped with a transmission oil temperature sensor and switch 5 must be placed in the "On" position if the vehicle is equipped with two drive axles. Switch 6 is not used currently and should be left in the "Off" position.

DIAGNOSTICS

The message center has the ability to display diagnostic information. This information comes from two sources and in two forms. The two sources of information are:

- Internal, directly monitored systems;
- External, data link monitored systems.

The two forms of information are:

- Warning messages, indicating the set parameters of the sensor have been exceeded;
- Diagnostic messages, indicating a failure condition in the circuit or sensor.

If a warning message or a diagnostic message occurs, it will be displayed immediately, even if the blank screen option has been selected

Both warning messages and diagnostic messages use two screens to display information being conveyed. The first depression of the STATUS button identifies the source of the message:

- ENGINE
- FAULT REPORT

The second depression of the STATUS button displays the message itself:

- ENGINE
- POWER SUPPLY LOW

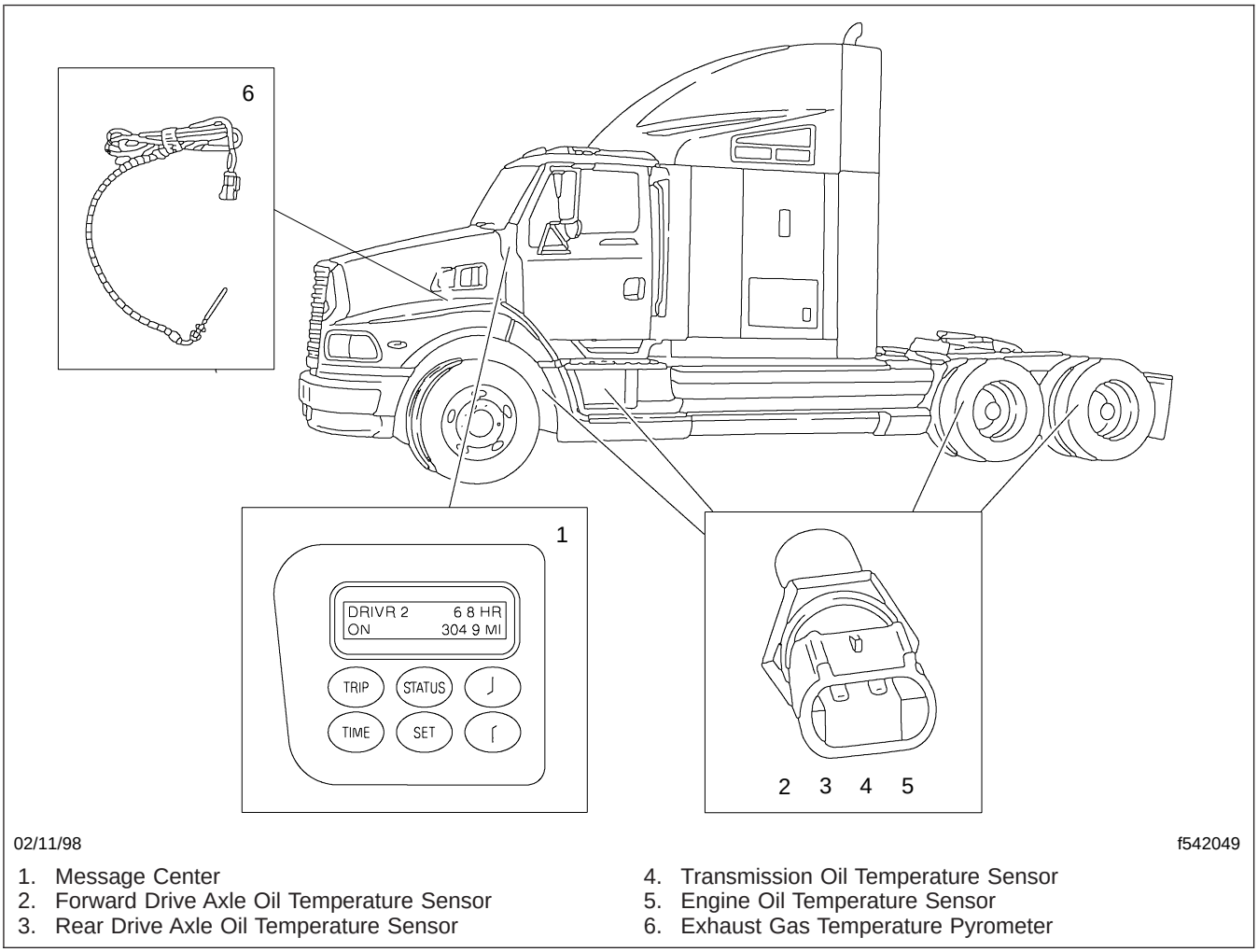
INTERNAL DIAGNOSTICS

Internal diagnostic information is used to provide the technician with information about the five systems monitored directly by the message center. This information is to be used by the technician to evaluate why the message was conveyed to the message center.

EXTERNAL DIAGNOSTICS

External diagnostic information from the data link is used to provide the technician with information about all systems connected to the data link. The message center interprets information from the major systems of the vehicle and displays results that are out of set parameters as a warning message or a diagnostic

General Information

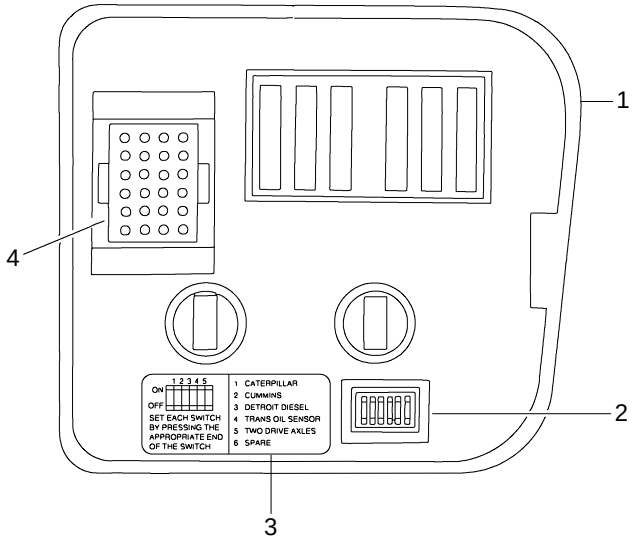


1. Message Center
2. Forward Drive Axle Oil Temperature Sensor
3. Rear Drive Axle Oil Temperature Sensor
4. Transmission Oil Temperature Sensor
5. Engine Oil Temperature Sensor
6. Exhaust Gas Temperature Pyrometer

Fig. 1, Message Center and Temperature Sensor Locations

message. Messages that cannot be interpreted directly are displayed as fault codes.

The message center can also indicate a concern with the data link itself. If information from the data link is interrupted, a message is displayed stating no data is being received.



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1. Message Center
2. Dip Switches
3. Calibration Label
4. Electrical Terminals, 24

Fig. 2, Calibration Settings and Dip Switches

Replacement

1. Disconnect the battery ground cable. See **Fig. 1**.

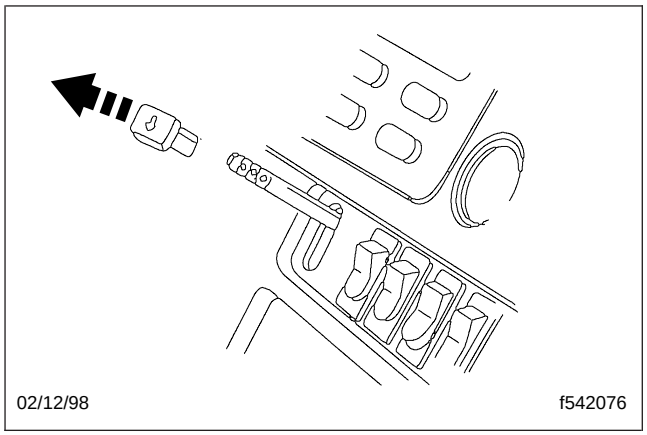


Fig. 1, Battery Ground Cable

2. Remove the trailer brake control valve knob.
3. Remove the screws. See **Fig. 2**.

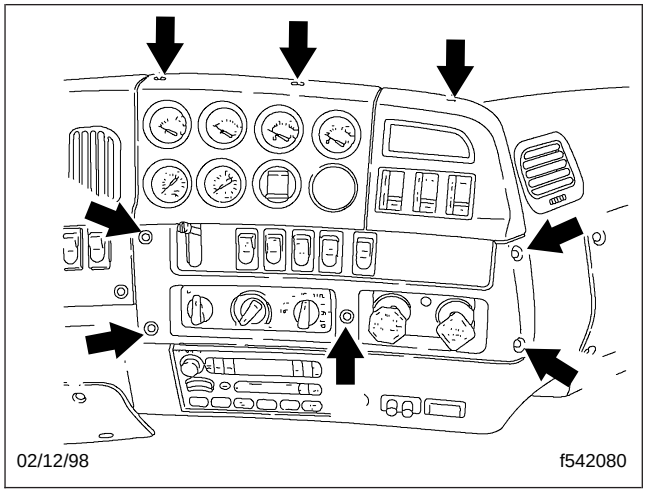


Fig. 2, Right-Hand Instrument Panel Screws

4. Tilt the top of the right-hand instrument panel finish panel away from the instrument panel to gain access to the message center retaining bracket and nuts. See **Fig. 3**.
5. Remove the message center. See **Fig. 4**.
   - 5.1 Disconnect the message center electrical connector.

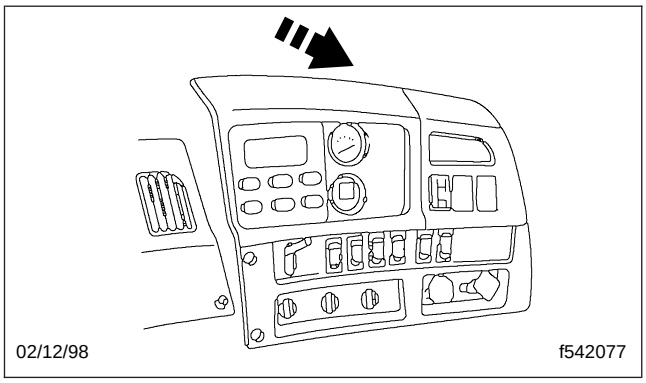
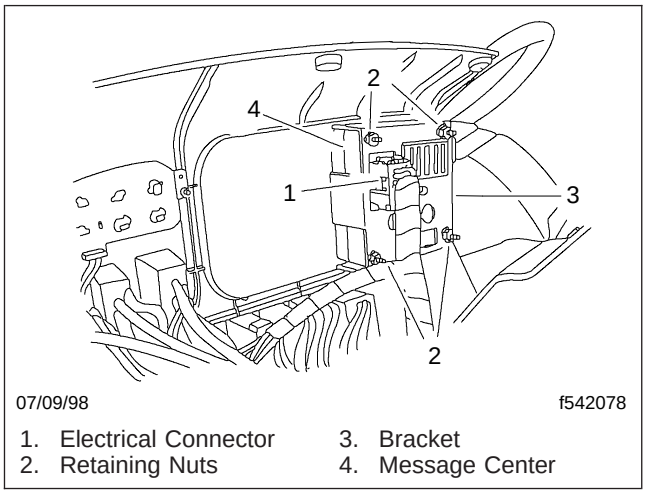


Fig. 3, Right-Hand Instrument Panel

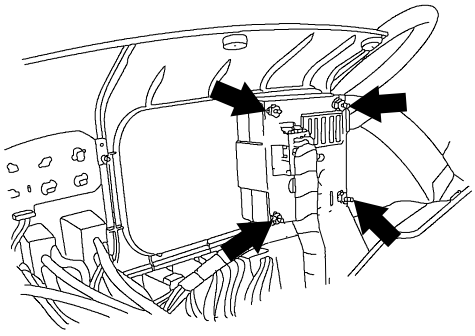


1. Electrical Connector
2. Retaining Nuts
3. Bracket
4. Message Center

Fig. 4, Message Center

   - 5.2 Remove the message center bracket retaining nuts.
   - 5.3 Remove the message center bracket.
   - 5.4 Remove the message center.
6. Install the message center.
   - 6.1 Connect the message center electrical connector.
   - 6.2 Install the message center bracket.
   - 6.3 Install the message center.
7. Install the message center bracket retaining nuts. See **Fig. 5**.
8. Position the right-hand instrument panel and install the screws.
9. Install the trailer brake control valve knob.

Message Center Replacement



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A. 8 to 10 lbf·in (90 to 110 N·cm)

Fig. 5, Message Center Retaining Nuts

10. Connect the battery ground cable.

Troubleshooting

Inspection and Verification

1. Verify the vehicle owner's original concern by operating the message center to duplicate the concern. See **Fig. 1**.

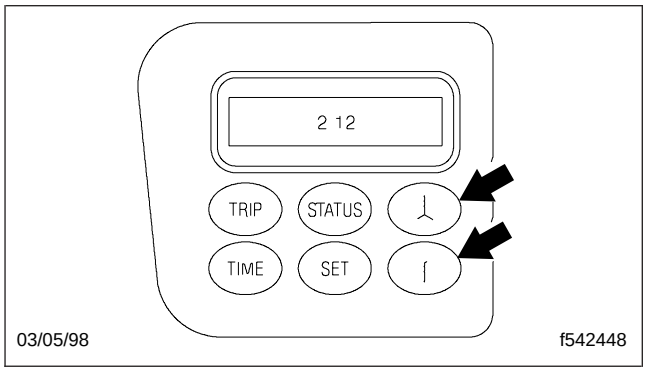

Fig. 1, Message Center

2. Simultaneously press and hold the arrow "Up" and "Down" buttons on the message center until a software revision level is displayed. If a software level of 2.12 or higher is displayed, continue with the inspection and verification. If a software revision level less than 2.12 is displayed, replace the message center.
3. Verify that other components and systems related to the message center fuses operate properly. If the other components and systems are not operating properly, a fuse, fuse feed circuit, or fuse load side circuit may be at fault.
4. Inspect to determine if one of the following mechanical or electrical concerns applies:

Visual Inspection Chart	
Mechanical	**Electrical**
Check message center for obvious damage	Open fuse: instrument panel fuse junction panel Fuse 15 (20 A) or Fuse 22 (10 A) or both
	Open/shorted circuits
	Damaged connectors

Table 1, Visual Inspection Chart

5. If the concern(s) remains after the inspection, determine the symptom(s) and proceed to the problem charts.

Troubleshooting

Problem—The Message Center is Not Operating Properly

Problem—The Message Center is Not Operating Properly (See Fig. 2)	
Possible Cause	**Remedy**
Circuitry	Check for power on Circuit 54 (GN/Y). NOTE: Make sure that the instrument cluster dimmer switch is not in full dim position. With the ignition "Off", disconnect the message center connector. Measure the voltage between the message center connector C294, Pin 24 Circuit 54 (GN/) and the chassis ground. If the voltage is not greater than 10 volts, repair Circuit 54 (GN/Y). Test the system for normal operation. If the voltage is greater than 10 volts, check for power on Circuit 976 (BK/GN). NOTE: Make sure that the instrument cluster dimmer switch is not in full dim position.
Message center	With the ignition in the "Run" position, measure the voltage between the message center connector C294, Pin 20 Circuit 976 (BK/GN) and the chassis ground. If the voltage is not greater than 10 volts, repair Circuit 976 (BK/GN). Test the system for normal operation. If the voltage is greater than 10 volts, check for Power on Circuit 25 (BK/O). With the ignition "Off", disconnect the message center connector. Measure the resistance between the message center connector C294, Pin 5 Circuit 25 (BK/O) and the chassis ground. If the resistance is less than 5 ohms replace the message center. Test the system for normal operation. If the resistance is not less than 5 ohms, repair Circuit 25 (BK/O). Test the system for normal operation.

Problem—Clock Display Malfunction

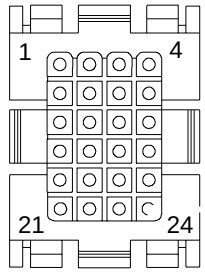

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Fig. 2, Message Center Connector

Problem—Clock Display Malfunction (See Fig. 2)	
Possible Cause	**Remedy**
NOTE: An intermittent power condition to the message center will cause the clock to be in error, the time zone to read "PST" and the date to go back to "SUN JAN 1, 1995".	
Circuitry	Check for power on Circuit 54 (GN/Y). Disconnect the message center connector. Measure the voltage between message center connector C294, Pin 24, Circuit 54 (GN/Y) and chassis ground. If the voltage is not greater than 10 volts, repair Circuit 54 (GN/Y). Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 54 (GN/Y) for an intermittent problem.
Message center	With the voltmeter still connected, wiggle the harness between the message center and instrument panel fuse junction panel and between the instrument panel fuse junction panel and power distribution box. If the voltage fluctuates when the harness is moved repair Circuit 54 (GN/Y) or the power supply to the instrument panel fuse junction panel. Test the system for normal operation. If the voltage does not fluctuate when the harness is moved, replace the message center. Test the system for normal operation.

Troubleshooting

Problem—The Computer Fuel Economy is Incorrect

Problem— (See Fig. 2, Fig. 3, Fig. 4, Fig. 5 and Fig. 6)The Computer Fuel Economy is Incorrect	
Possible Cause	**Remedy**
Circuitry	Check for a data link diagnostic code. Turn the ignition switch to the "On" position. Press the STATUS button on the message center to bring up diagnostic mode. If the display does not read "J1708 DATA LINK BAD UPDATE RATE", refer to the engine manufacturer's service literature for diagnosis of the ECM. If the display reads "J1708 DATA LINK BAD UPDATE RATE", check the data link circuits for a short to power. Turn the ignition switch to the "Off" position. Disconnect the message center and ECM connectors. Turn the ignition switch to the "On" position and measure the voltage between message center connector C294, Pin 16, Circuit 712 (P), Pin 12, Circuit 716 (Y) and chassis ground. If the voltage is greater than 10 volts on either circuit, repair the damaged circuit. Test the system for normal operation. If the voltage is not greater than 10 volts on either circuit, check the data link circuits for a short to ground. Turn the ignition switch to the "Off" position. Measure the resistance between message center connector C294, Pin 16, Circuit 712 (P), Pin 12, Circuit 716 (Y) and chassis ground. If the resistance is less than 5 ohms for either circuit, repair the damaged circuit. Test the system for normal operation. If the resistance is not less than 5 ohms for either circuit, check the data link circuits for an open.
Engine control module	Turn the ignition switch to the "Off" position. Measure the resistance between message center connector C294, Pin 16, Circuit 712 (P) and engine control module connector; C110 Pin 1 (Caterpillar Engine), C128 Pin 8 (Cummins Engine), C135 Pin C1 (Detroit Diesel) Circuit 712 (P). Measure the resistance between message center connector C294, Pin 12, Circuit 716 (Y) and engine control module connector; C110 Pin 7 (Caterpillar Engine), C128 Pin 27 (Cummins Engine), C135 Pin C2 (Detroit Diesel) Circuit 712 (Y). If the resistance is less than 5 ohms for both circuits, refer to the engine manufacturer's service literature for diagnosis of the ECM. If the resistance is more than 5 ohms for both circuits, repair the damaged circuit. Test the system for normal operation.

Problem—The Engine Oil Temperature Warning is Inoperative/Incorrect

Problem—The Engine Oil Temperature Warning is Inoperative/Incorrect (See Fig. 2, Fig. 3 and Fig. 7)	
Possible Cause	**Remedy**
Circuitry	Check for engine oil temperature circuit diagnostic high reading. Press the STATUS button on the message center to bring up the diagnostic mode for engine oil temperature. If the message center does not read "ENG OIL TEMP SENSOR VOLTS HI", check for engine oil temperature circuit diagnostic low reading. Press the STATUS button on the message center to bring up diagnostic mode for engine oil temperature. If the message center does not read "ENG OIL TEMP SENSOR VOLTS LOW", replace the message center. Test the system for normal operation. If the message center reads, "ENG OIL TEMP SENSOR VOLTS LOW", check the engine oil temperature sensor for a short. With the engine at room temperature measure the resistance between the engine oil temperature sensor terminals. If the resistance is not 300 to 700 ohms, replace the engine oil temperature sensor. Test the system for normal operation. If the resistance is 300 to 700 ohms, check Circuit 634 (BL) for a short to ground. Measure the resistance between engine oil sensor connector C113, Pin 1, Circuit 634 (BL) and chassis ground. If the resistance is less than 5 ohms, repair Circuit 634 (BL). Test the system for normal operation. If the resistance is more than 5 ohms, replace the message center. Test the system for normal operation. If the message center reads "ENG OIL TEMP SENSOR VOLTS HI", check Circuit 634 (BL) for a short to battery. Turn the ignition switch to the "Off" position. Disconnect the engine oil temperature sensor connector and turn the ignition switch to the "On" position. Measure the voltage between engine oil temperature sensor connector C113, Pin 1, Circuit 634 (BL) and chassis ground. If the voltage is not approximately 5 volts, check Circuit 634 (BL) for an open. Turn the ignition switch to the "Off" position. Disconnect the message center connector. Measure the resistance between message center connector C294, Pin 8, Circuit 634 (BL) and engine oil temperature sensor connector C113, Pin 1, Circuit 634 (BL). If the resistance is less than 5 ohms, replace the message center. Test the system for normal operation. If the resistance is more than 5 ohms, repair Circuit 634 (BL). Test the system for normal operation. If the voltage is approximately 5 volts, check Circuit 25 (BK/O) for an open. Turn the ignition switch to the "Off" position. Disconnect the message center connector. Measure the resistance between message center connector C294, Pin 4, Circuit 25 (BK/O) and engine oil temperature sensor connector C113, Pin 2, Circuit 25 (BK/O). If the resistance is more than 5 ohms, repair Circuit 25 (BK/O). Test the system for normal operation. If the resistance is less than 5 ohms, check the engine oil temperature sensor for an open. With the engine at room temperature, measure the resistance between the engine oil temperature sensor terminals. If the resistance is 300 to 700 ohms, replace the message center. Test the system for normal operation. If the resistance is not 300 to 700 ohms, replace the engine oil temperature sensor. Test the system for normal operation.
Engine oil temperature sensor	
Message center	

Troubleshooting

Problem—The Transmission Oil Temperature Warning is Inoperative/Incorrect

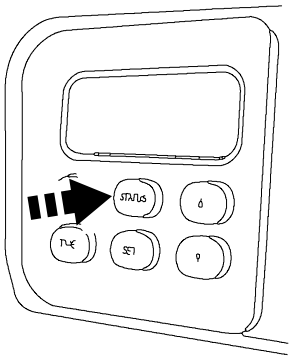

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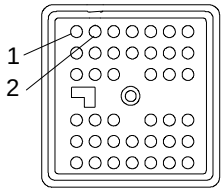
Fig. 3, STATUS Button



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1. Pin 1
2. Pin 12

Fig. 4, ECM Connector (Caterpillar Engine)

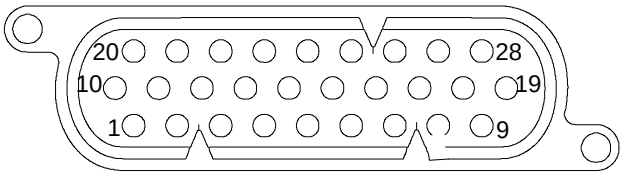

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Fig. 5, ECM Connector (Cummins Engine)

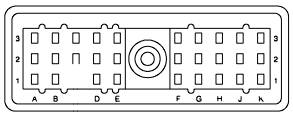

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Fig. 6, ECM Connector (Detroit Diesel Engine)

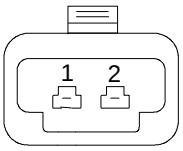

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Fig. 7, Oil Temperature Sensor Connector Pin Identification

Troubleshooting

Problem—The Transmission Oil Temperature Warning is Inoperative/Incorrect (See Fig. 2, Fig. 3 and Fig. 7)	
Possible Cause	**Remedy**
Circuitry	Check for transmission oil temperature circuit diagnostic high reading. Turn the ignition switch to the "On" position. Press the STATUS button on the message center to bring up the diagnostic mode for the transmission oil temperature. If the message center does not read "TRANS OIL TEMP SENSOR VOLTS HI", check for transmission oil temperature circuit diagnostic low reading. Press the STATUS button on the message center to bring up the diagnostic mode for the transmission oil temperature. If the message center does not read "TRANS OIL TEMP SENSOR VOLTS LOW", replace the message center. Test the system for normal operation. If the message center does read "TRANS OIL TEMP SENSOR VOLTS LOW", check the transmission oil temperature sensor for a short. Turn the ignition switch to the "Off" position. Disconnect the transmission oil temperature sensor connector. With the transmission at room temperature, measure the resistance between the transmission oil temperature sensor terminals. If the resistance is not 300 to 700 ohms, replace the transmission oil temperature sensor. Test the system for normal operation. If the resistance is 300 to 700 ohms, check Circuit 978 (Y) for a short to ground.
Transmission oil temperature	Disconnect the message center connector. Measure the resistance between transmission oil sensor connector C120, Pin 1, Circuit 978 (Y) and chassis ground. If the resistance is less than 5 ohms, repair Circuit 978 (Y). Test the system for normal operation. If the resistance is more than 5 ohms, replace the message center. Test the system for normal operation. If the message center reads "TRANS OIL TEMP SENSOR VOLTS HI", check Circuit 978 (Y) for a short to battery. Turn the ignition switch to the "Off" position. Disconnect the transmission oil temperature sensor. Turn the ignition switch to the "On" position. Measure the voltage between transmission oil temperature sensor connector C120, Pin 1, Circuit 978 (Y) and chassis ground. If the voltage is not approximately 5 volts, check Circuit 978 (Y) for an open. Turn the ignition switch to the "Off" position. Disconnect the message center connector. Measure the resistance between message center connector C294, Pin 23, Circuit 978 (Y) and transmission oil temperature sensor connector C120, Pin 1, Circuit 978 (Y). If the resistance is less than 5 ohms, replace the message center. Test the system for normal operation. If the resistance is more than 5 ohms, repair Circuit 978 (Y). Test the system for normal operation. If the voltage is approximately 5 volts, check Circuit 25 (BK/O) for an open.
Message center	Turn the ignition switch to the "Off" position. Disconnect the message center connector. Measure the resistance between message center connector C294, Pin 19, Circuit 25 (BK/O) and transmission oil temperature sensor connector C120, Pin 2, Circuit 25 (BK/O). If the resistance is more than 5 ohms, repair circuit 25 (BK/O). Test the system for normal operation. If the resistance is less than 5 ohms, check the transmission oil temperature. With the transmission at room temperature, measure the resistance between the transmission oil temperature sensor terminals. If the resistance is 300 to 700 ohms, replace the message center. Test the system for normal operation. If the resistance is not 300 to 700 ohms, replace the transmission oil temperature sensor. Test the system for normal operation.

Problem—The Forward Drive Axle Oil Temperature Warning is Inoperative/Incorrect

Problem—The Forward Drive Axle Oil Temperature Warning is Inoperative/Incorrect (See Fig. 2, Fig. 3 and Fig. 7)	
Possible Cause	**Remedy**
Circuitry	Check the forward axle oil temperature circuit diagnostic high reading. Turn the ignition switch to the "On" position. Press the STATUS button on the message center to bring up the diagnostic mode for the forward drive axle oil temperature. If the message center does not read "FRONT OIL TEMP SENSOR VOLTS HI", check for forward drive axle oil temperature circuit diagnostic low reading. Press the "STATUS" button on the message center to bring up the diagnostic mode for forward drive axle oil temperature. If the message does not read "FRONT OIL TEMP SENSOR VOLTS LOW", replace the message center. Test the system for normal operation. If the message does read "FRONT OIL TEMP SENSOR VOLTS LOW", check the forward drive axle oil temperature sensor for a short. Turn the ignition switch to the "Off" position. Disconnect the front oil temperature sensor connector. With the forward drive axle at room temperature, measure the resistance between the forward drive axle oil temperature sensor terminals. If the resistance is not 300 to 700 ohms, replace the forward drive axle oil temperature sensor. Test the system for normal operation. If the resistance is 300 to 700 ohms, check Circuit 962 (R) for a short to ground.
Front drive axle oil temperature sensor	Disconnect the message center connector. Measure the resistance between forward drive axle oil sensor connector C410, Pin 1, Circuit 962 (R) and chassis ground. If the resistance is less than 5 ohms, repair Circuit 962 (R). Test the system for normal operation. If the resistance is more than 5 ohms, replace the message center. Test the system for normal operation. If the message center reads "FRONT OIL TEMP SENSOR VOLTS HI", check Circuit 962 (R) for a short to battery. Turn the ignition switch to the "Off" position. Disconnect the front oil temperature sensor. Turn the ignition switch to the "On" position. Measure the voltage between forward drive axle oil temperature sensor connector C410, Pin 1, Circuit 962 (R) and chassis ground. If the voltage is not approximately 5 volts, check Circuit 962 (R) for an open.
Message center	Turn the ignition switch to the "Off" position. Disconnect the message center connector. Measure the resistance between message center connector C294, Pin 15, Circuit 962 (R) and forward drive axle oil temperature sensor connector C410, Pin 1, Circuit 962 (R). If the resistance is less than 5 ohms, replace the message center. Test the system for normal operation. If the resistance is more than 5 ohms, repair Circuit 962 (R). Test the system for normal operation. If the voltage is approximately 5 volts, check Circuit 25 (BK/O) for an open. Turn the ignition switch to the "Off" position. Disconnect the message center connector. Measure the resistance between message center connector C294, Pin 11, Circuit 25 (BK/O) and forward drive axle oil temperature sensor connector C410, Pin 2, Circuit 25 (BK/O). If the resistance is more than 5 ohms, repair Circuit 25 (BK/O). Test the system for normal operation. If the resistance is less than 5 ohms, check the forward axle oil temperature sensor for an open. With the forward drive axle at room temperature, measure the resistance between the forward drive axle oil temperature sensor terminals. If the resistance is 300 to 700 ohms, replace the message center. Test the system for normal operation. If the resistance is not 300 to 700 ohms, replace the forward drive axle oil temperature sensor. Test the system for normal operation.

Troubleshooting

Problem—The Rear Drive Axle Oil Temperature Warning is Inoperative/Incorrect

Problem—The Rear Drive Axle Oil Temperature Warning is Inoperative/Incorrect (See Fig. 2, Fig. 3 and Fig. 7)	
Possible Cause	**Remedy**
Circuitry	Check for rear drive axle oil temperature circuit diagnostic high reading. Turn the ignition to the "Off" position. Press the STATUS button on the message center to bring up the diagnostic mode for the rear drive axle oil temperature. If the message center does not read "REAR OIL TEMP SENSOR VOLTS HI", check for rear drive axle oil temperature circuit diagnostic low reading. Press the STATUS button on the message center to bring up the diagnostic mode for the rear drive axle oil temperature. If the message center does not read "REAR OIL TEMP SENSOR VOLTS LOW", replace the message center. Test the system for normal operation. If the message center does read "REAR OIL TEMP SENSOR VOLTS LOW", check Circuit 963 (GN) for an open. Turn the ignition to the "Off" position. Disconnect the rear oil temperature sensor. With the rear drive axle at room temperature, measure the resistance between the rear drive axle oil temperature sensor terminals. If the resistance is not 300 to 700 ohms, replace the rear drive axle oil temperature sensor. Test the system for normal operation. If the resistance is 300 to 700 ohms, check Circuit 963 (GN) for a short to ground.
Rear drive axle oil temperature sensor	Measure the resistance between rear drive axle oil sensor connector C408, Pin 1, Circuit 963 (GN) and chassis ground. If the resistance is less than 5 ohms, repair Circuit 963 (GN). Test the system for normal operation. If the resistance is more than 5 ohms, replace the message center. Test the system for normal operation. If the message center reads "REAR OIL TEMP SENSOR VOLTS HI", check Circuit 963 (GN) for a short to battery. Turn the ignition to the "Off" position. Disconnect the rear oil temperature sensor connector. Turn the ignition switch to the "Run" position. Measure the voltage between rear drive axle oil temperature sensor connector C408, Pin 1, Circuit 963 (GN) and chassis ground. If the voltage is not approximately 5 volts, check Circuit 963 (GN) for an open.
Message center	Turn the ignition to the "Off" position. Disconnect the message center connector. Measure the resistance between message center connector C294, Pin 7, Circuit 963 (GN) and rear drive axle oil temperature sensor connector C408, Pin 1, Circuit 963 (GN). If the resistance is more than 5 ohms, repair Circuit 963 (GN). Test the system for normal operation. If the resistance is less than 5 ohms, replace the message center. Test the system for normal operation. If the voltage is not approximately 5 volts, check Circuit 25 (BK/O) for an open. Turn the ignition to the "Off" position. Disconnect the message center connector. Measure the resistance between message center connector C294, Pin 3, Circuit 25 (BK/O) and rear drive axle oil temperature sensor connector C408, Pin 2, Circuit 25 (BK/O). If the resistance is more than 5 ohms, repair Circuit 25 (BK/O). Test the system for normal operation. If the resistance is less than 5 ohms, check rear drive axle oil temperature sensor for an open. With the rear drive axle at room temperature, measure the resistance between the rear drive axle oil temperature sensor terminals. If the resistance is 300 to 700 ohms, replace the message center. Test the system for normal operation. If the resistance is not 300 to 700, ohms replace the rear drive axle oil temperature sensor. Test the system for normal operation.

Problem—The Exhaust Gas Temperature Warning is Inoperative/Incorrect

Problem—The Exhaust Gas Temperature Warning is Inoperative/Incorrect (See Fig. 2, Fig. 3 and Fig. 8)	
Possible Cause	**Remedy**
Circuitry	Check the continuity of the circuits. Turn the ignition to the "Off" position. Disconnect the message center and exhaust gas pyrometer connectors. Measure the resistance between message center connector C294, Pin 2, Circuit 610 (R/Y) and exhaust gas pyrometer connector C298, Pin 2, Circuit 610 (R/Y).
Exhaust gas pyrometer	Measure the resistance between message center connector C294, Pin 6, Circuit 611 (Y) and exhaust gas pyrometer connector C298, Pin 1, Circuit 611 (Y). If the resistance is not less than 5 ohms for both circuits, repair the damaged circuit. Test the system for normal operation. If the resistance is less than 5 ohms for both circuits, check the exhaust gas pyrometer.
Message center	Temporarily install a known good exhaust gas pyrometer. Disconnect the message center and exhaust gas pyrometer connectors. Turn the ignition to the "Run" position. Press the STATUS button on the message center to bring up the exhaust gas temperature mode. If the message center functions properly, replace the exhaust gas pyrometer. Test the system for normal operation. If the message center does not function properly, replace the message center. Test system for normal operation.

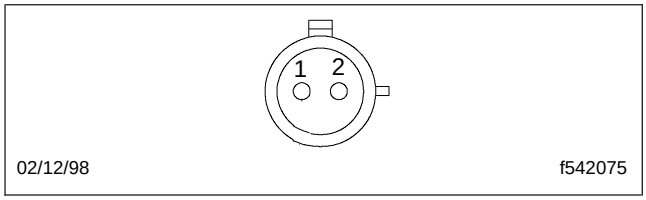


Fig. 8, Exhaust Gas Pyrometer Connector Pin Identification

See **Fig. 1** for a full view of the message center wiring.

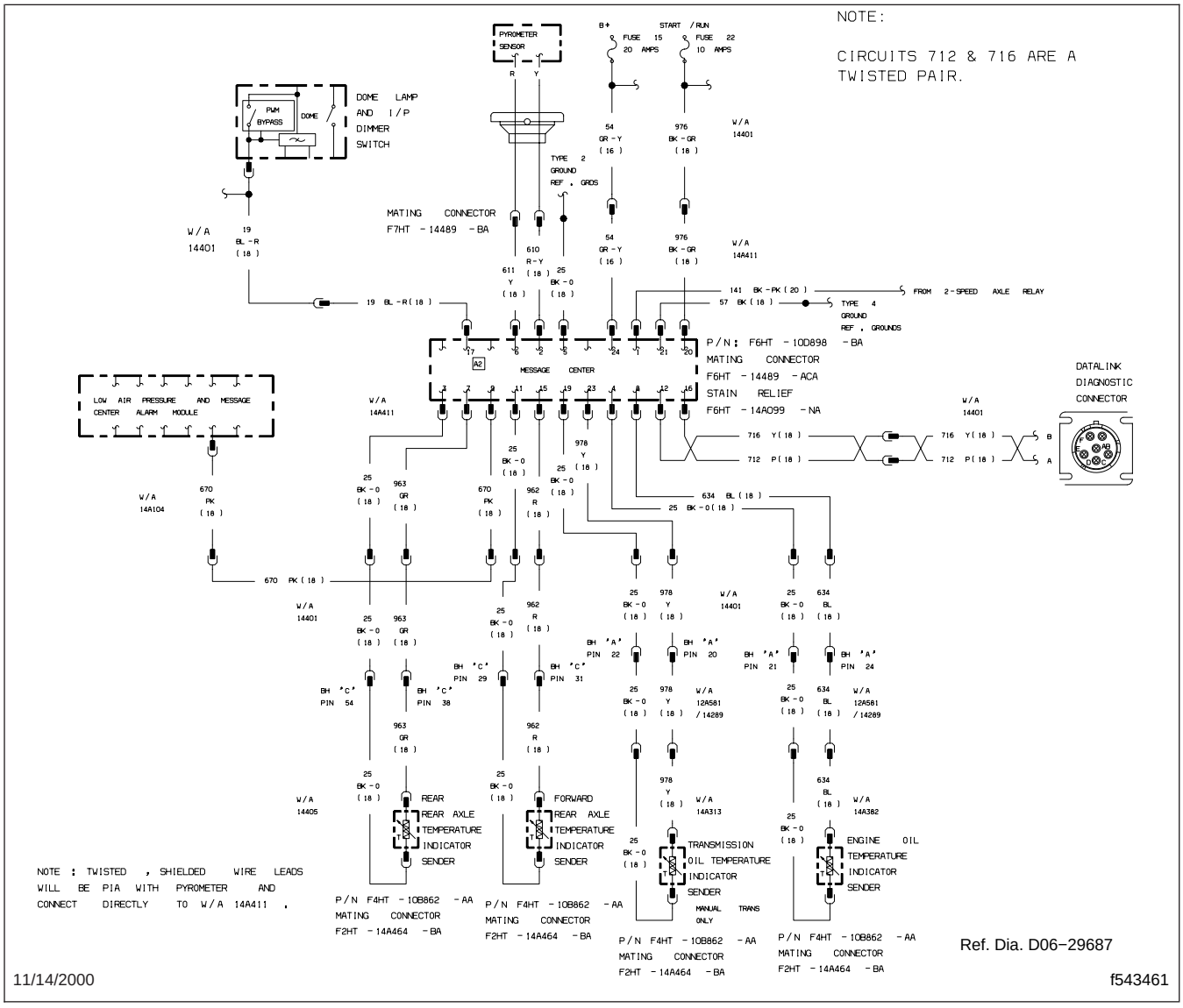


Fig. 1, Message Center Wiring

Torque Specifications	
Description	**lbf·in (N·cm)**
Message Center Retaining Nuts	8–10 (90–110)

Table 1, Torque Specifications

General Information

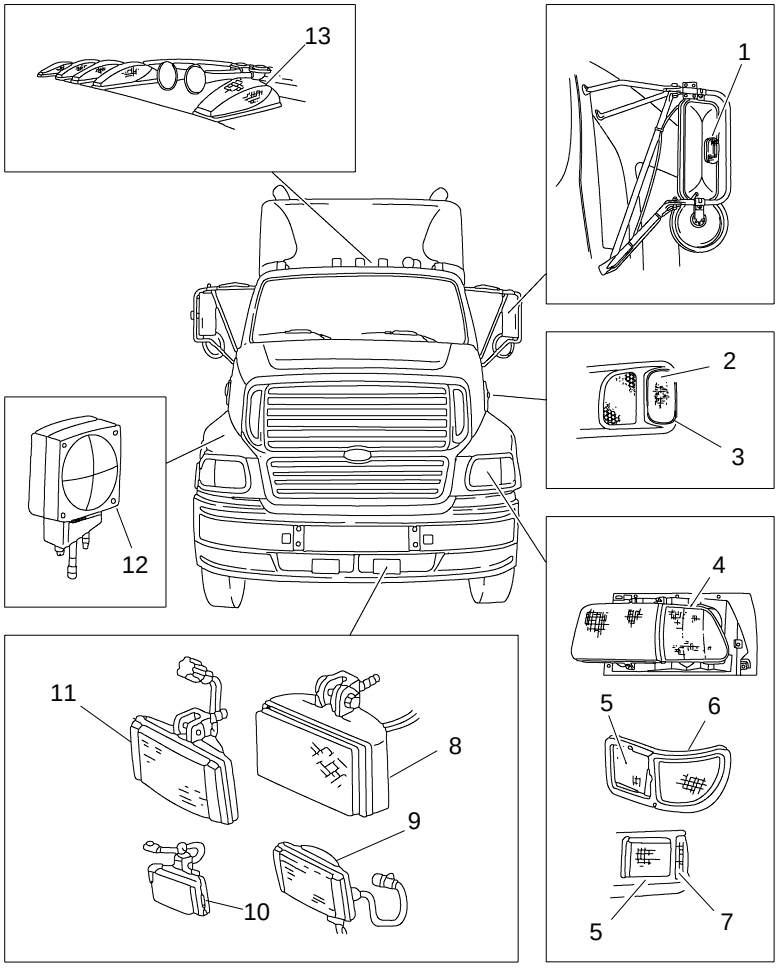
Exterior Lighting System

Fig. 1, **Fig. 2** and **Fig. 3** show exterior lighting components.

Interior Lighting System

The following components are included in the interior lighting system (see **Fig. 4**):

- vanity mirror



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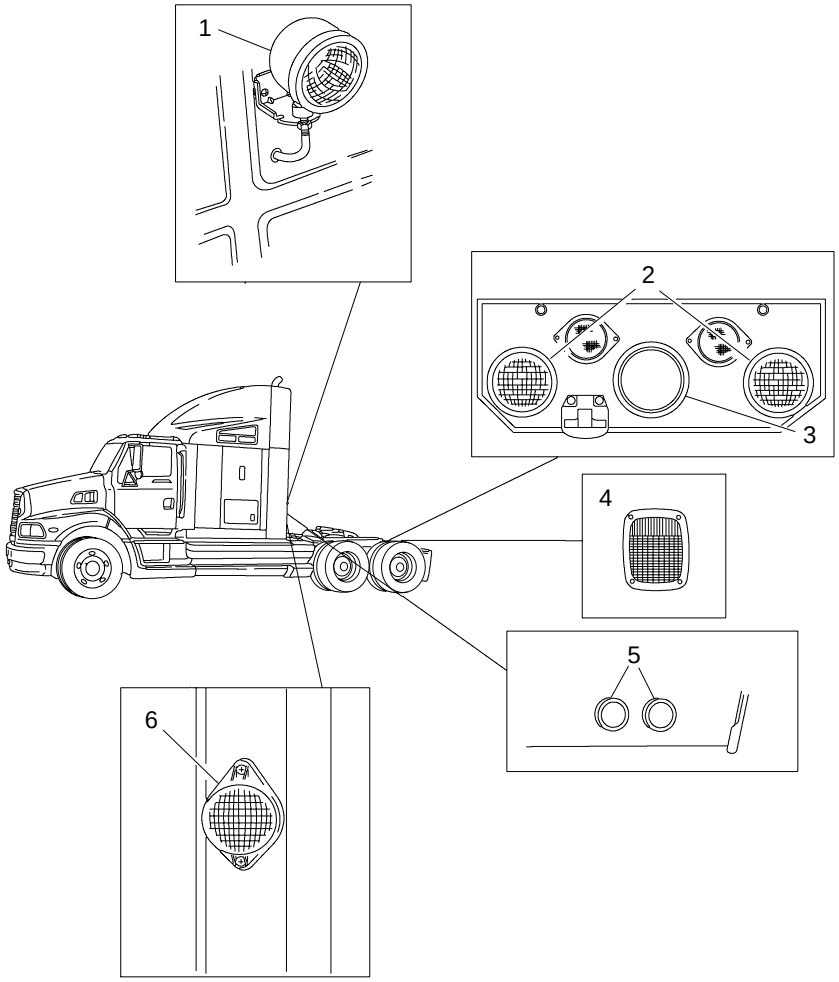
1. Mirror Marker Lamp
2. Hood-Mounted Turn Lamp Lens
3. Hood-Mounted Turn Lamp Housing
4. Headlamp Assembly (aerodynamic)
5. Sealed Beam Headlamp
6. Front Park/Turn Lamp and Bezel Assembly (101-inch BBC)
7. Front Park/Turn Lamp (113-inch and 122-inch BBC)
8. Fog/Road Lamp (113-inch and 122-inch BBC with steel bumper)
9. Fog/Road Lamp (101-inch BBC with full width bumper)
10. Fog/Road Lamp (113-inch and 122-inch BBC with aerodynamic bumper)
11. Fog/Road Lamp (101-inch BBC with cutoff bumper)
12. Fender-Mounted Turn Lamp
13. Roof Marker Lamp

Fig. 1, Exterior Lighting Components

General Information



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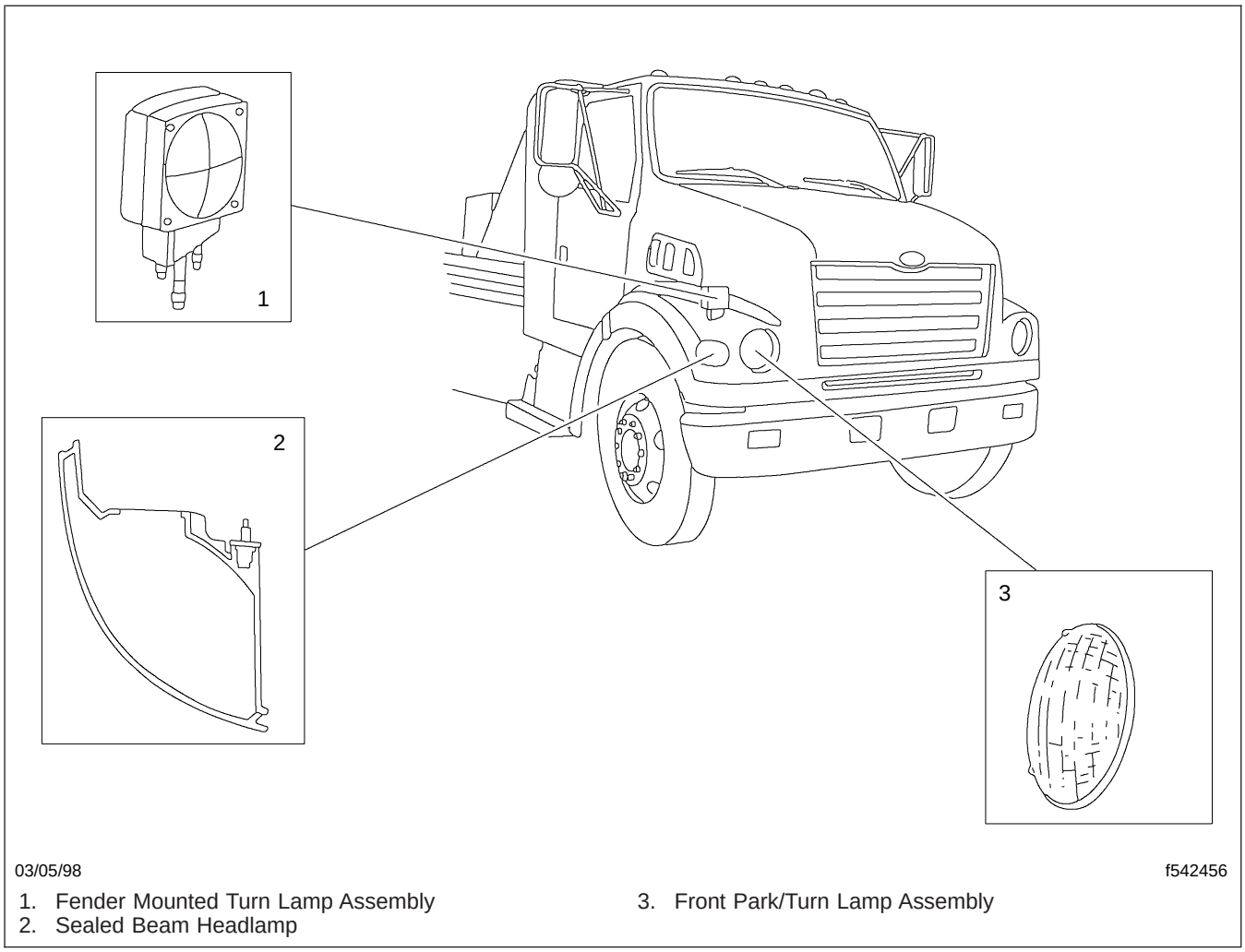
1. Aimable Trailer Hookup Lamp
2. Tail Lamp
3. Backup Lamp
4. Tail Lamp
5. Dual Recessed Trailer Hookup Lamps (with sleeper)
6. Fixed Trailer Hookup Lamp

Fig. 2, Exterior Lighting Components

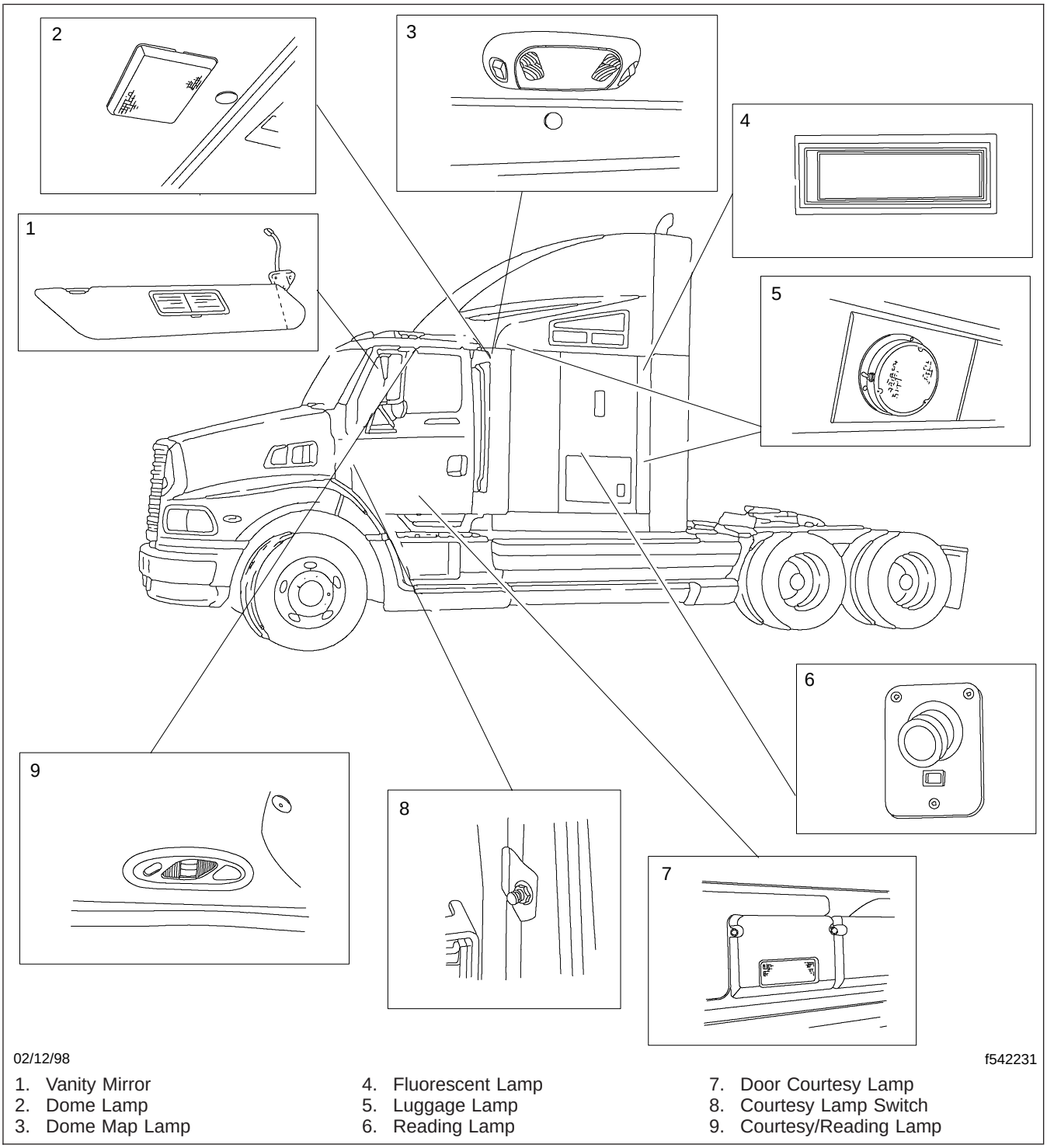
- dome lamp
- dome map lamp
- fluorescent lamp
- luggage lamp
- reading lamp
- door courtesy lamp
- courtesy lamp switch
- courtesy/reading lamp



1. Fender Mounted Turn Lamp Assembly
2. Sealed Beam Headlamp
3. Front Park/Turn Lamp Assembly

Fig. 3, Exterior Lighting Components

General Information



1. Vanity Mirror
2. Dome Lamp
3. Dome Map Lamp
4. Fluorescent Lamp
5. Luggage Lamp
6. Reading Lamp
7. Door Courtesy Lamp
8. Courtesy Lamp Switch
9. Courtesy/Reading Lamp

Fig. 4, Component Locator

Interior Light Replacement

ALL BASE-LEVEL TRIM AND L-LINE MID-LEVEL TRIM DOME LAMP ASSEMBLY

1. Disconnect the negative battery cable from the battery.
2. Remove the dome lamp lens. See **Fig. 1**.

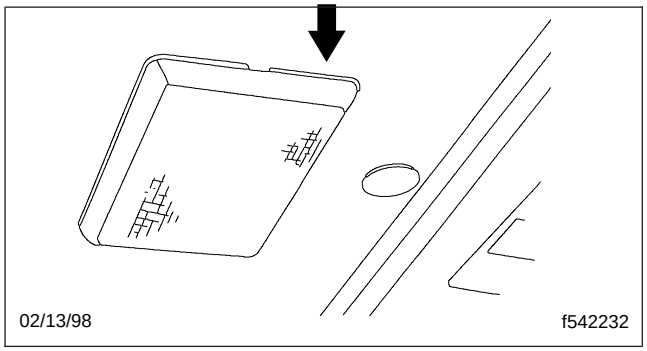


Fig. 1, Dome Lamp Lens

3. Remove the screws. See **Fig. 2**.

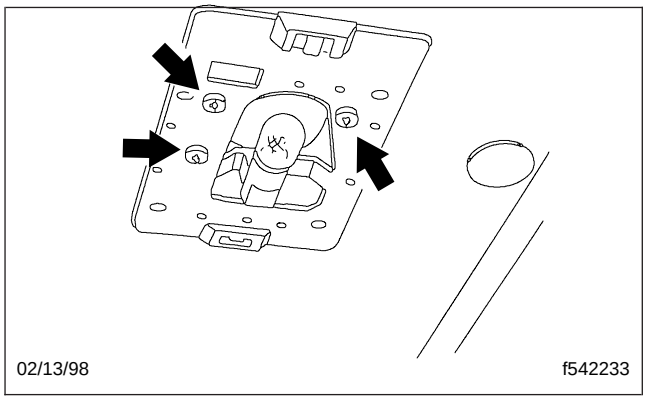


Fig. 2, Dome Lamp Screws

4. Disconnect the electrical connector, and remove the lamp assembly. See **Fig. 3**.
5. Connect the electrical connector, and install the lamp assembly.
6. Install the screws.
7. Reconnect the negative battery cable.

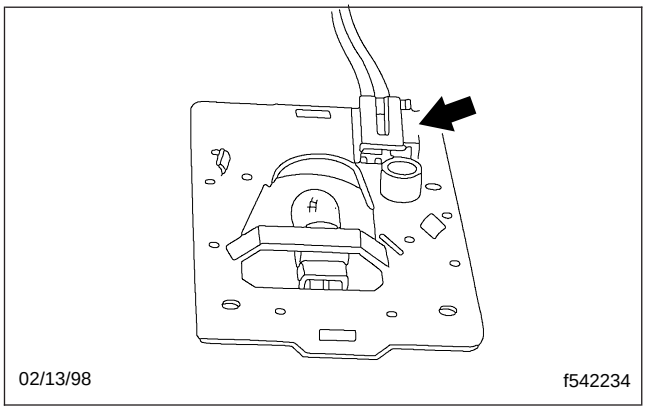


Fig. 3, Dome Lamp Electrical Connector

A-LINE HIGH-LEVEL TRIM DOME/MAP COMBINATION LAMP ASSEMBLY

1. Disconnect the negative battery cable from the battery.
2. Remove the dome lamp lens. See **Fig. 4**.

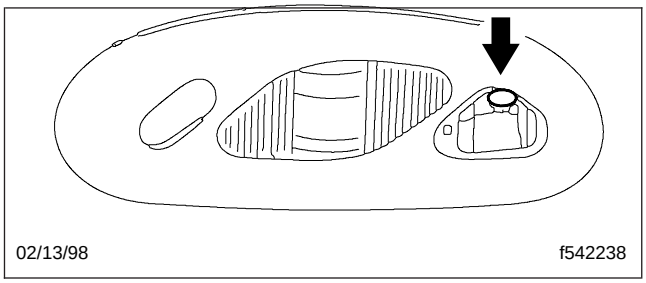


Fig. 4, Dome Lamp Lens

3. Remove the screws. See **Fig. 5**.

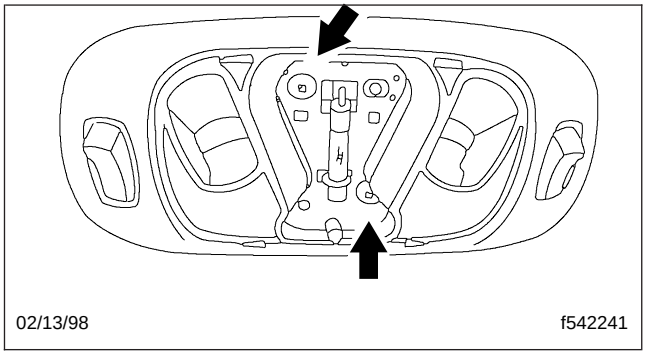


Fig. 5, Dome Lamp Screws

Interior Light Replacement

4. Disconnect the electrical connector, and remove the lamp assembly. See **Fig. 6**.

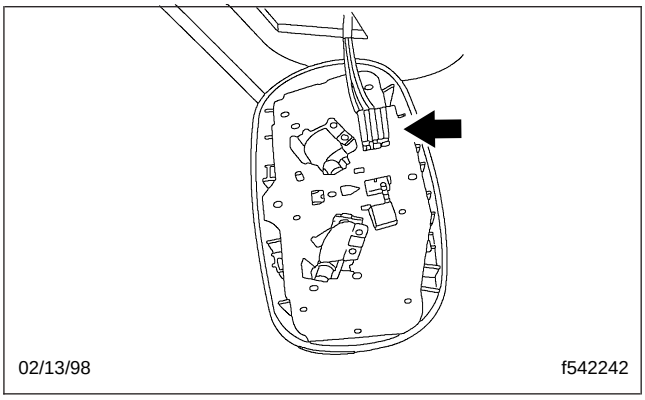


Fig. 6, Dome Lamp Electrical Connector

5. Reconnect the electrical connector and place the lamp assembly into position.
6. Install the screws.
7. Install the dome lamp lens.
8. Reconnect the negative battery cable.

COURTESY/READING LAMP ASSEMBLY

1. Disconnect the negative battery cable from the battery.
2. Remove the cover. See **Fig. 7**.

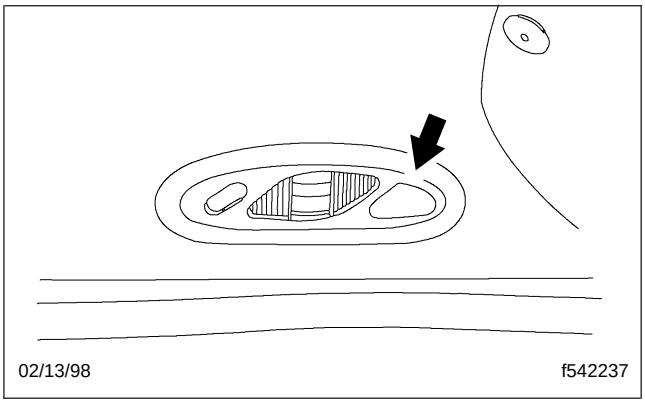


Fig. 7, Lamp Cover

3. Remove the screw. See **Fig. 8**.
4. Disconnect the electrical connector, and remove the lamp assembly. See **Fig. 9**.

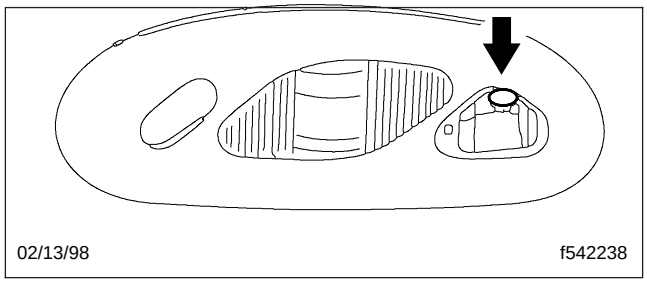


Fig. 8, Lamp Assembly Screw

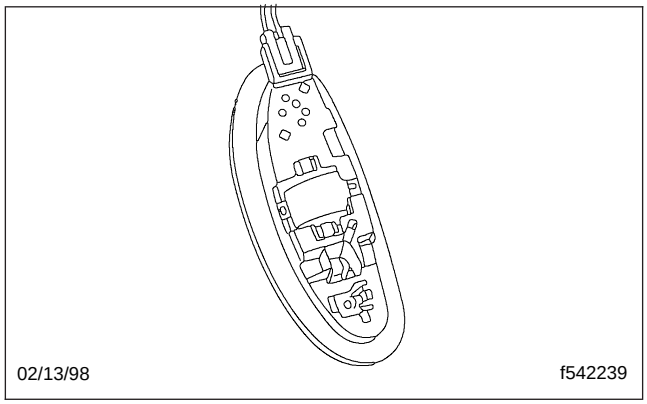


Fig. 9, Lamp Assembly

5. Reconnect the electrical connector and place the lamp assembly into position.
6. Install the screws.
7. Install the courtesy/reading lamp cover.
8. Reconnect the negative battery cable.

DOOR COURTESY LAMP ASSEMBLY

1. Disconnect the negative battery cable from the battery.
2. Remove the screws. See **Fig. 10**.
3. Disconnect the electrical connector, and remove the lamp assembly. See **Fig. 11**.
4. Reconnect the electrical connector and place the lamp assembly into position.
5. Install the screws.
6. Install the door courtesy lamp cover.
7. Reconnect the negative battery cable.

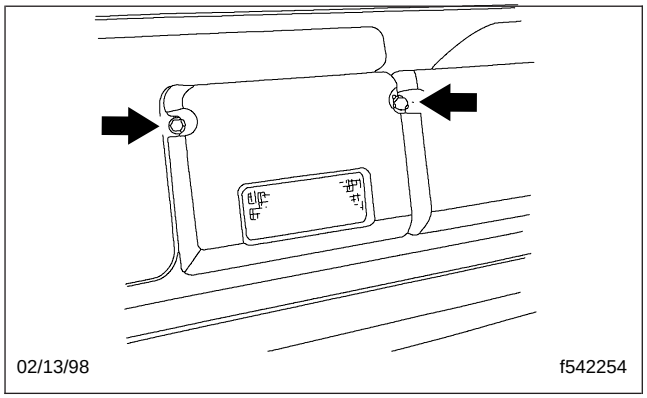


Fig. 10, Courtesy Lamp Screws

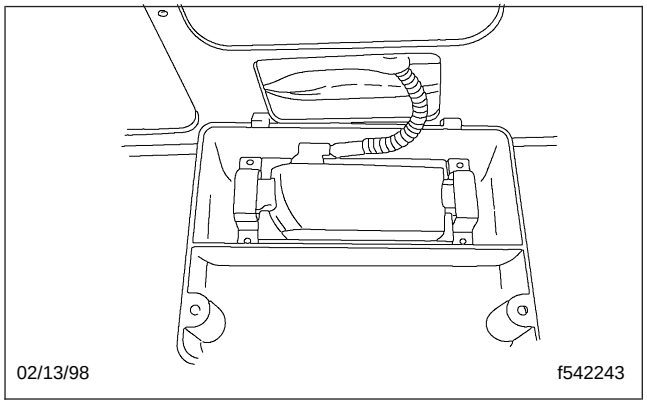


Fig. 11, Courtesy Lamp Electrical Connector

ABLE BODY FLAT TOP PLUS AND AERO BULLET PLUS READING LAMP ASSEMBLY

1. Disconnect the negative battery cable from the battery.
2. Remove the screws. See **Fig. 12**.
3. Disconnect the electrical connector, and remove the lamp assembly. See **Fig. 13**.
4. Reconnect the electrical connector and place the lamp assembly into position.
5. Install the screws.
6. Reconnect the negative battery cable.

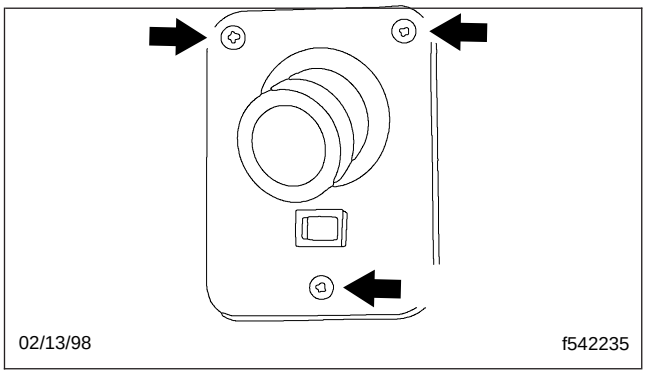


Fig. 12, Reading Lamp Screws

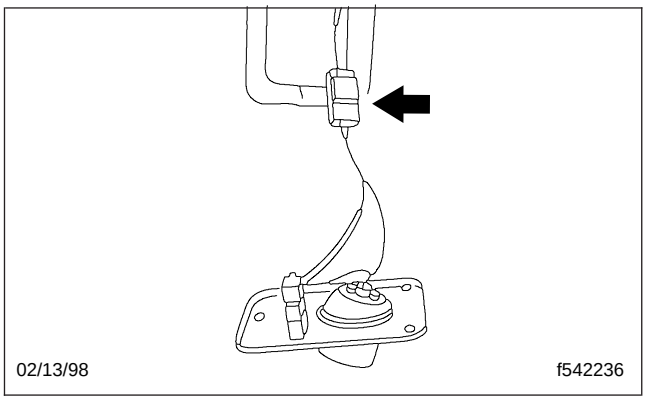


Fig. 13, Reading Lamp Electrical Connector

ABLE BODY FLAT TOP PLUS AND AERO BULLET PLUS FLUORESCENT LAMP ASSEMBLY

1. Disconnect the negative battery cable from the battery.
2. Remove the lens. See **Fig. 14**.
3. Remove the screws. See **Fig. 15**.
4. Disconnect the electrical connector, and remove the lamp assembly. See **Fig. 16**.
5. Reconnect the electrical connector and place the fluorescent lamp assembly into position.
6. Install the screws.
7. Reconnect the negative battery cable.

Interior Light Replacement

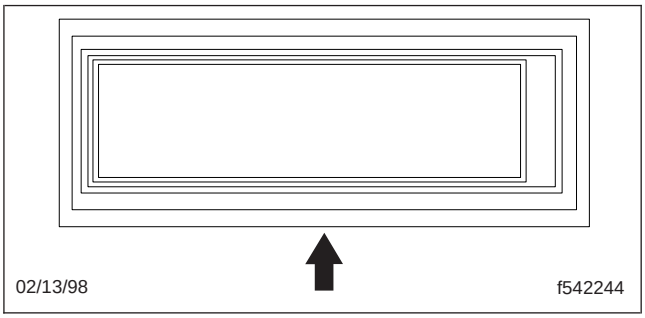


Fig. 14, Fluorescent Lamp Assembly Lens

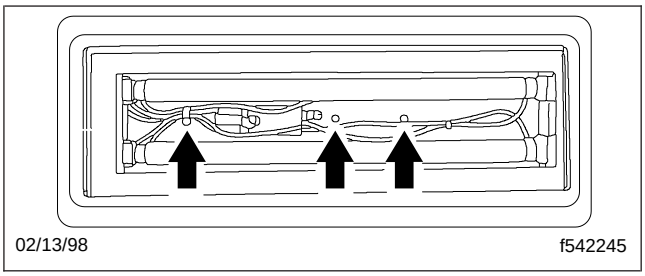


Fig. 15, Lamp Assembly Screws

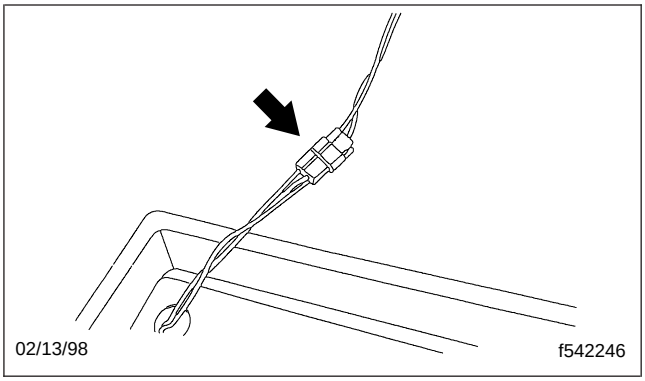


Fig. 16, Lamp Assembly Electrical Connector

ABLE BODY FLAT TOP PLUS AND AERO BULLET PLUS LUGGAGE LAMP ASSEMBLY

1. Disconnect the negative battery cable from the battery.
2. Remove the screws and the lens. See **Fig. 17**.
3. Remove the screws. See **Fig. 18**.
4. Disconnect the electrical connector, and remove the lamp assembly. See **Fig. 19**.

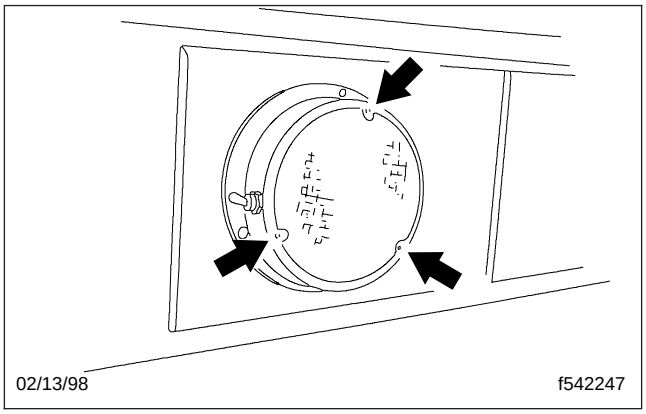


Fig. 17, Lens Screws

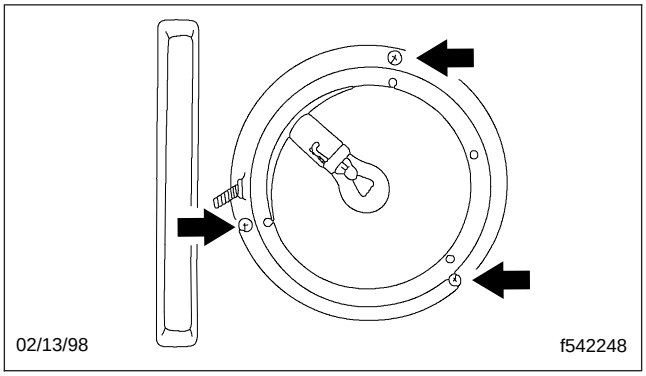


Fig. 18, Lamp Assembly Screws

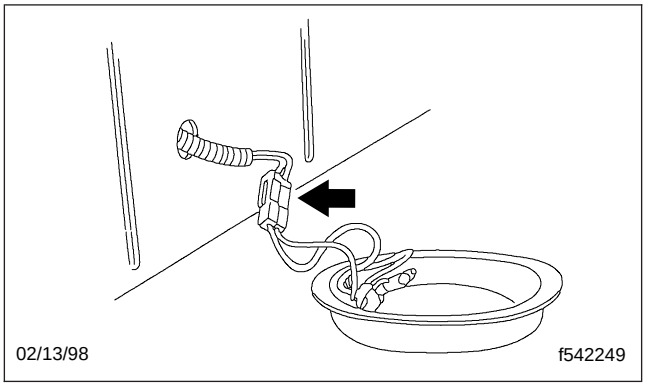


Fig. 19, Lamp Assembly Electrical Connector

5. Reconnect the electrical connector and place the lamp assembly into position.
6. Install the screws.
7. Reconnect the negative battery cable.

SILVERSTAR DOME LAMP ASSEMBLY (TYPICAL)

1. Disconnect the negative battery cable from the battery.
2. Remove the screws, and remove the lamp cover. See **Fig. 20**.

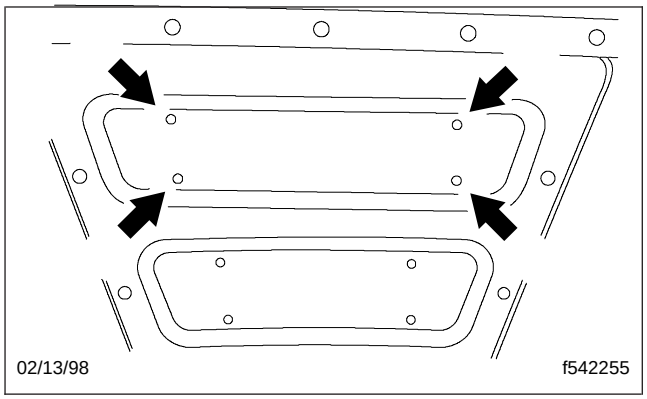


Fig. 20, Dome Lamp Screws

3. Remove the bulb. See **Fig. 21**.

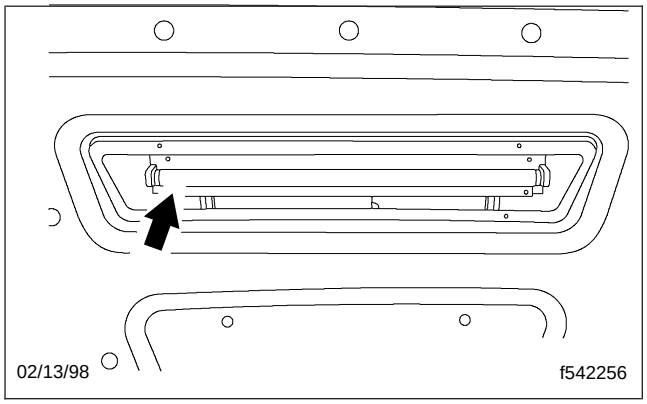


Fig. 21, Dome Lamp Bulb

4. Remove the fixture cover screws, then remove the cover. See **Fig. 22**.
5. Remove the dome lamp assembly screws. See **Fig. 23**.
6. Disconnect the electrical connector, and remove the dome lamp assembly. See **Fig. 24**.
7. Reconnect the electrical connector and place the lamp assembly into position.
8. Install the screws.

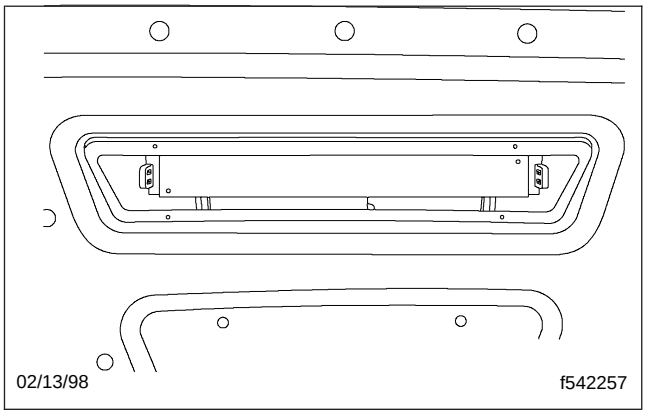


Fig. 22, Fixture Cover

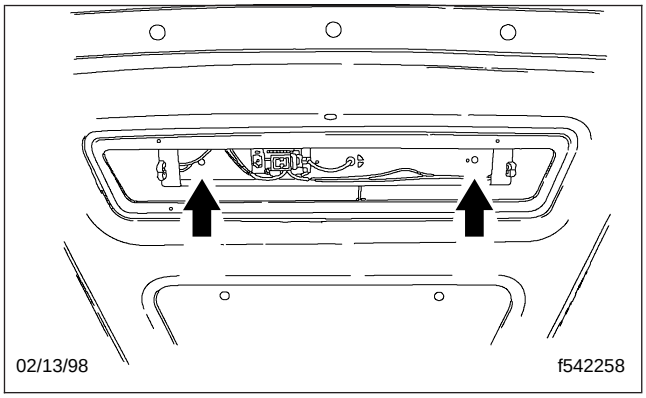


Fig. 23, Dome Lamp Assembly

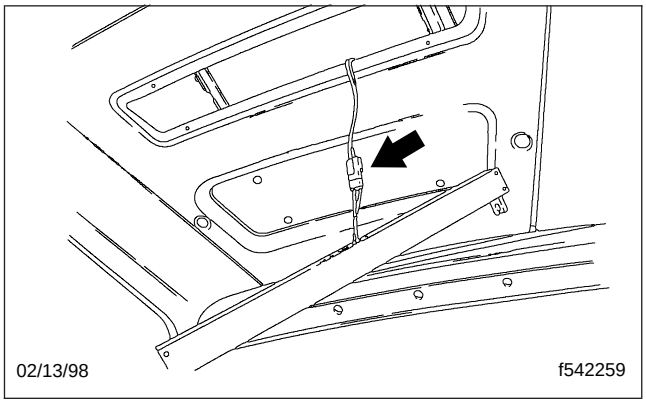


Fig. 24, Dome Lamp Assembly Electrical Connector

9. Reconnect the negative battery cable.

Interior Light Replacement

COURTESY LAMP SWITCH

1. Disconnect the negative battery cable from the battery.
2. Remove the courtesy lamp switch. See **Fig. 25**.

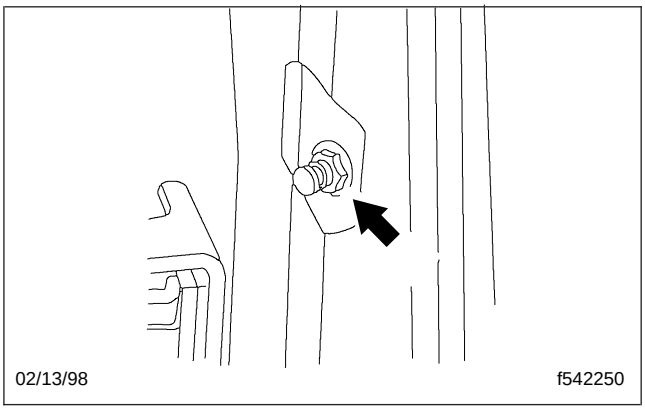


Fig. 25, Courtesy Lamp Switch

3. Disconnect the electrical connector. See **Fig. 26**.

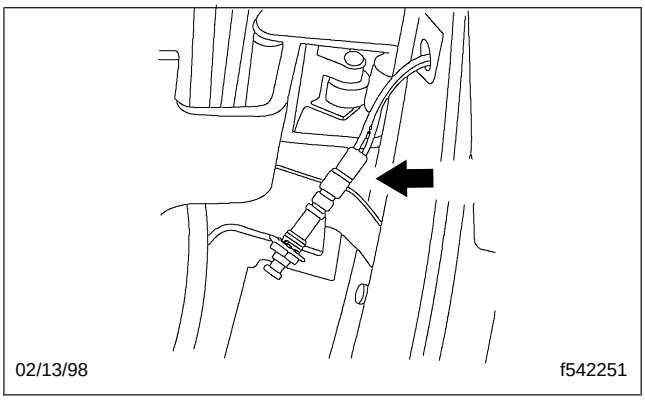


Fig. 26, Courtesy Lamp Electrical Connector

4. Reconnect the electrical connector and place the lamp assembly into position.
5. Install the screws.
6. Reconnect the negative battery cable.

ABLE BODY SLEEPER DOME LAMP SWITCH

1. Disconnect the negative battery cable from the battery.
2. Remove the screws. See **Fig. 27**.

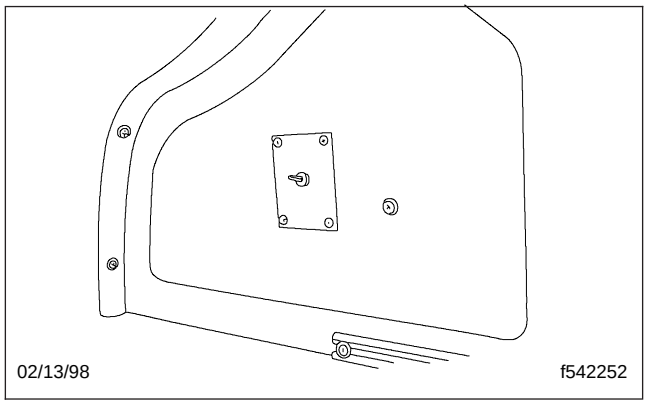


Fig. 27, Dome Light Switch Screws

3. Disconnect the electrical connections, and remove the switch. See **Fig. 28**.

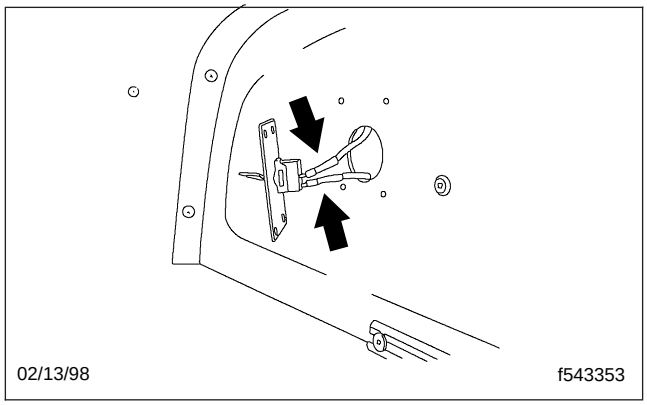


Fig. 28, Dome Lamp Electrical Connector

4. Reconnect the electrical connector and place the lamp assembly into position.
5. Install the screws.
6. Reconnect the negative battery cable.

SILVERSTAR INTERIOR LAMP SWITCH

1. Disconnect the negative battery cable from the battery.
2. Remove the cover. See **Fig. 29**.
3. Disconnect the electrical connector. See **Fig. 30**.
4. Release the locking tabs on the switch. See **Fig. 31**.
5. Remove the switch. See **Fig. 32**.

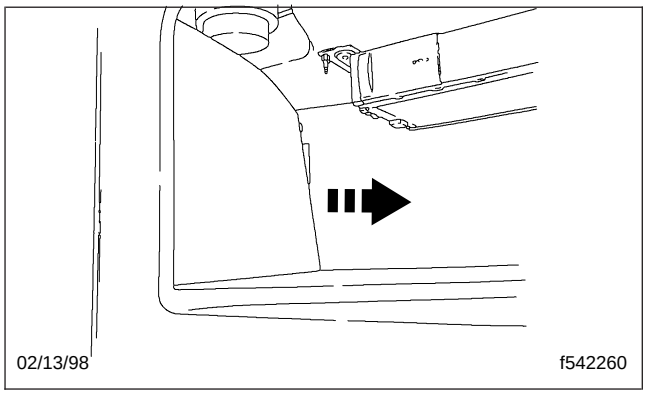


Fig. 29, Interior Lamp Switch Cover

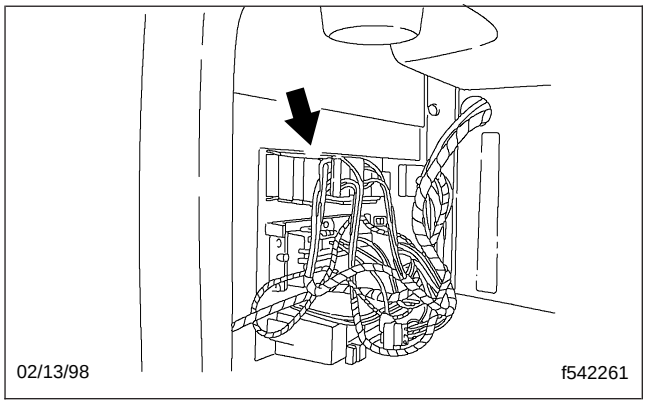


Fig. 30, Interior Lamp Switch Electrical Connector

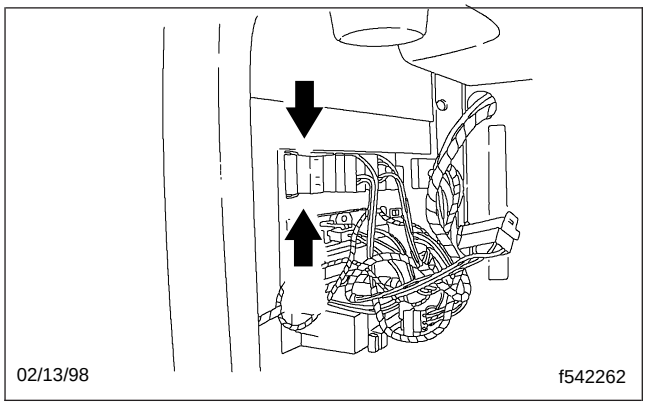


Fig. 31, Interior Lamp Switch Locking Tabs

6. Reconnect the electrical connector and place the lamp assembly into position.
7. Install the screws.
8. Reconnect the negative battery cable.

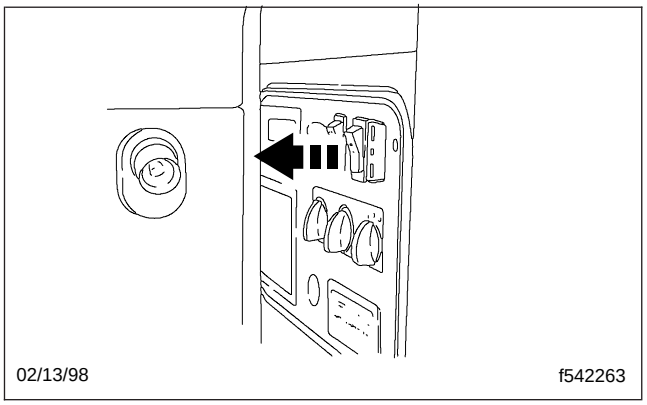


Fig. 32, Interior Lamp Switch Removal

Headlights

SINGLE AERODYNAMIC HALOGEN HEADLIGHT ASSEMBLY

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood to gain access to the headlight.
3. Disconnect the negative battery cable from the battery.
4. Remove the five rear headlight cover bolts. See **Fig. 1**.

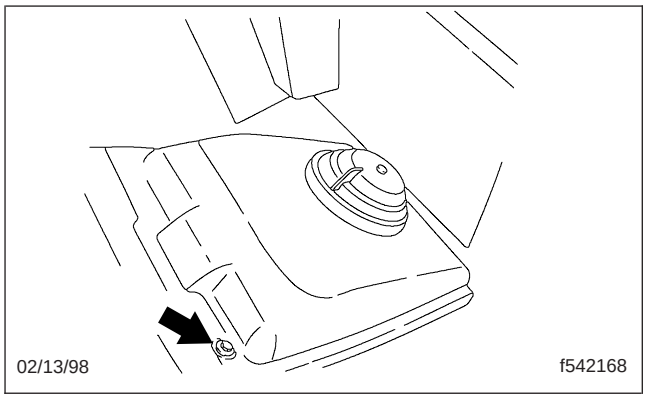


Fig. 1, Headlight Cover Panel Bolts

5. Disconnect the electrical connectors and remove the headlight assembly. See **Fig. 2**.

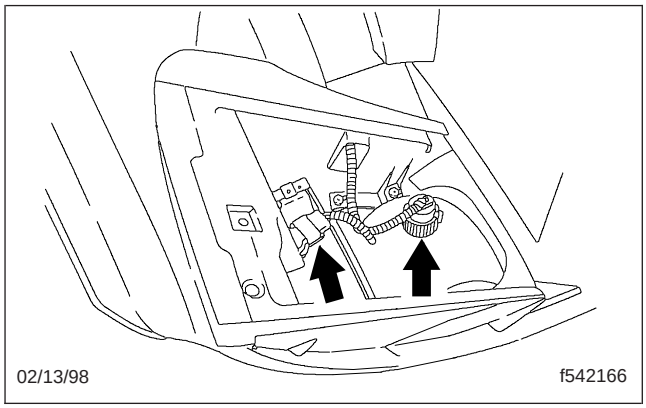


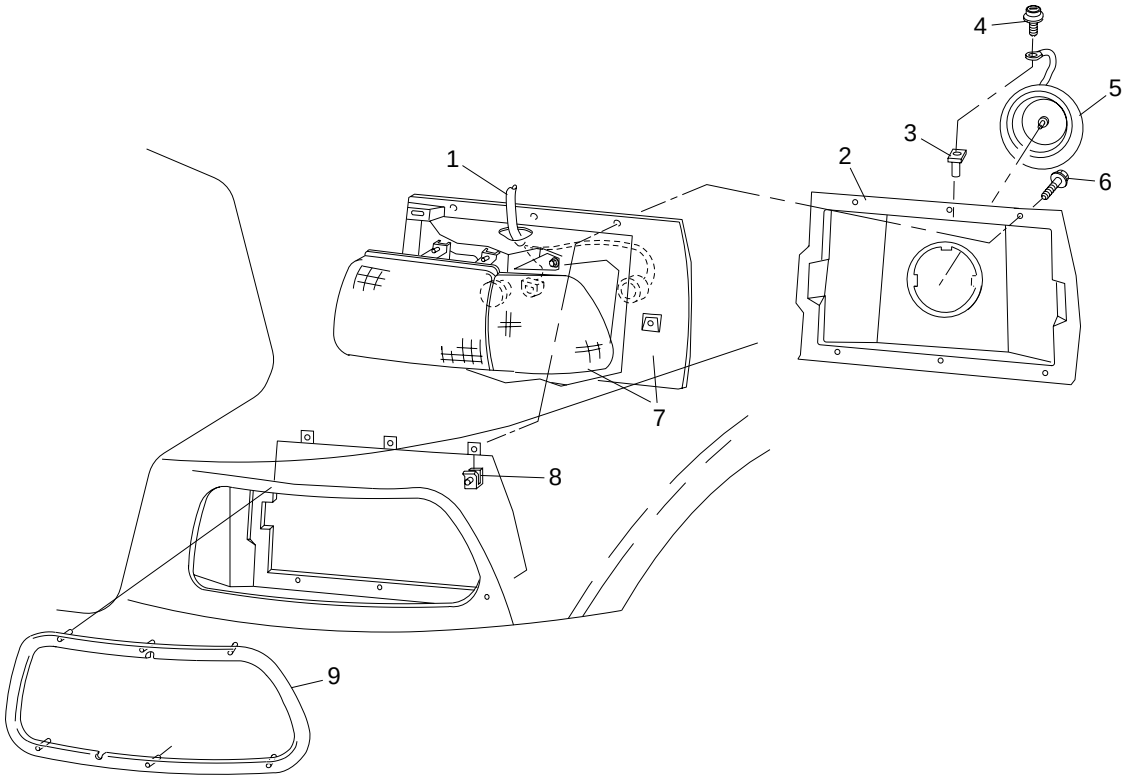
Fig. 2, Electrical Connectors

6. Remove the headlight assembly from the mounting bracket. See **Fig. 3**.
7. Install the headlight assembly on the mounting bracket.
8. Connect the electrical connectors and install the headlight assembly.
9. Install the five rear headlight cover bolts.
10. Close and latch the hood.
11. Connect the negative battery cable.
12. Remove the chocks from the rear tires.

SINGLE AERODYNAMIC HALOGEN HEADLIGHT BULB

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the negative battery cable from the battery.
3. Open the hood to gain access to the headlight.
4. Open the headlight access cover by turning it counterclockwise. See **Fig. 4**.
5. Disconnect the electrical connector. See **Fig. 5**.
6. Remove the bulb. See **Fig. 6**.
   - 6.1 Twist the headlight bulb retaining ring counterclockwise and remove the ring.
   - 6.2 Pull the headlight bulb directly out of the headlight assembly and remove the bulb.
7. Insert the headlight bulb into the headlight assembly.
8. Twist the headlight bulb retaining ring clockwise onto the assembly.
9. Connect the electrical connector.
10. Close the headlight access cover.
11. Close and latch the hood.
12. Connect the negative battery cable.
13. Remove the chocks from the rear tires.

Exterior Light Replacement



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1. Headlight Wire Assembly
2. Rear Cover
3. Nut
4. Screw
5. Access Cover
6. Hexhead Screw
7. Headlight Assembly
8. Nut
9. Bezel

Fig. 3, Aerodynamic Headlight

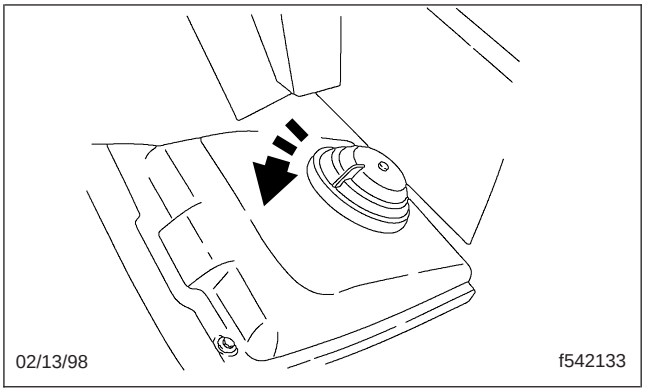

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Fig. 4, Headlight Access Cover

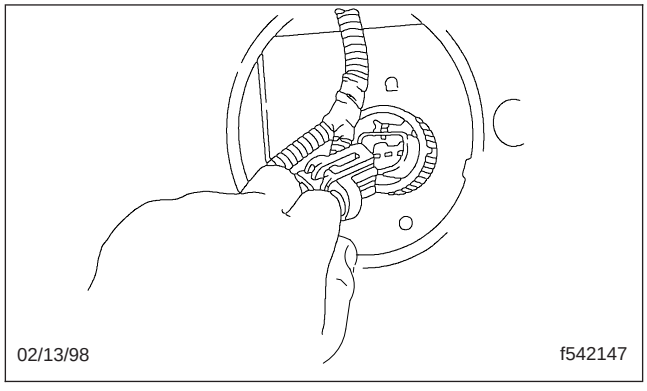

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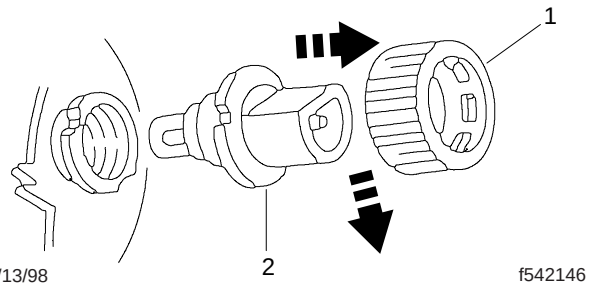
Fig. 5, Headlight Electrical Connector



1. Retaining Ring
2. Headlight Bulb

Fig. 6, Remove the Headlight Bulb

NON-AERODYNAMIC HEADLIGHT ASSEMBLY

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the negative battery cable from the battery.
3. Remove the retaining ring screws. See **Fig. 7**.
4. Disconnect the electrical connector and remove the headlight. See **Fig. 8**.
5. Connect the electrical connector and install the headlight.
6. Install the retaining screws.
7. Install the turnlight assembly nuts.
8. Connect the negative battery cable.
9. Remove the chocks from the rear tires.

ROUND HEADLIGHT ASSEMBLY

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the negative battery cable from the battery.
3. Remove the retaining ring screws and the retaining ring. See **Fig. 9**.
4. Disconnect the electrical connector.
5. Remove the headlight.
6. Install the headlight.
7. Connect the electrical connector.
8. Install the retaining ring and retaining screws.
9. Connect the negative battery cable.
10. Remove the chocks from the rear tires.

VOCATIONAL HEADLIGHT ASSEMBLY

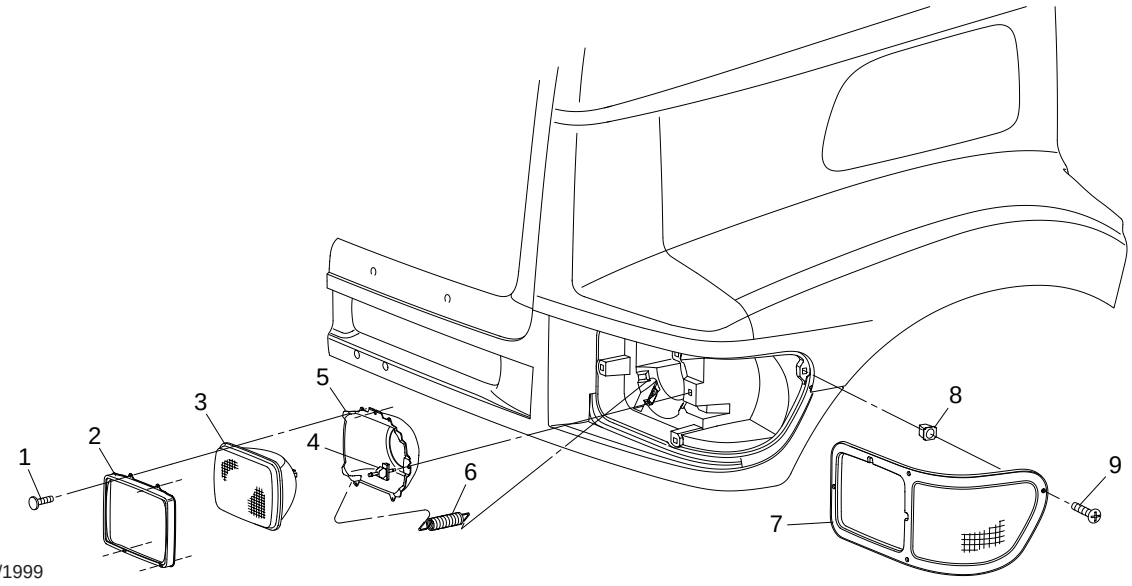
1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the negative battery cable from the battery.
3. Open the hood.
4. From under the hood, remove the five bolts from the rear light cover and remove the cover. See **Fig. 10**.
5. Disconnect the headlight electrical connector.
6. Close the hood.
7. Remove the two retaining screws in the headlight retaining ring.
8. Remove the headlight.
9. Install the headlight.
10. Install the two retaining screws in the headlight retaining ring.
11. Open the hood.
12. Connect the headlight electrical connector.
13. Position the rear light cover and install the five bolts.
14. Close and latch the hood.
15. Connect the negative battery cable.
16. Remove the chocks from the rear tires.

Turnlights

HOOD-MOUNTED TURNLIGHT ASSEMBLY

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.

Exterior Light Replacement



1. Retaining Screw
2. Headlight Attachment Ring
3. Headlight
4. Adjustment Screw and Nut
5. Headlight Adjustment Ring
6. Spring
7. Bezel
8. Nut
9. Screw

Fig. 7, Non-Aerodynamic Headlight

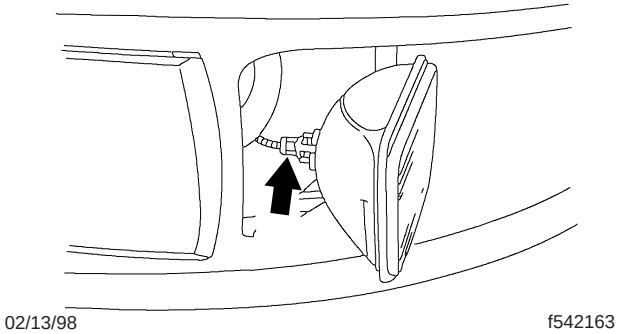
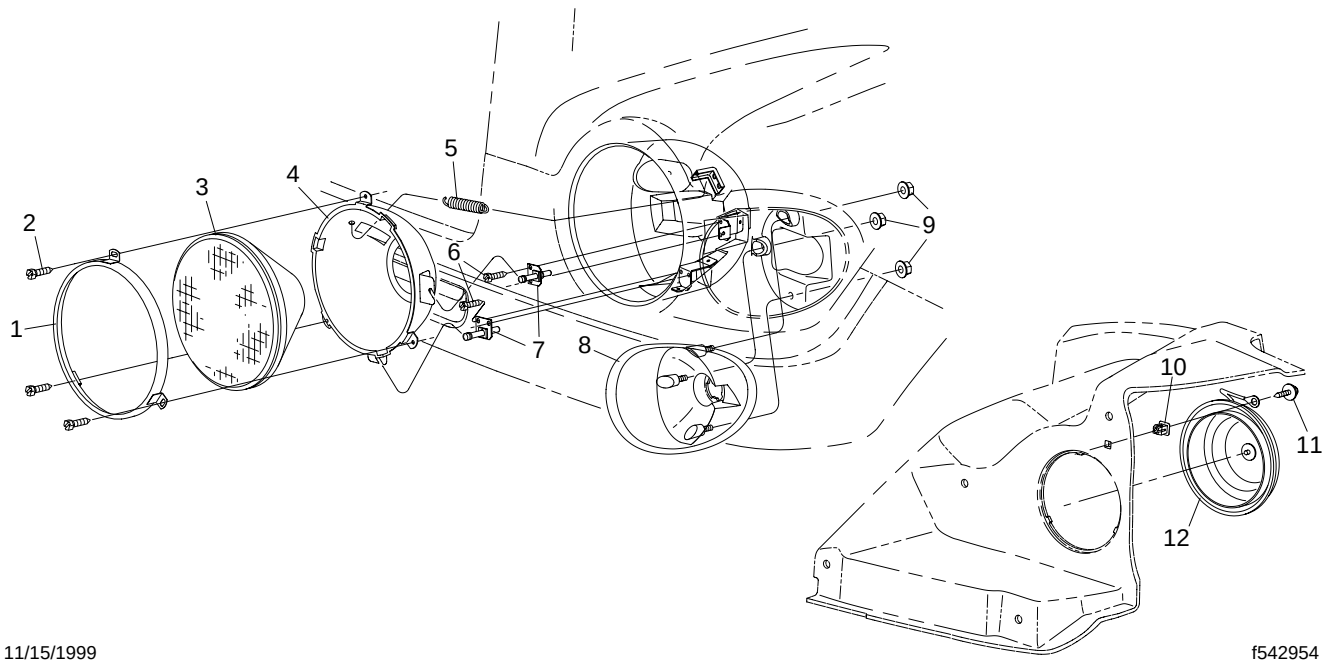


Fig. 8, Headlight Electrical Connector

2. Disconnect the negative battery cable from the battery.
3. Open the hood.
4. Disconnect the turnlight assembly electrical connector.
5. Remove the turnlight assembly nuts. See **Fig. 11**.
6. Remove the turnlight assembly.
7. Install the turnlight assembly nuts.
8. Connect the turnlight assembly electrical connector.
9. Close and latch the hood.
10. Connect the negative battery cable.
11. Remove the chocks from the rear tires.

SIDE AIR-INTAKE-MOUNTED TURNLIGHT ASSEMBLY

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the negative battery cable from the battery.
3. Pry the lens cover from the turnlight. See **Fig. 12**.
4. Remove the screws.
5. Disconnect the electrical connector and remove the turnlight assembly.



1. Headlight Attachment Ring
2. Retaining Screw
3. Headlight
4. Headlight Adjustment Ring
5. Spring
6. Screw
7. Adjustment Screw and Nut
8. Parking Light/Side Marker Light Assembly
9. Hexnut
10. Nut
11. Screw
12. Access Cover

Fig. 9, Round Headlight

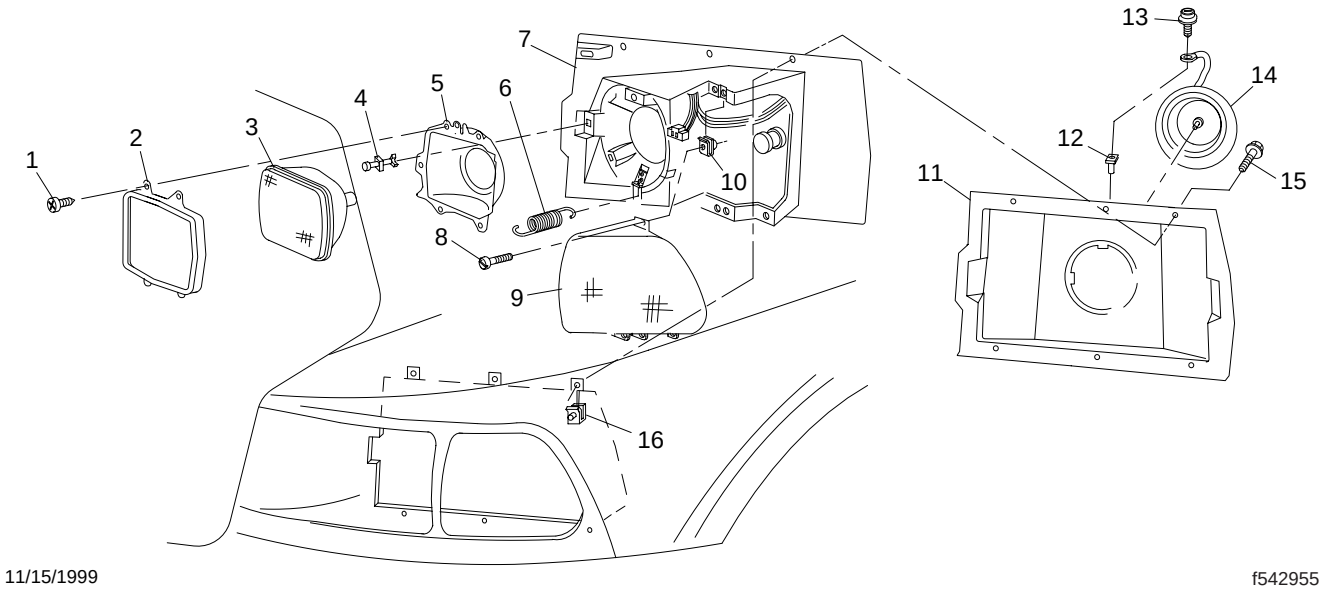
6. Connect the electrical connector and install the turnlight assembly.
7. Install the screws.
8. Install the lens cover onto the turnlight.
9. Connect the negative battery cable.
10. Remove the chocks from the rear tires.

Marker Lights

PARKING LIGHT/SIDE MARKER LIGHT ASSEMBLY

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Disconnect the negative battery cable from the battery.
4. Rotate and remove the parking light/side marker light assembly wiring harness assembly from the housing.
5. Remove the three bolts retaining the parking light/side marker light assembly. See **Fig. 9**.
6. Remove the parking light/side marker light assembly.
7. Install the parking light/side marker light assembly.
8. Install the three bolts retaining the parking light/side marker light assembly.
9. Install the parking light/side marker light assembly wiring harness into the housing.
10. Close and latch the hood.

Exterior Light Replacement



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1. Retaining Screw
2. Retaining Ring
3. Headlight
4. Adjustment Screw and Nut
5. Headlight Adjustment Ring
6. Spring
7. Headlight Mounting Panel
8. Screw
9. Side Turnlight Assembly
10. Nut
11. Rear Light Cover
12. Nut
13. Screw
14. Access Cover
15. Bolt

Fig. 10, Vocational Headlight

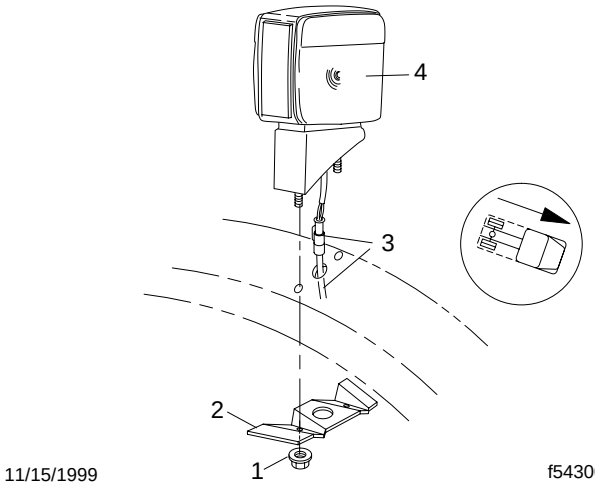
11. Connect the negative battery cable.
12. Remove the chocks from the rear tires.

ROOF-MOUNTED MARKER LIGHT ASSEMBLY (TYPICAL)

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the negative battery cable from the battery.
3. Remove the screw and the marker light cover. See **Fig. 13**.
4. Remove the screws. See **Fig. 14**.
5. Disconnect the electrical connector and remove the marker light assembly. See **Fig. 15**.
6. Connect the electrical connector and install the marker light assembly.
7. Install the marker light assembly retaining screws. Install the marker light cover.
8. Connect the negative battery cable.
9. Remove the chocks from the rear tires.

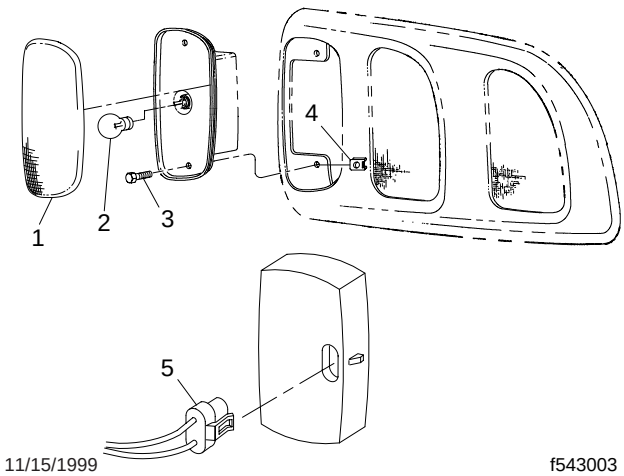
SIDE MARKER LIGHT ASSEMBLY, RIGHT-HAND-DRIVE VEHICLES

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the negative battery cable from the battery.
3. Disconnect the side marker light electrical connector. See **Fig. 16**.
4. Remove the fasteners and remove the side marker light. See **Fig. 17**.



1. Hexnut
2. Mounting Bracket
3. Hood Wire Assembly
4. Turnlight Assembly

Fig. 11, Hood-Mounted Turnlight



1. Lens Cover
2. Bulb
3. Screw
4. Nut
5. Electrical Connector

Fig. 12, Side Air-Intake-Mounted Turnlight

5. Connect the electrical connector and install the side marker light assembly.
6. Install the side marker light assembly retaining screws.

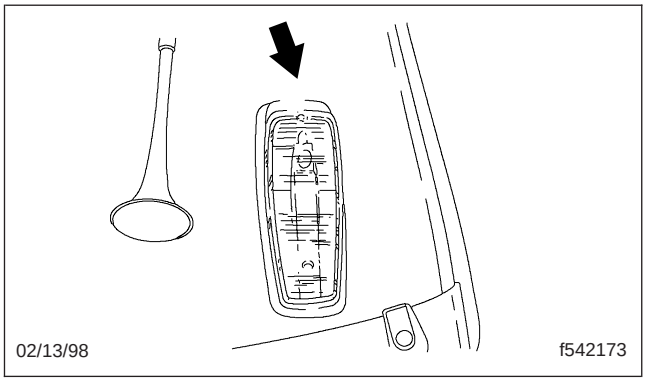


Fig. 13, Screw and Marker Light Cover

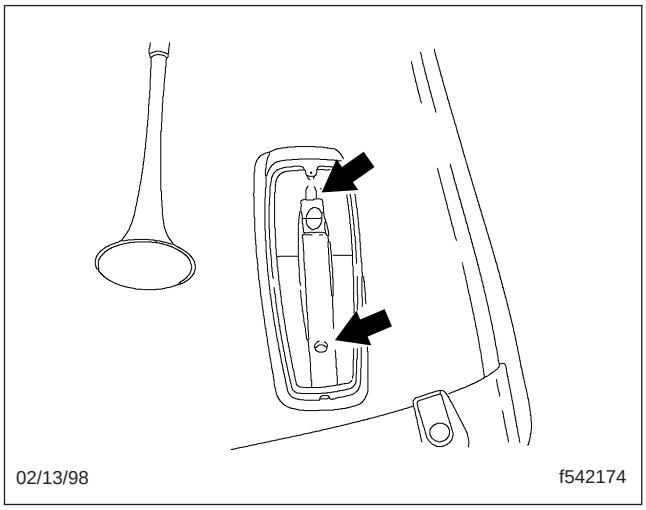


Fig. 14, Roof-Mounted Marker Light Screws

7. Connect the negative battery cable.
8. Remove the chocks from the rear tires.

Taillights

LEFT-HAND-DRIVE VEHICLES

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the negative battery cable from the battery.
3. Disconnect the electrical connector. See **Fig. 18**.
4. Remove the fasteners and remove the taillight. See **Fig. 19**.

Exterior Light Replacement

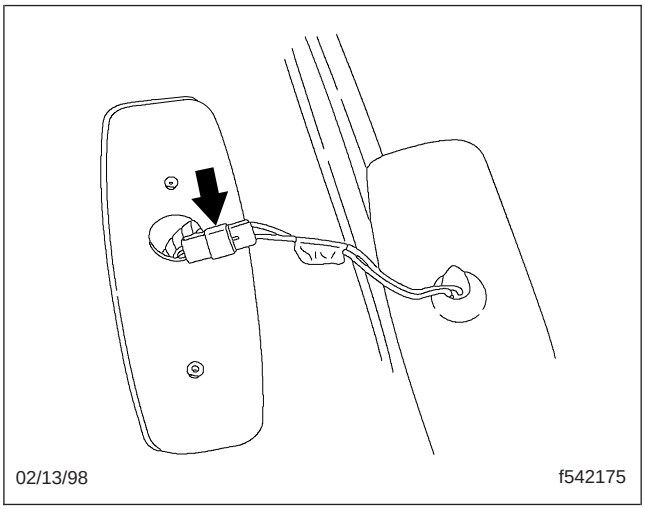


Fig. 15, Roof-Mounted Marker Light Electrical Connector

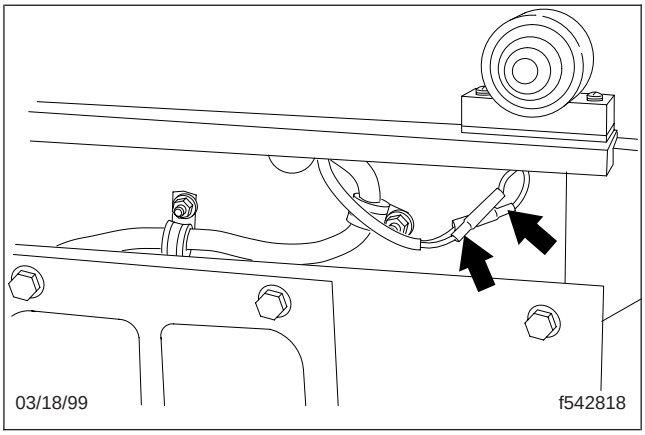
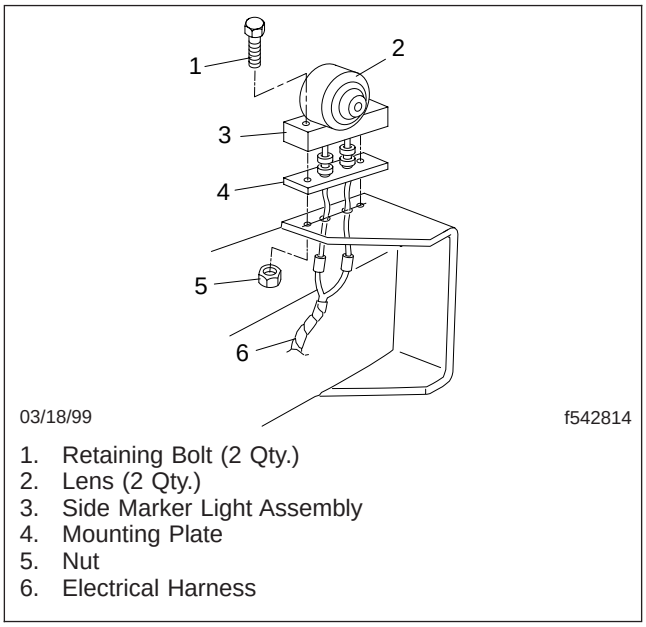


Fig. 16, Side Marker Light Connectors

5. Connect the electrical connector and install the taillight assembly.
6. Install the taillight assembly retaining screws.
7. Connect the negative battery cable.
8. Remove the chocks from the rear tires.

RIGHT-HAND-DRIVE VEHICLES

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the negative battery cable from the battery.



1. Retaining Bolt (2 Qty.)
2. Lens (2 Qty.)
3. Side Marker Light Assembly
4. Mounting Plate
5. Nut
6. Electrical Harness

Fig. 17, Side Marker Light and Fasteners

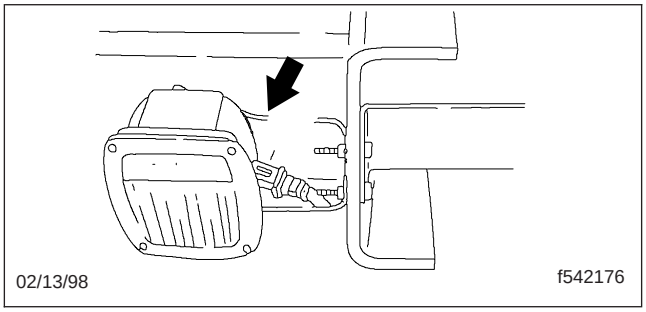


Fig. 18, Disconnect the Electrical Connector

3. Disconnect the side marker light electrical connector. See **Fig. 16**.
4. Disconnect the taillight/side marker light electrical harness connector. See **Fig. 20** and **Fig. 21**.
5. Remove the fasteners and remove the taillight assembly.
6. Connect the electrical connectors and install the taillight assembly.
7. Install the taillight assembly retaining screws.
8. Connect the negative battery cable.
9. Remove the chocks from the rear tires.

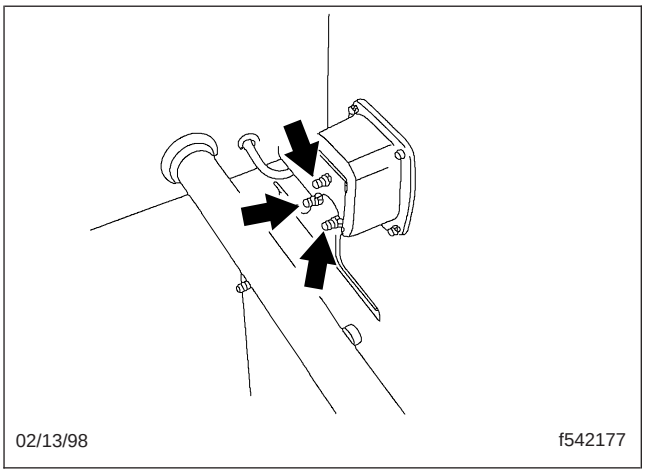


Fig. 19, Taillight Fasteners

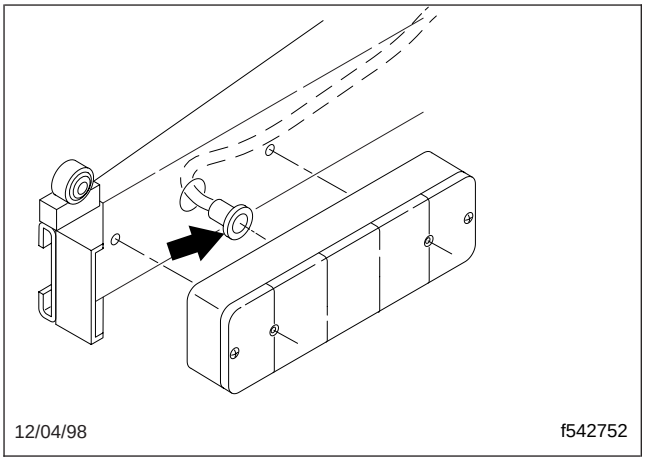


Fig. 20, Taillight/Side Marker Light Electrical Harness Connector Location

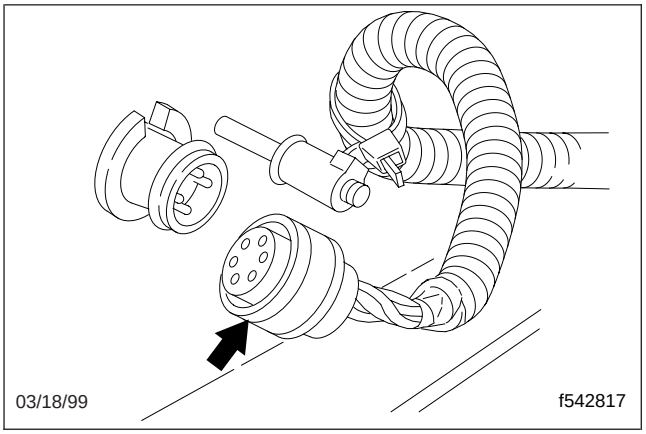


Fig. 21, Taillight/Side Marker Light Female Connector

Fog Lights

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the negative battery cable from the battery.
3. Disconnect the electrical connector. See **Fig. 22**.

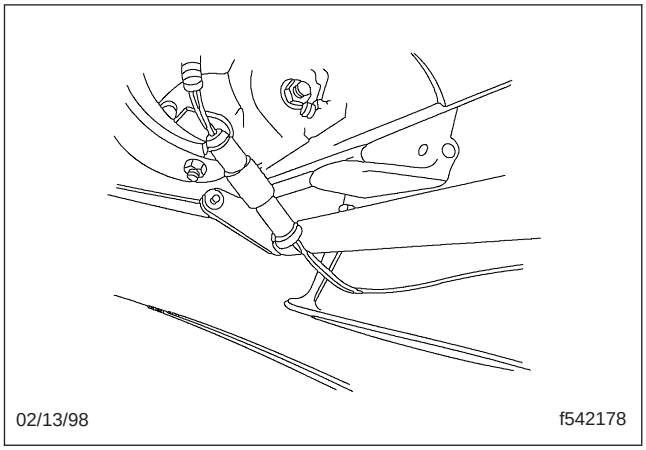


Fig. 22, Fog Light Assembly Electrical Connector

4. Remove the fastener and the fog light. See **Fig. 23**.

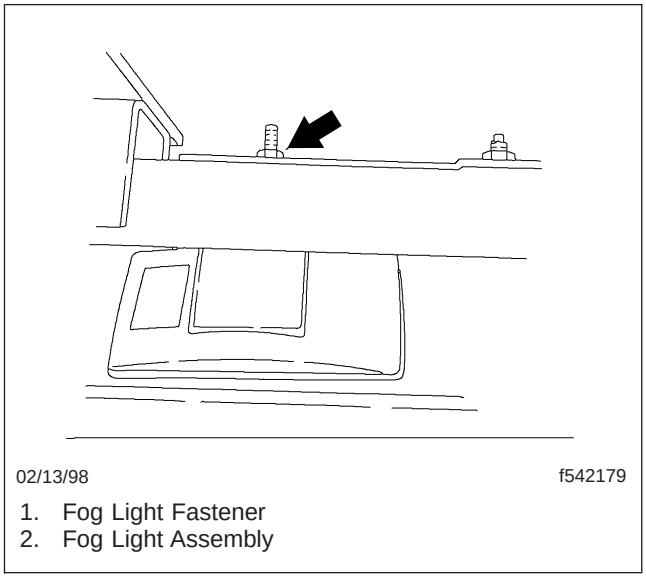


Fig. 23, Fog Light and Fastener

5. Install the fog light and fastener.

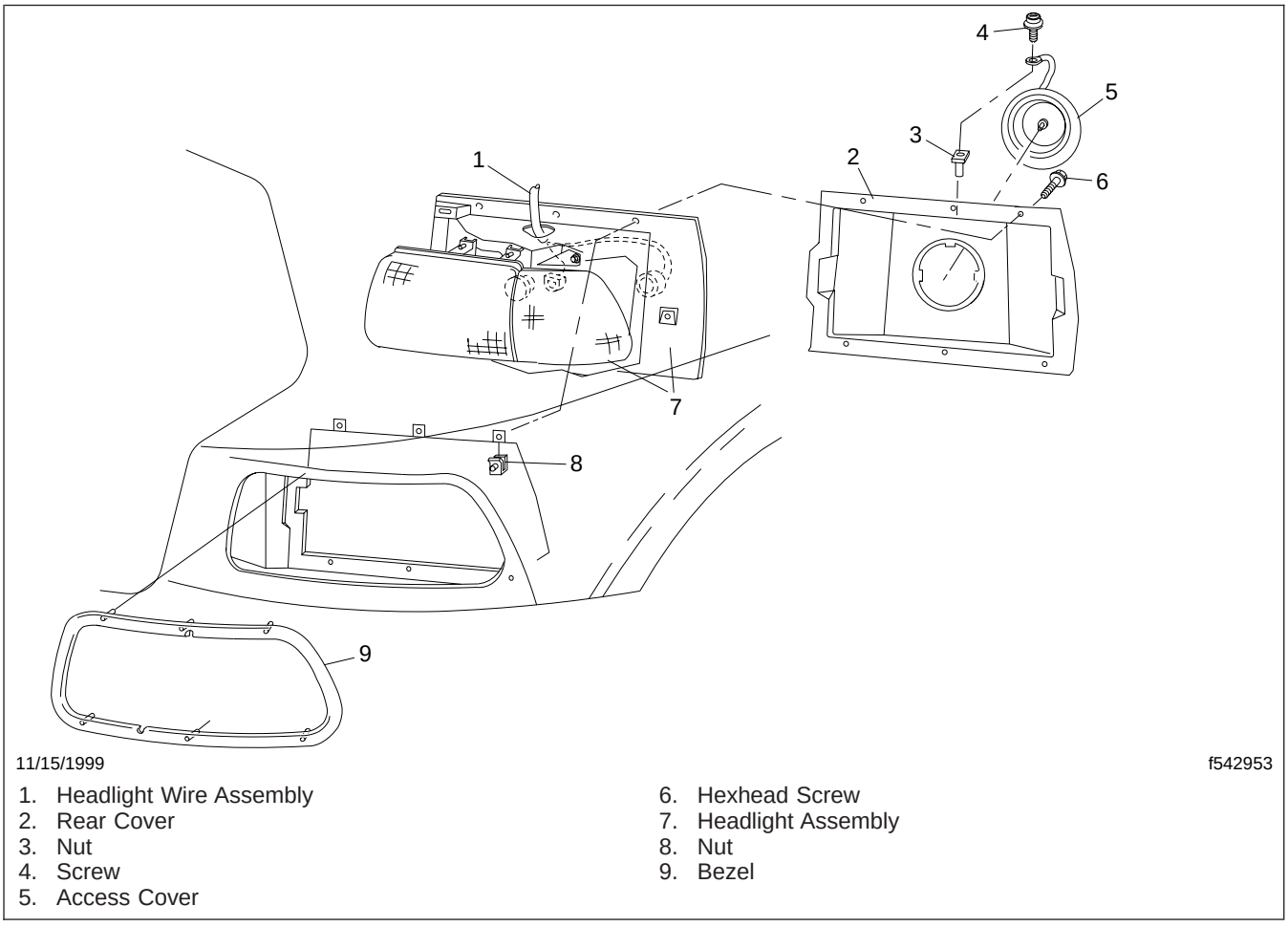
Exterior Light Replacement

6. Connect the electrical connector.
7. Connect the negative battery cable.
8. Remove the chocks from the rear tires.

Headlight Bezel Without Outside Fasteners

REMOVAL (See Fig. 1)

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the batteries.
3. Open the hood.
4. From under the hood, remove the five hexhead screws from the rear cover.
5. Remove the rear cover and set it aside.
6. Disconnect the wires to the headlights.
7. Remove the headlight assembly.
8. Remove the nuts holding the headlight bezel.
9. Remove the headlight bezel.



1. Headlight Wire Assembly
2. Rear Cover
3. Nut
4. Screw
5. Access Cover
6. Hexhead Screw
7. Headlight Assembly
8. Nut
9. Bezel

Fig. 1, Headlight Bezel Without Outside Fasteners

INSTALLATION (See Fig. 1)

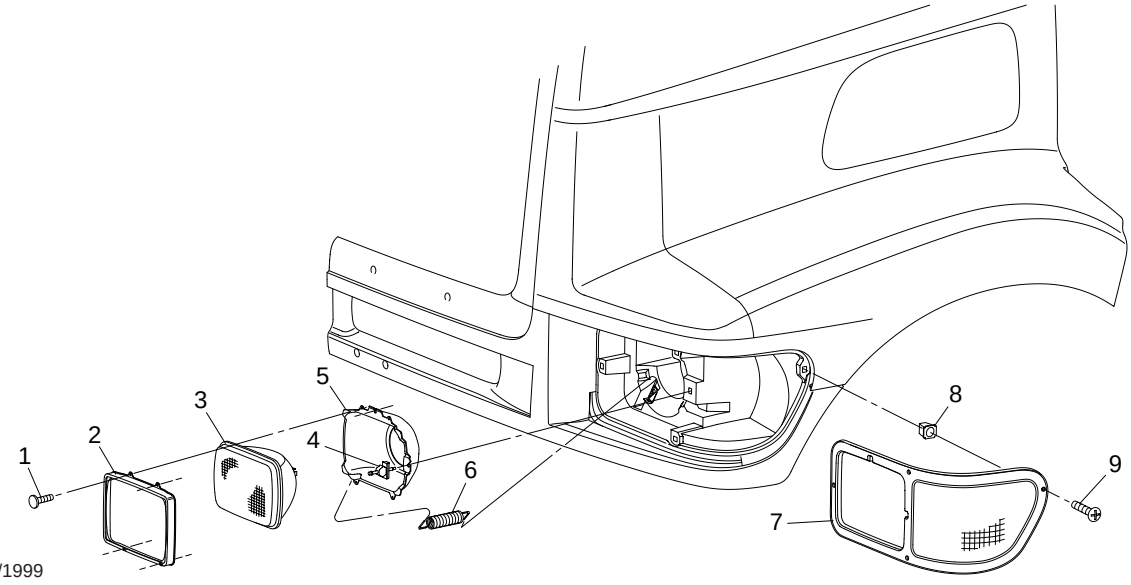
1. Position the headlight bezel and install the nuts.
2. Position the headlight assembly and connect the wires to the headlights.
3. Position the rear cover and install the five hex-head screws.
4. Close and latch the hood.
5. Connect the batteries.

Headlight Bezel Removal and Installation

6. Remove the chocks from the tires.

Headlight Bezel With Outside Fasteners

REMOVAL (See Fig. 2)



1. Retaining Screw
2. Headlight Attachment Ring
3. Headlight
4. Adjustment Screw and Nut
5. Headlight Adjustment Ring
6. Spring
7. Bezel
8. Nut
9. Screw

Fig. 2, Headlight Bezel With Outside Fasteners

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the batteries.
3. Remove the four screws holding the headlight bezel.
4. Disconnect the wires to the turn signal.
5. Remove the headlight bezel.

INSTALLATION (See Fig. 2)

1. Position the headlight bezel.
2. Connect the wires to the turn signal.
3. Install the four screws on the headlight bezel.
4. Connect the batteries.
5. Remove the chocks from the tires.

Headlight Aim Check and Adjustment

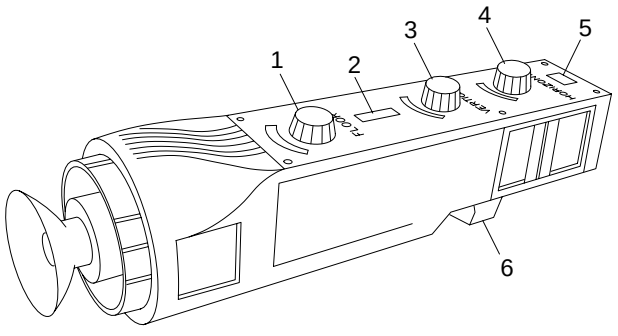
Before checking or adjusting the headlight aim, do the following:

- Remove large amounts of mud or ice from the undersides of the fenders.
- Check the springs for sagging or broken leaves. Check the suspension for proper functioning of the leveling mechanism.
- Clean the headlight lenses and aiming pads.
- Check the bulbs for burnout and broken aiming pads. Switch the beams from low to high to make sure they switch properly.
- With the vehicle unloaded, check that the tires are inflated to the recommended air pressure.

Check

For a quick check to see if the headlights need aiming, do the following procedure.

1. Move the vehicle onto a flat surface that has been calibrated for slope. Shut down the engine, set the parking brake, and chock the rear tires.
2. Attach a headlight aimer to each headlight. See **Fig. 1**.



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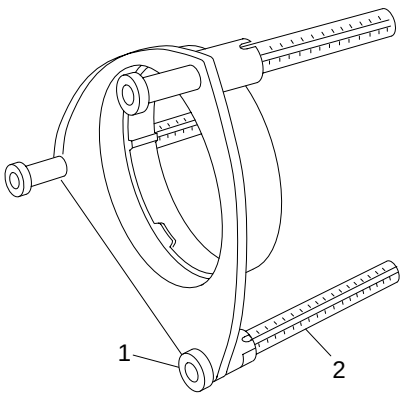
1. Floor Slope Dial
2. Level Vial
3. Vertical Dial
4. Horizontal Dial
5. Split Image View Port
6. Piston Handle

Fig. 1, Headlight Aimer

2.1 Attach the black universal adaptor to the aimer. Set the adjustment rods to "0" (zero). See **Fig. 2**.



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Set the adjustment rods to "0" (zero).

1. Adaptor Foot
2. Adjustment Rod

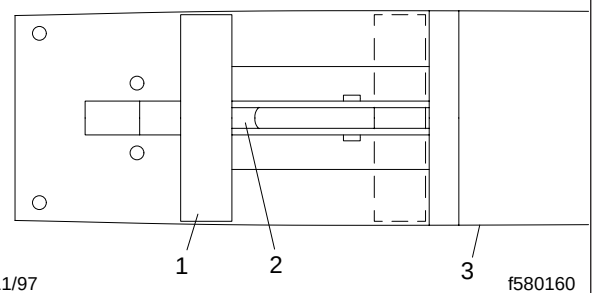
Fig. 2, Universal Adaptor

2.2 Align the adaptor with the aiming pads on the headlight lens.

2.3 Push the piston handle on the base of the aimer forward to engage the vacuum cup. Immediately pull the handle backward until it locks. See **Fig. 3**.

2.4 Do the same procedure with the other aimer.

3. Check the floor slope dial for the correct setting. See **Fig. 4**.



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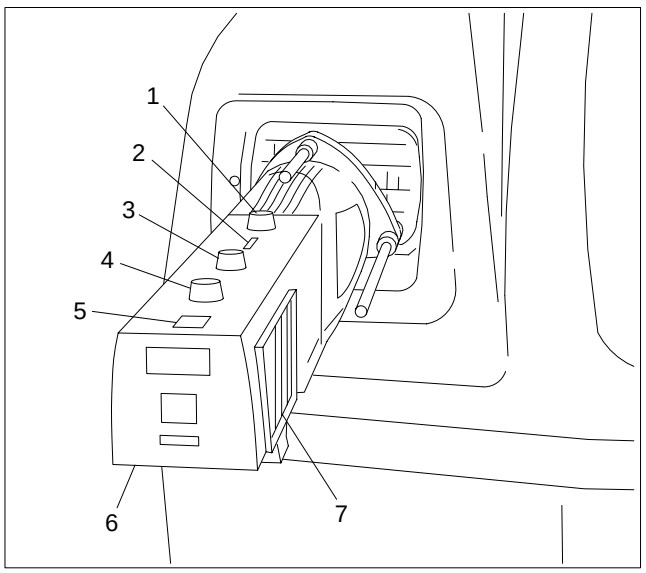
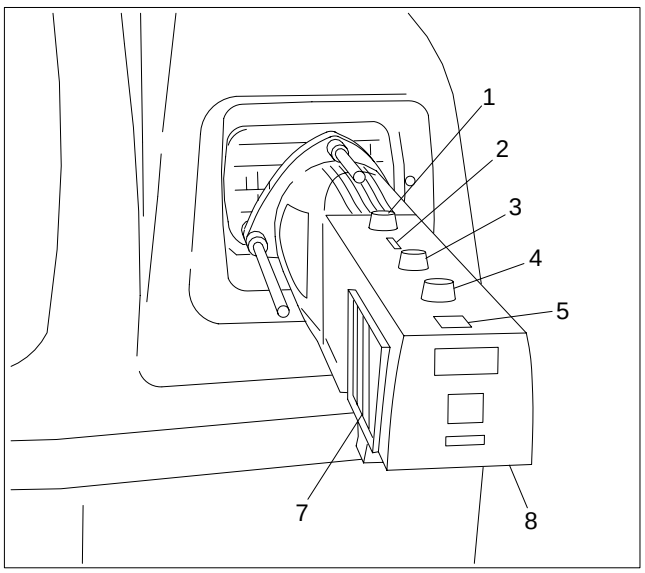
To attach, push the piston handle forward to engage the vacuum cup. Immediately pull the handle backward until it locks.
To remove, press the vacuum release button.

1. Piston Handle
2. Vacuum Release Button
3. Base of Aimer

Fig. 3, Aimer Attachment and Removal

Headlight Aim Check and Adjustment





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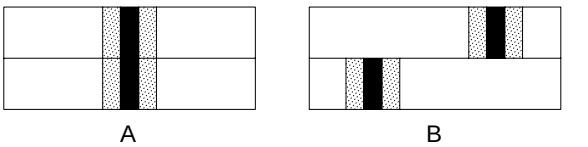
The sight openings must face each other.

1. Floor Slope Dial
2. Vertical Aim Level Vial
3. Vertical Dial
4. Horizontal Dial
5. Split Image View Port
6. Aimer (right-hand side)
7. Sight Opening
8. Aimer (left-hand side)

Fig. 4, Set-Up for Aiming

4. Check the horizontal aim. See **Fig. 5**.



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View through the split image view port.

A. Split Image Aligned
B. Split Image Not Aligned

Fig. 5, Horizontal Aim Split Image

4.1 Turn the horizontal dial until the split image is in alignment.

4.2 If the horizontal dial scale on either aimer reads more than "4," re-aim the headlight.

NOTE: If adjustment is required, see the procedures under "Adjustment" below.

5. Check the vertical aim. See **Fig. 6**.

5.1 Turn the vertical dial until the level vial is centered.

5.2 If the vertical dial scale on either aimer reads more than "4," re-aim the headlight.

NOTE: If adjustment is required, see the procedures under "Adjustment" below.

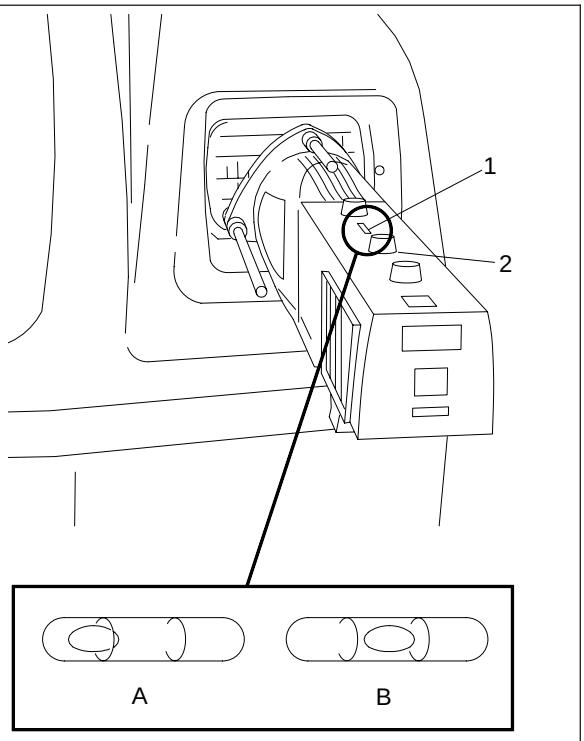
6. Remove the two headlight aimers. Hold each aimer securely, and then press the vacuum release button.

7. Remove the chocks from the rear tires.

Adjustment

If the headlights need adjusting, do this procedure.

1. If not already there, move the vehicle onto a flat surface that has been calibrated for slope. Shut down the engine, set the parking brake, and chock the rear tires.



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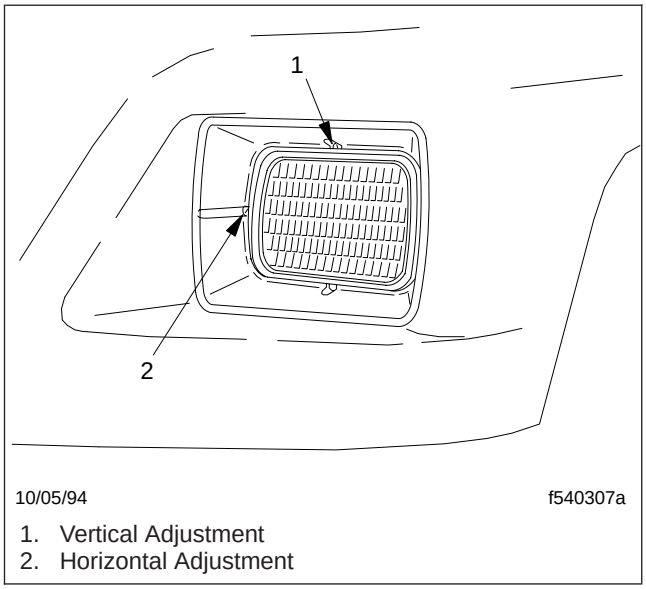
Set the vertical dial to "0" (zero).

A. Bubble Not Centered
B. Bubble Centered
1. Level Vial
2. Vertical Dial

Fig. 6, Vertical Aim Level Vial

2. Attach a headlight aimer to each headlight. See the procedures above under "Check" for detailed instructions.
3. Check the floor slope dial for the correct setting. See **Fig. 4**.
4. Adjust the horizontal aim. See **Fig. 5**.
   - 4.1 Set the horizontal dial to "0" (zero).
   - 4.2 Look in the viewing port for the split image target lines. If necessary, rotate either or both aimers until the lines are visible.
   - 4.3 Turn the horizontal adjustment screw as needed to make the split image appear as one solid line. See **Fig. 7**.

   IMPORTANT: To avoid backlash, make the final adjustment by turning the screw clockwise.



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1. Vertical Adjustment
2. Horizontal Adjustment

Fig. 7, Headlight Adjustment Screws

   - 4.4 Do the same procedure for the other headlight.
5. Adjust the vertical aim. See **Fig. 6**.
   - 5.1 Set the vertical dial to "0" (zero).
   - 5.2 Turn the vertical adjustment screw as needed to center the bubble in the level vial between the lines. See **Fig. 7**.

   IMPORTANT: To avoid backlash, make the final adjustment by turning the screw clockwise.

   - 5.3 Do the same procedure for the other headlight.
6. Recheck the horizontal alignment on both aimers. Readjust if necessary.
7. Remove both headlight aimers. While holding the aimer securely, press the vacuum release button. See **Fig. 3**.
8. Remove the chocks from the rear tires.

Troubleshooting

EXTERIOR AND INTERIOR LIGHTING

Problem—Both Headlamps Inoperative

Problem—Both Headlamps Inoperative	
Possible Cause	**Remedy**
Fuse	Check the supply voltage to the headlamp fuse. Measure the voltage between the power distribution box Fuse L (40 A) input terminal and ground. If the voltage is less than 10 volts, repair the fuse feed circuit. Test the system for normal operation. If the voltage is greater than 10 volts, check the headlamp switch input. Disconnect the headlamp switch connector harness connector. Measure the voltage between the headlamp switch connector C274 Pin B1, Circuit 37 (BK/Y) and ground. If the voltage is less than 10 volts, repair Circuit 37 (BK/Y). If blown, replace Fuse L (40 A). Test the system for normal operation. If the voltage is greater than 10 volts, check the headlamp switch output.
Headlamp switch	Reconnect the headlamp switch connector harness connector. Turn the headlamp switch to the full "On" position. Backprobe the switch and measure the voltage between the headlamp switch connector C274 Pin H, Circuit 15 (R/Y) and ground. If the voltage is less than 10 volts, replace the headlamp switch. Test the system for normal operation. If the voltage is greater than 10 volts, check the multi-function switch/windshield wiper control module input.
Multi-function switch	Disconnect the multi-function switch connector or the windshield wiper control module (Signal-Stat) connector harness connectors. Measure the voltage between the multi-function switch connector C252 Pin 2, Circuit 15 (R/Y) or at the windshield wiper control module (Signal-Stat) connector C244 Pin 13, Circuit 15 (R/Y) and ground. If the voltage is less than 10 volts, repair Circuit 15 (R/Y). Test the system for normal operation. If the voltage is greater than 10 volts, check the multi-function switch/windshield wiper control module input.
Circuitry open or shorted	While actuating the multi-function switch to the high and low positions, measure the voltage between Circuit 12 (GN/BK) and Circuit 13 (R/BK) by backprobing at the multi-function switch connector C252 or the windshield wiper control module (Signal-Stat) connector C244 and ground. If the voltage is less than 10 volts, replace the multi-function switch or the windshield wiper control module (Signal-Stat). Test the system for normal operation. If the voltage is greater than 10 volts, check the headlamp feed. Reconnect the multi-function switch connector or the windshield wiper control module (Signal-Stat) connector harness connectors. Disconnect the headlamp electrical connectors.
Ground connection	While actuating the multi-function switch to the high and low positions, measure the voltage at both headlamp connectors Circuit 12 (GN/BK) and Circuit 13 (R/BK) and ground. If the voltage is is less than 10 volts, repair Circuit 12 (GN/BK) or Circuit 13 (R/BK). Test the system for normal operation. If the voltage is greater than 10 volts, check headlamp grounds. Turn the headlamps off. Measure the resistance between the headlamp connectors Circuit 57 (BK) and ground. If the resistance is less than 5 ohms, replace the headlamp. Test the system for normal operation. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation.

Troubleshooting

Problem—One Low Beam Headlamp is Inoperative

Problem—One Low Beam Headlamp is Inoperative	
Possible Cause	**Remedy**
Headlamp bulb	Check the supply voltage to the inoperative headlamp. Turn the headlamp switch to the full "On" position. Disconnect the inoperative headlamp harness connector. Measure the voltage between the inoperative headlamp connector Circuit 13 (R/BK) and ground. If the voltage is less than 10 volts, repair Circuit 13 (R/BK). Test the system for normal operation. If the voltage is greater than 10 volts, check the headlamp ground. Measure the resistance between the inoperative headlamp connector Circuit 57 (BK) and ground. If the resistance is less than 5 ohms, replace the headlamp bulb. Test the system for normal operation. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation.
Bad ground connection	
Circuit open	

Problem—One High Beam Headlamp is Inoperative

Problem—One High Beam Headlamp is Inoperative	
Possible Cause	**Remedy**
Headlamp bulb	Check the supply voltage to the inoperative headlamp. Turn the headlamp switch to the full "On" position. Activate the high beam headlamps to the "On" position. Disconnect the inoperative headlamp harness connector. Measure the voltage between the inoperative headlamp connector Circuit 12 (GN/BK) and ground. If the voltage is less than 10 volts, repair Circuit 12 (GN/BK). Test the system for normal operation. If the voltage is greater than 10 volts, check the headlamp ground. Measure the resistance between the inoperative headlamp connector Circuit 57 (BK) and ground. If the resistance is less than 5 ohms, replace the headlamp or headlamp bulb. Test the system for normal operation. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation.
Bad ground connection	
Circuit open	

Problem—Headlamps Stay On Continuously

Problem—Headlamps Stay On Continuously	
Possible Cause	**Remedy**
Headlamp switch	Check the headlamp switch. Turn the headlamp switch to the "Off" position. Disconnect the multi-function switch, the windshield wiper control module (Signal-Stat) harness connectors. Measure the voltage between the multi-function switch connector C252 Pin 2, Circuit 15 (R/Y) or the windshield wiper control module (Signal-Stat) connector C244 Pin 13, Circuit 15 (R/Y) and ground.
Multi-function switch	If the voltage is less than 10 volts, repair Circuit 15 (R/Y). If OK, replace the headlamp switch. Test the system for normal operation. If the voltage is greater than 10 volts, check the multi-function switch/windshield wiper control module (Signal-Stat).
Circuitry shorted	Disconnect the multi-function switch, windshield wiper control module (Signal-Stat) harness connectors. If the headlamps are off, replace the multi-function switch (Sterling) or the windshield wiper control module (Signal-Stat). Test the system for normal operation. If the headlamps are still on, check and repair any defects found in Circuit 13 (R/BK) low beams and/or Circuit 12 (GN/BK) high beams. Test the system for normal operation.

Problem—Flash-to-Pass Inoperative (Signal-Stat)

Problem—Flash-to-Pass Inoperative (Signal-Stat)	
Possible Cause	**Remedy**
Fuse 36 (I/P fuse panel)	Check Circuit 575 (R/BK) for voltage. Disconnect the windshield wiper control module C244 harness connector. Measure the voltage between the windshield wiper control module connector C244 Pin 4, Circuit 575 (R/BK) and ground. If the voltage is less than 10 volts, repair Circuit 575 (R/BK). Test the system for normal operation. If the voltage is greater than 10 volts, check the multi-function switch.
Windshield wiper control module (Signal-Stat)	
Circuitry open	Disconnect the multi-function switch connector C247 harness connector. Measure the resistance between the multi-function switch terminals while holding the turn signal lever just before the high/low beam detent. If the resistance is greater than 5 ohms, replace the windshield wiper control module (Signal-Stat). Test the system for normal operation. If the resistance is less than 5 ohms, replace the multi-function switch (Signal-Stat). Test the system for normal operation.
Multi-function switch (Signal-Stat)	

Problem—Flash-to-Pass Inoperative

Problem—Flash-to-Pass Inoperative	
Possible Cause	**Remedy**
Multi-function switch	Verify that the headlamps are operating and the high/low beams are switching. If the headlamps operate, refer to "Headlamp Switch" in this section to verify the flash-to-pass feature. If the flash-to-pass is still inoperative, replace the multi-function switch.

Troubleshooting

Problem—Stoplamps are Inoperative

Problem—Stoplamps are Inoperative	
Possible Cause	**Remedy**
Stoplamp switch	Check supply voltage at the stoplamp switch. Measure the voltage between the stoplamp switch connector C266 or C265 Circuit 8 (O/Y) and ground. If the voltage is less than 10 volts, repair Circuit 8 (O/Y) or if blown, replace Fuse 42 (30 A). Test the system for normal operation. If the voltage is greater than 10 volts, check the stoplamp switch output. Measure the voltage by backprobing between the stoplamp switch connector Circuit 511 (GN) and ground while pressing the brake pedal. If the voltage is less than 10 volts, replace the stoplamp switch. Test the system for normal operation. If the voltage is greater than 5 volts, check the multi-function switch input.
Multi-function switch	Disconnect the multi-function switch connector harness connector. Measure the voltage between the multi-function switch connector C253 or C254 (Signal-Stat) Circuit 511 (GN) while pressing the brake pedal. If the voltage is less than 10 volts, repair Circuit 511 (GN). Test the system for normal operation. If the voltage is greater than 10 volts, check multi-function switch output.
Tail lamps	Reconnect the multi-function switch connector harness connector. Measure the voltage between the multi-function switch connector C253 or C254 (Signal-Stat) Circuits 282 (GN) right stoplamp or 283 (Y/BK) left stoplamp and ground while pressing the brake pedal. If the voltage is less than 10 volts, replace the multi-function switch. Test the system for normal operation. If the voltage is greater than 10 volts, check the stoplamp input.
Circuitry open or shorted	Disconnect the tail lamp connectors harness connector. Measure the voltage between the tail lamp connector C452 Circuit 282 (GN) right stoplamp or connector C450 Circuit 283 (Y/BK) left stoplamp while pressing the brake pedal. If the voltage is less than 10 volts, repair Circuit 282 (GN) or 283 (Y/BK). Test the system for normal operation. If the voltage is greater than 10 volts, check the tail lamp ground. Measure the resistance between the tail lamp connectors C452 and C450 Circuit 57 (BK) and ground. If the resistance is less than 5 ohms, replace the bulb. Test the system for normal operation. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation.

Problem—Stoplamps are On Continuously

Problem—Stoplamps are On Continuously	
Possible Cause	**Remedy**
Stoplamp switch	Check the stoplamp switch. Disconnect the stoplamp switch harness connector. If the stoplamps stay on, replace the stoplamp switch. Test the system for normal operation. If the stoplamps turn off, check Circuit 511 (GN).
Multi-function switch	Measure the voltage between the multi-function switch connector C253 or C254 (Signal-Stat) Circuit 511 (GN) and ground. If battery voltage is present, repair Circuit 511 (GN). Test the system for normal operation. If battery voltage is not present, check the multi-function switch.
Circuitry open or shorted	Disconnect the multi-function switch harness connector. If the stoplamps turn off replace the multi-function switch. Test the system for normal operation. If the stoplamps remain on, repair Circuit 282 (GN) right stoplamp or Circuit 283 (Y/BK). Test the system for normal operation.

Problem—Turn Signal Lamps are Inoperative

Problem—Turn Signal Lamps are Inoperative	
Possible Cause	**Remedy**
Multi-function switch	Check the turn signal flasher. Replace the electronic flasher. If the system operates properly with a new electronic flasher, test the system for normal operation. If the system does not operate properly, check the flasher supply voltage. Disconnect the electronic flasher connector harness connector. Measure the voltage between the electronic flasher connector C2033 Circuit 8 (O/Y) and ground. If the voltage is less than 10 volts, repair Circuit 8 (O/Y). Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 44 (BL). Disconnect the multi-function switch connector harness connector. Measure the resistance between the electronic flasher connector C2033 Circuit 44 (BL) and the multi-function switch connector C253 or C254 (Signal-Stat) Circuit 44 (BL). If the resistance is less than 5 ohms, repair Circuit 44 (BL). Test the system for normal operation. If the resistance is greater than 5 ohms, check the electronic flasher ground.
Turn signal flasher	Measure the resistance between the electronic flasher connector C2033 Circuit 57 (BK) and ground. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check for voltage at the left-hand bulb sockets. Reconnect the multi-function switch connector and the electronic flasher connector harness connectors. Turn the ignition switch to the "On" position. Turn the multi-function switch in the left turn position. Measure the voltage between the left-hand front turn signal lamp connector C152 Circuit 3 (GN/W) and ground, and the left-hand rear turn signal connector C452 Circuit 283 (Y/BK) and ground. If the voltage does not modulate between less than 1 volt and greater than 10 volts on each circuit, repair the affected circuit(s) between the multi-function switch and the bulb socket. If OK, replace the multi-function switch. Test the system for normal operation. If the voltage modulates between less than 1 volt and greater than 10 volts on each circuit, check for voltage at the right-hand bulb sockets. Turn the multi-function switch in the right turn position.
Circuitry open or shorted	Measure the voltage between the right-hand front turn signal lamp connector C140 Circuit 2 (W/BL) and ground, and the right-hand rear turn signal lamp connector C450 Circuit 282 (GN) and ground. If the voltage does not modulate between less than 1 volt and greater than 10 volts on each circuit, repair the affected circuit(s) between the multi-function switch and the bulb socket. If OK, replace the multi-function switch. Test the system for normal operation. If the voltage modulates between less than 1 volt and greater than 10 volts on each circuit, check the ground circuit. Measure the resistance between each of the turn signal connectors Circuit 57 (BK) and ground. If the resistance is less than 5 ohms at each turn signal lamp connector, replace the bulb(s). Test the system for normal operation. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation.

Troubleshooting

Problem—Hazard Flasher Lamps are Inoperative

Problem—Hazard Flasher Lamps are Inoperative	
Possible Cause	**Remedy**
Multi-function switch	Check the turn signal operation. If the turn signals operate properly, replace the multi-function switch. Test system for normal operation. If the turn signals do not operate properly, check the turn signal flasher. Replace the electronic flasher. If the system operates properly with a new electronic flasher, test the system for normal operation. If the system does not operate properly, check the flasher supply voltage. Disconnect the electronic flasher connector harness connector. Measure the voltage between the electronic flasher connector C2033 Circuit 8 (O/Y) and ground. If the voltage is less than 10 volts, repair Circuit 8 (O/Y). Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 44 (BL).
Turn signal flasher	Disconnect the multi-function switch connector harness connector. Measure the resistance between the electronic flasher connector C2033 Circuit 44 (BL) and the multi-function switch connector C253 or C254 (Signal-Stat) Circuit 44 (BL). If the resistance is less than 5 ohms, repair Circuit 44 (BL). Test the system for normal operation. If the resistance is greater than 5 ohms, check the electronic flasher ground. Measure the resistance between the electronic flasher connector C2033 Circuit 57 (BK) and ground. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check for voltage at the left-hand bulb sockets.
Circuitry open or shorted	Reconnect the multi-function switch connector and the electronic flasher connector harness connectors. Turn the ignition switch to the "On" position. Turn the multi-function switch in the left turn position. Measure the voltage between the left-hand front turn signal lamp connector C152 Circuit 3 (GN/W) and ground, and the left-hand rear turn signal connector C452 Circuit 283 (Y/BK) and ground. If the voltage does not modulate between less than 1 volt and greater than 10 volts on each circuit, repair the affected circuit(s) between the multi-function switch and the bulb socket. If OK, replace the multi-function switch. Test the system for normal operation. If the voltage modulates between less than 1 volt and greater than 10 volts on each circuit, check for voltage at the right-hand bulb sockets. Turn the multi-function switch in the right turn position.
Multi-function switch	Measure the voltage between the right-hand front turn signal lamp connector C140 Circuit 2 (W/BL) and ground, and the right-hand rear turn signal lamp connector C450 Circuit 282 (GN) and ground.
Turn signal flasher	If the voltage does not modulate between less than 1 volt and greater than 10 volts on each circuit, repair the affected circuit(s) between the multi-function switch and the bulb socket. If OK, replace the multi-function switch. Test the system for normal operation. If the voltage modulates between less than 1 volt and greater than 10 volts on each circuit, check the ground circuit. Measure the resistance between each of the turn signal connectors Circuit 57 (BK) and ground.
Circuitry open or shorted	If the resistance is less more than 5 ohms at each turn signal lamp connector, replace the bulb(s). Test the system for normal operation. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation.

Problem—Parking Lamps are Inoperative

Problem—Parking Lamps are Inoperative	
Possible Cause	**Remedy**
Fuse	Check the headlamp switch input. Disconnect the headlamp switch connector harness connector. Measure the voltage between the headlamp switch connector C274 Circuits 37 (BK/Y), 873 (W/BK) and ground. If the voltage is less than 10 volts, repair Circuit 37 (BK/Y) or 873 (W/BK). If OK, replace the power distribution box Fuse L (40 A) or the IP fuse junction panel Fuse 37 (15 A). Test the system for normal operation. If the voltage is greater than 10 volts, check the headlamp switch output.
Headlamp switch	Reconnect the headlamp switch connector harness connector. Turn the headlamp switch to the "Park" position. Measure the voltage between the headlamp switch connector C274 Circuit 11 (BK/Y) and ground. If the voltage is less than 10 volts, replace the headlamp switch. Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 11 (BK/Y).
Circuitry open or shorted	Measure the voltage of each parking lamp connector Circuit 11 (BK/Y) and ground. If the voltage at any of the connectors is less than 10 volts, repair Circuit 11 (BK/Y). Test the system for normal operation. If the voltage at the connectors is greater than 10 volts, check the ground circuit. Measure the resistance between each parking lamp connector Circuit 57 (BK) and ground. If the resistance is less than 5 ohms, replace the bulb(s). Test the system for normal operation. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation.

Problem—Parking Lamps are On Continuously

Problem—Parking Lamps are On Continuously	
Possible Cause	**Remedy**
Headlamp switch	Check the headlamp switch. Disconnect the headlamp switch harness connector. If the parking lamps turn off, replace the headlamp switch. Test the system for normal operation.
Circuitry open or shorted	If the parking lamps do not turn off, repair Circuit 11 (BK/Y). Test the system for normal operation.

Troubleshooting

Problem—Fog Lamps are Inoperative

Problem—Fog Lamps are Inoperative	
Possible Cause	**Remedy**
Fuses	Check Fuse 39 supply voltage. Turn the headlamps to the full "On" position. Measure the voltage between the load side of IP Fuse 39 (10 A) and ground. If the voltage is less than 10 volts, repair Circuit 15 (R/Y). If blown, replace IP fuse panel Fuse 39 (10 A) and repair Circuit 477 (BL/BK). Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 477 (BL/BK). Disconnect the fog lamp relay harness connector. Measure the resistance between the load side of Fuse 39 (10 A) and the fog lamp relay connector C2031 Pin 30, Circuit 477 (BL/BK). If the resistance is greater than 5 ohms, repair Circuit 477 (BL/BK). Test the system for normal operation. If the resistance is less than 5 ohms, check the fog lamp relay coil feed.
Headlamp switch	Turn the headlamps to the full "On" position. Actuate the multi-function switch to the "LO Beam" position with vehicles equipped with DRL or the "HIGH beam" position with vehicles equipped without DRL. Measure the voltage between the fog lamp relay connector C2031 Pin 85, Circuit 12 (GN/BK) without DRL, Circuit 41 (BK/Y) with US DRL, or Circuit 13 (R/BK) with Canadian DRL and ground. If the voltage is less than 10 volts, repair Circuit 12 (GN/BK), 41 (BK/Y), or 13 (R/BK). Test the system for normal operation. If the voltage is greater than 10 volts, check the fog lamp relay ground.
Fog lamp relay	Measure the resistance between the fog lamp relay connector C2031 Pin 86, Circuit 57 (BK) and ground. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, perform the "Relay Component Test" in this section. Check the relay switch feed circuit. Measure the resistance between the fog lamp relay connector C2031 Pin 87, Circuit 477 (BL/BK) and the fog lamp switch connector C2019 Pin 2, Circuit 477 (BL/BK). If the resistance is greater than 5 ohms, repair Circuit 477 (BL/BK). Test the system for normal operation. If the resistance is less than 5 ohms, check the fog lamp switch.
Fog lamp switch	Turn the fog lamp switch to the "On" position. Measure the resistance between the fog lamp switch Terminals 2 and 3. If the resistance is greater than 5 ohms, replace the fog lamp switch. Test the system for normal operation. If the resistance is less than 5 ohms, check the fog lamp feed circuit. Measure the resistance between the fog lamp switch connector C2019 Pin 3, Circuit 478 (GY) and the fog lamp connectors C1017 and C1016 Circuit 478 (GY). If the resistance is greater than 5 ohms, repair Circuit 478 (GY). Test the system for normal operation. If the resistance is less than 5 ohms, check the fog lamp ground.
Circuitry open or shorted	Measure the resistance between the fog lamp connectors C1017 and C1016 Circuit 57 (BK) and ground. If the resistance is less than 5 ohms, replace the bulb(s). Test the system for normal operation. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation.

Problem—Fog Lamps are On Continuously

Problem—Fog Lamps are On Continuously	
Possible Cause	**Remedy**
Circuitry shorted	Check the fog lamp switch. Disconnect the fog lamp switch connector. If the fog lamps turn off, replace the fog lamp switch. Test the system for normal operation. If the fog lamps do not turn off, repair Circuit 57 (BK). Test the system for normal operation.
Fog lamp switch	
Fog lamp relay	

Problem—Backup Lamps are Inoperative

Problem—Backup Lamps are Inoperative	
Possible Cause	**Remedy**
Backup lamp switch	Check the fuse feed circuit. Turn the ignition switch to the "Off" position. Disconnect the IP fuse junction panel Fuse 10 (10 A) harness connector. Turn the ignition switch to the "On" position. Measure the voltage between the IP fuse junction panel Fuse 10 (10 A) fuse feed circuit and ground. If the voltage is less than 10 volts, repair fuse feed circuit. Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 138 (W/P) for an open. Turn the ignition switch to the "Off" position. Reconnect the IP fuse junction panel Fuse 10 (10 A) harness connector. Disconnect the backup lamp switch connector harness connector. Turn the ignition switch to the "On" position. Measure the voltage between the backup lamp switch connector C121 (manual transmission) or connector C116 (automatic transmission), Circuit 138 (W/P) and ground. If the voltage is less than 10 volts, repair Circuit 138 (W/P). Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 140 (BK/R). Turn the ignition switch to the "Off" position. Disconnect the right rear combination lamp connector or backup lamp connector. Connect a jumper wire between the backup lamp switch connector C121 (manual transmission) or connectors C116 and C114 (automatic transmission). Turn the ignition switch to the "On" position. Measure the voltage between the right rear combination lamp connector C404 or the backup lamp connector C451, Circuit 140 (BK/R) and ground. If the voltage is less than 10 volts, repair Circuit 140 (BK/R). Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 57 (BK). Turn the ignition switch to the "Off" position. Measure the resistance between the right rear combination lamp connector C404 or the backup lamp connector C451, Circuit 57 (BK) and ground. If the resistance is less than 5 ohms, replace the backup lamp switch. Test the system for normal operation. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation.
Circuitry open or shorted	
Backup lamp	

Troubleshooting

Problem—Backup Lamps are Inoperative (Allison Electronic Transmissions Only)

Problem—Backup Lamps are Inoperative (Allison Electronic Transmissions Only)	
Possible Cause	**Remedy**
Backup lamp switch	Check the fuse feed circuit. Turn the ignition to the "Off" position. Disconnect the IP fuse junction panel Fuse 10 (10 A) harness connector. Turn the ignition switch to the "On" position. Measure the voltage between the IP fuse junction panel Fuse 10 (10 A) fuse feed circuit and ground. If the voltage is less than 10 volts, repair the fuse feed circuit. Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 138 (W/P) for an open. Turn the ignition switch to the "Off" position. Reconnect the IP fuse junction panel Fuse 10 (10 A) harness connector. Disconnect the vehicle interface module connector harness connector. Turn the ignition switch to the "On" position. Measure the voltage between the vehicle interface module connector C3006 Pin B1, Circuit 138 (W/P) and ground. If the voltage is less than 10 volts, repair Circuit 138 (W/P). Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 140 (BK/R). Turn the ignition switch to the "Off" position. Disconnect the right rear combination lamp connector or backup lamp connector harness connectors. Measure the resistance between the vehicle interface module connector C3006 Pin A1, Circuit 140 (BK/R) and the right rear combination lamp connector C404 or the backup lamp connector C451 Circuit 140 (BK/R). If the resistance is greater than 5 ohms, repair Circuit 140 (BK/R). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 57 (BK). Measure the resistance between the right rear combination lamp connector C404 or the backup lamp connector C451, Circuit 57 (BK) and ground. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, replace the vehicle interface module. Test the system for normal operation.
Circuitry open or shorted	
Backup lamp	

Problem—Individual Backup Lamps is Inoperative

Problem—Individual Backup Lamps is Inoperative	
Possible Cause	**Remedy**
Circuitry open or shorted	Check Circuit 140 (BK/R) for an open. Turn the ignition switch to the "Off" position. Disconnect the inoperative backup lamp connector. Place the transmission selector in reverse. Turn the ignition switch to the "On" position. Measure the voltage between the inoperative backup lamp connector Circuit 140 (BK/R) and ground. If the voltage is less than 10 volts, repair Circuit 140 (BK/R). Test the system for normal operation. If the resistance is greater than 10 volts, check Circuit 57 (BK) for an open. Turn the ignition switch to the "Off" position. Measure the resistance between the inoperative backup lamp connector Circuit 57 (BK) and ground. If the resistance is less than 5 ohms, replace the backup lamp bulb. Test the system for normal operation. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation.
Defective backup lamp	

Problem—Backup Lamps are On Continuously

Problem—Backup Lamps are On Continuously	
Possible Cause	**Remedy**
Circuitry shorted	Check Circuit 140 (BK/R) for a short to battery. Turn the ignition switch to the "Off" position. Make sure the gear selector is in "Park" or "Neutral". Disconnect the backup lamp switch connector, or the vehicle interface module (Allison electronic transmission) connector harness connector. Observe the backup lamps. If the backup lamps are on, repair Circuit 140 (BK/R). Test the system for normal operation. If the backup lamps do not operate, replace the backup lamp switch or if equipped with a vehicle interface module, replace the vehicle interface module. Test the system for normal operation.

Troubleshooting

Problem—Trailer Lamps are Inoperative (Stoplamps)

Problem—Trailer Lamps are Inoperative (Stoplamps)	
Possible Cause	**Remedy**
Circuitry shorted	Check Circuit 8 (O/Y). Measure the voltage between the stoplamp switch connector C265 or C266 Circuit 8 (O/Y) and ground. If the voltage is less than 10 volts, repair Circuit 8 (O/Y). Test the system for normal operation. If the voltage is greater than 10 volts, check the stoplamp switch. Reconnect the stoplamp switch connector harness connector. Measure the voltage by backprobing between the stoplamp switch connector C265 or C266 Circuit 511 (GN) and ground while holding the brake pedal down. If the voltage is less than 10 volts, replace the stoplamp switch. Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 511 (GN).
Trailer stoplamp relay	Disconnect the stoplamp low-pressure operating switch connector harness connector. Measure the voltage between the stoplamps low-pressure operating switch connector C267 Circuit 511 (GN) and ground while holding the brake pedal down. If the voltage is less than 10 volts, repair Circuit 511 (GN). Test the system for normal operation. If the voltage is greater than 10 volts, check the stoplamp low-pressure operating switch. Reconnect the stoplamp low-pressure operating switch connector harness connector. Measure the voltage by backprobing between the stoplamp low-pressure operating switch connector C267 Circuit 810 (R/BK) and ground while pressing the brake pedal down. If the voltage is less than 10 volts, replace the stoplamp low-pressure operating switch. Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 810 (R/BK).
Stoplight low-pressure operating switch	Disconnect the trailer stoplamp relay connector. Measure the voltage between the trailer stoplamp relay connector C187 Pin 85, Circuit 810 (R/BK) and ground while pressing the brake pedal down. If the voltage is less than 10 volts, repair Circuit 810 (R/BK). Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 37 (BK/Y). Measure the voltage between the trailer stoplamp relay connector C187 Pin 30, Circuit 37 (BK/Y) and ground while pressing the brake pedal down. If the voltage is less than 10 volts, repair Circuit 37 (BK/Y). Test the system for normal operation. If the voltage is greater than 10 volts, check the relay ground. Measure the resistance between the trailer stoplamp relay connector C187 Pin 86, Circuit 57 (BK) and ground. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check the trailer stoplamp relay.
Stoplight switches	Measure the voltage between the trailer stoplamp relay connector C187 Pin 87, Circuit 810 (R/BK) and ground while pressing the brake pedal down. If the voltage is less than 10 volts, replace the trailer stoplamp relay. Test the system for normal operation. If the voltage is greater than 10 volts, check the trailer stoplamp feed. Measure the voltage between the trailer tow connector C193 Pin U, Circuit 810 (R/BK) and ground while pressing the brake pedal down. If the voltage is less than 10 volts, repair the trailer wiring. Test the system for normal operation. If the voltage is greater than 10 volts, repair Circuit 810 (R/BK). Test the system for normal operation.

Problem—Trailer Lamps are Inoperative (Turn Signal/Hazard/Parklamps)

Problem—Trailer Lamps are Inoperative (Turn Signal/Hazard/Parklamps)	
Possible Cause	**Remedy**
Multi-function switch Circuitry Trailer right-hand and left-hand turn keys Turn signal flasher Trailer parklamp relay Headlamp switch	Check Circuit 8 (O/Y). Disconnect the electronic flasher harness connector. Measure the voltage between the electronic flasher connector C2033 Circuit 8 (O/Y) and ground. If the voltage is less than 10 volts, repair Circuit 8 (O/Y). Test the system for normal operation. If the voltage is greater than 10 volts check the turn signal flasher. Turn the ignition switch to the "On" position. Turn the multi-function switch to the right or left position. Measure the voltage between the turn signal flasher connector C2033 Circuit 44 (BL) and ground. If the voltage is greater than 10 volts, check the flasher ground. Disconnect the turn signal flasher harness connector. Measure the resistance between the turn signal flasher connector C2033 Circuit 57 (BK) and ground. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, replace the turn signal flasher. Test the system for normal operation. If the voltage between the flasher connector C2033 and ground is less than 10 volts, measure the voltage between the multi-function switch connector C253 Circuit 44 (BL) or C254 (Signal-Stat) Circuit 44 (BL) and ground. If the voltage is less than 10 volts, repair Circuit 44 (BL). Test the system for normal operation. If the voltage is greater than 10 volts, check the multi-function switch. Turn the multi-function switch to the left position. Measure the voltage between the multi-function switch connector C253 Circuit 3 (GN/W) or C254 (Signal-Stat) Circuit 3 (GN/W) and ground. Turn the multi-function switch to the right position. Measure the voltage between the multi-function switch connector C253 Circuit 2 (W/BL) or C254 (Signal-Stat) Circuit 2 (W/BL) and ground. If the voltage is less than 10 volts, replace the multi-function switch. Test the system for normal operation. If the voltage is greater than 10 volts, check the relay feeds. Disconnect the trailer turn lamp relays harness connector. Turn the multi-function switch to the right or left position. Measure the voltage between the right or left trailer turn lamp relay connector C183 Pin 85 or connector C184 Pin 85 and ground. If the voltage is less than 10 volts, repair Circuit 2 (W/BL) or Circuit 3 (GN/W). Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 37 (BK/Y). Measure the voltage between the trailer turn lamp relay connector C184 Pin 30 or C183 Pin 30 and ground. If the voltage is less than 10 volts, repair Circuit 37 (BK/Y). Test the system for normal operation. If the voltage is greater than 10 volts, check the relay grounds. Measure the resistance between the right or left trailer lamp relay connector C183 Pin 86 or C184 Pin 86 and ground. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, perform the "Relay Component Test" in this section. Check the trailer turn lamp feeds. Turn the multi-function switch to the right or left position. Measure the voltage between the trailer tow connector C193 Pin V and Pin Z and ground. If the voltage is greater than 10 volts, repair the trailer wiring. Test the system for normal operation. If the voltage is less than 10 volts, repair Circuit 283 (Y/BK) or Circuit 282 (GN). Test the system for normal operation.

Troubleshooting

Problem—Trailer Lamps are Continuously On (Stoplamps)

Problem—Trailer Lamps are Continuously On (Stoplamps)	
Possible Cause	**Remedy**
Circuitry	Check the relay Input. Disconnect the trailer stoplamp relay harness connector. Measure the voltage between the trailer stoplamp relay connector C187 Pin 85, Circuit 810 (R/BK) and ground. If the voltage is less than 10 volts, replace the trailer stoplamp relay. Test the system for normal operation.
Trailer stoplamp relay	If the truck is a tractor, check the stoplamp low-pressure switch. Measure the voltage between the stoplamp and the low-pressure operating switch connector C267 Circuit 810 (R/BK) and ground. If the voltage is less than 10 volts, repair Circuit 810 (R/BK). Test the system for normal operation. If the voltage is greater than 10 volts, check the brake system air pressure. If the system air pressure is within an acceptable range (90 to 120 psi [621 to 827 kPa]), replace the stoplamp low-pressure operating switch. Test the system for normal operation. If the brake system air pressure is not within an acceptable range, repair the air system problem. Test the system for normal operation. Then, retest the stoplamp low-pressure operating switch.
Stoplight low-pressure operating switch	
Stoplight switches	Check the stoplamp switches. Measure the voltage between the stoplamp switch connector C265 Circuit 511 (GN), C266 Circuit 511 (GN) and ground. If the voltage is less than 10 volts, replace the stoplamp switch. Test the system for normal operation. If the voltage is greater than 10 volts, check and repair Circuit 511 (GN) or Circuit 810 (R/BK). Test the system for normal operation.

Relay Component Test

Use the following procedure to test an ISO relay.

1. Locate and remove the ISO relay in the instrument panel fuse junction panel.
2. Using two No. 10 (or larger gauge) jumper wires, connect relay Terminals 86 and 30 directly to the positive battery terminal. See **Fig. 1**.

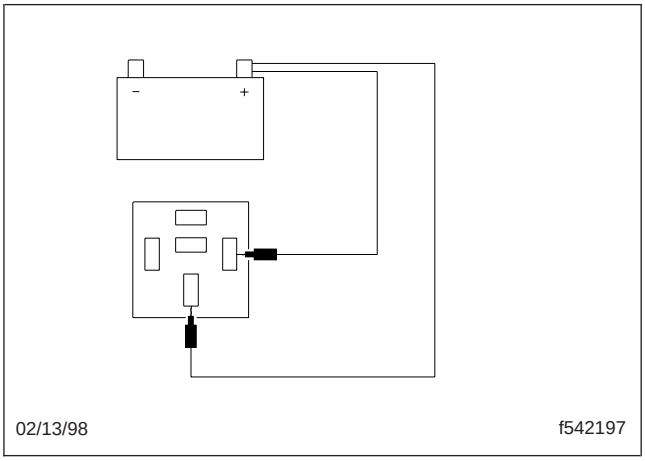

Fig. 1, Relay Terminals 86 & 30

3. Connect a volts, meter to Terminal 87a. Ten volts, or greater should be present. If 10 volts, or greater is not present, replace the relay. If 10 volts, or greater is present, continue with this test. See **Fig. 2**.

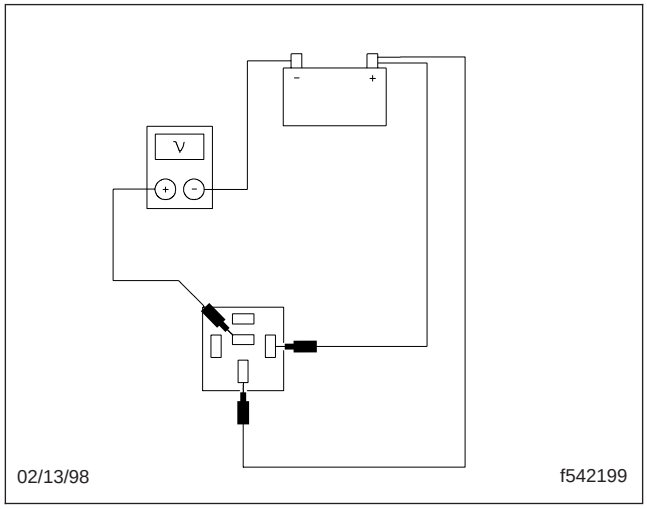

Fig. 2, Terminal 87A

4. Connect a third jumper wire to Terminal 85 and chassis ground. See **Fig. 3**.

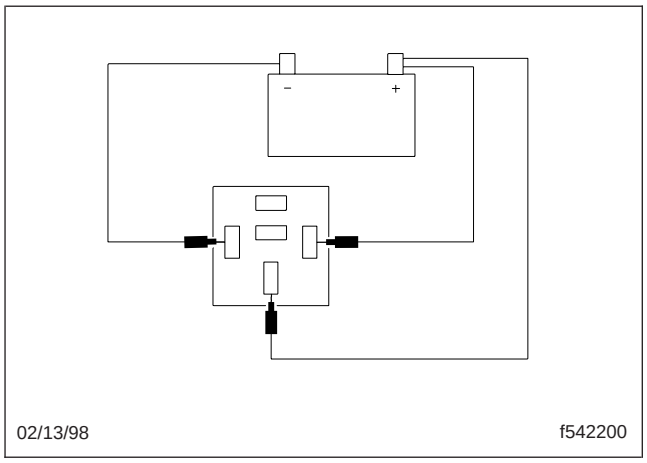

Fig. 3, Terminal 85

5. Check for voltage at Terminal 87. Ten volts, or greater should be present. If 10 volts, or greater is not present, replace the relay. See **Fig. 4**.

Interior Lighting System

1. Verify the vehicle owner's original concern by operating the courtesy lamps to duplicate the vehicle owner's concern.
2. Inspect to determine if one of the following mechanical or electrical concerns applies:

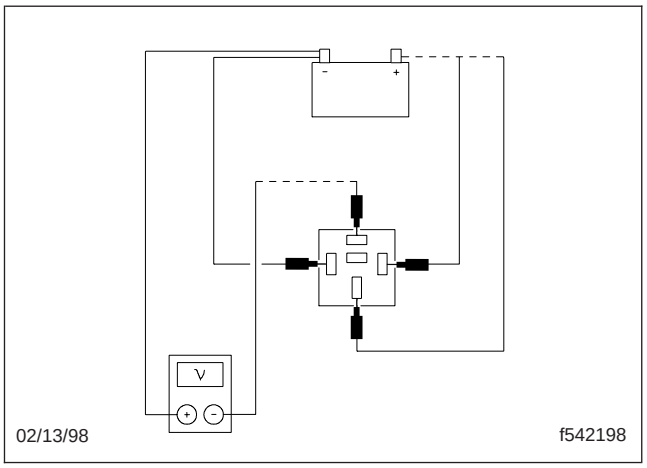

Fig. 4, Terminal 87

Visual Inspection Chart	
Mechanical	**Electrical**
Damaged lamp switch (courtesy)	IP fuse panel fuse
	Damaged bulbs
Stuck lamp switch (courtesy)	Circuitry open/shorted
	Connectors damaged/ corroded

Table 1, Visual Inspection Chart

Troubleshooting

Problem—Courtesy Lamps are Inoperative

Problem—Courtesy Lamps are Inoperative	
Possible Cause	**Remedy**
Blown fuses	Check the supply voltage at the dome lamp and IP dimmer switch. Turn the ignition to "Off" position. Measure the voltage between the dome lamp and IP dimmer switch connector Circuit 40 (BL/W) and ground. If the voltage is less than 10 volts, repair Circuit 40 (BL/W). replace the IP fuse 13 (15 A) if blown. Test the system for normal operation. If the voltage is greater than 10 volts, check the dome lamp IP dimmer switch output. Turn the dome lamps on with the dome lamp and IP dimmer switch. Measure the voltage between the dimmer witch connector Circuit 53 (BK/BL) and ground. If the voltage is less than 10 volts, replace the dome lamp and IP dimmer switch. Test the system for normal operation. If the voltage is greater than 10 volts, check the supply voltage at the courtesy lamp switches.
Open in circuitry	Disconnect the courtesy lamp switches. Measure the resistance between Circuit 54 (GN/Y) at each lamp switch and ground. If the voltage is less than 10 volts, at each lamp switch, repair circuit 54 (GN/Y) at the lamp switch. Replace the IP Fuse 31 (15 A) if blown. Test the system for normal operation. If the voltage is greater than 10 volts at each lamp switch, check the lamp switches. Measure the resistance between terminals on each lamp switch. If the resistance is less than 5 ohms, replace the lamp switch. Test the system for normal operation. If the resistance is greater than 5 ohms at any switch, check Circuit 53 (BK/BL).
Damaged courtesy lamp switches	Disconnect the dome lamp and IP dimmer switch. Measure the resistance between the dome lamp and IP dimmer switch connector Circuit 53 (BK/BL) and each courtesy lamp connector Circuit 53 (BK/BL). If the resistance is greater than 5 ohms, repair Circuit 53 (BK/BL). Test the system for normal operation. If the resistance is less than 5 ohms, check the courtesy lamp grounds. Measure the resistance between each courtesy lamp connector Circuit 57 (BK) and ground. If the resistance is less than 5 ohms, replace the bulb. Test the system for normal operation. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation.

Problem—Courtesy Lamps Stay On Continuously

Problem—Courtesy Lamps Stay On Continuously	
Possible Cause	**Remedy**
Short to power	Check Circuit 53 (BK/BL) for a short. Remove the IP fuse panel Fuses 13 (15 A) and 31 (15 A). If the courtesy lamps do not turn off, repair Circuit 53 (BK/BL). Test the system for normal operation. If the lamps turn off, check the courtesy lamp switches.
Damaged courtesy lamp switches	Depress each lamp switch to the closed-door position. Measure the resistance of each lamp switch. If the resistance is greater than 10,000 ohms, replace the dome lamp and IP dimmer switch. Test the system for normal operation. If the resistance is less than 10,000 ohms, replace the courtesy lamp switch. Test the system for normal operation.

Problem—Map Illumination Lamp is Inoperative

Problem—Map Illumination Lamp is Inoperative	
Possible Cause	**Remedy**
Blown fuses	Check for power to the map lamps. Disconnect the dome/map lamp connector. Measure the voltage between the lamp connector Circuit 54 (GN/Y) and ground. If the voltage is less than 10 volts, repair Circuit 54 (GN/Y). Replace the IP fuse 31 (15 A) if blown. Test the system for normal operation. If the voltage is greater than 10 volts, turn the dome lamp and IP dimmer switch to the "On" position for dome lamp activation. Measure the voltage between the dome lamp connector Circuit 53 (BK/BL) and ground. If the voltage is less than 10 volts, repair Circuit 53 (BK/BL). Test the system for normal operation. If the voltage is greater than 10 volts, check the map lamp ground. Measure the resistance between the lamp connector Circuit 57 (BK) and ground. If the resistance is less than 5 ohms, replace the bulb. Test the system for normal operation. If the resistance is greater than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation.
Open in circuitry	
Damaged courtesy lamp switches	

Specifications

See **Fig. 1** for a full view of the headlights wiring.

See **Fig. 2** for a full view of the back-up light wiring.

See **Fig. 3** for a full view of the trailer hook-up light wiring.

See **Fig. 4** for a full view of the interior lighting wiring.

See **Fig. 5** for a full view of the road and fog lights wiring.

See **Fig. 6** for a full view of the marker lights wiring.

See **Fig. 7** for a full view of the taillights wiring.

See **Fig. 8** for a full view of the Signal-Stat turn signal wiring.

See **Fig. 9** and **Fig. 10** for partial views of the Signal-Stat turn signal wiring.

See **Fig. 11** for a full view of the United Technologies turn signal wiring.

See **Fig. 12** and **Fig. 13** for partial views of the United Technologies turn signal wiring.

Specifications

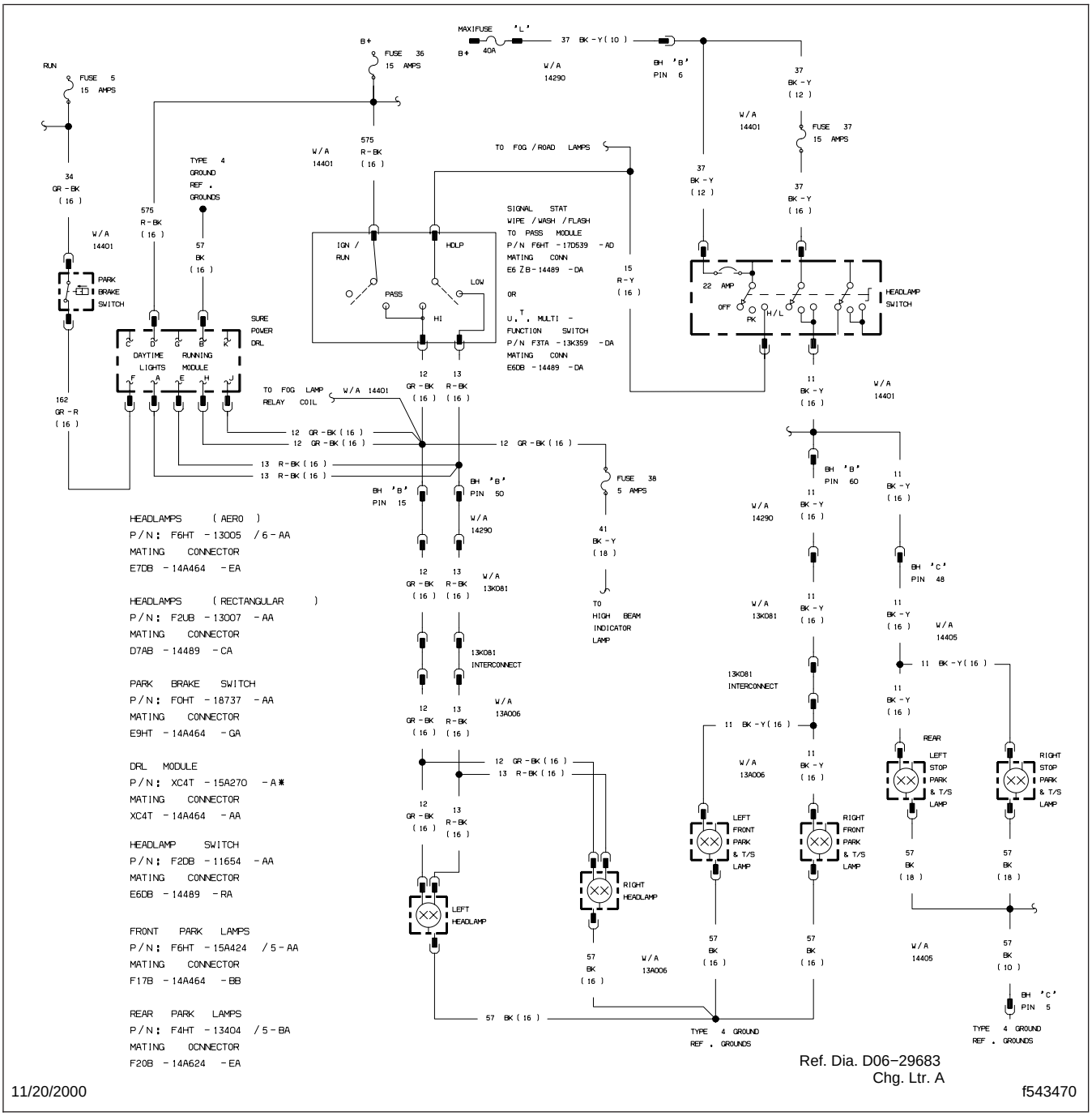

Fig. 1, Headlights Wiring (full view)

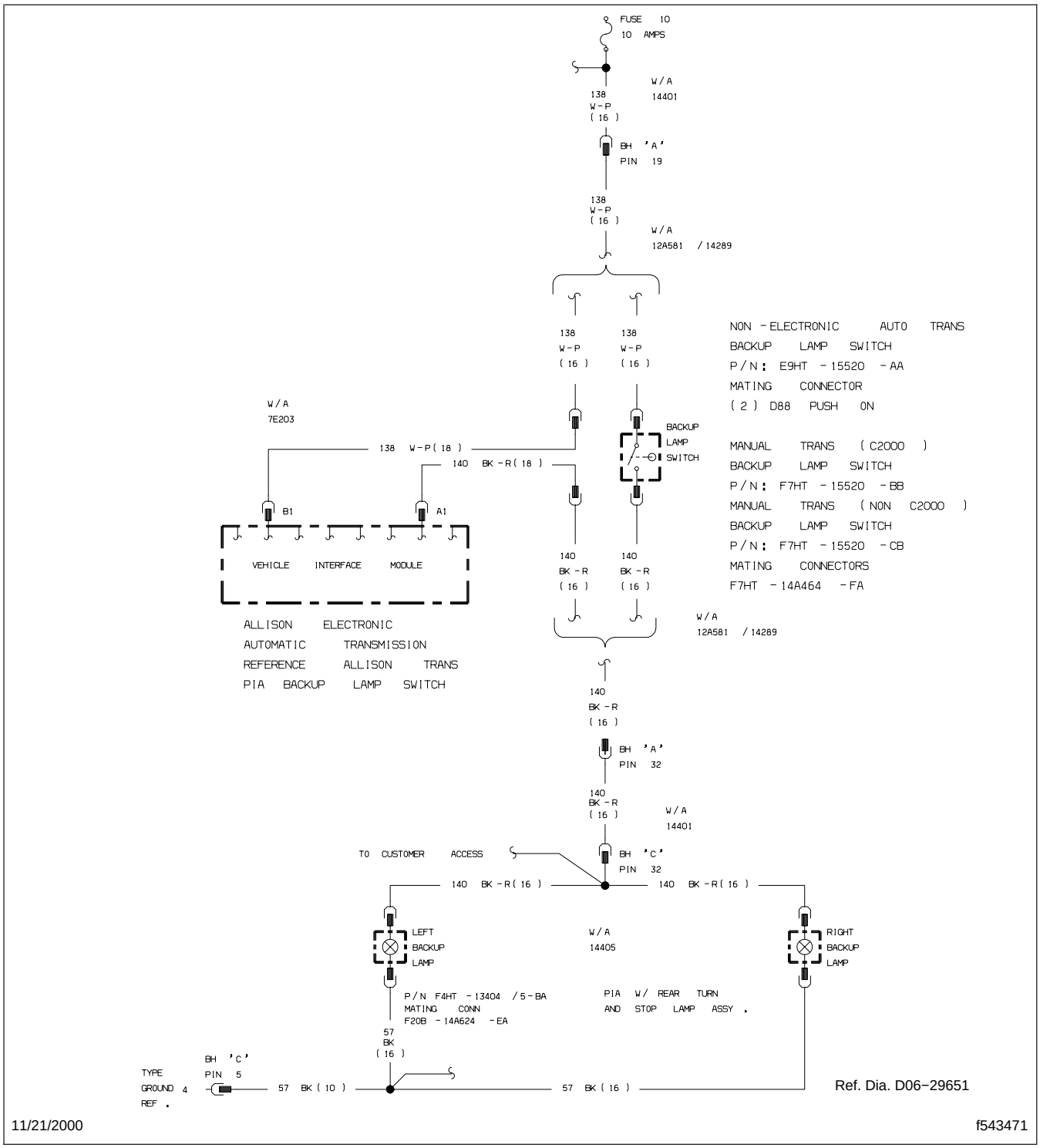

Fig. 2, Back-Up Light Wiring (full view)

Specifications

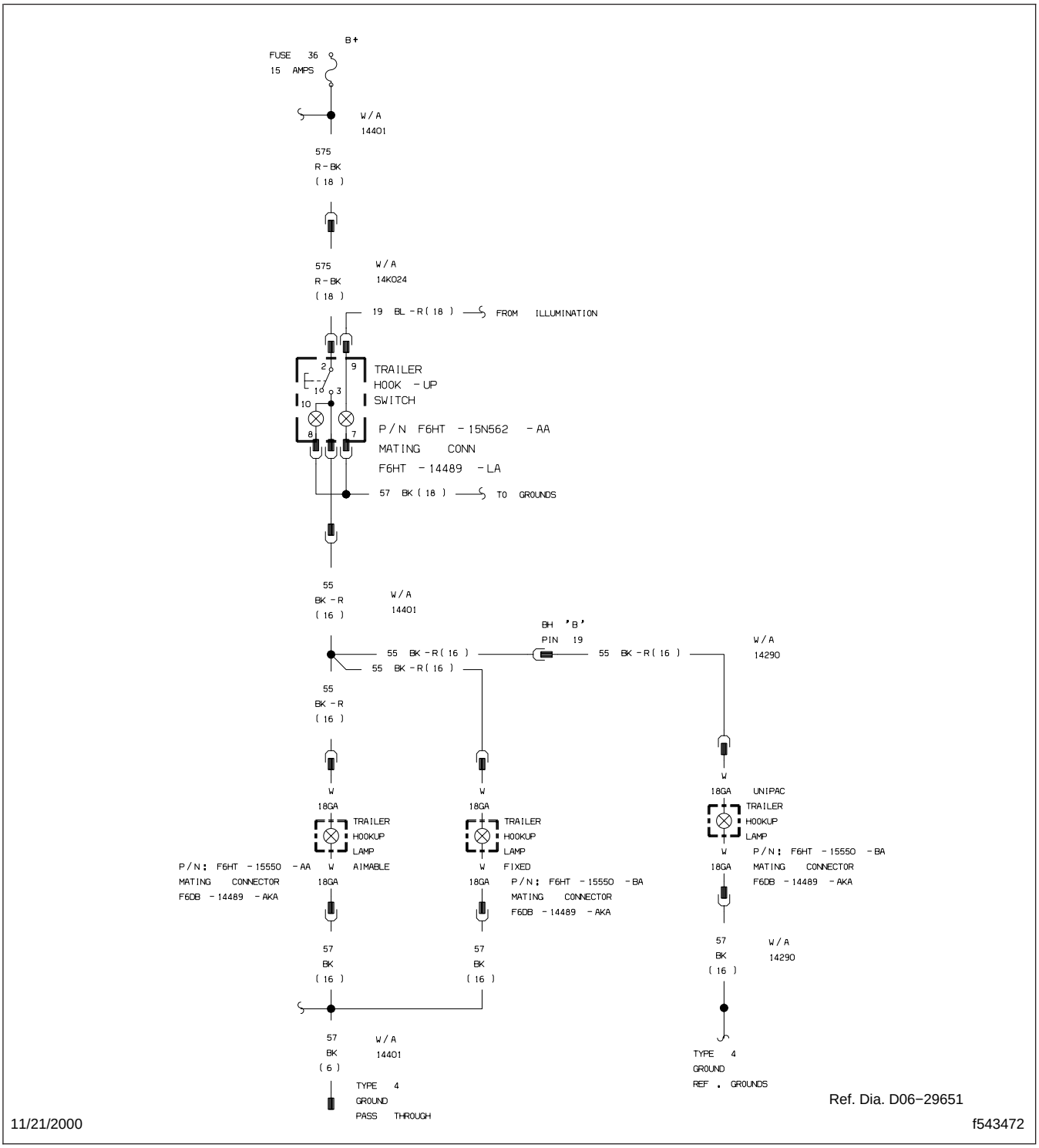

Fig. 3, Trailer Hook-Up Light Wiring (full view)

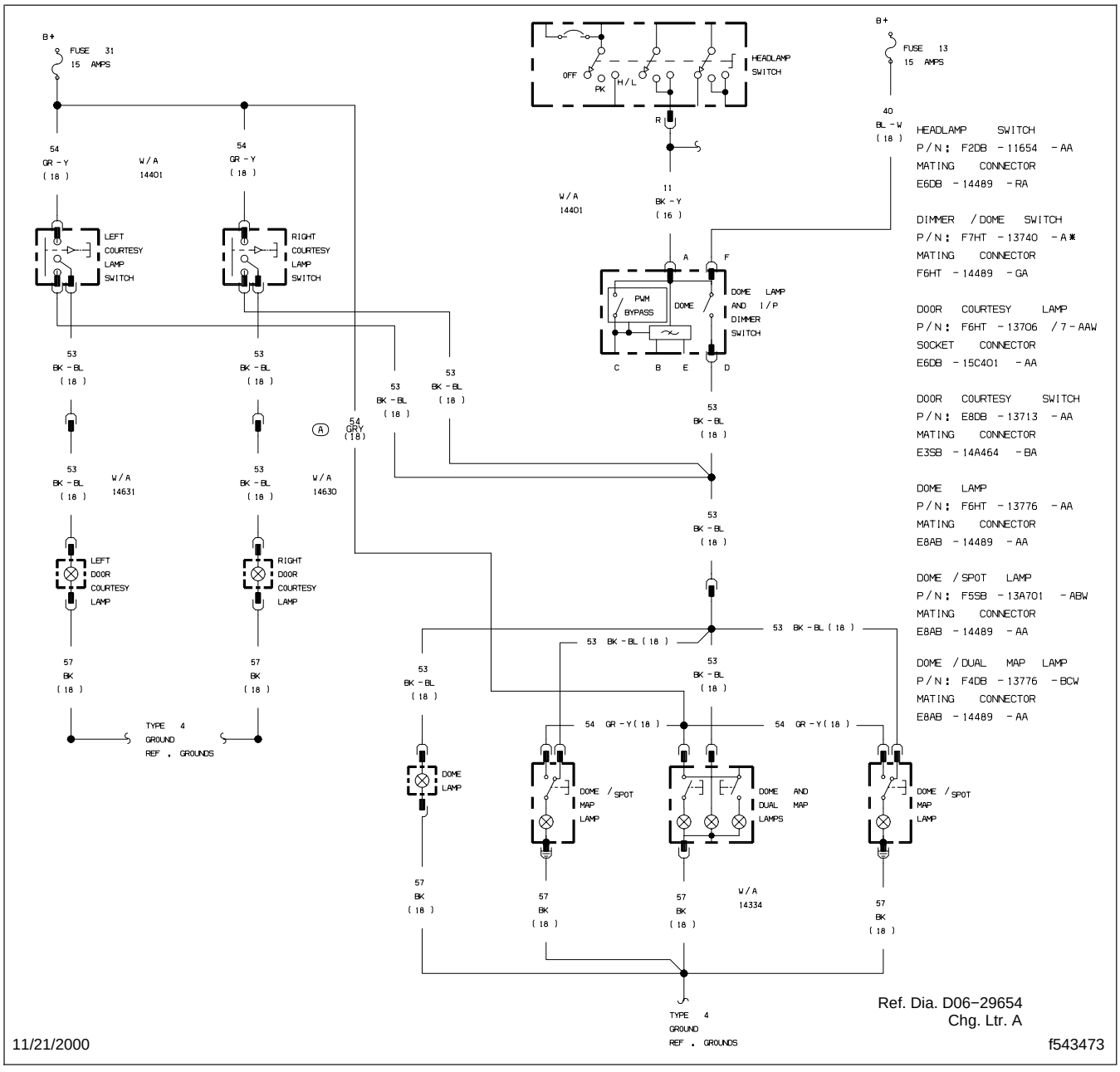

Fig. 4, Interior Lighting Wiring (full view)

Specifications

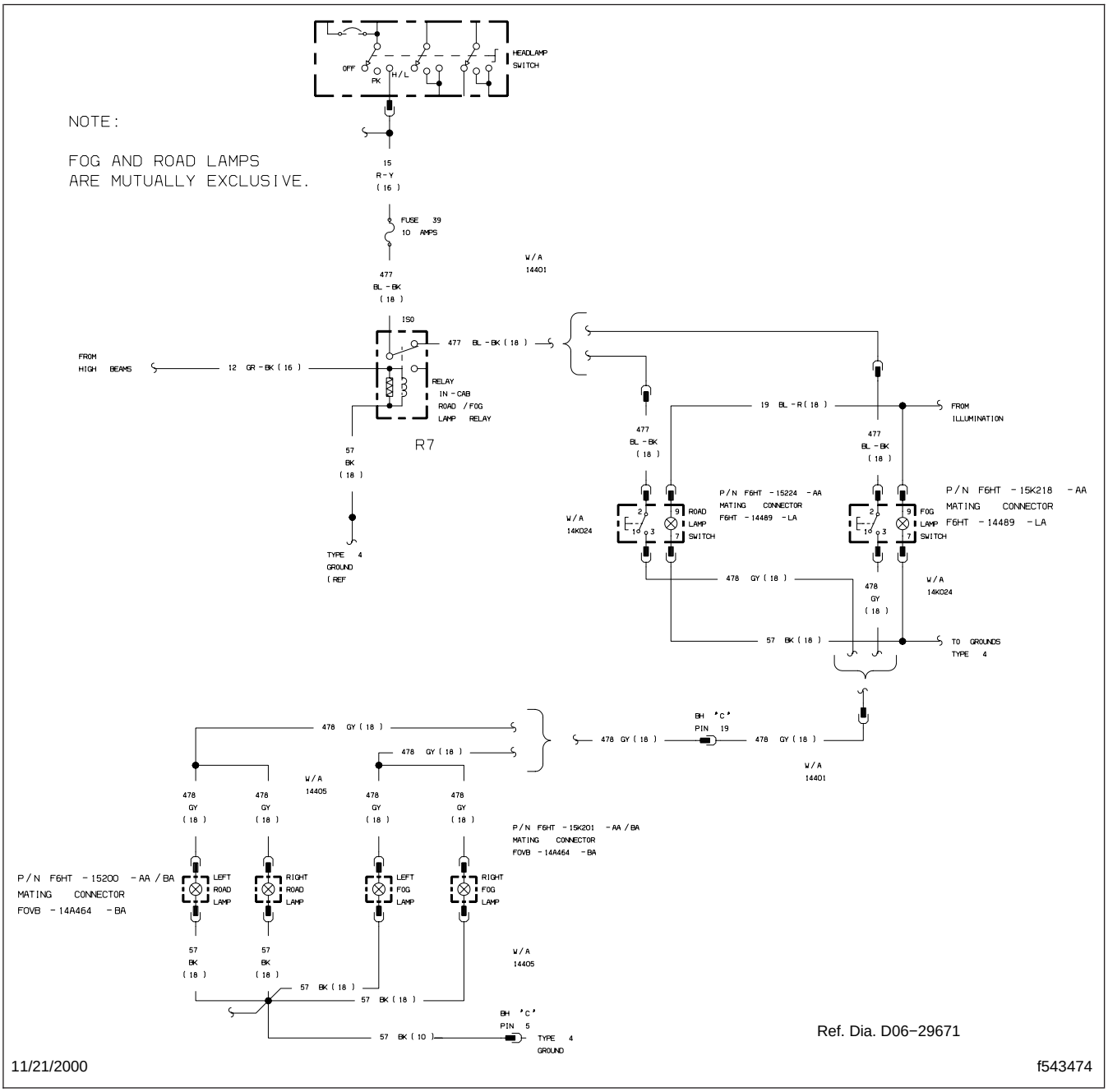

Fig. 5, Fog and Road Lights Wiring (full view)

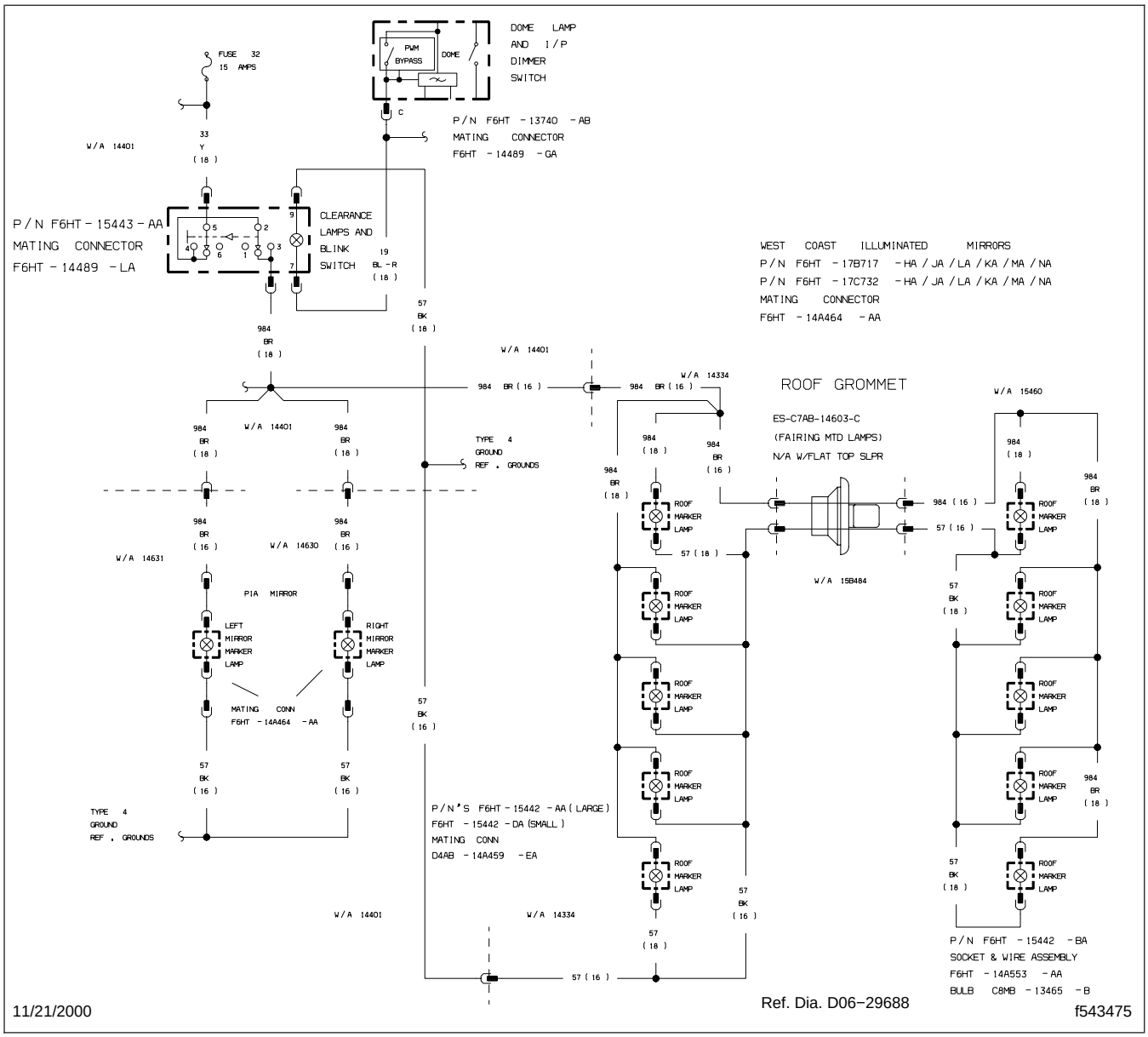

Fig. 6, Marker Lights Wiring (full view)

Specifications

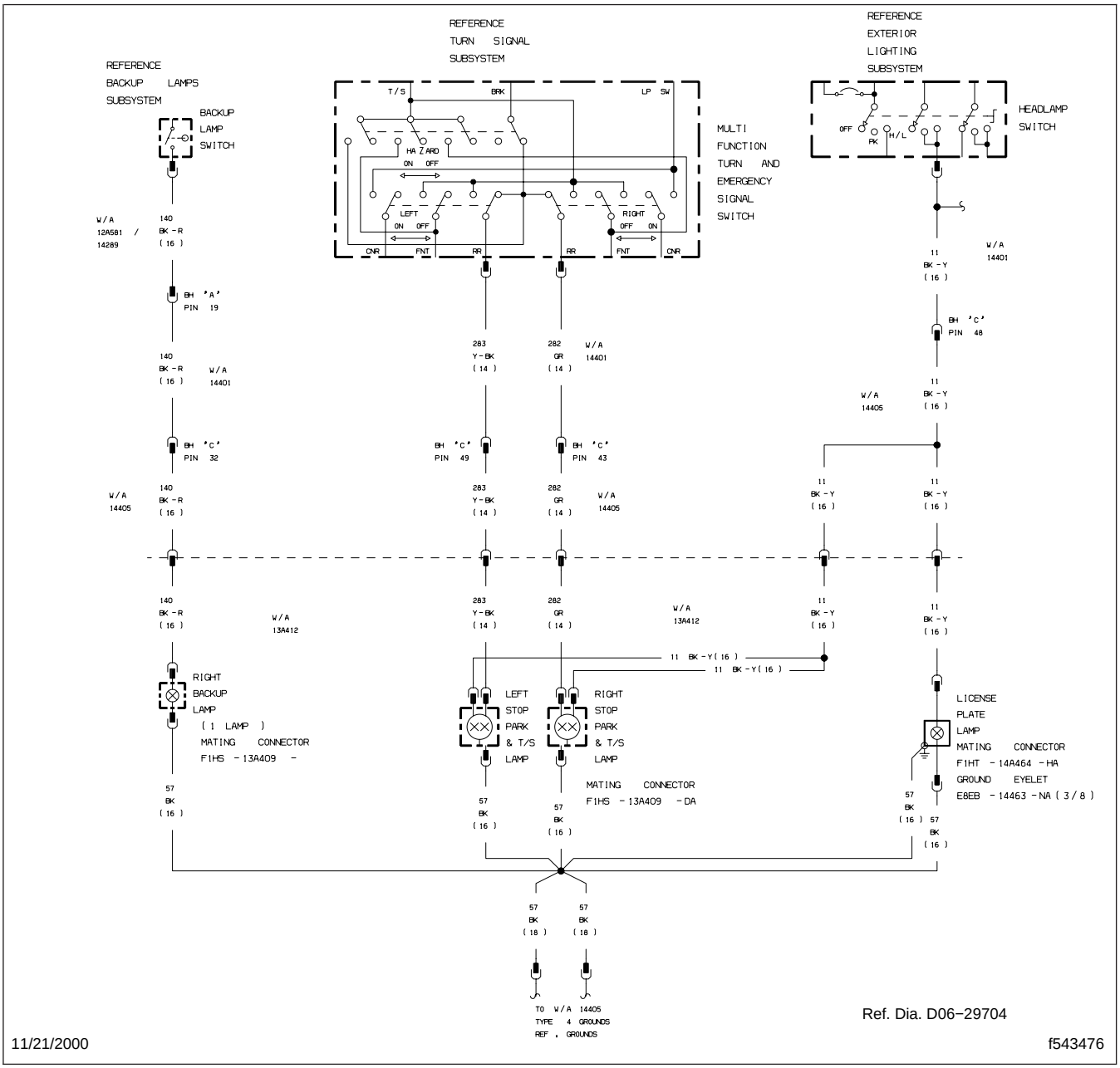

Fig. 7, Taillights Wiring (full view)

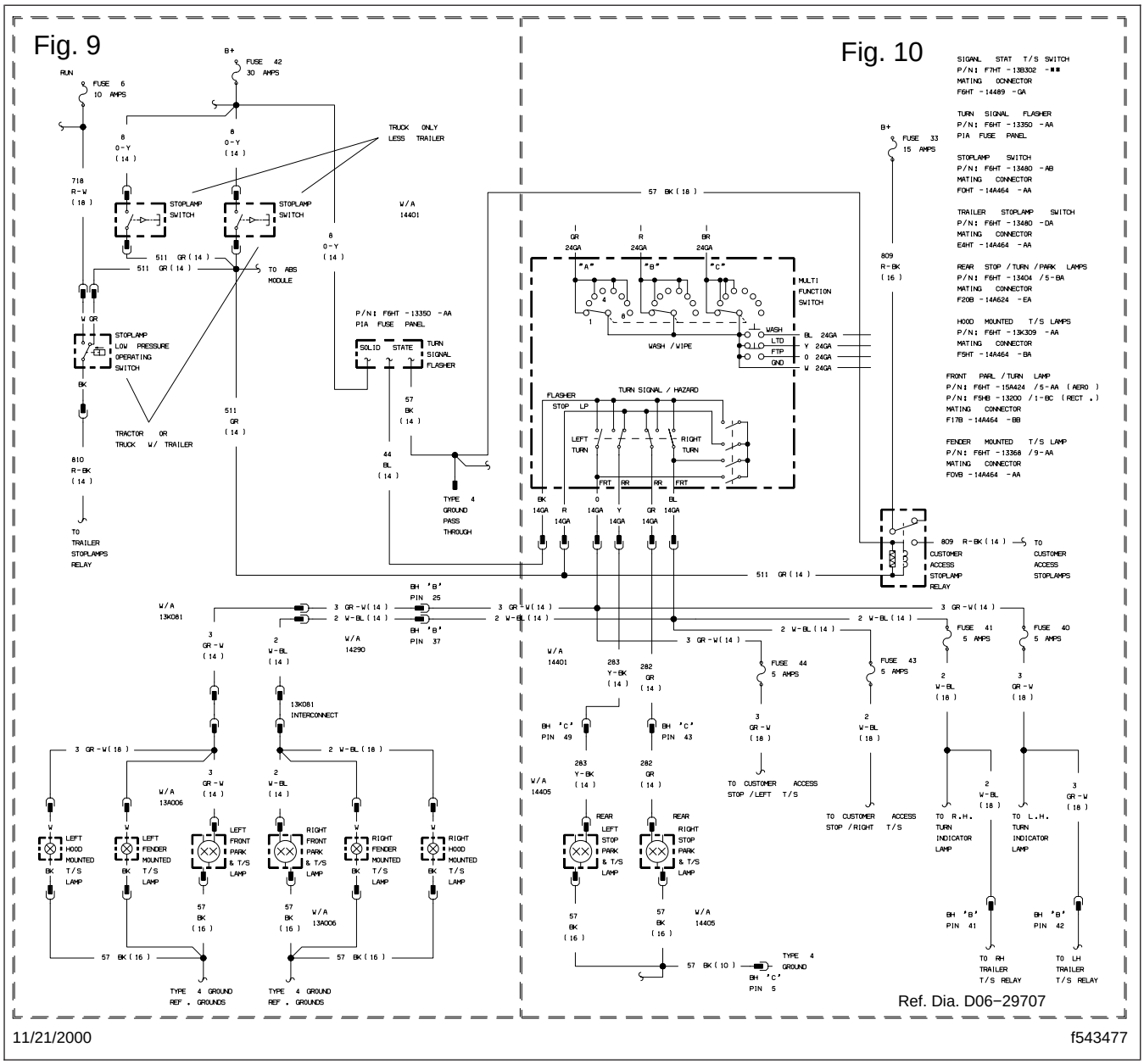

Fig. 8, Signal-Stat Turn Signal Wiring (full view)

Specifications

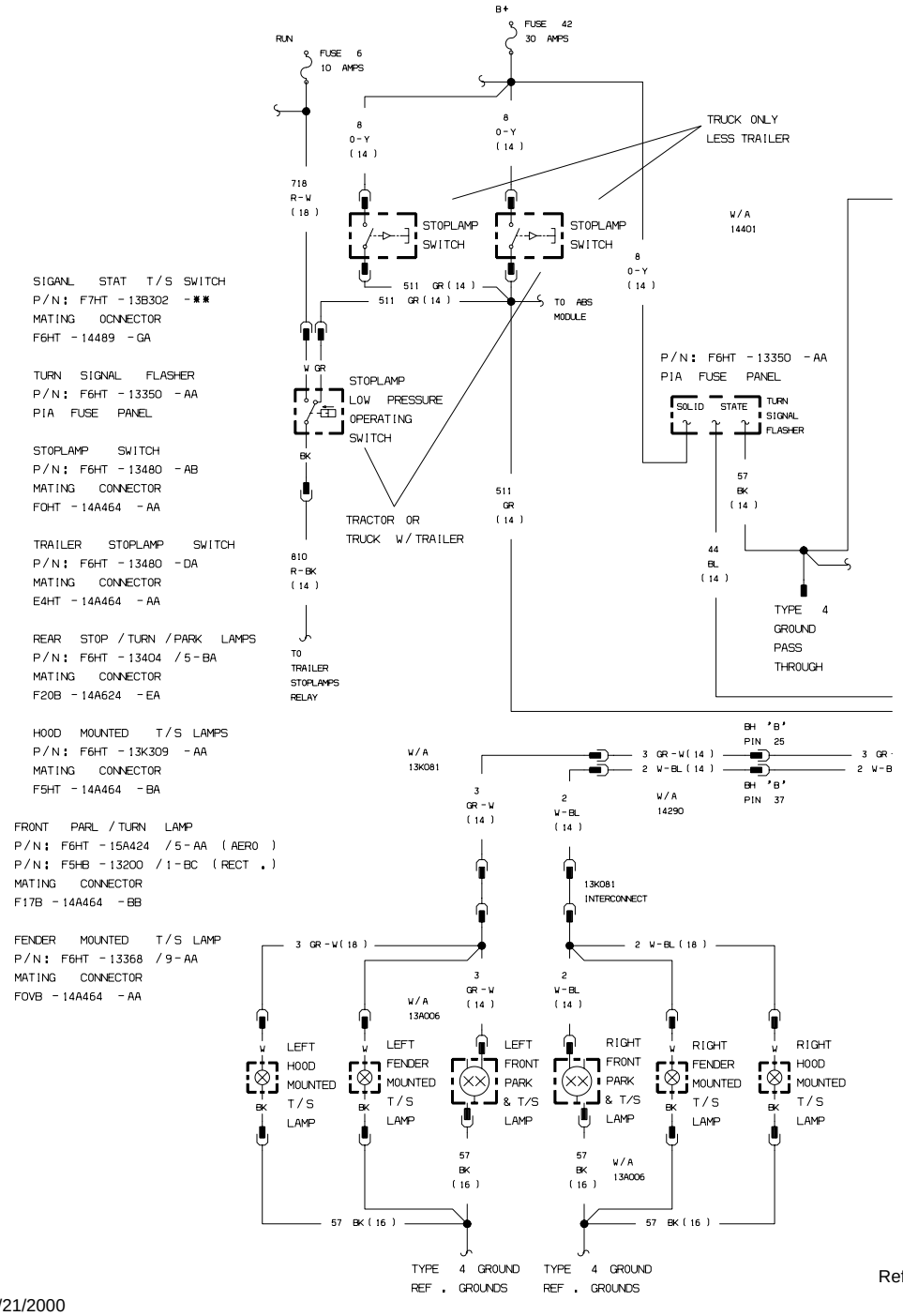

Fig. 10

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Fig. 9, Signal-Stat Turn Signal Wiring (partial view)

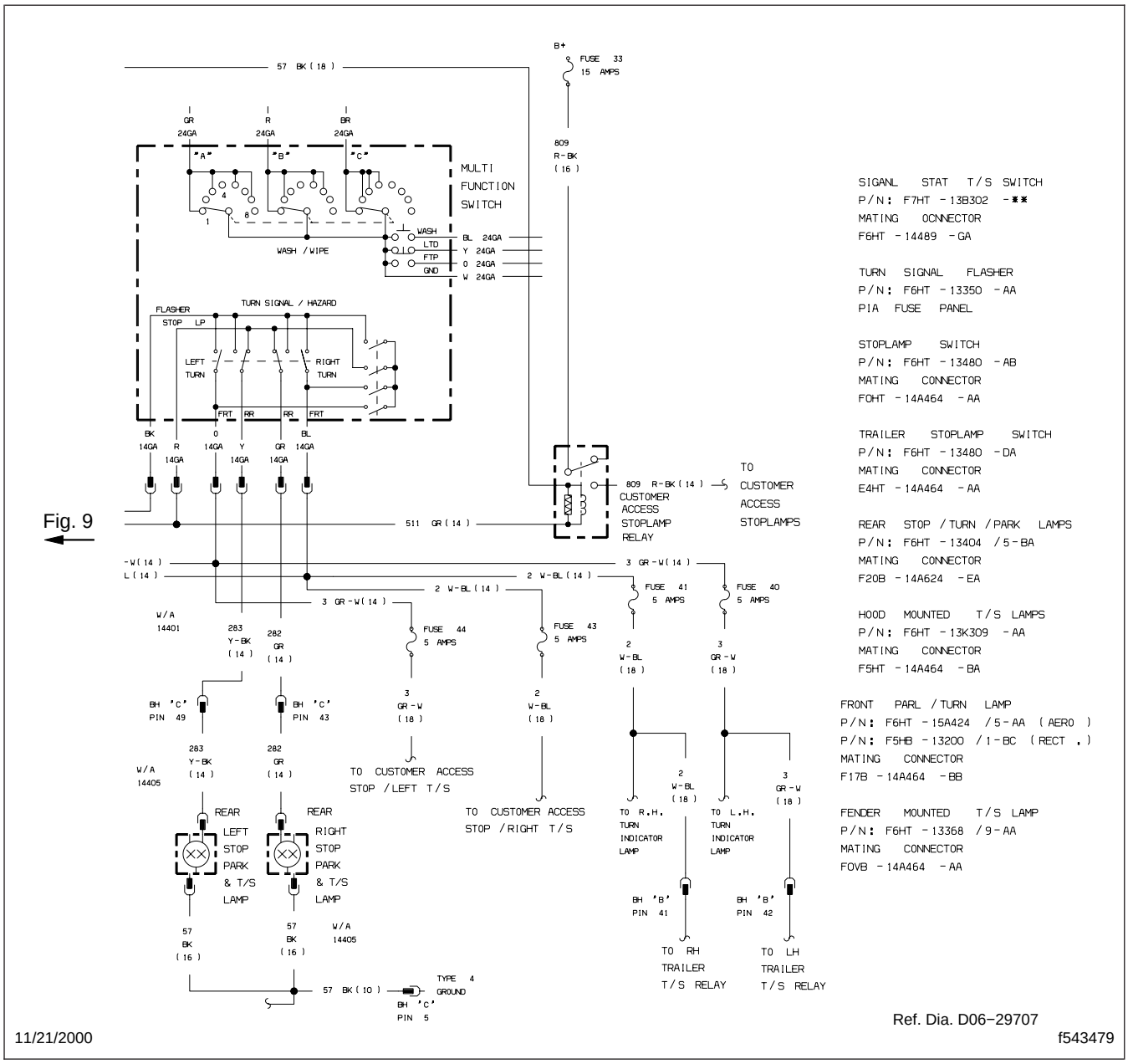

Fig. 9

Fig. 10, Signal-Stat Turn Signal Wiring (partial view)

Specifications

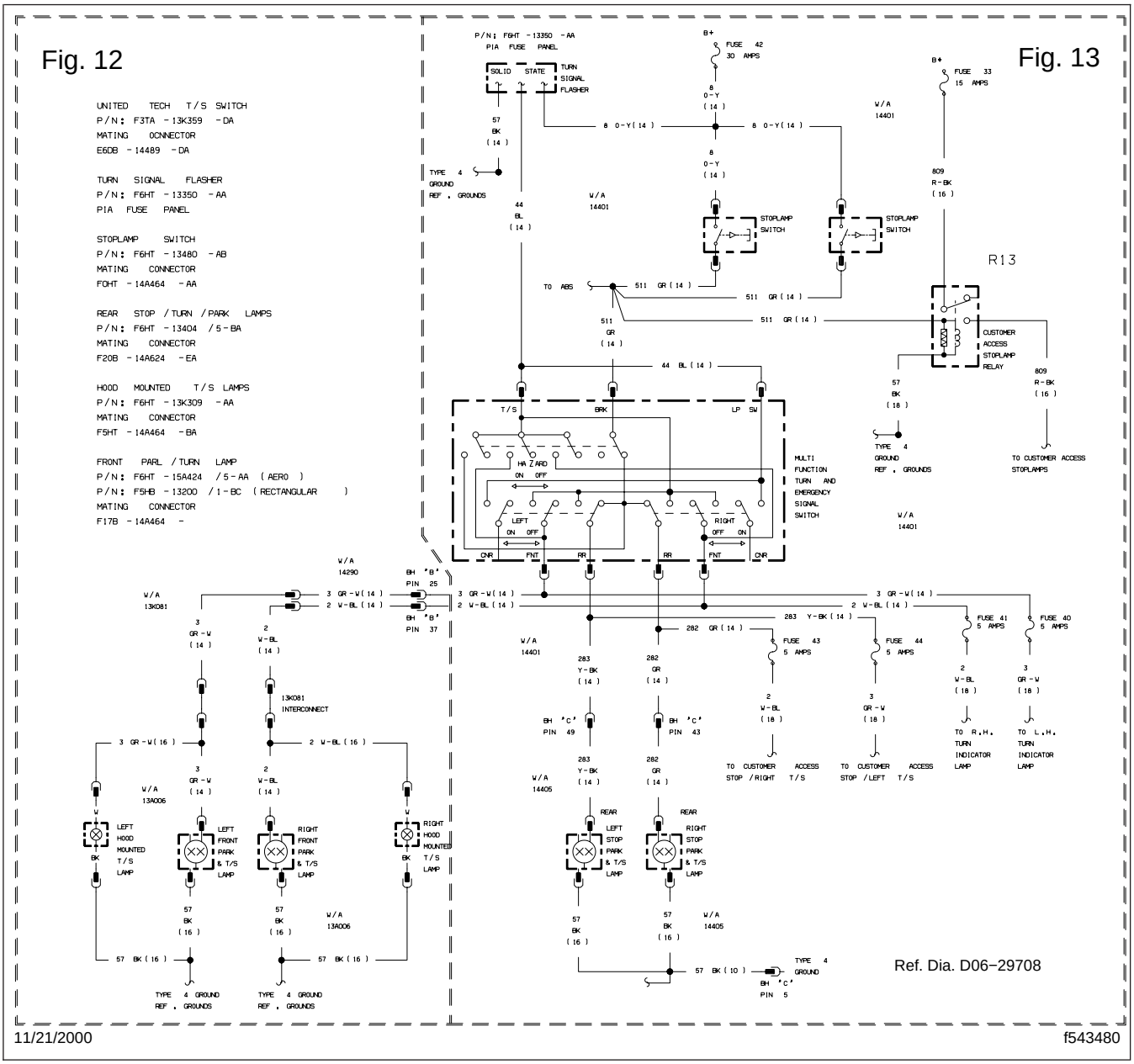

Fig. 11, United Technologies Turn Signal Wiring (full view)

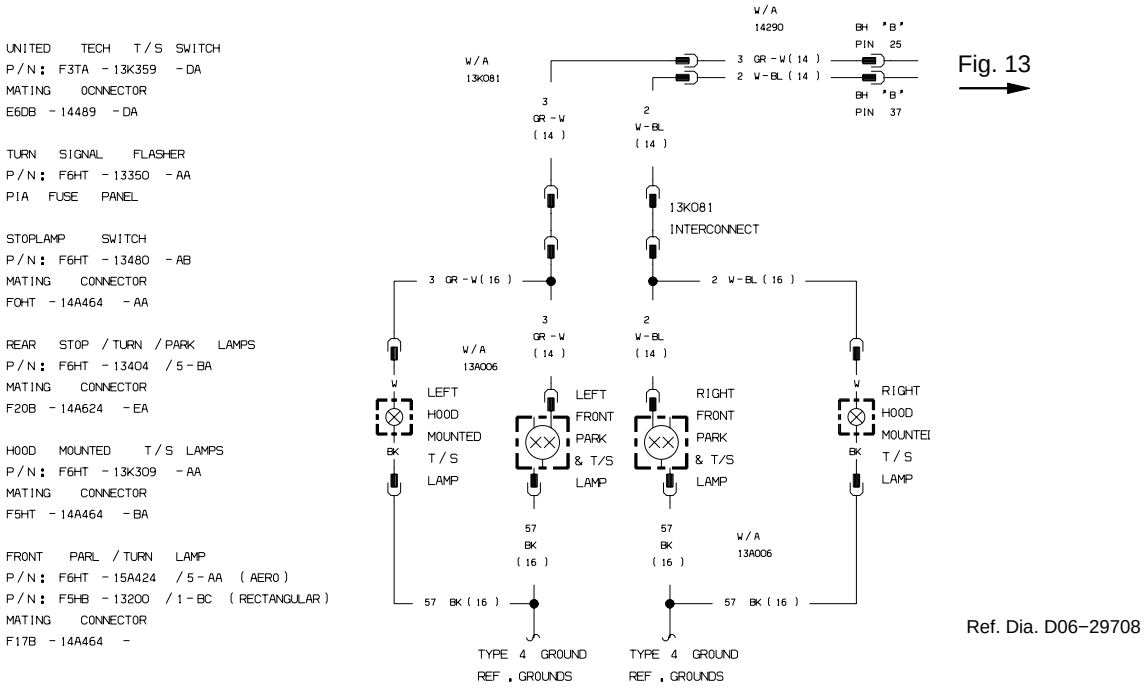

Fig. 12, United Technologies Turn Signal Wiring (partial view)

Specifications

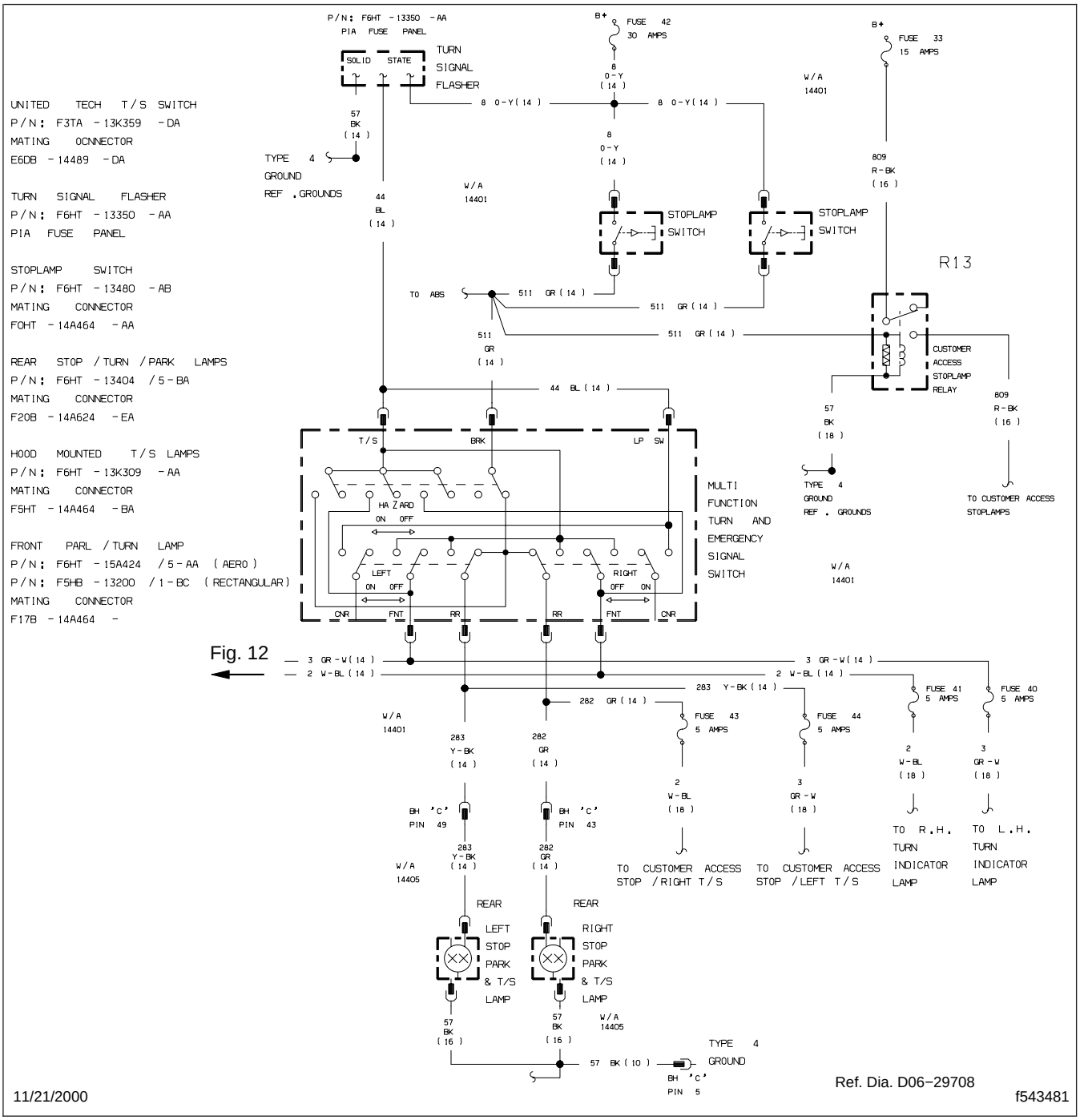

Fig. 12

Fig. 13, United Technologies Turn Signal Wiring (partial view)

Charging System

The alternator charging system is a negative ground system that consists of an alternator, voltage regulator, charge indicator, lead storage battery and associated wiring.

This section contains general information applicable to all charging systems and alternators. For information specific to the alternator, refer to **Group 15**.

Battery Charging

WARNING

Batteries release a gas mixture that is explosive. Don't smoke when working around batteries. Put out all flames, and remove any source of sparks or intense heat. Make sure the battery compartment has been completely vented before removing or connecting battery cables.

Battery acid is extremely harmful if splashed in the eyes or on the skin. Always wear safety goggles when working around batteries.

If excessive gassing or electrolyte spewing occurs during the charge, discontinue charging. the battery has reached serviceable charge. If the battery will not accept at least 5A after 20 minutes of charging, replace the battery.

- Before recharging a discharged battery, inspect and repair the following conditions, if they exist: loose drive belt, pinched or grounded alternator voltage regulator wiring, loose connections of the alternator voltage regulator wiring at the alternator or voltage regulator, loose or corroded connections at the battery, starter motor relay or engine, and excessive battery drain due to key off loads.
- Cold batteries will not readily accept a charge. Therefore, allow the battery to warm up to approximately 41°F (5°C) before charging. This can require 4 to 8 hours at room temperature, depending on the initial temperature and battery size.
- A battery which has been completely discharged can be slow to accept a charge initially, and in some cases will not accept a charge at the normal charger setting. When a battery is in this condition, charging can be started by the use of the dead battery switch on chargers so equipped.

1. To determine whether a battery is accepting a charge, follow the charger manufacturer's instructions for use of the dead battery switch. If the switch is the spring-loaded type, it must be held in the "On" position for up to 3 minutes.
2. After releasing the switch and with the charger still on, measure the battery voltage using Rotunda 73 Digital Multimeter. If it shows 12 volts or higher, the battery is accepting a charge and is capable of being recharged. However, it can require up to 2 hours of charging with batteries colder than 41°F (5°C) before the charge rate is high enough to show on the charger ammeter. It has been found that all non-damaged batteries can be charged by this procedure. If a battery cannot be charged by this procedure, replace it.

Regulator Output Adjustment, Delco Alternator

NOTE: After adjusting the setting, check for an improved battery condition over a service period of reasonable length. If adjusting the setting does not correct the battery condition, remove the alternator for service.

NOTE: Remember that if the battery state of charge is low, the regulator may not be limiting the voltage, and turning the adjusting screw will show no change on the voltmeter. However, turning the adjusting screw will change the voltage setting to a new value, which will be indicated by the voltmeter when the battery state of charge increases.

1. Remove the access pipe plug from the integral charging system.
2. Turn the adjusting screw one or two notches clockwise to raise the voltage setting and one or two notches counterclockwise to lower the voltage setting.
3. Replace the access pipe plug.

Troubleshooting

⚠ WARNING

Batteries release explosive gases. Do not smoke when working around batteries. Put out all flames, and remove any source of sparks or intense heat. Make sure the battery compartment has been completely vented before removing or connecting battery cables.

Battery acid is extremely harmful if splashed in the eyes or on the skin. Always wear safety goggles when working around batteries.

⚠ CAUTION

Do not attempt these tests on a lead-acid battery that has recently been recharged. Allow a reasonable amount of time to pass to allow the battery plates to cool to prevent battery damage.

NOTE: Before performing charging system tests on the vehicle, note the complaint (such as slow cranking, battery discharged or improper voltmeter reading). This information will aid in isolating the part of the system causing the symptom.

NOTE: Before any repair of the vehicle's charging system is done, perform a visual inspection. Use the following procedures for the visual inspection.

NOTE: Troubleshooting or diagnosis is required before actual service of the electrical system. Even where an obvious condition makes replacement of a component necessary, find out why the component failed.

1. Check the battery posts and battery cable terminals for clean and tight connections.
2. Remove the battery cables (if corroded), clean and install them securely.
3. Check for clean and tight wiring connections at the alternator, voltage regulator and the engine.
4. Check the drive belt tension; refer to **Group 01**.

IMPORTANT: Isolate the battery, the charging system, and the electrical circuits to correctly identify the problem area. Check the battery before performing any electrical system diagnosis. The battery must be in the proper state of charge and operation before areas of the electrical system can perform normally. Open circuits or other wiring concerns can prevent the alternator from operating normally.

5. Check the battery state of charge. Refer to the "Component Tests" in this subject.

Troubleshooting

Problem—The System Does Not Charge

Problem—The System Does Not Charge (See Fig. 1)	
Possible Cause	**Remedy**
Battery connections	Check for an open B+ Circuit. Turn the ignition switch to the "Off" position. Measure the voltage between the B+ terminal on the alternator, Circuit 37 (BK/Y) and chassis ground. If the voltage is not equal to the battery voltage, repair Circuit 37 (BK/Y). Test the system for normal operation. If the voltage is equal to the battery voltage, check for an open ground circuit.
Battery	Measure the voltage between the B+ terminal and the ground terminal on the alternator. If the voltage is not equal to the battery voltage, repair Circuit 57 (BK). Test the system for normal operation. If the voltage is equal to the battery voltage, if the vehicle is equipped with a Delco Remy alternator, replace the alternator. If equipped with a Motorcraft alternator, check for open in Circuit A.
Drive belt	Measure the voltage between the voltage regulator test point A and chassis ground. If the voltage is not equal to the battery voltage, repair Circuit 152 (Y). Test the system for normal operation. If the voltage is equal to the battery voltage check for an open field circuit. Turn the ignition switch to the "Off" position. Measure the voltage between the voltage regulator test point F and chassis ground. If the voltage is not equal to battery voltage, check for open/shorted field. Turn the ignition switch to the "Off" position. Disconnect the primary and auxiliary or secondary battery cables. Remove the alternator and then the voltage regulator. For instructions, see **Group 15**.
Alternator/voltage regulator	Measure the resistance between the alternator slip rings. If the resistance is greater than 10 ohms or less than 1 ohm, replace the alternator. Test the system for normal operation. If the resistance is less than 10 ohms or less than 1 ohm, check for brushes less than 8 mm long or open brush leads and replace if required. If the brushes are OK, replace the voltage regulator. Test the system for normal operation.

Problem—The System Does Not Charge

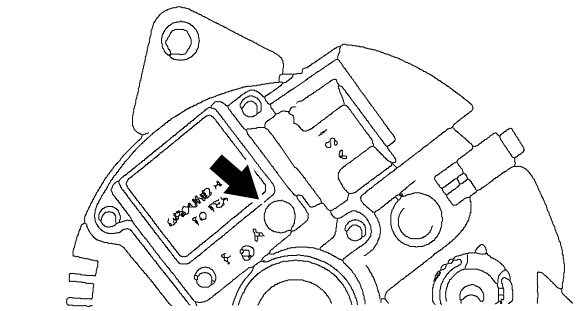

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Fig. 1, Voltage Regulator Test Point A

Problem—The System Does Not Charge (See Fig. 2 and Fig. 3)	
Possible Cause	**Remedy**
Battery connections	NOTE: The voltage regulator must be connected to the wiring harness to check for an open in the I-Circuit. If the voltage is equal to battery voltage, check for an open in Circuit I. Turn the ignition switch to the "On" position. Measure the voltage between the voltage regulator I terminal Circuit 69 (R/GN) and chassis ground. If the voltage is not 1 volt or greater, repair Circuit 69 (R/GN) or replace the voltage regulator. Test the system for normal operation. If the voltage is 1 volt or greater, check voltage drop in Circuit A.
Battery	Measure the voltage between the voltage regulator test point A and the battery positive post. If the voltage drop is not 0.25 volts or less, repair Circuit 152 (Y). Test the system for normal operation. If the voltage drop is 0.25 volts or less, check field turn-on.
Drive belt	Measure the voltage between the voltage regulator test point F and chassis ground. If the voltage is greater than 2 volts, check for open/shorted field. Turn the ignition switch to the "Off" position. Disconnect the primary and auxiliary or secondary battery cables. Remove the alternator and then the voltage regulator. For instructions see **Group 15**.
Alternator or voltage regulator	Measure the resistance between the alternator slip rings. If the resistance is greater than 10 ohms or less than 1 ohm, replace the alternator. Test the system for normal operation. If the resistance less than 10 ohms or less than 1 ohm check for brushes less than 8 mm long or open brush leads and replace if required. If the brush leads are OK, replace the voltage regulator. Test the system for normal operation. If the voltage is greater than 2 volts, check for a shorted rectifier. Turn the ignition switch to the "Off" position. Disconnect the alternator one-way connector harness connector. Measure the voltage between the alternator one-way terminal and chassis ground.

Troubleshooting

Problem—The System Does Not Charge

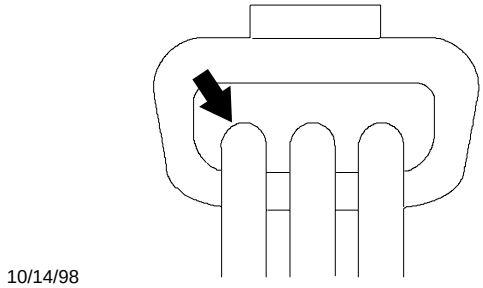


Fig. 2, Voltage Regulator I-Terminal

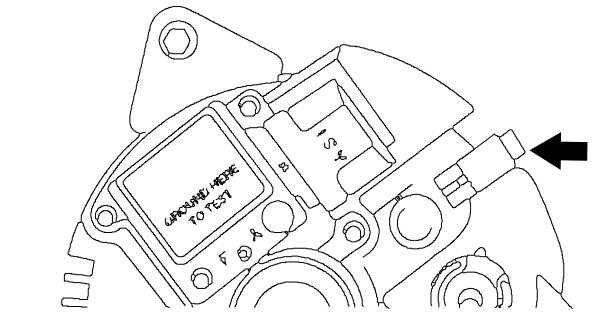


Fig. 3, Alternator One-Way Terminal

Problem—The System Does Not Charge (See Fig. 3 and Fig. 4)	
Possible Cause	**Remedy**
Battery connections	Measure the voltage between the battery positive post and the alternator one-way connector. If either voltage reading is greater than 1 volt, replace the alternator. Test the system for normal operation. If either voltage reading is less than 1 volt, check the voltage drop in the B+ Circuit.
Battery	Turn on the headlamps and the heater blower to the highest setting. Reconnect the alternator one-way connector harness connector. Turn the ignition switch to the "On" position. With the engine running at 2000 rpm, measure the voltage between the alternator B+ terminal and the battery positive post. If the voltage is greater than 0.5 volts, repair Circuit 37 (BK/Y) or Circuit 152 (Y) for high resistance. Test the system for normal operation. If the voltage is less than 0.5 volts, check for an open stator phase.
Drive belt	
Alternator/voltage regulator	Turn the ignition switch to the "Off" position. Connect a jumper wire between the voltage regulator test point F and the negative battery post. Repeat the alternator output test. If the alternator output is greater than the minimum output specified, replace the voltage regulator. Test the system for normal operation. If the alternator output less than the minimum output specified, replace the alternator. Test the system for normal operation.

Problem—The System Overcharges

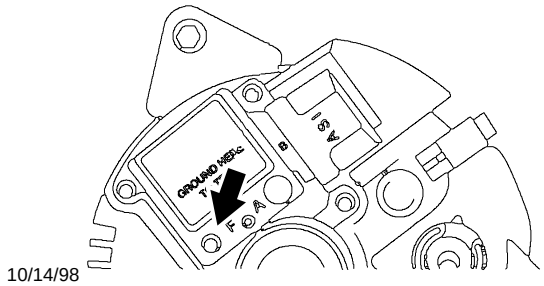


Fig. 4, Voltage Regulator Test Point F

Problem—The System Overcharges (See Fig. 2)	
Possible Cause	**Remedy**
Excessive voltage drop	Check the alternator output. Turn the ignition switch to the "Run" position. Measure the voltage between the B+ terminal on the alternator, Circuit 37 (BK/Y) and chassis ground. If the voltage is greater than 15 volts and equipped with a Delco Remy alternator, replace the alternator. Test the system for normal operation. If equipped with a Motorcraft alternator, check voltage in Circuit I. Turn the ignition switch to the "Off" position. Turn the ignition switch to the "On" position. Measure the voltage between the voltage regulator connector Pin I Circuit 69 (R/GN) and chassis ground. If the voltage is not 1 volt or greater repair high resistance or poor connection in Circuit 69. Test the system for normal operation. If the voltage is 1 volt or greater check voltage drop in Circuit A.
Poor ground	Turn the ignition switch to the "On" position. Measure the voltage between the voltage regulator test point A and the primary battery positive post. If the voltage is not 0.25 volt or less repair Circuit 37 (BK/Y) or 152 (Y). Test the system for normal operation. If the voltage is 0.25 volt or less check for poor grounds. Turn the ignition switch to the "Off" position. Check for poor ground connections between the voltage regulator and the alternator, the alternator and the engine, or the engine and the battery. If all the ground connections are not clean and tight clean and repair ground(s) as required. Test the system for normal operation. If all the ground connections are clean and tight check for field circuit drain.
Voltage regulator	Measure the voltage between the voltage regulator test point F and chassis ground. If the voltage is not equal to battery voltage replace the voltage regulator. Test the system for normal operation. If the voltage is equal to battery voltage check for grounded slip ring. Disconnect the alternator harness connector. Disconnect the voltage regulator harness connector. Remove the voltage regulator from the alternator. Refer to **Group 15**. Measure the resistance between each alternator slip ring and the alternator housing. If the resistance between any slip ring and the alternator housing is 200 ohms or less, clean the slip rings and measure the resistance of the slip rings again. If still less than 200 ohms, replace the alternator. Test the system for normal operation. If the resistance between any slip ring and the alternator housing is not 200 ohms or less, replace the voltage regulator. Test the system for normal operation.

Troubleshooting

Problem—The Voltage Gauge Reads High

Problem—The Voltage Gauge Reads High	
Possible Cause	**Remedy**
Alternator	Check the alternator. For instructions, see "Component Tests" in this section. If the alternator is OK, see "Instrument Cluster Troubleshooting" in **Section 54.04**. If the alternator is defective, repair or replace the alternator. Test the system for normal operation.
Voltage regulator	
Voltmeter	

Problem—The Voltage Gauge Reads Low

Problem—The Voltage Gauge Reads Low	
Possible Cause	**Remedy**
Alternator	Check the alternator. Perform the "Alternator On-Vehicle Tests" check. For instructions, see "Component Tests" in this section. If the alternator is OK, see "Instrument Cluster Troubleshooting" in **Section 54.04**. If the alternator is defective, repair or replace the alternator. Test the system for normal operation.
Voltage regulator	
Voltmeter	

Component Tests

BATTERY CAPACITY TESTING

NOTE: The battery must be fully charged before performing this test.

To perform this test, use a high rate discharge tester such as a Rotunda Alternator, Regulator, Battery and Starter Tester (ARBST), in conjunction with a digital multimeter.

1. Turn the high rate discharge tester off.
2. Turn the digital multimeter to the DV volt scale.
3. Connect the high rate discharge tester and the multimeter positive test leads to the positive battery post, and both negative leads to the negative battery post. The multimeter clips must contact the battery posts and not the high rate discharge tester tester clips.
4. Adjust the high rate discharge tester until the ammeter reads approximately one-half of the cold cranking amps of the battery.
5. With the ammeter reading the required load for 15 seconds, note the multimeter reading. Avoid leaving the high discharge load on the battery for periods longer than 15 seconds.
6. If the multimeter reading is 9.6 volts at 70°F (21°C) or more, the battery has a good output capacity and will readily accept a charge, if required.
7. If the voltage reading obtained during the capacity test is below 9.6 volts at 70°F (21°C), and the battery is fully charged, the battery is defective and must be replaced. If unsure about the battery's state of charge, charge the battery.
8. After the battery has been charged, repeat the capacity test. If the battery voltage is still less than 9.6 volts, replace the battery.
9. If the battery is found to be discharged only, check for a loose connection, check charging system performance, and perform a battery drain test.

BATTERY, DRAIN TESTING

⚠ WARNING

Batteries release a gas mixture that is explosive. Do not smoke when working around batteries. Put out all flames, and remove any source of sparks or intense heat. Make sure the battery compartment has been completely vented before removing or connecting battery cables.

Battery acid is extremely harmful if splashed in the eyes or on the skin. Always wear safety goggles when working around batteries.

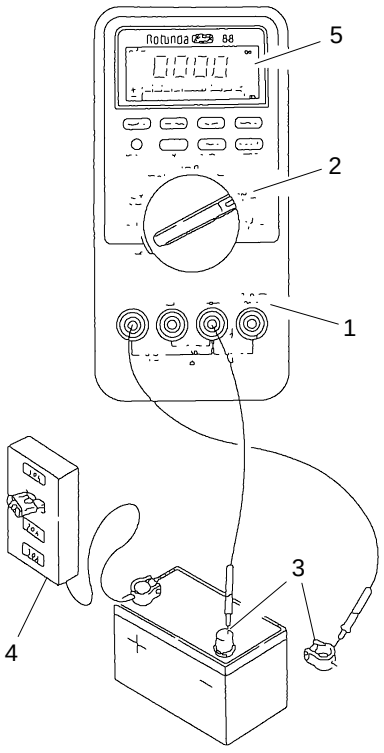
Do not attempt this test on a lead-acid battery that has recently been recharged.

⚠ CAUTION

Do not crank the engine or operate accessories that draw more than 10 amperes. Doing so can result in damage to the test equipment.

NOTE: Many on-board computers draw 10 milli-amperes or more, continuously.

Check for current drains on the battery in excess of 50 milliamperes with all the electrical accessories off and the vehicle at rest. See **Fig. 5**.



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1. Input Terminals
2. Function Selector Set at MA/A DC
3. Negative Post and Lead
4. Fuse Panel
5. Display Window

Fig. 5, Battery Drain Test Setup

1. Insert the test leads in the input terminals.
2. Turn the switch to MA/A DC.
3. Disconnect the battery terminal and touch probes as shown.
4. Isolate the circuit causing the drain by pulling out one fuse after another while reading the display.
5. Current reading will drop when the fuse on the bad circuit is pulled. Reinstall the fuse and test the components (including connectors) of that circuit to find the defective component(s).
6. Typically, a drain of approximately 1 ampere can be attributed to an engine compartment lamp, glove compartment lamp or other courtesy lamp staying on continuously. Other components or wiring shorts can be located by selectively pulling fuses or disconnecting fuse links to pinpoint the location of the current drain. When the current drain is located, the meter reading will drop to an acceptable level. If the short is still not located after checking all fuses and fuse links, the drain may be caused by the alternator.

ALTERNATOR ON-VEHICLE TESTS

1. Connect the test block to the alternator.
2. Assemble a closed-end terminal clip with a 1/2-inch (12.7-mm) hole to the output terminal, then connect the ammeter lead clip to this terminal clip.
3. With all accessories and carbon pile turned off, increase engine speed as required to obtain maximum voltage reading.
4. If voltage exceeds 15 volts, remove the integral charging system for service.
5. If voltage does not exceed these values, proceed as follows:
   - 5.1 Make sure that accessories have not been left on for extended periods.
   - 5.2 Check the drive belt for proper tension.
   - 5.3 Inspect the wiring for wear or damage. Check all connections for tightness and cleanliness, including the cable clamps and battery posts.
6. With the engine running, connect a voltmeter from the output terminal on the integral charging system to ground. A zero reading indicates an open between the voltmeter connection and the battery.
7. If the previous steps check out, test the integral charging system as follows:

Troubleshooting

7.1 Disconnect the battery ground cable.

7.2 Connect an ammeter in the circuit at the output terminal of the integral charging system.

7.3 Reconnect the battery ground cable.

7.4 Turn on the accessories. Connect the carbon pile across the battery.

NOTE: Initial voltage buildup is by residual magnetism in the rotor. Increase the speed as required to obtain maximum current output. Operate the engine at moderate speed as required, usually 4000 alternator rpm or more, and adjust carbon pile as required to obtain maximum current output.

8. If ampere output is not within 10 amperes of the rated output as stamped on the alternator frame, remove the alternator for service. If ampere output is within 10 amperes of the rated output as stamped on the alternator frame, the integral charging system is not worn or damaged.

ALTERNATOR BENCH TEST

If system diagnosis has isolated a problem in the alternator assembly, remove it from the vehicle for bench testing and repair or replace. Refer to **Group 15** for the appropriate alternator removal or disassembly procedure. In some cases, it is possible to replace a damaged regulator or brushes without removing the alternator assembly.

NOTE: The following tests are performed with an analog (needle-type) ohmmeter. Test values shown are referenced to the Rotunda Inductive Dwell-Tach-Volts-Ohms Tester. These values may be different for other ohmmeters. If you do not have a Rotunda Inductive Dwell-Tach-Volts-Ohms Tester, use known good parts to establish reference values for your own meter. These values can be written into the spaces provided in the meter reading charts for future reference.

NOTE: The Motorcraft integral rear mount regulator, internal fan type alternator, is serviced as an assembly. If the alternator requires service, it must be replaced as an assembly.

Rectifier and Stator Grounded Tests

NOTE: This test is performed with an ohmmeter, inductive dwell-tach-volts-ohms tester. Set the multiplier setting at 1 and calibrate the ohmmeter as directed.

NOTE: Digital meters cannot be used to perform these rectifier tests.

1. Connect one ohmmeter probe to one of the alternator B+ blade terminals and the other probe to the STA blade terminal. Reverse the ohmmeter probes and repeat the test. Normally, there will be no needle movement in one direction, indicating the rectifier diodes are being checked in the reverse current direction and are not shorted. A low reading with the probes reversed indicates that the rectifier positive diodes are being checked in the forward current direction. A reading in both directions indicates a bad positive diode or shorted radio suppression capacitor. The radio suppression capacitor is built into the rectifier assembly and is not individually serviceable.
2. Perform the same test using the STA and GND (ground) terminals of the alternator. A reading (needle movement) during both tests indicates either a bad negative diode, a grounded stator winding, a grounded stator terminal, a grounded positive diode plate, or a grounded BAT terminal. Infinite readings (no needle movement) in all four probe positions in the preceding tests indicate an open STA terminal lead connection inside the alternator.

Field Open or Short Circuit Test

NOTE: This test is performed with an ohmmeter, such as the Rotunda Inductive Dwell-Tach-Volts-Ohms Tester. Set the multiplier setting at 1 and calibrate the ohmmeter as directed.

NOTE: Digital meters cannot be used to perform these rectifier tests.

NOTE: This test is performed with an ohmmeter, such as the Rotunda Inductive Dwell-Tach-Volts-Ohms Tester.

1. Connect one ohmmeter probe to one of the alternator B+ blade terminals and the other probe to

the STA blade terminal. Reverse the ohmmeter probes and repeat the test. Normally, there will be no needle movement in one direction, indicating the rectifier diodes are being checked in the reverse current direction and are not shorted. A low reading with the probes reversed indicates that the rectifier positive diodes are being checked in the forward current direction. A reading in both directions indicates a bad positive diode or shorted radio suppression capacitor. The radio suppression capacitor is built into the rectifier assembly and is not individually serviceable.

2. Perform the same test using the STA and GND (ground) terminals of the alternator. A reading (needle movement) during both tests indicates either a bad negative diode, a grounded stator winding, a grounded stator terminal, a grounded positive diode plate, or a grounded BAT terminal.
3. Infinite readings (no needle movement) in all four probe positions in the preceding tests indicate an open STA terminal lead connection inside the alternator.
4. Set the multiplier setting at 1 and calibrate the ohmmeter according the manufacturer's instructions.
5. Contact the regulator A blade terminal with one probe and the regulator F screw head with the other probe.
6. Reverse the ohmmeter probes and repeat the test. In one probe direction, the ohmmeter reading should be between 2.2 and 100 and may fluctuate while the pulley is turning. In the other probe direction, the reading should fluctuate between 2.2 and about 9 ohms.
    - An infinite reading (on meter movement) in one direction and approximately 9 ohms in the other, indicates an open brush lead, worn or stuck brushes, a damaged rotor or a loose regulator to brush holder attaching screw.
    - An ohmmeter reading less than 2.2 ohms in both directions indicates a shorted rotor or damaged regulator.
    - An ohmmeter reading significantly over 9 ohms in both directions indicates an inoperative regulator or loose F terminal screw.
7. Contact the alternator rear housing with one ohmmeter probe and touch the other probe to the regulator F terminal. Reverse the probes and repeat the test. The ohmmeter reading should be infinite in one probe direction and approximately 9 ohms in the other.
    - A reading less than infinite in both directions indicates a grounded brush lead or an inoperative regulator.
    - A reading significantly over 9 ohms in both directions indicates an inoperative regulator or a damaged A terminal connection.

FIELD COIL CHECKS, DELCO REMY ALTERNATOR

1. Disconnect the two field coil leads from the regulator.
2. Separate the drive end frame assembly from the rectifier end frame assembly. This is done by removing the shaft nut, washer, pulley, fan, slinger and through-bolts from the end drive.
3. To check for grounds, connect a test lamp, or an ohmmeter, to one field coil lead and to the end frame. If the lamp lights, or if the ohmmeter reading is low, the field coil is grounded.
4. To check for opens, connect a test lamp or an ohmmeter to the two field coil leads. If the lamp fails to light, or if the ohmmeter reading is high (infinite), the field coil is open.
5. Disconnect the two field coil leads from the regulator.

Stator and Coil Grounded Test

1. Remove the stator from the alternator and disconnect it from the rectifier assembly as outlined. Set the ohmmeter multiplier setting at 1000.
2. Connect the ohmmeter probes to one of the stator lead terminals and to the stator laminated core. Make sure that the probe makes a good electrical connection with the stator core. The meter should show an infinite reading (no needle movement).
3. If the meter does not indicate an infinite reading (needle moves), the stator winding is grounded to the core and the stator must be replaced.

Troubleshooting

Stator and Coil Open Test

1. Disconnect the stator from the rectifier assembly. Set the ohmmeter multiplier setting at 1.
2. Connect one ohmmeter probe to a stator phase lead terminal and touch the other probe to another stator lead terminal. Check the meter reading.
3. Repeat this test with the other two stator lead combinations. If no meter movement occurs (infinite resistance) on a lead paired with either of the other phase leads, that phase is open and the stator must be replaced.

Alternator Rotor Open or Short Test

1. Remove the rotor from the alternator. Set the ohmmeter multiplier setting at 1 and calibrate the meter as directed.
2. Contact each ohmmeter probe to a rotor slip ring. The resistance of the rotor should be within 2.4 to 4.9 ohms.
    - A higher reading indicates a damaged slip ring, welded connection or a broken wire.
    - A lower reading indicates a shorted wire or slip ring.
3. Replace the rotor if it is damaged and cannot be serviced.
4. Contact one ohmmeter probe to a slip ring and the other probe to the rotor shaft. The meter reading should be infinite (no needle movement).
5. A reading other than infinite indicates the rotor coil is grounded to the shaft. Replace the rotor if it is grounded and cannot be serviced.

Rectifier

NOTE: Digital meters cannot be used to perform these diode tests.

1. To test the positive diodes, contact one probe to one of the rectifier assembly B+ blade terminals and contact each of the three stator terminals with the other probe. Reverse the probes and repeat the test. All diodes should show a low reading of approximately 7 ohms in one direction and an infinite reading (no needle movement) with the probes reversed. This reading may be checked against a good rectifier if one is available.
2. Remove the rectifier assembly from the alternator. Set the ohmmeter multiplier setting at 1 and calibrate the meter as directed.
3. Perform the preceding tests for the negative diodes by contacting the rectifier assembly base plate and the three stator terminals.
4. Replace the rectifier assembly if the meter readings within an acceptable range.

DIODE TESTS, MOTORCRAFT ALTERNATOR

NOTE: Digital meters cannot be used to perform these diode tests.

1. Remove the rectifier assembly from the alternator and stator assembly (unsolder the three stator leads). Set the ohmmeter multiplier setting at 1 and calibrate the meter according to the manufacturer's instructions.
2. If a Rotunda Inductive Dwell-Tach-Volts-Ohms Tester is not available, obtain a known good replacement rectifier and check the resistance of each diode as described below. Compare results obtained from the replacement rectifier with results obtained from the original rectifier. The low resistance readings will vary with the type of ohmmeter used.
3. To test one set of diodes, contact one probe to the terminal bolt and contact each of the three stator lead terminals with the other probe. Reverse the probes and repeat the test. All diodes should show a low reading of approximately 6 ohms when tested in one direction, and an infinite reading (no needle movement) with the probes reversed.
4. Repeat the preceding tests for the other set of diodes by connecting one probe to the ground terminal.
5. Replace the rectifier assembly if the meter readings are not within an acceptable range.

General Information

Lead-Acid Batteries

Batteries are electrochemical devices that 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 battery has three functions:

- To supply power to start the engine.
- To stabilize the voltage in the electrical system. The battery filters high voltage transients and protects electronic components in the vehicle.
- To supply 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.

In conventional liquid-electrolyte batteries (wet cells), each battery contains a group of plates immersed in a solution of electrolyte (dilute sulfuric acid).

Batteries may produce hydrogen gas when being charged. The vents allow the escape of gases produced in the battery.

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.

Proper testing will indicate the battery condition. For more information, see **Troubleshooting 300**.

Absorbed Glass Mat (AGM) Batteries

Absorbed Glass Mat (AGM) batteries are lead-acid batteries in which the electrolyte is contained in a fiberglass mat. AGM batteries are physically similar to standard batteries. Carefully check the label on every battery to be certain it is AGM, and **never install AGM batteries in the same circuit with other types of batteries.**

AGM batteries are designed for high cranking amps and repeated cycle service to accommodate many of the auxiliary loads on vehicle electrical systems. They offer good protection against damage due to vibration, and are leak- and spill-proof, even if cracked or broken. Also, they self-discharge more slowly, and generate less heat when charging or discharging.

IMPORTANT: AGM batteries may be damaged or ruined by equipment designed for other types of batteries. AGM battery chargers must be regulated to a charge voltage less than 15.4 DCV; many chargers provide excessive voltage. To get full service from AGM batteries, carefully follow the battery manufacturer's instructions regarding charging rates and procedures.

Parasitic Battery Drain

Batteries are replenished each time the vehicle is driven with normal vehicle use. In long-term parking situations, however, parasitic drains may discharge the batteries enough that the starter will not be able to crank the engine.

A parasitic drain is an electrical load that draws current from the batteries when the ignition remains off.

A typical parasitic drain falls into the 25 to 325 mA (0.025 to 0.325 amps) range. Multiply the drain (in amps) by the time (in hours) the batteries sit without being recharged. The result is the amount of ampere-hours consumed by the parasitic drain. The actual drain may be small, but over time the batteries grow steadily weaker.

At warm temperature of 77°F (25°C), using approximately 40 percent of the total available ampere-hours will bring fully charged batteries to a no-start condition. In colder temperatures, the batteries will reach a no-start condition sooner.

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.

- 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.
- Make sure that the area is well ventilated.
- 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.
- Make sure 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.
- 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.
- Do not smoke near batteries that are being charged or have recently been charged. Keep the batteries away from open flames or sparks.
- If the battery is frozen, let it reach room temperature and completely thaw before trying to charge it. Check for leaks and cracks before charging the battery. Replace the battery if leaks or cracks are seen.
- Take care that tools or metal objects do not fall across the battery terminals.

⚠ 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.

⚠ 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, 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.

Battery Removal, Cleaning and Inspection, and Installation

⚠ WARNING

Before doing any of the following procedures, see "Battery Safety Precautions" in Subject 100. Failure to follow the safety precautions could result in personal injury.

Removal

IMPORTANT: Before working on any battery box, make sure all electrical loads (lights, ignition, accessories) are turned off.

OUTSIDE-RAIL-MOUNTED BATTERY BOX (See Fig. 1)

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the threaded fasteners that attach the side fairing, if equipped, in front of the battery box. Remove the side fairing. For instructions, see Group 31.

   If no side fairing is installed, remove the step plate, if equipped.
3. Pull on the end of each hold-down latch until the end clears the cover-mounted catch. Pivot the latches out of the way, then lift off the battery box cover.
4. For assembly reference, note the locations of the battery positive and negative terminals in relation to surrounding components. Remove the battery cables.
5. Remove the battery retainer assembly. Remove the batteries from the carrier.
6. Remove the battery box.
   - 6.1 Remove the 1/2–13 nuts, bolts and flatwashers holding the battery box to the frame rail bracket.
   - 6.2 Remove the battery box from the bracket.
7. Remove the battery box brackets from the frame rail.
   - 7.1 Remove the 5/8–11 nuts, bolts and flatwashers holding the brackets to the frame rail.
   - 7.2 Remove the brackets from the frame rail.

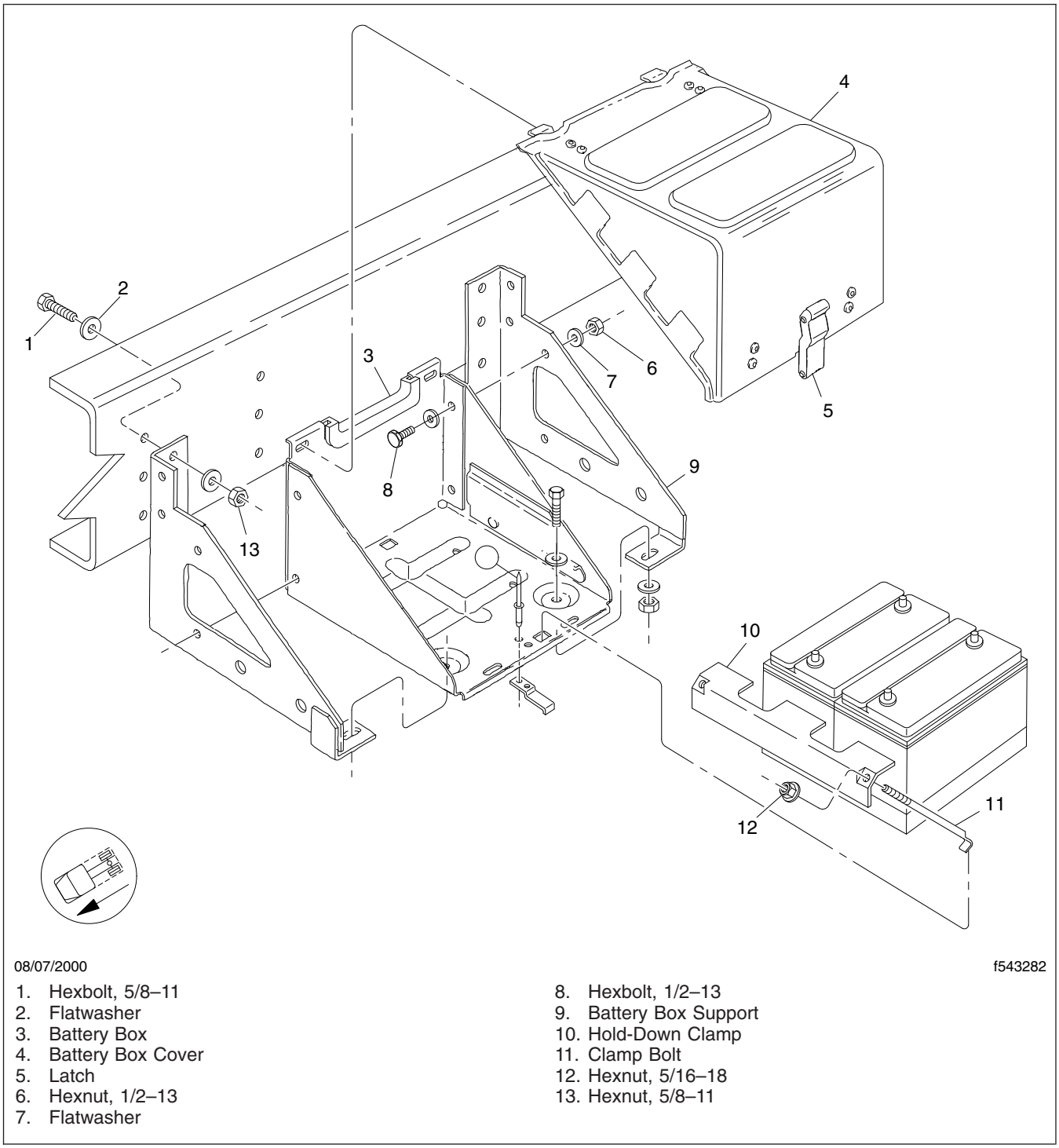
BETWEEN-RAIL-MOUNTED BATTERY BOX (See Fig. 2)

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the deck plate, if equipped. Release the handles from the tabs, unfold the handles and lift the plate.
3. Release the hold-downs and remove the battery box lid.
4. Disconnect the battery cables from the battery terminals and move the cables out of the way.
5. Remove the battery hold-down latches.
   - 5.1 Loosen the 1/2-inch nut and flatwasher holding the anchor bolt.
   - 5.2 Disconnect the anchor bolt from the box and set all hold-down hardware aside.
6. Remove the batteries from the box. For assembly reference, note the locations of the battery positive and negative terminals in relation to surrounding components.
7. Remove the battery box.
   - 7.1 From the inside of the battery box, remove the two 3/4-inch bolts and flatwashers from each side of the box.
   - 7.2 Remove the battery box from the vehicle.
8. Remove the battery box brackets from the frame rail.
   - 8.1 Remove the 15/16-inch hexhead nuts and flatwashers holding the rear bracket to the frame rail.
   - 8.2 Remove the 15/16-inch hexhead nuts and flatwashers holding the front bracket to the frame rail.
   - 8.3 Remove the brackets from the frame rail.

Cleaning and Inspection

1. Inspect all battery cables and interconnectors for wear, and replace them if necessary. Remove corrosion from cables, terminals, and battery

Battery Removal, Cleaning and Inspection, and Installation



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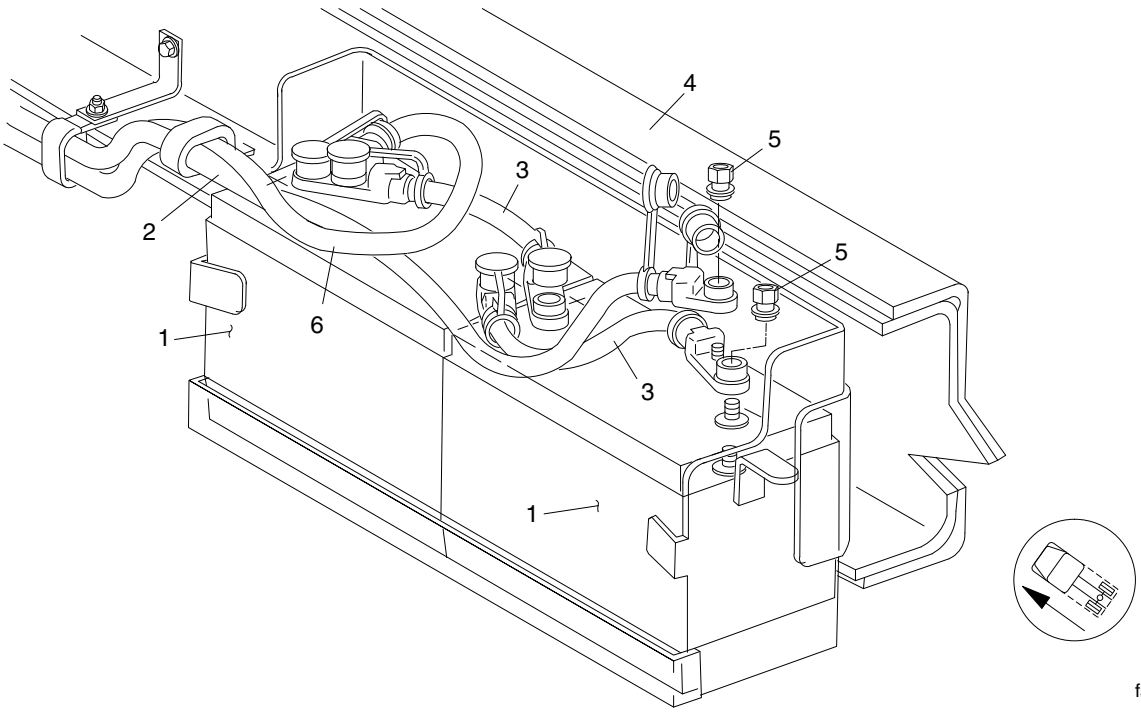
1. Hexbolt, 5/8–11
2. Flatwasher
3. Battery Box
4. Battery Box Cover
5. Latch
6. Hexnut, 1/2–13
7. Flatwasher
8. Hexbolt, 1/2–13
9. Battery Box Support
10. Hold-Down Clamp
11. Clamp Bolt
12. Hexnut, 5/16–18
13. Hexnut, 5/8–11

Fig. 1, Outside-Rail-Mounted Battery Box

Battery Removal, Cleaning and Inspection, and Installation



1. Battery
2. Battery Cable (–)
3. Jumper
4. Frame Rail
5. Nut
6. Battery Cable (+)

Fig. 2, Between-Rail-Mounted Battery Box

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. Inspect and ensure that the nut is self-locking 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 enamel.
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. To prevent rusting, paint the retainer assembly if needed.
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.

⚠ CAUTION

Using an undercapacity 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 130**.

Battery Removal, Cleaning and Inspection, and Installation

OUTSIDE-RAIL-MOUNTED BATTERY BOX

1. Place the batteries in the carrier with the terminals in the proper position, as referenced earlier. The batteries should rest level in the carrier.
2. Install the battery retainer assembly, and tighten it until the batteries are secure. See **Fig. 1**.

CAUTION

Do not overtighten the battery retainer assembly. Overtightening could damage the batteries.

3. Connect the battery cables to the batteries.
   - 3.1 To provide corrosion protection, apply pumpable dielectric grease liberally to the terminal pads. For a list of approved suppliers, see **Specifications 400**.
   - 3.2 Install the battery cable interconnectors.
   - 3.3 Tighten the battery cables to the torque specifications listed on the battery, generally 10 to 15 lbf·ft (14 to 20 N·m). Connect the ground cable last.

CAUTION

Make sure the polarity is correct. Reversed polarity may cause serious damage to the electrical system.

   - 3.4 Check for correct polarity with respect to the vehicle.
4. 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.

5. Install the battery box cover. Install the threaded fasteners that attach the side fairing (if equipped). For instructions, see **Group 31**.

   If removed, install the step plate.
6. Remove the chocks from the tires.

BETWEEN-RAIL-MOUNTED BATTERY BOX

1. Install the battery box brackets on the frame rail.
2. Install the battery box.
3. Place the batteries in the battery box with the terminals in the proper position, as referenced earlier. Make sure the batteries rest level in the box.
4. Install the battery hold-down latches.

CAUTION

Do not over-tighten the battery hold-down latches. Over-tightening could damage the batteries.

5. Connect the battery cables to the batteries.
   - 5.1 To provide corrosion protection, apply pumpable dielectric grease, No. 48-02349-000, liberally to the terminal pads. For a list of approved suppliers, see **Specifications 400**.
   - 5.2 Install the battery cable interconnectors.
   - 5.3 Tighten the battery cables to the torque specifications listed on the battery, generally 10 to 15 lbf·ft (14 to 20 N·m). Connect the ground cable last.
   - 5.4 Check for correct polarity with respect to the vehicle.

CAUTION

Make sure the polarity is correct. Reversed polarity can cause serious damage to the electrical system.

6. 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.

7. Install the battery box cover.

8. Install the deck plate, if equipped.
9. Remove the chocks from the tires.

Emergency Starting Using Booster Cables

WARNING

Before jump-starting a vehicle, read the instructions in Subject 100. Failure to follow the safety precautions could result in personal injury.

WARNING

Batteries release explosive gas. Do not smoke when working around batteries. Put out all flames and remove all sources of sparks or intense heat in the vicinity of the battery. Do not allow the vehicles to touch each other. Do not lean over the batteries when making connections, and keep all other persons away from the batteries. Failure to follow these precautions could lead to severe personal injury as a result of an explosion or acid burns.

NOTICE

Make sure both electrical systems are the same voltage. Electronic devices on both vehicles can be damaged when connected to a vehicle with a different operating voltage.

1. Apply the parking brakes and turn off all lights and other electrical devices. Ensure that the vehicles are not touching and both ignition switches are turned to the OFF position.

IMPORTANT: Do not attempt to jump start a damaged battery.

2. Remove the battery box cover. See **Fig. 1** for the standard battery compartment location.

NOTICE

Always connect the batteries and jumper cables correctly (positive-to-positive and negative-to-negative). Connecting a charging device backwards (positive-to-negative) can severely damage the vehicle electrical content and cause non-warrantable failures.

IMPORTANT: On vehicles equipped with optional jump start posts, connect to these posts instead of the battery terminals. Jump start

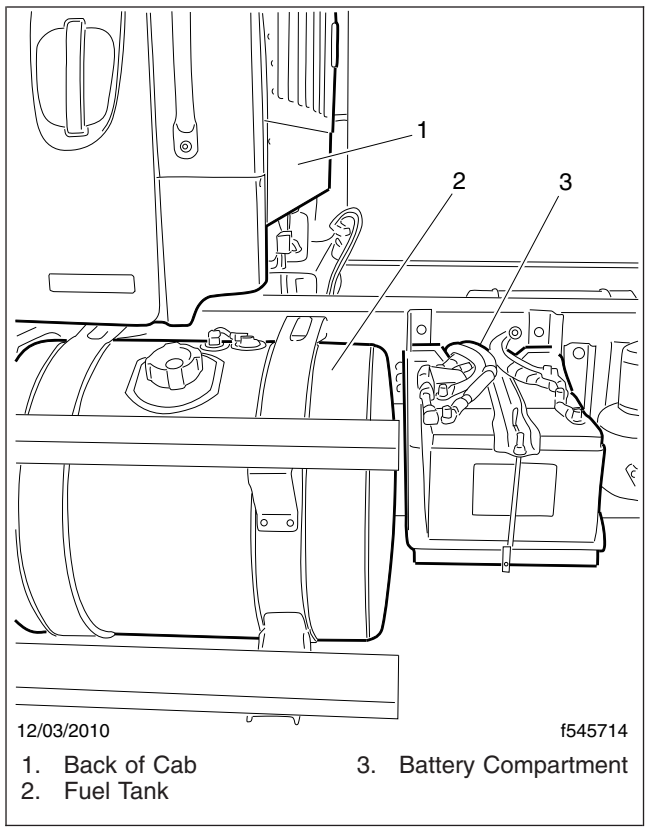


Fig. 1, Standard Battery Compartment Location

posts may be installed in various locations on the vehicle. See **Fig. 2**.

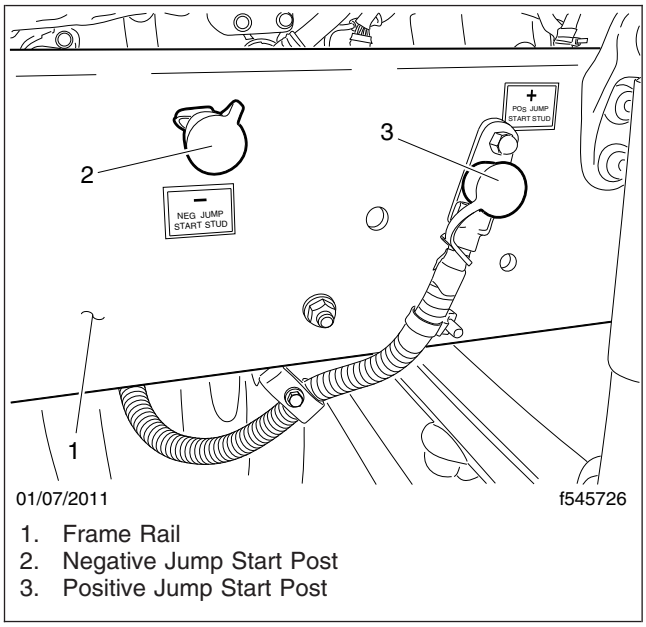
3. Connect the positive (+) jumper cable to the positive terminal or jump start post on the discharged battery. See **Fig. 3**.
4. Connect the other end of the positive jumper cable to the positive terminal or jump start post on the booster battery providing the charge.

WARNING

Do the next step exactly as instructed and do not allow the clamps of one cable to touch the clamps of the other cable. Otherwise, a spark could occur near a battery, possibly resulting in severe personal injury from explosion and acid burns.

5. Connect the negative (-) jumper cable to the negative terminal or jump start post on the booster battery.

Emergency Starting Using Booster Cables



1. Frame Rail
2. Negative Jump Start Post
3. Positive Jump Start Post

Fig. 2, Possible Jump Start Post Location (passenger-side engine compartment)

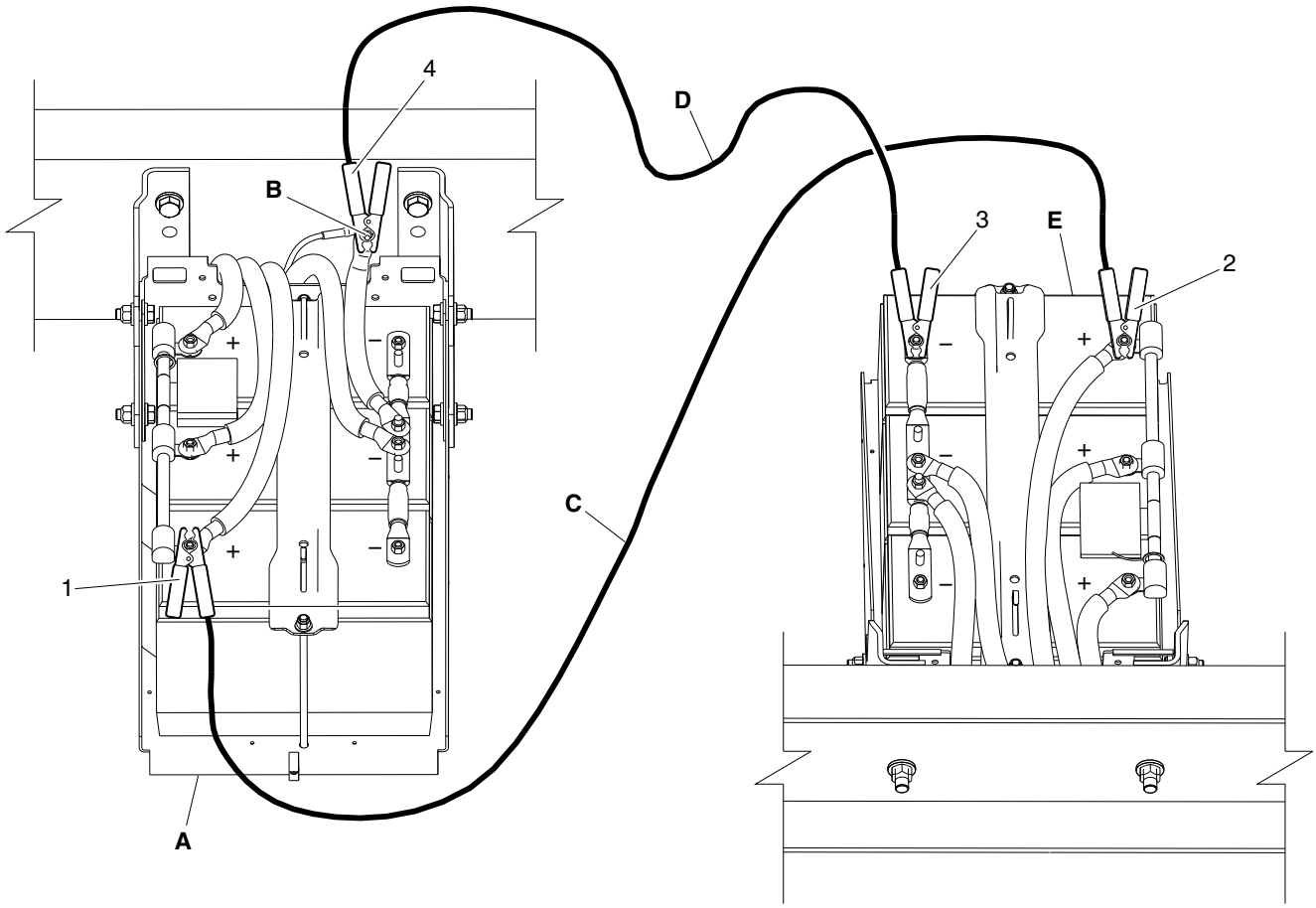
6. Connect the other end of the negative jumper cable to the negative ground stud on the vehicle requiring the jump start.
7. Start the engine of the vehicle providing the jump start and let the engine run a few minutes to charge the batteries of the other vehicle.
8. Attempt to start the engine of the vehicle receiving the jump. Do not operate the starter longer than 30 seconds, and wait at least two minutes between starting attempts to allow the starter to cool.
9. When the engine starts, let it idle a few minutes.

⚠ WARNING

Do the next step exactly as instructed and do not allow the clamps of one cable to touch the clamps of the other cable. Otherwise, a spark could occur near a battery, possibly resulting in severe personal injury from explosion and acid burns.

10. Disconnect the negative jumper cable from the negative cable stud on the jump-started vehicle.
11. Disconnect the negative jumper cable from the booster battery.
12. Disconnect the positive cable from the booster battery.
13. Disconnect the other end of the positive jumper cable from the jump-started vehicle.
14. Install the battery box cover; be sure it is positioned properly before fastening the latch.

Emergency Starting Using Booster Cables



Disconnect jumper cables in the REVERSE order that they were connected.

A. Discharged Battery
B. Negative Ground Stud
C. Positive Jumper Cable
D. Negative Jumper Cable
E. Booster Battery

1. 1st Connection: Positive Jumper Cable to Discharged Battery
2. 2nd Connection: Positive Jumper Cable to Booster Battery
3. 3rd Connection: Negative Jumper Cable to Booster Battery
4. 4th Connection: Negative Jumper Cable to Negative Ground Stud (discharged battery)

Fig. 3, Jumper Connections

⚠ WARNING

Before charging a battery, read the instructions in Subject 100. 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.

Battery Charging

AGM batteries may be charged only with a charger that is specified for AGM batteries. Many older chargers operate at a voltage that is too high for AGM batteries and will cause permanent damage. Never combine AGM and flooded batteries together for charging or for use in a vehicle.

See **Table 1** for voltage to approximate battery state of charge for flooded batteries.

Voltage to Approximate Battery State of Charge for Flooded batteries		
Voltage		State of Charge
Flooded	AGM	
12.6	12.8	100%
12.4	12.6	75%
12.2	12.3	50%
12.0	12.0	25%
11.8	11.8	0%

Table 1, Voltage to Approximate Battery State of Charge for Flooded batteries

1. If the batteries are not installed in the vehicle, install the lead adapters on the battery positive and negative posts.
2. Connect the charger to the battery following the manufacturer's instructions. Slightly rock the charger's clamps to insure a complete connection.

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.

3. 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.

Troubleshooting

If the batteries pass testing, check for the following causes:

1. Accessories were left on overnight.
2. A slipping alternator belt, high resistance in the wiring, or a defective alternator is causing the batteries to discharge.
3. The electrical loads are 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 a few days. Batteries left in a discharged condition are subject to freezing.

Electrical Drain and Parasitic Load

Batteries are replenished each time the vehicle is driven with normal vehicle use. In long-term parking situations, however, parasitic drains may discharge the batteries enough to cause a no-start condition.

A parasitic drain is an electrical load that draws current from the batteries when the ignition remains off. Some devices, such as the electronic control unit (ECU), the bulkhead module (BHM), the chassis module (CHM), the antilock braking system (ABS), and radio memory are intended to draw a very small current continuously. These draws are measured in milliamps (mA). Current draw should be less than 325 milliamps with no circuits active and the ECU, BHM, CHM, and ABS turned off.

Problem—The Batteries Are Undercharged

Problem—The Batteries Are Undercharged	
Possible Cause	**Remedy**
The drive belt is loose.	Check the drive belt and tensioner. 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 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 alternator section in **Group 15** for instructions.
The batteries are undercharged.	Perform a battery test. 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 alternator or battery cables are undersized.	Perform a cable load drop test.
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).	Refer to **Group 82, Subject 300** in this manual for instructions.

Battery Troubleshooting

1. **Check battery pack voltage to determine state of charge**.

   If equipped, set Load Disconnect Switch to "Off." With the DMM probes on the positive and negative posts of the battery pack, record the voltage. Due to differences in their design and operation, flooded cell and AGM batteries have different voltages at the same state of charge.

   Batteries should be fully charged before further testing. If batteries are not fully charged, they will draw current to recharge during testing, invalidating the troubleshooting test results. Fully charged batteries ensure reliable diagnosis.

   See **Table 1** for voltage as an approximate indicator of state of charge for AGM and flooded batteries.

   If the battery pack will not charge to 100% state of charge, there may be a shorted cell. Break the pack into individual batteries and test individually using an approved tester. Go to **Check 3, Individual Battery Testing**. After batteries have been tested individually, verify pack voltage once again.

Flooded	AGM	SoC
12.6	12.8	100%
12.4	12.6	80%
12.3	12.4	60%
12.1	12.2	40%
12	12	20%
11.8	11.8	0%

Table 1, Voltage to Approximate State of Charge (SoC)

2. **Remove surface charge: HVAC blower, lights on, 5 min.**

   Surface charge refers to a higher initial charge (volts), when discharging, in recently-charged batteries. This charge is a "shallow" charge, meaning that the charging-induced chemical reaction has mostly occurred at the surface of the lead plates, and has not equalized throughout the lead. Drawing current from the batteries before testing removes the surface charge, allowing for a better assessment of the "deep charge" state of the lead plates.

   After the surface charge is removed, the batteries need to be at least 80% SoC for further testing. See **Table 1** for voltage as an approximate indicator of state of charge.

3. **Test Individual Batteries**.

   IMPORTANT: Batteries should only be tested individually.

   3.1 Remove the negative cables of the batteries first, and secure the leads out of the way before touching the positive cables. Remove the battery cables and clean the terminal pads with a wire brush. The adapters will not make sufficient contact with dirty or corroded contact pads.

   3.2 Connect the battery tester's positive and negative clamps to the lead base terminal pads at the positive and negative studs. See **Fig. 1**.

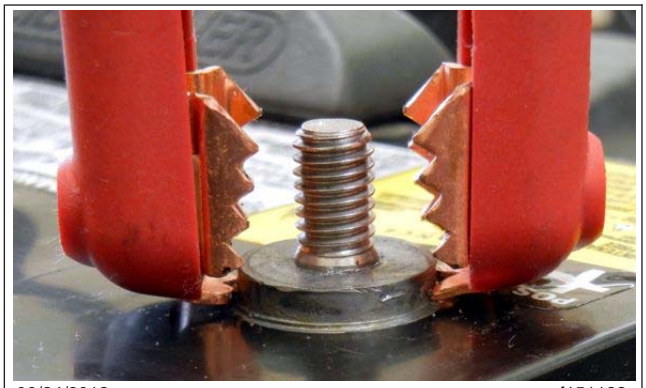


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Fig. 1, Tester Clamps Attached to the Post

The threaded portion of the battery posts are *not* the right place to clip: the steel threads won't make a good connection. The base of the post, on the lead, is the best place to clip. Taking a few extra seconds to make sure the tester, DMM, and carbon pile clips are well-connected can be the difference between a useful and a useless test.

NOTE: If the lead base is too small to clamp to, only lead stud adapters should be used, never nuts. The lead stud adapters must be screwed down tight against the cleaned lead base using a

hand tool. Lead adapters are available at most tool vendors.

Refer to the battery tester instruction manual for complete testing instructions.

If the battery tester requires the CCA rating of the battery, it should be on the battery label. See **Fig. 2**.

3.3 If the battery fails, enter the battery serial number and print out the result. The sensor windows on the tester and printer must be aligned to transmit the test results to the printer.

Fig. 2, Battery Label

See **Table 1** for recharge times. Refer to the commercial batteries page at **www.dekabatteries.com** for more information.

Recharge Time Using a Typical Charger (hours)						
Open Circuit Voltage		State of Charge	Charger Maximum Rate			
Flooded	AGM		50 Amps	30 Amps	20 Amps	10 Amps
12.6V	12.8V	100%	Ready to Use			
12.4V	12.6V	75%	0.6	0.9	1.3	2.5
12.2V	12.3V	50%	1.2	1.9	2.7	5.1
12.0V	12.0V	25%	1.8	2.9	4.3	10.7
11.8V	11.8V	0%	2.5	4.0	5.7	10.7

Table 1, Recharge Time Using a Typical Charger

AM/FM Radio Antenna Replacement

Replacement

1. Loosen and remove the antenna mast from the antenna base with the proper size wrench. See **Fig. 1**.

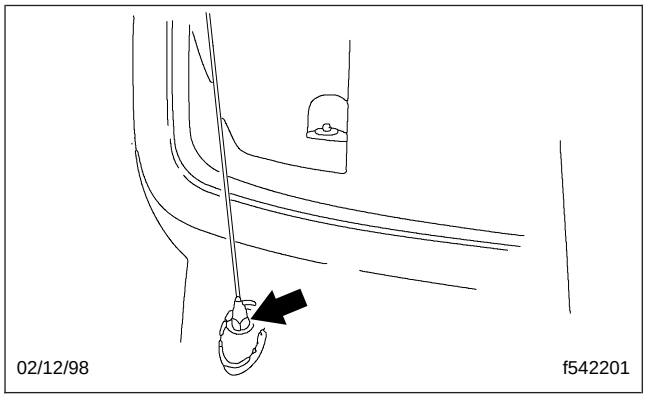


Fig. 1, Antenna Mast

2. Position the antenna mast into the antenna base and tighten with the proper wrench to specification; refer to **Specifications, 400** in this section.

AM/FM Radio Cable Replacement

Replacement

1. Remove the radio; refer to **Section 54.03** in this manual.
2. Loosen and remove the antenna mast from the antenna base with the proper size wrench. See **Fig. 1**.

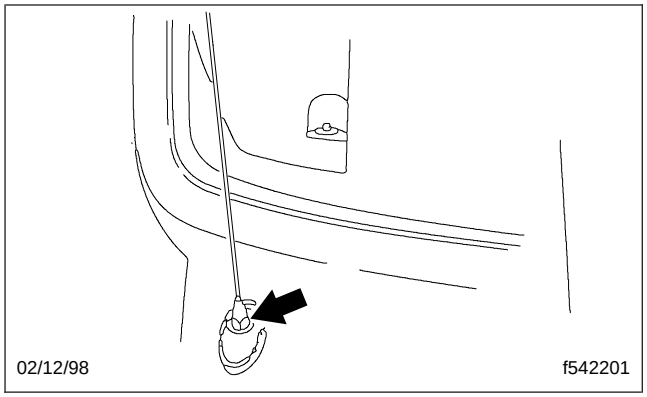


Fig. 1, Antenna Base Cap

3. Carefully pry the cap from the antenna base using both detents. See **Fig. 2**.

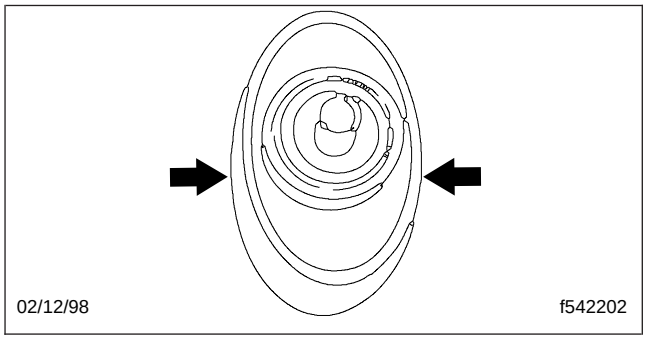


Fig. 2, Antenna Base Cap

4. Remove the antenna base retaining screws. See **Fig. 3**.
5. Raise the antenna base until the antenna lead-in cable is visible. See **Fig. 4**.
6. Pull the antenna base from the antenna lead-in cable. See **Fig. 5**.
7. Remove the screws retaining the fuse junction panel trim cover. See **Fig. 6**.
8. Disconnect the battery ground cable(s).

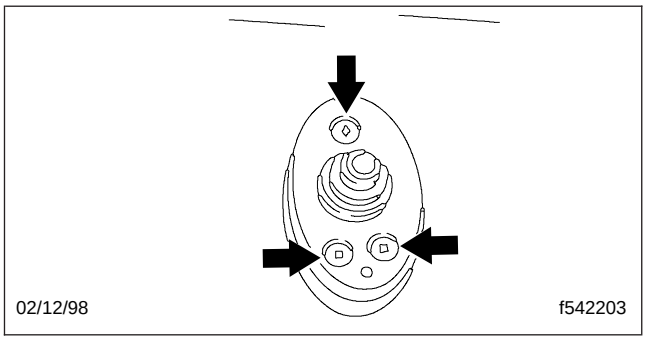


Fig. 3, Antenna Base Retaining Screws

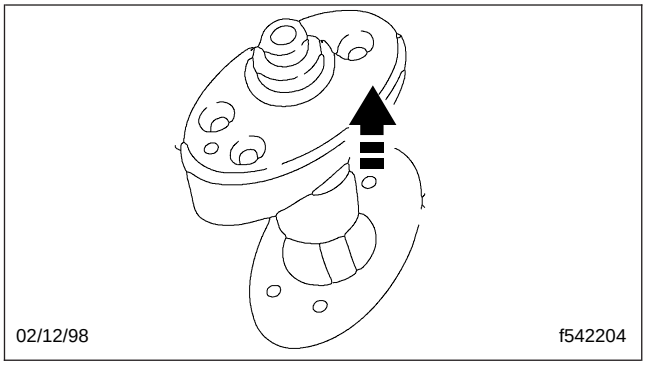


Fig. 4, Antenna Lead-In Cable

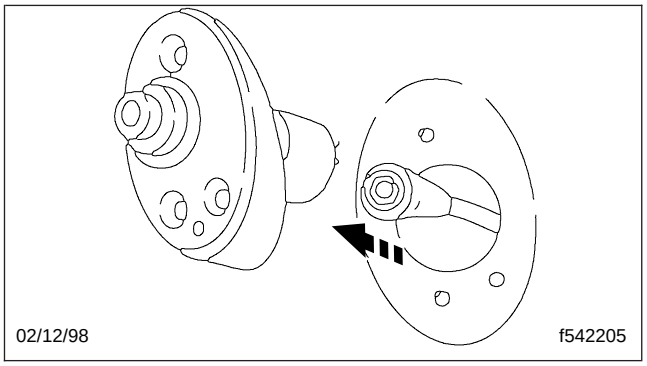


Fig. 5, Separating Antenna Base from the Antenna Lead-In Cable

9. Remove the fuse junction panel. See **Fig. 7**.
   - 9.1 Remove the fuse junction panel cover screws and remove the clear cover.
   - 9.2 Remove the fuse junction panel retaining screws.
10. Pull the fuse junction panel out of the seated position and support it. See **Fig. 8**.

AM/FM Radio Cable Replacement

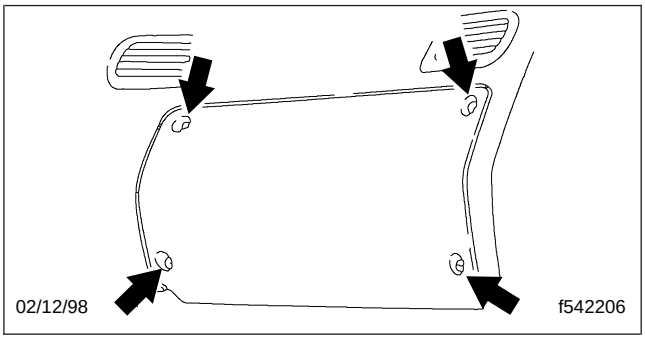
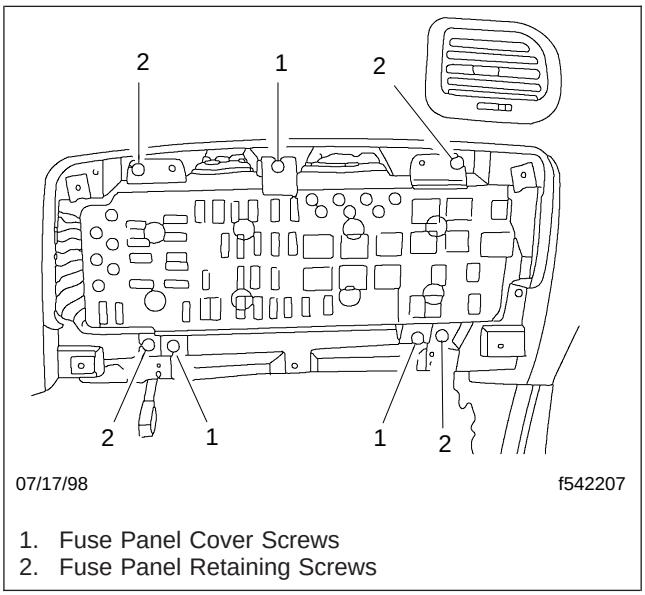


Fig. 6, Fuse Junction Panel Trim Cover Screws



1. Fuse Panel Cover Screws
2. Fuse Panel Retaining Screws

Fig. 7, Instrument Panel Fuse Junction Panel

11. From the passenger seat, pull the antenna lead-in cable and grommet through the dash panel. See **Fig. 9**.
12. Pull the antenna lead-in cable through the back of the heater air plenum chamber, noting the current routing.
13. Route the antenna lead-in cable and grommet through the dash panel.
14. Install the fuse junction panel and retaining screws.
15. Install the fuse junction panel trim cover.
16. Connect the antenna base to the antenna lead-in cable.

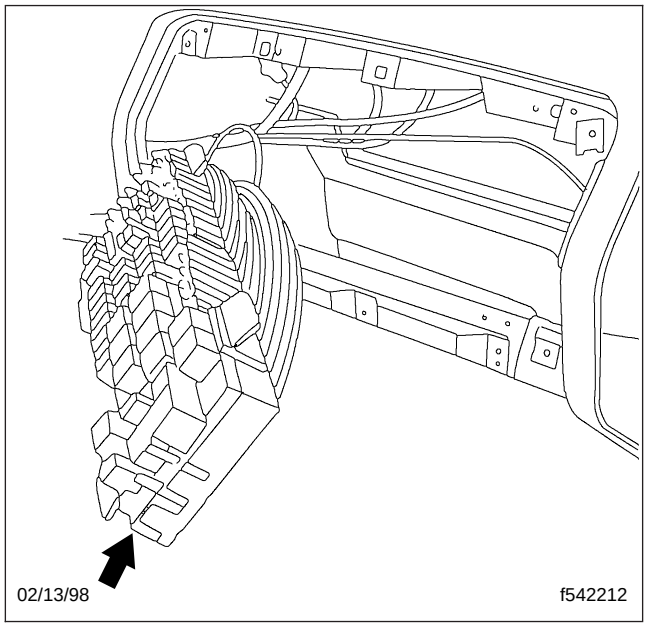


Fig. 8, Instrument Panel Fuse Junction Panel

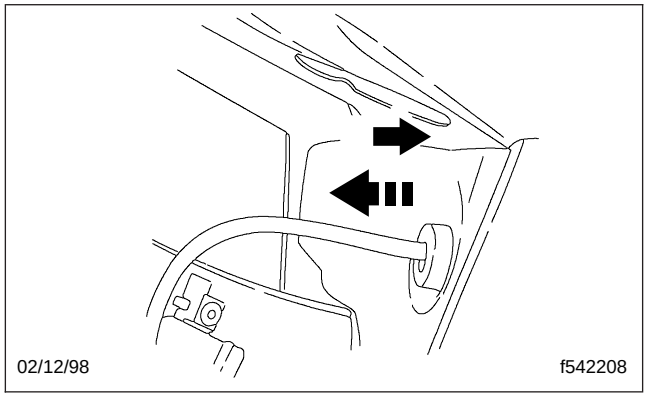


Fig. 9, Antenna Lead-In Cable and Grommet

17. Position the antenna base and install the retaining screws.
18. Install the antenna base cap.
19. Install the antenna mast.
20. Tighten the antenna mast to specification; refer to **Specifications, 400** in this section.
21. Install the radio; refer to **Section 54.03** in this manual.
22. Connect the battery ground cable(s).

CB Radio Antenna Replacement

Replacement

1. Loosen and remove the CB antenna mast from the antenna base with the proper size wrench. See **Fig. 1**.

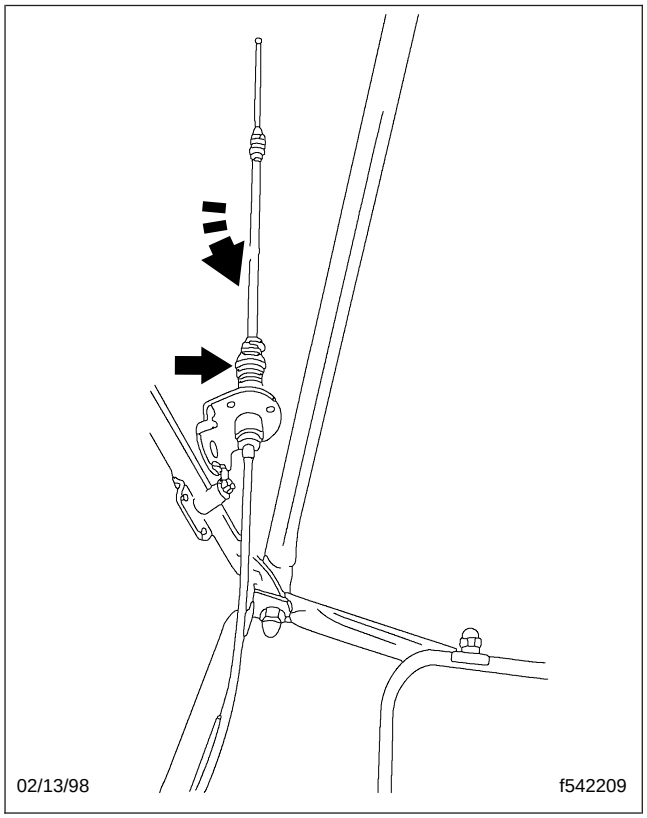


Fig. 1, CB Antenna Mast

2. Position the CB antenna mast into the CB antenna base and tighten until firm with the proper size wrench.

CB Radio Cable Removal and Installation

Removal

1. Remove the CB antenna cable from the antenna base. See **Fig. 1**.

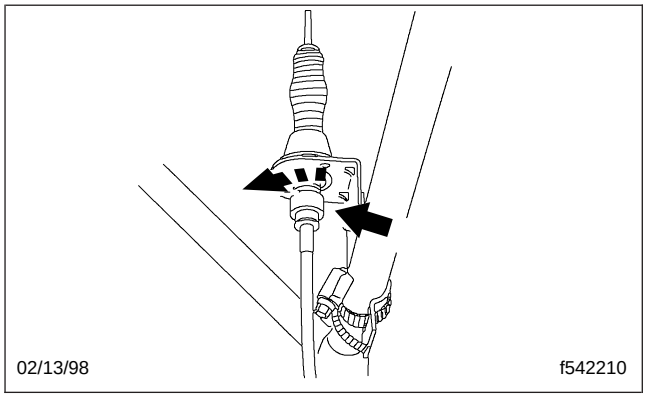


Fig. 1, CB Antenna

2. Cut the plastic ties retaining the CB antenna cable to the mirror bracket. See **Fig. 2**.
3. Remove the screws and the grab handle. See **Fig. 3**.
4. Pry the cover up from the door window handle, if so equipped. See **Fig. 4**.
5. Remove the screw and remove the door window handle, if so equipped. See **Fig. 5**.
6. Carefully pry the power mirror switch from the driver side door trim panel, if so equipped. See **Fig. 6**.
7. Press the electrical connector locking tab and separate the power mirror switch from the electrical harness, if so equipped.
8. Remove the screws and the door trim panel. See **Fig. 7**.
9. Tilt the door trim finish panel outward and disconnect the electrical connectors, if so equipped. See **Fig. 8**.
10. Remove the CB antenna cable from the plastic retainer. See **Fig. 9**.
11. Disconnect the inner door CB antenna cable connector. See **Fig. 10**.
12. Pull out the outer door grommet and remove the CB antenna cable. See **Fig. 11**.
13. Pull the door-to-A-pillar grommet from the seated position. See **Fig. 12**.

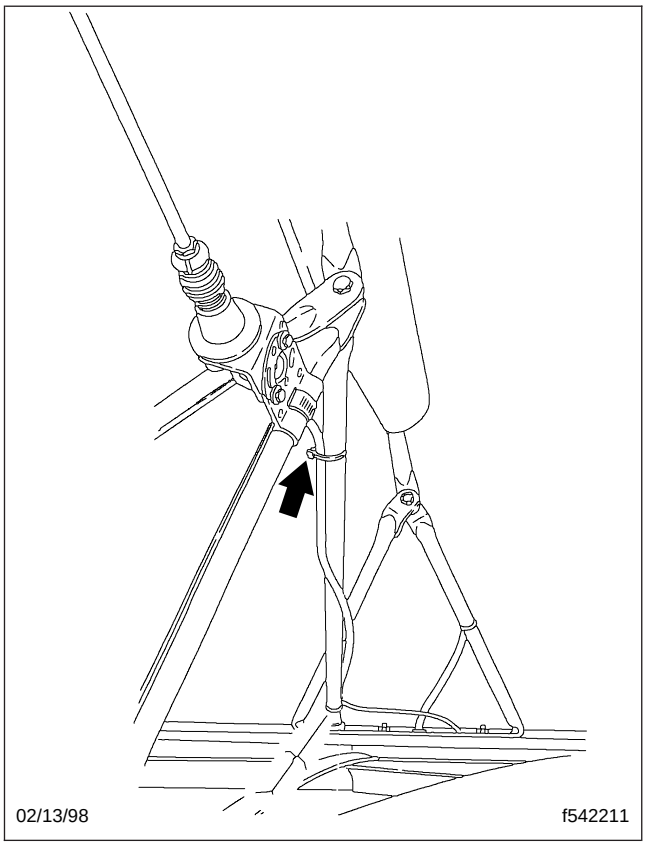


Fig. 2, Plastic Ties

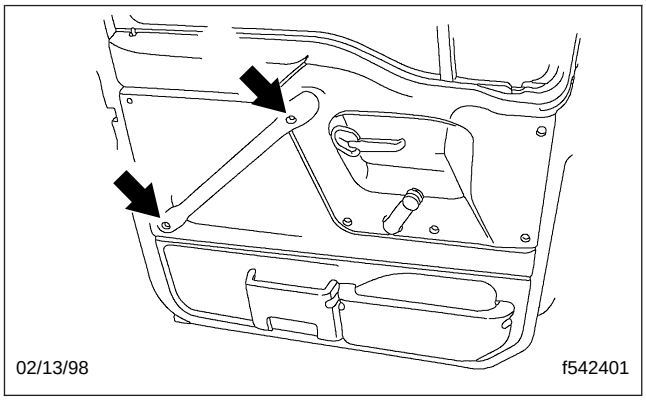


Fig. 3, Grab Handle

14. Pull the wire harness from the door until the CB antenna cable is exposed.
15. Remove the tape on the A-pillar side of the grommet and wiring. See **Fig. 13**.

CB Radio Cable Removal and Installation

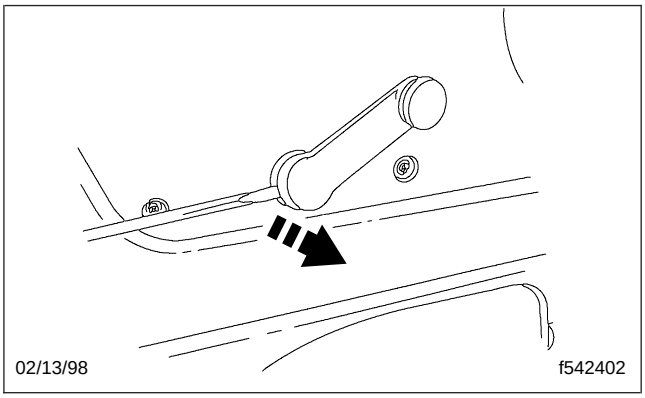


Fig. 4, Door Window Handle Cover

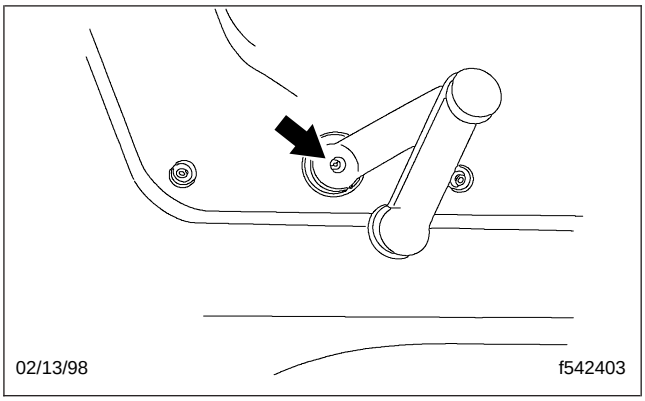


Fig. 5, Door Window Handle

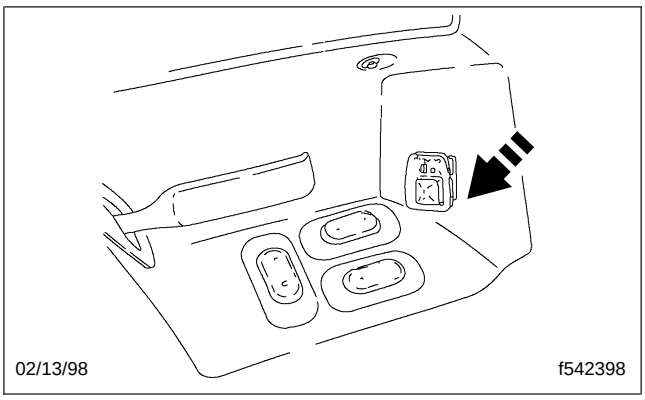


Fig. 6, Power Mirror Switch

⚠ CAUTION

Use extreme care while cutting the tape on the wire harness to prevent cutting into a wire.

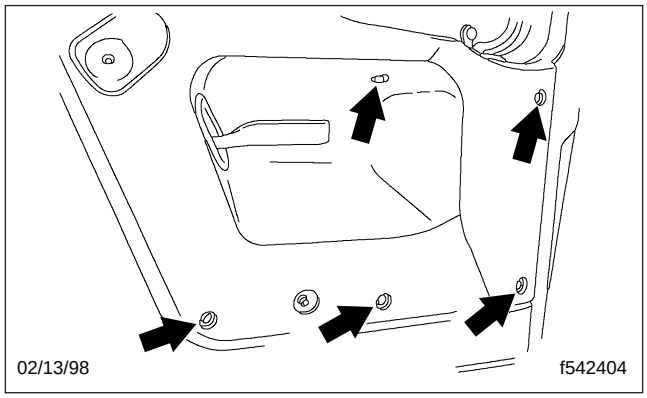


Fig. 7, Door Trim Panel

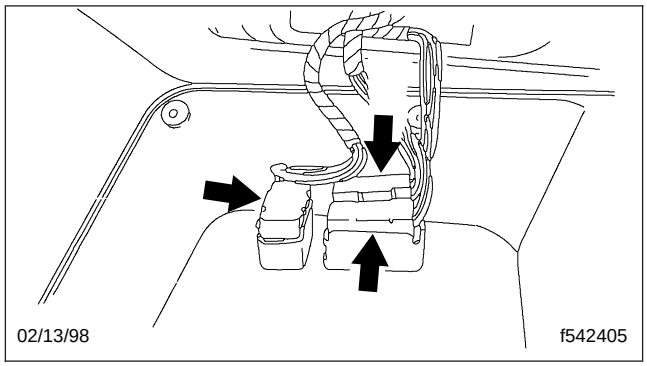


Fig. 8, Door Trim Finish Panel

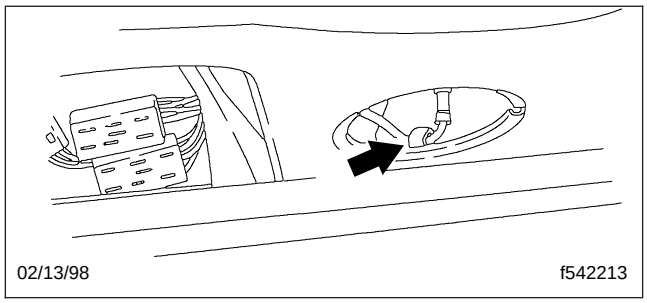


Fig. 9, CB Antenna Cable

NOTE: The door-to-A-pillar grommet must be compressed in order to cut the tape on the wire harness along the length that retains the CB antenna cable.

16. Carefully cut the tape retaining the CB antenna cable to the wire harness. See **Fig. 14**.
17. Remove the scuff panel. See **Fig. 15**.
18. Disconnect the inner cab CB antenna cable connector. See **Fig. 16**.

CB Radio Cable Removal and Installation

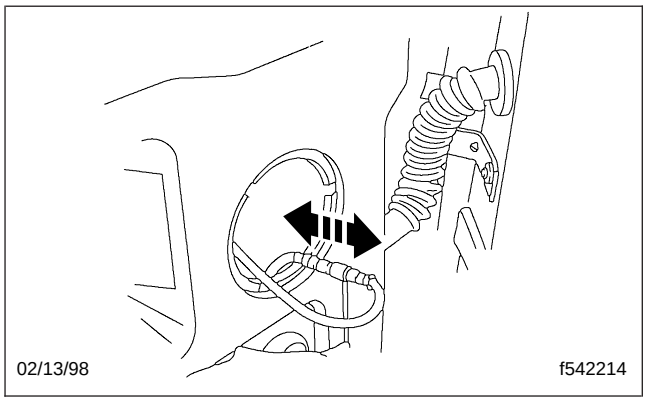


Fig. 10, CB Antenna Cable Connector

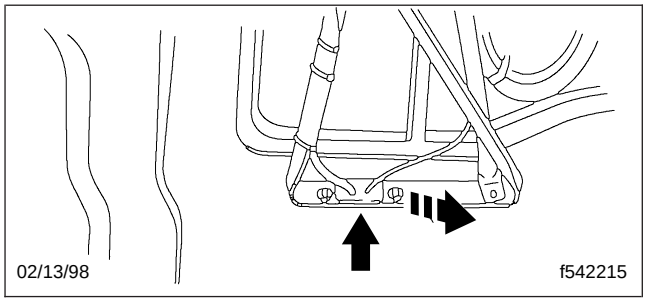


Fig. 11, Outer Door Grommet

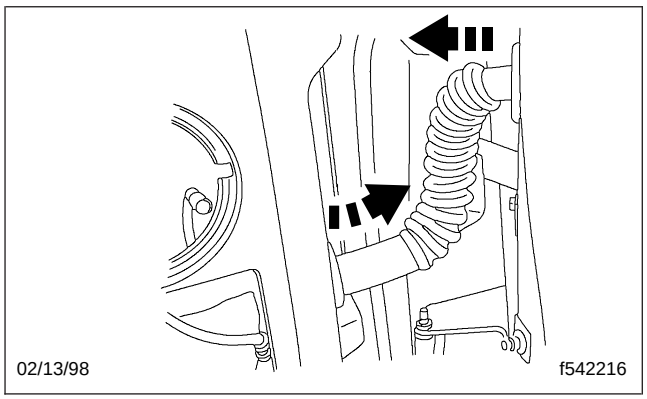


Fig. 12, Door-to-A-Pillar Grommet

19. Pull the CB antenna cable out from the inner cab.

Installation

1. Install the inner cab CB antenna cable through the cab and through the door-to-A-pillar grommet.

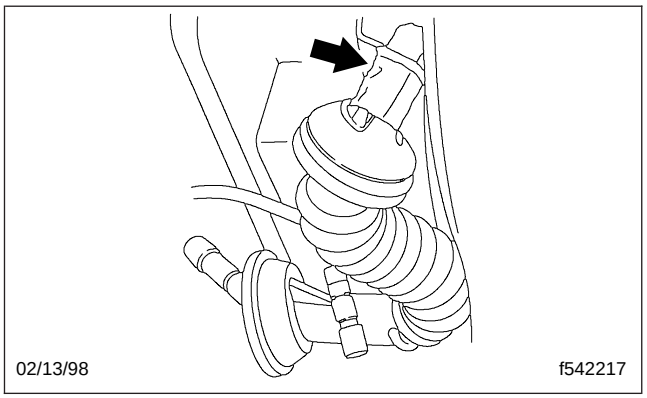


Fig. 13, Grommet and Wiring Tape

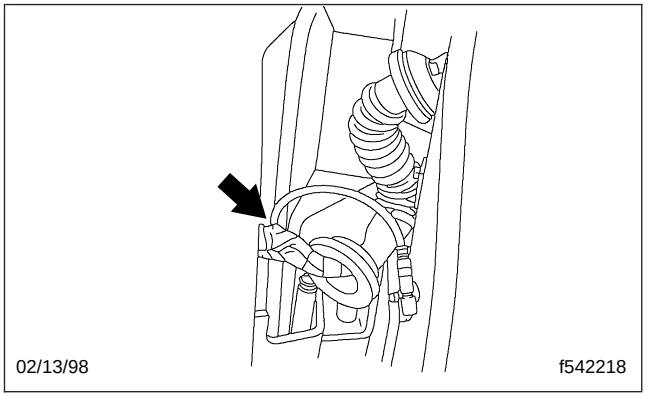


Fig. 14, Retaining Tape

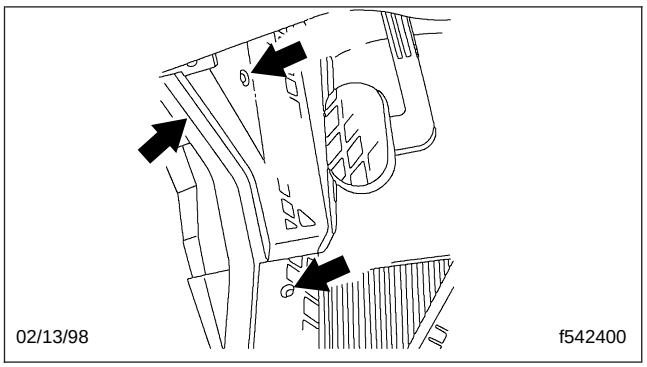


Fig. 15, Scuff Panel

2. Connect the inner cab CB antenna cable connector.
3. Install the scuff panel. See **Fig. 15**.

NOTE: The door-to-A-pillar grommet must be compressed in order to tape the CB antenna cable to the wire harness.

CB Radio Cable Removal and Installation

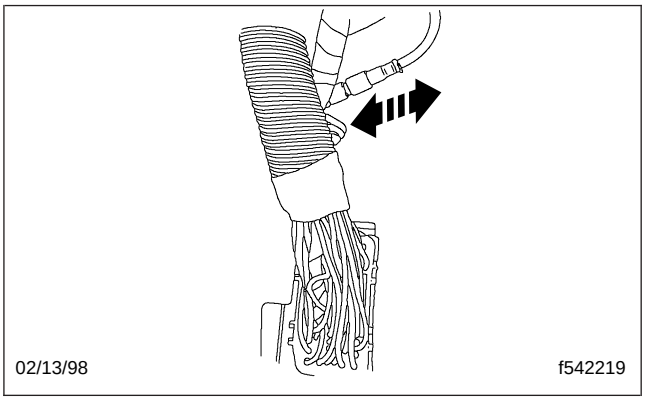


Fig. 16, Inner Cab CB Antenna Cable Connector

4. Tape the CB antenna cable to the wiring harness. See **Fig. 17**.

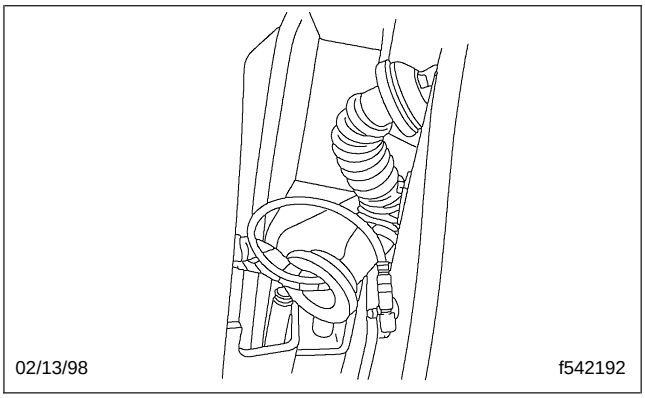


Fig. 17, Retaining Tape

5. Tape the A-pillar side of the grommet to the wiring. See **Fig. 19**.

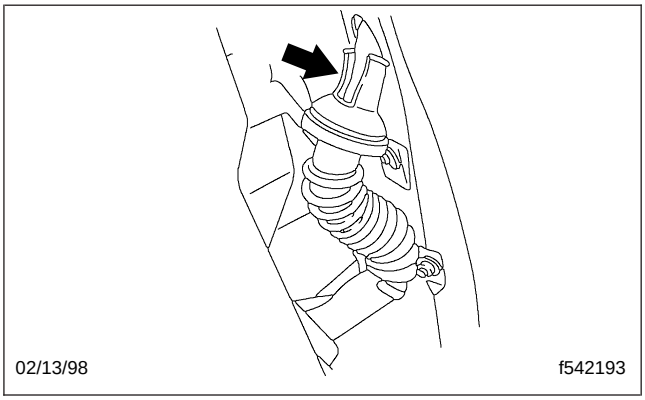


Fig. 18, A-Pillar Side Grommet

6. Install the wire harness into the door and push the door-to-A-pillar grommet into the seated position. See **Fig. 19**.

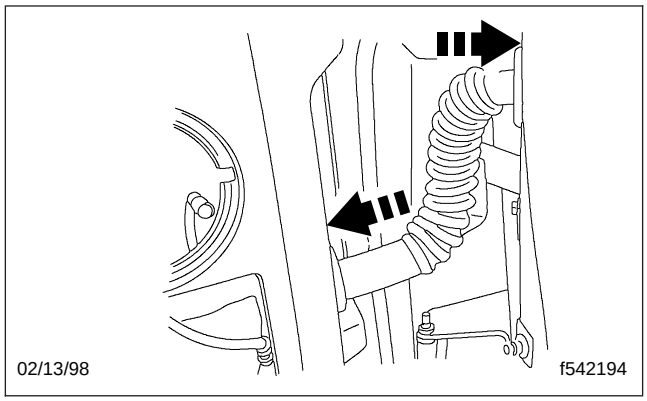


Fig. 19, Door-to-A-Pillar Grommet

7. Install the inner door CB antenna cable and install the outer door grommet. See **Fig. 20**.

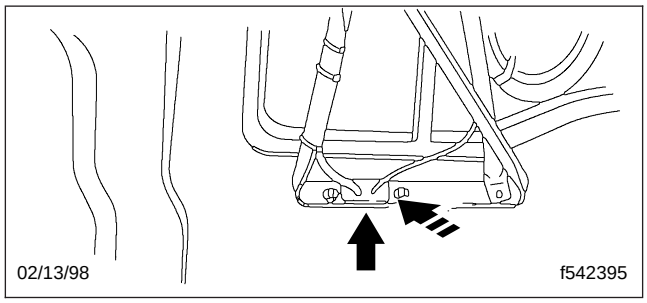


Fig. 20, Inner Door CB Antenna Cable

8. Connect the inner door CB antenna cable connector. See **Fig. 21**.

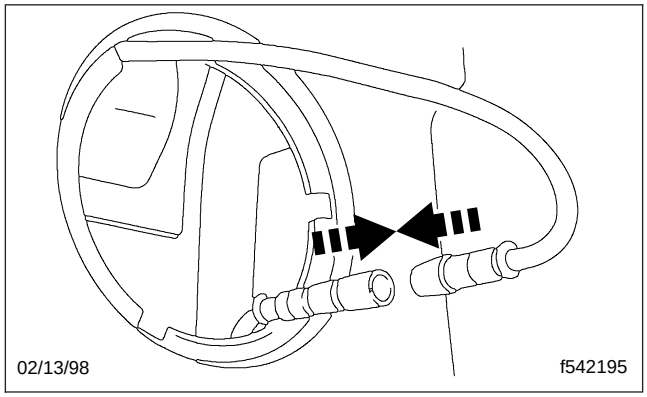


Fig. 21, Inner Door CB Antenna Cable Connector

CB Radio Cable Removal and Installation

9. Install the CB antenna cable to the plastic retainer. See **Fig. 9**.
10. Install the electrical connectors, if so equipped. See **Fig. 8**.
11. Install the door trim panel and the screws. See **Fig. 7**.
12. Install the power mirror switch to the electrical harness, if so equipped.
13. Push the power mirror switch into the driver side door trim panel, if so equipped. See **Fig. 22**.

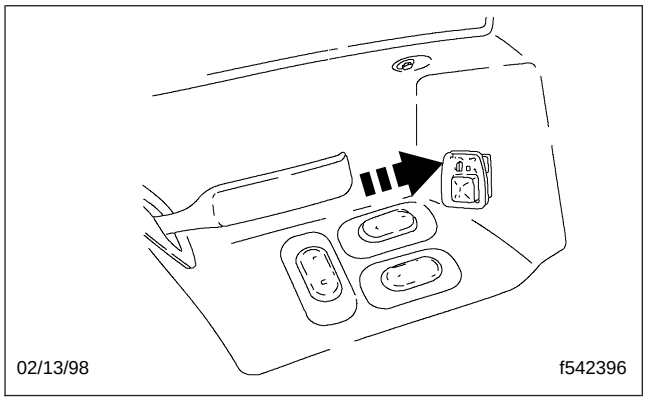


Fig. 22, Power Mirror Switch

14. Install the door window handle, screw, and door window handle cover, if so equipped. See **Fig. 5**.
15. Install the grab handle and the screws. See **Fig. 3**.
16. Install the plastic ties to the mirror bracket. See **Fig. 2**.
17. Install the CB antenna cable to the antenna base. See **Fig. 23**.

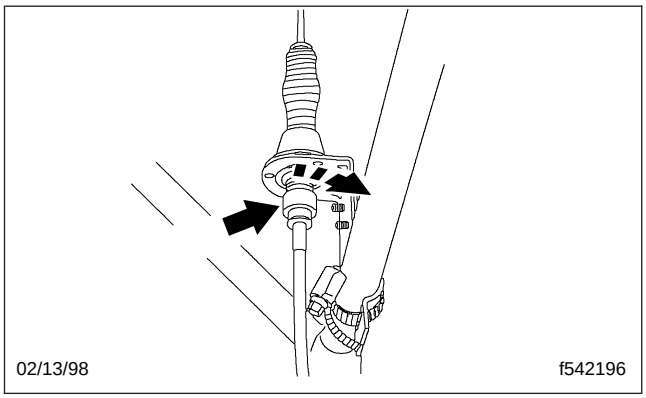


Fig. 23, CB Antenna Cable-to-Base

Specifications

Torque Specifications	
Description	**lbf·in (N·cm)**
Antenna Mast	9 (100)

Table 1, Torque Specifications

Replacement

1. Remove the radio speaker enclosure mounting screws, and remove the enclosure. See **Fig. 1**.

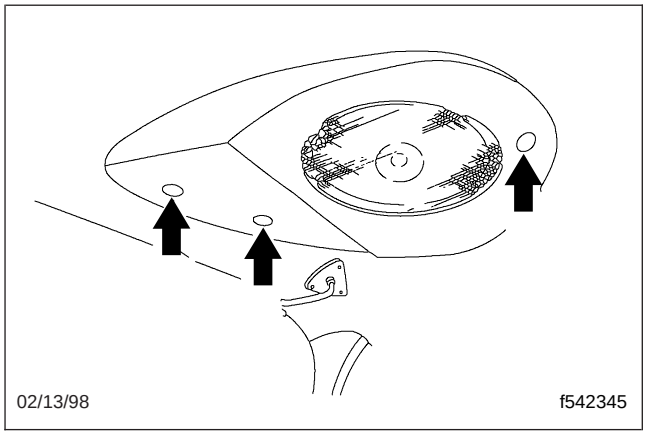


Fig. 1, Front Speaker Enclosure Mounting Screws

2. Support the speaker, and remove the retaining bolts. See **Fig. 2**.

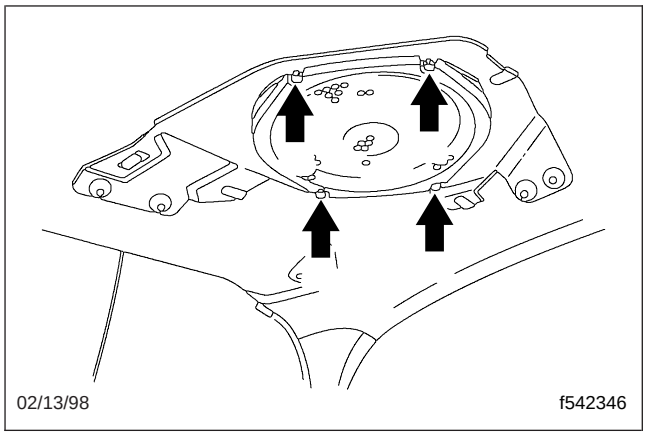


Fig. 2, Front Speaker Retaining Bolts

3. Disconnect the electrical connector, and remove the speaker from the roof. See **Fig. 3**.
4. Connect the electrical connector, and position the speaker over the bolt holes.
5. Install the speaker retaining bolts and tighten them until firm.
6. Install the front speaker enclosure and mounting screws.

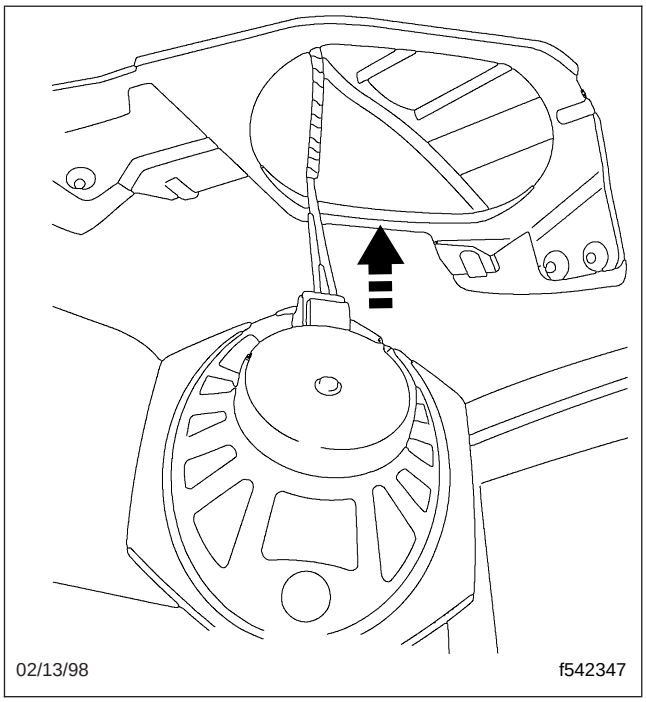
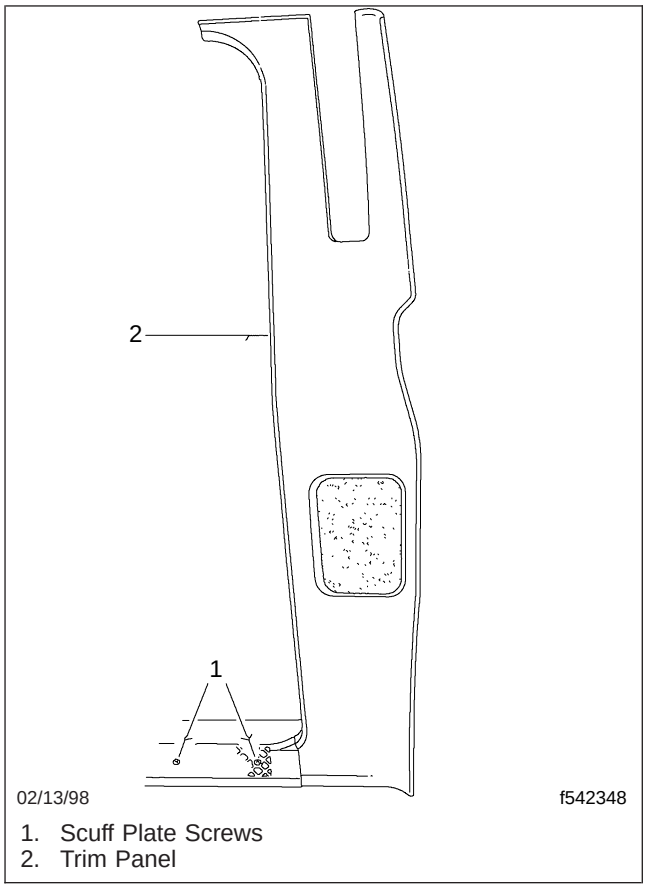


Fig. 3, Disconnecting the Front Speaker Electrical Connector

Replacement

1. Remove the B-pillar trim panel. See **Fig. 1**.



1. Scuff Plate Screws
2. Trim Panel

Fig. 1, B-Pillar Trim Panel Removal

1.1 Remove the two scuff plate screws next to the B-pillar.

1.2 Pull outward to disengage the trim panel locators, and slide the panel out through the front of the vehicle.

2. Support the speaker, and remove the retaining bolts. See **Fig. 2**.

3. Disconnect the electrical connector, and remove the speaker from the B-pillar. See **Fig. 3**.

NOTE: It may be necessary to partially remove the weatherstripping in order to install the B-pillar trim panel.

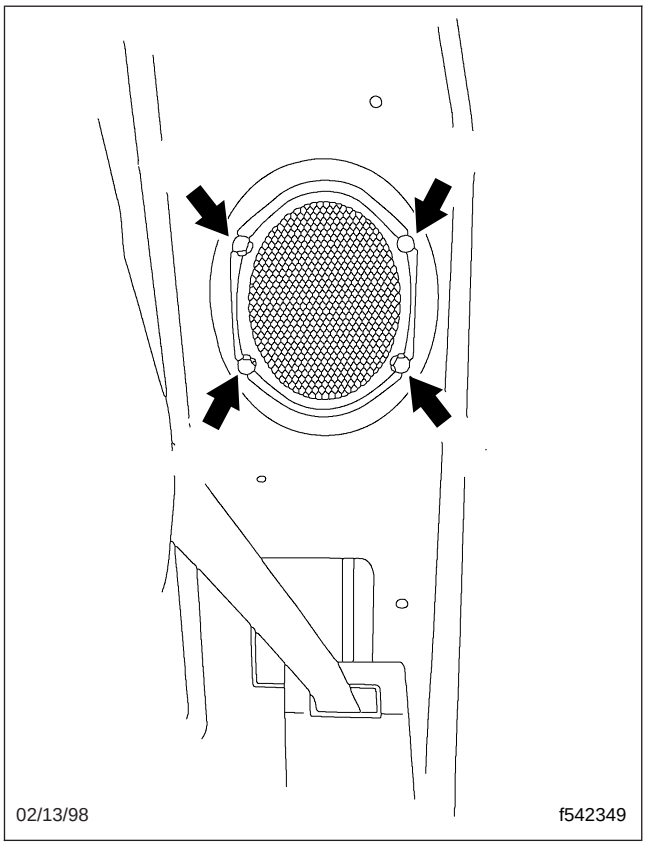


Fig. 2, Rear Speaker Retaining Bolts

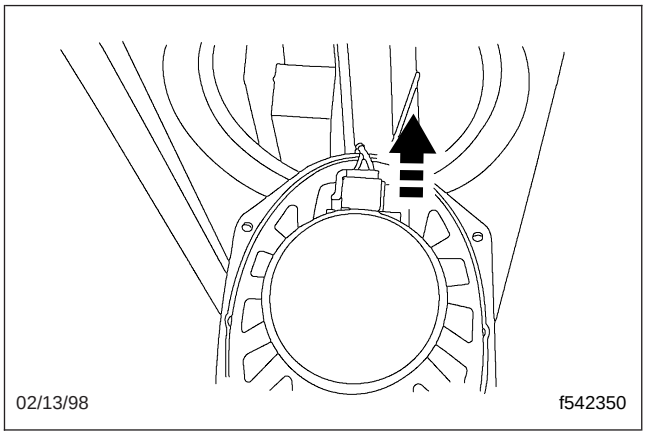


Fig. 3, Rear Speaker Electrical Connector

4. Connect the electrical connector, and position the speaker over the bolt holes.

5. Install the speaker retaining bolts and tighten them until firm.

Rear Speaker Replacement

6. Install the B-pillar trim panel.
   - 6.1 Position the B-pillar trim panel and install the trim panel locators.
   - 6.2 Install the two scuff plate screws as removed, and tighten until firm.

Roof Console Speaker Replacement

Replacement

1. Remove the roof console; for instructions, see **Group 60**.
2. Support the speaker, and remove the retaining bolts. See **Fig. 1**.

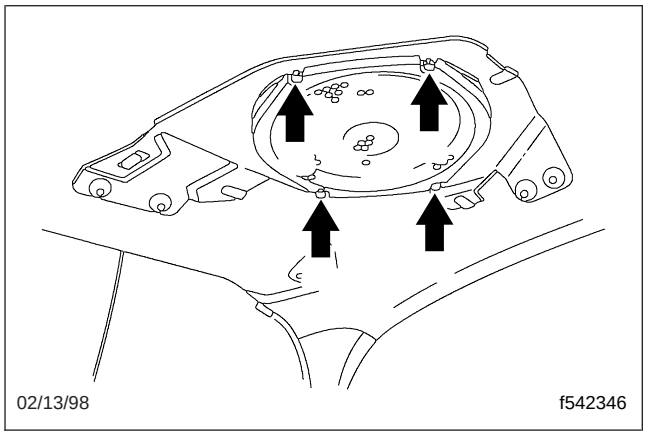


Fig. 1, Removing the Roof Console Speaker Retaining Bolts

3. Disconnect the electrical connector, and remove the speaker from the roof console. See **Fig. 2**
4. Connect the electrical connector, and position the speaker over the bolt holes.
5. Install the speaker retaining bolts, and tighten until firm.
6. Install the roof console; for instructions, see **Group 60**.

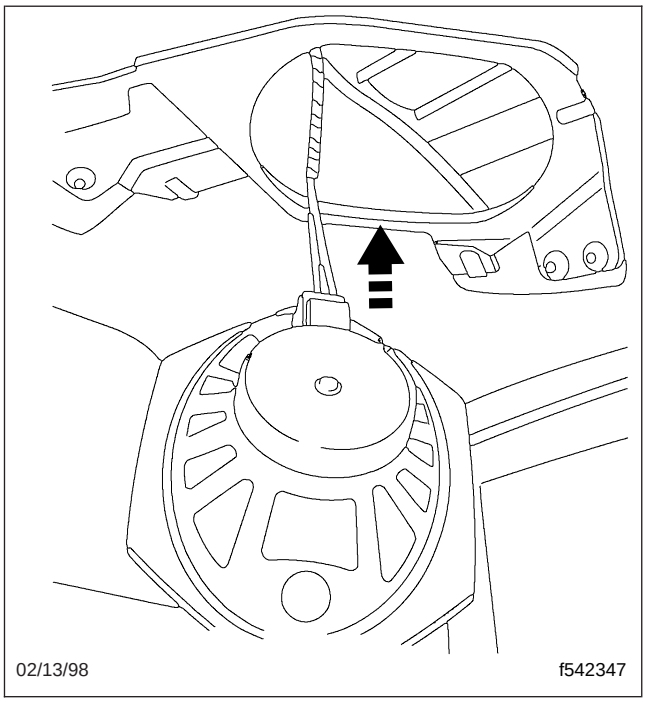


Fig. 2, Disconnecting the Roof Console Speaker Electrical Connector

Able Body Sleeper Speaker Replacement

Replacement

1. Carefully pry the speaker grille from the speaker. See **Fig. 1**.

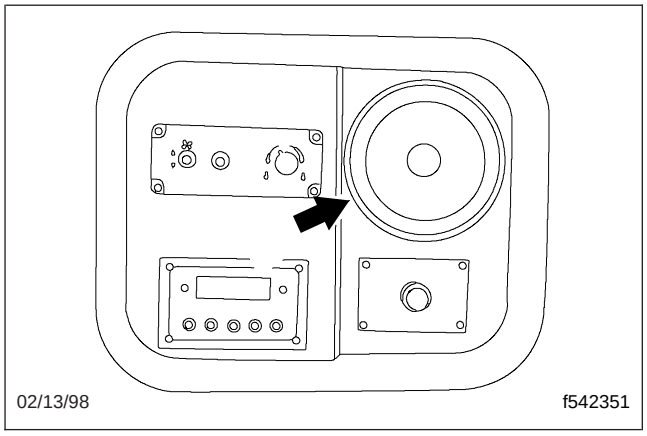


Fig. 1, Able Body Speaker Grille

2. Remove the speaker mounting screws, and support the speaker.
3. Disconnect the electrical connector, and remove the speaker from the sleeper radio control panel. See **Fig. 2**.

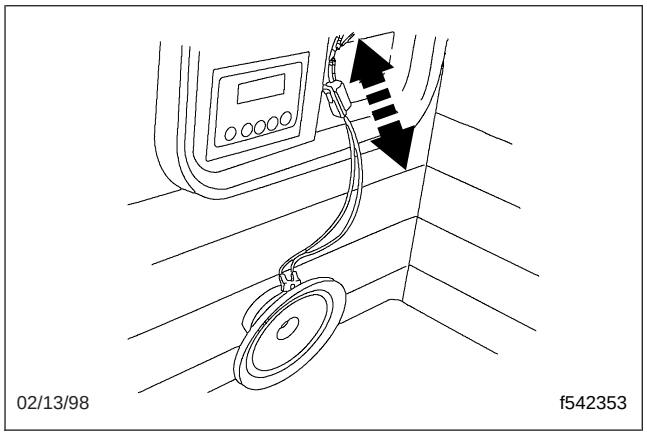


Fig. 2, Able Body Speaker Electrical Connector

4. Connect the electrical connector.
5. Install the speaker.
   - 5.1 Position the speaker over the screw holes.
   - 5.2 Install the speaker mounting screws and tighten until firm.
6. Install the speaker grille.

SilverStar Rear/Top Speaker Replacement

Replacement

NOTE: Left-hand shown, right-hand symmetrically opposite.

1. Remove the headliner. For instructions, see **Group 60**.
2. Remove the screws. See **Fig. 1.**

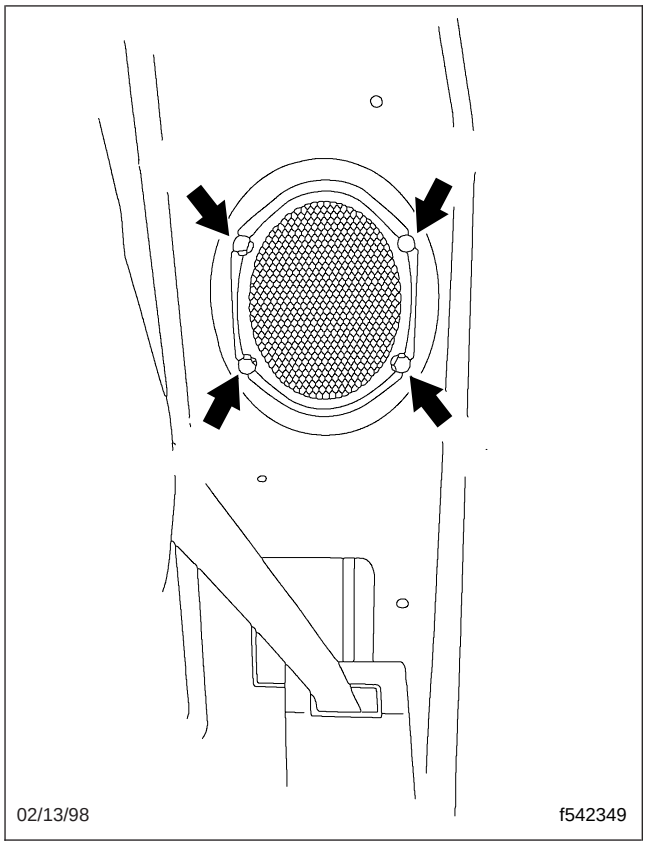


Fig. 1, SilverStar Speaker Screws

3. Disconnect the electrical connector, and remove the speaker from the roof. See **Fig. 2.**
4. Connect the electrical connector.
5. Install the speaker.
   - 5.1 Position the speaker over the screw holes.
   - 5.2 Install the speaker mounting screws and tighten until firm.
6. Install the speaker grille.

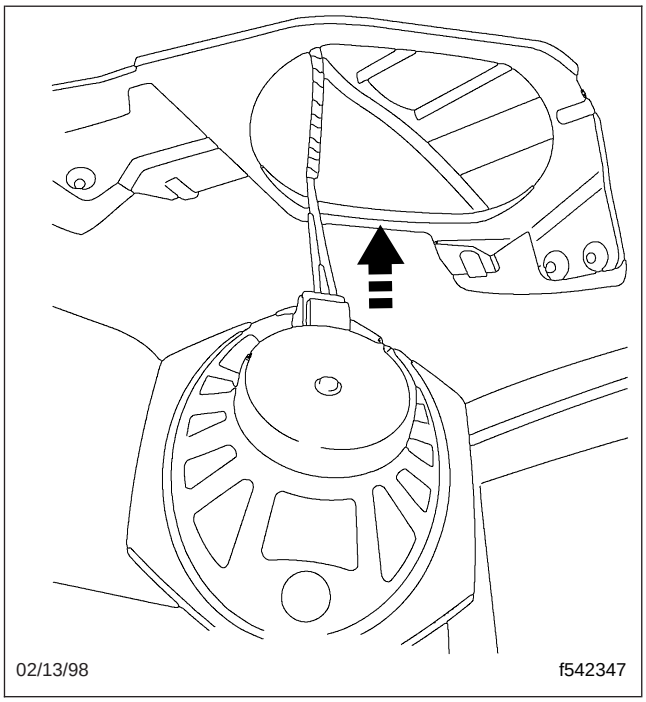


Fig. 2, SilverStar Speaker Electrical Connector

7. Install the headliner. For instructions, see **Group 60**.

SilverStar Subwoofer Speaker Replacement

Replacement

1. Raise the lower bunk assembly.
2. Remove the subwoofer assembly screws.

NOTE: Screws are on the sides of the subwoofer assembly.

3. Tilt the subwoofer assembly back, then remove the subwoofer speaker screws. See **Fig. 1**.

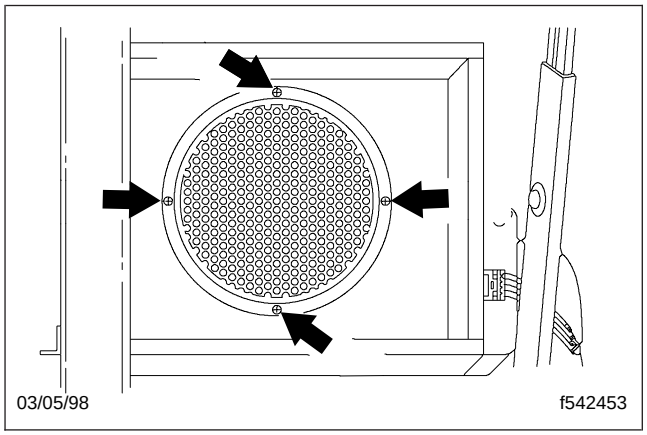


Fig. 1, SilverStar Subwoofer Speaker Screws

4. Disconnect the electrical connector, then remove the subwoofer speaker from the subwoofer assembly. See **Fig. 2**.

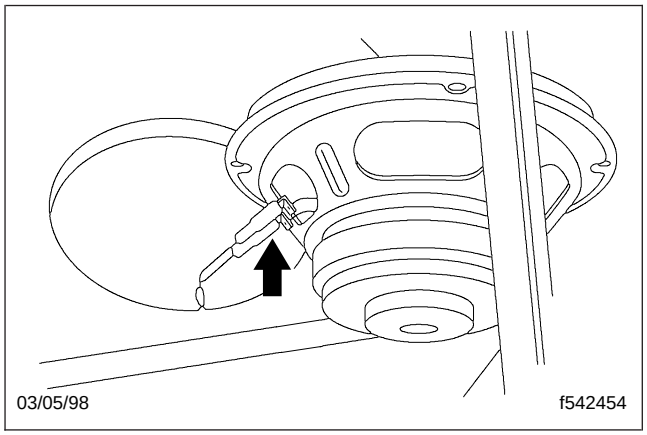


Fig. 2, Subwoofer Electrical Connector

5. Connect the subwoofer electrical connector and position the subwoofer speaker inside the subwoofer assembly.
6. Install the subwoofer speaker screws and tighten until firm.
7. Position the subwoofer assembly.
8. Install the subwoofer assembly screws and tighten until firm.
9. Lower the lower bunk assembly.

General Information

Sterling vehicles have a 12-volt, negative ground electrical system. See **Specifications 400** for a list of standard circuit numbers and circuit descriptions for vehicles built beginning February 27, 2001.

Fuses and Circuit Breakers

Sterling vehicles use blade-type fuses that have a transparent plastic housing enclosing the metal fuse element. A fuse is designed to melt the metal element at a certain amperage to protect the circuit wiring and components from damage due to an overcurrent condition. The ampere rating of a fuse can be determined by reading the number molded into the top end of the fuse or by color. See **Specifications 400** for the fuse amperage rating and color for that amperage rating.

Wire Color Code

Colored wiring aids in the diagnosis and testing of electrical systems. It allows for faster identification when testing circuits for failure. See **Specifications 400** for a list of standard wiring color-coding information for vehicles built beginning February 27, 2001.

In-Line Protection Devices

In addition to the fuses in the fuse junction panel and the power distribution module (PDM), there may be in-line fuses in the wiring harnesses. The fuses are located in the battery cable wiring assembly and provide power to the PDM fuses for the electrical, audio, and gauges in the cab. Two 10-gauge fuse links may be used on Sterling vehicles built before February 27, 2001: one is located between the starter motor battery terminal, the other is in the alternator wiring circuit protection.

Fusible Links

Fusible links are short lengths of wire that are smaller than the wires they are protecting. Fusible link wire is covered with a special, thick, non-flammable insulation. An overcurrent condition causes the insulation to blister and, if the overcurrent condition continues, the wire link will melt. To check a fusible link, look for blistered insulation. If the insulation is okay, pull lightly on the wire. If the fusible link insulation stretches, the wire has melted.

Shielded Wires

Shielding is necessary when a critical circuit is susceptible to electromagnetic interference. Shielded wire has three conducting strands. The outermost strand is grounded, which creates a ground plane around the two inner conductors. Any interference that enters the shielded cable will be conducted to ground instead of affecting the circuit's signal.

Engine, Cab, and Trailer Wiring

Sterling vehicles have two PDMs, one in the engine compartment and one in the cab. Both contain fuses, circuit breakers and relays used in the electrical system.

Engine Wiring

The engine compartment PDM has a decal identifying the location of the fuses, circuit breakers and relays on the outside of the PDM cover. See **Fig. 1** for right-hand-drive vehicles, **Fig. 2** for left-hand-drive vehicles built before February 27, 2001, or **Fig. 3** for left-hand-drive vehicles built since February 27, 2001 but prior to September 12, 2003. Depending on vehicle options, fuse/circuit breaker/relay locations may vary from those shown. For fuse/circuit breaker/relay identification information, see **Table 1** for right-hand-drive vehicles, **Table 2** for left-hand-drive vehicles built before February 27, 2001, or **Table 3** for left-hand-drive vehicles built since February 27, 2001 but prior to September 12, 2003.

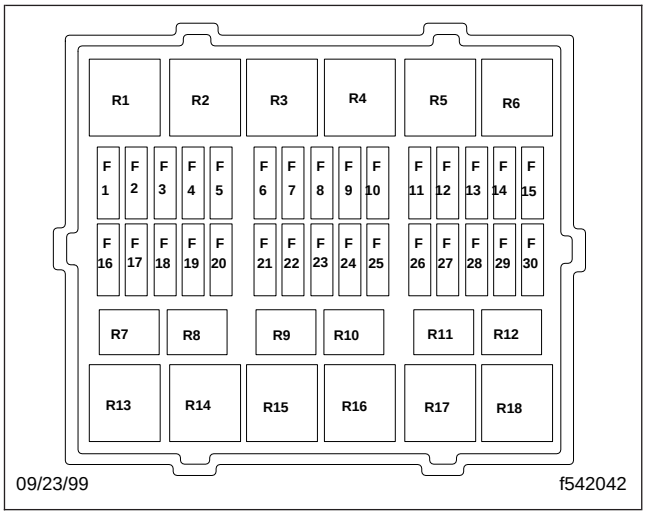


Fig. 1, Engine Compartment PDM, Right-Hand-Drive Vehicles

General Information

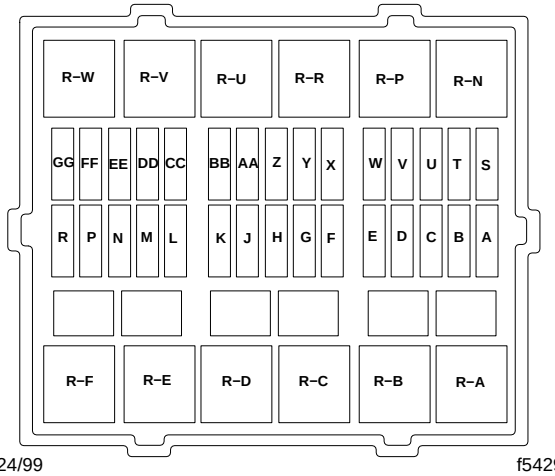


Fig. 2, Engine Compartment PDM, Left-Hand-Drive Vehicles (typical, for vehicles built before February 27, 2001)

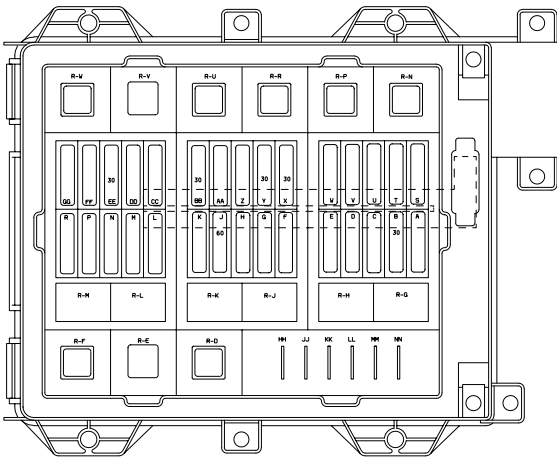


Fig. 3, Engine Compartment PDM, Left-Hand-Drive Vehicles (typical, for vehicles built since February 27, 2001 but prior to September 12, 2003)

Engine Compartment PDM, Right-Hand-Drive Vehicles		
Position	**Description**	**Rating**
Relays		
R1	Trailer Reverse Lamps	—
R2	Trailer Stop Lamps	—
R3	Trailer Left Turn	—
R4	Trailer Right Turn	—
R5	Trailer Park and Marker Lamps	—
R6	Trailer Auxiliary	—
R7	Not Used	—
R8	Not Used	—
R9	Not Used	—
R10	Not Used	—
R11	Not Used	—
R12	Not Used	—
R13	Aircon Pressure Switch	—
R14	Fog Lamps (Drive Option)	—
R15	High Beam Headlamps	—
R16	Low Beam Headlamps	—
R17	Road (Drive) Lamps	—
R18	Not Used	—
Circuit Breakers		
F1	Not Used	—
F2	Not Used	—
F3	Not Used	—
F4	Not Used	—
F5	Cab-Power-Window Right, Mirrors	20A
F6	Trailer Reverse Lamps	30A *
F7	Trailer Stop Lamps	30A *
F8	Trailer Left Turn	30A *
F9	Trailer Right Turn	30A *
F10	Trailer Park and Marker Lamps	30A *
F11	Cab-Stud Module	20A
F12	Cab-Windshield Wiper, F6	20A
F13	Cab-Stop, Reverse, F12	20A
F14	Cab-Accessory Relay	20A
F15	Cab-Park Lamps-Exterior	20A
F16	Not Used	—
F17	Not Used	—
F18	Not Used	—
F19	Not Used	—

Engine Compartment PDM, Right-Hand-Drive Vehicles		
Position	**Description**	**Rating**
F20	Cab-Power-Window Left, Door Locks	20A
F21	Fog Lamps (Drive Option)	20A *
F22	High Beam Headlamps	20A *
F23	Low Beam Headlamps	20A *
F24	Road (Drive) Lamps	20A *
F25	Trailer Auxiliary	20A *
F26	Cab-Customer Access	20A
F27	Cab-Lighting Control, Courtesy	20A
F28	Cab-Heater Aircon Blower Motor	30A Maxifuse
F29	Cab-Flasher Unit, Horn	20A
F30	Cab-Ignition Switch, Relay, Fuel Shutoff	20A

* Cycling Type (Automatic Reset)

Table 1, Engine Compartment PDM, Right-Hand-Drive Vehicles

Engine Compartment PDM, Left-Hand-Drive Vehicles (typical, for vehicles built before February 27, 2001)		
Position	**Description**	**Rating**
Relays		
R-A	Fuel Heater	—
R-B	Customer Access Park Lamps	—
R-C	Customer Access Marker Lamps	—
R-D	Not Used	—
R-E	Trailer ABS	—
R-F	Not Used	—
R-N	Trailer Left Turn Signal	—
R-P	Trailer Right Turn Signal	—
R-R	Trailer Park Lamps	—
R-U	Trailer Marker Lamps	—
R-V	Trailer Stop Lamps	—
R-W	Heated Moisture Ejectors	—
Fuses		
A	Fuel Heater Relay R-A	40A
B	Fuse 1 Fuel Solenoid	30A

Engine Compartment PDM, Left-Hand-Drive Vehicles (typical, for vehicles built before February 27, 2001)		
Position	**Description**	**Rating**
C	Customer Access, Marker and Park Lamp Relays R-B and R-C	40A
D	Fuse 13 Dome Lamp and Lighter, Fuse 14 Mirrors and Diagnostic Connection, Fuse 15 Audio/Phone	40A
E	Left-Hand Power Window Relay R2	40A
F	Run Relay R4, Fuse F36, Flash-to-Pass and Trailer Hookup Lamp	40A
G	Heater/AC Blower Relay R8	40A
H	Run Relay R6	40A
J	Ignition Switch and Run/Acc Relay R5	60A
K	Fuse 31 Courtesy Lamps, Fuse 32 Cab Marker Lamps, Fuse 33 Customer Access Stop Lamps	40A
L	Headlamp Fuse 37 and Headlamp Switch	40A
M	ABS	40A
N	Not Used	—
P	Not Used	—
R	Not Used	—
S	Fuse 3, Horns and C/B 4, Wiper	40A
T	Trailer Turn Lamps Relay, R-P and R-N	40A
U	Fuses 23 and 24, CB Hot Posts	40A
V	Right-Hand Power Window Relay R1	40A
W	Trailer Marker and Park Lamps Relays, R-U, R-R	40A
X	Customer Access, Stud "A", Instrument Panel	30A
Y	Heated Moisture Ejectors	30A
Z	Fuse 42, Turn Signals	40A
AA	Customer Access, Run/ACC Relay R10	40A
BB	Customer Access, Stud "H", Instrument Panel	30A
CC	Trailer Stop Lamps Relay R-V	40A

General Information

Engine Compartment PDM, Left-Hand-Drive Vehicles (typical, for vehicles built before February 27, 2001)		
Position	**Description**	**Rating**
DD	Not Used	—
EE	Trailer ABS	40A
FF	Not Used	—
GG	Not Used	—

Table 2, Engine Compartment PDM, Left-Hand-Drive Vehicles (typical, for vehicles built before February 27, 2001)

Engine Compartment PDM, Left-Hand-Drive Vehicles (typical, for vehicles built since February 27, 2001 but prior to September 12, 2003)		
Position	**Description**	**Rating**
Relays		
R-D	Option	—
R-E	Trailer - ABS ECU Power	—
R-F	Option	—
R-G	Reserved for transmission	—
R-H	Reserved for transmission	—
R-J	Tail Lamp (Body Builder/Custom ACC)	—
R-K	Marker Lamp (Body Builder/ Custom ACC)	—
R-L	Engine Supply	—
R-M	Not Used	—
R-N	Trailer LH Turn	—
R-P	Trailer RH Turn	—
R-R	Trailer Park Lamp	—
R-U	Trailer Marker Lamp	—
R-V	Trailer Stop Lamp	—
R-W	Air Dryer/Heated Moisture Ejector	—
Fuses		
A	Reserved for Fuel Heater Option	30A
B	Option	30A
C	Power to Relays R-J and R-K, Customer Access/Marker & Tail Lamps	30A

Engine Compartment PDM, Left-Hand-Drive Vehicles (typical, for vehicles built since February 27, 2001 but prior to September 12, 2003)		
Position	**Description**	**Rating**
D	Feed Fuses 13, 14, 15 Fuse # 13: Cigar Lighter/Dome Lamp Fuse # 14: Power Mirror & Diagnostic Fuse #15: Audio/Phone	30A
E	Power to R-2 Left Door	20A
F	Power to R-4 Ignition Run	40A
G	Power to R-8 HVAC Blower Motor	30A
H	Power to R-6 Ignition Run	40A
J	Ignition to R-5 Run Accessory	60A
K	Feed Fuses 31, 32, and 33. Fuse # 31: Courtesy Lamps Fuse # 32: Cab Marker Lamps Fuse # 33: Customer Access Stop Lamps	40A
L	Feed Fuse F37-Head Lamps	40A
M	Feed Fuse F26-ABS Power	40A
N	Power to Sleeper	60A
P	Power to Sleeper	60A
R	Not Used	—
S	Feed Fuses 1, 2, 3, 4 Fuse # 1: Fuel Shutoff Solenoid Fuse # 2: Option Fuse # 3: Horn Power Fuse # 4: Washer/Wiper Power	30A
T	Power to Relays R-N & R-P. Trailer LH/RH Turn Signals	40A
U	Feed Fuse 23 & 24 Fuse 23: CB Hot Post Fuse 24: CB Hot Post	40A
V	Power to Relay R-1 Right Door	20A
W	Power to Relays R-R & R-U, Trailer Marker & Park Lamps	30A
X	Custom/Option	40A

Engine Compartment PDM, Left-Hand-Drive Vehicles (typical, for vehicles built since February 27, 2001 but prior to September 12, 2003)		
Position	**Description**	**Rating**
Y	Power to Relay RW-Heated Moist/Dryer	30A
Z	Feed Fuse 42, Stop Lamps and Turn Signals	40A
AA	Power to Hydromax	40A
BB	Customer Access, Stud "H", Instrument Panel	40A
CC	Trailer Stop Lamps Relay R-V	40A
DD	Not Used	—
EE	Power to Relay R-E: Trailer ABS	40A
FF	Not Used	—
GG	Reserved for Engine	40A
HH	Option	Varied
JJ	Option	Varied
KK	Option	Varied
LL	Battery Power Supply to Transmission ECU	Varied
MM	Ignition Power Supply to Engine	Varied
NN	Ignition Power Supply to Transmission ECU	Varied

Table 3, Engine Compartment PDM, Left-Hand-Drive Vehicles (typical, for vehicles built since February 27, 2001 but prior to September 12, 2003)

Cab Wiring

The cab PDM is located on the passenger side within the instrument panel. See **Fig. 4** for right-hand-drive vehicles, **Fig. 5** for left-hand-drive vehicles built before February 27, 2001, or **Fig. 6** for left-hand-drive vehicles built since February 27, 2001 but prior to September 12, 2003. A trim panel covers the PDM and is attached to the instrument panel by quarter-turn fasteners. A decal identifying the location of the fuses, circuit breakers, and relays is attached to the back side of the trim panel. For fuse/circuit breaker/relay identification information, see **Table 4** for right-hand-drive vehicles, **Table 5** for left-hand-drive vehicles built before February 27, 2001, or **Table 6** for left-hand-drive vehicles built since February 27, 2001 but prior to September 12, 2003.

Cab PDM, Right-Hand-Drive Vehicles		
Position	**Description**	**Rating**
Circuit Breakers		
F1	Left Power Window	18A *
F2	Power Door Locks	10A
F3	Right Power Window	18A *
F4	Power Mirrors	10A
F5	Windshield Wiper/Washer	11A *
F6	Not Used	—
F7	Ignition Switch	10A
F8	Fuel Shutoff Relay	10A
F9	Not Used	—
F10	Reverse Lamps	10A
F11	Stop Lamps	10A
F12	Not Used	—
F13	Flasher Unit	10A
F14	Horn	10A
F15	Ignition Connection Antilock Brakes	5A
F16	Not Used	—
F17	Customer-Constant 12V	10A
F18	Customer-Accessory	10A
F19	A/C-Blend Motor, Blower Relay	5A
F20	Cigar Lighter	10A
F21	Mirror Heater	10A
F22	Switch-Trailer Auxiliary, Customer	5A
F23	Not Used	—
F24	Not Used	—
F25	Air Intake Heater Module	10A
F26	Engine/Exhaust Brake	10A
F27	Warning Lamps	5A
F28	Fan Clutch Solenoid, A/C Pressure Switch	5A
F29	Aircon Compressor	10A
F30	Air Switches	5A
F31	Clock Connection-Constant 12V	5A
F32	Dash Display, Diagnostic Connection 12V	5A

General Information

Cab PDM, Right-Hand-Drive Vehicles		
Position	**Description**	**Rating**
F33	Gauges	5A
F34	Clock, Road Speed Module-Ignition	5A
F35	Cruise Switch, Diagnostic Connection-Ignition	5A
F36	Not Used	—
F37	Headlamp Switch	10A
F38	Flash-to-Pass Switch	5A
F39	Courtesy Lamps	10A
F40	Low Beam Relay Control	5A
F41	Park Relay Control	5A
F42	Fog Lamps Switch	5A
F43	Radio-Cassette-Constant 12V	5A
F44	Audio Connector-Constant 12V	5A
F45	Radio-Cassette-Accessory	5A
F46	Audio Connector-Accessory	5A
F47	Stud Module A-Constant 12V	10A
F48	Stud Module C-Constant 12V	10A
F49	High Beam Relay Control	5A
F50	Road Lamp Switch, High Beam Indicator Lamp	5A
F51	Park Lamps-Front and Rear	10A
F52	Park Lamps-Roof and Mirror	10A
F53	Park-Radio/Cassette, Dash Display	5A
F54	Dimmer-Instrument Panel	10A
Relays		
R1	Left Power Window	—
R2	Right Power Window	—
R3	Horn	—
R4	Ignition CB25 to CB30	—
R5	Accessory CB19 to CB24	—
R6	Ignition-Stop, Reverse, CB12	—
R7	Interior Illumination	—
R8	Blower Motor	—
R9	Flasher	—
R10	Accessory-Customer	—
R11	Windshield Wiper/Washer-Accessory	—
R12	Fuel Shutoff	—
R13	Audio-Accessory	—
R14	Gauges/Electronics-Ignition	—
R15	Engine Control Module-Ignition	—
R16	Exterior Park Lamps	—
R17	Not Used	—
R18	Not Used	—
Stud Module		
A	(AA)/Battery	12V/40A
B	Accessory/Ignition	—
C	Ground	12V
D	Not Used	—
E	Not Used	—
F	Not Used	—
G	Not Used	—

* Cycling Type (Automatic Reset)

Table 4, Cab PDM, Right-Hand-Drive Vehicles

Cab PDM, Left-Hand-Drive Vehicles (typical, for vehicles built before February 27, 2001)		
Position	**Description**	**Rating**
Circuit Breakers		
1	Fuel Shutoff Solenoid	10A
2	Not Used	—
3	Horn Power	10A
4	Washer/Wiper Timer	11A *
5	Daytime Running Lights Module, High Beam Indicator	15A
6	Air Dryer, Instrument Panel Air Valves, Trailer Stop Relay	10A
7	Air Intake Heater Module	10A
8	Two-Speed Axle, ABS Relay	15A
9	Exhaust/Engine Brake Solenoid, A/C Clutch, Allison ABS Relay	10A
10	Backup Lamps	10A

Cab PDM, Left-Hand-Drive Vehicles (typical, for vehicles built before February 27, 2001)		
Position	**Description**	**Rating**
11	Pushbutton Start, Bulb Check Relay, Warning Lamps, Ether Solenoid	20A
12	Engine Fan Control	10A
13	Cigar Lighter/Dome Lamps	15A
14	Power Mirrors, Datalink Power	10A
15	Audio, Cellular Phone (Battery)	20A
16	Audio Cellular Phone, Sleeper Relay (Run/Accy)	10A
17	Heated Mirror, Power Window Relay, Washer/Wiper Relay	25A
18	Heated Seats, Blend Door Motor, Blower Motor Relay	15A
19	Electronic Transmission, Caterpillar 3126 Automatic Transmission (Run)	5A
20	Electronic Engine Control (Start/Run)	15A
21	Warning Lamps, Fuel Heater Relay	10A
22	Gauges, Speedometer, Message Center (Power)	10A
23	Hot Post Number 2 (Instrument Panel or Header Console)	15A
24	Hot Post Number 1 (Instrument Panel)	15A
25	Customer Accessory (Run/Accy)	25A
26	Not Used	—
27	Detroit Diesel and Cummins Electronic Engines	15A
28	Electronic Engines	15A-Detroit Diesel and Cummins, 20A-Caterpillar
29	To Electronic Engines (Battery)	15A
30	Electronic Automatic Transmission (Battery)	15A
31	Courtesy/Dome/Spot Lamps	15A
32	Door Locks, Horn Relay, Marker Lamps	15A

Cab PDM, Left-Hand-Drive Vehicles (typical, for vehicles built before February 27, 2001)		
Position	**Description**	**Rating**
33	Customer Accessory Stop Lamps	15A
34	Left-Hand Power Window	18A *
35	Right-Hand Power Window	18A *
36	Flash-to-Pass, Trailer Hookup Lamps, Windshield Wipers	15A
37	Instrument Panel Illumination, Park Lamps, Headlights, Customer Accessory Relay	15A
38	High Beam Indicator Lamp	5A
39	Fog/Road Lamps	10A
40	Left-Hand Turn Signal Indicator Lamp	5A
41	Right-Hand Turn Signal Indicator Lamp	5A
42	Turn Signals, Hazards	30A
43	Customer Access Front Left-Hand Turn Signal	5A
44	Customer Access Front Right-Hand Turn Signal	5A
45	Not Used	—
46	Starter Relay, Air Intake Module, Ether Solenoid	20A
47	Not Used	—
48	Two-Speed Axle Signal to Speedometer	5A
Relays		
R1	Right-Hand Power Window	—
R2	Left-Hand Power Window	—
R3	Two-Speed Axle	—
R4	Run Relay	—
R5	Run/Accessory	—
R6	Run Relay	—
R7	Fog/Road Lamps	—
R8	Blower Motor	—
R9	Turn Signal Flasher	—
R10	Customer Access (Run/Accy)	—
R11	Washer/Wiper	—
R12	ABS Power	—

General Information

Cab PDM, Left-Hand-Drive Vehicles (typical, for vehicles built before February 27, 2001)		
Position	**Description**	**Rating**
R13	Customer Access Stop Lamps	—
R14	Engine Brake Cut-Out	—
R15	A/C High Pressure	—
R16	Horn Power	—
R17	Bulb Check	—
R18	Exhaust Brake	—
R19	ABS Warning Lamp	—
R20	Fuel Shutoff Solenoid, Caterpillar 3126 Neutral Start	—
R21	Engine Fan Control	—
R22	Allison ABS	—
Customer Access Terminals		
A	Battery (AA)	12V/40A
B	Accessory/Ignition	—
C	Ground	12V
D	Feed Number 1 from Chassis	—
E	Feed Number 2 from Chassis	—
F	Auxiliary Switch Number 1	—
G	Auxiliary Switch Number 1	—
H	Battery (positive)	—
J	Road Speed	—
K	Datalink (positive)	—
L	Datalink (negative)	—
M	Stoplamps	—
N	Auxiliary Switch Number 2	—
P	Auxiliary Switch Number 2	—

* Special Cycling Circuit Breakers

Table 5, Cab PDM, Left-Hand-Drive Vehicles (typical, for vehicles built before February 27, 2001)

Cab PDM, Left-Hand-Drive Vehicles (typical, for vehicles built since February 27, 2001 but prior to September 12, 2003)		
Position	**Description**	**Rating**
Fuses		
1	Spare	—
2	Power Door Lock	10A
3	Horn Power/Cluster/AC Panel/ Diagnostic/Hydra Max	10A
4	Wash/Wipe Module	11A CB
5	Low Coolant/Cluster/Hydra Max/ Backup Lite/DRL	15A
6	Air Dryer/Htd Moisture Ejector	10A
7	Not Used	—
8	Two Speed Axle	15A
9	Water/Fuel Separator	20A
10	Customer Supply	10A
11	Gauge, Accessory Supply	10A
12	Spare	—
13	Spare	—
14	ABS Hydraulic Brake	25A
15	Radio System	20A
16	Radio System	10A
17	Mirror, Heated, Power	15A
18	Ignition, Accessories	15A
19	Meritor Transmission	10A
20	Spare	—
21	Not Used	—
22	Not Used	—
23	Spare	—
24	CB Hot Post	15A
25	Ignition, Key Start	10A
26	ABS-Hydraulic Pump	25A
27	Brake, Hydra-Max Pump	10A
28	Spare	—
29	Spare	—
30	Spare	—
31	Interior Light, Domelamp/ Courtesy Lamp	15A
32	Exterior Light, Marker Lamp	15A
33	Spare	—
34	LH Pwr Window	18A CB
35	RH Pwr Window	18A CB

Cab PDM, Left-Hand-Drive Vehicles (typical, for vehicles built since February 27, 2001 but prior to September 12, 2003)		
Position	**Description**	**Rating**
36	Exterior Light, Trailer Utility Light	10A
37	Park Lamp	15A
38	Headlamp	15A
39	Fog/Road Lamps	10A
40	Customer Access, Front, LH, T/S	5A
41	Customer Access, Front, RH, T/S	5A
42	Stoplamp Switch	10A CB
43	Turn Signal Flasher	25A CB
44	Spare	—
45	ABS Pneumatic Brake	10A
46	Ignition, Push Button Start	10A
47	ABS Hydraulic/ABS Pneumatic	5A/15A
48	Ignition-Engine/Transmission	10A
Relays		
R1	Right-Hand Power Window	—
R2	Left-Hand Power Window	—
R3	Two-Speed Axle	—
R4	Ignition Run	—
R5	Ignition Run/Accessory	—
R6	Ignition Run Relay	—
R7	Fog/Road Lamps	—
R8	Blower Motor	—
R9	Turn Signal Flasher	—
R10	Spare	—
R11	Washer/Wiper	—
R12	Spare	—
R13	Transmission	—
R14	Engine Brake Cut-Out	—
R15	DRL Park Brk Cut Off	—
R16	Horn Power	—
R17	ABS-Hyd Brake Pump Bulb Check	—
R18	Engine Brake	—
R19	ABS Warning Lamp	—
R20	2 Speed Axle	—
R21	Electrical Engine Service Brake	—
R22	Spare	—

Table 6, Cab PDM, Left-Hand-Drive Vehicles (typical, for vehicles built since February 27, 2001 but prior to September 12, 2003)

Trailer Wiring

The trailer wiring harness supplies power to the seven-pin trailer electrical supply socket located on the rear of the cab. See **Fig. 7**.

General Information

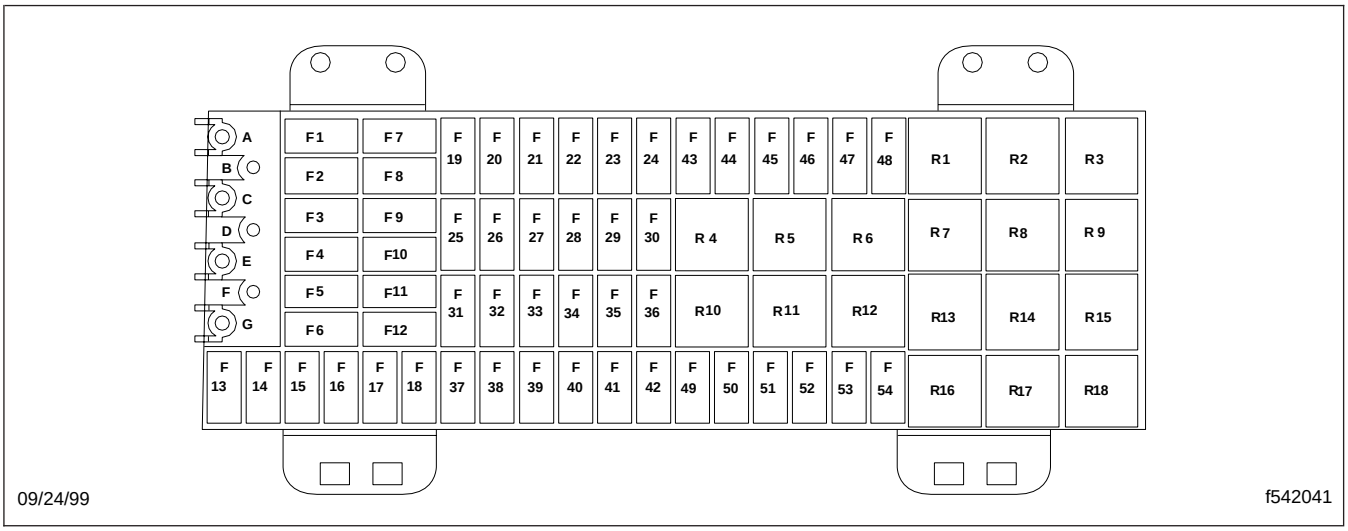


Fig. 4, Cab PDM, Right-Hand-Drive Vehicles

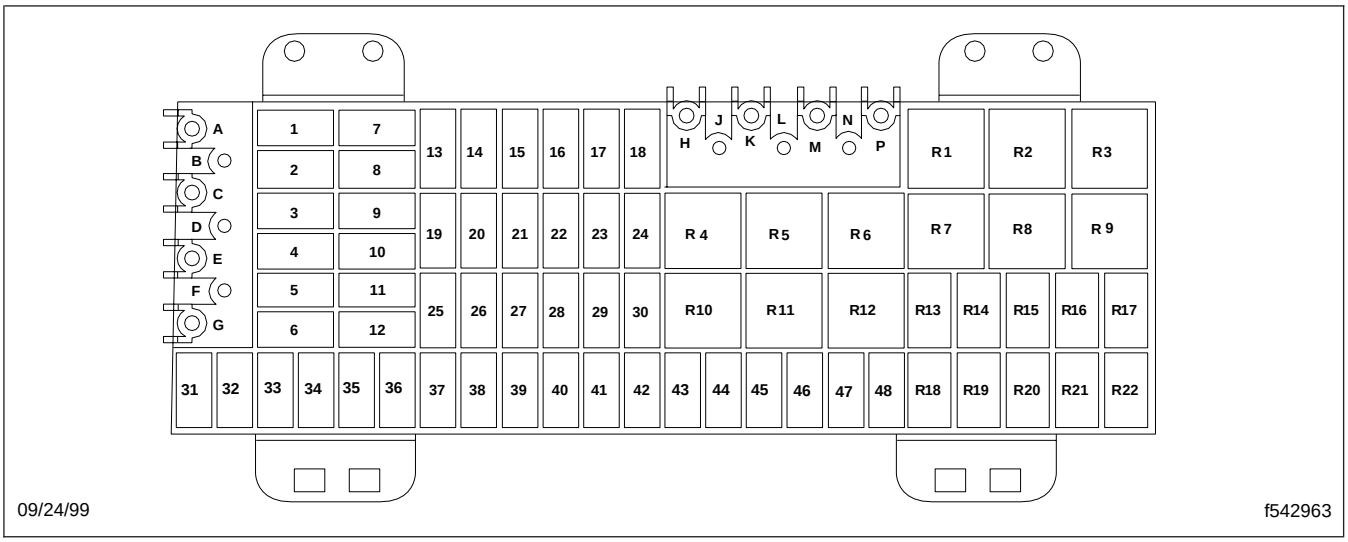


Fig. 5, Cab PDM, Left-Hand-Drive Vehicles (typical, for vehicles built before February 27, 2001)

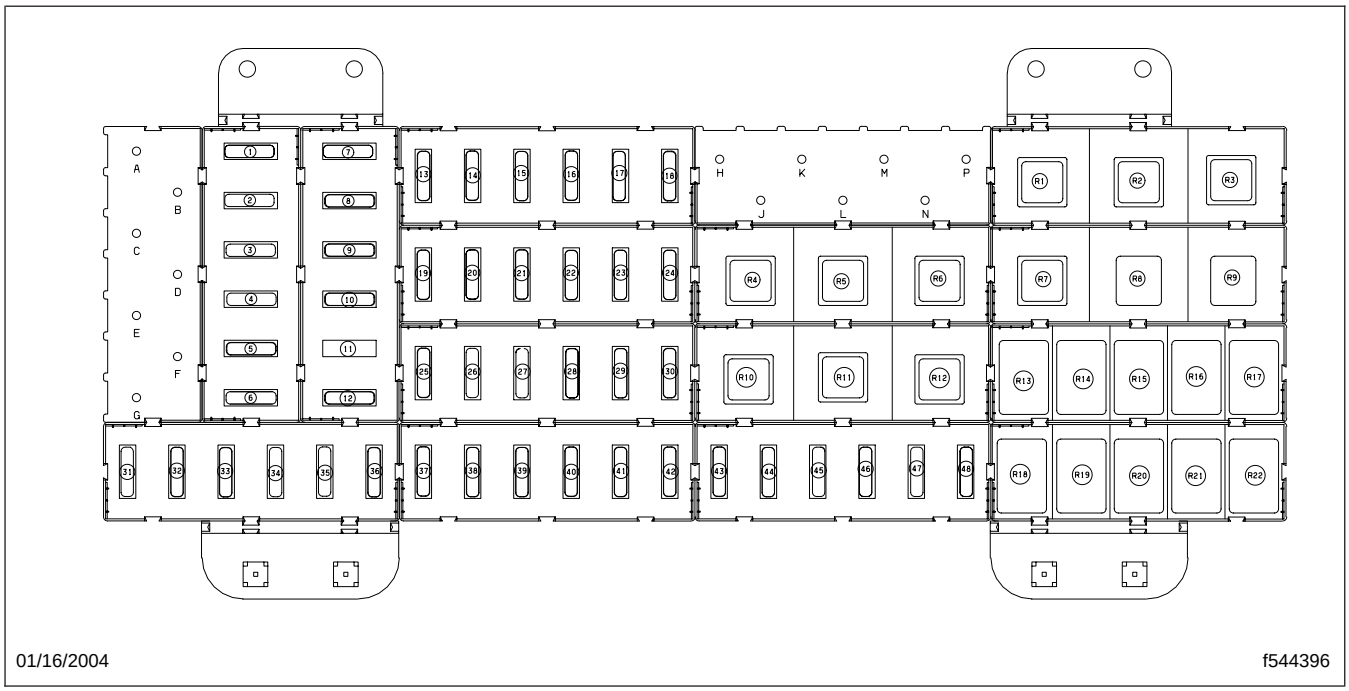
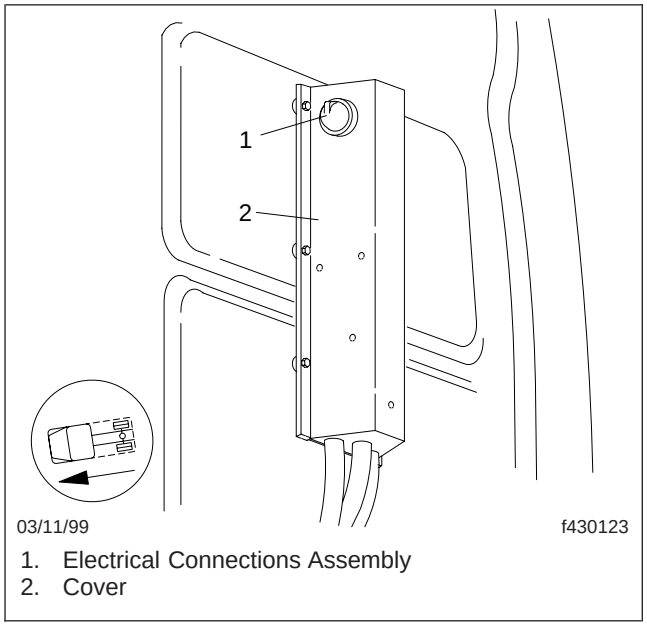


Fig. 6, Cab PDM, Left-Hand-Drive Vehicles (typical, for vehicles built since February 27, 2001 but prior to September 12, 2003)



1. Electrical Connections Assembly
2. Cover

Fig. 7, Trailer Electrical Connections Socket Location

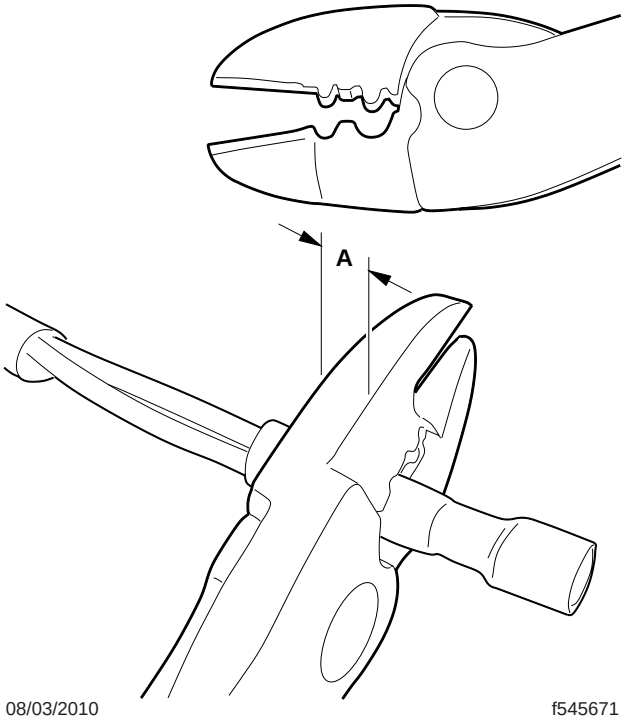
Wiring Repair Using Phillips STA-DRY® Solderless Connectors

Parts and Tools

Parts are available through the Parts Distribution Centers (PDCs) in packages of 25 connectors. Use the connectors and adhesive lined shrinkable tubing shown in **Table 1** when making a wiring splice.

Tools needed for wiring repair using solderless connectors include the following.

- A dimple-type crimp tool with a minimum 3/16-inch (7.6-cm) width. See **Fig. 1** for an example of a proper crimp tool. A typical manufacturer for this tool is Thomas & Betts.
- A heat gun rated at 1000°F (538°C).



A. Minimum 3/16-inch (7.6-cm) width.

Fig. 1, Dimple-Type Crimp Tool

Procedure

1. Dress the wires to be spliced by stripping the insulation to expose 1/4 inch (2.5 cm) of copper. Slide a 3-inch (7.6-cm) section of adhesive coated shrink tubing onto one of the wires.
2. Crimp the splice connector onto the wires. Use the type of crimp tool that makes a dimple in the connector. The dimple must be at least 3/16-inch (7.6-cm) wide or there will be too much space inside the connector and the solder will not flow into the wire. This crimp provides the mechanical retention needed. See **Fig. 2**.

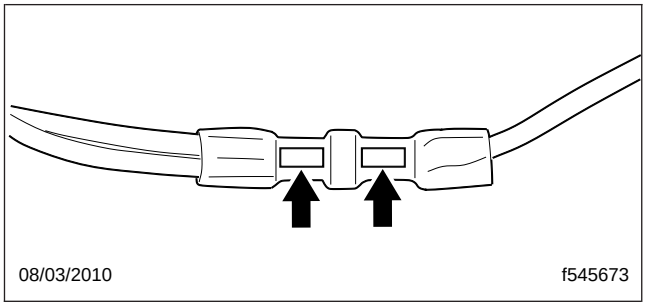


Fig. 2, Properly Crimped Splice

3. Pull test the wires by hand to ensure the crimp is mechanically solid.

IMPORTANT: A crimp tool that is too narrow will leave excessive air gaps in the crimp. The connection will not have the required amount of mechanical strength and the solder will not bond the wire to the connector. **Figure 3** shows an example of a bad crimp when the wrong tool is used.

4. Heat the properly crimped splice connector with the heat gun while slowly rotating the wire. The solder will take longer to flow than it will for the shrinkable insulation to contract. Heat until the solder band has completely melted into the connector. If the shrinkable insulation ruptures and a small amount of solder bubbles out, gently shake the splice to remove the solder. See **Fig. 4**.
5. When the connector has cooled, center the shrinkable tubing over the splice and heat the tubing until it has completely sealed the splice and a small fillet of adhesive is visible at the ends of the shrink tube. See **Fig. 4**.

6. A three-wire tap splice can be made following the same procedure. Use a connector that is large enough to fit all the strands of the wires. See **Fig. 5** for an example of the completed splice.

Solderless Connector Parts		
Wire Size: gauge (mm)	**Connector Part Number***	**Shrinkable Tubing (Daimler Part Number)**
20 to 18 (0.5 to 0.8)	PHM 1 1863	1/4 inch (2.5 cm) with internal adhesive coating (48-02461-025)
16 10 14 (1 to 2)	PHM 1 1862	1/4 inch (2.5 cm) with internal adhesive coating (48-02461-025)
12 to 10 (3 to 5)	PHM 1 1861	3/8 inch (7.6 cm) with internal adhesive coating–4 foot length (48-02461-038)
8 or larger (5 or larger)	Replace the terminal or the entire cable	Use adhesive lined red for positive cables and black for negative cables.

* Twenty-five connectors per pack.

Table 1, Solderless Connector Parts

Wiring Repair Using Daimler Trucks North America (DTNA) Kit ESY ES66 404

Parts and Tools

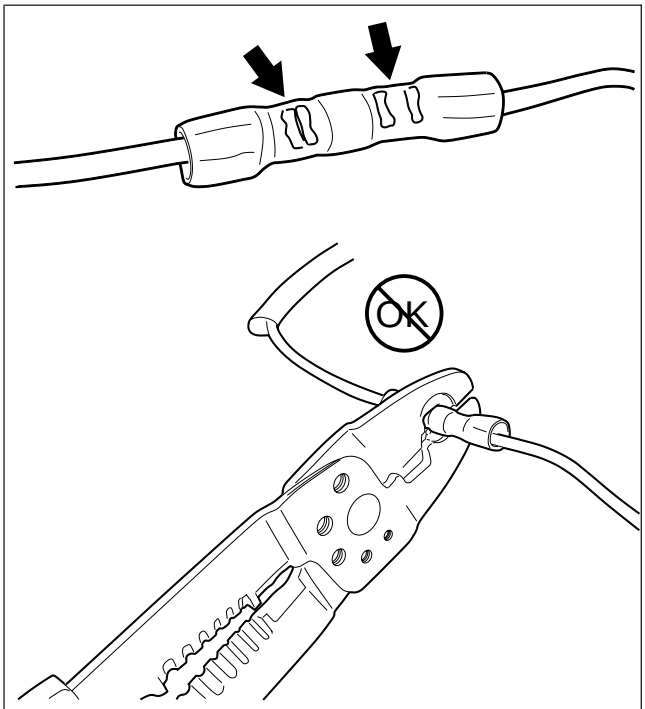
Parts are available through the Parts Distribution Centers (PDCs) in kits with material for 50 splices. This kit may be used on 16 to 14 gauge (1 to 2 mm) wire.

Tools needed for wiring repair using solderless connectors include the following.

- A dimple-type crimp tool with a minimum 3/16-inch (7.6-cm) width. See **Fig. 6** for an example of a proper crimp tool. A typical manufacturer for this tool is Thomas & Betts.
- A heat gun rated at 250°F (121°C).

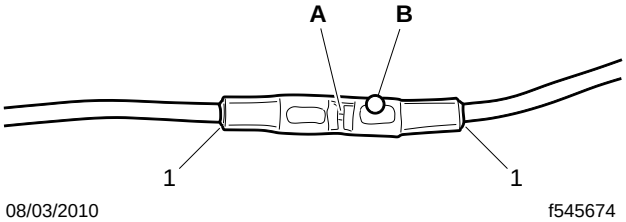
Procedure

1. Dress the wires to be spliced by stripping the insulation to expose 1/4 inch (2.5 cm) of copper. Slide a piece of the shrink tubing from the kit onto one of the wires.
2. Slide a shrinkable solder sleeve from the kit onto one of the wires.
3. Place the wires that will be spliced into each end of the barrel connector. See **Fig. 7** for an example of the splice.
4. Crimp each end of the barrel using a dimple-type crimp tool to secure the wires. See **Fig. 6** for an example of a proper crimp tool.
5. Pull test the wires by hand to ensure the crimp is mechanically solid.
6. Slide the shrinkable solder sleeve onto the barrel connector so the solder band is at the center of the barrel connector.
7. Heat the splice using a heat gun rated at 250°F (121°C) until the sleeve has completely shrunk against the wire and the solder flows into the barrel connector. A small fillet of adhesive may be visible at the ends of the connector. See **Fig. 8**.
8. Slide the shrinkable tubing over the splice and apply heat with a heat gun rated at 250°F (121°C) until it has completely shrunk against the wire insulation. A small fillet of adhesive should be visible at the ends of the shrinkable tubing.



NOTE: Even with two crimps, there is too much air gap; the solder will not bond.

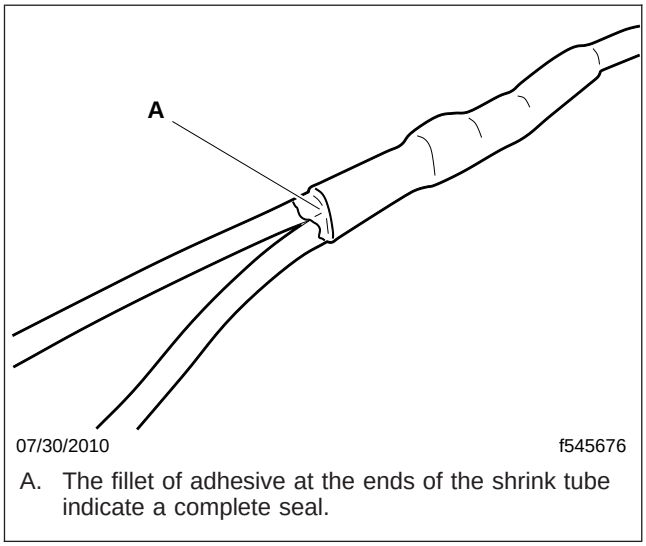
Fig. 3, Wrong Tool Being Used and a Crimp That Will Fail



A. The solder band is completely melted.
B. Insulation rupture; gently shake off the solder bead.

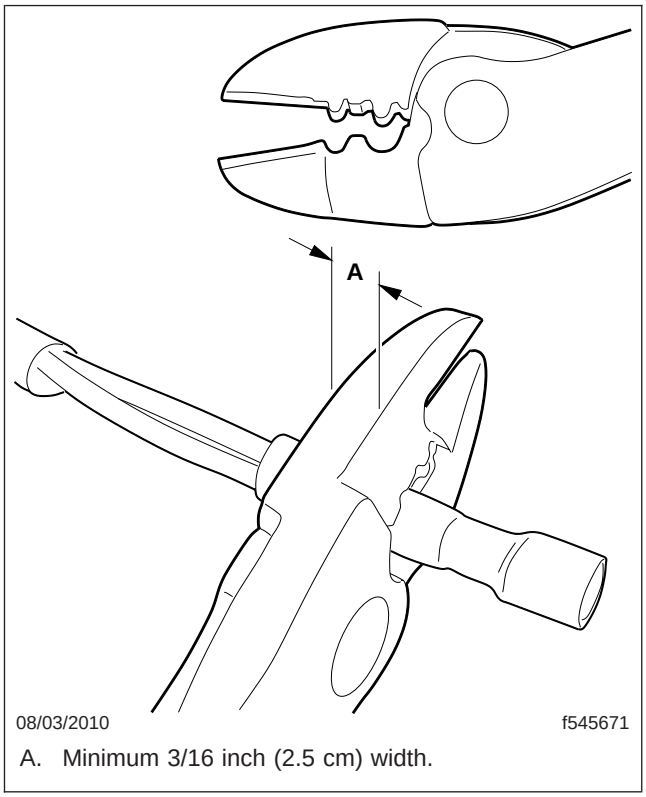
1. Adhesive Fillet

Fig. 4, Solder Bead Rupture



A. The fillet of adhesive at the ends of the shrink tube indicate a complete seal.

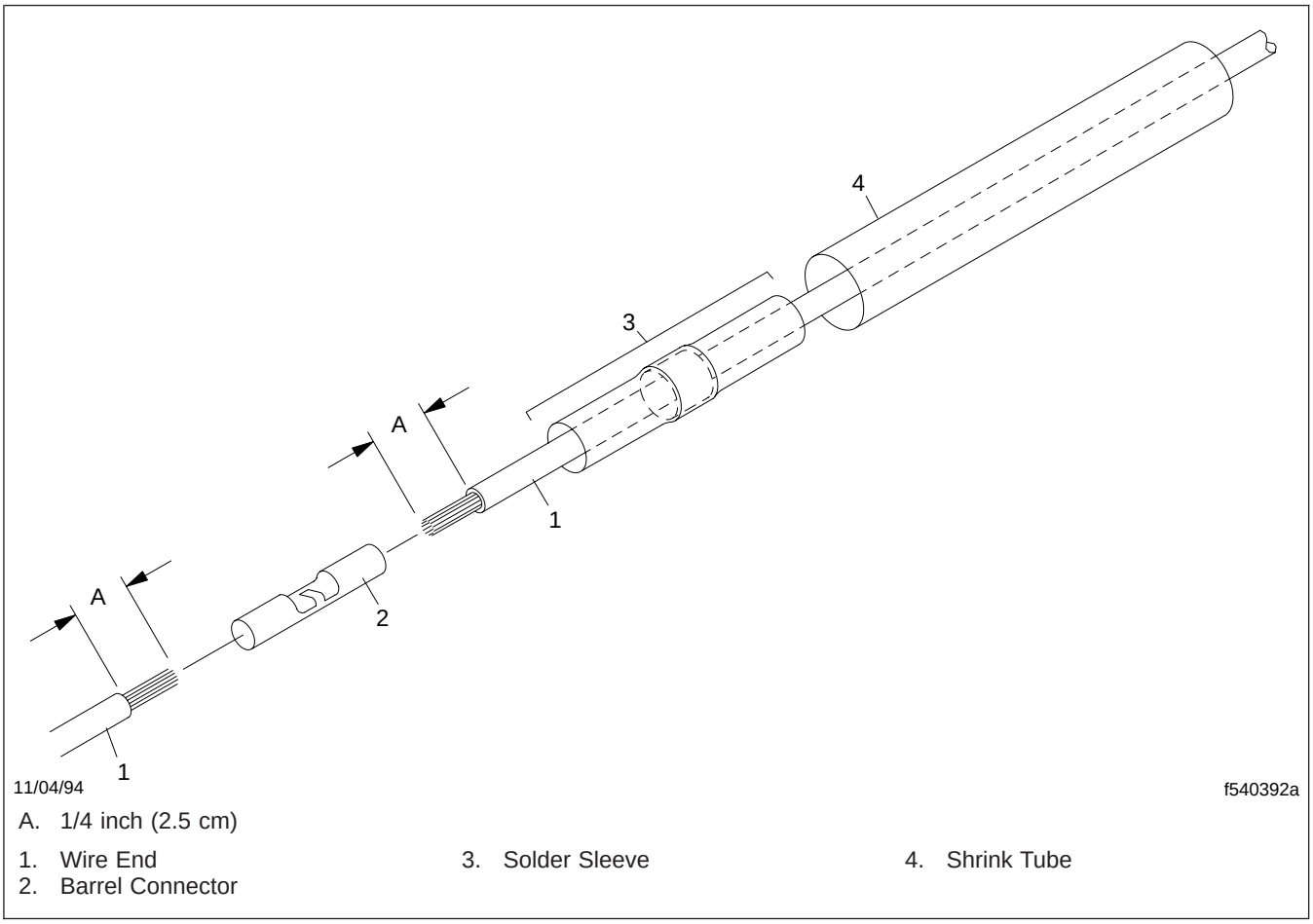
Fig. 5, Completed Three-Wire Tap Splice



A. Minimum 3/16 inch (2.5 cm) width.

Fig. 6, Dimple-Type Crimp Tool

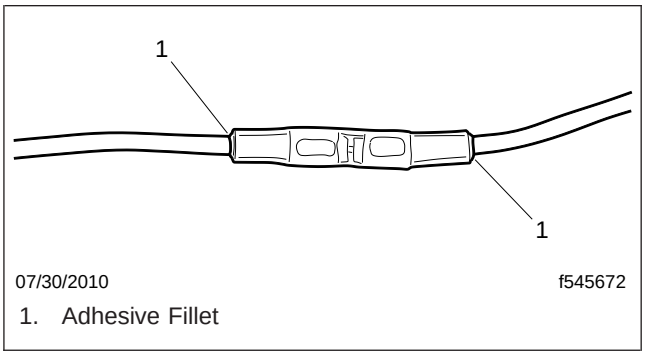
Wiring Repair and Replacement



A. 1/4 inch (2.5 cm)

1. Wire End
2. Barrel Connector
3. Solder Sleeve
4. Shrink Tube

Fig. 7, Splice Prepared with Parts in Kit ESY ES66 404



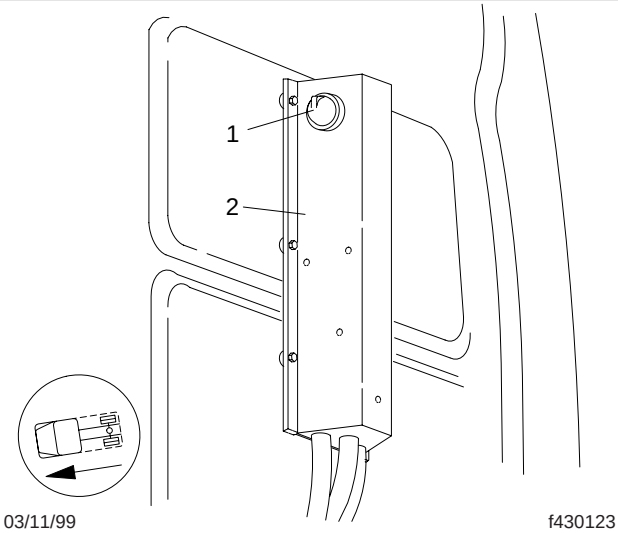
1. Adhesive Fillet

Fig. 8, Heated Solder Sleeve with Solder Band Melted into the Splice

Trailer Electrical Supply Socket Removal and Installation

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Remove the cover stud nuts retaining the cover to the cab.
4. Remove the cover. See **Fig. 1**.



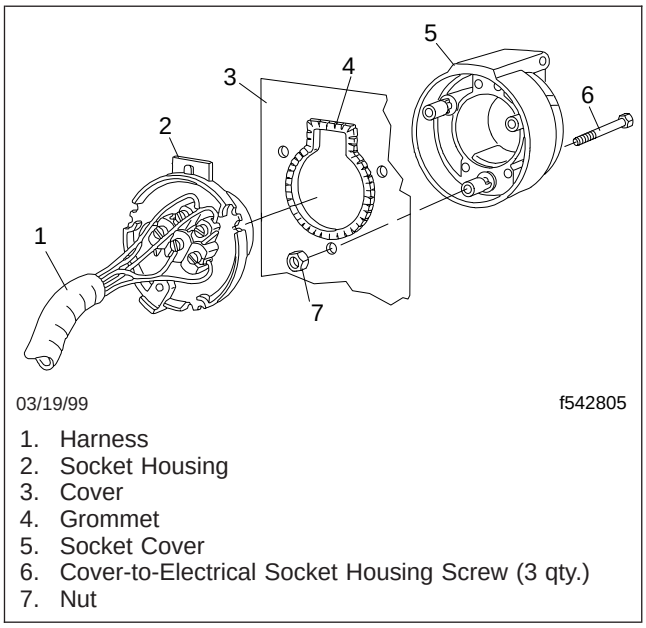
1. Electrical Socket Assembly
2. Cover

Fig. 1, Trailer Electrical Supply Socket Location

5. Remove the three screws holding the electrical socket to the cover. See **Fig. 2**.
6. Remove the housing cover from the electrical socket and remove the cap.
7. Mark and disconnect the wires from the electrical socket terminals.

Installation

1. Connect the wires to the electrical socket terminals.
2. Install the housing cover.
   - 2.1 Insert the electrical socket into the housing.



1. Harness
2. Socket Housing
3. Cover
4. Grommet
5. Socket Cover
6. Cover-to-Electrical Socket Housing Screw (3 qty.)
7. Nut

Fig. 2, Trailer Electrical Supply Socket and Components

   - 2.2 Tighten the three screws connecting the electrical socket to the housing cover. See **Fig. 2**.
3. Apply calking around the studs.
4. Slide the cover over the studs.
5. Install and tighten the nuts fastening the cover to the cab.
6. Connect the batteries.
7. Remove the chocks from the tires.

Specifications

IMPORTANT: All figures are typical for vehicles built before February 27, 2001.

See **Table 1** for fuse amperage ratings and colors for each amperage rating.

See **Table 2** for standard wiring color-coding information for vehicles built beginning February 27, 2001.

See **Table 3** for circuit numbers and descriptions for vehicles built beginning February 27, 2001.

See **Fig. 1** for a full view of the power distribution wiring.

See **Fig. 2** and **Fig. 3** for partial views of the power distribution wiring.

See **Fig. 4** for a full view of the customer access circuits wiring.

See **Fig. 5** and **Fig. 6** for partial views of the customer access circuits wiring.

See **Fig. 7** for a full view of the instrument panel wiring.

See **Fig. 8** for a full view of the cab ground summary.

See **Fig. 9** and **Fig. 10** for partial views of the cab ground summary.

See **Fig. 11** for a full view of the right-hand-drive chassis ground summary.

See **Fig. 12** for a full view of the left-hand-drive chassis ground summary.

See **Fig. 13** for bulkhead connector "A" pin and circuit number identification.

See **Fig. 14** for bulkhead connector "B" pin and circuit number identification.

See **Fig. 15** for bulkhead connector "C" pin and circuit number identification.

Blade Fuse Color-Coding Chart	
Ampere Rating	**Color**
5A ATO	Tan
10A ATO	Red
15A ATO	Light Blue
20A ATO	Yellow
25A ATO	Natural
30A ATO or Maxi	Light Green
40A Maxi	Amber

Table 1, Blade Fuse Color-Coding Chart

Standard Wiring Color-Coding for Vehicles Built Beginning February 27, 2001		
Color	**Abbr**	**Typical Usage**
Black	BK	Ground, General
Black-White	BK-W	Ground, Clean or Isolated
Blue DK	DKBL	Backup/Windshield Wiper/Trailer Auxiliary
Blue LT	LTBL	HVAC/Circulation Fans/1922+
Blue LT-White	LTBL-W	Water, Oil Gauge and Indicator (Engine and Transmission)
Brown	BR	Marker, Tail and Panel Lamps
Gray	GY	Electronic Engine (or TXL Insulation)
Green DK	DKG	Turn Signal, RH/Driver's Display/Data Record/1587+/1939–

Specifications

Standard Wiring Color-Coding for Vehicles Built Beginning February 27, 2001		
Color	**Abbr**	**Typical Usage**
Green DK-White	DKG-W	Starting Aids/Fuel Heaters/Material Control/Winch/Tailgate
Green LT	LTG	Headlamp/Roadlamp/DRL
Green LT-White	LTG-W	Axle Controls and Indicators/Suspension/Fifth Wheel
Orange	O	ABS/EBS/1587–
Pink	PK	Start Control/Ignition/Charging/Volt and Ammeter/1922–
Pink-White	PK-W	Fuel Control and Indicators/Shutdown/Speed Limiter
Purple	PRP	Engine Fan/PTO/Auto Lube and Oil
Purple-White	PRP-W	Utility/Spot/Ad/Interior/Emergency Lighting
Red	R	Power Distribution, Constant
Red-White	R-W	Brake/Pneumatic/Hydraulic/Retarder/Stop
Tan	T	MPH, RPM Signals/Horn/Flasher/Pyro/Turbo
Tan-White	T-W	Audio/Video/Security/Window/Computer/Seat/Mirror/Cab Tilt
White	W	Transmission (or SXL Insulation)
Yellow	Y	Turn Signal, LH/1939+ (or GXL Insulation)
Yellow-White	Y-W	Air Bag and SPACE

Table 2, Standard Wiring Color-Coding for Vehicles Built Beginning February 27, 2001

Circuit Numbers and Descriptions for Vehicles Built Beginning February 27, 2001	
Circuit Number	**Circuit Description**
1	Battery cable, ground
2	Battery cable, 6v positive
3	Battery cable, 6v negative
5	Battery cable, 6v, series/parallel terminal
6	Battery cable, 12v positive
7	Ground, starter terminal
8	Starter, battery terminal
9	Starter, solenoid switch terminal
13	Ground stud, series/parallel terminal
14	Cab power, main
15	Starter, engine
16	Alternator, main power cables, ammeter
18	Ignition switch power, misc. components
19	Voltage, meter/alarm

Circuit Numbers and Descriptions for Vehicles Built Beginning February 27, 2001	
Circuit Number	**Circuit Description**
20	Headlamp, LH
21	Headlamp, high beam, LH/RH
22	Headlamp, low beam, LH/RH
23	Tail/marker lamps
24	Horn, electric
25	Horn, electric, button
26	Horn, electric, supply
27	Roadlamp/foglamp
28	Roadlamp/foglamp
29	Panel/instrument lamps
30	Transmission oil temperature
31	Transmission oil temperature, auxiliary
32	Heater, RH auxiliary
33	Heater, auxiliary

Specifications

Circuit Numbers and Descriptions for Vehicles Built Beginning February 27, 2001	
Circuit Number	**Circuit Description**
34	Oil pressure, engine
35	Oil temperature, engine
36	Stop lamp
37	Turn signal flasher supply
38	Turn signal LH, EOF and trailer
39	Stop/turn combination lamp
40	Fan, windshield/sleeper
41	Dome lamp, interior
42	Axle oil temperature, forward
43	Axle oil temperature, rear
44	Axle oil temperature, center auxiliary
45	Receptacle, trailer
46	Marker/parking lamps
47	Fuel level
48	Fuel control and level, natural gas
52	Ignition switch and controls
54	Data recorder, speed and tach graph
55	Data recorder, speed and tach graph
57	Outlet, 12v power receptacle/cigar lighter
58	Heater, auxiliary
60	Turn signal, LH cab
61	Turn signal, RH cab
71	Ignition switch and controls
73	Utility lamp, back of cab
74	Starter mag switch/solenoid
75	Starter mag switch, ground, thermal protection
76	Mirror heat
77	Mirror heat, RH mirror supply
78	Spot lamp
80	Mirror heat, switch and controls
81	Ignition switch control devices
82	Starter mag switch, power supply
83	Alternator ground
84	Starting aid, glow plug heater
85	Starting aid, glow plug heater

Circuit Numbers and Descriptions for Vehicles Built Beginning February 27, 2001	
Circuit Number	**Circuit Description**
86	Axle lock, switch, interaxle
87	Axle lock
88	Lubrication system, automatic
90	Sander, road
91	Heater, diesel-fired auxiliary
94	Air dryer, heated
95	Speaker, radio
96	Oil level warning
97	Coolant level alarm, Perry
98	Heater A/C motor, blower
99	Fuel solenoid, engine run
101	Alternator control bus
102	Parking lamps
103	Parking lamps, RH
108	Door control dome lamp, LH
109	Door control dome lamp, RH
113	Baggage compartment lamps
116	Ground, cab stud
117	Speed sensor "+", vehicle, MPH/KPH
118	Speed sensor "–", vehicle, MPH/KPH
119	Coolant temperature, engine
120	Back-up/reverse lamp
121	Brake, engine/retarder/compression
122	Backup/reverse alarm
123	Alternator, voltage regulator/rectifier
124	Alternator regulator, ground
125	Park brake indicator/warning
130	Alternator/generator multi-voltage
131	Alternator "No Charge" indicator/warning
132	Alternator "No Charge" indicator/warning
137	Alternator "No Charge" indicator/warning
138	Starter lockout, alternator, ADLO
139	Starter lockout, alternator, ADLO
140	Oil pressure gauge, electronic
141	Starter lockout, alternator, ADLO

Specifications

Circuit Numbers and Descriptions for Vehicles Built Beginning February 27, 2001	
Circuit Number	**Circuit Description**
147	Fan control, engine, manual override
148	Fan control, engine, manual override
149	Fan manual controls, engine
150	Engine protection, shutdown/warning
151	Power inverter/converter 12v/110v
153	Axle declutch, front
154	Auxiliary air pressure
155	Axle lift controls
157	Mirror remote power controls
158	Engine protection, Kysor, shutdown/warning
159	Fan indicator/warning, engine
160	Power inverter/converter 110v to 12v
162	Tach sensor "+", engine, RPM
163	Tach sensor "–", engine, RPM
164	Axle indicator/warning, front
166	Starting aid, engine, ether
167	Oil fill system, leveler
168	Hour meter, engine
170	Fifth wheel slide lock indicator
171	Brakesaver, CAT
172	Clock
173	Coolant level, engine coolant
174	Engine protection, Nycal, warning
175	Engine protection, Nycal, warning
177	Engine protection, Robert Shaw, warning
178	Idle timer, delayed shutdown, cool down
179	Starting aid, glow plug heater
180	Engine protection, Corning Glass, warning
182	Fuel pressure
183	Air cleaner restriction indicator/warning
184	Starter lockout, neutral
185	Security system, Britec System 5
187	Fan ignition supply, engine
188	Antilock Brake System (ABS)
189	Antilock Brake System (ABS)

Circuit Numbers and Descriptions for Vehicles Built Beginning February 27, 2001	
Circuit Number	**Circuit Description**
190	Air dryer, heated, Graham-White
191	Starting aid, glow plug, heater
192	Axle indicator/warning, pusher
193	Cab tilt pump
196	Fuel/water separator heater
197	Transmission lockup sensor
198	Axle, two-speed shift control
200	PTO controls
202	Alternator, 24v
203	Exhaust brake
204	Seat belt indicator/warning
205	Fan controls and headlamp
206	Heater A/C with oil pressure controls
208	Axle control, tri-axle, steer lock
209	Axle, two-speed shift control
210	Power Distribution Module (PDM), outside cab
211	Security system; see 185
212	Refrigerator, power, (no outlet)
213	Power inverter/converter 110v to 12v
214	Generator, auxiliary
215	Heater, diesel-fired auxiliary, Webasto
216	Engine idler, Sterling Tech (SLG)
217	Fuel solenoid, engine, synchro start
218	Pyrometer, gauge
219	Turbo pressure gauge
220	Ignition switch, accessory
221	Suspension dump controls
222	Headlamp dimmer controls
223	Transmission controls, auto shift (axle shift, see 209)
224	Transmission controls (axle shift, see 209)
225	Air pressure gauge, primary
226	Air pressure gauge, secondary
227	Air pressure gauge, application
228	Oil pressure gauge, electronic

Specifications

Circuit Numbers and Descriptions for Vehicles Built Beginning February 27, 2001	
Circuit Number	**Circuit Description**
229	Retarder, Telma (TLM)
230	Retarder, Telma (TLM)
231	Cab tilt alarm
232	Transmission controls, power harness
233	Retarder, transmission (Allison)
234	Fan controls, engine
235	Speed limiter, vehicle, Lenmar (LNM)
236	Transmission neutral indicator
237	Axle lock, auto, Meritor
238	PTO controls, Chelsea
239	Axle lock, auto, Meritor
240	Fuel/water separator indicator/warning
241	Data recorder, Sangamo tacho graph
242	Seat controls
243	Power inverter/converter
244	Speed limiter, vehicle, Hewitt
245	Engine protection, warning, P & N Co. (PNC)
246	Fuel pump, electric
248	Engine protection, shutdown, Ulanet Watchdog (ULN)
250	Cruise control, Bendix (BW)
251	Speed limiter, vehicle, Cummins Arrest (CUM)
252	Engine protection, shutdown, Lenmar (LNM)
253	Cab tilt indicator
254	Emergency lamp, beacon
255	Advertising lamp
256	Optional power wire
257	Windshield wiper delay
258	Fifth wheel, indicator
259	Alternator multi-voltage
260	Engine protection, shutdown, Murphy (MUR)
261	Axle lock, controlled differential
262	Retarder, transmission (Allison)
263	Engine protection, shutdown, Sterling Tech (SLG)

Circuit Numbers and Descriptions for Vehicles Built Beginning February 27, 2001	
Circuit Number	**Circuit Description**
264	Coolant level alarm, Webb (WEI)
265	Oil level warning, Webb (WEI)
266	PTO controls, transfer case
268	Gauge alarm, Murphy (MUR)
269	Speedometer, Engler (ENG)
270	Tachometer, Engler (ENG)
271	Oil pressure gauge, electronic
272	Transmission, deep reduction indicator
273	Axle oil temperature indicator, rear
274	Transmission oil temperature
275	TRW ETEC
276	Oil fill system, leveler, Webb (WEI)
277	Idle limiter, Kysor Idlestop (KYS)
278	Windshield wiper control, RH
279	Windshield wiper control, LH
280	Pyrometer alarm/shutdown, Hewitt (HEW)
281	Oil filter change indicator/warning
282	Engine protection, shutdown
283	Engine idler, cycler, Webb (WEI)
284	Oil filter change indicator/warning, Big Cam3
285	Suspension electrical/air controls
286	Fuel/water separator indicator/warning, Racor (RAI)
287	Tachometer, Sangamo (SNG)
288	Engine protection, alarm, Sterling Tech (SLG)
289	Transmission indicator, neutral
290	Engine protection, alarm, Hewitt (HEW)
291	Engine protection, warning, Webb (WEI)
292	Fuel tachometer, Flowscan (FOS), Argo (ARG)
293	Starting aid, engine, ether, Lubristart
294	Air tank auto-drain valve, SAB
295	Radio, AM/FM/CB
296	Fuel transfer pump
297	Data recorder warning buzzer
298	Fuel pressure gauge

Specifications

Circuit Numbers and Descriptions for Vehicles Built Beginning February 27, 2001	
Circuit Number	**Circuit Description**
299	Air temperature, outside cab
300	Radio line level signals
301	Security system
302	CB Radio
303	Air pressure, low
304	Back-up/reverse lamp
305	Ignition switch, accessory
306	Ignition switch, run position
307	Headlamp switch
308	Fifth wheel, controls
309	Park brake indicator/warning
310	Axle lock
311	Ignition accessory option block
312	Radio
313	Turn signal flasher supply
314	Turn signal switch supply
315	Windshield wiper
316	Windshield wiper motor low speed
317	Windshield wiper motor park
318	Windshield wiper motor high speed
319	Windshield wiper motor park
320	Windshield wiper washer
321	Marker lamps, trailer, ICC
322	Headlamp switch, park mode
323	Odometer output
324	Lightbar high coolant temperature
325	Lightbar, engine oil pressure
326	Lightbar turn signal flasher control
327	Tachometer sensor, engine, RPM
328	Speed sensor, vehicle, MPH/KPH
329	Pyrometer sensor positive
330	Pyrometer sensor negative
331	Datalink signal, positive
332	Datalink return, negative
333	Air dryer, heated

Circuit Numbers and Descriptions for Vehicles Built Beginning February 27, 2001	
Circuit Number	**Circuit Description**
334	Door-activated dome lamp
335	A/C cold control jumper
336	Headlamp relay jumper
337	Roadlamp switch
338	Heater A/C electronic controls
339	Lightbar/cluster power
340	A/C cold control switch
341	Marker lamps, trailer
342	Ammeter gauge
343	Starting aid, glow plug switch, heater
344	Starting aid, glow plug pressure switch, heater
345	Starting aid, glow plug solenoid, heater
346	Speaker, radio, ground
347	Shutter, engine fan
348	Shutter control, engine fan
349	Shutter, engine fan
350	Lightbar, turn signal flasher timing
351	Speed limiter, vehicle, lightbar
352	Engine protection, delayed shutdown
353	Engine protection, delayed shutdown
354	Shutter transmission temperature control, engine fan
355	Fan transmission temperature control, engine
356	Speed control
357	Fuel solenoid delay shutdown
358	Trailer relay
359	Headlamp ON signal, lightbar/cluster
360	Fan controls, engine, Kysor lightbar
362	Fuel/water separator heater
363	Window power
364	Window power, up
365	Window power, down
367	Coolant temperature gauge, Kysor VIP
368	Coolant temperature gauge, Kysor VIP
369	Coolant temperature gauge, Kysor VIP

Specifications

Circuit Numbers and Descriptions for Vehicles Built Beginning February 27, 2001	
Circuit Number	**Circuit Description**
370	Receptacle auxiliary terminal, trailer
371	Marker lamp, fender guides
372	Receptacle, heavy duty, trailer
373	Fuel solenoid, engine run
374	Starter lockout
375	Daylight Running Lamps (DRL), neutral
376	Antilock Brake System (ABS) controls
377	Antilock Brake System (ABS) sensors
378	Antilock Brake System (ABS) valves
379	Daylight Running Lamps (DRL)
380	Daylight Running Lamps (DRL)
381	Daylight Running Lamps (DRL)
382	Daylight Running Lamps (DRL), LH headlamp
383	Daylight Running Lamps (DRL), RH headlamp
384	Daylight Running Lamps (DRL), program
385	Daylight Running Lamps (DRL), controls
386	Daylight Running Lamps (DRL), LH headlamp
387	Daylight Running Lamps (DRL), RH headlamp
388	Hydraulic brake power
389	Hydraulic brake relay
390	Hydraulic brake lamp
391	Hydraulic brake relay
392	Hydraulic brake motor
393	Hydraulic brake flow/relay
394	Hydraulic brake, park brake lamp
395	Hydraulic brake fluid sensor
396	Hydraulic brake buzzer/alarm
397	Hydraulic brake cab door signal
398	Hydraulic brake motor sense
399	Optional wire, cab/chassis, customer furnished
400	Optional wire, cab/chassis, customer furnished
401	Block coolant heater, Truck Comfort Sys (TCS)
403	Fuel restriction indicator, Hewitt (HEW)
404	Data recorder, ARI Trip
405	Data recorder

Circuit Numbers and Descriptions for Vehicles Built Beginning February 27, 2001	
Circuit Number	**Circuit Description**
406	Emergency lamp, alternating flashing
407	Emergency lamp, cross-fire lights
408	Emergency lamp, alley lights
409	Emergency lamp, bin lights
410	Emergency siren
411	Emergency fire truck miscellaneous
412	Data recorder, Isspro (ISP)
414	Tracking system, vehicle, Sony Geostrat RGSS
415	Idle governor, high
416	Refrigerator/television power, (no outlet)
417	Phone power, mobile
418	Tool box lamp, LH
419	Tool box lamp, RH
420	Military 24v lighting, blackout
421	Military 24v lighting, blackout
422	Military auxilliary 24v heater
423	Military, winch controls
424	Headlamp wiper/washer
425	Battery cutoff switch controls and bypass
426	Air inside/outside indicator
427	Tracking system, vehicle, satellite
428	Battery isolator protection system
429	Pyrometer alarm/warning
430	Windshield wiper heater
431	Starting aid, engine preheater, grid/flame
432	Seat controls
433	Data recorder, Data Hub (DDE)
434	Suspension controls, ECAS
435	Seat belt indicator/warning
436	Camera, rear and side view
437	Instrumentation Control Unit (ICU), dash display
439	Electronic engine ECU
440	Electronic engine ECU
442	Data recorder, Data Logger Unit (DLU)
443	Door lock

Specifications

Circuit Numbers and Descriptions for Vehicles Built Beginning February 27, 2001	
Circuit Number	**Circuit Description**
444	Obstacle Detection Sys (ODS), VORAD
445	Body controls, dump lock
446	Tire inflation, Central Tire Inflation Sys (CTIS)
447	Battery cutoff protection system, Hewitt (HEW)
448	Tailgate controls, material
449	Fueling data recording and transmitter
450	Mirror dimming controls (MSI)
454	Air Bag and Seat Pretention System (SPACE)
455	Instrument LH/RH side selection control
457	Dash controls, datalink, (BPU)
459	Steering pump controls
460	Transmission, automatic, Aisin Seiki, cab controls
461	Transmission, automatic, Aisin Seiki, chassis/ transmission controls
462	Headlamp, LH auxilary, snow plow
463	Headlamp, RH auxilary, snow plow
464	Transmission SmartShift control
465	Headlamp flashing control
466	Lane departure indicator/tracking system
467	Coolant flow, engine
468	Obstacle Detection Sys (ODS), VORAD
469	Level control power, body/chassis
500	Hydraulic brake ECU, brake signal
501	Buzzer
502	Oil level warning, engine low
503	Starting aid, engine preheater, flame start
505	Gauge sender, optional
516	Starting aid, engine preheater, flame start
1587	Databus, diagnostics, SAE J1587
1922	Databus, controls, SAE J1922
1939	Databus, controls, SAE J1939
BAT	Main battery power
GND	Ground, miscellaneous cab/chassis
NEW	Circuit number required

Circuit Numbers and Descriptions for Vehicles Built Beginning February 27, 2001	
Circuit Number	**Circuit Description**
OPT	Optional wiring, spare or customer furnished
B###	Bendix Antilock Brake System (ABS)
C###	Caterpillar electronic engine
D###	Detroit Diesel electronic engine (DDE)
E###	Allison electronic transmission
N###	Cummins electronic engine
S###	Spicer AutoMate transmission
T###	Twin Disc automatic transmission
W###	Eaton Ceemat/AutoShift transmission
X###	WABCO Anitlock Brake System (ABS); see 376, 377 and 378

Table 3, Circuit Numbers and Descriptions for Vehicles Built Beginning February 27, 2001

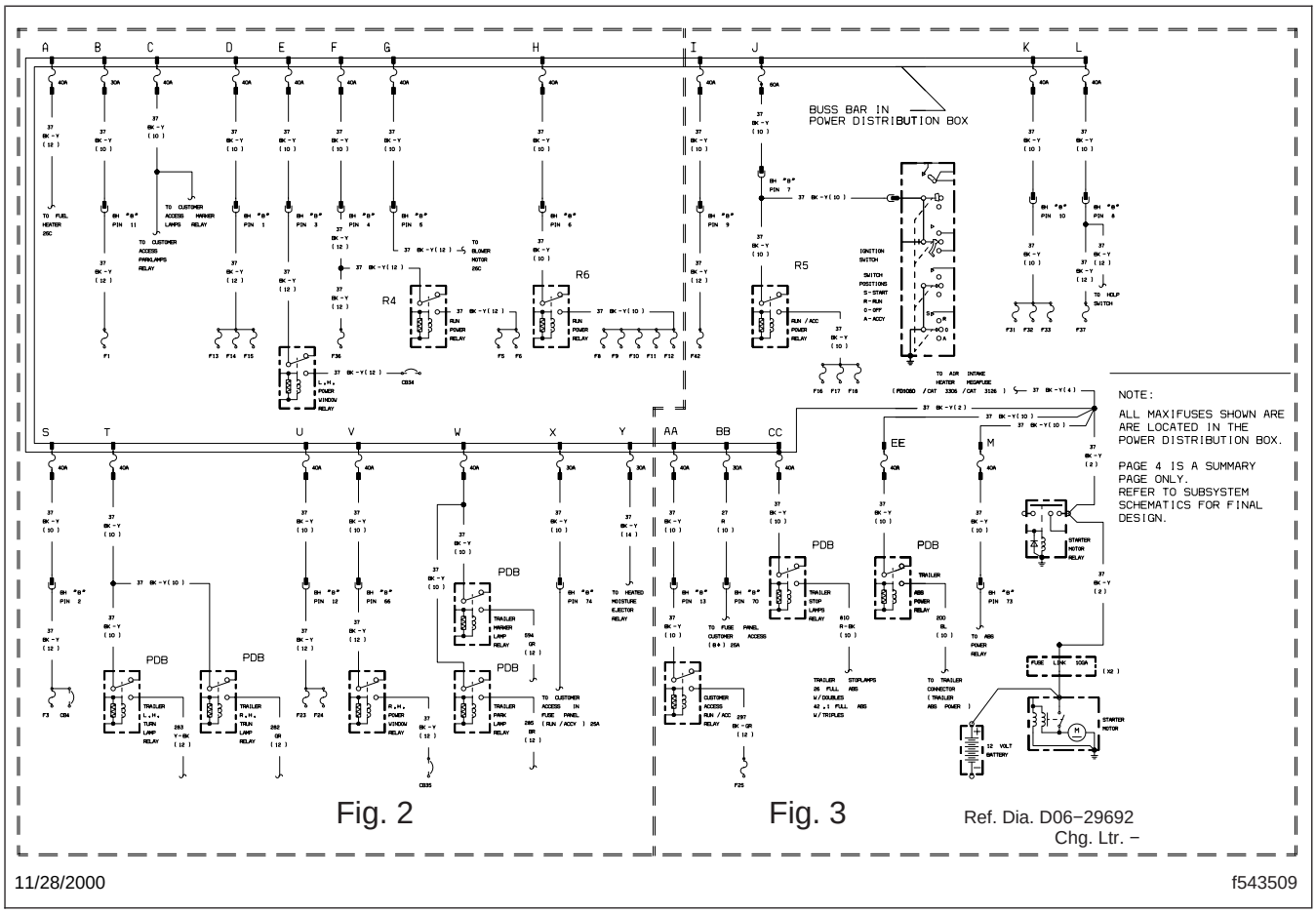
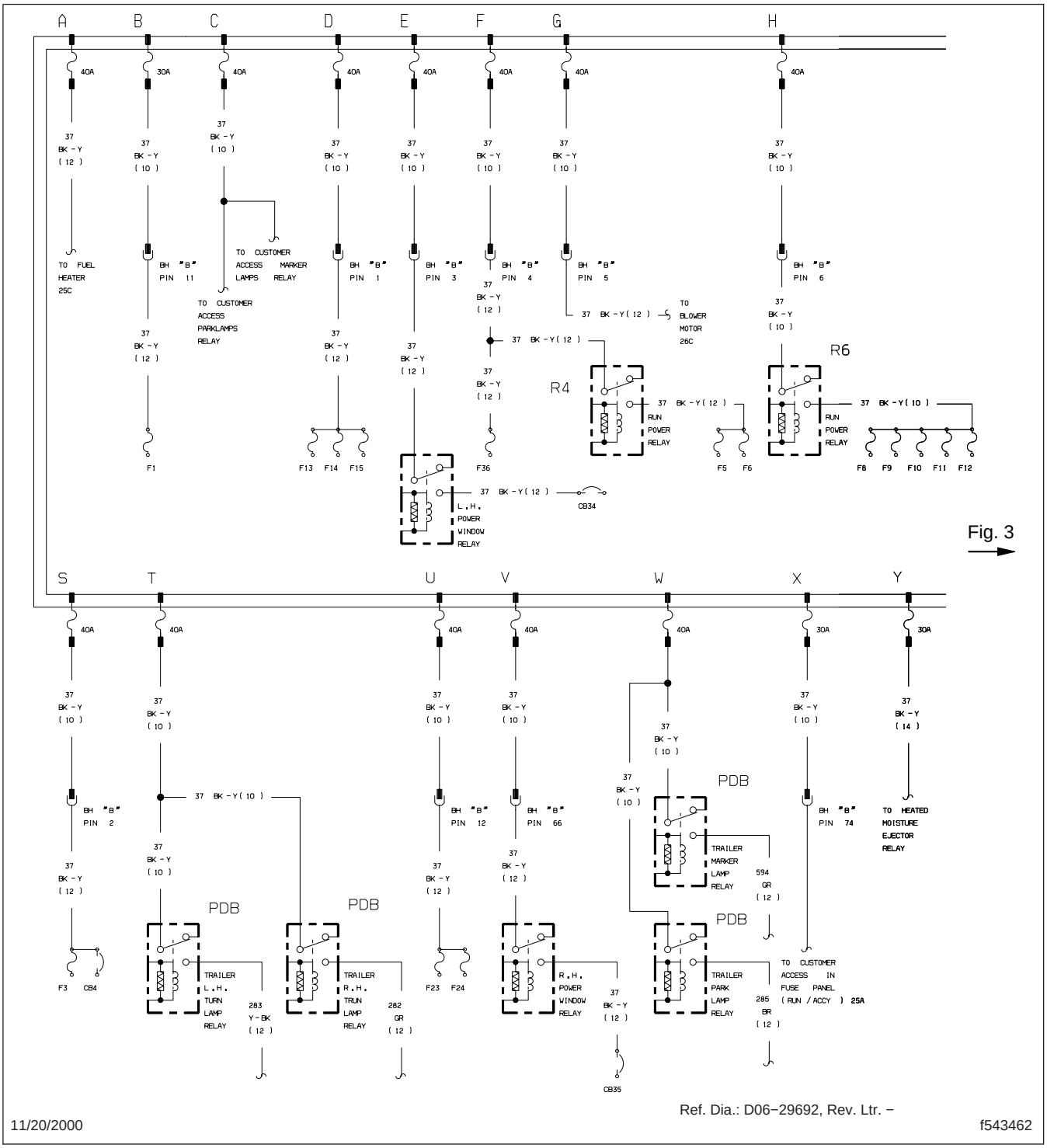


Fig. 1, Power Distribution Wiring (full view; typical, for vehicles built before February 27, 2001)

Specifications



Ref. Dia.: D06−29692, Rev. Ltr. −

11/20/2000 f543462

Fig. 2, Power Distribution Wiring (partial view; typical, for vehicles built before February 27, 2001)

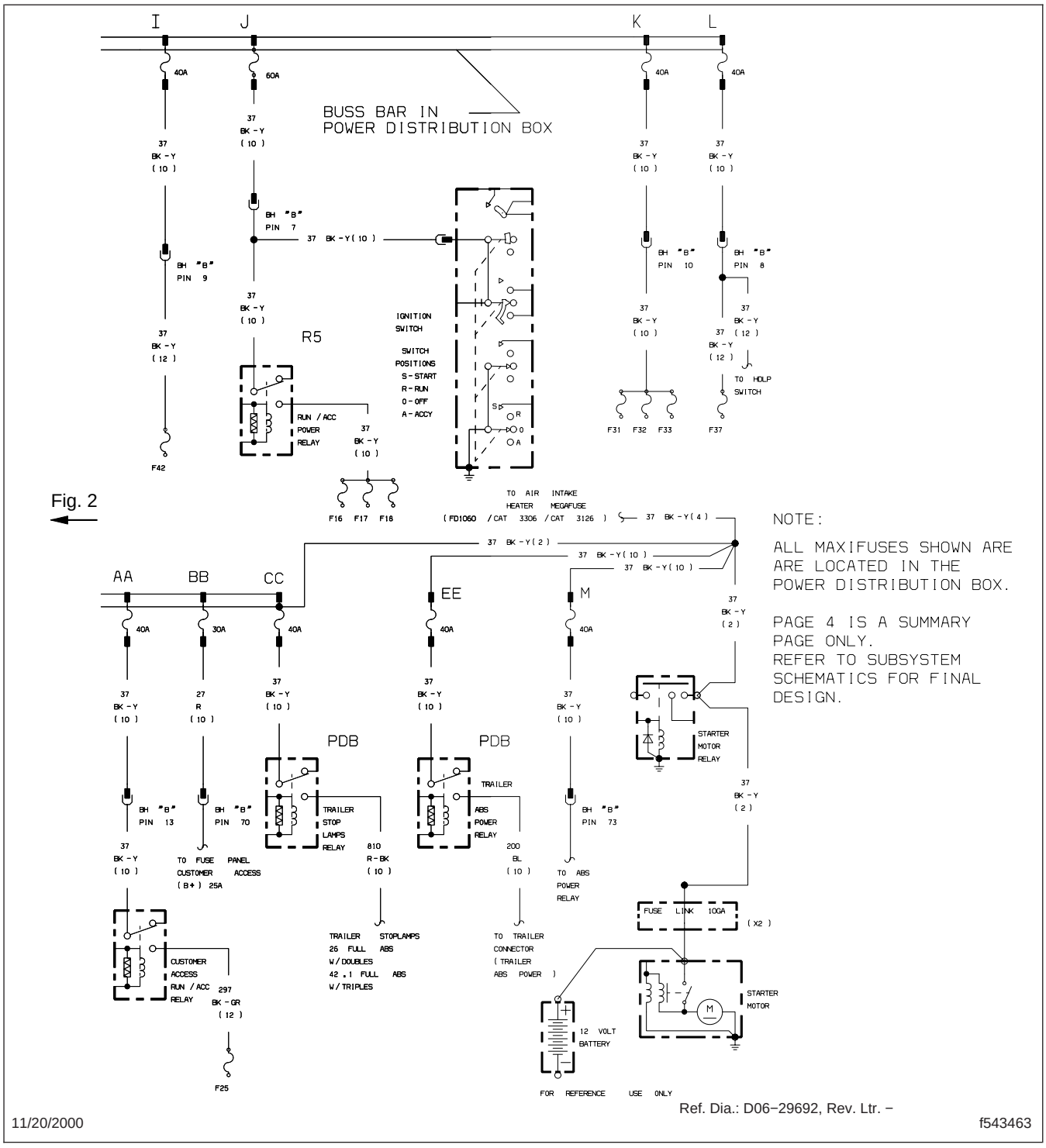


Fig. 2

Fig. 3, Power Distribution Wiring (partial view; typical, for vehicles built before February 27, 2001)

Specifications

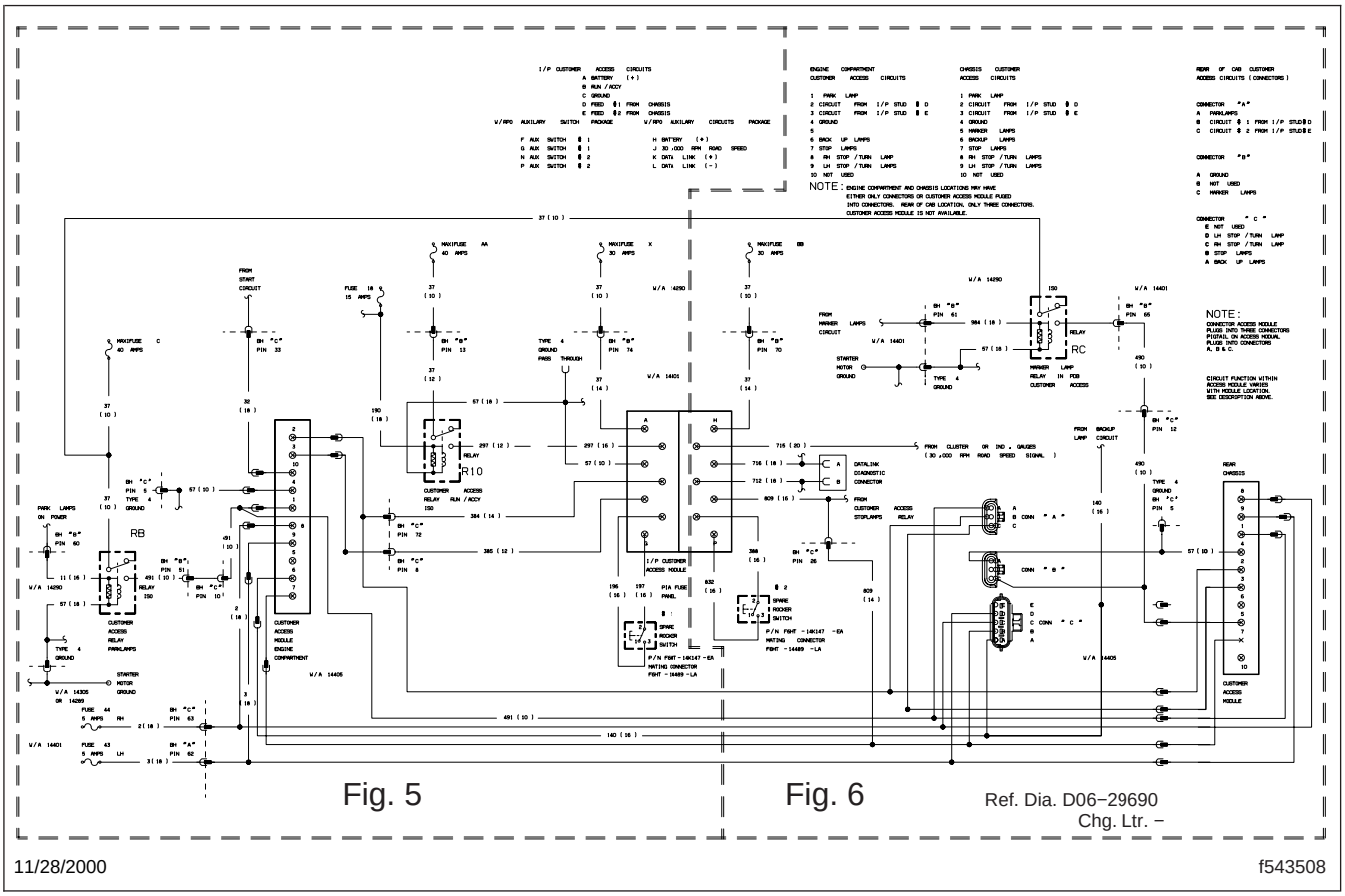


Fig. 4, Customer Access Circuits Wiring (full view; typical, for vehicles built before February 27, 2001)

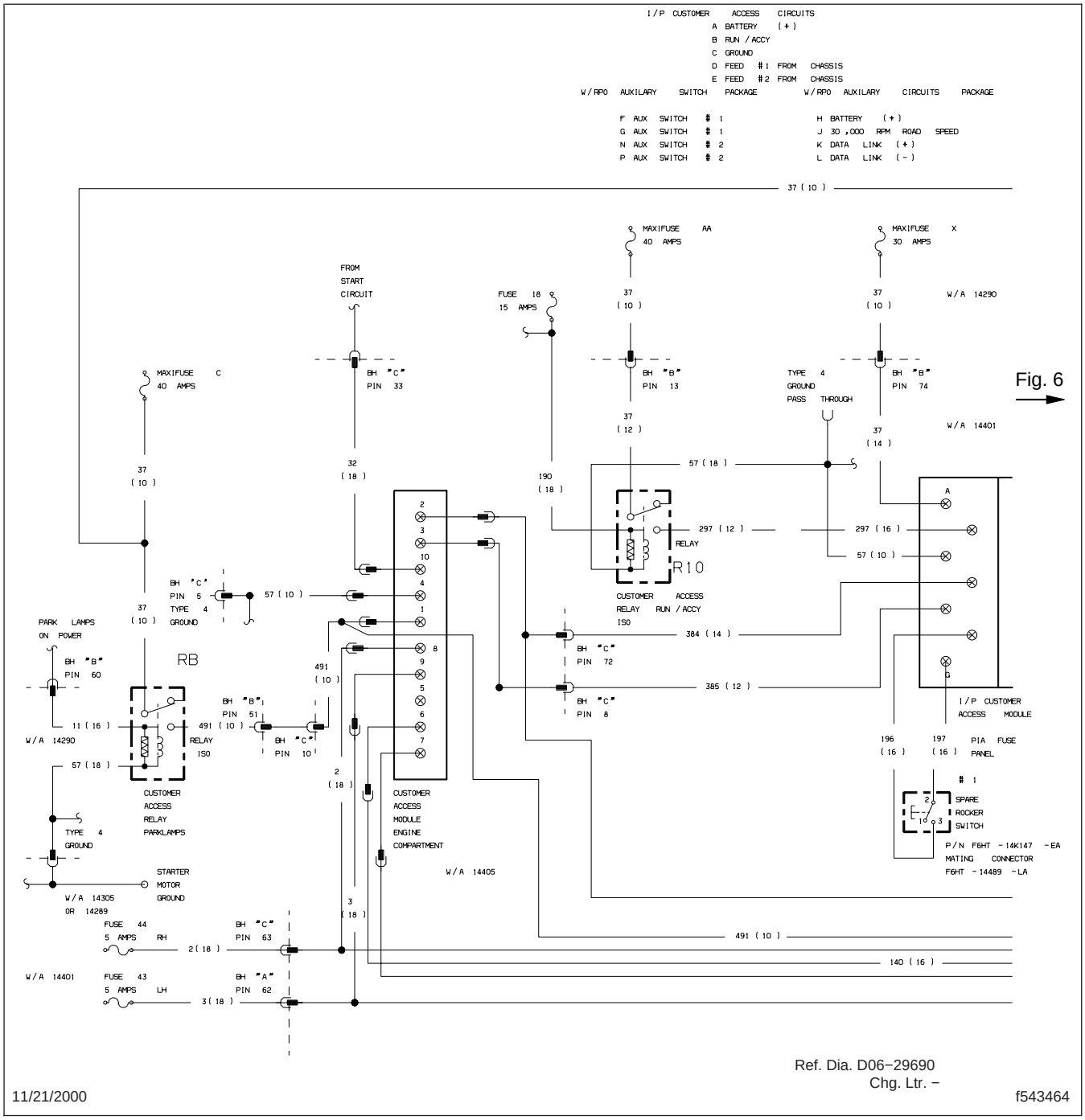


Fig. 6

Fig. 5, Customer Access Circuits Wiring (partial view; typical, for vehicles built before February 27, 2001)

Specifications

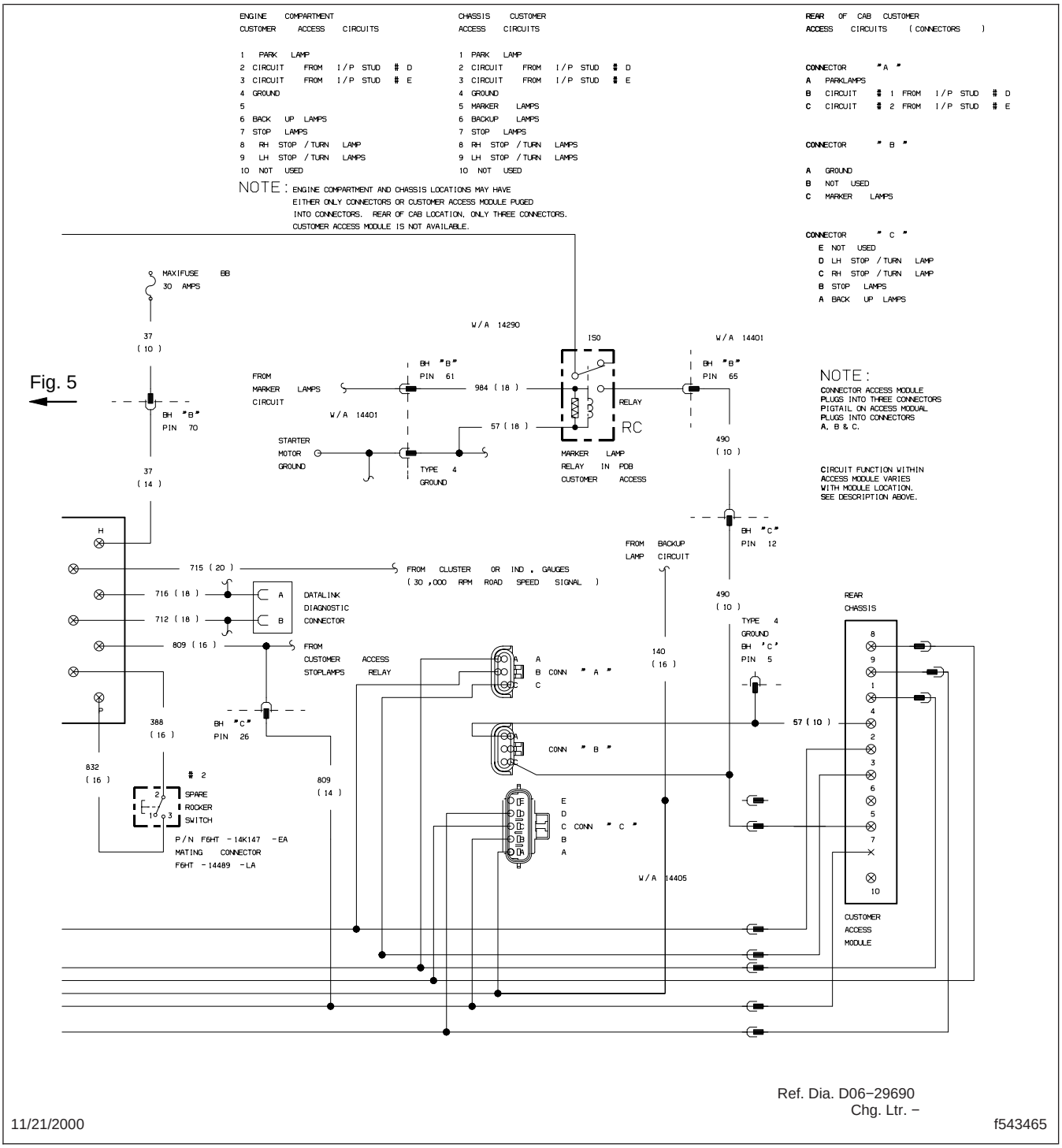


Fig. 5

Ref. Dia. D06−29690
Chg. Ltr. −

11/21/2000 f543465

Fig. 6, Customer Access Circuits Wiring (partial view; typical, for vehicles built before February 27, 2001)

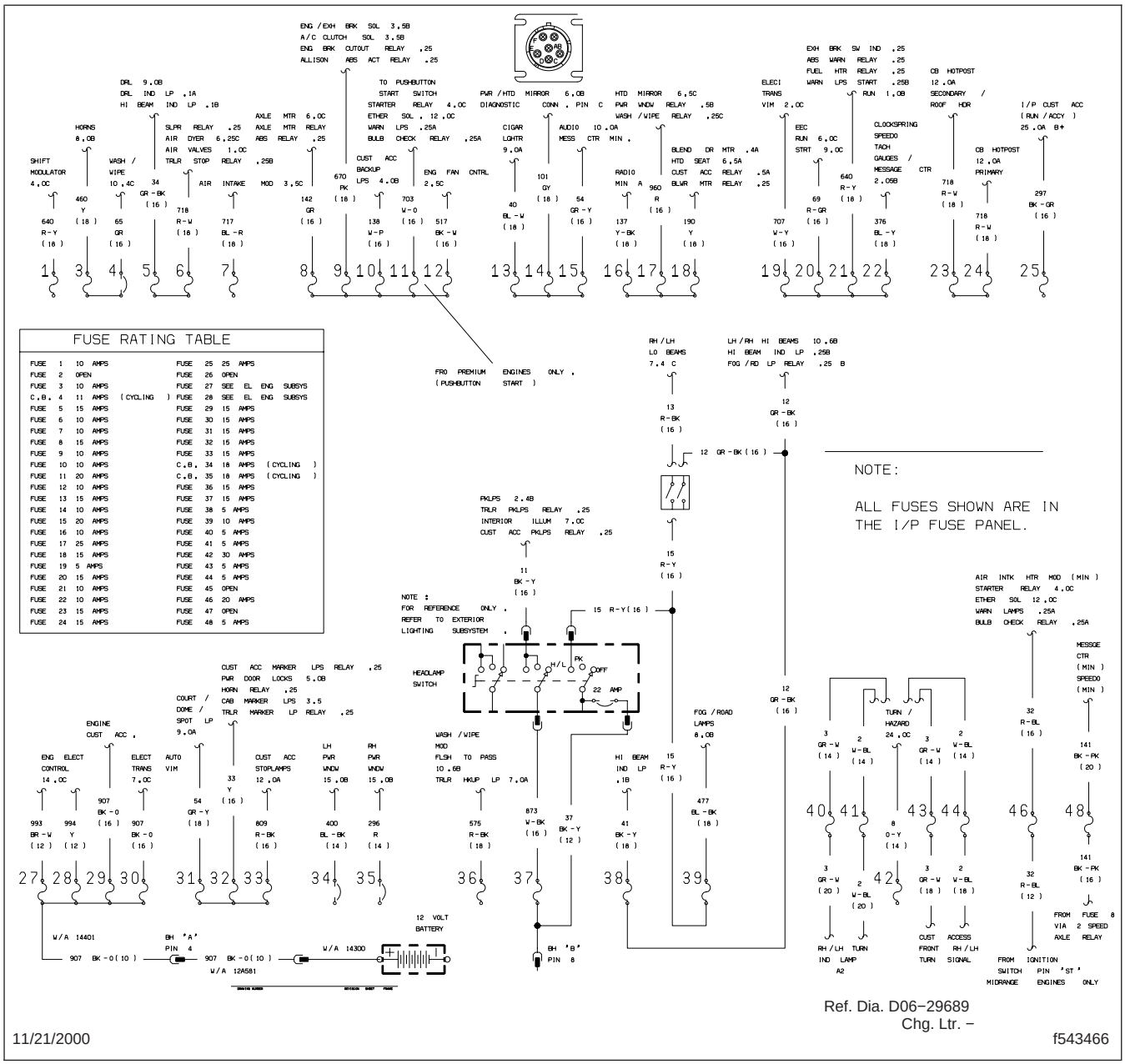


Fig. 7, Instrument Panel Wiring (full view; typical, for vehicles built before February 27, 2001)

Specifications

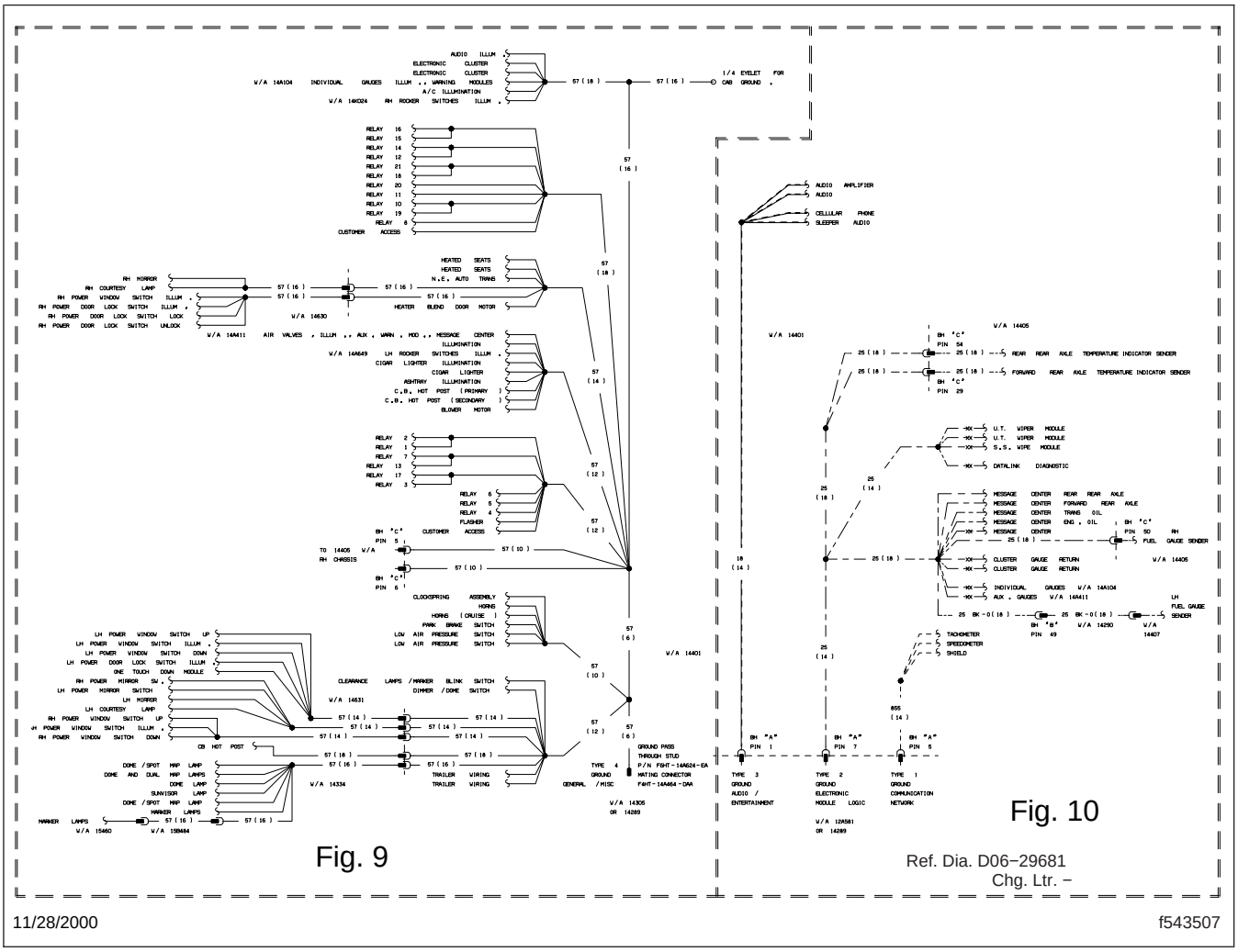


Fig. 8, Cab Ground Summary (full view; typical, for vehicles built before February 27, 2001)

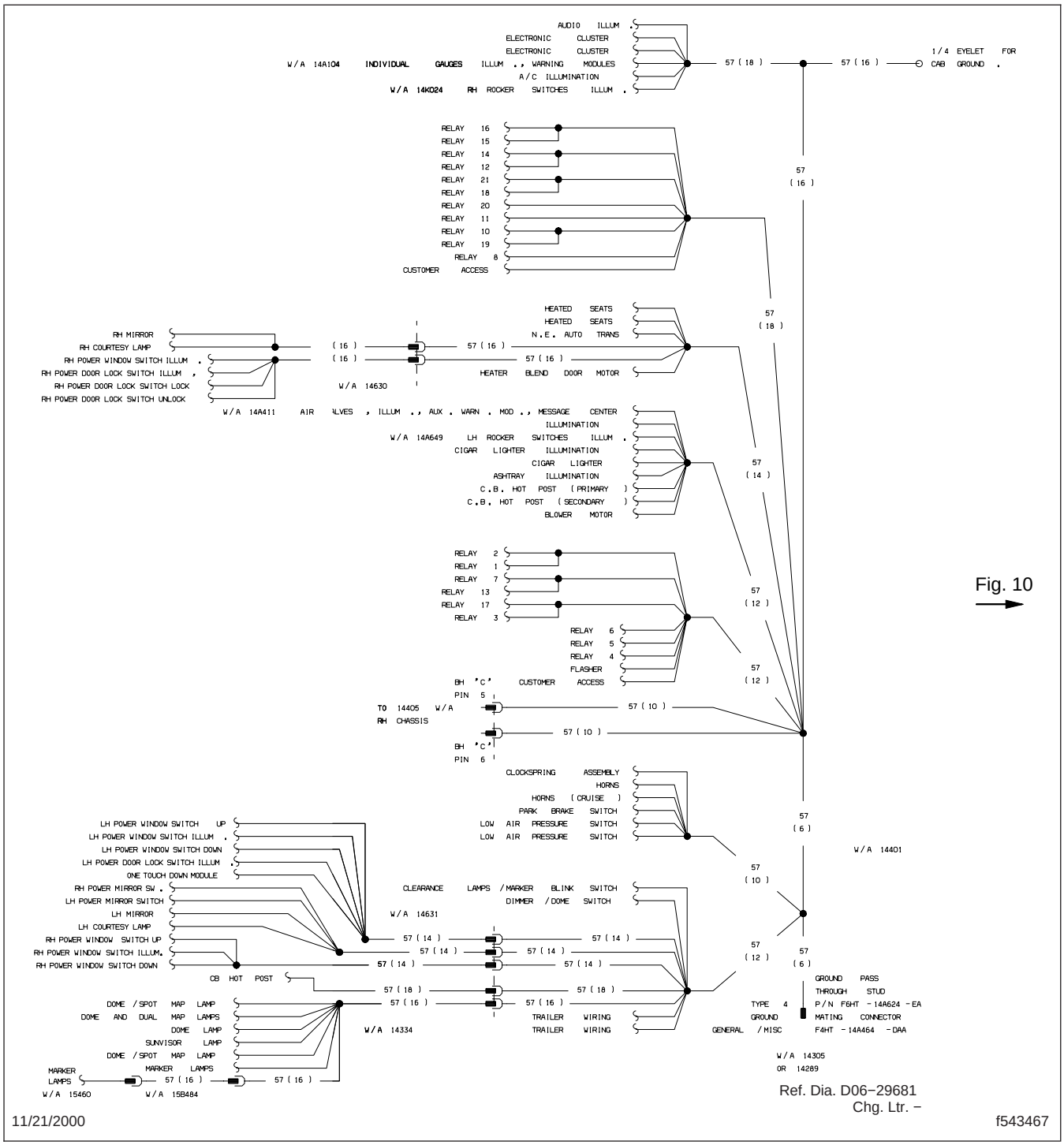


Fig. 10

Fig. 9, Cab Ground Summary (partial view; typical, for vehicles built before February 27, 2001)

Specifications

Fig. 9

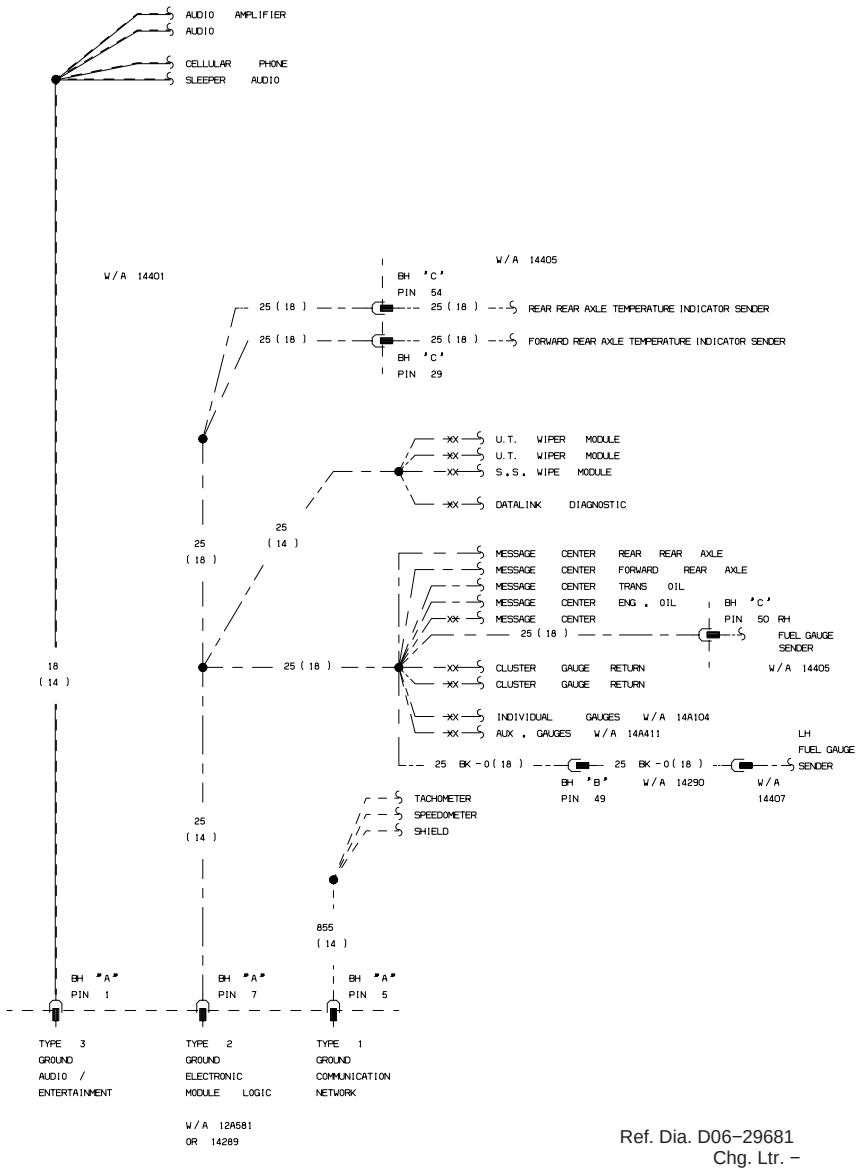


Fig. 10, Cab Ground Summary (partial view; typical, for vehicles built before February 27, 2001)

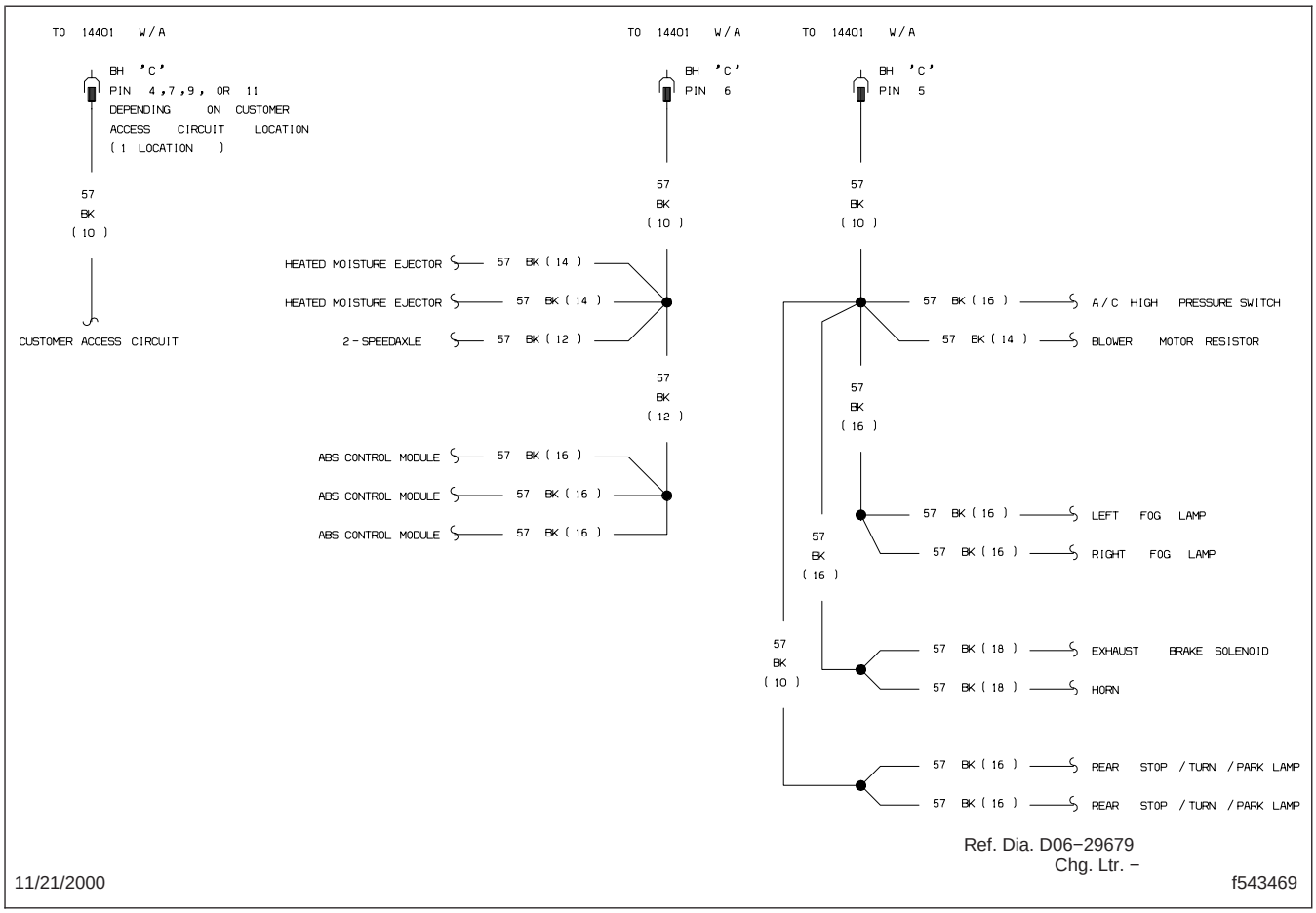


Fig. 11, Right-Hand-Drive Chassis Ground Summary (full view; typical, for vehicles built before February 27, 2001)

Specifications

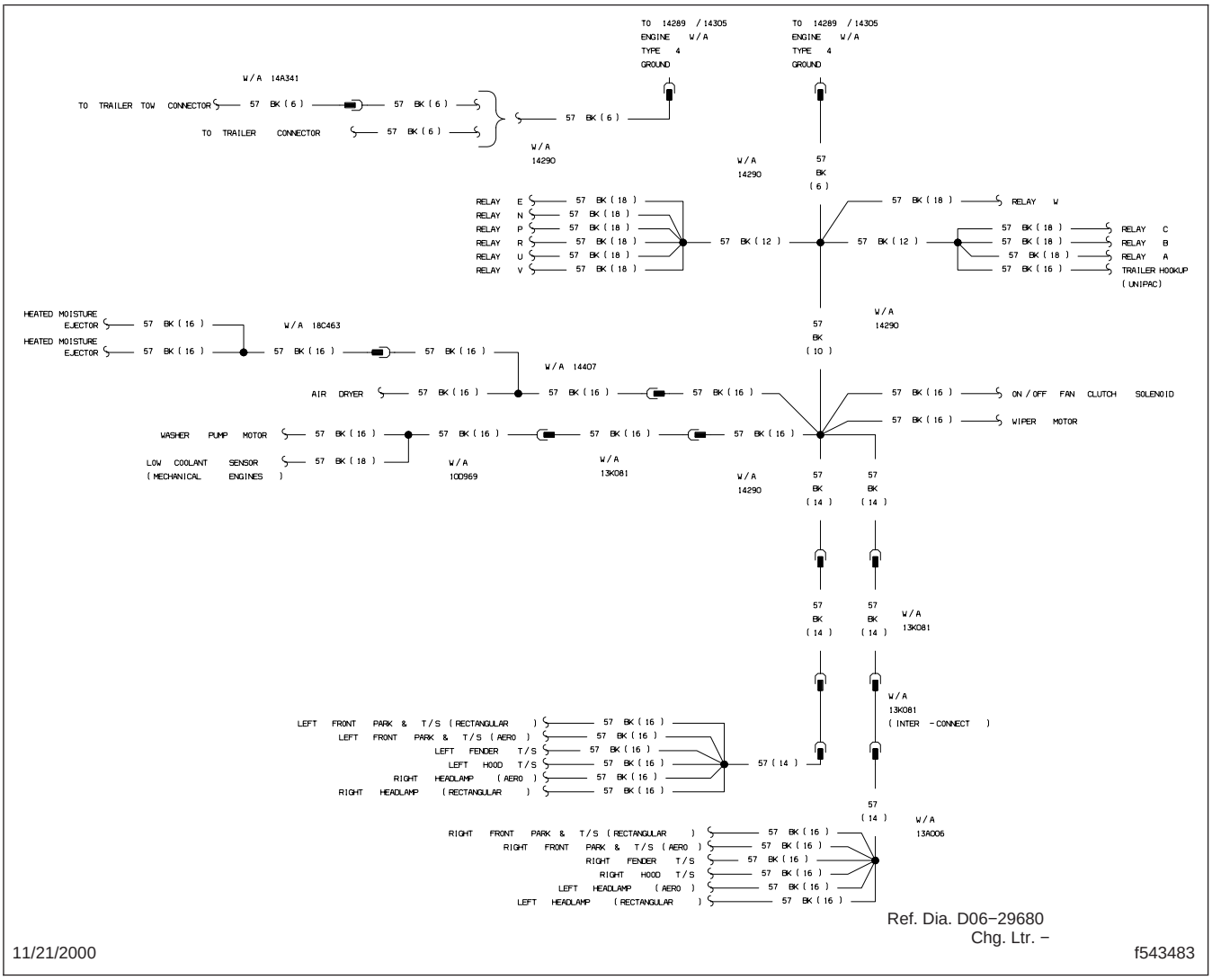


Fig. 12, Left-Hand-Drive Chassis Ground Summary (full view; typical, for vehicles built before February 27, 2001)

BULKHEAD "A"

PIN	CIRCUIT NUMBER	DESCRIPTION
1	18	TYPE 3 GROUND .
2	350	PRESSURE SWITCH TO A/C COMPRESSOR .
3		
4	907	DEDICATED BATTERY POWER (B+)
5	855	TYPE 1 GROUND .
6	907	BATTERY POWER TO TRANSMISSION VIM .
7	25	TYPE 2 GROUND .
8	678	FUEL HEATER
9	669	FUEL SHUTOFF SOLENOID
10	170 / 932	ALLISON SHIFT SELECTOR ◊/FUEL SHUTOFF
11	171	ALLISON SHIFT SELECTOR
12	172 / 162	ALLISON SHIFT SELECTOR ◊/ACCEL . SW .
13	162	EXHAUST BRAKE
14	184	A/C COMPRESSOR TO "CHECK A/C" IND . LAMP .
15	937	SENSOR COMMON
16	591	CRUISE CONTROL ON/OFF .
17	862	CRUISE CONTROL RES/ACC .
18	860	CRUISE CONTROL SET/COAST .
19	138	RUN POWER TO BACKUP LAMP SWITCH .
20	978	TRANS OIL TEMPERATURE GAUGE /SENDER
21	25	ENGINE OIL TEMPERATURE RETURN .
22	25	TRANS OIL TEMPERATURE RETURN .
23	614	SPEEDOMETER OUTPUT TO ECM .
24	634	ENGINE OIL TEMPERATURE SENDER .
25	978	TRANS OIL TEMP . SW . TO "CHECK TRANS " IND. LAMP.
26	669	FUEL SHUTOFF RELAY COIL
27	697 / 936	IDLE VALIDATION 1 /ON/OFF FAN CLUTCH
28	475 / 517	CLUTCH SWITCH TO ECM . /FAN CLUTCH
29	716	DATALINK (+).
30	712	DATALINK (-).
31	122	ALLISON SHIFT SELECTOR
32	140	BACKUP LAMPS SWITCH TO BACKUP LAMPS .
33	181	ALLISON SHIFT SELECTOR
34	911 / 910	ENGINE BRAKE LO/HI OR EXHAUST BRAKE
35	912	ENGINE BRAKE MED /HI .
36	39	WATER TEMPERATURE SENDER .
37	32	START CIRCUIT TO ETHER AND STARTER RELAY COIL.
38	925	SERVICE BRAKE SWITCH TO ECM .
39	721 / 90	ECM TO FAN CONTROL RELAY . COIL . H/FAN CLUTCH
40	60	THROTTLE POSITION SENSOR (+).
41	827	THROTTLE POSITION SENSOR INPUT .
42	828	THROTTLE POSITION SENSOR RETURN .
43	888	ELECTRONIC SHIFT MODULATOR
44	717	IDLE VALIDATION ACTIVE IDLE INPUT .
45	176	ECM TO "STOP ENGINE " IND . LAMP .
46	360	ECM TO "CHECK ENGINE WARNING " IND . LAMP .
47	704	PARK BRAKE SWITCH
48	161 / 635	ALLISON SENSOR COMMON RETURN! /OIL TEMP LP
49	689 / 17	J1922 (+) /LOW OIL PRESS SW .
50	642	J1922 (-)
51	707	START /RUN POWER FOR AUTO TRANS
52	69	START /RUN POWER TO ECM .
53	350	ECM TO A/C HIGH PRESS RELAY SWITCH .
54	594	ECM TO "SERVICE SOON " OR "ENG FLUIDS " IND LAMP.
55	154 / 45	ALLISON ABS ACTIVE SIGNAL /WATER TEMP LP
56	978	TRANS . VIM TO "CHECK TRANS " IND . LAMP .
57	922	ENGINE IDLE DECREMENT .
58	921	ENGINE IDLE INCREMENT .
59	713	TACHOMETER SIGNAL .
60	709 / 232	AIR INT HTR "WAIT TO START " LP/TACH RETURN
61	572	DIAGNOSTIC OR DDC ENG . SHUTDOWN OVERRIDE .
62	614	SPEEDOMETER SIGNAL .
63	826	SPEEDOMETER RETURN .
64	863	ALLISON ENGINE BRAKE CUTOUT
65	172	NEUTRAL SWITCH RELAY TO ECM
66	169	ALLISON ENGINE BRAKE CUTOUT
67	136	ALLISON SHIFT SELECTOR
68	143	ALLISON SHIFT SELECTOR
69	173	ALLISON SHIFT SELECTOR
70	174	ALLISON SHIFT SELECTOR
71	175	ALLISON SHIFT SELECTOR
72	147	ALLISON SHIFT SELECTOR
73	994	BATTERY POWER TO ECM .
74	993	BATTERY POWER TO ECM .
75	907	BATTERY POWER TO ENGINE CUSTOMER ACCESS .
76	48	SHIELD .

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Fig. 13, Bulkhead Connector "A" Pin and Circuit Number Identification (typical, for vehicles built before February 27, 2001)

BULKHEAD "B"

PIN	CIRCUIT NUMBER	DESCRIPTION
1	37	MAXIFUSE 'D'
2	37	MAXIFUSE 'S'
3	37	MAXIFUSE 'E' TO LH PWR WINDOW MOTOR .
4	37	MAXIFUSE 'F'
5	37	MAXIFUSE 'G' TO BLOWER MOTOR .
6	37	MAXIFUSE 'H' TO RUN RELAY .
7	37	MAXIFUSE 'J' TO IGNITION SWITCH .
8	37	MAXIFUSE 'L' TO HEADLAMP SWITCH .
9	37	MAXIFUSE 'Z' TO FLASHER .
10	37	MAXIFUSE 'K'
11	37	MAXIFUSE 'B'
12	37	MAXIFUSE 'U' TO C.B. HOT POST
13	37	MAXIFUSE 'AA' TO CUSTOMER ACCESS .
14	34	RUN POWER TO DRLM .
15	12	HEADLAMP SWITCH TO HIGH BEAMS .
16	41	DRLM OR HIGH BEAMS TO "HIGH BEAM " IND . LAMP .
17	201	DRLM TO "DAYTIME RUNNING " IND . LAMP .
18		
19	55	TRAILER HOOKUP LAMP .
20	718	RUN /ACCY FOR HTD MOIST EJECT OR AIR DRYER
21		
22	162	DRLM TO PARK BRAKE SWITCH .
23		
24		
25	3	LEFT FRONT TURN SIGNAL .
26		
27		
28		
29		
30		
31		
32	941	WIPE /WASH MODULE TO WASHER PUMP .
33	142	ABS TRAILER POWER
34	32	START CIRCUIT TO AIR INTAKE MOD .
35	717	START /RUN POWER TO AIR INTAKE MOD .
36	709	AIR INTAKE MOD . TO "WAIT TO START " IND . LAMP .
37	2	RIGHT FRONT TURN SIGNAL .
38		
39		
40		
41	2	RIGHT TURN SIGNAL TO TRAILER RELAY COIL .
42	3	LEFT TURN SIGNAL TO TRAILER RELAY COIL .
43	984	MARKER LAMPS TO TRAILER RELAY COIL .
44	810	STOPLAMPS TO TRAILER RELAY COIL .
45		
46		
47		
48	25	TYPE 2 FUEL SENDER GROUND
49	286	FUEL SENDER SIGNAL
50	13	HEADLAMP SWITCH TO LOW BEAMS .
51	491	CUSTOMER ACCESS PARKLAMPS
52	936	ON/OFF FAN CONTROL SOLENOID TO FAN CONTROL RELAY SWITCH
53		
54	640	START /RUN POWER TO FUEL HEATER RELAY COIL .
55	670	LOW COOLANT SENSOR TO IND . LAMP .
56		
57		
58		
59		
60	11	HEADLAMP SWITCH TO PARKLAMPS .
61	984	CUSTOMER ACCESS MARKER LAMPS .
62		
63	65	BATTERY POWER TO WIPER MOTOR .
64		
65	490	CUSTOMER ACCESS PARKLAMPS
66	37	MAXIFUSE 'V' TO RH PWR WINDOW MOTOR .
67	56	WIPE /WASH MODULE TO WIPER MOTOR 'HIGH'.
68	58	WIPE /WASH MODULE TO WIPER MOTOR 'LOW'.
69	28	WIPE /WASH MODULE TO WIPER MOTOR 'PARK'.
70	37	MAXIFUSE 'BB' TO CUSTOMER ACCESS .
71	678	FUEL HEATER
72	838	HEATED MOISTURE EJECTORS
73	37	MAXIFUSE 'M' TO ABS
74	37	MAXIFUSE 'X' TO CUSTOMER ACCESS .
75		
76		

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Fig. 14, Bulkhead Connector "B" Pin and Circuit Number Identification (typical, for vehicles built before February 27, 2001)

Specifications

BULKHEAD "C"

PIN	CIRCUIT NUMBER	DESCRIPTION
1	270	BLOWER MOTOR HIGH .
2	269	BLOWER MOTOR MED .
3	268	BLOWER MOTOR LO .
4		
5	57	TYPE 4 GROUND .
6	57	TYPE 4 GROUND .
7		
8	385	CUSTOMER ACCESS POWER .
9		
10	491	CUSTOMER ACCESS PARKLAMPS .
11		
12	490	CUSTOMER ACCESS MARKER LAMPS .
13		
14	718	TO WHEEL TO WHEEL DIFF LOCK SWITCH
15	210	FROM WHEEL TO WHEEL DIFF LOCK SWITCH
16		
17	350	A/C PRESSURE SW . TO A/C COMPRESSOR .
18	350	SELECTOR SWITCH TO A/C PRESSURE SWITCH .
19	478	FOG /ROAD LAMPS .
20	642	J1922 (-)
21		
22	670	ABS TO ENGINE BRK CUT - OUT RELAY COIL .
23		
24		
25	90	A/C CLUTCH SW . TO A/C HIGH PRESS . RELAY COIL .
26	809	CUSTOMER ACCESS STOPLAMPS .
27		
28		
29	25	FORWARD REAR AXLE TEMP . RETURN .
30		
31	962	FORWARD REAR AXLE TEMP SENDER .
32	140	BACKUP LAMPS SW . TO BACKUP LAMPS .
33	32	START CIRCUIT TO CUSTOMER ACCESS .
34	689	J1922 (+)
35	482	BATTERY POWER TO HORNS .
36		
37	286	FUEL SENDER .
38	963	REAR REAR AXLE TEMP . SENDER .
39		
40		
41	712	DATALINK (-) .
42	723	ABS TO ABS WARNING LIGHT RELAY COIL .
43	282	RIGHT REAR TURN SIGNAL .
44		
45		
46		
47		
48	11	RIGHT AND LEFT REAR PARKLAMPS .
49	283	LEFT REAR TURN SIGNAL .
50	25	FUEL GAUGE RETURN .
51		
52	171	TRACTION CONTROL SWITCH
53	716	DATALINK (+) .
54	25	REAR REAR AXLE TEMP . SENDER .
55		
56		
57	66	TRACTION CONTROL WARNING LAMP
58		
59		
60	162	EXH . BRK . CONTROL SW . TO EXH . BRK . CONTROL SOL .
61		
62	3	CUSTOMER ACCESS LEFT TURN SIGNAL .
63	2	CUSTOMER ACCESS RIGHT TURN SIGNAL .
64	692	ABS POWER
65		
66		
67	183	BLOWER MOTOR TO BLOWER MOTOR SWITCH
68		
69	143	RUN POWER TO TWO SPEED AXLE 'HIGH ' .
70	141	RUN POWER TO TWO SPEED AXLE 'LOW ' .
71	838	HEATED MOISTURE EJECTOR
72	384	CUSTOMER ACCESS POWER .
73		
74		
75		
76		

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Fig. 15, Bulkhead Connector "C" Pin and Circuit Number Identification (typical, for vehicles built before February 27, 2001)

General Information

A "datalink" is an electrical network that connects two or more computers to exchange data. The simplest datalink is a pair of wires between two computers. Freightliner uses datalinks to connect the Electronic Control Units (ECUs) for the electronically controlled vehicle systems with each other and with the Instrumentation Control Unit (ICU). A personal computer using Freightliner's ServiceLink diagnostic software can also be connected to the network via a datalink.

Datalink Systems

Different types of datalinks are used to connect certain ECUs. The vehicle may have any of the following datalinks:

J1587/J1708

J1587/J1708 is a low speed vehicle datalink that communicates information between the ECUs on the vehicle. The J1587 datalink is also referred to as J1708. See **Fig. 1**. J1708 refers to the SAE standard for the physical part of the datalink, such as the wiring and the electronic components. J1587 refers to the SAE standard for the messaging protocol that communicates on the J1708 network. In the context of vehicle repair, the terms J1708 and J1587 are used interchangeably.

The J1587 datalink uses a twisted pair of wires to reduce interference from digital messages being sent on the wires. Wire colors for the J1587 datalink are:

- Orange **J1587 Low**
- Green **J1587 High**

J1939

J1939 is a high-speed vehicle datalink that communicates information between ECUs on the vehicle. The J1939 datalink replaced the J1922 datalink. See **Fig. 2**.

Unlike the J1587 datalink, the J1939 datalink allows an ECU to broadcast requests as well as information. Examples of information that can be communicated on the J1939 datalink are:

- engine rotational speed;
- road speed;
- transmission tailshaft speed;
- engine retarder deactivation request;
- engine torque reduction request.

The J1939 datalink uses a twisted pair of wires to reduce interference from digital messages being sent on the wires. Wire colors for the J1939 datalink are:

- Yellow **J1939 High**
- Green **J1939 Low**

The back bone of the J1939 datalink is the section of the datalink that is between two terminating resistors. An ECU can be connected anywhere along the length of the backbone in between the terminating resistors. The wiring between the ECU and the J1939 backbone is called a circuit. The maximum distance of the terminating resistor is 3 feet from the last ECU or diagnostic connector.

The purpose of the terminating resistors is to minimize the reflection of data on the datalink which can cause J1939 messages to become partially or completely lost. Terminating resistors prevent this from occurring. Each terminating resistor is 120 Ohms, but the equivalent of two 120 Ohms resistors in parallel is 60 Ohms. With both resistors installed in the circuit, there should be 60 Ohms measured at any two points between **J1939 High** and **J1939 Low** in the circuit.

Each ECU is generally connected to the J1939 backbone using a tee connector or splice. See **Fig. 3**.

Making the Pinout Measurements Easier to See

The pins on the diagnostic connector may be difficult to see when testing. If the pins are difficult to see, use a Y-cable as an extension to the diagnostic connector to make test measurements easier. See **Fig. 4** for a drawing of the connector at the end of the Y-cable and the corresponding 9-pin diagnostic connector pins.

NOTE: Be sure to attach a meter with a proper jumper kit to prevent unintentional shorting to other pins and possible damage to ECUs.

The Roll Call

To check the readiness of the ECUs on the datalink, the ICU sends a signal to other ECUs and expects a

General Information

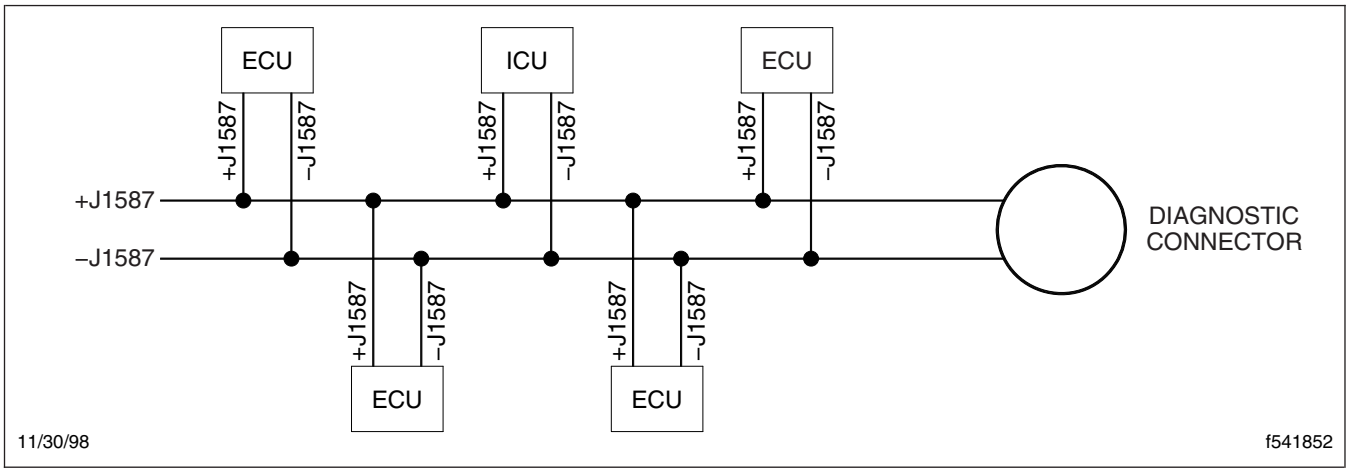


Fig. 1, J1587 Datalink

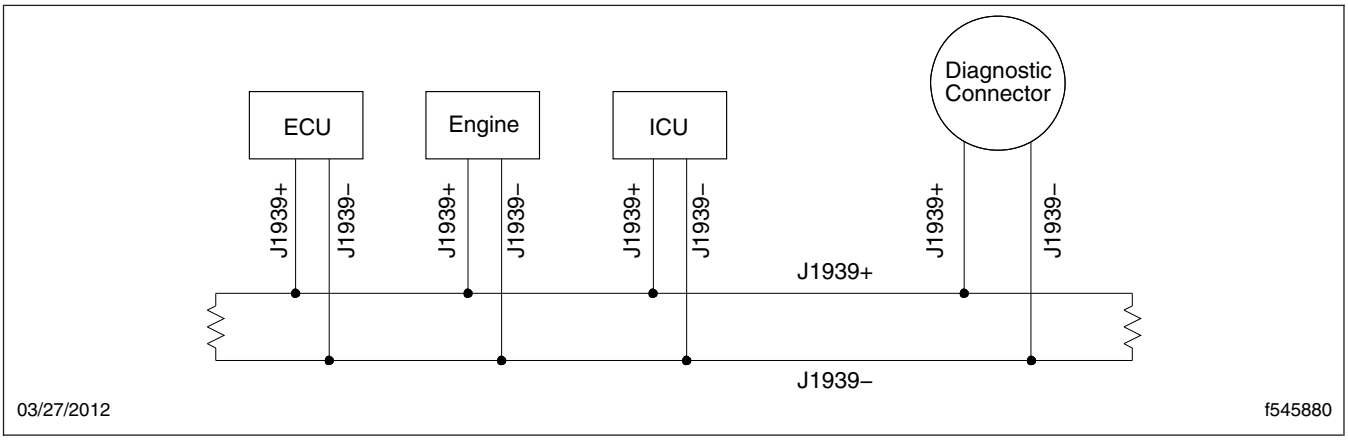


Fig. 2, J1939 Datalink

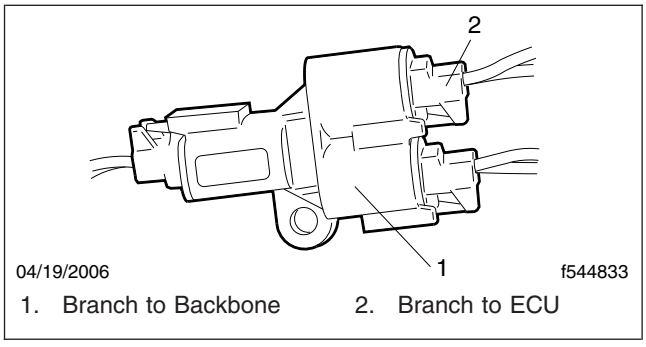


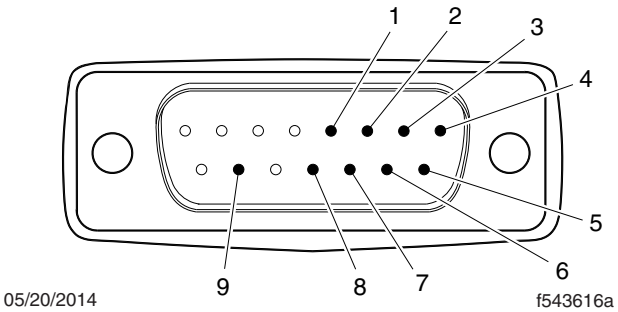
Fig. 3, J1939 Tee Connector

response from each. This "Roll Call" procedure tells the ICU which ECUs are functioning correctly. When the list of functioning ECUs is compared against the parameter list of factory-installed ECUs that are supposed to respond, the technician can determine which ECUs or datalinks are bad.

If the ICU does not receive a signal on the datalink from one or more of the active ECUs, it displays a roll call fault. The roll call fault is displayed *only* on the dash driver display screen. It is not broadcast on the datalink; therefore, it cannot be read by Service-Link. However, Servicelink can be used to determine if an ECU is not responding because it polls all ECUs on the datalink when it first connects to the vehicle datalink.

Datalink Junction Blocks

For the J1587 datalink, the wires routed through the vehicle cab have two datalink junction blocks and



1. Pin H (Diagnostic CAN High)
2. Pin A
3. Pin E
4. Pin B
5. Pin F
6. Pin G
7. Pin C (J1939 High)
8. Pin D (J1939 Low)
9. Pin J (Diagnostic CAN Low)

Fig. 4, Y-Cable Pinouts

two datalink connections. The ICU3 uses only one connection to the ICU.

Locating J1939 Wiring Diagrams

The J1939 wiring diagram can be found in module 160. Other modules may also contain datalink wiring information. See **Table 1**.

Use PartsPro® to obtain drawing numbers for installation drawings, harness assembly drawings, and wiring diagrams applicable to the vehicle being worked on.

Component Module Locations	
Component	**Module Number**
General J1939 harness drawings, schematics, and installation drawings	160
Engine harness and installation drawings	283 and 286
Transmission harness and installation drawings	34A and 343
ABS harness and installation drawings	330, 332, and 333

Table 1, Component Module Locations

Datalink Repairs

J1587 and J1922 Repairs

Use the same methods of repair for the twisted-pair datalink wiring as are used for the other wires on the vehicle. However, the datalink wires must be twisted at a rate of a minimum one turn per inch (25 mm) of length.

J1939 Repairs

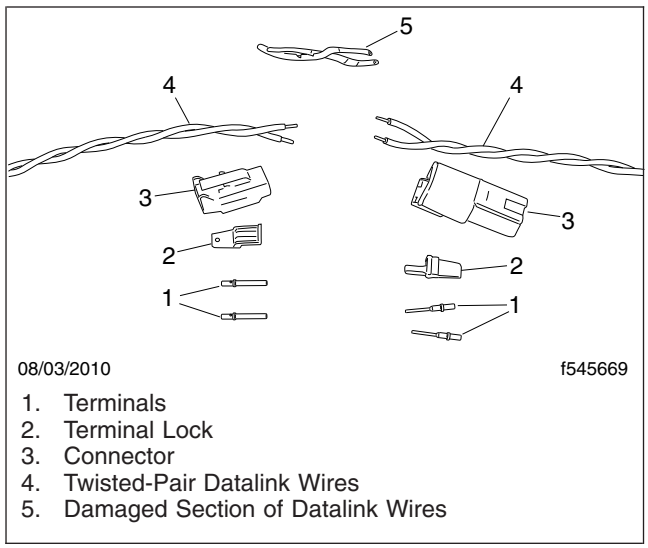
A special cable must be used for repairs to the J1939 datalink wiring. The two types of J1939 cable ("heavy" and "lite") can be spliced together as long as the pass-through connectors are the "heavy" type. The "lite" cable (because of its lower cost) is recommended for repairs on both types of J1939 cable. Refer to Appendix C of SAE J1939-11 for the special procedures for repairing the "heavy" J1939 datalink.

Parts

Twisted-pair datalink wires may be spliced using a mating connector set. See **Table 1** for a typical set of datalink connector parts.

Procedure

1. Cut out any damaged section of datalink wire, keeping the lengths of the two wires equal. See **Fig. 1** for an example of a damaged section of datalink wire that has been removed and the datalink prepared for repair.
2. Crimp the terminals onto the wires using the proper crimp tool.
3. Pull test the terminals by hand to ensure the crimp is mechanically solid.
4. Insert the terminated wires into the connector body and install the terminal lock. The protocol for J1939 is for the yellow wire to be in cavity 1 and the green wire to be in cavity 2. Note that the lock is installed while holding the wires in position. Test the installation. If the wires slipped back during the lock installation, they will pull out of the connector.
5. Make certain the wires are twisted as close to the entry point of the connector as possible. Plug the two connector halves together. See **Fig. 2**.



1. Terminals
2. Terminal Lock
3. Connector
4. Twisted-Pair Datalink Wires
5. Damaged Section of Datalink Wires

Fig. 1, Datalink Splice Parts

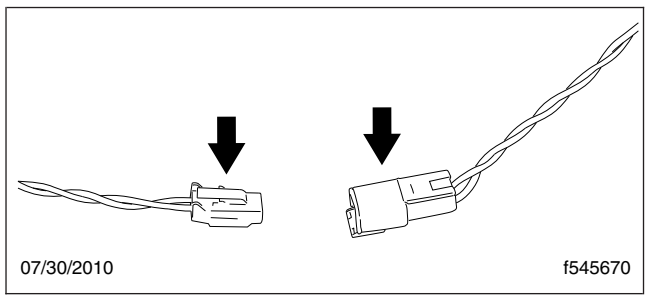


Fig. 2, Datalink Connectors

Datalink Repairs

Datalink Connector Parts		
Description	**Part Number**	**Quantity**
Connector Body Plug	23-13148-204	1
Terminal Lock	23-13303-015	1
Terminals	23-13210-020	2
Connector Body Receptacle	23-13148-206	1
Terminal Lock	23-13303-013	1
Terminals	23-13210-030	2

Table 1, Datalink Connector Parts

General Information

This Troubleshooting subject has three main parts:

- Troubleshooting Tables

  Use the Troubleshooting Tables to get ideas on what could be causing the problem and the possible remedies to that problem.

- Troubleshooting Procedures

  Follow the Troubleshooting Procedures section to isolate the areas that have faults and to know which tests to perform.

- Testing Procedures

  The Testing Procedures section has the individual tests and specifications needed to determine whether a part must be repaired or replaced.

NOTE: Be sure to attach a meter with a proper jumper kit to prevent unintentional shorting to other pins and possible damage to ECUs.

Troubleshooting Tables

Use the following troubleshooting tables to find remedies to possible causes of datalink problems.

Problem—Power-On Roll Call Reports Fault

Problem—Power-On Roll Call Reports Fault	
Possible Cause	**Remedy**
The ECU does not support roll call function (ICU1/2M only).	Reset the ECU parameter to disable roll call.
The datalink wiring has a fault.	Repair or replace the wiring.
Wrong power supply voltage or ground to ECU.	Replace the fuse or circuit breaker, charge the battery, the check connections.
The connector has a fault - (Pass-through, Branch, Diagnostic)	Repair or replace the wiring.
The ECU has a fault.	Replace the ECU.
The ICU has a fault.	Replace the ICU.
The terminating resistor for J1939 datalink is missing or has a fault.	Replace the terminating resistor.
The branch length is too long on J1939 datalink.	Shorten "lite" branch to less than 10 feet (3 m).
The battery is discharged or is bad.	Charge or replace the battery.

Problem—ServiceLink Will Not Connect

Problem—ServiceLink Will Not Connect	
Possible Cause	**Remedy**
ICU is older series that does not support roll call.	Use ICU for display of active fault codes only.
One or more ECUs has a fault.	Remove suspected ECUs one at a time until ServiceLink can be connected.
ServiceLink computer is not configured or connected correctly.	Check the computer settings, communication adaptor and cabling between the computer, communication adaptor, and diagnostic connector.
Connector types are different.	The J1939 datalink and new J1587 datalinks have 9-pin connectors. Connect an adapter or use the ICU for the diagnostics information display.
Battery is discharged, has a bad connection, or has a fault.	Charge, clean terminals, or replace battery.

Troubleshooting

Problem—Missing Data on Datalink-Driven Gauges

Problem—Missing Data on Datalink-Driven Gauges *	
Possible Cause	**Remedy**
ICU or engine ECU is not communicating on datalink.	Test wiring and ICU or engine ECU.
Datalink wiring has a fault.	Test and repair wiring.
Connector or junction block has a fault.	Repair or replace connector.
Incorrect voltage to ECUs	Test datalink and vehicle wiring.

* Datalink-driven gauges include: engine oil pressure, coolant temperature, engine oil temperature, turbo air pressure, tachometer, speedometer

Troubleshooting Procedures

To find the part of the datalink system that is causing a problem, follow the Troubleshooting Procedures and refer to the appropriate Troubleshooting Tests for the test points and specifications. Perform the steps of the Troubleshooting Procedures in sequence until you locate the fault.

The seven steps to diagnosing a datalink problem are:

1. Determine which types of datalink are installed on the vehicle.

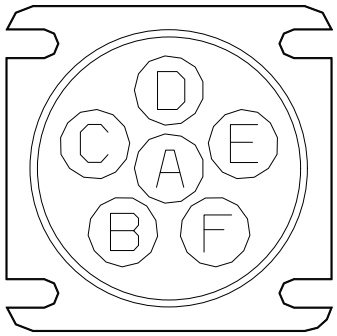
   1.1 Check the diagnostic connector. A 6-pin connector (or a 9-pin connector without pins C and D installed) is used for J1587 datalinks. See **Fig. 1** and **Fig. 2**. J1939 datalinks have pins C and D installed in the 9-pin diagnostics connector.

   1.2 Check the wires. J1939 cable has a heavy jacket. Note that some non-Freightliner ECUs have their J1587 wires inside a jacket as well. If all the wiring has a jacket, the datalink is a J1939 datalink.

   If the J1939 cable has a drain wire inside the shielding, it is a "heavy" cable. The J1939 "lite" cable (with no drain wire) can be spliced into a section of "heavy" cable.

   1.3 Determine whether a Cummins IS Series, Caterpillar CFE, or a Mercedes-Benz engine is installed with an ABS system that has traction control. These systems use a J1939 datalink.

   1.4 A J1939 datalink is used when an Eaton® Fuller® AutoShift transmission is installed. The WABCO EBS (brake-by-wire) system and certain Eaton VORAD EVT-300 systems also require J1939 datalinks. Certain other ECUs may require a J1939 datalink.



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1. Pin A (J1587 High)
2. Pin B (J1587 Low)
3. Pin C (12V+)
4. Pin D (Reserved)
5. Pin E (Ground)
6. Pin F (Reserved)

Fig. 1, J1587 6-Pin Diagnostics Connector

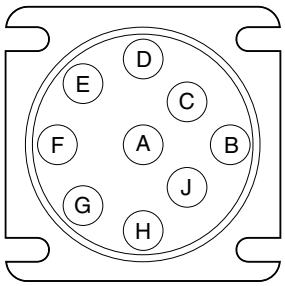
2. Determine which ECUs are not communicating with ServiceLink.

   2.1 Connect to the vehicle with ServiceLink

   2.2 Compare the ICU roll call list with ServiceLink ECU list.

   Note: Some ECUs cannot communicate with the ICU, but will appear on the ServiceLink parameter list. The ICU2L and ICU3 rollcall function is limited to the engine ECU and the ABS ECU.

   2.3 If an ECU is not communicating on the datalink, disconnect all the generic ECUs, one at a time, until no faults are displayed on the ICU screen or until ServiceLink



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NOTE: Pins C and D are not installed in the J1587 diagnostics connector.

1. Pin A Battery (Low)
2. Pin B Battery (High)
3. Pin C (J1939 High)
4. Pin D (J1939 Low)
5. Pin E (Shield)
6. Pin F (J1587 High)
7. Pin G (J1587 Low)
8. Pin H (Diagnostic CAN High)
9. Pin J (Diagnostic CAN LOW)

Fig. 2, J1939/J1587 9-Pin Diagnostics Connector

connects to the system. The last ECU to be disconnected before the successful ServiceLink connection is the one causing the problem.

3. Check the suspected ECU.
   - 3.1 Check the resistance and voltage at the ECU connectors. See **Testing the ECUs** in the datalink testing procedures section of this subject.
   - 3.2 Temporarily replace the ECU with an ECU known to be good. If the ICU (or ServiceLink) now lists that ECU, install a new ECU.
4. Check the wires and connectors from the ICU at the connector for the suspected faulty ECU. See **Testing the J1587 Datalink** or **Testing the J1939 Datalink** in the datalink testing procedures section of this subject.
   - 4.1 Check the power supply voltage.
   - 4.2 Check the data signal voltage.
   - 4.3 Check the continuity and resistance to ground. If the readings are outside the acceptable range and are found at several test points, suspect that the datalink has a fault.
5. Determine which branch includes the suspected faulty ECU. Find the connectors and junction blocks that are in series with the suspected faulty ECU.
6. Check the wiring between the branch connector and the ECU and the wiring from the ICU to the branch connector. See **Testing the J1587 Datalink** or **Testing the J1939 Datalink** in the datalink testing procedures section of this subject.
   - 6.1 Check power supply voltage.
   - 6.2 Check the data signal voltage.
   - 6.3 Check the continuity and resistance to ground.
7. Check the ICU. See **Testing the ICU** in the datalink testing procedures section of this subject.
   - 7.1 Check the voltages at the junction block to the ICU.
   - 7.2 Replace the ICU with an ICU known to be good.

Datalink Testing Procedures

The following procedures give the test points and specifications for checking the various types of datalinks, connectors, ECUs and ICUs. Refer to the datalink troubleshooting tables, and the datalink troubleshooting procedures, above, for information on when to test the particular parts of the datalink system.

Testing at the ECUs

1. Make sure that the vehicle battery is charged and the fuses and circuit breakers are good before testing the ECU connectors.
2. The keyswitch must be in the OFF position. Disconnect the ECU datalink circuit at the connector closest to the ECU. Turn the keyswitch to the ON position and check the voltage at the ECU harness connector. See **Table 1** for the acceptable results.
3. Connect the ECU to the datalink connector when the keyswitch is in the OFF position. Turn the keyswitch to the ON position for this test. Touch the probes of the digital multimeter (on the DC voltmeter scale) to the metal terminals of the ECU connector as shown in **Table 1** to test the ECU. Use the AC scale for the voltage tests if

the multimeter will not display the rapidly changing DC voltage using the DC scale. If the test results are not within the range shown, replace the ECU and test again.

NOTE: Voltages in **Table 1** will be varying.

ECU Harness Voltage Tests		
J1587 aDatalink		
Meter (High) Probe	**Meter (Low) Probe**	**Acceptable Meter Reading (VDC)**
ECU Datalink High Terminal	ECU Datalink Low Terminal	1 to 4 VDC (1 to 3V on the AC Scale)
Battery Positive Post	ECU Datalink High Terminal	6 to 11 VDC *
	ECU Datalink – Terminal	9 to 13.5 VDC *
J1939 Datalink		
Diagnostics Pin C (J1939 High)	Diagnostics Pin D (J1939 Low)	.2 to 5 VDC (.1 to 4V on the AC Scale)
Diagnostics Pin B (BAT High)	Diagnostics Pin C	6 to 11 VDC*
	Diagnostics Pin D	9 to 13.5 VDC*

* If datalink wire connections are reversed, the results are reversed.

Table 1, ECU Harness Voltage Tests

Testing the J1587 Twisted-Pair Datalink

1. Make sure that all fuses and circuit breakers are in good condition.
2. Turn the keyswitch to the OFF position before disconnecting or connecting any part of the datalink system. Disconnect the J1587 connector for the datalink section you are testing.

IMPORTANT: Do NOT disconnect the datalink by disconnecting the engine, frontwall or chassis electrical connectors.

IMPORTANT: The batteries **MUST** be disconnected and the ignition must be **OFF** prior to any J1587 resistance tests. Failure to do so may result in inconclusive resistance measurements. The J1939 datalink is not completely inactive with only the ignition off. It may be active even if there appears to be no voltage on the the datalink.

3. Turn the keyswitch to the OFF position. Test the continuity of a J1587 twisted-wire pair by touching the red (positive) probe of a digital multimeter (set to the ohmmeter mode) to the **J1587 High** terminal of the connector. Connect the black (negative) probe to the J1587– wire terminal. See **Table 2** for the results.

   Check the datalink isolation to the vehicle ground by holding one ohmmeter probe on the **J1587 Low** wire and the other probe to a good ground. Perform this test again with the ohmmeter leads reversed. **Table 2** shows the acceptable resistances for these tests.

J1587 Resistance Tests		
Meter (High) Probe	**Meter (Low) Probe**	**Acceptable Meter Reading (Ohms)**
High	Low	1k to 30k Ohms
High	Vehicle Ground	More than 1k Ohms
Low	Vehicle Ground	More than 1k Ohms

Table 2, J1587 Resistance Tests

4. Test the signal voltage on the J1587 twisted pair as shown in **Table 1**. The keyswitch must be in the ON position for the voltage tests. Use the AC scale for the voltage tests if your multimeter will not display the rapidly changing DC voltage using the DC scale.

NOTE: If any voltage reading is a steady 0 VDC or a steady 12 VDC, the ECU or datalink wiring has a fault.

Testing the J1939 Datalink

Use the following five basic steps in the order given to successfully locate J1939 datalink problems. Do not skip steps or tests unless directed to do so.

J1939 Resistance Test

This test checks whether or not both terminating resistors are installed, and ensures that there is a complete circuit from the diagnostic connector through the backbone loop. It does not ensure that branch circuits to each ECU are OK.

Tests in this subject are performed using a digital multimeter set to read ohms.

IMPORTANT: The batteries **MUST** be disconnected and the ignition must be **OFF** prior to any J1939 resistance tests. Failure to do so may result in inconclusive resistance measurements. The J1939 datalink is not completely inactive with only the ignition off. It may be active even if there appears to be no voltage on the the datalink.

1. Turn the ignition OFF and disconnect the batteries.
2. Connect the meter leads of a digital multimeter set to read ohms to pins C and D of the 9-pin diagnostic connector and measure the resistance.
3. Reconnect the batteries after the test is completed.

See **Table 3** for test results and possible causes.

J1939 Resistance Test	
Result	**Possible Cause**
60Ω ± 6Ω	The J1939 datalink backbone is intact and both terminating resistors are installed. Go to step 2.
120Ω ± 12Ω	Any of the following: • One of the terminating resistors is missing. • One of the terminating resistors is open. • The circuit may be open anywhere between the terminating resistors.
40Ω ± 4Ω	Three terminating resistors have been installed; one must be removed. There must be one terminating resistor at each end of the backbone for a total of two.
0Ω to 5Ω	**J1939 High** and **J1939 Low** have shorted together somewhere in the system.
Greater than 1000Ω	The most likely cause is an open circuit between the diagnostic connector and the J1939 backbone. It may also be that both terminating resistors are missing or open.
Any other readings	Any of the following: • Incorrect terminating resistor resistance. • Poor or corroded connections. • Short circuit to ground or an open circuit somewhere on the datalink. Go to step 2 to pinpoint the problem.

Table 3, J1939 Resistance Test

ECU Communication Test

The following series of tests check for communication with each ECU connected to the J1939 datalink. If one fails to communicate, pinpoint whether the problem is wiring or an ECU. If all ECUs communicate as they should, J1939 is probably not the problem.

1. **Check whether each ECU connected to the J1939 datalink responds.**

   1.1 Connect the computer to the diagnostic connector.

   1.2 Start the J1939 Datalink Monitor template.

   NOTE: The template contains instructions on its use.

   1.3 Check whether each ECU that is supposed to be connected to the datalink responds. See **Table 4** for test results and possible causes.

Check whether each ECU connected to the J1939 datalink responds	
Result	**Possible Cause**
All ECUs respond	The J1939 datalink is probably not the problem.
One ECU fails to respond.	Go to step 2.
No ECUs respond	Possible explanations are: • The **J1939 High** and **J1939 Low** pinouts may be reversed at the diagnostic connector, or at any other connector in the system. Check their polarity. • There may be a problem with the PC to vehicle interface. • The entire datalink may be down due to a short to power or short to ground. Go to Step 3 to pinpoint the problem.

Table 4, Check Whether Each ECU Connected to the J1939 Datalink Responds

2. **Check the J1939 datalink wiring to the ECU that does not respond.**

   IMPORTANT: The batteries **MUST** be disconnected and the ignition must be **OFF** prior to any J1939 resistance tests.

   2.1 Turn the ignition OFF and disconnect the batteries.

   2.2 Locate the connector at the ECU in Step 2, Test 1 that did not respond and disconnect it.

   2.3 Locate the pins for **J1939 High** and **J1939 Low**. Refer to Freightliner or component supplier literature or wiring diagrams for the specific component.

   2.4 Check to make sure that **J1939 High** and **J1939 Low** polarity is correct at the component before proceeding. If not, this is the most likely problem.

   2.5 Using a digital multimeter set to read ohms, measure the resistance across the two J1939 datalink pins at the connector to the suspect ECU.

   2.6 Reconnect the batteries after the test is completed. See **Table 5** for test results and possible causes.

Check the J1939 datalink wiring to the ECU that does not respond	
Result	**Possible Cause**
60Ω ± 6Ω	The datalink itself is probably not the problem. Make sure that any changeable J1939 parameters for this ECU are set correctly before proceeding. Also, make sure that there is power and ground to the suspect ECU. Go to **step 3** once the following have been confirmed: • J1939 parameters for the ECU (if they can be changed) are correct. • There is power and ground to the suspect ECU.
Not 60Ω ± 6Ω	There is a problem with the J1939 wiring between the ECU connector and its connection to the J1939 backbone. Repair as necessary.

Table 5, Check the J1939 Datalink Wiring to the ECU That Does Not Respond

3. **Install a test ECU to confirm the problem.**
   - 3.1 Install a test ECU and make sure that all J1939 parameters (if changeable) are set correctly.
   - 3.2 Using the J1939 Datalink Monitor template, check to see if every ECU that is supposed to be connected to the datalink responds. See **Table 6** for test results and possible causes.

Install a test ECU to confirm the problem	
Result	**Possible Cause**
All ECUs respond	The ECU was faulty and the test ECU confirmed this. Replace the ECU.
The ECU still does not respond.	The problem has not been confirmed. Carefully repeat all the diagnostics. If the ECU still does not respond, contact your District Service Manager or the ECU supplier directly for assistance.

Table 6, Install a Test ECU to Confirm the Problem

Test J1939 Voltage for Circuit Faults (Shorts to Power and Ground)

These tests check for shorts to power and shorts to ground on the J1939 datalink.

NOTE: All tests are performed using a digital multimeter set to read voltage.

NOTE: Before proceeding, verify that battery voltage (approximately +12 VDC) is available at pin B of the diagnostic connector. With the ignition ON, use a digital multimeter to test for voltage at pin B by placing the red (+) lead on pin B and the black (-) lead on a good chassis ground.

1. **Test J1939 High for shorts to power and ground.**
   - 1.1 Turn the ignition ON.
   - 1.2 Touch the red (+) lead to pin B (+12 VDC) and the black (-) lead to pin C (**J1939 High**) of the diagnostic connector. See **Table 7** for test results and possible causes.

Shorts to Power and Ground (J1939 High)	
Result	**Possible Cause**
0 VDC	**J1939 High** is shorted to power. Continue to the next test, "Pinpointing Short Circuits on the J1939 Datalink."

Troubleshooting

Shorts to Power and Ground (J1939 High)	
Result	**Possible Cause**
12 VDC (battery voltage)	**J1939 High** is shorted to ground. Continue to the next test, "Pinpointing Short Circuits on the J1939 Datalink."
Any other reading	**J1939 High** is not shorted to power or ground. Go to step 2.

Table 7, Shorts to Power and Ground (J1939 High)

2. **Test J1939 Low for shorts to power and ground.**

   2.1 Turn the ignition ON.

   2.2 Touch the red (+) lead to pin B (+12 VDC) and the black (-) lead to pin D (**J1939 Low**) of the diagnostic connector. See **Table 8** for test results and possible causes.

Shorts to Power and Ground (J1939 Low)	
Result	**Possible Cause**
0 VDC	**J1939 Low** is shorted to power. Continue to the next test, "Pinpointing Short Circuits on the J1939 Datalink."
12 VDC (battery voltage)	**J1939 Low** is shorted to ground. Continue to the next test, "Pinpointing Short Circuits on the J1939 Datalink."
Any other reading	**J1939 Low** is not shorted to power or ground. There may be a problem with the vehicle to computer interface. The datalink itself appears to be OK.

Table 8, Shorts to Power and Ground (J1939 Low)

Databus Quick Test

NOTE: All voltages in **Table 1**, except for BAT + and BAT – will be varying.

Databus Quick Test				
No.	**Test**	**Red Lead/Black Lead**	**Specification**	**Result**
Battery Connected – Ignition ON				
1	Bat+ to Bat-	Pin B to Pin A	Source Voltage (> 12.4)	
2	J1587+ to J1587–	Pin F to Pin G	1 – 5 VDC (0 – 4 VAC)	
3	Bat+ to J1587+	Pin B to Pin F	6 – 11 VDC	
4	Bat+ to J1587–	Pin B to Pin G	9 – 13.5 VDC	
5	J1939+ to J1939–	Pin C to Pin D	.2 – 5 VDC (.1 – 4 VAC)	
6	Bat+ to J1939+	Pin B to Pin C	6 – 11 VDC	
7	Bat+ to J1939–	Pin B to Pin D	9 – 13.5 VDC	
Ignition OFF – Battery Disconnected at Batteries – NOT Cab Load Disconnect Switch				
8	J1587+ to J1587–	Pin F to Pin G	1k – 30k Ohms	
9	J1587+ to Bat–	Pin F to Pin A	> 1k Ohms	
10	J1587- to Bat–	Pin G to Pin A	> 1k Ohms	
11	J1939+ to J1939–	Pin C to Pin D	55 – 65 Ohms	
12	J1939+ to Bat–	Pin C to Pin A	> 1k Ohms	
13	J1939- to Bat–	Pin D to Pin A	> 1k Ohms	
14	Terminating Resistors	—	110 – 130 ohms	

Table 1, Databus Quick Tests

NOTE: J1939 tests can also be performed on Diagnostic CAN High – Pin H, and Diagnostic CAN Low – Pin J for similar results.

The following diagrams show the wiring circuits installed by Sterling. For detailed engine wiring, see the applicable Caterpillar™ manual.

See **Fig. 1** for a full view of the Caterpillar C10, C12 and 3406 engine controls wiring.

See **Fig. 2**, **Fig. 3** and **Fig. 4** for partial views of the Caterpillar C10, C12 and 3406 engine controls wiring.

See **Fig. 5** for a full view of the Caterpillar 3126 engine controls wiring.

See **Fig. 6**, **Fig. 7** and **Fig. 8** for partial views of the Caterpillar 3126 engine controls wiring.

See **Fig. 9** for a full view of the Caterpillar 3306 engine ground summary.

See **Fig. 10** for a full view of the Caterpillar 3126 and 3406 engine ground summary.

See **Fig. 11** for a full view of the Caterpillar C10 and C12 engine ground summary.

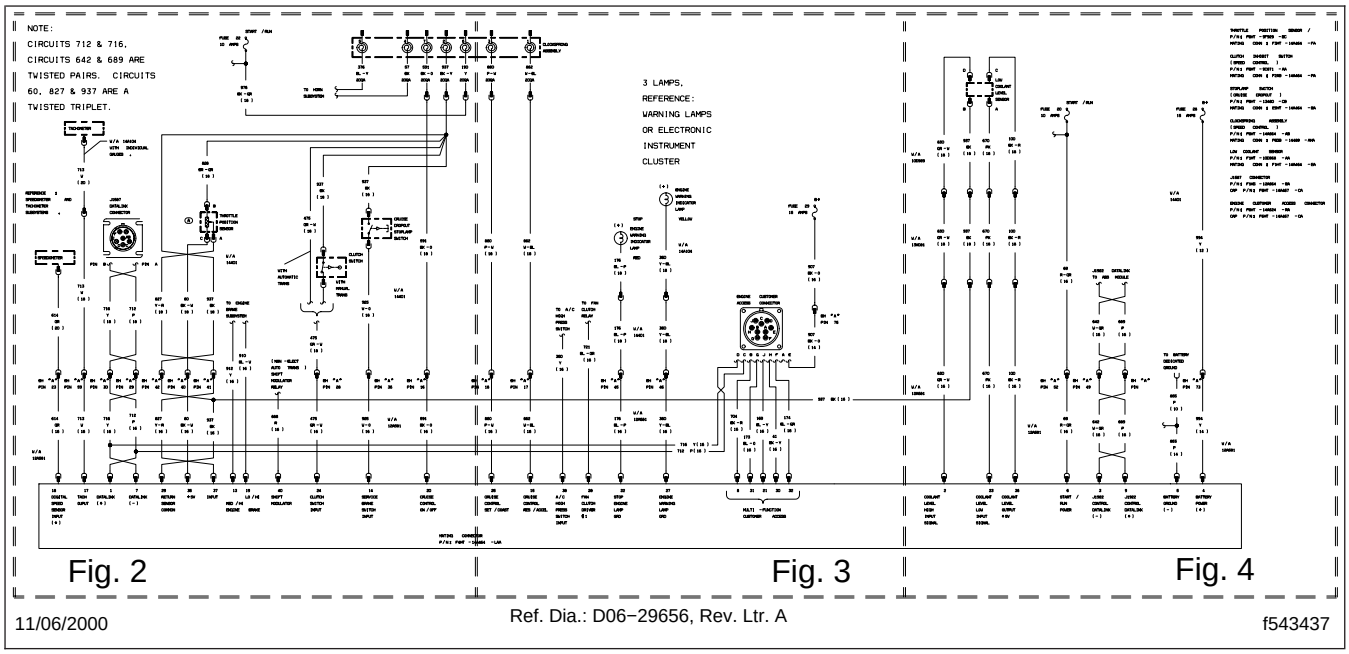

Fig. 1, Caterpillar C10, C12 and 3406 Engine Controls Wiring (full view)

Specifications

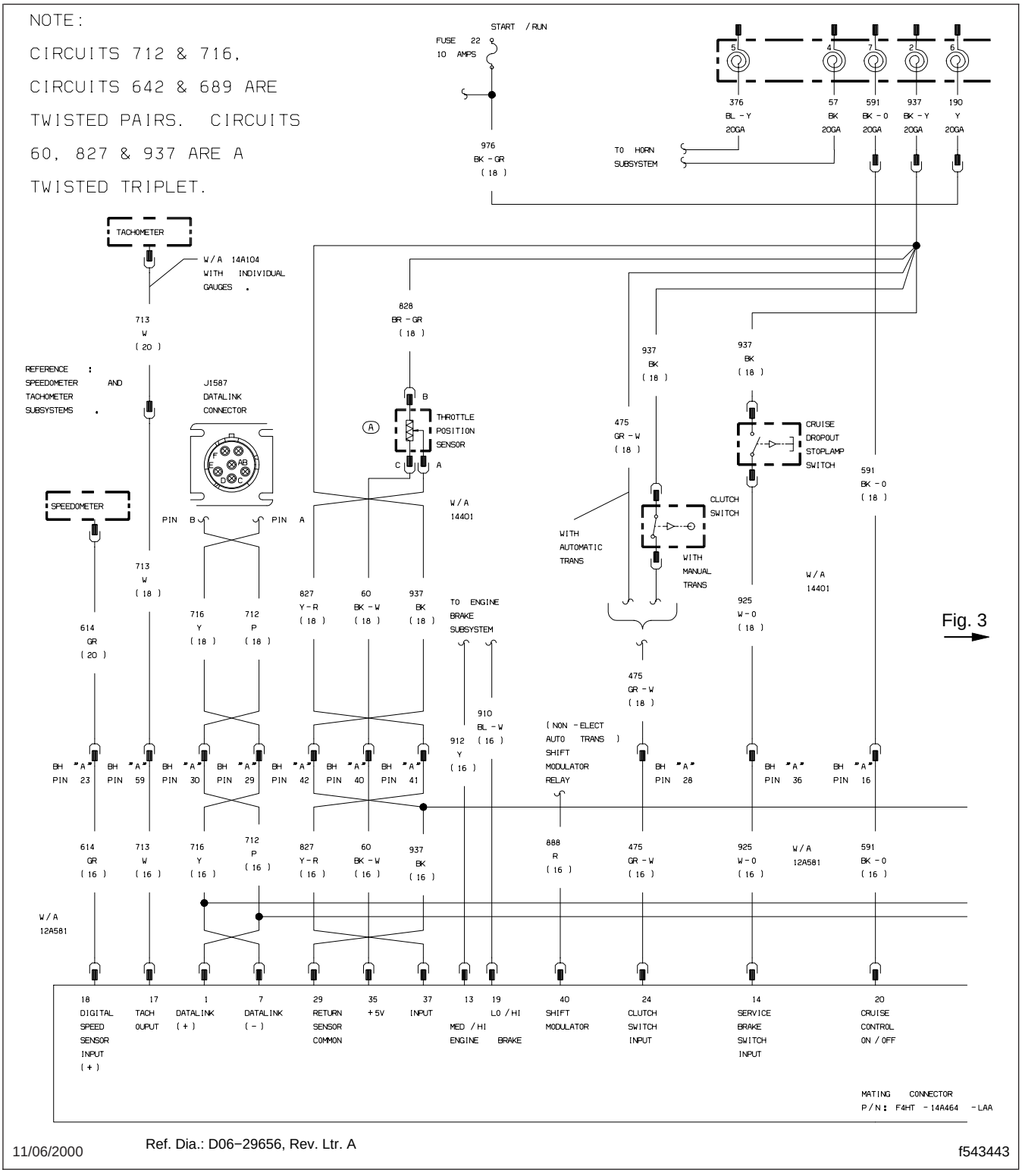

Fig. 2, Caterpillar C10, C12 and 3406 Engine Controls Wiring (partial view)

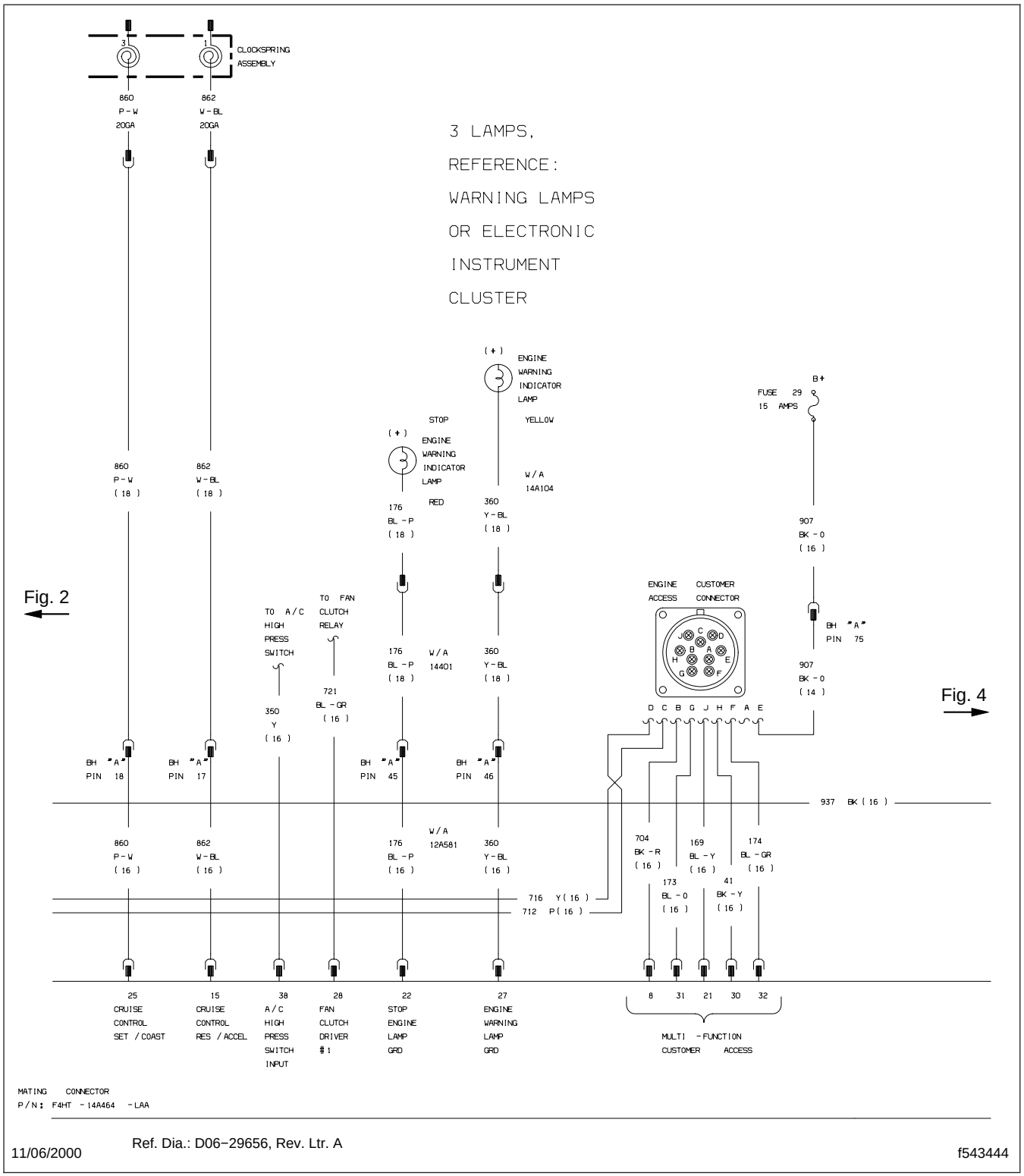

Fig. 3, Caterpillar C10, C12 and 3406 Engine Controls Wiring (partial view)

Specifications

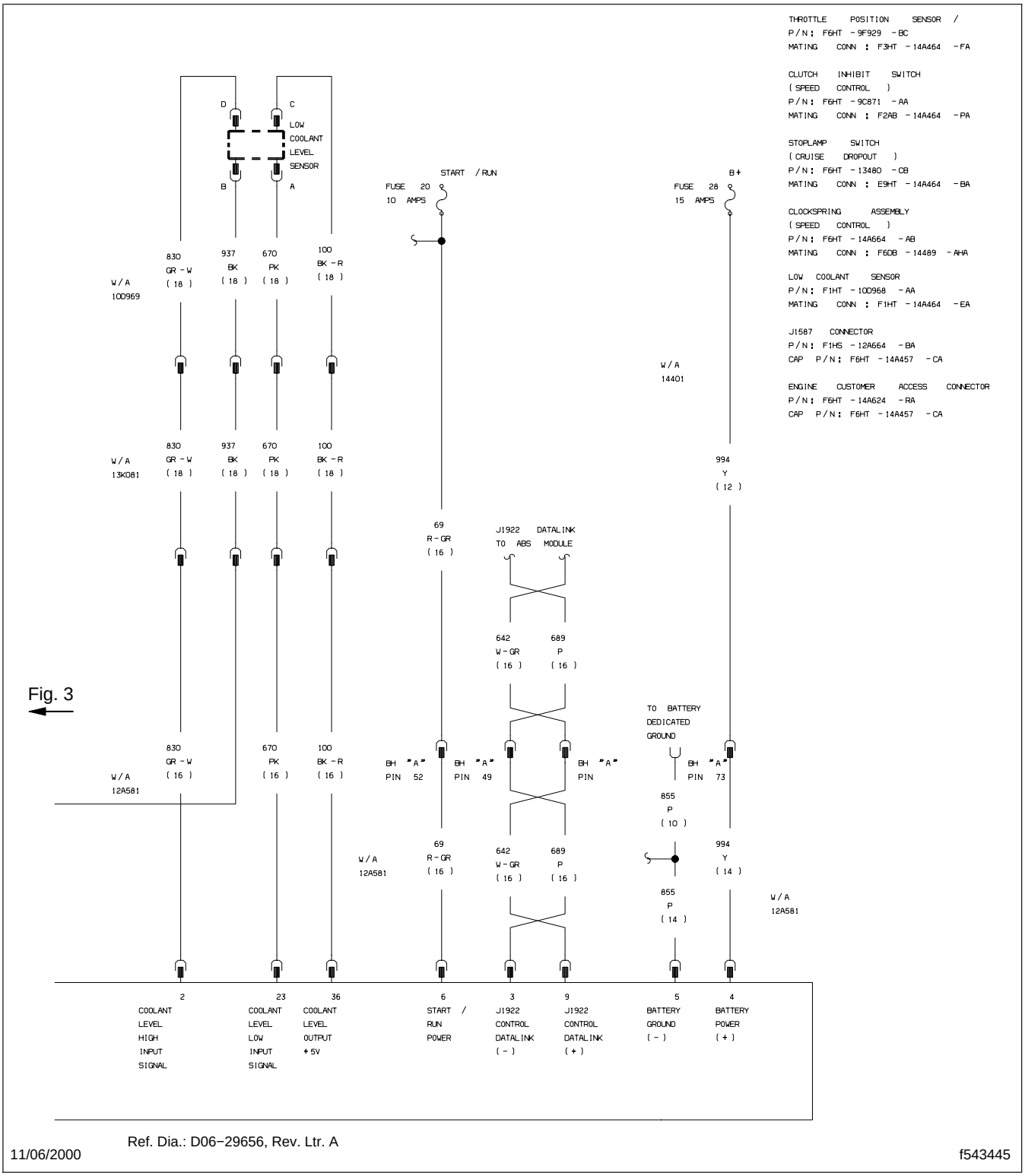

Fig. 3

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Fig. 4, Caterpillar C10, C12 and 3406 Engine Controls Wiring (partial view)

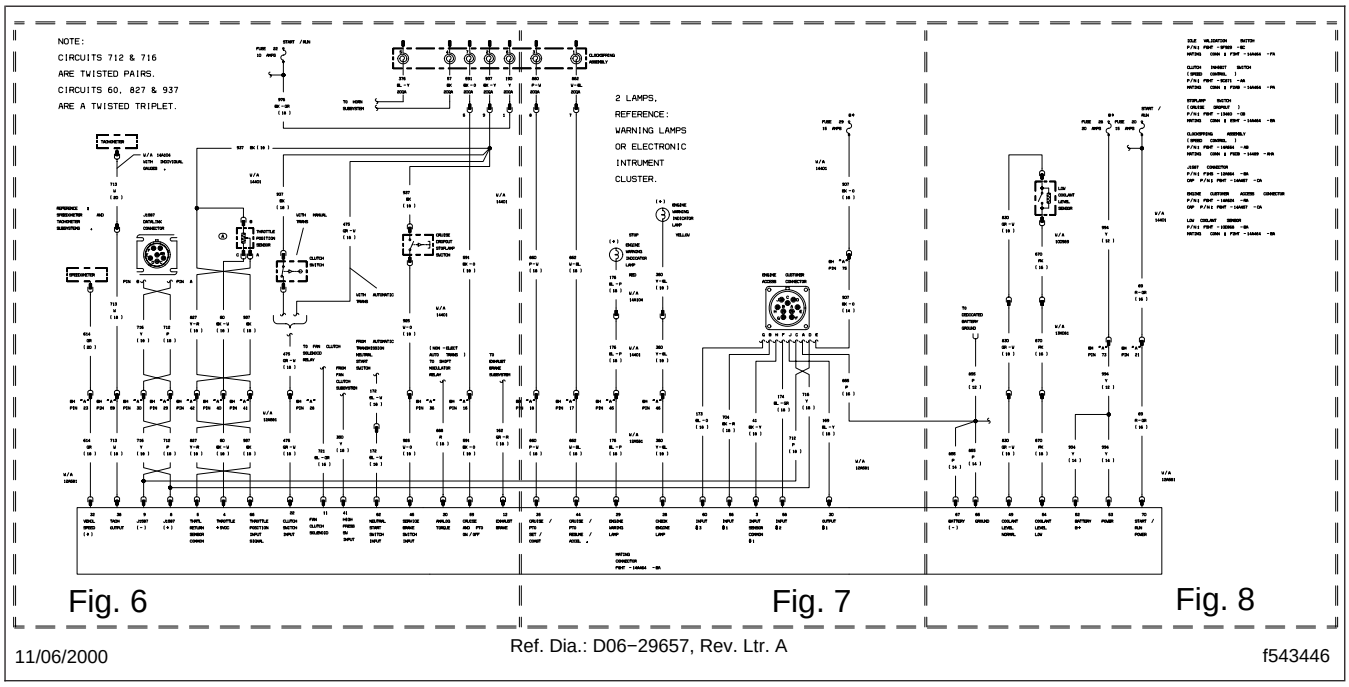

Fig. 5, Caterpillar 3126 Engine Controls Wiring (full view)

Specifications

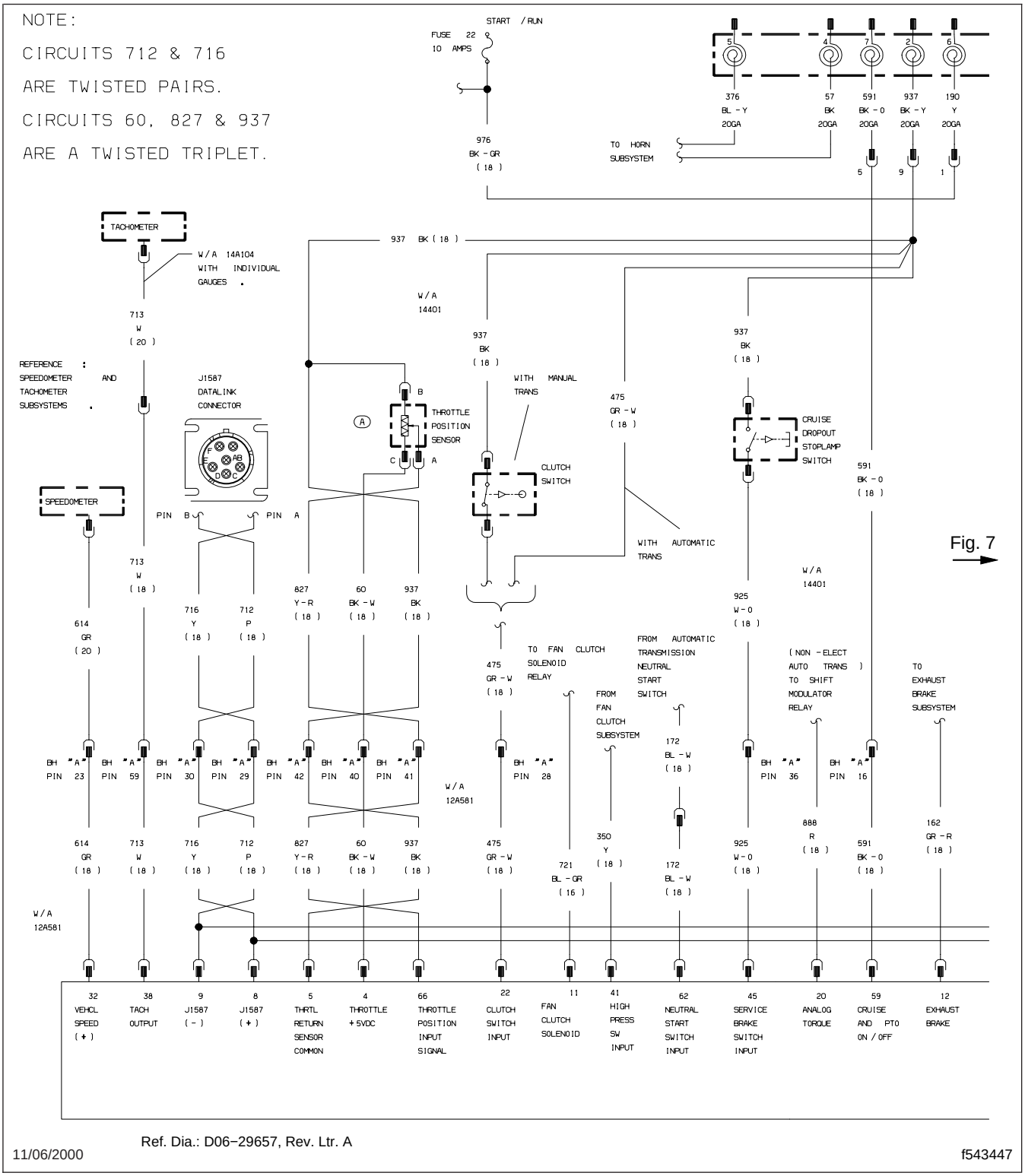

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Fig. 6, Caterpillar 3126 Engine Controls Wiring (partial view)

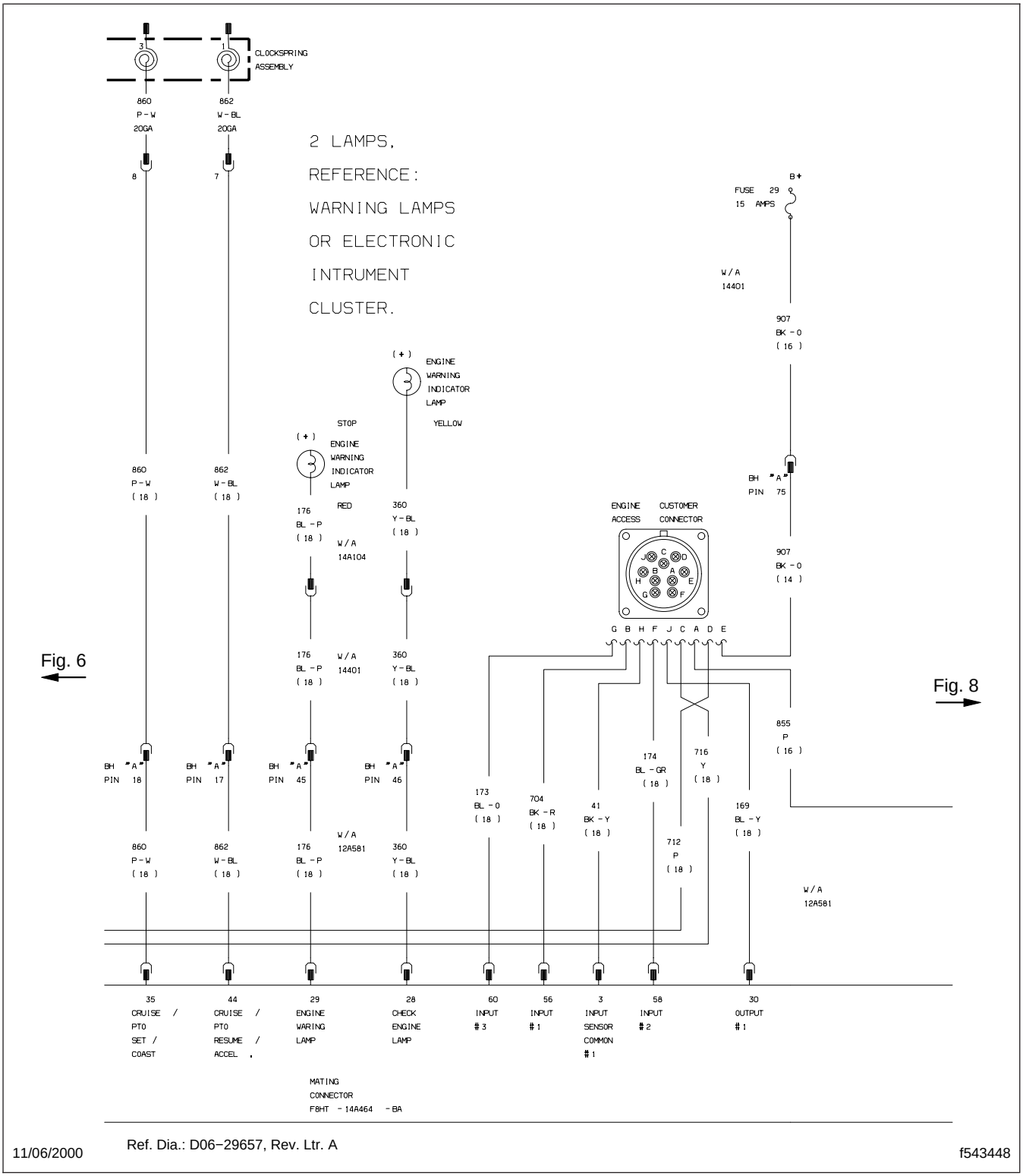

Fig. 7, Caterpillar 3126 Engine Controls Wiring (partial view)

Specifications

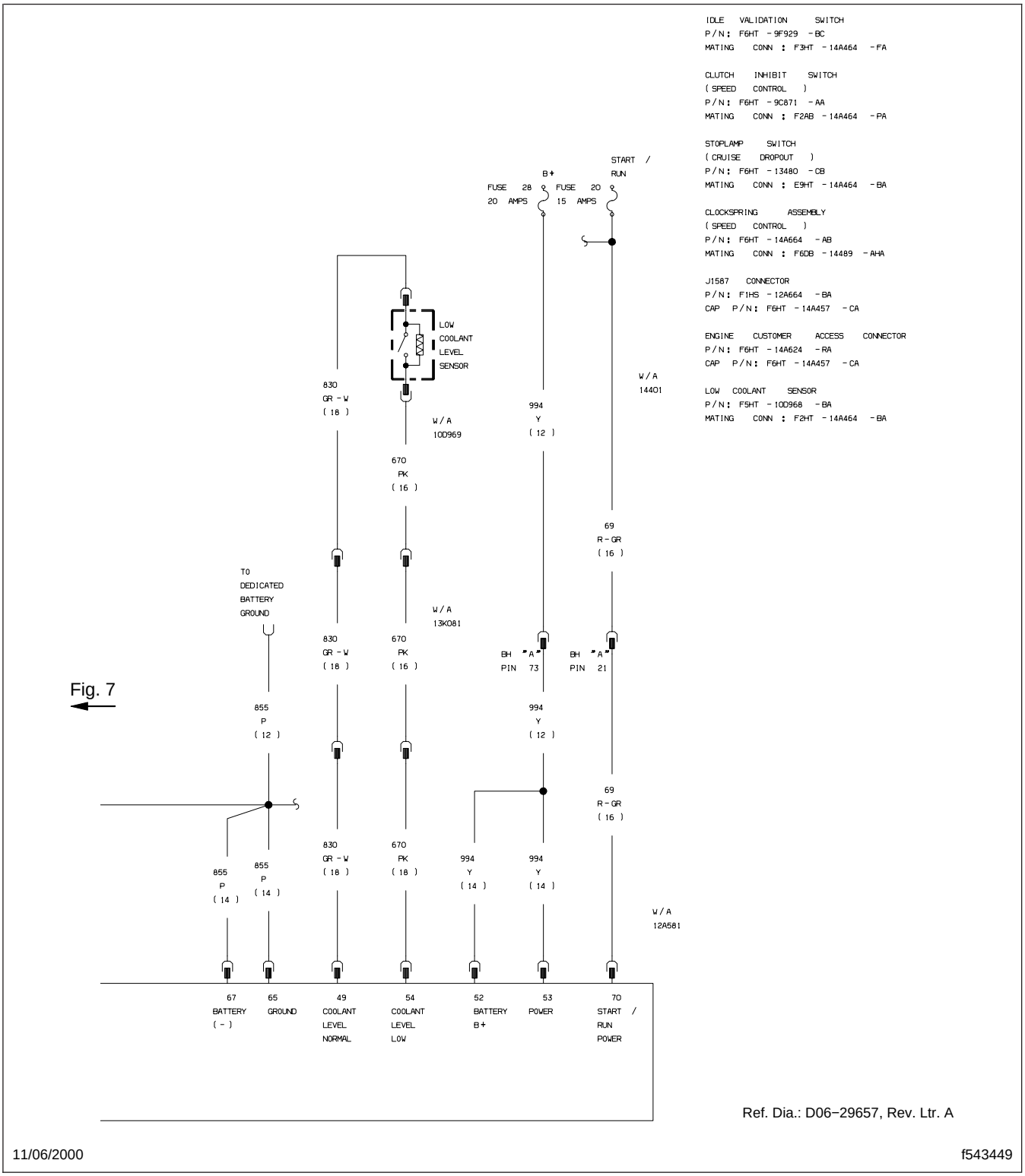

Fig. 7

Fig. 8, Caterpillar 3126 Engine Controls Wiring (partial view)

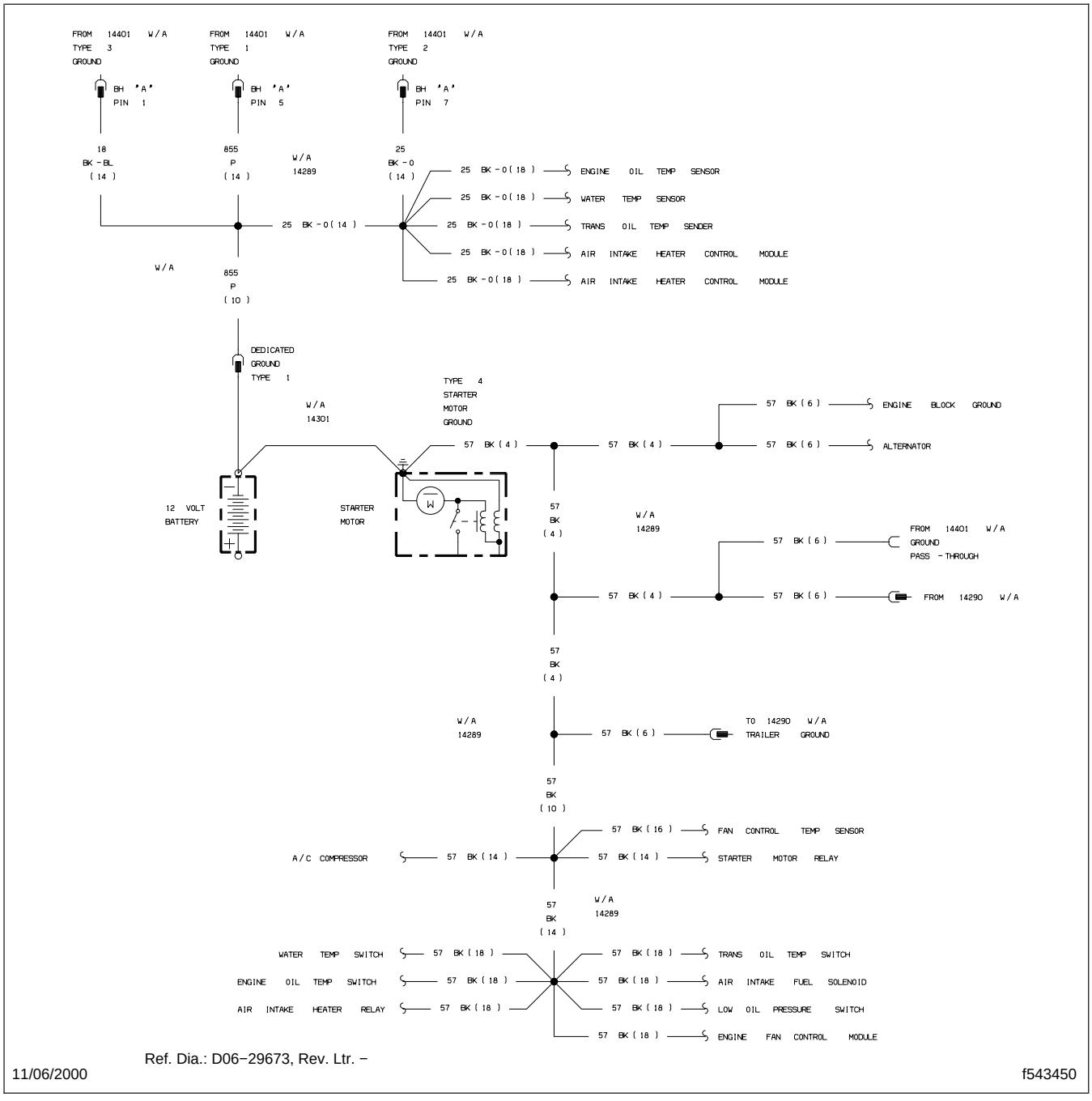

Fig. 9, Caterpillar 3306 Engine Ground Summary (full view)

Specifications

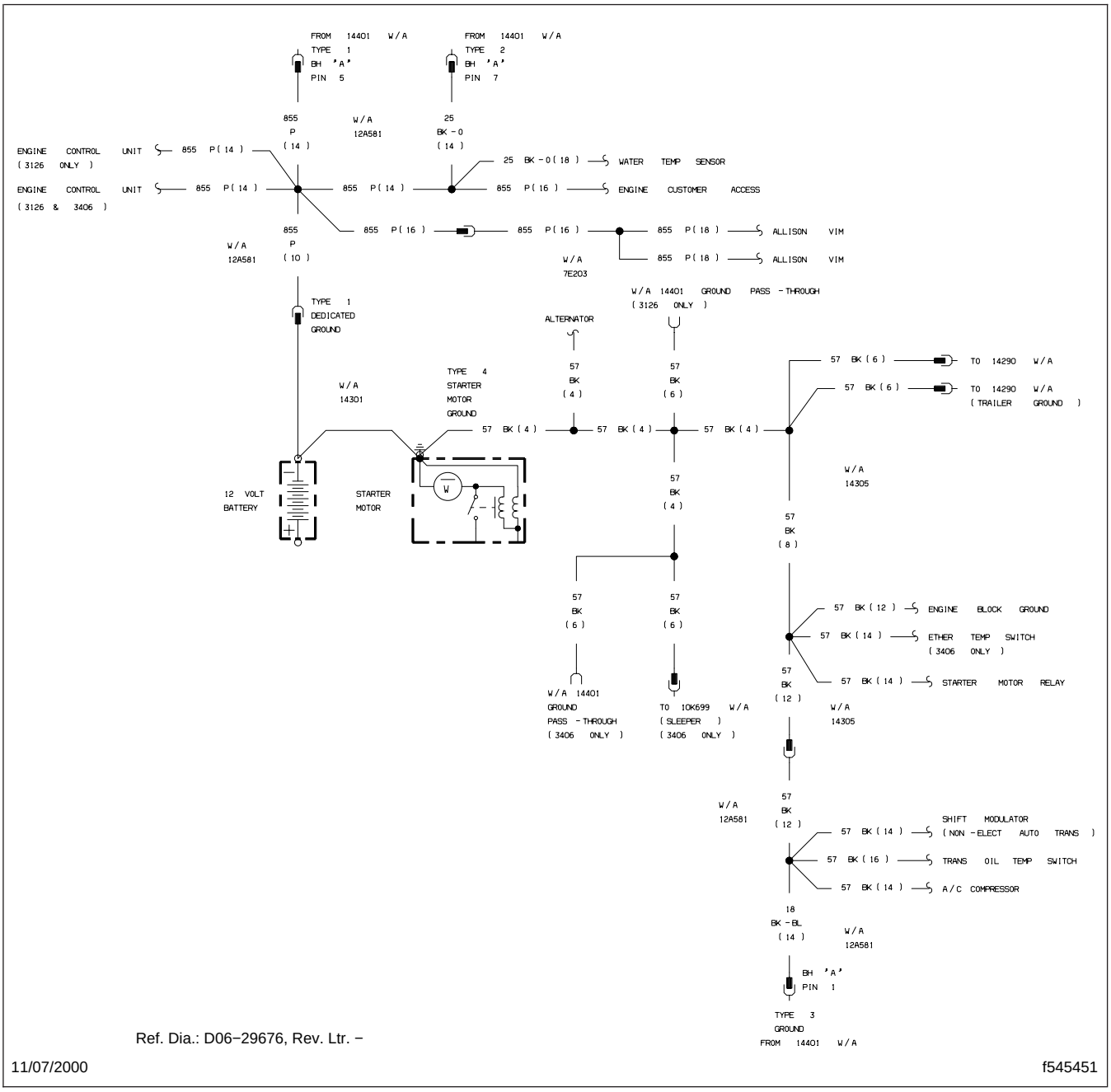

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Fig. 10, Caterpillar 3126 and 3406 Engine Ground Summary (full view)

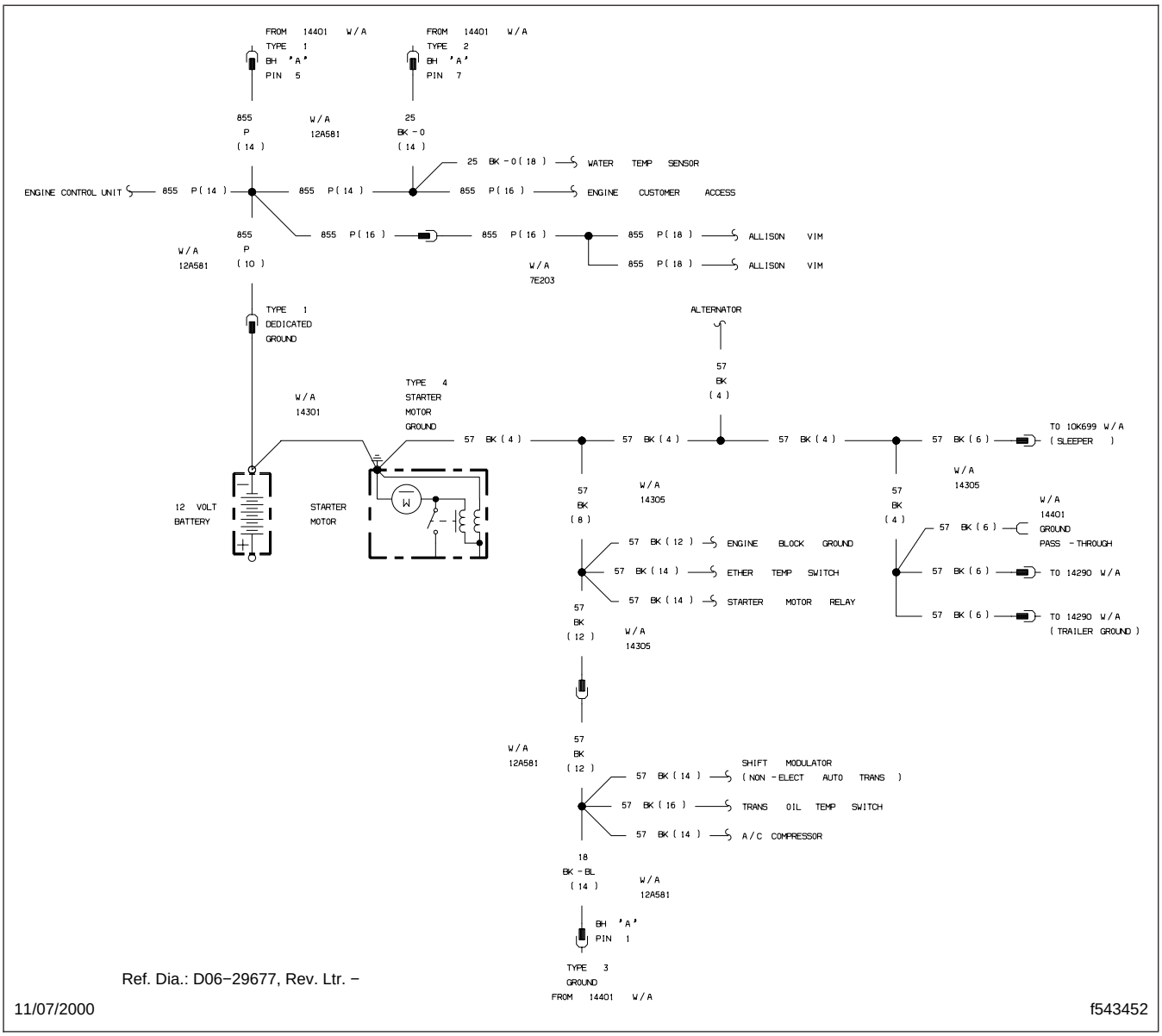

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Fig. 11, Caterpillar C10 and C12 Engine Ground Summary (full view)

The following diagrams show the wiring circuits installed by Sterling. For detailed engine wiring, see the applicable Cummins manual.

See **Fig. 1** for a full view of the Cummins engine controls wiring.

See **Fig. 2**, **Fig. 3** and **Fig. 4** for partial views of the Cummins engine controls wiring.

See **Fig. 5** for a full view of the Cummins engine ground summary.

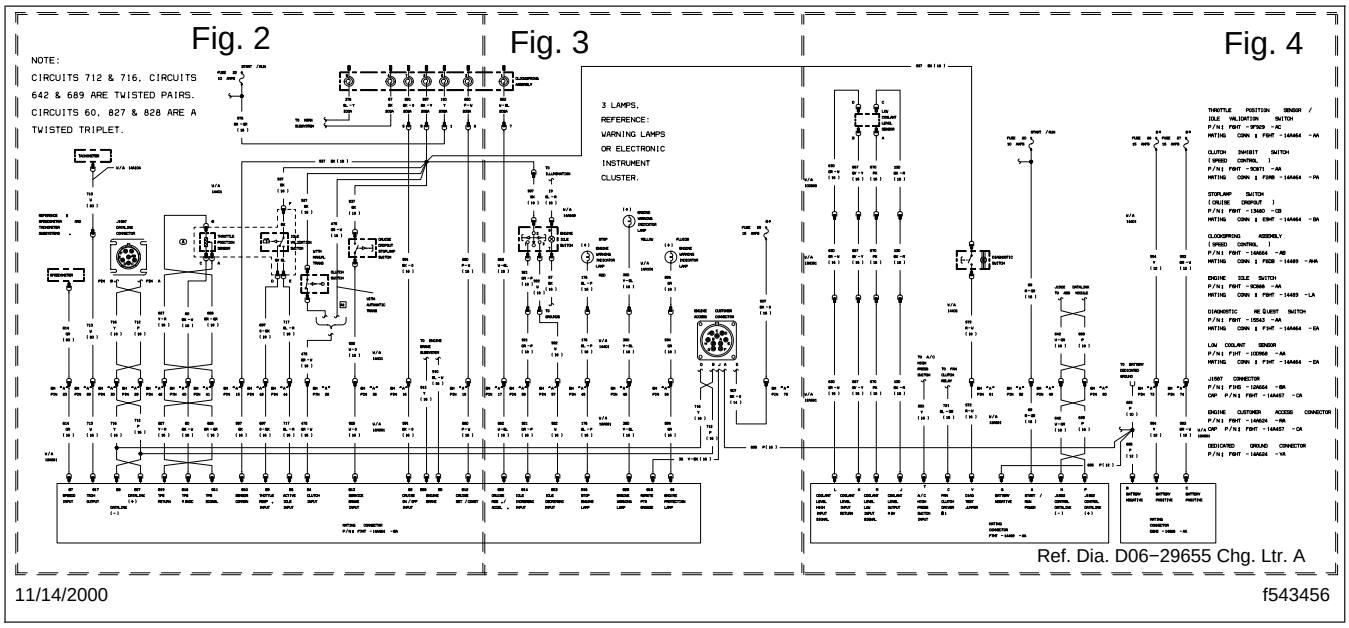

Fig. 1, Cummins Engine Controls Wiring (full view)

Specifications

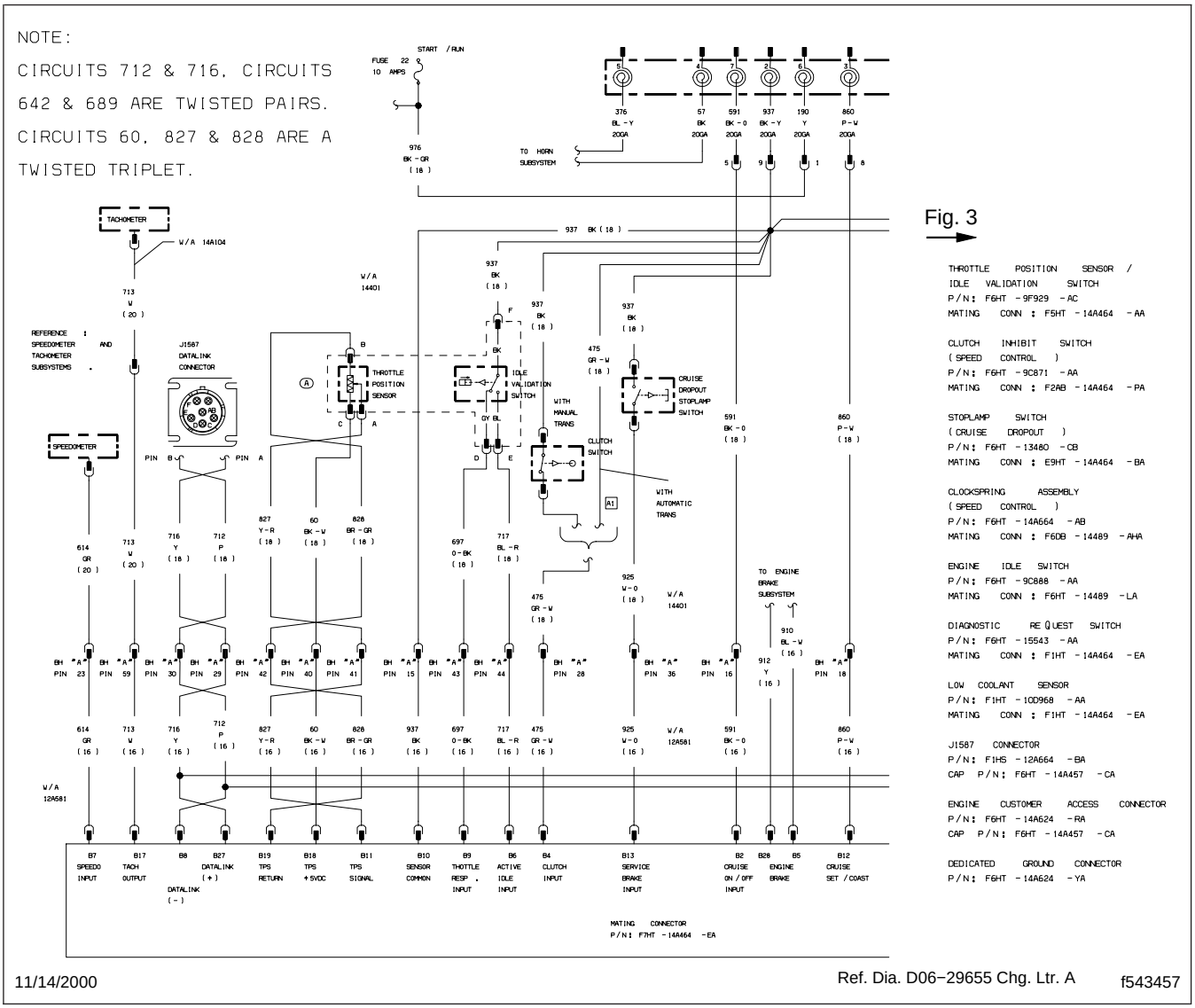

Fig. 2, Cummins Engine Controls Wiring (partial view)

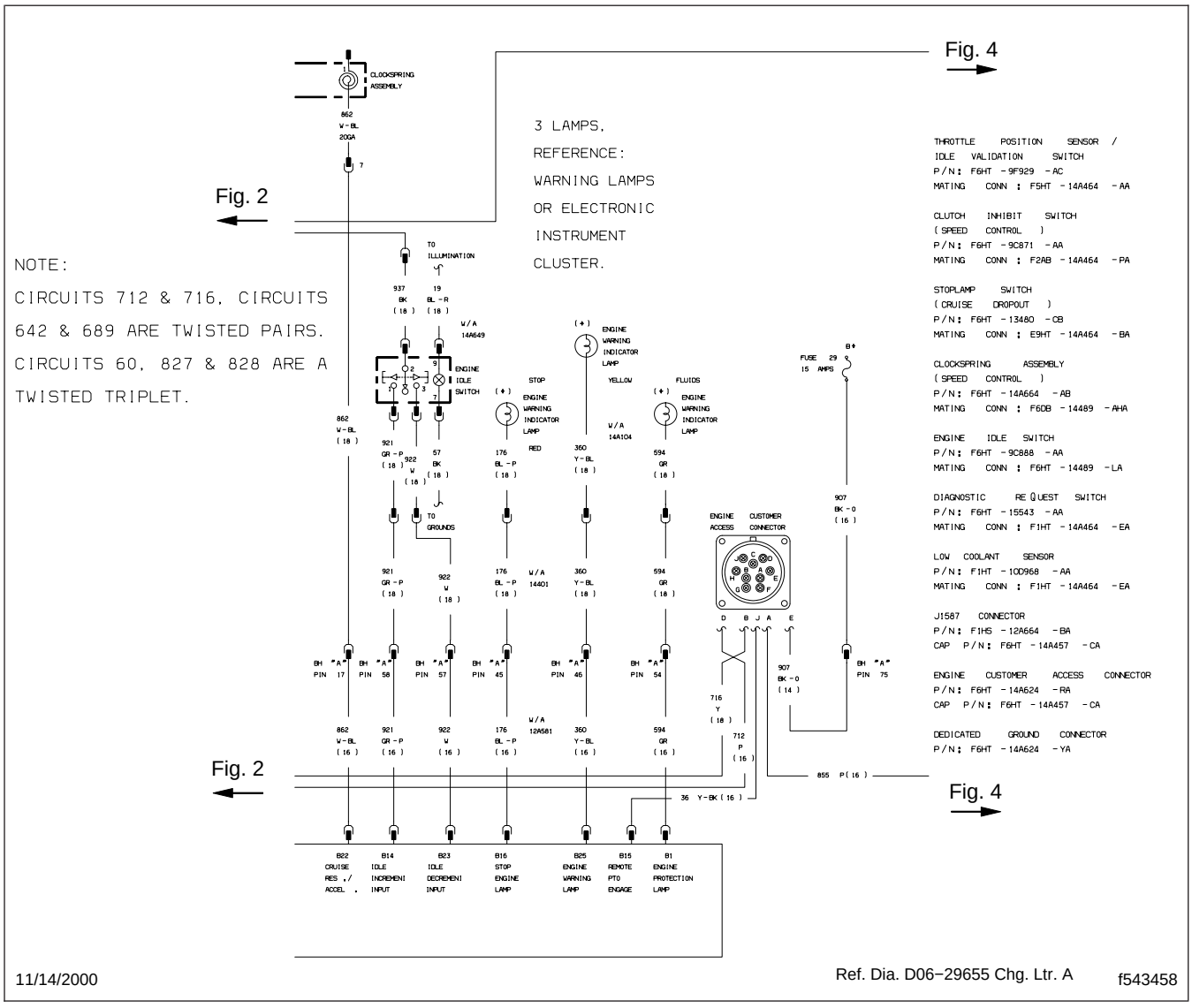

Fig. 3, Cummins Engine Controls Wiring (partial view)

Specifications

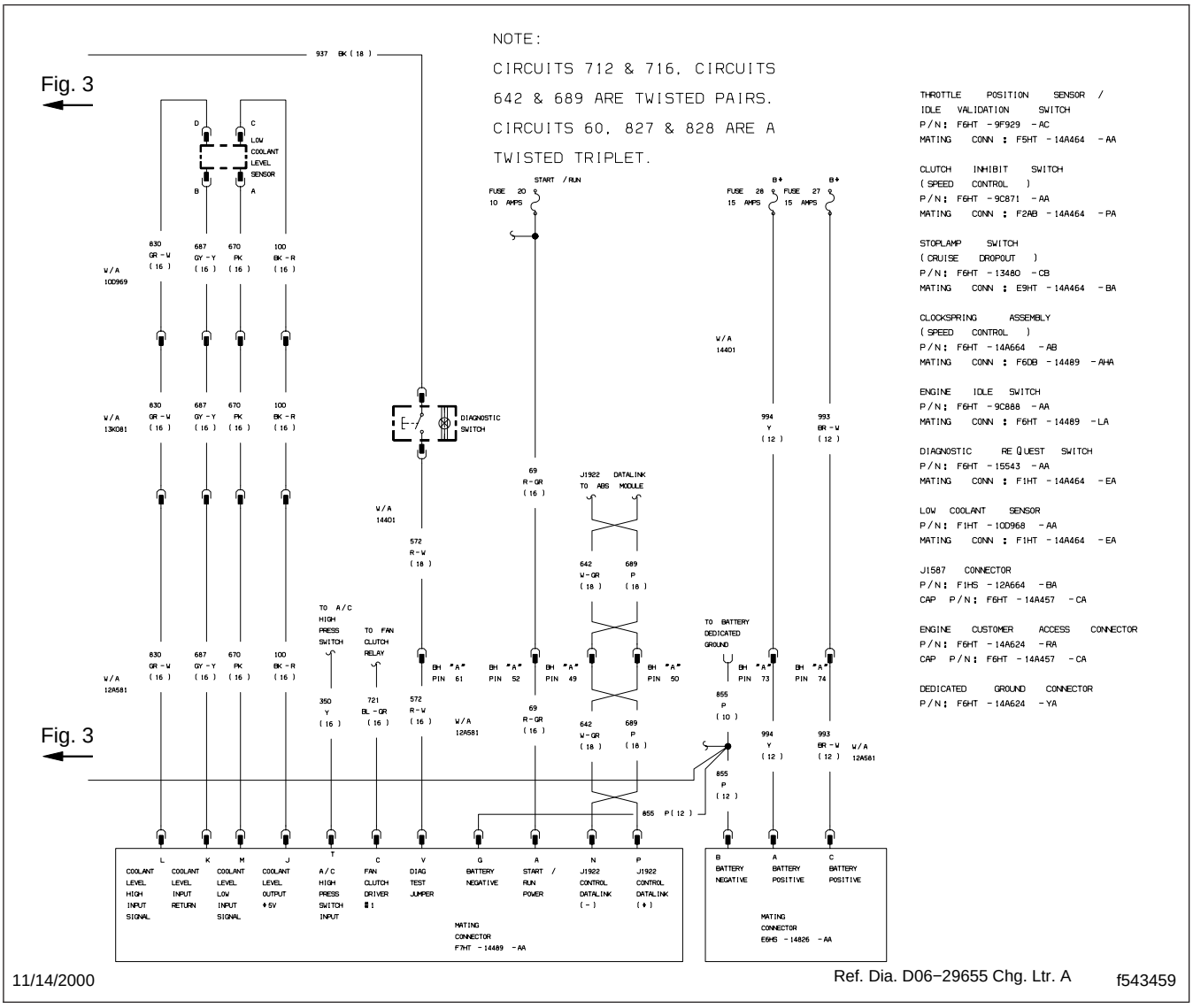

Fig. 4, Cummins Engine Controls Wiring (partial view)

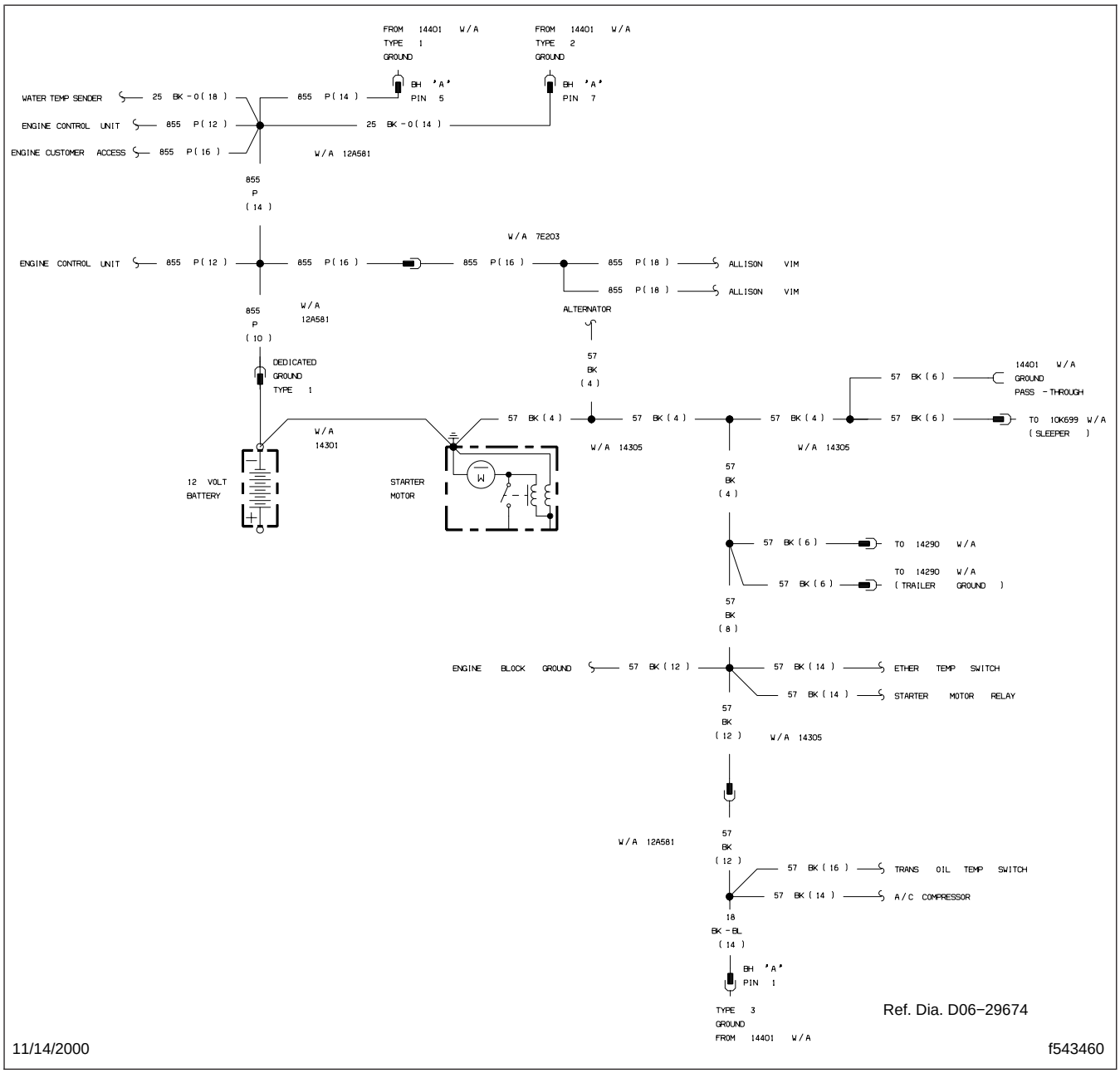

Fig. 5, Cummins Engine Ground Summary (full view)

The following diagrams show the wiring circuits installed by Sterling. For detailed engine wiring, see the applicable Detroit Diesel manual.

See **Fig. 1** for a full view of the Detroit Diesel Series 60 engine controls wiring.

See **Fig. 2**, **Fig. 3** and **Fig. 4** for partial views of the Detroit Diesel Series 60 engine controls wiring.

See **Fig. 5** for a full view of the Detroit Diesel Series 60 engine ground summary.

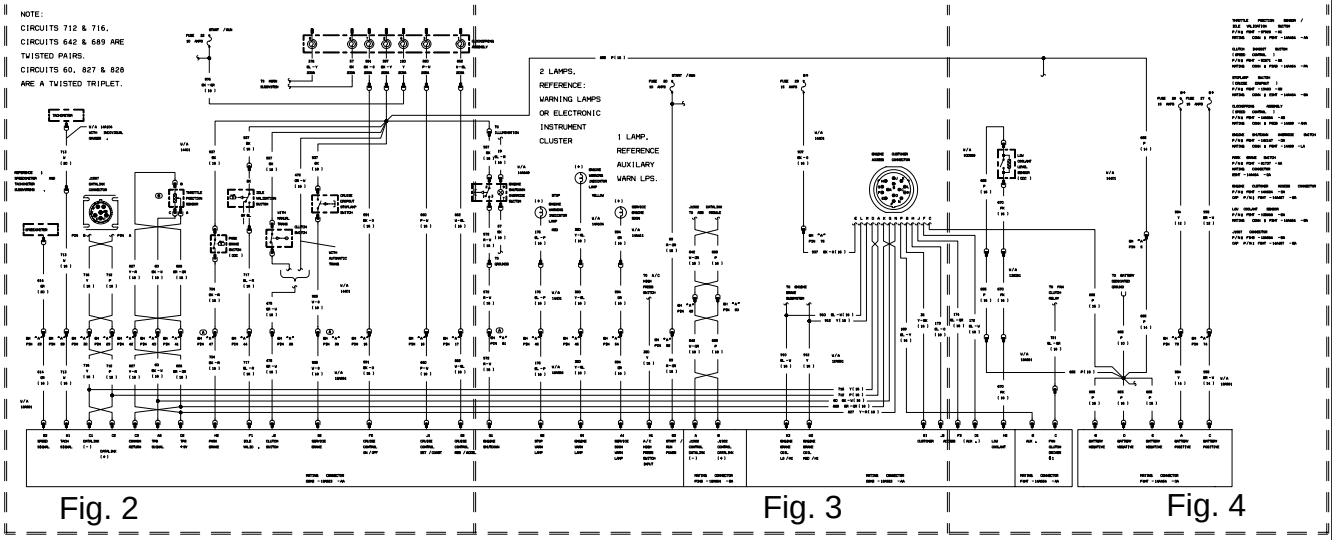

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Fig. 1, Detroit Diesel Series 60 Engine Controls Wiring (full view)

Specifications

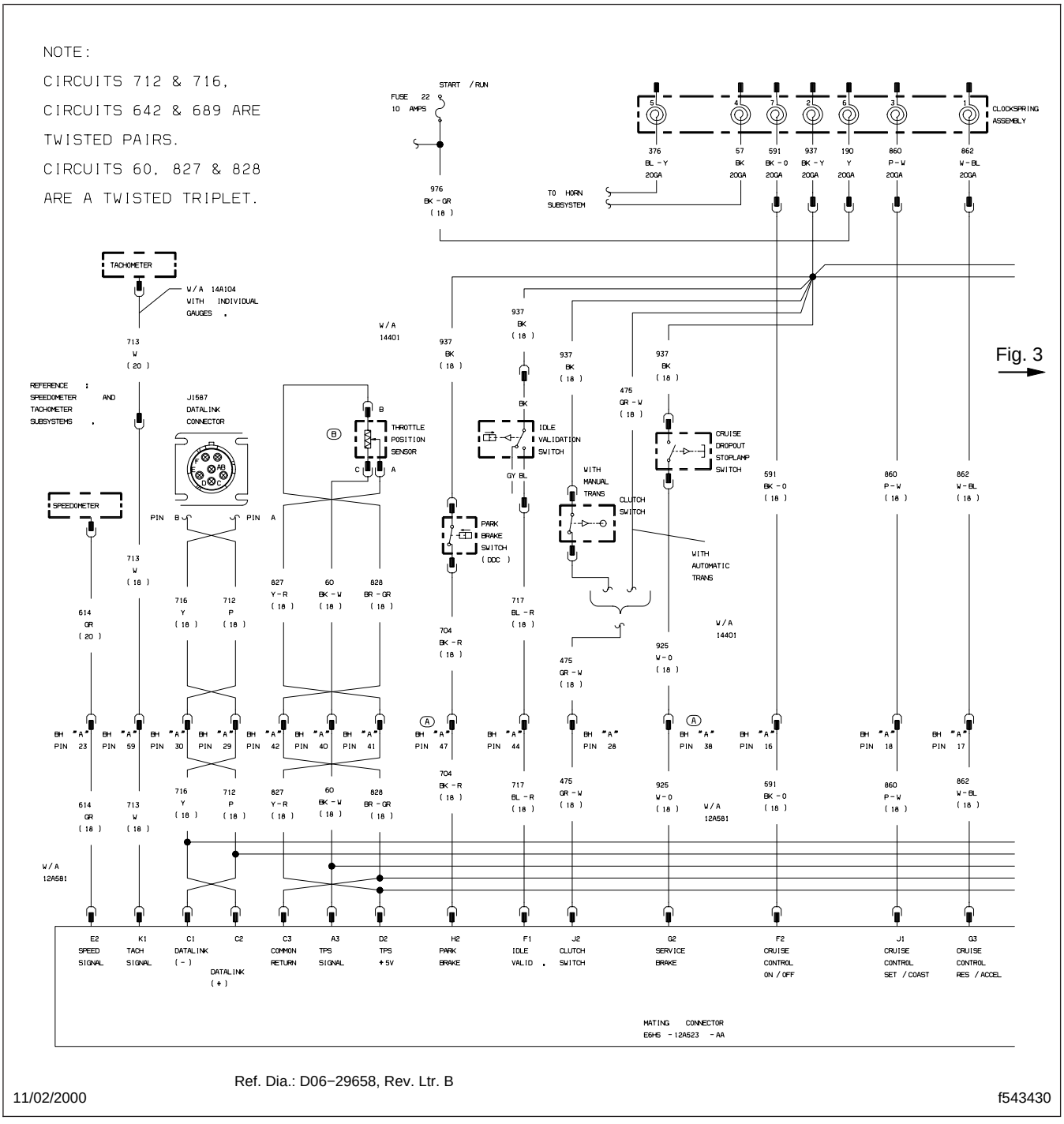

Fig. 2, Detroit Diesel Series 60 Engine Controls Wiring (partial view)

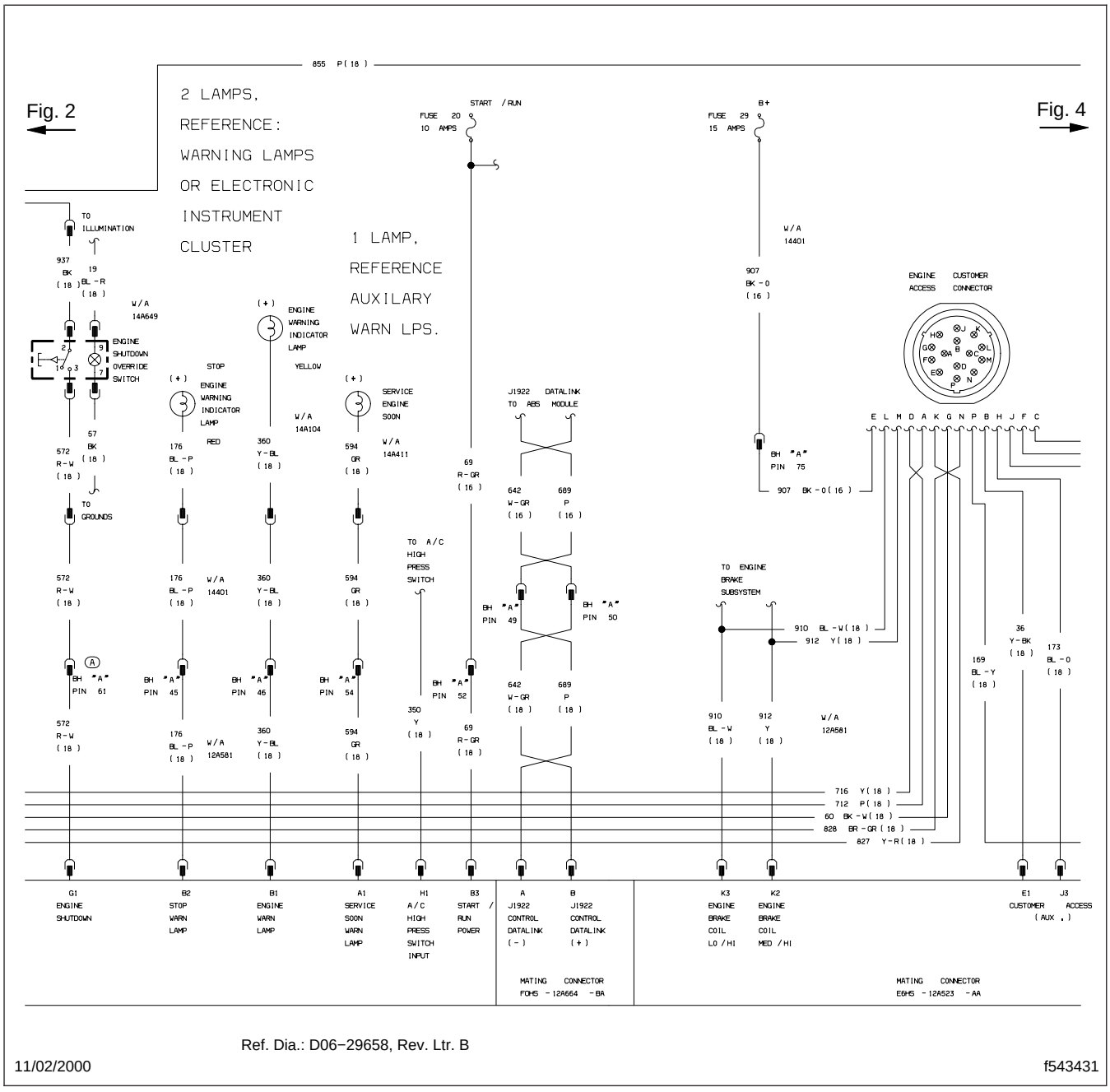

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Fig. 3, Detroit Diesel Series 60 Engine Controls Wiring (partial view)

Specifications

Fig. 3

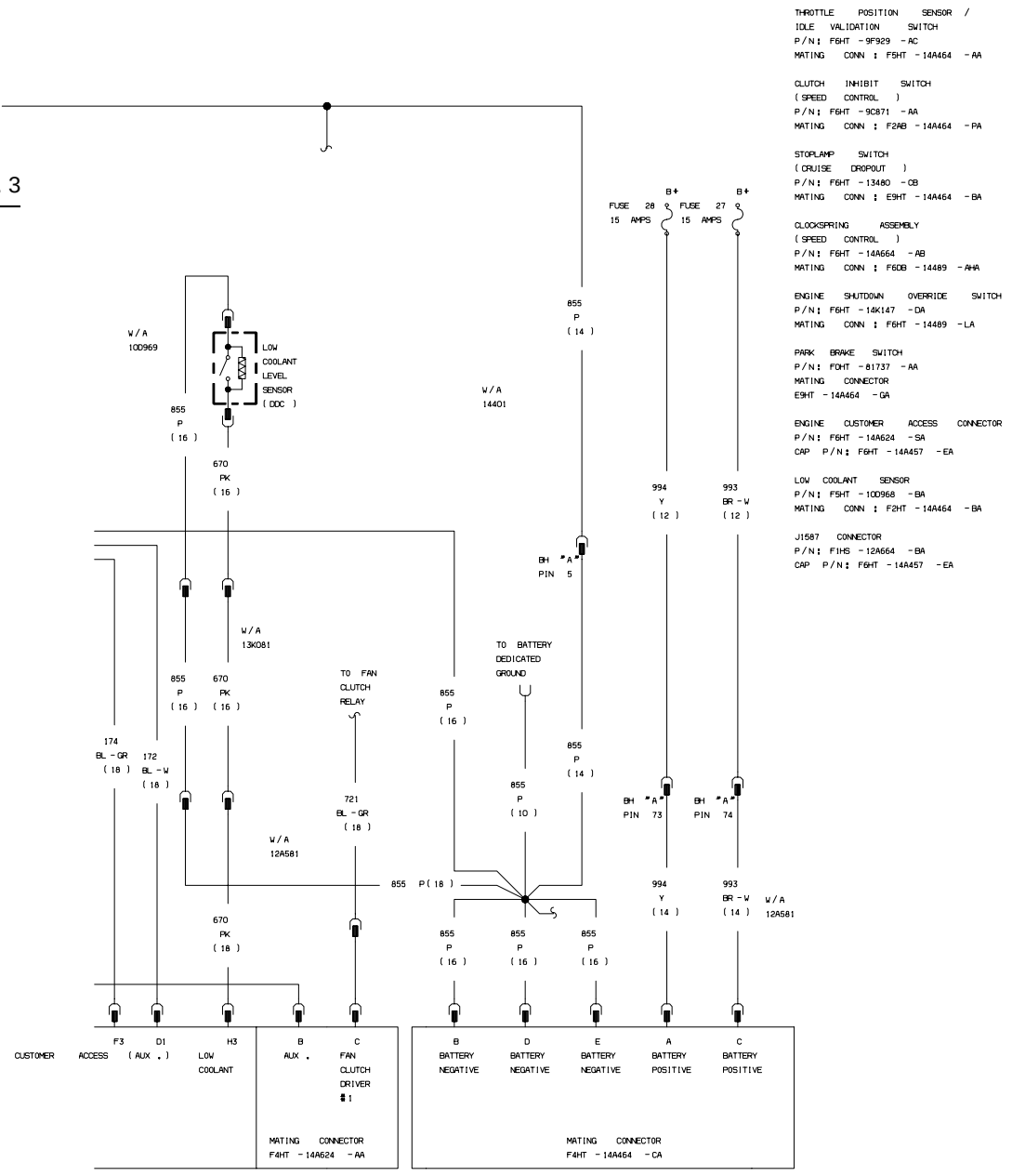

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Fig. 4, Detroit Diesel Series 60 Engine Controls Wiring (partial view)

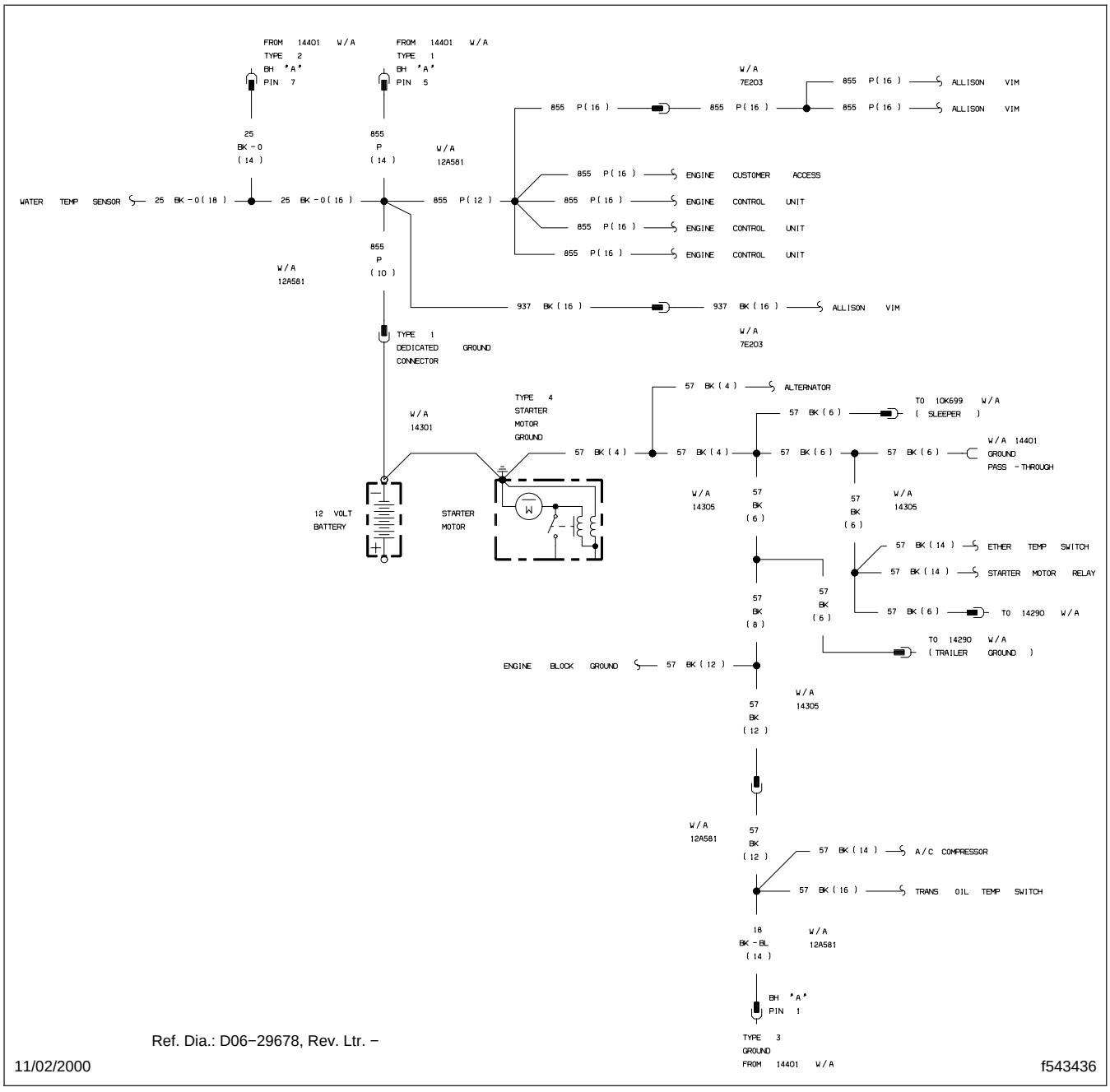


Fig. 5, Detroit Diesel Series 60 Engine Ground Summary (full view)

NGI Instrument Cluster

The optional AMETEK/Dixson Next Generation Instrumentation (NGI) gauge set is a full-featured individual gauge instrument cluster with a 21-telltale light bar. See **Fig. 1**. The individual gauges receive their signal over a serial data link driven by a processor, referred to as the SCU, located in the speedometer. The SCU receives and processes inputs from SAE J1587 data link, sensors, and discrete inputs for driving the various gauges and telltales. The individual gauges have stepper motor movements with Light Emitting Diode (LED) backlighting. All of the electronic gauges have LED-lit telltales. The light bar has 14 fixed positions, using LEDs to light the telltales, and seven optional telltales, six lit with replaceable incandescent bulbs for color flexibility, and one lit with an amber LED. The vehicle odometer is displayed using a Liquid Crystal Display (LCD) located in the speedometer. A collection of stand-alone mechanical and electrical gauges completes the NGI instrument package. The speedometer and tachometer are five-inch diameter data-buss driven gauges. All other gauges are approximately 2-inch diameter, data-buss driven, and have a red LED-lit telltale except the fuel gauge, which is driven by the sensor in the fuel tank, and the air pressure gauges, which are mechanically driven. A transmission fluid temperature gauge is required on vehicles with automatic transmissions.

Driver's Message Center

The driver's message center has two parts; a 21 telltale light bar located in the top center of the instrument cluster, and a one-row, seven-character liquid crystal display (LCD) located on the speedometer.

Light Bar

The light bar has three rows of seven warning lights. See **Fig. 2**. The seven telltales on the top row of the light bar will vary depending on the vehicle configuration and customer preference. The two lower rows contain the 14 standard telltales shown in **Table 1**.

NGI Light Bar Standard Telltales	
Light	**LED Color**
Left Turn Signal	Green
Check Engine	Amber
Engine Protection	Red
Fasten Seat Belt Symbol	Red
High Beam Headlamps.	Blue
Tractor ABS (Antilock Brake System)	Amber
Parking/Emergency Brake	Red
Air Intake Filter Restriction	Amber
Right Turn Signal	Green
Trailer ABS	Amber
Water in Fuel	Amber
Intake Heater	Amber
Check A/C	Amber
Low Air	Red

Table 1, NGI Light Bar Standard Telltales

Message Center

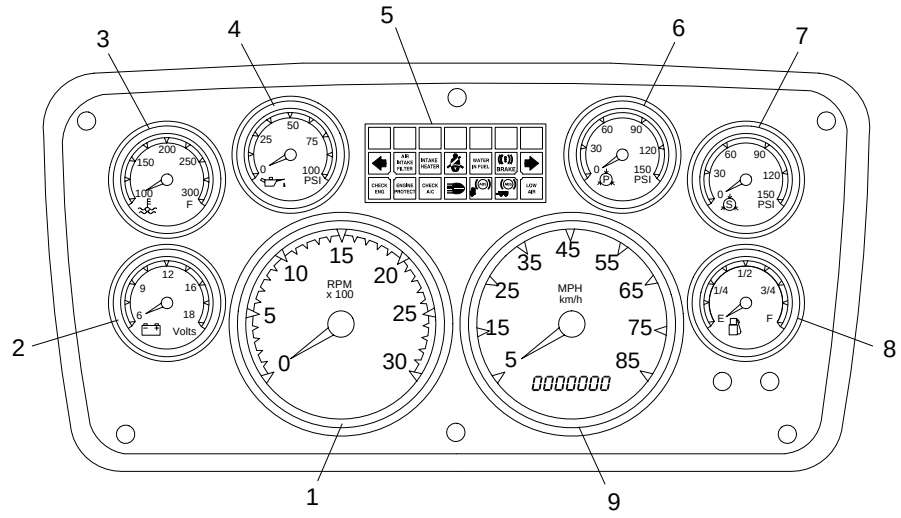
The NGI message center, **Fig. 3** is a one-row, seven-character liquid crystal display (LCD) located on the speedometer that displays the following information:

- Odometer
- Trip Odometers (two)
- Engine Hour Meter
- System Diagnostic Menu
- NGI-specific warning messages

Below the LCD there are five indicators along lower section of LCD, HR, MI, KM, TRIP, and a bell icon (not used at this time). **MI** or **KM** coincide with the primary scale of the speedometer when mileage is being displayed. The other icons display mode settings.

The odometer, hour meter, and trip odometers are primary screens. When a primary screen is displayed for 3 seconds or more it becomes the default screen. The default screen is displayed at ignition and will remain so until manually adjusted using the Mode and Set buttons.

General Information



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1. Tachometer
2. Voltmeter
3. Coolant Temperature
4. Engine Oil Pressure
5. Light Bar
6. Primary Air Pressure
7. Secondary Air Pressure
8. Fuel Level
9. Speedometer

Fig. 1, NGI Instrument Cluster

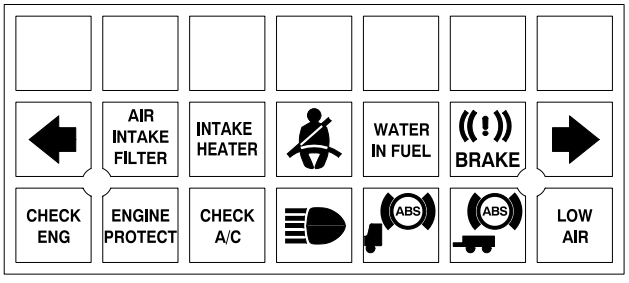

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Fig. 2, NGI Light Bar

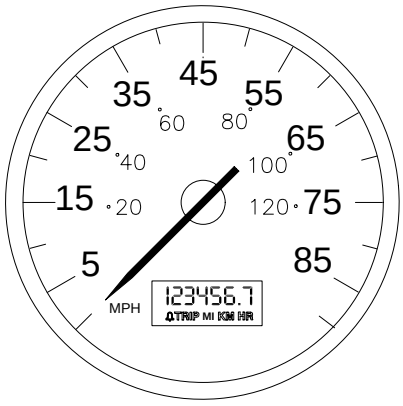

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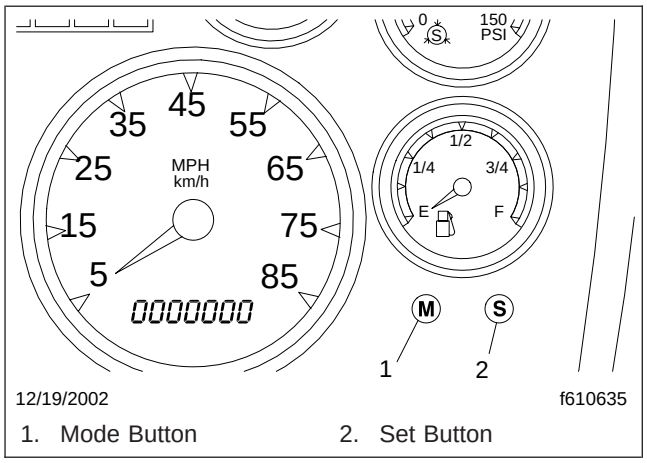
Fig. 3, Message Center

Mode and Set Buttons

The Mode and Set buttons are located in the lower right corner of the instrument cluster. See **Fig. 4**. Pressing the Mode button cycles through the various functions. Pressing the Set button selects the desired function. See **Fig. 5**. In the Odometer mode, the Set button toggles to MI or KM. In the Trip 1 and 2 Odometer modes, the Set button resets the Trip meter to zero. In the Engine hours mode, total engine hours are displayed. This is not resetable. In the System mode, the Set button initiates the System Diagnostics test and will display any warning messages that are present in the system. To run the system diagnostics, the following conditions must be met:

- Ignition on
- Park brake set
- Road speed below 2 mph (3 km/h)
- Engine RPM at or below 1000



1. Mode Button 2. Set Button

Fig. 4, Mode and Set Buttons

- No low air pressure warning in effect

Buzzer

The buzzer sounds during the ignition sequence and whenever:

- The engine oil pressure falls below the preset level, which is 5 to 9 psi (35 to 60 kPa) on most engines;
- The coolant temperature rises above the preset level, which is 215°F (101°C) on Caterpillar engines, 220°F (104°C) on Cummins engines and 189°F (87°C) on MBE900 engines;
- The air pressure falls below the preset level of approximately 70 psi (483 kPa);
- The parking brake is set with the vehicle moving at a speed greater than 2 miles per hour (3 km/h).

Ignition Sequence

NOTE: If the headlights are turned on, the screen displays the odometer and waits for the ignition to be turned on.

When the ignition is turned on, the SCU performs a self-test, looking for active faults. All the electronic gauges complete a full sweep of their dials, the warning and indicator lights light up and the buzzer sounds for 3 seconds. During the first half of the self-test, all segments of the driver dash display screen illuminate as follows: "888888.8." During the second half of the self-test, the software revision level is displayed.

NOTE: The engine and ABS warning lights go on during the SCU self-test, but they are not controlled by the SCU. They are controlled by their own system electronic control unit (ECU).

If the SCU receives active fault codes from other devices, the screen displays a three-letter acronym and message identifier (MID), indicating the ECU or system that is not functioning properly. For a list of MIDs, see **Specifications, 400**. Each active fault is displayed for 3 seconds, one after the other, until the parking brake is released or the ignition is turned off. Once the parking brake is released, the screen displays the odometer. If there are no active faults, the screen displays the odometer.

NOTE: If the SCU receives a message from an ECU that has not been pre-programmed into the SCU memory, it displays "SYS ###", where ### is replaced by the MID of the broadcasting device.

General Information

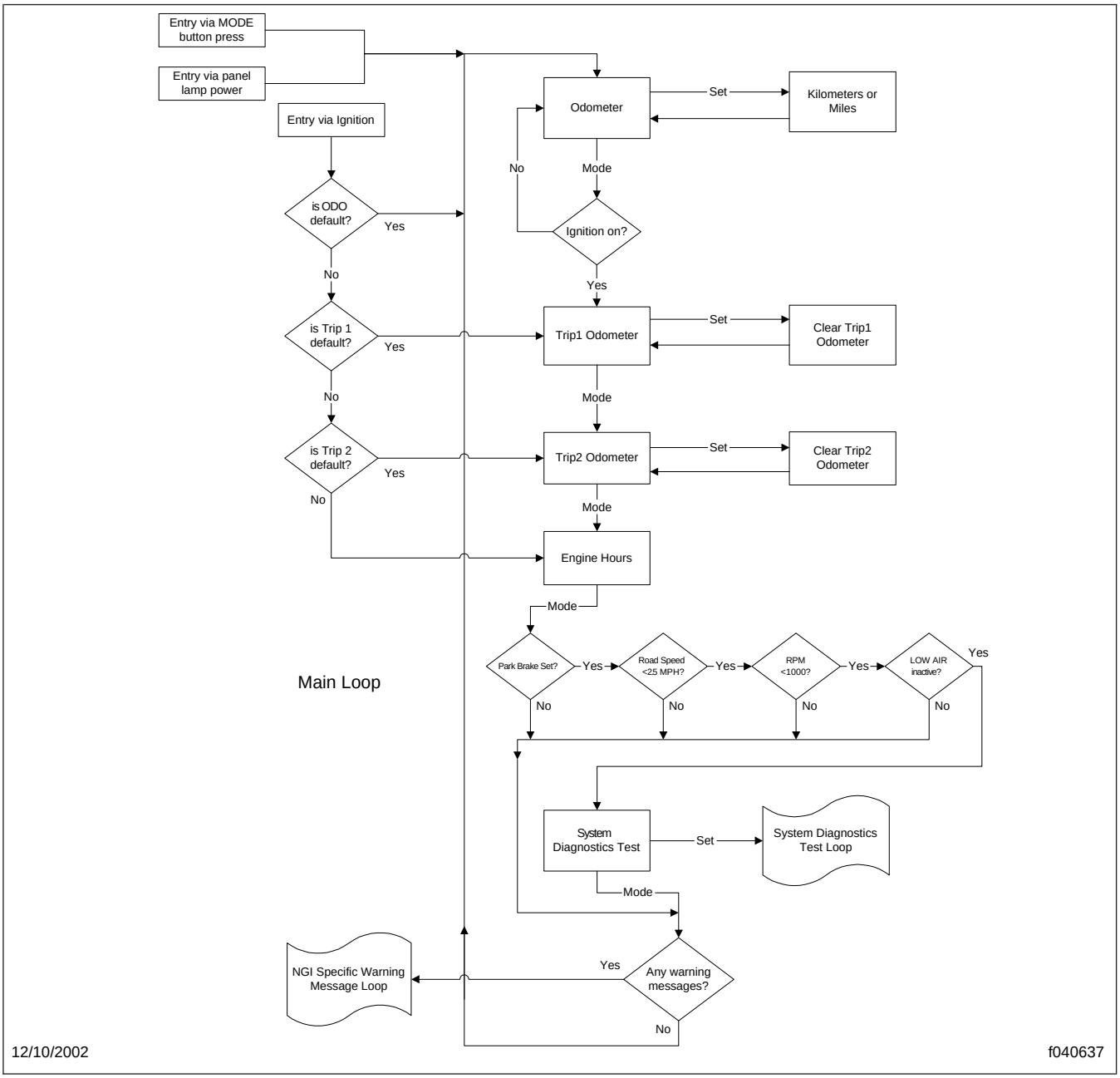


Fig. 5, State Diagram for LCD Display

Instrument Cluster Removal and Installation

NOTE: The NGI instrument cluster is designed for easy access. It is not necessary to disassemble the entire dash to service the gauges.

Removal

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

⚠ WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the air system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

3. Drain the air system.
4. Loosen the six quarter-turn Torx fasteners around the edge of the instrument cluster. See **Fig. 1**.

⚠ CAUTION

Do not forcibly pull the instrument cluster from the dash. This may dislodge wires from the harness electrical connectors on the back of the instrument cluster and damage the wires, the instrument cluster, or the dash.

5. Tilt the instrument cluster away from the dash.
6. Disconnect the connectors from the back of the instrument cluster.
   - 6.1 Disconnect the two electrical connectors (E3 & E6) from the back of the speedometer.
   - 6.2 Disconnect the air pressure lines from the primary and secondary air pressure gauges; see **Section 42.05**, Subject 110.
7. Remove the instrument cluster from the dash.

Installation

1. Position the instrument cluster in front of the dash opening.
2. Connect the connectors from the back of the instrument cluster.
   - 2.1 Connect the two electrical connectors (E3 & E6) to the back of the speedometer. See **Fig. 2**.
   - 2.2 Connect the air pressure lines to the primary and secondary air pressure gauges; see **Section 42.05**, Subject 110.
3. Pressurize the air system.
4. Check for air leaks.
5. Position the instrument cluster in the opening in the dash.
6. Fasten the six quarter-turn Torx fasteners.
7. Connect the batteries.
8. Remove the chocks.

Instrument Cluster Removal and Installation

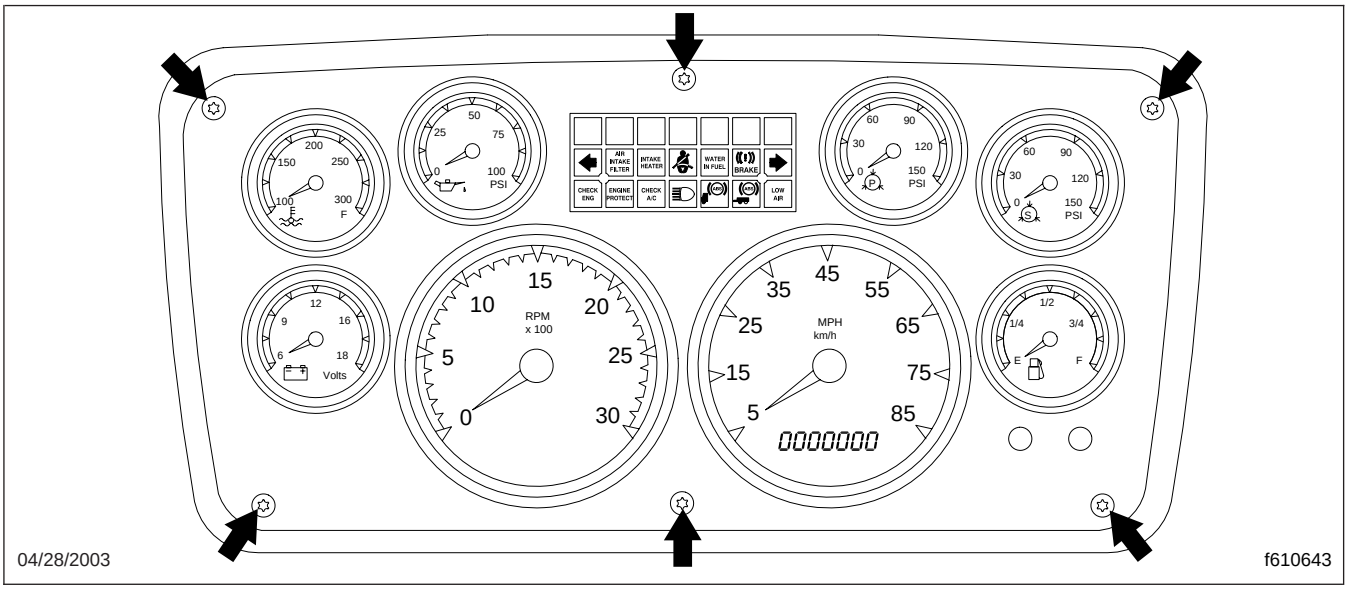


Fig. 1, Instrument Cluster Fasteners

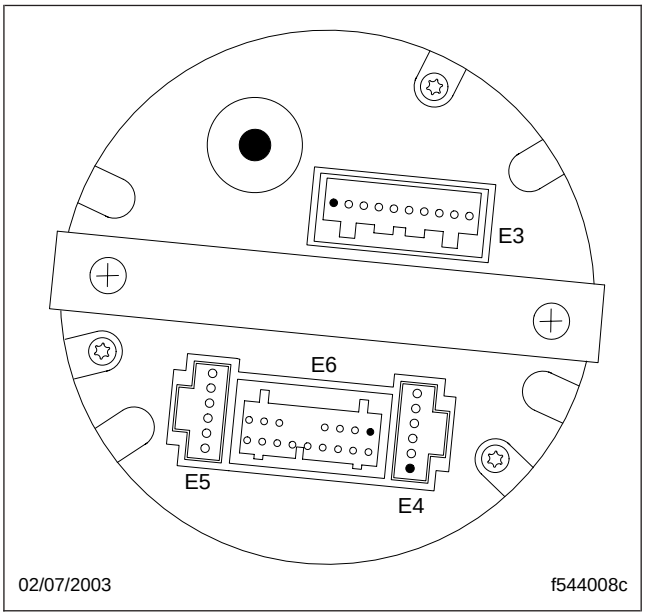


Fig. 2, Speedometer Electrical Connectors

NOTE: The instrument cluster need not be completely removed from the vehicle to remove and replace individual gauges. However, if removing the cluster is preferred, refer to **Subject 100** for the complete procedure.

Large Face Gauges

Removal

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

WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the air system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

3. Drain the air system if air gauges are to be disconnected.

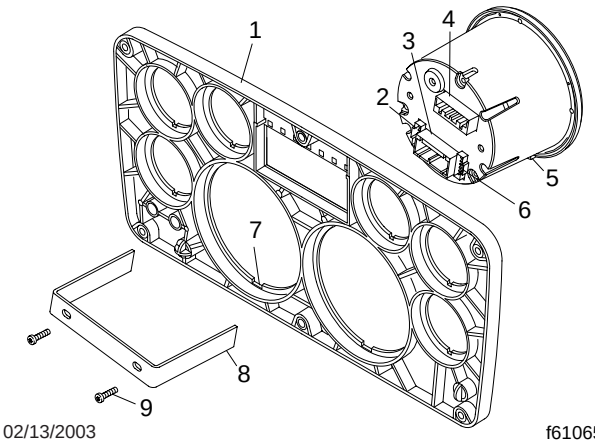
CAUTION

Do not forcibly pull the instrument cluster from the dash. This may dislodge wires from the harness electrical connectors on the back of the instrument cluster and damage the wires, the instrument cluster, or the dash.

4. Access the back of the instrument cluster. Refer to **Subject 100** for the instrument cluster removal and installation procedure.
5. Disconnect the wire connectors from the back of the gauge to be removed. See **Fig. 1**. There are four connectors on the speedometer and two on the tachometer.
6. Remove the two screws from the U-clamp.
7. Slide the gauge out through the front of the Instrument panel.

Installation

1. Slide the gauge into position from the front of the instrument panel. Make sure the locating pin on the bottom of the gauge near the bezel fits into the notch in the gauge mounting hole.
2. Position the U-clamp and install the retaining screws.
3. Connect the wire connectors to the back of the gauge.
4. Install the instrument cluster. Refer to **Subject 100**.
5. Connect the batteries.
6. Remove the chocks.



1. Instrument Panel
2. NGI Buss, E5
3. Analog or Switched Inputs, E6
4. A/N Display, E3
5. Alignment Tab
6. NGI Buss, E4
7. Alignment Notch
8. U-clamp
9. Mounting Screw

Fig. 1, Installation, Large Face Gauges (speedometer)

Small Face Gauges

Removal

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

WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the air system. Failure to relieve

Gauge Removal and Installation

air pressure could cause the lines to whip, resulting in personal injury.

3. Drain the air system if air gauges are to be disconnected.

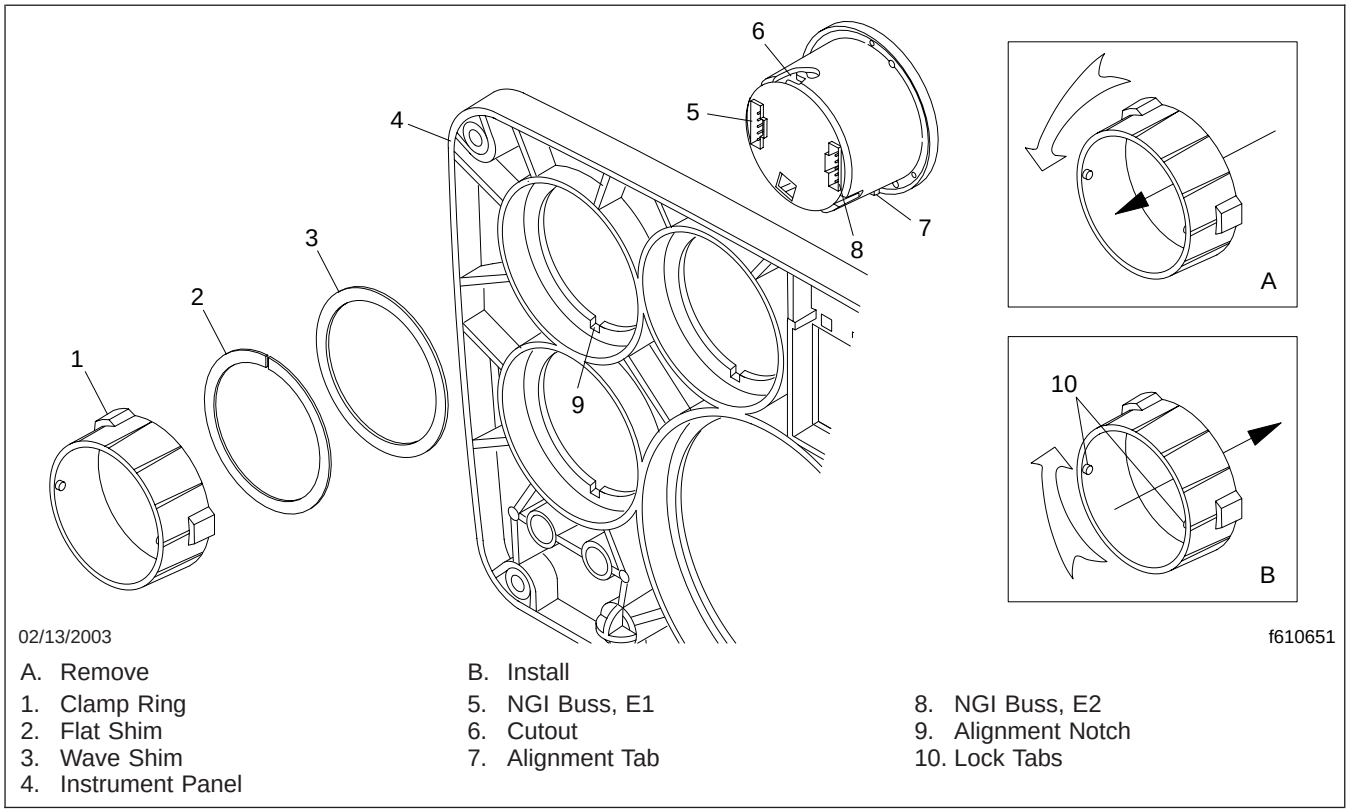
CAUTION

Do not forcibly pull the instrument cluster from the dash. This may dislodge wires from the harness electrical connectors on the back of the instrument cluster and damage the wires, the instrument cluster, or the dash.

4. Access the back of the instrument cluster. Refer to **Subject 100** for the instrument cluster removal and installation procedure.
5. Disconnect the wire connectors from the back of the gauge to be removed.
6. If an air pressure gauge is to be removed, disconnect the air pressure lines from the press-to-release fitting on the gauge back; see **Section 42.05**, Subject 110.
7. While holding the front of the gauge, press and turn the clamp ring counterclockwise about 1/16-inch until it releases. See **Fig. 2** for exploded view of gauge installation.
8. Remove the clamp ring, flat shim, and wave shim from the back of the gauge.
9. Slide the gauge out through the front of the cluster panel.

Installation

1. Slide the gauge into position from the front of the cluster panel. Make sure the locating pin on the bottom of the gauge near the bezel fits into the notch in the gauge mounting hole.
2. Put the wave shim, flat shim, and clamp ring on the back of the gauge.
3. While holding the front of the gauge in position, press and turn the clamp ring clockwise about 1/16-inch until it locks into place.
4. Connect the wire connectors to the back of the gauge.
5. If applicable, connect the air pressure lines to the press-to-release fitting on the back of the air pressure gauge. For the correct procedure see **Section 42.05**, Subject 110.
6. Pressurize the air system and check for leaks.
7. Install the instrument cluster. Refer to **Subject 100**.
8. Connect the batteries.
9. Remove the chocks.



A. Remove
B. Install
1. Clamp Ring
2. Flat Shim
3. Wave Shim
4. Instrument Panel
5. NGI Buss, E1
6. Cutout
7. Alignment Tab
8. NGI Buss, E2
9. Alignment Notch
10. Lock Tabs

Fig. 2, Installation, Small Face Gauges

Light Bar Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Loosen the six quarter-turn Torx fasteners around the edge of the instrument cluster. See **Fig. 1**.

Installation

1. Position the light bar into the mounting panel.
2. Install the four T10 Torx retaining screws.
3. Connect the electrical connectors to the rear of the light bar.
4. Position the instrument cluster in the dash opening.

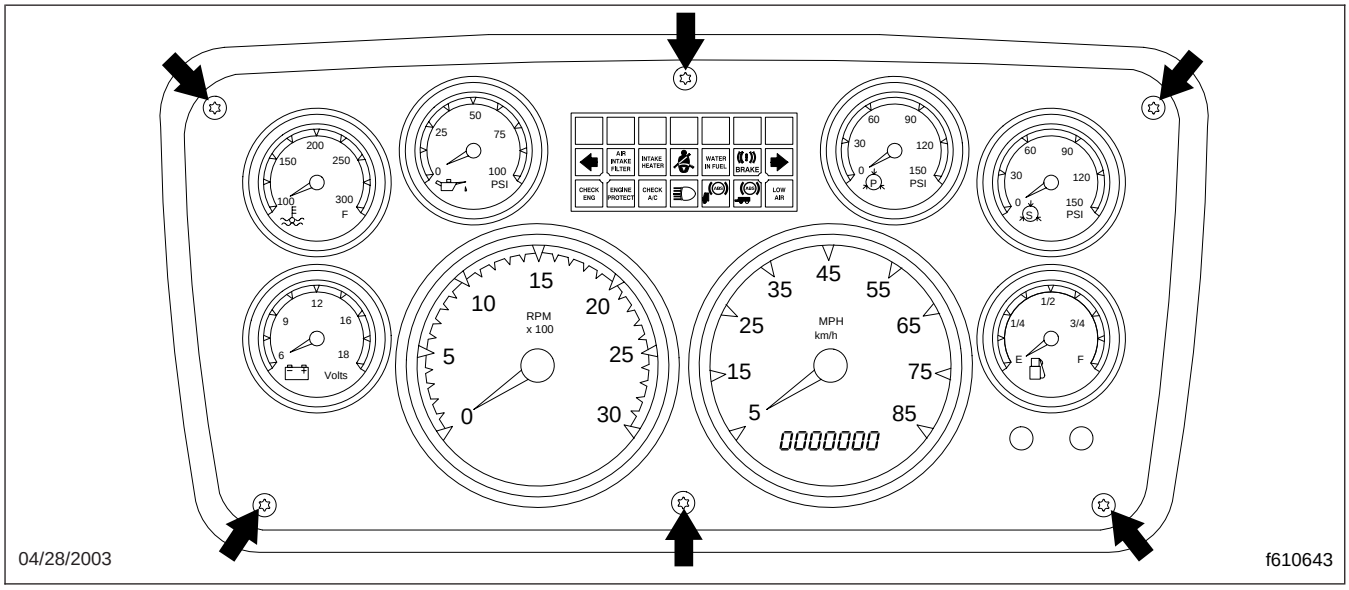


Fig. 1, Instrument Cluster Fasteners

CAUTION

Do not forcibly pull the instrument cluster from the dash. This may dislodge wires from the harness electrical connectors on the back of the instrument cluster and damage the wires, the instrument cluster, or the dash.

4. Tilt the instrument cluster out of the dash opening.
5. Depress the locking tabs and disconnect the electrical connectors from the rear of the light bar.
6. Remove the four T10 Torx screws holding the light bar to the panel. See **Fig. 2**.
7. Remove the light bar from the mounting panel.

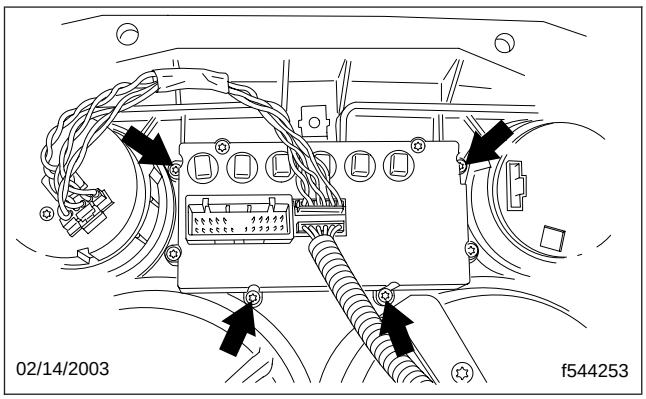


Fig. 2, Light Bar Mounting Screws

5. Fasten the six quarter-turn Torx-head fasteners.
6. Connect the batteries.
7. Remove the chocks.

Terms, Abbreviations, and Definitions

Terms, Abbreviations, and Definitions are listed below for your convenience.

- **ECU**–Electronic Control Unit
- **GC**–In the flow charts, a connector that is mounted on a gauge or other system component.
- **HC**–In the flow charts, a connector that is part of the vehicle's wiring harness.
- **LED**–Light-Emitting Diode
- **NGI**–Next Generation Instrumentation
- **SCU**–System Control Unit (Speedometer)

Mode and Set Switch Functions

Use the following flow charts to cycle through the Mode/Reset switch functions and screens when instructed to do so in the diagnostic flow charts.

See **Fig. 1** for Main Loop function flow chart.

See **Fig. 2** for Warning Message Loop function flow chart.

See **Fig. 3** for System Diagnostics Test Loop function flow chart.

See **Fig. 4** for Manual Mode Test Loop function flow chart.

See **Fig. 5** for Alpha Display Main Loop function flow chart.

Troubleshooting

For troubleshooting procedures, see Tables 1 through 7 later in this subject.

Flow Chart Information

Troubleshooting flow charts begin with Fig. 6. See Tables 1 through 7 to determine which troubleshooting flow chart to use. The black box(es) in each flow chart is the starting point for that chart. Follow the instructions in each box. The path to the next box depends upon how you answered the question in the previous box (i.e. "yes" or "no"). As you work your way through the chart you will eventually come to a box containing **bold type**. This represents the end of the flow chart. If you reach this box and your problem is still present, call the AMETEK Dixson Product Support Department for additional assistance at (800) 205-7710.

In the flow charts, "HC" refers to the connector on the wiring harness and "GC" refers to the connector on the gauge or lightbar.

Using the Automatic Mode Test Procedure

NOTE: Use this procedure when instructed to do so in the diagnostic flowcharts.

1. Using the mode switch, scroll until **DIAGTST** is displayed.
2. Press the set switch to enter the test mode.
3. Press the mode switch to scroll between **AUTO**, **MANUAL**, and **EXIT**.
4. When **AUTO** is displayed press the set switch to start the auto test.

NOTE: Light bar telltales will stay on if the condition that lights them is true.

5. The gauges, Check Engine light, and light bar will begin to cycle in the following manner with a corresponding message in the alphanumeric display. Verify that the gauges and light bar telltales function as follows:
   - **MIN** — All gauge pointers go to zero scale. All warning LEDs and all light bar telltales are off.
   - **MID**—All gauge pointers go to mid-scale. All warning LEDs are off, the Check Engine light is on, and every other telltale in the light bar is on.
   - **MAX**—All gauge pointers go to full-scale. All warning LEDs are off, the Check Engine light is off, and the light bar telltales change states.
   - **LED**—All gauge pointers go to zero-scale. All warning LEDs are on and only the Neutral, Park Brake and PTO telltales in the light bar are on.

Troubleshooting

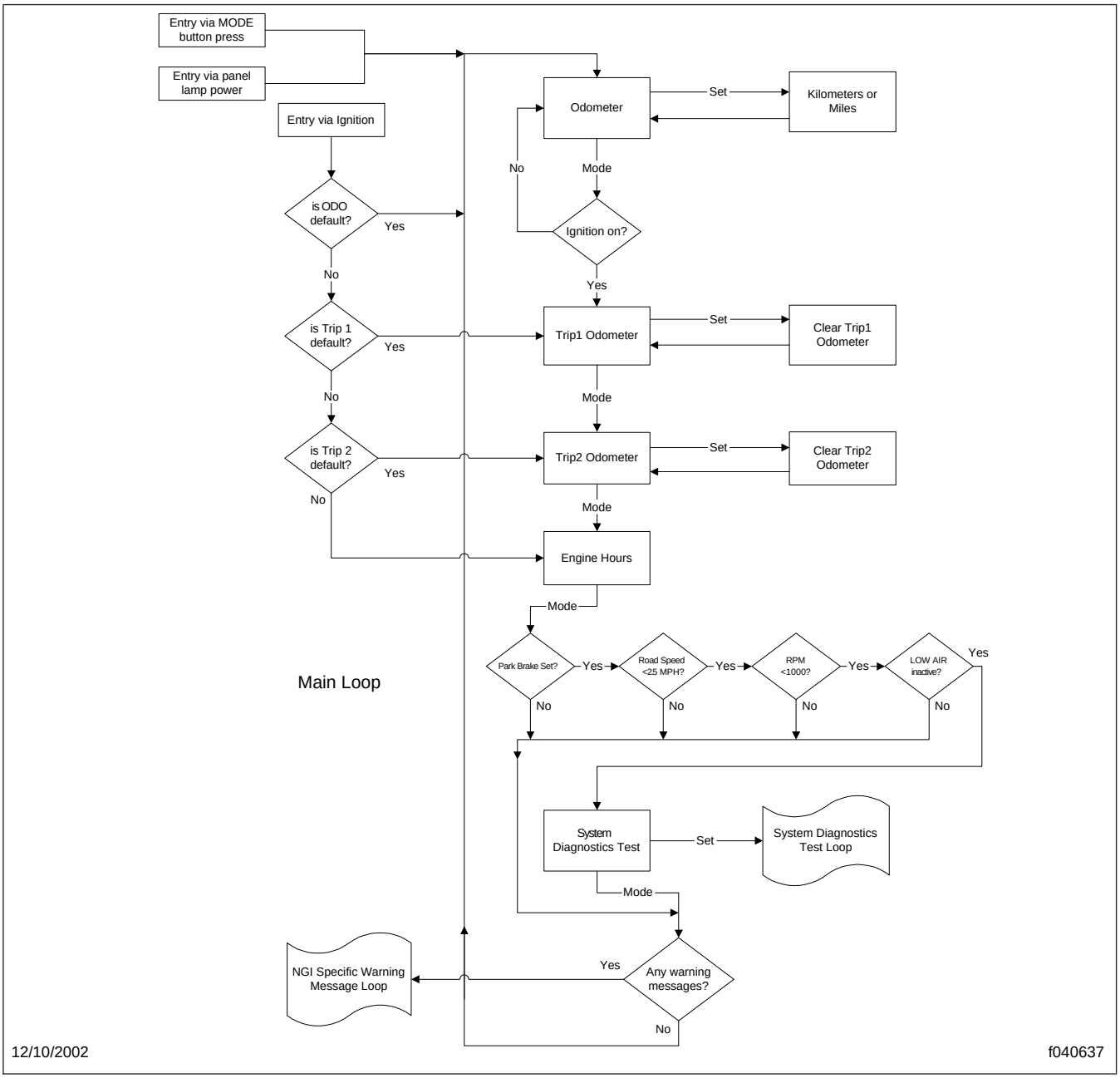


Fig. 1, Main Loop

6. All gauges, warning LEDs, and telltales must function as described.
7. When the test is complete push the set or mode switch to stop the test.
8. Use the mode switch to scroll until **EXIT** appears.

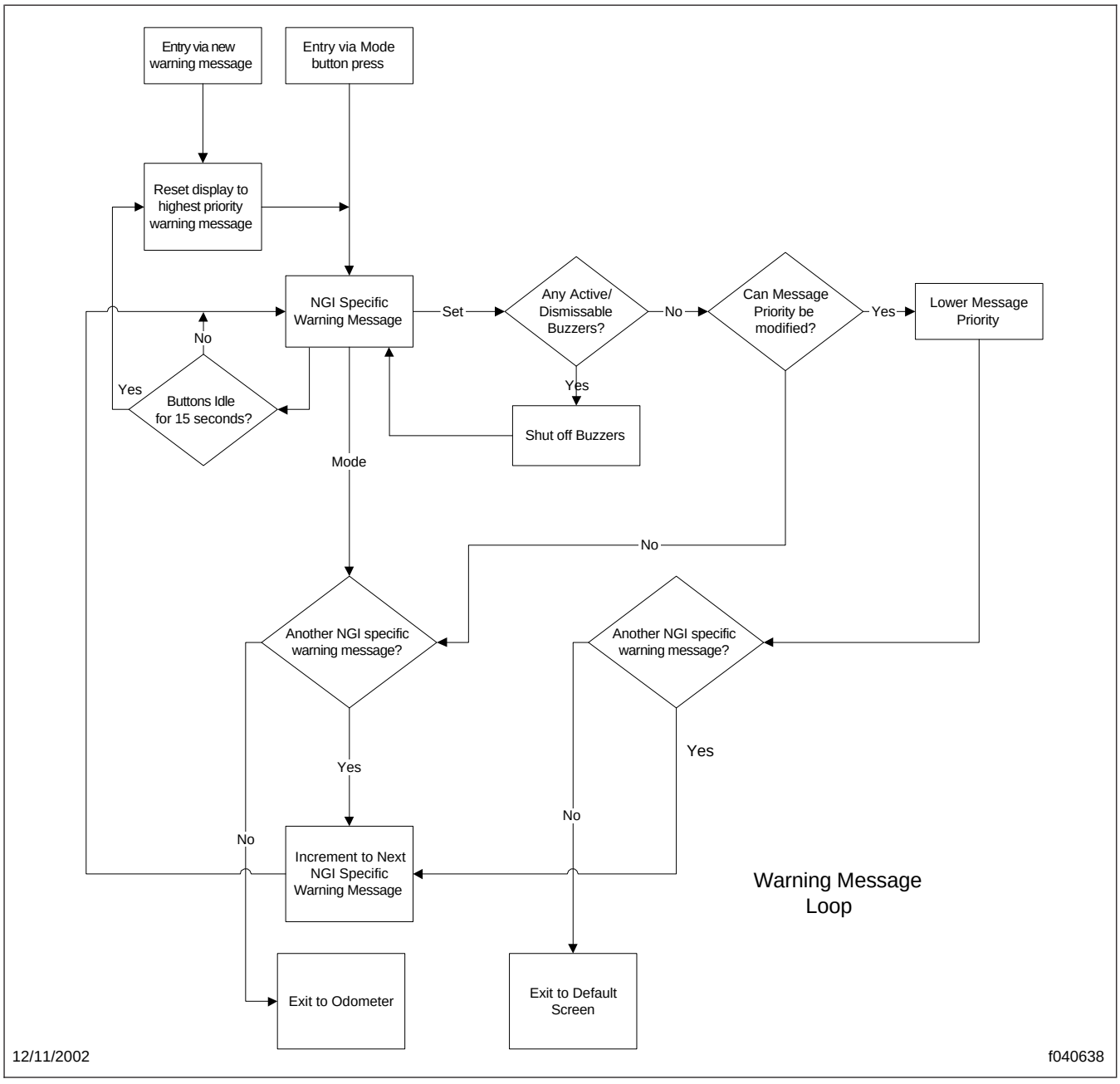


Fig. 2, Warning Message Loop

Using the Manual Mode Test Procedure

NOTE: Use this procedure when instructed to do so in the diagnostic flowcharts.

1. Using the mode switch scroll until **DIAGTST** is displayed.
2. Push the set switch to return to normal operation.
3. Press the set switch to enter the test mode.

Troubleshooting

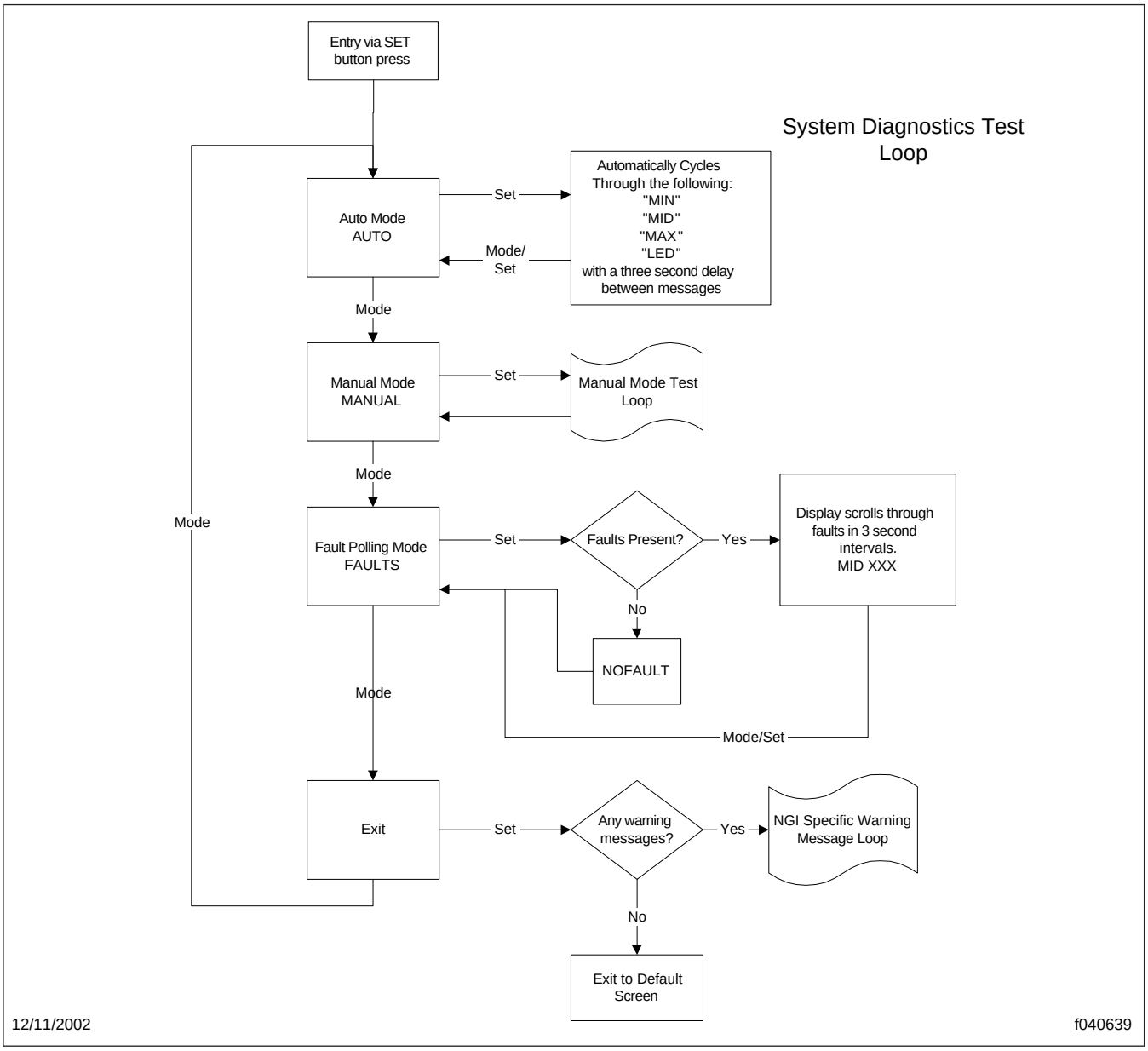


Fig. 3, System Diagnostics Test Loop

4. Press the mode switch to scroll between **AUTO**, **Manual**, and **EXIT**.
5. When **MANUAL** is displayed press the set switch.
6. To test a gauge:

6.1 Press the mode switch to scroll through the menu until the name of the gauge you wish to test is displayed.

6.2 Press the set switch to enable the test for the selected gauge.

6.3 Verify the gauge or light bar telltale behaves as follows:

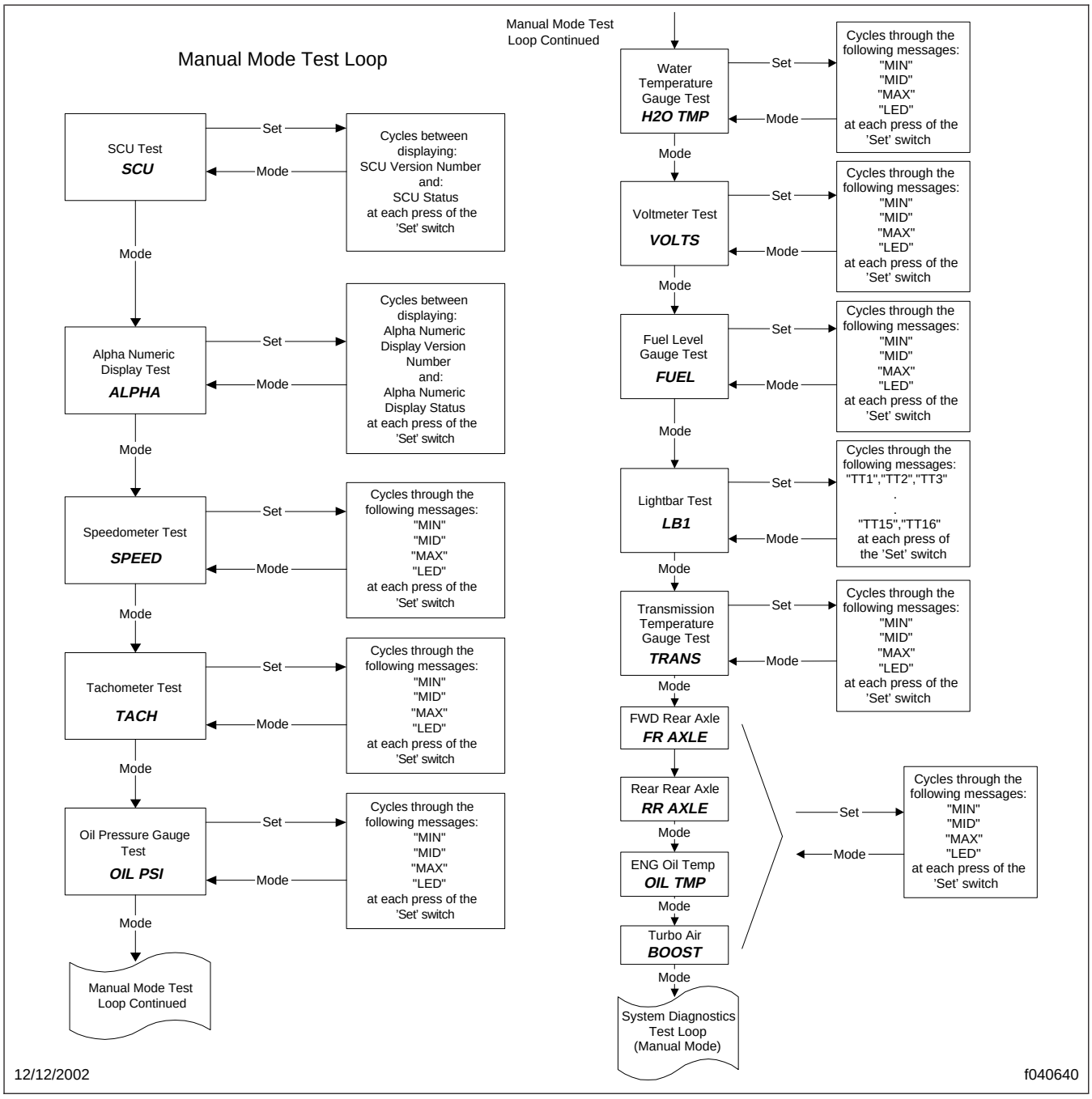


Fig. 4, Manual Mode Test Loop

- **MIN**— The gauge pointer goes to the zero scale and its warning LED is off.
- **MID**— The gauge pointer goes to mid-scale and its warning LED is off.

Troubleshooting

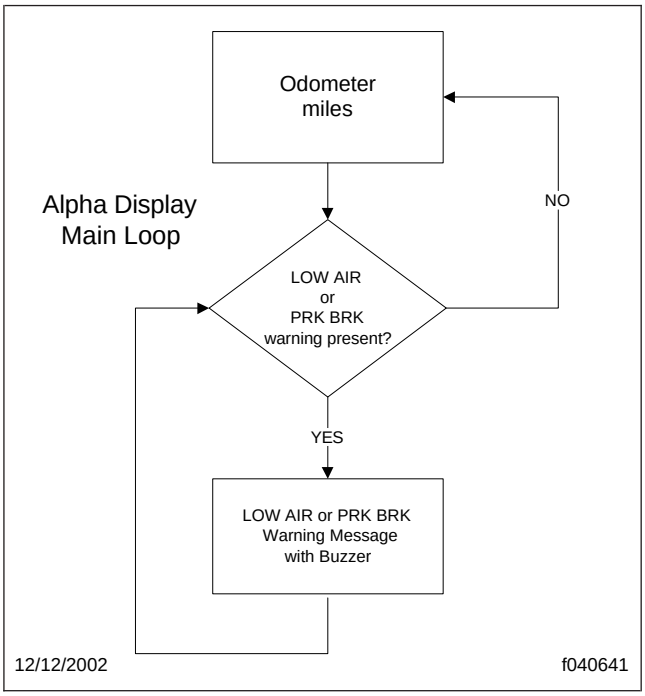


Fig. 5, Alpha Display Main Loop

- **MAX**—The gauge pointer goes to full scale and its warning LED is off.
- **LED**—The gauge pointer goes to the zero scale and its warning LED is on.

6.4 Press the set switch again to cycle through each test. You must continue pressing the set switch to cycle through the test.

6.5 Press the mode switch to exit the gauge test.

7. To test the light bar or one of its telltales:

7.1 When **MANUAL** is displayed press the set switch.

7.2 Press the mode switch until **LB1** is displayed.

7.3 Press the set switch to cycle through **TT1** to **TT16**. The location of the telltales T1 through T15 will be shown in the display. TT16 will turn the **CHECK ENGINE** light on.

7.4 Verify the correct light is on as indicated in the alphanumeric display.

7.5 Press the mode switch to exit the light bar test.

8. To exit the manual mode:

8.1 Continue pressing the mode switch to scroll through the menu until **EXIT** appears.

8.2 Press the set switch to exit the manual mode and return to normal operation.

Diagnostic Procedures

When troubleshooting the instrumentation, switch the ignition on and observe all the gauges during the initialization period. Locate the general symptom in **Table 1**, then follow the instructions.

NOTE: See **Subject 400** for instrumentation connector locations and pin identification.

General Symptoms	
Problem	**Remedy**
Problem with speedometer or alphanumeric display.	See **Table 2**.
Problem with 2-inch gauge or tachometer.	See **Table 3** or **Table 4**.
Problem with air pressure gauges.	See **Table 5**.
Problem with light bar telltales.	See **Table 6** and **Table 7**.
Problem with Check Engine light.	
Problem with left or right turn indicator.	See **Table 7**.
Problem with high beam indicator.	See **Table 7**.

General Symptoms	
Problem	**Remedy**
Warning message displayed.	See **Table 8**.
No audible warning when warning message displayed.	Replace the speedometer.

Table 1, General Symptoms

Problem With Speedometer			
Problem	**Initialization results***	**Possible Cause**	**Remedy**
LCD is dead and speedometer pointer does not move to initialization point.	Fail	No power from battery or ignition switch; defective speedometer.	See **Fig. 6**.
Speedometer pointer does not move to its initialization point.	Fail	Defective speedometer.	Replace speedometer.
Speedometer pointer goes to and stays at minimum or full scale.	Pass	Engine ECU out of range.	See **Fig. 7**.
Speedometer pointer stays at minimum scale (LCD may read **NO DATA**).	Pass	No data from Engine ECU; NGI bus problem; defective speedometer.	
Inaccurate speed indication.	Pass	Problem with Engine ECU; defective speedometer.	See **Fig. 15**
NO DATA displayed. All other components function properly.	Pass	Defective speedometer.	Replace speedometer.
Select/mode buttons not functioning.	Pass	Defective speedometer.	Replace speedometer.
LCD is dead but speedometer pointer does move to initialization point.	Fail	Defective speedometer.	Replace speedometer.
LCD is missing segments.	Fail	Defective speedometer.	Replace speedometer.
LCD backlighting not working.	Pass	Defective speedometer.	Replace speedometer.
No odometer or engine hours display.	Pass	Engine ECU not sending data; defective speedometer.	See **Fig. 8**.
Odometer or engine hour display not advancing.	Pass	Engine ECU not sending data; defective speedometer.	See **Fig. 8**.
Cannot reset trip odometer.	Pass	Defective speedometer.	Replace speedometer.
No backlighting.	Pass	Power or ground problem.	See **Fig. 9**.

* When ignition is first turned on, each gauge pointer should sweep below minimum scale and the LED should be lit, then the pointer should return to minimum scale. *This does not apply to the air pressure gauges.*

Table 2, Problem With Speedometer

Troubleshooting

Problems with J1587 Driven Gauges: Tachometer, Coolant Temperature, Oil Pressure, Voltmeter, Engine Oil Temperature, Turbo Boost			
Symptom	**Initialization Results**	**Probable Cause**	**Remedy**
Dead. Gauge pointer does not move and LED does not light.	Fail	NGI Power missing; power not getting to speedometer or gauge; defective speedometer or gauge.	See **Fig. 6**.
Gauge pointer moves correctly but LED does not light.	Fail	Defective gauge.	Replace gauge.
LED lights, but gauge pointer does not position correctly.	Fail	Defective gauge.	Replace gauge.
Gauge pointer goes to zero and LED flashes slowly.*	Pass	Open or shorted NGI bus; defective gauge or speedometer; data not on J1587 databus.	See **Fig. 10**.
Gauge inaccurate.	Pass	Engine ECU; defective sensor, speedometer.	See **Fig. 15**.
No backlighting.	Pass	Backlight power or ground problem.	See **Fig. 9**.

* Slowly means one flash per second.

Table 3, Problem With J1587 Driven Gauge

Problems with Sensor Driven Gauges: Fuel Level, Trans Oil Temperature, Axle Temperature (front and rear)			
Symptom	**Initialization Results**	**Probable Cause**	**Remedy**
Dead. Gauge pointer does not move and LED does not light.	Fail	NGI Power missing; power not getting to speedometer or gauge; defective speedometer or gauge.	See **Fig. 6**.
Gauge pointer moves correctly but LED does not light.	Fail	Defective gauge.	Replace gauge.
LED lights, but gauge pointer does not position correctly.	Fail	Defective gauge.	Replace gauge.
Gauge pointer goes to zero and LED flashes slowly.	Pass	Open or shorted NGI bus; defective gauge or speedometer.	See **Fig. 10**.
Fuel Gauge Only: Gauge pointer goes to minimum scale and LED may be lit.	Pass	Faulty sensor; open or shorted sensor wiring leading to instrumentation.	See **Fig. 16**
Transmission and Axle Temperature Gauges Only: Gauge pointer goes to minimum scale, or pointer goes to maximum scale and the LED is lit.	Pass	Faulty sensor; open or shorted sensor wiring leading to instrumentation.	See **Fig. 13**
Gauge inaccurate.	Pass	Defective sensor	Fuel level gauge: see **Fig. 16** All others: see **Fig. 13**

Problems with Sensor Driven Gauges: Fuel Level, Trans Oil Temperature, Axle Temperature (front and rear)			
Symptom	**Initialization Results**	**Probable Cause**	**Remedy**
No backlighting.	Pass	Backlight power or ground problem.	See **Fig. 9**.

Table 4, Problems with Sensor Driven Gauges

Problems with Air Pressure Gauges: Primary and Secondary Air Pressure, Service Brake Application			
Symptom	**Initialization Results**	**Probable Cause**	**Remedy**
Dead. Gauge pointer does not move.	N/A	Defective gauge; no air pressure reaching gauge.	See **Fig. 14**.
Gauge inaccurate.	N/A	Defective gauge.	See **Fig. 14**.
No backlighting.	N/A	Backlight power or ground problem.	See **Fig. 9**.

Table 5, Problems with Air Pressure Gauges

Problem With Light Bar During Initialization		
Problem	**Probable Cause**	**Remedy**
Only some telltales turn on. Fasten seatbelt telltale does not turn on. NOTE: Bulb checks for discrete input telltales (hard wired) are controlled by the ECU they are connected to.	Light bar faulty.	Replace light bar.
No telltales turn on.	No power or ground to light bar.	See **Fig. 17**

Table 6, Problem With Light Bar During Initialization

Problem With Light Bar During Operation	
Problem	**Remedy**
Optional Telltale #1 always/never on.	See **Fig. 18**.
Low Coolant telltale always/never on.	See **Fig. 18**.
Engine Protection telltale always/never on.	See **Fig. 18**.
Water in fuel telltale always/never on.	See **Fig. 18**.
Air Intake Filter telltale always/never on.	See **Fig. 18**.
Low Air telltale always/never on.	See **Fig. 22**.
Tractor ABS, telltales always/never on.	Check wiring and ABS ECUs. If OK, replace lightbar.
Trailer ABS, telltales always/never on.	
Check engine light always/never on.	See **Fig. 18**.
Optional Telltale #2 through #7 always/never on.	See **Fig. 19**.
Right/Left Turn Signal always/never on.	See **Fig. 20**.
Check A/C telltale always/never on.	See **Fig. 20**.

Troubleshooting

Problem With Light Bar During Operation	
Problem	**Remedy**
High Beam Indicator telltale always/never on.	See **Fig. 20**.
Fasten Seat Belt telltale always/never on.	See **Fig. 21**.

Table 7, Problem With Light Bar During Operation

Warning Messages

Warning messages are listed in **Table 8**. Read the message and determine what condition is causing it.

Should **NO DATA** be displayed, go to **Table 2** (Problem With Speedometer).

If you suspect the alarm condition is false and a problem does not really exist, then follow the gauge accuracy troubleshooting procedures for that gauge by going to **Table 3** (Problem With J1587 Driven Gauge).

Warning Messages	
Warning Message	**Probable Cause**
LOW AIR	Air pressure low
PRK BRK	Air tank #2 low
LOW OIL	Engine oil pressure low
H2OTMP	Coolant temperature high
No Data	See **Table 2**.

Table 8, Warning Messages

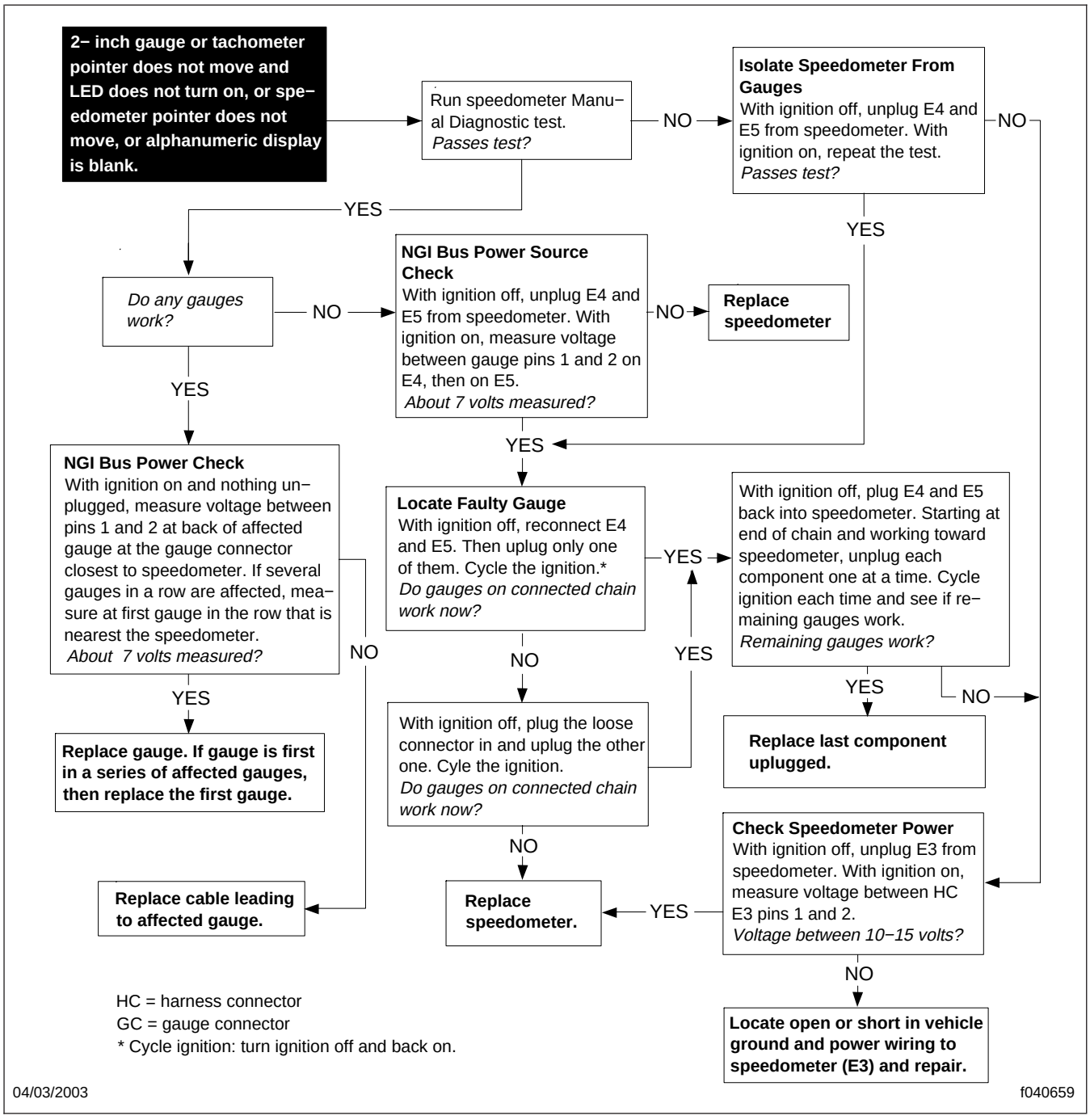


Fig. 6, Gauge Appears Dead

Troubleshooting

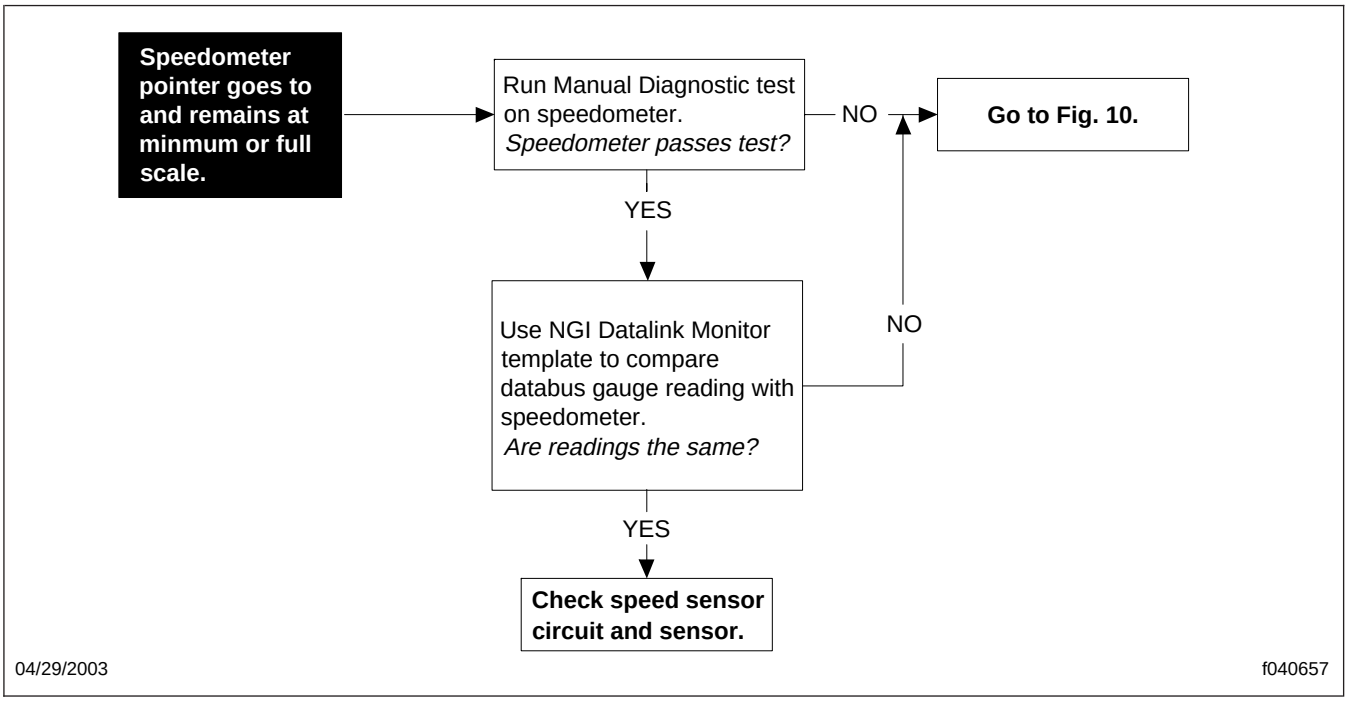


Fig. 7, No Speed Indication

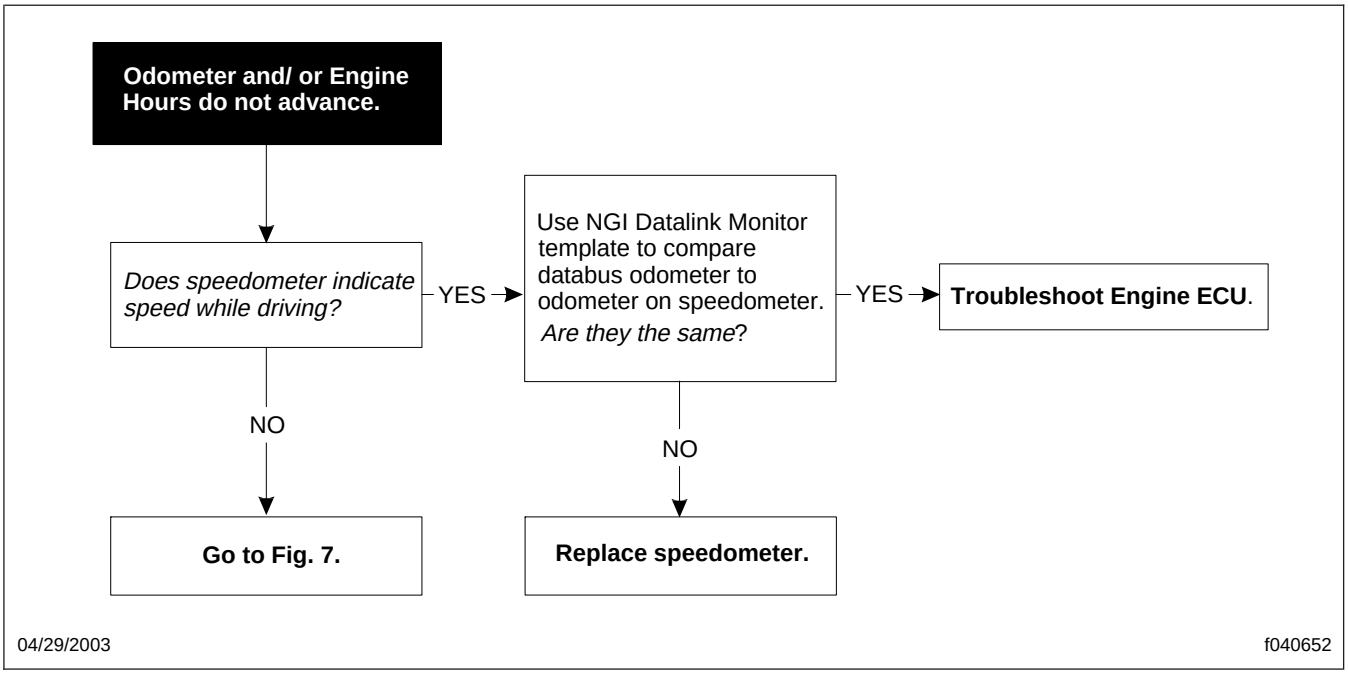


Fig. 8, Problem With Odometer or Engine Hourmeter

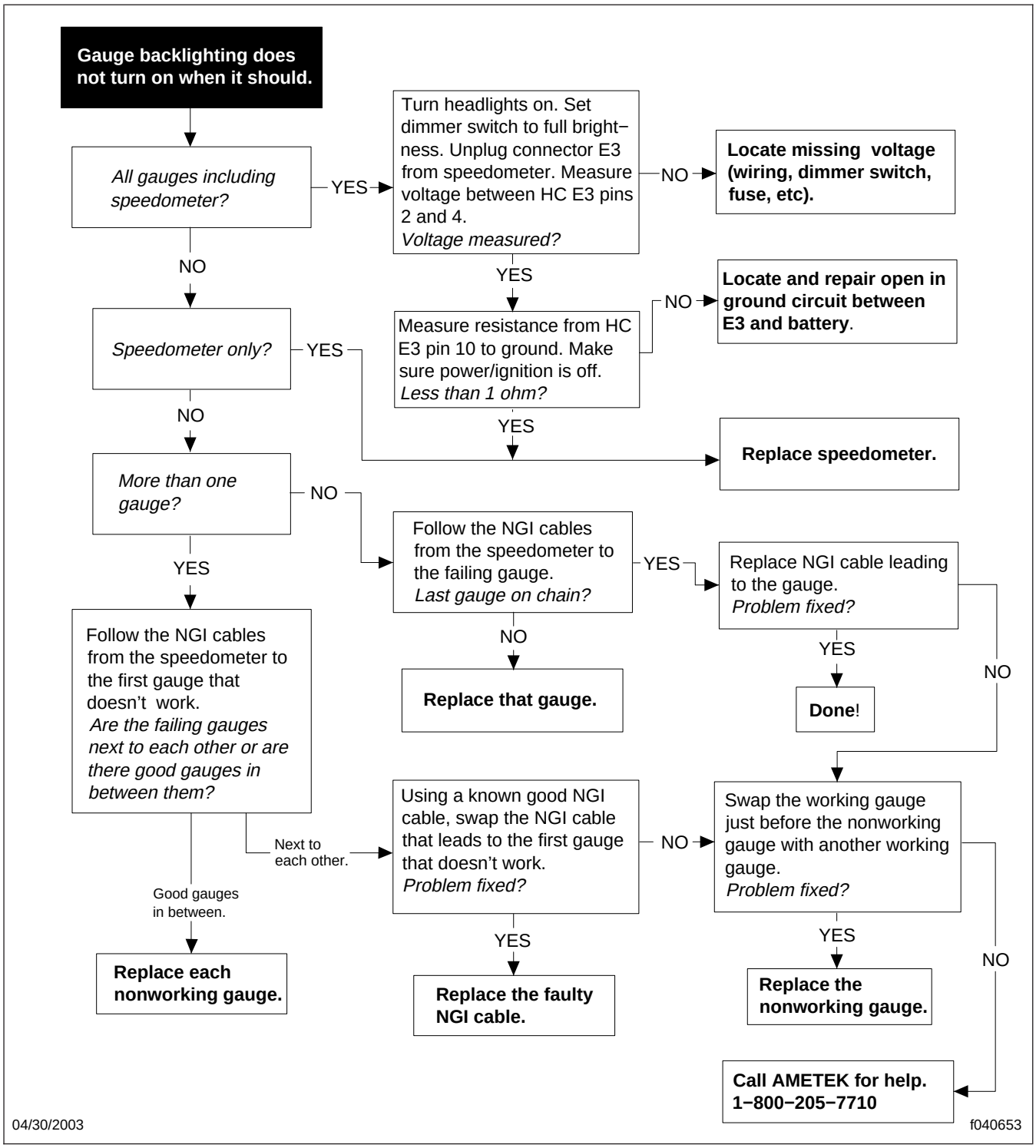


Fig. 9, Backlighting Problems

Troubleshooting

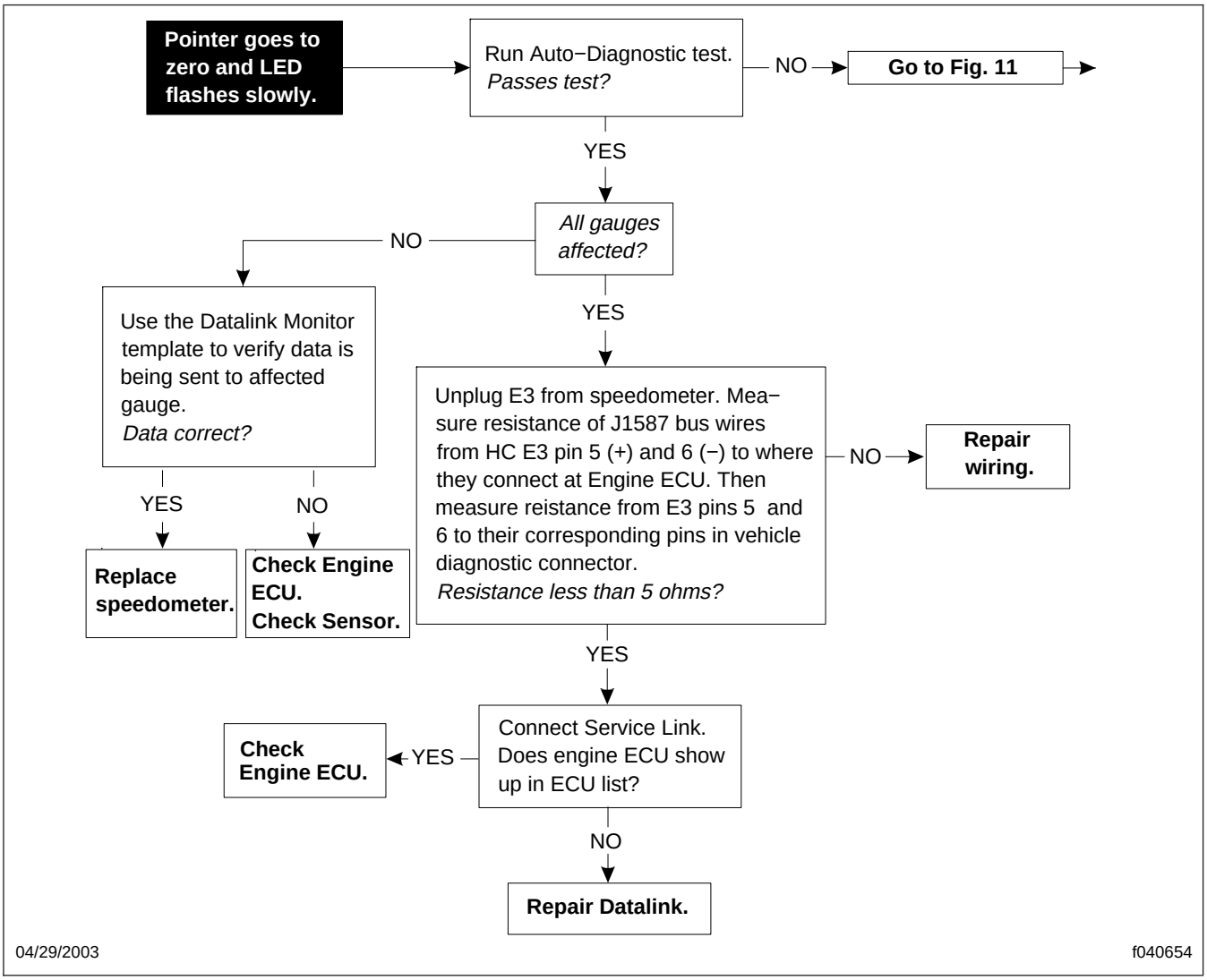


Fig. 10, Slow Flashing LED

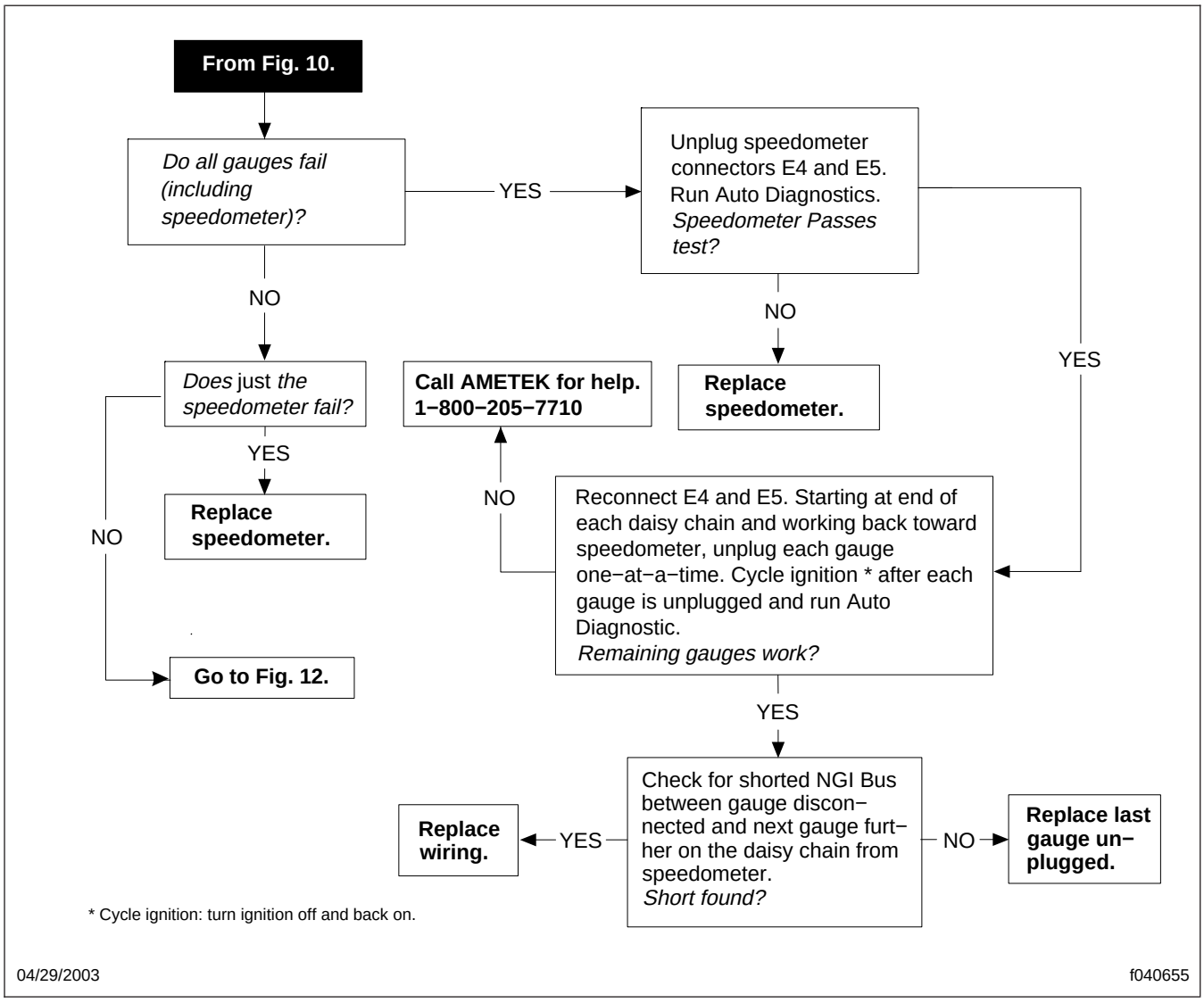


Fig. 11, Slow Flashing LED (part 2)

Troubleshooting

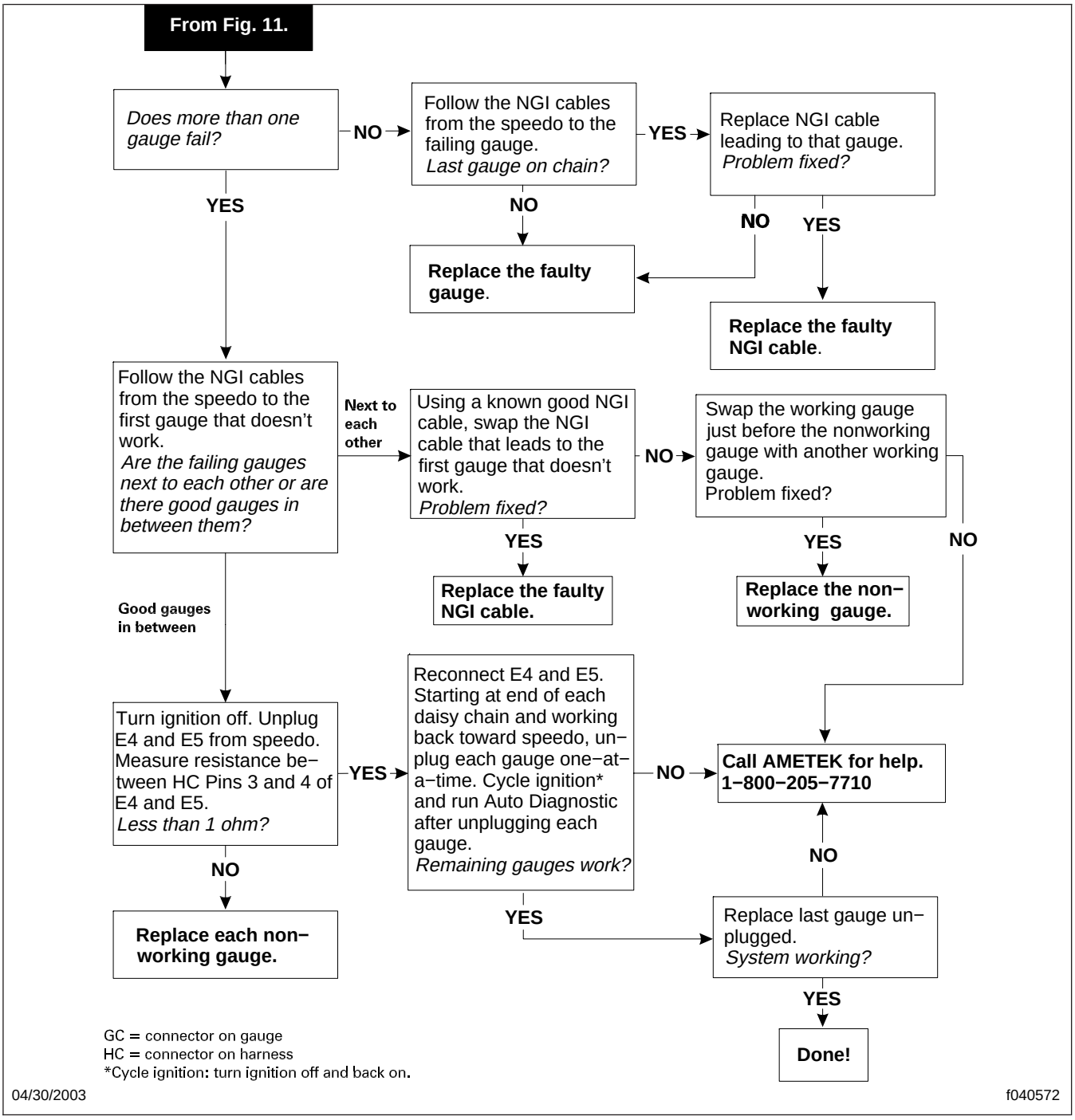


Fig. 12, Slow Flashing LED (part 3)

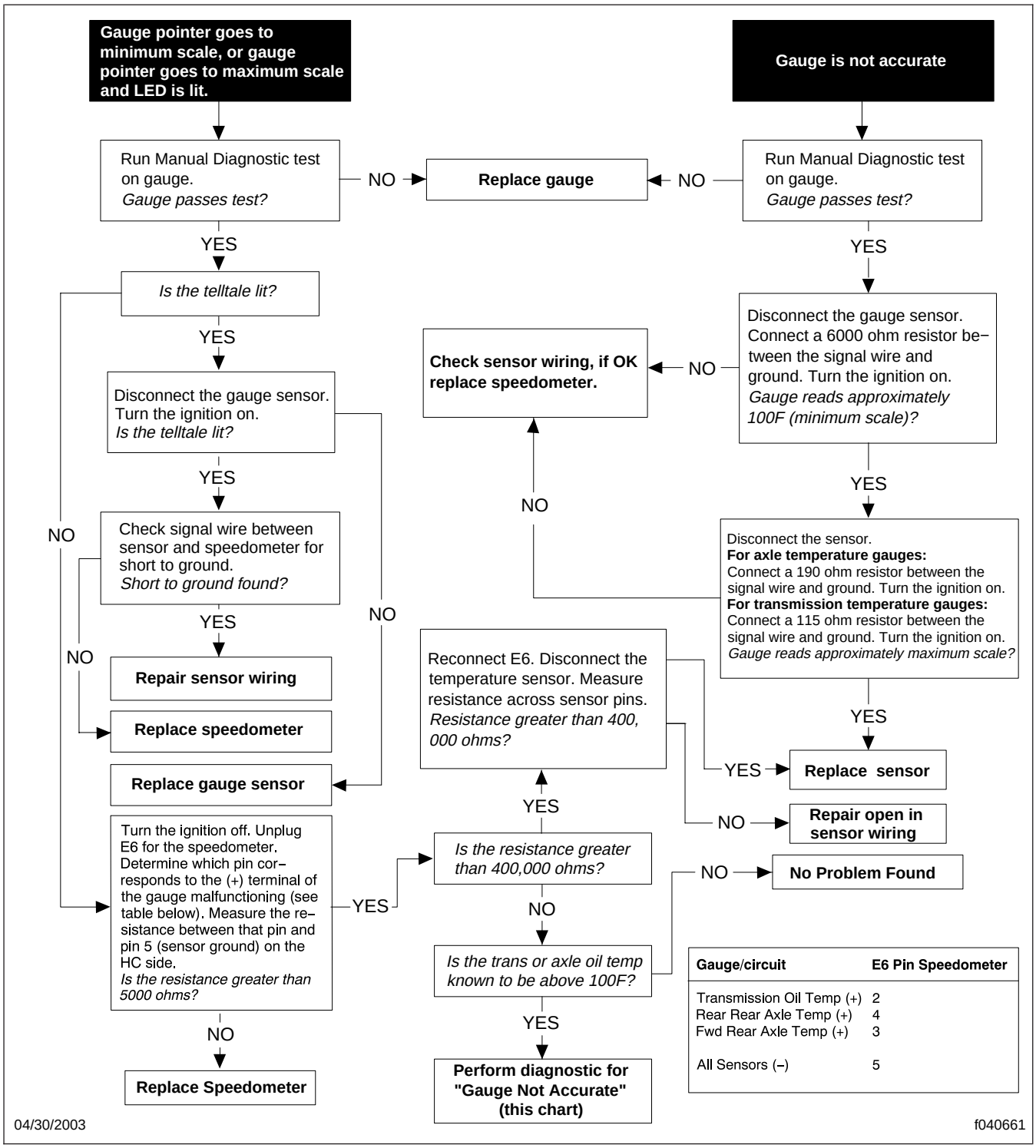


Fig. 13, Sensor Driven Gauge Problem (except fuel level gauge)

Troubleshooting

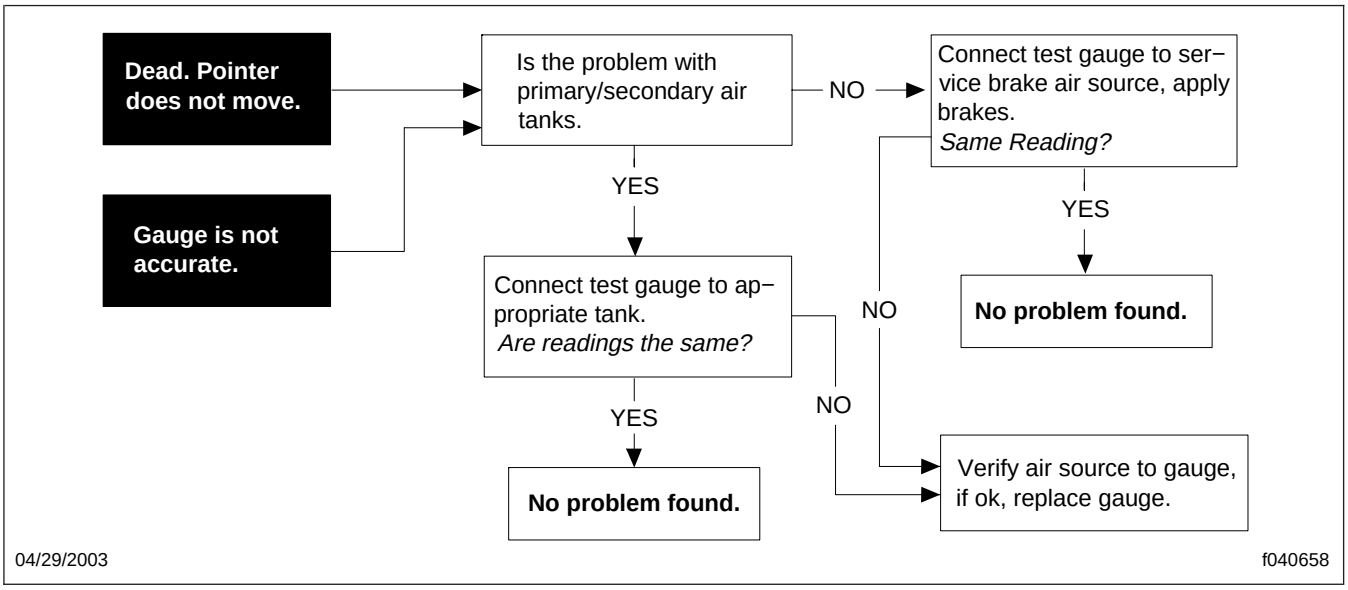


Fig. 14, Air Pressure Gauge Problem

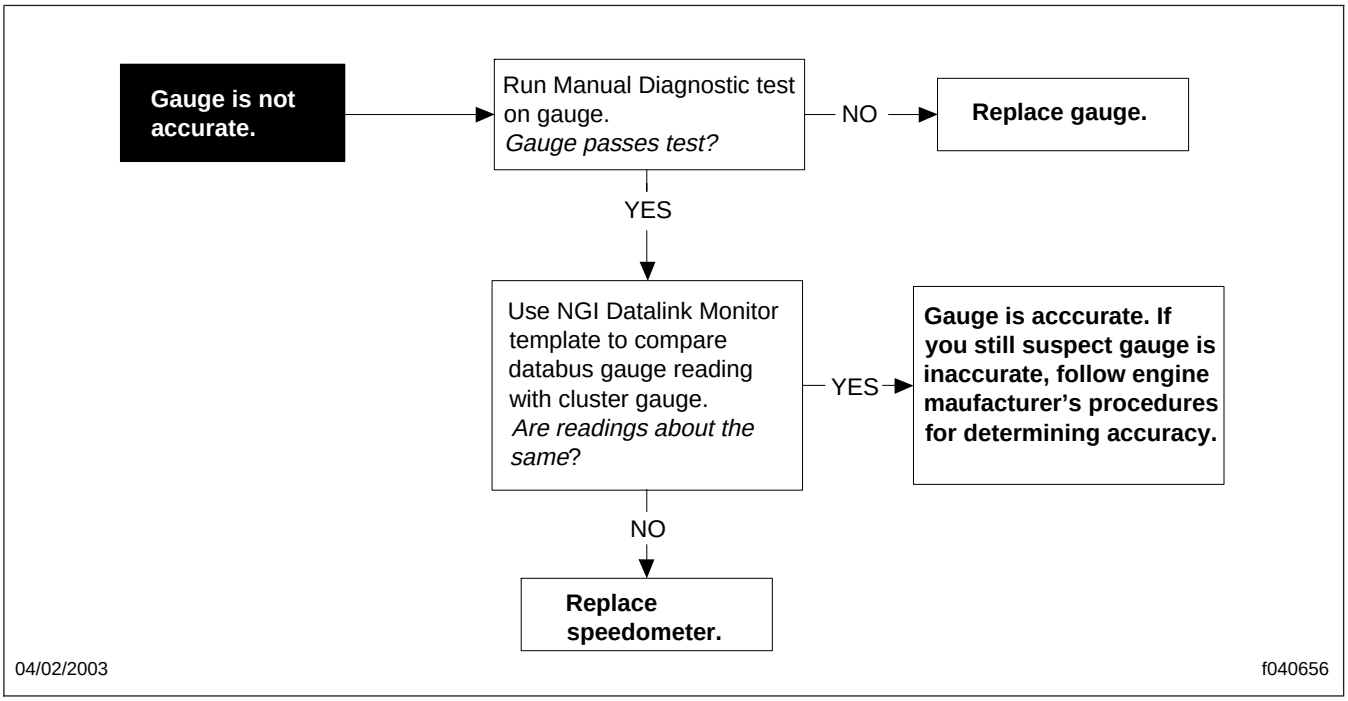


Fig. 15, Gauge Inaccurate

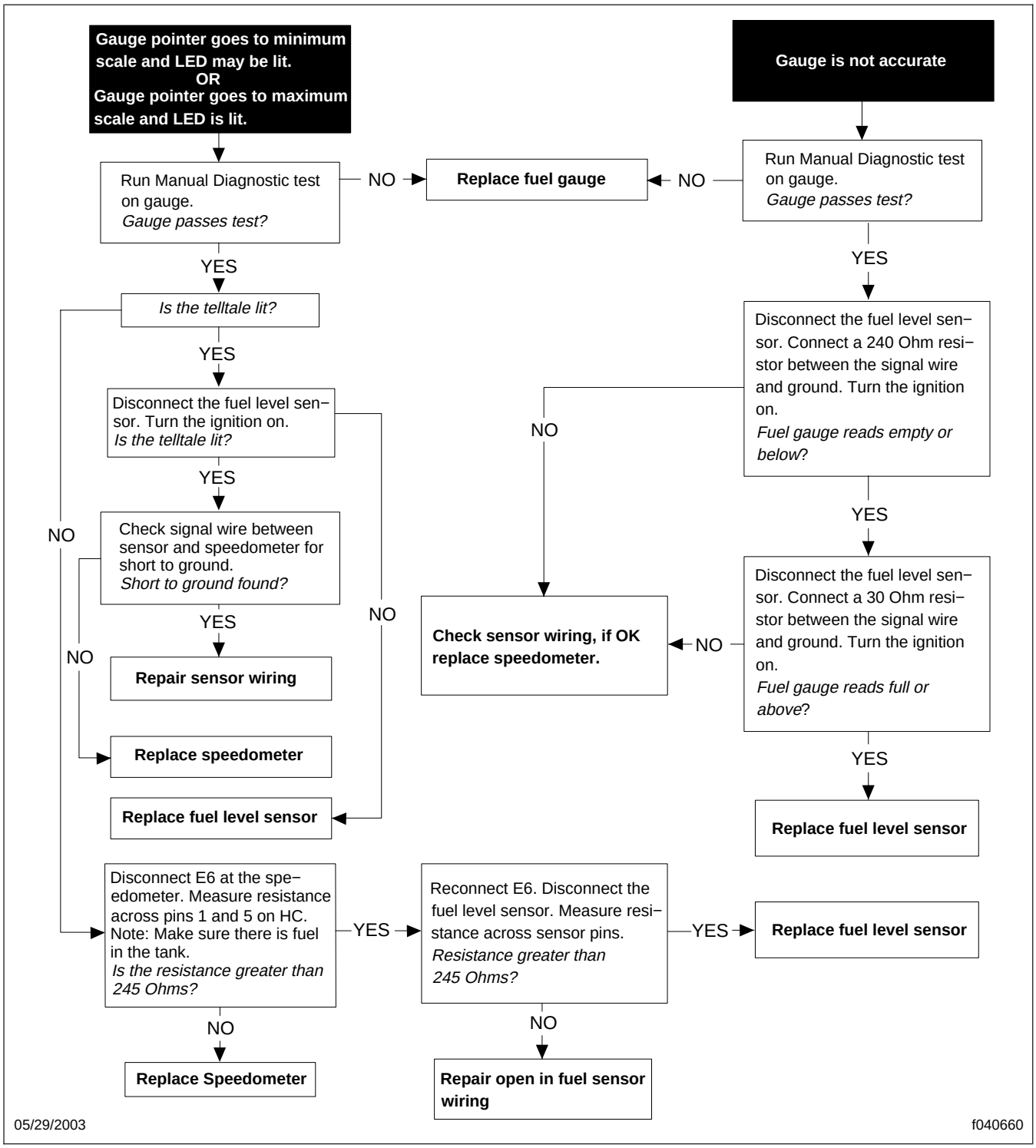


Fig. 16, Fuel Level Gauge Problem

Troubleshooting

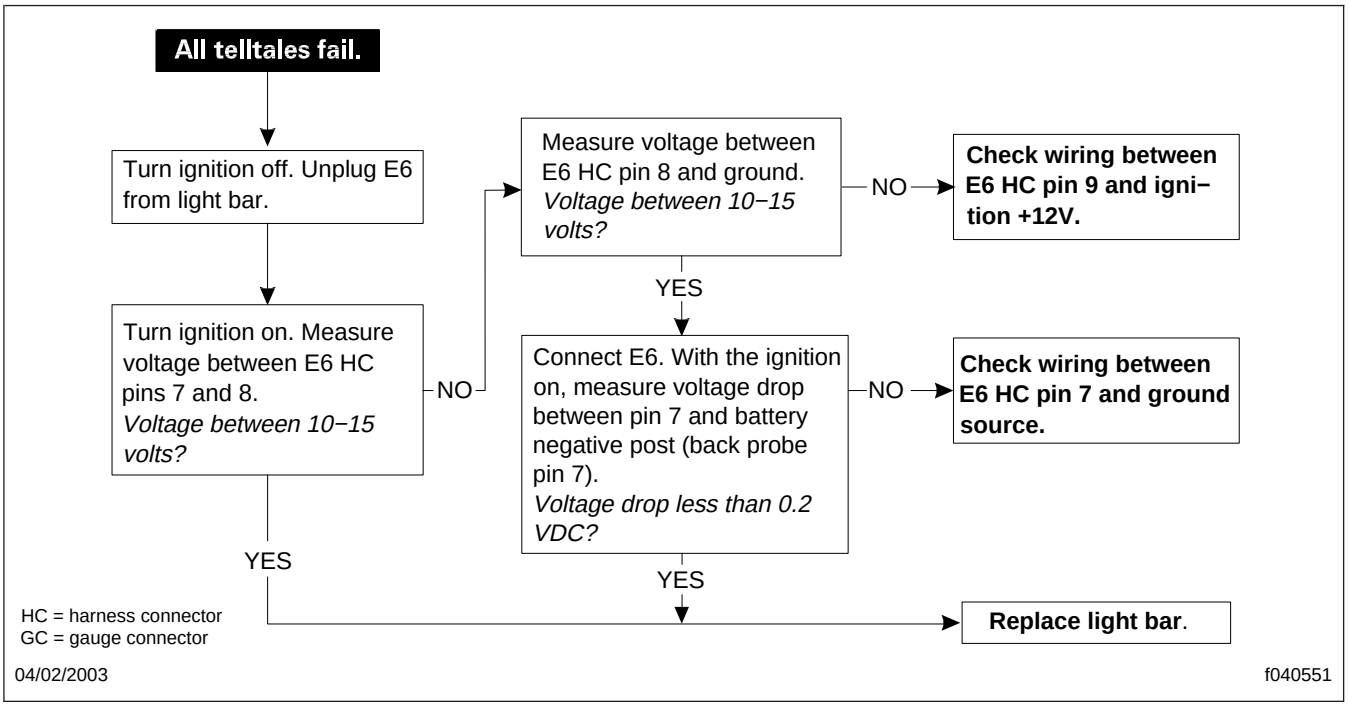


Fig. 17, No Telltales Turn On

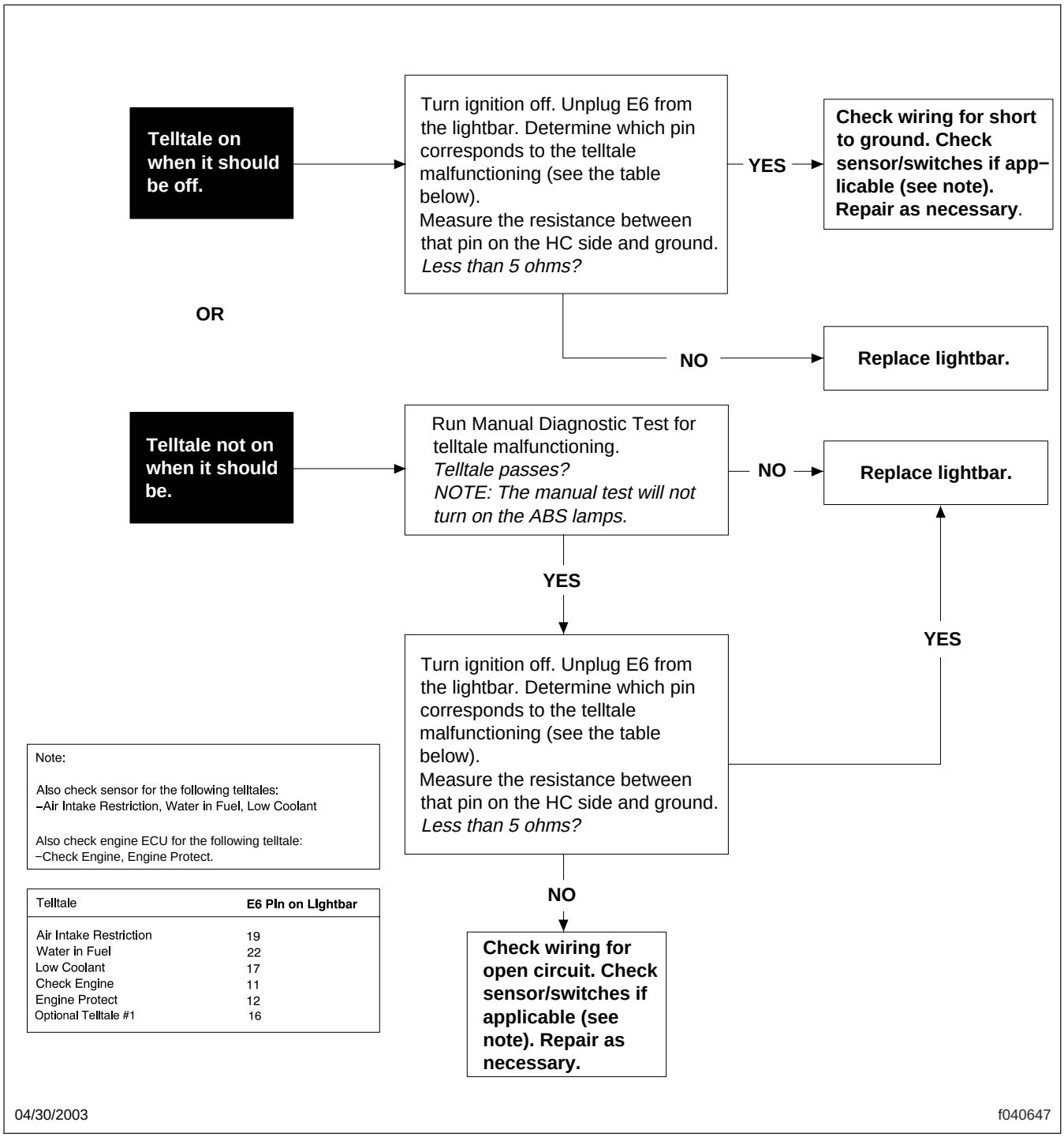


Fig. 18, Ground-Activated Telltales Wired Directly to the Lightbar Always/Never On (except tractor and trailer ABS)

Troubleshooting

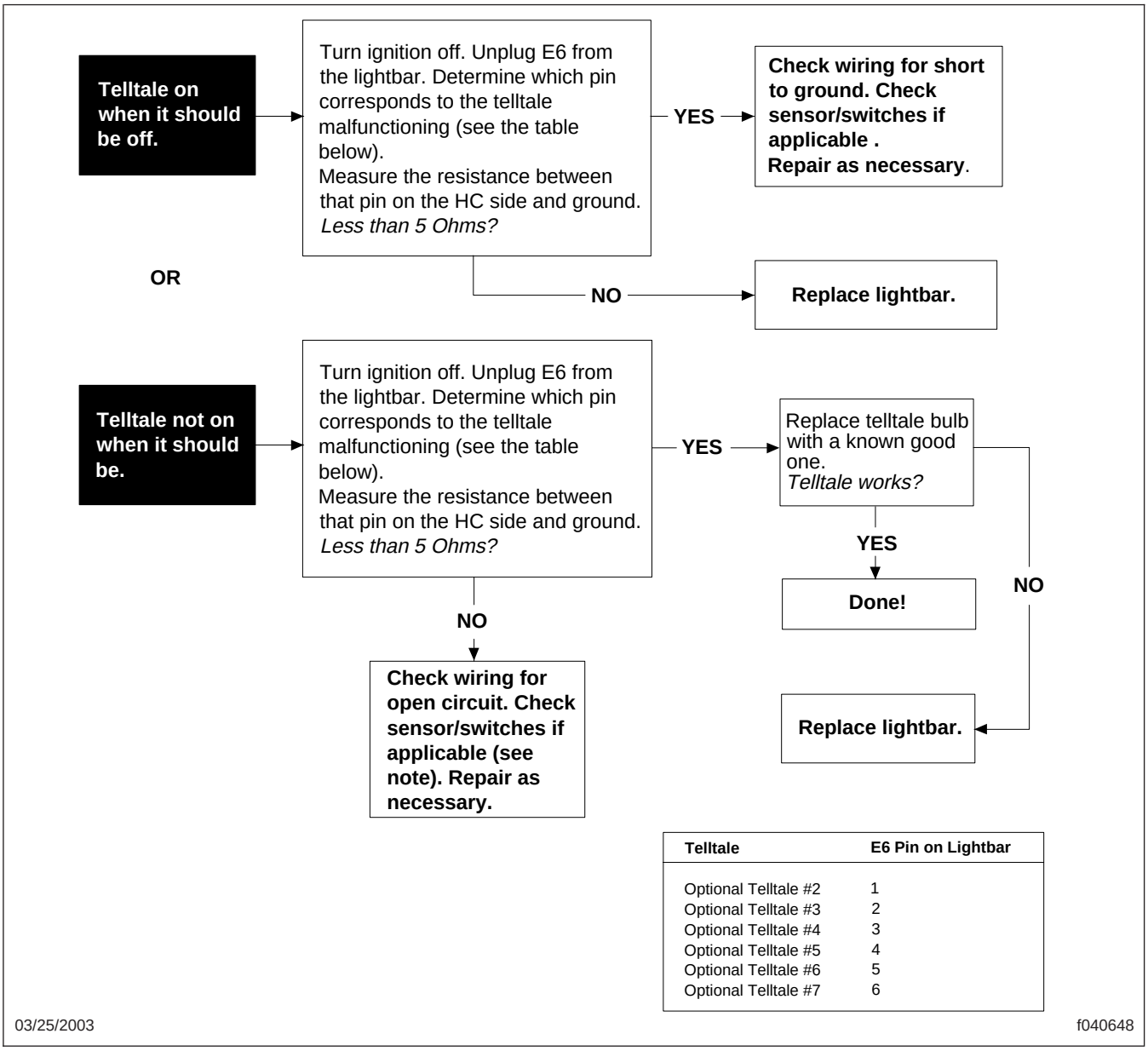


Fig. 19, Ground-Activated Telltales Wired Directly to the Lightbar, Non-LED Optional Telltales Number 2 through 7 Always/Never On

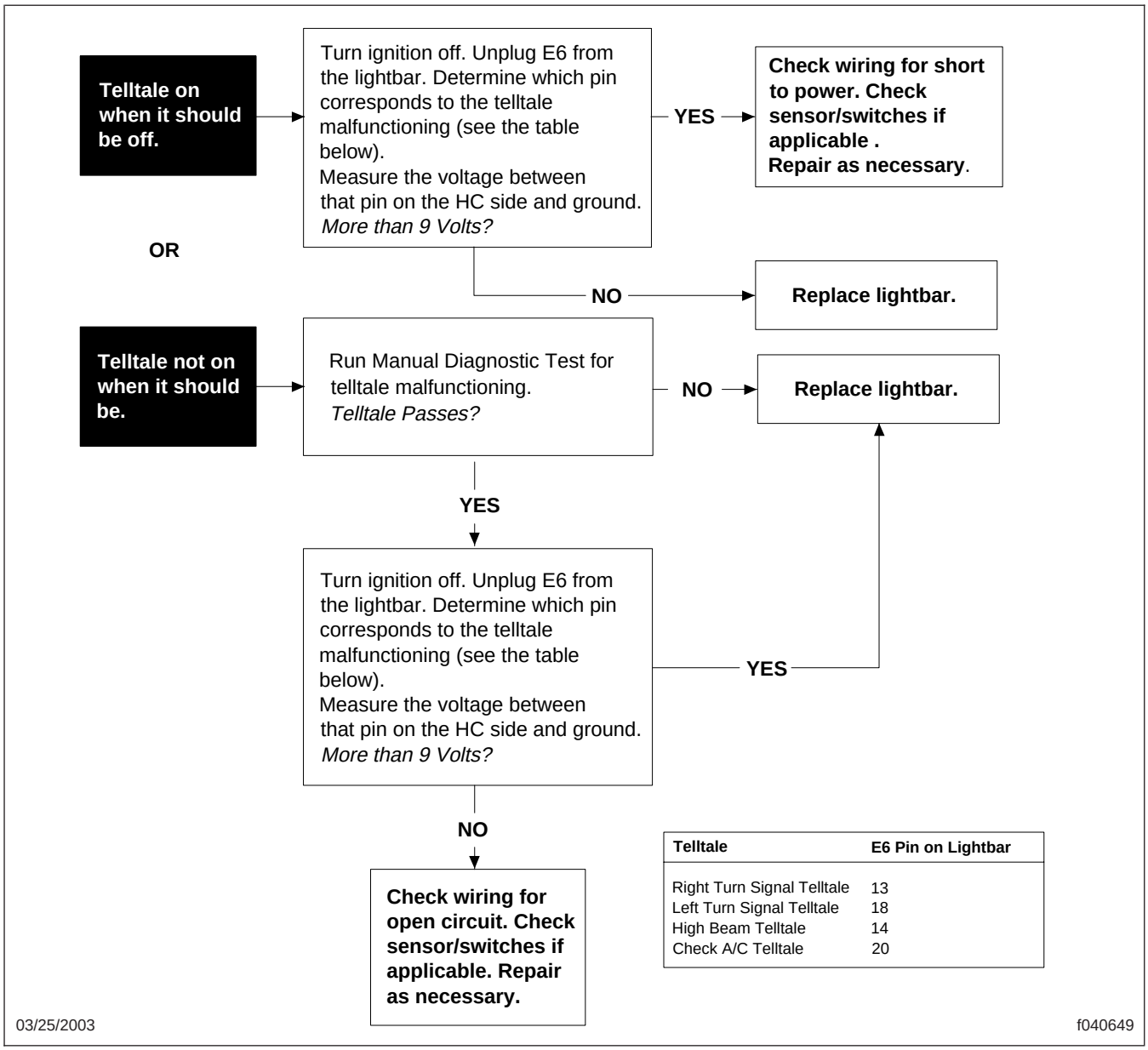


Fig. 20, Power-Activated Telltales Wired Directly to the Lightbar Always/Never On

Troubleshooting

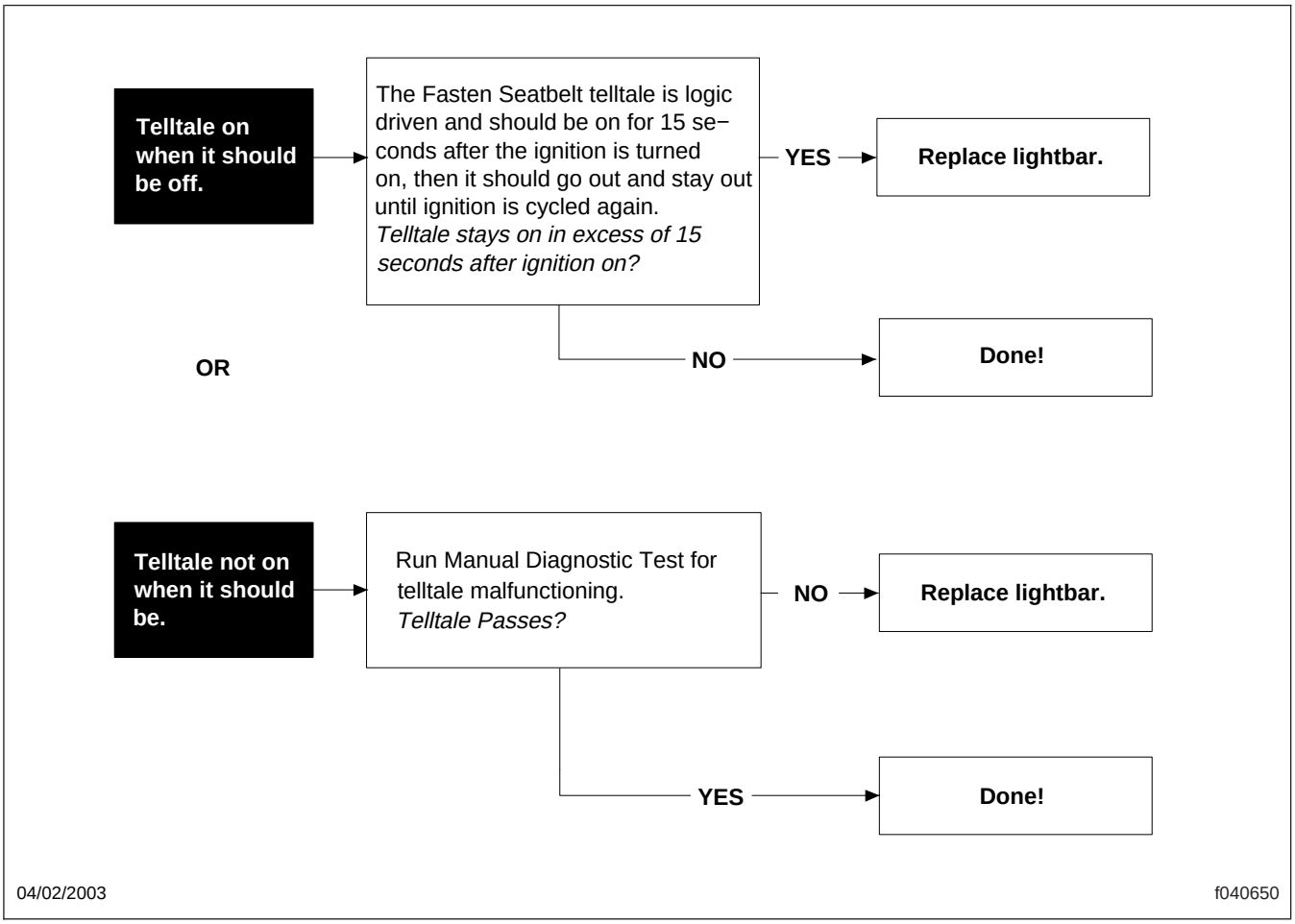


Fig. 21, Fasten Seatbelt Telltale Always/Never On

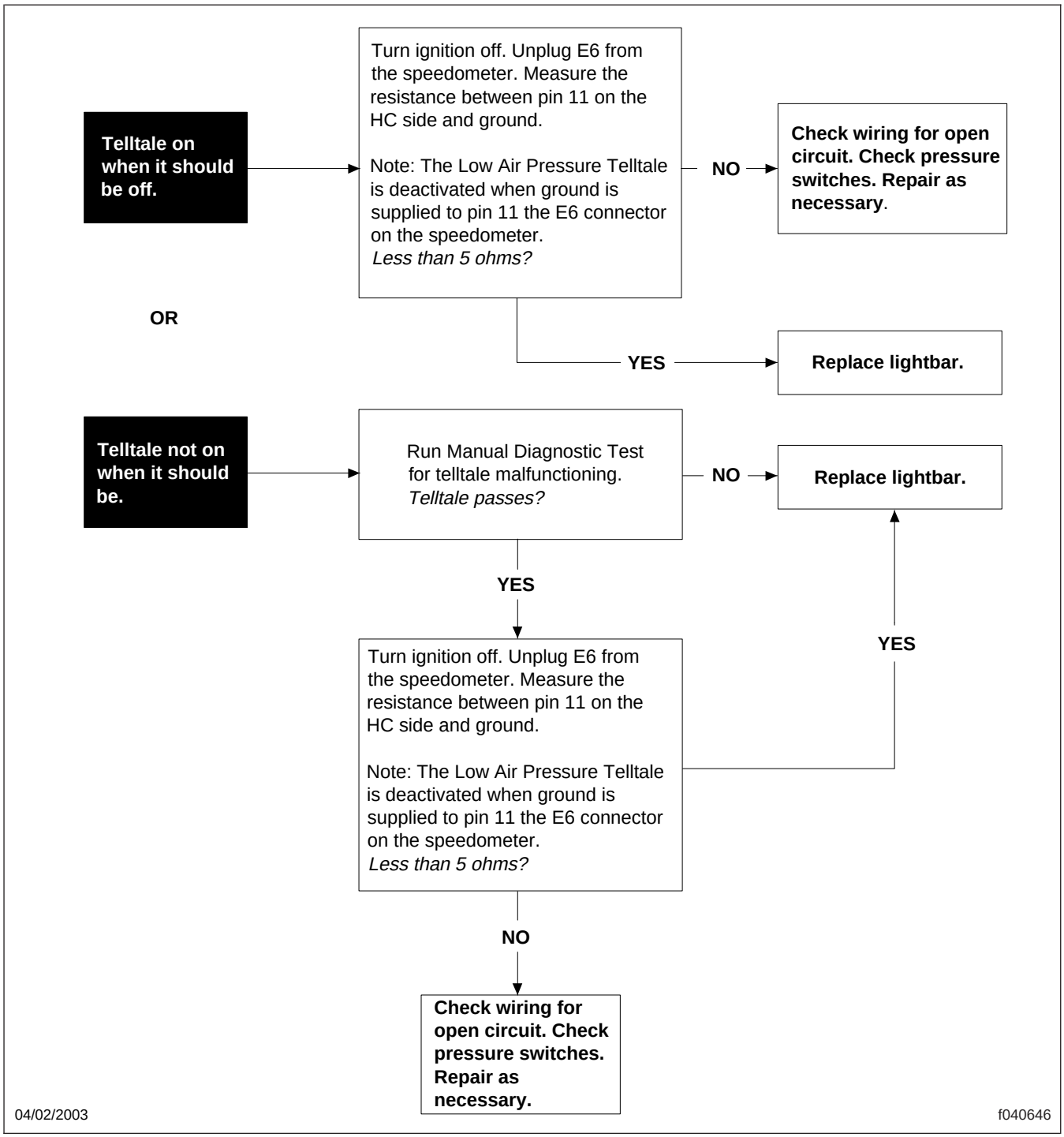
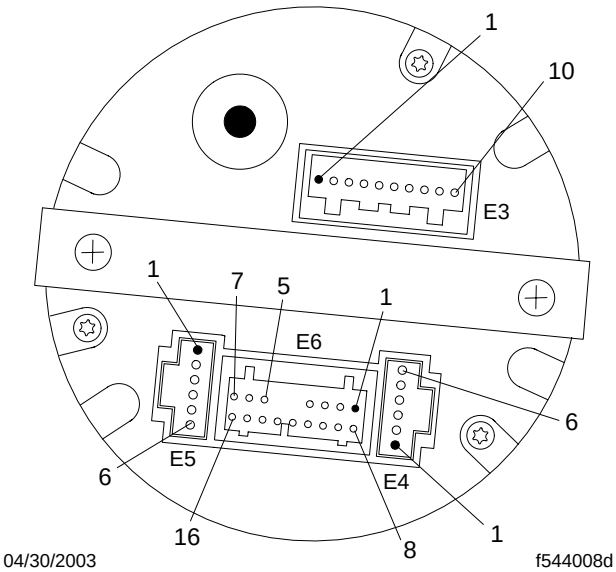


Fig. 22, Low Air Telltale Always/Never On

See **Fig. 1** for speedometer connector locations.



NOTE: E4 and E5 are internally connected in parallel.

Fig. 1, Speedometer Connectors

Speedometer Connector E3	
Cavity	**Circuit Description**
Pin 1	Battery +
Pin 2	Battery Ground
Pin 3	Ignition +
Pin 4	Backlight Power (from PWM dimmer switch)
Pin 5	J1587 Bus +
Pin 6	J1587 Bus -
Pin 7	Not Used
Pin 8	Not Used
Pin 9	Not Used
Pin 10	Backlight Ground

Table 1, Speedometer Connector E3 Pin Identification

Speedometer Connector E6 (Analog and Switched Inputs)	
Cavity	**Circuit Description**
Pin 1	Fuel Level Sensor +
Pin 2	Transmission Oil Temperature Sensor +
Pin 3	Fwd Rear Axle Temperature Sensor +
Pin 4	Rear Rear Axle Temperature Sensor +
Pin 5	Sensor Ground
Pin 6	Not Used
Pin 7	Not Used
Pin 8	Not Used
Pin 9	Not Used
Pin 10	No Charge Telltale
Pin 11	Low Air Buzzer/Lamp (ground to turn off)
Pin 12	Park Brake Telltale
Pin 13	External Buzzer Input
Pin 14	Not Used
Pin 15	Transmission Temperature Telltale
Pin 16	Not Used

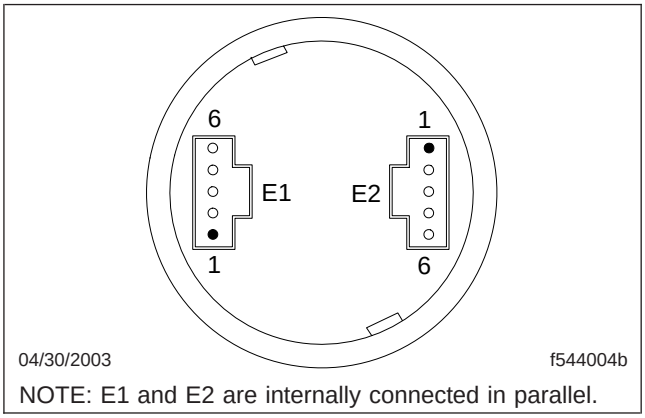
Table 2, Speedometer Connector E6 Pin Identification

Speedometer Connector E4 and E5 (NGI Bus)	
Cavity	**Circuit Description**
Pin 1	NGI Power (+ 7.6VDC)
Pin 2	NGI Ground
Pin 3	NGI Bus Positive (+)
Pin 4	NGI Bus Negative (-)
Pin 5	Backlight Ground
Pin 6	Backlight Power

Table 3, Speedometer Connectors E4 and E5 Pin Identification

See **Fig. 2** for two-inch gauge connector locations.

Specifications



NOTE: E1 and E2 are internally connected in parallel.

Fig. 2, Two-Inch Gauge Connectors

Two-Inch Gauge Connectors E1 and E2 (NGI BUS)	
Cavity	**Circuit Description**
Pin 1	NGI Power (+ 7.6VDC)
Pin 2	NGI Ground
Pin 3	NGI Bus Positive (+)
Pin 4	NGI Bus Negative (-)
Pin 5	Backlight Ground
Pin 6	Backlight Power

Table 4, Two-Inch Gauge Connectors E1 and E2 Pin Identification

See **Fig. 3** for lightbar connector locations.

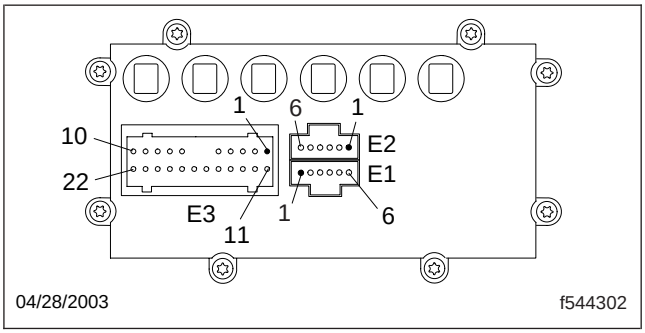


Fig. 3, Light Bar Connectors

Light Bar Connector E3 Pin Identification		
Cavity Pin #	**Function**	**Activation**
1	Optional Telltale #2	Ground (ignition OFF)

Light Bar Connector E3 Pin Identification		
Cavity Pin #	**Function**	**Activation**
2	Optional Telltale #3	Ground
3	Optional Telltale #4	Ground
4	Optional Telltale #5	Ground
5	Optional Telltale #6	Ground
6	Optional Telltale #7	Ground
7	Lightbar Ground	N/A
8	Lightbar + 12V (ignition)	N/A
9	Not Used	N/A
10	Not Used	N/A
11	Check Engine Telltale	Ground
12	Engine Protection Telltale	Ground
13	Right Turn Signal	+12V
14	High Beam Telltale	+12V
15	Trailer ABS Telltale	Ground
16	Optional Telltale #1	Ground
17	Intake Heater	Ground
18	Left Turn Signal	+12V
19	Air Filter Restriction Telltale	Ground
20	Low Air	Ground
21	Tractor ABS Telltale	Ground
22	Park Brake	Ground

Table 5, Light Bar Connector E3 Pin Identification

Light Bar Connectors E1 and E2 (NGI BUS)	
Cavity	**Circuit Description**
Pin 1	NGI Power (+ 7.6VDC)
Pin 2	NGI Ground
Pin 3	NGI Bus Positive (+)
Pin 4	NGI Bus Negative (-)
Pin 5	Backlight Ground
Pin 6	Backlight Power

Table 6, Lightbar Connectors E1 and E2 Pin Identification

See **Fig. 4** for the Packard dash harness to instrument cluster connectors.

See **Fig. 5** for the NGI Interface Schematic.

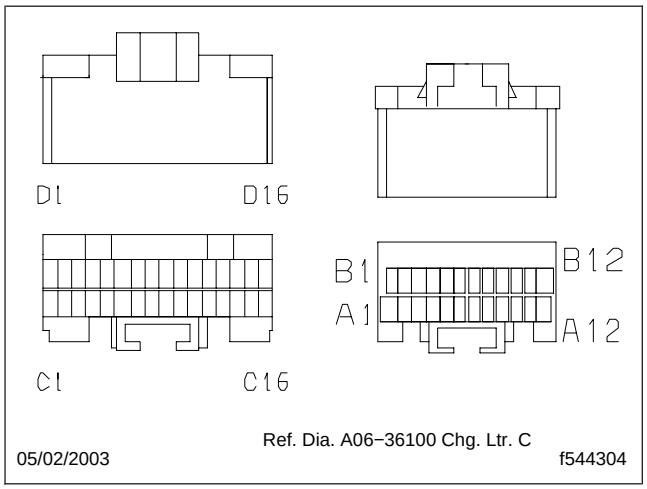


Fig. 4, Packard Connectors, Dash Harness to Instrument Cluster (dash side shown)

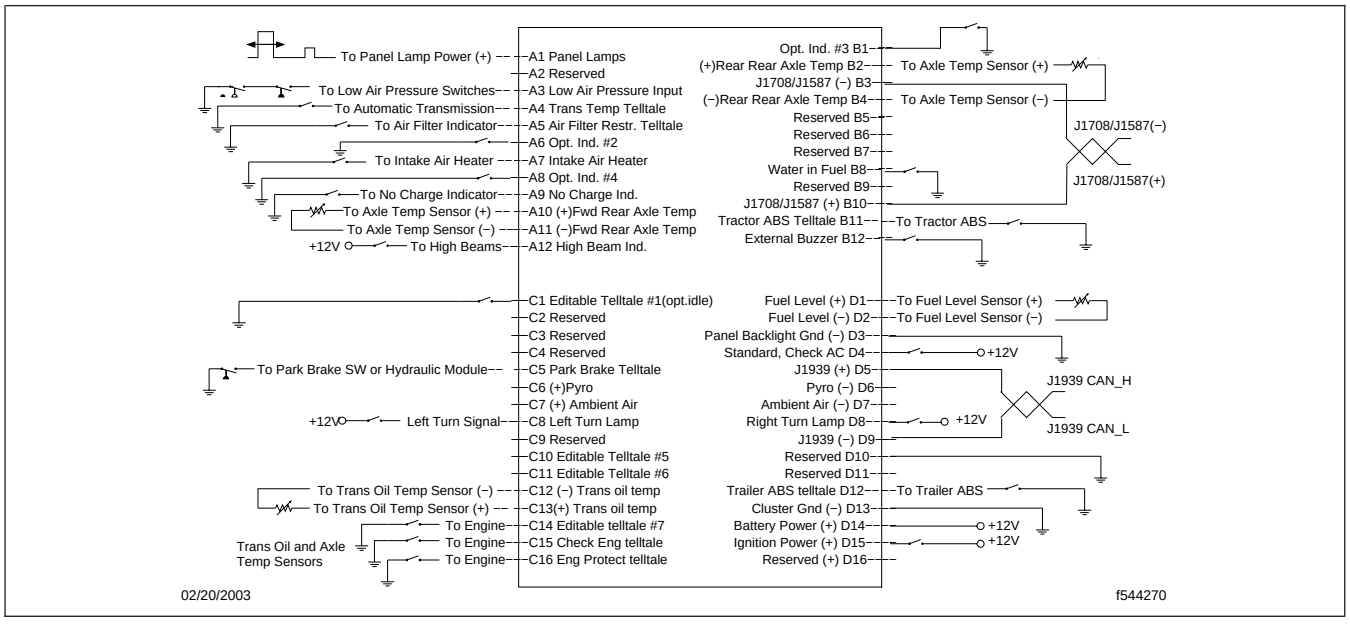


Fig. 5, NGI Interface Schematic

NGI Cluster to Vehicle Interface Connector Pinouts		
Pin	**Designation**	**Description**
A 1	(+) Panel Lamps	Panel backlight power from pulse width modulator (PWM) dimmer switch.
A 2	Reserved	N/A
A 3	Low Air Pressure Input	Closed (ground) turns off buzzer and lamp. Open (float) turns on buzzer and lamp.

Specifications

NGI Cluster to Vehicle Interface Connector Pinouts		
Pin	**Designation**	**Description**
A 4	Trans Temp Telltale	Ground activated telltale.
A 5	Air Filter Restr. Telltale	Ground activated telltale.
A 6	Opt. Ind. #2	Optional ground activated telltale (ignition off).
A 7	Intake Air Heater	Ground activated telltale. (standard)
A 8	Opt. Ind. #4	Optional ground activated telltale.
A 9	No Charge Ind.	Optional Ground activated telltale.
A 10	(+) Fwd Rear Axle Temp	High side of variable resistance sensor.
A 11	(-) Fwd Rear Axle Temp	Low side of variable resistance sensor. Connected to signal ground.
A 12	High Beam Ind.	12V activated telltale.
B 1	Opt. Ind. #3	Optional ground activated telltale.
B 2	(+) Rear Rear Axle Temp	High side of variable resistance sensor. (Optional)
B 3	J1708/J1587 (-)	J1587 (-)
B 4	(-) Rear Rear Axle Temp	Low side of variable resistance sensor, connected to signal ground. (Optional)
B 5	Reserved	N/A
B 6	Reserved	N/A
B 7	Reserved	N/A
B 8	Water in Fuel	Ground activated telltale.
B 9	Reserved	N/A
B 10	J1708/J1587 (+)	J1587 (+)
B 11	Tractor ABS Telltale	Ground activated telltale.
B 12	External Buzzer	Ground activated, warning enabled.
C 1	Editable Telltale #1 (opt. idle)	Ground activated telltale. (Opt. Idle has highest priority)
C 2	Reserved	N/A
C 3	Reserved	N/A
C 4	Reserved	N/A
C 5	Park Brake Telltale	N/C switch = brake on (input grounded); sw open = brake off (input floating).
C 6	(+) Pyro	High side of pyrometer amplifier output. (reserved)
C 7	(+) Ambient Air	High side of variable resistance thermistor. (reserved)
C 8	Left Turn Lamp	12V activated telltale.
C 9	Reserved	N/A
C 10	Editable Telltale #5	Optional ground activated telltale.
C 11	Editable Telltale #6	Optional ground activated telltale.
C 12	(-) Tran Oil Temp	Low side of variable resistance sensor.

NGI Cluster to Vehicle Interface Connector Pinouts		
Pin	**Designation**	**Description**
C 13	(+) Tran Oil Temp	High side of variable resistance sensor.
C 14	Editable Telltale #7	Optional ground activated telltale.
C 15	Check Eng Telltale	Ground activated telltale.
C 16	Engine Protection Telltale	Ground activated telltale.
D 1	Fuel Level (+)	High side of variable resistance fuel level sensor.
D 2	Fuel Level (-)	Low side of variable resistance fuel level sensor.
D 3	(-) Panel Backlight Ground	Ground for panel backlight.
D 4	Standard, Check A/C	12V activated telltale.
D 5	J1939 (+)	Not used
D 6	Pyro (-)	Low side of pyrometer amplifier output.
D 7	Ambient Air (-)	Low side of variable resistance thermistor.
D 8	Right Turn Telltale	12 V and micro activated telltale.
D 9	J1939 (-)	Not used.
D 10	Reserved	N/A
D 11	Reserved	N/A
D 12	Trailer ABS Telltale	Ground activated telltale.
D 13	Cluster Ground (-)	Ground for NGI Cluster.
D 14	Battery Power(+)	Constant 12V to cluster.
D 15	Ignition Power (+)	Ignition switched + 12V to cluster.
D 16	Reserved	N/A

Table 7, Connector Pin-out

Telltale Drive Functionality						
Telltale	**Drive**	**Connection**	**Active State**	**Location**	**Cleaning Current**	**Vehicle Interface PIN #**
Left Turn Signal	Discrete	Lightbar	High	Std. Lightbar	No	C8
Right Turn Signal	Discrete	Lightbar	High	Std. Lightbar	No	D8
Check Engine	Discrete	Lightbar	Low	Std. Lightbar	Yes	C15
Engine Protect	Discrete	Lightbar	Low	Std. Lightbar	Yes	C16
Fasten Seat Belt	Logic	N/A	N/A	Std. Lightbar	N/A	N/A
High Beam	Discrete	Lightbar	High	Std. Lightbar	No	A12
Tractor ABS	Discrete	Lightbar	Low	Std. Lightbar	Yes	B11
Trailer ABS	Discrete	Lightbar	Low	Std. Lightbar	Yes	D12
Parking Brake	Discrete	SCU and Lightbar	Low	Std. Lightbar	Yes	C5

Specifications

Telltale Drive Functionality						
Telltale	**Drive**	**Connection**	**Active State**	**Location**	**Cleaning Current**	**Vehicle Interface PIN #**
Air Intake Restriction	Discrete	Lightbar	Low	Std. Lightbar	Yes	A5
Water in Fuel	Discrete	SCU	Low	Std. Lightbar	Yes	B8
Intake Heater	Discrete	Lightbar	Low	Std. Lightbar	Yes	A7
Check A/C	Discrete	SCU	High	Std. Lightbar	No	D4
Low Air Pressure	Discrete	SCU and Lightbar	Low	Std. Lightbar	Yes	A3
High Coolant Temp	Data Bus	N/A	N/A	Gauge	N/A	N/A
Low Oil Pressure	Data Bus	N/A	N/A	Gauge	N/A	N/A
Low Voltage	Data Bus	N/A	N/A	Gauge	N/A	N/A
No Charge	Discrete	SCU	Low	Gauge	N/A	A9
Trans Temp	Discrete	SCU	Low	Gauge	No	A4
Opt. #1 Editable (Amber LED)	Discrete	Lightbar	Low	Opt. Lightbar	Yes	C1
Opt. #2 Editable (Bulb)	Discrete	Lightbar	Low	Opt. Lightbar	Yes	A6
Opt. #3 Editable (Bulb)	Discrete	Lightbar	Low	Opt. Lightbar	Yes	B1
Opt. #4 Editable (Bulb)	Discrete	Lightbar	Low	Opt. Lightbar	Yes	A8
Opt. #5 Editable (Bulb)	Discrete	Lightbar	Low	Opt. Lightbar	Yes	C10
Opt. #6 Editable (Bulb)	Discrete	Lightbar	Low	Opt. Lightbar	Yes	C11
Opt. #7 Editable (Bulb)	Discrete	Lightbar	Low	Opt. Lightbar	Yes	C14
Opt. Data Bus Gauges per Sec 1.2.3	Data Bus	N/A	N/A	Gauge	N/A	N/A
Opt. Sensor Gauges per Sec 1.2.3	SCU	N/A	N/A	Gauge	N/A	N/A

Table 8, Telltale Drive Functionality

Stewart Warner Fuel Sensor Resistance Values			
Meter Indication	**Resistance: ohms**		
	Minimum	**Nominal**	**Maximum**
Empty Stop	244.0	246.50	249.0
Empty	232.0	235.60	239.2
1/8		193.80	
1/4	149.6	152.10	154.5
3/8		127.50	
1/2	102.5	103.00	103.5
5/8		85.00	
3/4	66.2	67.00	67.8
7/8		48.50	

Stewart Warner Fuel Sensor Resistance Values			
Meter Indication	Resistance: ohms		
	Minimum	Nominal	Maximum
Full	29.4	30.00	30.6

Table 9, Stewart Warner Fuel Sensor Resistance Values

High-Stat Oil Temperature Sensor Resistance Values				
Temp °F	Temp °C	Resistance: ohms		
		Minimum	Nominal	Maximum
-40	-40	291,490	336,600	381,710
-4	-20	85,850	97,120	108,390
14	-10	49,250	55,340	61,430
32	0	29,330	32,660	35,990
50	10	17,990	19,900	21,810
68	20	11,370	12,490	13,610
77	25	9,120	10,000	10,880
86	30	7,370	8,060	8,750
104	40	4,900	5,325	5,750
122	50	3,330	3,605	3,880
140	60	2,310	2,490	2,670
158	70	1,630	1,750	1,870
176	80	1,170	1,255	1,340
194	90	860	915	970
212	100	640	680	720
230	110	480	510	540
248	120	370	390	410
266	130	282	300	318
284	140	219	234	249
302	150	170	185	200
311	155	150	165	180
320	160	130	145	160
329	165	115	130	145
338	170	105	120	135
347	175	90	105	120
356	180	80	95	110

Table 10, High-Stat Oil Temperature Sensor Resistance Values

Specifications

Lightbar Schematic (pins are on vehicle interface connectors)						
Pin C1 Opt 1 LED	Pin A6 Opt 2 Incandescent	Pin B1 Opt 3 Incandescent	Pin A8 Opt 4 Incandescent	Pin C10 Opt 5 Incandescent	Pin C11 Opt 6 Incandescent	Pin C14 Opt 7 Incandescent
Pin C8 Left Turn	Pin A5 Air Filter	Pin A7 Intake Heater	Fasten Seatbelt	Pin B8 Water in Fuel	Pin C5 Park Brake	Pin B8 Right turn
Pin C15 Check Engine	Pin C16 Engine Protect	Pin D4 Check A/C	Pin A12 High Beam	Pin B11 Tractor ABS	Pin D12 Trailer ABS	Pin A3 Low Air Pressure

Table 11, Lightbar Schematic

Message Identifiers (MIDs)		
MID	**Description**	**Text Message**
128	Engine Control Unit	ECU128
130	Transmission Control Unit	TCU130
136	Antilock Brake System (ABS)	ABS136
140	Instrumentation Control Unit	ICU140
223	Transmission Shift Unit	TSU223
###	Generic MID	SYS###

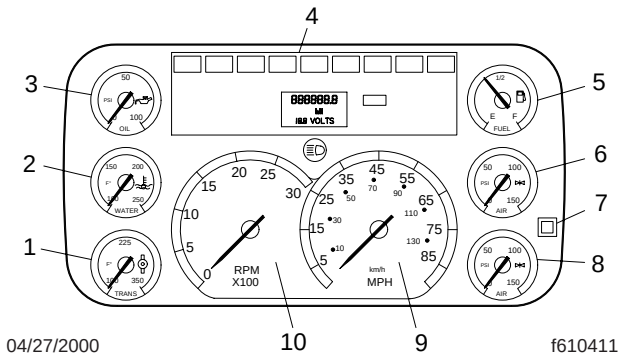
Table 12, Message Identifiers (MIDs)

General Information

Instrumentation Control Unit (ICU3)

The instrumentation control unit (ICU3) is a basic electronic dashboard that accepts input from the fuel level sensor, the transmission temperature sensor (if installed), and the J1587 datalink. The information is processed by a micro-computer and displayed on electronic gauges driven by stepper motors. Air gauges operate mechanically.

The speedometer and tachometer are large-faced electronic gauges located below the dash message center. See **Fig. 1**.



1. Transmission Fluid Temperature Gauge
2. Coolant Temperature Gauge
3. Engine Oil Pressure Gauge
4. Dash Message Center
5. Fuel Level Gauge
6. Primary Air Pressure Gauge
7. Optional Mode/Reset Push Button
8. Secondary Air Pressure Gauge
9. Speedometer
10. Tachometer

Fig. 1, ICU3 Gauge Layout (typical)

The other gauges are small-faced and located to either side of the speedometer and tachometer. The engine oil pressure, coolant temperature, transmission fluid temperature and fuel level gauges are electronic; the air pressure gauges are mechanical. The ICU3 can not drive gauges located on the auxiliary instrument panel.

A transmission fluid temperature gauge is required on vehicles with automatic transmissions.

The following items are replaceable:

- air pressure gauges
- light bulbs
- lens/mask assembly
- mode/reset button
- top row warning and indicator lenses
- back cover

Dash Message Center

The dash message center has two parts: a dash driver display screen and a set of 26 warning and indicator lights similar to those found on a conventional lightbar.

Dash Driver Display

The dash driver display screen is a 1-line by 7-character liquid crystal display (LCD) that is normally used to display the odometer reading. In addition, there is a separate voltmeter display underneath the odometer display.

The information that can be provided by the message center includes:

- Odometer readings;
- Trip miles;
- Trip engine hours;
- A listing of active faults.

With the optional Mode/Reset button, you can switch the odometer to display either miles or kilometers, invoke the trip odometer and trip engine hours, and call up diagnostic messages (active faults).

Odometer

The odometer is set to display in either miles or kilometers, depending on the primary scale of the speedometer. The legend, either "MI" or "KM," illuminates between the odometer and the volts display when the engine is running or the headlights are turned on.

The odometer is a seven-digit display with a decimal point, until the vehicle has traveled 999,999.9 miles or kilometers (km). At one million miles (km), the odometer rolls over to "1000000," without the decimal point, and can continue up to 9,999,999. The odometer only displays significant figures (no leading zeros).

General Information

IMPORTANT: The odometer uses data supplied by the engine ECU to update its count. However, it keeps its own mileage (starting at zero) from when it was first installed. The ICU3 odometer will not match the engine ECU odometer if the engine has been operated with the ICU3 disconnected, during factory break-in or engine service, or if the ICU3 has been replaced.

Warning and Indicator Lights

There are spaces on the dash message center for 26 warning and indicator lights. See **Fig. 2** for a typical installation.

There are four rows of lights. The lights in the top row are all optional and may be installed in any order, except for STOP ENGINE (Cummins engines only) and WHEEL SPIN that are typically installed at a fixed position:

NOTE: Positions 1 through 8 are ground-activated circuits. Position 2 can be activated with the ignition switch in the OFF position. Position 9 is power-activated.

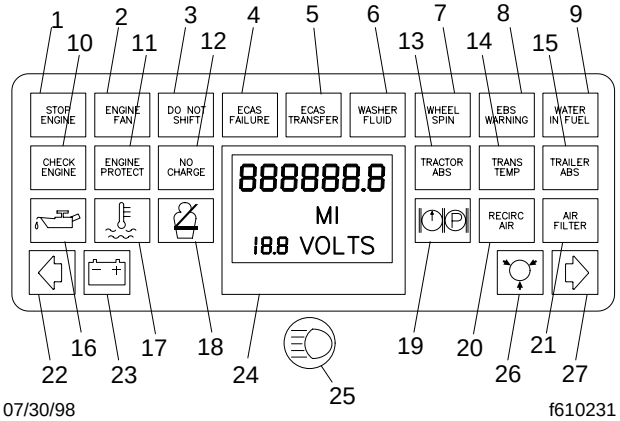
On the other three rows, the lights are installed at fixed positions. Some lights are optional; if an optional light is not requested, the position is blank (does not light up).

All light bulbs are replaceable in the field, including gauge light bulbs and warning/indicator light bulbs.

Buzzer

The buzzer sounds during the ignition sequence and whenever:

- The engine oil pressure falls below the preset level, which is 5 to 9 psi (35 to 60 kPa) on most engines;
- The coolant temperature rises above the preset level, which is 215°F (101°C) on Caterpillar™ engines, 220°F (104°C) on Cummins engines and 189°F (87°C) on MBE900 engines;
- The air pressure falls below the preset level of approximately 70 psi (483 kPa);
- The parking brake is set with the vehicle moving at a speed greater than 2 miles per hour (3 km/h).



1. Stop Engine Warning (Cummins engines only)
2. Engine Fan On Indicator (optional)
3. Do Not Shift Indicator (optional)
4. ECAS Failure Warning (optional)
5. ECAS Transfer Indicator (optional)
6. Low Washer Fluid Indicator (optional)
7. Wheel Spin Indicator (optional)
8. EBS Warning (optional)
9. Water In Fuel Indicator (optional)
10. Check Engine Indicator
11. Engine Protection Warning
12. Alternator No Charge Indicator (optional)
13. Tractor ABS Warning
14. Transmission Temperature Warning (optional)
15. Trailer ABS Warning (optional)
16. Low Engine Oil Pressure Warning
17. High Coolant Temperature Warning
18. Fasten Seat Belt Warning
19. Parking Brake On Warning
20. Recirculated Air Indicator
21. Air Restriction Indicator (optional)
22. Left Turn Signal
23. Low Battery Voltage Warning
24. Dash Driver Display Screen
25. High Beams On Indicator
26. Low Air Pressure Warning
27. Right Turn Signal

Fig. 2, ICU3 Dash Message Center

Ignition Sequence

NOTE: If the headlights are turned on, the screen displays the odometer and waits for the ignition to be turned on.

When the ignition is turned on, the ICU3 performs a self-test, looking for active faults. All the electronic gauges complete a full sweep of their dials, the warning and indicator lights light up and the buzzer

sounds for 3 seconds. During the first half of the self-test, all segments of the driver dash display screen illuminate as follows: "888888.8." During the second half of the self-test, the software revision level is displayed.

NOTE: The engine and ABS warning lights go on during the ICU3 self-test, but they are not controlled by the ICU3. They are controlled by their own system electronic control unit (ECU).

If the ICU3 receives active fault codes from other devices, the screen displays a three-letter acronym and message identifier (MID), indicating the ECU or system that is not functioning properly. For a list of MIDs, see **Mode/Reset Switch Functions 410**. Each active fault is displayed for 3 seconds, one after the other, until the parking brake is released or the ignition is turned off. Once the parking brake is released, the screen displays the odometer. If there are no active faults, the screen displays the odometer.

NOTE: If the ICU3 receives a message from an ECU that has not been pre-programmed into the ICU3's memory, it displays "SYS ###", where ### is replaced by the MID of the broadcasting device.

Replacement

CAUTION

Electronic components of the ICU3 are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU3 circuitry.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Disconnect the batteries.

WARNING

Drain all air from the compressed air tanks before trying to remove the air hoses. Failure to do so can cause the hoses to move uncontrollably when disconnected, possibly causing personal injury or equipment damage.

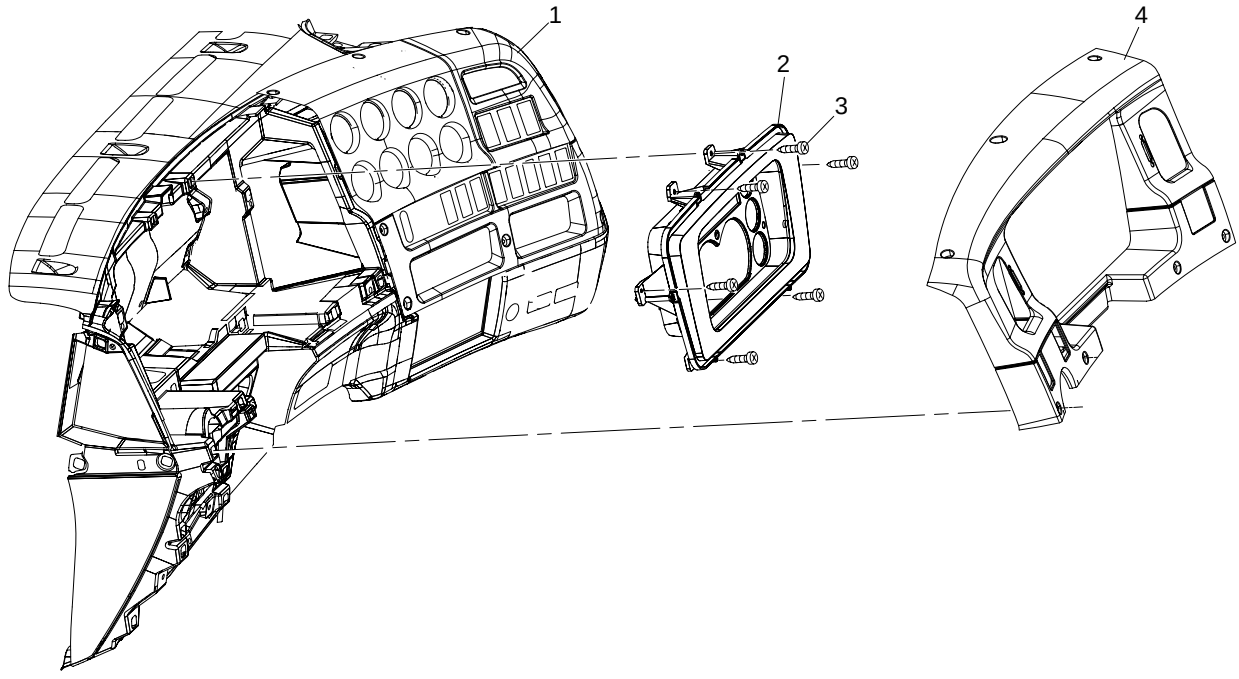
3. Drain the air system.
4. Remove the driver side finish panel. For instructions, see **Section 60.01**.
5. Remove the ICU3 mounting fasteners. See **Fig. 1**.

CAUTION

Do not forcibly pull the ICU3 from the dash. This may dislodge wires from the harness electrical connectors on the back of the ICU3 and damage the wires, the ICU3 or the dash.

6. Tilt the ICU3 away from the dash.
7. Disconnect the connectors from the back of the ICU3.
   - 7.1 Disconnect the two electrical connectors.
   - 7.2 Disconnect the air pressure lines from the brass fittings.
8. Remove the ICU3 from the vehicle.
9. Position the ICU3 on the dash.
10. Connect the connectors to the back of the ICU3.
    - 10.1 Connect the air pressure lines to the brass fittings.
    - 10.2 Connect the two electrical connectors.
11. Install the ICU3 mounting fasteners.
12. Install the driver side finish panel. For instructions, see **Section 60.01**.
13. Connect the batteries.
14. Turn on the ignition and test the operation of the ICU3.
15. Remove the chocks from the rear tires.

Instrument Control Unit (ICU3) Replacement



1. Instrument Panel
2. Instrument Cluster
3. Fasteners
4. Driver Side Finish Panel

Fig. 1, Instrument Cluster Mounting

Replacement

CAUTION

Electronic components of the instrumentation control unit (ICU3) are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU3 circuitry.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Disconnect the batteries.

WARNING

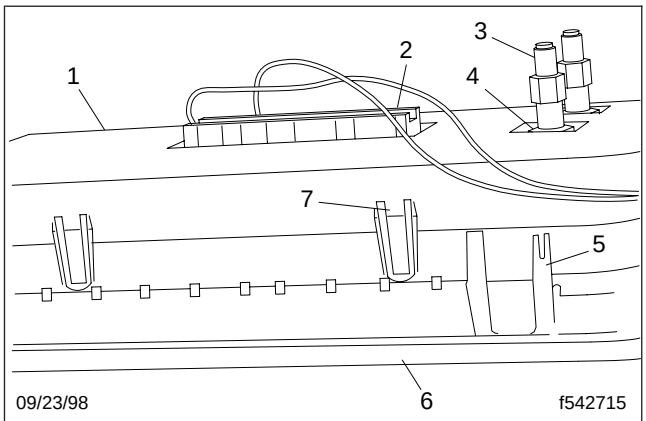
Drain all air from the compressed air tanks before trying to remove the air hoses. Failure to do so can cause the hoses to move uncontrollably when disconnected, possibly causing personal injury or equipment damage.

3. Drain the air system.
4. Remove the ICU3. For instructions, see **Subject 100**.

CAUTION

Use extreme care to avoid breaking the clips when prying them off the ICU housing. The clips are under tension and are easy to damage.

5. Using a thin-bladed screwdriver, very carefully pry the nine large white clips away from the sides of the ICU3 housing. It is helpful to use a small thin piece of metal, such as a spade terminal, to hold each clip away from the housing after it has been gently levered off its pawl. Remove the bezel from the ICU3 housing. See **Fig. 1**.
6. From the back of the ICU3 housing, remove the quick-disconnect fitting and nut from the threaded tube coming out the back of the air gauge.
7. Remove the air gauge from the ICU3.



1. ICU3 Housing
2. Electrical Connector
3. Quick-Disconnect Fitting
4. Nut
5. Bezel Clip (white)
6. Bezel
7. Back Cover Clip (black)

Fig. 1, Air Pressure Gauge Installation

8. Remove the air gauge fitting from the air gauge.
9. Install the air gauge fitting on the new air gauge.
10. Install the air gauge.
    - 10.1 Insert the gauge into the hole in the ICU3 housing.
    - 10.2 Tighten the nut on the threaded tube.
    - 10.3 Install the quick-disconnect fitting.
11. Position the bezel on the ICU3 housing. Fasten the nine white clips to the sides of the ICU3 housing.
12. Install the ICU3. For instructions, see **Subject 100**.
13. Connect the batteries.
14. Start the engine and verify the proper operation of the new gauge as the air pressure builds up.
15. Remove the chocks from the tires.

Replacement

CAUTION

Electronic components of the ICU3 are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with ICU3 circuitry.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Disconnect the batteries.

WARNING

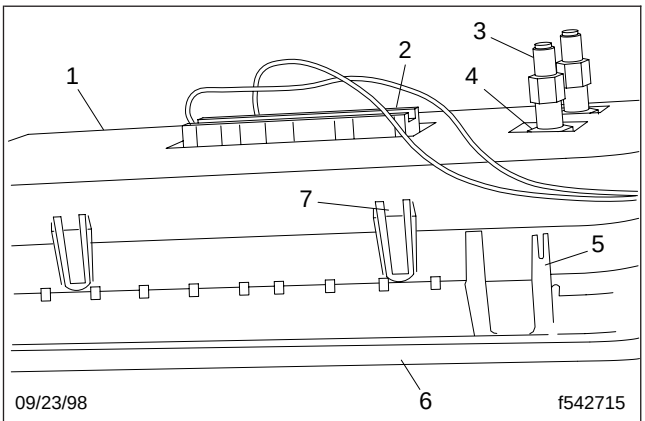
Drain all air from the compressed air tanks before trying to remove the air hoses. Failure to do so can cause the hoses to move uncontrollably when disconnected, possibly causing personal injury or equipment damage.

3. Drain the air system.
4. Remove the ICU3. For instructions, see **Subject 100**.

CAUTION

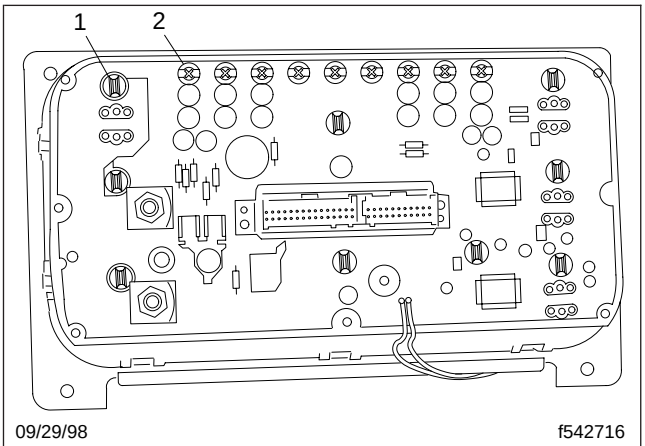
Use extreme care to avoid breaking the clips when prying them off the ICU housing. The clips are under tension and are easy to damage.

5. Pry off the four small black clips from the sides of the ICU3 housing. See **Fig. 1**.
6. Remove the two screws from the back of the housing, one on the middle of each side, and remove the back cover from the ICU3 housing.
7. Remove the burned out light bulb(s). See **Fig. 2**.
   - 7.1 To remove gauge light bulbs, twist the bulb base a quarter-turn counterclockwise and pull out.
   - 7.2 To remove warning/indicator light bulbs, use a small screwdriver to twist out the bulb base behind the affected light.



1. ICU3 Housing
2. Electrical Connector
3. Quick-Disconnect Fitting
4. Nut
5. Bezel Clip (white)
6. Bezel
7. Back Cover Clip (black)

Fig. 1, Back Cover Installation



1. Gauge Light Bulb Base
2. Warning and Indicator Light Bulb Base

Fig. 2, Light Bulb Installation

8. Install the new light bulb(s).
   - 8.1 To install gauge light bulbs, twist the bulb holder into the slot from which the old one was removed.
   - 8.2 To install warning/indicator light bulbs, insert the new bulb base into the proper slot and use a small screwdriver to tighten it.

Light Bulb Replacement

NOTE: Light emitting diodes (LEDs) must be installed with correct polarity. Insert the LED into the socket, rotating and pushing gently until it touches the contacts. If it lights, push it the rest of the way into the socket. Otherwise, pull it out, rotate it a half-turn, and check for lighting again. If it still does not light, you need to push it further into the socket, the socket is not getting power, or you may have a bad LED.

9. Position the back cover on the ICU3 housing. Fasten the four black clips to the sides of the ICU3 housing.
10. Install the two screws on the back of the housing, one on the middle of each side.
11. Install the ICU3. For instructions, see **Subject 100**.
12. Connect the batteries.
13. Turn on the ignition. Check all bulbs for correct operation.
14. Remove the chocks from the tires.

Fuel Level Gauge Diagnosis

The fuel level gauge is controlled by the ICU using a variable resistance input from the fuel level sending unit that is located in the fuel tank. The fuel level sending unit resistance varies linearly from 31±2Ω with a full tank to 247±3Ω when empty.

If the ICU3 is measuring a resistance greater than 284Ω between circuit 47 and ground, a fault will be set for fuel level circuit open. If the ICU3 is measuring less than 23.5Ω between circuit 47 and ground, a fault will be set for fuel level circuit shorted low. ServiceLink may be used to monitor for these faults. The gauge will read empty until the measurement from the sensor is between 284Ω and 23.5Ω. Refer to **Table 1** for the fuel level diagnostic procedure.

NOTE: If the fuel level sensor is below the minimum resistance (short to ground) or above the maximum (open), the fuel gauge will read empty. Shorting the fuel sensor wires will not drive the gauge to full scale.

Fuel Level Gauge Diagnosis

Step	Test Procedure	Test Result	Action
1	If a 100 ohm resistor is available, disconnect the fuel level sender connector and place the resistor across circuit 47 and ground in the wiring harness connector to simulate the fuel level sending unit. Turn the ignition to the ON position and observe the fuel gauge. If, after gauge initialization, the gauge points closely to the half tank mark, then the wiring and ICU are all operating correctly. Jump to Step 4 if there is no problem with the wiring and ICU. Does the fuel level gauge stay at empty even though there is fuel in the tank or is the complaint an inaccurate and intermittent reading? Note - turn the ignition to OFF and disconnect the batteries before continuing.	Stays at Empty	Go to Step 2.
		Inaccurate or Intermittent	Go to Step 4.
2	Disconnect the connector at the fuel level sender and measure the resistance of the sender. What is the resistance of the sender?	Greater than 284Ω or Less than 23.5Ω	Go to Step 4.
		Between 284Ω and 23.5Ω	Go to Step 3.
3	Connect the fuel level sender and disconnect the connectors on the back of the ICU. Measure the resistance in the vehicle wiring between circuit 47 in connector pin D1 and the ground circuit in connector pin D2. What is the resistance of the circuit?	Greater than 284Ω	Troubleshoot and repair an open circuit on either circuit 47 or the ground between the ICU connector and the fuel level sender.
		Between 284Ω and 23.5Ω	This is the valid resistance range. If the fuel tank is full and the resistance is close to 31Ω, replace the ICU. Otherwise no problem is indicated.
		Less than 23.5Ω	Troubleshoot and repair a short to ground on circuit 47 between the ICU connector and the fuel level sender.

Troubleshooting

Fuel Level Gauge Diagnosis			
Step	**Test Procedure**	**Test Result**	**Action**
4	Remove the fuel sending unit from the fuel tank. Connect an ohm meter to the pins at the fuel level sender connector. Slowly move the level of the float arm from full to empty. See **Fig. 1**. Does the resistance vary linearly from 31±2Ω to 247±3Ω?	Yes	Troubleshoot and repair for corrosion or an intermittent connection in the circuitry between the ICU and the fuel level sender.
		No	Replace the fuel level sending unit.

Table 1, Fuel Level Gauge Diagnosis

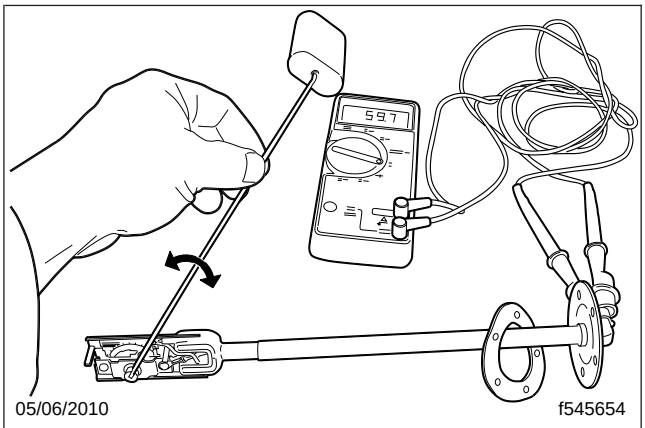


Fig. 1, Testing the Fuel Level Sending Unit

Specifications

For vehicle specific ICU3 wiring schematics, look up module 732 BOM in PartsPro to get the correct drawing number, then use EZWiring in ServicePro to access the drawing.

For fuel level wiring schematics, use module 847 BOM in PartsPro to get the correct drawing number, then use EZWiring in ServicePro to access the drawing.

For Stewart-Warner Fuel Level Sensor, Curve Values, see **Table 1**.

For Hi-Stat Temperature Sensor, Curve Value, see **Table 2** and **Table 3**.

Fuel Level Sensor (Stewart-Warner) Resistance		
Gauge Reading	**Sensor Resistance:ohms**	
	Acceptable Range	**Nominal**
Empty Stop	244.0–249.0	246.5
Empty	232.0–239.2	235.6
1/8	190.8–196.9	193.8
1/4	149.6–154.5	152.1
3/8	126.1–129.0	127.5
1/2	102.5–103.5	103.0
5/8	84.4–85.7	85.0
3/4	66.2–67.8	67.0
7/8	47.8–49.2	48.5
Full	29.4–30.6	30.0

Table 1, Fuel Level Sensor (Stewart-Warner) Resistance

Transmission Temperature Sensor (Hi-Stat) Resistance Standard Gauge (°F)		
Gauge Reading (°F)	**Sensor Resistance (OHMS)**	
	Acceptable Range	**Nominal**
125	3135–3678	3419
162.5	1515–1738	1626
200	787–887	837
237.5	434–486	460
275	251–284	276
312.5	147–177	162
350	87–117	102

Table 2, Transmission Temperature Sensor (Hi-Stat) Resistance Standard Gauge (Degrees Farenheit)

Specifications

Transmission Temperature Sensor (Hi-Stat) Resistance Metric Gauge (°C)		
Gauge Reading (°C)	Sensor Resistance (OHMS)	
	Acceptable Range	Nominal
60	2310–2670	2490
80	1170–1340	1255
100	640–720	680
120	370–410	390
140	219–249	234
160	130–160	145
180	80–110	95

Table 3, Transmission Temperature Sensor (Hi-Stat) Resistance Metric Gauge (Degrees Centigrade)

Mode/Reset Switch Functions

Use the following flow charts to cycle through the Mode/Reset switch functions and screens.

See **Fig. 1**, for Mode/Reset Switch Start Sequence.

See **Fig. 2**, for Mode/Reset Switch Trip Screens.

See **Fig. 3**, for Mode/Reset Switch Engine Miles and Service Screens.

See **Fig. 4**, for Mode/Reset Switch Fault Screens.

See **Fig. 5**, for Mode/Reset Switch Service Screens.

See **Fig. 6**, for Mode/Reset Switch Oil Level Screens.

See **Fig. 7**, for Mode/Reset Switch Reset and Toggle Screens.

Service Interval Tables

NOTE: At the appropriate screen, each press of the mode/reset switch advances to the next value in the table.

For service interval miles and kilometers settings, see **Table 1**.

For service interval hours settings, see **Table 2**.

For message identifiers, see **Table 3**.

Service Interval Distance Settings		
Number	**Miles**	**Kilometers**
1	1000	1610
2	1500	2415
3	2000	3220
4	2500	4025
5	3000	4830
6	3500	5635
7	4000	6440
8	4500	7245
9	5000	8050
10	5500	8855
11	6000	9660
12	6500	10465
13	7000	11270
14	7500	12075
15	8000	12880
16	8500	13685
17	9000	14490
18	9500	15295
19	10000	16100
20	11000	17710
21	12000	19320
22	13000	20930
23	14000	22540
24	15000	24150
25	16000	25760
26	17000	27370
27	18000	28980
28	19000	30590
29	20000	32200
30	21000	33810
31	22000	35420
32	23000	37030
33	24000	38640
34	25000	40250

Table 1, Service Interval Distance Settings

Mode/Reset Switch Functions

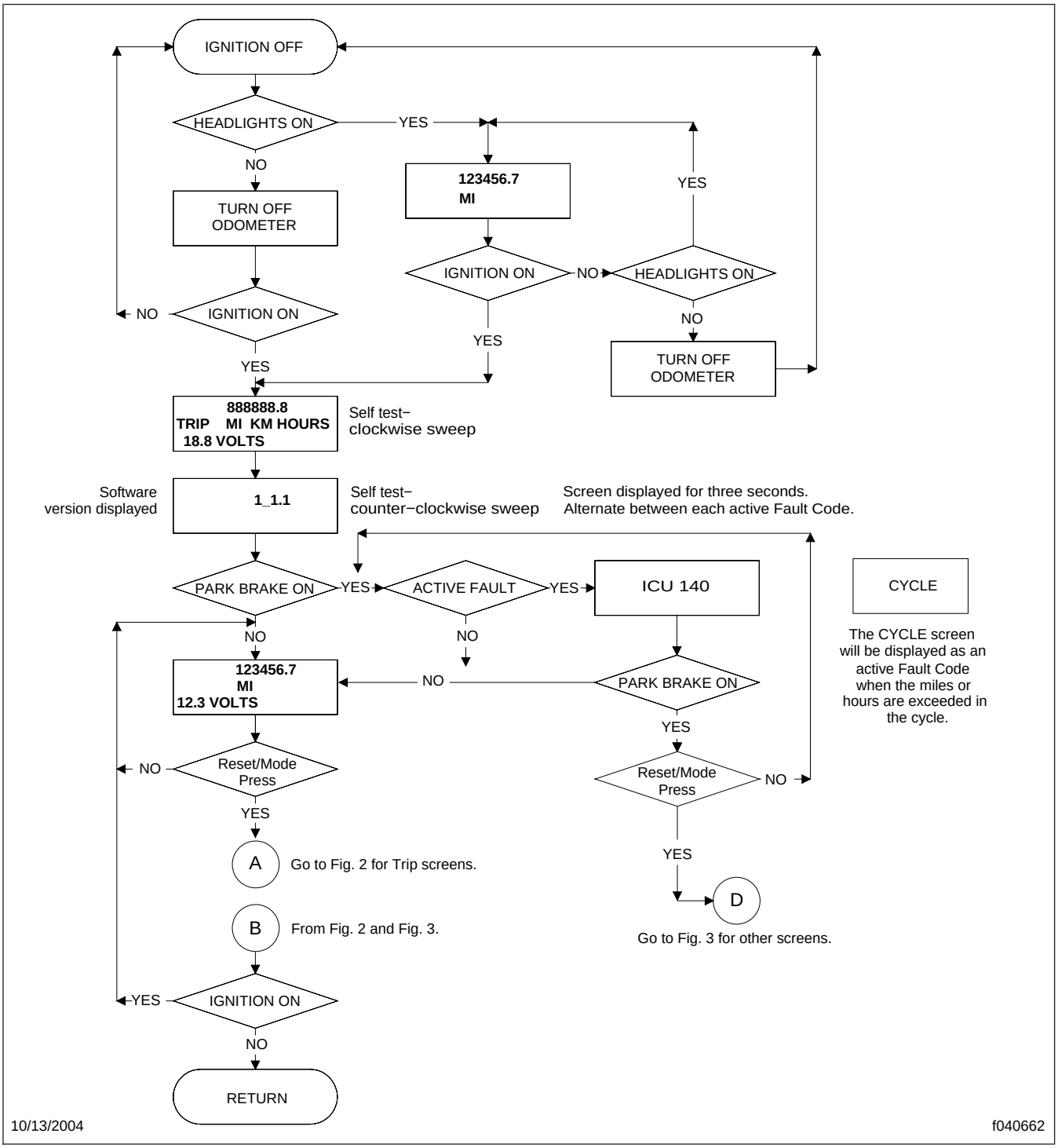


Fig. 1, Mode/Reset Switch Start Sequence

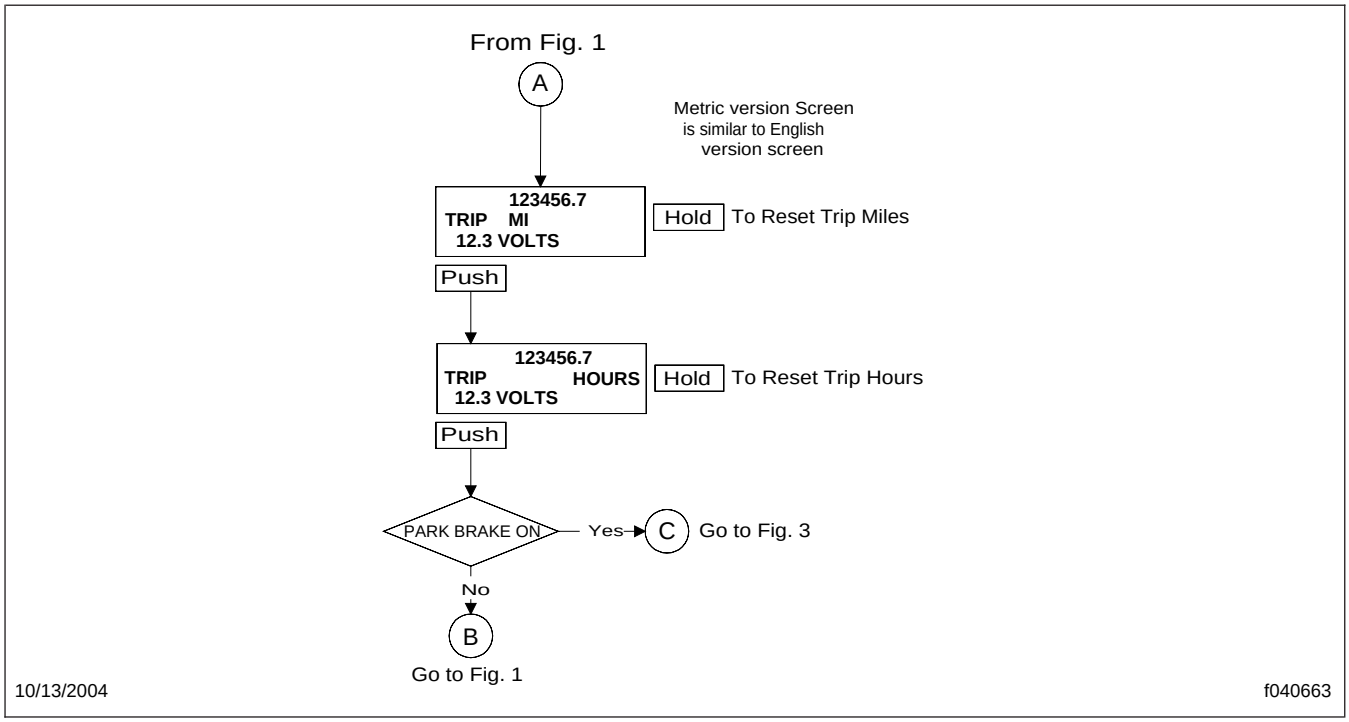


Fig. 2, Mode/Reset Switch Trip Screens

Mode/Reset Switch Functions

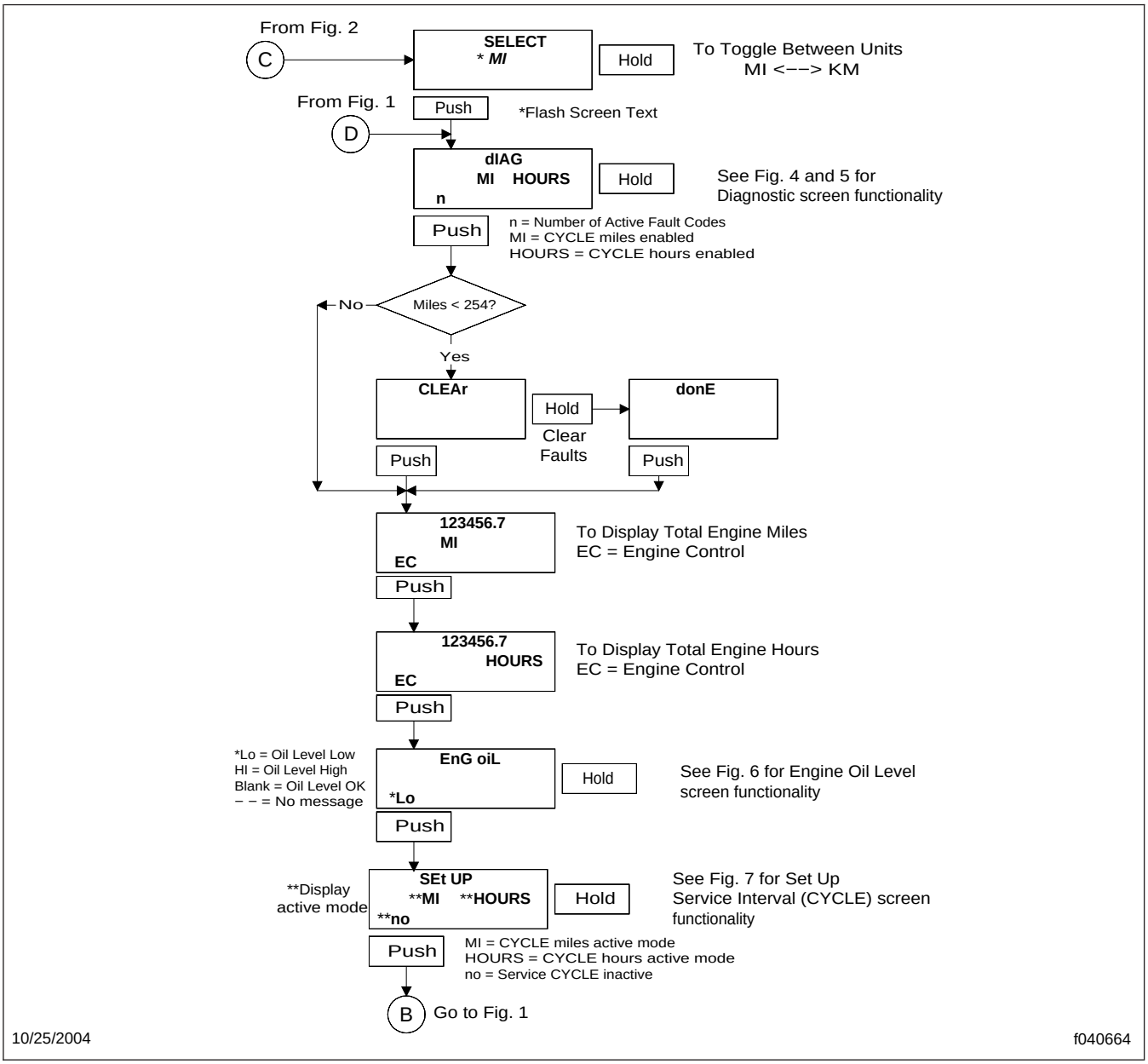


Fig. 3, Mode/Reset Switch Engine Miles and Service Screens

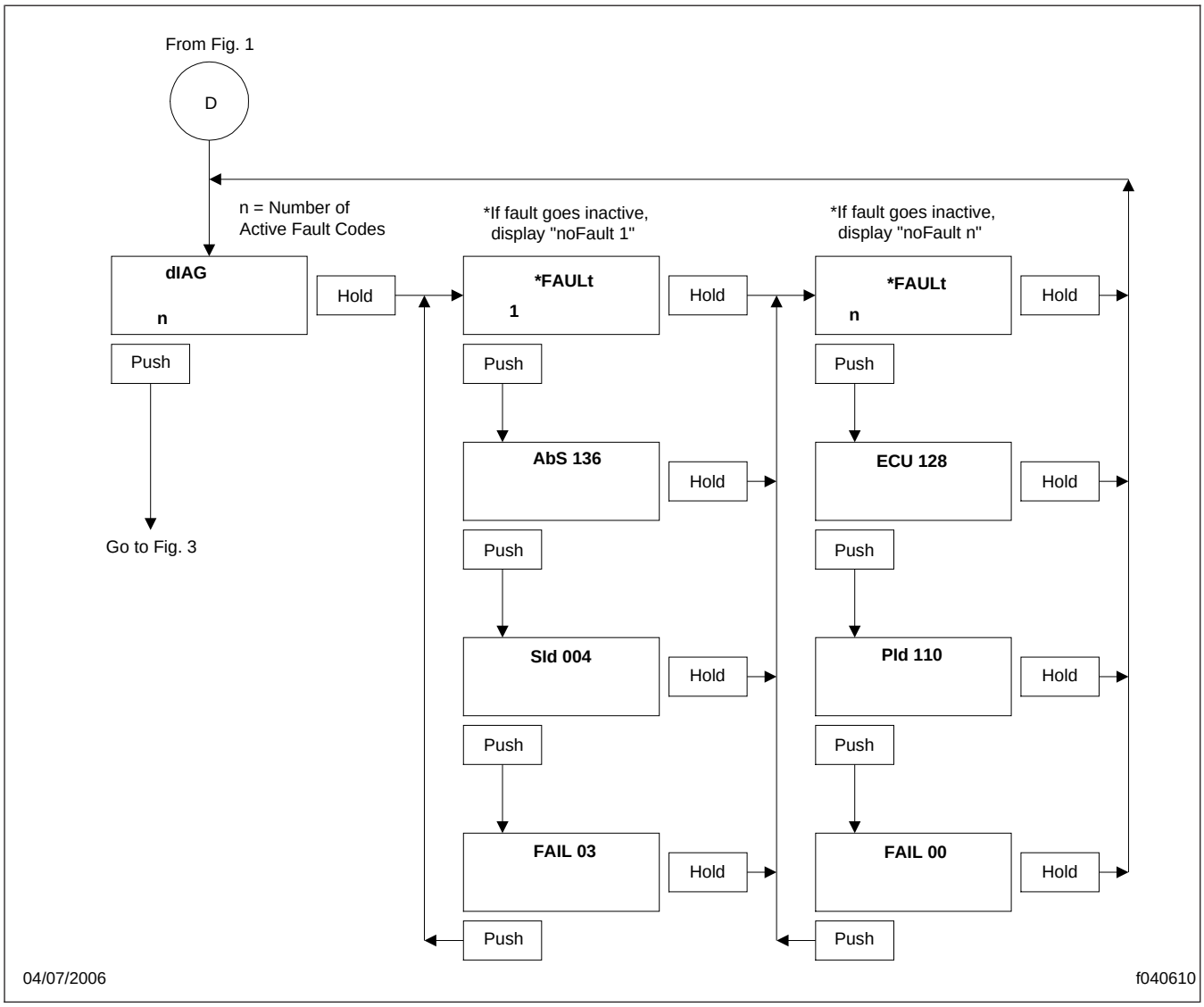


Fig. 4, Mode/Reset Switch Fault Screens

Mode/Reset Switch Functions

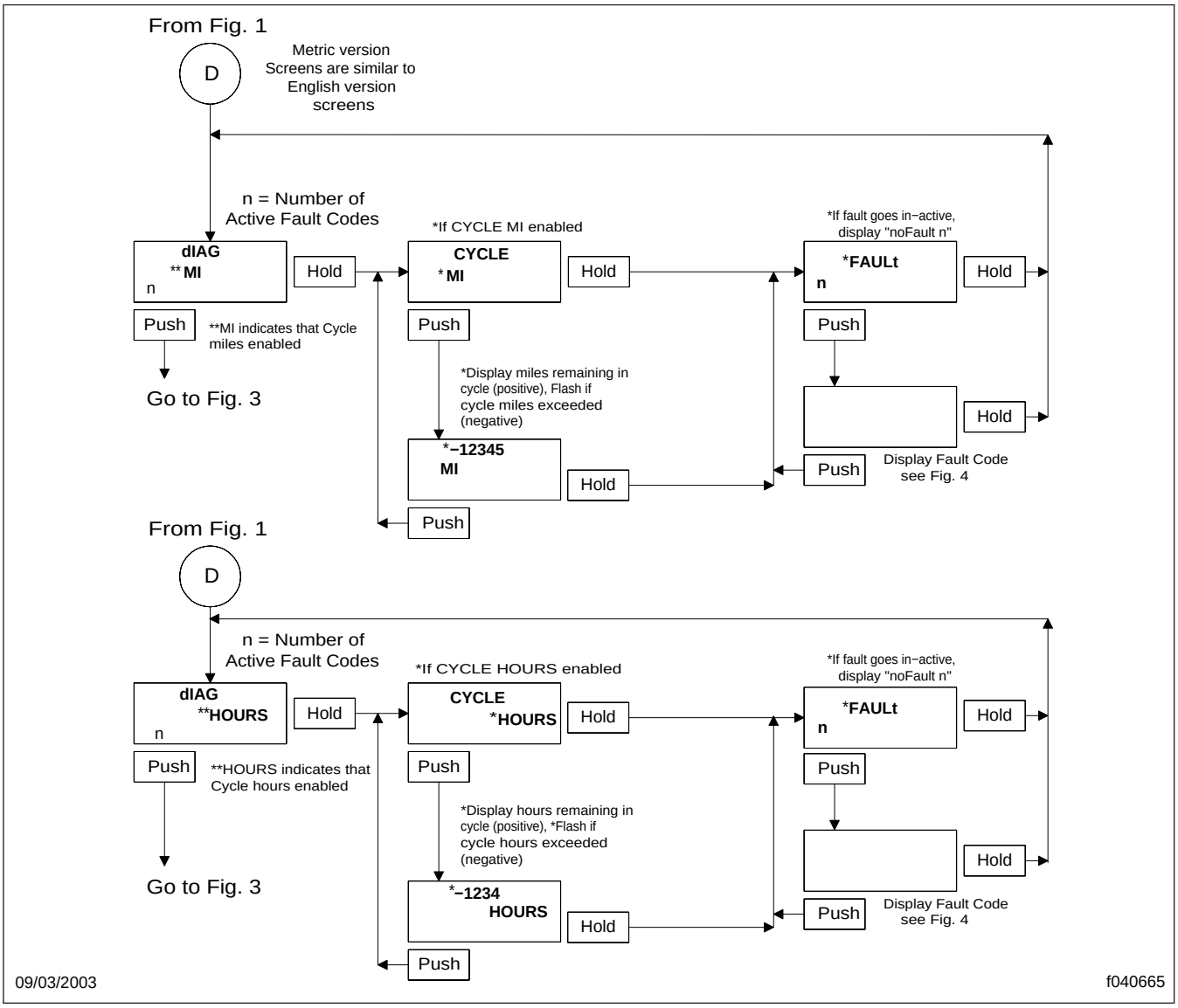


Fig. 5, Mode/Reset Switch Service Screens

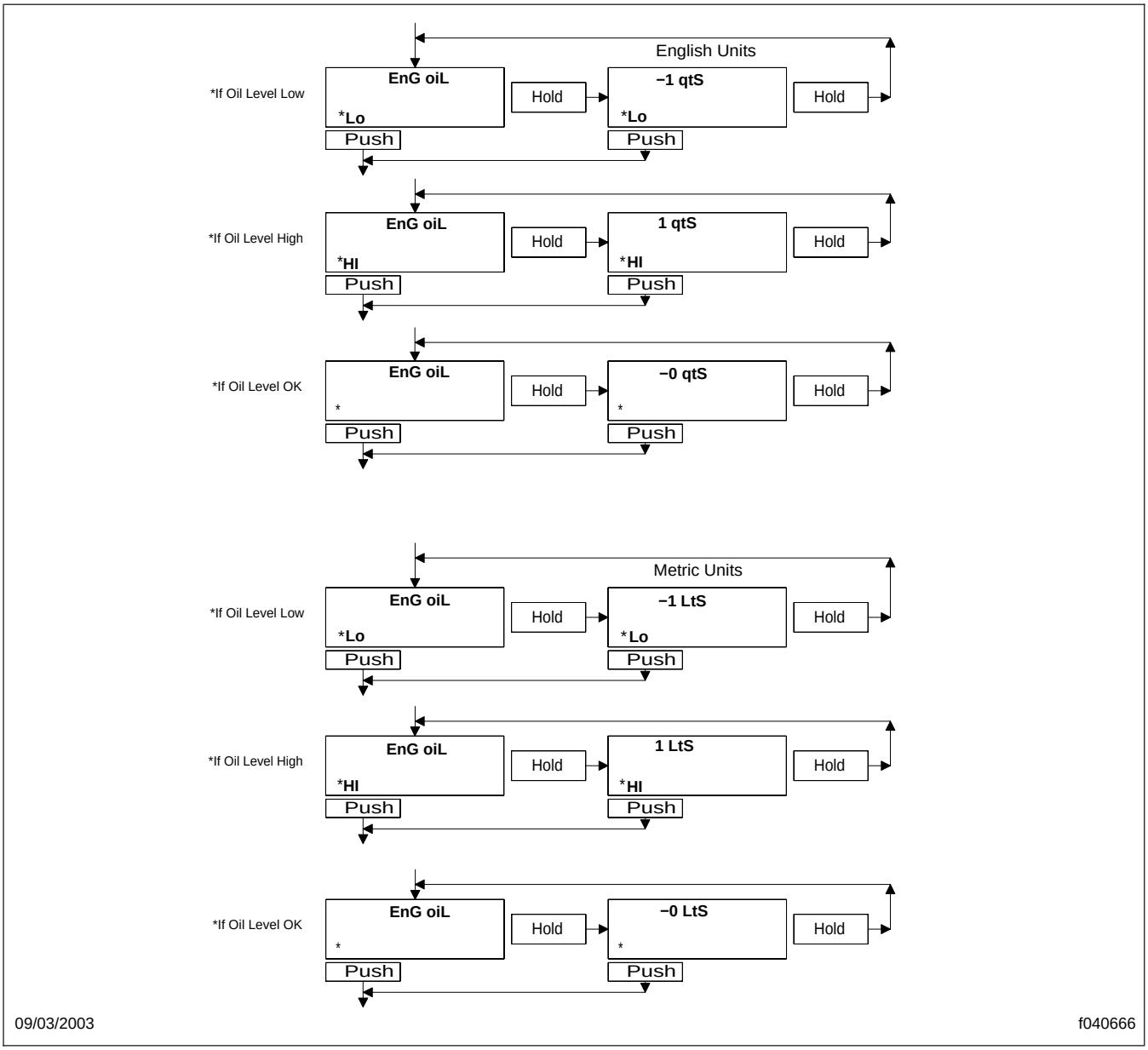


Fig. 6, Mode/Reset Switch Oil Level Screens

Mode/Reset Switch Functions

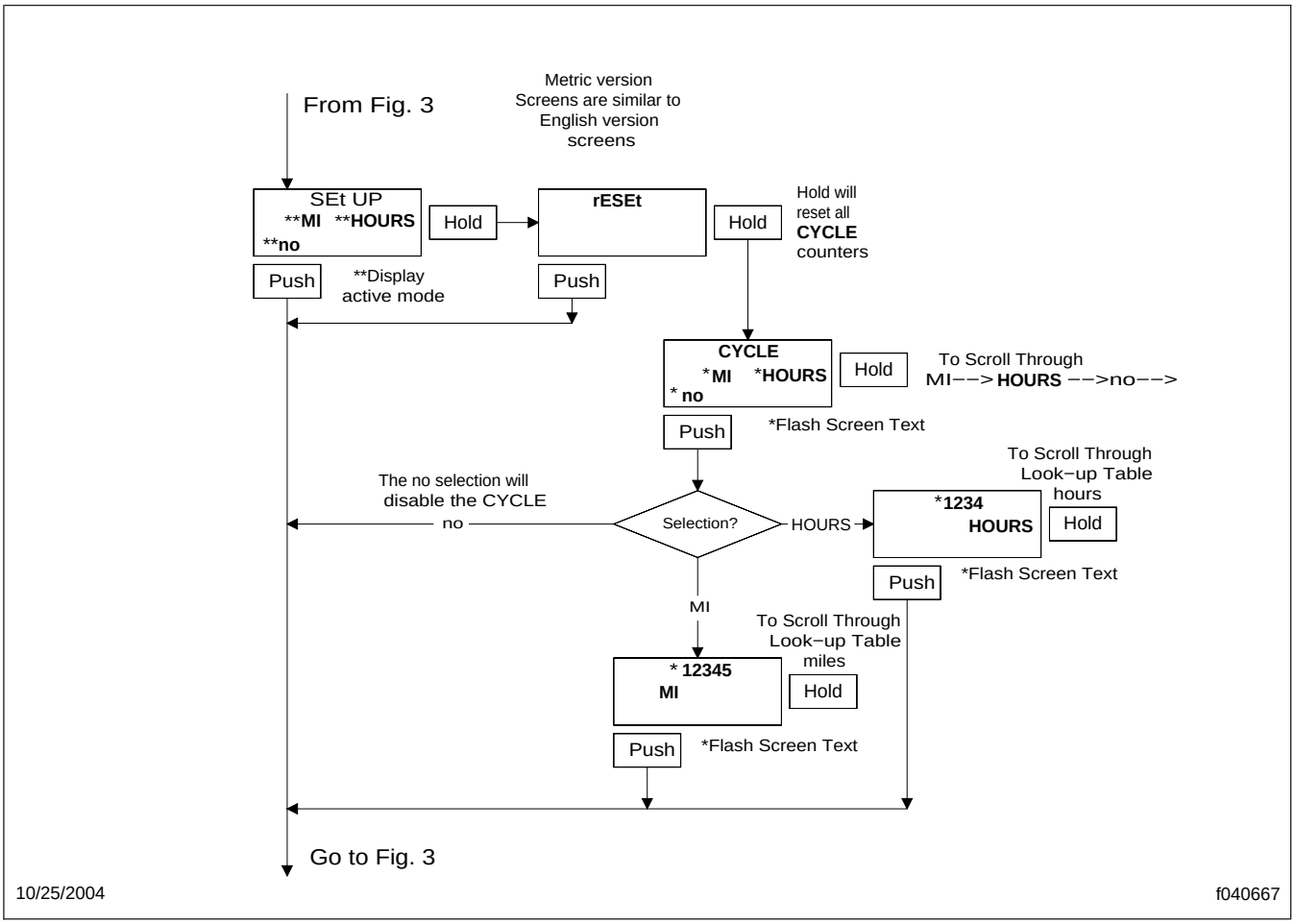


Fig. 7, Mode/Reset Switch Reset and Toggle Screens

Service Interval Hours Settings	
Number	**Hours**
1	50
2	75
3	100
4	125
5	150
6	175
7	200
8	225
9	250
10	300
11	350

Service Interval Hours Settings	
Number	**Hours**
12	400
13	450
14	500
15	550
16	600
17	650
18	700
19	750
20	800
21	850
22	900

Service Interval Hours Settings	
Number	**Hours**
23	950
24	1000

Table 2, Service Interval Hours Settings

Message Identifiers (MIDs)		
MID	**Description**	**Text Message**
128	Engine Control Unit	ECU128
130	Transmission Control Unit	TCU130
136	Antilock Brake System (ABS)	ABS136
140	Instrumentation Control Unit	ICU140
223	Transmission Shift Unit	TSU223
###	Generic MID	SYS###

Table 3, Message Identifiers (MIDs)

Windshield Glass Removal and Installation

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Open the hood.
3. Remove the windshield wipers. For instructions, see **Group 82**.
4. Remove the cowl-mounted antenna mast, if equipped. For instructions, see **Group 54**.
5. Close the hood.
6. Remove the exterior visor, if equipped.

⚠ WARNING

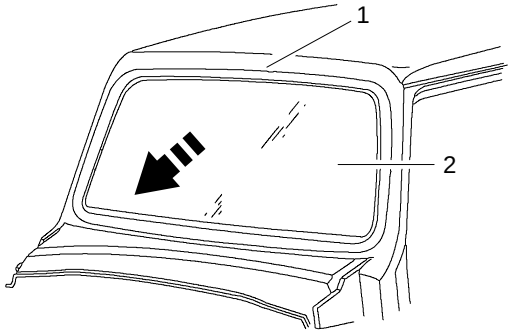
Wear protective gloves and safety glasses when replacing windshield glass. Gloves will protect your hands from sharp edges, and allow a better grip. Failure to wear gloves and safety glasses when handling glass could result in injury to hands or eyes.

NOTE: An assistant is necessary to remove the windshield glass.

7. Remove the windshield glass.
   - 7.1 Starting at the top and using a hook tool, lift the edge of the weatherstrip over the lip of the pinch weld from inside the vehicle.
   - 7.2 Push outward from inside the vehicle to remove the windshield glass.
8. Remove the weatherstrip from the glass. See **Fig. 1**.

Installation

1. Using a clean cloth and water, remove any foreign material from the glass and weatherstrip. The weatherstrip must be replaced if it is cracked or weather damaged.
2. Install the weatherstrip on the glass.
3. Insert a draw cord in the pinch weld opening of the weatherstrip. Overlap the cord 18 inches (457 mm) at the lower center of the glass. See **Fig. 2**.



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1. Weatherstrip
2. Windshield Glass

Fig. 1, Windshield Glass

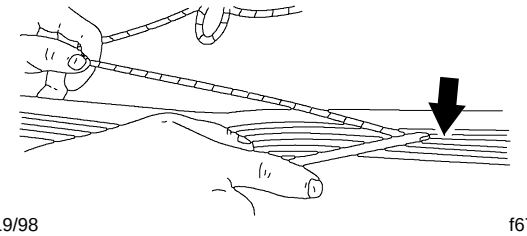

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Fig. 2, Draw Cord in Pinch Weld Opening

4. Tape the ends of the cord to the inside of the glass.
5. Lubricate the weatherstrip with water.

IMPORTANT: Any scratches through the paint in the pinch weld area must be repainted or sealed prior to reinstalling the windshield. The pinch weld can rust and possibly bleed from under the seal if it is not repaired.

NOTE: An assistant is necessary to install the windshield glass.

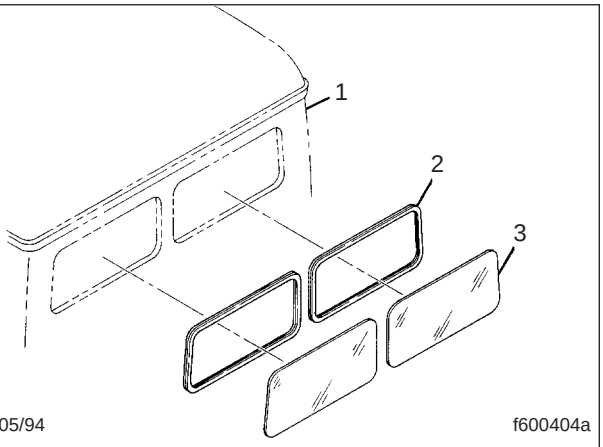
6. Place the windshield back into the pinch weld making sure the bottom of the pinch weld lip falls into the weatherstrip. See **Fig. 1**.
7. From outside the vehicle, slide a plastic stick around the outer edge of the weatherstrip until the weatherstrip is resting on the pinch weld.
8. Apply pressure to the outside of the windshield and pull the cord from the inside to pull the lip of the weatherstrip over the pinch weld.

Windshield Glass Removal and Installation

9. Water test the installation for leaks. If leaks exist, apply 3M Windshield Sealer (or an equivalent) where required.
10. Clean the glass and surrounding areas.
11. Open the hood.
12. Install the antenna mast. For instructions, see **Group 54**.
13. Install the windshield wipers. For instructions, see **Group 82**.
14. Close the hood.
15. Remove the chocks from the tires.

Rear Window Removal and Installation

Removal (See Fig. 1)



1. Cab
2. Weather Seal Retainer
3. Window Glass

Fig. 1, Rear Window Installation

CAUTION

When replacing a broken rear window, it is very important to find the cause of the glass breakage, and correct the condition before installing a new window. A small obstruction or high spot somewhere around the window opening may break the replacement glass, especially when it is exposed to high winds, pressure, temperature extremes, and vehicle motion.

1. Disconnect the batteries.
2. Use tape and paper around the window opening and outside surfaces to protect the paint finish and cab interior. Before removing the window, mark the weather-seal retainer and opening with the location of the break at the edge of the window.

WARNING

Wear protective gloves and safety glasses when replacing windshield glass. Gloves will protect your hands from sharp edges, and allow a better grip. Failure to wear gloves and safety glasses when handling glass could result in injury to hands or eyes.

3. Install vacuum cups on the window, and have an assistant secure the window before removal.
4. Loosen the lip of the weather-seal retainer from the flange along the top and at the sides by applying firm, controlled pressure to the edge of the glass. At the same time, use a putty knife to lift the retainer over the window opening flange. Remove the window glass.

Installation

CAUTION

When handling the window glass, use care not to nick or splinter the edges of the glass. Chipped edges could cause future breaks.

IMPORTANT: Two people are required to install rear window glass.

1. Remove the sealant from the window opening flange.
2. Check for the following conditions at the previously marked point of fracture on the window opening flange:
   - chipped edges on the glass
   - high spots or obstructions in the window opening flange
   - high spots or obstructions in the weather-seal retainer
3. Correct any areas on the window opening that need to be fixed.
4. With the window supported and centered in the opening, check the relationship of the glass to the opening.
5. Mark any areas on the flange to be fixed. Remove the glass, and fix the flange as necessary.
6. Install the retainer on the glass.
7. Install a 1/8-inch (3-mm) nylon cord around the edge of the retainer, leaving a loop at the top and loose ends at the bottom. See **Fig. 2**.
8. Apply a lubricant to the retainer to ease installation.
9. Place the window and retainer assembly in the opening.

Rear Window Removal and Installation

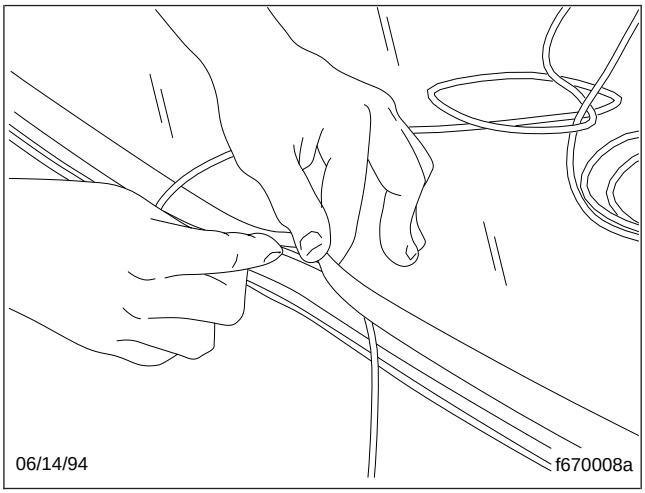


Fig. 2, Nylon Cord Installation

IMPORTANT: Use care not to tear the cab upholstery when pulling on the cord.

10. With one person lightly pushing in on the window, have another person pull on the loose ends of the cord until each is within 2 inches (51 mm) of its respective upper corner.
11. Pull on the loop until the cord is within 2 inches (51 mm) of the upper corners.
12. Finish seating the corners by pulling both ends of the cord at the same time at each corner. This will position the upper corner.
13. Be sure the window and retainer are correctly positioned in relation to each other.
14. Connect the batteries.
15. Remove the chocks from the tires.

Left-Hand Drive Instrument Panel Removal and Installation

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Drain the air system.
4. Remove the under steering panel.
5. Remove the steering column. For instructions, see **Group 46**.
6. Remove the driver side finish panel.
7. Remove the instrument cluster.
8. Remove the driver side ignition switch bezel. Hold the ignition switch, headlight switch and starter button.
9. Remove the screws and remove the driver side end panel. See **Fig. 1**.

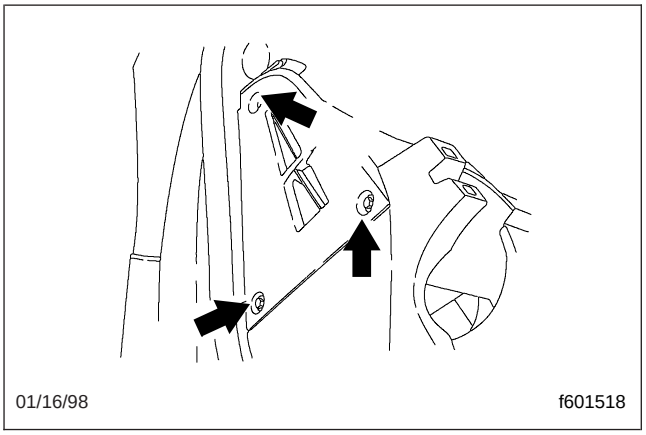


Fig. 1, Driver Side End Panel

10. Remove the auxiliary finish panel. Hold the engine brake switch and differential lock switch.
11. Remove the top of the dash cover.
12. Remove the radio. For instructions, see **Group 54**.
13. Remove the center bracket. Remove the manifold screws and remove the manifold. See **Fig. 2**. Disconnect the air lines to the tractor and trailer air valves. See **Fig. 3**.
14. Remove the mounting screws from the heater control panel. Leave the air hoses connected to the control panel.

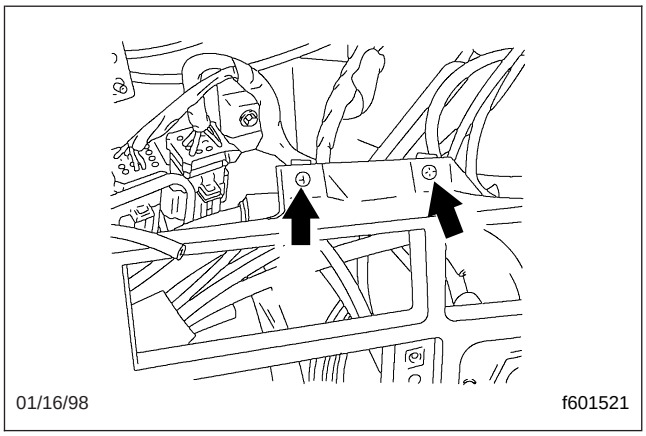


Fig. 2, Manifold Screws

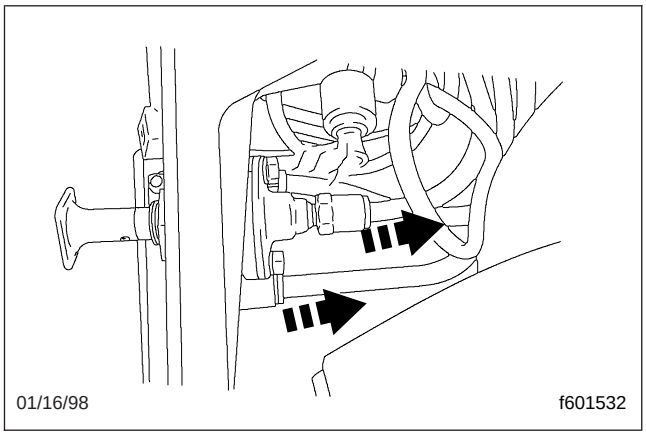


Fig. 3, Air Lines

15. Disconnect the electrical connectors located behind the hot-posts and the cigar lighter. See **Fig. 4**.
16. Remove the screws located behind the radio bracket retaining the connectors to the instrument panel and lower the harness between the instrument panel and the engine cover opening. See **Fig. 5**.
17. Release the four quarter-turn fasteners and remove the power distribution module cover. See **Fig. 6**.
18. Remove the screws and remove the power distribution module mask. See **Fig. 7**.
19. Remove the screws and lower the power distribution module to the cab floor. See **Fig. 8**.
20. Remove the screws and remove the passenger side end panel. See **Fig. 9**.

Left-Hand Drive Instrument Panel Removal and Installation

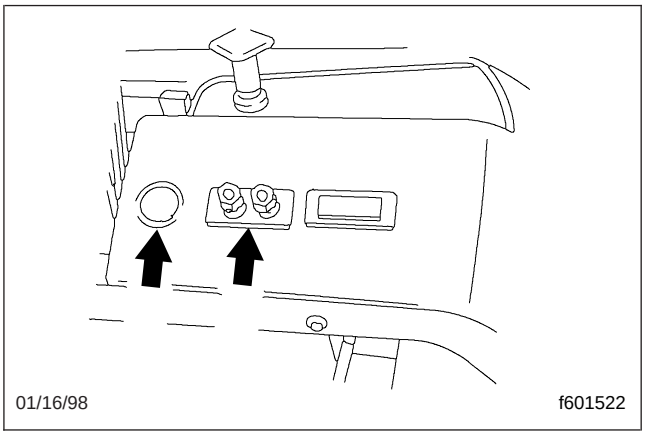


Fig. 4, Electrical Connectors

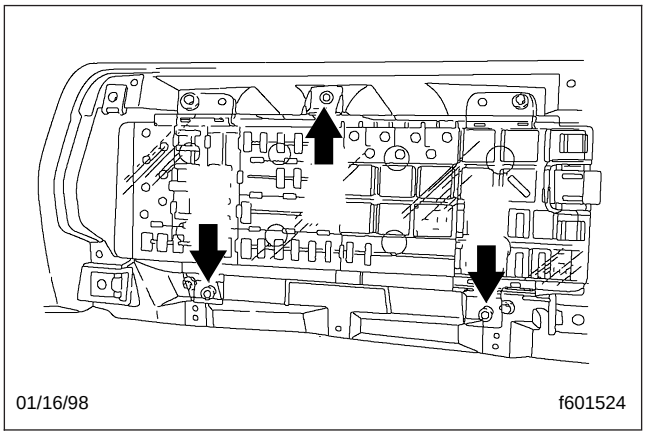


Fig. 7, Power Distribution Module Mask

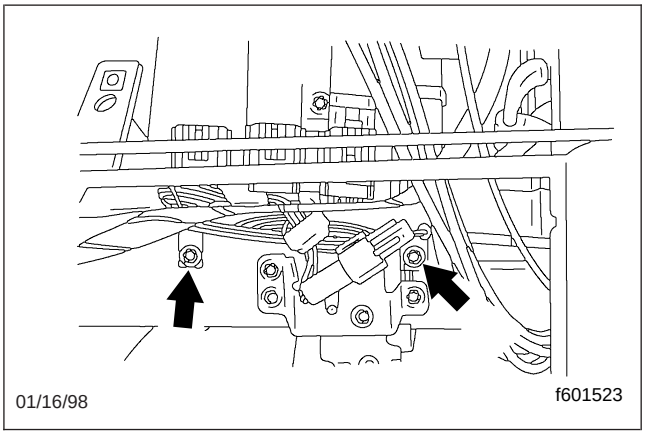


Fig. 5, Instrument Panel Connector Retaining Screws

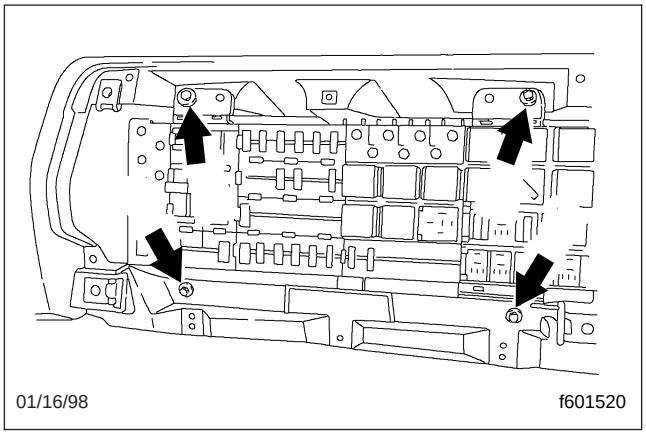


Fig. 8, Power Distribution Module Screws

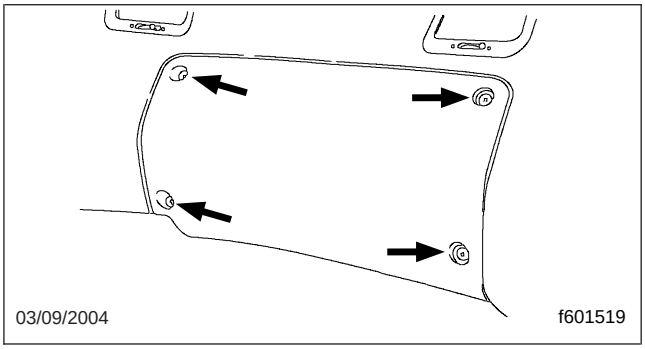


Fig. 6, Power Distribution Module Cover Fasteners

21. Remove the passenger side instrument panel mounting bolts. See **Fig. 10**.
22. Remove the five top instrument panel retaining bolts. See **Fig. 11**.

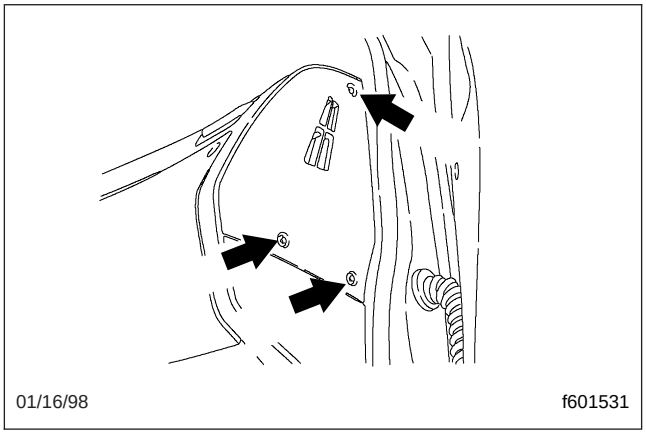


Fig. 9, Passenger Side End Panel

23. Remove the driver side instrument panel mounting bolts. See **Fig. 12**.

Left-Hand Drive Instrument Panel Removal and Installation

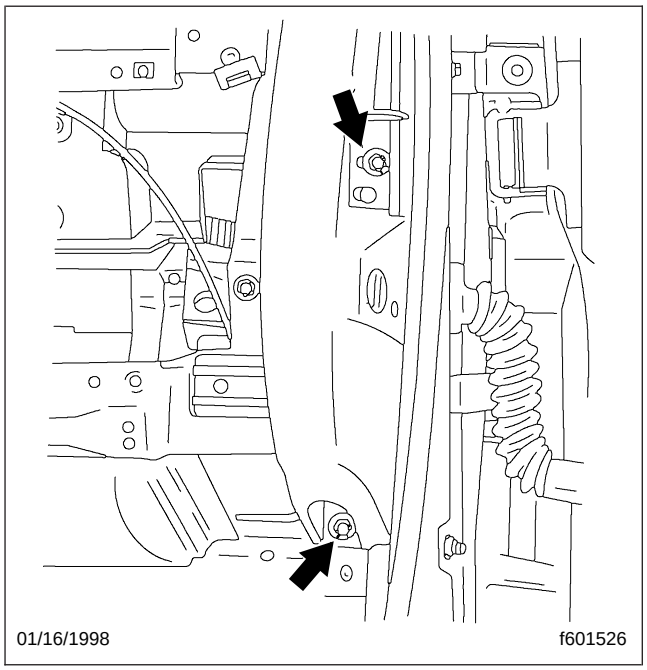


Fig. 10, Passenger Side Instrument Panel Mounting Bolts

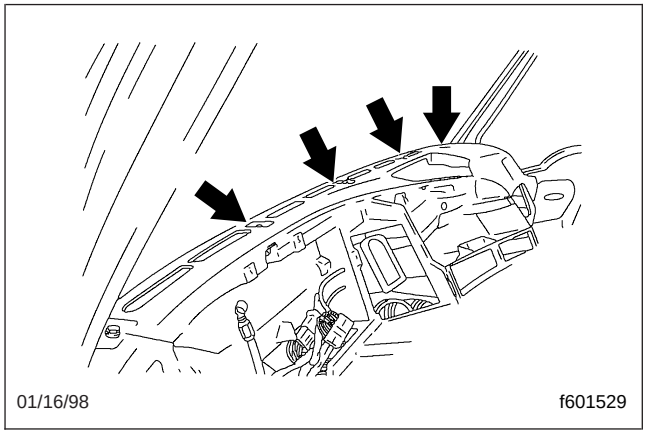


Fig. 11, Instrument Panel Retaining Bolts

24. Remove the bolt located behind the lap duct. See **Fig. 13**.
25. Remove all remaining mounting screws. This includes four behind the instrument cluster, two lower right of the steering column, three lower left of the steering column, four on the lower edge under the radio/cigar lighter, four behind the center instrument panel, and three behind the fuse block.

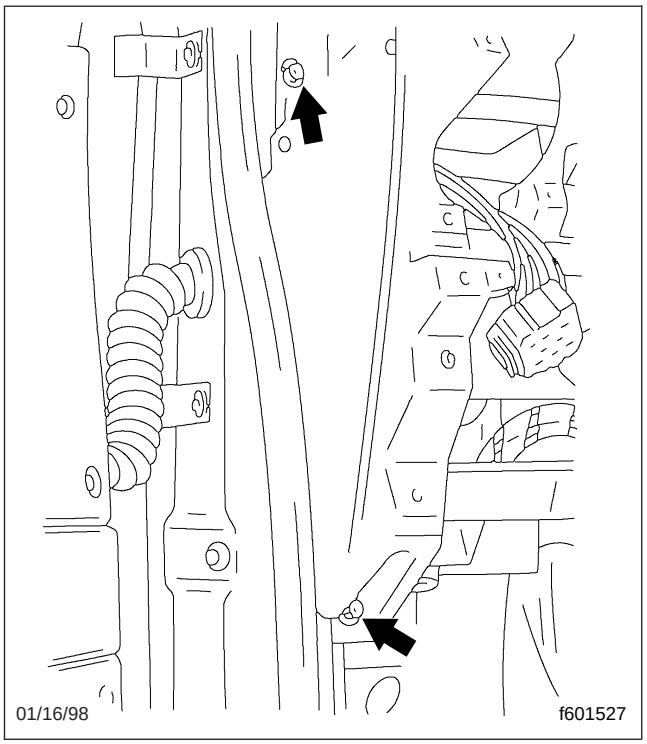


Fig. 12, Driver Side Instrument Panel Mounting Bolts

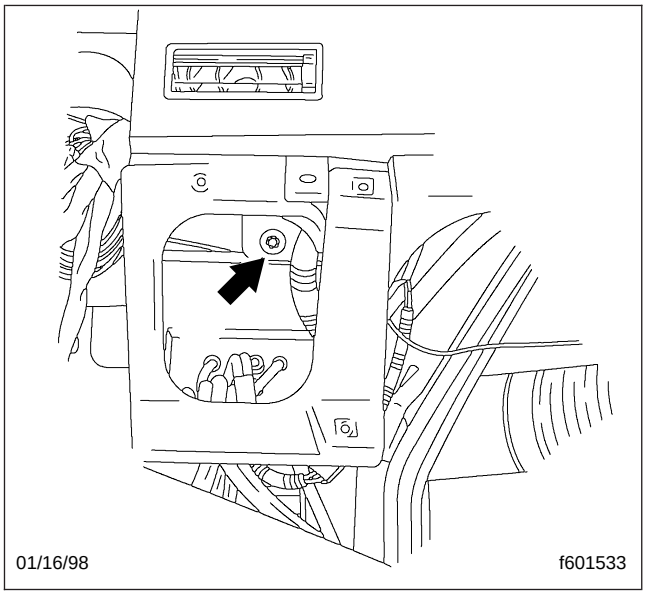


Fig. 13, Bolt Behind Lap Duct

26. Remove the diagnostic link connector, if equipped. See **Fig. 14**.

Left-Hand Drive Instrument Panel Removal and Installation

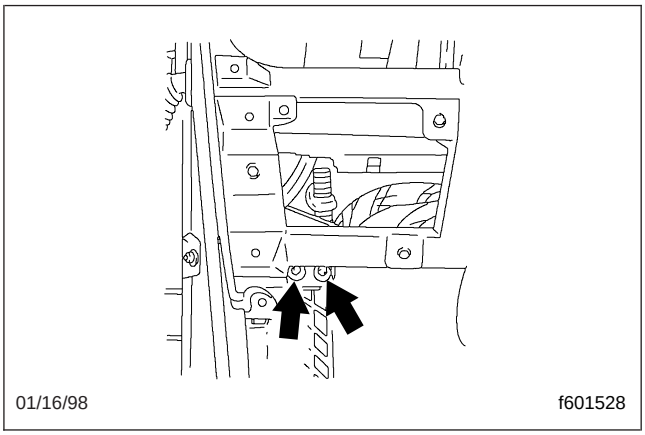


Fig. 14, Diagnostic Connector Mounting Bolts

NOTE: Carefully pull the instrument panel away from the vehicle noting not to damage any of the air pressure lines or the wiring harnesses.

27. Remove the instrument panel.

Installation

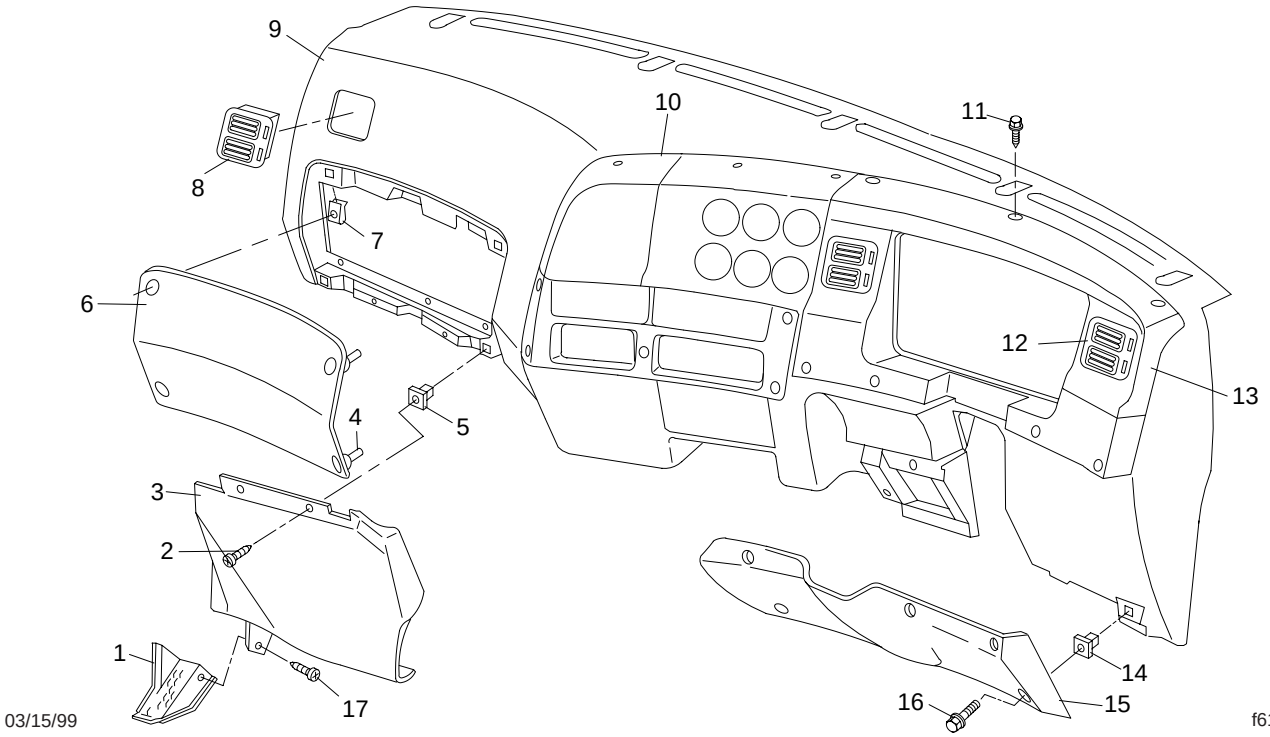
NOTE: Make sure all the air pressure lines and wiring harnesses are clear of the instrument panel mounting surfaces.

1. With the help of an assistant, position the instrument panel in the vehicle.
2. Install the five top instrument panel retaining bolts. Tighten the bolts 44 to 53 lbf·in (500 to 600 N·cm). See **Fig. 11**.
3. Install the bolts retaining the diagnostic link connector, if equipped. See **Fig. 14**.
4. Install the driver side instrument panel mounting bolts. Tighten the bolts to 27 to 35 lbf·in (300 to 400 N·cm). See **Fig. 12**.
5. Install the passenger side instrument panel mounting bolts. Tighten the bolts to 27 to 35 lbf·in (300 to 400 N·cm). See **Fig. 10**.
6. Install the four mounting screws behind the instrument cluster. Install the mounting screws in the lower left and right sides of the steering column, on the lower edge under the radio/cigar lighter, behind the center instrument panel, and behind the fuse block.
7. Install the bolt located behind the lap duct. Tighten the bolt to 44 to 53 lbf·in (500 to 600 N·cm). See **Fig. 13**.
8. Route the wiring harness between the instrument panel and the engine cover opening. Install the screws located behind the radio bracket. See **Fig. 5**.
9. Connect the electrical connectors located behind the hot-posts and the cigar lighter. See **Fig. 4**.
10. Attach the air manifold to the center bracket.
11. Connect the air lines to the brake valves and install the center mount bracket.
12. Install the power distribution module and the screws. See **Fig. 8**.
13. Install the power distribution module mask and the screws. See **Fig. 7**.
14. Install the power distribution module cover and the quarter-turn screws. See **Fig. 6**.
15. Install the passenger side end panel and the screws. See **Fig. 9**.
16. Install the top of the dash cover.
17. Install the auxiliary finish panel. Position the engine brake switch and differential lock switch.
18. Install the driver side end panel and the screws. See **Fig. 1**.
19. Install the driver side ignition switch bezel. Position the ignition switch, headlight switch and starter button.
20. Install the instrument cluster. For instructions, see **Group 54**.
21. Install the driver side finish panel.
22. Install the radio. For instructions, see **Group 54**.
23. Install the steering column. For instructions, see **Group 46**.
24. Install the under steering panel.
25. Connect the batteries.
26. Charge the brake air systems and check for leaks.
27. Remove the chocks from the tires.

Right-Hand Drive Instrument Panel Removal and Installation

Removal

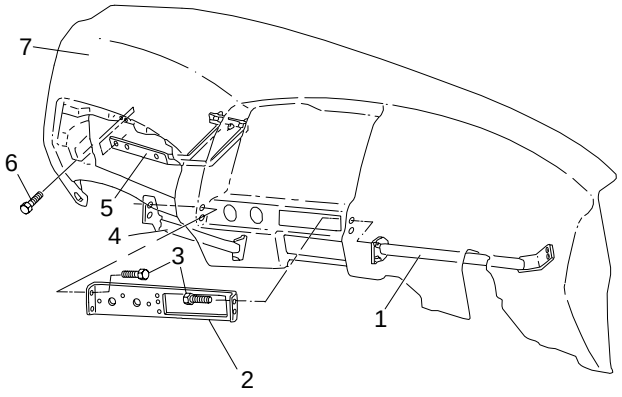
1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the battery ground cable.
3. Prepare the vehicle for instrument panel removal.
   - 3.1 Drain the air system.
   - 3.2 Remove the radio. For instructions, see **Group 54**.
   - 3.3 Remove the under steering panel assembly. See **Fig. 1**.
   - 3.4 Disconnect the steering column and rest it on the cab floor. For instructions, see **Group 46**.
4. Remove the power distribution module cover.
5. Remove the instrument panel bracket retaining bolts. See **Fig. 2**.
6. Remove the passenger side finish panel assembly. See **Fig. 1**.
7. Remove the trailer air supply valve and parking brake control valve knobs.
8. Remove the auxiliary finish panel retaining screws. See **Fig. 1**.



1. Lower Trim Panel
2. Retaining Screw
3. Passenger Side Finish Panel Assembly
4. Quarter-Turn Fastener (4 qty.)
5. Screw Retainer
6. Power Distribution Module Cover
7. Quarter-Turn Fastener Retainer (4 qty.)
8. Air Register
9. Instrument Panel Assembly
10. Auxiliary Finish Panel
11. Finish Panel Retaining Screw (15 qty.)
12. Air Register
13. Driver Side Finish Panel
14. Under Steering Panel Assembly Screw Retainer
15. Under Steering Panel Assembly
16. Retaining Screw
17. Retaining Screw

Fig. 1, Right-Hand Drive Instrument Panel and Finish Panels

Right-Hand Drive Instrument Panel Removal and Installation



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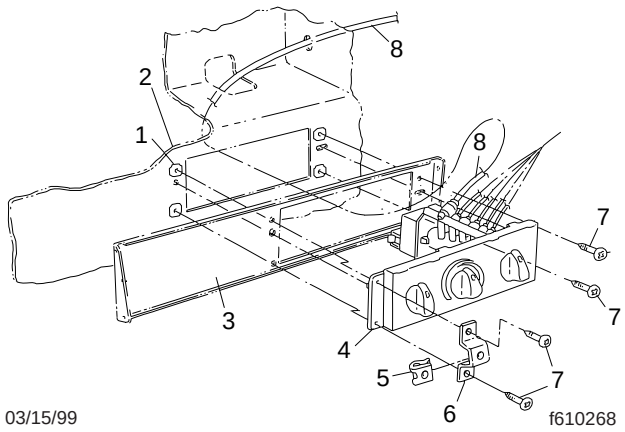
1. Right-Side Instrument Panel Bracket
2. Auxiliary Instrument Panel Support Bracket
3. Retaining Bolt (4 qty.)
4. Left-Side Instrument Panel Bracket
5. Retaining Bracket
6. Retaining Bolt
7. Instrument Panel

Fig. 2, Instrument Panel Mounting Brackets

9. Tag and remove the electrical, air, and HVAC vacuum lines.
10. Remove the auxiliary finish panel.
11. Remove the HVAC control module retaining screws. Disconnect the colored air lines and remove the module. See **Fig. 3**.
12. Working from the engine compartment, remove the left-side instrument panel bracket retaining bolts. See **Fig. 2**.
13. Remove the driver side finish panel. See **Fig. 1**.
14. Turn the six quarter-turn fasteners to release the instrument cluster assembly. See **Fig. 4**.
15. Remove the instrument cluster outer frame screws. See **Fig. 5**.
16. Pull the cluster forward. Label each electrical connector and disconnect them. See **Fig. 6**.
17. Disconnect the oil pressure hose from the oil pressure gauge. See **Fig. 7**.
18. Remove the instrument cluster assembly.
19. Remove the trailer brake hand control valve.
    - 19.1 Remove the lever with a firm pull.



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1. Screw Retainer
2. Instrument Panel
3. Center Finish Panel Bracket
4. HVAC Control Module
5. Screw Retainer
6. Instrument Panel Center Support Bracket
7. Retaining Screws
8. Air Lines

Fig. 3, HVAC Control Panel and Components

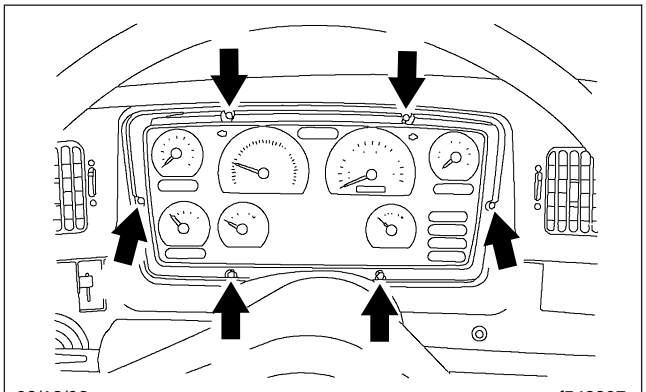

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Fig. 4, Quarter-Turn Fasteners

- 19.2 Remove the four trailer brake hand control valve retaining screws.
- 19.3 Tag and disconnect the air lines. Remove the valve.

20. Remove the ashtray and the ashtray bracket. See **Fig. 8**.
21. Remove the four left-side finish instrument panel bracket bolts. See **Fig. 2**.

Right-Hand Drive Instrument Panel Removal and Installation

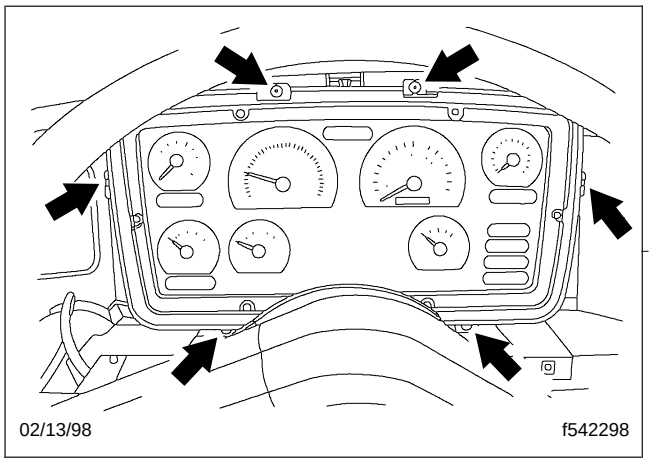


Fig. 5, Instrument Cluster Outer Frame Screws

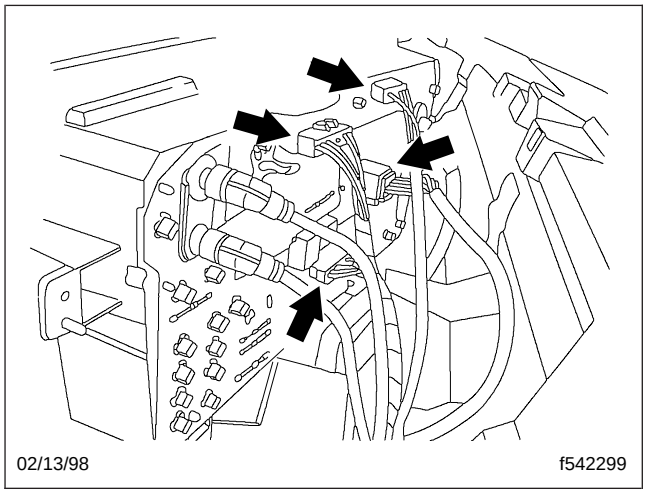


Fig. 6, Instrument Cluster Electrical Connectors

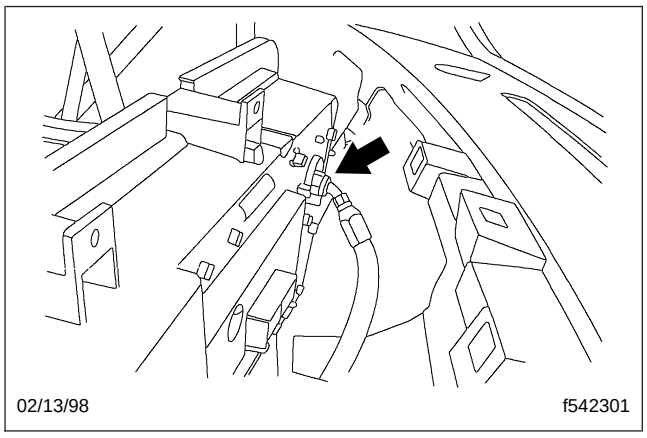
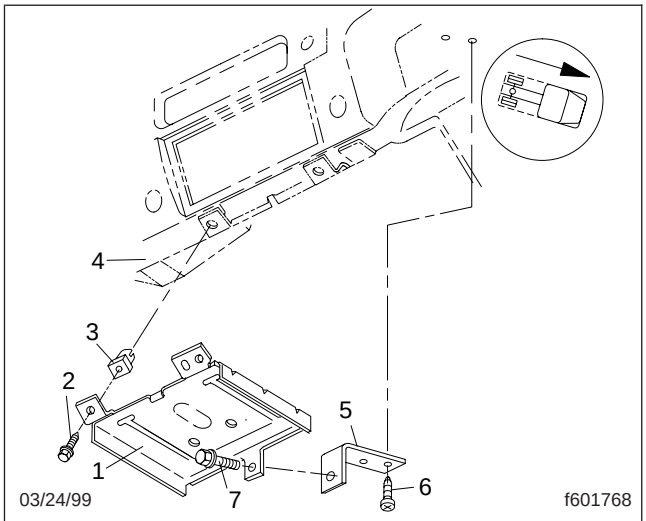


Fig. 7, Oil Pressure Hose Location



1. Ashtray Bracket
2. Retaining Screw
3. Screw Retainer
4. Instrument Panel
5. Instrument Panel Bracket
6. Retaining Screw (2 qty.)
7. Retaining Screw

Fig. 8, Ashtray Bracket

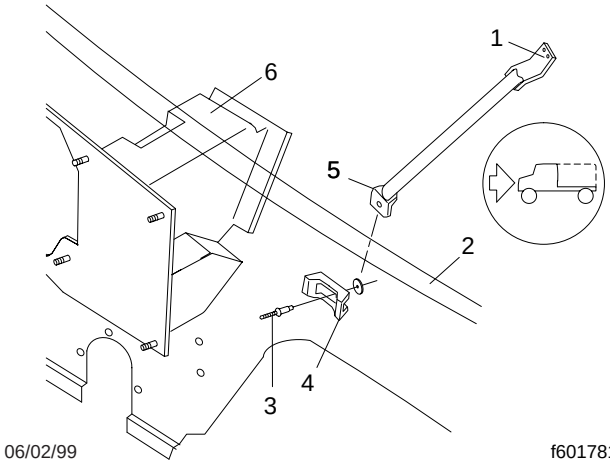
22. Working from the engine compartment, drill out the rivet that retains the left-side instrument panel bracket. See **Fig. 9**.
23. Remove the five instrument panel retaining bolts. See **Fig. 10**.
24. With the help of an assistant, position the defrost duct out the way and remove the instrument panel from the vehicle. Be careful not to damage any of the air lines or wiring. See **Fig. 11**.

Installation

NOTE: Make sure all the air lines and wiring harnesses are clear of the instrument panel mounting surfaces.

1. With the help of an assistant, position the instrument panel in the vehicle while aligning the defrost duct in place. See **Fig. 11**.
2. Install the five top instrument panel retaining bolts. Tighten the bolts 44 to 53 lbf·in (500 to 600 N·cm). See **Fig. 10**.

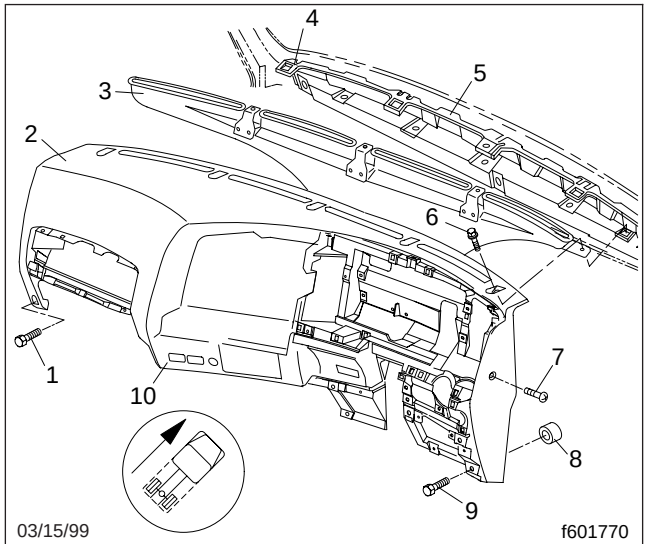
Right-Hand Drive Instrument Panel Removal and Installation



1. Instrument Panel Mounting Bracket (to instrument panel)
2. Cab Wall
3. Rivet
4. Wiring Harness/Air Line Retainer
5. Instrument Panel Mounting Bracket (to cab wall)
6. Clutch Pedal Housing

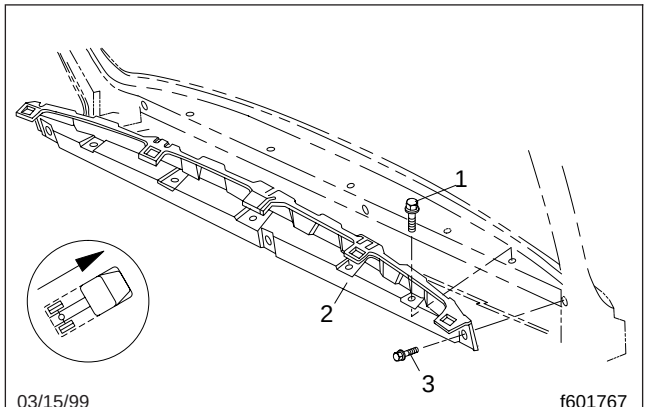
Fig. 9, Left-Side Instrument Panel Mounting Bracket and Rivet

3. Feed the electrical, air lines and vacuum lines into the proper positions in the instrument panel.
4. Install the left-side instrument panel mounting bolts. Tighten the bolts to 27 to 35 lbf·in (300 to 400 N·cm). See **Fig. 10**.
5. Install the right-side instrument panel mounting bolts. Tighten the bolts to 27 to 35 lbf·in (300 to 400 N·cm). See **Fig. 10**.
6. Install the auxiliary instrument panel support bracket and fasteners. See **Fig. 2**.
7. Connect the colored air lines.
8. Install the electrical, air, and HVAC vacuum lines.
9. Install the HVAC control module and the retaining screws. See **Fig. 3**.
10. Connect the air lines to the trailer air supply valve and the parking brake control valve and install the knobs.
11. Install the auxiliary finish panel.
12. Position the instrument cluster. Connect the electrical harness and the air lines.



1. Left-Side Instrument Panel Mounting Bolt
2. Instrument Panel
3. Defrost Duct
4. Top Instrument Panel-to-Cab Mounting Bracket
5. Cab Frame
6. Top Instrument Panel Retaining Bolt
7. Right-Side Instrument Panel Mounting Bolt
8. Spacer
9. Instrument Panel Retaining Bolt
10. Auxiliary Instrument Panel Support Bracket

Fig. 10, Instrument Panel Mounting Bolts



1. Defrost Duct-to-Instrument Panel Retaining Screw (5 qty.)
2. Defrost Duct
3. Defrost Duct-to-Cab Retaining Screw (3 qty.)

Fig. 11, Defrost Ducting

13. Connect the oil pressure hose to the oil pressure gauge. See **Fig. 7**.
14. Install the instrument cluster assembly into the instrument panel.
15. Tighten the instrument cluster outer frame screws. See **Fig. 5**.
16. Tighten the six quarter-turn fasteners to secure the instrument cluster assembly to the frame. See **Fig. 4**.
17. Install the driver side finish panel. See **Fig. 1**.
18. Install the trailer brake hand control valve.
    - 18.1 Connect the air lines and position the valve.
    - 18.2 Install the four trailer brake hand control valve retaining screws.
    - 18.3 Install the trailer brake hand control valve lever with a firm push.
19. Install the steering column. For instructions, see **Group 46**.
20. Install the under steering finish panel.
21. Install the radio. For instructions, see **Group 54**.
22. Install the ashtray bracket and the ashtray. See **Fig. 8**.
23. Install the passenger side finish panel assembly. See **Fig. 1**.
24. Install the power distribution module cover. See **Fig. 1**.
25. Connect the battery ground cable.
26. Remove the chocks from the tires.

Under Steering Panel Removal and Installation

Removal

NOTE: This procedure is typical and covers left-hand-drive and right-hand-drive vehicles.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the five screws from the under steering panel. See **Fig. 1**.

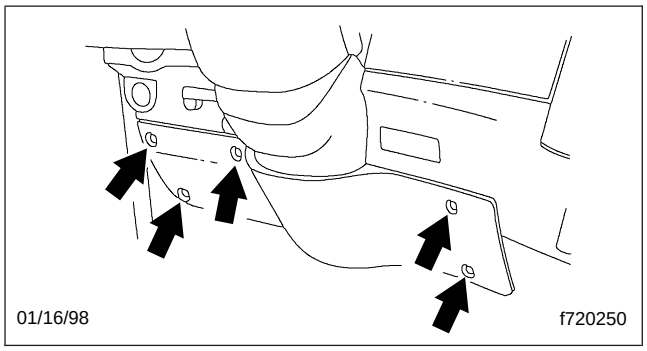


Fig. 1, Under Steering Panel Screw Location

3. Remove the spacer.
4. Remove the panel.

Installation

1. Position the under steering panel.
2. Install the spacer.
3. Tighten the five screws. See **Fig. 1**.
4. Remove the chocks from the tires.

Instrument Cluster Finish Panels Removal and Installation

Driver Side Finish Panel

NOTE: This procedure is typical and covers left-hand-drive and right-hand-drive vehicles.

REMOVAL

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the screws from the driver side finish panel. See **Fig. 1**.

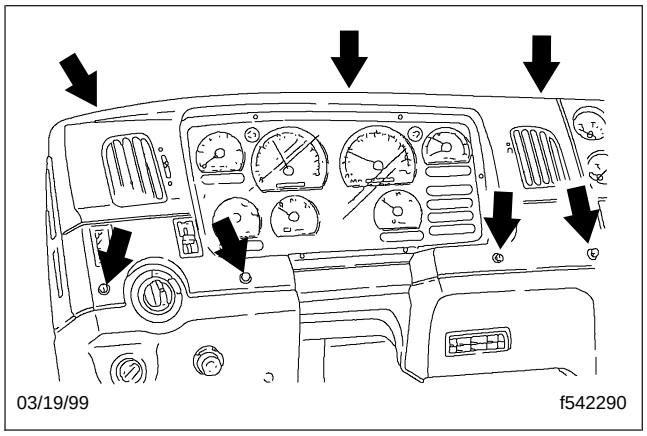


Fig. 1, Driver Side Finish Panel Screws

3. Remove only the auxiliary finish panel screws from the side closest to the driver side finish panel. See **Fig. 2**.
4. Remove the driver side finish panel.

INSTALLATION

1. Install the driver side finish panel.
2. Install and tighten the auxiliary finish panel. See **Fig. 2**.
3. Tighten the driver side finish panel screws. See **Fig. 1**.
4. Remove the chocks from the tires.

Auxiliary Finish Panel

NOTE: This procedure is typical and covers left-hand-drive and right-hand-drive vehicles.

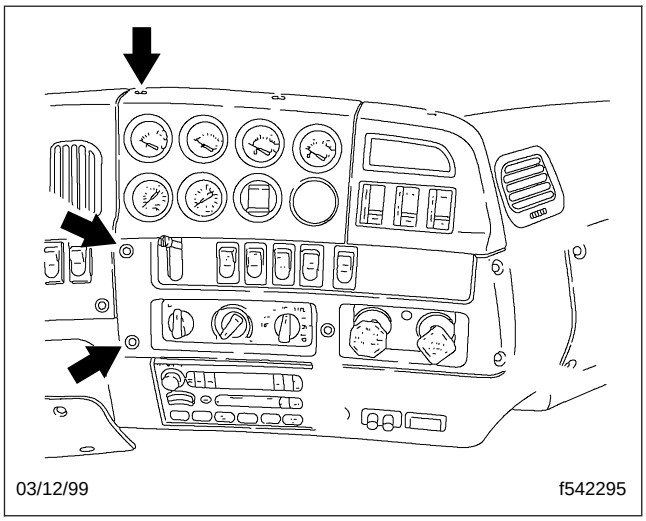


Fig. 2, Auxiliary Finish Panel Screws

REMOVAL

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the trailer brake hand control valve knob. See **Fig. 3**.

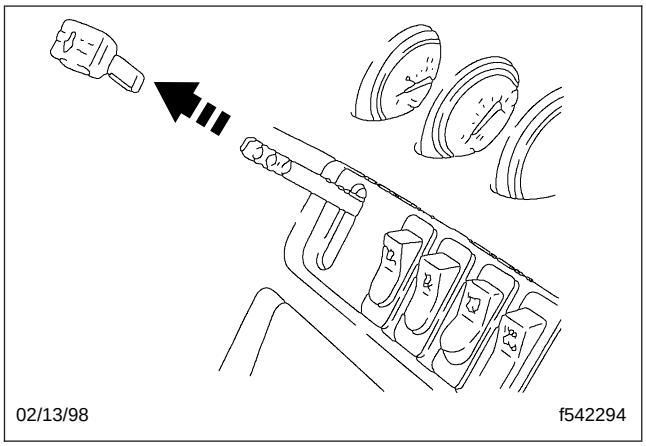


Fig. 3, Trailer Brake Hand Control Valve Knob

3. Remove the auxiliary finish panel screws and remove the panel. See **Fig. 4**.
4. Bleed the air from both the primary and secondary brake air systems, if so equipped.
5. Disconnect the electrical connectors and remove the auxiliary finish panel.

Instrument Cluster Finish Panels Removal and Installation

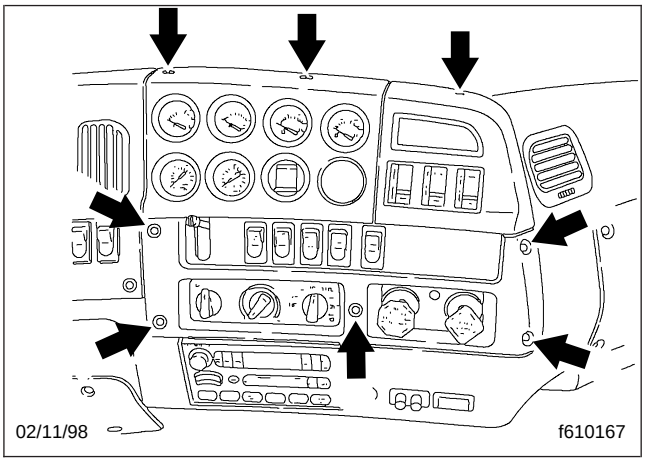


Fig. 4, Auxiliary Finish Panel Screws

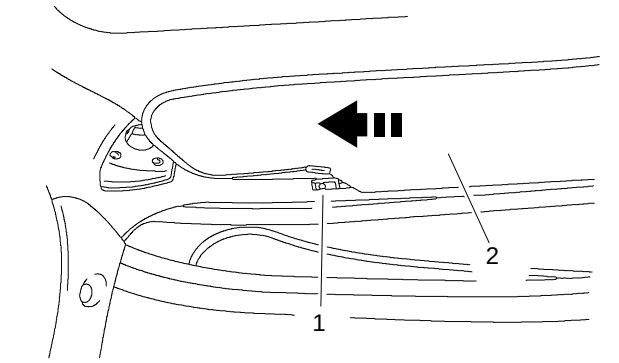
6. Disconnect the air lines.

INSTALLATION

1. Connect the electrical connectors and the air lines.
2. Install the auxiliary finish panel.
3. Install the trailer brake hand control valve knob. See **Fig. 3**.
4. Install and tighten the auxiliary finish panel screws. See **Fig. 4**.
5. Remove the chocks from the tires.

Replacement

1. If equipped with dual visors, remove the visor assembly.
   1.1 Remove the screws.
   1.2 Remove the visor assembly.
2. If equipped with dual visors, remove the secondary visor assembly (left-side shown, right-side symmetrically opposite). See **Fig. 1**.



1. Secondary Visor Assembly Screw Location
2. Secondary Visor Assembly

Fig. 1, Secondary Visor Assembly Removal

   2.1 Remove the screw.
   2.2 Slide the visor outward and remove the secondary visor assembly.

NOTE: Support the roof console before all the fasteners are removed.

3. Remove the fasteners retaining the roof console. See **Fig. 2**.
4. Disconnect the microphone connector, if so equipped. See **Fig. 3**.
5. Disconnect the hot-post connector, if so equipped. See **Fig. 4**.
6. Remove the roof console.
7. Install the roof console.
8. Connect the hot-post connector, if so equipped. See **Fig. 4**.
9. Connect the microphone connector, if so equipped. See **Fig. 3**.

NOTE: Support the roof console before reattaching all the fasteners.

10. Reattach the fasteners retaining the roof console. See **Fig. 2**.
11. If equipped with dual visors, attach the secondary visor assembly (left-side shown, right-side symmetrically opposite). See **Fig. 1**.
    11.1 Slide the visor inward and install the secondary visor assembly.
    11.2 Attach the screw.
12. If equipped with dual visors, remove the visor assembly.
    12.1 Install the visor assembly.
    12.2 Attach the screws.

Roof Console Replacement

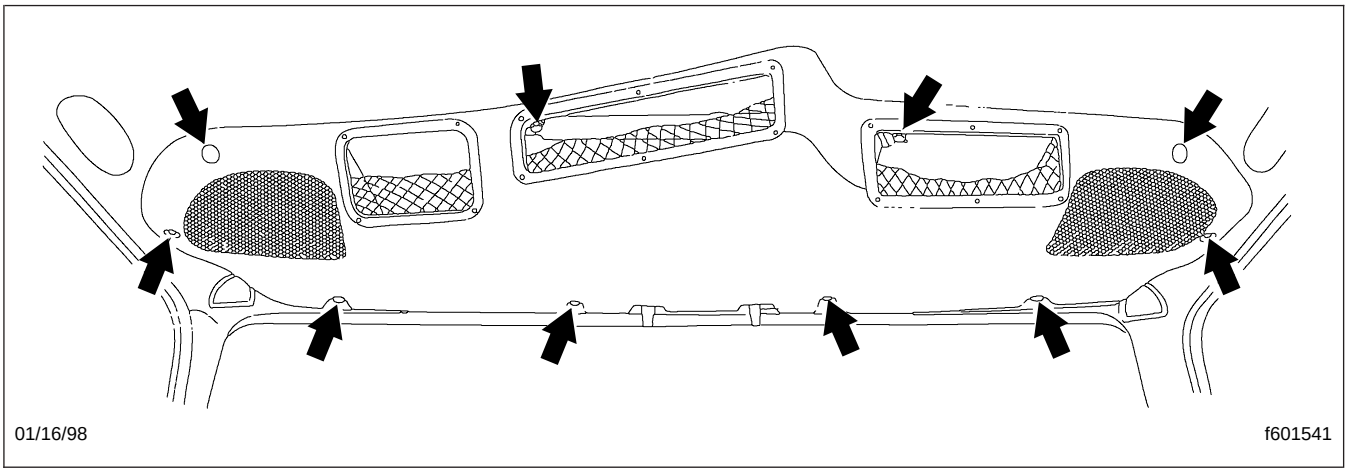


Fig. 2, Roof Console Retaining Fasteners

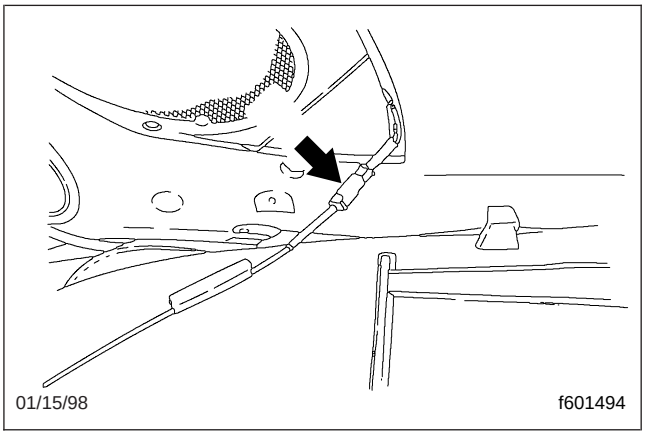


Fig. 3, Microphone Connector

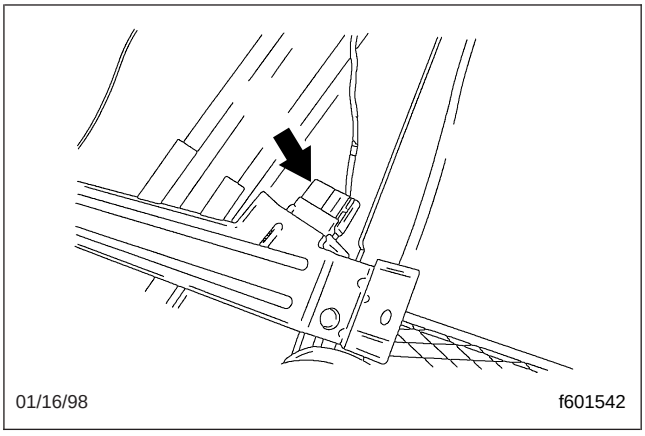


Fig. 4, Hot-Post Connector

Specifications

Torque Specifications	
Description	**lbf·in (N·cm)**
Instrument Panel Top and Side Cowl Screws	44–53 (500–600)
Instrument Panel Finish End Panel Screws	27–35 (300–400)
Instrument Panel Extension Bracket Screws	44–53 (500–600)

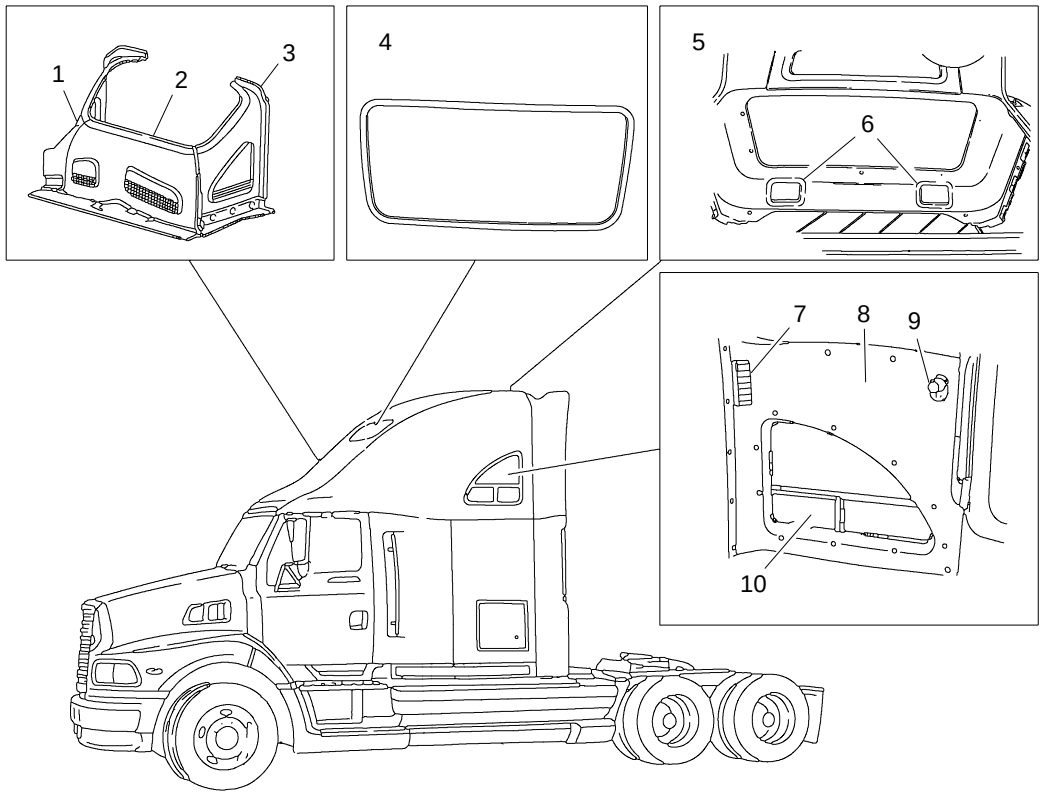
Table 1, Torque Specifications

General Information

SILVERSTAR INTEGRATED SLEEPER

Fig. 1 illustrates the SilverStar sleeper components.

Fig. 2 illustrates the SilverStar sleeper door trim, accessories, and controls.

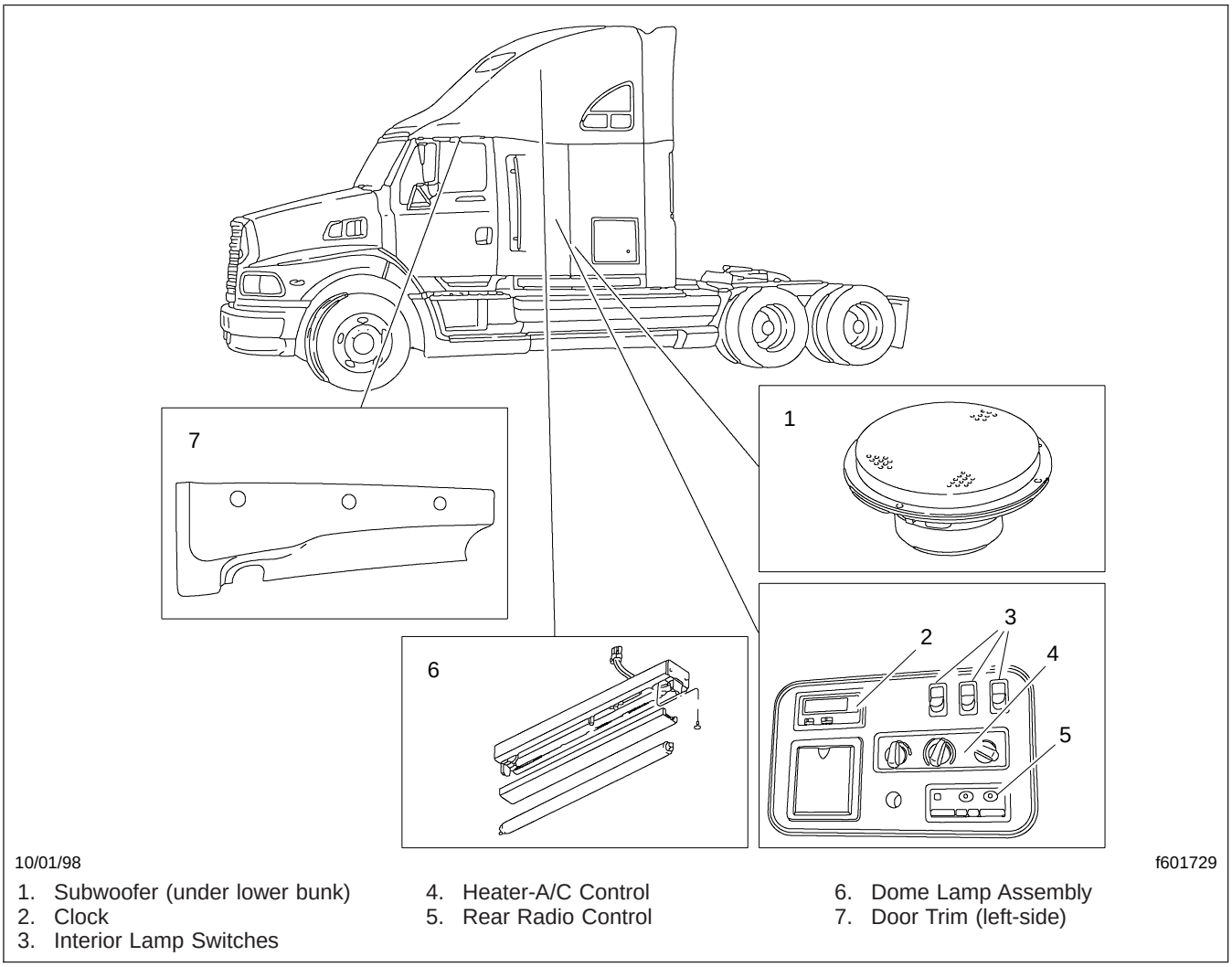


10/01/98 f601514

1. Storage Compartment (right-side)
2. Storage Compartment (center)
3. Storage Compartment (left-side)
4. Moon Roof/Sun Roof
5. Headliner
6. Rear Speakers
7. Register
8. Window Side Trim Panel (left-side)
9. Reading Lamp
10. Side Window (left-side)

Fig. 1, SilverStar Sleeper Components Location

General Information



1. Subwoofer (under lower bunk)
2. Clock
3. Interior Lamp Switches
4. Heater-A/C Control
5. Rear Radio Control
6. Dome Lamp Assembly
7. Door Trim (left-side)

Fig. 2, Location Of SilverStar Door Trim, Accessories and Controls

Replacement (See Fig. 1)

1. Remove the upper trim panel over the door and the trim panel below the window. Refer to **Subject 110**.

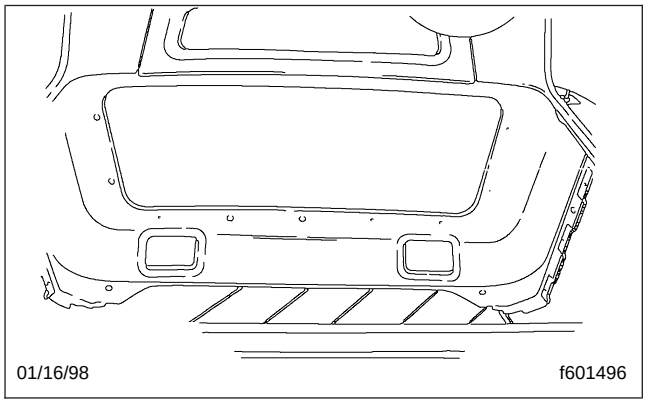


Fig. 1, Headliner

2. Remove the 27 pushpins, and remove the headliner.
3. Position the headliner, and attach the 27 pushpins.
4. Install the upper trim panel over the door and the trim panel below the window. Refer to **Subject 110**.

Side Window Panel Trim Replacement

Replacement

NOTE: Left-hand shown, right-hand symmetrically opposite.

1. Remove the shade, if so equipped. See **Fig. 1**.

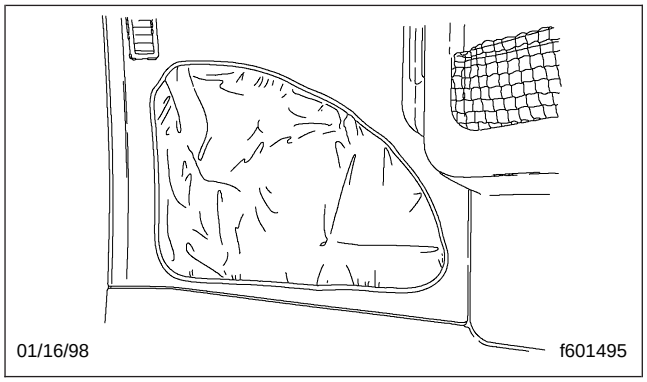
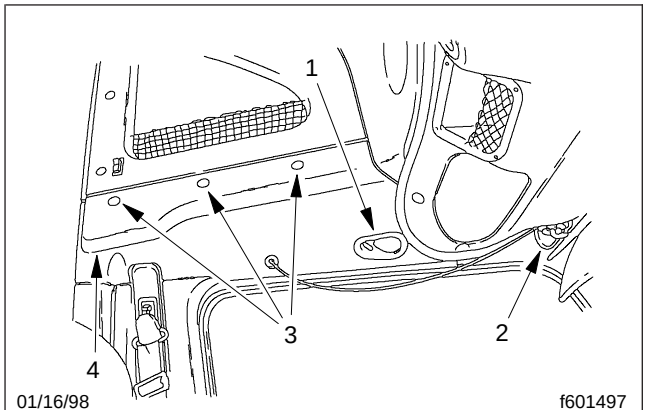


Fig. 1, Side Window Shade

2. Remove the trim panel over the left-hand door. See **Fig. 2**.



1. Reading Lamp
2. Screw
3. Pushpins
4. Trim Panel

Fig. 2, Trim Panel Removal

2.1 Remove the reading lamp.

2.2 Remove the screw.

2.3 Remove the pushpins.

2.4 Remove the trim panel.

3. Remove the pushpins. See **Fig. 3**.

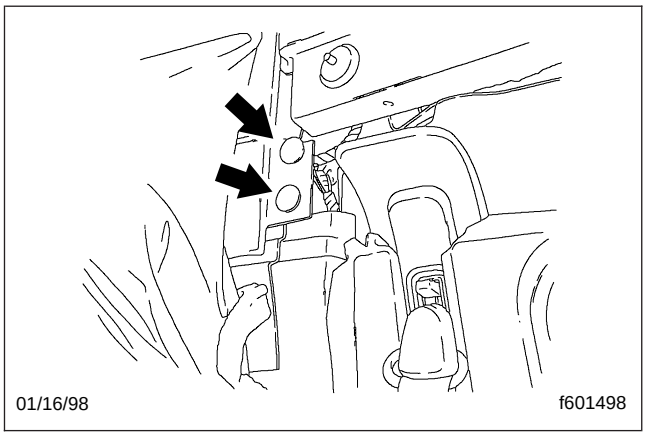


Fig. 3, Pushpins

4. Raise the bunk. Remove the pushpins, and remove the upper bunk support trim. See **Fig. 4**.

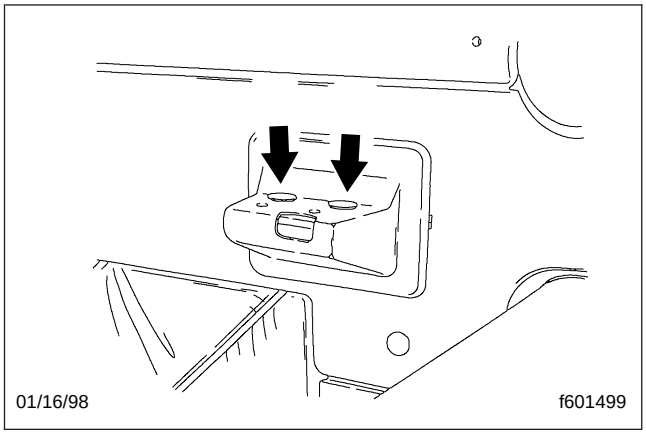


Fig. 4, Bunk Support Trim and Pushpins

5. Remove the pushpins. See **Fig. 5**.
6. Lower the bunk. Pull the trim back, and remove the pushpins. See **Fig. 6**.
7. Remove the 11 pushpins. See **Fig. 7**.
8. Pull the trim panel back, and disconnect the reading lamp connector, if so equipped. See **Fig. 8**.
9. Remove the side window trim panel.
10. Connect the reading lamp connector, if so equipped. See **Fig. 8**.
11. Replace the side window trim panel.
12. Install the 11 trim panel pushpins. See **Fig. 7**.

Side Window Panel Trim Replacement

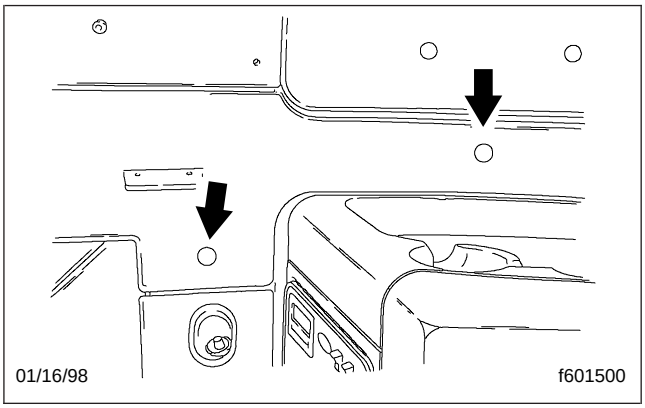


Fig. 5, Pushpins

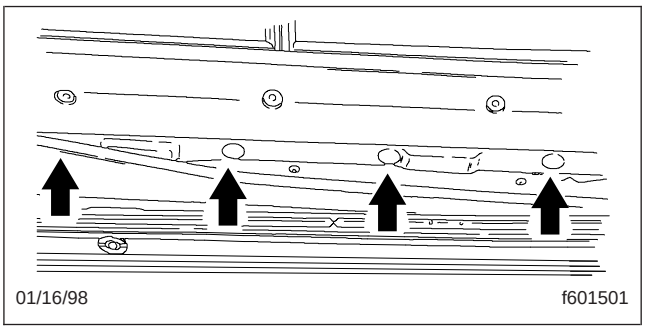


Fig. 6, Pushpins Under Bunk Trim

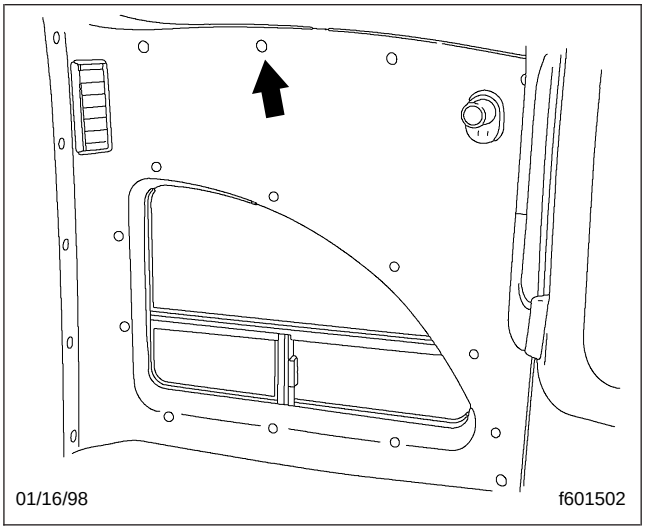


Fig. 7, Window Trim Panel Pushpins

13. Pull the trim back, and install the pushpins. See **Fig. 6**.
14. Install the pushpins. See **Fig. 5**.

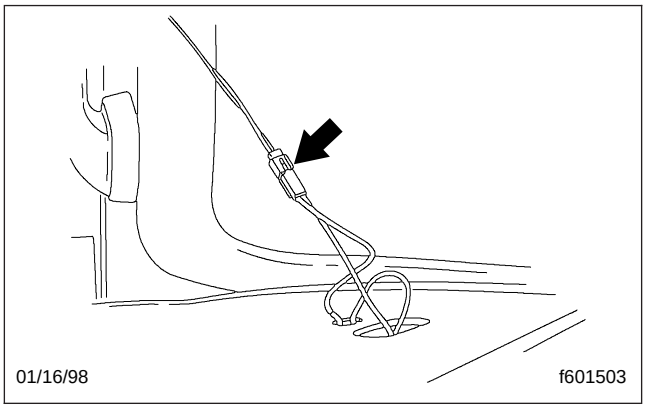


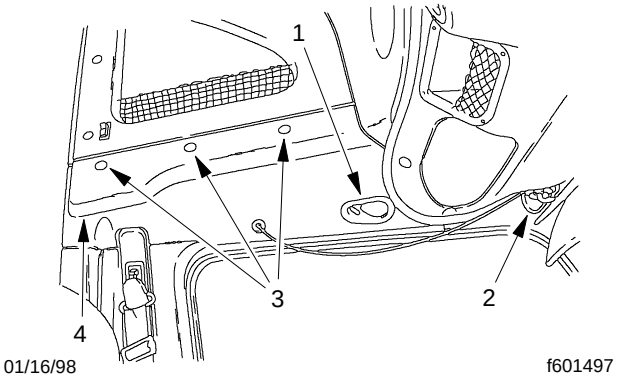
Fig. 8, Reading Lamp Connector

15. Raise the bunk. Install the pushpins, and install the upper bunk support trim. See **Fig. 4**.
16. Attach the pushpins. See **Fig. 3**.
17. Attach the trim panel over the left-hand door. See **Fig. 2**.
    - 17.1 Install the reading lamp.
    - 17.2 Install the screw.
    - 17.3 Install the pushpins.
    - 17.4 Install the trim panel.
18. Install the left-hand and right-hand shade, if so equipped. See **Fig. 1**.

Overhead Storage Compartment Trim Replacement

Replacement

1. Remove the trim panel over the left-hand door. See **Fig. 1**.



1. Reading Lamp
2. Screw
3. Pushpins
4. Trim Panel

Fig. 1, Left-Hand Trim Panel

1.1 Remove the reading lamp.

1.2 Remove the screw.

1.3 Remove the pushpins.

1.4 Remove the trim panel.

2. Remove the pushpins, and remove the trim panel over the right-hand door. See **Fig. 2**.

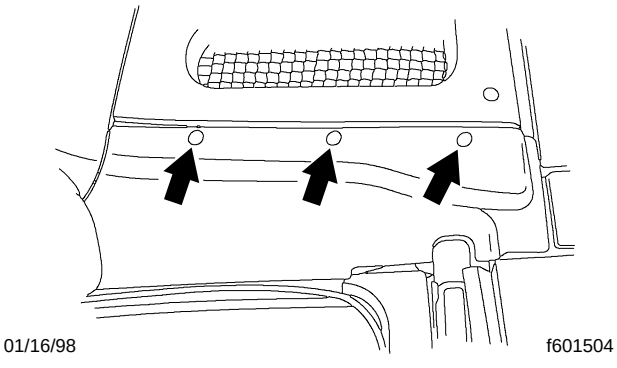


Fig. 2, Right-Hand Trim Panel

3. Disconnect the curtain from the curtain track. See **Fig. 3**.

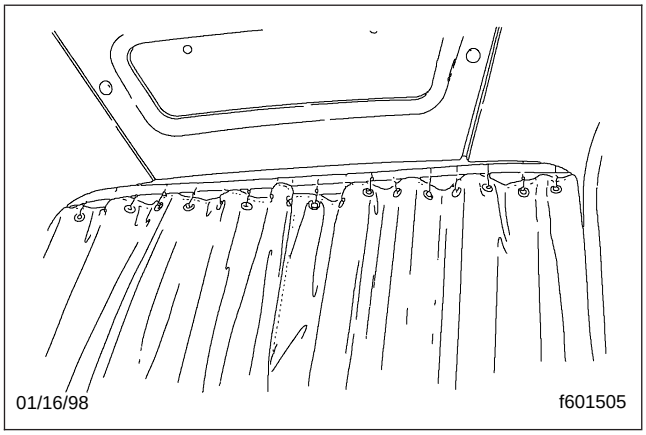


Fig. 3, Curtain

4. Remove the screws, and remove the curtain track. See **Fig. 4**.

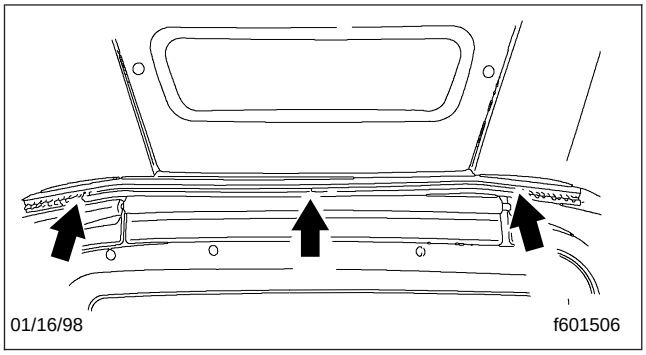


Fig. 4, Curtain Track

5. Remove the roof console.

NOTE: Left-hand shown, right-hand symmetrically opposite.

6. Remove the speaker bolts. See **Fig. 5**.
7. Disconnect the speaker electrical connectors.
8. Disconnect the interior lamp switch electrical connector. See **Fig. 6**.
9. Remove the 29 pushpins securing the overhead storage compartment. See **Fig. 7** and **Fig. 8**.

NOTE: To fully remove the overhead storage compartment, it may be necessary to remove the seats.

10. Remove the overhead storage compartment. See **Fig. 9**.

Overhead Storage Compartment Trim Replacement

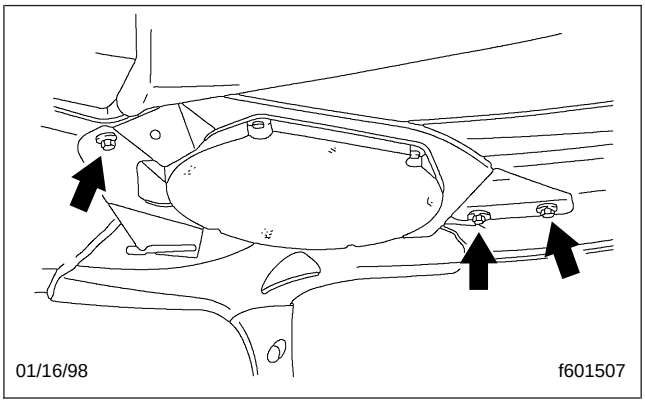


Fig. 5, Speaker Bolts

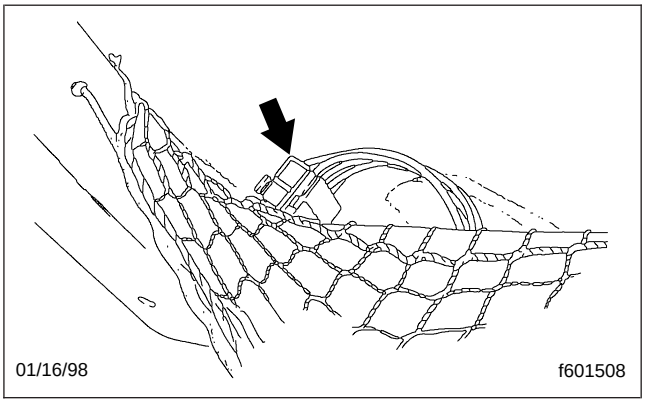


Fig. 6, Interior Lamp Electrical Switch

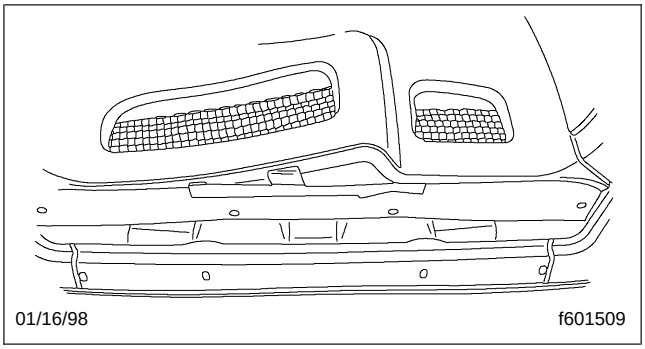


Fig. 7, Lower Storage Compartment Pushpins

NOTE: To prevent damage to the overhead storage compartment during installation, it may be necessary to drill out and remove the rivets attaching the left and right compartments to the center compartment. Install the rivets once the complete assembly is in place.

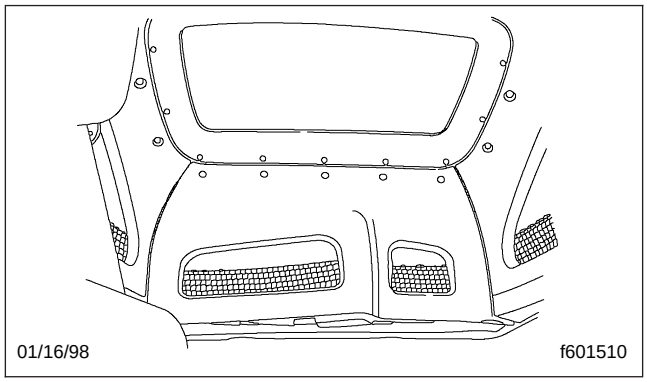


Fig. 8, Upper Storage Compartment Pushpins

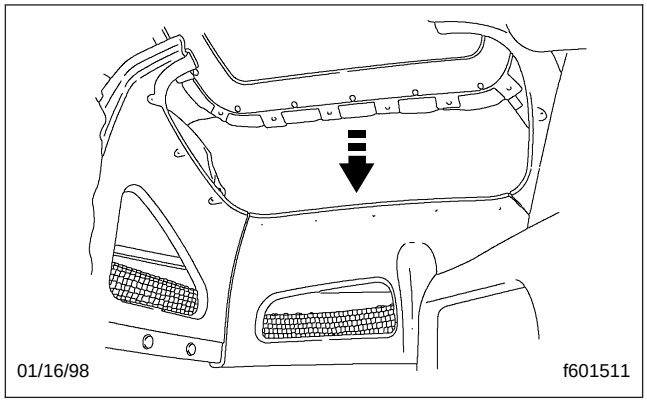


Fig. 9, Overhead Storage Compartment Removal

11. Replace the overhead storage compartment. See **Fig. 9**.
12. Install the 29 pushpins securing the overhead storage compartment. See **Fig. 7** and **Fig. 8**.
13. Connect the interior lamp switch electrical connector. See **Fig. 6**.
14. Install the speaker bolts. See **Fig. 5**.
15. Install the roof console.
16. Position the curtain track and attach the screws. See **Fig. 4**.
17. Attach the curtain to the curtain track. See **Fig. 3**.
18. Position the trim panel over the right-hand door and install the pushpins. See **Fig. 2**.
19. Install the trim panel over the left-hand door. See **Fig. 1**.

    19.1 Position the trim panel.

19.2 Install the pushpins.

19.3 Install the screw.

19.4 Install the reading lamp.

Replacement

1. Remove the screws. See **Fig. 1**.

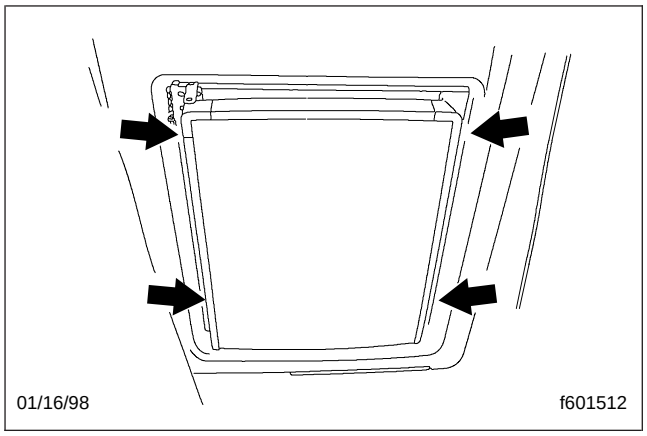


Fig. 1, Refrigerator Screw Location

2. Slide the refrigerator out of the storage compartment. See **Fig. 2**.

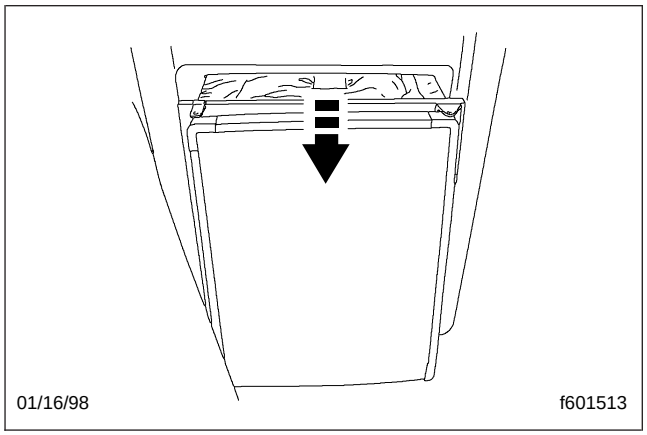


Fig. 2, Refrigerator Storage Compartment Removal

3. Disconnect the electrical connector.
4. Connect the electrical connector.
5. Slide the refrigerator into the storage compartment. See **Fig. 2**.
6. Install the screws. See **Fig. 1**.

General Information

The cab is of all-welded construction, and consists of the underbody assembly (includes the front wall and cab deck), side-wall (door-opening frame) assemblies, back-wall assembly, cowl top assembly, cowl side panels, windshield header, and roof assembly. See **Fig. 1**.

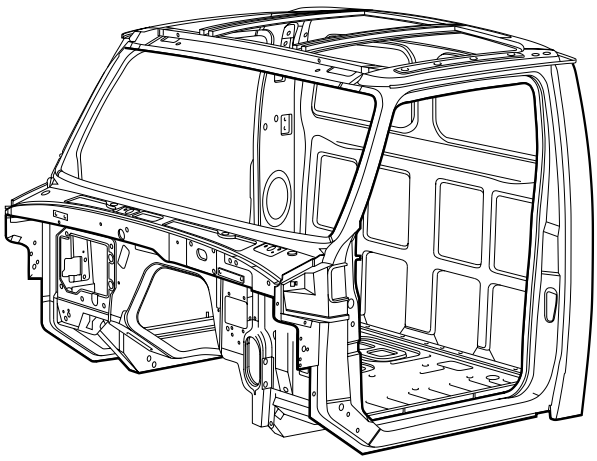


Fig. 1, Cab Structure (day cab shown)

The underbody assembly is of 3/64 inch (1.4 mm) minimum thickness for steel, and 5/64 inch (2.0 mm) minimum thickness for aluminum. Reinforcements provide added support for the engine access cover and seats. The engine cover is attached to the underbody with two bolts and two latches for rapid removal and installation. Cross sills provide reinforcement under the cab deck. Two "sled runner" shaped cab reinforcing members extend for the length of the underbody, from high on the frontwall to the rear cross sill. The rear cross sill is reinforced in the cab mount area.

Each side-wall assembly has reinforcements at all four corners. The door pillar hinge-attachment areas are strengthened by reinforcement plates.

The windshield header for sleepers and the roof side rails are of box-section construction for strength. The roof panel is contoured for stiffness.

The exterior back-wall panel has stamped ribs for stiffness. Reinforcements are located at attaching points for handles and vertical exhaust pipes. The interior upper back-wall panel has a box-section reinforcement across the width of the panel, below the window.

The cab is sealed with an epoxy structural adhesive for added structural integrity.

Rust and corrosion resistance is provided by the use of coated metals and composite materials. The roof panel, cowl sides, cowl top panel, door opening frames, rocker panels, A-pillars, floor pan, back wall panel, rear corner panels, and selected structural underbody members are made of galvanized steel. Steel-to-aluminum contact areas are protected with galvanized steel and E-coated steel components.

Insulation is located above the headliner, facing the front wall, underneath the floor mat, and at the back wall. A temperature-resistant molded engine panel is located in the engine cover area.

When any repairs are done to the cab, it is necessary to check the frame rails for correct alignment and squaring. Then the cab must be leveled and squared. If the cab is repaired without straightening the frame rails, undue stress could be put on the cab, which could weaken it. Also, it may be impossible to square the cab.

Cab Water-Leak Detection

Use the following procedure to locate areas where water may intrude into the cab.

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Prepare a wash solution of at least one-quarter cup of soap to one gallon of water in a spray bottle.
3. Place tape over the cab exhausters.
4. Close all doors, windows, and vents.
5. With the HVAC system in "Fresh Air" mode, turn the fan blower motor on high.

NOTE: Perform the leak detection test with the HVAC system in the "Fresh Air" mode only. Do not set the system in the "Recirculation" mode.

6. Spray the cab and sleeper, if so equipped, with the wash solution and look for bubbles. See **Fig. 1**. Inspect all applicable areas listed below:
    - windshield perimeter
    - visor brackets (if so equipped)
    - cab and sleeper roof seams (if present)
    - air horns and marker lights (if so equipped)
    - roof deflector mounts (if so equipped)
    - sleeper boot (if so equipped)
    - sleeper roof side windows (if present)

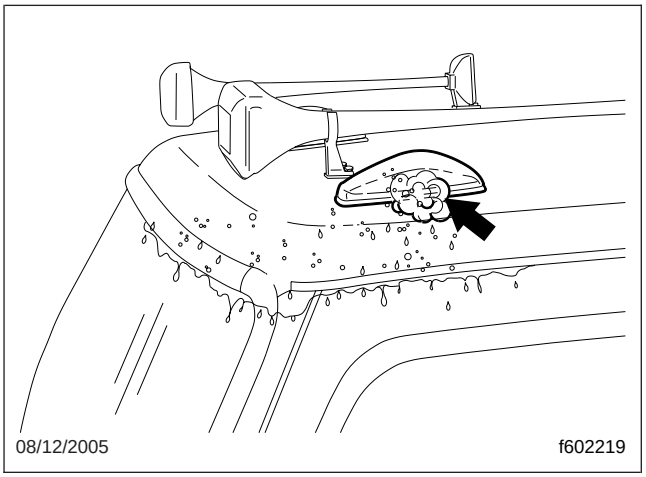


Fig. 1, Cab Water Leak Detection with Wash Solution

7. Mark areas of suspected leaks.

NOTE: This method of leak detection may also identify areas that will not leak water, even though those areas produce bubbles. Bubbles around door seals, baggage doors, and along the vehicle side walls will likely not cause water intrusion issues.

If small bubbles are found in an area that is not suspected to leak, a repair may not be necessary.

8. Rinse the wash solution off the vehicle with water.
9. Turn off the fan blower motor.
10. Remove the tape from the cab exhausters.
11. Remove the chocks.

Cab Water-Leak Repair

If a leak is found, the repair method will depend on the area and type of leak. It may be necessary to remove some components, though most leaks should be repairable by sealing the area of the leak with silicone sealant.

Repair leaks in the windshield using the approved method. See **Section 60.00, Subject 100**.

Removal

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Disconnect the battery.
3. Remove the fenders; see **Section 88.00, Subject 140**.
4. Remove the cowl side panels; see **Section 88.00, Subject 130**.
5. On each side of the vehicle, remove the fender braces from the cab.
   - 5.1 Remove the fasteners that attach the fender brace to the rocker panel; see **Fig. 1**.
   - 5.2 Remove the fasteners that attach the fender brace to the cab; see **Fig. 2**. Remove the brace.

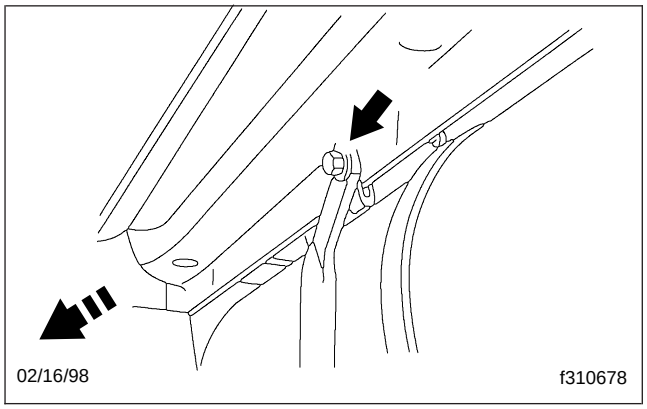


Fig. 1, Fender Brace-to-Rocker Panel Bolt

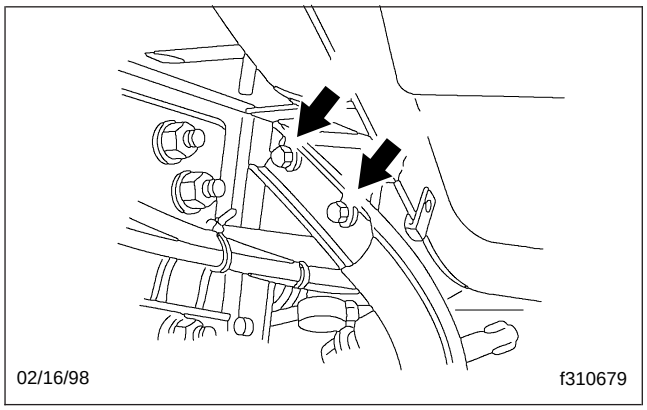


Fig. 2, Fender Brace-to-Cab Bolts

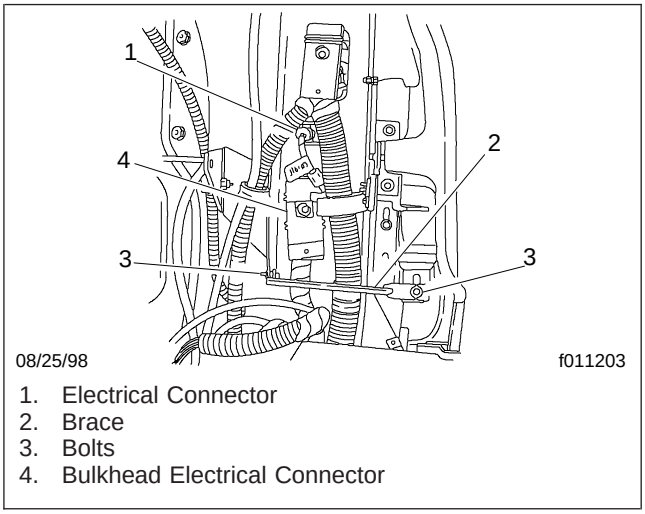
6. Remove the air cleaner assembly; see **Section 09.02**.
7. Disconnect the clutch linkage; see **Section 25.01**.
8. Disconnect the accelerator linkage; see **Group 30**.
9. Disconnect the steering linkage; see **Section 46.01**.
10. Disconnect the oil pressure gauge line fitting.
11. Disconnect the windshield washer hose.
12. Disconnect the windshield washer electrical connectors.
13. For vehicles with cab rear air suspension, place blocks between the frame and the bottom of the cab, or use jack stands to keep the cab in position when the air spring is deflated.
14. Drain the air system.

⚠ WARNING

Make sure the air system has been completely drained before attempting to remove an air line. Do not disconnect pressurized air lines as they may whip as air escapes. Before working on or around air lines and components, see the safety precautions in Section 42.06, Subject 100. Failure to take all necessary precautions could result in personal injury.

15. Disconnect the air lines from the in-cab air manifold.
16. Remove the air line retainer.
17. Disconnect the air lines from the in-dash air manifold.
18. Disconnect the bulkhead electrical connector. See **Fig. 3**.
19. Disconnect the air lines at the foot control valve; see **Group 42**.
20. Disconnect the heater hoses; see **Group 83**.
21. Disconnect the air conditioning hoses, if so equipped; see **Section 83.01, Subject 190**.
22. Disconnect the heater and air conditioning electrical connectors.
23. Remove the wire harness retainers.

Cab Removal and Installation



1. Electrical Connector
2. Brace
3. Bolts
4. Bulkhead Electrical Connector

Fig. 3, Bulkhead Electrical Connector

24. Disconnect the wire harness electrical connectors.
25. If the vehicle is equipped with a cab-mounted exhaust system, disconnect the exhaust system at the muffler. Remove the exhaust mounting bolts and the exhaust.
26. Disconnect any transmission electrical wiring, air lines, or linkages from the cab; see **Group 26**.
27. Attach the straps of a suitable lift at four points to the cab (two forward, and two rear). Support the cab with the lift while disconnecting the cab mounts.
28. On both sides of the vehicle, remove the front cab support-to-isolator mounting bolt; see **Fig. 4**.

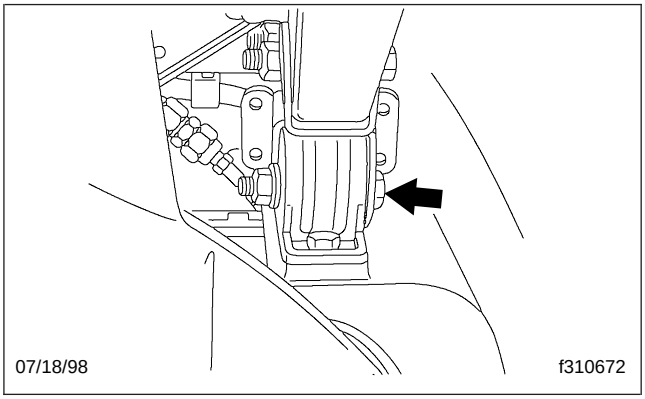


Fig. 4, Front Cab Support-to-Isolator Mounting Bolt

29. For vehicles with fixed cab rear mounts equipped with lateral bolts, remove the bolts; see **Fig. 5**.

    For vehicles with other fixed cab rear mounts, and vehicles with rear hydromounts, remove the cab upper rear-mount nuts from inside the cab; see **Section 60.07, Subject 110**.

    For vehicles with cab rear air suspension, do the following:

    29.1 Detach the tops of the air springs from the cab; see **Section 60.06, Subject 140**.

    29.2 Disconnect the height-adjustment valve vertical linkage from the cab; see **Section 60.06, Subject 170**.

    29.3 Detach the lateral control rod from the cab; see **Section 60.06, Subject 160**.

    29.4 Detach the shock absorbers from the cab; see **Section 60.06, Subject 150**.

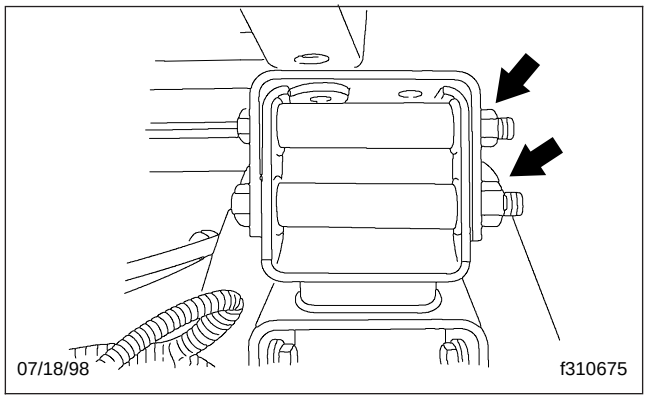


Fig. 5, Rear Cab Support Lateral Bolts

⚠ WARNING

Before lifting the cab from the chassis, make sure the cab is correctly balanced, that it is supported in at least four places, and that the hoist is strong enough to support the cab. Failure to do so could result in the cab falling.

Do not get underneath or near a cab that is supported only by a hoist. Should the cab fall, serious injury or death could result.

30. With the hood open, remove the cab with a suitable lift.

Installation

WARNING

Do not get underneath or near a cab that is supported only by a hoist. Should the cab fall, serious injury or death could result.

NOTE: For a vehicle with cab rear air suspension, make sure the blocks or jack stands are placed to hold the rear of the cab in an elevated position when the cab is lowered. This will make it easier to connect the cab rear air suspension components to the cab.

1. With the vehicle tires chocked and the hood open, lower the cab in place, using a suitable lift.
2. On both sides of the vehicle, install the front cab support-to-isolator mounting bolt; see **Fig. 4**.

   Tighten 150 to 175 lbf·ft (203 to 237 N·m) for 3/4–10 bolt.

   Tighten 120 to 152 lbf·ft (163 to 206 N·m) for 5/8–11 bolt.
3. For vehicles with fixed cab rear mounts equipped with lateral bolts, install the bolts; see **Fig. 5**.

   For vehicles with other fixed cab rear mounts, and vehicles with rear hydromounts, install the cab upper rear-mount nuts inside the cab; see **Section 60.07, Subject 110**.

   For vehicles with cab rear air suspension, do the following:

   3.1 Attach the tops of the air springs to the cab; see **Section 60.06, Subject 140**.

   3.2 Attach the shock absorbers to the cab; see **Section 60.06, Subject 150**.

   3.3 Attach the lateral control rod to the cab; see **Section 60.06, Subject 160**.

   3.4 Connect the height-adjustment valve vertical linkage to the cab; see **Section 60.06, Subject 170**.

NOTE: Unless specified in the applicable subject, tighten all rear cab mount fasteners using the torque specifications listed in **Section 00.06**.

4. Detach the lift straps from the cab.
5. Connect any transmission electrical wiring, air lines, or linkages to the cab; see **Group 26**.
6. If the vehicle is equipped with a cab-mounted exhaust system, install the exhaust and mounting bolts. Connect the exhaust system to the muffler.
7. Connect the wire harness electrical connectors.
8. Install the wire harness retainers.
9. Connect the heater and air conditioning electrical connectors.
10. Connect the air conditioning hoses, and charge the air conditioning system; see **Group 83**.
11. Connect the heater hoses; see **Group 83**.
12. Connect the air lines at the brake foot control valve; see **Group 42**.
13. Connect the bulkhead electrical connector. See **Fig. 3**.
14. Connect the air lines to the in-dash air manifold.
15. Install the air line retainer.
16. Connect the air lines to the in-cab air manifold.
17. Connect the windshield washer electrical connectors.
18. Connect the windshield washer hose.
19. Connect the oil pressure gauge line fitting.
20. Connect the steering linkage; see **Section 46.01**.
21. Connect the accelerator linkage; see **Group 30**.
22. Connect the clutch linkage; see **Section 25.01**.
23. Install the air cleaner assembly; see **Section 09.02**.
24. On each side of the vehicle, install the fender braces on the cab, as follows.

    24.1 Position the fender brace in place. Install the fasteners that attach the fender brace to the cab; see **Fig. 2**.

    24.2 Install the fasteners that attach the fender brace to the rocker panel; see **Fig. 1**.
25. Install the cowl side panels; see **Section 88.00, Subject 130**.
26. Install the fenders; see **Section 88.00, Subject 140**.
27. Connect the battery.
28. Pressurize the air system, and check it for leaks.

Cab Removal and Installation

29. For vehicles with cab rear air suspension, remove the blocks or jack stands used to keep the rear of the cab elevated.
30. Remove the chocks.

Troubleshooting

CAUTION

If welding is required for cab repair procedures, all electronic control modules on the vehicle must be isolated from ground during welding to prevent damage to the electronic components.

On vehicles using aluminum cab construction, use only original equipment manufacturer replacement parts including fasteners. This must be strictly adhered to in order to reduce the possibility of galvanic corrosion.

Problem—Dust and Water Leaks

Problem—Dust and Water Leaks	
Possible Cause	**Remedy**
Cab sealer missing	Remove trim. Check for leaks and seal with appropriate sealer. Road test or water hose test for leaks. See **Subject 100** for water hose test instructions. Recheck trim for leaks. Or use a light under the vehicle with trim removed. Check the cab interior at joints and weld lines.
Openings in welds or cab joints	
Components not fully installed	
Components missing	
Components damaged	
Missing or damaged plugs or grommets	Check plugs for proper installation. Replace if necessary.

Problem—Door Drain Holes Collecting Water

Problem—Door Drain Holes Collecting Water	
Possible Cause	**Remedy**
Holes clogged with mud or road tar	Check drain holes regularly. Clean drain holes of dirt and foreign material with a punch or screwdriver.

Problem—Wind Noise, Air Entering Vehicle Through Small Holes in Cab

Problem—Wind Noise, Air Entering Vehicle Through Small Holes in Cab	
Possible Cause	**Remedy**
Leaks at door and window seals or sheet metal joints in doors or door openings	Seal leaks with appropriate sealer. Check door adjustment; see **Section 72.00, Subject 110**. Road test.

Problem—Rattles

Problem—Rattles	
Possible Cause	**Remedy**
Loose screws, nuts, bolts, small pieces of deadener in door wells, pillars, and quarter panels	Check the doors by carefully striking underside of door with a rubber mallet and listen for loose objects in the door. Tighten the cab bolts and screws. If tightening the bolts does not eliminate the rattle, the cause could be misalignment; refer to **Group 72**.
Weather-stripping or anti-squeak material has slipped out of position	Apply additional sealer. Install in proper location to eliminate rattle.

Cab Sealers, Adhesives, and Lubricants

See **Table 1** for sealer, adhesive, and lubricant specifications and applications.

Cab Sealers, Adhesives, and Lubricants		
Item	**Specification**	**Application**
Sealers		
Liquid Butyl Sealer C9AZ–19554–B	ESB–M4G162–A	Butyl-Installed Windows and Backlights
Caulking Cord D6AZ–19560–A	ESB–M4G32–A	Surfaces Not Sealed by Gaskets
Adhesives		
Weatherstrip Adhesive E8AZ–19552–A	ESB–M2G14–A	Door Weatherstripping
Lubricants		
Silicone Lubricant COAZ–19553–AA or F7AZ–19553–AA	ESR–M13P4–A	Rubber Parts Exposed to Weather

Table 1, Cab Sealers, Adhesives, and Lubricants

Liquid Butyl Sealer

Liquid Butyl Sealer C9AZ–19554–B or equivalent meeting specification ESB–M4G162–A:

- can be used to maintain leak-free sealing around windows and backlights;
- is recommended for water leak repairs and as an after-sealer for glass replacement on butyl-installed windows and backlights;
- has excellent flow characteristics and will not run when exposed to heat.

Caulking Cord

Caulking Cord D6AZ–19560–A or equivalent meeting specification ESB–M4G32–A:

- has a plastic base with a filler;
- is heavy-bodied;
- is commonly known as perma-gum;
- can be used for seam sealing in such areas as the floorpan, wheelhouse, running board, dash panel, door openings, and drip rails;
- is used on spot-weld holes, around mounting clips, and between surfaces not sealed by a gasket.

Weatherstrip Adhesive

Weatherstrip Adhesive E8AZ–19552–A or equivalent meeting specification ESB–M2G14–A is a quick-drying, strong adhesive designed to hold or repair weatherstripping on doors, bodies, and the surrounding metal.

Silicone Lubricant

Silicone Lubricant COAZ–19553–AA or F7AZ–19553–AA or equivalent meeting specification ESR–M13P4–A:

- is used to lubricate rubber parts exposed to the weather;
- is used on the door and window weatherstrips;
- must be applied to the weatherstrips at every lubrication period;
- makes the doors easier to close;
- avoids weatherstrip squeaks;
- retards weatherstrip wear;
- helps maintain door window alignment by reducing the friction between the glass frame and the rubber weatherstrips.

Replacement

NOTE: Left-hand shown, right-hand symmetrically opposite.

1. Remove the fasteners and remove the grab handle. See **Fig. 1**.

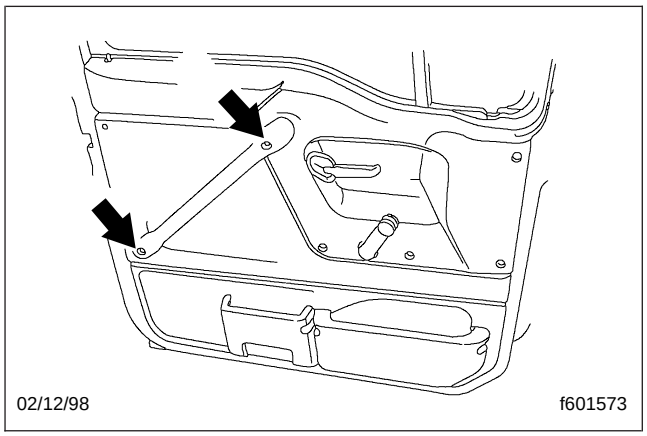


Fig. 1, Grab Handle Fasteners

2. Pry the cover up from the door window handle, if so equipped. See **Fig. 2**.

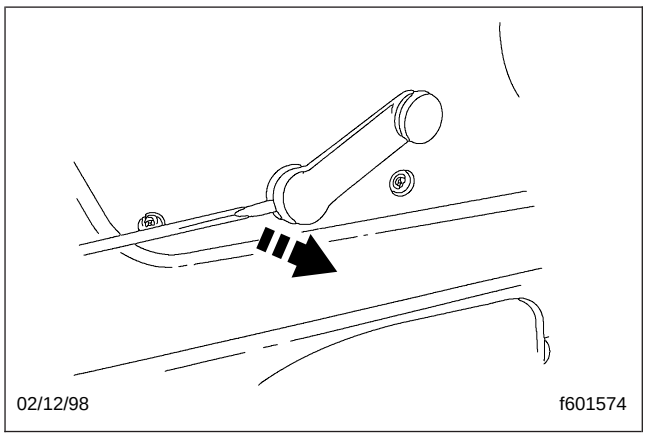


Fig. 2, Door Window Handle Cover

3. Remove the screw and remove the door window handle, if so equipped. See **Fig. 3**.
4. Remove the screws. See **Fig. 4**.
5. Tilt the door trim finish panel outward and disconnect the electrical connectors, if so equipped. See **Fig. 5**.
6. Remove the screws. See **Fig. 6**.

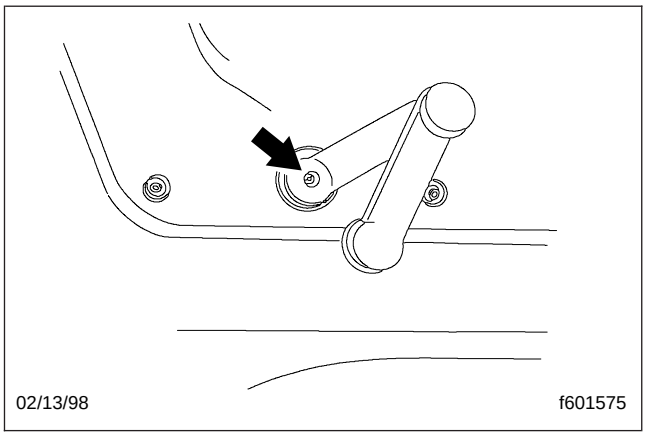


Fig. 3, Door Window Handle Screw

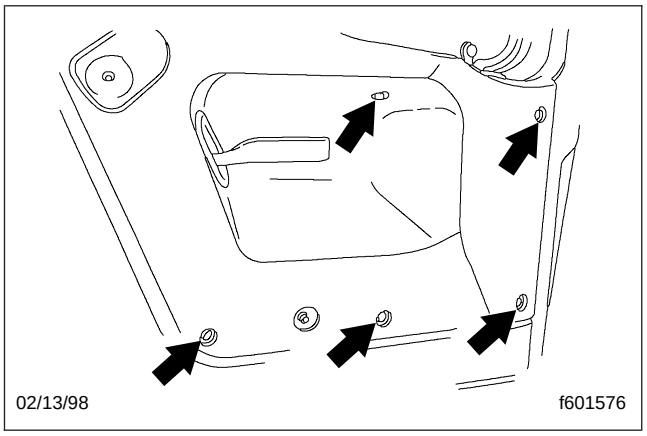


Fig. 4, Panel Screws

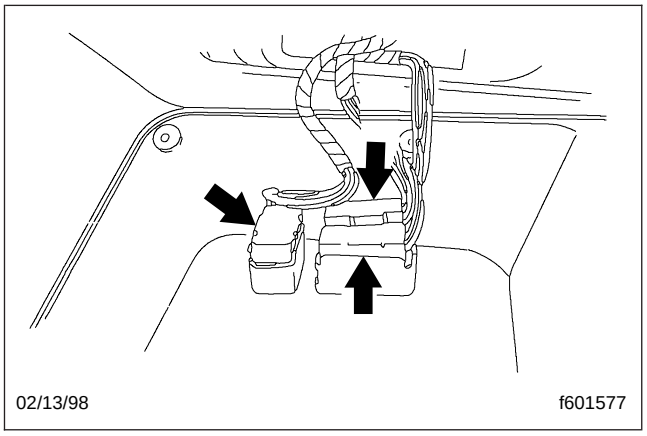


Fig. 5, Door Trim Panel Electrical Connectors

7. Disconnect the courtesy lamp electrical connector. See **Fig. 7**.

Door Trim Panel Replacement

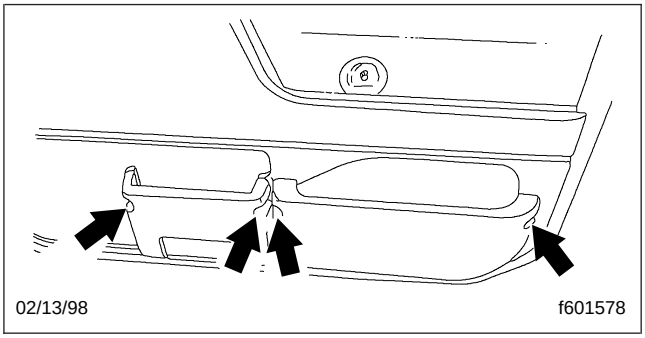


Fig. 6, Door Storage Compartment Screws

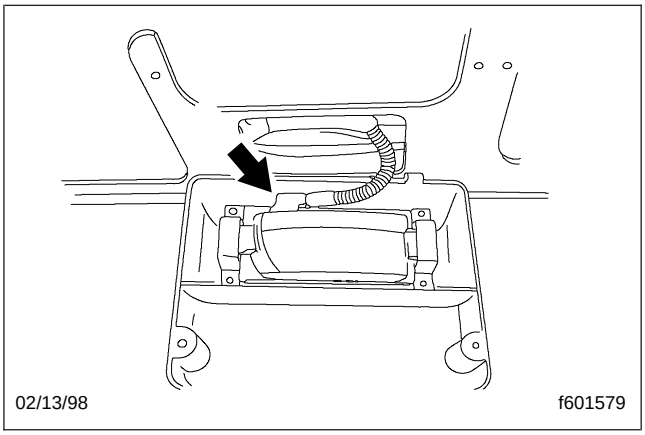


Fig. 7, Courtesy Lamp Electrical Connector

8. Remove the door trim panel retainers and remove the door trim panel. See **Fig. 8**.

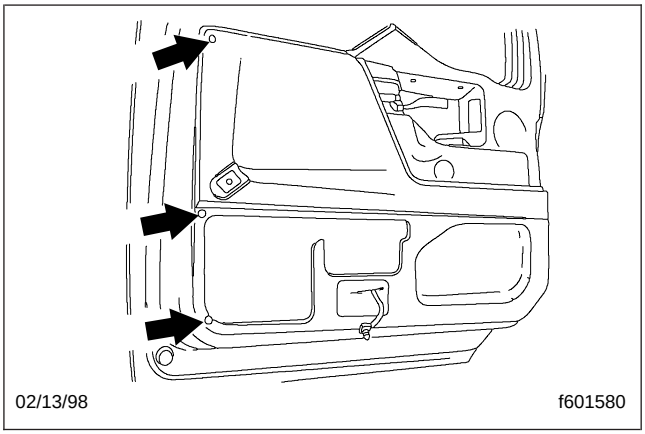


Fig. 8, Door Trim Panel Retainers

9. Position the door trim panel and install the door trim panel retainers. See **Fig. 8**.
10. Connect the courtesy lamp electrical connector. See **Fig. 7**.
11. Install the screws. See **Fig. 6**.
12. Tilt the door trim finish panel inward and connect the electrical connectors, if so equipped. See **Fig. 5**.
13. Install the screws. See **Fig. 4**.
14. Position the door window handle and install the screw, if so equipped. See **Fig. 3**.
15. Push the cover down onto the door window handle, if so equipped. See **Fig. 2**.

NOTE: Left-hand shown, right-hand symmetrically opposite.

16. Position the grab handle and attach the fasteners. See **Fig. 1**.

Replacement

1. Remove the roof console, if so equipped.
2. Remove the speaker cover bolts, if so equipped (left-hand shown, right-hand symmetrically opposite). See **Fig. 1**.

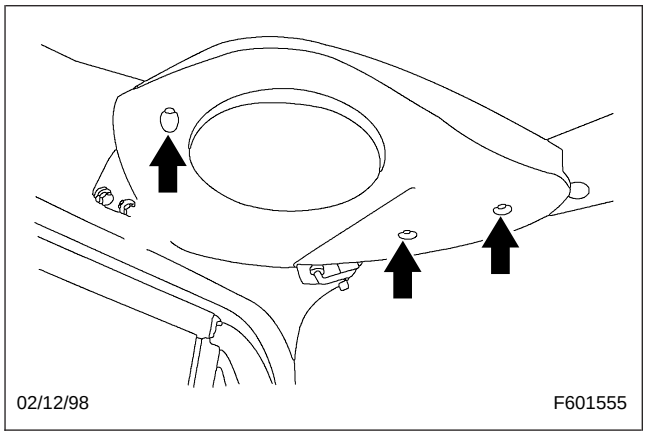


Fig. 1, Speaker Cover Bolts

3. Remove the radio speakers. Refer to **Group 54**.
4. Remove the dome lamp. Refer to **Group 54**.
5. Remove the headliner retainers and remove the headliner. See **Fig. 2**.

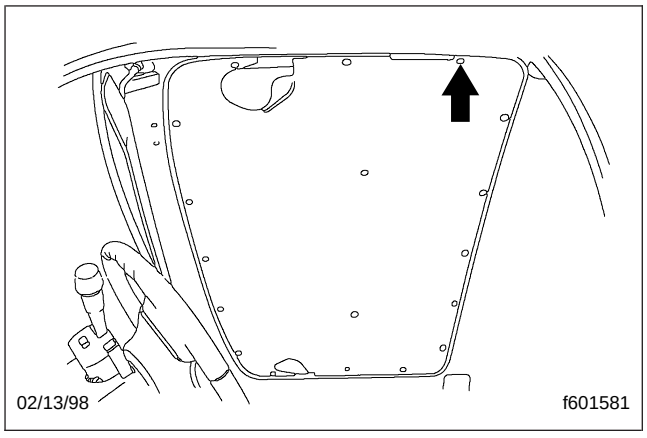


Fig. 2, Headliner Retainers

6. Replace the headliner and install the headliner retainers. See **Fig. 2**.
7. Install the dome lamp. Refer to **Group 54**.
8. Install the radio speakers. Refer to **Group 54**.
9. Install the speaker cover bolts, if so equipped (left-hand shown, right-hand symmetrically opposite). See **Fig. 1**.
10. Install the roof console, if so equipped.

Replacement

NOTE: Part of the carpet or mat assembly may need to be removed to access the engine cover.

1. Remove the bolts and remove the engine cover. See **Fig. 1**.

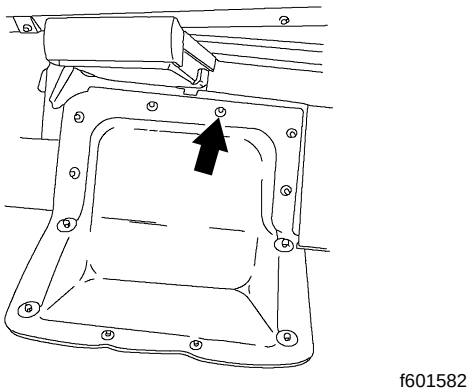


Fig. 1, Base Engine Cover

2. Position the engine cover in the cab and install the bolts.

Replacement

NOTE: Partial removal of the passenger seat assembly or removal of the manual shift lever may be necessary in order to remove some types of engine covers.

1. Release the six engine cover latches and remove the engine cover. See **Fig. 1**.

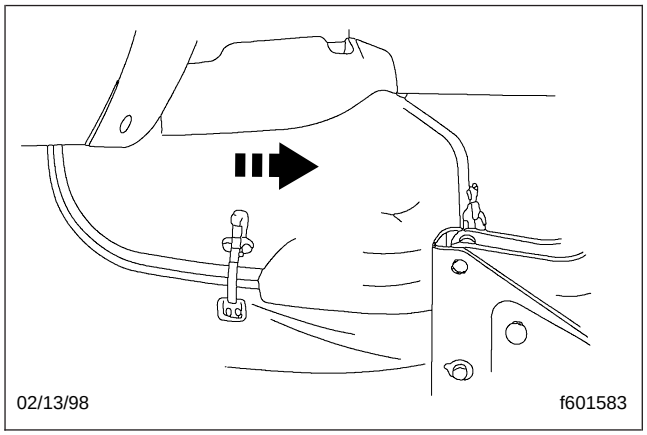


Fig. 1, Raised Engine Cover

2. Position the engine cover in the cab and latch the six engine cover latches.

Lighted Marker and Heated Western-Type Mirror Replacement

Replacement

1. Remove the left-side door trim panel.
2. Remove the inner watershield.
3. Disconnect the electrical connector. See **Fig. 1**.

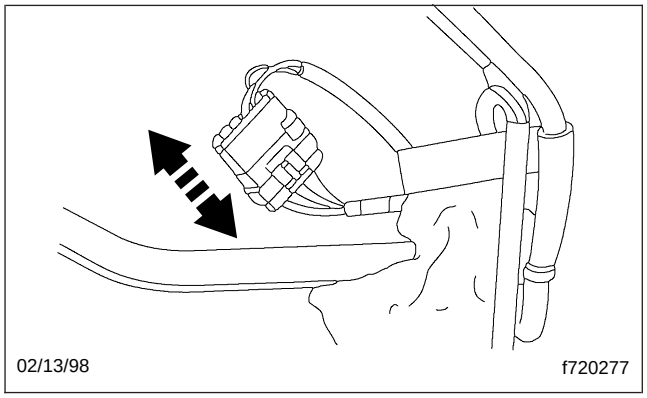


Fig. 1, Mirror Electrical Connector

4. Remove the wire grommet from the mirror bracket. See **Fig. 2**.

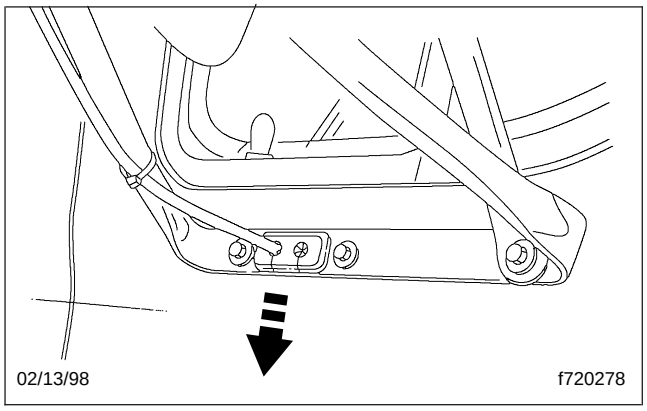


Fig. 2, Mirror Bracket Wire Grommet

5. Remove the wire from the left-side door. See **Fig. 3**.
6. Cut the cable wraps on the mirror bracket. See **Fig. 4**.
7. Remove the upper and lower retaining nuts and remove the mirror. See **Fig. 5**.
8. Replace the mirror and install the upper and lower retaining nuts. Tighten the nuts 9 to 12 lbf·ft (12 to 16 N·m). See **Fig. 5**.

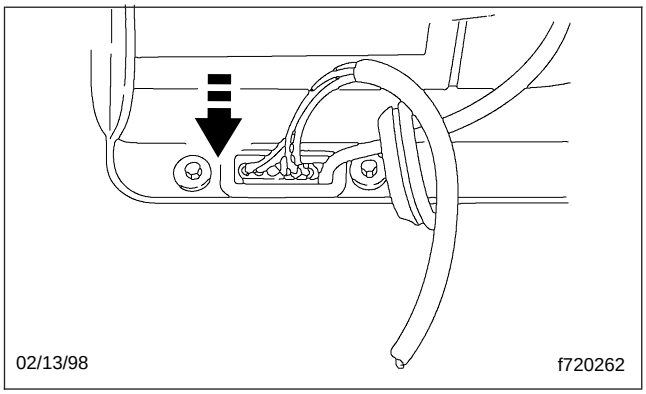


Fig. 3, Left-Side Door Wire

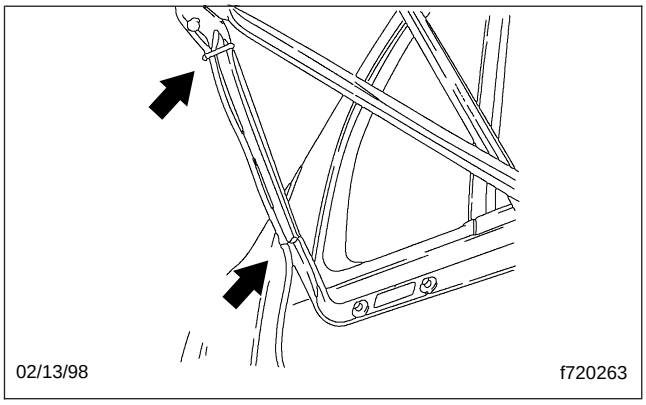


Fig. 4, Mirror Bracket Cable Wraps

9. Attach the cable wraps on the mirror bracket. See **Fig. 4**.
10. Install the mirror wire on the left-side door. See **Fig. 3**.
11. Install the wire grommet on the mirror bracket. See **Fig. 2**.
12. Connect the mirror electrical connector. See **Fig. 1**.
13. Install the inner watershield.
14. Install the left-side door trim panel.

Lighted Marker and Heated Western-Type Mirror Replacement

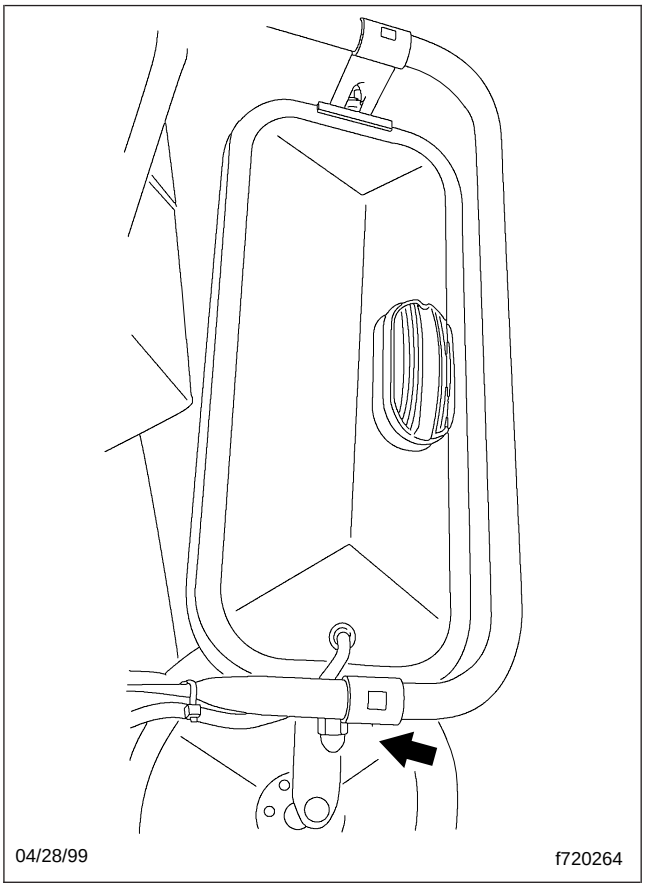


Fig. 5, Mirror Retaining Nuts

Western-Type Power Mirror Replacement

Replacement

1. Carefully pry the power mirror switch from the left-side door trim panel. See **Fig. 1**.

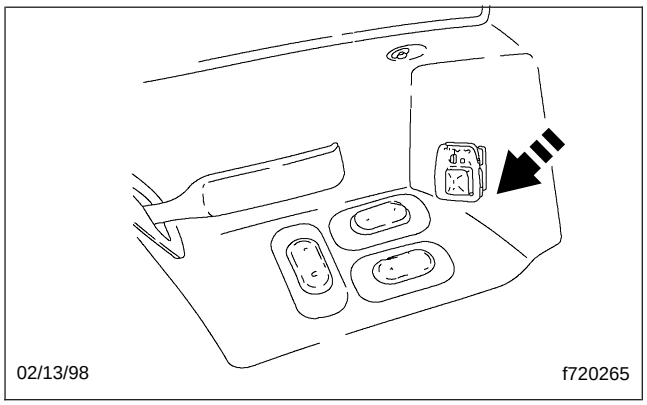


Fig. 1, Power Mirror Switch

2. Depress the electrical connector locking tab and separate the power mirror switch from the electrical harness. See **Fig. 2**.

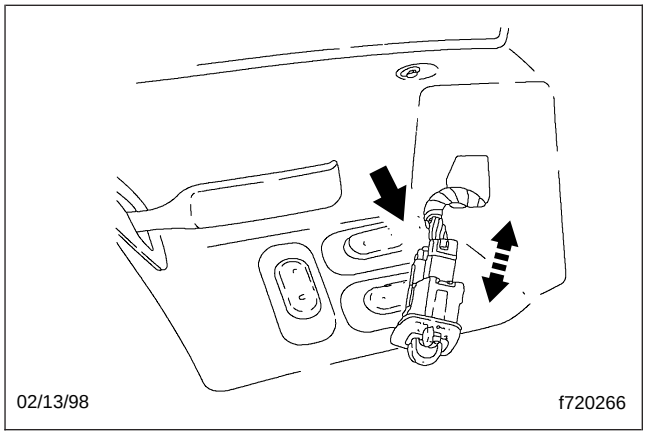


Fig. 2, Power Mirror Electrical Connector

3. Remove the left-side door trim panel.
4. Remove the wire grommet from the power mirror bracket. See **Fig. 3**.
5. Remove the power mirror wire from the left-side door. See **Fig. 4**.
6. Cut the cable wraps on the mirror bracket. See **Fig. 5**.
7. Remove the upper and lower retaining nuts, and remove the mirror. See **Fig. 6**.

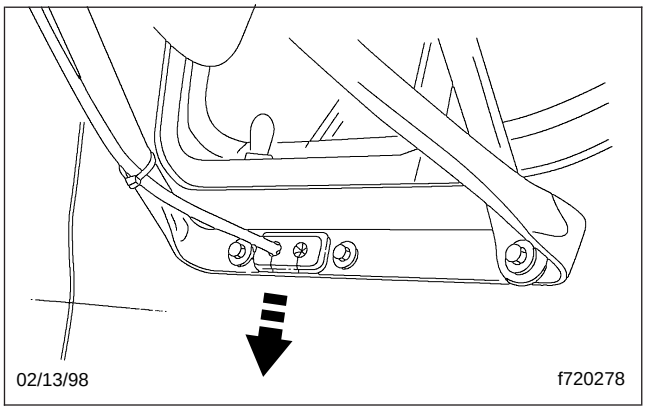


Fig. 3, Power Mirror Bracket Wire Grommet

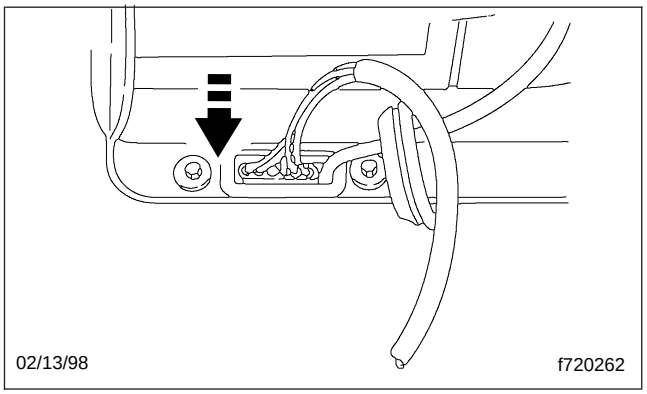


Fig. 4, Left-Side Door Mirror Wire

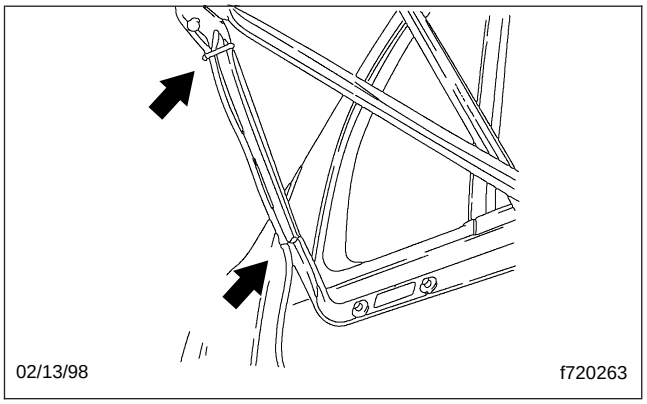


Fig. 5, Mirror Bracket Cable Wraps

8. Replace the mirror and install the upper and lower retaining nuts. Tighten the nuts 9 to 12 lbf·ft (12 to 16 N·m). See **Fig. 6**.
9. Install the cable wraps on the mirror bracket. See **Fig. 5**.

Western-Type Power Mirror Replacement

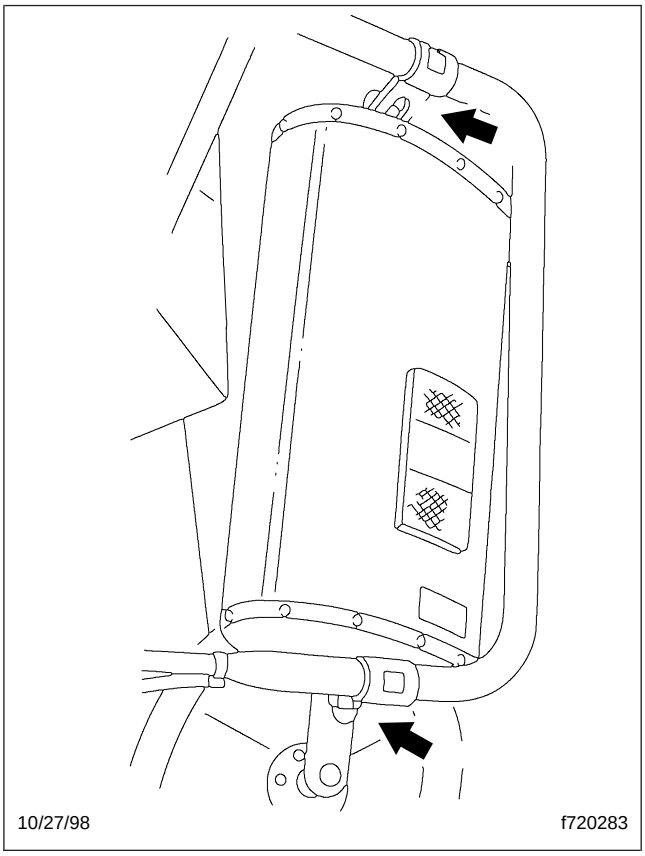


Fig. 6, Mirror Retaining Nuts

10. Install the power mirror wire on the left-side door. See **Fig. 4**.
11. Install the wire grommet on the power mirror bracket. See **Fig. 3**.
12. Remove the left-side door trim panel.
13. Connect the power mirror switch to the electrical harness. See **Fig. 2**.
14. Install the power mirror switch into the left-side door trim panel. See **Fig. 1**.

Western-Type Mirror Mounting Bracket Replacement

Replacement

1. Remove the rearview mirror. If equipped with a power or heated/lighted mirror, refer to **Subject 100** or **Subject 110**.
2. If equipped with a CB antenna, refer to **Group 54** to remove the antenna and cable.
3. Remove the seven screws, and remove the bracket. See **Fig. 1**.

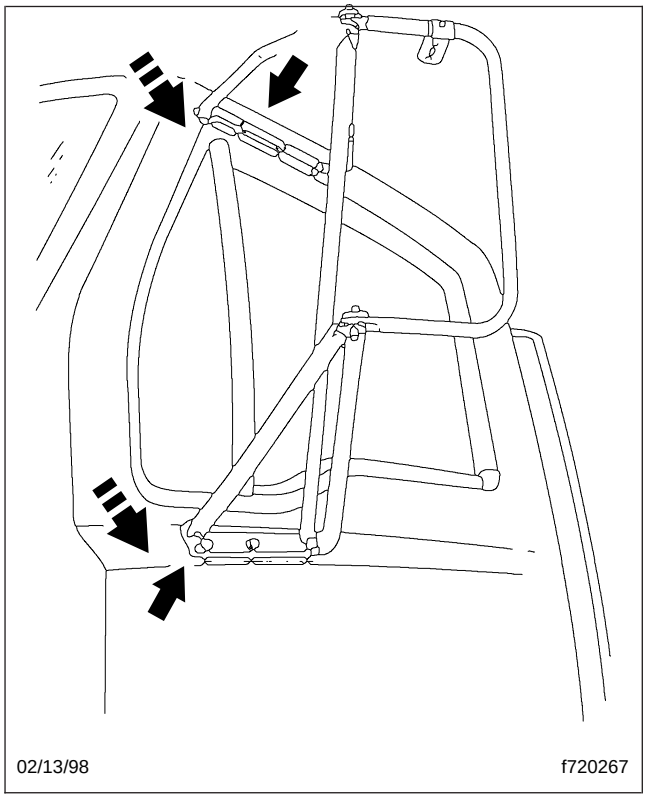


Fig. 1, Bracket Screw Removal

4. Replace the mirror bracket and install the seven screws. Tighten the screws 72 to 108 lbf·in (99 to 120 N·cm). See **Fig. 2**.
5. If equipped with a CB antenna, refer to **Group 54** to install the antenna and cable.
6. Install the rearview mirror. If equipped with a power or heated/lighted mirror, refer to **Subject 100** or **Subject 110**.

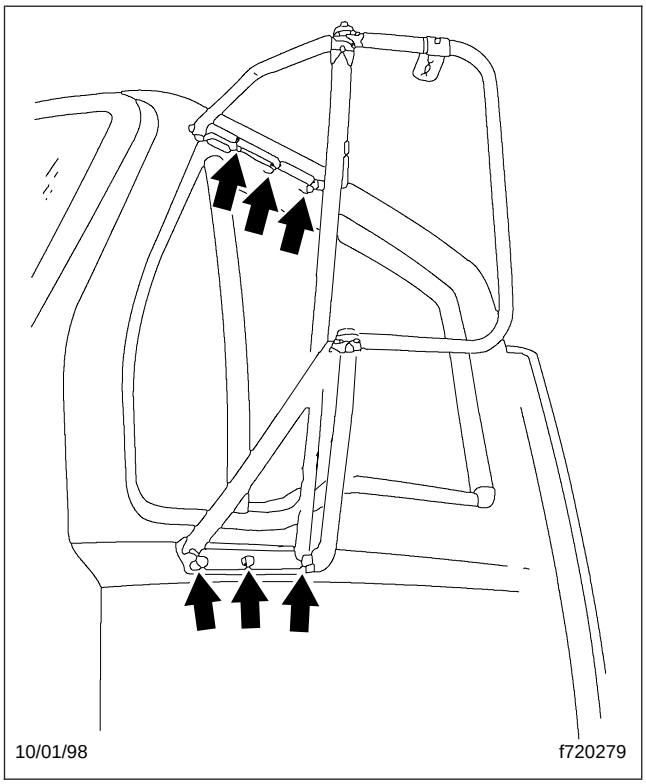


Fig. 2, Bracket Screw Installation

Aerodynamic Mirror Replacement

Replacement

1. Remove the CB antenna.
2. Remove the door trim panel. See **Fig. 1**.

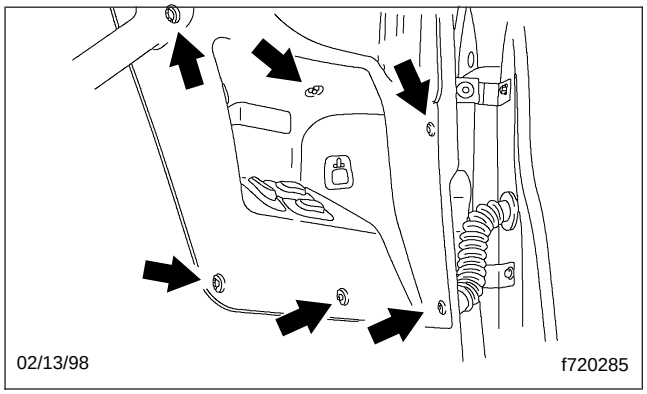


Fig. 1, Door Trim Panel

3. Disconnect the power mirror switch(es). See **Fig. 2**.

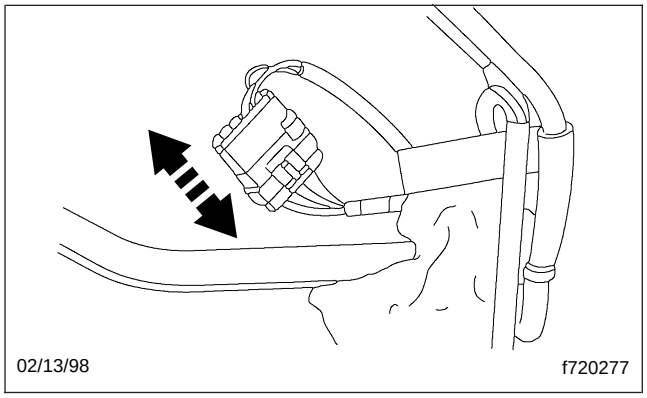


Fig. 2, Power Mirror Switch

4. Disconnect the CB antenna cable.
5. Remove the lower mirror bracket trim cover. See **Fig. 3**.
6. Remove the lower mirror bracket bolts. See **Fig. 4**.
7. Remove the upper mirror bracket bolts. See **Fig. 5**.
8. Remove the mirror assembly.

NOTE: Make sure the wiring harness does not interfere with window travel.

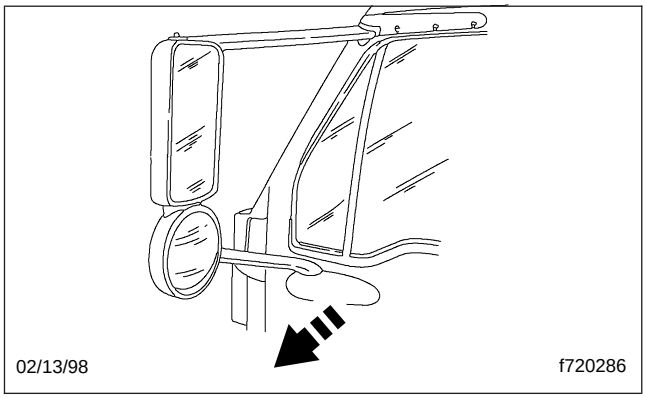


Fig. 3, Lower Mirror Bracket Trim Cover

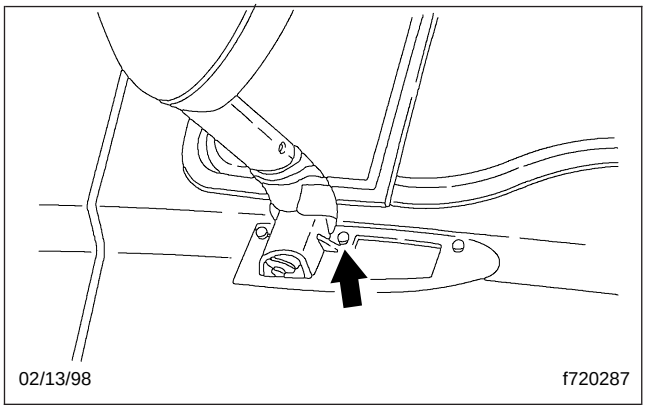


Fig. 4, Lower Mirror Bracket Bolts

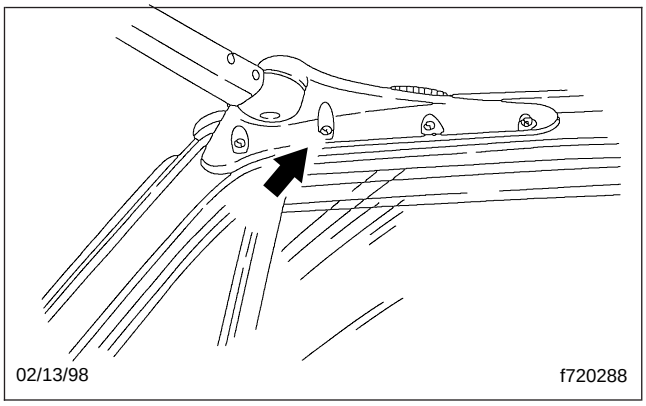


Fig. 5, Upper Mirror Bracket Bolts

9. Install the mirror assembly.
10. Install the upper mirror bracket bolts. See **Fig. 5**. Tighten the bolts 30 lbf·ft (40 N·m).

Aerodynamic Mirror Replacement

11. Install the lower mirror bracket bolts. See **Fig. 4**. Tighten the bolts 84 to 108 lbf·in (99 to 120 N·cm).
12. Install the lower mirror bracket trim cover. See **Fig. 3**.
13. Connect the CB antenna cable.
14. Connect the power mirror switch(es). See **Fig. 2**.
15. Install the door trim panel. See **Fig. 1**.
16. Install the CB antenna.

Aerodynamic Mirror Glass Removal and Installation

Removal

NOTE: The upper and lower glass are removed in the same manner.

1. Position the mirror glass in the full up-facing position, and slide the mirror glass upward until maximum travel is attained. See **Fig. 1**.

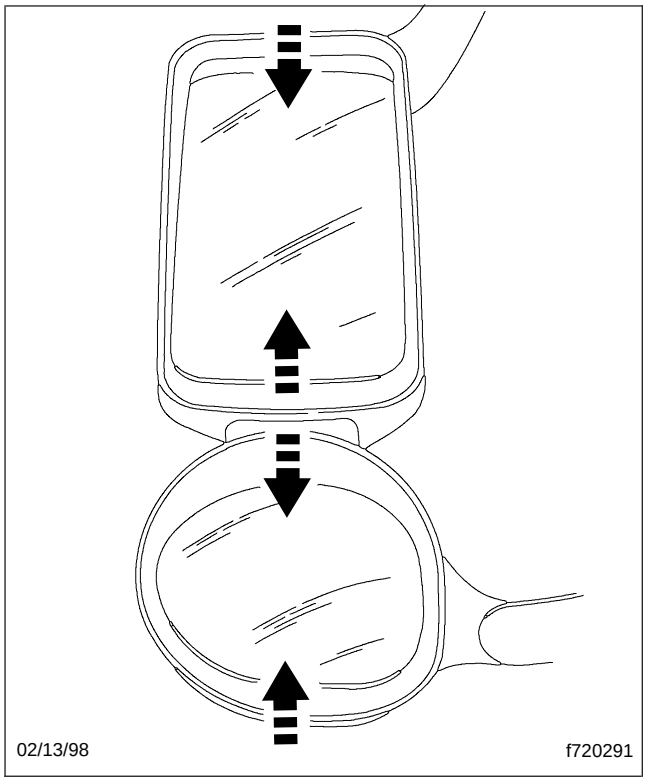


Fig. 1, Mirror Glass

2. Position the mirror glass in the full down-facing position. Place a hand on the bottom of the mirror glass, and lift upward until the glass is released. See **Fig. 2**.
3. Disconnect the electrical connectors, and remove the mirror glass. See **Fig. 3**.

Installation

1. Connect the electrical connectors to the mirror glass.

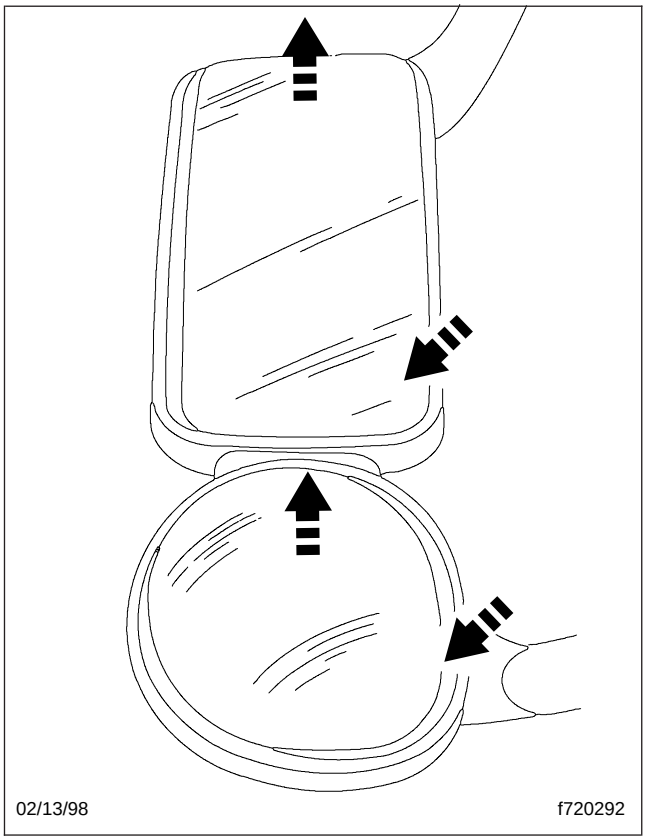


Fig. 2, Glass Removal

2. Align the mirror glass retainer tabs on the mirror actuator, and slide downward until the mirror and actuator are fully engaged.

Aerodynamic Mirror Glass Removal and Installation

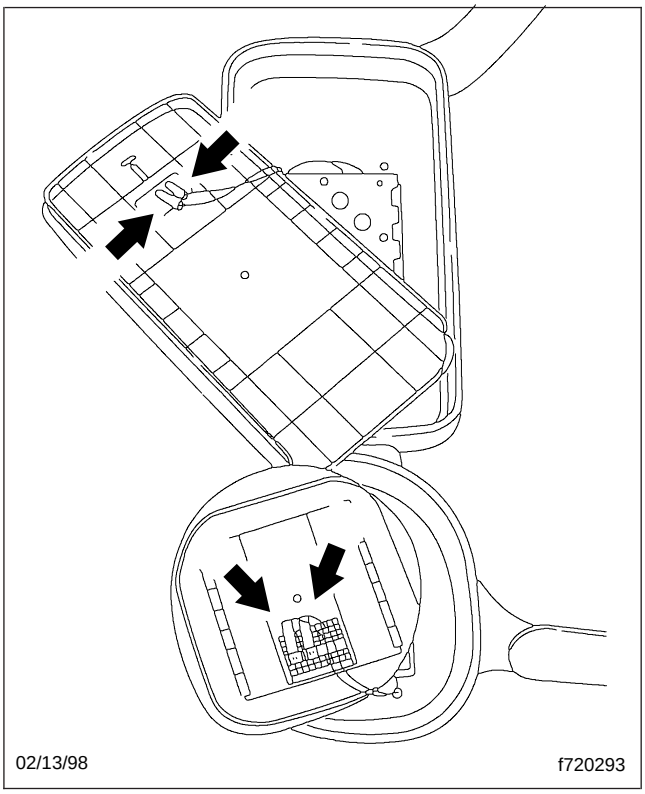


Fig. 3, Mirror Electrical Connector

Aerodynamic Mirror Actuator Replacement

Replacement

NOTE: Removal of the upper and lower actuator follows the same procedure.

1. Remove the mirror glass. Refer to **Subject 140**.
2. Remove the Allen-head screws. See **Fig. 1**.

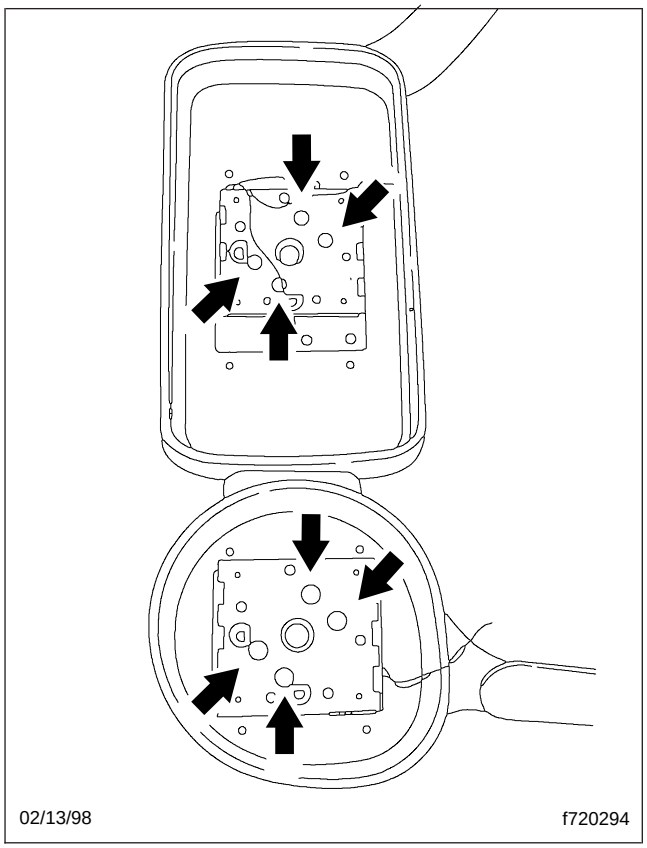


Fig. 1, Location of Allen Head Screws

3. Disconnect the actuator electrical connectors. Pay particular attention to the wiring order to aid in installation. See **Fig. 2**.
4. Remove the actuator.
5. Replace the actuator.
6. Connect the actuator electrical connectors. See **Fig. 2**.
7. Install the Allen-head screws. See **Fig. 1**.
8. Install the mirror glass. Refer to **Subject 140**.

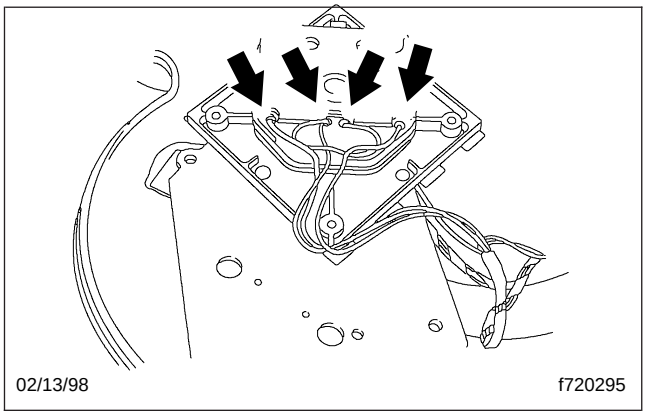


Fig. 2, Actuator Electrical Connectors

Aerodynamic Mirror Harness Replacement

Replacement

1. Remove the mirror glass. Refer to **Subject 140**.
2. Remove the actuator. Refer to **Subject 150**.
3. Remove the mirror bezel screws and the mirror bezel. See **Fig. 1**.

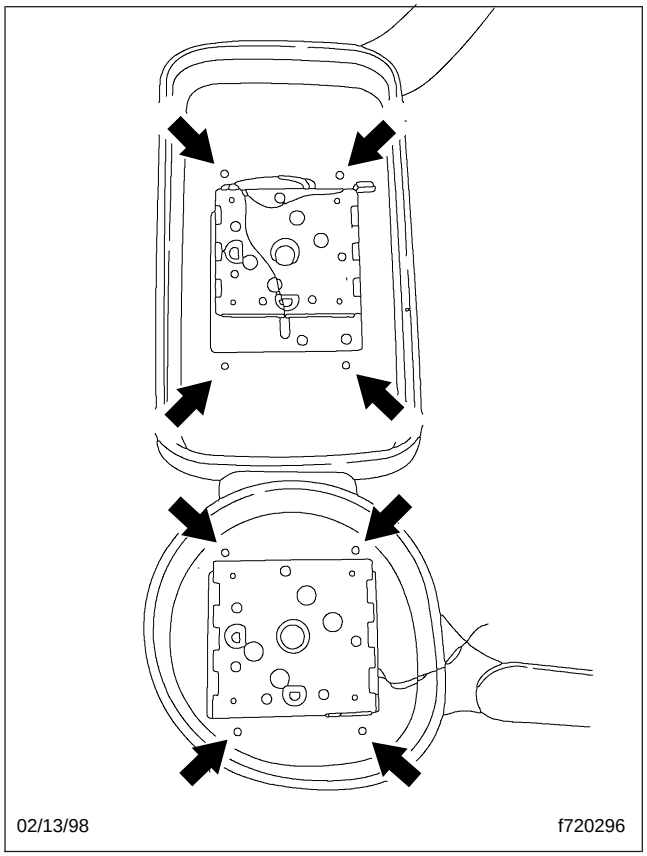


Fig. 1, Mirror Bezel and Screws

4. Remove the power mirror switch(es). Refer to **Subject 170**.
5. Remove the door trim panel. See **Fig. 2**.
6. Remove the lower mirror bracket trim cover. See **Fig. 3**.
7. Support the mirror assembly and remove the lower mirror bracket pivot bolt, shim and spring. See **Fig. 4**.
8. Remove the lower mirror mounting bracket.
9. Remove the harness through the door.

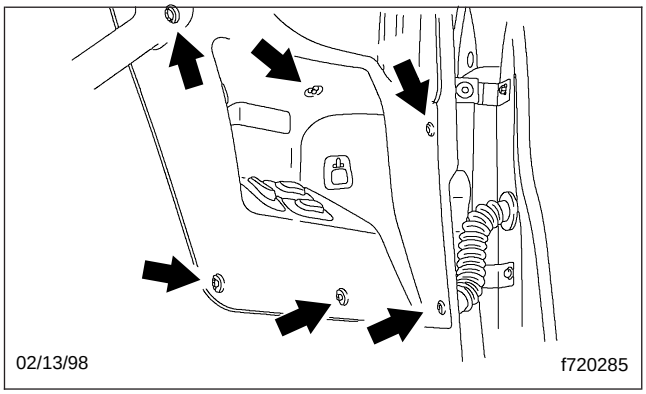


Fig. 2, Door Trim Panel

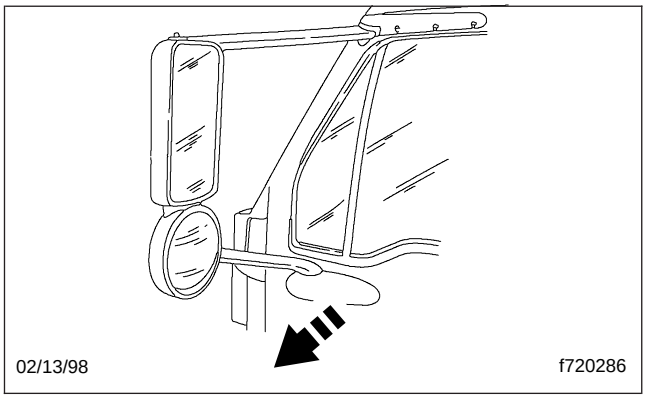


Fig. 3, Lower Mirror Bracket Trim Cover

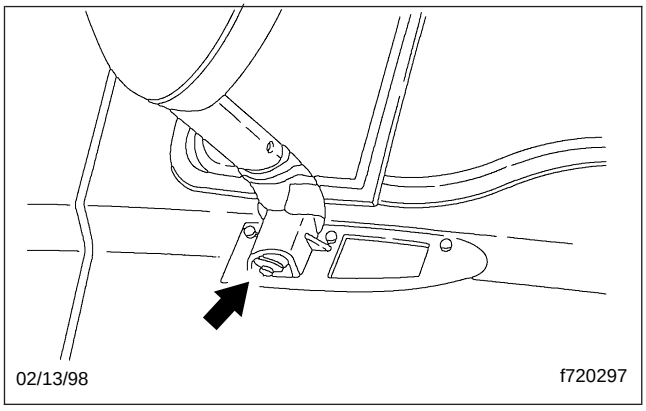


Fig. 4, Pivot Bolt

10. Install the harness through the door.
11. Install the lower mirror mounting bracket. Tighten the screws 84 to 108 lbf·in (99 to 120 N·cm).

Aerodynamic Mirror Harness Replacement

12. Support the mirror assembly and Install the lower mirror bracket pivot bolt, shim and spring. See **Fig. 4**. Tighten the bolt 30 lbf·ft (40 N·m).
13. Install the lower mirror bracket trim cover. See **Fig. 3**.
14. Install the door trim panel. See **Fig. 2**.
15. Install the power mirror switch(es). Refer to **Subject 170**.
16. Install the mirror bezel screws and the mirror bezel. See **Fig. 1**.
17. Install the actuator. Refer to **Subject 150**.
18. Install the mirror glass. Refer to **Subject 140**.

Replacement

1. Carefully pry the power mirror switch from the driver side door trim panel. See **Fig. 1**.

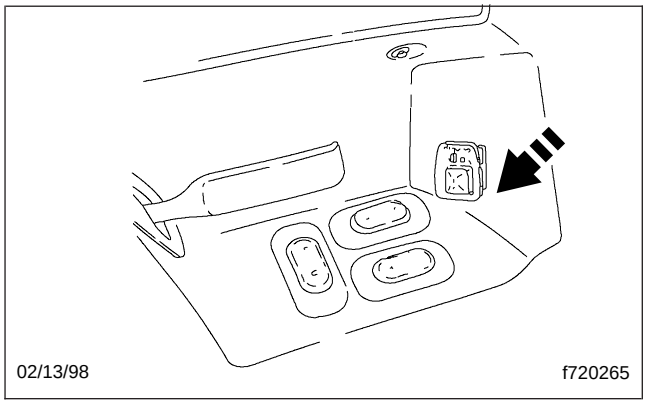


Fig. 1, Power Mirror Switch

2. Depress the electrical connector locking tab and separate the power mirror switch from the electrical harness. See **Fig. 2**.

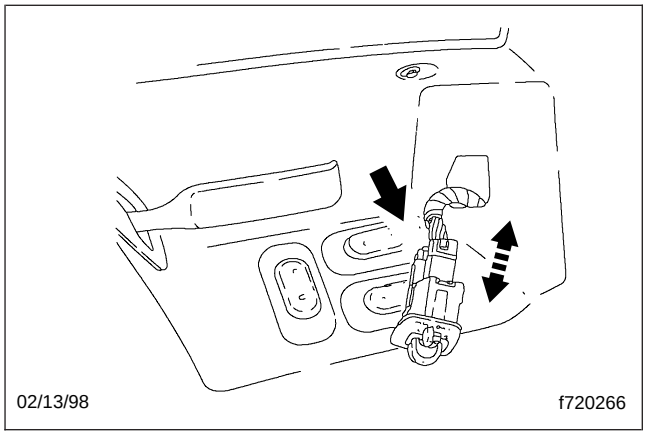


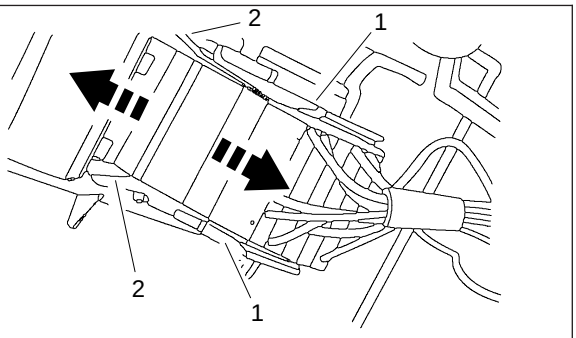
Fig. 2, Power Mirror Switch Electrical Connector

3. Connect the power mirror switch to the electrical harness. See **Fig. 2**.
4. Install power mirror switch into the driver side door trim panel. See **Fig. 1**.

Heated Mirror Switch Replacement

Replacement

1. Remove the right-hand instrument panel trim panel. Refer to **Group 54**.
2. Remove the heated mirror switch. See **Fig. 1**.



02/13/98 f720268

1. Electrical Connector Locking Tabs
2. Heated Mirror Retaining Tabs

Fig. 1, Heated Mirror Switch Removal

   2.1 Release the locking tabs, and disconnect the electrical connector.

   2.2 Depress the heated mirror retaining tabs, and push the switch through the front of the trim panel.

3. Install the heated mirror switch. See **Fig. 1**.

   3.1 Depress the heated mirror retaining tabs, and push the switch into the front of the trim panel.

   3.2 Insert the locking tabs, and connect the electrical connector.

4. Install the right-hand instrument panel trim panel. Refer to **Group 54**.

Troubleshooting

Inspection and Verification

1. Verify the customer complaint by operating the rearview mirrors.
2. Visually inspect for obvious signs of mechanical and electrical damage. Refer to **Table 1**.

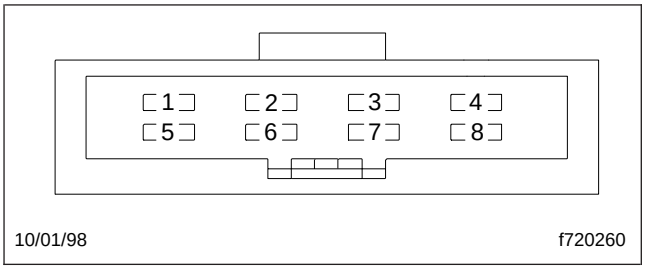


Fig. 1, Rearview Mirror Control Pin Identification

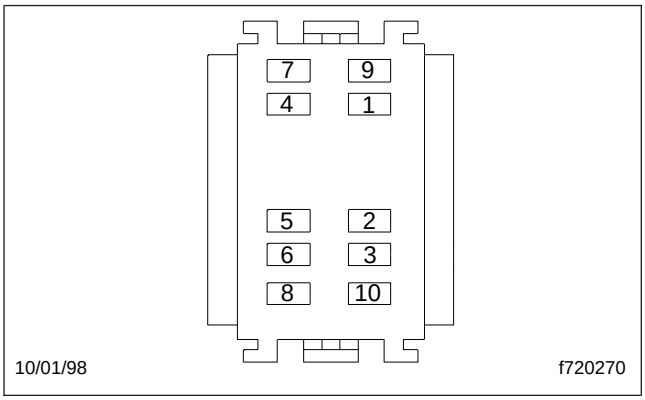


Fig. 2, Heated Mirror Connector Pin Identification

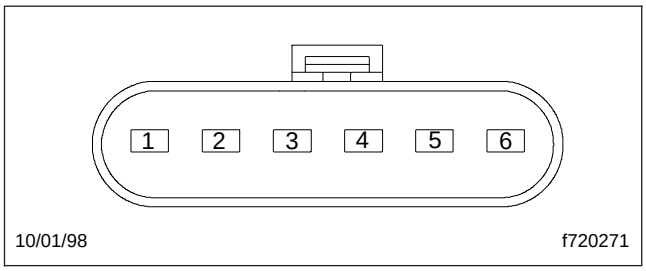


Fig. 3, Left Heated Mirror Connector Pin Identification

Visual Inspection Chart	
Mechanical	**Electrical**
Damaged mirror(s) Damaged outside rearview mirror control	Blown fuse Damaged wiring Loose, corroded, or dirty connections Damaged outside rearview mirror control Damaged rearview mirror heating element

Table 1, Visual Inspection Chart

Problem—Both Right-Hand and Left-Hand Mirrors Inoperative

Problem—Both Right-Hand and Left-Hand Mirrors Inoperative (See Fig. 1)	
Possible Cause	**Remedy**
Fuse	Check the fuse input voltage. Disconnect the IP fuse junction panel, Fuse 14, (10 A) harness connector. Measure the voltage on the input side of fuse Cavity 14. If the voltage is less than 10 volts, repair the IP fuse junction panel feed circuit. Test the system for normal operation. If the voltage is 10 volts or greater, reinstall Fuse 14 (10 A) and check the rearview mirror control.

Troubleshooting

Problem—Both Right-Hand and Left-Hand Mirrors Inoperative (See Fig. 1)	
Possible Cause	**Remedy**
Mirror control	Check the rearview mirror control. Disconnect the rearview mirror control harness connector. Recheck the rearview mirror control. If the rearview mirror control does not work, replace the rearview mirror control. Test the system for normal operation. If the rearview mirror control is OK, check the system ground circuit. Measure the resistance between the rearview mirror connector C509, Pin 4, Circuit 57 (BK) and a known good ground. If the resistance is 5 ohms or less, repair Circuit 101 (GY). Test the system for normal operation. If the resistance is more than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation.
Ground Circuit	
Circuit	
Motor	

Problem—Single Mirror Inoperative

Problem—Single Mirror Inoperative	
Possible Cause	**Remedy**
Mirror control	Check the rearview mirror control. Disconnect the rearview mirror control harness connector. Test the rearview mirror control. If the rearview mirror control does not test OK, replace the rearview mirror control. Test the system for normal operation. If the rearview mirror control does test OK, check the inoperative rearview mirror motor. Disconnect the inoperative rearview mirror harness connector. Check the operation of the inoperative rearview mirror motor. Refer to "Outside Mirror Motor" under "Component Tests" in this subject. If the inoperative rearview mirror motor tests OK, repair Circuit 24 (BL/Y) or Circuit 104 (GN) (left-hand), Circuit 102 (P) or Circuit 104 (GN) (right-hand). Test the system for normal operation. If the inoperative rearview mirror motor does not test OK, replace the inoperative rearview mirror motor. Test the system for normal operation.
Motor	
Circuit	

Problem—Heated Outside Mirror Does Not Defrost

Problem—Heated Outside Mirror Does Not Defrost (See Fig. 1 and Fig. 2)	
Possible Cause	**Remedy**
Relay	Check the windshield wiper operation. Turn the ignition switch to the ACC position. Check the operation of the windshield wipers. If the windshield wipers do not operate, check the run/accessory power relay. Disconnect the IP fuse junction panel run/accessory power replay harness connector. Check the run/accessory power relay. Refer to "Relay" under "Component Tests" in this subject. If the relay tests OK, reinstall the relay. Repair Circuit 37 (BK/Y). Test the system for normal operation. If the relay does not test OK, replace the relay. Test the system for normal operation. If the windshield wipers do operate, check the heated mirror switch.
Fuse	
Switch	Check the heated mirror switch. Disconnect the heated mirror switch harness connector. Disconnect and remove the heated mirror switch. Refer to "Replacement" in **Subject 100**. Place the heated mirror switch in the "On" position. Measure the resistance of the heated mirror switch between Pin 2B and Pin 3. If the resistance is not 5 ohms or less, replace the heated mirror switch. Test the system for normal operation. If the resistance is 5 ohms or less between Pin 2B and Pin 3, check Circuit 960 (R).

Problem—Heated Outside Mirror Does Not Defrost (See Fig. 1 and Fig. 2)	
Possible Cause	**Remedy**
Circuit	Check Circuit 960 (R). Turn the ignition switch to the ACC position. Measure the voltage on the heated mirror connector C2021, Pin 3, Circuit 960 (R). If the voltage is less than 10 volts, repair Circuit 960 (R). Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 59 (GN/P). Measure the resistance between the heated mirror switch connector C2021, Pin 3, Circuit 59 (GN/P) and the left heated mirror connector C506, Pin 3, Circuit 59 (GN/P). Repeat the step for the right heated mirror connector C601, Pin 3, Circuit 59 (GN/P). If the resistance is more than 5 ohms, repair Circuit 59 (GN/P). Test the system for normal operation. If the resistance is less than 5 ohms, check ground Circuit 57 (BK).
Heating element	Measure the resistance between the left heated mirror connector C506, Pin 1, Circuit 57 (BK) and a known good ground. Repeat the step for the right heated mirror connector C601, Pin 1, Circuit 57 (BK). If the resistance is 5 ohms or less, replace the outside mirror. Test the system for normal operation. If the resistance is more than 5 ohms, repair Circuit 57 (BK). Test the system for normal operation.

Component Tests

Outside Mirror Motor

1. Disconnect the suspect outside rearview mirror. Refer to "Western-Type Power Mirror Replacement" in **Subject 110**.
2. Connect jumper wires to the rearview mirror motor. See **Fig. 4**
   - 2.1 Connect a 10 gauge (or larger) jumper wire to Terminal 5 of the rearview mirror motor.
   - 2.2 Connect a second 10 gauge (or larger) jumper wire to Terminal 6 of the rearview mirror motor.
   - 2.3 Observe the operation of the rearview mirror.
3. Reverse the jumper wires. See **Fig. 5**.
   - 3.1 Reverse the jumper wires on the rearview mirror motor.
   - 3.2 Observe the operation of the rearview mirror (the mirror should operate in reverse).
4. If the rearview mirror motor does not operate, the rearview mirror must be replaced. Refer to "Western-Type Power Mirror Replacement" in **Subject 110**.

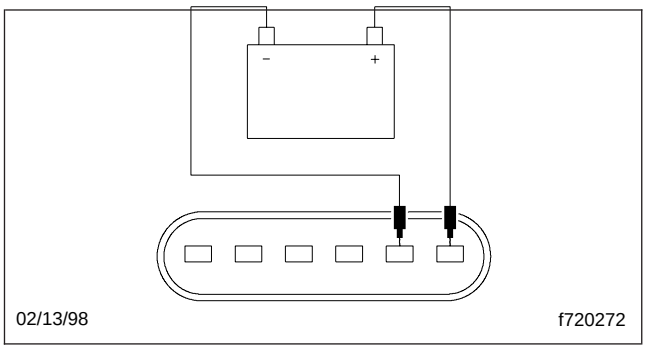


Fig. 4, Connect Jumper Wires

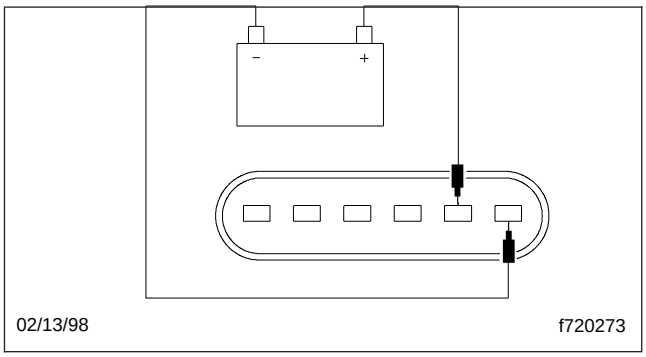


Fig. 5, Reverse the Jumper Wires

Relay

Use the following procedure to test the run/accessory power relay:

Troubleshooting

1. Locate and remove the run/accessory power relay in the instrument panel fuse junction panel. See **Fig. 6**.

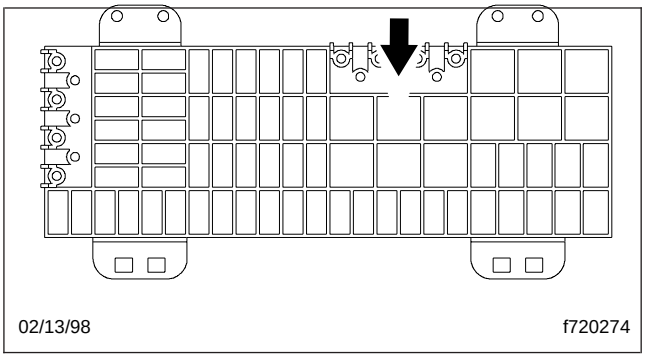


Fig. 6, Instrument Panel Fuse Junction Panel

2. Using two No. 10 (or larger gauge) jumper wires, connect relay Terminals 86 and 30 directly to the positive battery terminal. See **Fig. 7**.

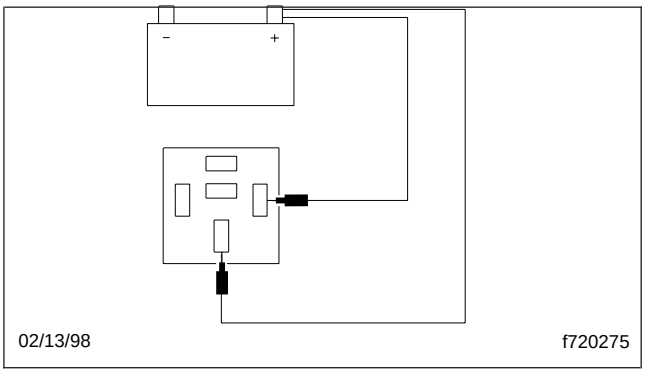


Fig. 7, Connect a Jumper From Terminals 86 and 30 to Battery

3. Connect a voltmeter to Terminal 87A. Ten volts or greater should be present. If 10 volts or greater is not present, replace the relay. If 10 volts or greater is present, continue with the test. See **Fig. 8**.
4. Connect a third jumper wire to Terminal 85 and chassis ground. See **Fig. 9**.
5. Check for voltage at Terminal 87. Ten volts or greater should be present. If 10 volts or greater is not present, replace the relay. See **Fig. 10**.

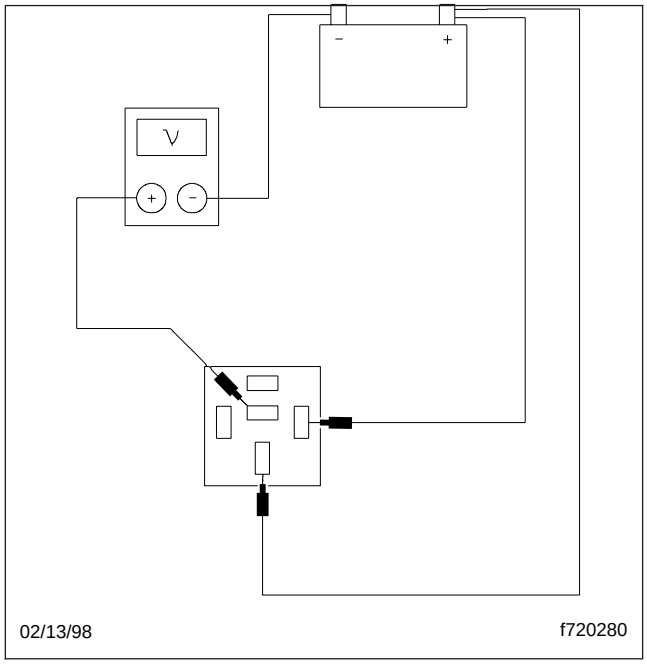


Fig. 8, Connect a Voltmeter to Terminal 87A

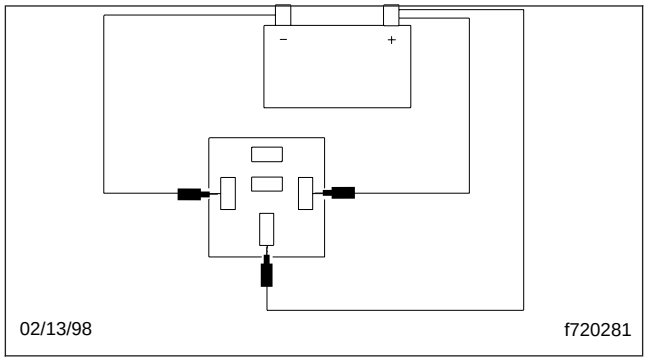


Fig. 9, Connect a Jumper From Terminal 85 to Ground

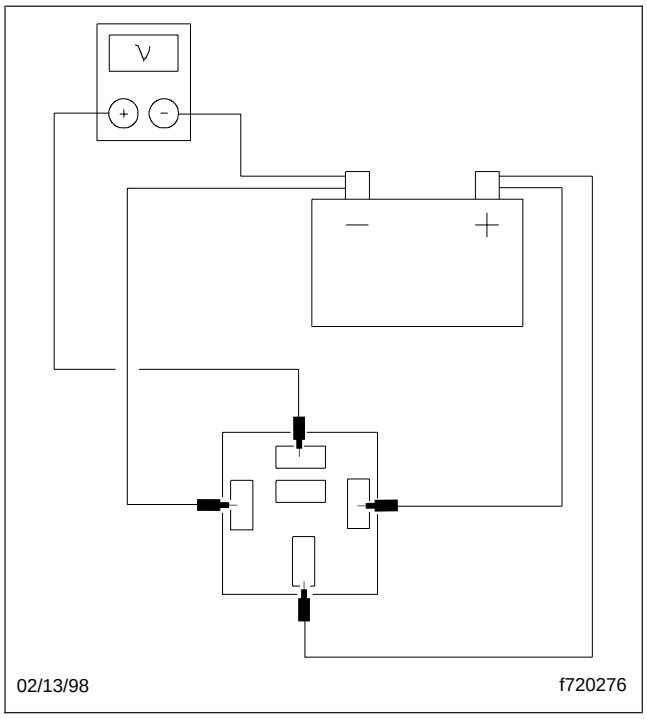


Fig. 10, Connect a Jumper From Terminal 87 to Ground

Specifications

Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Western-Type Mirror Nuts	—	108–120 (99–120)
Western-Type Mirror Bracket Nuts	—	72–108 (99–120)
Aerodynamic Style Lower Mirror Bracket Bolts	—	84–108 (99–120)
Aerodynamic Style Upper Mirror Bracket Bolts	30 (40)	—
Aerodynamic Style Lower Mirror Bracket Pivot Bolt	30 (40)	—

Table 1, Torque Specifications

General Information

Cab rear air-suspension systems absorb road shocks better than solid-mount systems, and thus provide a smoother ride for cab occupants and cab-mounted equipment.

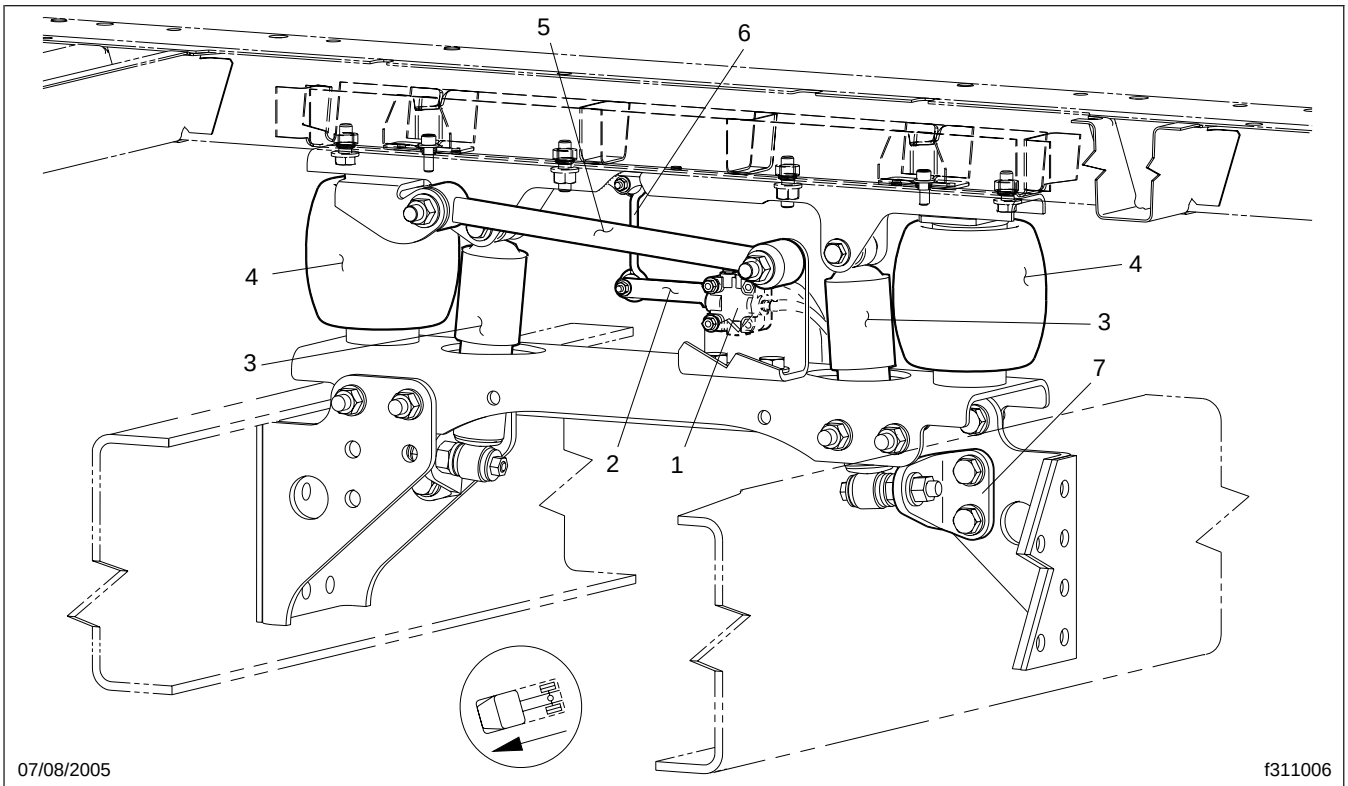
The cab air-suspension system consists of one or two air springs, a height-control valve, a lateral control rod, two shock absorbers, and a vertical linkage. See **Fig. 1**. Several types of cab air-suspension are used in the L-Line and A-Line models, depending on the size of the cab; see **Fig. 2**.

changes in cab load by maintaining the correct cab height at the rear of the cab.

Height-Control Valve

NOTE: If a leak occurs in the cab air-suspension system, a pressure protection valve (located at the secondary air tank, which supplies the air to the height-control valve) will maintain a minimum pressure of about 65 psi (450 kPa) in the vehicle secondary air system.

All of the air in the cab air-suspension system is admitted through or exhausted from the height-control valve. The height-control valve has a horizontal control lever, the outboard end of which is connected to a vertical linkage. The upper end of the vertical linkage is attached to the cab underbody.



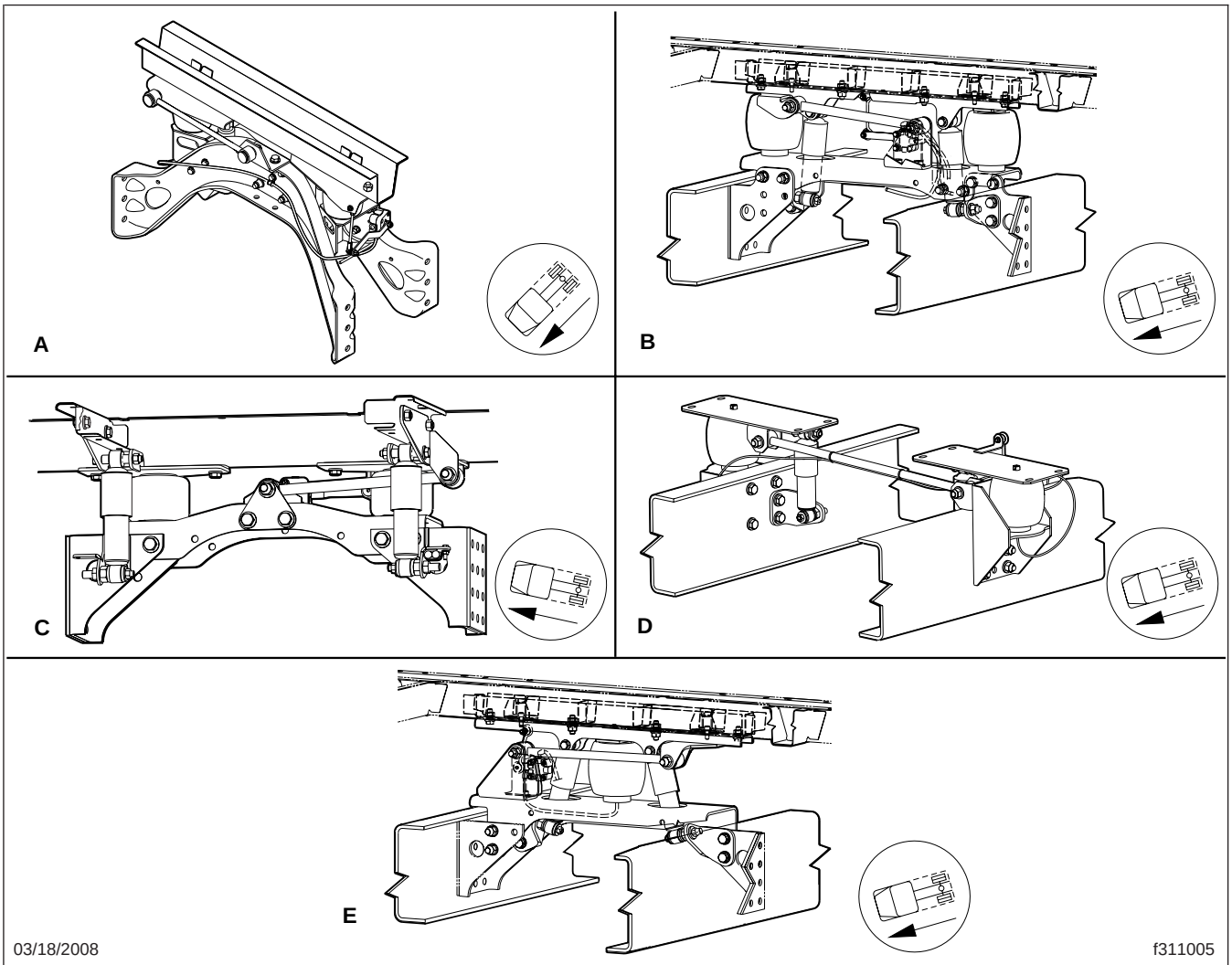
1. Cab Height-Control Valve
2. Horizontal Control Lever
3. Shock Absorber
4. Air Spring
5. Lateral Control Rod
6. Vertical Linkage
7. Lower Shock Mount Bracket

Fig. 1, Cab Air Suspension Installation

Air Springs

The top of each air spring is mounted to a bracket on the cab underbody, and the bottom is mounted to the frame rail crossmember or bracket. Together with the height-control valve, the air springs compensate for

General Information



A. A-Line (including SilverStar) and L-Line
B. A-Line (including SilverStar) and L-Line
C. A-Line and L-Line with 101-inch Cab
D. A-Line (including SilverStar) and L-Line with Sleeper
E. L-Line with 111- or 113-inch Day Cab

Fig. 2, Cab Air Suspension Systems

When the load on the cab increases, the dimension between the cab and the crossmember decreases, causing the vertical linkage to push downward on the end of the horizontal control lever. This turns the height-control valve shaft, which activates the height-control valve. Air flows through the valve and into the air springs until the pressure in the springs raises the cab to the correct height. At this height, the control lever and the control shaft are returned to their neutral positions, closing the intake air supply.

When the load on the cab decreases, the rear of the cab rises, causing the vertical linkage to pull up on the end of the horizontal control lever. Turning the height-control valve shaft in this direction activates an exhaust port in the valve. This allows air pressure in the air springs to decrease until the cab is lowered to the correct height. Again, the control lever and control shaft are returned to their neutral positions, and air flow is stopped.

When the vehicle is in motion, small and abrupt movements of the cab will occur, resulting in small or abrupt movements of the control lever. These movements of the control lever do not activate the height-control valve to correct the cab ride height.

Changes in load that occur when occupants or heavy items are added to or removed from the cab will activate the height-control valve to correct the cab ride height. Also, when the vehicle is moving forward at high speed or in a high headwind, a major change in load occurs from the downforce applied to an optional air shield or air fairing. When these changes in load occur, the cab air-suspension system will correct the cab ride height at the rear of the cab.

Lateral Control Rod

The lateral control rod limits the side-to-side motion of the rear of the cab.

Shock Absorbers

The shock absorbers control the air spring and cab suspension movement, and reduce the amount of oscillation in the cab suspension system.

Fitting Leakage Repair

1. Apply the parking brakes and chock the tires.

⚠ WARNING

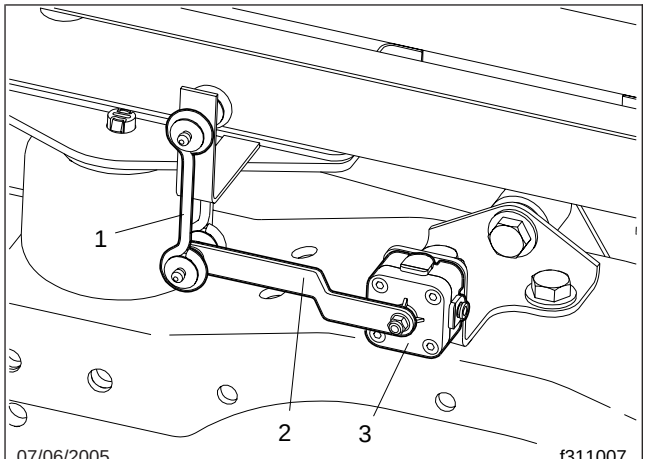
Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

2. Place blocks between the frame and the bottom of the cab to keep the cab in position when the air springs are deflated.
3. Drain all air from the air tanks.

⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

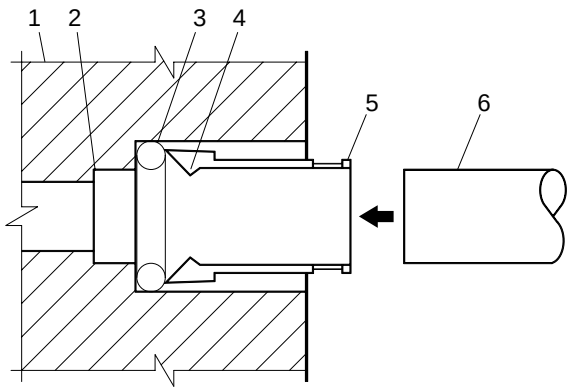
4. Remove the nut and washer that attach the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.



1. Vertical Linkage
2. Horizontal Control Lever
3. Cab Height-Control Valve

Fig. 1, Cab Height-Control Valve Linkage

5. Rotate and hold the control lever up until all air is exhausted from the air spring.
6. Push the collar of the quick-connect fitting into the fitting body with a 1/4-inch (7-mm) open-end wrench; see **Fig. 2**. With the collar pushed into the fitting, pull the tubing from the fitting. The fitting should easily release the tubing.



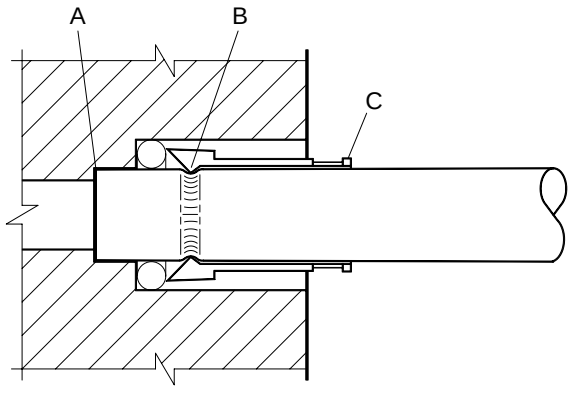
1. Fitting Body
2. Shoulder
3. Release Ring
4. Clamping Ring
5. Collar
6. Nylon Tube

Fig. 2, Parts of the Quick-Connect Fitting

NOTE: Find the mark on the tubing, about 1/4 inch (7 mm) from the end, where the collar clamped the tubing; see **Fig. 3**. If this mark is less than 1/4 inch (7 mm) from the end of the tubing, the fitting was not assembled correctly and could have caused an air leak.

7. Inspect the end of the tubing for paint or debris that could prevent full insertion of the tubing into the fitting. Remove any dirt from the tubing and fitting.
8. Check that the end of the tubing is cut square. If the tubing is cut at an angle, the fitting will not seal correctly; cut the end of the tubing at an angle of 90 degrees.
9. Insert the squared end of the tubing into the fitting. An initial resistance is felt when the tubing touches the clamping ring section of the collar. Push the tubing past this resistance another 1/4 inch (7 mm) or so until the tubing is fully seated against the shoulder.

Quick-Connect Fittings



A. Square end of the tube against the shoulder.
B. The collar clamps the tube here.
C. Push the collar to release the tube.

Fig. 3, Correctly Installed Quick-Connect Fitting

10. Tug on the air tubing to ensure the tubing is clamped in the collar.
11. Align the vertical linkage with the control lever, and install the washer and nut.
12. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Check for air leaks.
13. Remove the blocks that were installed to support the cab.
14. Remove the chocks.

Fitting Leakage Repair

1. Apply the parking brakes and chock the tires.

⚠ WARNING

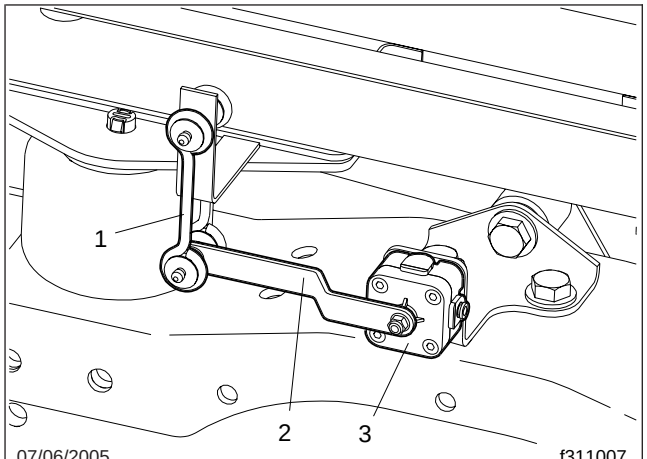
Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

2. Place blocks between the frame and the bottom of the cab to keep the cab in position when the air springs are deflated.
3. Drain all air from the air tanks.

⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

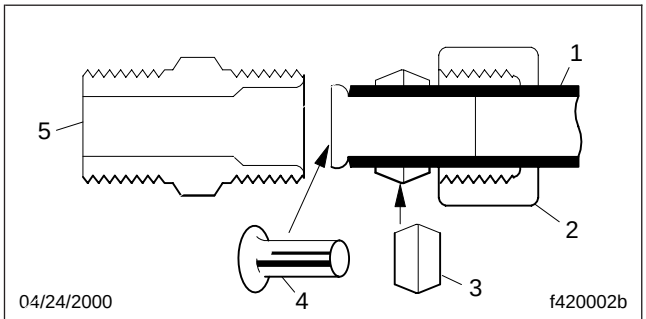
4. Remove the nut and washer that attach the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.



1. Vertical Linkage
2. Horizontal Control Lever
3. Cab Height-Control Valve

Fig. 1, Cab Height-Control Valve Linkage

5. Rotate and hold the control lever up until all air is exhausted from the air spring.
6. Loosen the fitting nut and remove the air tube; see **Fig. 2**.



1. Air Tube
2. Nut
3. Sleeve
4. Stainless Steel Insert
5. Body

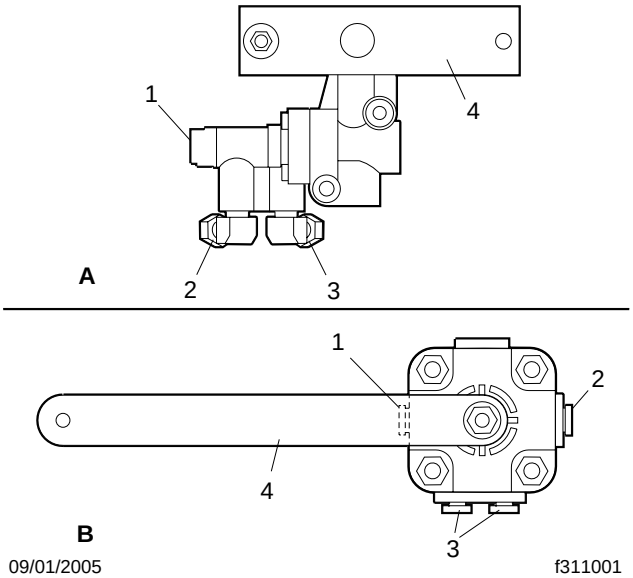
Fig. 2, Air Tube and Compression Fitting

7. Clean all of the fitting components.
8. Check that the end of the tubing is cut square. If the tubing is cut at an angle other than 90 degrees, the fitting will not seal correctly; cut the end of the tubing at a 90-degree angle.
9. Install the nut and sleeve on the air tube.
10. Insert the squared end of the air tube onto the stainless steel insert. Push it into the body of the fitting until it is fully seated against the shoulder.
11. Tighten the nut finger-tight, then an additional three turns.
12. Tug on the air tube to ensure that it is clamped in the nut.
13. Align the vertical linkage with the control lever, and install the washer and nut.
14. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Check for air leaks.
15. Remove the blocks that were installed to support the cab.
16. Remove the chocks.

Height-Control Valve Checking

It is normal to hear air leaking from the height-control valve for as much as five minutes after getting out of the vehicle. This air leakage is just the height-control valve exhausting air from the cab suspension air spring to reach the neutral position.

Two types of height-control valves are used on L-Line and A-Line vehicles: a Sterling height-control valve or a Barksdale height-control valve; see **Fig. 1**. Two methods are available to check the operation of the Barksdale height-control valves. A leak in the valve may be discovered without using a test kit, but a test kit is necessary to determine if the valve has an unacceptable rate of leakage. The Sterling valve can only be checked without a test kit.



A. Sterling Height-Control Valve
B. Barksdale Height-Control Valve

1. Exhaust Port
2. Supply Port
3. Air Spring Port
4. Horizontal Control Lever

Fig. 1, Height-Control Valves

Some Barksdale height-control valves have been returned for warranty because the four bolts in the valve housing were overtightened, often, enough to crack the valve housing. These bolts should not be loose, and should not normally require tightening, as there are no serviceable parts in the valve.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- If it is necessary to remove a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, crushing the valve body and damaging the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

Checking a Sterling or Barksdale Height-Control Valve Without Using a Test Kit

WARNING

Keep your hands and all objects away from the area under and around the cab when removing the pressure from the air system. Parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

1. If not already done, apply the parking brakes and chock the tires.

Height-Control Valve Checking

2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. Check all of the fittings and the valve body using a soap-and-water solution. Seal any leaks as necessary.
5. Check the valve exhaust port, and the rubber exhaust flapper, if so equipped, for leaks using a soap-and-water solution. The exhaust port is on the side opposite the supply port of the valve.

NOTE: If a leak is detected on a Barksdale height-control valve, go to "Checking a Barksdale Height-Control Valve Using a Test Kit". Barksdale valves have an acceptable leak rate of 3 cubic inches (50 cc) per minute. You can determine if a leak is acceptable only by using the Barksdale test kit.

If a leak is detected at the exhaust port on a Sterling height-control valve, the valve is defective. Replace it, following the procedure in **Subject 130**.

⚠ WARNING

Do not disconnect the vertical linkage in the cab suspension system without first blocking the cab securely. If the cab is not securely blocked, moving the control lever could cause the cab to drop abruptly, possibly resulting in serious injury.

6. Disconnect the vertical linkage from the control lever.
7. Pull the control lever up about 45 degrees for 6 to 8 seconds. If air passes through the valve, that section of the valve is okay.
8. Return the control lever to the neutral position.
9. Push the control lever down about 45 degrees for 6 to 8 seconds. If the air spring inflates, that section of the valve is okay.
10. Return the control lever to the neutral position. If the air stops again in the neutral position, the valve is working correctly.
11. If the valve works as stated in all of the above steps, no further checking is needed. Connect the vertical linkage to the control lever, then tighten the linkage nut.

    If needed, adjust the cab ride height or replace the height-control valve. For adjustment of the cab ride height, see **Subject 180**. For replacement of the height-control valve, see **Subject 130**.

NOTE: For some vehicle applications, the cab ride height is preset in the factory, and is not adjustable.

12. Remove the chocks.

Checking a Barksdale Height-Control Valve Using a Test Kit

IMPORTANT: The procedure described below is for use on Barksdale height-control valves only.

⚠ WARNING

Keep your hands and all objects away from the area under and around the cab when removing the pressure from the air system. Parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

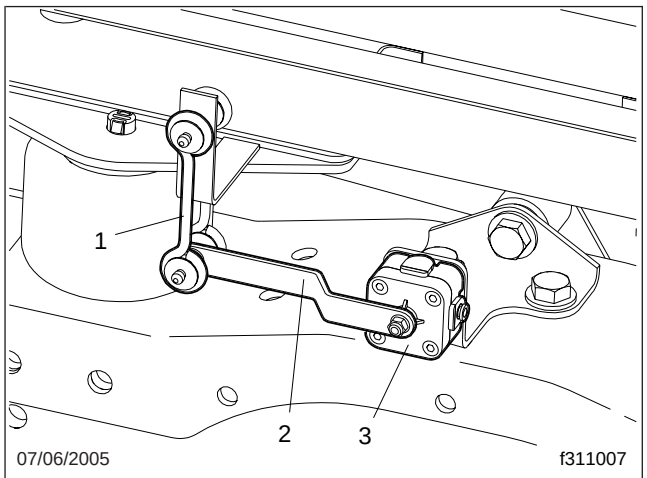
NOTE: The Barksdale field test kit is designed to be used with the height-control valve installed on the vehicle. Refer to **Specifications 400** for information on ordering the Barksdale height-control valve test kit KD2264.

1. If not already done, park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to

settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. Check the rubber exhaust flapper at the back of the valve housing for leaks. Use a soapy solution.
5. Disconnect the vertical linkage from the control lever; see **Fig. 2**.



1. Vertical Linkage
2. Horizontal Control Lever
3. Cab Height-Control Valve

Fig. 2, Height-Control Valve Linkage (Barksdale shown)

6. Rotate and hold the control lever up at about 45 degrees to exhaust air from the air springs.
7. Disconnect the air lines from the air spring ports on the height-control valve. Leave the elbow fittings (if equipped) in place. Install a Parker plug into each air spring port (or elbow fitting); see **Fig. 3**.
8. If a flapper is present on the exhaust port of the height-control valve, remove it using needlenose pliers.
9. Clean the surface around the exhaust port, then install the test fitting into the exhaust port. The centering pin on the fitting must align with the slot on the exhaust port. Rotate the test fitting 45 degrees clockwise to lock it in place; see **Fig. 3**.
10. Connect one end of the air hose from the kit to the test connector on the exhaust port, and the other end to the test gauge.
11. Check the height-control valve in the fill mode, as follows.
    - 11.1 Rotate the valve control lever down 45 degrees from the horizontal to the fill position.
    - 11.2 Press the reset button on the test gauge.
    - 11.3 Observe the test gauge for 30 seconds. Refer to **Fig. 4** for the maximum allowable exhaust pressure change versus inlet pressure.

      The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

      If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

12. Check the height-control valve in the exhaust mode, as follows.
    - 12.1 Rotate the valve control lever up 45 degrees from the horizontal to the exhaust position.
    - 12.2 Press the reset button on the test gauge.
    - 12.3 Observe the test gauge for 30 seconds. Refer to **Fig. 4** for the maximum allowable exhaust pressure change versus inlet pressure.

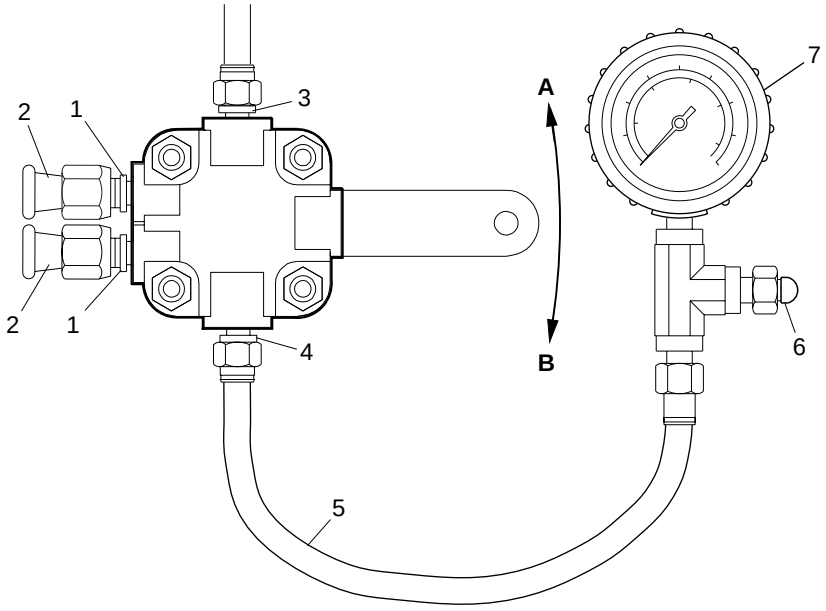
      The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

      If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

13. Disconnect the test gauge and connector from the valve exhaust port.
14. If the height-control valve is defective, replace it; see **Subject 130**.
15. Install the flapper on the exhaust port by pressing it into place.

Height-Control Valve Checking



A. Exhaust
B. Fill

1. Air Spring Port
2. Parker Plug
3. Air Intake Port
4. Exhaust Port Test Fitting
5. Air Line
6. Reset Button
7. Test Gauge Assembly

Fig. 3, Test Connections

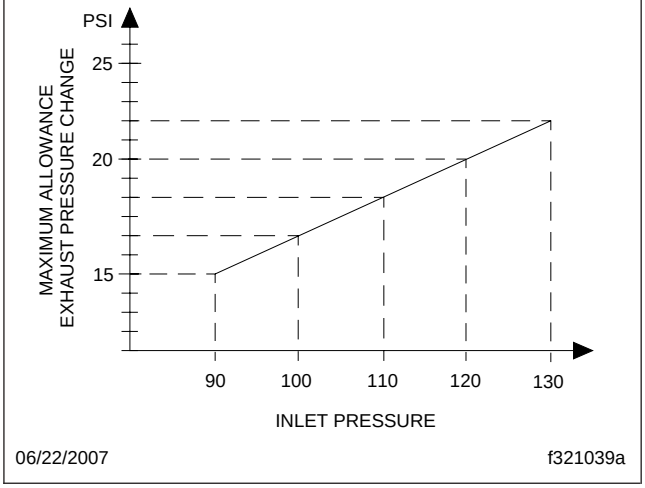


Fig. 4, Inlet Pressure vs. Exhaust Pressure Change in 30 Seconds

16. Remove the two Parker plugs from the air spring ports, and connect the air lines to the air spring ports (or elbow fittings). Connect the vertical linkage to the height-control valve control lever. The ride height will automatically return to the correct position.
17. Remove the chocks.

Height-Control Valve Replacement

IMPORTANT: Before replacing the height-control valve, perform the steps in **Subject 120** to see if the height-control valve is actually damaged or just out of adjustment.

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

⚠ WARNING

Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

2. Place blocks between the frame and the bottom of the cab, or use jack stands to keep the cab in position when the air spring is deflated.
3. Drain all air from the air tanks.

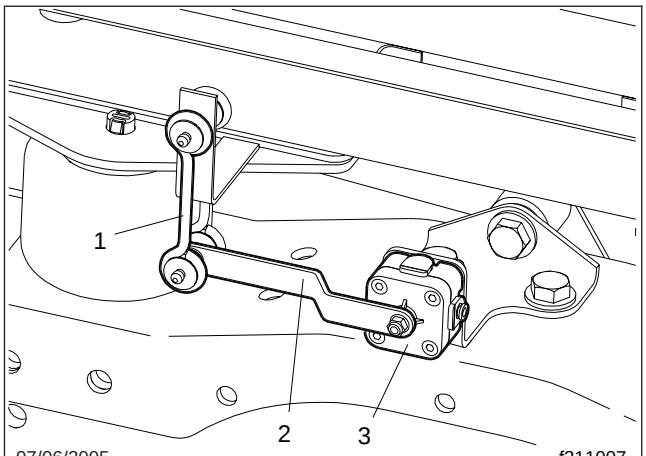
⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

4. Remove the nut and washer that attach the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
5. Rotate and hold the horizontal control lever up until all air is exhausted from the air spring.
6. Mark the air tubing to the height-control valve for later reference, then disconnect the tubing; see **Subject 100** and **Subject 110**.

⚠ CAUTION

When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.



NOTE: Barksdale height-control valve shown.

1. Vertical Linkage
2. Horizontal Control Lever
3. Cab Height-Control Valve

Fig. 1, Cab Height-Control Valve Linkage

7. While holding the height-control valve mounting studs in place with an Allen wrench, remove the nuts and washers that attach the valve to the mounting bracket. Remove the height-control valve.
8. Position the new height-control valve on the height-control bracket. While holding the height-control valve mounting studs in place with an Allen wrench, install the nuts and washers, and tighten 45 lbf·in (500 N·cm). Do not overtighten.
9. Connect the air tubing to the height-control valve; see **Subject 100** and **Subject 110** for instructions.
10. Align the vertical linkage with the horizontal control lever and install the washer and nut.
11. Start the engine and run it until air pressure builds to at least 100 psi (690 kPa).
12. Check all air tubing and fittings for leaks.
13. Remove the cab supports.
14. Remove the chocks.

Air Spring Replacement

Two types of air spring are installed on L-Line and A-Line vehicles. To hold the air spring in place, one type uses a nut at the bottom and a bolt at the top, the other uses tangs at the top and bottom.

To determine the type of air spring used, look at the bottom of the air spring and see if a nylon nut is holding the air spring in place.

Cab Air Spring with Nut

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

⚠ WARNING

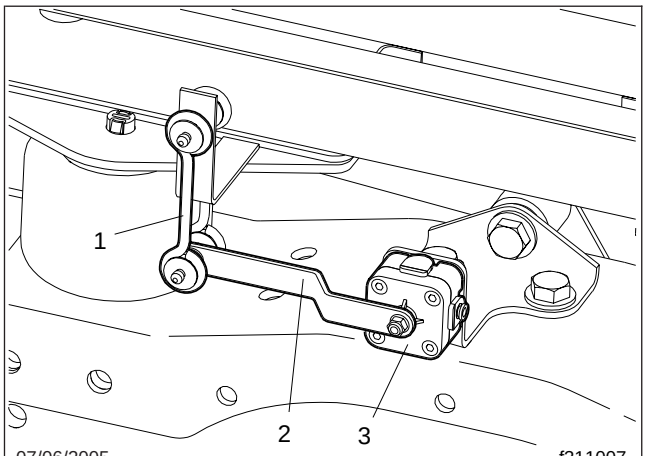
Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

2. Place blocks between the frame and the bottom of the cab, or use jack stands to keep the cab in position when the air spring is deflated.
3. Drain all air from the air tanks.

⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

4. Remove the nut and washer that attach the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
5. Rotate and hold the horizontal control lever up until all air is exhausted from the air spring.
6. From inside the cab, remove the four screws that hold the air-valve distribution-box cover to the air valve. Remove the cover; see **Fig. 2**.
7. Roll up the carpeting or floor matting and place it out of the way.
8. Remove the screws that hold the metal floor cover to the cab deck. Remove the cover; see **Fig. 3**.



1. Vertical Linkage
2. Horizontal Control Lever
3. Cab Height-Control Valve

Fig. 1, Cab Height-Control Valve Linkage

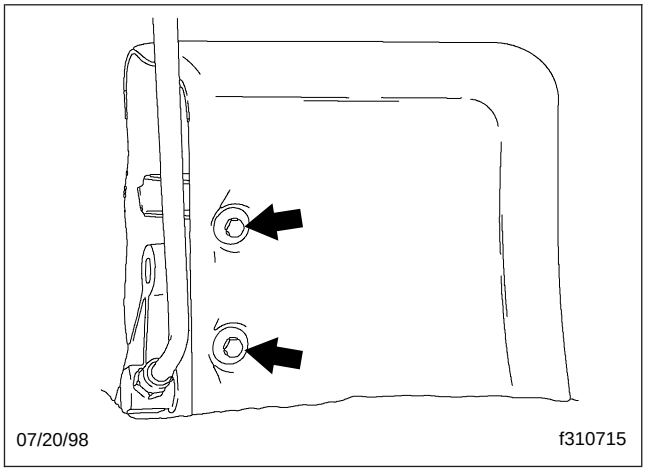


Fig. 2, Air-Valve Distribution-Box Cover Screws

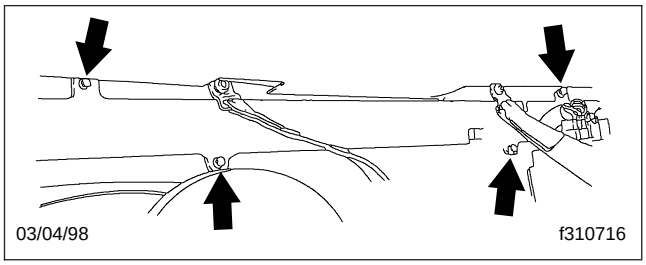


Fig. 3, Metal Floor-Cover Screws

9. Remove the rubber cover; see **Fig. 4**.

Air Spring Replacement

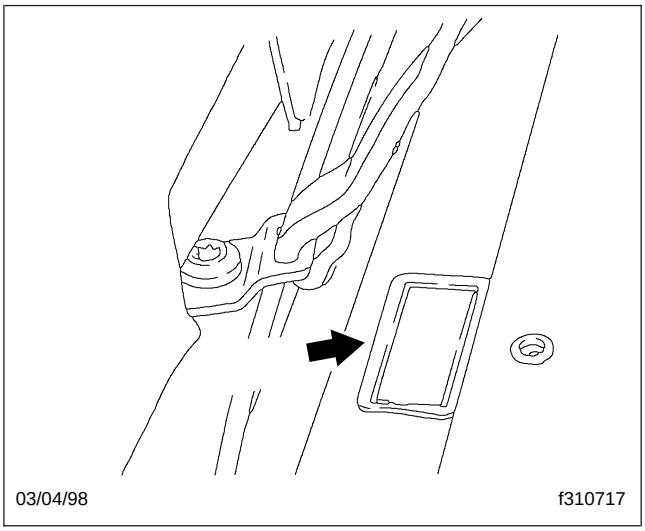


Fig. 4, Rubber Cover

10. Remove the top air-spring mounting bolt.
11. From outside the cab, disconnect the supply air tubing from the bottom of the air spring; see **Subject 100** and **Subject 110**. If the new air spring will not be installed immediately, cover the open end of the air tubing to prevent dirt or other foreign material from entering.
12. Remove the jam nut from the bottom of the air spring. Remove the air spring.
13. Place the bottom of the new air spring on the lower mounting bracket and install the jam nut on the bottom. Tighten the nut 35 lbf·in (400 N·cm).
14. Remove the cover from the air tubing, then connect it to the bottom of the new air spring; see **Subject 100** and **Subject 110**.
15. From inside the cab, install the top air-spring mounting bolt. Tighten the bolt 42 lbf·in (475 N·cm).
16. Install the rubber cover.
17. Install the metal floor cover and attach it with the screws to the cab deck.
18. Roll the carpet or matting in position.
19. Install the air-valve distribution-box cover and attach it with the four screws.
20. Align the vertical linkage with the control lever and install the washer and nut.
21. Start the engine, and run it until air pressure builds to at least 100 psi (690 kPa). Check for air leaks at the air spring.
22. Remove the cab supports.
23. Remove the chocks.

Cab Air Spring without Nut

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

⚠ WARNING

Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

2. Place blocks between the frame and the bottom of the cab, or use jack stands to keep the cab in position when the air spring is deflated.
3. Drain all air from the air tanks.

⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

4. Remove the nut and washer that attach the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
5. Rotate and hold the horizontal control lever up until all air is exhausted from the air spring.
6. Insert a screwdriver between the upper cab mount and air spring, and pry the air spring away from the mount to pop the air spring tangs out of the bracket. Repeat the procedure for the bottom of the air spring, then pull the air spring out enough to access the supply air tubing.
7. Disconnect the supply air tubing from the bottom of the air spring; see **Subject 100** and **Subject 110**. If the new air spring will not be installed immediately, cover the open end of the air tubing to prevent dirt or other foreign material from entering.

8. Remove the air spring.
9. Remove the cover from the air tubing, then connect it to the bottom of the new air spring; see **Subject 100** and **Subject 110**.
10. Install the new air spring by snapping it, first into the bottom bracket, then into the top bracket.
11. Align the vertical linkage with the control lever and install the washer and nut.
12. Start the engine, and run it until air pressure builds to at least 100 psi (690 kPa). Check for air leaks at the air spring.
13. Remove the cab supports.
14. Remove the chocks.

Sleeper Air Spring with Nut

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

⚠ WARNING

Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

2. Place blocks between the frame and the bottom of the sleeper, or use jack stands to keep the sleeper and cab in position when the air spring is deflated.
3. Remove the four bolts, washers, and nuts that attach the top air-spring mount assembly to the sleeper crossmembers.
4. Drain all air from the air tanks.

⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

5. Remove the nut and washer that attach the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
6. Rotate and hold the horizontal control lever up until all air is exhausted from the air spring.
7. Remove the top air-spring-mounting bolt.
8. Disconnect the supply air tubing from the bottom of the air spring; see **Subject 100** and **Subject 110**. If the new air spring will not be installed immediately, cover the open end of the air tubing to prevent dirt or other foreign material from entering.
9. Remove the jam nut from the bottom of the air spring. Remove the air spring.
10. Place the bottom of the new air spring on the lower mounting bracket and install the jam nut on the bottom. Tighten the nut 35 lbf·in (400 N·cm).
11. Remove the cover from the air tubing, then connect it to the bottom of the new air spring; see **Subject 100** and **Subject 110**.
12. Install the top air-spring mounting bolt. Tighten the bolt 42 lbf·in (475 N·cm).
13. Position the top of the air spring mount assembly against the sleeper crossmember, and attach it with four bolts, washers, and nuts.
14. Align the vertical linkage with the control lever and install the washer and nut.
15. Start the engine, and run it until air pressure builds to at least 100 psi (690 kPa). Check for air leaks at the air spring.
16. Remove the cab supports.
17. Remove the chocks.

Sleeper Air Spring without Nut

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

⚠ WARNING

Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.

2. Place blocks between the frame and the bottom of the sleeper, or use jack stands to keep the sleeper and cab in position when the air spring is deflated.

Air Spring Replacement

3. Drain all air from the air tanks.

⚠ WARNING

Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.

4. Remove the nut and washer that attach the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
5. Rotate and hold the horizontal control lever up until all air is exhausted from the air spring.
6. Insert a screwdriver between the upper cab mount and air spring, and pry the air spring away from the mount to pop the air spring tangs out of the bracket. Repeat the procedure for the bottom of the air spring, then pull the air spring out enough to access the supply air tubing.
7. Disconnect the supply air tubing from the bottom of the air spring; see **Subject 100** and **Subject 110**. If the new air spring will not be installed immediately, cover the open end of the air tubing to prevent dirt or other foreign material from entering.
8. Remove the cover from the air tubing, then connect it to the bottom of the new air spring; see **Subject 100** and **Subject 110**.
9. Install the new air spring by snapping it, first into the bottom bracket, then into the top bracket.
10. Align the vertical linkage with the control lever and install the washer and nut.
11. Start the engine, and run it until air pressure builds to at least 100 psi (690 kPa). Check for air leaks at the air spring.
12. Remove the cab supports.
13. Remove the chocks.

Shock Absorber Replacement

1. Park the vehicle, apply the parking brakes, shut down the engine, and chock the front and rear tires.
2. Place blocks between the frame and the bottom of the cab, or use jack stands to keep the cab in position when the shock is removed.
3. Remove the nut, washers, and bolt that attach the shock absorber to the cab mount bracket.
4. Remove the nut, washers, and bolt that attach the shock to the chassis mount bracket, and remove the shock.
5. Install the new shock in the chassis mount bracket and install the bolt, washers, and nut.
6. Position the upper end of the shock in the cab mount bracket and install the bolt, washers, and nut.
7. Torque the upper and lower nuts to 45 lbf·ft (61 N·m).
8. Remove the cab supports.
9. Remove the chocks from the tires.

Lateral Control Rod Replacement

1. Park the vehicle, apply the parking brakes, shut down the engine, and chock the front and rear tires.
2. Place blocks between the frame and the bottom of the cab, or use jack stands to keep the cab in position when the lateral control rod is removed.
3. Remove the nut, washers, and bolt that attach the lateral control rod to the cab mount bracket.
4. Remove the nut, washers, and bolt that attach the lateral control rod to the chassis mount bracket, and remove the lateral control rod.
5. Install the new lateral control rod in the chassis mount bracket and install the bolt, washers, and nut.
6. Position the upper end of the lateral control rod in the cab mount bracket and install the bolt, washers, and nut.
7. Torque the upper and lower nuts to 45 lbf·ft (61 N·m).
8. Remove the cab supports.
9. Remove the chocks from the tires.

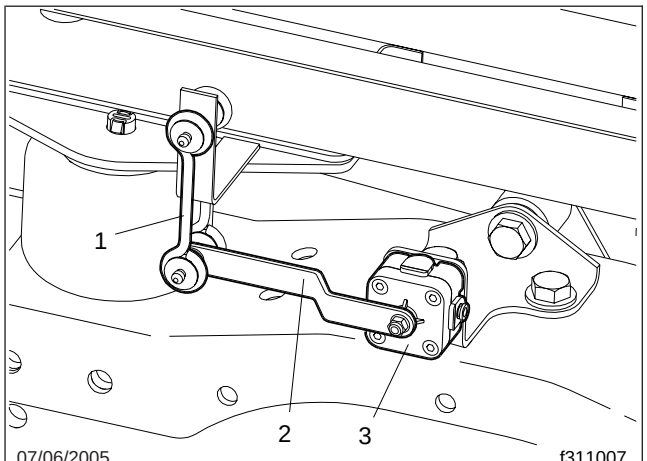
Vertical Linkage Replacement

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Run the engine to build up vehicle air pressure to at least 100 psi (690 kPa), then shut off the engine.

⚠ WARNING

Do not disconnect the vertical linkage in the cab suspension system without first blocking the cab securely and inserting a pin in the neutral-position hole of the height-control valve and the horizontal control lever. If the cab is not securely blocked, dislodging the pin and moving the control lever could cause the cab to fall or rise abruptly, possibly resulting in serious injury.

3. Place blocks between the frame and the bottom of the cab or use jack stands to keep the cab in position.
4. Insert a 5/32-inch (4-mm) pin or drill bit into the neutral-position hole of the height-control valve and horizontal control lever.
5. Remove the nut and washer that attach the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.



1. Vertical Linkage
2. Horizontal Control Lever
3. Cab Height-Control Valve

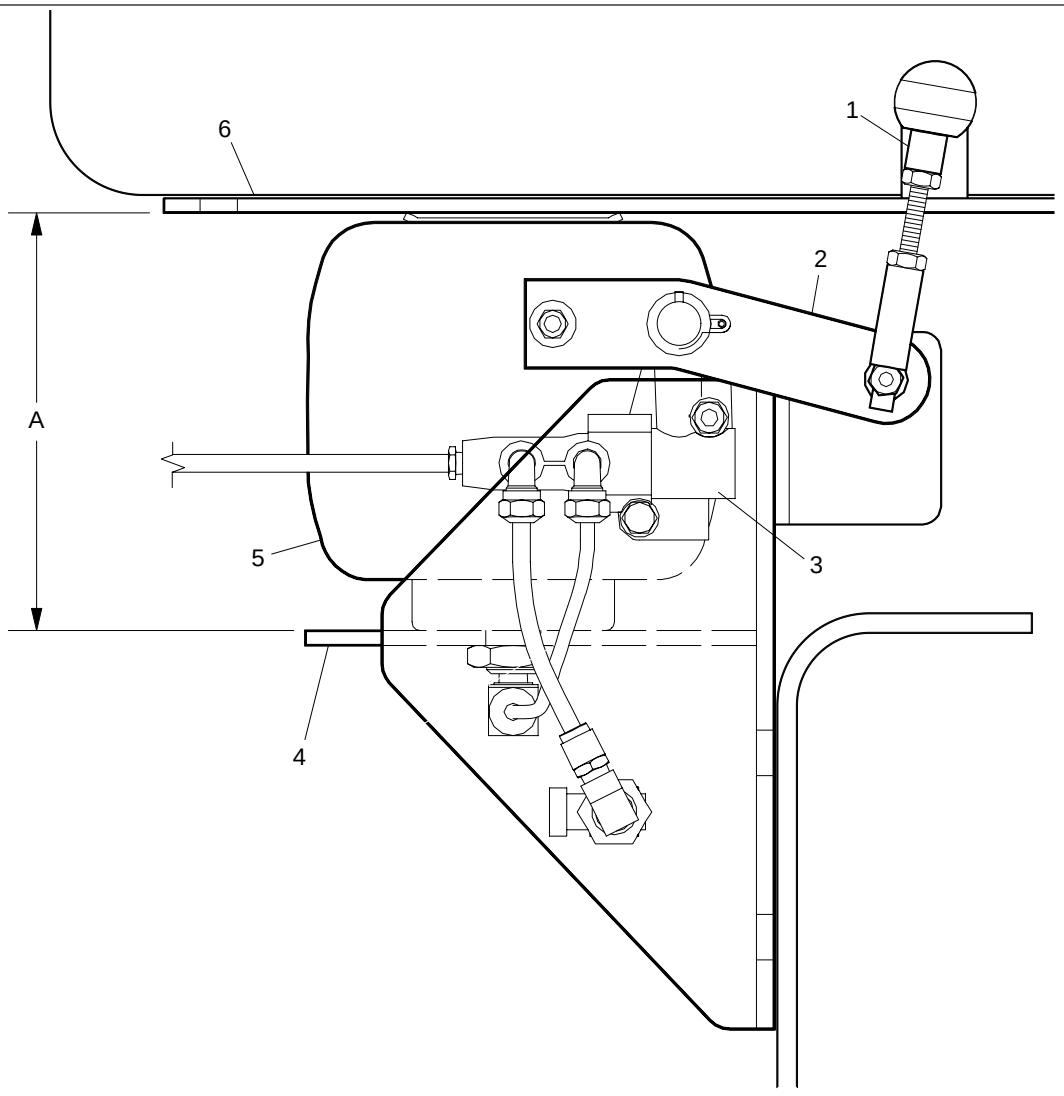
Fig. 1, Cab Height-Control Valve Linkage

6. Remove the nut and washer that attach the vertical linkage to the vertical linkage bracket.
7. Attach the new vertical linkage to the vertical linkage bracket with the washer and nut.
8. Align the vertical linkage with the horizontal control lever, and install the washer and nut.
9. Remove the drill bit or pin from the height-control valve.
10. Remove the cab supports.
11. Remove the chocks.

Cab Ride-Height Adjustment

NOTE: Cab ride height is adjustable only on vehicles built before March 2002 (**Fig. 1**), which have an adjustable vertical linkage. Vehicles built from March 2002 have a fixed vertical linkage, with cab ride height preset at the factory.

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Run the engine to build vehicle air pressure to 105 to 135 psi (724 to 930 kPa).
3. Shut down the engine.



A. Cab Ride-Height Measurement

1. Vertical Linkage Assembly
2. Horizontal Control Lever
3. Height-Control Valve
4. Lower Bracket
5. Air Spring
6. Upper Bracket

Fig. 1, Cab Air Suspension Components (vehicles built before March 2002)

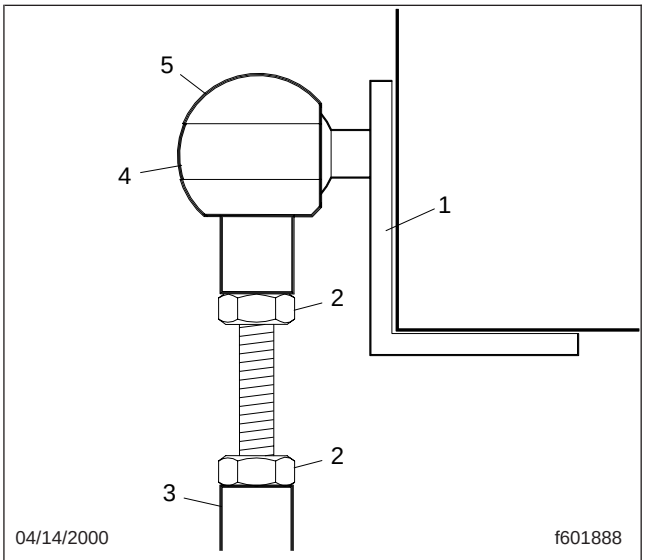
Cab Ride-Height Adjustment

4. Find the cab air spring and measure the distance between the bottom surface of the top bracket and the top surface of the bottom bracket. See **Fig. 1**. If the measured dimension is within the tolerance given in **Table 1**, then no adjustment is necessary.

Cab Ride-Height Measurement	
Application	**Dimension A (see Fig. 1)**
Day Cab	4-1/2 ± 1/8 in (116 ± 3 mm)
SilverStar	6-1/2 ± 1/8 in (165 ± 3 mm)

Table 1, Cab Ride-Height Measurement

5. Disconnect the vertical linkage of the height-control valve from the cab mounting bracket. See **Fig. 2**.



1. Cab Mounting Bracket
2. Jam Nut
3. Vertical Linkage Assembly
4. Linkage Ball Safety Clip
5. Vertical Linkage Cap

Fig. 2, Vertical Linkage and Cab Bracket

6. Adjust the cab ride height by either lifting the control lever to lower the cab, or depressing the control lever to raise the cab. Set the height to the measument given in **Table 1**.
7. Loosen the jam nuts on the linkage arm. Turn the linkage to the correct length so that the ball cap at the top of the vertical linkage lines up with the cab mounting bracket.

NOTE: The ends of the threaded rod must be threaded a minimum of five complete threads into the linkage barrel and the ball cap.

8. Snap the top of the vertical linkage into place over the ball on the cab mounting bracket.
9. Tighten the two jam nuts on the vertical linkage assembly.
10. Remove the chocks from the tires.

Checking the Cab Height-Control System for Air Leaks

⚠ WARNING

Keep your hands and all objects away from the area under and around the cab when removing the pressure from the air system. Parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- If it is necessary to remove a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, crushing the valve body and damaging the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Turn off the engine and wait 5 to 10 minutes for the system to equalize.

   NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal and does not indicate a damaged valve.
3. Apply a soap-and-water solution to the outside of the air fittings on the height-control valve and on the suspension air springs. Look for bubbles indicating an air leak.
4. If bubbles are seen, check that the air tubing is installed correctly into the fitting; see **Subject 100** or **Subject 110**.

   If no bubbles are seen, check the height-control valve for air leaks; see **Subject 120**.

Diagnostics and Testing

Air Spring

Inspect the exterior surfaces of the air spring, looking for wear. With the air spring fully inflated, check to see if there is sufficient clearance around the air spring to prevent lines or objects from rubbing against the air spring. Air tubing or cab components that rub against the air spring will cause damage to the air spring. If the air spring is not capable of lifting the cab to its proper ride height, check to see if the shock absorber is damaged. A binding shock absorber will limit the air spring's ability to extend. To clean the air spring, use soap and water.

NOTE: Do not use organic solvents, abrasives, or pressurized steam cleaners to clean the air spring.

Shock Absorber

Inspect the shock body for damage such as bends or dents in the piston. Bends or dents in the shock body will negatively affect the operation of the shock. Inspect the shock body for signs of leaking fluid. Normal operation of the shock will result in some misting of the hydraulic fluid onto the exterior shock body. Large streams of fluid indicate a leak, and the shock should be replaced; see **Fig. 1**.

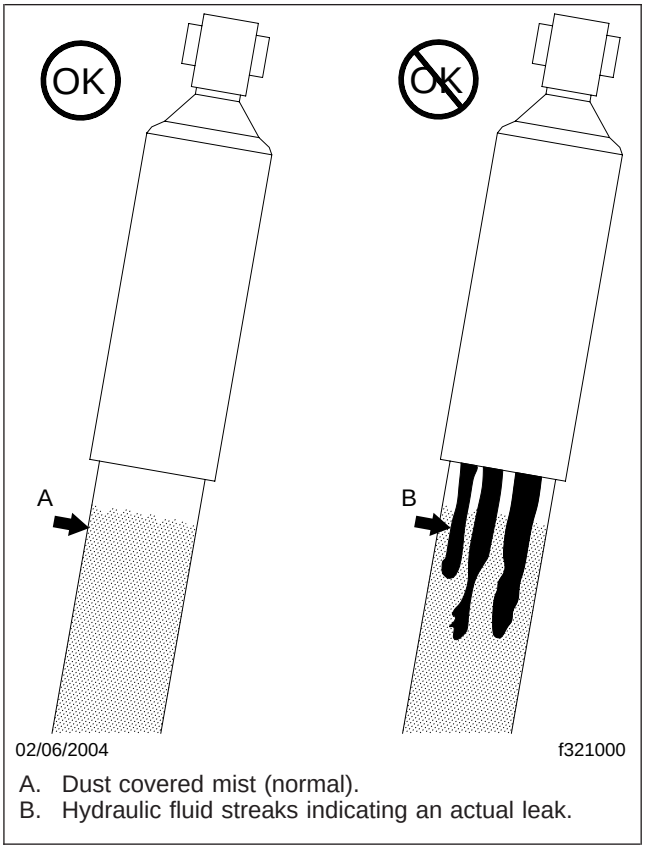
To test the operation of a shock absorber, hold the shock in an upright position and cycle the piston at least five times by pushing the piston up and down. The piston should move evenly throughout each section of the cycle. If the shock does not move evenly

Troubleshooting

when pushed down or pulled up, the shock should be replaced.

Noises such as squeaks, which may be intermittent, may be caused by the valves used to regulate the internal hydraulic fluid. This problem is not repairable and the shock will need to be replaced. Noises from the shock, such as knocking or rattling, may be due to movement between the bushings and mounting brackets. Inspect the bushings or mounting brackets for wear. Repair worn components as necessary. Check the torque of the shock absorber mounting nuts, and tighten if necessary.

NOTE: The shock absorber bushings do not require any type of lubrication. Do not attempt to stop bushing noise by lubricating them; grease and mineral-oil-base lubricants will deteriorate the bushing rubber.



A. Dust covered mist (normal).
B. Hydraulic fluid streaks indicating an actual leak.

Fig. 1, Differences Between Misting and Leaking

Cab Ride Height

Cab ride height is set by the vertical linkage, which is adjustable only on vehicles built before March 2002. Vehicles built from March 2002 have a fixed vertical linkage, with cab ride height preset at the factory.

The ride-height setting depends on the type of cab air suspension system installed in the vehicle; see **Fig. 1** and **Table 1**. All cab ride-height measurements are measured between the lower and upper air spring mounting brackets.

Torque Specifications

Unless listed in **Table 2**, tighten all fasteners using the torque specifications found in **Section 00.06**.

Special Tools

Use the kit shown in **Fig. 2** to test a Barksdale height-control valve. Test kit BKS KD2264 is available via the Direct Ship program in paragon, or directly from Barksdale, at **www.barksdale.com**, or:

Barksdale, Inc.
3211 Fruitland Avenue
Los Angeles, California 90058
Telephone: 866-832-6278

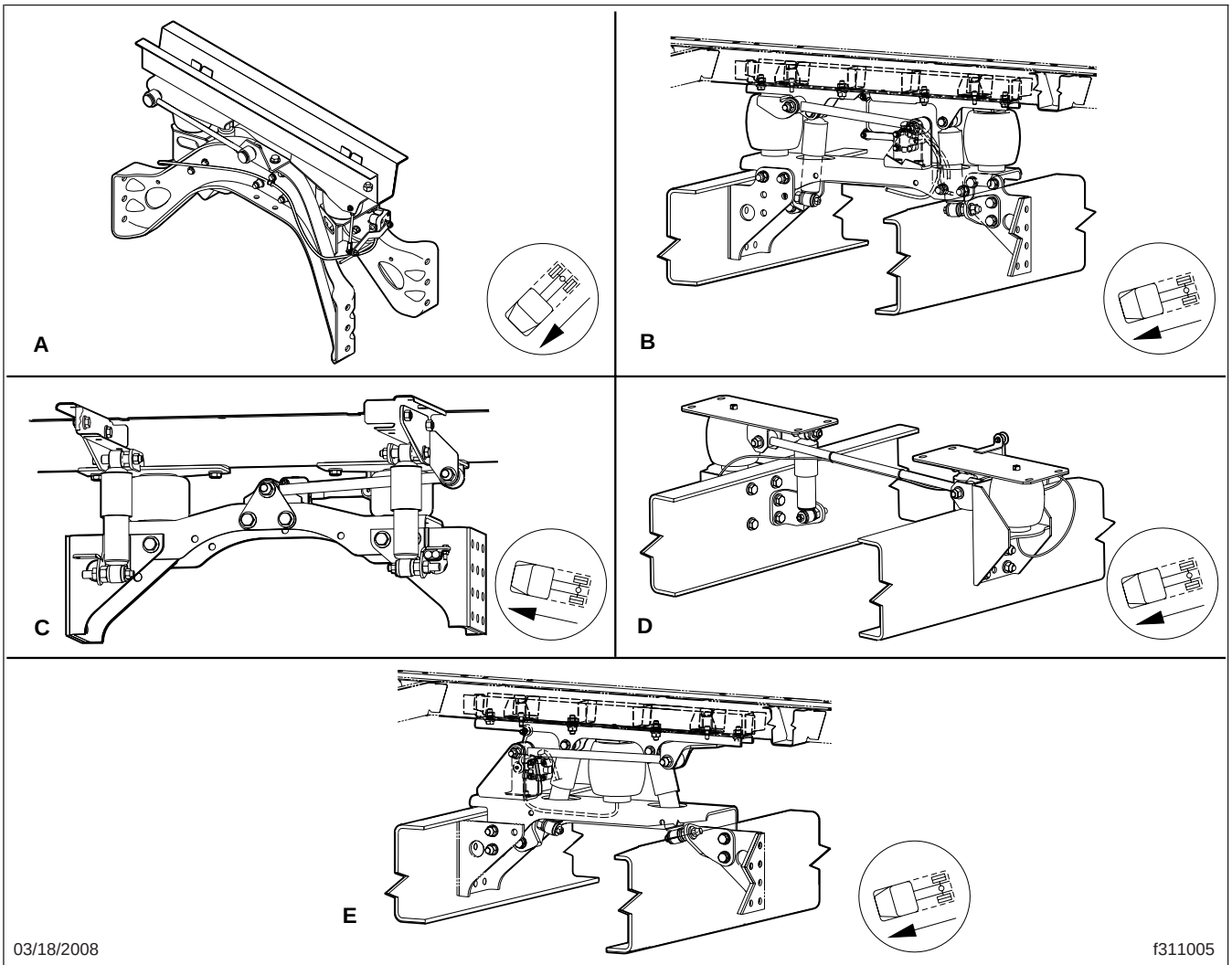
Cab Ride Height Setting				
Cab Air Suspension System (see Fig. 1)	Vehicle Application	Height Measurement		Adjustable
		inch	mm	
A	A-Line (including SilverStar) and L-Line	4-1/2 ± 1/8	116 ± 3	No
B	A-Line (including SilverStar) and L-Line	6-1/2 ± 1/8	165 ± 3	No
C	A-Line and L-Line with 101-inch Cab	4-1/2 ± 1/8	116 ± 3	No
D	A-Line (including SilverStar) and L-Line with Sleeper	6-1/2 ± 1/8	165 ± 3	No
E	L-Line with 111- or 113-inch Day Cab	6-1/2 ± 1/8	165 ± 3	No
not shown	L-Line with Day Cab Built Before March 2002	4-1/2 ± 1/8	116 ± 3	Yes
not shown	A-Line SilverStar Built Before March 2002	6-1/2 ± 1/8	165 ± 3	Yes

Table 1, Cab Ride Height Setting

Torque Specifications				
Fastener Description	lbf·ft	N·m	lbf·in	N·cm
Lateral Control Rod Upper and Lower Nut	45	61	—	—
Shock Absorber Upper and Lower Nut	27	36	—	—
Shock Absorber Mounting Stud	73	99	—	—
Height-Control Valve Mounting Nuts	—	—	45	500
Air Spring Lower Retaining Nut	—	—	35	400
Air Spring Upper Retaining Bolt	—	—	42	475

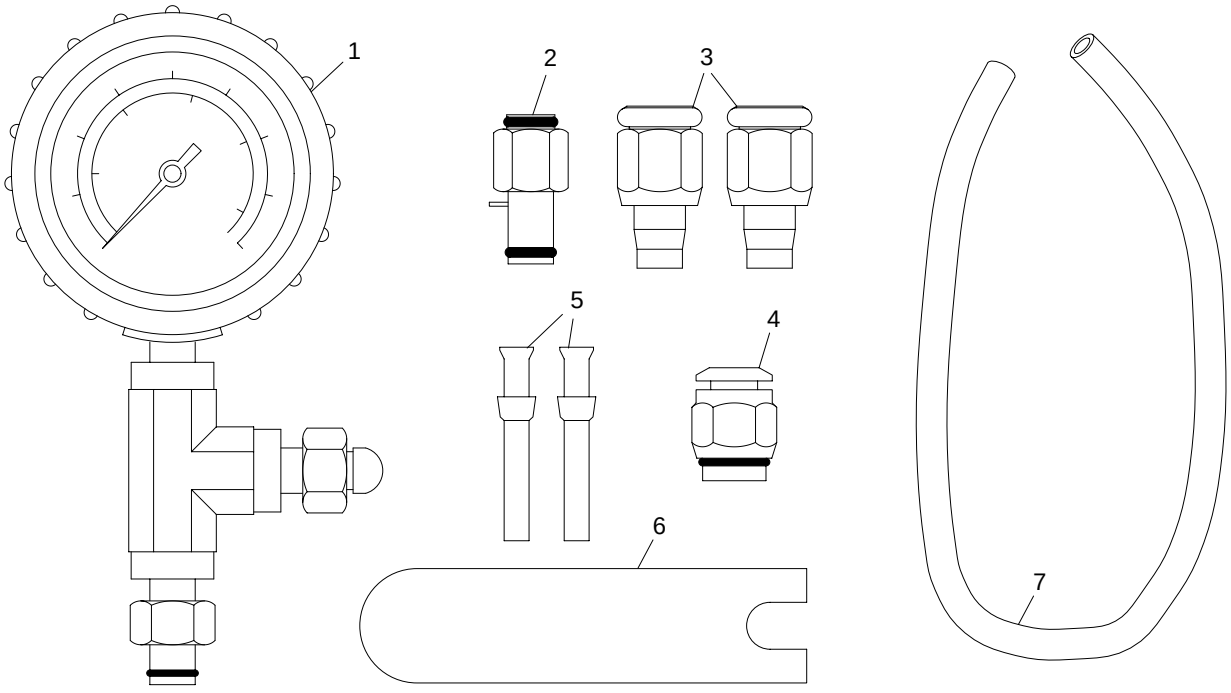
Table 2, Torque Specifications

Specifications



A. A-Line (including SilverStar) and L-Line
B. A-Line (including SilverStar) and L-Line
C. A-Line and L-Line with 101-inch Cab
D. A-Line (including SilverStar) and L-Line with Sleeper
E. L-Line with 111 or 113-inch Day Cab

Fig. 1, Cab Air Suspension Systems

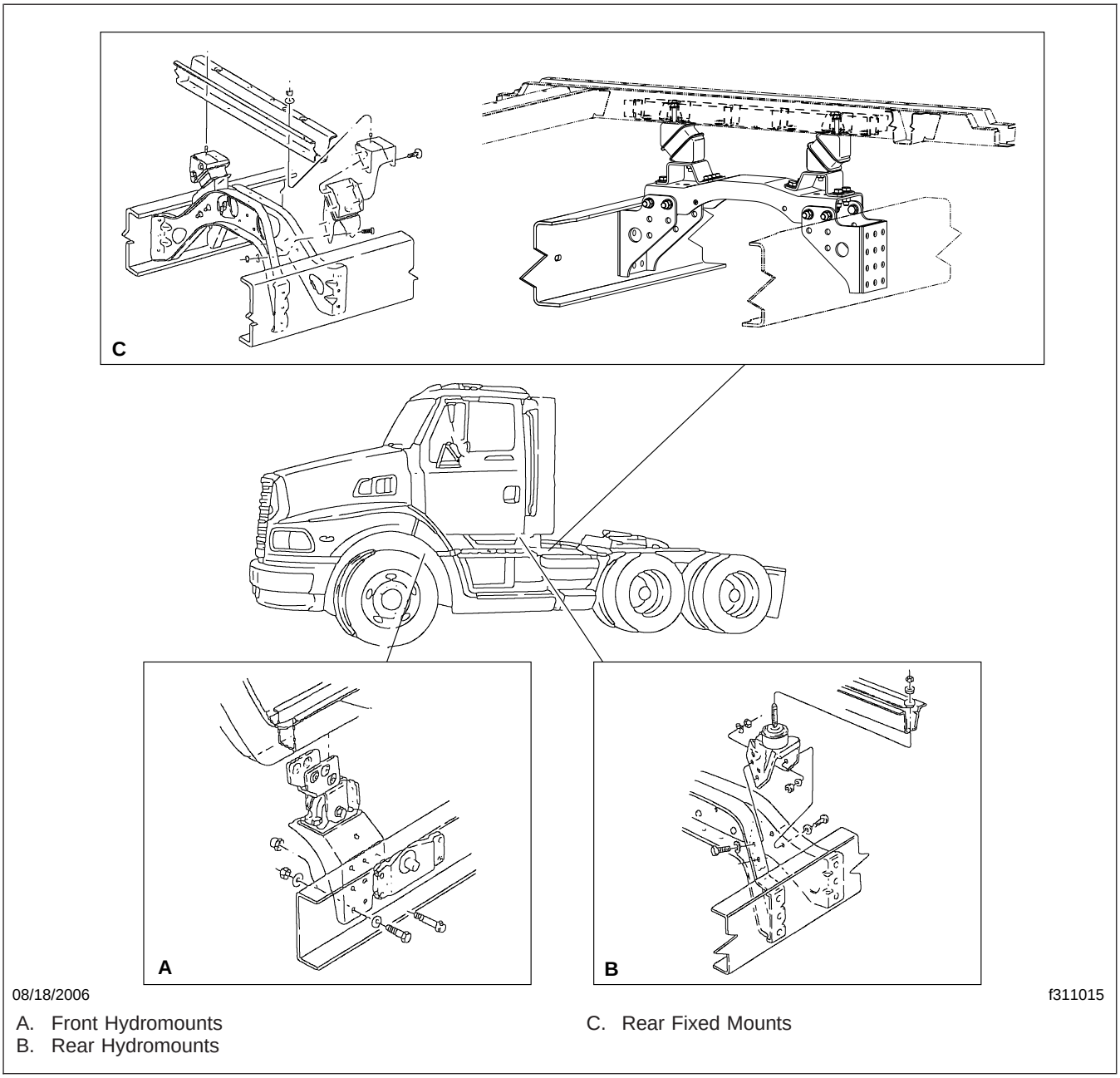


1. Test Gauge Assembly with Reset Button
2. Exhaust Port Test Connector for Cab Suspension Valve
3. Parker Plugs
4. Exhaust Port Test Connector for Chassis Suspension Valve
5. Test Plugs for Cab Suspension Valve
6. Special Tool for Disconnecting Air Line
7. Air Line

Fig. 2, Barksdale Height-Control Valve Test Kit KD2264

General Information

See **Fig. 1** for cab front and rear hydromounts, and rear fixed mounts.



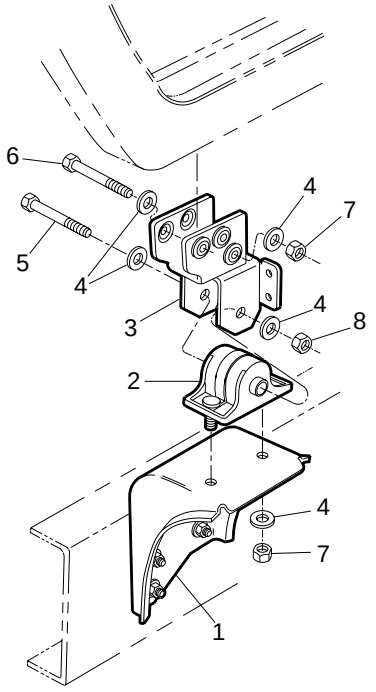
A. Front Hydromounts
B. Rear Hydromounts
C. Rear Fixed Mounts

Fig. 1, Cab Mount Locations

Front Cab Support Removal and Installation

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Remove the front cab support-to-isolator mounting bolt. See **Fig. 1**.



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1. Chassis-Mounted Bracket
2. Isolator
3. Cab-Mounted Bracket
4. Washer
5. Cab Support-to-Isolator Mounting Bolt
6. Cab Support-to-Cab Mounting Bolt
7. Nut, 5/8–11
8. Nut, 3/4–10

Fig. 1, Front Cab Support Installation

3. Raise and support the front of the cab.
4. Remove the nuts and washers that attach the isolator to the chassis-mounted bracket. Remove the isolator.
5. If it is necessary to remove the cab-mounted bracket, remove the 5/8–11 mounting bolts that attach the bracket to the cab. Remove the bracket.

Installation

1. With the tires chocked, attach the front cab-mounted bracket (if removed) to the cab with the 5/8–11 mounting bolts. Tighten the nuts 85 to 95 lbf·ft (115 to 129 N·m). See **Fig. 1**.
2. Attach the isolator to the chassis-mounted bracket with the nuts and washers. Tighten the nuts 136 lbf·ft (184 N·m).
3. Lower the front of the cab.
4. Install the front cab support-to-isolator mounting bolt. For 3/4–10 nut, tighten 150 to 175 lbf·ft (203 to 237 N·m). For 5/8–11 nut, tighten 120 to 152 lbf·ft (163 to 206 N·m).
5. Remove the chocks.

Rear Cab Support Removal and Installation

Removal

NOTE: Left-side is shown in the Figures, right-side is symmetrically opposite.

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Roll up the carpeting or floor matting, and place it out of the way.
3. If the vehicle is equipped with a metal floor cover over the cab support access holes, remove the screws that hold the cover to the cab deck. Remove the cover. See **Fig. 1**.

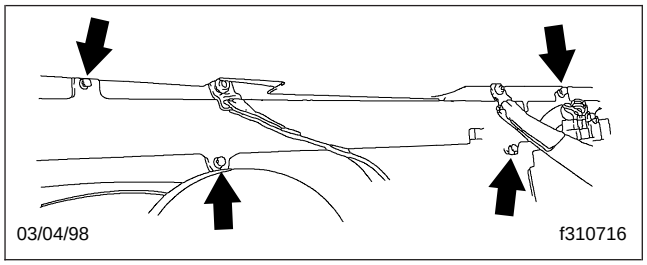


Fig. 1, Metal Floor Cover Screws

4. Remove the rubber cover from the access hole. See **Fig. 2**.

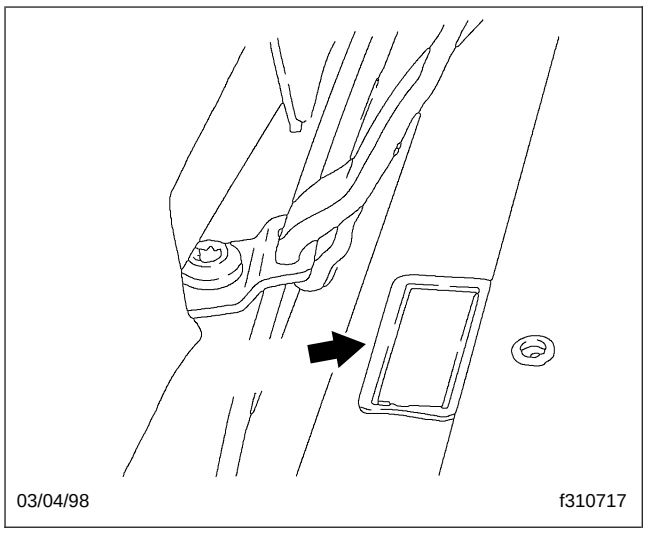
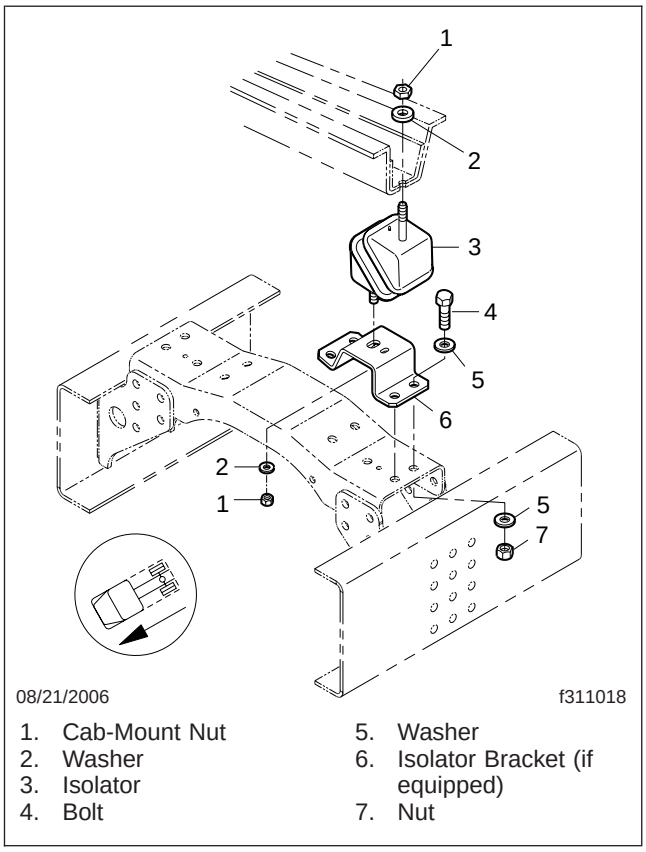


Fig. 2, Rubber Cover

5. Through the access hole, remove the upper cab-mount nut. See **Fig. 3** (fixed mount) or **Fig. 4** (hydromount).



1. Cab-Mount Nut
2. Washer
3. Isolator
4. Bolt
5. Washer
6. Isolator Bracket (if equipped)
7. Nut

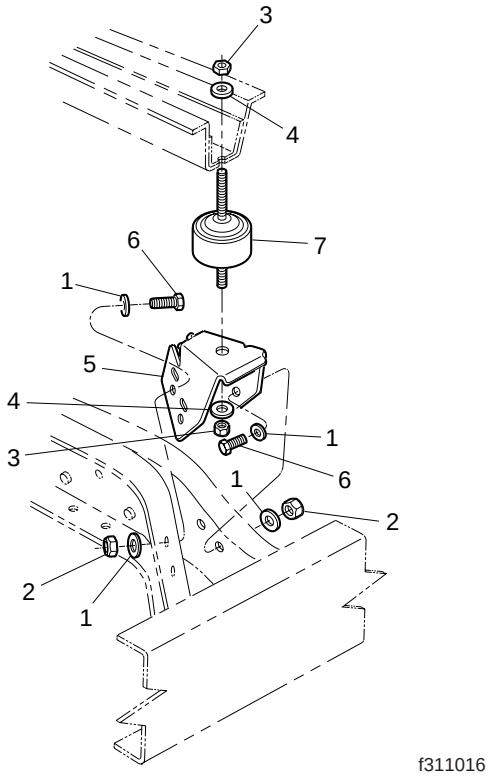
Fig. 3, Rear Fixed Mount Installation (typical)

6. Using a suitable jack, raise and support the cab enough to remove the mount and bracket.
7. Remove the lower cab-mount fasteners. Remove the isolator and isolator bracket (if so equipped), or the hydromount absorber and bracket, as applicable.

Installation

1. With the tires chocked, install the isolator and isolator bracket (if so equipped), or the hydromount absorber and bracket, using the lower cab-mount fasteners. See **Fig. 3** or **Fig. 4**. Tighten the lower cab-mount nut 68 lbf·ft (92 N·m).
2. Lower the cab.
3. Inside the cab, through the access hole, install the upper cab-mount nut. Tighten the nut 68 lbf·ft (92 N·m).

Rear Cab Support Removal and Installation



1. Washer
2. Bracket Nut
3. Cab-Mount Nut
4. Flatwasher
5. Hydromount Bracket
6. Bracket Bolt
7. Hydromount Absorber

Fig. 4, Rear Hydromount Installation

4. Install the rubber cover over the access hole. See **Fig. 2**.
5. Install the metal floor cover, if so equipped, and attach it with the screws to the cab deck. See **Fig. 1**.
6. Roll the carpet or matting in position.
7. Remove the chocks.

Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.06**.

Torque Specifications			
Description	**Size**	**lbf·ft**	**N·cm**
Front Cab Support-to-Isolator Mounting-Bolt Nut	3/4–10	150–175	203–237
	5/8–11	120–152	163–206
Front Cab Isolator-to-Chassis Bracket Nut	5/8–11	136	184
Front Cab Support-to-Cab Mounting-Bolt Nut	5/8–11	85–95	115–129
Rear Cab-Mount Nuts, Upper and Lower	1/2–13	68	92

Table 1, Torque Specifications

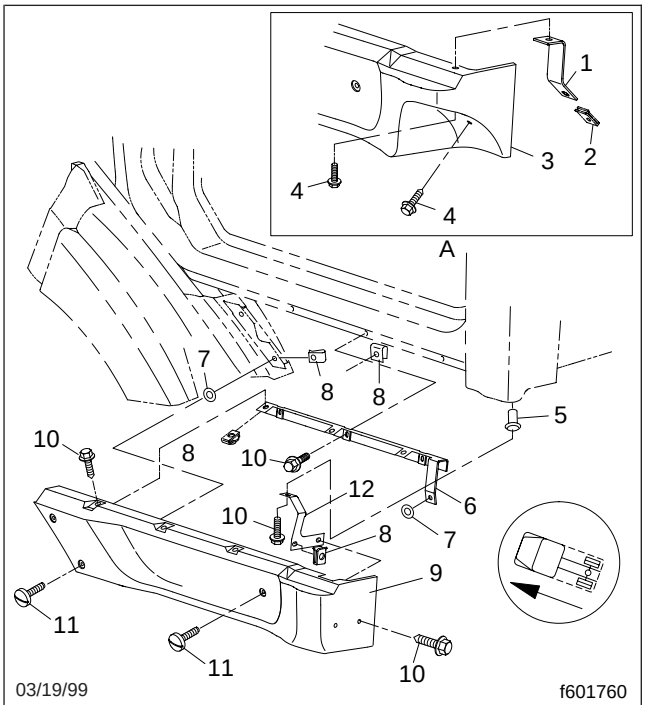
Valance Panel Removal and Installation

Removal

CAUTION

On vehicles using aluminum cab construction, only use fasteners and other replacement parts manufactured by the original equipment manufacturer. This must be strictly adhered to in order to reduce the possibility of galvanic corrosion.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Open the door.
3. Loosen and remove the slotted screws and the hexhead screws. See **Fig. 1**.

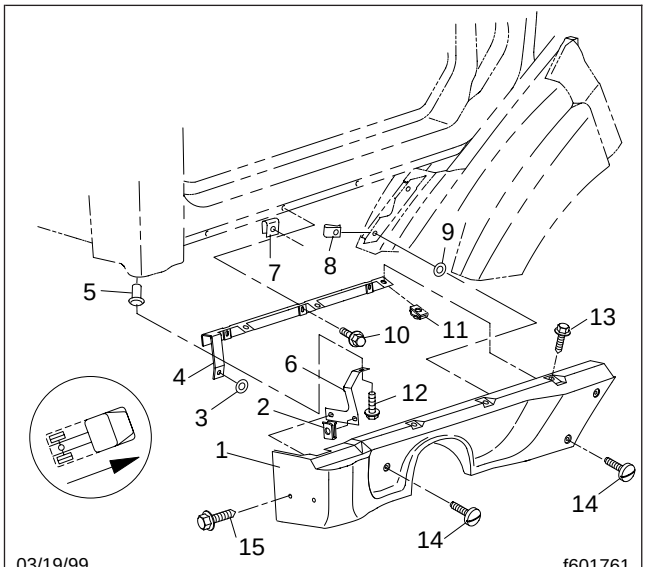


A. Valance with rear cut-out

1. Bracket
2. Screw Retainer
3. Valance
4. Hexhead Screw
5. Sleeve
6. Bracket
7. Washer
8. Screw Retainer
9. Valance
10. Bolt
11. Slotted Screw
12. Bracket

Fig. 1, Valance and Mounting Components

4. Remove the valance panel. For center cut-out valance panels, see **Fig. 2**.



1. Valance
2. Screw Retainer
3. Washer
4. Bracket
5. Sleeve
6. Bracket
7. Screw Retainer
8. Screw Retainer
9. Washer
10. Bolt
11. Screw Retainer
12. Screw
13. Screw
14. Slotted Screw
15. Screw

Fig. 2, Valance with Center Cut-Out

4.1 Pull the valance away from the cab and tilt the valance forward and rotate it counterclockwise.

4.2 Slide the bracket through the slot on the right-side of the valance. Be careful not to scratch the panel on the step.

Installation

1. Position the valance panel. For the center cut-out valance, install the valance panel by placing the right-side in first.
2. Install and tighten the hexhead screws and the slotted screws. See **Fig. 1** or **Fig. 2**. For torque values, see **Specifications, 400**.
3. Close the door.
4. Remove the chocks from the tires.

Specifications

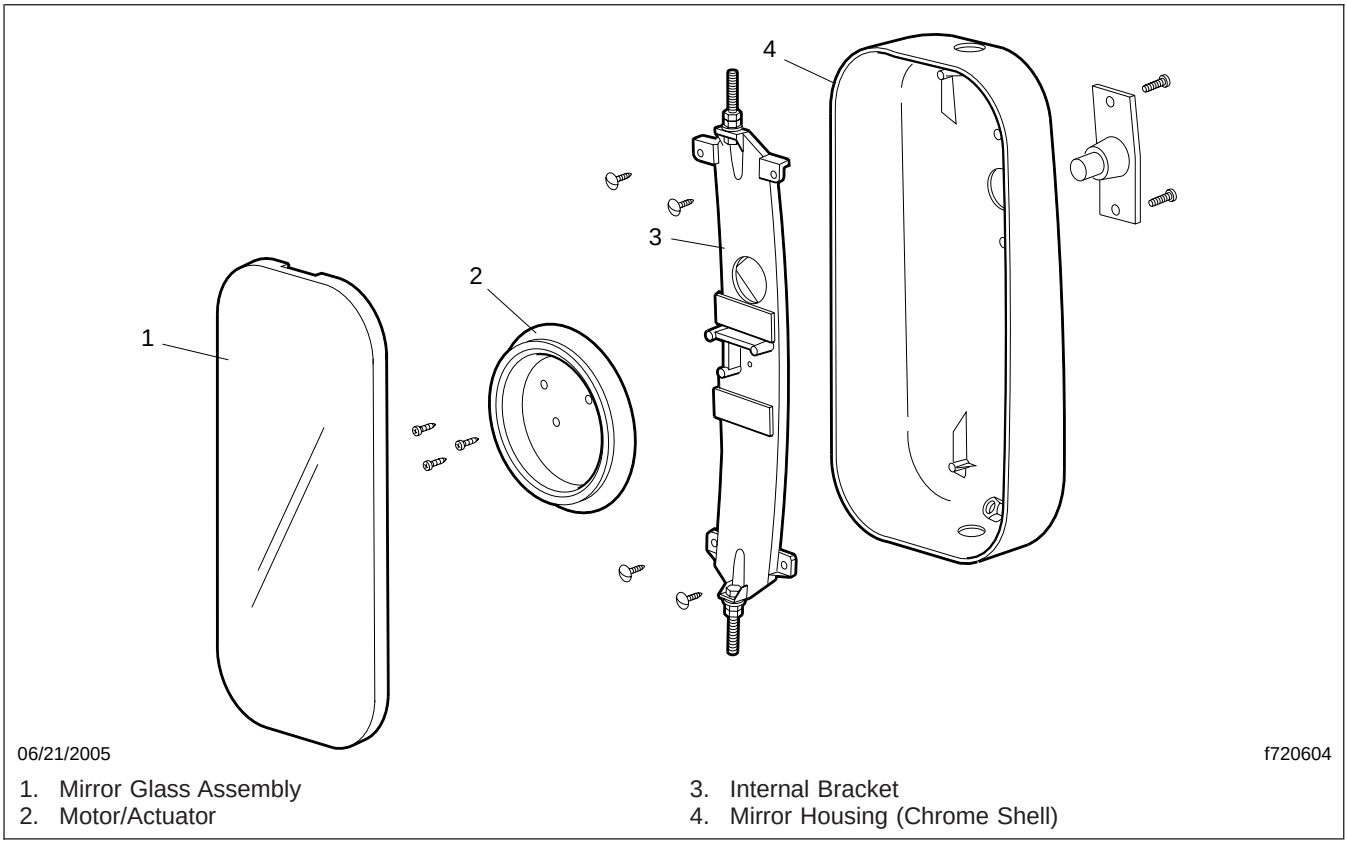
Torque Specifications	
Description	**lbf·in (N·cm)**
Slotted Screws	10–15 (100–180)
Hex Head Screws (Valance Bracket-to-Cab)	80–115 (900–1300)
Hex Head Screws (Valance-to-Bracket)	44–71 (500–800)

Table 1, Torque Specifications

General Information

The Hadley 4WAY mirror (**Fig. 1**) is manually adjustable. When adjusting the mirror, only the glass moves, not the entire mirror housing as in traditional single-axis-movement mirrors. Whether the mirror is motorized or not, its position may be changed by simply pushing on the mirror glass, without causing drive system damage.

Both the mirror glass assembly and the motor/actuator are fully replaceable in the field.



1. Mirror Glass Assembly
2. Motor/Actuator
3. Internal Bracket
4. Mirror Housing (Chrome Shell)

Fig. 1, Hadley 4WAY Mirror Assembly

Removal

1. Rotate the mirror fully to the right.
2. Find the small lever near the center of the left edge of the mirror glass. Push the lever down while holding on to the mirror glass. Pull the mirror glass assembly out of the mirror housing.
3. Disconnect the heater wire connections at the bottom of the mirror glass assembly.

Installation

1. Connect the heater wire connections to the mirror glass assembly.

NOTE: Each heater wire can be connected to either heater terminal, since the heater is not polarity-sensitive.

2. Push the mirror lever fully down, then position the mirror glass assembly on the motor/actuator. Ensure that the mirror glass assembly is fully engaged on the motor/actuator, and while holding it in place, move the lever up to lock it in place.

Motor/Actuator Replacement

1. Remove the mirror glass assembly as described in **Subject 100**.
2. Locate the wires that are routed from the harness to the motor/actuator, and remove the electrical tape. Cut the green, yellow, and white wires just below the connection to the motor/actuator wires.
3. Using a T15 Torx® driver, remove the three motor/actuator retaining screws, and set them aside. Remove the motor/actuator from the housing.
4. Strip approximately 1/4 inch of the insulation from the harness wires.
5. Connect the harness wires to the new motor/actuator wires, matching the colors as shown in **Table 1**.

Wire Color Matching	
Harness Wire Colors	**Motor/Actuator Wire Colors**
Green	White
Yellow	Black
White	Yellow and Blue

Table 1, Wire Color Matching

6. Ensure that the two black motor/actuator mounting pads are still in place on the bracket before installing the motor/actuator. Place the motor/actuator on the mounting points, and attach it with the three screws. Do not over-tighten the screws.
7. Install the mirror glass assembly as described in **Subject 100**.

Troubleshooting Tables

Problem—Mirror Glass Will Not Move When Activating Mirror Switch

Problem—Mirror Glass Will Not Move When Activating Mirror Switch	
Possible Cause	**Remedy**
The mirror head is not motorized.	Confirm that the mirror head is a motorized head by removing the glass and checking if there are wires attached to the motor/actuator.
The fuse or circuit breaker is open.	Replace the fuse or reset the circuit breaker.
An obstruction in the mirror head is preventing the mirror glass from moving.	Have an assistant listen to the motor/actuator as you activate the mirror switch. If the motor is attempting to move the mirror glass, check for any possible obstructions that may keep the mirror glass from moving.
The motor/actuator is not working.	Find and disconnect the mirror harness connector from the truck cab connector. Using the mirror operation tables in **Specifications 400**, supply power to the motor/actuator from an external power source. If the motor/actuator still does not work, replace it. If it does work, check the mirror switch and wiring.

Problem—The Mirror Will Not Stay Adjusted, Moves at High Speed, or Vibrates

Problem—The Mirror Will Not Stay Adjusted, Moves at High Speed, or Vibrates	
Possible Cause	**Remedy**
The mirror bracket is loose.	Check all mirror bracket fasteners. Tighten any that are loose.
The mirror head is loose.	Check the mirror-head mounting nuts. Tightening any that are loose.
The motor/actuator is loose.	Check the motor/actuator screws. Tighten any that are loose, using a T15 Torx driver.
The mirror has broken or worn parts.	Check for broken or worn parts. Check the mirror glass assembly, the motor/actuator mounting ring, and the internal bracket. Replace them, if necessary. NOTE: If there is noticeable wear on the motor/actuator or the mirror glass assembly, replace both components.

Problem—The Mirror Heater Does Not Work

Problem—The Mirror Heater Does Not Work	
Possible Cause	**Remedy**
The fuse or circuit breaker is open.	Replace the fuse or reset the circuit breaker.
The heater switch connections are loose.	Check the heater switch connections. Reconnect loose wires, if necessary.

Troubleshooting

Problem—The Mirror Heater Does Not Work	
Possible Cause	**Remedy**
The heater element does not work.	Remove the mirror glass assembly. Carefully disconnect the heater element wires from the heater element terminals. Place the mirror heater switch in the "On" position. With a voltage meter, check the heater element wires for the presence of 12 volts (or the battery source voltage). If the source voltage is present, replace the mirror glass assembly. If the voltage is not present, check and repair the wiring and connectors.
The wiring is damaged or disconnected.	NOTE: The heater element can also be checked by applying 12 volts directly from a battery or a power supply to the heater element terminals. Since the heater element is not polarity-sensitive, each power lead can be connected to either terminal. The heater should draw 2 to 5 amps, depending on the ambient temperature at the time of the test. Allow two minutes for the glass to become warm to the touch.

See **Fig. 1** for the Hadley 4WAY mirror wiring-harness-connector pin numbers. See **Table 1** and **Table 2** for the wire function and motor/actuator operation information.

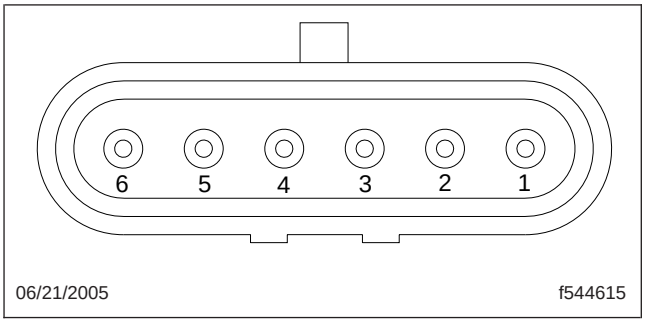


Fig. 1, Mirror Wiring Harness Connector

Mirror Wire Harness		
Pin Number (see Fig. 1)	**Wire Color**	**Wire Function**
1	Black	Heat (Ground)
2	Blue	Light (Positive)
3	Red	Heat (Positive)
4	Yellow	Motor—Y Axis
5	Green	Motor—X Axis
6	White	Motor—Common

Table 1, Mirror Wire Harness

Motor/Actuator Operation		
Apply Positive (+) Voltage	**Apply Negative (-) Ground**	**Motor Movement**
Yellow (Pin #4)	White (Pin #6)	Up
White (Pin #6)	Yellow (Pin #4)	Down
Green (Pin #5)	White (Pin #6)	Left
White (Pin #6)	Green (Pin #5)	Right

Table 2, Motor/Actuator Operation

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Roll down the window.
4. Pull the door wiring grommet from the seated position. See **Fig. 1**.

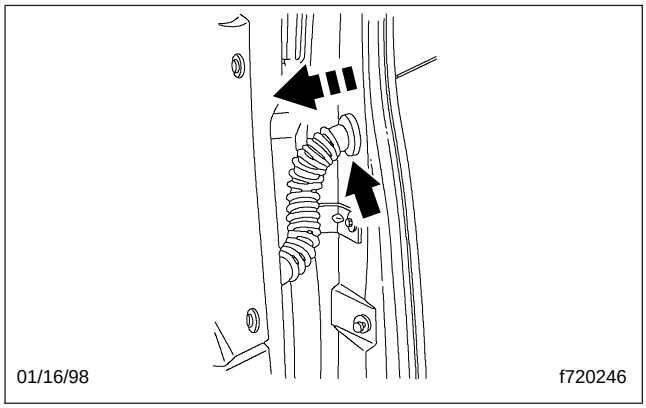


Fig. 1, Door Wiring Grommet

5. Remove the scuff panel. See **Fig. 2**.

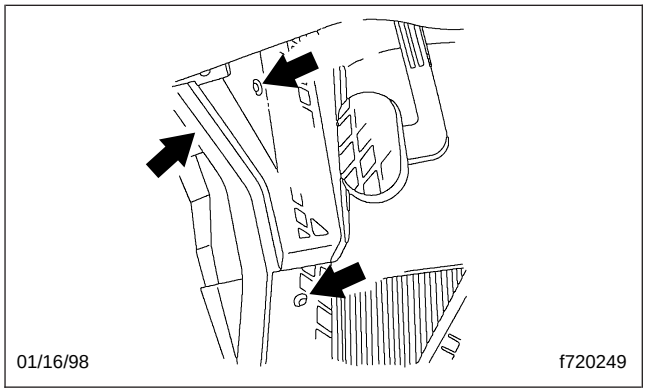


Fig. 2, Scuff Panel

6. Remove the under steering panel screws and remove the panel. See **Fig. 3**.
7. Disconnect the electrical connectors. See **Fig. 4**.
8. Disconnect the CB antenna cable.
9. Remove the ground bolt and the ground strap. See **Fig. 5**.

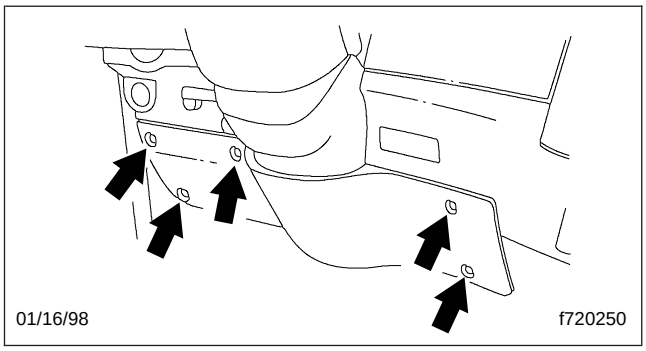


Fig. 3, Under Steering Panel Screw Locations

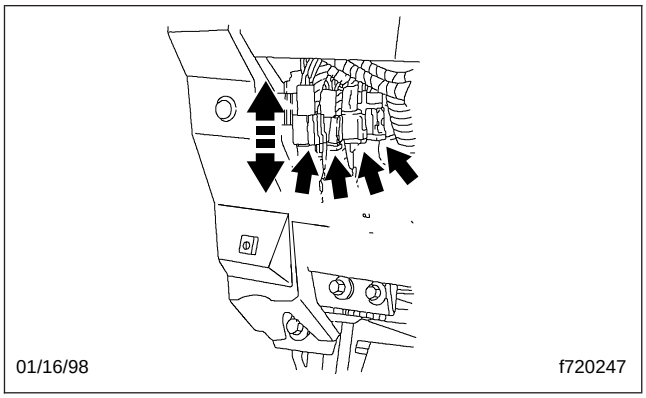


Fig. 4, Electrical Connectors

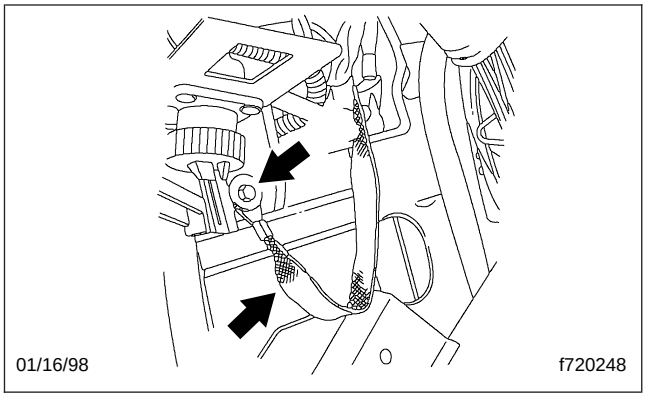


Fig. 5, Ground Bolt and Ground Strap

10. Pull the wiring out of the A-pillar, one connector at a time.
11. Remove the cowl panel. For instructions, see **Group 88**.
12. Place indicator marks around the door hinges on the door surface.

Door Removal and Installation

13. Close the door and remove the hinge-to-door bolts. Remove the door. See **Fig. 6**.

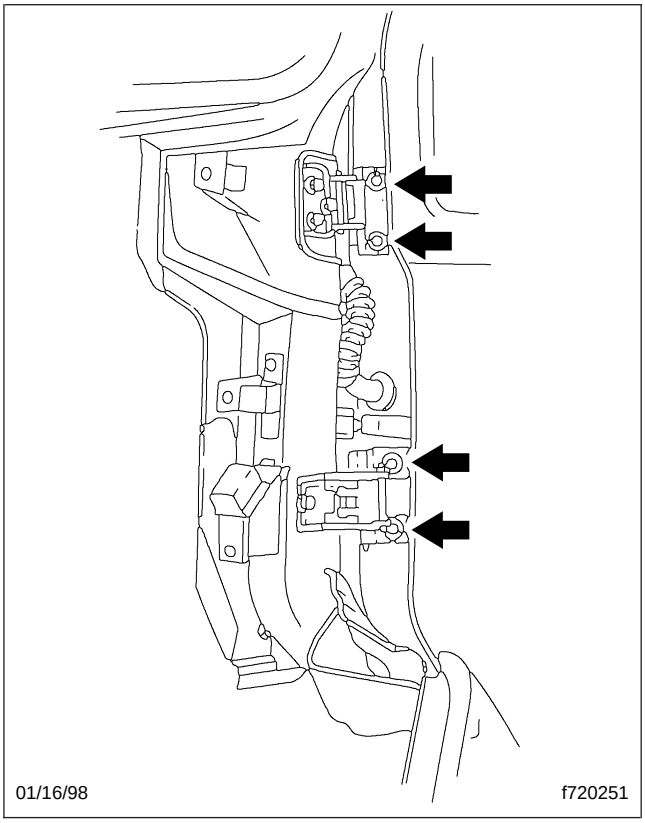


Fig. 6, Hinge-to-Door Bolts

Installation

1. Position the door and install the hinge-to-door bolts. Align the door hinges with the marks made during removal. Tighten the nuts 15 to 24 lbf·ft (21 to 32 N·m). See **Fig. 6**.
2. Install the cowl panel. For instructions, see **Group 88**.
3. Feed the wiring into the A-pillar, one connector at a time.
4. Install the ground bolt and the ground strap. See **Fig. 5**.
5. Connect the CB antenna cable.
6. Connect the electrical connectors. See **Fig. 4**.
7. Install the under steering panel. See **Fig. 3**.
8. Install the scuff panel. See **Fig. 2**.
9. Position and seat the door wiring grommet. See **Fig. 1**.
10. Roll up the window.
11. Connect the batteries.
12. Remove the chocks from the tires.

Adjustment

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the rear tires.
2. Remove the cowl panel. For instructions, see **Group 88**.
3. Loosen the bolts if necessary, and adjust the door at the A-pillar for up-down and fore-aft movement. See **Fig. 1**.

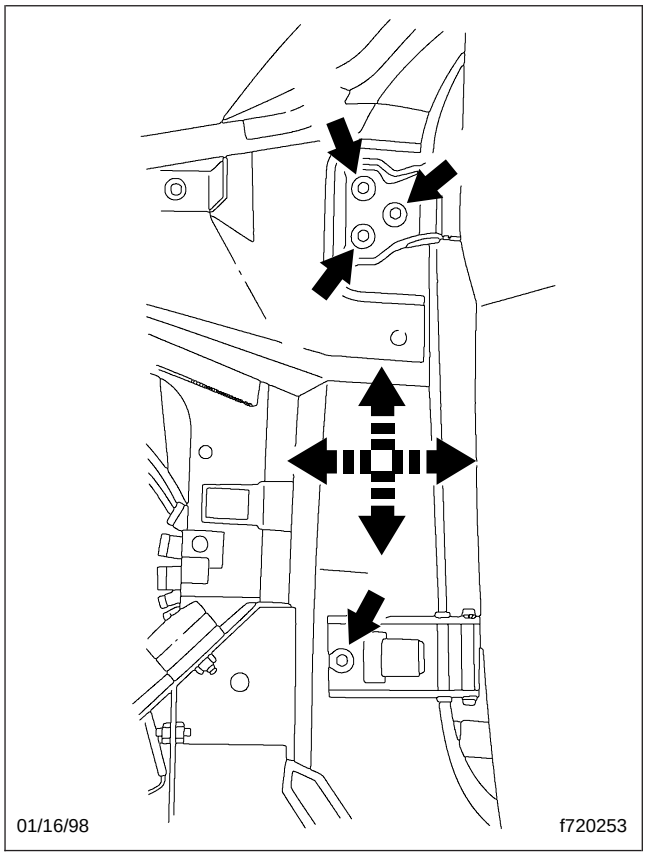


Fig. 1, Adjusting Up-Down and Fore-Aft Movement

4. Loosen the bolts if necessary, and adjust at the door for in-out movement. See **Fig. 2**.

CAUTION

To ensure proper fit of the door, this adjustment procedure must be performed on both upper and lower hinges. Failure to adjust both hinges could result in premature wear of the hinges.

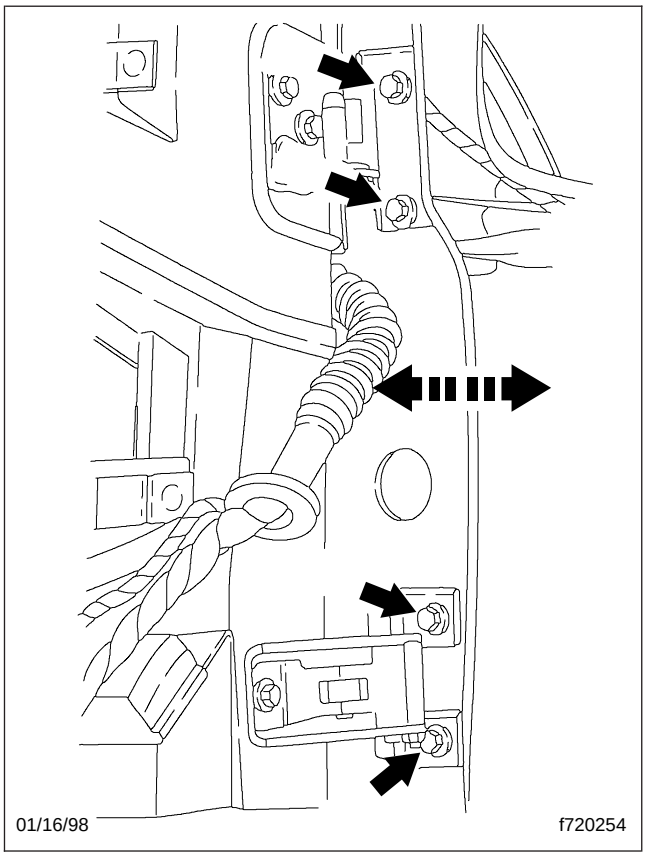


Fig. 2, Adjusting In-Out Movement

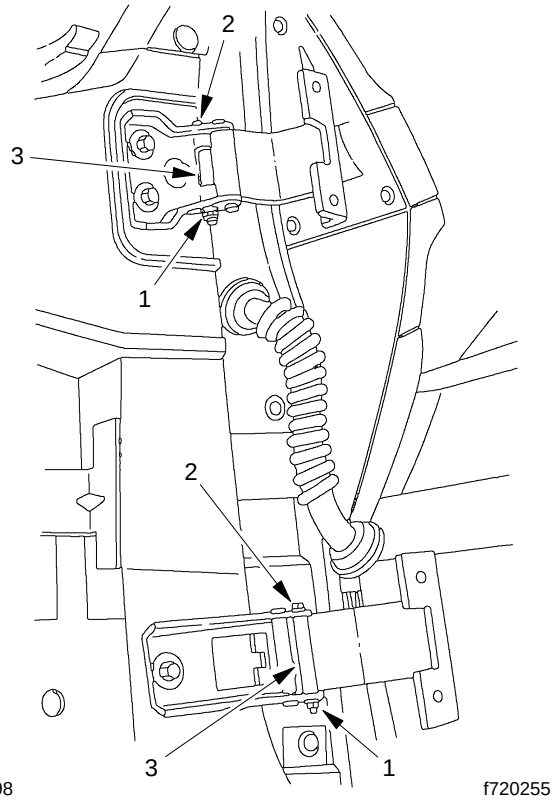
NOTE: The door opening clearance is 55 degrees with the door hinge bushings installed and 65 degrees with the door hinge bushings uninstalled.

5. Adjust the door opening clearance to 65 degrees, if necessary. See **Fig. 3**.
   - 5.1 Remove the hinge bushing nut.
   - 5.2 Pull out the hinge bushing bolt.
   - 5.3 Remove the hinge bushing, and install the hinge bushing bolt and nut.

IMPORTANT: To be certain the doors are properly positioned within the door opening, it is necessary to measure the door alignment.

6. Measure the door alignment.
   - 6.1 Locally fabricate a door alignment gauge. See **Fig. 4**.

Door Adjustment

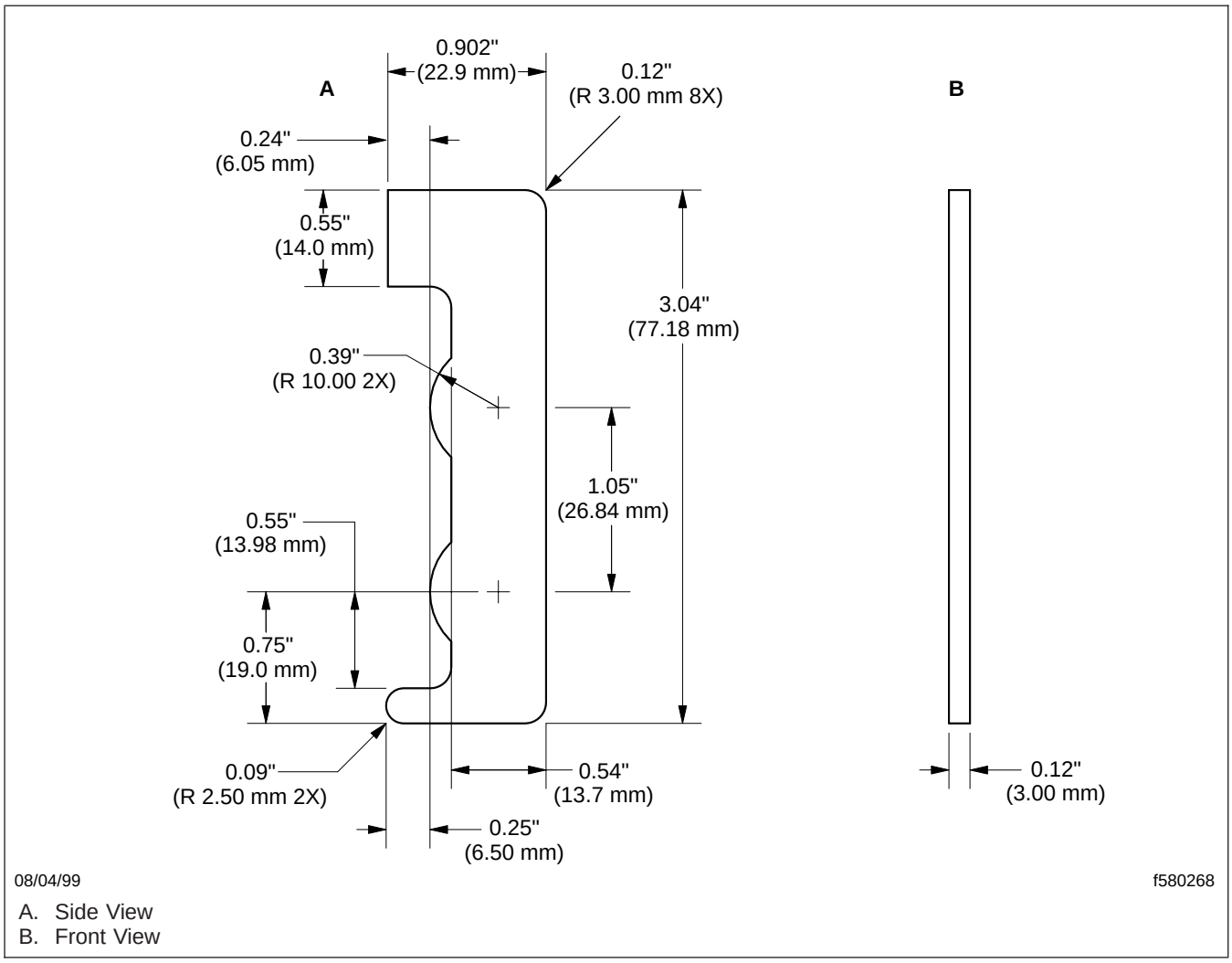


1. Hinge Bushing Nut
2. Hinge Bushing Bolt
3. Hinge Bushing

Fig. 3, Adjusting Door Opening Clearance

6.2 Use the gauge to check the alignment of the door to the cab A-pillar. The measurement should be made on the front edge of the door, approximately 8 inches (203 mm) below the front upper corner. See **Fig. 5**. The gauge should rest on the door window frame and contact the A-pillar as shown in **Fig. 6**. If the gauge does not make contact with the A-pillar, adjust the door as necessary to obtain the proper door alignment.

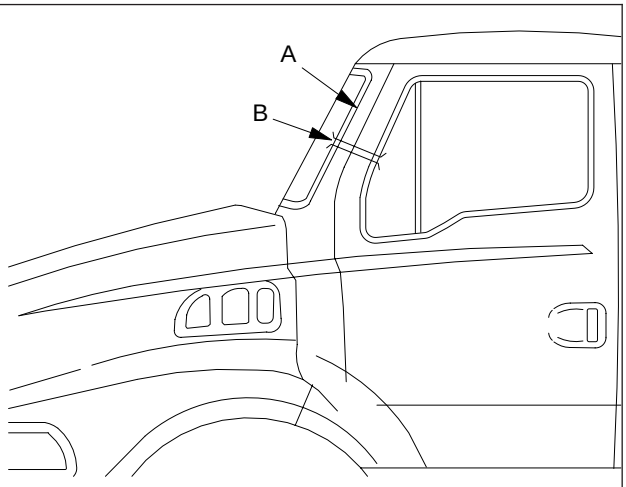
7. Tighten the fasteners to specification. See **Fig. 7**.
8. Install the cowl panel. For instructions, see **Group 88**.
9. Remove the chocks from the rear tires.



A. Side View
B. Front View

Fig. 4, Door Alignment Template

Door Adjustment



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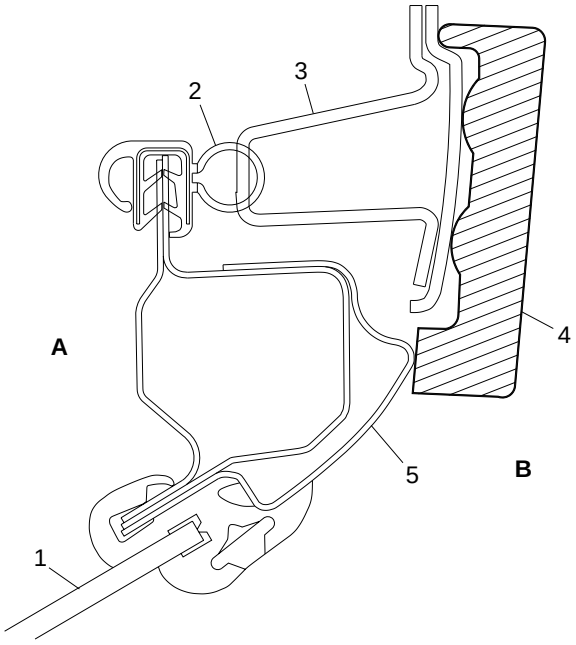
A. Measure the alignment at this point.
B. See Figure 6 for a cross-section view.

Fig. 5, Template Placement



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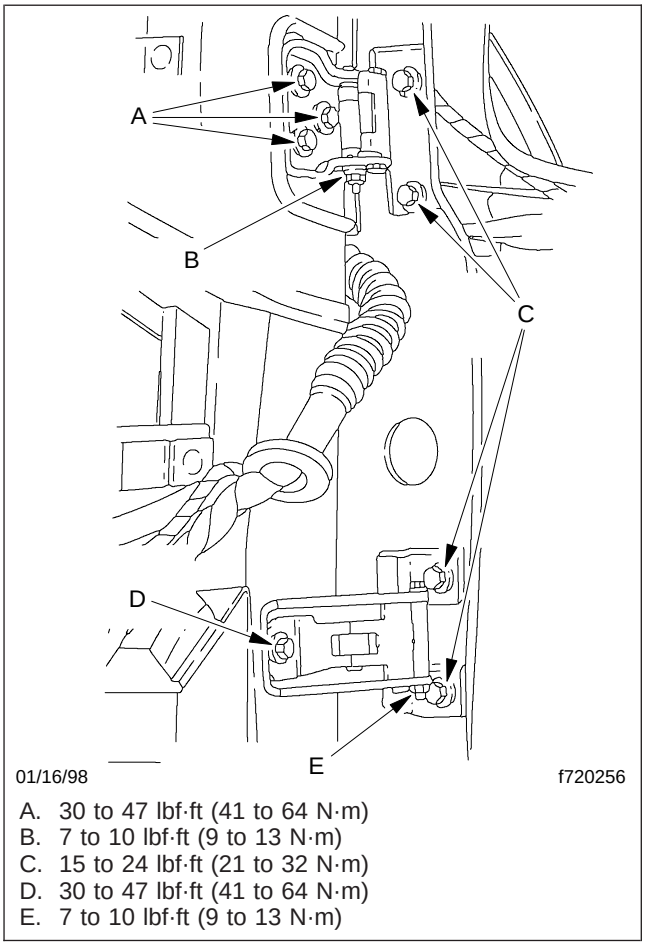
A. Inside Cab
B. Outside Cab
1. Windshield
2. Door Opening Weatherstrip
3. Door
4. Door Alignment Gauge
5. Cab A-Pillar

Fig. 6, Cross-Section View



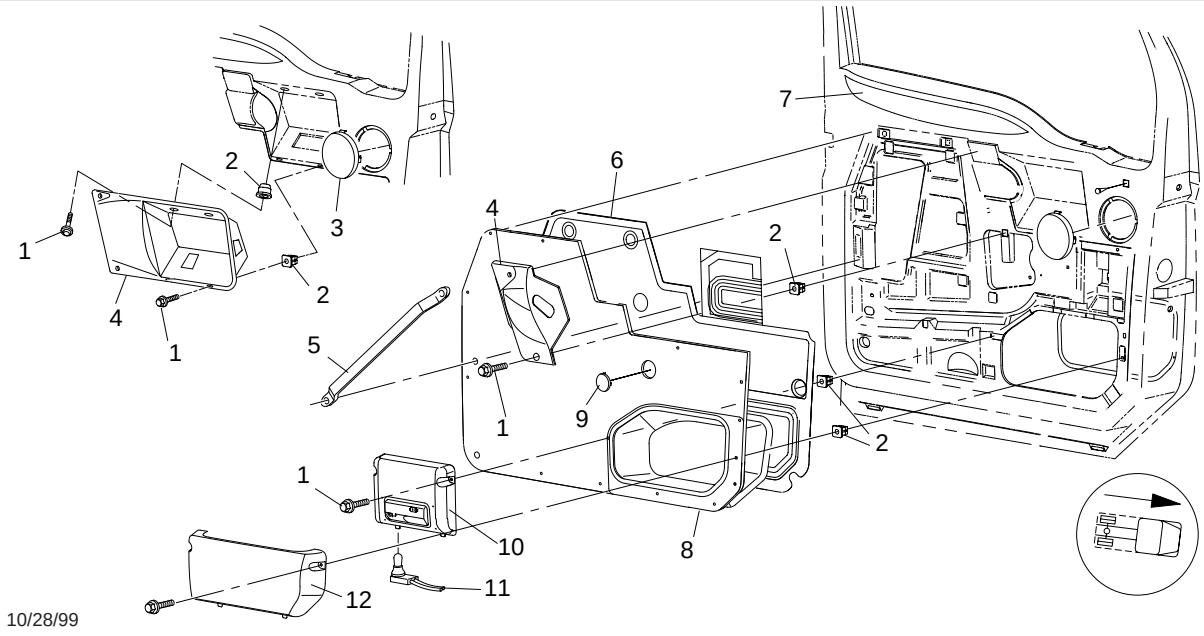
A. 30 to 47 lbf·ft (41 to 64 N·m)
B. 7 to 10 lbf·ft (9 to 13 N·m)
C. 15 to 24 lbf·ft (21 to 32 N·m)
D. 30 to 47 lbf·ft (41 to 64 N·m)
E. 7 to 10 lbf·ft (9 to 13 N·m)

Fig. 7, Tightening Specifications

Door Window Glass Replacement

Replacement

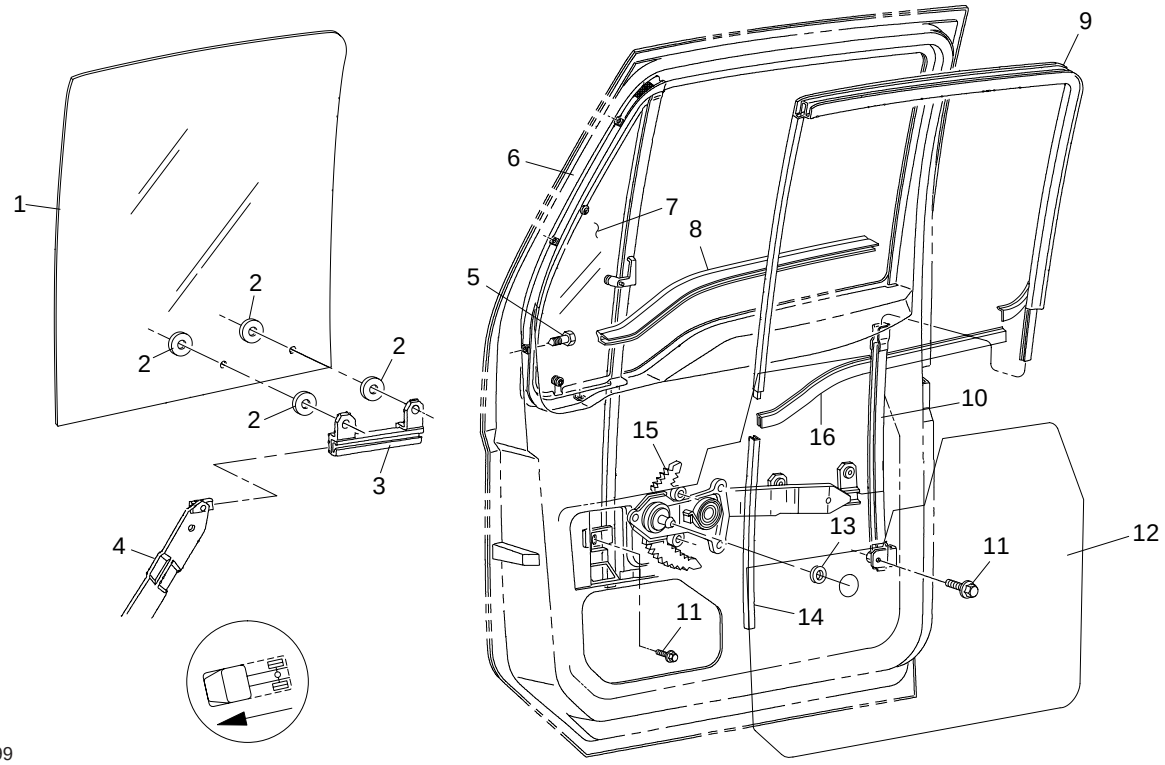
1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Remove the grab handle. See **Fig. 1**.
4. Remove the power window switch cover, the power door locks switch cover and the mirror control trim cover, if equipped.
5. Remove the door window regulator crankhandle, if equipped.
6. Remove the door trim panels. See **Fig. 1**.
   - 6.1 Remove the door trim finish panel.
   - 6.2 Remove the map pocket, if equipped.
   - 6.3 Remove the courtesy lamp.
   - 6.4 Remove the door trim panel.
   - 6.5 Remove the armrest assembly.
7. Remove the door trim watershield. See **Fig. 1**.
8. Lower the window.
9. Remove the door glass run assembly and the interior door window glass weatherstrip. See **Fig. 2**.
   - 9.1 Pull the door glass run assembly from the flange.
   - 9.2 Pull the interior door window glass weatherstrip from the flange.
10. Disconnect the electrical connector from the window motor, if equipped.
11. Remove the four screws from the window regulator assembly, if equipped. Remove the window regulator assembly and the window motor. See **Fig. 2**.
12. Remove the door glass run retainer bolts.



1. Self Tapping Screw
2. Screw Insert
3. Door Trim Panel Opening Cover
4. Door Trim Finish Panel
5. Grab Handle
6. Door Trim Watershield
7. Armrest Assembly
8. Door Trim Panel
9. Window Regulator Opening
10. Courtesy Lamp
11. Wiring Harness
12. Map Pocket

Fig. 1, Door Trim and Components

Door Window Glass Replacement



1. Door Window Glass
2. Spacers
3. Window Glass Channel
4. Window Regulator (track follower end)
5. Screw
6. Vent Window Assembly
7. Vent Window Glass
8. Exterior Door Window Glass Weatherstrip
9. Door Glass Run Assembly
10. Rear Door Glass Run
11. Hexhead Screw
12. Door Trim Watershield
13. Window Regulator Seal
14. Vent Window/Door Glass Divider
15. Window Regulator
16. Interior Door Window Glass Weatherstrip

Fig. 2, Door Interior Components

13. Remove the four retaining screws from the vent window/door glass divider. Pull the vent window/door glass divider out. See **Fig. 3**.
14. Lower the window until the track follower end of the window regulator can be seen through the rear access hole in the door panel.
15. Push the window glass forward to remove the window regulator track follower from the window glass channel. See **Fig. 2**.
16. Lift the window out of the door and through the window opening.
17. Drill out the window glass channel rivets and replace them if new window glass is being installed. See **Fig. 4**.
18. Position the window into the door.
19. Insert the window regulator track follower into the window glass channel. See **Fig. 2**.
20. Install the vent window/door glass divider and the door glass run retainer in the door. See **Fig. 2**.
21. Using the four retaining screws, install the vent window/door glass divider. See **Fig. 3**.
22. Install the door glass run retainer bolts.
23. Position the window regulator assembly and the window motor, if equipped, in the door. Install the four retaining screws. See **Fig. 2**.

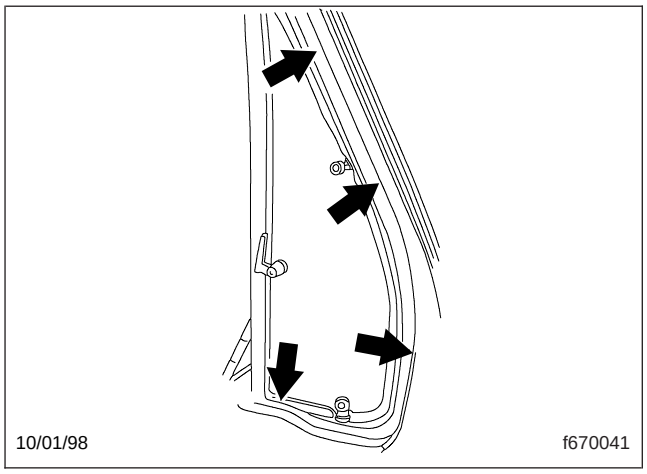


Fig. 3, Vent Window Division Bar Screw Locations

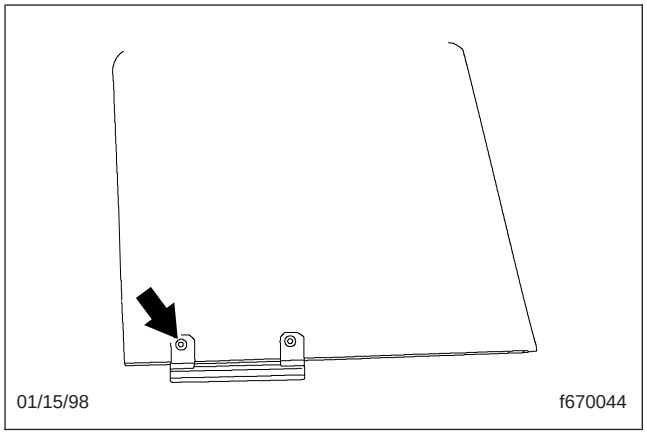


Fig. 4, Window Glass Channel Rivet

24. Connect the window motor electrical connector, if equipped.
25. Install the door window glass weatherstrip. See **Fig. 2**.
26. Push the door glass run assembly and the door window glass weatherstrip into the pinch weld. See **Fig. 2**.
27. Raise and lower the window to make sure it operates properly.
28. Install the door trim watershield. See **Fig. 1**.
29. Install the door trim panels. See **Fig. 1**.
    - 29.1 Install the armrest assembly.
    - 29.2 Install the door trim panel.
    - 29.3 Install the courtesy lamp.
    - 29.4 Install the map pocket, if equipped.
    - 29.5 Install the door trim finish panel.
30. Install the power window switch cover, the power door locks switch cover and the mirror control trim cover, if equipped.
31. Install the door window regulator crankhandle, if equipped.
32. Install the grab handle. See **Fig. 1**.
33. Connect the batteries.
34. Remove the chocks from the tires.

Observation Window Glass Replacement

Replacement

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Protect the paint finish by taping paper around the opening.
3. From outside the vehicle, unzip the integral locking tab on the rubber seal. See **Fig. 1**.

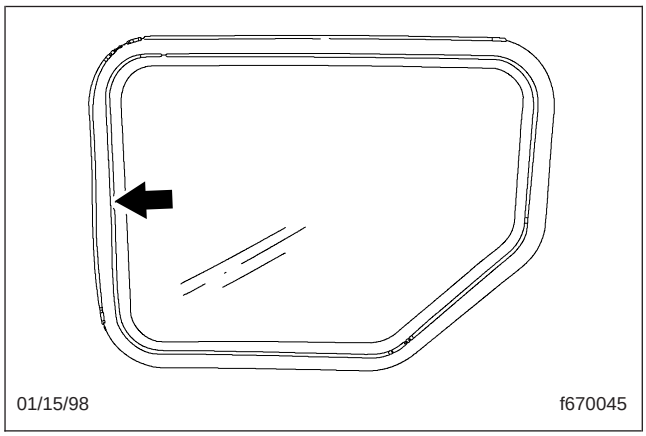


Fig. 1, Integral Locking Tab

NOTE: One assistant is necessary to push on the glass from the inside.

4. Insert an appropriate tool and pry the glass from the rubber seal. See **Fig. 2**.

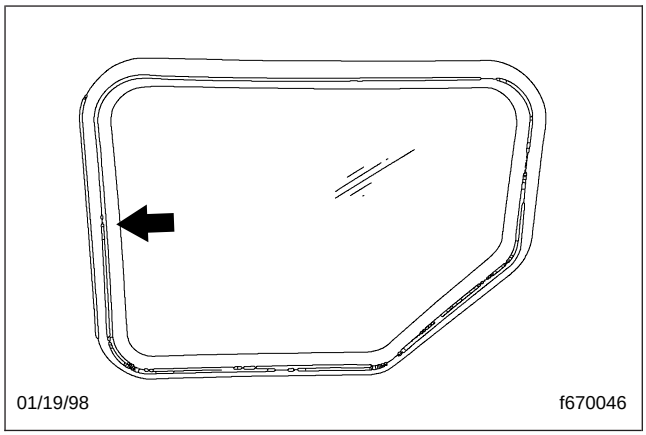


Fig. 2, Rubber Glass Seal

5. Remove the rubber seal from the door. See **Fig. 3**.

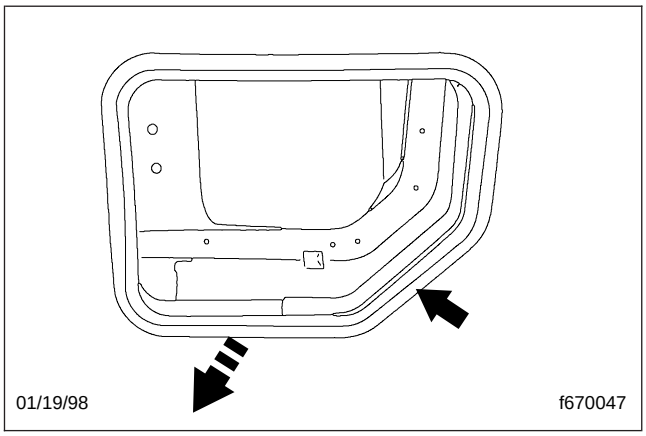
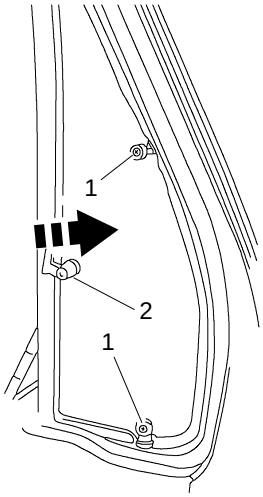


Fig. 3, Rubber Door Seal

6. Install the rubber seal around the door.
7. Lubricate the rubber seal with a soap and water solution.
8. Using an appropriate tool, install the new glass into the rubber seal.
9. From outside the vehicle, install the integral locking tab on the rubber seal.
10. Remove the protective tape from around the opening.
11. Remove the chocks from the tires.

Replacement

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Roll down the window.
3. Remove the vent window glass. See **Fig. 1**.



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1. Bolts
2. Locking Lever

Fig. 1, Vent Window

   3.1 Remove the bolts.

   3.2 Turn the locking lever clockwise and remove the vent window glass.

4. Install the vent window glass.

   4.1 Insert the vent window glass and turn the locking lever counterclockwise.

   4.2 Install the bolts.

5. Roll up the window.
6. Remove the chocks from the tires.

Vent Window Glass Latch Replacement

Replacement

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Punch out the locking lever pin and remove the handle. See **Fig. 1**.

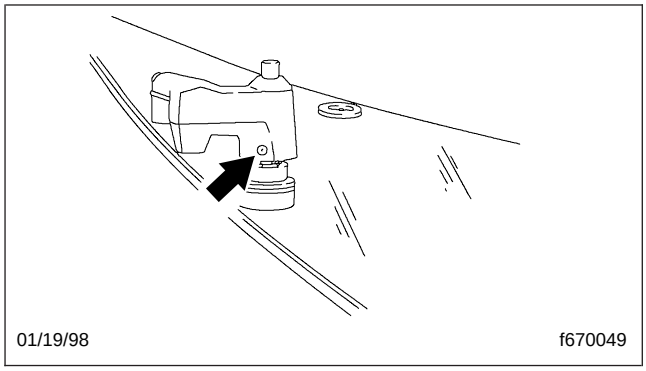


Fig. 1, Locking Lever Pin

3. Lift off the top locking lever piece. See **Fig. 2**.

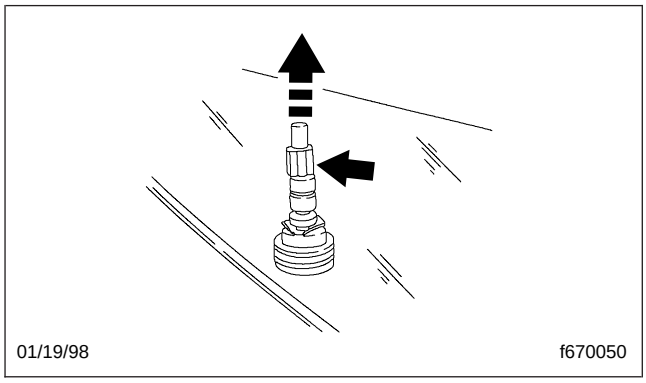
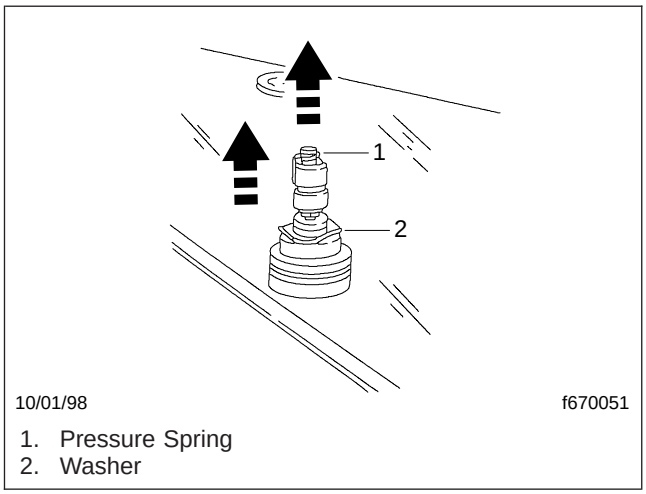


Fig. 2, Locking Lever Piece

4. Remove the locking lever pressure spring and the washer. See **Fig. 3**.

NOTE: Reference the locking lever post position.

5. Remove the locking lever locking nut and slide the locking lever post and washers from the glass. See **Fig. 4**.
6. Replace the washers, locking lever post, and locking nut.



1. Pressure Spring
2. Washer

Fig. 3, Locking Lever Pressure Spring and Washer

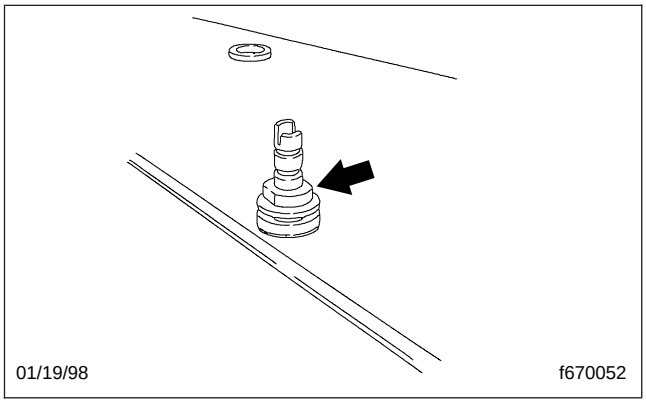


Fig. 4, Locking Lever Locking Nut

7. Replace the pressure spring and the washer. See **Fig. 3**.
8. Install the top locking lever piece.
9. Install the handle and locking lever pin.
10. Remove the chocks from the tires.

Window Motor Removal and Installation

WARNING

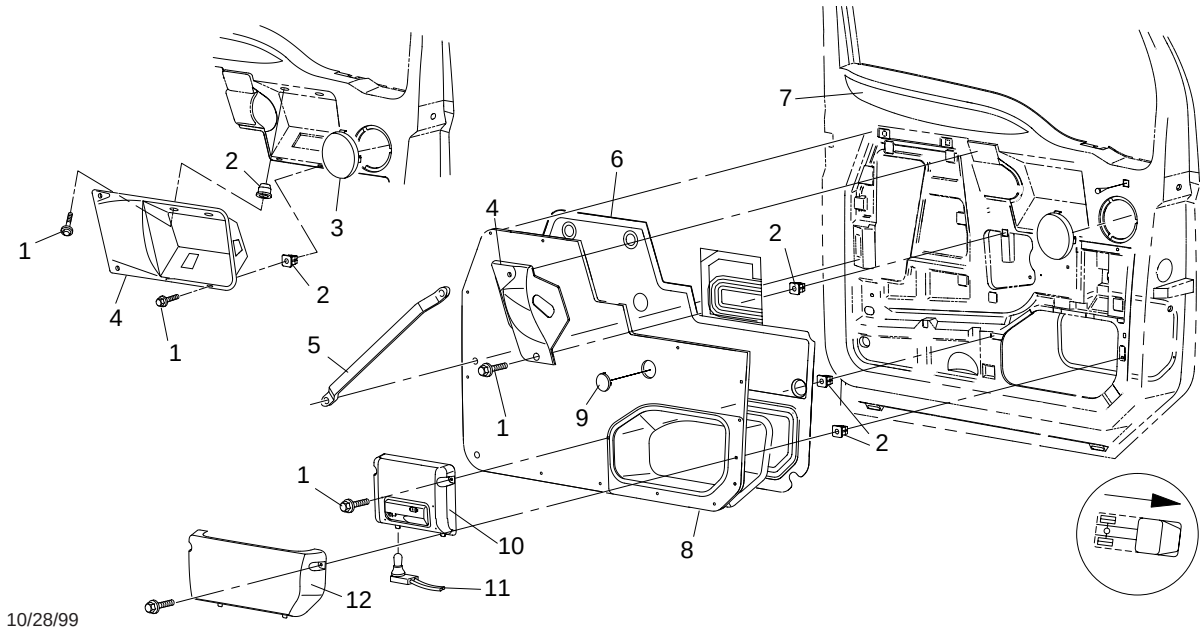
The window motor must be removed and installed as described below. The motor should be removed only while the regulator is firmly mounted to the door. Do not loosen or remove any fasteners that attach the regulator assembly to the door. The regulator mechanism contains a large spring under tension, which can be released if the regulator is disassembled or loosened, possibly resulting in personal injury.

Removal

If it is necessary to remove or service the regulator assembly, follow the procedure in **Subject 170**.

1. Apply the parking brakes and chock the tires.
2. Roll up the window, if possible, leaving a gap of no more than 1/4 inch (6 mm) at the top.
3. Disconnect the batteries.
4. Remove the grab handle; see **Fig. 1**.
5. Remove the power window switch cover, the power door locks switch cover, and the mirror control trim cover, if equipped. Use care when removing the covers to prevent damage to the switches.
6. Remove the door trim panels, as follows; see **Fig. 1**.
   - 6.1 Remove the door trim finish panel.
   - 6.2 Remove the map pocket, if equipped.
   - 6.3 Remove the courtesy lamp.
   - 6.4 Remove the door trim panel.
   - 6.5 Remove the armrest assembly.
7. Remove the door trim watershield; see **Fig. 1**.

NOTE: The window motor removal procedure requires drilling of the inner door. See **Fig. 2** and **Fig. 3** for the templates (to scale) to use when this procedure is required.



1. Self-Tapping Screw
2. Screw Insert
3. Door Trim Panel Opening Cover
4. Door Trim Finish Panel
5. Grab Handle
6. Door Trim Watershield
7. Armrest Assembly
8. Door Trim Panel
9. Window Regulator Opening
10. Courtesy Lamp
11. Wiring Harness
12. Map Pocket

Fig. 1, Door Trim and Components

Window Motor Removal and Installation

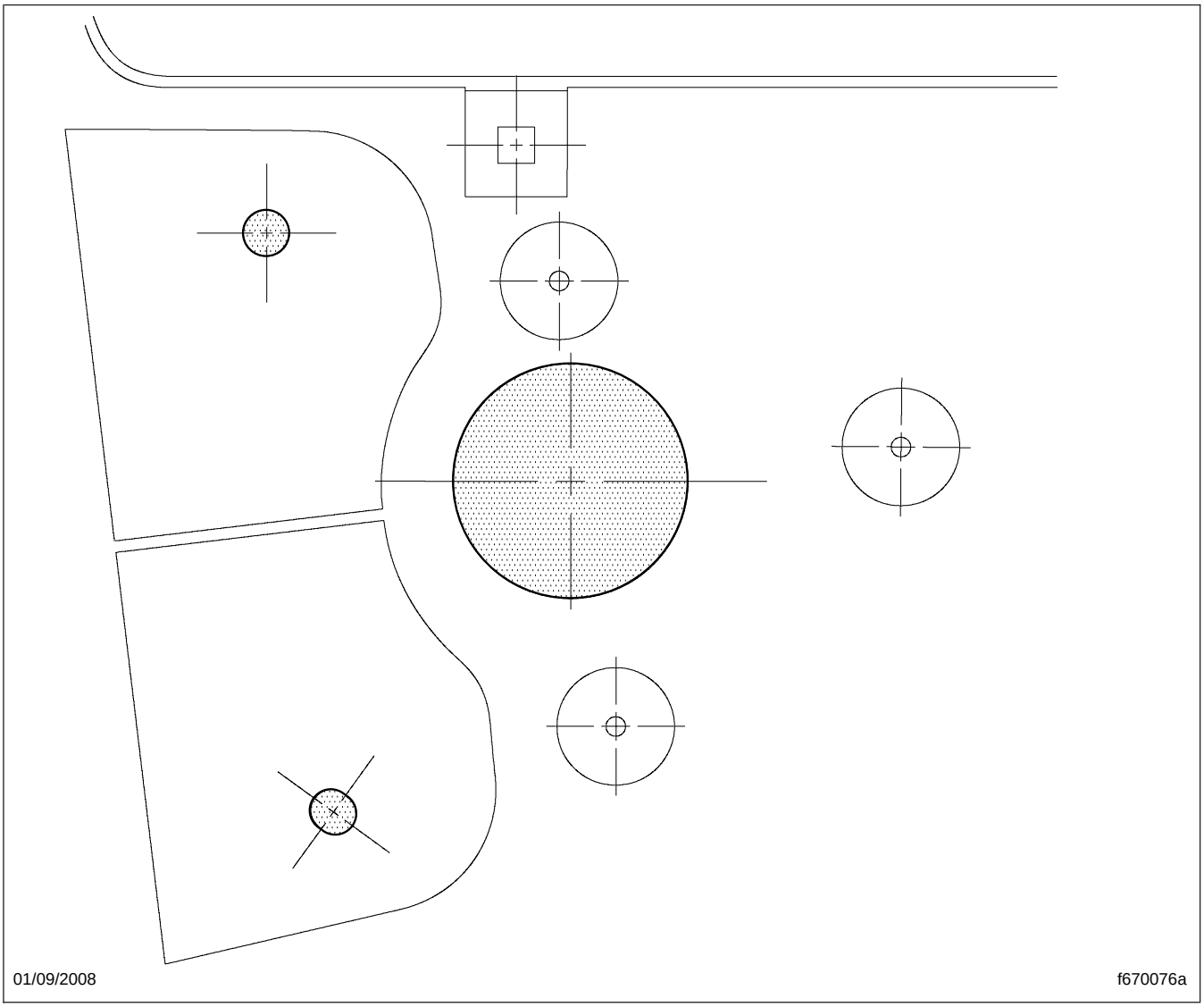


Fig. 2, Left Inner Door Window Motor Template

8. Photocopy the template without reduction or enlargement.
9. Prepare the template, and using a razor knife, cut out the inside of the shaded circles as accurately as possible.
10. Align the template and center punch the holes, as follows; see **Fig. 4**.
    - 10.1 Align the template to the door using the large hole and the upper inner door line.
    - 10.2 Tape the template securely in place.
    - 10.3 Center punch the three retaining bolt hole centers.
11. Remove the template.
12. Using an 18-mm diameter hole saw drill bit, drill out the three retaining bolt access holes; see **Fig. 5**.
13. Disconnect the motor electrical connector.
14. Tape the window glass to the door; see **Fig. 6**.
15. Support the motor and remove the retaining bolts; see **Fig. 7**. Remove the motor.

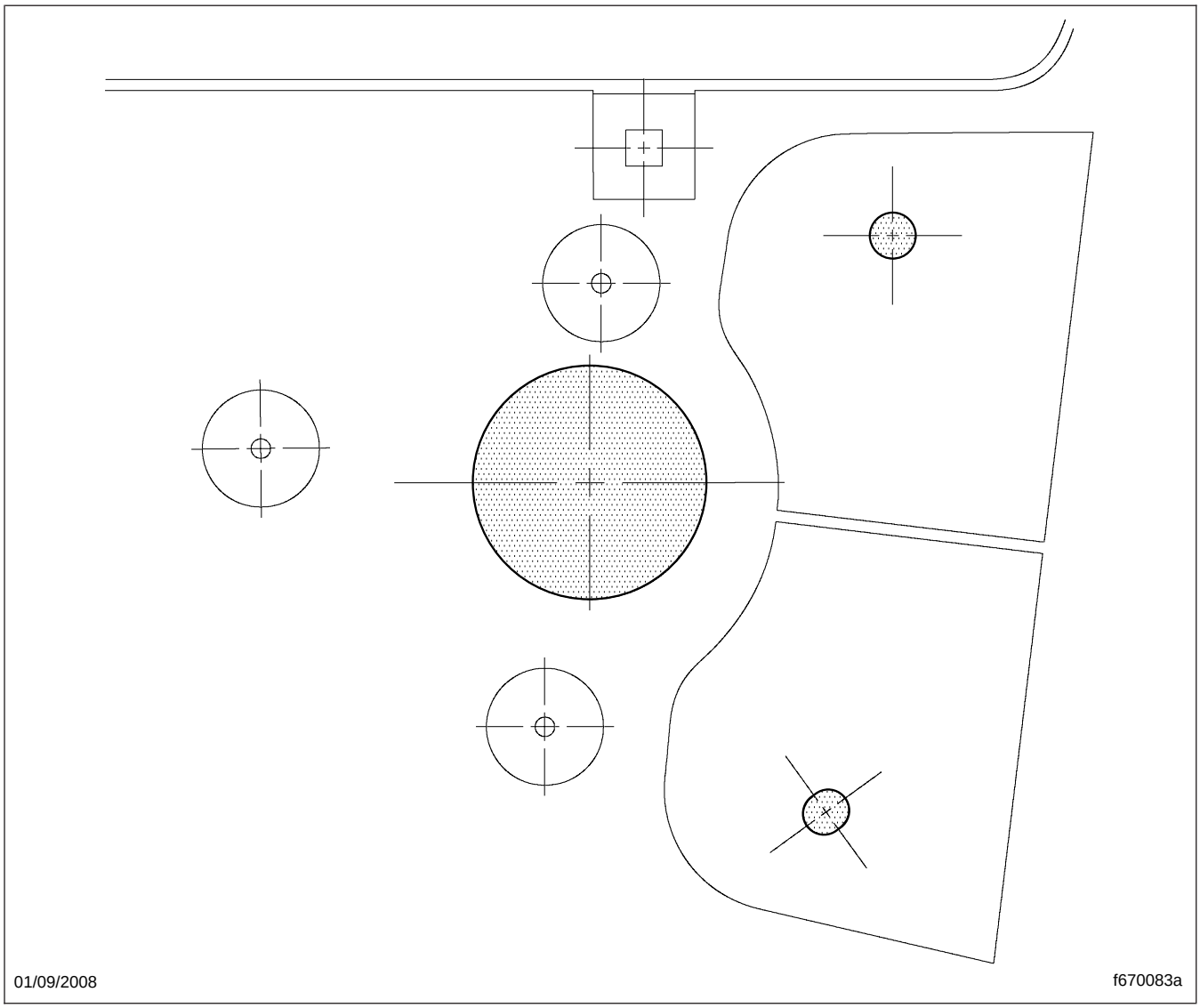
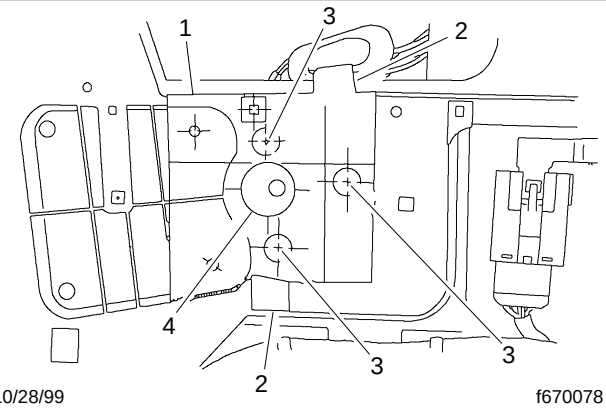


Fig. 3, Right Inner Door Window Motor Template

Installation

1. With the vehicle tires chocked, install the motor and the retaining bolts. Tighten the bolts 7 to 10 lbf·ft (9 to 13 N·m); see **Fig. 7**.
2. Remove the tape from the window; see **Fig. 6**.
3. Connect the motor electrical connector.
4. Install the door trim watershield; see **Fig. 1**.
5. Install the door trim panels, as follows; see **Fig. 1**.
   - 5.1 Install the armrest assembly.
   - 5.2 Install the door trim panel.
   - 5.3 Install the courtesy lamp.
   - 5.4 Install the map pocket, if equipped.
   - 5.5 Install the door trim finish panel.

Window Motor Removal and Installation



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1. Upper Inner Door Line
2. Tape
3. Retaining Bolt Access Hole (centerpunched)
4. Large Hole

Fig. 4, Aligning the Template

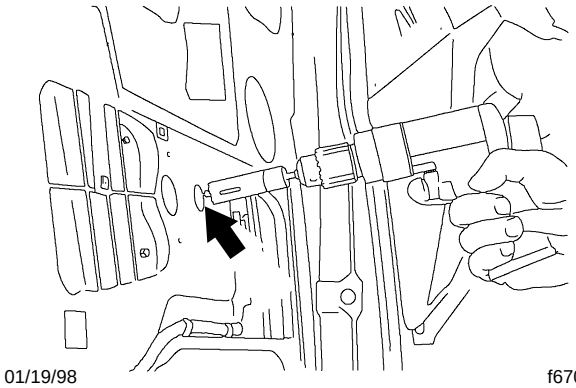

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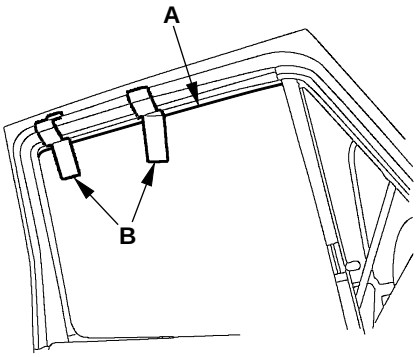
Fig. 5, 18-mm Diameter Hole Saw Drill Bit

6. Install the power window switch cover, the power door locks switch cover, and the mirror control trim cover, if equipped.
7. Install the grab handle; see **Fig. 1**.
8. Connect the batteries.
9. Remove the chocks.



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A. 1/4-inch (6-mm) gap at the top of the window
B. Tape the window glass to the door.

Fig. 6, Securing the Window Glass

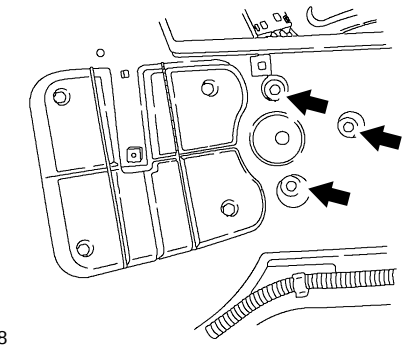

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Fig. 7, Retaining Bolts

Manual and Power Window Regulator Replacement

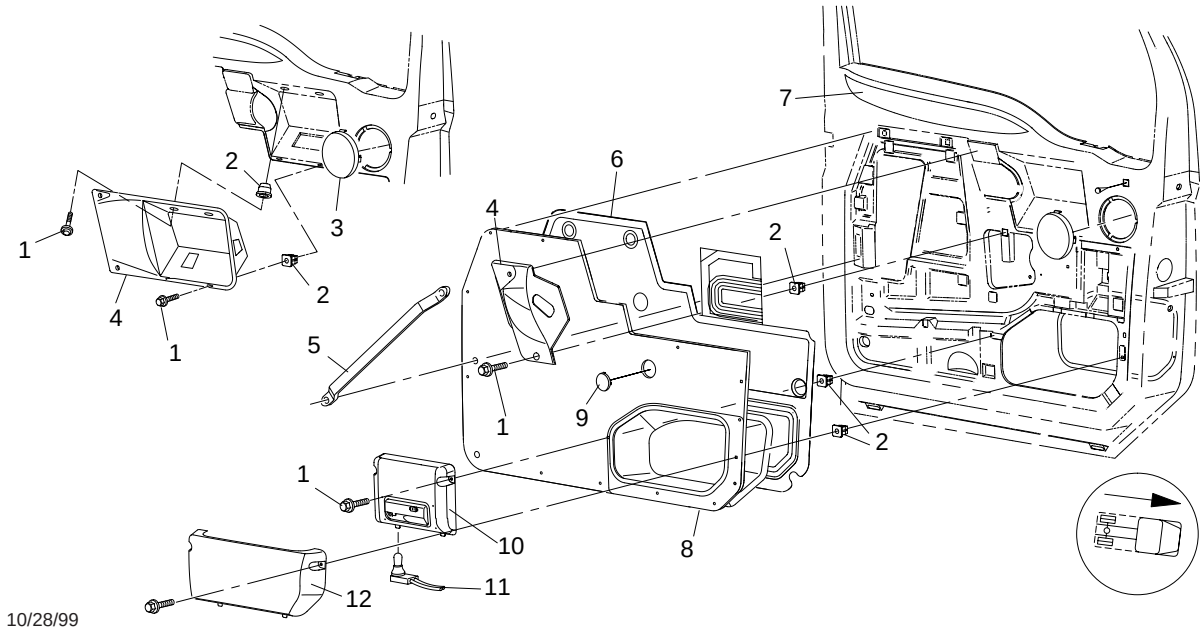
Replacement

WARNING

The window regulator must be removed as described below. The regulator mechanism contains a large spring under tension, which can be released, possibly resulting in personal injury. Follow the precautions listed below when replacing the regulator.

- **Keep the window motor, if so equipped, secured to the regulator while removing the regulator.**
- **Do not attempt to disassemble the regulator or motor until they have been removed from the door as an assembly. Once removed from the door, use caution if removing the motor from the regulator, as the spring is held under tension by the motor.**
- **Do not loosen or remove the regulator fasteners if the motor has been loosened or removed.**

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries.
3. Remove the grab handle; see **Fig. 1**.
4. Remove the power window switch cover, the power door locks switch cover, and the mirror control trim cover, if equipped. Use care when removing the covers to prevent damage to the switches.
5. Remove the door window regulator crankhandle, if equipped.
6. Remove the door trim panels, as follows; see **Fig. 1**.
   - 6.1 Remove the door trim finish panel.
   - 6.2 Remove the map pocket, if equipped.
   - 6.3 Remove the courtesy lamp.
   - 6.4 Remove the door trim panel.
   - 6.5 Remove the armrest assembly.
7. Remove the door trim watershield; see **Fig. 1**.



1. Self-Tapping Screw
2. Screw Insert
3. Door Trim Panel Opening Cover
4. Door Trim Finish Panel
5. Grab Handle
6. Door Trim Watershield
7. Armrest Assembly
8. Door Trim Panel
9. Window Regulator Opening
10. Courtesy Lamp
11. Wiring Harness
12. Map Pocket

Fig. 1, Door Trim and Components (door with power window regulator shown)

Manual and Power Window Regulator Replacement

8. Lower the window until the track follower end of the window regulator is visible; see **Fig. 2**.

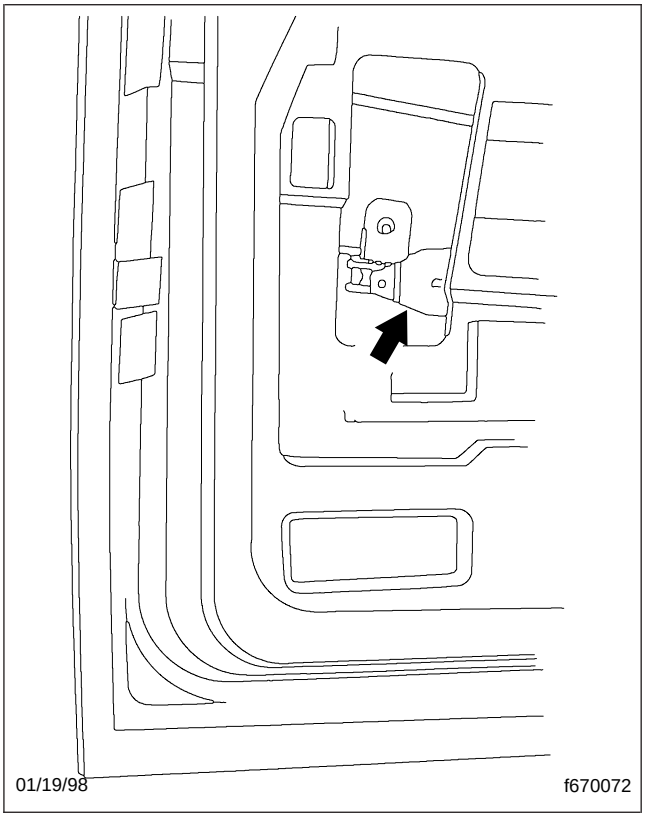


Fig. 2, Track Follower End of the Window Regulator

9. Using a suitable tool, wedge the window in place.
10. If equipped with power windows, disconnect the window motor connector.
11. Remove the window regulator bolts; see **Fig. 3**.
12. Lower the forward end of the window regulator to the forward access hole in the door.
13. Push the window regulator rearward to remove the track follower from the window glass channel.

NOTE: It may be necessary to reposition the window to align the new window regulator with the mounting holes.

14. Pull the window regulator out of the access hole in the door.
15. Place the new window regulator in the access hole in the door.

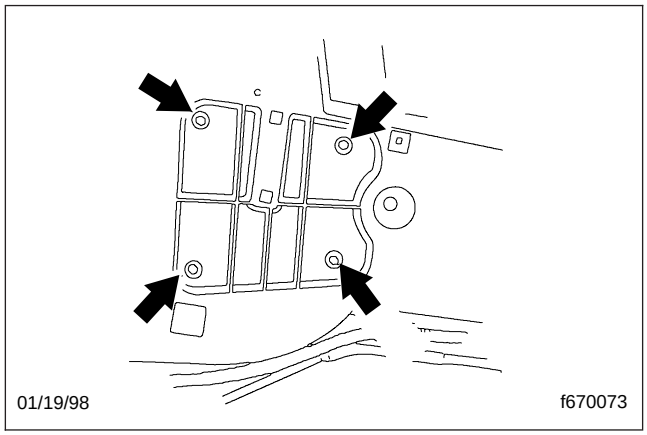


Fig. 3, Window Regulator Bolts

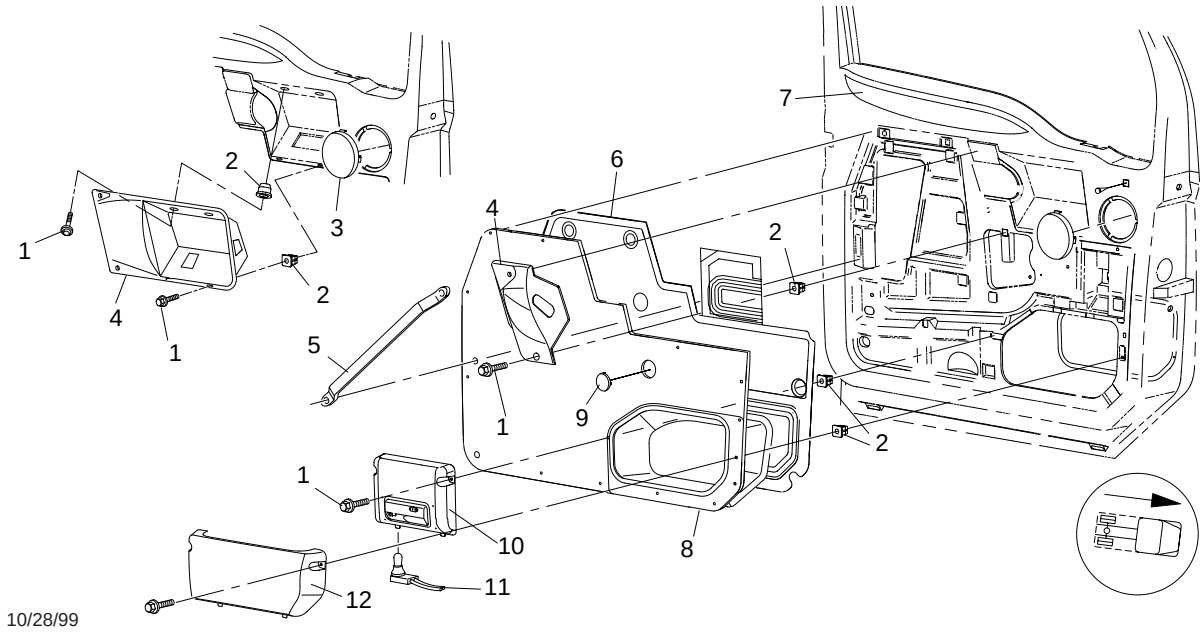
16. Push the window regulator forward to insert the track follower into the window glass channel.
17. Raise the forward end of the window regulator to the forward access hole in the door.
18. Install and tighten the window motor bolts 7 to 10 lbf·ft (9 to 13 N·m); see **Fig. 3**.
19. If equipped with power windows, connect the window motor connector.
20. Remove the wedge that's supporting the window.
21. Lower the window into the track follower end until the window regulator is visible; see **Fig. 2**.
22. Install the door trim watershield; see **Fig. 1**.
23. Install the door trim panels, as follows; see **Fig. 1**.
    - 23.1 Install the armrest assembly.
    - 23.2 Install the door trim panel.
    - 23.3 Install the courtesy lamp.
    - 23.4 Install the map pocket, if equipped.
    - 23.5 Install the door trim finish panel.
24. Install the power window switch cover, the power door locks switch cover, and the mirror control trim cover, if equipped.
25. Install the door window regulator crankhandle, if equipped.
26. Install the grab handle; see **Fig. 1**.
27. Connect the batteries.
28. Remove the chocks.

Door Latch Replacement

Replacement

NOTE: For this procedure, the window must be fully closed.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Remove the grab handle. See **Fig. 1**.
   - 6.4 Remove the door trim panel.
   - 6.5 Remove the armrest assembly.
7. Remove the door trim watershield. See **Fig. 1**.
8. Remove the lower rear window run. See **Fig. 2**.
   - 8.1 Remove the bolt.
   - 8.2 Pull the run straight down to disconnect it and remove the lower rear window run.



1. Self Tapping Screw
2. Screw Insert
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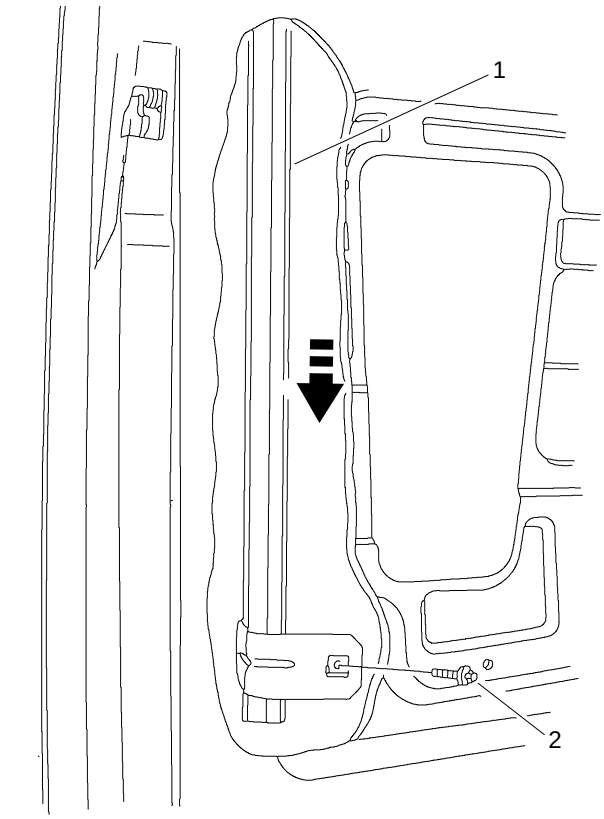
5. Grab Handle
6. Door Trim Watershield
7. Armrest Assembly
8. Door Trim Panel
9. Window Regulator Opening
10. Courtesy Lamp
11. Wiring Harness
12. Map Pocket

Fig. 1, Door Trim and Components

4. Remove the power window switch cover, the power door locks switch cover and the mirror control trim cover, if equipped.
5. Remove the door window regulator crankhandle, if equipped.
6. Remove the door trim panels. See **Fig. 1**.
   - 6.1 Remove the door trim finish panel.
   - 6.2 Remove the map pocket, if equipped.
   - 6.3 Remove the courtesy lamp.
9. Disconnect the outside door handle rod. See **Fig. 3**.
10. Disconnect the inside door handle remote control rod. See **Fig. 4**.
11. Disconnect the lock cylinder rod. See **Fig. 5**.
12. Drill out the power door lock actuator rivet and disconnect the electrical connector, if so equipped. See **Fig. 6**.
13. Remove the door latch attachment screws and remove the door latch. See **Fig. 7**.

Door Latch Replacement



1. Lower Rear Window Run
2. Bolt

Fig. 2, Lower Rear Window Run Removal

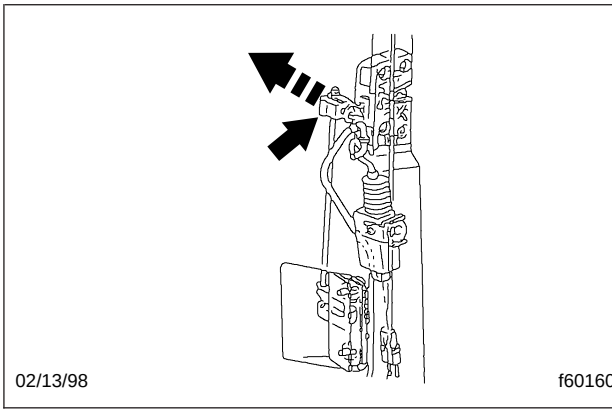


Fig. 3, Outside Door Handle Rod

IMPORTANT: Connect the inside door handle remote control rod, lock cylinder control rod, push button rod and the power door lock actuator and rod (if so equipped) to the door latch before installation of the new latch.

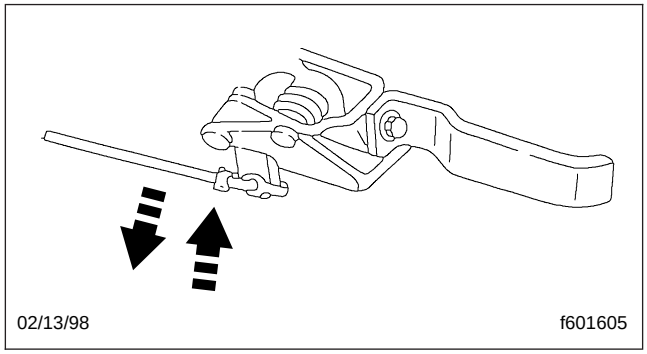


Fig. 4, Inside Door Handle Remote Control Rod

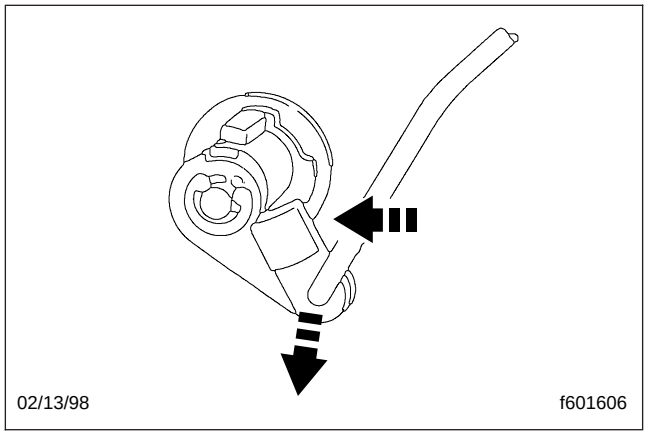
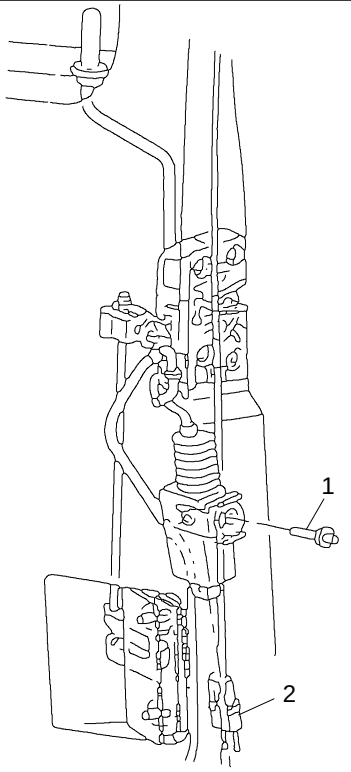


Fig. 5, Lock Cylinder Rod

14. Install the door latch. See **Fig. 7**.
    - 14.1 Position the door latch.
    - 14.2 Install the screws. Tighten the screws 7 to 10 lbf·ft (9 to 13 N·m).
15. Connect the electrical connector and install the power door lock actuator rivet, if so equipped. See **Fig. 6**.
16. Connect the lock cylinder rod. See **Fig. 5**.
17. Connect the inside door handle remote control rod. See **Fig. 4**.
18. Connect the outside door handle rod. See **Fig. 3**.
19. Install the lower rear window run. See **Fig. 2**.
    - 19.1 Pull the lower rear window run straight up and connect it.



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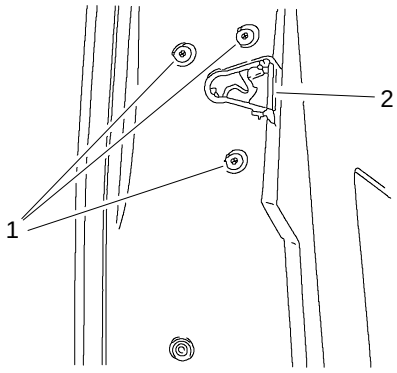
1. Rivet
2. Electrical Connector

Fig. 6, Power Door Lock Actuator



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1. Door Latch Screws
2. Door Latch

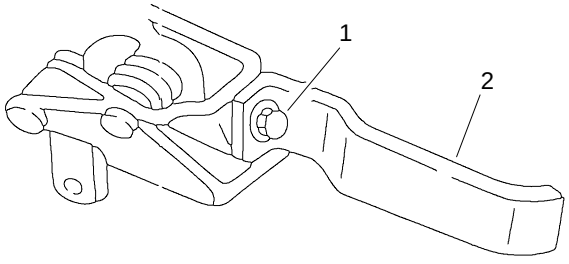
Fig. 7, Door Latch Removal

19.2 Install the bolt.

20. Install the door trim watershield. See **Fig. 1**.
21. Install the door trim panels. See **Fig. 1**.
    - 21.1 Install the armrest assembly.
    - 21.2 Install the door trim panel.
    - 21.3 Install the courtesy lamp.
    - 21.4 Install the map pocket, if equipped.
    - 21.5 Install the door trim finish panel.
22. Install the power window switch cover, the power door locks switch cover and the mirror control trim cover, if equipped.
23. Install the door window regulator crankhandle, if equipped.
24. Install the grab handle. See **Fig. 1**.
25. Connect the batteries.
26. Remove the chocks from the tires.

Replacement

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the inside door handle boot.
3. Remove the handle bolt and the handle. See **Fig. 1**.



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1. Handle Bolt
2. Handle

Fig. 1, Handle Removal

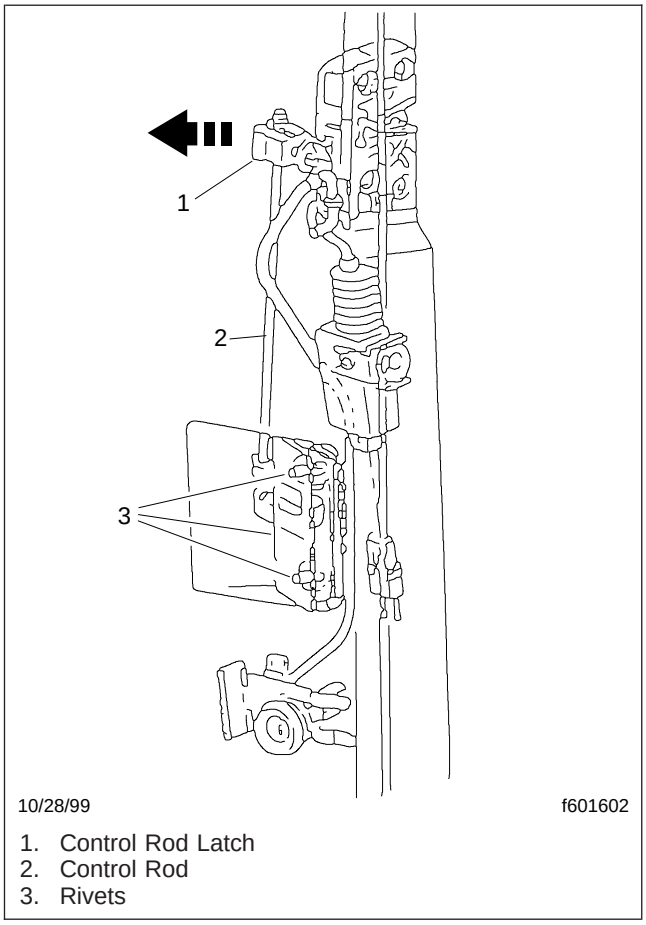
4. Position the handle and install the bolt. Tighten the bolt 7 to 10 lbf·ft (9 to 13 N·m). See **Fig. 1**.
5. Install the inside door handle boot.
6. Remove the chocks from the tires.

Outside Door Handle Replacement

Replacement

NOTE: For this procedure, the window must be fully closed.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Remove the door trim panels.
   - 3.1 Remove the inside door handle.
   - 3.2 Remove the door window regulator crank handle, if equipped.
   - 3.3 Remove the door trim finish panel.
   - 3.4 Remove the map pocket, if equipped.
   - 3.5 Remove the courtesy lamp.
   - 3.6 Remove the door trim panel.
4. Remove the watershield.
5. Remove the outside door handle. See **Fig. 1**.
   - 5.1 Disconnect the control rod at the latch.
   - 5.2 Drill out the two rivets and remove the outside door handle.
6. Install the outside door handle. See **Fig. 1**.
   - 6.1 Connect the control rod at the latch.
   - 6.2 Install the two outside door handle rivets.
7. Install the watershield.
8. Install the door trim panels.
   - 8.1 Install the door trim panel.
   - 8.2 Install the courtesy lamp.
   - 8.3 Install the map pocket, if equipped.
   - 8.4 Install the door trim finish panel.
   - 8.5 Install the door window regulator crank handle, if equipped.
   - 8.6 Install the inside door handle.
9. Connect the batteries.
10. Remove the chocks from the tires.



1. Control Rod Latch
2. Control Rod
3. Rivets

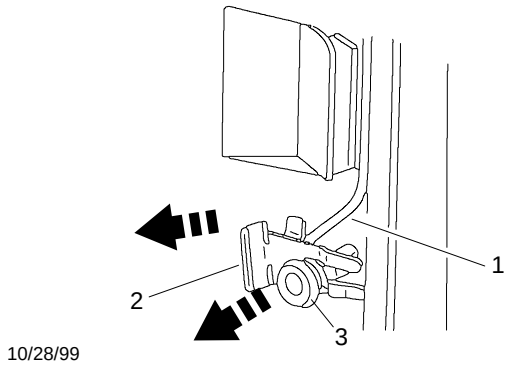
Fig. 1, Door Handle Mechanism (Inside Door)

Replacement

NOTE: When a lock cylinder is replaced, both door lock cylinders and the ignition lock cylinder should be replaced in a set; this will eliminate carrying an extra key which will fit only one lock. If a lock cylinder is to be replaced, the new key code is stamped on a metal tag attached to the key.

NOTE: For this procedure, the window must be fully closed.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the door trim panel.
   - 2.1 Remove the courtesy lamp.
   - 2.2 Remove the map pocket, if equipped.
   - 2.3 Remove the door trim panel.
3. Partially remove the watershield.
4. Remove the lock cylinder. See **Fig. 1**.



1. Door Latch Control Rod
2. Retainer Clip
3. Lock Cylinder

Fig. 1, Lock Cylinder Removal

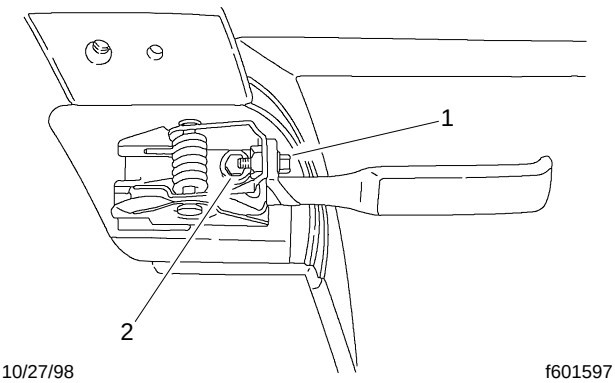
   - 4.1 Disconnect the door latch control rod at the lock cylinder.
   - 4.2 Remove the lock cylinder retainer clip and remove the lock cylinder.

NOTE: The window must be fully closed.

5. Replace the lock cylinder. See **Fig. 1**.
   - 5.1 Connect the door latch control rod at the lock cylinder.
   - 5.2 Attach the lock cylinder retainer clip.
6. Install the watershield.
7. Install the door trim panel.
   - 7.1 Install the door trim panel.
   - 7.2 Install the map pocket, if equipped.
   - 7.3 Install the courtesy lamp.
8. Remove the chocks from the tires.

Replacement

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Remove the door window regulator crank handle, if equipped.
4. Remove the door trim panels.
   - 4.1 Remove the inside door panel.
   - 4.2 Remove the door trim finish panel.
   - 4.3 Remove the map pocket, if equipped.
   - 4.4 Remove the courtesy lamp.
   - 4.5 Remove the door trim panel.
5. Remove the latch control. See **Fig. 1**.



1. Door Handle Bolt
2. Latch Control Bolt

Fig. 1, Latch Control

   - 5.1 Remove the inside door handle bolt and handle.
   - 5.2 Remove the latch control bolt.
   - 5.3 Rotate the latch control 90 degrees counterclockwise and remove the latch control.
6. Install the latch control. Tighten the bolts 7 to 10 lbf·ft (9 to 13 N·m). See **Fig. 1**.
   - 6.1 Position the latch control and install the bolt.
   - 6.2 Position the inside door handle and install the bolt.
7. Install the door trim panels.
   - 7.1 Install the door trim panel.
   - 7.2 Install the map pocket, if equipped.
   - 7.3 Install the courtesy lamp.
   - 7.4 Install the door trim finish panel.
8. Install the door window regulator crank handle, if equipped.
9. Connect the batteries.
10. Remove the chocks from the tires.

Push Button Rod Replacement

Replacement

NOTE: For this procedure, the window must be fully closed.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the door trim panel.
   - 2.1 Remove the courtesy lamp.
   - 2.2 Remove the map pocket, if equipped.
   - 2.3 Remove the door trim panel.
3. Set aside the watershield.
4. Remove the three screws from the door latch. See **Fig. 1**.

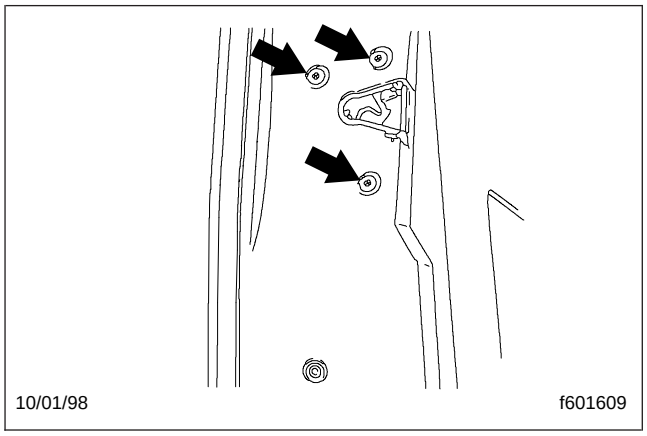
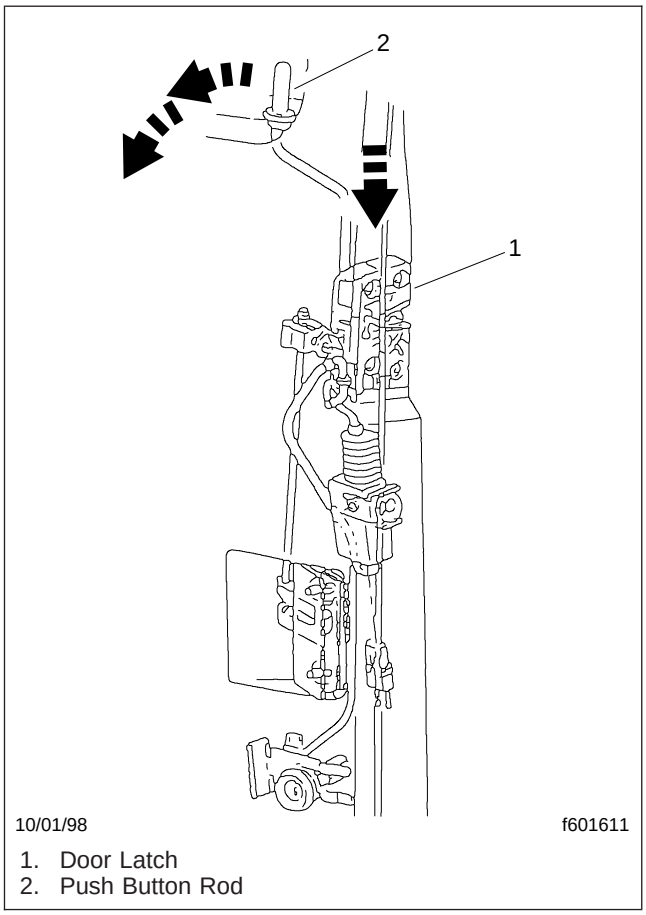


Fig. 1, Door Latch Screws

5. Remove the push button. See **Fig. 2**.
   - 5.1 Lower the door latch enough to let the push button rod clear the door.
   - 5.2 Swing the top of the push button rod away from the door latch and remove it from the door latch.
6. Replace the push button.
   - 6.1 Replace the door latch and position it with the push button rod.
   - 6.2 Swing the top of the push button rod to the door latch and connect it to the door latch.



1. Door Latch
2. Push Button Rod

Fig. 2, Push Button Assembly

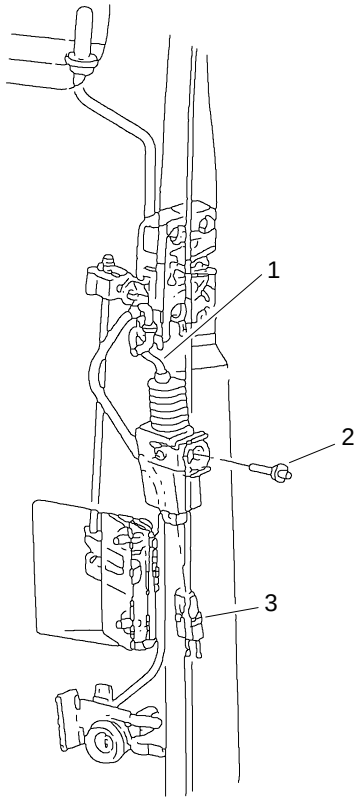
7. Install the three screws to the door latch. Tighten the screws 7 to 10 lbf·ft (9 to 13 N·m). See **Fig. 1**.
8. Install the watershield.
9. Install the door trim panel.
   - 9.1 Install the door trim panel.
   - 9.2 Install the map pocket, if equipped.
   - 9.3 Install the courtesy lamp.
10. Remove the chocks from the tires.

Power Door Lock Actuator Replacement

Replacement

NOTE: For this procedure, the window must be fully closed.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Remove the door trim panel.
   - 3.1 Remove the courtesy lamp.
   - 3.2 Remove the map pocket, if equipped.
   - 3.3 Remove the door trim panel.
4. Set aside the watershield.
5. Remove the power door lock actuator. See **Fig. 1**.
   - 5.1 Remove the door glass run.
   - 5.2 Disconnect the electrical connector.
   - 5.3 Remove the actuator from the retainer bracket.
   - 5.4 Rotate the actuator upward 90 degrees and disconnect the actuator rod and remove the actuator.
6. Install the power door lock actuator. See **Fig. 1**.
   - 6.1 With the actuator at 90 degrees, connect the actuator rod.
   - 6.2 Install the actuator into the retainer bracket.
   - 6.3 Connect the electrical connector.
   - 6.4 Connect the actuator rod.
   - 6.5 Install the rear glass door run.
7. Install the watershield.
8. Install the door trim panel.
   - 8.1 Install the door trim panel.
   - 8.2 Install the map pocket, if equipped.
   - 8.3 Install the courtesy lamp.
9. Connect the batteries.
10. Remove the chocks from the tires.



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1. Actuator Rod
2. Rivet
3. Electrical Connector

Fig. 1, Power Door Lock Actuator

Troubleshooting

Power Windows

Inspection and Verification

1. Verify the original problem by operating the power window system to duplicate the original condition.
2. Check for one of the following electrical problems:
   - short circuits
   - power distribution box fuses E and V
   - power distribution module fuses 17, 34 CB, and 35 CB
3. If the problem(s) remains after the inspection, determine the symptom(s) and proceed to the following problem chart.

Handles, Locks, Latches, and Mechanisms

Inspection and Verification

1. Verify the owner's original problem by operating the handles, locks, latches, and mechanisms to duplicate the problem.

NOTE: Before starting any electrical diagnosis, make sure the battery is charged and check for mechanical binds by manually operating the door lock. Then operate the door lock system several times from each switch, while observing the operation of all door locks.

2. Verify that other components and systems related to the door lock fuse operate properly. If the other components and systems are not operating properly, the fuse, fuse feed circuit or load side circuit may be at fault.
3. Visually inspect for obvious signs of mechanical and electrical damage. See **Table 1**.

Visual Inspection Chart	
Mechanical	**Electrical**
Binding latch mechanisms Binding linkage Misaligned door	Open fuse: instrument panel fuse junction panel fuse 32 (15 A) Damaged door lock switch Damaged power door lock actuator Damaged circuitry Corroded connectors

Table 1, Visual Inspection Chart

4. If the problem is not visually evident, determine the possible cause and proceed to the problem charts.

Component Tests

Switches

Switches		
Pins	**Switch Position**	**Result**
1,2	Neutral	Open
1,2	Lock	Open
1,2	Unlock	Open
1,3	Neutral	Open
1,3	Lock	Open
1,3	Unlock	Open
1,4	Neutral	Open
1,4	Lock	Open
1,4	Unlock	Open
1,5	Neutral	Open
1,5	Lock	Open
1,5	Unlock	Open
1,6	Neutral	Open
1,6	Lock	Open
1,6	Unlock	Open
1,7	Neutral	Open
1,7	Lock	Open
1,7	Unlock	Open
2,3	Neutral	Closed

Troubleshooting

Switches		
Pins	**Switch Position**	**Result**
2,3	Lock	Open
2,3	Unlock	Closed
2,4	Neutral	Open
2,4	Lock	Closed
2,4	Unlock	Open
2,5	Neutral	Open
2,5	Lock	Open
2,5	Unlock	Closed
2,6	Neutral	Open
2,6	Lock	Open
2,6	Unlock	Open
2,7	Neutral	Open
2,7	Lock	Open
2,7	Unlock	Open
3,4	Neutral	Open
3,4	Lock	Open
3,4	Unlock	Open
3,5	Neutral	Open
3,5	Lock	Open
3,5	Unlock	Open
3,6	Neutral	Open
3,6	Lock	Open
3,6	Unlock	Open

Switches		
Pins	**Switch Position**	**Result**
3,7	Neutral	Open
3,7	Lock	Open
3,7	Unlock	Open
4,5	Neutral	Open
4,5	Lock	Open
4,5	Unlock	Open
4,6	Neutral	Open
4,6	Lock	Open
4,6	Unlock	Open
4,7	Neutral	Open
4,7	Lock	Open
4,7	Unlock	Closed
5,6	Neutral	Open
5,6	Lock	Open
5,6	Unlock	Open
5,7	Neutral	Open
5,7	Lock	Open
5,7	Unlock	Open
6,7	Neutral	Closed
6,7	Lock	Closed
6,7	Unlock	Open

Table 2, Switches

Problem—Power Windows are Inoperative

Problem—Power Windows are Inoperative (See Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5, Fig. 6 and Fig. 7)	
Possible Cause	**Remedy**
Power feeds	Turn the ignition switch to the "On" position. Pull the power distribution module fuses 34 CB and 35 CB out just enough to probe the top terminals. Measure the voltage between the top terminals of the power distribution module fuses 34 CB and 35 CB, circuits 400 (BL/BK) and 296 (R) and ground. If the voltage is less than 10 volts, check the driver and passenger power window relays. If the voltage is greater than 10 volts, check the window switches.
Power window relays	Turn the ignition switch to the "Off" position. Remove the driver and passenger power window relays from the power distribution module and substitute known good relays. Turn the ignition switch to the "On" position. If the system operates correctly, replace the power window relay(s). Test the system for normal operation. If the system does not operate correctly, check the relay feed wiring.

Problem—Power Windows are Inoperative (See Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5, Fig. 6 and Fig. 7)	
Possible Cause	**Remedy**
Relay feed wiring	Turn the ignition switch to the "Off" position. Disconnect the power window relay connectors C2025 and C2026. Turn the ignition switch to the "On" position. Measure the voltage between the passenger or driver power window relay connector C2025 Pins 30 and 85, circuits 37 (BK/Y) and 960 (R) and ground. If the voltage is less than 10 volts, repair the open in circuit 960 (R) at the power distribution module or circuit 37 (BK/Y) between the power distribution box, fuses V and E and the power distribution module power window relays. If the voltage is greater than 10 volts, repair the affected relay ground(s) Pin 86, circuit 57 (BK). Test the system for normal operation.
Window switch(es)	Remove, but do not disconnect, the driver window switch and the passenger window switch located on the driver door. Remove the plastic covers to gain access to the pins. Measure the voltage between the driver window switch connector C503 Pin 4, and the passenger window switch connector C502 Pin 4, circuits 400 (BL/BK) and 296 (R) and ground. Remove, but do not disconnect, the passenger window switch. Remove the plastic cover to gain access to the pins. Measure the voltage between the passenger window switch connector C604 Pin 4, circuit 296 (R) and ground. If the voltage is less than 10 volts, repair circuit 400 (BL/BK) or 296 (R) between the power distribution module and the window switch. Test the system for normal operation. If the voltage is greater than 10 volts, check the system grounds.

Troubleshooting

Problem—Power Windows are Inoperative (See Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5, Fig. 6 and Fig. 7)	
Possible Cause	**Remedy**
System grounds	Turn the ignition switch to the "Off" position. Disconnect the battery ground cable(s). Disconnect the driver window switch connector C503, window regulator assembly Connector C511, driver door passenger window switch connector C502, and passenger window switch connector C604. Measure the resistance between the driver window switch connector C503 Pins 2 and 7, the window regulator assembly connector C511 Pin 5 and the driver door passenger window switch connector C502 Pins 2 and 7, circuit 57 (BK) and ground. If the resistance is more than 5 ohms, repair the open in circuit 57 (BK) between the affected window switch and ground. Test the system for normal operation. If the resistance is less than 5 ohms, check the driver or the passenger system. If the symptom is present in the passenger window, check the passenger power window. Connect the battery ground cable(s). Connect the driver window switch connector C503, window regulator assembly connector C511, driver door passenger window switch connector C503, and passenger window switch connector C604. Turn the ignition switch to the "On" position. Actuate the driver door passenger window switch to the up position. Measure the voltage between the driver door passenger window switch connector C502 Pin 6, circuit 314 (W/O) and the driver door passenger window switch connector C502 Pin 3, circuit 313 (O/W). Actuate the driver door passenger window switch to the down position. Measure the voltage between the driver door passenger window switch connector C502 Pin 3, circuit 313 (O/W) and the driver door passenger window switch connector C502 Pin 6, circuit 314 (W/O). If the voltage is less than 10 volts, replace the driver door passenger window switch. Test the system for normal operation. If the voltage is greater than 10 volts, check the vehicle options. If the vehicle equipped with a passenger power window only, check the passenger window motor connector C607. Actuate the driver door passenger window switch to the up position. Measure the voltage between the passenger window motor connector C607, circuit 314 (W/O) and the passenger window motor connector C607, circuit 313 (O/W). Actuate the driver door passenger window switch to the down position. Measure the voltage between the passenger window motor connector C607, circuit 313 (O/W) and the passenger window motor connector C607, circuit 314 (W/O). If the voltage is greater than 10 volts, replace the passenger window motor. Test the system for normal operation. If the voltage is less than 10 volts, repair the open circuit between the driver door passenger window switch and the passenger window motor. Test the system for normal operation.

Problem—Power Windows are Inoperative (See Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5, Fig. 6 and Fig. 7)	
Possible Cause	**Remedy**
Passenger window switch	If the vehicle is equipped with power windows on both the passenger- and driver-sides, check the voltage at the passenger window switch. Actuate the driver door passenger window switch to the up position. Measure the voltage between the passenger window switch connector C604 Pin 7, circuit 314 (W/O) and the passenger window switch connector C604 Pin 2, circuit 313 (O/W). Actuate the driver door passenger window switch to the down position. Measure the voltage between the passenger window switch connector C604 Pin 2, circuit 313 (O/W) and the passenger window switch connector C604 Pin 7, circuit 314 (W/O). If the voltage is less than 10 volts, repair the open in the affected circuit(s). Test the system for normal operation. If the voltage is greater than 10 volts, check the passenger window switch. Actuate the passenger window switch to the up position. Measure the voltage between the passenger window switch connector C604 Pin 6, circuit 314 (W/O) and the passenger window switch connector C604 Pin 3, circuit 313 (O/W). Actuate the passenger window switch to the down position. Measure the voltage between the passenger window switch connector C604 Pin 3, circuit 313 (O/W) and the passenger window switch connector C604 Pin 6, circuit 314 (W/O). If the voltage is less than 10 volts, replace the passenger window switch. Test the system for normal operation. If the voltage is greater than 10 volts, check the passenger window motor and wiring.
Passenger window motor and wiring	Disconnect the passenger window motor connector C607. Actuate the passenger window switch to the up position. Measure the voltage between the passenger window motor connector C607, circuit 314 (W/O) and the passenger window motor connector C607, circuit 313 (O/W). Actuate the passenger window switch to the down position. Measure the voltage between the passenger window motor connector C607, circuit 313 (O/W) and the passenger window motor connector C607, circuit 314 (W/O). If the voltage is greater than 10 volts, replace the passenger window motor. Test the system for normal operation. If the voltage is less than 10 volts, repair the open in the affected circuit(s). Test the system for normal operation.

Troubleshooting

Problem—Power Windows are Inoperative (See Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5, Fig. 6 and Fig. 7)	
Possible Cause	**Remedy**
Driver window switch	Connect the driver window switch connector C502, window regulator assembly connector C511, driver door passenger window switch connector C502, and the passenger window switch connector C604. Connect the battery ground cable. Turn the ignition switch to the "On" position. Actuate the driver window switch to the up position. Measure the voltage between the driver window switch connector C503 Pin 6, circuit 314 (O/W) and the driver window switch connector C503 Pin 3, circuit 313 (W/O). Actuate the driver window switch to the down position. Measure the voltage between the driver window switch connector C503 Pin 3, circuit 313 (O/W) and the driver window switch connector C503 Pin 6, circuit 314 (W/O). If the voltage is less than 10 volts, replace the driver window switch. Test the system for normal operation. If the voltage is greater than 10 volts, check the window regulator assembly switch. Disconnect the window regulator assembly connector C511. Measure the voltage between the window regulator assembly connector C511 Pin 3, circuit 400 (BL/BK) and ground. If the voltage is less than 10 volts, repair the open in circuit 400 (BL/BK) between the power distribution module fuse 34 CB and the window regulator assembly. Test the system for normal operation. If the voltage is greater than 10 volts, check the inputs to the window regulator assembly switch.
Inputs to window regulator assembly switch	Connect the window regulator assembly connector C511. Actuate the driver window switch to the up position. Using sharp probes, measure the voltage between the window regulator assembly connector C511 Pin 4 wire, circuit 314 (W/O) and the window regulator assembly connector C511 Pin 2 wire, circuit 313 (O/W). Actuate the driver window switch to the down position. Using sharp probes, measure the voltage between the window regulator assembly connector C511 Pin 2 wire, circuit 313 (O/W) and the window regulator assembly connector C511 Pin 4 wire, circuit 314 (W/O). If the voltage is less than 10 volts, repair the open in the affected circuit(s). Test the system for normal operation. If the voltage is greater than 10 volts, check the window regulator assembly.
Window regulator assembly	Actuate the driver window completely up. Actuate the driver window switch to the down position momentarily. Using sharp probes, measure the voltage between the window regulator assembly connector C511 Pin 1 wire, circuit 333 (Y/R) and the window regulator assembly connector C511 Pin 4 wire, circuit 314 (W/O). If the voltage is not greater than 10 volts for about 2.5 seconds, replace the window regulator assembly. Test the system for normal operation. If the voltage is greater than 10 volts, check the motor and wiring.
Motor and wiring	Close the driver window completely. Disconnect the driver window module connector C510. Actuate the driver window switch to the down position momentarily. Measure the voltage between the driver window motor connector C510, circuit 333 (Y/R) and the driver window motor connector C510, circuit 314 (W/O). If the voltage is greater than 10 volts for about 2.5 seconds, replace the driver window motor. Test the system for normal operation. If the voltage is not greater than 10 volts for about 2.5 seconds, repair the open in the affected circuit(s). Test the system for normal operation.

Problem—The Door Lock is Inoperative

Problem—The Door Lock is Inoperative (See Fig. 8)	
Possible Cause	**Remedy**
Stuck or binding components	Check the operation of the inoperative door lock. Manually operate the inoperative door lock. Check for a binding or stuck condition. If the door lock is stuck or binding, repair or replace the stuck or binding component. Test the system for normal operation. If the door lock is not stuck or binding, check the inoperative door lock actuator lock operation.
Lock operation	Disconnect the inoperative door lock actuator harness connector. Measure the voltage between door lock actuator connector C504, Pin 1, circuit 117 (PK/BK) for the driver door or C605, Pin 1, circuit 117 (PK/BK) for the passenger door and chassis ground while operating the door lock switch to the LOCK position. If the voltage is not greater than 10 volts, repair circuit 117 (PK/BK). Test the system for normal operation. If the voltage is greater than 10 volts, check the inoperative door lock actuator for unlock operation.
Unlock operation	Measure the voltage between door lock actuator connector C504, Pin 2, circuit 122 (PK/O) for the driver door or C605, Pin 2, circuit 122 (PK/O) for the passenger door and chassis ground while operating the door lock switch to the UNLOCK position. If the voltage is greater than 10 volts, replace the power door lock actuator. Test the system for normal operation. If the voltage is not greater than 10 volts, repair circuit 122 (PK/O). Test the system for normal operation.

Problem—The Door Locks are Inoperative

Problem—The Door Locks are Inoperative (See Fig. 8 and Fig. 9)	
Possible Cause	**Remedy**
Door lock switch	Check for power to the passenger door lock switch. Disconnect the passenger door lock switch harness connector. Measure the voltage between passenger door lock switch connector C603, Pin 4, circuit 33 (Y) and chassis ground. If the voltage is less than 10 volts, repair circuit 33 (Y). Test the system for normal operation. If the voltage is greater than 10 volts, check the ground circuit.
Ground circuit	Measure the voltage between passenger door lock switch connector C603, Pin 4, circuit 33 (Y) and Pin 2, circuit 57 (BK). If the voltage is less than 10 volts, repair circuit 57 (BK). Test the system for normal operation. If the voltage is greater than 10 volts, check the passenger door switch to driver door switch circuits.
Passenger door to driver door switch circuits	Disconnect the driver door lock switch harness connector. Measure the resistance between driver door lock switch connector C501, Pin 7, circuit 119 (PK/Y) and passenger door lock switch connector C603, Pin 6, circuit 119 (PK/Y). Measure the resistance between driver door lock switch connector C501, Pin 2, circuit 121 (PK/GN) and passenger door lock switch connector C603, Pin 3, circuit 121 (PK/GN). If the resistance is not less than 5 ohms on both circuits, repair the damaged circuit. Test the system for normal operation. If the resistance is less than 5 ohms on both circuits, check the passenger door lock switch for power.

Troubleshooting

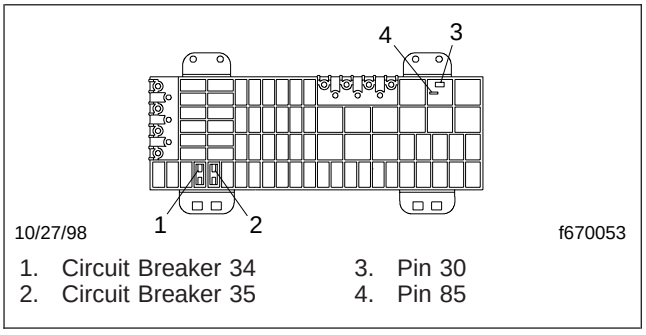
Problem—The Door Locks are Inoperative (See Fig. 8 and Fig. 9)	
Possible Cause	**Remedy**
Passenger door lock switch power	Reconnect the passenger door lock switch harness connector. Measure the voltage between driver door lock switch connector C501, Pin 2, circuit 121 (PK/GN) and chassis ground while operating the passenger door lock switch to the UNLOCK position. Measure the voltage between driver door lock switch connector C501, Pin 7, circuit 119 (PK/Y) and chassis ground while operating the passenger door lock switch to the LOCK position. If the voltage is not greater than 10 volts on both circuits, replace the passenger door lock switch. Test the system for normal operation. If the voltage is greater than 10 volts on both circuits, check the passenger door switch for continuity to ground.
Passenger door switch continuity to ground	Measure the resistance between driver door lock switch connector C501, Pin 2, circuit 121 (PK/GN) and chassis ground while the door lock switch is in the neutral position. Measure the resistance between driver door lock switch connector C501, Pin 7, circuit 119 (PK/Y) and chassis ground while the door lock switch is in the neutral position. If the resistance is not less than 5 ohms on both circuits, replace the passenger door lock switch. Test the system for normal operation. If the resistance is less than 5 ohms on both circuits, check the driver door lock switch output circuits.
Driver door lock switch output circuit	Disconnect the driver door lock actuator harness connector. Measure the resistance between driver door lock switch connector C501, Pin 3, circuit 122 (PK/O) and driver door lock actuator connector C504, Pin 2, circuit 122 (PK/O). Measure the resistance between driver door lock switch connector C501, Pin 6, circuit 117 (PK/BK) and driver door lock actuator connector C504, Pin 1, circuit 122 (PK/BK). If the resistance is less than 5 ohms for both circuits, replace the driver door lock switch. Test the system for normal operation. If the resistance is not less than 5 ohms for both circuits, repair the damaged circuit. Test the system for normal operation.

Problem—All Locks Operate from One Switch Only

Problem—All Locks Operate from One Switch Only (See Fig. 9)	
Possible Cause	**Remedy**
Supply voltage	Disconnect the inoperative door lock switch harness connector. Measure the voltage between the inoperative door lock switch connector, C603 for the passenger door lock switch or C501 for the driver door lock switch, Pin 4, circuit 33 (Y) and chassis ground. If the voltage is greater than 10 volts, replace the inoperative door lock switch. Test the system for normal operation. If the voltage is less than 10 volts, repair circuit 33 (Y). Test the system for normal operation.

Problem—The Door Locks Operate Only One Way

Problem—The Door Locks Operate Only One Way (See Fig. 9)	
Possible Cause	**Remedy**
Ground circuits	Disconnect the driver door lock switch harness connector. Measure the resistance between driver door lock switch connector C501, Pin 2, circuit 121 (PK/GN) and chassis ground with the passenger door lock switch operated to the LOCK position. Measure the resistance between driver door lock switch connector C501, Pin 7, circuit 119 (PK/Y) and chassis ground with the passenger door lock switch operated to the UNLOCK position. If the resistance is less than 5 ohms for both circuits, replace the driver door lock switch. Test the system for normal operation. If the resistance is not less than 5 ohms for both circuits, check the passenger door lock switch.
Passenger door lock switch	Disconnect the passenger door lock switch harness connector. Measure the resistance between passenger door lock switch connector C603, Pin 2, circuit 57 (BK) and chassis ground. Measure the resistance between passenger door lock switch connector C603, Pin 7, circuit 57 (BK) and chassis ground. If the resistance is less than 5 ohms for both circuits, replace the passenger door lock switch. Test the system for normal operation. If the resistance is not less than 5 ohms for both circuits, repair the damaged circuit. Test the system for normal operation.



1. Circuit Breaker 34
2. Circuit Breaker 35
3. Pin 30
4. Pin 85

Fig. 1, Power Distribution Module Terminal Identification

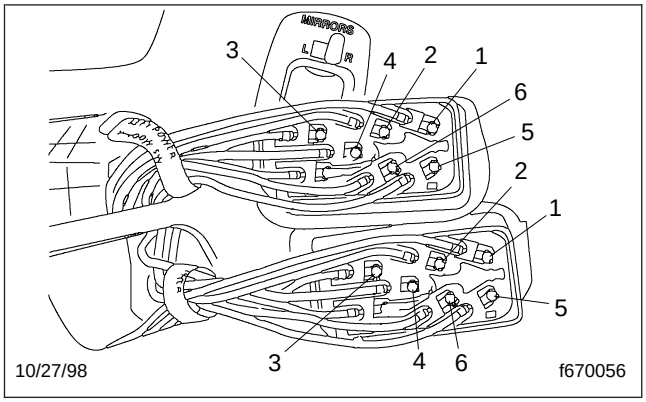


Fig. 3, Driver-Side Window Switches Pin Identification

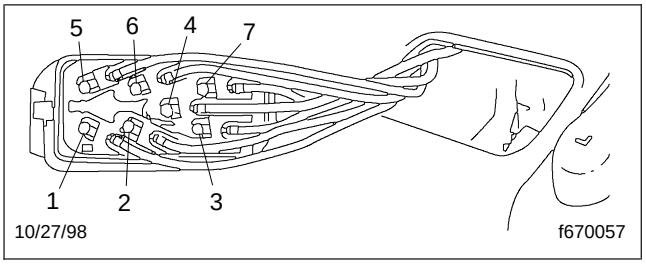


Fig. 2, Passenger-Side Window Switch Pin Identification

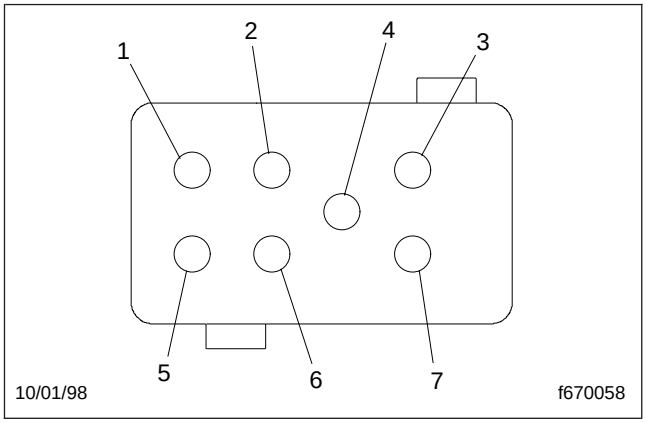


Fig. 4, Passenger Window Switch Connector Pin Identification

Troubleshooting

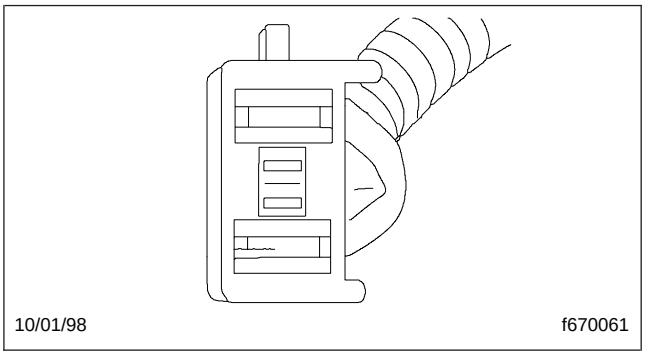


Fig. 5, Driver and Passenger Window Motor Connector

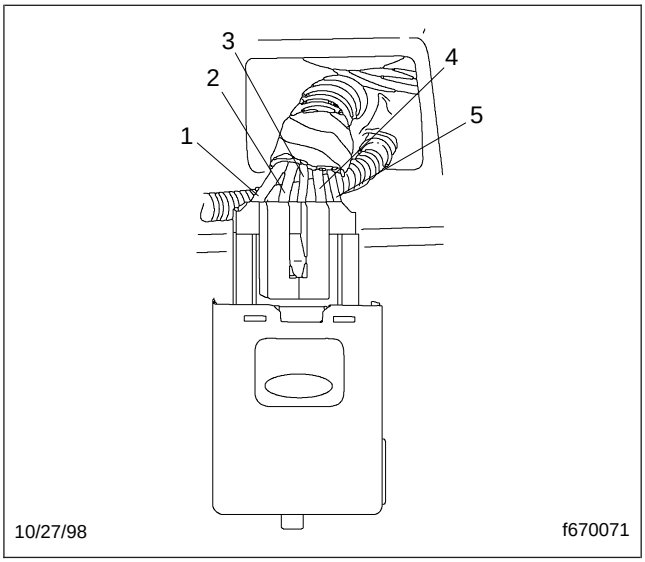


Fig. 6, Window Regulator Assembly Pin Identification

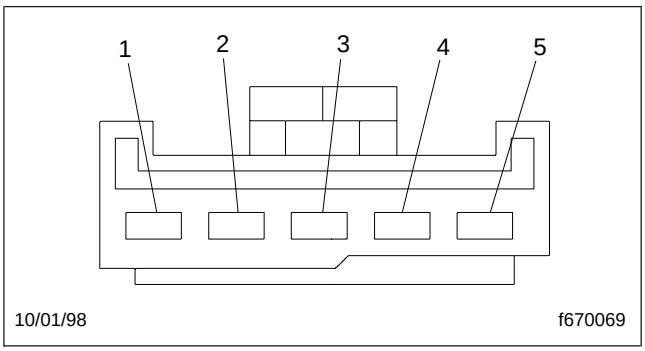


Fig. 7, Window Regulator Assembly Connector Pin Identification

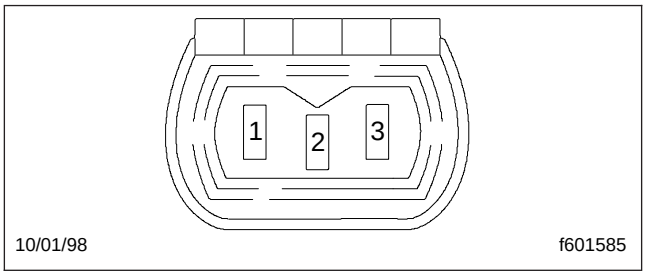


Fig. 8, Door Lock Actuator Connector Pin Identification

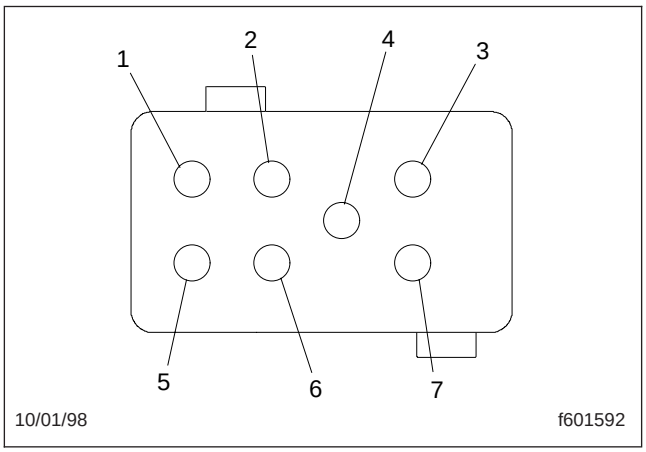


Fig. 9, Door Lock Switch Connector Pin Identification

Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Door Hinge-to-A-Pillar Bolts	30–47 (41–64)
Door Hinge-to-Door Bolts	15–24 (21–32)
Door Hinge Bushing Nuts	7–10 (9–13)
Window Motor Bolts	7–10 (9–13)
Inside Door Handle Remote Control Bolt	7–10 (9–13)
Inside Door Handle Bolt	7–10 (9–13)
Door Latch Screws	7–10 (9–13)

Table 1, Torque Specifications

Specifications For Manual Windows	
Item	**Specification**
Window Handle Effort	22–31 lbf·in (240–360 N·cm)

Table 2, Specifications For Manual Windows

Specifications For Power Windows	
Item	**Specification**
Window Motor Current Draw—Up and Down	15 amps (maximum)
Window Motor Current Draw—Stall	38 amps (maximum)
Window Motor Resistance	0.16–0.20 ohms
Full Drop Time—Up or Down	2.7–4 seconds
Full Drop Time—Restricted Up or Down	2.3–3.5 seconds

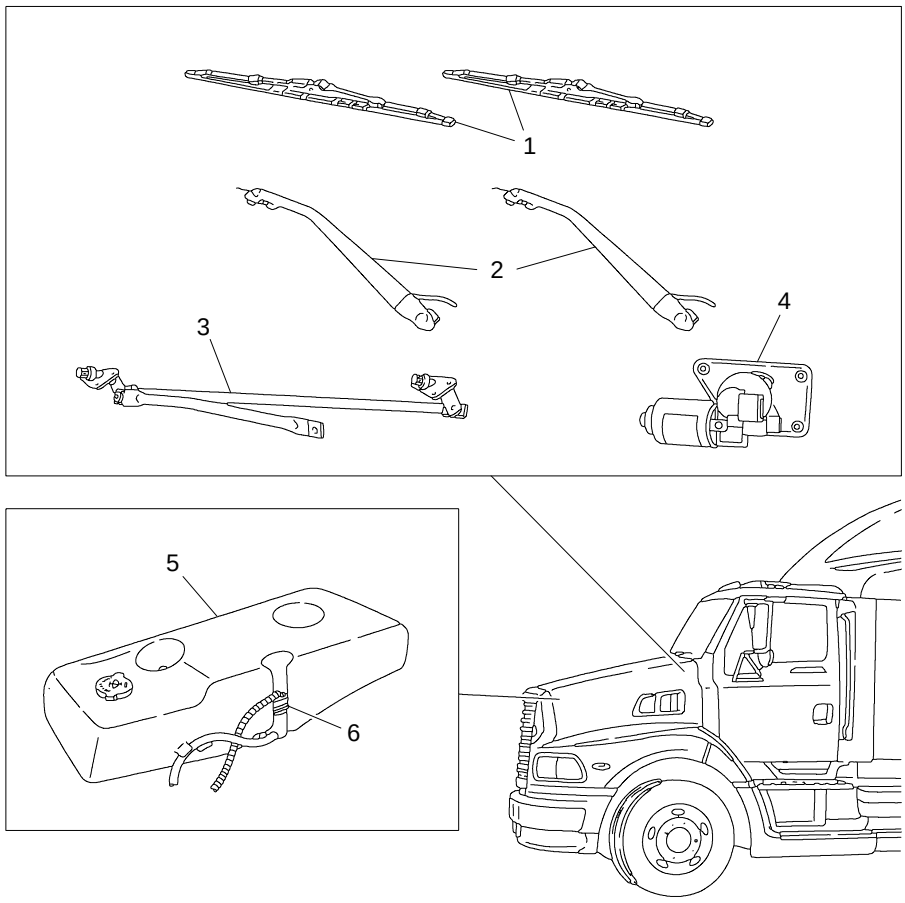
Table 3, Specifications For Power Windows

Approved Sealants	
Item	**Specification**
Liquid Butyl Sealer C9AZ-19554-B	ESB-M4G162-A

Table 4, Approved Sealants

General Information

For the wiper system component locations, see **Fig. 1**, **Fig. 2**, and **Fig. 3**.



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1. Windshield Wiper Blades
2. Windshield Wiper Arms
3. Windshield Wiper Linkage and Pivots
4. Windshield Wiper Motor
5. Windshield Washer Reservoir
6. Windshield Washer Pump

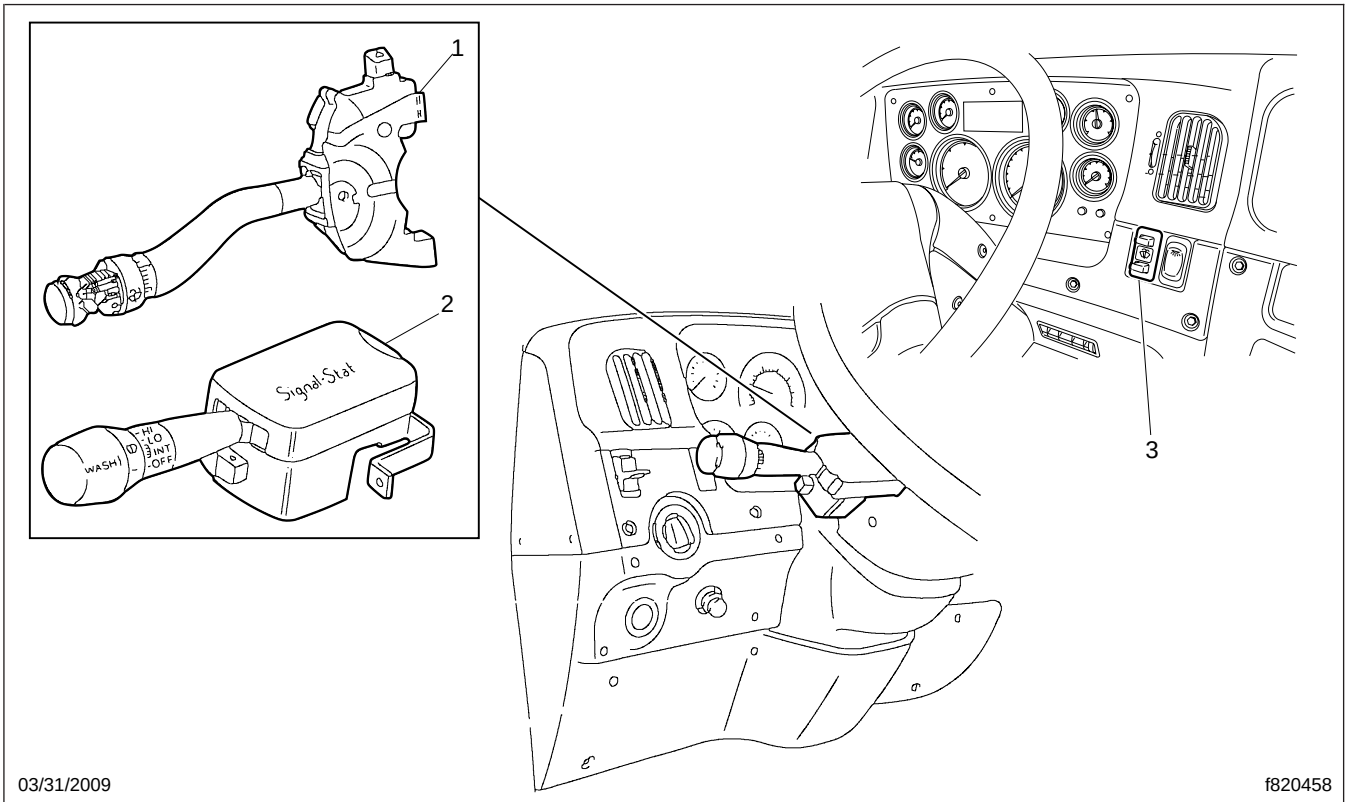
Fig. 1, Wiper/Washer System, Exterior Component Location

Wiper/Washer Switch, Multi-Function

The United Technologies multi-function switch uses a series of internal resistances to determine which mode the windshield wiper control module will place the windshield wiper motor. It is important that each resistance or combination of resistances be within the specified range.

The Signal-Stat multi-function switch uses a binary code strategy to determine which mode the windshield wiper control module will place the windshield wiper motor. This strategy is based on the windshield wiper control module receiving a combination of ground and open signals from the multi-function switch. Each different combination directs the windshield wiper control module to place the windshield wiper motor in a different mode.

General Information



1. Multi-Function Switch, United Technologies
2. Multi-Function Switch, Signal-Stat
3. Wiper/Washer Switch, Dash-Mounted

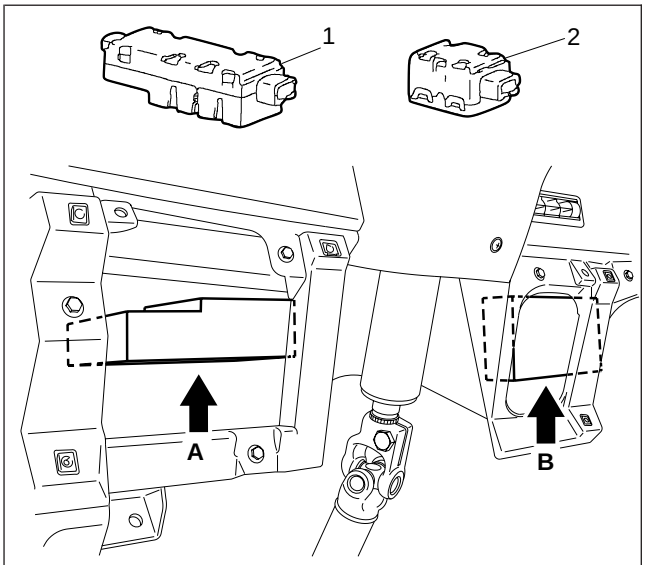
Fig. 2, Wiper/Washer System, Switch Location

There are four modes of wiper operation:

- **Off:** In this mode, there is no windshield wiper motor activity and the windshield wiper motor will be in the "Park" position.
- **Low Speed:** In this mode, the windshield wiper control module will activate the windshield wiper motor through the low speed motor winding.
- **High Speed:** In this mode, the windshield wiper control module will activate the windshield wiper motor through the high speed motor winding.
- **Interval:** In this mode, the windshield wiper control module will activate the windshield wiper motor through the low speed motor winding.

When the switch is in the interval position (**Fig. 4**), the windshield wipers will make a single sweep followed by a pause. The pause duration is controlled by the setting the operator has selected for the control knob on the end of the multi-function switch.

To engage the windshield washer, push the knob at the end of the multi-function switch; see **Fig. 5**. When the multi-function switch is in the "Off" or "Intermittent" position, the windshield wipers will run in "Low" while the knob is pushed in. When the washer knob is released, the washer will stop immediately, but the windshield wipers will continue to run for two or three sweeps, then return to their previously set mode. Washer engagement does not affect windshield wiper operation when the multi-function switch is in the "Low" or "High" position.



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NOTE: The wiper/washer control module is found at either location A or location B.

1. Windshield Wiper Control Module, Signal-Stat
2. Windshield Wiper Control Module, United Technologies

Fig. 3, Wiper/Washer System, Control Module Location

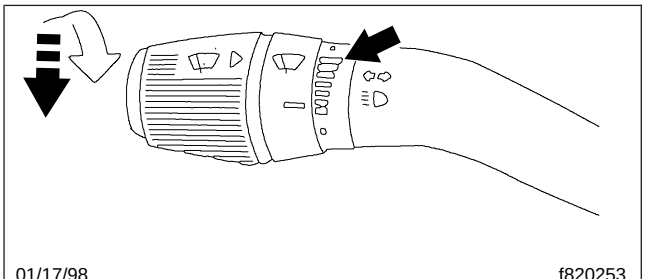

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Fig. 4, Windshield Wiper Switch, Interval Position

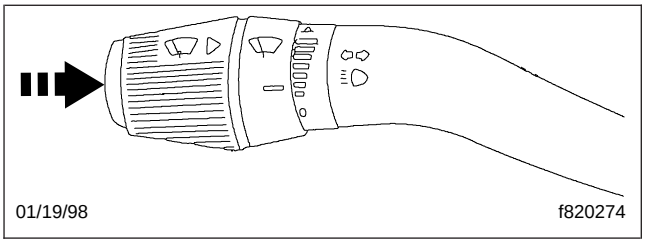

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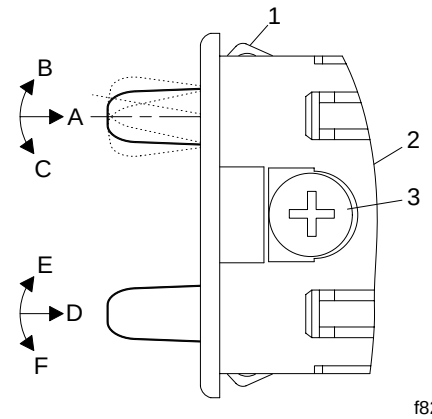
Fig. 5, Windshield Washer

Wiper/Washer Switch, Dash-Mounted

The dash-mounted wiper switch controls the wipers through relays that are located in the dash-mounted power distribution module (PDM). Wiper speed and delay timing are controlled by electronics in the switch.

The windshield wipers and washers are operated by a double-paddle switch mounted on the auxiliary instrument panel. Each paddle can be pushed in, up, or down, for three different functions. For wiper switch functions and operation, see **Fig. 6**.



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A. Push in to turn wipers on (low speed) or off.
B. Push up for high speed.
C. Push down for low speed.
D. Push in momentarily for mist cycle. Push in and hold in for wash cycle.
E. Push up for fast delay. If already in delay, push up for the next faster delay.
F. Push down for slow delay. If already in delay, push down for the next slower delay.

1. Locking Clip
2. Wiper/Washer Switch
3. Light Bulb Screw

Fig. 6, Dash-Mounted Wiper/Washer Switch Operation

The wipers have five cycles: fast, slow, mist, wash, and delay. There are six delay intervals, 3 seconds, 5 seconds (default fast), 8 seconds, 12 seconds, 17 seconds (default slow), and 23 seconds.

The top paddle, when pushed in, turns the wipers on (if they are off) or off (if they are on). When pushed up, the top paddle switches the wipers to

high speed; when pushed down, it switches them to low speed.

The bottom paddle, when pushed in momentarily (for less than 1/2 second), turns the wipers on mist (one dry cycle at low speed). When pushed in and held in (for at least 1/2 second), the bottom paddle turns on the washers for a minimum of three cycles after release. For more wash cycles, hold the bottom paddle in longer (but it will always cycle three more times after release).

Pushing **the bottom paddle** up or down controls the delay cycle of the intermittent wipers. If the wipers are not in delay, push up for default fast delay (5 seconds) or down for default slow delay (17 seconds). If the wipers are already in delay, push up for the next faster delay or push down for the next slower delay.

Windshield Washer System

The windshield washer nozzles are an integral part of the windshield wiper arm. They are not serviceable separate from the windshield wiper arm.

Replacement

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries.

CAUTION

Disconnect the batteries before working on the wipers. This will prevent the windshield wiper motor from cycling. The motor could cycle if the wiper linkage driveshaft is forced out of the parked position, which could result in personal injury.

3. Disconnect the washer hose; see **Fig. 1**.

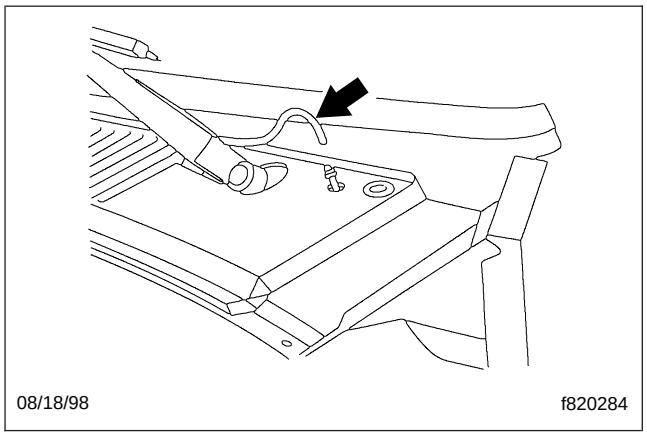


Fig. 1, Windshield Washer Hose

NOTE: The windshield wiper arm can be removed at any point in the wiper sweep without the use of any special tools.

4. Carefully raise the windshield wiper blade away from the windshield glass until it stops.
5. Pull the locking lever away from the windshield wiper arm; see **Fig. 2**.
6. Lift the windshield wiper arm from the pivot shaft; see **Fig. 3**.
7. Install the new windshield wiper arm on the pivot shaft; see **Fig. 3**.
8. Close the locking lever on the windshield wiper arm; see **Fig. 2**.
9. Connect the washer hose; see **Fig. 1**.
10. Connect the batteries.

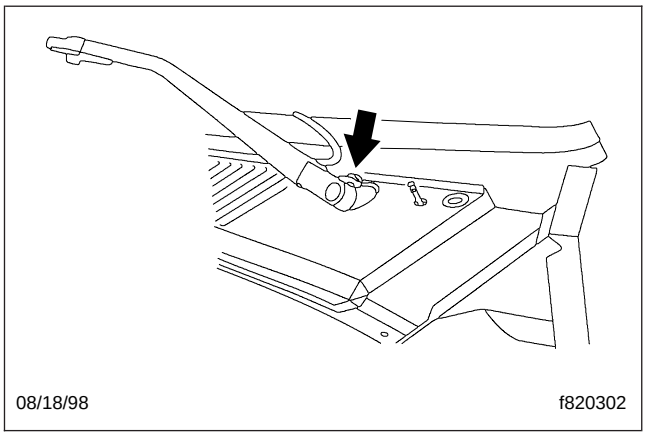


Fig. 2, Windshield Wiper Arm Locking Lever

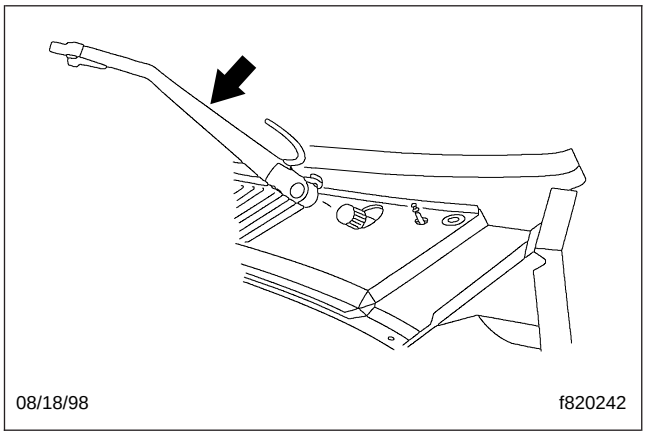


Fig. 3, Windshield Wiper Arm

11. Check and if necessary, adjust the windshield wiper arm; see **Subject 160**.

Replacement

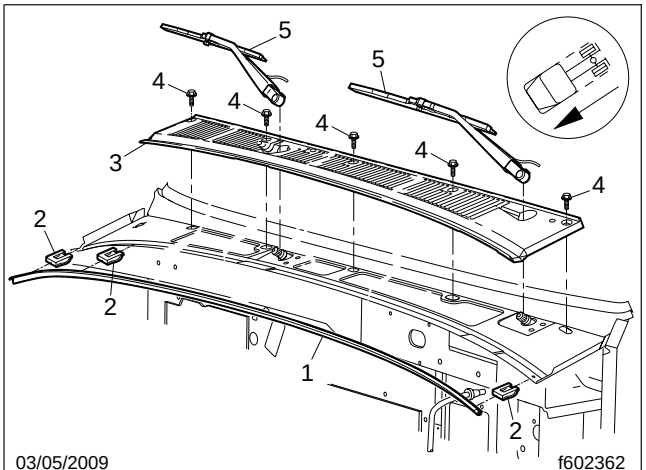
NOTE: The windshield wiper linkage and pivot shafts are serviced as an assembly.

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries.

CAUTION

Disconnect the batteries before working on the wipers. This will prevent the windshield wiper motor from cycling. The motor could cycle if the wiper linkage driveshaft is forced out of the parked position, which could result in personal injury.

3. Remove the windshield wiper arms; see **Subject 100**.
4. Remove the cowl top vent panel (rain tray grille) as follows.
   - 4.1 Remove the rubber seal from the forward edge of the rain tray.
   - 4.2 Remove the five screws that attach the vent panel to the top of the rain tray; see **Fig. 1**. Remove the vent panel.



1. Rubber Seal
2. Retainer
3. Vent Panel
4. Screw
5. Wiper Arm and Blade

Fig. 1, Cowl Top Vent Panel Installation

5. Remove the retaining clip and disconnect the windshield wiper linkage from the wiper motor arm; see **Fig. 2**. Note that some linkages are secured with an E-clip, two seals, and a washer.

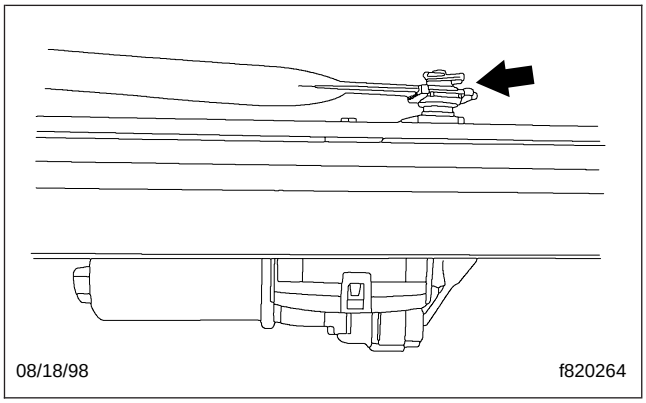
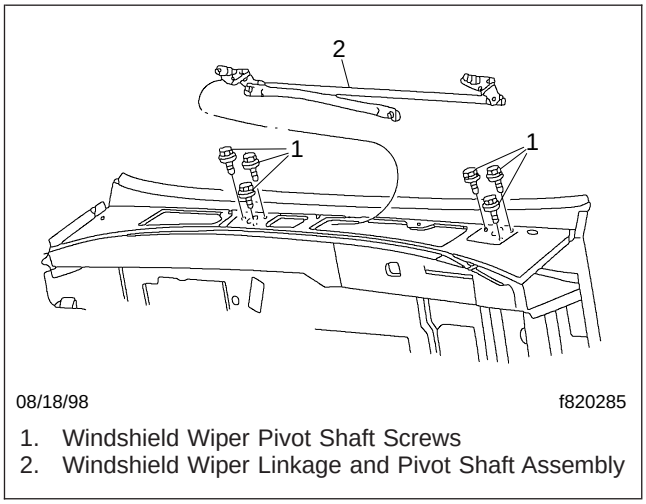


Fig. 2, Windshield Wiper Linkage Retaining Clip

6. Remove the windshield wiper linkage and pivot shaft assembly as follows; see **Fig. 3**.



1. Windshield Wiper Pivot Shaft Screws
2. Windshield Wiper Linkage and Pivot Shaft Assembly

Fig. 3, Windshield Wiper Linkage and Pivot Shafts

   - 6.1 Remove the six pivot shaft screws.
   - 6.2 Slide the windshield wiper linkage and pivot shaft assembly to the passenger side of the vehicle until the driver-side pivot clears the opening in the cowl. Bring the assembly up and out through the large cowl opening.
7. Install the new windshield wiper linkage and pivot shaft assembly as follows; see **Fig. 3**.
   - 7.1 Slide the windshield wiper linkage assembly in through the large cowl opening to-

Wiper Linkage Replacement

ward the passenger side until it drops into the cowl rain tray. Align the assmbly and lift the pivots through the openings in the cowl top panel.

7.2 Install the six pivot shaft screws (**Fig. 3**, Items 1), then tighten them 80 to 115 lbf·in (900 to 1300 N·cm).

8. Connect the windshield wiper motor arm to the linkage and install the retaining clip (or if so equipped, the E-clip, two seals, and washer); see **Fig. 2**. Apply grease to the joint.
9. Install the cowl top vent panel (rain tray grille) as follows.

   9.1 Attach the vent panel to the top the rain tray, using the five screws.

   9.2 Install the rubber seal on the forward edge of the rain tray.
10. Install the windshield wiper arms; see **Subject 100**.
11. Connect the batteries.
12. Check and, if necessary, adjust the windshield wiper arms; see **Subject 160**.

Windshield Wiper Motor Replacement

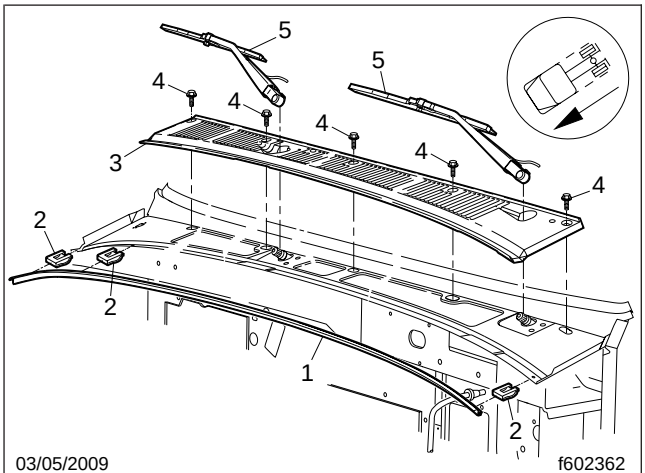
Replacement

1. Apply the parking brakes and chock the tires.
2. Open the hood.
3. Disconnect the batteries.

⚠ CAUTION

Disconnect the batteries before working on the wipers. This will prevent the windshield wiper motor from cycling. The motor could cycle if the wiper linkage driveshaft is forced out of the parked position, which could result in personal injury.

4. Remove the windshield wiper arms; see **Subject 100**.
5. Remove the cowl top vent panel (rain tray grille) as follows.
   - 5.1 Remove the rubber seal from the forward edge of the rain tray.
   - 5.2 Remove the five screws that attach the vent panel to the top of the rain tray; see **Fig. 1**. Remove the vent panel.



1. Rubber Seal
2. Retainer
3. Vent Panel
4. Screw
5. Wiper Arm and Blade

Fig. 1, Cowl Top Vent Panel Installation

6. Remove the retaining clip and disconnect the windshield wiper linkage from the wiper motor arm; see **Fig. 2**. Note that some linkages are secured with an E-clip, two seals, and a washer.

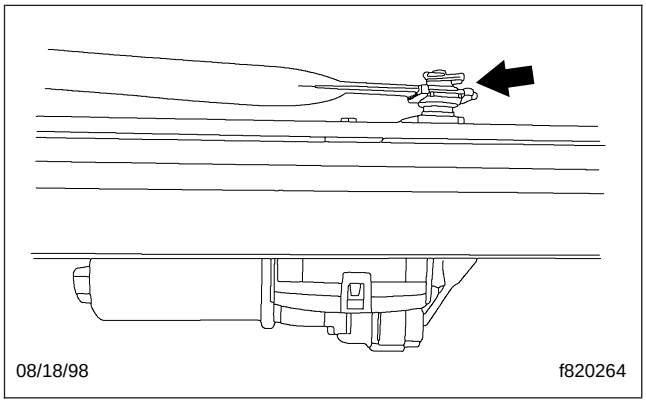
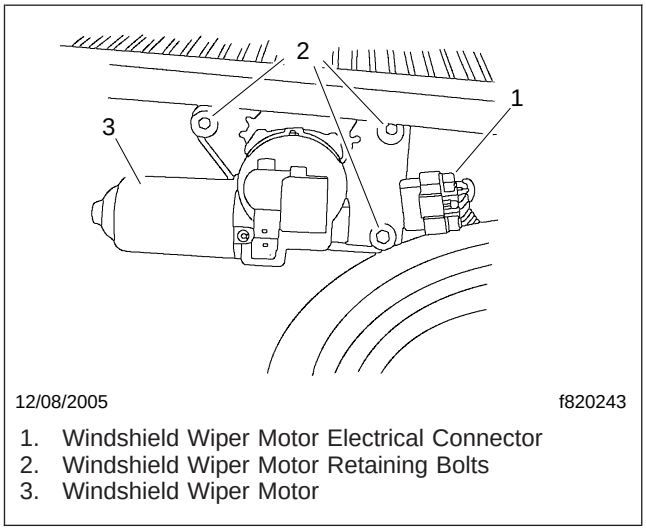


Fig. 2, Windshield Wiper Linkage Retaining Clip

7. Disconnect the wiper motor electrical connector; see **Fig. 3**.



1. Windshield Wiper Motor Electrical Connector
2. Windshield Wiper Motor Retaining Bolts
3. Windshield Wiper Motor

Fig. 3, Windshield Wiper Motor

8. Remove the three wiper motor mounting bolts, then remove the wiper motor.
9. Install the new windshield wiper motor, using the three mounting bolts; see **Fig. 3**. Tighten the bolts 80 to 115 lbf·in (900 to 1300 N·cm).
10. Connect the wiper motor electrical connector.
11. Connect the windshield wiper motor arm to the linkage, then install the retaining clip (or if so equipped, the E-clip, two seals, and washer); see **Fig. 2**. Apply grease to the joint.

Windshield Wiper Motor Replacement

12. Install the cowl top vent panel (rain tray grille) as follows.
    - 12.1 Attach the vent panel to the top the rain tray, using the five screws.
    - 12.2 Install the rubber seal on the forward edge of the rain tray.
13. Install the windshield wiper arms; see **Subject 100**.
14. Connect the batteries and close the hood.
15. Check and, if necessary, adjust the windshield wiper arms; see **Subject 160**.

Windshield Washer Reservoir Replacement

Replacement

1. Open the hood.

NOTE: Windshield washer fluid must be collected in a container after the windshield washer hose is disconnected.

2. Disconnect the electrical connector and the washer hose. See **Fig. 1**.

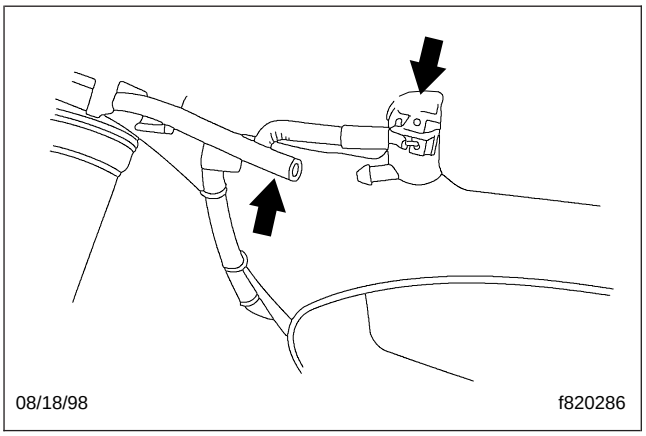
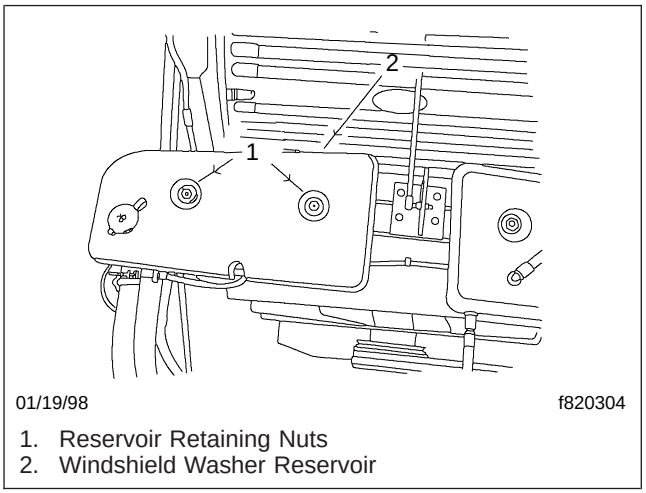


Fig. 1, Windshield Washer Pump Electrical Connector and Hose

3. Remove the windshield washer reservoir. See **Fig. 2**.



1. Reservoir Retaining Nuts
2. Windshield Washer Reservoir

Fig. 2, Windshield Washer Reservoir

3.1 Remove the two retaining nuts.

3.2 Remove the windshield washer reservoir.

4. Install the windshield washer reservoir. See **Fig. 2**.

4.1 Install the windshield washer reservoir.

4.2 Install the two retaining nuts.

5. Connect the washer hose. See **Fig. 1**.

CAUTION

Do not connect the electrical connector prior to filling the windshield washer reservoir or operate the windshield washer pump prior to filling the windshield washer reservoir or damage to the pump could result.

6. Fill the windshield washer reservoir with windshield washer fluid.
7. Connect the electrical connector. See **Fig. 1**.
8. Close the hood.

Washer Pump Replacement

Replacement

1. Open the hood.

NOTE: Windshield washer fluid must be collected in a container after the windshield washer hose is disconnected.

2. Disconnect the windshield washer pump electrical connector and washer hose. See **Fig. 1**.

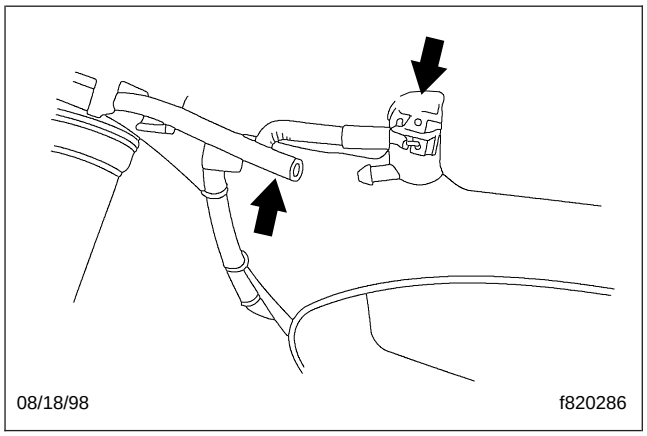


Fig. 1, Windshield Washer Pump Electrical Connector and Hose

3. Remove the windshield washer pump. See **Fig. 2**.
4. Install the windshield washer pump. See **Fig. 2**.
5. Connect the washer hose. See **Fig. 1**.

⚠ CAUTION

Do not connect the electrical connector prior to filling the windshield washer reservoir or operate the windshield washer pump prior to filling the windshield washer reservoir or damage to the pump could result.

6. Fill the windshield washer reservoir with windshield washer fluid.
7. Connect the electrical connector. See **Fig. 1**.
8. Close the hood.

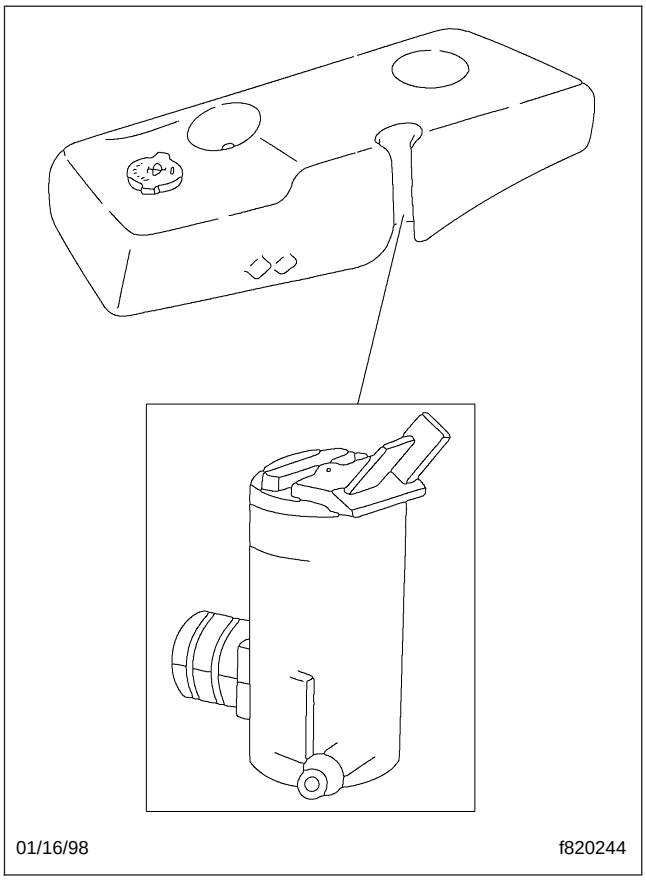


Fig. 2, Windshield Washer Pump

Wiper Control Module Replacement

NOTE: The following procedure applies to United Technologies and Signal Stat wiper systems. On the dash-mounted wiper switch systems, there is no separate wiper control module.

Replacement

1. Apply the parking brakes and chock the tires.
2. Remove the five under-steering-panel screws, then remove the panel; see **Fig. 1**.

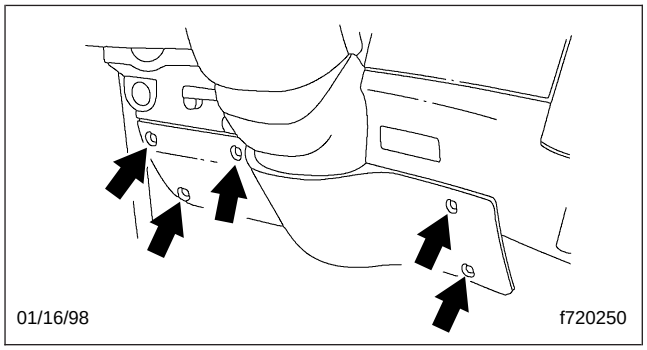
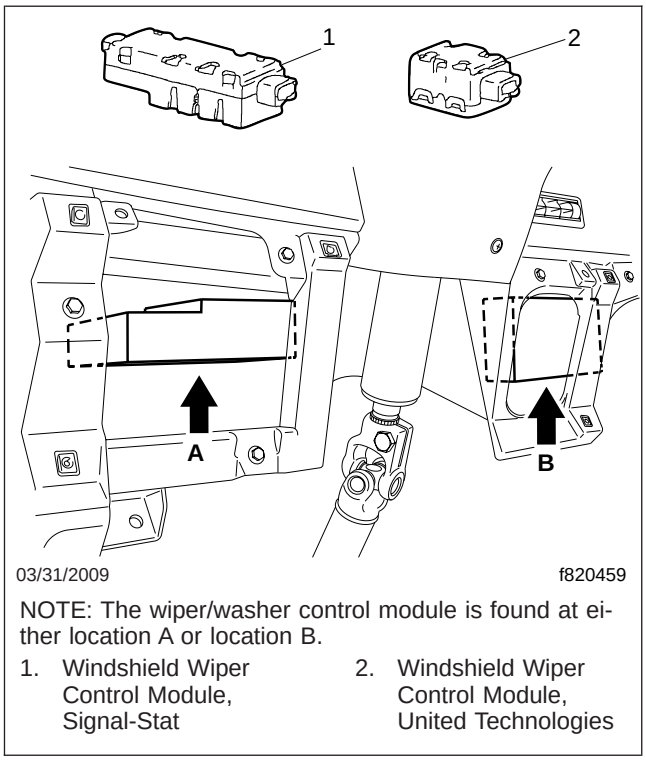


Fig. 1, Under-Steering-Panel Screws

3. Locate the wiper control module, either to the left or right of the steering column; see **Fig. 2**. Disconnect the electrical connector(s).

NOTE: United Technologies wiper control modules have one electrical connector, and Signal Stat wiper control modules have two electrical connectors.

4. Pull the wiper control module off the wiper control module mounting bracket; see **Fig. 2**.
5. Install the new wiper control module.
6. Connect the electrical connector(s).
7. Attach the under-steering panel to the dash, using the five screws; see **Fig. 1**.

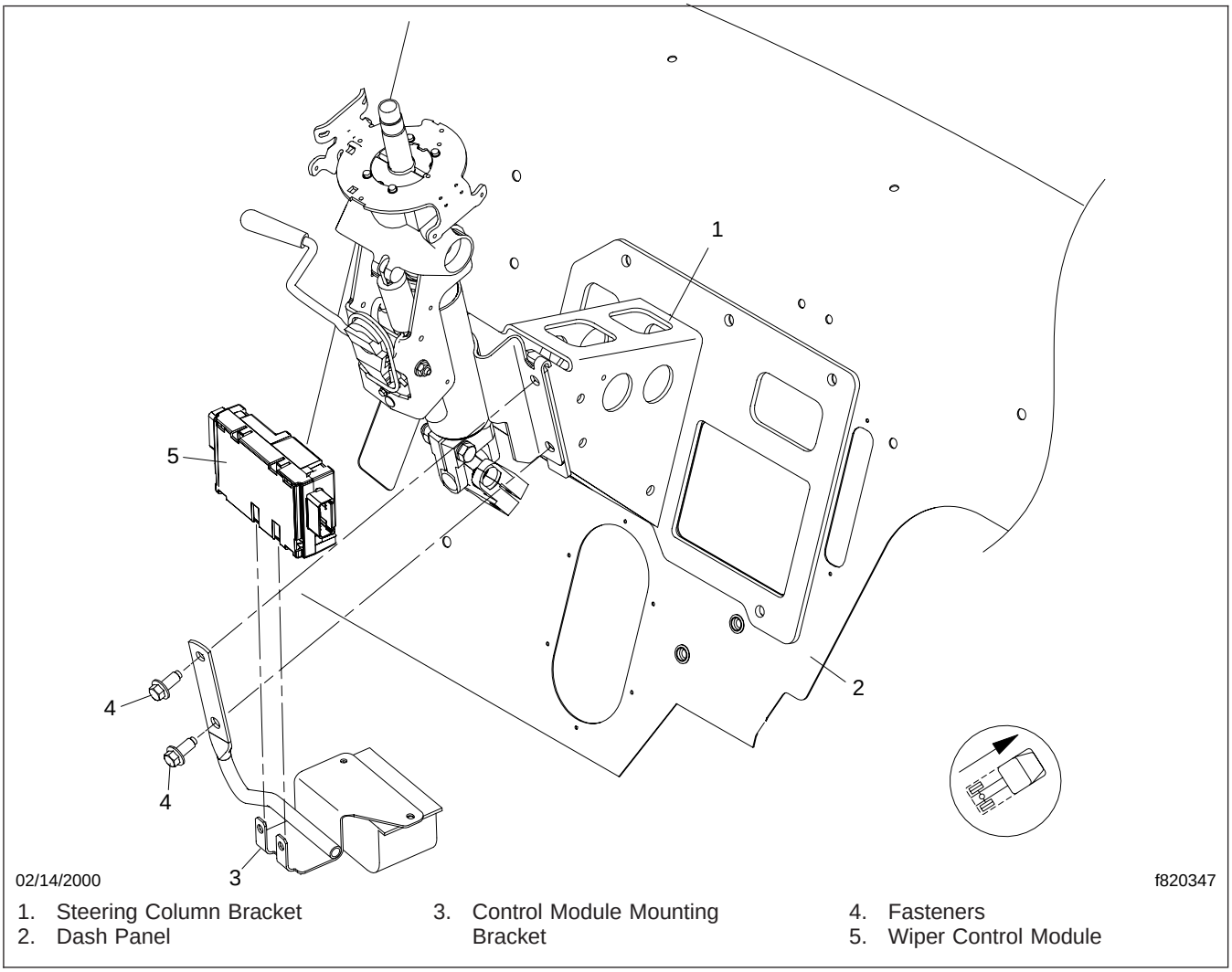


NOTE: The wiper/washer control module is found at either location A or location B.

1. Windshield Wiper Control Module, Signal-Stat
2. Windshield Wiper Control Module, United Technologies

Fig. 2, Wiper/Washer System, Control Module Location

Wiper Control Module Replacement



1. Steering Column Bracket
2. Dash Panel
3. Control Module Mounting Bracket
4. Fasteners
5. Wiper Control Module

Fig. 3, Wiper Control Module Mounting (typical)

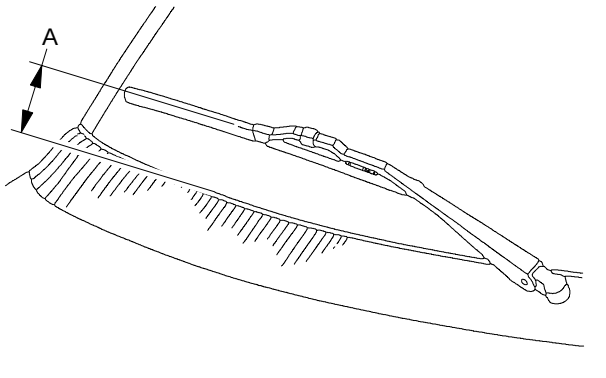
Adjustment

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries.

CAUTION

Disconnect the batteries before working on the wipers. This will prevent the windshield wiper motor from cycling. The motor could cycle if the wiper linkage driveshaft is forced out of the parked position, which could result in personal injury.

3. Cycle and park the windshield wipers.
4. Verify that the distance between the center of the right-hand windshield wiper blade and the cowl top vent panel is within 3 inches (76 mm); see **Fig. 1**.



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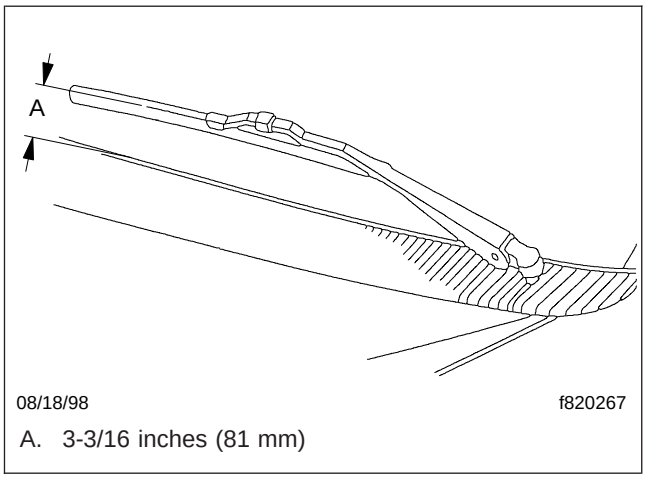
A. 3 inches (76 mm)

Fig. 1, Right-Hand Windshield Blade Park Dimension

5. Verify that the distance between the center of the left-hand windshield wiper blade and the cowl top vent panel is within 3-3/16 inches (81 mm); see **Fig. 2**.
6. If a windshield wiper arm is not positioned within the above specifications, remove and reposition the wiper arm; see **Subject 100**.
7. Connect the batteries.



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A. 3-3/16 inches (81 mm)

Fig. 2, Left-Hand Windshield Blade Park Dimension

Troubleshooting, United Technologies Wiper and Washer

Troubleshooting

CAUTION

Use caution when working on or near the wiper linkage, arms, and motor. An intermittent wiper system may swipe without warning, posing a risk of personal injury.

NOTICE

Make sure the ignition switch is off before disconnecting any wiper/washer harness connectors. Removing connectors with the ignition switch on may cause electrical arcing, which will damage the pins.

Preliminary Checks

Before beginning the troubleshooting procedures, verify the driver's complaint by checking the system components, and operating the wiper and washer to duplicate the problem.

1. Check the wiper arms, blades, and linkage for wear and damage.
2. Check the washer fluid level in the reservoir.
3. Turn the ignition switch to the ON position without starting the engine.
4. Test the wipers on low speed, high speed, and several intermittent speeds.
5. Test the windshield washers.
6. Turn the ignition switch to the OFF position.
7. Check the washer hoses for leaks and damage.

Diagnostic Procedures

Symptoms

The diagnostic procedures listed in **Table 1** are described in detail in the succeeding tables. When performing the diagnostic procedures, refer to the wiring diagram (**Fig. 1**) and the tables in this subject.

NOTICE

Use caution when backprobing sealed connectors. If the seal is damaged, water could intrude into the connection, resulting in corrosion and electrical failure.

IMPORTANT: The following wiper and washer diagnostic procedures are performed with the ignition switch in the ON position, and the engine NOT running.

Troubleshooting Procedures	
Symptom	**Table Number**
Wipers are inoperative in all modes	**Table 2**
High-speed mode only is inoperative	**Table 3**
Low-speed and all intermittent speed modes are inoperative, high-speed mode is OK	**Table 4**
Some intermittent setting modes are inoperative	**Table 5**
Wipers do not park in the proper position	**Table 6**
Wipers stay on or swipe intermittently until ignition is turned off	**Table 7**
Washers are inoperative, wipers are OK	**Table 8**
Washer spray does not correctly cover wipe area	**Table 9**

Table 1, Troubleshooting Procedures

Troubleshooting, United Technologies Wiper and Washer

Wipers Are Inoperative In All Modes			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—
2	With the connector remaining connected, backprobe the wiper motor connector on pins 2 and 3 to measure for battery voltage; see **Table 10**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 120**.
		Low or at zero	Go to **step 3**.
3	Access the wiper control module (**Fig. 2**), and backprobe pin 8 to measure the voltage, with the connector remaining connected to the module; see **Fig. 3**. Is battery voltage present?	Yes	There is a wiring fault on circuit 315L or the wiper motor ground circuit. Disconnect the power, and perform continuity testing to locate the circuit fault, then repair as appropriate.
		No	Go to **step 4**.
4	Measure the voltage on pins 2 and 11 of the wiper control module; see **Fig. 3**. Is battery voltage present on both pins, one pin (either 2 or 11), or neither pin?	Both pins	Test the wiper switch; see **Table 11**. Test the wiring from the wiper switch to the wiper control module for open or short circuits. If any of the wiper switch tests fail, replace the switch.
		One pin (either 2 or 11)	Locate the open circuit between splice S48 and the wiper control module in the circuit 315 wire that does not have voltage.
		Neither pin	Verify that fuse S in the underhood PDM is not open. Fuse S supplies the wipers in addition to F1, F2, and F3 in the dashboard PDM. Test relay R11 and circuit breaker CB4 in the dashboard PDM; see **Fig. 4**. Circuit breaker CB4 or fuse S will open if the wiper control module is internally shorted. If unplugging the wiper module allows circuit breaker CB4 to reset, then replace the wiper control module; see **Subject 150**. Otherwise, troubleshoot for wiring problems with circuit 315.
5	Turn the ignition switch to the OFF position, then test for continuity to ground at pins 3 and 5 of the wiper control module connector; see **Fig. 3**. Are both pins low resistance to ground?	Yes	Go to **step 6**.
		No	Locate and repair the open ground circuit.
6	Did all the preceding tests pass?	Yes	Replace the wiper control module; see **Subject 150**.

Table 2, Wipers Are Inoperative In All Modes

High-Speed Mode Only Is Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to high speed.	—	—

Troubleshooting, United Technologies Wiper and Washer

High-Speed Mode Only Is Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
2	With the connector remaining connected, backprobe the wiper motor connector on pins 1 and 3 to measure for battery voltage; see **Table 10**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 120**.
		Low or at zero	Go to **step 3**.
3	Access the wiper control module (**Fig. 2**), and backprobe pin 14 to measure the voltage, with the connector remaining connected to the module; see **Fig. 3**. Is battery voltage present?	Yes	There is a wiring fault on circuit 315H. Disconnect the power, and perform continuity testing to locate the circuit fault, then repair as appropriate.
		No	Go to **step 4**.
4	Test the wiper switch. Perform the wiper switch resistance test; see **Table 11**. Check the wiring from the wiper switch to the wiper control module for open or short circuits. Did any of the wiper switch tests fail?	Yes	Replace the wiper switch.
		No	Replace the wiper control module; see **Subject 150**.

Table 3, High-Speed Mode Only Is Inoperative

Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—
2	With the connector remaining connected, backprobe the wiper motor connector on pins 2 and 3 to measure for battery voltage; see **Fig. 3**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 120**.
		Low or at zero	Go to **step 3**.
3	Access the wiper control module (**Fig. 2**), and backprobe pin 8 to measure the voltage, with the connector remaining connected to the module; see **Fig. 3**. Is battery voltage present?	Yes	There is a wiring fault on circuit 315L. Disconnect the power, and perform continuity testing to locate the circuit fault, then repair as appropriate.
		No	Go to **step 4**.
4	Test the wiper switch. Perform the wiper switch resistance test; see **Table 11**. Check the wiring from the wiper switch to the wiper control module for open or short circuits. Did any of the wiper switch tests fail?	Yes	Replace the wiper switch.
		No	Replace the wiper control module; see **Subject 150**.

Table 4, Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK

Troubleshooting, United Technologies Wiper and Washer

Some Intermittent Setting Modes Are Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
1	Test the wiper switch. Perform the wiper switch resistance test; see **Table 11**. Check the wiring from the wiper switch to the wiper control module (**Fig. 2**) for open or short circuits. Did all the tests pass?	Yes	Replace the wiper control module; see **Subject 150**.
		No	Replace the wiper switch.

Table 5, Some Intermittent Setting Modes Are Inoperative

Wipers Do Not Park in Proper Position			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—
2	Turn the wiper switch off when the wipers are in mid-swipe. Do the wipers stop immediately, or continue traveling, then stop?	Immediately	Go to **step 3**.
		Continue traveling, then stop	Note the stopped position. Repeat the test to make sure that the wipers always stop in the same position. If the wipers always stop in the same position, regardless of where the switch was turned off, the wiper arm position is improperly adjusted. Turn the ignition switch to OFF, disconnect the batteries, then adjust the wiper arms to the correct position; see **Subject 160**.
3	With the ignition switch in the ON position, the wipers switched off, and the connector remaining connected, backprobe to measure the voltage on pin 4 of the wiper motor connector; see **Table 10**. Is battery voltage present?	Yes	Go to **step 4**.
		No	Locate and repair the open circuit on circuit 315 between the wiper motor and splice S48.
4	With the ignition in the ON position and the wipers switched to low speed, backprobe to measure the voltage on pin 5 of the wiper motor connector; see **Table 10**. Battery voltage should be present except when the wipers travel through the park position and the circuit is momentarily at ground. Is battery voltage present?	Yes	Go to **step 5**.
		No	Replace the wiper motor; see **Subject 120**.
5	With the ignition switch in the ON position and the wipers on low speed, backprobe to measure the voltage on pin 13 of the wiper control module; see **Fig. 2** and **Fig. 3**. Is battery voltage present?	Yes	Replace the wiper control module; see **Subject 150**.
		No	Locate and repair the open circuit between pin 13 and the wiper motor in circuit 315P.

Table 6, Wipers Do Not Park in Proper Position

Troubleshooting, United Technologies Wiper and Washer

Wipers Stay On or Wipe Intermittently Until Ignition Is Turned Off			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and leave the wiper switch in the OFF position. Do the wipers remain on, swiping continuously or intermittently?	Yes	Go to **step 2**.
		No	Go to **step 3**.
2	Disconnect power, then perform the wiper switch test measuring for the resistance values shown in **Table 11**. Did any of the resistance tests fail?	Yes	Replace the wiper switch.
		No	Go to **step 3**.
3	With the ignition switch in the ON position, the wipers on low speed, and the connector remaining connected, backprobe pin 5 of the wiper motor connector to check the voltage through the wiper motor's internal park switch; see **Table 10**. When the wipers travel through the park position, pin 5 should be momentarily at ground. Most voltmeters respond quickly enough to show this momentary voltage transition. Is the momentary voltage transition to ground present?	Yes	Go to **step 4**.
		No	The wiper motor internal park switch is not working. Replace the wiper motor; see **Subject 120**.
4	With the ignition switch in the ON position, the wipers on low speed, and the connector remaining connected, backprobe pin 13 of the wiper control module; see **Fig. 2** and **Fig. 3**. Verify that the momentary voltage transition to ground is present.	Yes	Replace the wiper control module; see **Subject 150**.
		No	Locate and repair the wiring fault on circuit 315P between the wiper motor and the wiper control module.

Table 7, Wipers Stay On or Wipe Intermittently Until Ignition Is Turned Off

Washers Are Inoperative, Wipers Are OK			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed. Do the wipers work?	Yes	Turn the wipers off. Go to **step 2**.
		No	Follow the troubleshooting procedure under "Wipers Are Inoperative In All Modes"; see **Table 2**.
2	Check the washer reservoir fluid level. Add fluid if needed, then test the washer operation. Hold the washer switch on for at least 5 seconds in case the hoses are leaking, or the system has lost its prime. Is the pump running?	Yes	Check the system for leaks. Also follow the troubleshooting procedure under "Washer Spray Does Not Correctly Cover Wipe Area"; see **Table 9**.
		No	Go to **step 3**.
3	If the system is not leaking, backprobe the connections at the washer pump, and test for battery voltage when the washer switch is activated; see **Table 12**. Is battery voltage present?	Yes	Replace the washer pump; see **Subject 140**.
		No	Go to **step 4**.

Troubleshooting, United Technologies Wiper and Washer

Washers Are Inoperative, Wipers Are OK			
Step	**Test Procedure**	**Test Result**	**Action**
4	Disconnect the wiper control module connector (**Fig. 2**), and perform a continuity test between pins 9 and 7 of the harness. When the washer switch is activated, there should be continuity. Is there continuity?	Yes	Go to **step 5**.
		No	Troubleshoot for open wiring in circuits 315D and 315C, and also for an open in the wiper switch. Replace the switch if it tests open.
5	Connect the wiper module connector, then turn the ignition switch to ON. Turn on the washers while backprobing pin 4 of the wiper control module connector; see **Fig. 3**. Is battery voltage present?	Yes	Troubleshoot and repair a wiring fault in circuit 320 between the washer pump and the wiper control module.
		No	Replace the wiper control module; see **Subject 150**.

Table 8, Washers Are Inoperative, Wipers Are OK

Washer Spray Does Not Correctly Cover Wipe Area			
Step	**Test Procedure**	**Test Result**	**Action**
1	Make sure that the fluid level in the washer fluid reservoir is adequate. If needed, add fluid.	—	—
2	Test the washer operation. Hold the washer switch in the ON position for at least 5 seconds, in case the washer system has lost its prime. Is the fluid flow adequate?	Yes	Troubleshooting is completed.
		No	Check the nozzles for damage, plugging, or improper installation. Check the hoses for kinks, or tie-wraps that may be too tight. Make sure that there are no breaks or disconnected fittings. Go to **step 3**.
3	Test the washer operation. Does the washer work properly?	Yes	Troubleshooting is completed.
		No	Replace the washer pump; see **Subject 140**.

Table 9, Washer Spray Does Not Correctly Cover Wipe Area

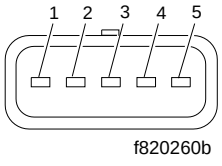
Terminal Identification of the Wiper Motor Harness Connector			
Wiper Motor Harness Connector (wire insertion view)	**Pin**	**Circuit Number**	**Circuit Description**
 f820260b	1	315H	Wiper Motor High Speed
	2	315L	Wiper Motor Low Speed
	3	GND	Ground
	4	315	Ignition Power
	5	315P	Park Switch Signal

Table 10, Terminal Identification of the Wiper Motor Harness Connector

Troubleshooting, United Technologies Wiper and Washer

Wiper/Washer Switch Resistance Values				
Switch Position	Pins 1 to 2 (kohms)		Pins 2 to 3 (kohms)	
	Lowest	Highest	Lowest	Highest
Off	95.0	105.0	46.8	48.3
Int 1	95.0	105.0	10.86	11.54
Int 2	77.9	86.1	10.86	11.54
Int 3	64.6	71.4	10.86	11.54
Int 4	48.45	53.55	10.86	11.54
Int 5	34.2	37.8	10.86	11.54
Int 6	19.0	21.0	10.86	11.54
Int 7	3.14	3.47	10.86	11.54
Low	3.14	3.47	3.96	4.20
Hi	3.14	3.47	0.0	0.4
Wash	0.0	0.4	—	—

Table 11, Wiper/Washer Switch Resistance Values

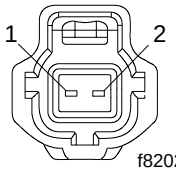
Terminal Identification of the Washer Pump Connector				
Washer Pump Connector	Terminal	Circuit Number	Color	Circuit Description
	1	320	Dark Blue	Washer Power
	2	GND	Black	Washer Ground

Table 12, Terminal Identification of the Washer Pump Connector

Troubleshooting, United Technologies Wiper and Washer

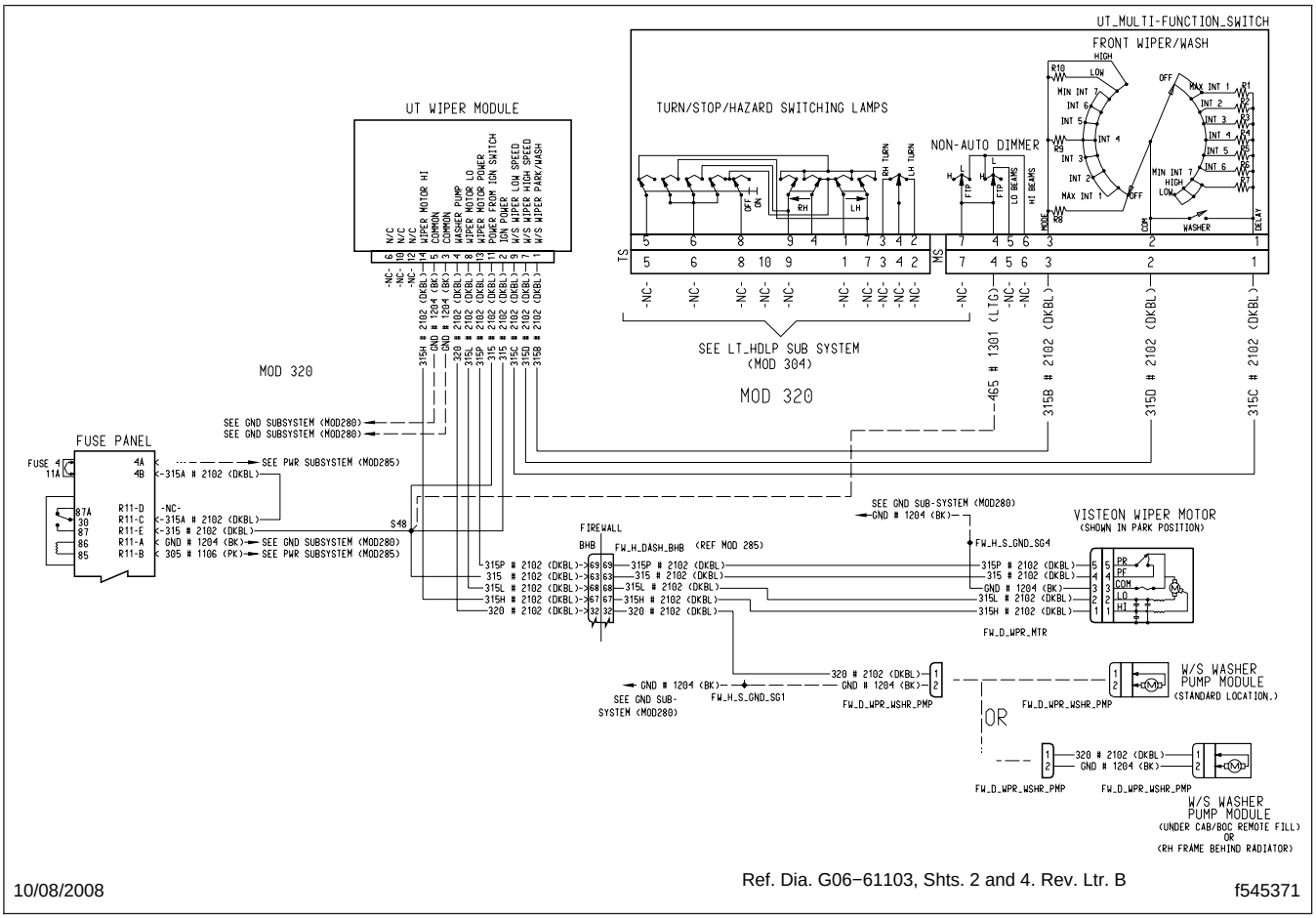
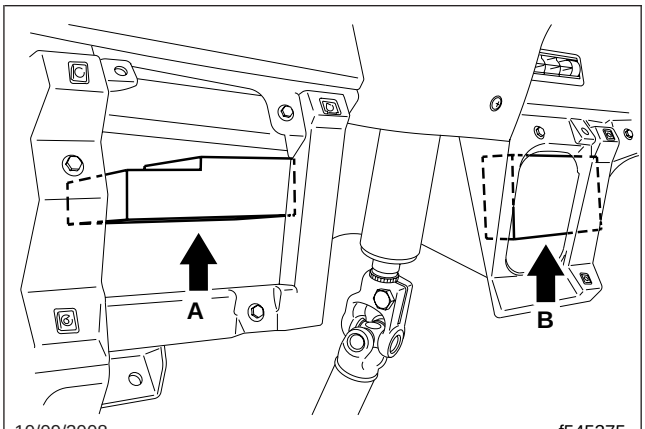


Fig. 1, Wiper/Washer With United Technologies Switch Wiring



NOTE: The wiper control module is found at either location A or location B.

Fig. 2, Wiper Control Module Location

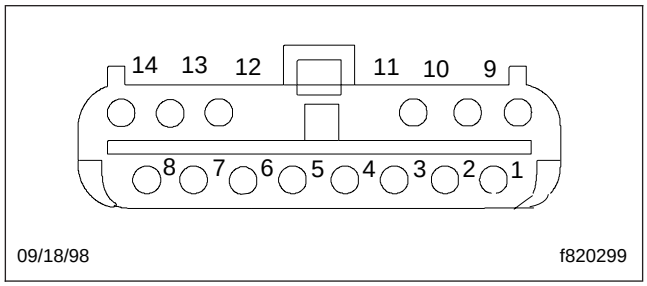
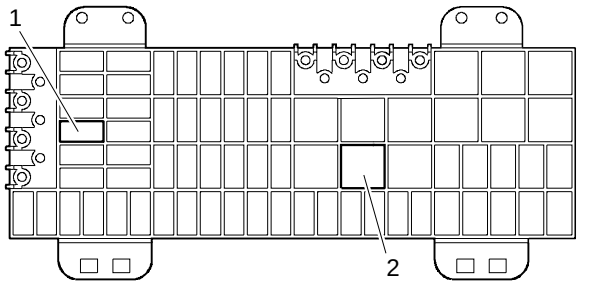


Fig. 3, Wiper Control Module Connector

Troubleshooting, United Technologies Wiper and Washer



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1. CB4, Wiper/Washer Power
2. R11, Wiper/Washer Power

Fig. 4, Power Distribution Module (PDM), Instrument Panel

Troubleshooting

CAUTION

Use caution when working on or near the wiper linkage, arms, and motor. An intermittent wiper system may swipe without warning, posing a risk of personal injury.

NOTICE

Make sure the ignition switch is off before disconnecting any wiper/washer harness connectors. Removing connectors with the ignition switch on may cause electrical arcing, which will damage the pins.

Preliminary Checks

Before beginning the troubleshooting procedures, verify the driver's complaint by checking the system components, and operating the wiper and washer to duplicate the problem.

1. Check the wiper arms, blades, and linkage for wear and damage.
2. Check the washer fluid level in the reservoir.
3. Turn the ignition switch to the ON position without starting the engine.
4. Test the wipers on low speed, high speed, and several intermittent speeds.
5. Test the windshield washers.
6. Turn the ignition switch to the OFF position.
7. Check the washer hoses for leaks and damage.

Diagnostic Procedures

Symptoms

The diagnostic procedures listed in **Table 1** are described in detail in the succeeding tables. When performing the diagnostic procedures, refer to the applicable wiring diagram (**Fig. 1** for vehicles built from November 2001, or **Fig. 2** for vehicles built before November 2001) and the tables in this subject.

NOTICE

Use caution when backprobing sealed connectors. If the seal is damaged, water could intrude into the connection, resulting in corrosion and electrical failure.

IMPORTANT: The following wiper and washer diagnostic procedures are performed with the ignition switch in the ON position, and the engine NOT running.

Troubleshooting Procedures	
Symptom	**Table Number**
Wipers are inoperative in all modes	**Table 2**
High-speed mode only is inoperative	**Table 3**
Low-speed and all intermittent speed modes are inoperative, high-speed mode is OK	**Table 4**
Some intermittent setting modes are inoperative	**Table 5**
Wipers do not park in the proper position	**Table 6**
Wipers stay on or swipe intermittently until ignition is turned off	**Table 7**
Washers are inoperative, wipers are OK	**Table 8**
Washer spray does not correctly cover wipe area	**Table 9**

Table 1, Troubleshooting Procedures

Troubleshooting, Signal Stat Wiper and Washer

NOTE: When working on vehicles built before November 2001, use the circuit numbers referenced in parenthesis in the troubleshooting tables.

Wipers Are Inoperative In All Modes			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—
2	With the connector remaining connected, backprobe the wiper motor connector on pins 2 and 3 to measure for battery voltage; see **Table 10**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 120**.
		Low or at zero	Go to **step 3**.
3	Access the wiper control module (**Fig. 3**), and backprobe pin 9 of the vehicle harness connector to measure the voltage, with the connector remaining connected to the module; see **Fig. 4**. Is battery voltage present?	Yes	There is a wiring fault on circuit 315L (58) or the wiper motor ground circuit. Disconnect the power, and perform continuity testing to locate the circuit fault, then repair as appropriate.
		No	Go to **step 4**.
4	Measure the voltage on pins 4 and 11 of the vehicle harness connector; see **Fig. 4**. Is battery voltage present on both pins, one pin (either 4 or 11), or neither pin?	Both pins	Test the wiper switch. Perform the wiper switch continuity test; see **Table 11**. Test the wiring from the wiper switch to the wiper control module for open or short circuits. If any of the wiper switch tests fail, replace the switch.
		One pin (either 4 or 11)	**Vehicles built from November 2001:** Locate and repair the open circuit between splice S4 and the wiper control module in the circuit 315/465 wire that does not have voltage. **Vehicles built before November 2001:** If battery voltage is present on pin 11, and not pin 4, test fuse F36 and circuit 575 for wiring faults. If battery voltage is present on pin 4, and not pin 11, test relay R11 and circuit breaker CB4 in the dashboard PDM (**Fig. 5**), in addition to testing for wiring faults in the relay ground circuit and circuit 65.
		Neither pin	Verify that fuse S in the underhood PDM is not open. Fuse S supplies the wipers in addition to F1, F2, and F3 in the dashboard PDM. Test for shorts in the circuits powered through these fuses, in addition to shorts to the wipers, if fuse S is open. Test relay 11 and circuit breaker CB4 in the dashboard PDM; see **Fig. 5**. Circuit breaker CB4 or fuse S will open if the wiper control module is internally shorted. If unplugging the wiper module allows circuit breaker CB4 to reset, then replace the wiper control module; see **Subject 150**.

Troubleshooting, Signal Stat Wiper and Washer

Wipers Are Inoperative In All Modes			
Step	**Test Procedure**	**Test Result**	**Action**
5	Turn the ignition switch to the OFF position, then test for continuity to ground at pin 6 of the wiper module vehicle harness connector; see **Fig. 4**. Is the pin low resistance to ground?	Yes	Go to **step 6**.
		No	Locate and repair the open ground circuit.
6	Did all the preceding tests pass?	Yes	Replace the wiper control module; see **Subject 150**.

Table 2, Wipers Are Inoperative In All Modes

High-Speed Mode Only Is Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to high speed.	—	—
2	With the connector remaining connected, backprobe the wiper motor connector on pins 1 and 3 to measure for battery voltage; see **Table 10**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 120**.
		Low or at zero	Go to **step 3**.
3	Access the wiper control module (**Fig. 3**), and backprobe pin 5 on the vehicle harness connector to measure the voltage, with the connector remaining connected to the module; see **Fig. 4**. Is battery voltage present?	Yes	There is a wiring fault on circuit 315H (56). Disconnect the power, and perform continuity testing to locate the circuit fault, then repair as appropriate.
		No	Go to **step 4**.
4	Test the wiper switch. Perform the wiper switch continuity test; see **Table 11**. Check the wiring from the wiper switch to the wiper control module for open or short circuits. Did any of the wiper switch tests fail?	Yes	Replace the wiper switch.
		No	Replace the wiper control module; see **Subject 150**.

Table 3, High-Speed Mode Only Is Inoperative

Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—
2	With the connector remaining connected, backprobe the wiper motor connector on pins 2 and 3 to measure for battery voltage; see **Table 10**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 120**.
		Low or at zero	Go to **step 3**.

Troubleshooting, Signal Stat Wiper and Washer

Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK			
Step	**Test Procedure**	**Test Result**	**Action**
3	Access the wiper control module (**Fig. 3**), and backprobe pin 9 on the vehicle harness connector to measure the voltage, with the connector remaining connected to the module; see **Fig. 4**. Is battery voltage present?	Yes	There is a wiring fault on circuit 315L (58). Disconnect the power, and perform continuity testing to locate the circuit fault, then repair as appropriate.
		No	Go to **step 4**.
4	Test the wiper switch. Perform the wiper switch continuity test; see **Table 11**. Check the wiring from the wiper switch to the wiper control module for open or short circuits. Did any of the wiper switch tests fail?	Yes	Replace the wiper switch.
		No	Replace the wiper control module; see **Subject 150**.

Table 4, Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK

Some Intermittent Setting Modes Are Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
1	Test the wiper switch. Perform the wiper switch continuity test; see **Table 11**. Check the wiring from the wiper switch to the wiper control module (**Fig. 3**) for open or short circuits. Did all the tests pass?	Yes	Replace the wiper control module; see **Subject 150**.
		No	Replace the wiper switch.

Table 5, Some Intermittent Setting Modes Are Inoperative

Wipers Do Not Park in Proper Position			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—
2	Turn the wiper switch off when the wipers are in mid-swipe. Do the wipers stop immediately, or continue traveling, then stop?	Immediately	Go to **step 3**.
		Continue traveling, then stop	Note the stopped position. Repeat the test to make sure that the wipers always stop in the same position. If the wipers always stop in the same position, regardless of where the switch was turned off, the wiper arm position is improperly adjusted. Turn the ignition switch to OFF, disconnect the batteries, then adjust the wiper arms to the correct position; see **Subject 160**.
3	With the ignition switch in the ON position, the wipers switched off, and the connector remaining connected, backprobe to measure the voltage on pin 4 of the wiper motor connector; see **Table 10**. Is battery voltage present?	Yes	Go to **step 4**.
		No	Locate and repair the open circuit on circuit 315 (65) between the wiper motor and the splice.

Wipers Do Not Park in Proper Position			
Step	**Test Procedure**	**Test Result**	**Action**
4	With the ignition in the ON position and the wipers switched to low speed, backprobe to measure the voltage on pin 5 of the wiper motor connector; see **Table 10**. Battery voltage should be present except when the wipers travel through the park position and the circuit is momentarily at ground. Is battery voltage present?	Yes	Go to **step 5**.
		No	Replace the wiper motor; see **Subject 120**.
5	With the ignition switch in the ON position and the wipers on low speed, backprobe to measure the voltage on pin 10 of the vehicle harness connector at the wiper control module; see **Fig. 3** and **Fig. 4**. Is battery voltage present?	Yes	Replace the wiper control module; see **Subject 150**.
		No	Locate and repair the open circuit between pin 10 and the wiper motor in circuit 315P (28).

Table 6, Wipers Do Not Park in Proper Position

Wipers Stay On or Wipe Intermittently Until Ignition Is Turned Off			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and leave the wiper switch in the OFF position. Do the wipers remain on, swiping continuously or intermittently?	Yes	Go to **step 2**.
		No	Go to **step 3**.
2	Disconnect power, then perform the wiper switch test measuring for continuity as shown in **Table 11**. Did any of the tests fail?	Yes	Replace the wiper switch.
		No	Go to **step 3**.
3	With the ignition switch in the ON position, the wipers on low speed, and the connector remaining connected, backprobe pin 5 of the wiper motor connector to check the voltage through the wiper motor's internal park switch; see **Table 10**. When the wipers travel through the park position, pin 5 should be momentarily at ground. Most voltmeters respond quickly enough to show this momentary voltage transition. Is the momentary voltage transition to ground present?	Yes	Go to **step 4**.
		No	The wiper motor internal park switch is not working. Replace the wiper motor; see **Subject 120**.
4	With the ignition switch in the ON position, and the wipers on low speed, backprobe pin 10 of the vehicle harness connector at the wiper control module; see **Fig. 3** and **Fig. 4**. Verify that the momentary voltage transition to ground is present.	Yes	Replace the wiper control module; see **Subject 150**.
		No	Locate and repair the wiring fault on circuit 315P (28) between the wiper motor and the wiper control module.

Table 7, Wipers Stay On or Wipe Intermittently Until Ignition Is Turned Off

Troubleshooting, Signal Stat Wiper and Washer

Washers Are Inoperative, Wipers Are OK			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed. Do the wipers work?	Yes	Turn the wipers off. Go to **step 2**.
		No	Follow the troubleshooting procedure under "Wipers Are Inoperative In All Modes"; see **Table 2**.
2	Check the washer reservoir fluid level. Add fluid if needed, then test the washer operation. Hold the washer switch on for at least 5 seconds in case the hoses are leaking, or the system has lost its prime. Is the pump running?	Yes	Check the system for leaks. Also follow the troubleshooting procedure under "Washer Spray Does Not Correctly Cover Wipe Area"; see **Table 9**.
		No	Go to **step 3**.
3	If the system is not leaking, backprobe the connections at the washer pump, and test for battery voltage when the washer switch is activated; see **Table 12**. Is battery voltage present?	Yes	Replace the washer pump; see **Subject 140**.
		No	Go to **step 4**.
4	Disconnect the wiper switch, and perform a continuity test between pins 1 and 6 of the switch harness connector. When the washer switch is activated, there should be continuity. Is there continuity?	Yes	Go to **step 5**.
		No	Troubleshoot for open wiring between the wiper control module (**Fig. 3**) and the wiper switch, and also for an open in the switch. Replace the switch if it tests open.
5	Connect the wiper switch, then turn the ignition switch to ON. Turn on the washers while backprobing pin 8 of the vehicle harness connector at the wiper control module connector; see **Fig. 3** and **Fig. 4**. Is battery voltage present?	Yes	Troubleshoot and repair a wiring fault in circuit 320 (941) between the washer pump and the wiper control module.
		No	Replace the wiper control module; see **Subject 150**.

Table 8, Washers Are Inoperative, Wipers Are OK

Washer Spray Does Not Correctly Cover Wipe Area			
Step	**Test Procedure**	**Test Result**	**Action**
1	Make sure that the fluid level in the washer fluid reservoir is adequate. If needed, add fluid.	—	—
2	Test the washer operation. Hold the washer switch in the ON position for at least 5 seconds, in case the washer system has lost its prime. Is the fluid flow adequate?	Yes	Troubleshooting is completed.
		No	Check the nozzles for damage, plugging, or improper installation. Check the hoses for kinks, or tie-wraps that may be too tight. Make sure that there are no breaks or disconnected fittings. Go to **step 3**.
3	Test the washer operation. Does the washer work properly?	Yes	Troubleshooting is completed.
		No	Replace the washer pump; see **Subject 140**.

Table 9, Washer Spray Does Not Correctly Cover Wipe Area

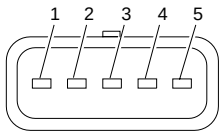
Terminal Identification of the Wiper Motor Harness Connector			
Wiper Motor Harness Connector (wire insertion view)	**Pin**	**Circuit Number**	**Circuit Description**
 f820260b	*Vehicles Built Before February 2001*		
	1	56	Wiper Motor High Speed
	2	58	Wiper Motor Low Speed
	3	57	Ground
	4	65	Ignition Power
	5	26	Park Switch Signal
	Vehicles Built From February 2001		
	1	315H	Wiper Motor High Speed
	2	315L	Wiper Motor Low Speed
	3	GND	Ground
	4	315	Ignition Power
	5	315P	Park Switch Signal

Table 10, Terminal Identification of the Wiper Motor Harness Connector

Values for Wiper Switch Positions Test*			
Switch Position	**Pin 6 to 7**	**Pin 6 to 8**	**Pin 6 to 14**
Off	1	1	1
Delay 1	1	1	0
Delay 2	1	0	1
Delay 3	1	0	0
Delay 4	0	1	1
Delay 5	0	1	0

Values for Wiper Switch Positions Test*			
Switch Position	**Pin 6 to 7**	**Pin 6 to 8**	**Pin 6 to 14**
Low Speed	0	0	1
High Speed	0	0	0

* Test for continuity betweens pin 6 and pins 7, 8, and 14. In the table, 1 indicates continuity, and 0 indicates an open circuit. When the measured resistance is less than 0.4 kohms, the continuity test passes. Replace the switch assembly if the test fails for any of the switch positions.

Table 11, Values for Wiper Switch Positions Test

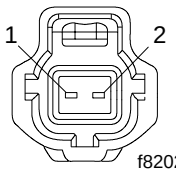
Terminal Identification of the Washer Pump Connector				
Washer Pump Connector	**Terminal**	**Circuit Number**	**Color**	**Circuit Description**
 f820296a	*Vehicles Built Before November 2001*			
	1	941	Black/White	Washer Power
	2	57	Black	Washer Ground
	Vehicles Built From November 2001			
	1	320	Dark Blue	Washer Power
	2	GND	Black	Washer Ground

Table 12, Terminal Identification of the Washer Pump Connector

Troubleshooting, Signal Stat Wiper and Washer

Terminal Identification of the Vehicle Harness Connector (see Fig. 4, Ref. D)		
Pin*	**Circuit Number**	**Circuit Function**
Vehicles Built From February 2001		
4	465	Battery Power 12V+ Module Supply
5	315H	High Speed to Wiper Motor 12V+
6	GND	Module Ground
8	320	Washer Pump 12V+
9	315L	Low Speed to Wiper Motor 12V+
10	315P	Park Switch Signal from Wiper Motor
11	315	Park Switch and Module 12V+ Supply
Vehicles Built Before February 2001		
4	575	Battery Power 12V+ Module Supply
5	56	High Speed to Wiper Motor 12V+
6	25	Module Ground
8	941	Washer Pump 12V+
9	58	Low Speed to Wiper Motor 12V+
10	28	Park Switch Signal from Wiper Motor
11	65	Park Switch and Module 12V+ Supply

* Pin numbers not listed are not used.

Table 13, Terminal Identification of the Vehicle Harness Connector

Terminal Identification of the Wiper Switch Connector (see Fig. 4, Ref. E)		
Pin*	**Color**	**Circuit Function**
1	Blue	Washer
6	White	Ground
7	Brown	Code C
8	Red	Code B
14	Green	Code A

* Pin numbers not listed are not used.

Table 14, Terminal Identification of the Wiper Switch Connector

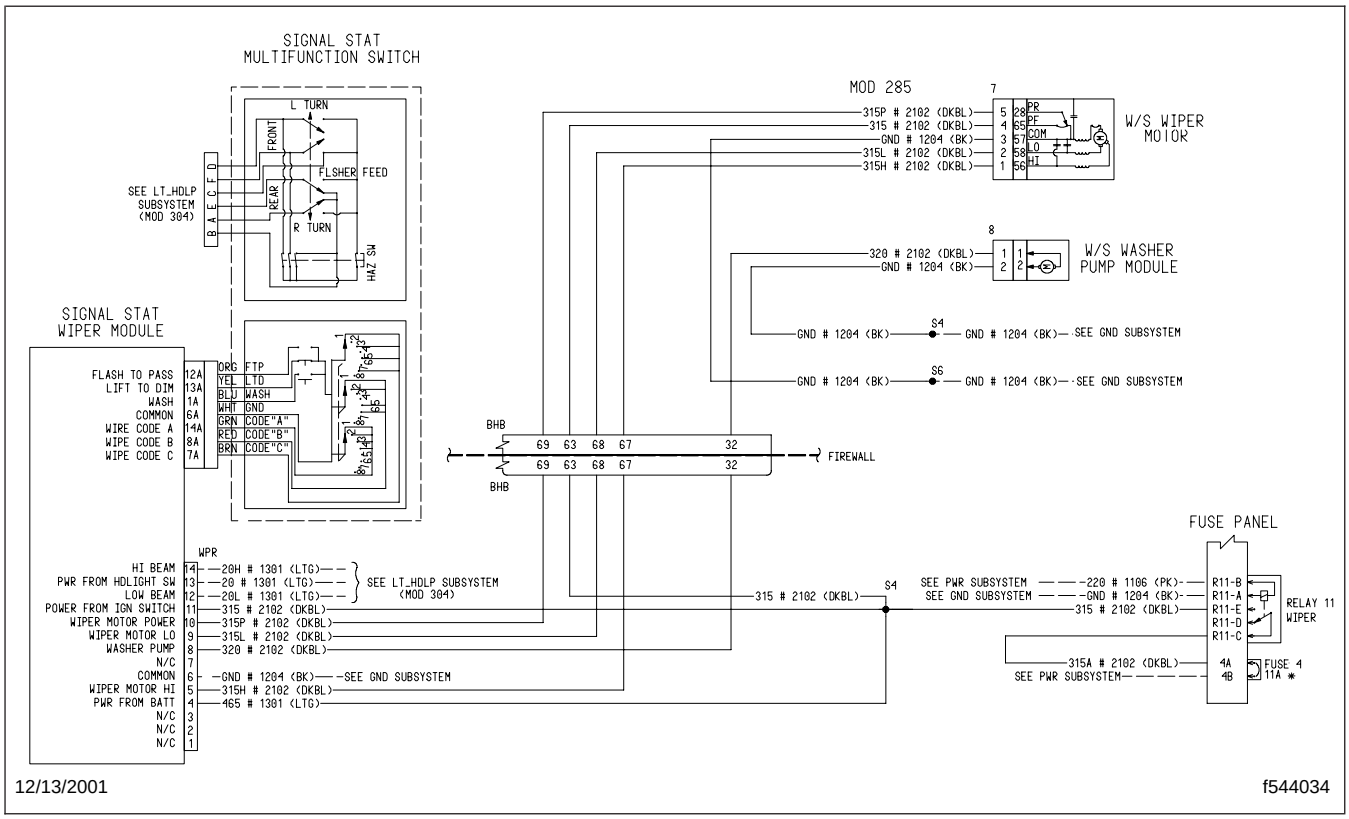


Fig. 1, Signal Stat Wiper/Washer Wiring Diagram, Vehicles Built From November 2001

Troubleshooting, Signal Stat Wiper and Washer

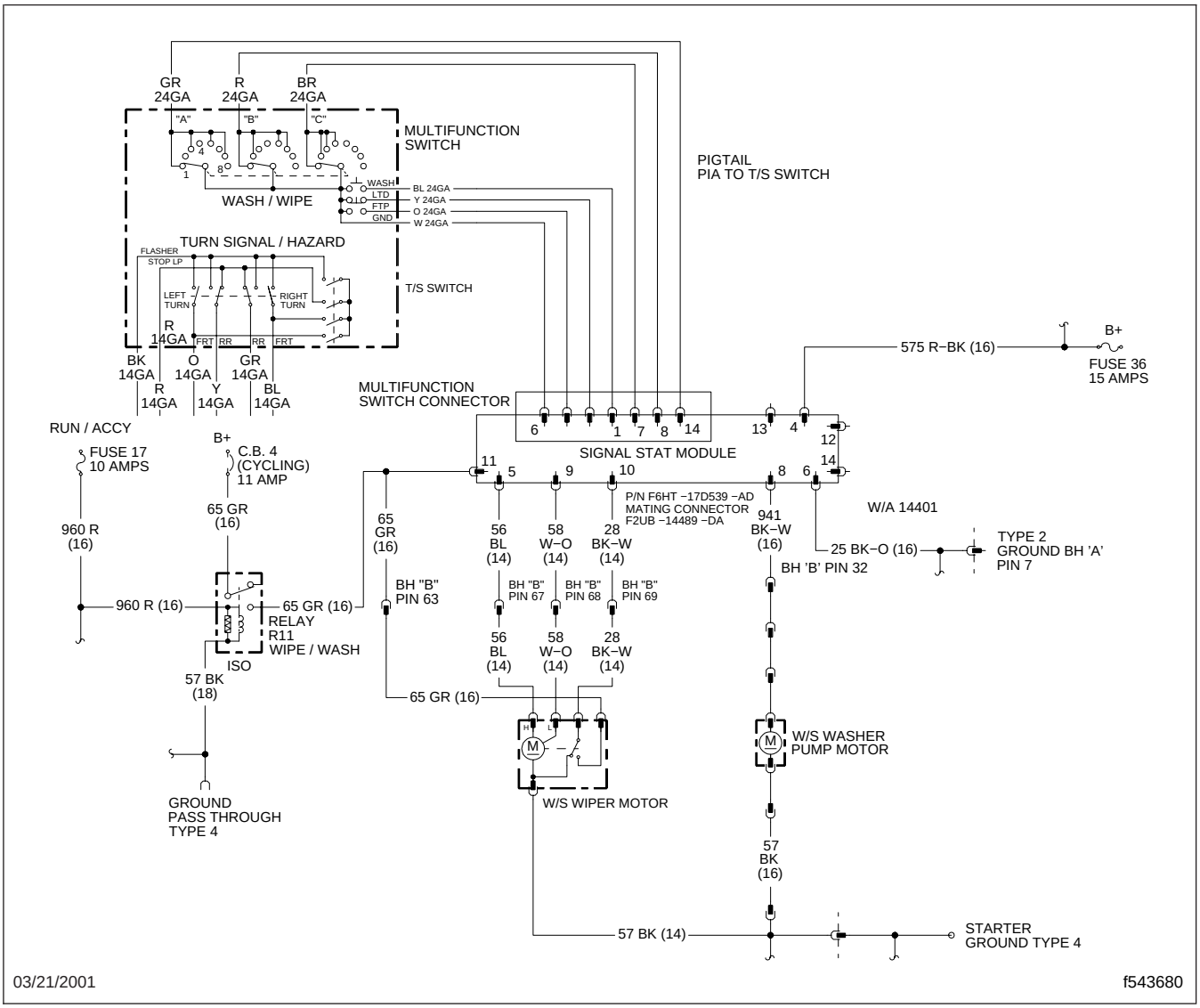
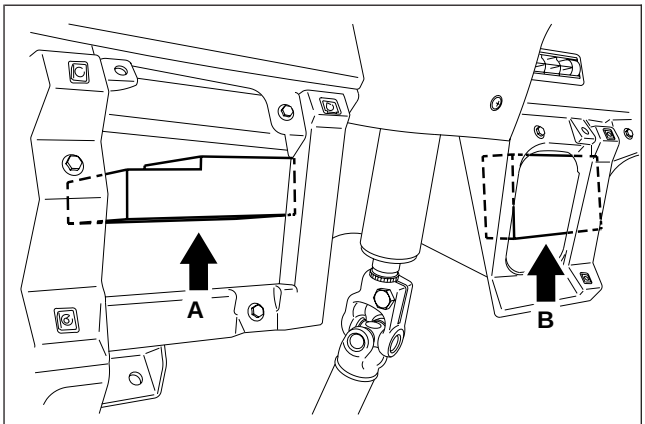


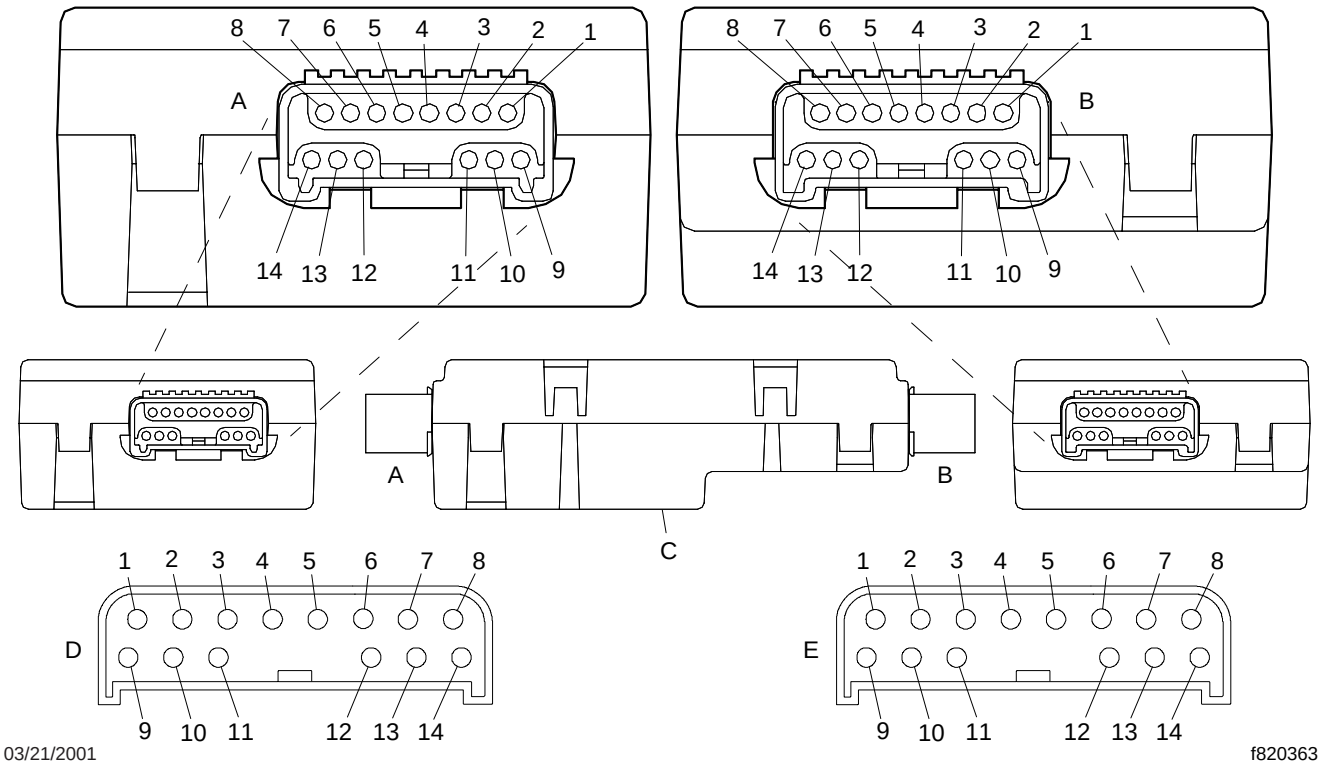
Fig. 2, Signal Stat Wiper/Washer Wiring Diagram, Vehicles Built Before November 2001



NOTE: The wiper control module is found at either location A or location B.

Fig. 3, Wiper Control Module Location

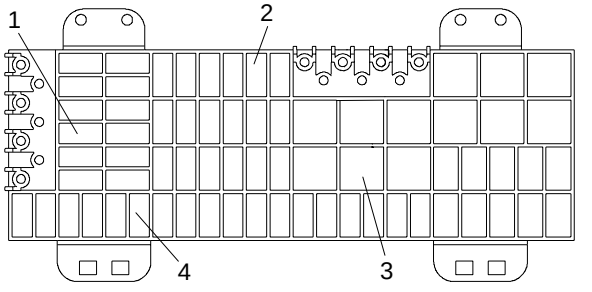
Troubleshooting, Signal Stat Wiper and Washer



NOTE: For terminal identification of the vehicle harness connector to and from the vehicle, items A and D, see **Table 13**. For terminal identification of the connector to and from the multifunction wiper control switch, items B and E, see **Table 14**.

A. Port A of Control Module, To and From the Vehicle
B. Port B of Control Module, To and From the Wiper Control Switch
C. Signal Stat Control Module
D. Vehicle Harness Connector To and From the Vehicle
E. Connector To and From the Multifunction Wiper Control Switch

Fig. 4, Signal Stat Control Module and Mating Connectors



1. CB4, Wiper/Washer Power
2. Fuse 17, Wiper/Washer Relay Ignition Switched Power
3. R11, Wiper/Washer Power
4. Fuse 36, Wiper/Washer Power

Fig. 5, Power Distribution Module (PDM), Instrument Panel

Troubleshooting, Wiper System with Dash-Mounted Switch

Troubleshooting

CAUTION

Use caution when working on or near the wiper linkage, arms, and motor. An intermittent wiper system may swipe without warning, posing a risk of personal injury.

NOTICE

Make sure the ignition switch is off before disconnecting any wiper/washer harness connectors. Removing connectors with the ignition switch on may cause electrical arcing, which will damage the pins.

Preliminary Checks

Before beginning the troubleshooting procedures, verify the driver's complaint by checking the system components, and operating the wiper and washer to duplicate the problem.

1. Check the wiper arms, blades, and linkage for wear and damage.
2. Check the washer fluid level in the reservoir.
3. Turn the ignition switch to the ON position without starting the engine.
4. Test the wipers on low speed, high speed, and several intermittent speeds.
5. Test the windshield washers.
6. Turn the ignition switch to the OFF position.
7. Check the washer hoses for leaks and damage.

Diagnostic Procedures

Symptoms

The diagnostic procedures listed in **Table 1** are described in detail in the succeeding tables. When performing the diagnostic procedures, refer to the wiring diagram (**Fig. 1**) and the tables in this subject.

NOTICE

Use caution when backprobing sealed connectors. If the seal is damaged, water could intrude into the connection, resulting in corrosion and electrical failure.

IMPORTANT: The following wiper and washer diagnostic procedures are performed with the ignition switch in the ON position, and the engine NOT running.

Troubleshooting Procedures	
Symptom	**Table Number**
Wipers are inoperative in all modes	**Table 2**
High-speed mode only is inoperative	**Table 3**
Low-speed and all intermittent speed modes are inoperative, high-speed mode is OK	**Table 4**
Wipers do not park in the proper position	**Table 5**
Wipers stay on until ignition is turned off	**Table 6**
Washers are inoperative	**Table 7**
Washer spray does not correctly cover wipe area	**Table 8**

Table 1, Troubleshooting Procedures

Wipers Are Inoperative In All Modes			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—

Troubleshooting, Wiper System with Dash-Mounted Switch

Wipers Are Inoperative In All Modes			
Step	**Test Procedure**	**Test Result**	**Action**
2	With the connector remaining connected, backprobe the wiper motor connector on pins 2 and 3 to measure for battery voltage; see **Table 9**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 120**.
		Low or at zero	Go to **step 3**.
3	Verify that pin 3 of the wiper motor connector is at ground potential; see **Table 9**. Is pin 3 at ground potential?	Yes	Go to **step 4**.
		No	Troubleshoot and repair the wiring fault in the ground circuit.
4	Access the wiper switch (**Fig. 2**) connector, and backprobe pin 1 to measure the voltage, with the connector remaining connected to the module; see **Table 10**. Is battery voltage present on pin 1?	Yes	Go to **step 5**.
		Low or at zero	Verify that fuse S in the underhood PDM is not open. Fuse S supplies the wipers in addition to F1, F2, and F3 in the dashboard PDM. Test for shorts in the circuits powered through these fuses, in addition to shorts to the wipers in circuits 315 and 315A, if fuse S is open. Test relay R11 and circuit breaker CB4 in the dashboard PDM; see **Fig. 3**. Circuit breaker CB4 or fuse S will open if the wiper switch is internally shorted. If unplugging the wiper switch allows circuit breaker CB4 to reset, then replace the wiper switch.
5	Test for ground at pin 6 of the wiper switch connector; see **Table 10**. Is ground present?	Yes	Go to **step 6**.
		No	Locate and repair the wiring fault in the ground circuit.
6	With the ignition set to the ON position and the wipers switched to low speed, measure the voltage on pin 3 of the wiper switch connector. Is the measured voltage at or within a few tenths of a volt to ground?	Yes	Test for an open circuit through the speed switching relays R24 and R25. Troubleshoot circuits 315, 315H, and 315L from the PDM to the wiper motor for wiring faults.
		No	Replace the wiper switch.

Table 2, Wipers Are Inoperative In All Modes

High-Speed Mode Only Is Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to high speed.	—	—
2	With the connector remaining connected, backprobe the wiper motor connector on pins 1 and 3 to measure for battery voltage; see **Table 9**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 120**.
		Low or at zero	Go to **step 3**.

Troubleshooting, Wiper System with Dash-Mounted Switch

High-Speed Mode Only Is Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
3	Access the wiper switch (**Fig. 2**) connector, and backprobe pin 4 to measure the voltage, with the connector remaining connected to the module, the ignition switch in the ON position, and the wipers set to high speed; see **Table 10**. Is the measured voltage at or within a few tenths of a volt to ground?	Yes	Test for an open circuit through relay R25 and its interconnecting wiring, including circuit 315H from the PDM to the wiper motor.
		No	Replace the wiper switch.

Table 3, High-Speed Mode Only Is Inoperative

Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—
2	With the connector remaining connected, backprobe the wiper motor connector on pins 2 and 3 to measure for battery voltage; see **Table 9**. Is battery voltage present?	Yes	Make sure that the wiper linkage is not slipping or binding. Otherwise, replace the wiper motor; see **Subject 120**.
		Low or at zero	Go to **step 3**.
3	Verify the ground at pin 3 of the wiper motor connector. Is it at ground potential?	Yes	Go to **step 4**.
		No	Repair the ground circuit 320.
4	With the wiper switch (**Fig. 2**) remaining connected to the connector, the ignition switch in the ON position, and the wipers set to low speed, backprobe the wiper switch connector on pin 3 to measure for battery voltage; see **Table 10**. Is the measured voltage at or within a few tenths of a volt to ground?	Yes	Test for an open circuit through the speed switching relays R24 and R25, and the interconnected wiring. Troubleshoot circuit 315L from the PDM to the wiper motor. Make sure that circuit 316 is at ground potential at both the wiper switch and at relay R24.
		No	Replace the wiper switch.

Table 4, Low Speed and All Intermittent Setting Modes Are Inoperative, High Speed Mode Is OK

Wipers Do Not Park in Proper Position			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed.	—	—

Troubleshooting, Wiper System with Dash-Mounted Switch

Wipers Do Not Park in Proper Position			
Step	**Test Procedure**	**Test Result**	**Action**
2	Turn the wiper switch off when the wipers are in mid-swipe. Do the wipers stop immediately, or continue traveling, then stop?	Immediately	Go to **step 3**.
		Continue traveling, then stop	Note the stopped position. Repeat the test to make sure that the wipers always stop in the same position. If the wipers always stop in the same position, regardless of where the switch was turned off, the wiper arm position is improperly adjusted. Turn the ignition switch to OFF, disconnect the batteries, then adjust the wiper arms to the correct position; see **Subject 160**.
3	With the ignition switch in the ON position and the wipers switched off, measure the voltage on pin 4 of the wiper motor connector; see **Table 9**. Is battery voltage present?	Yes	Go to **step 4**.
		No	Locate and repair the open circuit on circuit 315 between the wiper motor and splice S48.
4	With the ignition in the ON position and the wipers switched to low speed, measure the voltage on pin 5 of the wiper motor connector; see **Table 9**. Battery voltage should be present except when the wipers travel through the park position and the circuit is momentarily at ground. Is battery voltage present?	Yes	Go to **step 5**.
		No	Replace the wiper motor; see **Subject 120**.
5	With the wipers switched on, measure the voltage at terminal 87A of relay R24; see **Fig. 3**. Is battery voltage present?	Yes	Test for an open R24 relay.
		No	Locate and repair the open circuit between relay R24 and the wiper motor in circuit 315P.

Table 5, Wipers Do Not Park in Proper Position

Wipers Stay On Until Ignition Is Turned Off			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position. Leave the wiper switch in the OFF position. Do the wipers stay on at high speed or low speed?	High Speed	Troubleshoot for circuit 318 shorted to ground, and for relay R25 shorted between terminals 87 and 30.
		Low Speed	Go to **step 2**.
2	Backprobe pin 5 of the wiper motor connector to check the voltage through the wiper motor's internal park switch; see **Table 9**. When the wipers travel through the park position, pin 5 should be momentarily at ground. Most voltmeters respond quickly enough to show this momentary voltage transition. Is the momentary voltage transition to ground present?	Yes	Troubleshoot and repair for circuit 316 shorted to ground, and for relay R24 shorted between terminals 87 and 30.
		No	The wiper motor internal park switch is not working. Replace the wiper motor; see **Subject 120**.

Troubleshooting, Wiper System with Dash-Mounted Switch

Wipers Stay On Until Ignition Is Turned Off			
Step	**Test Procedure**	**Test Result**	**Action**
3	Did all the preceding tests pass?	Yes	Replace the wiper switch.

Table 6, Wipers Stay On Until Ignition Is Turned Off

Washers Are Inoperative			
Step	**Test Procedure**	**Test Result**	**Action**
1	Turn the ignition switch to the ON position, and the wiper switch to low speed. Do the wipers work?	Yes	Turn the wipers off. Go to **step 2**.
		No	Follow the troubleshooting procedure under "Wipers Are Inoperative In All Modes"; see **Table 2**.
2	Check the washer reservoir fluid level. Add fluid if needed, then test the washer operation. Hold the washer switch on for at least 5 seconds in case the hoses are leaking, or the system has lost its prime. Is the pump running?	Yes	Check the system for leaks. Also follow the troubleshooting procedure under "Washer Spray Does Not Correctly Cover Wipe Area"; see **Table 8**.
		No	Go to **step 3**.
3	If the system is not leaking, backprobe the connections at the washer pump, and test for battery voltage when the washer switch is activated. Is battery voltage present?	Yes	Replace the washer pump; see **Subject 140**.
		No	Go to **step 4**.
4	With the wiper switch (**Fig. 2**) remaining connected to the connector, and the ignition switch in the ON position, backprobe pin 5 of the wiper switch to measure for battery voltage; see **Table 10**. When the washers are activated, is the measured voltage at or within a few tenths of a volt to ground?	Yes	Troubleshoot for a fault in circuit 320 or with relay R20 and its wiring. Also troubleshoot for a fault in the ground circuit between the washer pump and the ground stud.
		No	Replace the wiper switch.

Table 7, Washers Are Inoperative

Washer Spray Does Not Correctly Cover Wipe Area			
Step	**Test Procedure**	**Test Result**	**Action**
1	Make sure that the fluid level in the washer fluid reservoir is adequate. If needed, add fluid.	—	—
2	Test the washer operation. Hold the washer switch in the ON position for at least 5 seconds, in case the washer system has lost its prime. Is the fluid flow adequate?	Yes	Troubleshooting is completed.
		No	Check the nozzles for damage, plugging, or improper installation. Check the hoses for kinks, or tie-wraps that may be too tight. Make sure that there are no breaks or disconnected fittings. Go to **step 3**.

Troubleshooting, Wiper System with Dash-Mounted Switch

Washer Spray Does Not Correctly Cover Wipe Area			
Step	**Test Procedure**	**Test Result**	**Action**
3	Test the washer operation. Does the washer work properly?	Yes	Troubleshooting is completed.
		No	Replace the washer pump; see **Subject 140**.

Table 8, Washer Spray Does Not Correctly Cover Wipe Area

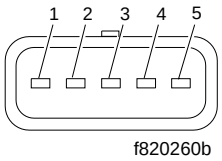
Terminal Identification of the Wiper Motor Harness Connector			
Wiper Motor Harness Connector (wire insertion view)	**Pin**	**Circuit Number**	**Circuit Description**
 f820260b	1	315H	Wiper Motor High Speed
	2	315L	Wiper Motor Low Speed
	3	GND	Ground
	4	315	Ignition Power
	5	315P	Park Switch Signal

Table 9, Terminal Identification of the Wiper Motor Harness Connector

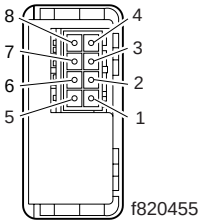
Terminal Identification of the Wiper/Washer Switch Connector			
Washer/Wiper Switch Connector	**Pin**	**Circuit Number**	**Circuit Description**
 f820455	1	315	Ignition Power
	2	29A	Backlighting
	3	316	Wiper Motor Low Speed
	4	318	Wiper Motor High Speed
	5	320A	Washer Pump
	6	GND	Ground
	7	—	Not used
	8	—	Not used

Table 10, Terminal Identification of the Wiper/Washer Switch Connector

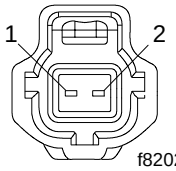
Terminal Identification of the Washer Pump Connector				
Washer Pump Connector	**Terminal**	**Circuit Number**	**Color**	**Circuit Description**
 f820296a	1	320	Dark Blue	Washer Power
	2	GND	Black	Washer Ground

Table 11, Terminal Identification of the Washer Pump Connector

Troubleshooting, Wiper System with Dash-Mounted Switch

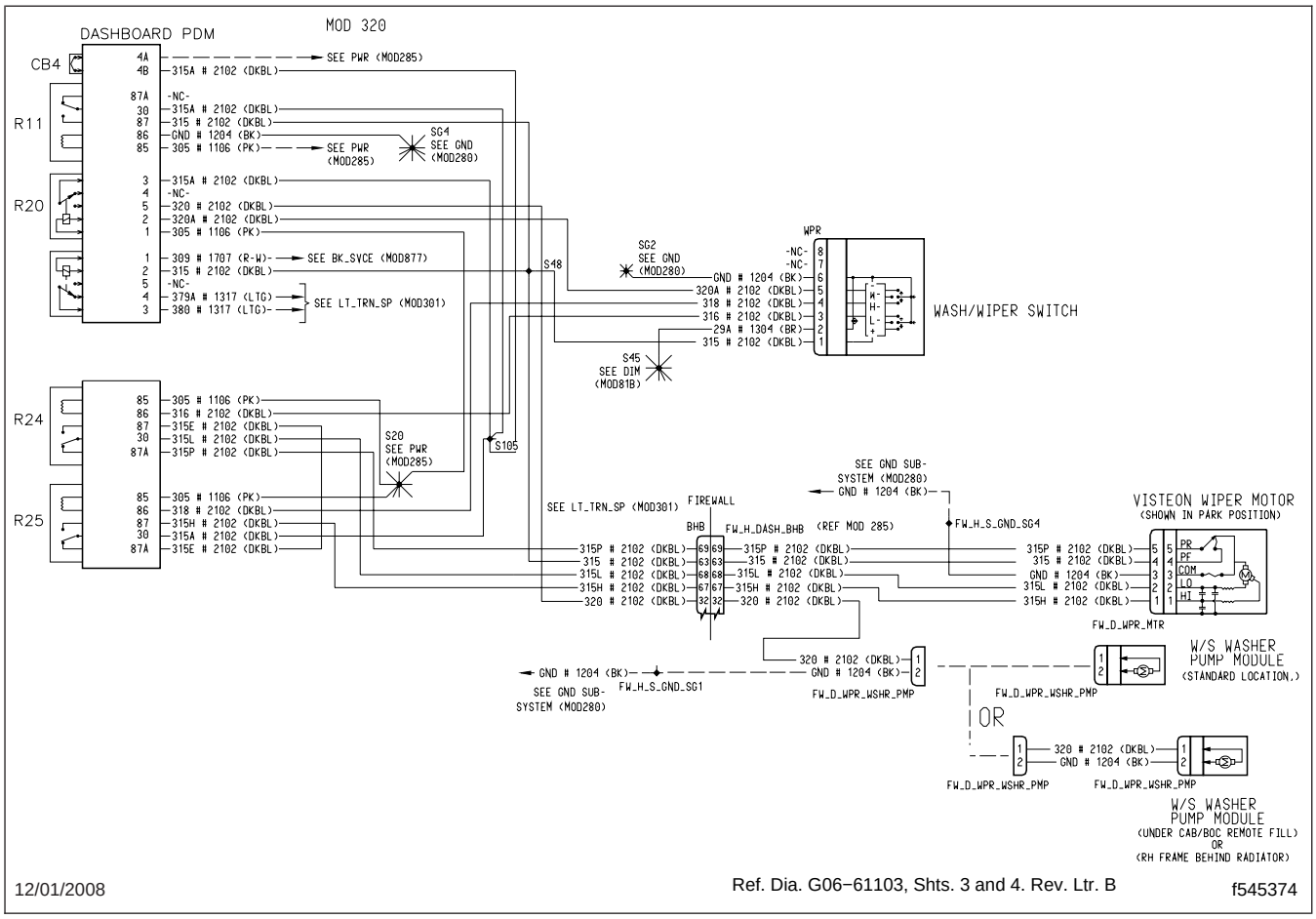


Fig. 1, Wiring Diagram, Wiper/Washer With a Dash-Mounted Switch

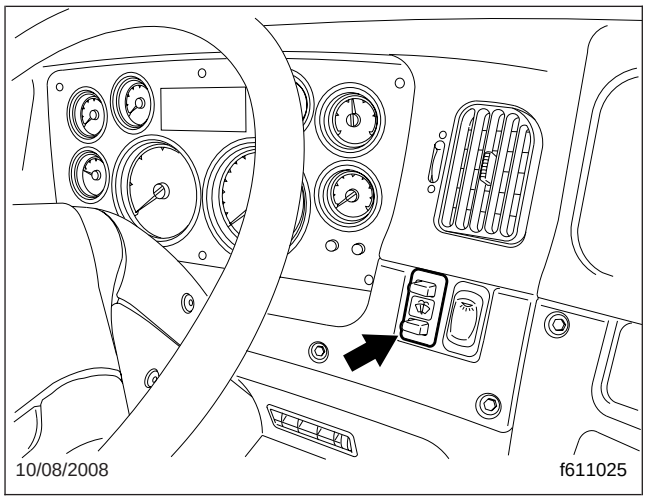
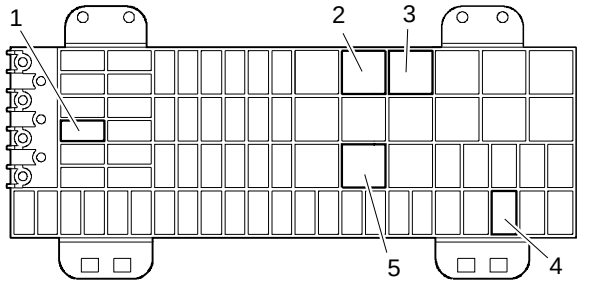


Fig. 2, Location of Dash-Mounted Wiper/Washer Switch

Troubleshooting, Wiper System with Dash-Mounted Switch



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1. CB4, Wiper/Washer Power
2. R24, Wiper—Low Speed
3. R25, Wiper—High Speed
4. R20, Washer Pump
5. R11, Wiper/Washer Power

Fig. 3, Power Distribution Module (PDM), Instrument Panel

Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.06**.

Torque Specifications	
Description	**lbf·in (N·cm)**
Wiper Motor Retaining Screws	80–115 (900–1300)
Mounting Arm and Pivot Shaft Retaining Screws	80–115 (900–1300)

Table 1, Torque Specifications

Thermodynamic Principles

Air conditioning is the cooling or refrigeration of the air in the passenger compartment. Refrigeration is accomplished by making practical use of three thermodynamic principles. These principles and their practical application are described below.

Heat Transfer

If two objects of different temperatures are placed near each other, the heat in the warmer object will always travel to the cooler object until both are of equal temperature.

For example, a block of ice in a refrigerator does not transfer its coldness to a nearby carton of milk. Rather, the heat in the warm milk automatically flows to the ice.

The British Thermal Unit (BTU) is used to determine the amount of heat transferred from one object to another. One BTU is the amount of heat required to raise the temperature of 1 pound (0.45 kg) of water 1°F (0.55°C).

For example, to raise the temperature of 1 pound (0.45 kg) of water from 32°F to 212°F (0°C to 100°C), one BTU of heat must be added for 1°F (0.55°C) rise in temperature or a total of 180 BTUs of heat. Conversely, in order to lower the temperature of 1 pound (0.45 kg) of water from 212°F to 32°F (100°C to 0°C), 180 BTUs of heat must be removed from the water.

Latent Heat of Vaporization

When a liquid boils, it absorbs heat without raising the temperature of the resulting gas. When the gas condenses (changes back to a liquid), it gives off heat without lowering the temperature of the resulting liquid.

For example, when 1 pound (0.45 kg) of water at 32°F (0°C) is placed in a container over a flame, the temperature of the water rises 1°F (0.55°C) with each BTU of heat that the water absorbs from the flame. Thus, after it has absorbed 180 BTUs of heat, the water reaches a temperature of 212°F (100°C).

Even though the flame continues to give its heat to the water, the temperature of the water remains at 212°F (100°C). The water however starts to boil or change from a liquid to a gaseous state. It continues to boil until the water has passed off into the atmosphere as vapor. If this vapor were checked with a thermometer, it also would show a temperature of 212°F (100°C).

In other words, there was a rise of only 180°F (from 32°F to 212°F or 0°C to 100°C) in the water and vapor temperature even though the flame applied many more than 180 BTUs of heat. In this case, the heat is absorbed by the liquid in the process of boiling and disappears in the vapor. If the vapor were brought in contact with cool air, the hidden heat would flow into the cooler air and the vapor condensed back to water. Scientists refer to this principle as the latent (hidden) heat of vaporization.

Water has a latent heat of vaporization of 970 BTUs and a boiling point of 212°F (100°C). This means that 1 pound (0.45 kg) of water at 212°F (100°C) will absorb 970 BTUs of heat when changing to vapor at 212°F (100°C). Conversely, the vapor will give off 970 BTUs of heat when condensing back to water at 212°F (100°C).

This heat transfer, occurring when a liquid boils or a vapor condenses, forms the basic principle of all conventional refrigerant systems.

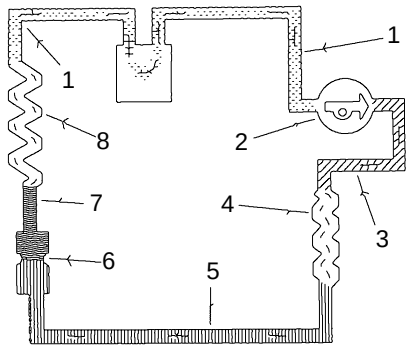
For a liquid to be a refrigerant, it must also have a low boiling point. That is, the temperature at which it boils must be lower than the substance to be cooled.

R–134a is a non-CFC refrigerant. Its temperature/pressure relationship makes it suitable for mobile air conditioning systems.

Effect of Pressure on Boiling or Condensation

As refrigerant passes through an air conditioning system, it flows under high-pressure conditions, first as a high-pressure vapor between the refrigerant compressor and the condenser, then as a high-pressure liquid between the condenser and the evaporator orifice. It expands to a low-pressure vapor between the evaporator orifice and the refrigerant return port in the refrigerant compressor. As pressures in the closed refrigerant circuit vary, temperatures will also vary. As pressure increases, temperatures also increase; as the pressure decreases, temperatures also decrease. The refrigerant flow diagram highlights the changes that take place. See **Fig. 1**.

General Information



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1. Low-Pressure Vapor
2. Refrigerant Compressor
3. High-Pressure Vapor
4. Condenser
5. High-Pressure Liquid
6. Restriction
7. Low-Pressure Liquid
8. Evaporator

Fig. 1, Refrigerant Flow

General Information (See Fig. 1)

The heater and air conditioner assembly is mounted behind the passenger dash panels and on the engine side of the frontwall. The heater and air conditioner assembly contains the following major components:

- accumulator
- blower motor
- climate control panel
- condenser
- electric actuators
- evaporator
- heater core
- orifice tube
- refrigerant compressor
- refrigerant compressor cycling switch

The heating, air conditioning, and ventilating functions of the cab heater and air conditioner system are controlled by the cab climate control panel mounted on the dashboard. Refer to the *L-Line and A-Line Driver's Manual* for operating instructions.

Description of Components

Accumulator

When entering the inlet of the accumulator, the refrigerant contacts the liquid diverter dome and flows to the bottom of the housing. The refrigerant completes vaporization and passes into the suction inlet. A small, screened bleed hole in the bottom allows oil to be sucked into the suction tube to return to the compressor.

A desiccant bag inside the accumulator absorbs any moisture that may be in the system. A fitting on the accumulator is used to mount the refrigerant compressor cycling switch. The fitting prevents refrigerant loss when the cycling switch is removed.

Blower Motor

The blower motor forces air through the HVAC assembly and through the duct work.

Climate Control Panel

The fan switch, temperature control switch, and air selection switch are mounted on the climate control panel, which is also called the control head. The fan switch is used to control the rate of airflow through the outlets. The temperature control switch is used to select the desired temperature. The air selection switch is used to select the direction of warm or cool air through the air outlets.

Condenser

A condenser turns hot refrigerant gas coming from the refrigerant compressor into liquid. The condenser is mounted in front of the radiator. 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.

Electric Actuator

The electric actuator is a combined motor and gearbox that is used to control the position of the doors within the HVAC assembly. The position of the doors is controlled by the settings on the climate control panel. There are five electric actuators on the HVAC assembly:

- the temperature/blend air actuator

- the defrost/panel actuator
- the right-side panel/demist actuator
- fresh air/recirculation actuator
- panel/floor actuator

Evaporator

The evaporator is located in the evaporator housing on the engine side of the frontwall. Because the evaporator is an area of low pressure in the refrigerant system, the boiling point of refrigerant lowers, which causes it to absorb heat from the tubing walls and fins. As it absorbs heat, liquid refrigerant quickly boils and turns into a gas.

As heat is absorbed from the outside surfaces of the evaporator, air passing over the unit loses its heat to these cooler surfaces. Moisture in the air condenses on the outside of the evaporator and drains off as water; the air becomes dehumidified.

Heater Core

When the engine is on, coolant flows through the heater core tubes heating the tubes and fins. The heat is absorbed by air that is forced through the heater core by the blower motor.

Orifice Tube

The orifice tube separates the high- and low-pressure sides of the HVAC system and meters the flow of refrigerant into the evaporator. The orifice tube is located in the inlet tube to the evaporator. The orifice tube has screens on the inlet and outlet ends of the tube. The inlet screen is a strainer for the liquid refrigerant flowing through the opening. The outlet screen reduces the noise of the refrigerant flowing through the orifice tube. O-rings on the orifice tube prevent the high pressure liquid refrigerant from bypassing the orifice tube. The orifice tube cannot be adjusted or repaired; it must be replaced.

Refrigerant Compressor

Heat in the low-pressure gas of the evaporator 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 evaporator is very cold. As a result, there is the problem of how to remove heat from cool 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.

Refrigerant Compressor Cycling Switch

The refrigerant compressor cycling switch is mounted on the accumulator. The electrical contacts within the cycling switch are normally open below an operating pressure of about 23 psi (159 kPa). The electrical contacts close to allow compressor operation when internal pressure rises above approximately 40 to 47 psi (275 to 324 kPa). Lower ambient air temperatures (below 50°F or 10°C) during cold seasons will also open the contacts due to the pressure/temperature relationship of the refrigerant in the system.

The electrical contacts control the circuit to the compressor clutch field coil. When the contacts are closed, the compressor clutch field is energized and the clutch engages to drive the compressor. When the contacts are open, the compressor clutch field coil is de-energized and the compressor does not operate. The cycling switch, when operating properly, will control the refrigerant pressure within the evaporator at a point when the plate/fin surface of the evaporator will be maintained slightly above freezing to prevent icing and blockage of airflow.

Definition of Terms

Refer to the following terms for a better understanding of the HVAC system.

Accumulator A combination desiccant, filter, and storage container for liquid refrigerant.

Air Conditioner A system used to control the temperature, humidity, and movement of air in the cab.

Ambient Air Temperature The temperature of air around an object or the outside temperature.

Binary Switch See high-pressure switch and low-pressure switch.

General Information

Blower Motor A blower motor forces air through the HVAC assembly and through the duct work.

Blower Resistor Block Assembly Inline resistors that control the amount of voltage going to the blower motor. By controlling the voltage, you can control the fan speed.

Boiling Point The temperature at which a liquid changes to a gas. The boiling point varies with pressure.

Bulk Charging Use of large containers of refrigerant for charging a refrigerant system. Normally used for charging empty systems.

Charge A specific amount of refrigerant or oil by volume or weight. Also, the act of placing an amount of refrigerant or oil in the air conditioning system.

Clutch Cycling Switch Engages or disengages the refrigerant compressor depending on changes in system pressure on the low side. Same as low-pressure switch.

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. Typically the condenser is mounted in front of the radiator.

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, dirt, or air in the system.

Cycling Clutch System A system that 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.

Dehydrate To remove all traces of moisture from the refrigerant system. This process occurs during evacuation.

Desiccant A drying agent used in the accumulator to remove water and create an extremely dry condition.

Discharge Line Connects the refrigerant compressor outlet to the condenser inlet.

Discharge Pressure High-side pressure or condensing pressure being discharged from the compressor.

Drive Pulley A pulley attached to the front of the engine crankshaft. It drives the compressor clutch pulley with a belt.

Duct A passageway for the transfer of air from one point to another.

Electric Actuator The actuator is a combined motor and gearbox used to drive the doors within the HVAC assembly.

Evacuate To place a high vacuum in the refrigerant system to remove air and dehydrate or remove traces of moisture.

Evaporate To change state from a liquid to a gas.

Evaporator A component in which liquid refrigerant changes to a gas after it absorbs heat from the air. It 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 normal condition in the evaporator of an orifice tube system. The evaporator operates flooded and evaporates only the liquid closest to the outlet.

Flushing A process of passing liquid refrigerant through an air-conditioner component to remove dirt and water from the part. Liquid refrigerant removes heavy contamination, such as gritty dirt and large dirt buildup.

Freeze-Up Failure of a unit to operate properly because of ice forming at the expansion valve orifice or on the evaporator.

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-Pressure Switch Located on the discharge side of the refrigerant compressor, the high-pressure switch signals the fan on and the refrigerant compressor off in the event of a high pressure condition.

High-Side Service Valve A device located on the liquid line before the expansion device. 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 condenser to the expansion device.

Low Head Pressure High-side pressure that is lower than normal due to a system problem.

Low-Pressure Switch Located on the suction side of the refrigerant compressor, the low pressure switch signals the clutch to cycle or shut down in extremely cold temperatures, or if there is a loss of charge.

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 A device to control refrigerant flow for system test purposes. It is 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. The unit of measure is used to measure vacuum drawn from a refrigerant system by a vacuum pump.

Nitrogen A colorless, odorless, dry, inert gas.

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.

Orifice Tube Fixed expansion device located in the cab evaporator inlet that controls the amount of refrigerant that passes into the evaporator.

Overcharge Too much refrigerant or oil in the system.

Polyalkylene Glycol (PAG) Highly refined synthetic refrigerant oil that is used in R–134a air conditioning systems.

psia Pounds per square inch, absolute pressure. 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.

Recovery Removal of the refrigerant from the air conditioning system.

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.

Refrigerant 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.

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 accumulator outlet to the compressor inlet.

Suction Pressure Compressor inlet pressure or the system's low-side pressure.

Suction Service Valve A device located on the suction hose near the accumulator 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 device 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 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.

General Information

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.

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, 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.

R–134a refrigerant 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 that could cause personal injury or property damage.

You must work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG) oil is used in the compressor. When handling PAG oil:

- Keep the oil free of contaminants;
- Do not expose the air conditioning system or the PAG oil container to air for long periods of time. PAG oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use;
- Use care when handling spilled oil. The oil could damage painted surfaces, plastic parts, and other components, such as drive belts;
- Never mix PAG oil with other types of refrigerant oil.

Required Equipment

You will need a machine, or machines, to identify the refrigerant and to recover, evacuate, flush, and charge the refrigerant system. Ideally, one machine can perform all the following functions:

- Identification–The machine must be able to verify the purity of the refrigerant in the refrigerant system and the presence of hydrocarbon-based refrigerants or other unapproved refrigerants.
- Recovery–The machine must be able to fully recover the refrigerant from the refrigerant system.
- Evacuation–Ideally, the machine should have a vacuum pump rated at 6 cfm and be maintenance free. A machine that requires maintenance is acceptable as long as it is properly maintained.
- Charging–The scale used in charging should be accurate to within ±1 ounce (30 mL).
- Flushing–Adaptors for the compressor(s), expansion device(s), and accumulator-drier should be purchased or fabricated to flush the system with refrigerant.

Refrigerant Identification

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

IMPORTANT: Identify the refrigerant in the refrigerant system if you suspect one of the following conditions:

- an excess noncondensable gas, such as nitrogen or air, is in the system
- an unapproved refrigerant is in the system
- the history of refrigerant system repairs is unknown

1. Using a high-quality refrigerant identifier and the manufacturer's instructions, attach the identifier to the vehicle and perform the test.
2. If the vehicle passed the test, it is safe to recover the refrigerant.
3. If the vehicle failed the test due to an excessive amount of noncondensable gas, recover the refrigerant system, then purge the recovery tank of the noncondensable gas.
4. If the vehicle failed the test due to the presence of a hydrocarbon-based refrigerant or a refrigerant other than R-134a, **do not recover the refrigerant into the general-use machine.** To recover the refrigerant system, recover the refrigerant into a separate container that contains refrigerant that must be recycled by a qualified recycling center. It is best to refer the customer to the place where the vehicle was last serviced.

Recovery

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against 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. Turn off the engine, apply the parking brakes, chock the tires, and open the hood.
2. Remove the caps from the suction and discharge service valves.
3. If the history of refrigerant system repairs is unknown, or if you suspect that the system is charged with an unapproved refrigerant, identify the refrigerant using the "Refrigerant Identification" procedures.
4. Wearing protective goggles and nonleather gloves, attach the refrigerant recovery and charging machine 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.

5. Follow the refrigerant recovery and charging machine manufacturer's instructions and recover all of the refrigerant from the refrigerant system.

IMPORTANT: Always comply with all federal and local regulations regarding refrigerant recovery and disposal. You may be subject to substantial penalties for improper procedures.

6. Measure the oil recovered during the recovery process. The refrigerant system will have to be filled 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 accumulator-drier, and flush the condenser and evaporator(s). After the system is charged, perform a performance check to ensure that the heat exchangers are not plugged.

Evacuating

The main purpose in evacuating the refrigerant system is to remove noncondensable gases (NCG), such as nitrogen and air. The secondary purpose is to boil off free water molecules.

In rare cases, water forms ice crystals at the expansion valve. Ice crystals retard or stop the flow of refrigerant, causing a reduction or complete loss of cooling. As the expansion valve warms due to the lack of refrigerant, the ice melts and passes through the expansion valve. Then refrigerant will flow again until the ice crystals re-form. The result is intermittent cooling.

Refrigerant oil has an extremely high moisture absorption capacity. Typically, the moisture picked up by the oil is passed on to the accumulator-drier. If excessive moisture exists in the system, the lubricating ability of the oil is reduced, which could damage the compressor and other components.

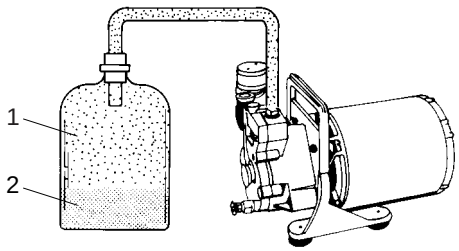
Effects of Pressure on the Boiling Point of Water

⚠ WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

Water boils at 212°F (100°C) at an atmospheric pressure of 14.7 psi (101 kPa) at 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 you 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 lowest at the pump, NCG and water vapor are pulled out of the system. This process is called evacuation or dehydration. See **Fig. 1**.



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1. Vapor 2. Water

Fig. 1, Water to Vapor

Measuring Vacuum

Vacuum should be measured with an electronic thermistor vacuum gauge, which is designed for use with high vacuum pumps and can accurately read as low as 100 microns. This gauge can have an analog scale or a digital (LED or LCD) display.

The location of the vacuum gauge will affect the reading. The closer to the vacuum source, the lower the reading will be. Follow the manufacturer's instructions for proper use of the vacuum gauge.

If the pressure will not stabilize, it is an indication of a leak. If it does stabilize at a vacuum that is too high, for example 1500 microns Hg, it is an indication of moisture and more evacuation is required.

Boiling Temperatures of Water at Converted Pressures		
Boiling Temperature of Water: °F (°C)	**Absolute Pressure: psi (microns Hg)**	**Vacuum: inHg (mmHg)**
212 (100)	14.696 (759993.4)	0 (0)
205 (96)	12.770 (660400.0)	3.92 (99.6)
194 (90)	10.169 (523881.6)	9.22 (234.2)
176 (80)	6.8699 (355269.8)	15.93 (404.6)
158 (70)	4.5207 (233786.7)	20.72 (526.3)
140 (60)	2.8900 (149580.7)	24.04 (610.6)
122 (50)	1.7987 (92555.1)	26.28 (667.5)
104 (40)	1.0700 (55336.4)	27.74 (704.6)
89 (30)	0.61540 (31826.2)	28.67 (728.2)
86 (27)	0.57010 (26220.4)	28.89 (733.8)
76 (24)	0.44435 (22979.9)	29.02 (737.1)
72 (22)	0.38856 (20094.7)	29.13 (739.9)
69 (21)	0.35084 (18143.7)	29.21 (741.9)
64 (18)	0.29505 (15258.5)	29.32 (744.7)
59 (15)	0.24720 (12783.8)	29.42 (747.3)
53 (12)	0.19888 (10285.0)	29.52 (749.8)
45 (7)	0.14746 (7625.8)	29.62 (752.3)
32 (0)	0.08858 (4579.6)	29.74 (755.4)
21 (–6)	0.05293 (2738.1)	29.81 (757.2)
6 (–14)	0.02521 (1304.0)	29.87 (758.7)
–24 (–31)	0.004905 (253.7)	29.911 (759.74)
–35 (–37)	0.002544 (131.6)	29.915 (759.84)
–60 (–51)	0.0004972 (25.7)	29.9200 (759.968)
–70 (–57)	0.0002443 (12.69)	29.92050 (759.9807)
–90 (–68)	0.0000526 (2.72)	29.92089 (759.9906)

Table 1, Boiling Temperatures of Water at Converted Pressures

Holding a vacuum is only an indication that there are not any leaks that are present under a vacuum. Other leaks may exist when the system is pressurized, so a proper leak test must be performed in conjunction with holding a vacuum.

Maintaining an Oil-Lubricated Vacuum Pump

Maintenance is important for a high-vacuum pump. The oil must be changed at regular intervals to prevent moisture buildup, which will cause decreased pump performance and eventual pump failure.

Pumping down for extremely wet air conditioning systems can completely saturate the pump oil, which will require the replacement of the vacuum pump oil.

⚠ CAUTION

Flush the vacuum pump every fourth time it is used, and before storing for long periods of time.

Acid will form and corrode the pump, if water-laden oil remains in the pump for an extended period.

Vacuum pump oil is water soluble. This aids the pump in reaching a high vacuum by absorbing water and sealing the pump.

Use only vacuum pump oil 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 refrigerant compressor filled with the correct amount of refrigerant oil. Replace the accumulator-drier if the system conditions require it.
2. Make sure the vacuum pump has been properly maintained.
3. Wearing protective goggles and nonleather gloves, attach the refrigerant recovery and charging machine hoses, or a vacuum pump, 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.

4. Follow the refrigerant recovery and charging machine manufacturer's instructions and evacuate the refrigerant system.
5. A minimum of 10 minutes with a 6-cfm pump should be used to evacuate the system. Evacuate the system for a longer period of time if using a smaller pump. Make sure that the vacuum level reaches a point where water would boil and does not go back to zero, then proceed with charging and leak testing the system.

Flushing

⚠ WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

Flushing removes moisture-laden oil and some contamination, such as dirty oil and some particle. When a part is flushed, liquid refrigerant is forced through it. The liquid picks up the contaminants and flushes them out.

Whether to flush, or replace a part depends on how much contamination there is as previously described.

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 and/or refrigerant parts show signs of internal corrosion and grit, the system is contaminated.

If the system is contaminated with moisture, flush all sections of the system. Then change the oil in the compressor and replace the accumulator-drier prior to evacuating and charging the system.

If the system is heavily contaminated or if desiccant has circulated through the system, replace the accumulator-drier, expansion valve(s), and inspect the compressor.

Do not flush the accumulator-drier or the compressor.

Flush the system in segments to lessen the chance of blowing deposits against a port.

Flush the system in the opposite direction of refrigerant flow. In other words, backflush the sections.

Flushing parts with refrigerant requires a refrigerant recovery and charging machine.

Flushing Procedure

Method 1

NOTE: Use this method when the recovery and charging machine is equipped with a flush cycle.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), accumulator-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter and follow the instructions from the manufacturer of the recovery and charging machine to perform the flush. When flushing the entire system, use an adaptor that fits where the compressor was located and backflush.
4. Remove the adaptors and bypass devices and install the expansion device(s), the compressor, and a new accumulator-drier.
5. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
6. Charge the system with refrigerant and check the system performance.

Method 2

NOTE: Use this method when two recovery and charging machines are available.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), accumulator-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter. When flushing the entire system, use an adaptor that fits where the compressor was located and backflush.
4. Charge the part with 2 pounds (0.9 kg) of refrigerant or the system with 5 pounds (2.3 kg) of refrigerant, then recover the refrigerant with a second machine. It is desirable to start the recovery slightly before the charge cycle is done since this helps to push fluid through the system. Repeat the process several times until you think that all the oil has been removed.
5. Remove the adaptors and bypass devices and install the expansion device(s), the compressor(s), and a new accumulator-drier.
6. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
7. Charge the system with refrigerant and check the system performance.

Charging

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against 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 charging machine connected to the service and discharge port connections.

1. Obtain enough refrigerant to fully charge the system. To determine the amount of refrigerant needed to fully charge the system, read the Air Conditioner label on the vehicle or see **Specifications 400**.
2. Charge the system on the high side following the refrigerant recovery and charging machine manufacturer's instructions.
3. While the compressor is engaged, check the duct temperature and operating pressures at the suction and discharge ports. Compare the temperature and pressures to those in **Specifications 400**. If the operating pressures are not acceptable, see **Subject 300** for troubleshooting procedures.
4. Disconnect the hoses.
5. Shut down the engine.
6. Recover the refrigerant that is in the hoses.

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 nearly 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. 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 refrigerant 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 the workshop manual. Visible dye on the front of the compressor clutch **does not** verify that there is a repairable 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.

UV Dye Leak Detection

IMPORTANT: When using the UV dye leak detection method, always wear protective eyewear that blocks UV rays and enhances the appearance of the dye. Always wear nonleather gloves and protective eyewear when servicing the air conditioning system.

1. Inspect the refrigerant system for leaks using a UV lamp.
   - 1.1 Inspect the entire refrigerant 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 refrigerant 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 over time.

3. See **Table 2** for a list of products that have been tested and approved for use by Freightliner dealers.
4. Close the hood and remove the chocks from the tires.

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 2, Approved Products for UV Dye Leak Detection

Electronic Leak Detection

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.

When checking for leaks, move the probe all the way around the fitting or suspected leak.

Freightliner recommends using only certain makes of the heated diode and infrared (IR) types of electronic leak detectors.

Recommended electronic heated diode type leak detectors are available from their manufacturers. See **Table 3**.

Another type of detector, the corona discharge type, is specifically **not recommended**.

Use the following procedures to locate refrigerant system refrigerant gas leaks using an 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. Typically, one-half pound (0.22 kg) of refrigerant is sufficient to create 50 psi (345 kPa) of pressure. 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).

Refrigerant Service Operations

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 3, Electronic Leak Detectors

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 does not 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. 2**. Inspect two-cylinder reciprocating type compressors (Climate Control) by placing the probe between the clutch coil and the compressor. See **Fig. 3**.

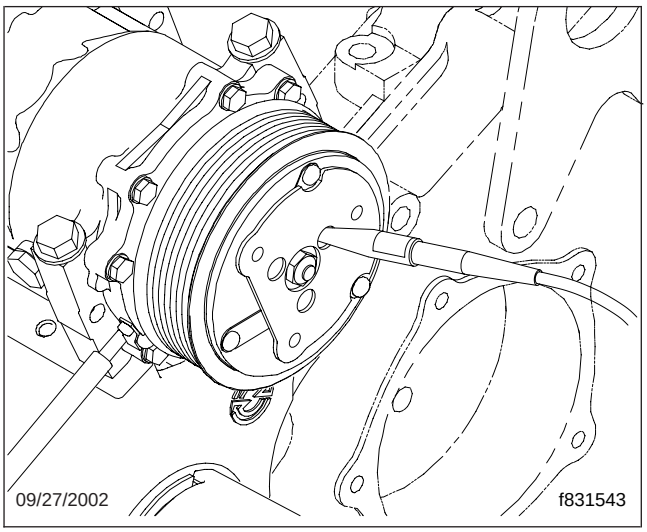


Fig. 2, Axial Type Compressor

IMPORTANT: Be careful not to damage the clutch bearing seal with high pressure shop air.

11. Leak test repaired areas of the system after repairs have been performed. Leak test the service ports (with caps installed) after any service which disturbs the refrigerant system.

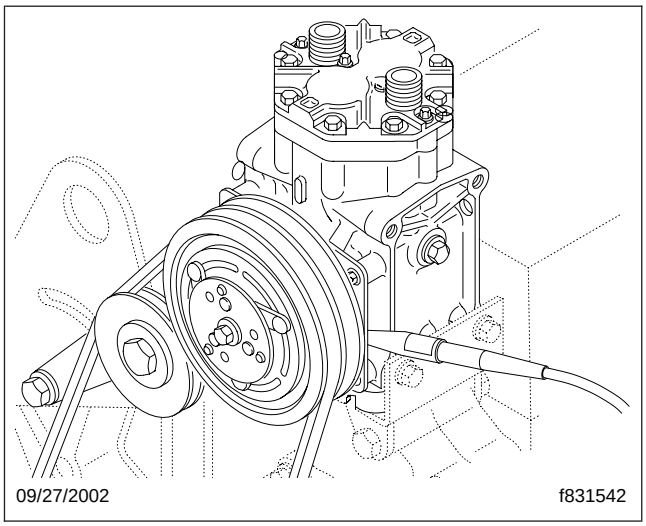


Fig. 3, Two-Cylinder Reciprocating Compressor

Replacement

Left-Hand-Drive Vehicle

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Open the hood.
3. Disconnect the batteries.
4. Disconnect the electrical connector. See **Fig. 1**.

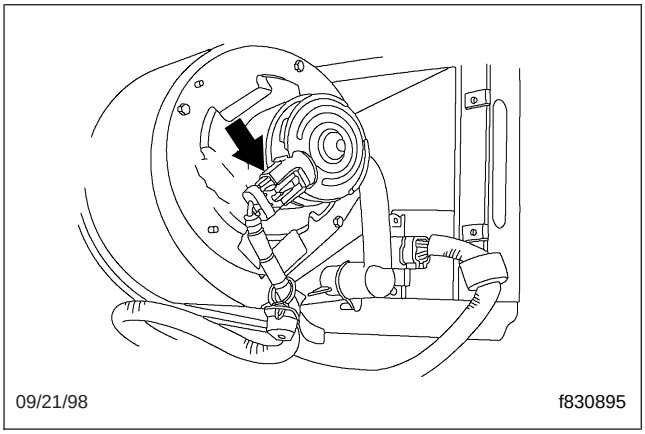


Fig. 1, Electrical Connector

5. Disconnect the blower motor tube to full open position. See **Fig. 2**.

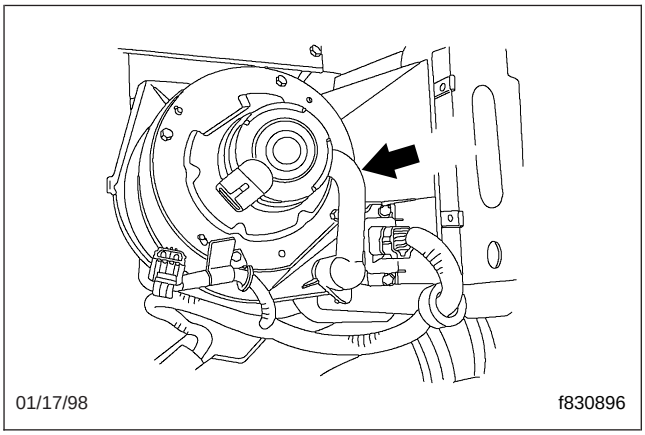
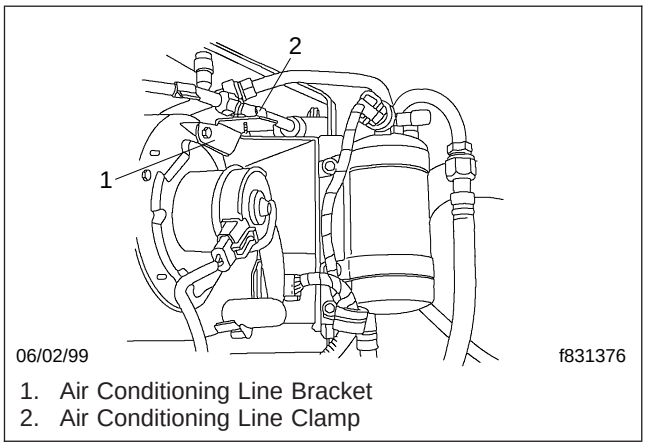


Fig. 2, Blower Motor Tube

6. Remove the air conditioning line clamp and the air conditioning line support bracket. See **Fig. 3**.



1. Air Conditioning Line Bracket
2. Air Conditioning Line Clamp

Fig. 3, Air Conditioning Line Clamp and Bracket

7. Remove the screws and pull the blower motor outward. See **Fig. 4**.

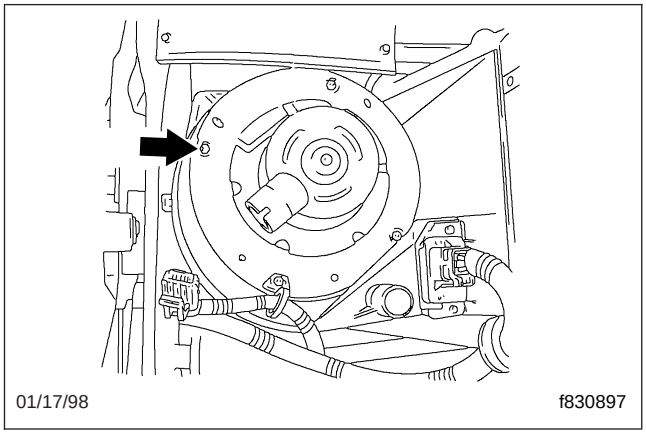


Fig. 4, Blower Motor Screws

8. Remove the push-on retaining clip that attaches the blower motor wheel to the blower motor, and remove the blower motor wheel. See **Fig. 5**.

NOTE: The push-on retaining clip that attaches the blower motor wheel to the blower motor is a single-use item. If the blower motor and blower motor wheel are separated, the retaining clip must be replaced with a new one.

9. Install the blower motor wheel. Install a new push-on retaining clip. See **Fig. 5**.
10. Install the blower motor and the screws. See **Fig. 4**.

Blower Motor Replacement

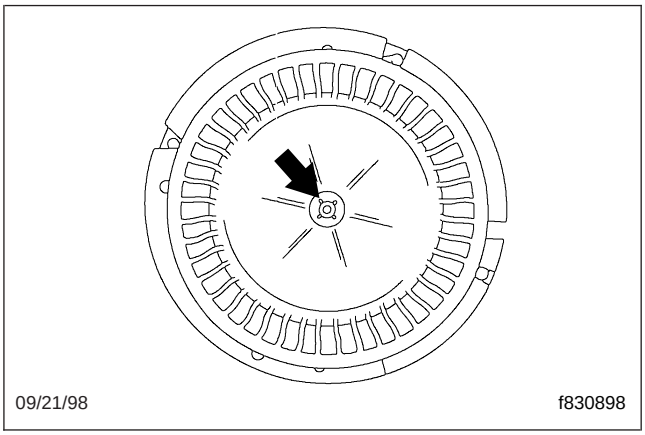
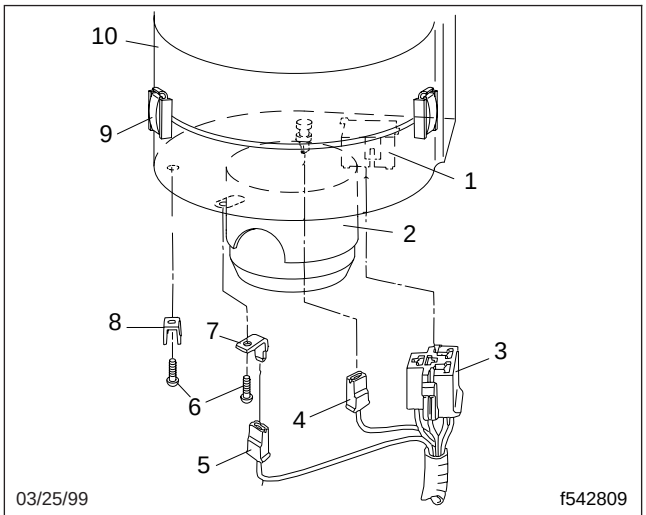


Fig. 5, Push-On Retaining Clip

11. Install the air conditioning line clamp and the air conditioning line support bracket.
12. Install the blower motor tube.
13. Connect the electrical connector.
14. Close and latch the hood.
15. Connect the batteries.
16. Remove the chocks from the tires.

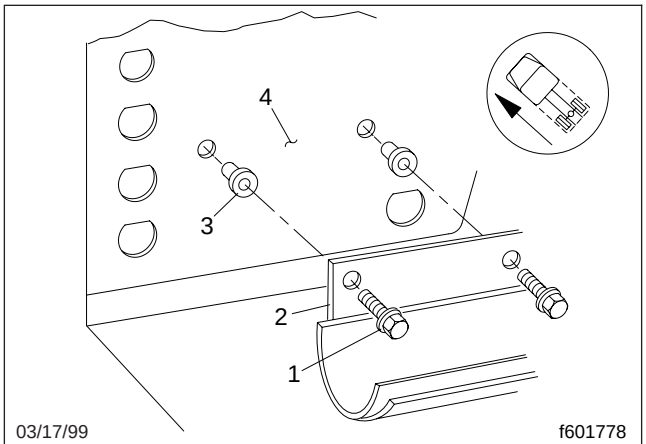
Right-Hand-Drive Vehicle

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Remove the glove compartment door trim panel and the lower air conditioning housing cover assembly. For instructions, see **Group 60**.
4. Disconnect the blower motor electrical connectors. See **Fig. 6**.
5. Remove the wiring harness support bracket mounting screws to access the blower motor assembly retaining screws. See **Fig. 7**.
6. Remove the blower motor tube.
7. Remove the blower motor assembly from the HVAC unit.
8. Remove the push-on retaining clip that attaches the blower motor wheel to the blower motor and remove the blower motor wheel.



1. Blower Motor Resistor
2. Blower Motor
3. Blower Motor Resistor Connector
4. Blower Motor Connector (+)
5. Blower Motor Connector (–)
6. Blower Motor Retaining Screw
7. Blower Motor Connector
8. Blower Motor Assembly Screw Retainer
9. HVAC Unit Retaining Clip
10. HVAC Unit

Fig. 6, Blower Motor and Components



1. Retaining Bolt
2. Support Bracket
3. Retaining Nut
4. Cab Wall

Fig. 7, Wiring Harness Support Bracket

NOTE: The push-on retaining clip that attaches the blower motor wheel to the blower motor is a single-use item. If the blower motor and blower

motor wheel are separated, the retaining clip must be replaced with a new one.

9. Install the blower motor wheel. Install a new retaining clip.
10. Connect the blower motor resistor electrical connector.
11. Install the blower motor tube.
12. Install the blower motor assembly and the screws.
13. Connect the blower motor electrical connectors.
14. Position and install the wiring harness support bracket and the mounting screws.
15. Install the glove compartment door trim panel and the lower air conditioning housing cover assembly. For instructions, see **Group 60**.
16. Connect the batteries.
17. Remove the chocks from the tires.

Heater Core Housing Replacement

Replacement

1. Remove the heater core. For instructions, see **Subject 150**.
2. Remove the evaporator housing. For instructions, see **Subject 140**.
3. Disconnect the electrical connector.
4. Remove the two nuts that attach the heater core housing to the dash panel. See **Fig. 1**.

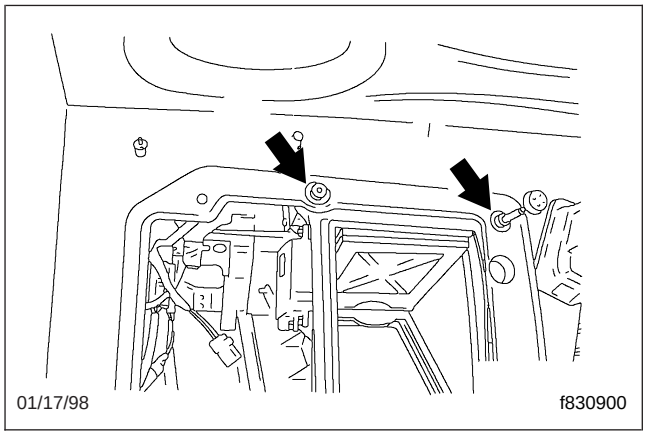


Fig. 1, Heater Core Housing Nuts

5. Pull the heater core housing outward and remove the heater core housing. See **Fig. 2**.

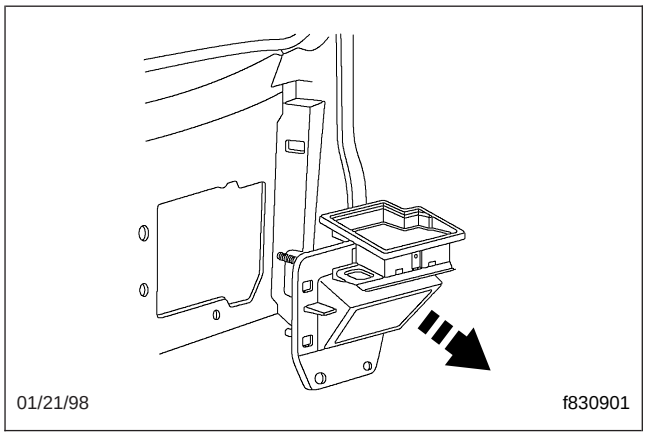


Fig. 2, Heater Core Housing

6. Install the heater core housing.
7. Install the two nuts that attach the heater core housing to the dash panel. See **Fig. 1**.
8. Connect the electrical connector.
9. Install the evaporator housing. For instructions, see **Subject 140**.
10. Install the heater core. For instructions, see **Subject 150**.

Evaporator Housing Removal and Installation

Removal

WARNING

The engine must be off and fully cool and the cooling system fully depressurized before attempting to disconnect any heater water hoses. Failure to comply with these warnings can result in serious injury and burns from the engine cooling system.

NOTE: For vehicles equipped with air conditioning, the system must be discharged and the evaporator disconnected.

1. Partially drain the engine cooling system. For instructions, see **Group 20**.
2. If necessary, remove the blower motor. For instructions, see **Subject 120**.
3. Remove the outside-recirculation door pneumatic actuator.
4. Remove the bolts and the instrument panel support brace. See **Fig. 1**.

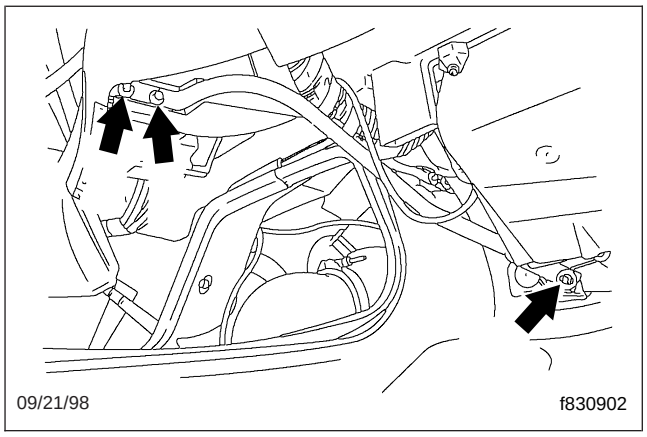


Fig. 1, Instrument Panel Support Brace

5. Remove the nuts that attach the evaporator housing to the inside of the dash panel. See **Fig. 2**.
6. Loosen the hose clamps and remove the heater hoses from the heater core. See **Fig. 3**.
7. Remove the screw retaining the wiring harness to the evaporator housing. See **Fig. 4**
8. Remove the blower motor resistor connector and the wiring harness fastener. See **Fig. 5**.

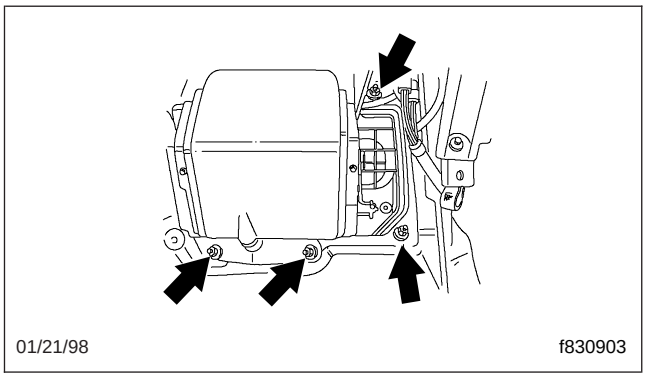


Fig. 2, Evaporator Housing Nuts

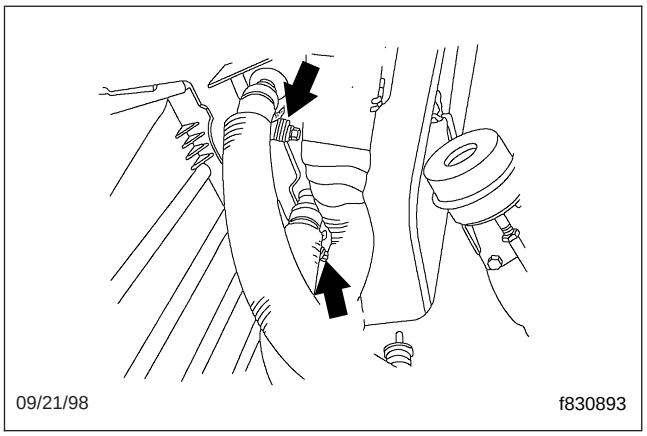


Fig. 3, Hose Clamps

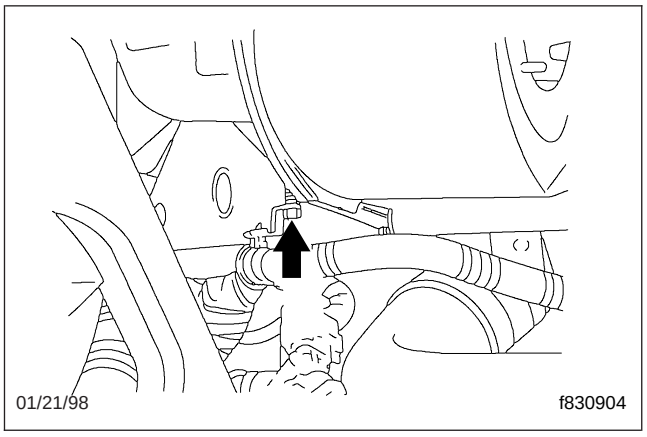
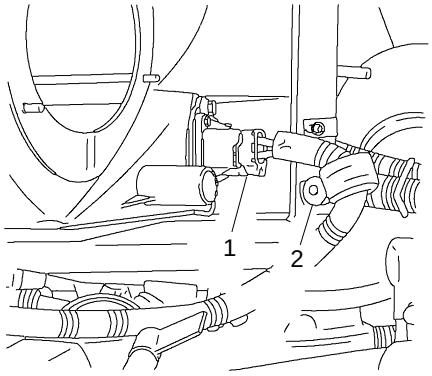


Fig. 4, Wiring Harness Screw

9. Remove the nut that attaches the evaporator housing to the outside of the dash panel. See **Fig. 6**.
10. Remove the bolts. See **Fig. 7**.

Evaporator Housing Removal and Installation



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1. Connector 2. Harness Retainer

Fig. 5, Blower Motor Resistor Connector

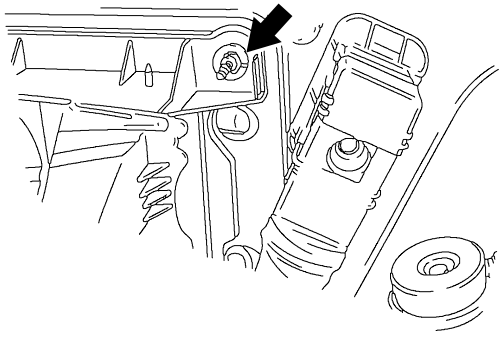

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Fig. 6, Evaporator Housing Nut

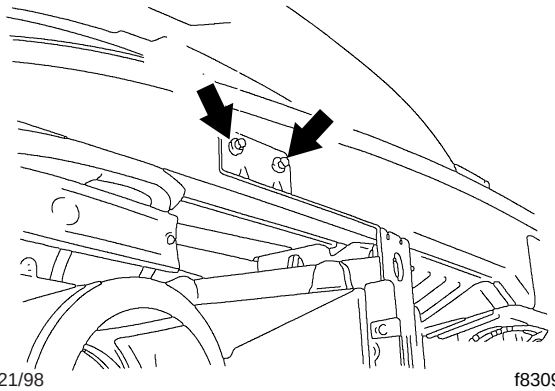

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Fig. 7, Evaporator Housing Retaining Bolts

11. Remove the evaporator housing. See **Fig. 8**.

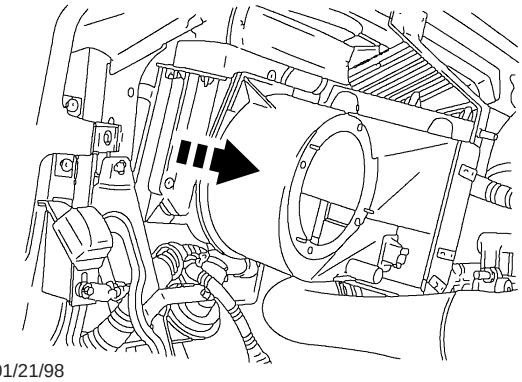

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Fig. 8, Evaporator Housing

Installation

NOTE: If a new evaporator housing is to be installed, the blower motor and wheel, blower motor tube, air inlet duct heater, heater blower motor switch resistor, air inlet duct actuator, evaporator housing support bracket and fresh air filter must be transferred to the new evaporator housing. These procedures can be done prior to installation of the evaporator housing to ease the installation.

1. Install the evaporator.
2. Install the evaporator housing. See **Fig. 8**.
3. Install the bolts.
4. Install the nut that attaches the evaporator housing to the outside of the dash panel.
5. Install the blower motor resistor connector and the wiring harness fastener.
6. Install the screw retaining the wiring harness to the evaporator housing.
7. Install the heater hoses to the heater core and tighten the hose clamps.
8. Install the nuts that attach the evaporator housing to the inside of the dash panel. See **Fig. 2**.
9. Install the instrument panel support brace and the bolts. See **Fig. 1**.
10. Install the outside-recirculation door pneumatic actuator.

11. If necessary, install the blower motor. For instructions, see **Subject 120**.
12. Refill the engine cooling system. For instructions, see **Group 20**.

Replacement

Left-Hand-Drive Vehicle

⚠ WARNING

The engine must be fully cooled and the cooling system fully depressurized before attempting to disconnect any heater water hoses. Failure to comply with these warnings may result in serious injury and burns from the hot liquid escaping from the engine cooling system.

1. Close the heater core shutoff valve and partially drain the engine cooling system. For instructions, see **Group 20**.
2. Loosen the hose clamps and remove the heater hoses from the heater core. See **Fig. 1**.

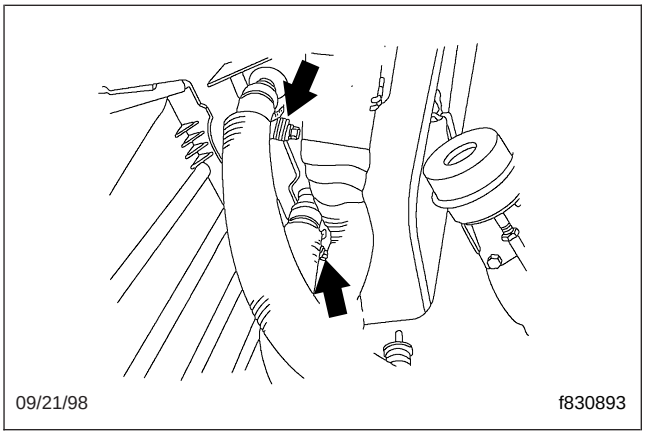


Fig. 1, Hose Clamps

3. Remove the screws that secure the passenger-side heater outlet floor duct. See **Fig. 2**.
4. Remove the seven screws and the heater core cover. See **Fig. 3**.

NOTE: Use care not to spill the coolant remaining in the heater core during removal.

5. Remove the heater core from the heater core housing. See **Fig. 4**.

NOTE: Apply rubber suspension insulator lube or equivalent to the tube ends and on the inside dash seals to allow the heater core tubes to pass easily through the dash seal during installation.

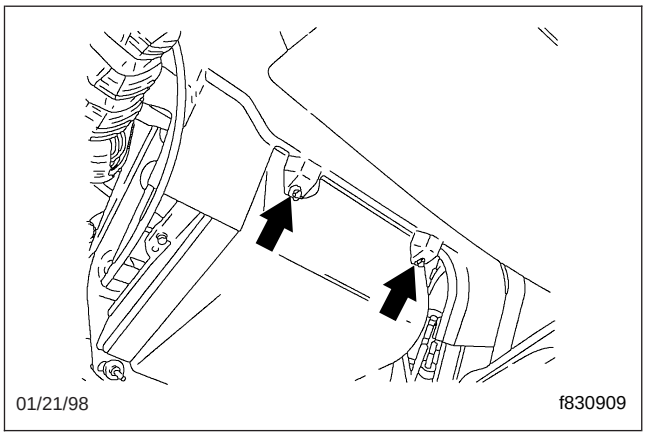


Fig. 2, Floor Duct Screws

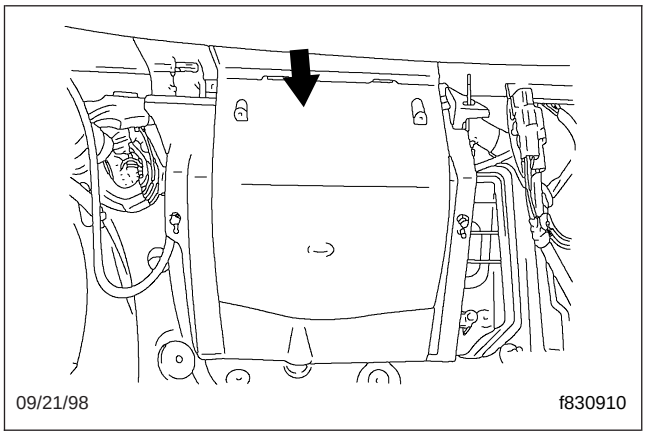


Fig. 3, Heater Core Cover

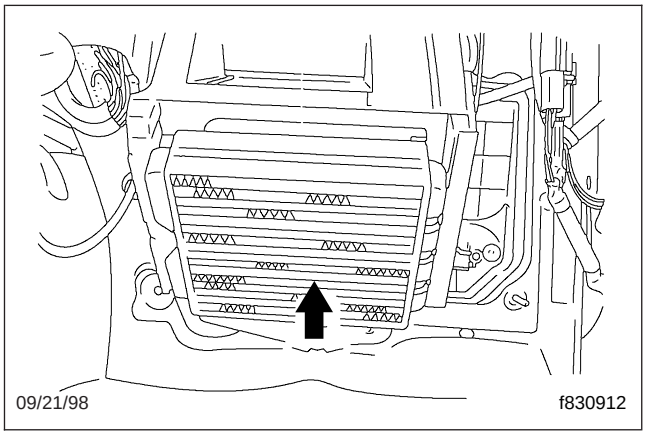


Fig. 4, Heater Core

6. Install the heater core in the heater core housing. See **Fig. 4**.

Heater Core Replacement

7. Install the heater core cover and the seven screws.
8. Install the screws securing the passenger-side heater outlet floor duct.
9. Install the heater hoses to the heater core and tighten the hose clamps.
10. Open the heater core shutoff valve and refill the engine cooling system. For instructions, see **Group 20**.

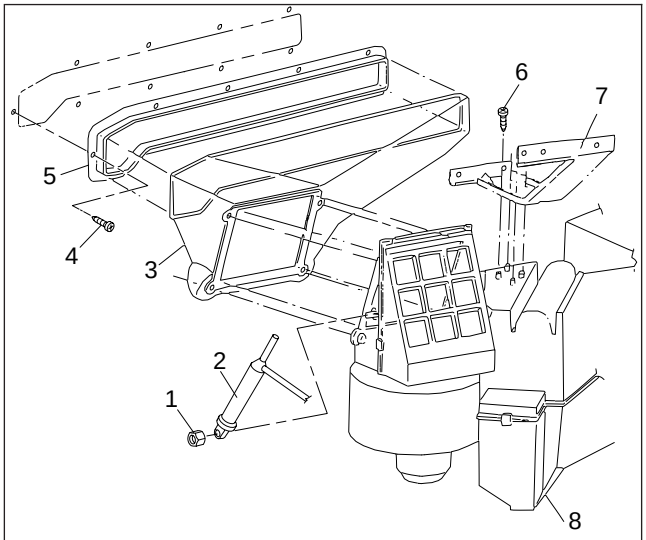
Right-Hand-Drive Vehicle

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.

⚠ WARNING

The engine must be fully cooled and the cooling system fully depressurized before attempting to disconnect any heater water hoses. Failure to comply with these warnings may result in serious injury and burns from the hot liquid escaping from the engine cooling system.

2. Close the heater core shutoff valve and partially drain the engine cooling system. For instructions, see **Subject 250**.
3. Remove the instrument panel. For instructions, see **Section 60.01**.
4. Remove the HVAC unit. For instructions, see **Subject 280**.
5. Remove the ducting from the HVAC unit. See **Fig. 5**.
6. Remove the vacuum actuators from the HVAC unit. See **Fig. 5**.
7. Remove the HVAC air blend motor retaining screws. Remove the component. See **Fig. 6**.
8. Remove the clips. Separate the HVAC unit into two halves.
9. Remove the heater core. See **Fig. 7**.
10. Replace the heater core.
11. Install the HVAC air blend motor and the retaining screws in the HVAC unit. See **Fig. 6**.
12. Join the two halves of the HVAC unit and install the clips.



1. Nut
2. Vacuum Actuator
3. Air Intake Duct
4. Screw
5. Duct Retainer
6. Screw
7. PDM Mounting Bracket
8. HVAC Unit

Fig. 5, HVAC Unit and Ducting

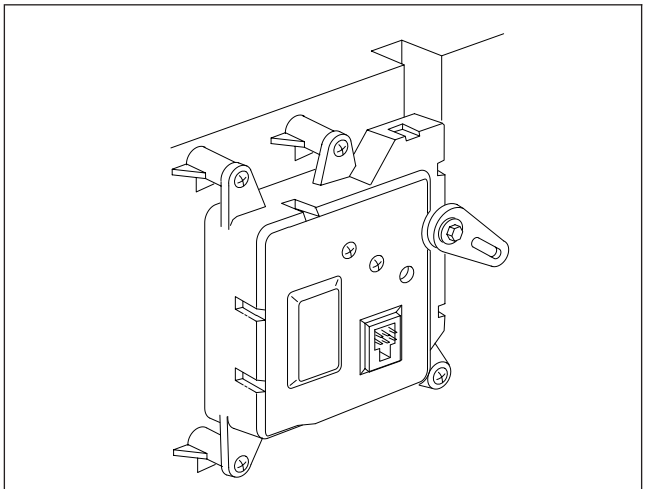
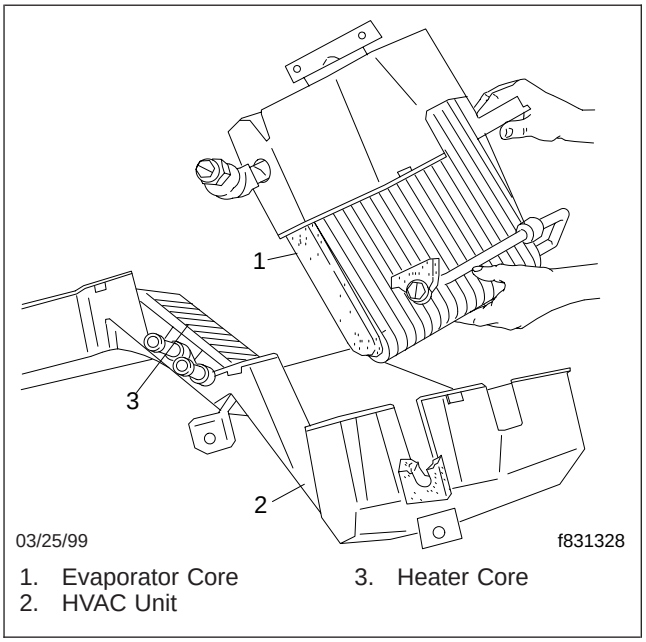


Fig. 6, Air Blend Motor

13. Install the vacuum actuators on the HVAC unit. See **Fig. 5**.
14. Install the ducting on the HVAC unit.
15. Install the HVAC unit. For instructions, see **Subject 280**.



1. Evaporator Core
2. HVAC Unit
3. Heater Core

Fig. 7, Heater Core Location

16. Install the instrument panel. For instructions, see **Section 60.01**.
17. Open the heater core shutoff valve and replace the drained coolant. For instructions, see **Group 20**.
18. Remove the chocks from the tires.

Evaporator and Evaporator Orifice Replacement

WARNING

Before starting any of the procedures below, see "Safety Precautions" in Subject 100. Failure to do so may result in personal injury.

Evaporator Replacement

Left-Hand-Drive Vehicle

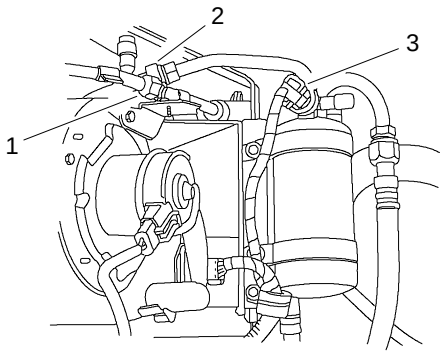
WARNING

The engine must be fully cooled and the cooling system fully depressurized before attempting to disconnect any heater water hoses. Failure to comply with these warnings may result in serious injury and burns from the hot liquid escaping from the engine cooling system.

1. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.01, Subject 110**.

NOTE: All open refrigerant lines and connections must be capped or plugged to prevent dirt and moisture from entering and contaminating the system during repair.

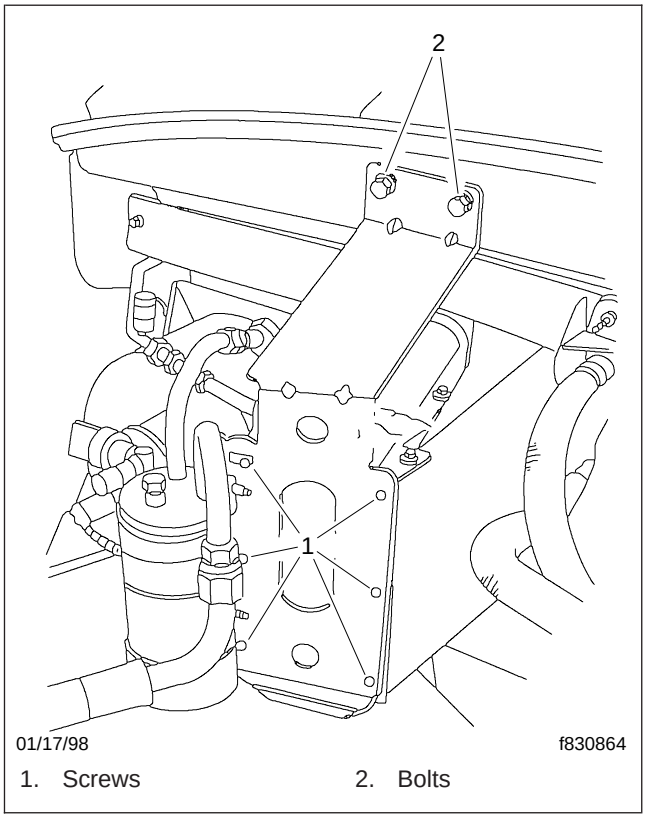
2. Disconnect the evaporator inlet and outlet lines. See **Fig. 1**.



1. Inlet Line
2. Outlet Line
3. Electrical Connector

Fig. 1, Evaporator Lines and Electrical Connector

3. Disconnect the electrical connector.
4. Remove the screws that secure the accumulator/drier and bracket, then swing the accumulator/drier and bracket out of the way. See **Fig. 2**.



1. Screws
2. Bolts

Fig. 2, Accumulator/Drier and Bracket

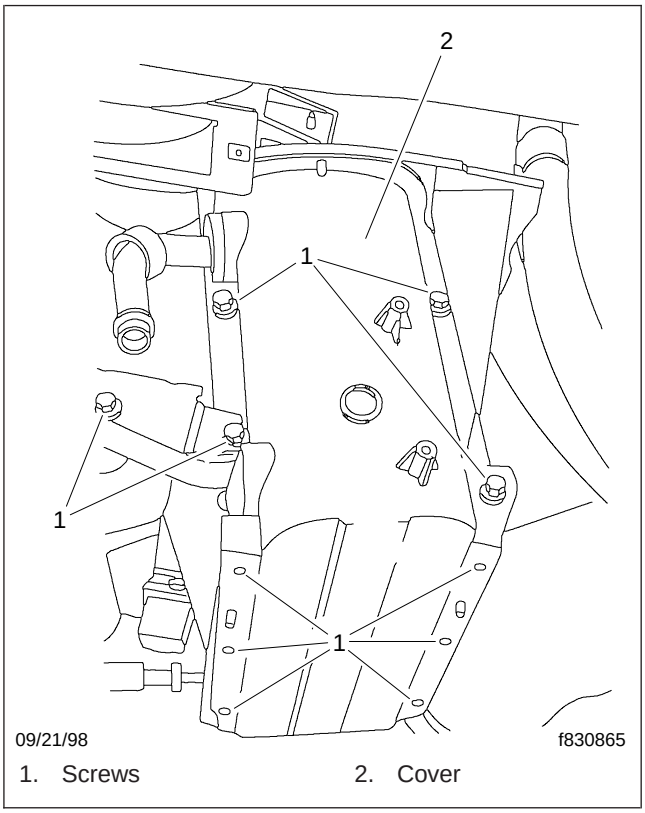
5. Remove the screws that secure the evaporator case cover, then remove the cover.
6. Remove the evaporator case cover. See **Fig. 3**.
7. Remove the evaporator core and seals. See **Fig. 4**.

NOTE: When the A/C system connections have been opened, the O-rings must be replaced with new O-rings lubricated in clean refrigerant oil.

NOTE: If the evaporator core is to be replaced, see "Refrigerant Oil Replacement and Measurement" in **Section 83.02**.

8. Install the evaporator core and seals.
9. Using screws, install the evaporator case cover.
10. Using screws, install the accumulator/drier and bracket.
11. Connect the evaporator core. See **Fig. 1**.

Evaporator and Evaporator Orifice Replacement



1. Screws 2. Cover

Fig. 3, Evaporator Case Cover

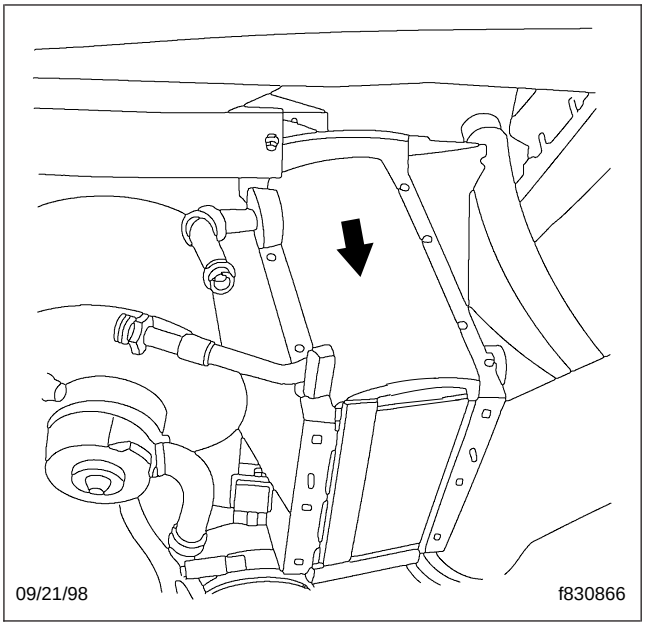


Fig. 4, Evaporator and Seals

11.1 Connect the evaporator inlet line and torque the fitting 15 to 20 lbf·ft (20 to 27 N·m).

11.2 Connect the evaporator outlet line and torque the fitting 25 to 30 lbf·ft (34 to 41 N·m).

11.3 Connect the electrical connector.

12. Evacuate, charge, and leak test the air conditioning system. For instructions, see **Section 83.01, Subject 110**.

Right-Hand-Drive Vehicle

⚠ WARNING

The engine must be fully cooled and the cooling system fully depressurized before attempting to disconnect any heater water hoses. Failure to comply with these warnings may result in serious injury and burns from the hot liquid escaping from the engine cooling system.

1. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.01, Subject 110**.
2. Remove the HVAC unit. For instructions, see **Subject 280**.
3. Disassemble the HVAC unit. For instructions, see **Subject 290**.
4. Remove the evaporator slide tab. See **Fig. 5**.

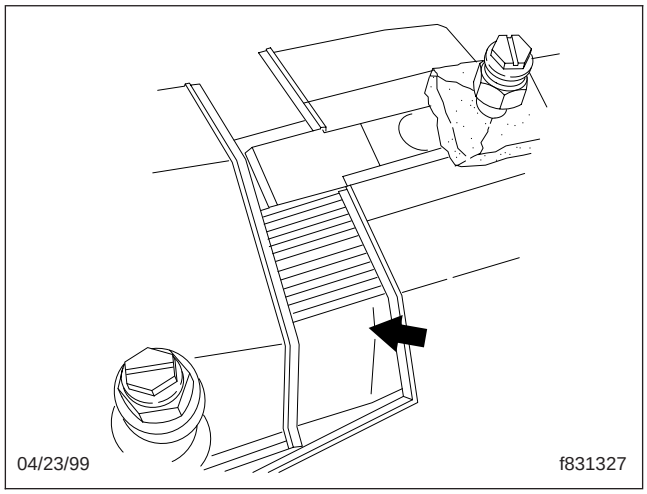
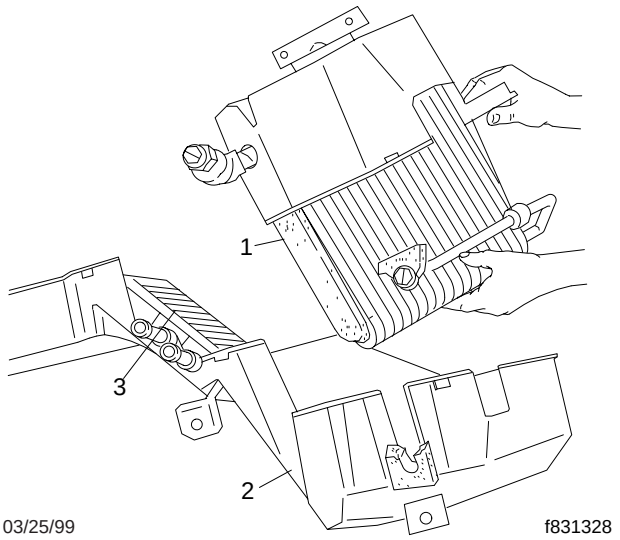


Fig. 5, Evaporator Tab

5. Replace the evaporator. See **Fig. 6**.



1. Evaporator
2. HVAC Unit
3. Heater Core

Fig. 6, Evaporator Core

6. Install the evaporator core support.
7. Assemble the HVAC unit. For instructions, see **Subject 290**.
8. Install the HVAC unit. For instructions, see **Subject 280**.
9. Open the heater core shutoff valve and replace the drained coolant. For instructions, see **Group 20**.
10. Evacuate, charge, and leak test the air conditioning system. For instructions, see **Section 83.01, Subject 110**.

Evaporator Orifice Replacement

NOTE: All open refrigerant lines and connections must be capped or plugged to prevent dirt and moisture from entering and contaminating the system during repair.

NOTE: When the A/C system connections have been opened, the O-rings must be replaced with new O-rings lubricated in clean refrigerant oil.

1. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.01, Subject 110**.
2. Disconnect the evaporator orifice fitting. See **Fig. 7**.

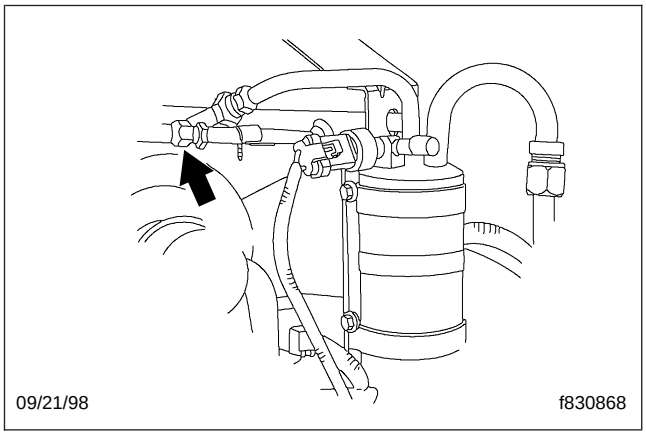


Fig. 7, Evaporator Orifice Fitting

3. Remove the orifice tube.
4. Install the orifice tube.
5. Connect the fitting. See **Fig. 7**. Tighten the fitting 15 to 20 lbf·ft (20 to 27 N·m).
6. Evacuate, charge, and leak test the air conditioning system. For instructions, see **Section 83.01, Subject 110**.

Accumulator/Drier Replacement

⚠ WARNING

Before starting any of the procedures below, see "Safety Precautions" in Subject 100. Failure to do so may result in personal injury.

Replacement Guidelines

NOTE: The accumulator/drier contains a desiccant bag to absorb any moisture that may be in the system. It is important to protect the accumulator/drier by capping any open lines when performing service work on the refrigerant system. Replacement of the accumulator/drier is necessary anytime a major component of the refrigerant system is replaced. Major components include the condenser, the refrigerant compressor, the evaporator, or a refrigerant hose or line. An orifice tube or an O-ring is not considered a major component. However, the orifice tube must be replaced whenever the compressor is replaced.

In addition, the accumulator/drier must be replaced if:

- The accumulator/drier is leaking;
- There has been any significant leak or loss of charge in the refrigerant system;
- There is evidence of moisture in the system, such as internal corrosion of metal refrigerant lines or the refrigerant oil is thick and dark.

NOTE: When replacing the accumulator/drier, this procedure must be followed to make sure that the total oil charge in the system is correct after the new accumulator/drier is installed.

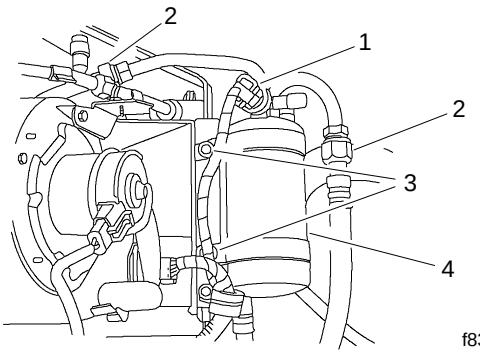
1. Drain the oil from the removed accumulator/drier into a measuring container. It may be necessary to drill one or two 1/2-inch (12.7-mm) holes in the bottom of the accumulator/drier to make sure all the oil has been drained out.
2. Add the same amount of new, clean refrigerant oil, plus the amount of oil that was removed from the system during refrigerant recovery, to the new accumulator/drier. Use only the oil specified for the specific vehicle being serviced.

Replacement

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.01, Subject 110**.

NOTE: All open refrigerant lines and connections must be capped or plugged to prevent dirt and moisture from entering and contaminating the system during repair.

3. Disconnect the electrical connector from the accumulator/drier. See **Fig. 1**.



1. Electrical Connector
2. Fitting
3. Capscrew
4. Accumulator/Drier

Fig. 1, Accumulator/Drier

4. Disconnect the fittings from the accumulator/drier.
5. Remove the capscrews that secure the accumulator/drier and remove the accumulator/drier.
6. Using capscrews, install a new accumulator/drier.
7. Connect the fittings to the accumulator/drier, then torque the fittings 22 to 27 lbf·ft (30 to 37 N·m).
8. Connect the electrical connector to the accumulator/drier.
9. Evacuate, charge, and leak test the air conditioning system. For instructions, see **Section 83.01, Subject 110**.
10. Remove the chocks from the tires.

Condenser Removal and Installation

WARNING

Before doing any of the work below, read the safety precautions in Section 83.01, Subject 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.01, Subject 110**.
4. Disconnect the refrigerant lines from the condenser. Quickly cap the refrigerant lines, and cap the condenser inlet and outlet ports if the condenser will be reinstalled.

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through the refrigerant lines since shop air is wet (humid).

5. Remove the fasteners that attach the condenser to the radiator. Remove the condenser.

Installation

1. Using fasteners, install the condenser on the radiator. Torque the fasteners 23 to 29 lbf·ft (31 to 39 N·m).
2. Uncap the inlet and outlet ports on the condenser and uncap the refrigerant lines.
3. On refrigerant line connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On refrigerant line connections that have Mini Stat-O-Seals, replace the seals. **Do not** lubricate Mini Stat-O-Seals prior to installation. Use only a Mini Stat-O-Seal on a Mini Stat-O-Seal assembly.
4. Connect the refrigerant lines to the condenser.

   On refrigerant line connections that threaded fittings, tighten the fittings to the appropriate torque specification in **Table 1**.

   On refrigerant line connections that have a Mini Stat-O-Seal assembly, torque the bolt on the Mini Stat-O-Seal assembly 13 to 15 lbf·ft (18 to 20 N·m).
5. Add refrigerant oil to the compressor to replace that which is lost in the old condenser. For instructions, see **Section 83.02, Subject 150**.
6. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Section 83.01, Subject 110**.
7. Return the hood to the operating position.
8. Remove the chocks from the tires.

A/C Threaded Fitting Torque Specifications*	
Refrigerant Line Size	**Torque: lbf·ft (N·m)**
#6	20 to 25 (27 to 34)
#8	30 to 35 (41 to 47)
#10 and #12	35 to 40 (47 to 54)

* One-inch fittings on the A/C compressor need to be torqued 21 to 27 lbf·ft (28 to 37 N·m) regardless of refrigerant line size.

Table 1, A/C Threaded Fitting Torque Specifications

WARNING

Before starting any of the procedures below, see "Safety Precautions" in Subject 100. Failure to do so may result in personal injury.

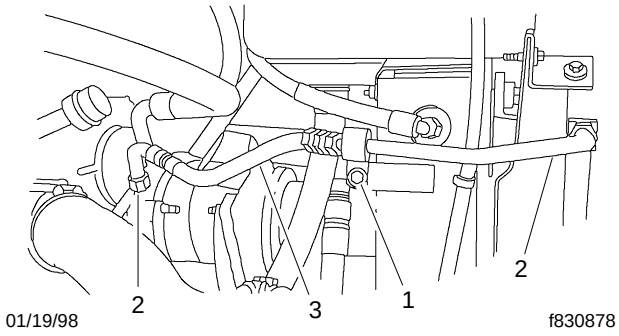
Replacement of the Discharge Line Between the Refrigerant Compressor and Condenser

1. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 110**.

NOTE: The following is a procedure typical of all engine applications.

NOTE: All open refrigerant lines and connections must be capped or plugged to prevent dirt and moisture from entering and contaminating the system during repair.

2. Remove the clamp that secures the discharge line. Disconnect the fittings and remove the discharge line. See **Fig. 1**.



1. Clamp
2. Fitting
3. Discharge Line

Fig. 1, Discharge Line

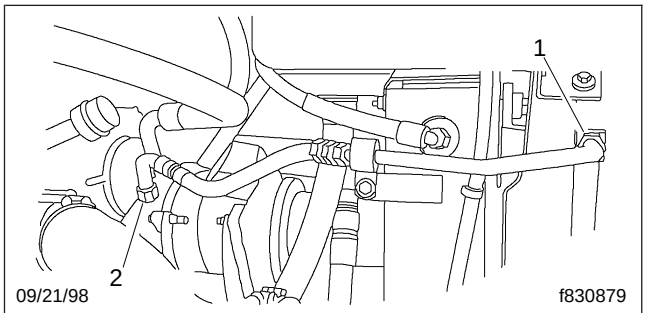
NOTE: When the air conditioning system connections have been opened, the O-rings must be replaced with new O-rings lubricated in clean refrigerant oil.

NOTE: If the discharge line is to be replaced, see "Refrigerant Oil Replacement and Measurement" in **Section 83.02**.

NOTE: The following is a procedure typical of all engine applications.

NOTE: All open refrigerant lines and connections must be capped or plugged to prevent dirt and moisture from entering and contaminating the system during repair.

3. Install the discharge line, then connect the fittings. Torque the fitting at the refrigerant compressor 15 to 20 lbf·ft (20 to 27 N·m). Torque the fitting at the condenser 20 to 25 lbf·ft (27 to 34 N·m). See **Fig. 2**.



1. Compressor Fitting
2. Condenser Fitting

Fig. 2, Discharge Line Fittings

4. Install the clamp on the discharge line.
5. Evacuate, charge, and leak test the air conditioning system. For instructions, see **Subject 110**.

Replacement of the Liquid Line Between the Condenser and Evaporator

1. Discharge the air conditioning system. For instructions, see **Subject 110**.

NOTE: The following is a procedure typical of all engine applications.

NOTE: All open refrigerant lines and connections must be capped or plugged to prevent dirt and moisture from entering and contaminating the system during repair.

2. Disconnect the line at the condenser and remove the clamps. See **Fig. 3**.
3. Disconnect the pressure cut out switch connector.

Line Replacement

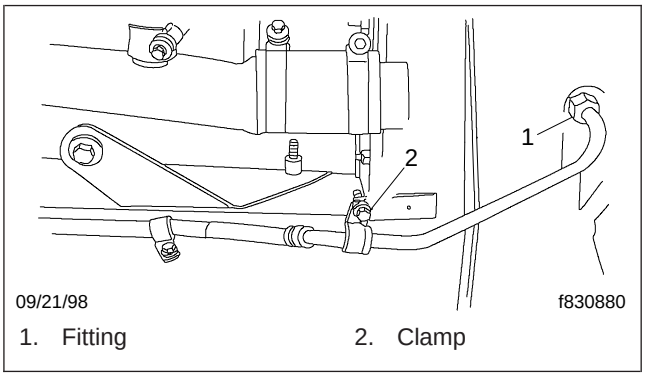


Fig. 3, Condenser Line

4. Disconnect the line at the evaporator and remove the line. See **Fig. 4**.

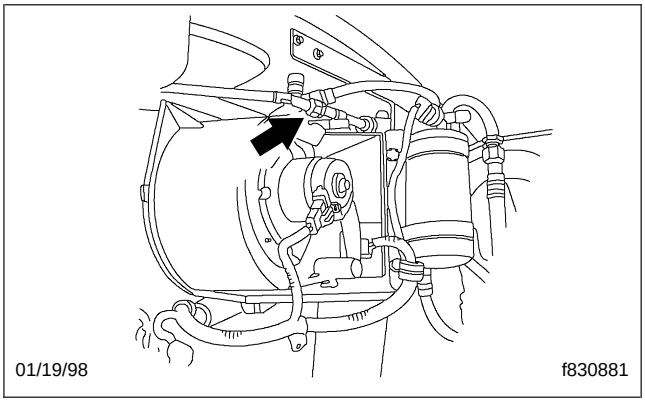


Fig. 4, Evaporator Line

5. Install and connect the line at the evaporator.
6. Connect the pressure cut out switch connector.
7. Install the clamps and connect the line at the condenser.

NOTE: When the air conditioning system connections have been opened, the O-rings must be replaced with new O-rings lubricated in clean refrigerant oil.

NOTE: If the liquid line is to be replaced, see "Refrigerant Oil Replacement and Measurement" in **Section 83.02**.

8. Tighten the condenser fitting 10 to 15 lbf·ft (14 to 20 N·m). Tighten the evaporator fitting in 15 to 20 lbf·ft (20 to 27 N·m).
9. Evacuate, charge, and leak test the air conditioning system. For instructions, see **Subject 110**.

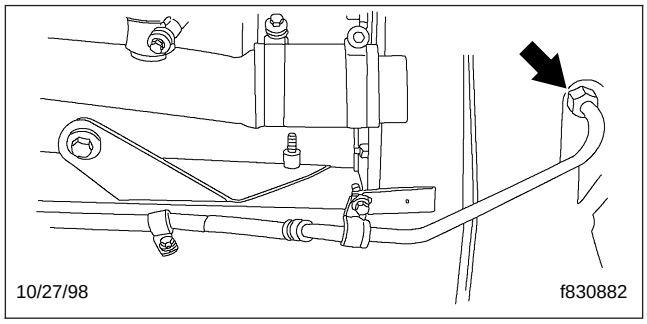


Fig. 5, Condenser Fitting

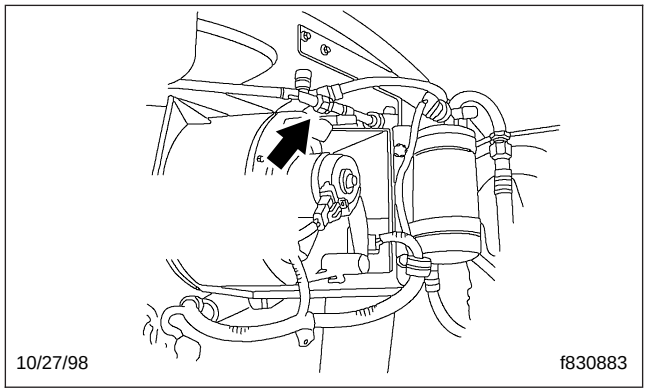


Fig. 6, Evaporator Fitting

Replacement of the Suction Line Between the Evaporator and Compressor

1. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 110**.

NOTE: The following is a procedure typical of all engine applications.

NOTE: All open refrigerant lines and connections must be capped or plugged to prevent dirt and moisture from entering and contaminating the system during repair.

2. Disconnect the fittings on the suction line and remove the line. See **Fig. 7**.

NOTE: When the air conditioning system connections have been opened, the O-rings must be replaced with new O-rings lubricated in clean refrigerant oil.

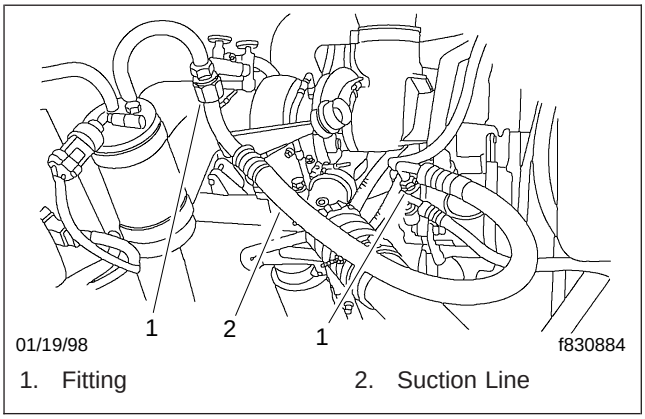


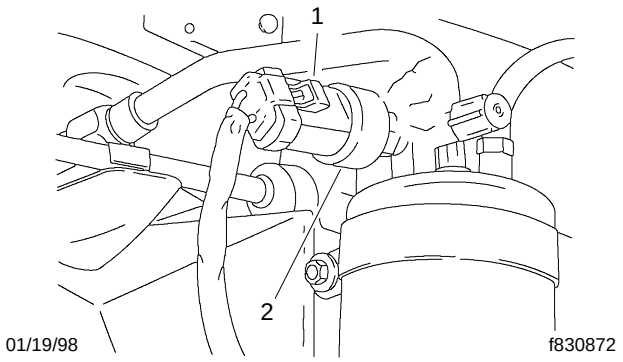
Fig. 7, Suction Line

NOTE: If the suction line is to be replaced, see "Refrigerant Oil Replacement and Measurement" in **Section 83.02**.

3. Connect the fittings to the suction line and install the line. Torque the fitting at the accumulator 22 to 27 lbf·ft (30 to 37 N·m). Torque the fitting at the compressor 21 to 27 lbf·ft (28 to 37 N·m).
4. Evacuate, charge, and leak test the air conditioning system. For instructions, see **Subject 110**.

Replacement

1. Disconnect the electrical connector from the A/C cycling switch. See **Fig. 1**.
2. Remove the A/C cycling switch.



1. Electrical Connector 2. A/C Cycling Switch

Fig. 1, A/C Cycling Switch

NOTE: Make sure the O-ring is not damaged and is in place before installing the switch.

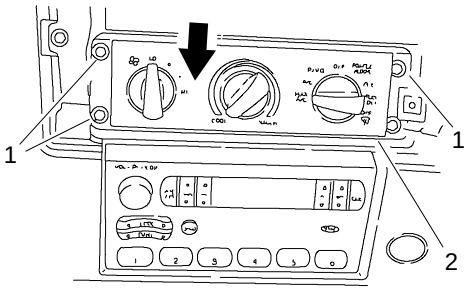
3. Install a new A/C cycling switch. Tighten the switch by hand only.
4. Connect the electrical connector to the A/C cycling switch.

Replacement

WARNING

To reduce the risk of personal injury, the brake system must be bled of all air pressure before removal of any tubes or lines carrying air pressure to any component.

1. Remove the instrument panel center trim panel. For instructions, see **Group 54**.
2. Remove the screws that attach the climate control panel to the dashboard, then pull the control panel forward. See **Fig. 1**.



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1. Screw
2. Climate Control Panel

Fig. 1, Climate Control Panel

NOTE: The pneumatic lines are quick-release lines.

3. Disconnect the pneumatic lines. For instructions, see **Subject 260**. See **Fig. 2**.

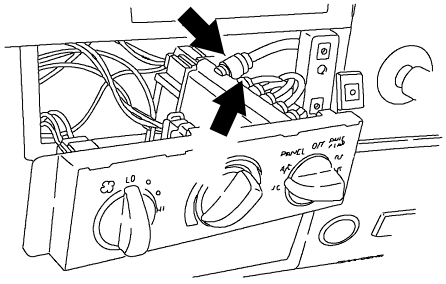

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Fig. 2, Pneumatic Lines

4. Disconnect the electrical connectors and remove the climate control panel. See **Fig. 3**.

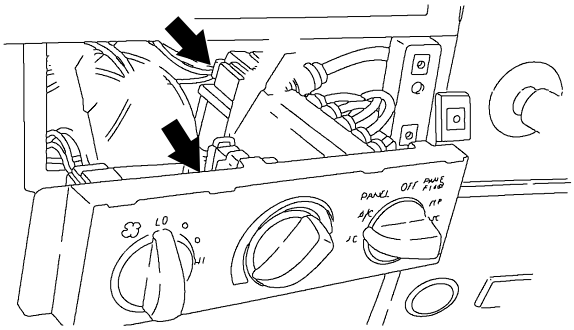

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Fig. 3, Electrical Connectors

5. Using screws, install a new climate control panel.
6. Connect the electrical connectors to the climate control panel.
7. Connect the pneumatic lines to the climate control panel. For instructions, see **Subject 260**.
8. Using screws, install the control panel to the dashboard.
9. Install the instrument panel center trim panel. For instructions, see **Group 54**.

Fan Switch Replacement

1. Remove the fan switch knob by pulling it off the fan switch.
2. Remove the climate control panel. For instructions, see **Subject 210**.
3. Remove the screw, then rotate and remove the fan switch. See **Fig. 1**.

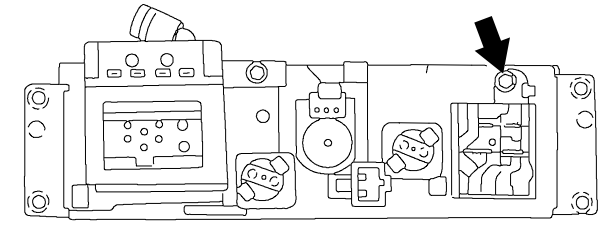


Fig. 1, Fan Switch Screw

4. Using a screw, install a new fan switch. See **Fig. 1**.
5. Install the climate control panel. For instructions, see **Subject 210**.
6. Install the fan switch knob by pushing it on the fan switch.

Temperature Control Switch Replacement

1. Remove the temperature control switch knob by pulling it off the temperature control switch.
2. Remove the climate control panel. For instructions, see **Subject 210**.
3. Remove the screw, then rotate and remove the temperature control switch. See **Fig. 2**.
4. Using a screw, install a new temperature control switch. See **Fig. 2**.
5. Install the climate control panel. For instructions, see **Subject 210**.
6. Install the temperature control switch knob by pushing it on the temperature control switch.

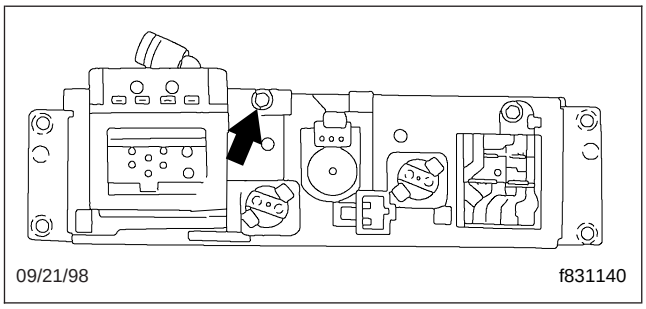


Fig. 2, Temperature Control Switch Screw

Air Selection Switch Replacement

1. Remove the air selection switch knob by pulling it off the air selection switch.
2. Remove the climate control panel. For instructions, see **Subject 210**.
3. Remove the screw, then rotate and remove the air selection switch.
4. Using a screw, install a new air selection switch.
5. Install the climate control panel. For instructions, see **Subject 210**.
6. Install the air selection switch knob by pushing it on the air selection switch.

Temperature Actuator Replacement

NOTE: The first two steps of the following procedure apply only if the vehicle is equipped with a passenger-side lower instrument panel trim cover.

1. Remove the quick-release screws, then remove the IP fuse junction panel trim cover. See **Fig. 1**.

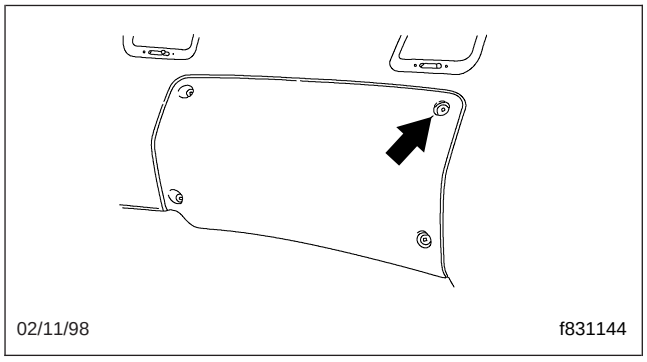


Fig. 1, Quick-Release Screw

2. Remove the instrument panel lower trim cover. See **Fig. 2**.

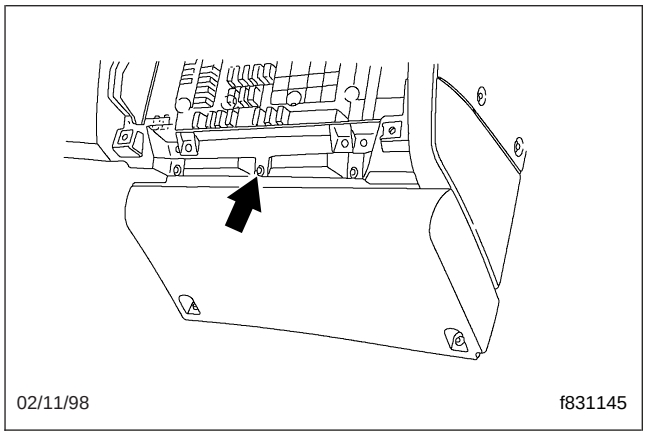


Fig. 2, Instrument Panel Lower Trim Cover

3. Remove the floor duct. See **Fig. 3**.
4. Disconnect the electrical connector from the blend door actuator. See **Fig. 4**.
5. Remove the screws that secure the blend door actuator, then remove the actuator.
6. Using screws, install a new blend door actuator.

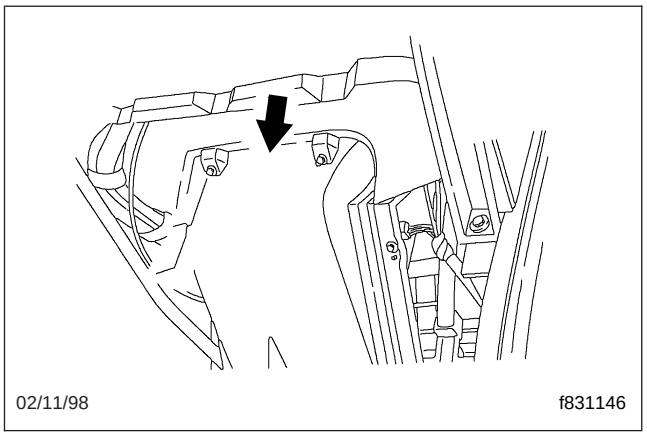
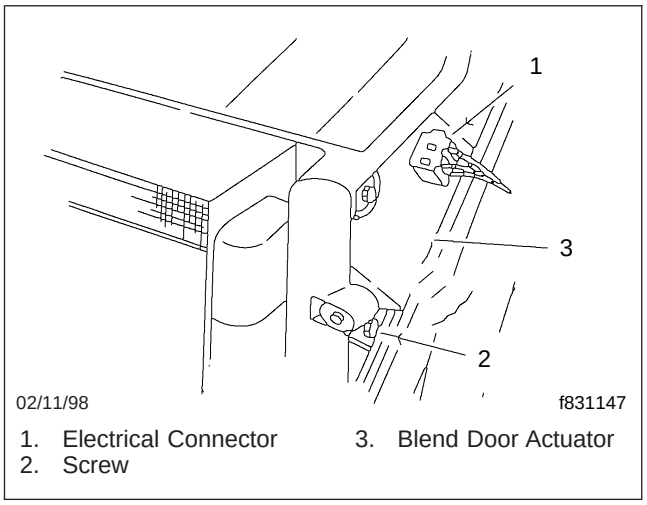


Fig. 3, Floor Duct



1. Electrical Connector
2. Screw
3. Blend Door Actuator

Fig. 4, Blend Door Actuator

7. Connect the electrical connector to the actuator.
8. Install the floor duct.
9. Install the instrument panel lower trim cover.
10. Using quick-release screws, install the IP fuse junction panel trim cover. Torque the screws 18 to 27 lbf·in (170 to 280 N·cm).

Pneumatic Actuator Replacement, Panel/Defrost Doors

1. Remove the panel/defrost pneumatic actuator trim cover. See **Fig. 5**.

Actuator Replacement

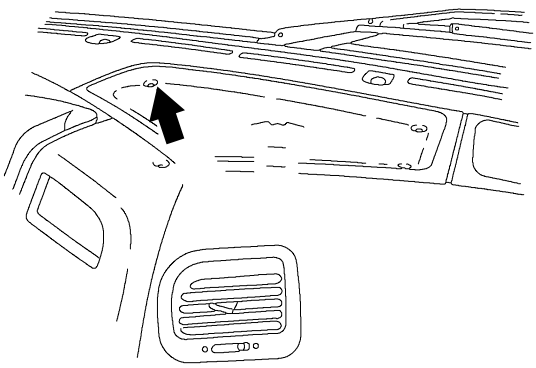
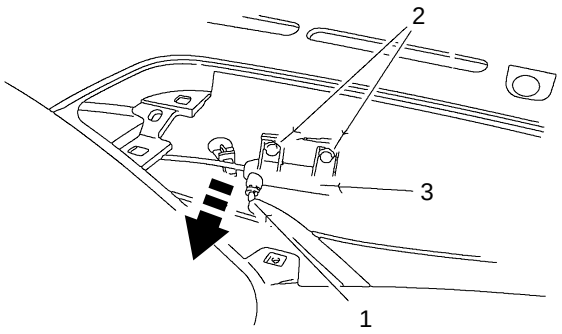


Fig. 5, Panel/Defrost Pneumatic Actuator Trim Cover

WARNING

All air pressure in the vehicle air brake system must be relieved before disconnecting any pneumatic tubes. Hoses will whip dangerously if disconnected under pressure.

2. Disconnect the pneumatic tube from the panel/defrost door actuator. See **Fig. 6**.



1. Pneumatic Tube
2. Screw
3. Actuator

Fig. 6, Panel/Defrost Actuator

3. Remove the screws that secure the actuator, then remove the actuator.
4. Using screws, install a new actuator.
5. Connect the pneumatic tube to the actuator.
6. Install the panel/defrost pneumatic actuator trim cover.

Pneumatic Actuator Replacement, Panel/Floor Doors

NOTE: Items 3 and 12 in **Fig. 7** are bonded together when manufactured and are shown separated for clarification only.

1. If necessary, remove the engine cover.
2. Access the panel/floor door actuator that is located behind the instrument panel between the fuse junction panel and the radio. Note the orientation of the actuator so that it is installed correctly later.

WARNING

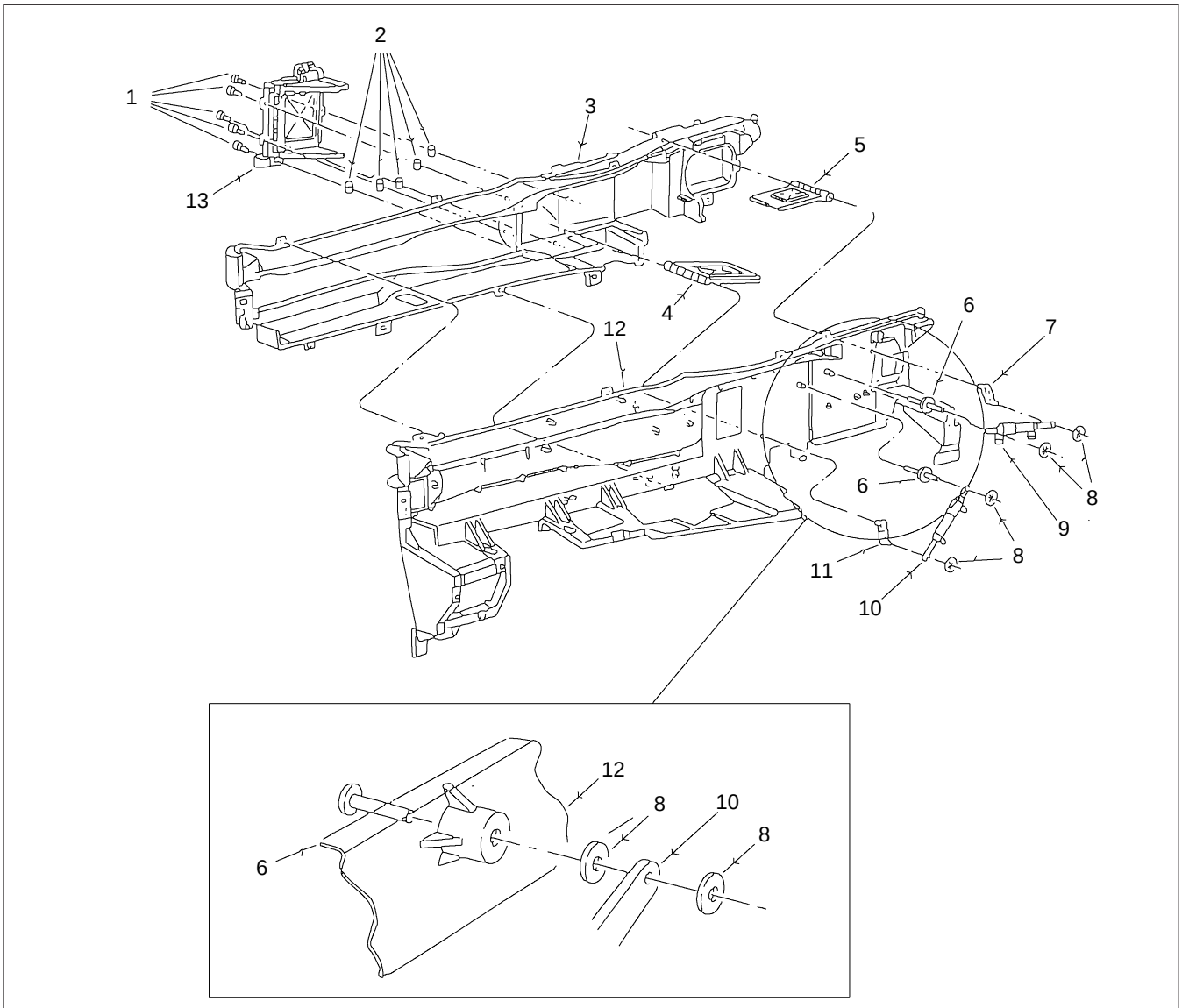
All air pressure in the vehicle air brake system must be relieved before disconnecting any pneumatic tubes. Hoses will whip dangerously if disconnected under pressure.

3. Disconnect the two pneumatic tubes from the actuator.
4. Remove the spring nuts, then remove the actuator.
5. Using new spring nuts, install a new actuator. Make sure the orientation of the actuator is correct.
6. Connect the two pneumatic tubes to the actuator.
7. If necessary, install the engine cover.

Pneumatic Actuator Replacement, Demister/Panel Doors

NOTE: The first two steps of the following procedure apply only if the vehicle is equipped with a passenger-side lower instrument panel trim cover.

1. Remove the quick-release screws, then remove the IP fuse junction panel trim cover. See **Fig. 1**.
2. Remove the IP fuse junction panel dust cover. See **Fig. 8**.



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1. Screw
2. Pushnut
3. Plenum
4. Heater and A/C Inlet Duct Door (left panel/floor)
5. Heater and A/C Inlet Duct Door (right panel/demister)
6. Pivot Stud
7. Actuator Crank Arm (right panel/demister)
8. Spring Nut
9. Pneumatic Door Actuator (right panel/demister)
10. Pneumatic Door Actuator (left panel/floor)
11. Actuator Crank Arm (left panel/floor)
12. Plenum
13. Defrost Door Assembly

Fig. 7, Plenum, Exploded View

Actuator Replacement

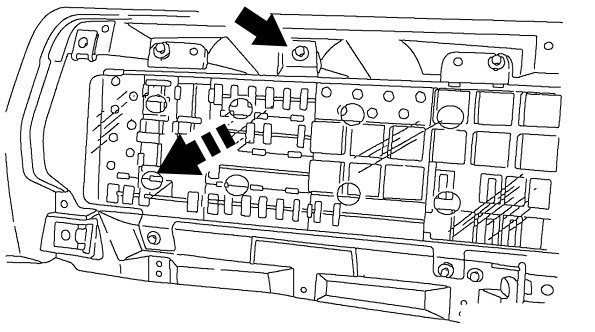
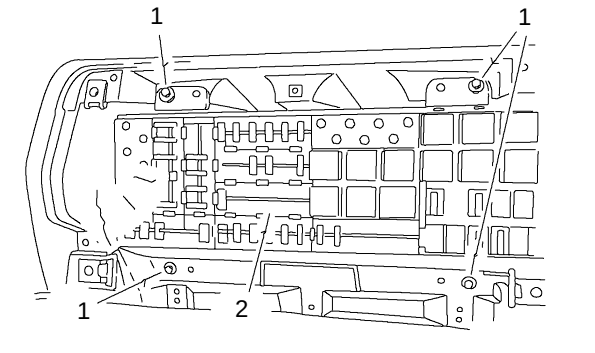


Fig. 8, IP Fuse Junction Panel Dust Cover

3. Remove the screws that secure the IP fuse junction panel and move the panel out of the way. See **Fig. 9**.



1. Screw 2. Junction Panel

Fig. 9, IP Fuse Junction Panel

WARNING

All air pressure in the vehicle air brake system must be relieved before disconnecting any pneumatic tubes. Hoses will whip dangerously if disconnected under pressure.

NOTE: Note the orientation of the demister/panel door actuator so that it is installed correctly later.

4. Disconnect the two pneumatic tubes from the demister/panel door actuator.
5. Remove the two spring nuts that secure the actuator, then remove the actuator.
6. Using spring nuts, install a new actuator.
7. Connect the two pneumatic tubes to the actuator.
8. Using screws, install the IP fuse junction panel.
9. Install the IP fuse junction panel dust cover.
10. Using quick-release screws, install the IP fuse junction panel trim cover.

Pneumatic Actuator Replacement, Outside-Recirculation Door

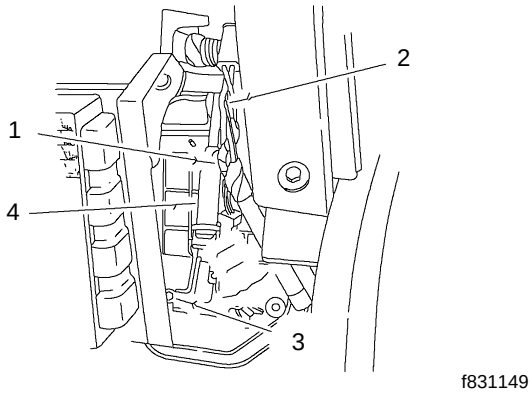
NOTE: The first two steps of the following procedure apply only if the vehicle is equipped with a passenger-side lower instrument panel trim cover.

1. Remove the quick-release screws, then remove the IP fuse junction panel trim cover. See **Fig. 1**.
2. Remove the instrument panel lower trim cover. See **Fig. 2**.
3. Remove the floor duct. See **Fig. 3**.

WARNING

All air pressure in the vehicle air brake system must be relieved before disconnecting any pneumatic tubes. Hoses will whip dangerously if disconnected under pressure.

4. Disconnect the pneumatic tube from the outside-recirculation door actuator. See **Fig. 10**.
5. Remove the pivot pin and the clevis pin, then remove the actuator.
6. Install a new actuator.
7. Install the clevis pin and the pivot pin.
8. Connect the pneumatic tube to the actuator.
9. Install the floor duct.
10. Install the instrument panel lower trim cover.
11. Using quick-release screws, install the IP fuse junction panel trim cover.



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1. Pneumatic Tube
2. Pivot Pin
3. Clevis Pin
4. Actuator

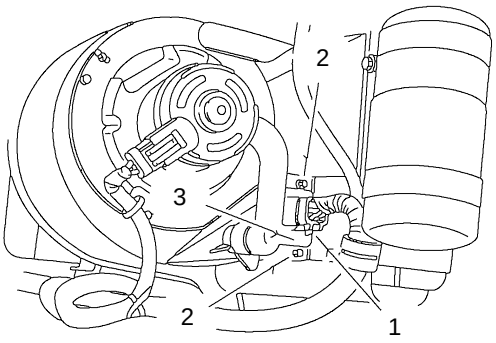
Fig. 10, Actuator

Blower Motor Resistor Replacement

Replacement

Left-Hand-Drive Vehicles

1. Disconnect the batteries.
2. Open the hood.
3. Disconnect the electrical connector from the blower motor resistor. See **Fig. 1**.
4. Remove the screws that secure the blower motor resistor, then remove the resistor.



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1. Electrical Connector
2. Screws
3. Resistor

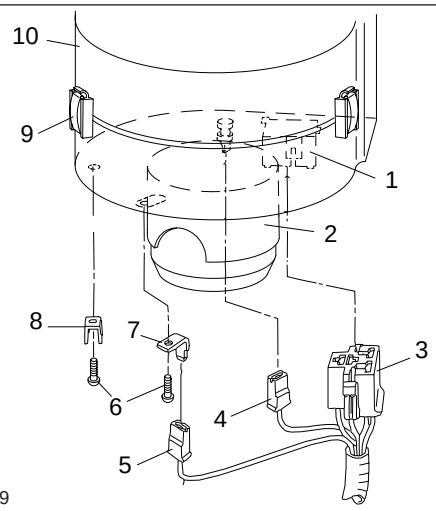
Fig. 1, Blower Motor Resistor

NOTE: The weatherproof gasket on the blower motor resistor flange must be inspected before installing the unit in the vehicle. If the gasket is damaged, replace the resistor or seal the resistor mounting flange using silicone rubber.

5. Using screws, install a new resistor. Torque the screws 18 to 27 lbf·in (170 to 280 N·cm).
6. Connect the electrical connector to the resistor.
7. Connect the batteries.
8. Close the hood.

Right-Hand-Drive Vehicles

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries.
3. Remove the glove compartment door trim panel.
4. Remove the lower A/C housing cover assembly.
5. Disconnect the electrical connectors from the blower motor. See **Fig. 2**.
6. Remove the wiring harness support bracket mounting screws to access the blower motor mounting screws.
7. Remove the blower motor air tube.
8. Remove the blower motor.
9. Disconnect the electrical connector from the blower motor resistor.
10. Remove the screws that secure the blower motor resistor, then remove the resistor. See **Fig. 2**.



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1. Blower Motor Resistor
2. Blower Motor
3. Blower Motor Resistor Connector
4. Blower Motor Connector (+)
5. Blower Motor Connector (-)
6. Blower Motor Mounting Screw
7. Blower Motor Connector
8. Blower Motor Assembly Screw Retainer
9. HVAC Unit Retaining Clip
10. HVAC Unit

Fig. 2, Blower Motor Resistor and Components

11. Using screws, install a new resistor. Torque the screws 18 to 27 lbf·in (170 to 280 N·cm).
12. Connect the electrical connector to the resistor.
13. Install the blower motor.
14. Install the blower motor air tube.

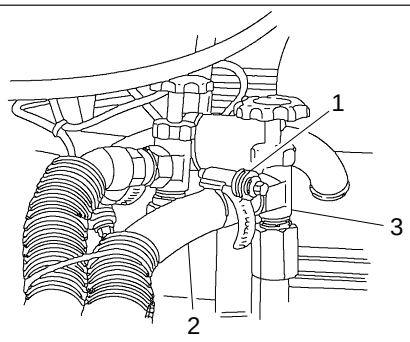
Blower Motor Resistor Replacement

15. Install the wiring harness support bracket mounting screws.
16. Connect the electrical connectors to the blower motor.
17. Install the lower A/C housing cover assembly.
18. Install the glove compartment door trim panel.
19. Connect the batteries.
20. Remove the chocks from the tires.

Replacement

NOTE: The following procedure is typical for all L-Line and A-Line heater core shutoff valves.

1. Allow the engine to cool, then drain the cooling system. For instructions, see **Group 20**.
2. Loosen the hose clamp, then remove the heater hose. See **Fig. 1**.



1. Hose Clamp
2. Heater Hose
3. Shutoff Valve

Fig. 1, Shutoff Valve

3. Remove the shutoff valve.

NOTE: Before installing the heater core shutoff valve, apply a coating of Pipe Sealant with Teflon® D8AZ–19554–A or equivalent meeting specifications WSK–M2G350–AZ and ESR–M18P7–A to the valve threads.

4. Install a new shutoff valve.
5. Install the heater hose on the shutoff valve and secure the hose with a hose clamp.
6. Fill the cooling system. For instructions, see **Group 20**.

Pneumatic Tube Removal and Installation

Removal

NOTE: Each pneumatic tube is color-coded and corresponds to a color-coded port on the air selection manifold and to a color-coded port on each of the pneumatic actuators. This color coding ensures correct operation in each function selection setting when properly matched between the tube and the various ports.

NOTE: When removing a pneumatic tube, pay particular attention to the tube routing for installation purposes.

1. Remove the climate control panel. For instructions, refer to **Subject 210**.
2. Locate the tube to be removed on the air selection manifold, and push it inward toward the manifold port.
3. Maintain pressure on the tube and push in the color-coded retaining collar toward the manifold port.

NOTE: Each port has a metal insert or sleeve that engages the tube inside diameter. If this insert pulls out with the tube during removal, make sure it is re-engaged into the replacement tube upon installation.

4. Pull the tube away from the manifold maintaining pressure on the retaining collar.
5. Locate the pneumatic actuator that corresponds with the port on the manifold and, using the same method as previously outlined in this procedure, remove the tube.

NOTE: Pay close attention to the tube routing for installation purposes.

6. Remove the tube from the vehicle.

Installation

1. Route the tube in the same manner as the tube removed.
2. Insert the tube into the actuator or manifold and push until fully seated.
3. Repeat the procedure for the opposite end of the tube.
4. Install the control. For instructions, refer to **Subject 210**.

Right-Hand-Drive HVAC Unit Removal and Installation

⚠ WARNING

Before starting any of the procedures below, see "Safety Precautions" in Subject 100. Failure to do so may result in personal injury.

Removal

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Remove the instrument panel. For instructions, see **Section 60.01**.
3. Disconnect the heater hoses from the heater core. For instructions, see **Group 20**.
4. Recover the air conditioning refrigerant, then disconnect the evaporator. For instructions, see **Subject 110**.
5. Remove the air filter housing. For instructions, see **Group 09**.
6. Remove the heater core grommets and the air conditioning evaporator condensation drain tube.
7. Remove the HVAC unit from the cab.

Installation

1. Using screws, install the HVAC unit in the cab.
2. Install the heater core grommets and the air conditioning evaporator condensation drain tube.
3. Install the instrument panel. For instructions, see **Section 60.01**.
4. Connect the heater hoses to the heater core. For instructions, see **Group 20**.
5. Connect the evaporator core lines and charge the air conditioning refrigerant. For instructions, see **Subject 110**.
6. Remove the chocks from the tires.

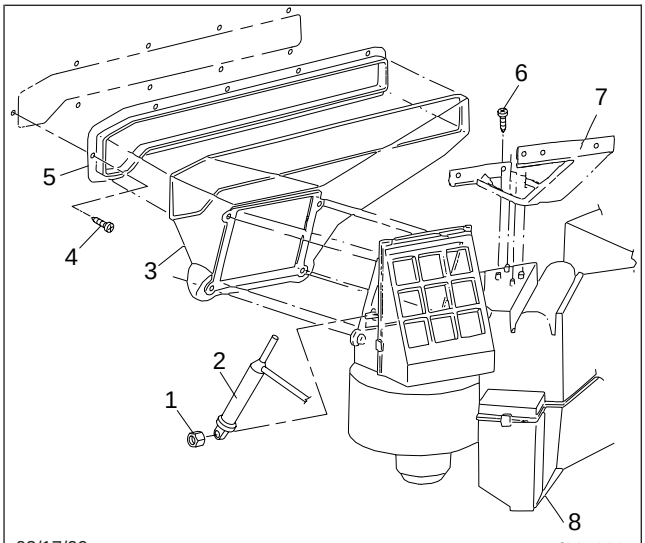
Right-Hand-Drive HVAC Unit Disassembly and Assembly

⚠ WARNING

Before starting any of the procedures below, see "Safety Precautions" in Subject 100. Failure to do so may result in personal injury.

Disassembly

1. Remove the HVAC unit. For instructions, see **Subject 280**.
2. Remove the ducting from the HVAC unit. See **Fig. 1**.



1. Nut
2. Vacuum Actuator
3. Air Intake Duct
4. Mounting Screw
5. Duct Retainer
6. Retaining Screw
7. PDM Mounting Bracket
8. HVAC Unit

Fig. 1, HVAC Unit and Ducting

3. Remove the vacuum actuators from the HVAC unit. See **Fig. 1**.
4. Remove the HVAC air blend motor mounting screws, then remove the motor. See **Fig. 2**.
5. Remove the clips and fasteners, then separate the HVAC unit into two halves.

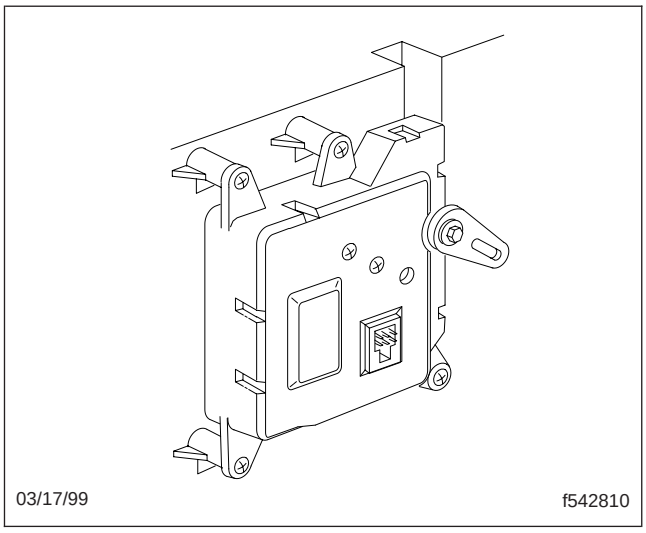
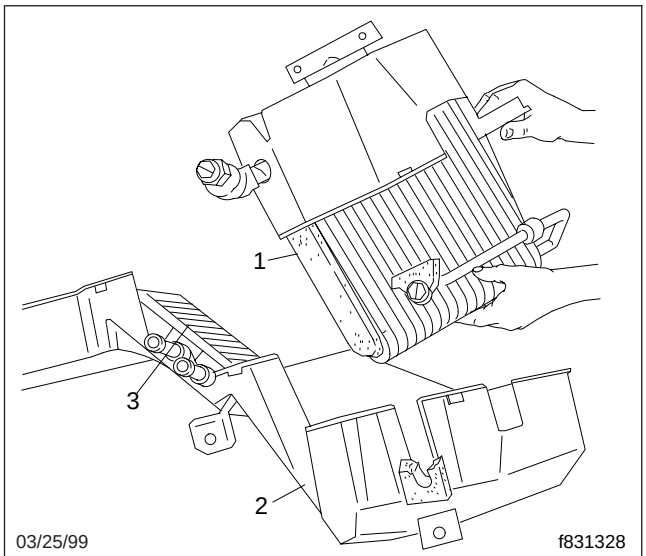


Fig. 2, Air Blend Motor

6. Remove the heater core and the evaporator. See **Fig. 3**.



1. Evaporator
2. HVAC Unit
3. Heater Core

Fig. 3, HVAC Unit and Ducting

Assembly

1. Install the heater core and the evaporator. See **Fig. 3**.

Right-Hand-Drive HVAC Unit Disassembly and Assembly

2. Using mounting screws, install the HVAC air blend motor in the HVAC unit. See **Fig. 2**.
3. Join the two halves of the HVAC unit and install the clips and fasteners.
4. Install the vacuum actuators on the HVAC unit. See **Fig. 1**.
5. Install the ducting on the HVAC unit.
6. Install the HVAC unit. For instructions, see **Subject 280**.

Troubleshooting

For a schematic of the air lines, see **Fig. 1**.

NOTE: All actuators fully extend with 0 air pressure and retract with 80 to 130 psi (552 to 896 kPa) air pressure applied.

Panel/floor and demister/panel actuators are dual position, providing half stroke and full stroke retraction of actuator rods.

Inspection and Verification

1. Verify the customer complaint by operating the climate control system.
2. Visually inspect for obvious signs of mechanical and electrical damage. See **Table 1**.
3. If the fault is not visually evident, determine the symptom and proceed to the troubleshooting tables.

Visual Inspection Chart	
Mechanical	**Electrical**
Drive belt	Fuse
A/C clutch	Blower motor
Pneumatic lines	Refrigerant compressor
Discharged A/C system	Cooling fan
Refrigerant lines	Circuit
Pneumatic actuator	Electrical connectors

Table 1, Visual Inspection Chart

Component Tests

Heater Core, In-Vehicle Pressure Test

For an illustration of the heater core in-vehicle pressure test, see **Fig. 2**.

1. Drain the engine coolant system. For instructions, see **Group 20**.
2. Disconnect the inlet and outlet heater water hoses.
3. Install a short piece of heater water hose, approximately 4 inches (100 mm) long, on each heater core tube.
4. Fill the heater core and heater core water hoses with water.
5. Install a plug and adaptor, from the Radiator/Heater Core Pressure Tester, in the ends of the heater hoses. Secure the heater hoses, plug, and adaptor with hose clamps.
6. Attach the Radiator/Heater Core Pressure Tester to the adaptor. Close the bleed valve at the base of the gauge and pump 30 psi (206 kPa) of air pressure into the heater core.
7. Observe the pressure gauge for a minimum of three minutes. The pressure should not drop.
8. If the pressure does not drop, no leaks are indicated.

NOTE: Severe distortion of the heater core tubes can cause leakage at the coupling connection. Repair or replace as necessary.

9. If the pressure drops, check the coupling and hose connections to the heater core tubes for leaks. If the couplings and hose connections do not leak, perform the following bench test.

Heater Core, On-Bench Pressure Test

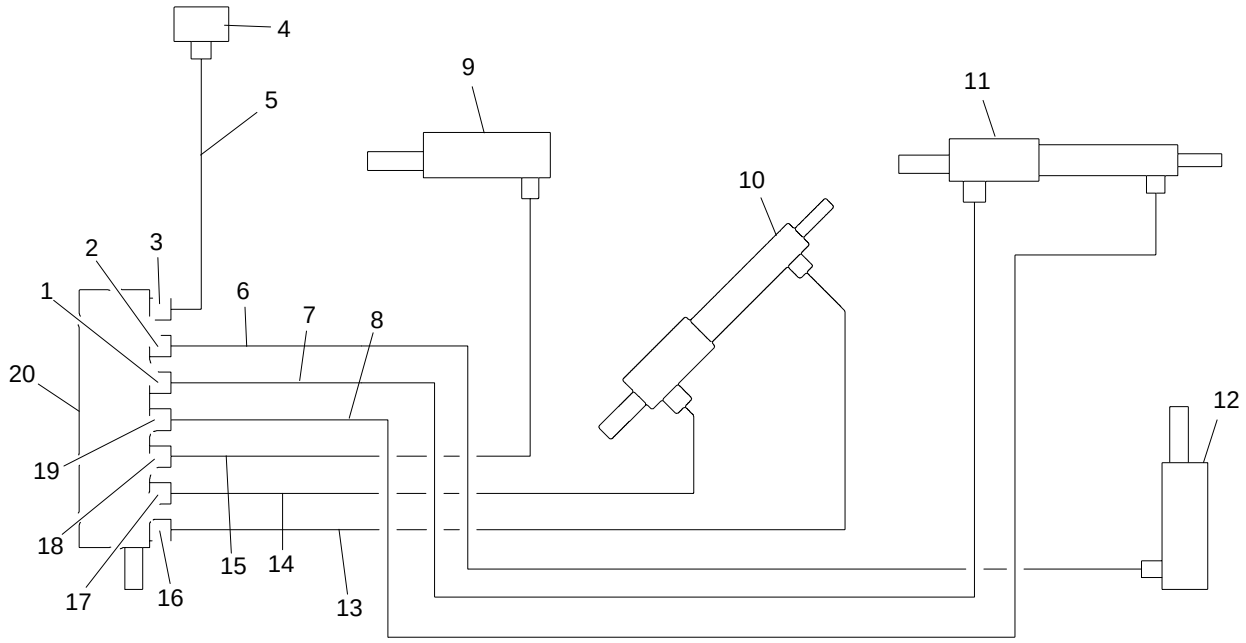
For an illustration of the heater core on-bench pressure test, see **Fig. 3**.

1. Drain the engine cooling system. For instructions, see **Group 20**.
2. Remove the heater core.
3. Connect the four-inch (100-mm) test heater water hoses to the heater core.
4. Install the plug and adaptor.
5. Connect the Radiator/Heater Core Pressure Tester to the adaptor.
6. Apply 30 psi (206 kPa) of air pressure to the heater core.
7. Submerge the heater core in water.
8. If a leak is observed, repair or replace the heater core.

A/C Evaporator, A/C Vacuum Leak Test

IMPORTANT: See **Safety Precautions 100** before performing this procedure.

Troubleshooting



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1. Green Port
2. Black Port
3. 1/4-inch Black Port
4. Source (manifold)
5. Black Pneumatic Line (1/4 inch)
6. Black Pneumatic Line
7. Green Pneumatic Line
8. Yellow Pneumatic Line
9. Panel/Def Door Actuator
10. Panel/Floor Door Actuator
11. Demister/Panel Door Actuator
12. Outside Air/Off Actuator (heat only) Outside Air/ Recirculation Actuator (A/C-heater)
13. Blue Pneumatic Line
14. Red Pneumatic Line
15. Gray Pneumatic Line
16. Blue Port
17. Red Port
18. White Port
19. Yellow Port
20. Function Control Manifold

Fig. 1, Air Line Schematic

⚠ CAUTION

The A/C refrigerant of all vehicles must be identified and analyzed prior to refrigerant recovery. Failure to do so can contaminate the shop bulk refrigerant and other vehicles.

1. Verify that the manifold gauge set is capable of holding a vacuum.

   1.1 Connect the red and blue hoses together using a 1/4-inch flare coupling.

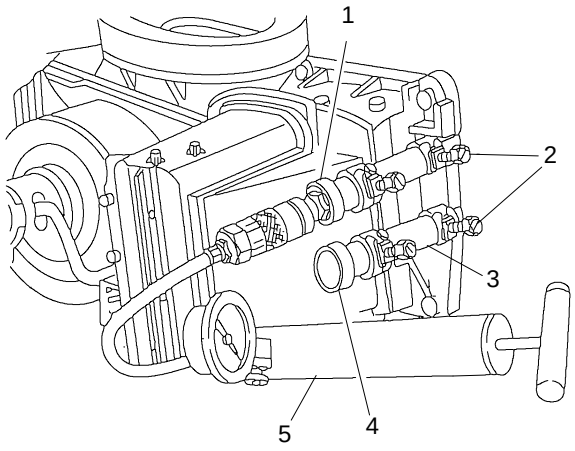
   1.2 Connect the gauge set yellow hose to a known good vacuum pump.

   1.3 Turn the vacuum pump ON and open both gauge set valves.

   1.4 Operate the vacuum pump for 1 minute and close both gauge set valves. The low side gauge should indicate approximately 30 in Hg (762 mm Hg) of vacuum.

   1.5 Allow the gauge set, with vacuum applied, to set for at least 30 minutes.

   1.6 If the gauge reading drops during that time, the gauge set hose connections, gauges or valves are leaking and must be repaired before proceeding with the leak test.



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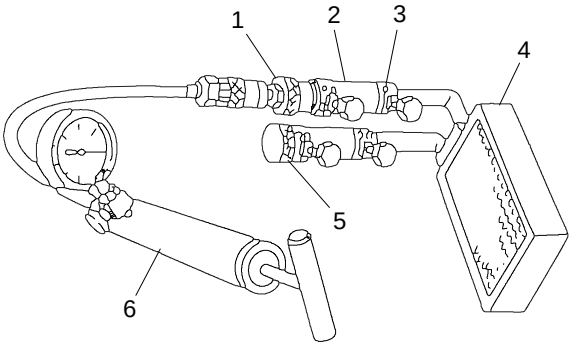
1. Adaptor
2. Hose Clamp
3. Heater Water Hose
4. Plug
5. Radiator/Heater Core Pressure Tester

Fig. 2, Heater Core, In-Vehicle Pressure Test



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1. Adaptor
2. Heater Water Hose
3. Hose Clamp
4. Heater Core
5. Plug
6. Heater Core/Radiator Pressure Tester

Fig. 3, Heater Core, On-Bench Pressure Test

2. Discharge the A/C system. For instructions, see **Subject 110**.

NOTE: Do not leak test an evaporator with the suction accumulator/drier attached to the evaporator tubes. Refrigerant outgassing from the oil and desiccant in the suction accumulator/drier will indicate a false leak condition.

3. Disconnect both the liquid line and suction accumulator line from the evaporator. Plug the liquid and the suction accumulator/drier lines.

NOTE: Polish the tube O-fitting using a twisting motion so that any scratches made will not cross the O-ring sealing surface.

4. Clean the evaporator lines.
   - 4.1 Remove any surface residue from the fitting by polishing with a 400-grit emery cloth.
   - 4.2 Perform additional polishing with a 600-grit emery cloth.
   - 4.3 Remove all polishing residue with a lint-free rag.

NOTE: The automatic shutoff valves on some gauge set hoses do not open when connected to the test fittings. Use hoses without the shutoff valves if they are available. If hoses with shutoff valves are used, make sure that the valves open when they are attached to the test fittings before installing them and proceeding with the leak test. The test will be invalid if the automatic shutoff valves do not open, in which case only the hose will be tested.

5. Connect the appropriate test fittings from the test adaptor set to the evaporator connections. Then, connect the gauge set red and blue hoses to the test fittings. Connect the yellow gauge set hose to a known good quality vacuum pump.

NOTE: Use only a good quality vacuum pump. A vacuum pump requires maintenance for optimum performance. The condition of the vacuum pump oil is critical to pump performance and durability. Dirty or moisture-laden oil reduces the vacuum pump's ability to draw high vacuum levels which are required to extract refrigerant from the oil in the evaporator. As a general rule, vacuum pump manufacturers recommend replacing the oil in the vacuum pump after every 10 hours of operation. Some manufacturers may recommend even more frequent oil change intervals.

6. Open both gauge valves and start the vacuum pump. Turn the heater blower motor switch to LO and allow the vacuum pump to operate for a minimum of 30 minutes after the gauge set low-pressure gauge indicates 30 in Hg (762 mm Hg). The 30-minute evacuation is necessary to remove any refrigerant from oil left in the evaporator. If the refrigerant is not completely removed from the oil, gassing will occur and degrade the vacuum and appear as a refrigerant leak. After evacuation for 30 minutes, close the gauge set valves and stop the vacuum pump. Observe the low pressure gauge; it should remain at the 30 in Hg (762 mm Hg) mark.
7. If the low pressure gauge reading will not drop to 30 in Hg (762 mm Hg) when the gauge and manifold set valves are open and the vacuum pump is operating, then close the valves and observe the low pressure gauge. If the pressure rises rapidly to zero, a large leak is indicated. Check the test fitting connections and gauge set connections before replacing the evaporator.
8. If the low pressure gauge reading rises 10 or more in Hg (254 mm Hg) from the 30 in Hg (762 mm Hg) mark in 10 minutes, a leak is indicated. If a very small leak is suspected, wait 30 minutes and observe the vacuum gauge. If a small amount of vacuum is lost, operate the vacuum pump with the gauge valves open for an additional 30 minutes with the heater blower motor switch on LO to remove any remaining refrigerant from the evaporator. Then, check for the loss of vacuum as outlined above. If a very small leak is suspected, allow the system to sit overnight with a vacuum applied and check for a vacuum loss the next day. Always remember that a leaking fitting, gauge set, or hose connection will appear as a leaking evaporator.

A/C Condenser, A/C Vacuum Leak Test

IMPORTANT: Refer to **Safety Precautions 100** before performing this procedure.

⚠ CAUTION

The A/C refrigerant of all vehicles must be identified and analyzed prior to refrigerant recovery. Failure to do so can contaminate the shop bulk refrigerant and other vehicles.

1. Verify that the manifold gauge set is capable of holding a vacuum.
   - 1.1 Connect the red and blue hoses together using a 1/4-inch flare coupling.
   - 1.2 Connect the gauge set yellow hose to a known good vacuum pump.
   - 1.3 Turn the vacuum pump on and open both gauge set valves.
   - 1.4 Operate the vacuum pump for 1 minute and close both gauge set valves. The low side gauge should indicate approximately 30 inches of vacuum.
   - 1.5 Allow the gauge set, with vacuum applied, to set for at least 30 minutes.
   - 1.6 If the gauge reading drops during that time, the gauge set hose connections, gauges, or valves are leaking and must be repaired before proceeding with the leak test.
2. Discharge the A/C system. For instructions, see **Subject 110**.
3. Disconnect the high-pressure line and discharge line from condenser. Plug the lines leading to the refrigerant compressor and the evaporator.

NOTE: Polish the tube O-fitting using a twisting motion so that any scratches made will not cross the O-ring sealing surface.

4. Clean the condenser lines.
   - 4.1 Remove any surface residue from the fitting by polishing with a 400-grit emery cloth.
   - 4.2 Perform additional polishing with a 600-grit emery cloth.
   - 4.3 Remove all polishing residue with a lint-free rag.

NOTE: The automatic shutoff valves on some gauge set hoses do not open when connected to the test fittings. Use hoses without the shutoff valves if they are available. If hoses with shutoff valves are used, make sure that the valves open when they are attached to the test fittings before installing them and proceeding with the leak test. The test will be invalid if the automatic

shutoff valves do not open in which case only the hose will be tested.

5. Connect the appropriate test fittings from the test adaptor set to the condenser tube connections. Then connect the gauge set red and blue hoses to the test fittings. Connect the yellow gauge set hose to a known good quality vacuum pump.

NOTE: Use only a good quality vacuum pump. A vacuum pump requires maintenance for optimum performance. The condition of the vacuum pump oil is critical to pump performance and durability. Dirty or moisture-laden oil reduces the vacuum pump's ability to draw high vacuum levels which are required to extract refrigerant from the oil in the condenser. As a general rule, vacuum pump manufacturers recommend replacing the oil in the vacuum pump after every 10 hours of operation. Some manufacturers may recommend even more frequent oil change intervals.

6. Open both gauge valves and start the vacuum pump. Turn the heater blower motor on to LO and allow the vacuum pump to operate for a minimum of 45 minutes after the gauge set low-pressure gauge indicates 30 in Hg (762 mm Hg). The 45-minute evacuation is necessary to remove any refrigerant from oil left in the condenser. If the refrigerant is not completely removed from the oil, gassing will occur and degrade the vacuum and appear as a refrigerant leak. After evacuation for 45 minutes, close the gauge set valves and stop the vacuum pump. Observe the low pressure gauge; it should remain at the 30 in Hg (762 mm Hg) mark.
7. If the low pressure gauge reading will not drop to 30 in Hg (762 mm Hg) when the gauge and manifold set valves are open and the vacuum pump is operating, then close the valves and observe the low pressure gauge. If the pressure rises rapidly to zero, a large leak is indicated. Check the test fitting connections and gauge set connections before replacing the condenser.
8. If the low pressure gauge reading rises 10 or more in Hg (254 mm Hg) from the 30 in Hg (762 mm Hg) mark in 10 minutes, a leak is indicated. If a very small leak is suspected, wait 30 minutes and observe the vacuum gauge. If a small amount of vacuum is lost, operate the vacuum pump with the gauge valves open for an additional 45 minutes with the heater blower motor switch on LO to remove any remaining refrigerant from the condenser. Then, recheck for the loss of vacuum as outlined above. If a very small leak is suspected, allow the system to sit overnight with a vacuum applied and check for a vacuum loss the next day. Always remember that a leaking fitting, gauge set, or hose connection will appear as a leaking condenser.

Blower Motor

1. Connect a jumper wire (10 gauge or larger) directly from the positive battery terminal to Terminal No. 1 of the blower motor. See **Fig. 4**.

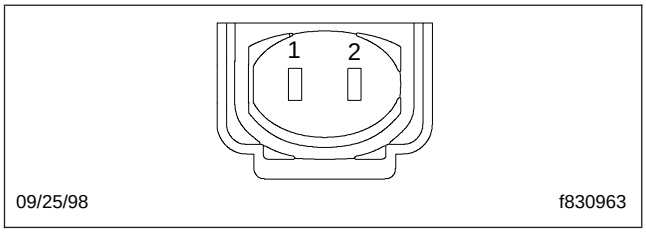


Fig. 4, Blower Motor Switch Connector Terminal Identification

2. Connect a second jumper wire (10 gauge or larger) from Terminal No. 2 to a known good ground. See **Fig. 4**.
3. If the blower motor does not run, then the blower motor needs to be replaced.

Main System Heater Blower Motor Switch Resistor

For indentification of the teminals on the main system blower motor switch resistor, see **Fig. 5**. For acceptable values for the main system heater blower motor switch resistor test, see **Table 2**.

Troubleshooting

Main System Heater Blower Motor Switch Resistor Test		
To Test	**Measure the Resistance Between**	**Resistance Should Read**
MED-HI Speed	Terminal 2 and Terminal 4	0.25 ohms ± 10%
MED-LO Speed	Terminal 2 and Terminal 1	1.05 ohms ± 10%
LO Speed	Terminal 2 and Terminal 3	3.75 ohms ± 10%

Table 2, Main System Heater Blower Motor Switch Resistor Test

SilverStar Auxiliary Blower Motor

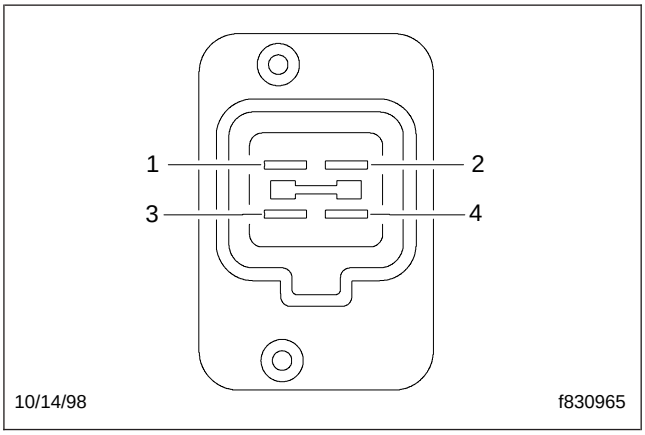


Fig. 5, Main System Heater Blower Motor Switch Resistor Terminal Identification

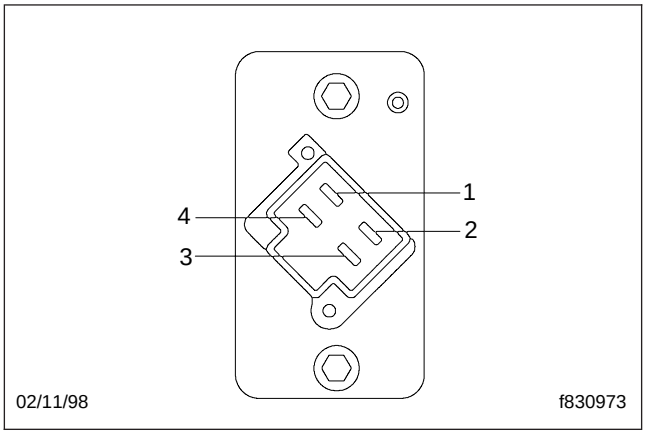


Fig. 6, SilverStar Auxiliary Blower Motor Resistor Terminal Identification

Resistor

For identification of terminals on a SilverStar auxiliary blower motor resistor, see **Fig. 6**. For acceptable values for the SilverStar auxiliary blower motor switch resistor test, see **Table 3**.

Main A/C-Heater Air Selection Switch

For indentification of the teminals of the main and SilverStar auxiliary A/C-heater air selection switch, see **Fig. 7**. For acceptable values for the main A/C-heater air selection switch test, see **Table 4**.

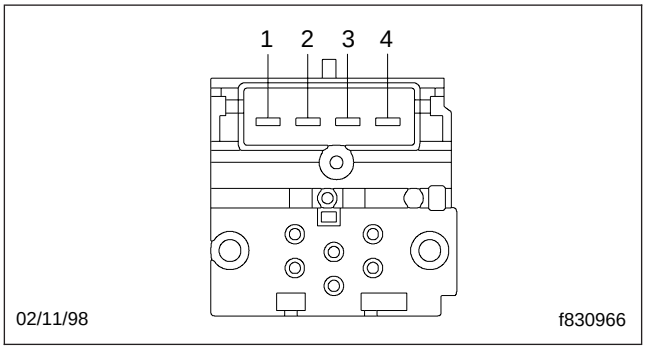


Fig. 7, Main and SilverStar Auxiliary A/C-Heater Air Selection Switch Terminal Identification

SilverStar Auxiliary Blower Motor Resistor Test		
To Test	**Measure the Resistance Between**	**Resistance Should Read**
MED-HI Speed	Terminal 3 and Terminal 1	0.25 ohms ± 10%
MED-LO Speed	Terminal 3 and Terminal 4	0.80 ohms ± 10%
LO Speed	Terminal 3 and Terminal 2	2.70 ohms ± 10%

Table 3, SilverStar Auxiliary Blower Motor Resistor Test

Main A/C-Heater Air Selection Switch Test			
To Test	**Measure the Resistance Between**	**Set the Switch to These Positions**	**Resistance Should Read**
A/C Clutch Circuit	Terminal 1 and Terminal 2	Off	Greater than 10,000 ohms
		Max A/C	Less than 5 ohms
		Norm A/C	Less than 5 ohms
		Vent	Greater than 10,000 ohms
		Floor	Greater than 10,000 ohms
		Mix	Less than 5 ohms
		Defrost	Less than 5 ohms
Blower Motor Circuit	Terminal 4 and Terminal 3	Off	Greater than 10,000 ohms
		All Other Positions	Less than 5 ohms

Table 4, Main A/C-Heater Air Selection Switch Test

SilverStar Auxiliary A/C-Heater Air Selection Switch

For indentification of the teminals of the main and SilverStar auxiliary A/C-heater air selection switch, see **Fig. 7**. For acceptable values for the SilverStar auxiliary A/C-heater air selection switch test, see **Table 5**.

Main or Auxiliary SilverStar Blower Motor Switch

For identification of the pins of the main or auxiliary AilverStar blower motor switch, see **Fig. 8**. For acceptable test results for the main or auxiliary SilverStar blower motor switch test, see **Table 6**.

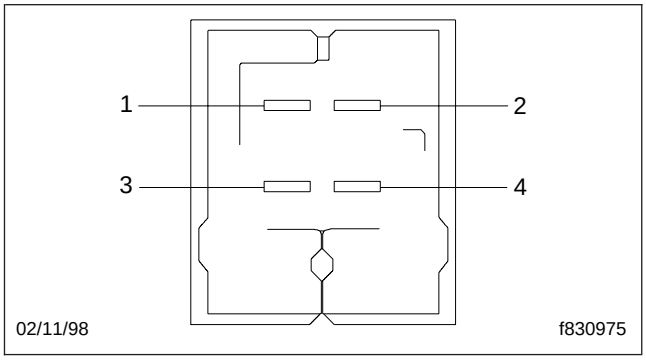


Fig. 8, Main or Auxiliary SilverStar Blower Motor Switch Pin Identification

SilverStar Auxiliary A/C-Heater Air Selection Switch Test			
To Test	**Measure the Resistance Between**	**Set the Switch to These Positions**	**Resistance Should Read**
Blower Motor Circuit	Terminal 3 and Terminal 1	Off	Greater than 10,000 ohms
		On	Less than 5 ohms

Table 5, SilverStar Auxiliary A/C-Heater Air Selection Switch Test

Main or Auxiliary SilverStar Blower Motor Switch Test		
Switch Position	**Pins**	**A Good Switch Will Test As**
LO	1, 2	Open
LO	1, 3	Open
LO	1, 4	Open

Main or Auxiliary SilverStar Blower Motor Switch Test		
Switch Position	**Pins**	**A Good Switch Will Test As**
LO	2, 3	Open
LO	2, 4	Open
LO	3, 4	Open

Troubleshooting

Main or Auxiliary SilverStar Blower Motor Switch Test		
Switch Position	**Pins**	**A Good Switch Will Test As**
MED-LO	1, 2	Open
MED-LO	1, 3	Open
MED-LO	1, 4	Closed
MED-LO	2, 3	Open
MED-LO	2, 4	Open
MED-LO	3, 4	Open
MED-HI	1, 2	Open
MED-HI	1, 3	Open
MED-HI	1, 4	Closed
MED-HI	2, 3	Open
MED-HI	2, 4	Open
MED-HI	3, 4	Closed
HI	1, 2	Closed
HI	1, 3	Closed
HI	1, 4	Open
HI	2, 3	Closed
HI	2, 4	Open
HI	3, 4	Open

Table 6, Main or Auxiliary SilverStar Blower Motor Switch Test

Thermal Protection Switch

1. Disconnect the refrigerant compressor connector C125 from the main wiring harness.
2. Measure the resistance between the refrigerant compressor connector C125 pin 4 (BR) and pin 2 (BK/W). If the resistance is less than 5 ohms, the thermal protection switch is good. If the resistance is greater than 5 ohms, replace the thermal protection switch.
3. Disconnect the A/C clutch connector. See **Fig. 9**.
4. Install a jumper wire between the A/C clutch connector pin 1 and pin 2. See **Fig. 10**.

Main System Temperature Potentiometer Switch

For identification of the pins of the main system temperature potentiometer switch, see **Fig. 11**.

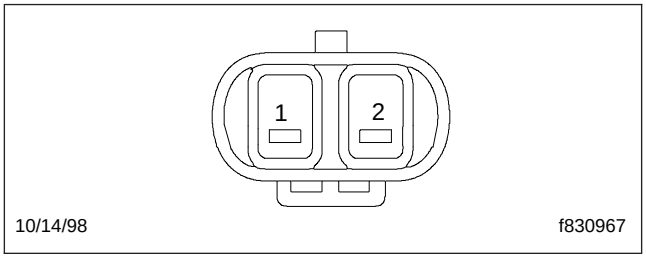


Fig. 9, A/C Clutch Connector

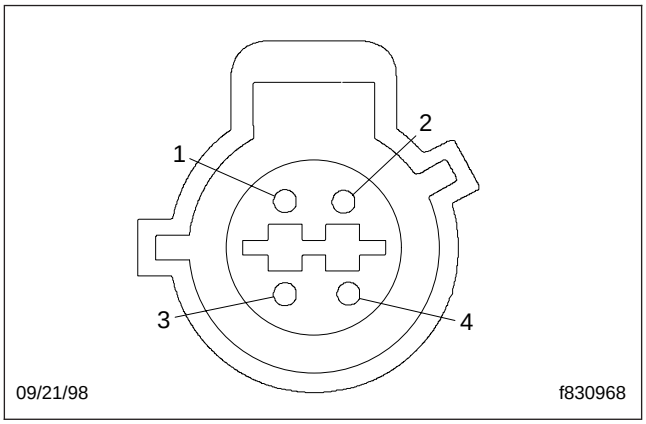


Fig. 10, A/C Clutch Test

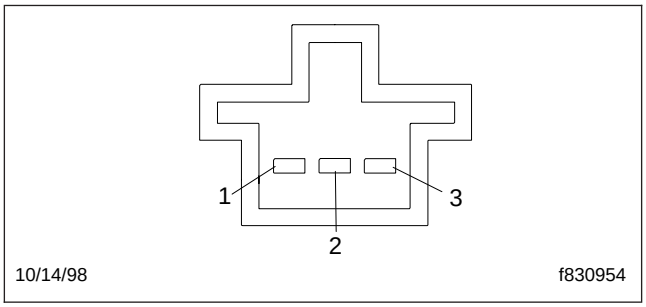


Fig. 11, Main System Temperature Potentiometer Switch

Measure the resistance between the temperature potentiometer pin 1 and pin 2 with the switch at full COOL and full WARM. With the switch at full COOL, the resistance should be less than 100 ohms. With the switch at full WARM, the resistance should be 4 to 6 kohms. If the switch does not meet the specifications, replace the switch.

A-Line Auxiliary System Thermal Potentiometer Switch

For identification of the pins of the A-Line auxiliary system thermal potentiometer switch, see **Fig. 12**.

ISO Relay

1. Measure the resistance between the relay terminal 85 and all other terminals. If the resistance is 5 ohms or less, replace the relay. See **Fig. 13**.

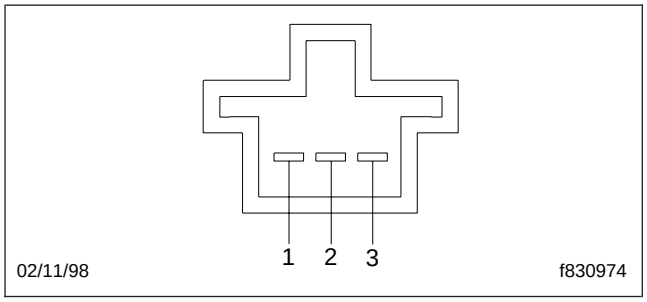


Fig. 12, A-Line Auxiliary System Thermal Potentiometer Switch

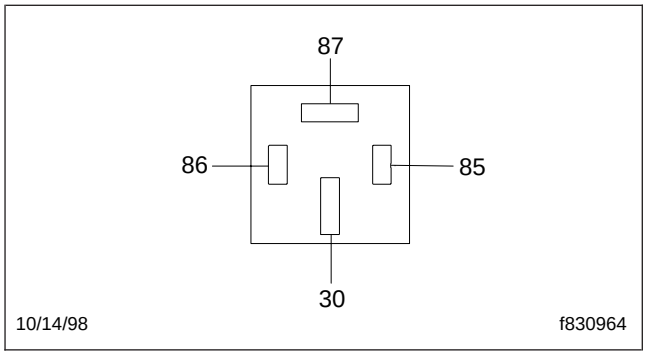


Fig. 13, Relay Resistance Check

2. Using two jumper wires (10 gauge or larger), connect the relay terminals 86 and 30 directly to the positive battery terminal.
3. Measure the voltage between the relay terminal 87 and ground. If the voltage is 10 volts or greater, replace the relay.
4. Using a third jumper wire (10 gauge or larger), connect the relay terminal 85 to a known good ground.
5. Measure the voltage between the relay terminal 87 and ground. If the voltage is less than 10 volts, replace the relay.

Refrigerant System Tests

For the system pressure and cycle timing evaluation chart, see **Fig. 14**.

IMPORTANT: See **Safety Precautions 100** before performing this procedure.

NOTE: Poor air conditioning system performance can be caused by a plugged evaporator or if the airflow is restricted.

This condition can be detected by checking the center register discharge temperature. An abnormally low temperature indicates air is spending more time in the evaporator and is very cold when discharged, although the airflow volume is not enough to cool the vehicle properly.

Additional causes are listed at the bottom of the chart for poor compressor operation or a damaged compressor condition.

These diagnosis charts provide the most direct and sure way to determine the cause of any problem in a poorly performing refrigerant system.

After servicing and correcting a refrigerant system problem, take additional pressure readings and observe the cycle rate while meeting the conditional requirements to be sure the problem has been corrected.

To diagnose a concern in the refrigerant system, note the system pressure (shown by the gauges) and the clutch cycle rate, then compare readings with the charts.

The system pressures are low (compressor suction) and high (compressor discharge).

A cycle is the time the A/C clutch is engaged plus the time it is disengaged (time on plus time off).

Cycle times are the lengths of time (in seconds) that the A/C clutch is on or off.

The test conditions specified at the top of each of the charts must be met to obtain accurate test results.

To achieve accurate diagnosis results in the least amount of time, use the following proce-

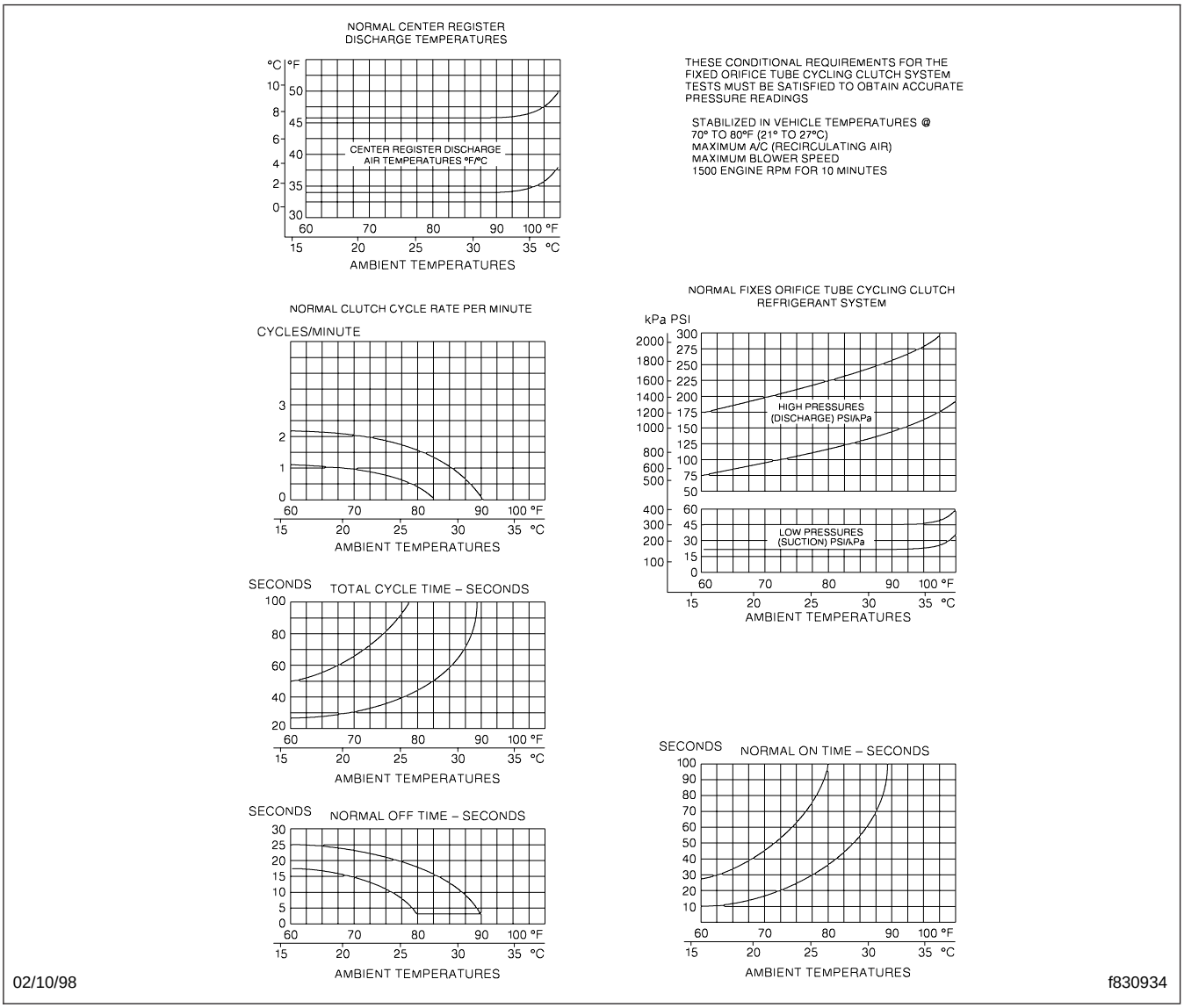


Fig. 14, System Pressure and Cycle Timing Evaluation Chart

dure and refer to the "Refrigerant System Pressure and Cycle Timing Evaluation Chart for Evaporator Orifice Cycling Systems."

1. Connect a gauge set to the system.
2. When the system has stabilized, record high and low pressures as shown by the gauges.
3. Determine the cycle rate per minute (on time plus off time equals one cycle).
4. Record the off time in seconds.
5. Record the on time in seconds.
6. Note center register discharge temperature.
7. Determine and record the ambient temperature.
8. Compare the test readings on the appropriate chart.

   Plot a vertical line for recorded ambient temperature from the scale at the bottom to the top of each chart.

Plot a horizontal line for other test readings from the scale at the left side of the appropriate chart.

If the point where the two lines cross on each chart falls within the heavy lines, the system is operating normally. If the lines cross outside the heavy lines on one or more of the charts, there is a problem and the specific cause must be determined. The following five system operating conditions are indicated where the lines cross the chart:

- system high (discharge) pressure is high, low, or normal
- system low (suction) pressure is high, low, or normal
- cycle rate is fast, slow, or A/C clutch runs continuously
- on time is long or short
- off time is long or short

NOTE: Normal system conditional requirements must be maintained to properly evaluate refrigerant system pressures. Refer to the charts applicable to the system under the test.

9. Match these conditions to the conditions shown in the five columns toward the left in **Table 7**. All five system conditions will be indicated on one line. The most likely component(s) causing the concern is indicated in the right column.

Refrigerant System Pressure and Cycle Timing Evaluation Chart for Evaporator Orifice Cycling Systems

High (discharge) Pressure	Low (suction) Pressure	Clutch Cycle Time			Component and Causes
		Rate	On	Off	
High	High	Continuous Run	Continuous Run	Continuous Run	A/C condenser, inadequate airflow.
High	Normal to High	Continuous Run	Continuous Run	Continuous Run	Engine overheating.
Normal to High	Normal	Continuous Run	Continuous Run	Continuous Run	Air in refrigerant. Refrigerant overcharge.* Humidity or ambient temperature very high.†
Normal	High	Continuous Run	Continuous Run	Continuous Run	Evaporator orifice missing. O-rings leaking/missing.
Normal	High	Slow	Long	Long	A/C clutch cycling pressure switch, high cut-in.
Normal	Normal	Slow or No Cycle	Long or Continuous	Normal or No Cycle	Moisture in refrigerant system. Excessive refrigerant oil.
Normal	Normal	Fast	Short	Short	A/C clutch cycling pressure switch, cut-in or high cut-out.
Normal	Low	Slow	Long	Long	A/C clutch cycling pressure switch, low cut-out.
Normal to Low	High	Continuous Run	Continuous Run	Continuous Run	Compressor, low performance.
Normal to Low	Normal to High	Continuous Run	Continuous Run	Continuous Run	Evaporator to compressor suction line—partially restricted or plugged.‡
Normal to Low	Normal	Fast	Short	Normal	Evaporator, low airflow.
Normal to Low	Normal	Fast	Short to Very Short	Normal to Long	Condenser, evaporator orifice, or dryer to evaporator liquid line, partially restricted or plugged.

Troubleshooting

Refrigerant System Pressure and Cycle Timing Evaluation Chart for Evaporator Orifice Cycling Systems					
High (discharge) Pressure	**Low (suction) Pressure**	**Clutch Cycle Time**			**Component and Causes**
		Rate	**On**	**Off**	
Normal to Low	Normal	Fast	Short to Very Short	Short to Very Short	Low refrigerant charge.
Normal to Low	Normal	Fast	Short to Very Short	Long	Evaporator, partially restricted or plugged.
Normal to Low	Low	Continuous Run	Continuous Run	Continuous Run	Evaporator to compressor suction line—partially restricted or plugged.§ A/C clutch cycling switch, sticking closed.
Low	Normal	Very Fast	Very Short	Very Short	A/C clutch cycling switch, cycling range too close.
Erratic Operation or Compressor Not Running	Erratic Operation or Compressor Not Running	—	—	—	A/C clutch cycling switch—dirty contacts or sticking open. Poor connection at A/C clutch connector or A/C clutch cycling pressure switch connector. A/C electrical circuit erratic.
Additional Possible Cause Components Associated with Inadequate Refrigerant Compressor Operation					
Refrigerant Compressor Drive Belt	—	—	—	—	Refrigerant compressor drive belt loose.
A/C Clutch	—	—	—	—	A/C clutch slipping.
A/C Clutch Field Coil	—	—	—	—	A/C clutch field coil open, shorted, or loose mounting.
Climate Control Panel Switch	—	—	—	—	Climate control panel switch, dirty contacts or sticking open.
A/C Clutch Wiring Circuit	—	—	—	—	A/C clutch wiring circuit, high resistance, open or blown fuse.
Additional Possible Cause Components Associated with a Damaged Compressor					
A/C Cycling Switch	—	—	—	—	A/C cycling switch, sticking closed or A/C clutch seized.
A/C Suction Accumulator Drier	—	—	—	—	A/C suction accumulator drier, refrigerant oil bleed hole plugged.
Refrigerant Low	—	—	—	—	Refrigerant leaks.

* The compressor may make noise on the initial run. This is a slugging condition caused by excessive liquid refrigerant.

† The A/C clutch may not cycle in ambient temperatures above 80°F (27°C) depending on humidity conditions.

‡ The low pressure reading will be normal to high if pressure is taken at the accumulator and if the restriction is downstream of the service access valve.

§ The low pressure reading will be low if the pressure is taken near the compressor and the restriction is upstream of the service access valve.

Table 7, Refrigerant System Pressure and Cycle Timing Evaluation Chart for Evaporator Orifice Cycling Systems

Mode Selector Valve Logic Chart, Heat-Only Units							
Port	**Function**	**Panel**	**Pnl/Flr**	**Off**	**Floor**	**Flr/Def**	**Defrost**
Blue	Panel/Floor	O*	I†	O	O	I	O
Red	Floor	O	O	O	I	O	O
White	Defrost/ Left-Hand Panel	I	I	I	O	O	O
Yellow	Demister	I	O	I	O	O	O
Green	Right-Hand Panel/ Demister	O	I	O	O	O	O
Black	Outside Air/Off	O	O	I	O	O	O
Black	Source	I	I	I	I	I	I

* O = Air pressure off (atmosphere).

† I = Air pressure on.

Table 8, Mode Selector Valve Logic Chart, Heat-Only Units

Mode Selector Valve Logic Chart, Heat and A/C Units									
Port	**Function**	**Max A/C**	**A/C**	**Panel**	**Off**	**Pnl/Flr**	**Floor**	**Flr/Def**	**Defrost**
Blue	Panel/ Floor	O*	O	O	O	I†	I	I	O
Red	Floor	O	O	O	O	O	I	O	O
White	Defrost/ Left-Hand Panel	I	I	I	I	I	O	O	O
Yellow	Demister	I	I	I	I	O	O	O	O
Green	Right-Hand Panel/ Demister	O	O	O	O	I	O	O	O
Black	Outside Air/Recirc.	I	O	O	I	O	O	O	O
Black	Source	I	I	I	I	I	I	I	I

* O = Air pressure off (atmosphere).

† I = Air pressure on.

Table 9, Mode Selector Valve Logic Chart, Heat and A/C Units

Troubleshooting

Problem—Improper/Erratic Direction of Airflow from Outlets (main system)

Problem—Improper/Erratic Direction of Airflow from Outlets (main system)	
Possible Cause	**Remedy**
No pressure to A/C-heater air selection switch	Check the air selection valve connections. Remove the climate control panel to gain access to the pneumatic hose connections. Inspect the pneumatic hose connections at the rear of the panel. If all of the pneumatic hoses are not securely connected to the panel, repair or replace pneumatic hoses as necessary. Test the system for normal operation. If all of the pneumatic hoses are securely connected to the panel, check the source operating pressure.
A/C-heater air selection switch leaks	Disconnect the black pneumatic hose from the rear of the climate control panel. Connect the Vacuum/Pressure Tester to the black pneumatic hose. Start the vehicle and observe the Vacuum/Pressure Tester gauge. If the Vacuum/Pressure Tester gauge indicates no pressure reading, locate the restriction or break in the pneumatic hose. Repair or replace as necessary. Restore the vehicle. Test the system for normal operation. If the Vacuum/Pressure Tester gauge indicates a pressure reading, test the air selection switch.
Damaged/kinked/pinched air line(s)	Connect the black pneumatic hose to the rear of the climate control panel. Disconnect the red, blue and gray pneumatic hoses from the rear of the panel. Start the vehicle. Move the air selection knob through each position while testing the corresponding port for operating pressure using the Vacuum/Pressure Tester. Refer to the appropriate "Mode Selector Valve Logic Chart" at the beginning of this section for corresponding port operating pressures. If the air selection valve does not deliver pressure to each port correctly, replace the air selection switch. Restore the vehicle. Test the system for normal operation. If the air selection valve does deliver pressure to each port correctly, restore the vehicle.
Leaking/damaged pneumatic actuator	
Leaking/damaged check valve	Test the floor/defrost door actuator pneumatic operation. Connect the red, blue and gray pneumatic hoses to the rear of the climate control panel. Disconnect the red pneumatic hose from the floor/defrost door actuator. Connect the Vacuum/Pressure Tester to the red pneumatic hose. Start the vehicle and cycle the air selection knob between the FLOOR and DEFROST positions while observing the gauge on the Vacuum/Pressure Tester.
Pneumatic actuator not connected to door crank	If the Vacuum/Pressure Tester gauge indicates a pressure reading, check for binding in the defrost door. Repair as necessary. If no binding is observed, replace the floor/defrost door actuator. Restore the vehicle. Test the system for normal operation. If the Vacuum/Pressure Tester gauge indicates no pressure reading, locate the restriction or break in the pneumatic hose. repair or replace as necessary. Restore the vehicle. Test the system for normal operation.

Problem—Improper/Erratic Direction of Airflow from Outlets (main system)	
Possible Cause	**Remedy**
No pressure to A/C-heater air selection switch	Test the panel/floor door actuator pneumatic operation. Connect the red pneumatic hose to the floor/defrost door actuator. Disconnect the gray pneumatic hose (spliced to the blue pneumatic hose) from the panel/floor door actuator. Connect the Vacuum/Pressure Tester to the gray pneumatic hose. Start the vehicle and cycle the air selection knob between the PANEL and FLOOR positions while observing the gauge on the Vacuum/Pressure Tester. If the Vacuum/Pressure Tester gauge indicates a pressure reading, check for binding in the panel/floor door. Repair as necessary. If no binding is observed, replace the panel/floor door actuator. Restore the vehicle. Test the system for normal operation. If the Vacuum/Pressure Tester gauge indicates a pressure reading, locate the restriction or break in the pneumatic hose. Repair or replace as necessary. Restore the vehicle. Test the system for normal operation. Test the outside air door actuator pneumatic operation. Connect the gray pneumatic hose to the panel/floor door actuator. Disconnect the black pneumatic hose from the outside air door actuator. Connect the Vacuum/Pressure Tester to the black pneumatic hose. Start the vehicle and place the air selection knob in the PANEL position while observing the gauge on the Vacuum/Pressure Tester. If the Vacuum/Pressure Tester gauge indicates a pressure reading, check the binding in the outside air door. Repair as necessary. If no binding is observed, replace the outside air door actuator. Restore the vehicle. Test the system for normal operation. If the Vacuum/Pressure Tester gauge indicates a pressure reading, locate the restriction or break in the pneumatic hose. Repair or replace as necessary. Restore the vehicle. Test the system for normal operation.
A/C-heater air selection switch leaks	
Damaged/kinked/pinched air line(s)	
Leaking/damaged pneumatic actuator	
Leaking/damaged check valve	
Pneumatic actuator not connected to door crank	

Problem—Insufficient, Erratic, or No Heat (main and auxiliary systems)

Problem—Insufficient, Erratic, or No Heat (main and auxiliary systems)	
Possible Cause	**Remedy**
Low engine coolant level.	Check for the proper engine coolant level. If the engine coolant is not at the proper level, check the coolant system including the radiator cap for leaks. Fill the engine coolant system to the specified level. For instructions, refer to **Group 20**. NOTE: It is not necessary to check each of the engine coolant system components separately at this time. Perform a pressure check on the engine coolant system. For instructions, refer to **Group 20**. If the engine cooling system, including the radiator cap, does not hold pressure, repair the engine cooling system. For instructions, refer to **Group 20**. Restore the vehicle. Test the system for proper operation. Check for hot water to the heater core inlet hose. Start the engine. Bring the engine to normal operating temperature. Lightly touch the inlet heater water hose. If the inlet heater water hose is not hot, repair or replace the heater core. Restore the vehicle. Test the system for proper operation. If the inlet heater water hose is hot, check the heater core outlet hose for hot water. Run the engine. Bring the engine to normal operating temperature. Lightly touch the outlet heater water hose. If the heater outlet water hose is cool or cold, refer to "Problem—A/C Does Not Operate Properly" chart in this subject.
Plugged or partially plugged heater core.	
Inoperative A/C electronic door actuator motor.	
Engine overheating.	

Troubleshooting

Problem—A/C Does Not Operate Properly

Problem—A/C Does Not Operate Properly See Fig. 15, Fig. 16, Fig. 17, Fig. 18, Fig. 19, Fig. 20, Fig. 21 and Fig. 22.	
Possible Cause	**Remedy**
Restricted evaporator orifice	Check the A/C clutch operation. NOTE: The outside air temperature must be above 50°F (10°C) for refrigerant compressor operation. Start the engine. Set the A/C-heater air selection switch to MAX A/C. Set the heater blower motor switch to HIGH. Observe the A/C clutch for proper operation. If the A/C clutch engages, check for an intermittent problem. Restore the vehicle. Test the system for proper operation. If the A/C clutch does not engage, check the A/C cycling switch.
Low refrigerant level	
Damaged/inoperative A/C cycling switch	Install a jumper wire between the A/C cycling switch connector C1014 pin 1 and pin 2. Start the engine. Set the A/C-heater air selection switch to A/C. Set the heater blower motor switch to HI. Check for A/C clutch engagement. If the A/C clutch engages, check the refrigerant system pressure. Install an R–134a manifold gauge set. For instructions, refer to Subject 110. Measure the refrigerant system pressure. If the refrigerant system pressure is greater than 50 psi, replace the A/C cycling switch. Restore the vehicle. Test the system for operation. If the refrigerant system pressure is less than 50 psi, check the system for leaks. For instructions, refer to Subject 110.
Inoperative A/C electronic door actuator motor	
Thermal protection switch	Check the voltage at the A/C pressure cutoff switch. Set the A/C-heater air selection switch to MAX A/C. Measure the voltage between the A/C pressure cutoff switch connector C1010, pin 4 (viscous fan) or connector C1011, pin 4 ("On/Off" fan), circuit 350 (Y) and ground. If the voltage is greater than 10 volts, measure the A/C pressure cutoff switch resistance. Measure the resistance between the A/C pressure cut-off switch connector C1010 pin 1 and pin 3 (viscous fan) or connector C1011 pin 2 and pin 4 (on/off fan). If the resistance is not less than 5 ohms, replace the A/C pressure cut-off switch. Restore the vehicle. Test the system for proper operation. If the resistance is less than 5 ohms, check the voltage at the A/C cycling switch. Set the A/C-heater air selection switch to MAX A/C.
Circuitry	
A/C clutch field coil	Measure the voltage between the A/C cycling switch connector C1014 pin 1, circuit 350 (Y) and ground. If the voltage is less than 10 volts, repair circuit 350 (Y). Restore the vehicle. Test the system for normal operation. Measure the resistance between the thermal protection switch terminals. Refer to "Thermal Protection Switch" under "Component Tests" in this subject. If the resistance does not meet the specifications in the component test, replace the thermal protection switch. Restore the vehicle. Test the system for normal operation. If the resistance meets the specifications in the component test, check the voltage supply to the A/C clutch. Set the A/C-heater air selection switch to MAX A/C.
A/C-heater air selection switch	

<table>
<tr><th colspan="2">Problem—A/C Does Not Operate Properly</th></tr>
<tr><th>Possible Cause</th><th>Remedy</th></tr>
<tr><td>Restricted evaporator orifice</td><td rowspan="8">Measure the voltage between the A/C clutch connector pin 1 (BR) and ground. If the voltage is not greater than 10 volts, repair circuit 350 (Y). Restore the vehicle. Test the system for proper operation. If the voltage is greater than 10 volts, check the A/C clutch ground circuit.

Measure the resistance between the A/C clutch connector pin 2 (BR) and ground. If the resistance is more than 5 ohms, repair circuit 57 (BK). Restore the vehicle. Test the system for proper operation. If the resistance is less than 5 ohms, check the A/C clutch field coil resistance.

Measure the resistance between the A/C clutch field coil connector pin 1 and pin 2. If the resistance is greater than 6 ohms, replace the A/C clutch field coil. Restore the vehicle. Test the system for proper operation. If the resistance is less than 6 ohms, check the A/C clutch field coil current draw. Install a jumper wire between the A/C clutch connector pin 1 (BR) and the A/C clutch field coil connector pin 2 (BR).

WARNING

Always use jumper wires when measuring the A/C clutch field coil amperage draw or serious injury can occur.

Measure the current draw between the A/C clutch connector pin 2 (BR) and the A/C clutch field coil connector pin 1 (BR). If the current draw is 3.6 to 3.7 amperes, adjust the A/C clutch air gap. For instructions, refer to Subject 110. Restore the vehicle. Test the system for proper operation. If the current draw is not 3.6 to 3.7 amperes, replace the A/C clutch field coil. Restore the vehicle. Test the system for proper operation.

Check the voltage at the A/C-heater air selection switch. Measure the voltage between the A/C-heater air selection switch connector C229 pin 1, circuit 670 (PK) and ground. If the voltage is less than 10 volts, check fuse 9 (10A). If the fuse is OK, check for an open in circuit 670 (PK). Repair circuit 670 (PK) as necessary. Restore the vehicle. Test the system for proper operation. If the fuse is not OK, replace the A/C-heater air selection switch fuse 9 (10A). Test the system for proper operation. If the fuse blows again, check circuits 670 (PK) and 350 (Y) for a short. Repair damaged circuits as necessary. Restore the vehicle. Test the system for proper operation.

Check the A/C-heater air selection switch positions. Set the A/C-heater air selection switch to each air selection position.

NOTE: The voltage measurement will be taken from the back of the connector with it connected to the A/C-heater air selection switch.

Measure the voltage between the A/C-heater air selection switch pin 2, circuit 350 (Y) and ground. If the voltage is greater than 10 volts, repair circuit 350 (Y). Restore the vehicle. Test the system for proper operation. If the voltage is greater than 10 volts, replace the A/C-heater air selection switch. Restore the vehicle. Test the system for proper operation.</td></tr>
<tr><td>Low refrigerant level</td></tr>
<tr><td>Damaged/inoperative A/C cycling switch</td></tr>
<tr><td>Inoperative A/C electronic door actuator motor</td></tr>
<tr><td>Thermal protection switch</td></tr>
<tr><td>Circuitry</td></tr>
<tr><td>A/C clutch field coil</td></tr>
<tr><td>A/C-heater air selection switch</td></tr>
</table>

Troubleshooting

Problem—A/C Electronic Blend Door Actuator Inoperative, Intermittent, or Improper Operation (main system)

Problem—A/C Electronic Blend Door Actuator Inoperative, Intermittent, or Improper Operation (main system) See Fig. 23, Fig. 24, and Fig. 25.	
Possible Cause	**Remedy**
Damaged/inoperative A/C electronic door actuator motor	Check the A/C electronic blend door actuator system. Start the engine. Bring the engine to normal operating temperature. Set the A/C-heater air selection switch to MAX A/C. Set the temperature control switch to full COOL. Check the discharge air temperature. Set the temperature control switch to full WARM. Check the discharge air temperature. Set the temperature control switch to the midpoint of the temperature range. Check the discharge air temperature. If the discharge air temperature changes, check for an intermittent problem. Restore the vehicle. Test the system for proper operation. If the discharge air temperature does not change, check the A/C electronic blend door actuator system fuse. If the fuse is not OK, replace the A/C-heater air selection switch fuse 18 (15A). Test the system for proper operation. If the fuse blows again, check for a short in circuit 190 (Y). Repair circuit 190 (Y) as necessary. Restore the vehicle. Test the system for proper operation. If the fuse is OK, check the A/C electronic blend door actuator supply voltage. NOTE: A quick check can be done by connecting a replacement A/C electronic door actuator motor to the 8-way electrical hardshell connector and operating the system to check for proper operation.
Damaged/inoperative temperature control switch	Measure the voltage between the A/C electronic door actuator motor connector C222 pin 6, circuit 190 (Y) and pin 5, circuit 57 (BK). If the voltage is less than 9 volts, check for shorts/opens in circuits 190 (Y) and 57 (BK). Repair circuits 190 (Y) and 57 (BK) as necessary. Restore the vehicle. Test the system for proper operation. If the voltage is equal to or greater than 9 volts, check the control head potentiometer voltage. Measure the voltage between the temperature control switch connector C228 pin 3, circuit 348 (GN/W) and pin 1, circuit 349 (BR). If the voltage is equal to or greater than 9 volts, check the control head potentiometer. Measure the resistance between the temperature control switch pin 1 and pin 2. With the switch at full COOL, the resistance should be less than 100 ohms. With the switch at full WARM, the resistance should be between 4 and 6 kohms. If the resistance is less than 100 ohms at full COOL and between 4 and 6 kohms at full WARM, replace the A/C electronic door actuator motor. Restore the vehicle. Test the system for proper operation. If the resistance is not less than 100 ohms at full COOL and between 4 and 6 kohms at full WARM, replace the temperature control switch. Restore the vehicle. Test the system for proper operation.
Circuitry open/shorted	Check circuit 351 (R). Measure the resistance between the temperature control switch connector C228 pin 2, circuit 351 (R) and the A/C electronic door actuator motor connector C222 pin 2, circuit 351 (R). If the resistance is not less than 5 ohms, repair circuit 351 (R). Restore the vehicle. Test the system for proper operation. If the resistance is less than 5 ohms, check circuit 349 (BR). Measure the resistance between the temperature control switch connector C228 pin 1, circuit 349 (BR) and the A/C electronic door actuator motor connector C222 pin 1, circuit 349 (BR). If the resistance is less than 5 ohms, replace the A/C electronic door actuator motor. Restore the vehicle. Test the system for proper operation. If the resistance is not less than 5 ohms, repair circuit 349 (BR). Restore the vehicle. Test the system for proper operation.

Problem—Blower Motor Does Not Operate (main system)

Problem—Blower Motor Does Not Operate (main system) See Fig. 21, Fig. 26, Fig. 27, and Fig. 28.	
Possible Cause	**Remedy**
Blown fuse	Check the blower motor operation. Set the A/C-heater air selection switch to FLR. Set the heater blower motor switch to HI. Check the blower motor for operation. If the blower motor operates, check for intermittent operation. Repair or replace if necessary. Restore the vehicle. Test the system for proper operation. If the blower motor does not operate, check the A/C-heater air selection switch fuse 18 (15A). If the fuse is not OK, replace the A/C-heater air selection switch fuse 18 (15A). Test the system for proper operation. If the fuse blows, check circuits 190 (Y) and 277 (GN) for a short. Repair damaged circuits as necessary. Restore the vehicle. Test the system for proper operation. If the fuse is OK, check the blower motor relay fuse (40A).
Circuitry open/shorted	If the fuse is not OK, replace the blower motor relay fuse (40A). Test the system for proper operation. If the fuse blows, check circuits 37 (BK/Y) and 183 (BR). Repair damaged circuits as necessary. Restore the vehicle. Test the system for proper operation. If the fuse is OK, check the voltage at the A/C-heater air selection switch. NOTE: The voltage measurement will be taken at the back of the connector with the connector installed.
Damaged/inoperative heater blower motor switch	Remove the A/C control far enough to gain access to the A/C-heater air selection switch. Set the A/C-heater air selection switch to each operation position. Measure the voltage between the A/C-heater air selection switch connector C229 pin 3, circuit 277 (GN) and ground in each selection position. If the voltage is not greater than 10 volts in each selection position, check the A/C-heater air selection switch. NOTE: The voltage measurement will be taken at the back of the connector with the connector installed. Measure the voltage between the A/C-heater air selection switch connector C229 pin 4, circuit 190 (Y) and ground in each selection position. If the voltage is not greater than 10 volts in each selection position, measure the resistance in all of the A/C-heater air selection switch positions. Refer to "Main A/C-Heater Air Selection Switch" under "Component Tests" in this subject. Replace the A/C-heater air selection switch as necessary. Restore the vehicle. Test the system for proper operation. If the voltage is greater than 10 volts in each selection position, check circuit 190 (Y) for a short/open. Repair as necessary. Restore the vehicle. Test the system for proper operation.
Damaged/inoperative blower motor	
Damaged/inoperative heater blower motor switch resistor	Check for voltage in circuit 277 (GN). Set the A/C-heater air selection switch to FLR. Set the heater blower motor switch to HI. Measure the voltage between the IP fuse junction panel relay 8, circuit 277 (GN) and ground. If the voltage is not greater than 10 volts, repair circuit 277 (GN). Restore the vehicle. Test the system for proper operation. If the voltage is greater than 10 volts, check the blower motor switch relay. Check the blower motor relay for proper operation. Refer to "ISO Relay" under "Component Tests" in this subject. If the blower motor relay does not meet the specifications in the component test, replace the blower motor relay. Restore the vehicle. Test the system for proper operation. If the blower motor relay meets the specifications in the component test, check circuit 57 (BK).

Troubleshooting

Problem—Blower Motor Does Not Operate (main system)	
Possible Cause	**Remedy**
Blown fuse	Measure the resistance between the IP fuse junction panel relay 8, circuit 57 (BK) and ground. If the resistance is not less than 5 ohms, repair circuit 57 (BK). Restore the vehicle. Test the system for proper operation. If the resistance is less than 5 ohms, check the voltage in circuit 37 (BK/Y)
Circuitry open/shorted	Measure the voltage between the IP fuse junction panel relay 8, circuit 37 (BK/Y) and ground. If the voltage is not greater than 10 volts, repair circuit 37 (BK/Y). Restore the vehicle. Test the system for proper operation. If the voltage is greater than 10 volts, check circuit 183 (BR).
Damaged/inoperative heater blower motor switch	Measure the resistance between the IP fuse junction panel relay 8, circuit 183 (BR) and the blower motor connector C1013 pin 2, circuit 183 (BR). If the resistance is not less than 5 ohms, repair circuit 183 (BR). Restore the vehicle. Test the system for proper operation. If the resistance is less than 5 ohms, check circuit 270 (BK/Y).
Damaged/inoperative blower motor	Measure the resistance between the blower motor connector C1013 pin 1, circuit 270 (BK/Y) and the blower motor switch resistor connector C1015 pin 4, circuit 270 (BK/Y). Measure the resistance between the blower motor connector C1013 pin 1, circuit 270 (BK/Y) and the heater blower motor switch connector C226 pin 1, circuit 270 (BK/Y). If the resistance is not less than 5 ohms, repair circuit 270 (BK/Y). Restore the vehicle. Test the system for proper operation. If the resistance is less than 5 ohms, check the heater blower motor switch.
Damaged/inoperative heater blower motor switch resistor	Measure the resistance between the heater blower motor switch terminals. Refer to "Main A/C-Heater Air Selection Switch" under "Component Tests" in this section. If the resistance meets the specifications in the component test, check the blower motor. Refer to "Blower Motor" under "Component Tests" in this section. Replace the blower motor if necessary. Restore the vehicle. Test the system for proper operation. If the resistance does not meet the specifications in the component test, replace the heater blower motor switch. Restore the vehicle. Test the system for proper operation.

Problem—Blower Motor Operates in High Speed Only (main system)

Problem—Blower Motor Operates in High Speed Only (main system) See Fig. 26 and Fig. 27.	
Possible Cause	**Remedy**
Damaged/inoperative heater blower motor switch	Check the blower motor operation. Set the A/C-heater air selection switch to FLR. Set the heater blower motor switch to LO. Check for blower motor operation. If the blower motor operates, check the blower motor switch. Set the heater blower motor switch in each position several times. Check for proper blower motor operation. If the blower motor operates properly, check the climate control system operation in all function positions and blower speeds. If the system is OK, instruct the owner on the correct operation of the system. If the blower motor does not operate properly, check the blower switch resistance. Measure the resistance through the heater blower motor switch circuits. Refer to "Main or Auxiliary SilverStar Blower Motor Switch" under "Component Tests" in this subject. If the resistance meets the specifications shown in the component test, check circuits 268 (R/BK) and 269 (BL/R) for shorts/opens. Repair as necessary. Restore the vehicle. Test the system for proper operation. If the resistance does not meet the specifications shown in the component test, replace the heater blower motor switch. Restore the vehicle. Test the system for proper operation.
Damaged/inoperative heater blower motor switch resistor	If the blower motor does not operate, check the blower switch operation. Set the A/C-heater air selection switch to FLR. Slowly set the heater blower motor switch to each position. Check for blower motor operation. If the blower motor operates HI position only, check the ground circuit. Measure the resistance between the heater blower motor switch resistor connector C101 pin 1, circuit 57 (BK) and ground. If the resistance is less than 5 ohms, replace the heater blower motor switch. Restore the vehicle. Test the system for proper operation. If the resistance is not less than 5 ohms, repair circuit 57 (BK). Restore the vehicle. Test the system for proper operation.
Circuitry open/shorted	If the blower motor operates in any position except for HI, check circuit 270 (BK/Y). Measure the resistance between the blower motor connector C1013 pin 1, circuit 270 (BK/Y) and the heater blower motor switch resistor connector C1015 pin 4, circuit 270 (BK/Y). If the resistance is less than 5 ohms, replace the heater blower motor switch resistor. Restore the vehicle. Test the system for proper operation. If the resistance is not less than 5 ohms, repair circuit 270 (BK/Y). Restore the vehicle. Test the system for proper operation.

Troubleshooting

Problem—No Operation in High Blower Setting

Problem—No Operation in High Blower Setting	
Possible Cause	**Remedy**
Damaged/inoperative heater blower motor switch	Check the blower motor speed. Set the A/C-heater air selection to FLR. Set the heater blower motor switch to HI. If the heater blower motor operates on HI, check for an intermittent problem. Restore the vehicle. Test the system for proper operation. If the heater blower motor does not operate on HI, check the heater blower motor switch.
Circuitry open/shorted	Measure the resistance between the heater blower motor switch terminals. Refer to "Heater Blower Motor Switch" under "Component Tests" in this subject. If the resistance meets the specifications in the component test, repair circuit 270 (BK/Y). Restore the vehicle. Test the system for proper operation. If the resistance does not meet the specifications in the component test, replace the heater blower motor switch. Restore the vehicle. Test the system for proper operation.

A-Line Auxiliary System Thermal Potentiometer Switch Test			
To Test	**Measure the Resistance Between**	**Set the Switch to These Positions**	**Resistance Should Read**
Temperature Potentiometer Switch	Terminal 1 and Terminal 2	Full COOL	Less than 100 ohms
		Full WARM	4–6 kohms

Table 10, A-Line Auxiliary System Thermal Potentiometer Switch Test

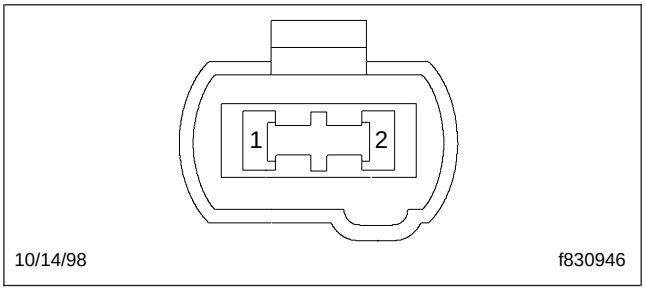


Fig. 15, A/C Cycling Switch Connector Pin Identification

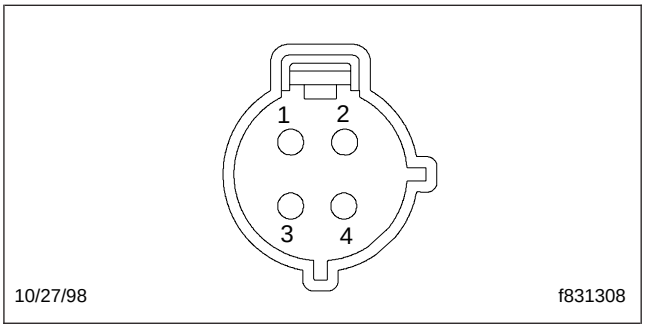


Fig. 16, Connector C1010 Pin Identification

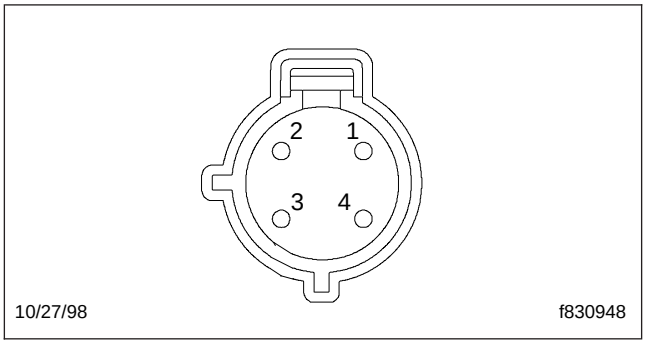


Fig. 17, Connector C1011 Pin Identification

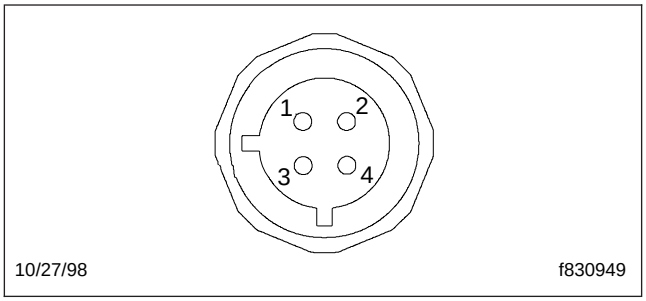


Fig. 18, Connector C1010 Pin Identification

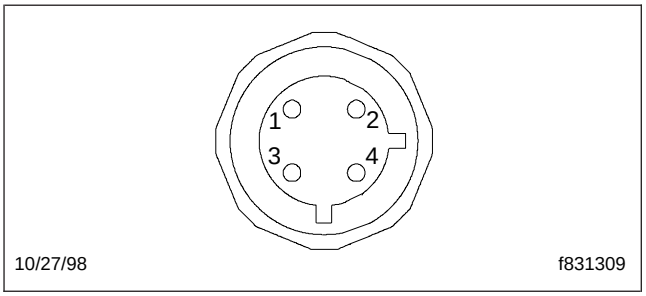


Fig. 19, Connector C1011 Pin Identification

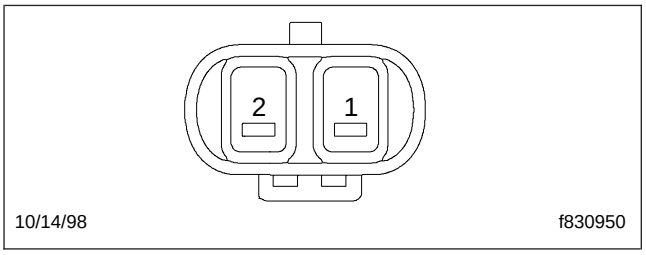


Fig. 20, A/C Clutch Connector Pin Identification

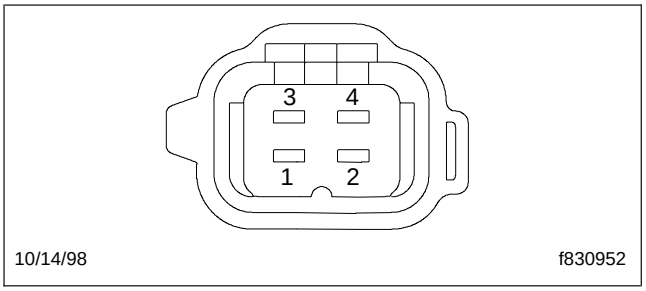


Fig. 21, A/C Clutch Field Coil Connector Pin Identification

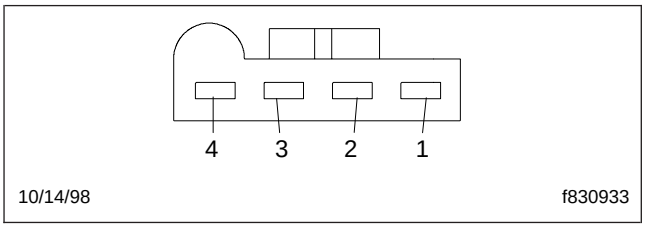


Fig. 22, A/C Heater Function Selector Switch Connector Pin Identification

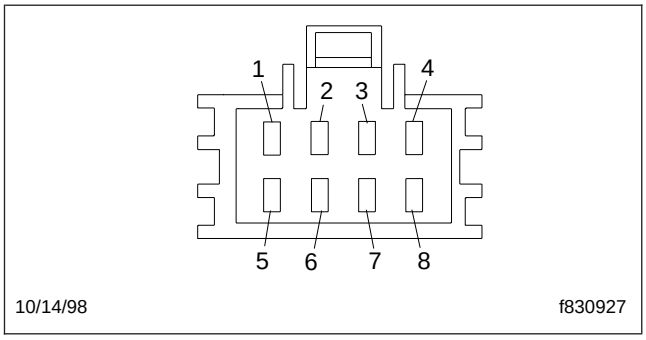


Fig. 23, A/C Electronic Door Actuator Motor Connector Pin Identification

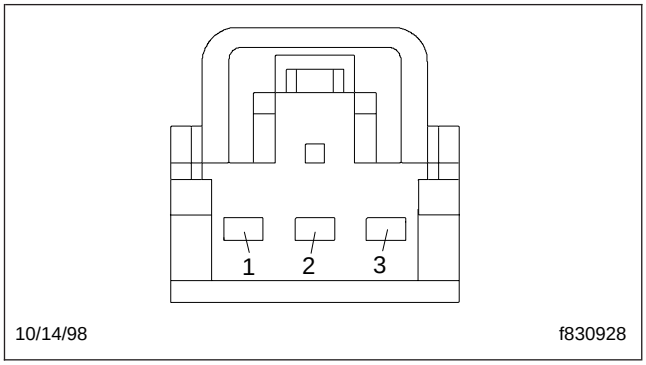


Fig. 24, Temperature Control Switch Connector Pin Identification

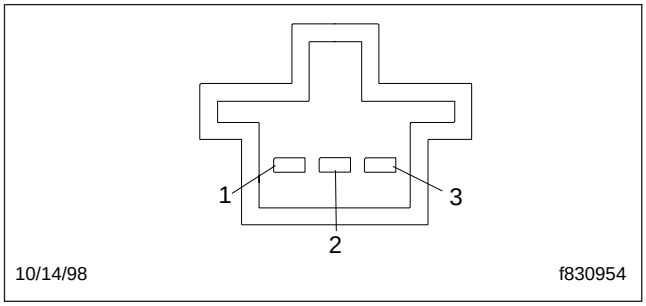


Fig. 25, Temperature Control Pin Identification

Troubleshooting

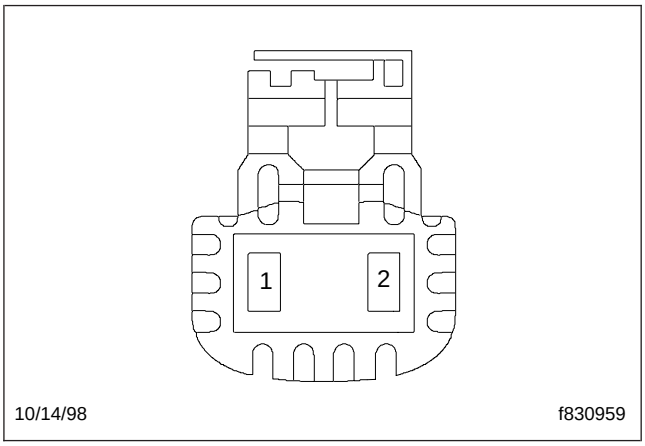


Fig. 26, Blower Motor Connector Pin Identification

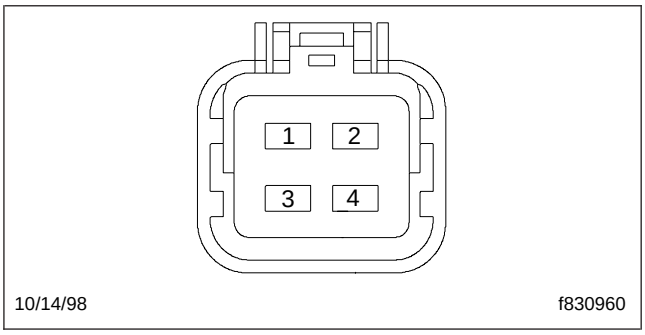


Fig. 27, Blower Motor Switch Resistor Connector Pin Identification

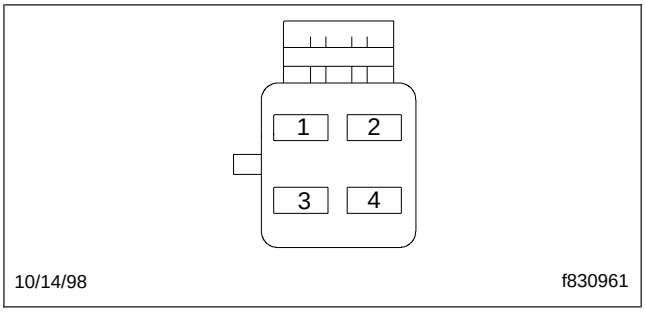


Fig. 28, Heater Blower Motor Switch Connector Pin Identification

Specifications

⚠ WARNING

R–134a is the only refrigerant that is approved for use on Sterling vehicles. Several companies offer less expensive, hydrocarbon-based refrigerant, such as propane and methane. Use of these refrigerants will void the warranty on the 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. No vehicle built by Sterling Trucks can be safely charged with hydrocarbon-based refrigerants, regardless of what the refrigerant supplier states.

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.

General Specifications	
Item	**Specification**
Adhesives	
Silicone Rubber D6AZ–19562–AA	ESB–M4G92–A or ESE–M4G195–A
Pipe Sealant with Teflon® D8AZ–19554–A	WSK–M2G350–AZ and ESR–M18P7–A
Lubricant	
Rubber Suspension Insulator Lube E25Y–19553–A	ESF–M99B112–A
R–134a Refrigerant Oil	SP-20 or SP-15

Table 1, General Specifications

Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Accumulator End of Suction Line Between the Evaporator and Compressor	22–27 (30–37)	—
Compressor End of Suction Line Between Evaporator and Compressor	21–27 (28–37)	—
Compressor End of Discharge Line Between Compressor and Condenser	15–20 (20–27)	—
Condenser End of Discharge Line Between Compressor and Condenser	20–25 (27–34)	—
Condenser End of Line Between Condenser and Evaporator	10–15 (14–20)	—
Evaporator End of Line Between Condenser and Evaporator	15–20 (20–27)	—
Condenser End of Line Between Condenser and Evaporator	10–15 (14–20)	—
Suction Accumulator/Drier (to evaporator)	25–30 (34–41)	—
A/C Pressure Cutoff Switch	—	25–35 (282–295)
Pressure Relief Valve	9–13 (12–18)	—
Condenser Core Nut	28–34 (38–46)	—
A/C Clutch Plate Nut	25–30 (34–41)	—
Blend Door Actuator Screw	—	18–27 (203–305)
Blower Motor Resistor Screw	—	18–27 (203–305)
Temperature Control Sensor Screws, SilverStar	—	18–27 (203–305)

Specifications

Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Evaporator Expansion Valve to Evaporator, Able Body	20 (27)	—
Evaporator Expansion Valve Refrigerant Line (small), Able Body	18 (24)	—
Evaporator Expansion Valve Refrigerant Line (large), Able Body	23 (31)	—
Evaporator Expansion Valve Bolt, Able Body	—	10–12 (113–136)

Table 2, Torque Specifications

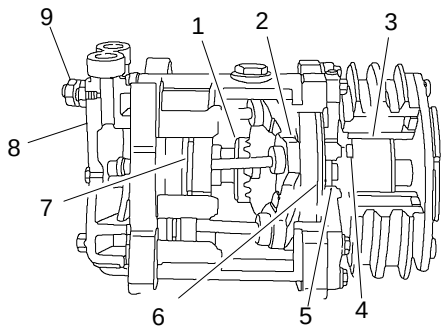
General Information

Refrigerant Compressor

The Sanden refrigerant compressor has:

- seven cylinders;
- an axial design with mounting brackets for radial mounting;
- reed-type suction and discharge valve plates located between the cylinder assembly and the head;
- an integral cycling-type magnetic clutch with a compressor clutch field coil.

The compressor is engine mounted in line with the accessory drive belt. The drive belt rotates the compressor clutch. When the compressor clutch field coil is energized, it causes the compressor clutch hub to magnetically draw inward against the pulley. This magnetic force locks the clutch plate and hub assembly against the pulley which then drives the compressor main shaft causing the piston to draw the refrigerant gas through the compressor and circulate through the system. See **Fig. 1**.



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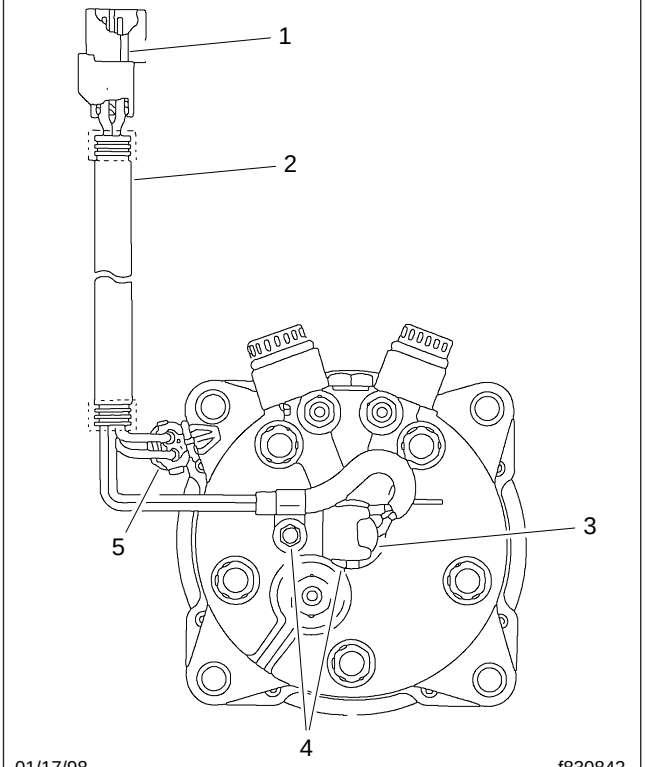
1. Anti-rotation Gear
2. Wobble Plate
3. Clutch Bearings
4. Shaft Seal
5. Front Housing and O-Ring
6. Needle Thrust Bearing
7. Piston
8. Compressor
9. Pressure Relief Valve

Fig. 1, Compressor, Side View

The compressor is equipped with a thermal protection switch to automatically shut down the operation of the compressor by interrupting the electrical power to the compressor clutch field coil when the compressor temperature exceeds approximately 240°F (116°C). The compressor will automatically restart when it has cooled to approximately 210°F (99°C). See **Fig. 2**.



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1. Compressor Harness Connector (gray)
2. Compressor Harness
3. Thermal Protection Switch
4. Retaining Plate and Screw
5. Compressor Clutch Connector (white)

Fig. 2, Compressor, Rear View

Refrigerant Compressor Pressure Relief Valve

Under extreme pressure conditions, the compressor pressure relief valve will momentarily open, allowing refrigerant vapor to escape. This relieves excessive pressure that may damage the compressor. The valve closes as soon as pressure is lower than the relief setting. This prevents complete loss of the re-

General Information

frigerant charge. The compressor pressure relief valve is located in the rear of the compressor.

Refrigerant Compressor Removal and Installation

⚠ WARNING

Before doing any of the work below, read the safety precautions in Section 83.01, Subject 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.01, Subject 110**, or **Section 83.05, Subject 130**.
4. Remove the serpentine belt. Do not pry or roll the belt off the pulleys.
5. Disconnect the electrical connector from the refrigerant compressor.
6. Disconnect the discharge and suction lines from the refrigerant compressor. Quickly cap the discharge and suction ports and the refrigerant lines.

IMPORTANT: Under no circumstances should the ports on the refrigerant compressor or the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through the refrigerant lines since shop air is wet (humid).

7. Being careful not to spill any refrigerant oil, remove the capscrews and washers that attach the refrigerant compressor to the engine and remove the compressor.

Installation

IMPORTANT: A new refrigerant compressor is filled with refrigerant oil and nitrogen gas. The quantity is printed on a label attached to the compressor. When installing a new compressor on the vehicle, do all the steps below. If installing a used compressor, disregard the first step.

1. Prepare a new refrigerant compressor.
   - 1.1 Gently release the nitrogen gas from the discharge side of the refrigerant compressor. Be careful not to let the oil flow out.
   - 1.2 Turn the refrigerant compressor shaft several times by hand to distribute oil which has settled in the cylinder.
2. If installing a new refrigerant compressor, adjust the refrigerant oil level in the new compressor. For instructions, see **Section 83.02, Subject 150**.
3. Using capscrews and washers, install the refrigerant compressor on the engine. Torque the capscrews 15 to 19 lbf·ft (20 to 26 N·m).
4. Uncap the discharge and suction ports and the refrigerant lines. Check the refrigerant lines and the discharge and suction ports. They must be clean and free of nicks, gasket residue, and other foreign material.
5. On refrigerant line connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.

   On refrigerant line connections that have Mini Stat-O-Seals, replace the seals. **Do not** lubricate Mini Stat-O-Seals prior to installation. Use only a Mini Stat-O-Seal on a Mini Stat-O-Seal assembly.
6. Connect the refrigerant lines to the refrigerant compressor.

   On refrigerant line connections that have threaded fittings, torque the fittings 33 lbf·ft (45 N·m).

   On refrigerant line connections that have Mini Stat-O-Seal assemblies, torque the bolts on the Mini Stat-O-Seal assemblies 13 to 15 lbf·ft (18 to 20 N·m).
7. Connect the electrical connector to the refrigerant compressor.
8. Install the serpentine belt.
9. If replacing a refrigerant compressor that had an internal failure or if the system was without any refrigerant pressure before repairs were started, replace the accumulator/drier. For instructions, see **Section 83.01, Subject 170**, or **Section 83.05, Subject 170**.

Refrigerant Compressor Removal and Installation

10. Evacuate, charge, and leak test the system. For instructions, see **Section 83.01, Subject 110**, or **Section 83.05, Subject 130**.
11. Remove the chocks from the tires.

Replacement

1. Recover the refrigerant from the air conditioning system.
2. Remove the pressure relief valve from the refrigerant compressor. See **Fig. 1**.

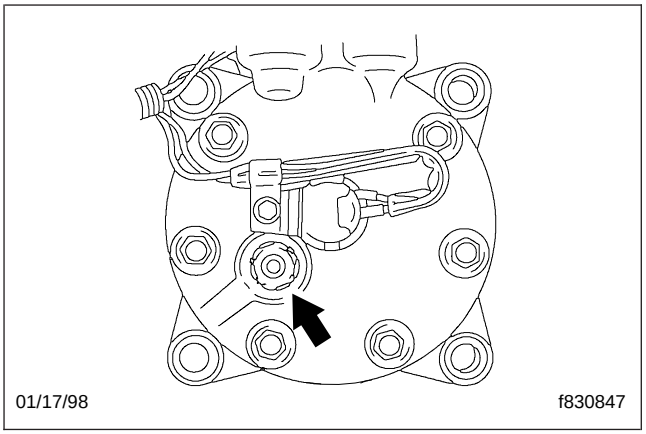

Fig. 1, Pressure Relief Valve

3. Coat the O-ring on the new pressure relief valve with clean refrigerant oil.
4. Install the new pressure relief valve on the refrigerant compressor. Tighten the pressure relief valve 72 to 108 lbf·in (813 to 1220 N·cm).
5. Evacuate, charge, and leak test the system. For instructions, see **Section 83.01, Subject 110** or **Section 83.05, Subject 130**.

Compressor Clutch and Pulley Removal and Installation

Removal

1. Remove the refrigerant compressor. For instructions, see **Subject 100**.
2. Place the compressor in a bench-mounted holding device.
3. Hold the clutch plate stationary using a suitable spanner wrench and remove the nut. See **Fig. 1**.

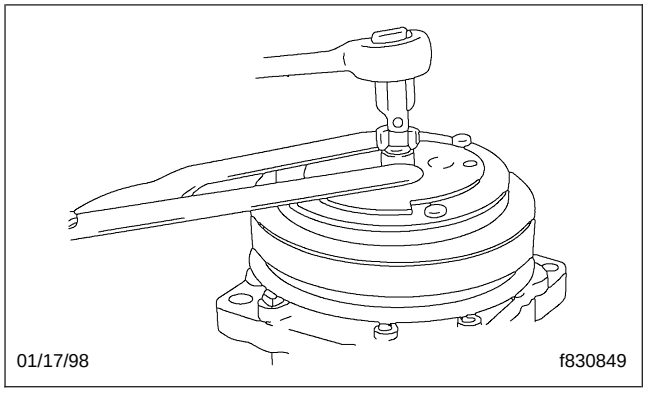

Fig. 1, Clutch Plate Nut

4. Using a suitable puller, remove the clutch plate from the compressor shaft. See **Fig. 2**.

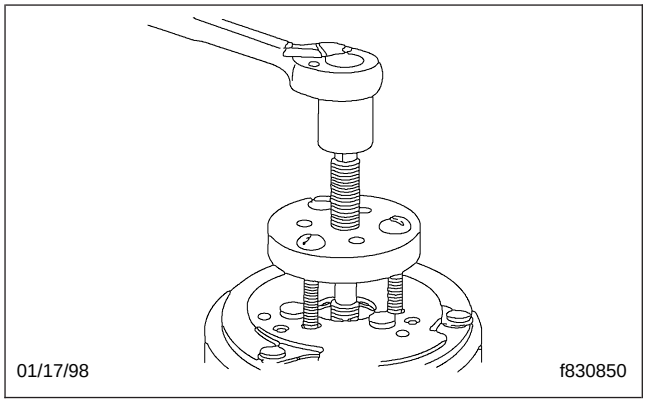

Fig. 2, Clutch Plate

5. Carefully remove the bearing dust cover. See **Fig. 3**.
6. Carefully tap the shaft key loose using a hammer and slotted screwdriver and remove the shaft key. See **Fig. 4**.
7. Remove the snap ring. See **Fig. 5**.
8. Remove the second snap ring. See **Fig. 6**.

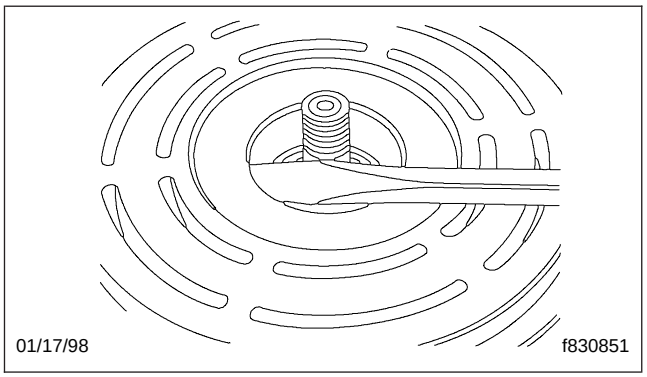

Fig. 3, Bearing Dust Cover

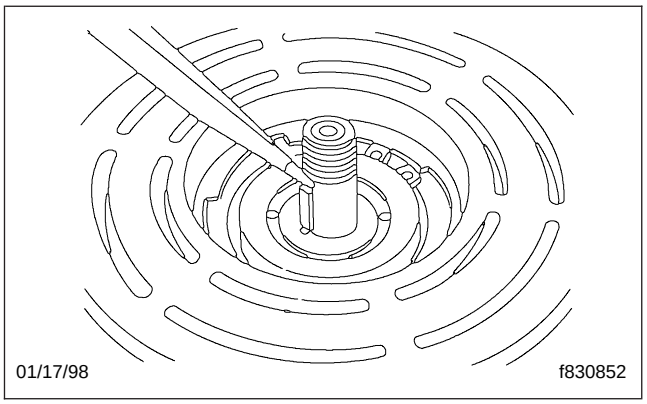

Fig. 4, Shaft Key

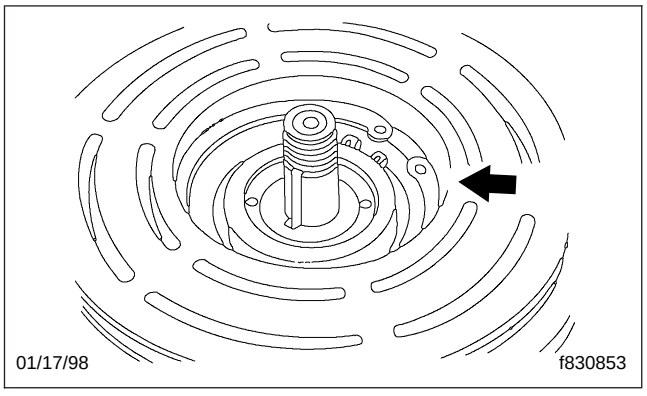

Fig. 5, Snap Ring

9. Install the pulley remover. See **Fig. 7**.
10. Remove the pulley.

Compressor Clutch and Pulley Removal and Installation

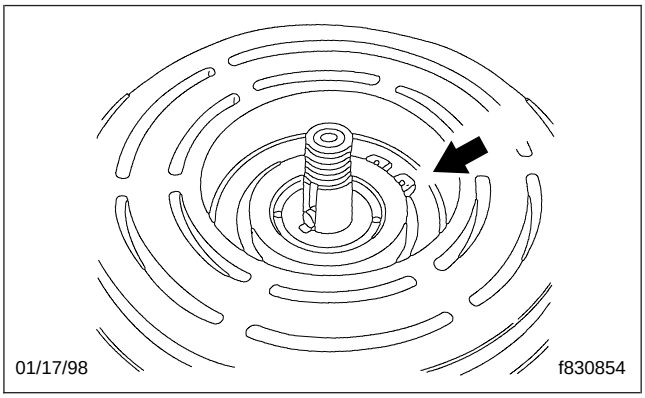

Fig. 6, Snap Ring

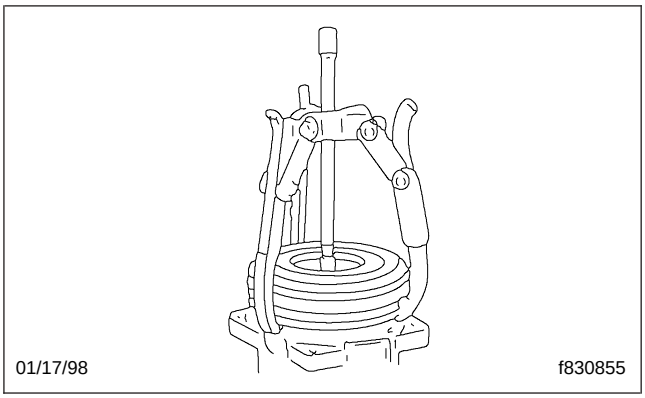

Fig. 7, Pulley Remover

Installation

1. Align the pulley squarely on the refrigerant compressor housing hub. See **Fig. 8**.

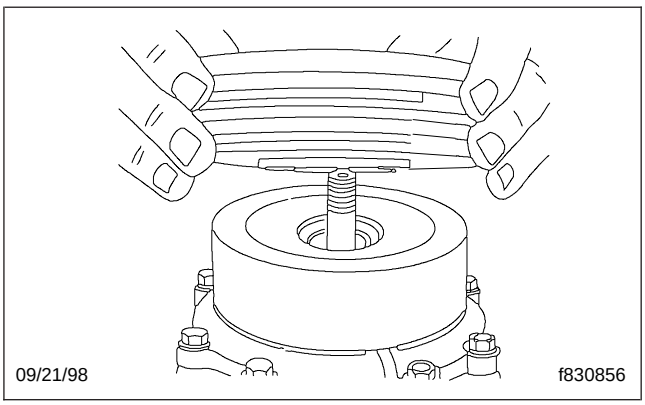

Fig. 8, Aligning Pulley

2. Install the pulley. See **Fig. 9**.

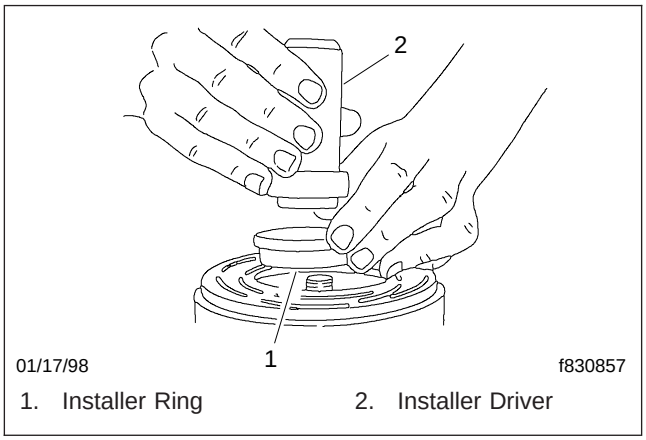

Fig. 9, Installing Pulley

2.1 Place the installer ring in the bearing cavity.

2.2 Using a hammer, place the installer driver in the installer ring and carefully drive the pulley until it is fully seated on the refrigerant compressor.

3. Install the snap rings.
4. Install the bearing dust cover.
5. Install the clutch plate.
6. Align the clutch plate keyway with the compressor shaft keyway and install the compressor shaft key.
7. Seat the clutch plate. See **Fig. 10**.

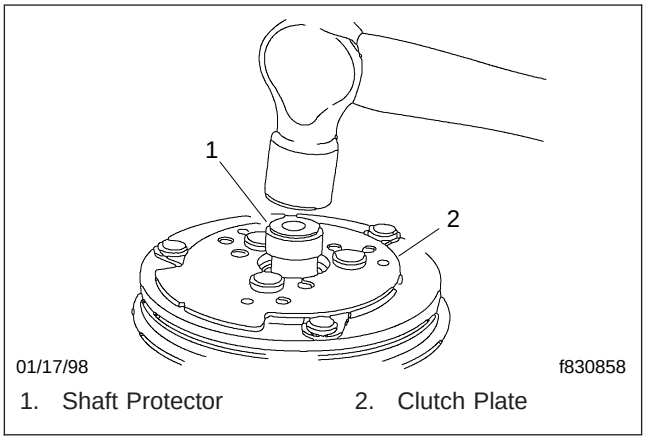

Fig. 10, Seating Clutch Plate

7.1 Install the shaft protector.

7.2 Carefully drive the clutch plate onto the compressor until fully seated.

8. Install the clutch plate nut. Tighten the nut 25 to 30 lbf·ft (34 to 40 N·m). See **Fig. 11**.

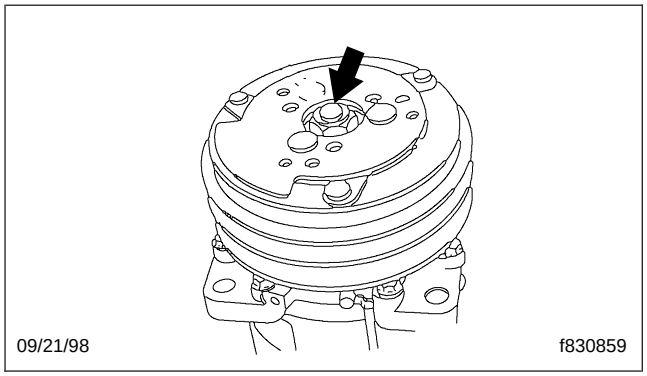

Fig. 11, Tightening Nut

9. Using a 0.016-inch to 0.031-inch feeler gauge, check the compressor air gap between the clutch plate and pulley surface in three locations equally spaced around the pulley. See **Fig. 12**.

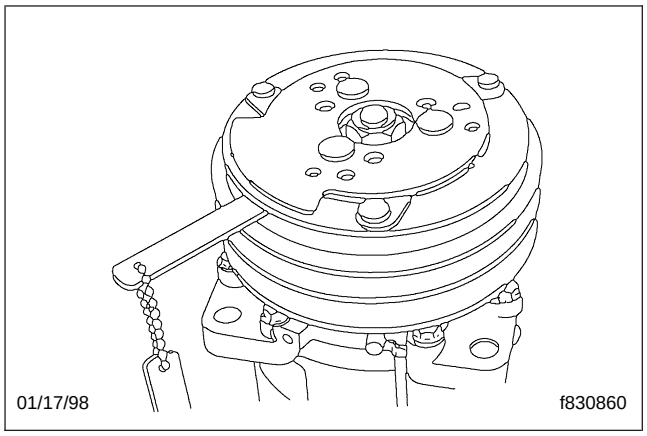

Fig. 12, Checking Air Gap

10. Rotate the compressor pulley one-half turn (180 degrees) and repeat the air gap measurement. The smallest air gap measurement must be within specified limits for the air gap.

11. Install the refrigerant compressor. For instructions, see **Subject 100**.

Clutch Field Coil Replacement

Replacement

1. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.01, Subject 110** or **Section 83.05, Subject 130**.
2. Remove the refrigerant compressor. For instructions, see **Subject 100**.
3. Remove the clutch and pulley.
4. Remove the coil lead wire clip. See **Fig. 1**.

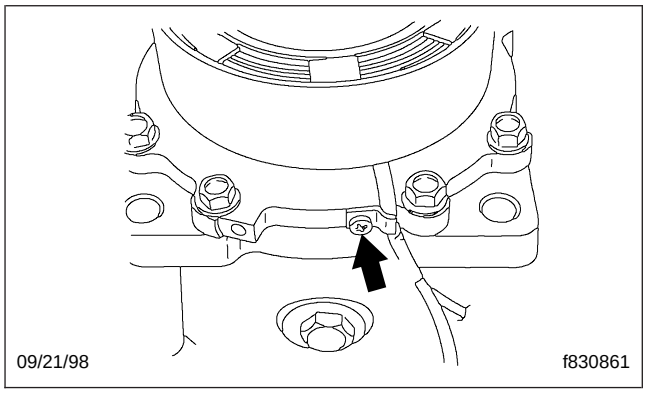

Fig. 1, Coil Lead Wire Clip

5. Remove the field coil. See **Fig. 2**.

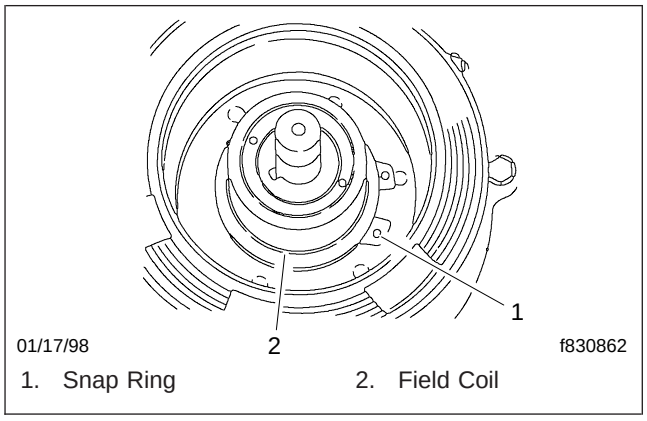

Fig. 2, Field Coil

   5.1 Remove the snap ring.

   5.2 Remove the field coil.

6. Install the field coil.

   6.1 Install the field coil.

   6.2 Install the snap ring.

7. Install the coil lead wire clip.
8. Install the clutch and pulley.
9. Install the refrigerant compressor. For instructions, see **Subject 100**.
10. Evacuate, charge, and leak test the system. For instructions, see **Section 83.01, Subject 110** or **Section 83.05, Subject 130**.

Adjustment

1. Check the clutch air gap at three equally spaced places between the clutch hub and the clutch pulley. See **Fig. 1**.

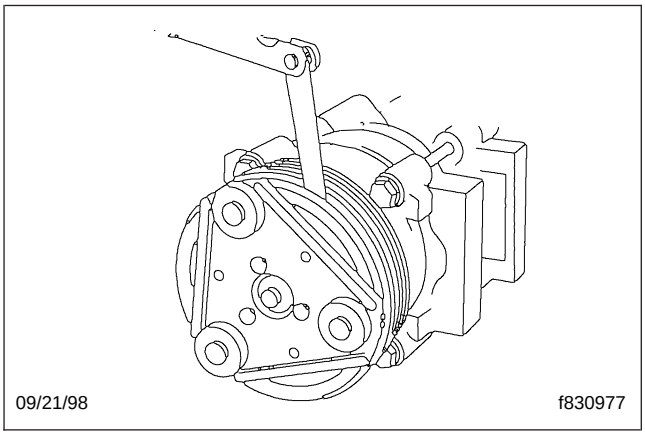

Fig. 1, Checking Air Gap

2. Add or remove shims between the clutch and the refrigerant compressor shaft until the clearance is within 0.016 to 0.031 inch (0.40 to 0.80 mm).

Refrigerant Oil Replacement and Measurement

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

General Information

Compressors are charged with 10 fl oz (296 mL) of refrigerant oil. When the air conditioning system is operating, some refrigerant oil leaves the compressor and is circulated through the system with the refrigerant, but the refrigerant oil cannot leave the system except when there is a leak, when the refrigerant is recovered, or when a system part is replaced.

It is important that the air conditioning system has the correct amount of refrigerant oil for proper operation. Too little oil will result in compressor failure. Too much oil will degrade the performance of the air conditioner and may cause damage to the compressor.

IMPORTANT: Whenever the air conditioning system is discharged or recovered, the recovered oil, from the charging machine, must be measured in order to know how much oil must be returned to the system. When a system component is replaced, a quantity of new oil equal to the recovered oil plus the oil coating the inside of the component must be returned to the system. New oil must be from a container that has not been opened or that has been tightly sealed since its last use.

Order Sanden PAG oil SKI 7803 1997 (type SP–20) for an 8.45-ounce (250-mL) can of refrigerant oil from your local Daimler parts distribution center. Tubing, funnels, or other equipment used to transfer the oil should be very clean and dry.

When handling refrigerant oil:

- Be sure that the oil is free of water, dust, metal powder, and other foreign substances;
- Do not mix the refrigerant oil with other types or viscosities of oil;
- Quickly seal the oil container after use. Refrigerant oil absorbs moisture when exposed to the air for any period of time.

Checking and Adding Refrigerant Oil

WARNING

Do not remove the oil fill plug on the refrigerant compressor without first recovering the system. Failure to recover the system could cause uncontrolled release of high-pressure refrigerant, which can freeze skin and eye tissue causing serious injury or blindness.

1. Before beginning the refrigerant recovery process, make sure that the oil accumulator and oil drain bottle on the recovery/recycle machine are emptied of oil from previous repairs.
2. Recover all of the refrigerant from the system. See **Section 83.01, Subject 110** for instructions.
3. Drain the recovered oil into the calibrated drain bottle of the recovery/recycle machine. Record the amount of oil recovered.
4. Inspect the refrigerant oil. If the oil has any of the following characteristics, flush and charge the system with 10 fl oz (296 mL) of oil.
   - silver or black oil—indicates metal in the air conditioning system due to compressor wear
   - milky oil—may indicate moisture in the system
   - grit or debris in the oil
5. Properly dispose of the recovered oil.
6. After repairs are finished, refer to **Table 1** and use the following equation to determine the quantity of refrigerant oil that needs to be added to the system.

   [Quantity Recovered] + [Quantity for All Replaced Components] = [Quantity to add to the System]

   Table 1 provides the quantities of oil that need to be added to the system for each component that was replaced. Add the quantities listed in the table for each component that was replaced. Use the sum of the quantities or 6 fl oz (177 mL), whichever is less.

Refrigerant Oil Replacement and Measurement

Refrigerant Oil Quantities for Replaced Components	
Add the quantities listed in this table for each component that was replaced. Use the sum of the quantities or 6 fl oz (177 mL), whichever is less.	
Component	**Quantity: oz (mL)**
High Pressure Line (main A/C)	1 (30)
Low Pressure Line (main A/C)	2 (59)
High Pressure Line (auxiliary A/C)	1 (30)
Low Pressure Line (auxiliary A/C)	3 (89)
Condenser	1 (30)
Evaporator (main A/C)	3 (89)
Evaporator (auxiliary A/C)	2 (59)
Receiver-Drier	3 (89)
Minor Leak at Connector Only	0.5 (15)
Major Leak at Connector Only	2 (59)

Table 1, Refrigerant Oil Quantities for Replaced Components

7. Remove the oil fill plug on the refrigerant compressor and add the refrigerant oil. Never add more than 8 fl oz (237 mL) to the system unless the system has been flushed.
8. Evacuate, charge, and leak test the refrigerant system. See **Section 83.01, Subject 110** for instructions.

Adjusting the Refrigerant Oil Level in a New Compressor

Sanden refrigerant compressors are charged with 10 fl oz (296 mL) of refrigerant oil. If the air conditioning system has been flushed, the compressor will need a 10-ounce charge. If the system has not been flushed, use the following procedure to adjust the oil level in the compressor.

Use the "Worksheet for Adjusting the Refrigerant Oil Level in a New Compressor" shown in **Fig. 1** to adjust the refrigerant oil level in a new compressor.

Worksheet for Adjusting the Refrigerant Oil Level in a New Compressor

1. Drain the oil from the old compressor.
   - 1.1 Remove the oil plug and drain as much oil as possible into a clean, calibrated container.
   - 1.2 If there are caps on the suction and discharge ports, remove them.
   - 1.3 Drain the oil from the suction and discharge ports into the container while turning the shaft clockwise using a socket wrench on the armature retaining nut.
   - 1.4 Enter the amount of oil that was drained from the compressor. 1. ☐
2. See Table 1 of this subject to determine the total amount of refrigerant oil that is needed for each component that was replaced. Enter the amount, up to 6 fl oz (177 mL), here. 2. ☐
3. Add the amounts from steps 1 and 2 and enter the total. 3. ☐
4. Subtract the total in step 3 from 10 and enter that number. For example, if the total in line 3 was six, the calculation would be 10 − 6 = 4. 4. ☐
5. Refer to the table below for the amount of oil that must be drained from the new compressor.

If the number in step 4 is:	Drain this amount from the new compressor:
a negative number(−)	2 fl oz (59 mL)
0	2 fl oz (59 mL)
1	2 fl oz (59 mL)
2	2 fl oz (59 mL)
3	3 fl oz (89 mL)
4	4 fl oz (118 mL)
5	4 fl oz (118 mL)
6	4 fl oz (118 mL)
7	4 fl oz (118 mL)
8	4 fl oz (118 mL)
9	4 fl oz (118 mL)
10	4 fl oz (118 mL)

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Fig. 1, Worksheet for Adjusting the Refrigerant Oil Level in a New Compressor

Specifications

⚠ WARNING

R–134a is the only refrigerant that is approved for use on Sterling vehicles. Several companies offer less expensive, hydrocarbon-based refrigerant, such as propane and methane. Use of these refrigerants will void the warranty on the 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. No vehicle built by Sterling Trucks can be safely charged with hydrocarbon-based refrigerants, regardless of what the refrigerant supplier states.

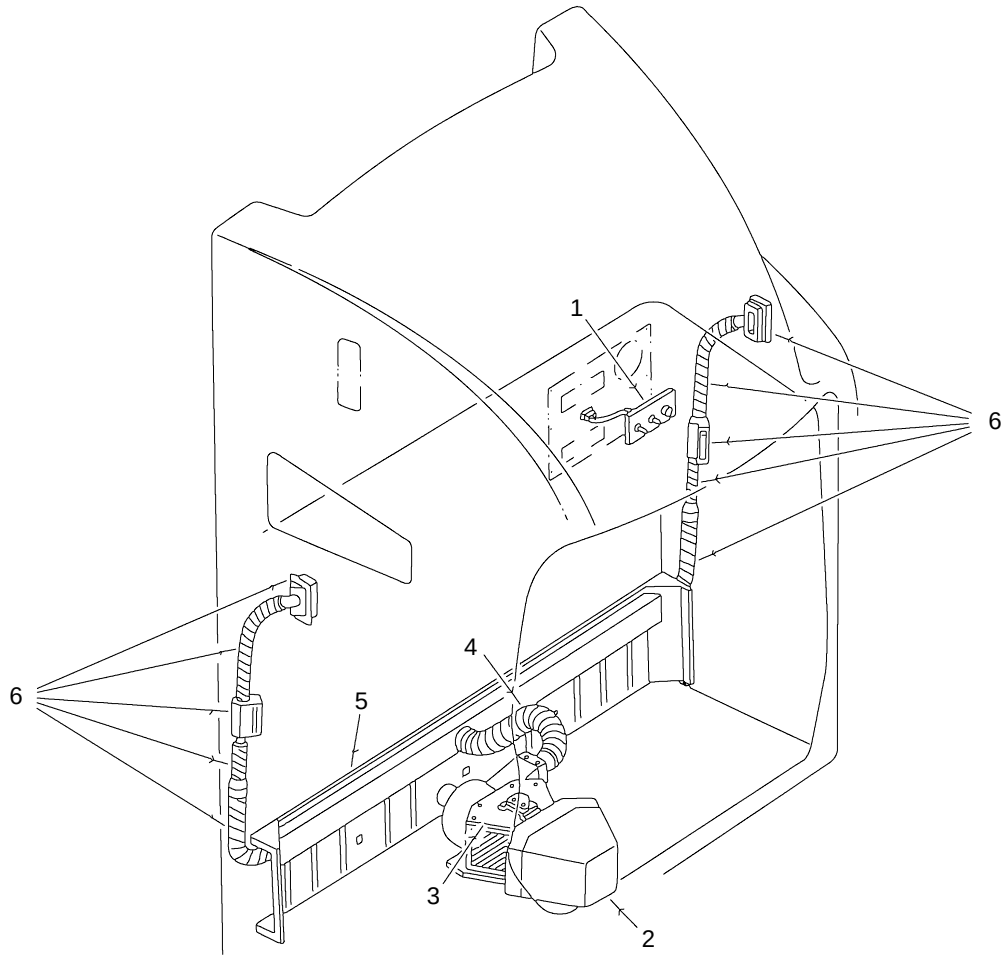
When servicing an air-conditioning system, be sure to use a refrigerant identifier to ensure that the system has not been charged with something other than R–134a. This should be standard practice since there is no way to tell what services have been previously performed. Identification by service technicians will help to avoid the risk of explosion and guard against contamination of equipment when refrigerant is recovered and recycled.

Freightliner LLC recommends using SP-15 or equivalent refrigerant oil for a Sanden refrigerant compressor.

Torque Specifications	
Description	**Value**
Compressor End of Suction Line Between the Evaporator and Compressor	21–27 lbf·ft (28–37 N·m)
Compressor End of Discharge Line Between the Refrigerant Compressor and the Condenser	15–20 lbf·ft (20–27 N·m)
Pressure Relief Valve	9–13 lbf·ft (12–18 N·m)
Refrigerant Clutch Plate Nut	25–30 lbf·ft (30–40 N·m)
Mini Stat-O-Seal Bolt	13–15 lbf·ft (18–20 N·m)

Table 1, Torque Specifications

General Information (See Fig. 1)



1. Auxiliary Climate Control Assembly
2. Auxiliary Air Conditioning and Heating Assembly Shroud
3. Auxiliary Air Conditioning and Heating Assembly
4. Flex Tubing
5. Rear Plenum Duct
6. Registers and Ductwork

Fig. 1, Auxiliary A/C and Heating System Component Locations

The auxiliary air conditioning and heating assembly is a compact unit encompassing both air conditioning and heating capabilities. The one-piece unit housing the major components of the system is mounted on the floor of the sleeper, beneath the lower bunk. The ductwork and registers are located behind the sleeper side and rear trim panels. The A/C and heating unit can be serviced as an assembly or as individual components. The components are serviced under Able Body part numbers and are handled only by Able Body Corporation of Joplin, Missouri.

Except for line and hose connection or disconnection, all components, including the auxiliary climate control assembly, blower motor, blower motor resistor, blower motor relay, blower wheel, heater core, A/C evaporator core, evaporator expansion valve, blend door actuator and ductwork, are serviceable from inside the vehicle.

General Information

The auxiliary air conditioning system will only operate when the engine is running and the front air conditioning mode switch is in an air conditioning setting. There is no direct control of the A/C compressor from the auxiliary climate control assembly.

Heater and Air Conditioning Assembly Removal and Installation

Removal

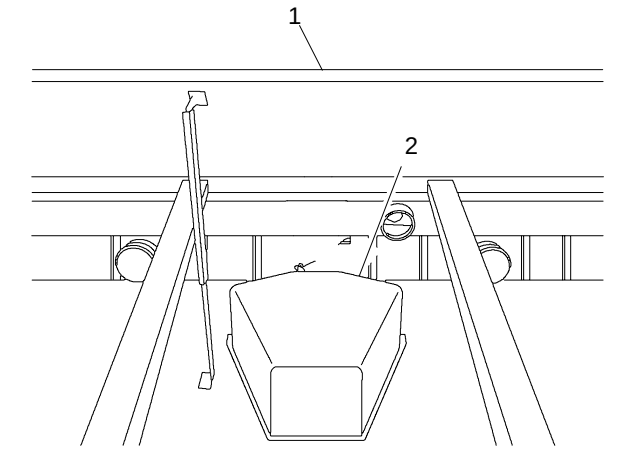
1. Prepare the vehicle for auxiliary heating and air conditioning assembly removal.

   1.1 Recover the air conditioning refrigerant. For instructions, refer to **Section 83.00**.

   NOTE: Cap or plug all open refrigerant line fittings to prevent entry of dirt and moisture.

   1.2 Drain the engine cooling system. For instructions, refer to **Group 20**.

2. Remove the auxiliary air conditioning and heating assembly shroud. See **Fig. 1**.



1. Lower Bunk
2. Auxiliary Air Conditioning and Heating Assembly Shroud

Fig. 1, Heating and Auxiliary Air Conditioning Assembly Shroud

   2.1 Raise the lower bunk.

   2.2 Remove the auxiliary air conditioning and heating assembly shroud.

3. Disconnect the air outlet flex hose. See **Fig. 2**.
4. Disconnect the electrical connectors. See **Fig. 3**.
5. Disconnect the inlet lines. See **Fig. 4**.

   5.1 Disconnect the A/C expansion valve refrigerant lines.

   5.2 Disconnect the heater core lines.

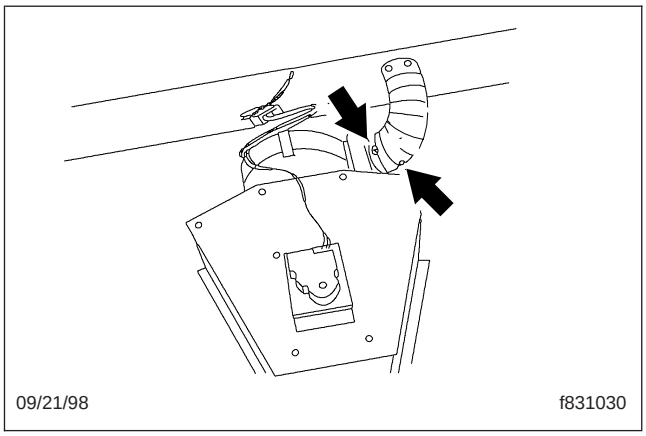


Fig. 2, Air Outlet Flex Hose

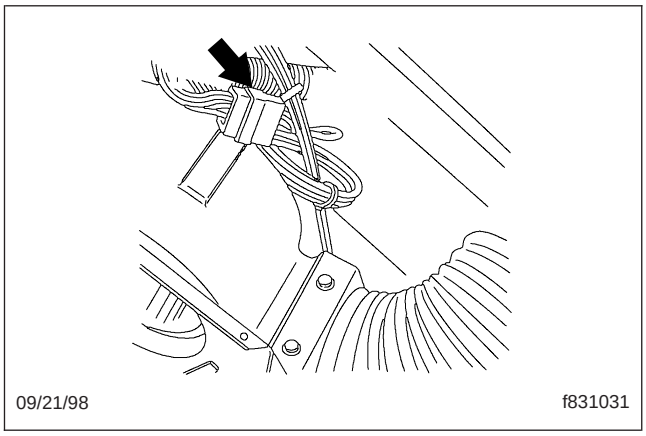


Fig. 3, Electrical Connectors

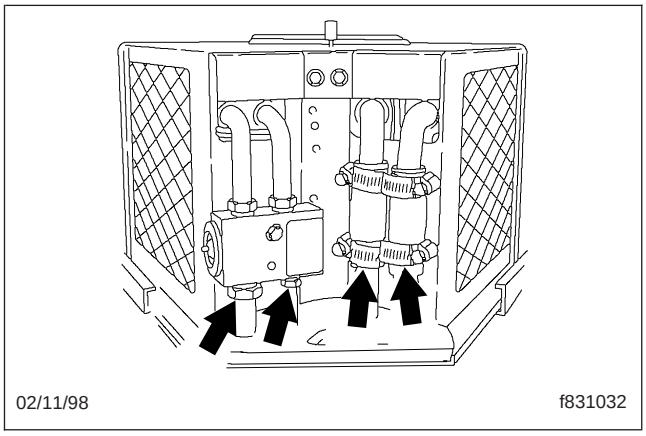


Fig. 4, Auxiliary Heating and Air Conditioning Line Connection Location

Heater and Air Conditioning Assembly Removal and Installation

6. Remove the auxiliary air conditioning and heating assembly bolts and remove the assembly. See **Fig. 5**.

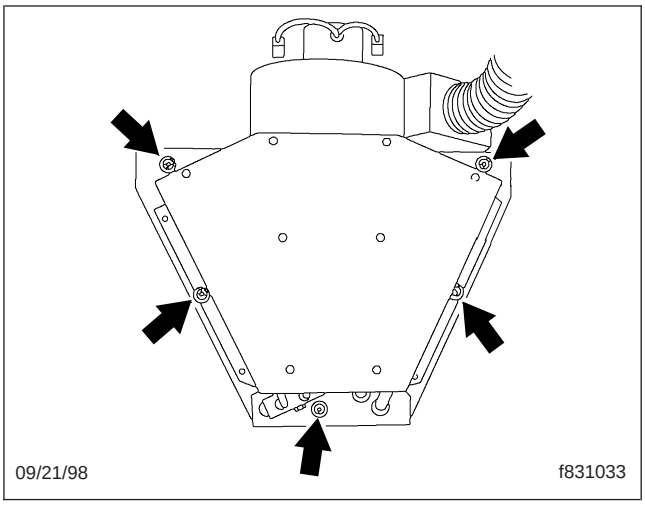


Fig. 5, Auxiliary Heating and Air Conditioning Assembly Bolts

Installation

1. Install the heating and auxiliary air conditioning assembly and the retaining bolts. See **Fig. 5**.
2. Connect the inlet lines. See **Fig. 4**.
   - 2.1 Connect the expansion valve refrigerant lines.
   - 2.2 Connect the heater core lines.
3. Connect the electrical connectors. See **Fig. 3**.
4. Connect the air outlet flex hose. See **Fig. 2**.
5. Install the heating and auxiliary air conditioning assembly shroud. See **Fig. 1**.
   - 5.1 Install the heating and auxiliary air conditioning assembly shroud.
   - 5.2 Lower the lower bunk.
6. Fill the engine cooling system. For instructions, refer to **Group 20**.
7. Evacuate, charge, and leak test the A/C system. For instructions, refer to **Section 83.00**.

Replacement

1. Remove the screws from the auxiliary climate control assembly. See **Fig. 1**.

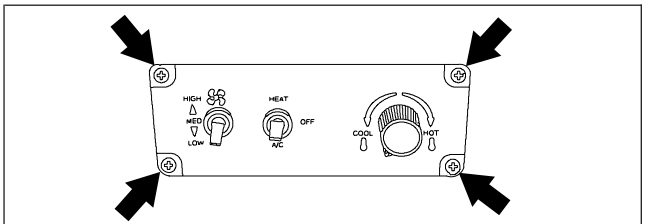


Fig. 1, Auxiliary Climate Control Assembly Screws

2. Disconnect the electrical connector and remove the auxiliary climate control assembly. See **Fig. 2**.

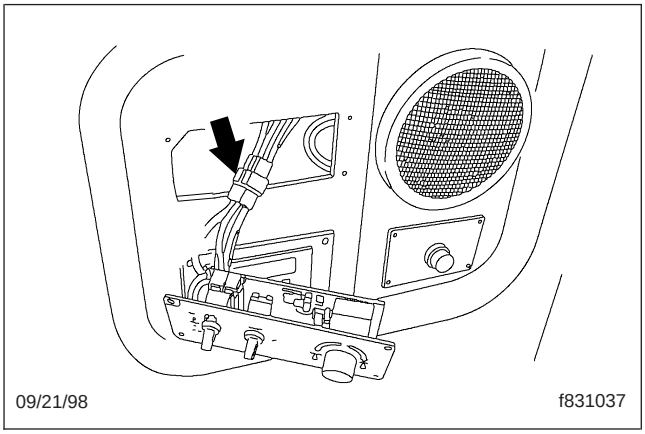
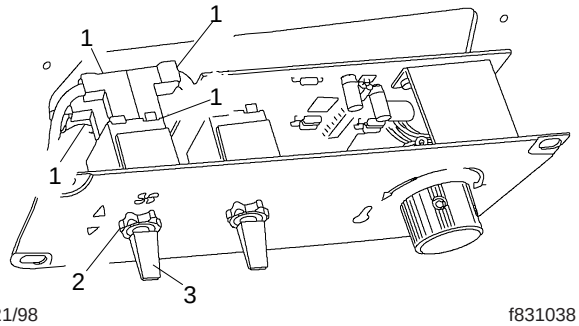


Fig. 2, Electrical Connector

3. Install the auxiliary climate control assembly and connect the electrical connector. See **Fig. 2**.
4. Install and securely tighten the screws. See **Fig. 1**.

Blower Motor Switch Replacement

1. Remove the auxiliary climate control assembly.
2. Remove the switch. See **Fig. 1**.



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1. Electrical Connectors
2. Retaining Nut
3. Switch

Fig. 1, Blower Motor Switch

2.1 Disconnect the four electrical connectors.

2.2 Remove the retaining nut and remove the switch.

3. Install the switch. See **Fig. 1**.

3.1 Install the switch and install the retaining nut.

3.2 Connect the four electrical connectors.

4. Install the auxiliary climate control assembly.

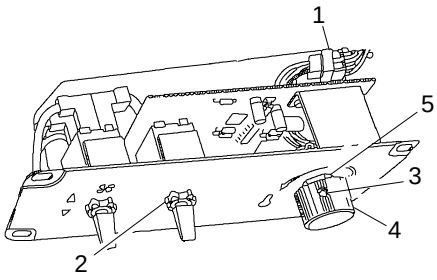
Mode Switch and Temperature Control Assembly Replacement

1. Remove the auxiliary climate control assembly enough to gain access to the rear of the assembly.
2. Remove the mode switch and temperature control assembly. See **Fig. 2**.

2.1 Disconnect the electrical connector.

2.2 Remove the switch retaining nut.

2.3 Loosen the temperature control knob setscrew and remove the knob.



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1. Electrical Connectors
2. Retaining Nut
3. Setscrew
4. Control Knob
5. Retaining Nut

Fig. 2, Mode Switch and Temperature Control Assembly

2.4 Remove the temperature control retaining nut and remove the assembly.

3. Install the mode switch and temperature control assembly. See **Fig. 2**.

3.1 Install the assembly and install the temperature control retaining nut.

3.2 Install the knob and tighten the temperature control knob setscrew.

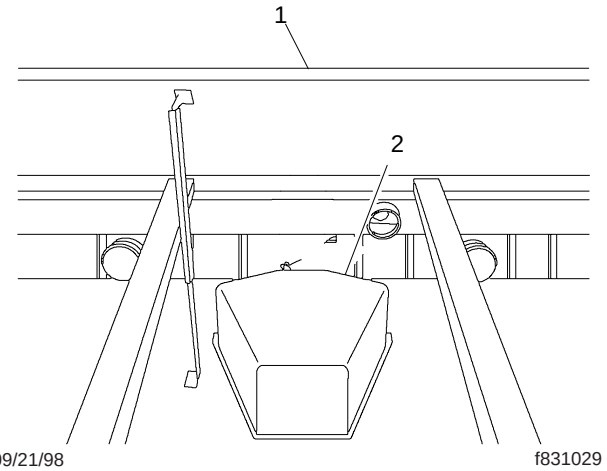
3.3 Install the switch retaining nut.

3.4 Connect the electrical connector.

4. Install the auxiliary climate control assembly.

Replacement

1. Remove the auxiliary heating and air conditioning assembly shroud, then raise the lower bunk. See **Fig. 1**.

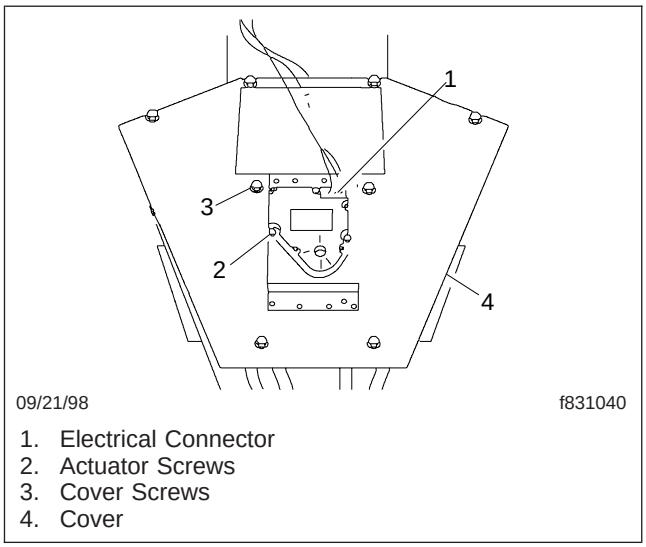


1. Lower Bunk
2. Auxiliary Heating and Air Conditioning Assembly Shroud

Fig. 1, Auxiliary Heating and Air Conditioning Assembly Shroud

NOTE: Care must be taken not to lose the plastic bushing between the blend door actuator and the blend door.

2. Remove the auxiliary heating and air conditioning assembly case cover. See **Fig. 2**.
   - 2.1 Remove the blend door actuator electrical connector.
   - 2.2 Loosen the blend door actuator screws.
   - 2.3 Remove the eight case cover screws.
   - 2.4 Remove the case cover.
3. Remove the blower wheel retaining clamp. See **Fig. 3**.
4. Remove the blower motor. See **Fig. 4**.
   - 4.1 Remove the retaining screws.
   - 4.2 Separate the blower motor from the blower motor wheel, and remove the blower motor.



1. Electrical Connector
2. Actuator Screws
3. Cover Screws
4. Cover

Fig. 2, Auxiliary Heating and Air Conditioning Assembly Case Cover

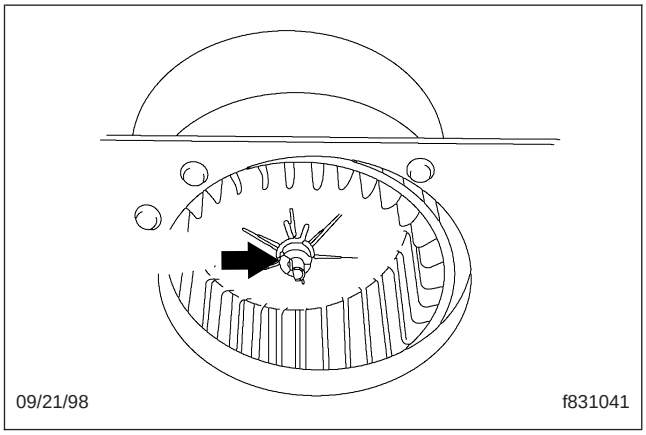
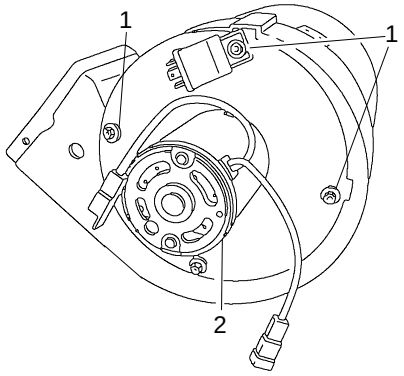


Fig. 3, Blower Wheel Retaining Clamp

5. Remove the blower motor wheel from the blower motor plenum.
6. Install the blower motor wheel to the blower motor plenum.
7. Install the blower motor. See **Fig. 4**.
   - 7.1 Install the retaining screws.
   - 7.2 Install the blower motor to the blower motor wheel.
8. Install the blower wheel retaining clamp. See **Fig. 3**.

Blower Motor and Wheel Replacement



1. Retaining Screws
2. Blower Motor

Fig. 4, Blower Motor

9. Install the auxiliary heating and air conditioning assembly case cover. See **Fig. 2**.
   - 9.1 Install the case cover.
   - 9.2 Install the eight case cover screws.
   - 9.3 Tighten the blend door actuator screws.
   - 9.4 Install the blend door actuator electrical connector.
10. Lower the lower bunk, then install the auxiliary heating and air conditioning assembly shroud. See **Fig. 1**.

Blower Motor Housing Replacement

Replacement

1. Remove the blower motor and wheel.
2. Remove the blower motor resistor.
3. Remove the three air conditioning and heater outlet duct screws and remove the outlet duct. See **Fig. 1**.

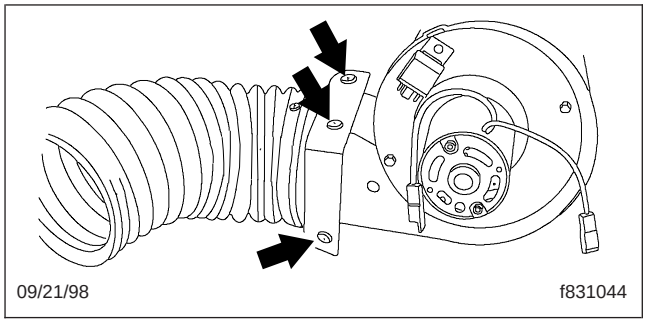


Fig. 1, Outlet Duct Screws

4. Remove the thermistor from the blower motor housing. See **Fig. 2**.

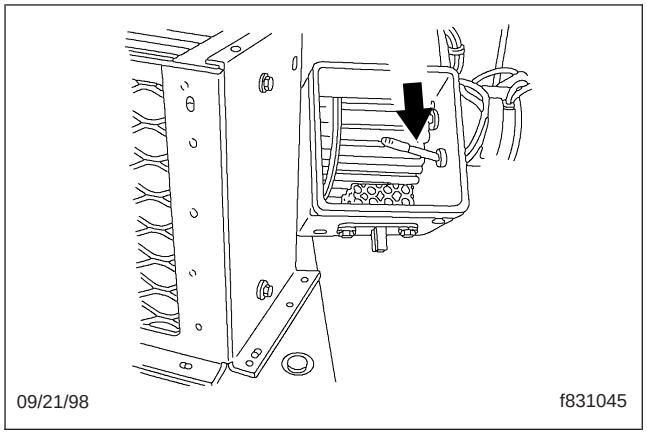


Fig. 2, Thermistor

5. Remove the screws and remove the housing. See **Fig. 3**.
6. Install the housing and the screws. See **Fig. 3**.
7. Install the thermistor to the blower motor housing. See **Fig. 2**.
8. Install the outlet duct and the three air conditioning and heater outlet duct screws. See **Fig. 1**.
9. Install the blower motor resistor.

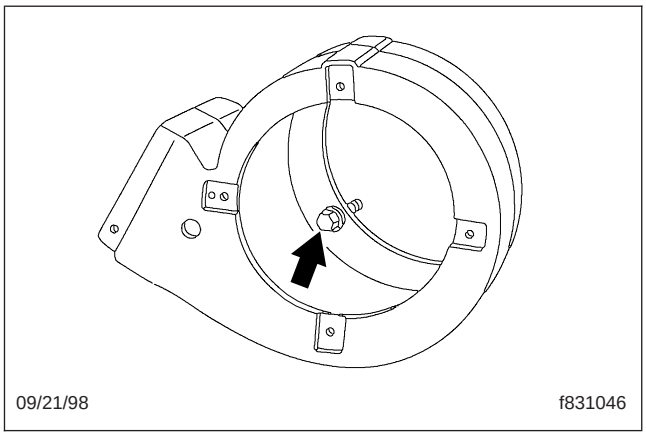
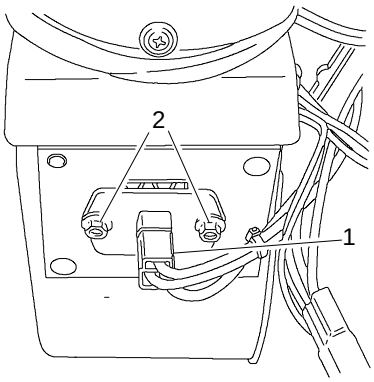


Fig. 3, Housing and Screws

10. Install the blower motor and wheel.

Replacement

1. Remove the blower motor resistor. See **Fig. 1**.



1. Electrical Connector
2. Screws

Fig. 1, Blower Motor Resistor

1.1 Disconnect the electrical connector.

1.2 Remove the screws and remove the resistor.

2. Install the blower motor resistor. See **Fig. 1**.

2.1 Connect the electrical connector.

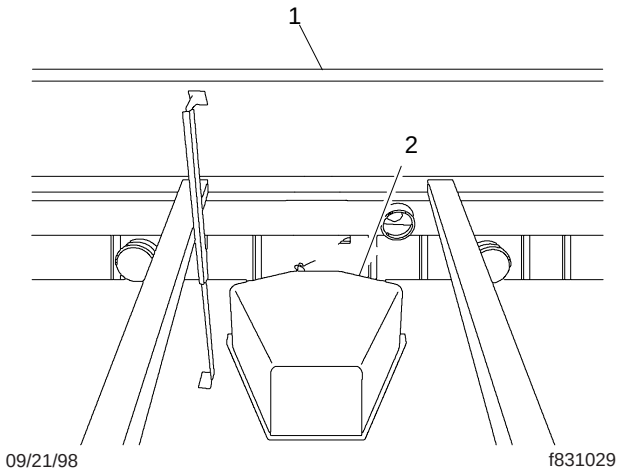
2.2 Install the resistor and the screws.

Evaporator Core Removal and Installation

Removal

NOTE: Cap or plug all open refrigerant line fittings to prevent entry of dirt and moisture.

1. Recover the refrigerant. For instructions, refer to **Section 83.00**.
2. Raise the lower bunk, then remove the auxiliary air conditioning and heating assembly shroud. See **Fig. 1**.



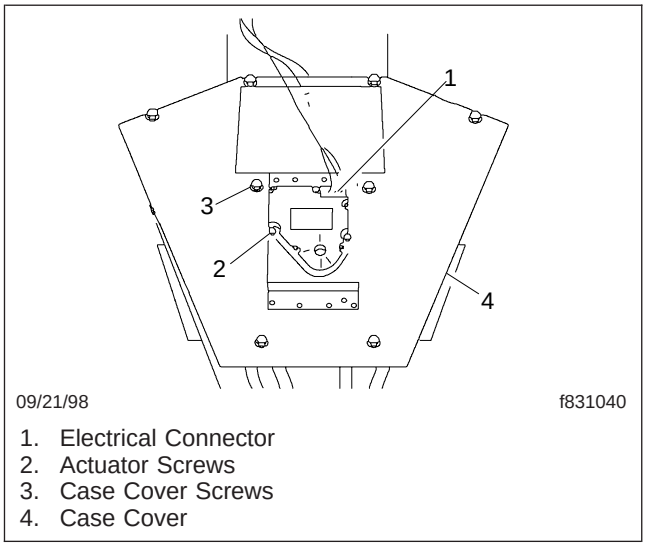
1. Lower Bunk
2. Auxiliary Heating and Air Conditioning Assembly Shroud

Fig. 1, Auxiliary Heating and Air Conditioning Assembly Shroud

NOTE: Care must be taken not to lose the plastic bushing between the blend door actuator and the blend door.

3. Remove the auxiliary heating and air conditioning assembly case cover. See **Fig. 2**.
   - 3.1 Remove the blend door actuator electrical connector.
   - 3.2 Loosen the blend door actuator screws.
   - 3.3 Remove the eight case cover screws.
   - 3.4 Remove the case cover.

NOTE: Cap or plug all open refrigerant line fittings to prevent entry of dirt and moisture.



1. Electrical Connector
2. Actuator Screws
3. Case Cover Screws
4. Case Cover

Fig. 2, Auxiliary Heating and Air Conditioning Assembly Case Cover

4. Disconnect the evaporator core refrigerant tubes from the evaporator expansion valve. See **Fig. 3**.

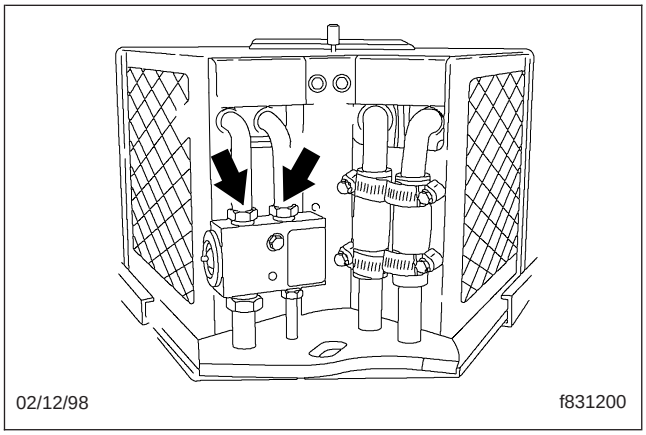


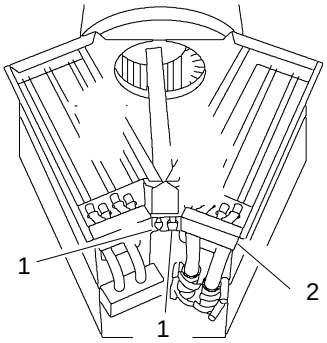
Fig. 3, A/C Evaporator Core Refrigerant Tubes

5. Remove the evaporator core. See **Fig. 4**.
   - 5.1 Remove the evaporator core/heater core retaining bracket screws.
   - 5.2 Remove the evaporator core/heater core retaining bracket and remove the evaporator core.

Installation

1. Install the evaporator core. See **Fig. 4**.

Evaporator Core Removal and Installation



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1. Retaining Screws
2. Retaining Bracket

Fig. 4, Evaporator Core

1.1 Install the evaporator core and the evaporator core/heater core retaining bracket.

1.2 Install the evaporator core/heater core retaining bracket screws.

2. Connect the A/C evaporator core refrigerant tubes to the evaporator expansion valve. See **Fig. 3**.

NOTE: Make sure the plastic blend door bushing is placed on the blend door shaft prior to installation of the case cover. The blend door actuator can be aligned with the bushing by looking through the blend door actuator.

3. Install the auxiliary air conditioning and heating assembly case cover. See **Fig. 2**.

3.1 Install the blend door actuator electrical connector.

3.2 Tighten the blend door actuator screws.

3.3 Install the case cover, then install the eight case cover screws.

4. Install the auxiliary air conditioning and heating assembly shroud. See **Fig. 1**.

4.1 Install the auxiliary air conditioning and heating assembly shroud.

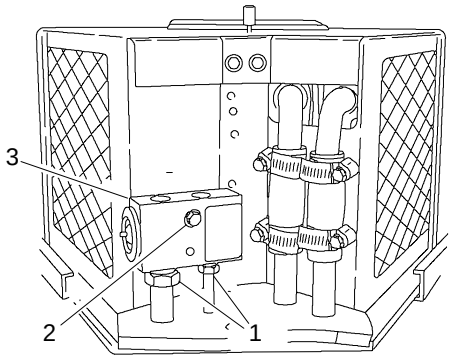
4.2 Lower the lower bunk.

5. Restore the vehicle to operating condition. Evacuate, charge and leak test the A/C system. For instructions, refer to **Section 83.00**.

Evaporator Core Expansion Valve Replacement

Replacement

1. Recover the R–134a refrigerant from the system. For instructions, refer to **Section 83.00**.
2. Remove the evaporator core.
3. Remove the expansion valve. See **Fig. 1**.



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1. Refrigerant Lines
2. Bolt
3. Expansion Valve

Fig. 1, Expansion Valve

   3.1 Disconnect the refrigerant lines.

   3.2 Remove the bolt.

   3.3 Remove the expansion valve.

4. Install the expansion valve. See **Fig. 1**.

   4.1 Install the expansion valve.

   4.2 Install the bolt.

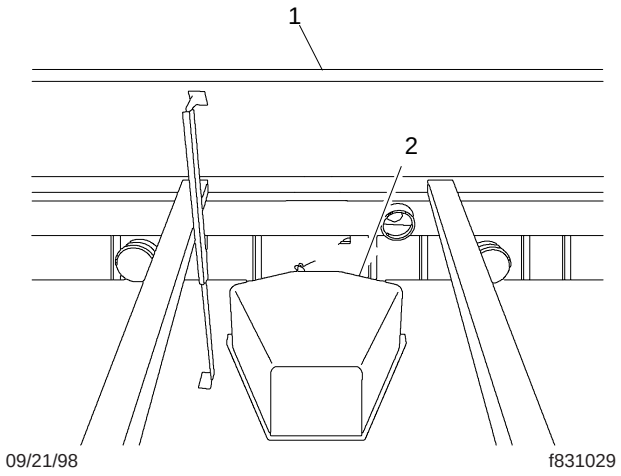
   4.3 Connect the refrigerant lines. See **Specifications, 400**. See **Fig. 1**.

5. Install the evaporator core.
6. Restore the vehicle to operating condition. Evacuate, charge, and leak test the A/C system. For instructions, refer to **Section 83.00**.

Heater Core Removal and Installation

Removal

1. Drain the engine coolant. Refer to **Group 20**.
2. Raise the lower bunk, then remove the auxiliary heating and air conditioning assembly shroud. See **Fig. 1**.

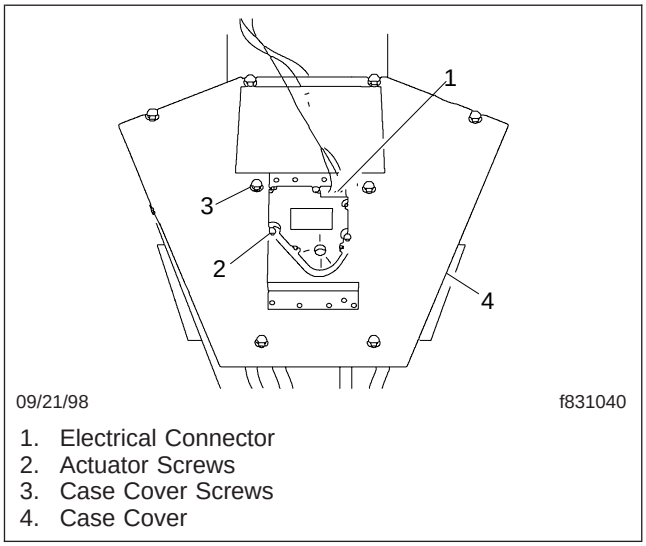


1. Lower Bunk
2. Auxiliary Heating and Air Conditioning Assembly Shroud

Fig. 1, Auxiliary Heating and Air Conditioning Assembly Shroud

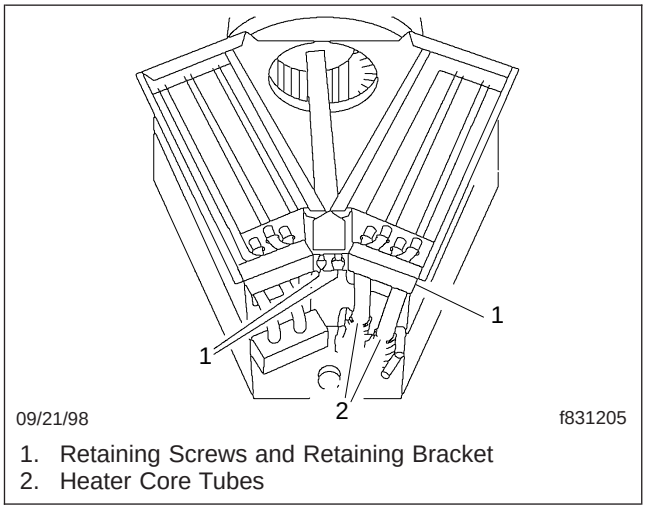
NOTE: Care must be taken not to lose the plastic bushing between the blend door actuator and the blend door.

3. Remove the auxiliary heating and air conditioning assembly case cover. See **Fig. 2**.
   - 3.1 Remove the blend door actuator electrical connector.
   - 3.2 Loosen the blend door actuator screws.
   - 3.3 Remove the eight case cover screws.
   - 3.4 Remove the case cover.
4. Remove the heater core. See **Fig. 3**.
   - 4.1 Remove the evaporator core/heater core retaining bracket screws and bracket.
   - 4.2 Disconnect the heater core tubes, and remove the heater core.



1. Electrical Connector
2. Actuator Screws
3. Case Cover Screws
4. Case Cover

Fig. 2, Auxiliary Heating and Air Conditioning Assembly Case Cover



1. Retaining Screws and Retaining Bracket
2. Heater Core Tubes

Fig. 3, Heater Core

Installation

1. Install the heater core. See **Fig. 3**.
   - 1.1 Install the heater core and connect the heater core tubes.
   - 1.2 Install the evaporator core/heater core retaining bracket and bracket screws.
2. Install the auxiliary heating and air conditioning assembly case cover. See **Fig. 2**.

Heater Core Removal and Installation

2.1 Install the case cover.

2.2 Install the eight case cover screws.

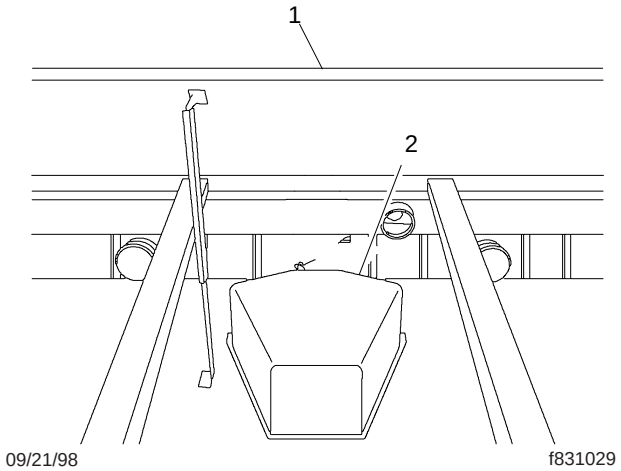
2.3 Tighten the blend door actuator screws.

2.4 Install the blend door actuator electrical connector.

3. Install the auxiliary heating and air conditioning assembly shroud and lower bunk. See **Fig. 1**.
4. Restore the vehicle to operating condition. Refill the engine cooling system. For instructions, refer to **Group 20**.

Replacement

1. Raise the lower bunk, then remove the auxiliary air conditioning and heating assembly shroud. See **Fig. 1**.



1. Lower Bunk
2. Auxiliary Air Conditioning and Heating Assembly Shroud

Fig. 1, Auxiliary Air Conditioning and Heating Assembly Shroud

NOTE: Care must be taken not to lose the plastic spacers and blend door bushing.

2. Remove the screws and remove the blend door actuator. See **Fig. 2**.

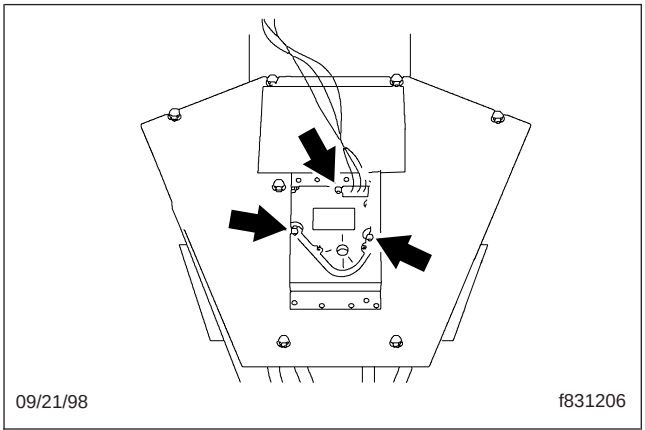
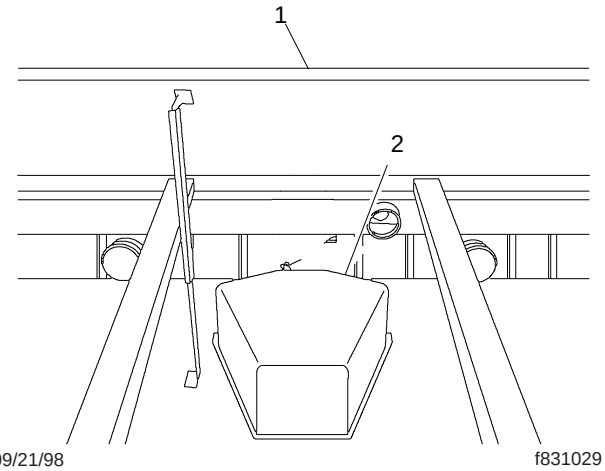


Fig. 2, Blend Door Actuator

3. Install the blend door actuator and the screws. See **Fig. 2**.
4. Install the auxiliary air conditioning and heating assembly shroud, then lower the lower bunk. See **Fig. 1**.

Replacement

1. Raise the lower bunk, then remove the auxiliary heating and air conditioning assembly shroud. See **Fig. 1**.



1. Lower Bunk
2. Auxiliary Heating and Air Conditioning Assembly Shroud

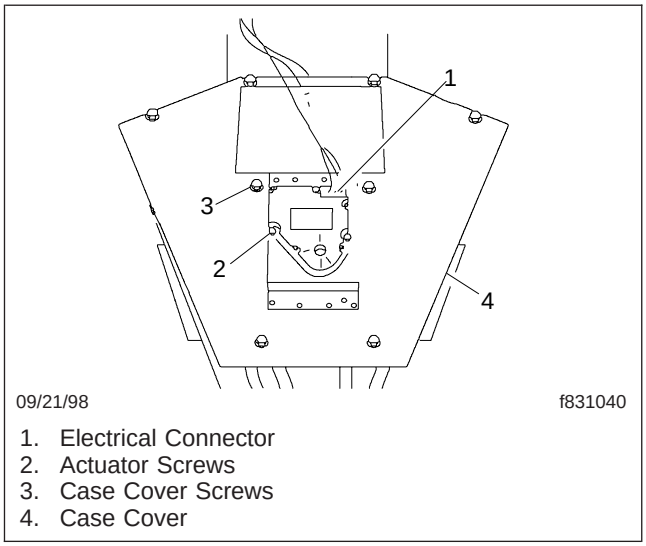
Fig. 1, Auxiliary Heating and Air Conditioning Assembly Shroud

NOTE: Care must be taken not to lose the plastic bushing between the blend door actuator and the blend door.

2. Remove the auxiliary heating and air conditioning assembly case cover. See **Fig. 2**.
   - 2.1 Remove the blend door actuator electrical connector.
   - 2.2 Loosen the blend door actuator screws.
   - 2.3 Remove the eight case cover screws.
   - 2.4 Remove the case cover.
3. Push down on the end of the blend door, and remove it from the case. See **Fig. 3**.

NOTE: Installing the blend door plastic bushing on the blend door shaft will facilitate the installation process.

4. Install the blend door in the case. See **Fig. 3**.



1. Electrical Connector
2. Actuator Screws
3. Case Cover Screws
4. Case Cover

Fig. 2, Auxiliary Heating and Air Conditioning Assembly Case Cover

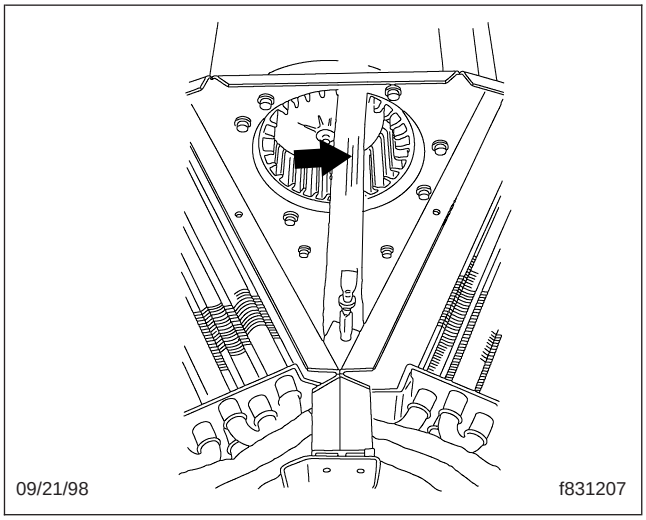


Fig. 3, Blend Door Removal/Installation

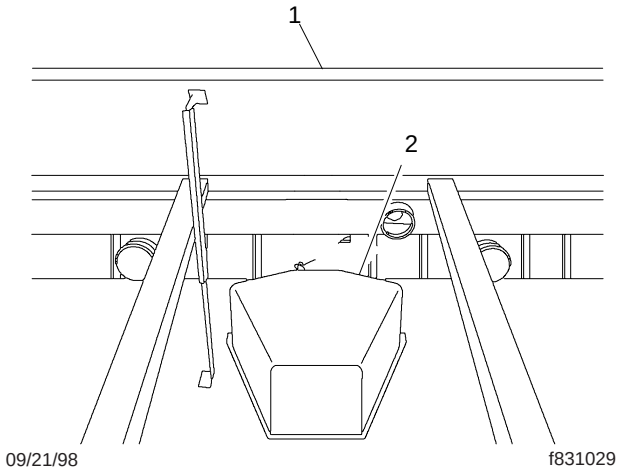
5. Install the auxiliary heating and air conditioning assembly case cover. See **Fig. 2**.
   - 5.1 Install the case cover.
   - 5.2 Install the eight case cover screws.
   - 5.3 Tighten the blend door actuator screws.
   - 5.4 Install the blend door actuator electrical connector.

Blend Door Replacement

6. Install the auxiliary heating and air conditioning assembly shroud, then lower the lower bunk. See **Fig. 1**.

Replacement

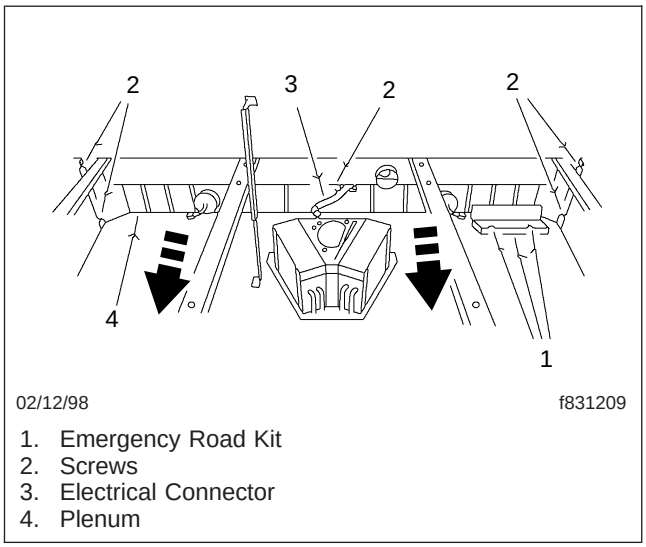
1. Raise the lower bunk, then remove the auxiliary air conditioning and heating assembly shroud. See **Fig. 1**.



1. Lower Bunk
2. Auxiliary Air Conditioning and Heating Assembly Shroud

Fig. 1, Auxiliary Air Conditioning and Heating Assembly Shroud

2. Remove the blower housing.
3. Remove the cargo lamps.
4. Pull the rear plenum duct forward to gain access to the lower register ductwork. See **Fig. 2**.
   - 4.1 Remove the emergency road kit.
   - 4.2 Remove the plenum retaining screws.
   - 4.3 Disconnect the main 10-pin auxiliary air conditioning and heating assembly electrical connector.
   - 4.4 Tilt the bottom of the plenum forward, and pull the plenum forward.
5. Disconnect the lower register ductwork and remove the rear plenum duct. See **Fig. 3**.
6. Install the rear plenum duct and connect the lower register ductwork. See **Fig. 3**.
7. Install the cargo lamps.
8. Install the blower housing.



1. Emergency Road Kit
2. Screws
3. Electrical Connector
4. Plenum

Fig. 2, Accessing Lower Register Ductwork

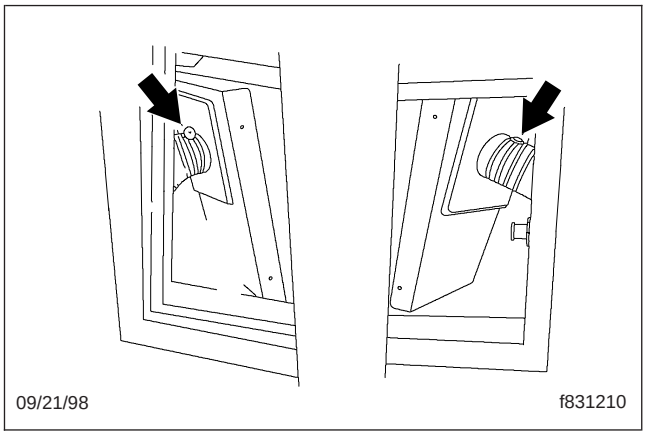
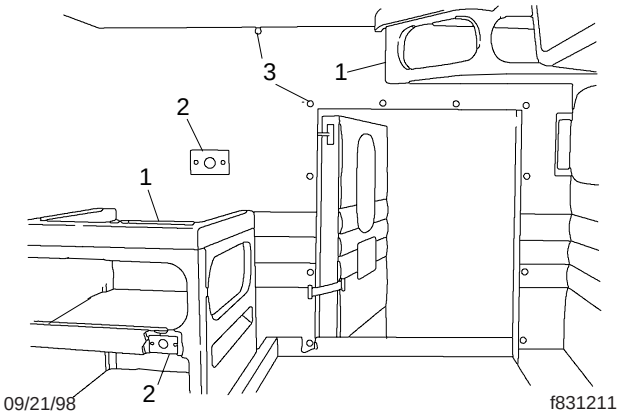


Fig. 3, Lower Register Ductwork

9. Install the auxiliary air conditioning and heating assembly shroud, then lower the lower bunk. See **Fig. 1**.

Right-Hand Lower Register Replacement

1. Remove the right-hand lower trim panel. See **Fig. 1**.



1. Storage Accessories
2. Power Points
3. Trim Panel Screws

Fig. 1, Right-Hand Lower Trim Panel

   1.1 Remove the storage accessories.

   1.2 Remove both power points.

   1.3 Remove the screws, and remove the trim panel.

2. Remove the rear lower trim panel.
3. Remove the right-hand lower register. See **Fig. 2**.

   3.1 Remove the register retaining screw.

   3.2 Remove the retaining screws, and disconnect the upper and lower ductwork.

   3.3 Remove the register.

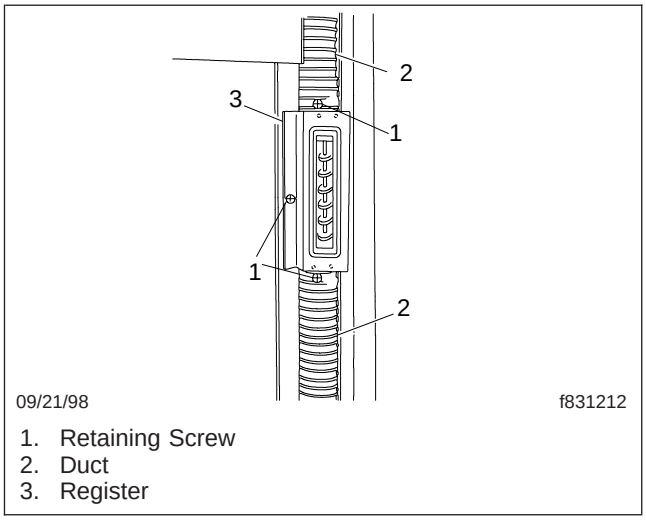
4. Install the right-hand lower register. See **Fig. 2**.

   4.1 Install the register.

   4.2 Connect the upper and lower ductwork and install the retaining screws.

   4.3 Install the register retaining screw.

5. Install the rear lower trim panel.



1. Retaining Screw
2. Duct
3. Register

Fig. 2, Right-Hand Lower Register

6. Install the right-hand lower trim panel. See **Fig. 1**.

   6.1 Install the trim panel and the screws.

   6.2 Install both power points.

   6.3 Install the storage accessories.

Left-Hand Lower Register Replacement

1. Remove the left-hand lower trim panel. See **Fig. 3**.

   1.1 Remove the storage accessories.

   1.2 Remove the vent trim.

   1.3 Remove the reading lamp.

   1.4 Remove the retaining screws and remove the trim panel.

2. Remove the rear lower trim panel.
3. Remove the left-hand lower register. See **Fig. 4**.

   3.1 Remove the register retaining screw.

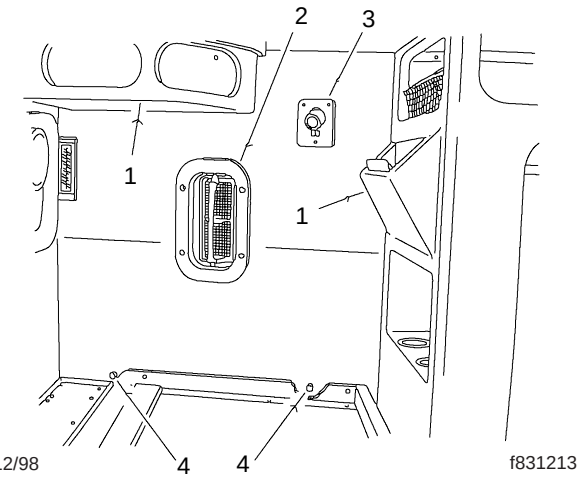
   3.2 Remove the retaining screws, and disconnect the upper and lower ductwork.

   3.3 Remove the register.

4. Install the left-hand lower register. See **Fig. 4**.

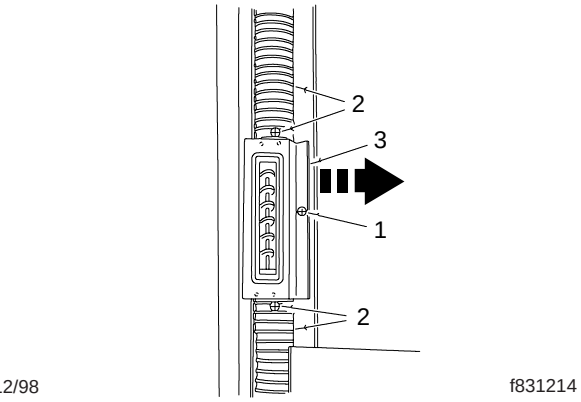
   4.1 Install the register.

Register Replacement



1. Storage Accessories
2. Vent Trim
3. Reading Lamp
4. Trim Panel Screws

Fig. 3, Left-Hand Lower Trim Panel



1. Retaining Screw
2. Duct and Retaining Screw
3. Register

Fig. 4, Left-Hand Lower Register

4.2 Connect the upper and lower ductwork and install the retaining screws.

4.3 Install the register retaining screw.

5. Install the rear lower trim panel.
6. Install the left-hand lower trim panel. See **Fig. 3**.

6.1 Install the trim panel and the retaining screws.

6.2 Install the reading lamp.

6.3 Install the vent trim.

6.4 Install the storage accessories.

Troubleshooting

INSPECTION AND VERIFICATION

Before doing any testing on the auxiliary air conditioning and heating system, make sure the front air conditioning and heating system is functioning properly and that the engine cooling system is functioning properly. Refer to diagnosis and testing of the front air conditioning and heating system. Refer to **Group 20** for diagnosis and testing of the engine cooling system.

Diagnosis and testing of the auxiliary air conditioning and heating evaporator core and heater core is the same as the front air conditioning and heating evaporator core and heater core.

1. Verify the owner's original concern by operating the system to duplicate the concern.
2. Visually inspect for obvious signs of mechanical and electrical damage. Refer to the following chart:

Visual Inspection Chart	
Mechanical	**Electrical**
Damaged evaporator core	Open fuse: sleeper fuse junction panel Fuse 6 (30 A) or Fuse 22 (25 A)
Damaged heater core	Damaged HVAC relay or blower relay
Kinked, bent or damaged A/C or coolant hoses	Damaged circuitry
Damaged blower motor housing	Corroded connectors
Damaged ductwork	Damaged control panel components
Damaged A/C heater assembly housing	
Coolant leak	
Refrigerant leak	

Table 1, Visual Inspection Chart

3. If the fault is not visually evident, determine the problem and proceed to the problem charts.

Problem—Insufficient or No Heat

Problem—Insufficient or No Heat	
Possible Cause	**Remedy**
Inoperative blend door actuator	Repair or replace as necessary.
Damaged blend door	
Plugged or partially plugged heater core—internally or externally	

Problem—Insufficient Cooling

Problem—Insufficient Cooling	
Possible Cause	**Remedy**
Inoperative blend door actuator	Repair or replace as necessary.
Damaged blend door	
Plugged or partially plugged evaporator core—internally or externally	
Damaged evaporator expansion valve	

Troubleshooting

Problem—No Operation in All Temperature Settings

Problem—No Operation in All Temperature Settings	
Possible Cause	**Remedy**
Circuitry	Repair or replace as necessary.
Damaged HVAC relay	
Damaged mode switch	

Problem—Auxiliary Blower Motor Does Not Operate

Problem—Auxiliary Blower Motor Does Not Operate	
Possible Cause	**Remedy**
Circuitry	Repair or replace as necessary.
Blower switch	
Blower motor	

Problem—Blower Operates Continuously in High Speed

Problem—Blower Operates Continuously in High Speed	
Possible Cause	**Remedy**
Circuitry	Repair or replace as necessary.
Blower switch	

Problem—No Blower Operation in High Speed

Problem—No Blower Operation in High Speed	
Possible Cause	**Remedy**
Circuitry	Repair or replace as necessary.
Blower switch	

Problem—No Blower Operation in Lower Speeds

Problem—No Blower Operation in Lower Speeds	
Possible Cause	**Remedy**
Circuitry	Repair or replace as necessary.
Blower resistor	
Blower switch	
Blower resistor	

Problem—Auxiliary Controls are Operational With the Function Selector OFF

Problem—Auxiliary Controls are Operational With the Function Selector OFF	
Possible Cause	**Remedy**
Mode/temperature control	Replace the mode/temperature control.

Specifications

Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Air Conditioning and Heating Assembly Case Cover Screws	—	11–13 (130–150)
Air Conditioning and Heating Assembly Mounting Bolts	—	106 (1200)
A/C No. 6 Inlet Line to Expansion Valve	18 (24)	—
A/C No. 10 Inlet Line to Expansion Valve	23 (31)	—
Evaporator to Expansion Valve	20 (27)	—
Evaporator Valve Retaining Bolt	—	10–12 (110–140)

Table 1, Torque Specifications

General Information

The auxiliary air conditioning and heating system is standard on the SilverStar sleeper. This system is equipped with an auxiliary air conditioning and heating assembly, an auxiliary climate control assembly, an auxiliary air conditioning control module, a return air temperature sensor and the ducts and registers for the direction of air distribution.

AUXILIARY AIR CONDITIONING AND HEATING ASSEMBLY

The auxiliary air conditioning and heating assembly is a one-piece unit mounted on the right-hand rear of the sleeper, under the lower bunk. Some components of the assembly, including the auxiliary blower motor, the auxiliary blower motor resistor, the auxiliary air conditioning temperature blend door actuator and the air conditioning evaporator expansion valve are serviceable from inside the sleeper. The internal components of the assembly, including the heater core, the evaporator core and the temperature blend door are serviced on-bench.

AUXILIARY CLIMATE CONTROL PANEL

The auxiliary climate control panel located in the control panel assembly provides settings for temperature, function selection (ON/OFF) and blower speed selection.

AUXILIARY AIR CONDITIONING CONTROL MODULE

The auxiliary air conditioning control module controls the positioning of the temperature blend door. Using input signals from the temperature potentiometer switch in the auxiliary climate control panel and the return air temperature sensor in the auxiliary air conditioning and heating assembly, the auxiliary air conditioning control module provides an output to the auxiliary air conditioning temperature blend door actuator to properly position the temperature blend door.

RETURN AIR TEMPERATURE SENSOR

The return air temperature sensor is located in the right-hand rear corner of the sleeper, under the lower bunk, and adjacent to the auxiliary air conditioning and heating assembly blower motor air inlet. The sensor provides return air temperature input signals to the auxiliary air conditioning control module.

DUCTS AND REGISTERS

The ducts and registers of the auxiliary air conditioning and heating system provide air distribution to the lower, mid and upper portions of the sleeper.

Auxiliary Air Conditioning and Heating Assembly Replacement

Replacement

1. Recover the air conditioning system refrigerant. For instructions, see Section 83.00, **Subject 110**.
2. Disconnect the battery ground cable.
3. Place a suitable container under the sleeper to collect the coolant.
4. Clamp off the auxiliary heater jumper hoses near the bulkhead elbows under the sleeper. See **Fig. 1**.

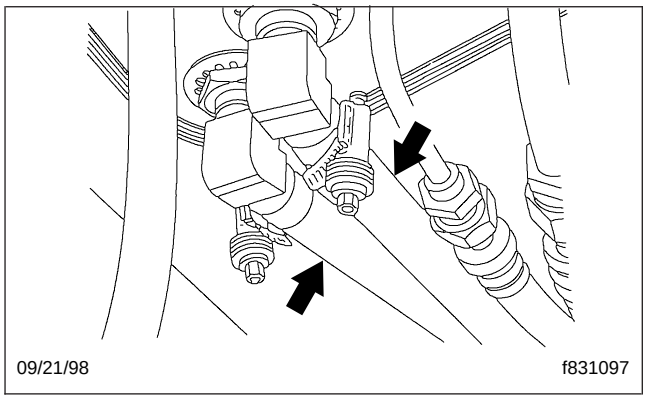


Fig. 1, Auxiliary Heater Jumper Hoses

⚠ WARNING

The engine must be off and fully cool, and the cooling system fully depressurized before attempting to disconnect any heater hoses. Failure to comply with these warnings can result in serious injury and burns from hot liquid escaping from the engine cooling system.

5. Disconnect the auxiliary heater jumper hoses from the bulkhead elbows and allow the coolant to drain from the heater core and auxiliary heater hoses.
6. Raise the lower bunk.
7. Disconnect the auxiliary air conditioning control module electrical connector. See **Fig. 2**.
8. Remove the retaining screws, then remove the auxiliary air conditioning and heating assembly shield. See **Fig. 3**.
9. Disconnect the air distribution ducts. See **Fig. 4**.
10. Remove the auxiliary air conditioning and heating assembly. See **Fig. 5**.

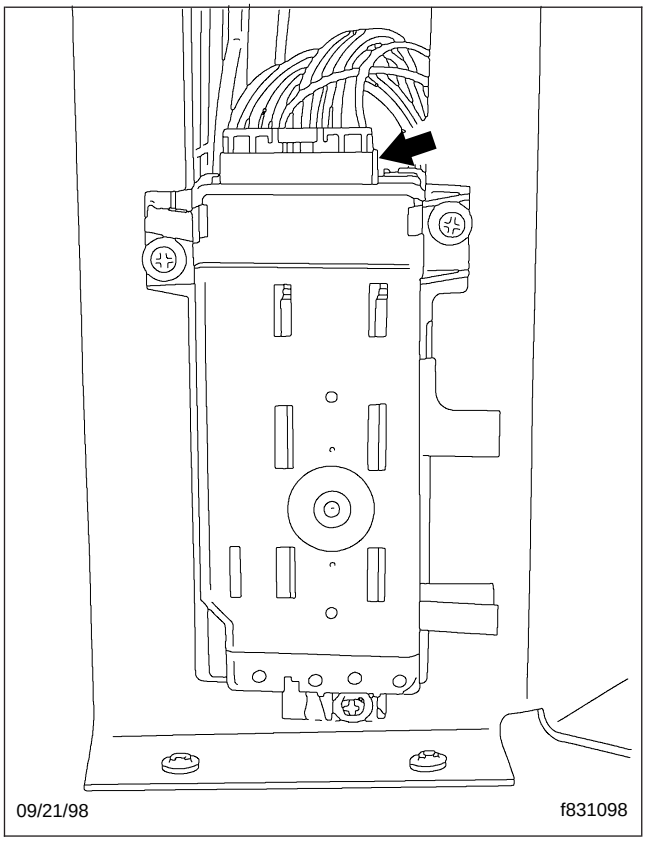
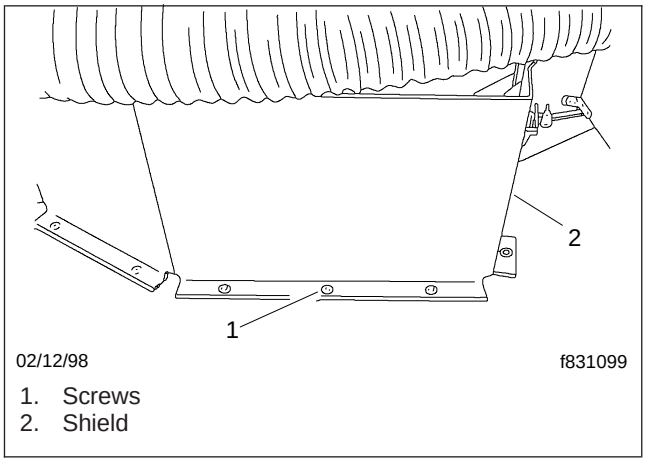


Fig. 2, Auxiliary Air Conditioning Control Module Electrical Connector



1. Screws
2. Shield

Fig. 3, Auxiliary Air Conditioning and Heating Assembly Shield

10.1 Disconnect the auxiliary heater hoses from the heater core.

Auxiliary Air Conditioning and Heating Assembly Replacement

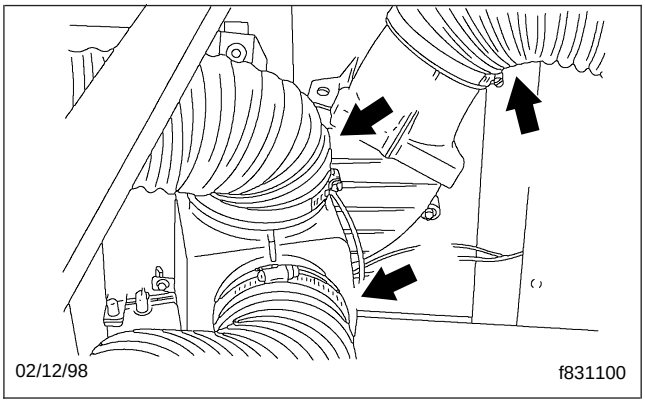


Fig. 4, Air Distribution Ducts

10.2 Disconnect the evaporator core from the thermal expansion valve.

10.3 Disconnect the electrical connectors.

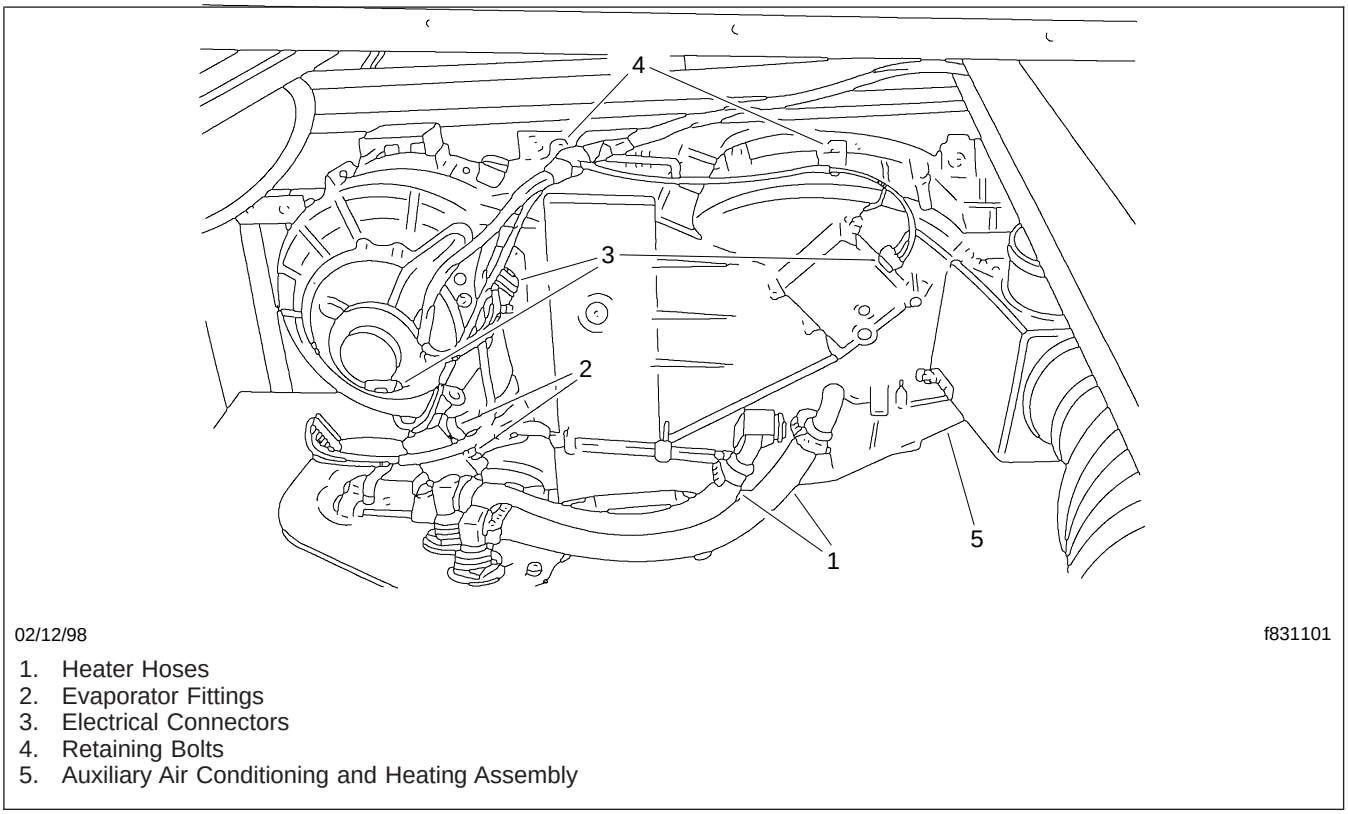
10.4 Remove the auxiliary air conditioning and heating assembly retaining bolts.

10.5 Remove the auxiliary air conditioning and heating assembly.

11. Install the auxiliary air conditioning and heating assembly. See **Fig. 5**.
12. Install the auxiliary air conditioning and heating assembly retaining bolts.
13. Connect the electrical connectors.
14. Connect the evaporator core to the thermal expansion valve.
15. Connect the auxiliary heater hoses to the heater core.
16. Connect the air distribution ducts. See **Fig. 4**.
17. Install the auxiliary air conditioning and heating assembly shield. See **Fig. 3**.

    17.1 Install the auxiliary air conditioning and heating assembly shield.

    17.2 Install the retaining screws.



1. Heater Hoses
2. Evaporator Fittings
3. Electrical Connectors
4. Retaining Bolts
5. Auxiliary Air Conditioning and Heating Assembly

Fig. 5, Auxiliary Air Conditioning and Heating Assembly

18. Connect the auxiliary air conditioning control module electrical connector. See **Fig. 2**.
19. Lower the lower bunk.
20. Connect the auxiliary heater jumper hoses from the bulkhead elbows.
21. Remove clamps from the auxiliary heater jumper hoses near the bulkhead elbows under the sleeper. See **Fig. 1**.
22. Connect the battery ground cable.

CAUTION

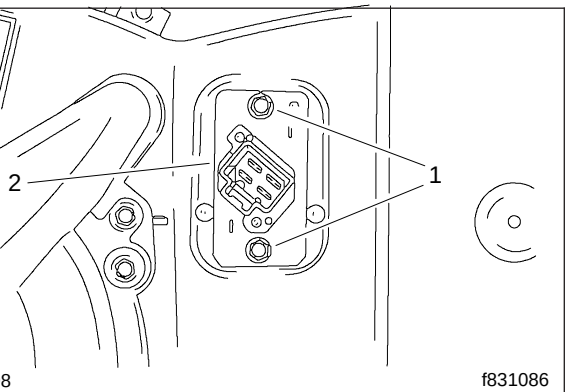
Make certain that the auxiliary heater hose connections are installed correctly and that the heater hoses cannot become pinched.

23. Fill and bleed the cooling system. For instructions, refer to **Group 20**.
24. Evacuate, charge and leak-test the air conditioning system.

Auxiliary Heater Blower Motor Resistor Replacement

Replacement

1. Disconnect the battery ground cable.
2. Raise the lower bunk.
3. Disconnect the auxiliary heater blower motor resistor electrical connector.
4. Remove the retaining screws, then remove the resistor. See **Fig. 1**.



1. Retaining Screws
2. Resistor

Fig. 1, Auxiliary Heater Blower Motor Resistor

5. Install the auxiliary heater blower motor resistor. See **Fig. 1**.
   - 5.1 Install the auxiliary heater blower motor resistor.
   - 5.2 Install the auxiliary heater blower motor resistor retaining screws.
6. Connect the auxiliary heater blower motor resistor electrical connector.
7. Lower the lower bunk.
8. Connect the battery ground cable.

Auxiliary Heater Blower Motor Replacement

Replacement

1. Disconnect the battery ground cable.
2. Disconnect the auxiliary air conditioning control module electrical connector. See **Fig. 1**.

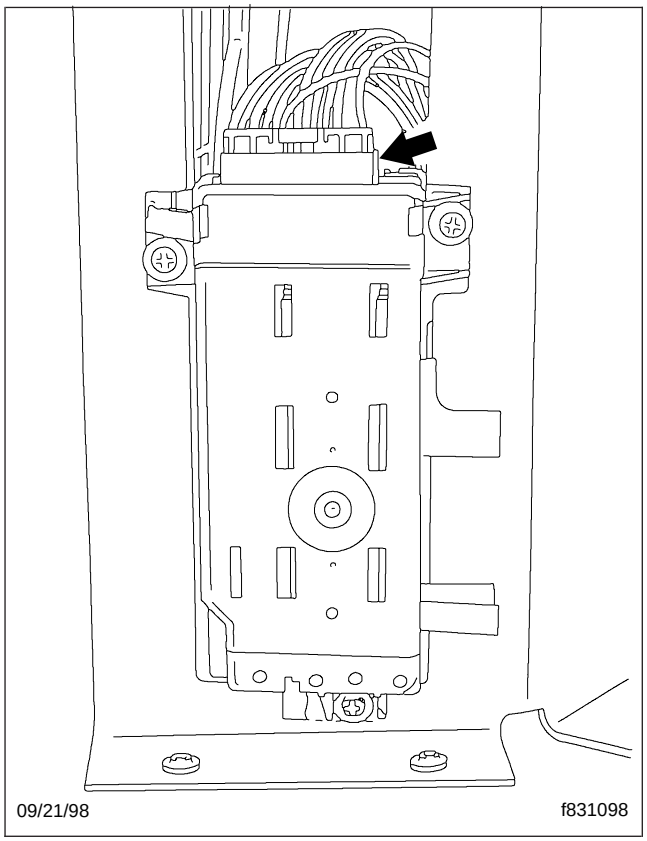
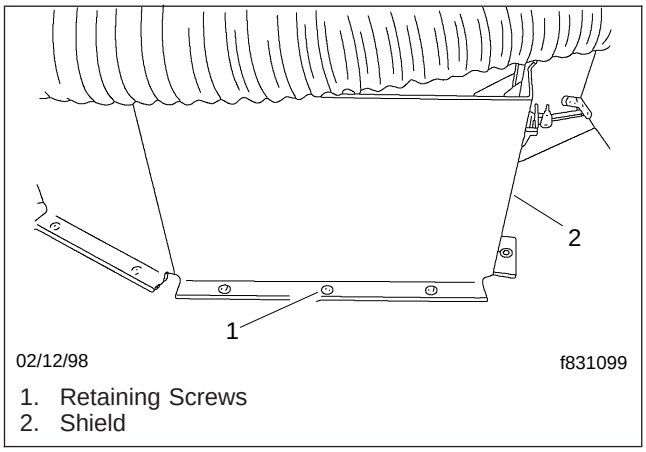


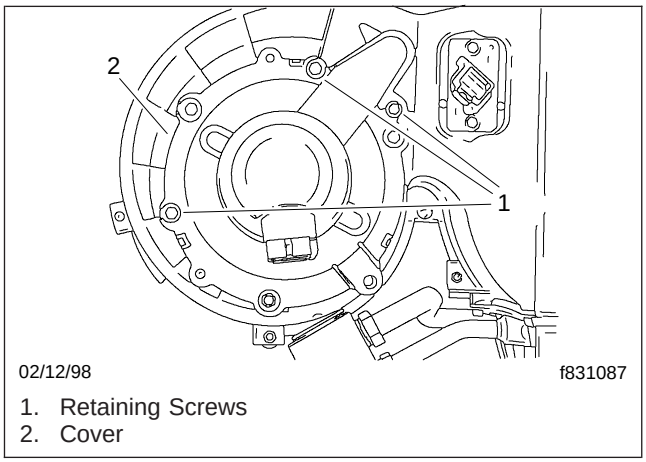
Fig. 1, Auxiliary Air Conditioning Control Module Electrical Connector

3. Remove the retaining screws, then remove the auxiliary air conditioning and heating assembly shield. See **Fig. 2**.
4. Disconnect the auxiliary heater blower motor electrical connector.
5. Remove the auxiliary heater blower motor cover. See **Fig. 3**.
   - 5.1 Remove the auxiliary heater blower motor cover retaining screws.
   - 5.2 Remove the auxiliary heater blower motor cover.



1. Retaining Screws
2. Shield

Fig. 2, Auxiliary Air Conditioning and Heating Assembly Shield

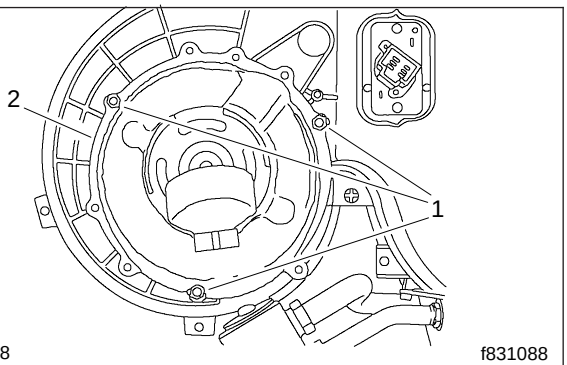


1. Retaining Screws
2. Cover

Fig. 3, Auxiliary Heater Blower Motor Cover

6. Remove the auxiliary heater blower motor retaining screws, then remove the auxiliary heater blower motor. See **Fig. 4**.
7. Install the auxiliary heater blower motor retaining screws, then install the auxiliary heater blower motor. See **Fig. 4**.
8. Install the auxiliary heater blower motor cover retaining screws, install the auxiliary heater blower motor cover. See **Fig. 3**.
9. Connect the auxiliary heater blower motor electrical connector.
10. Install the auxiliary air conditioning and heating assembly shield and install the retaining screws. See **Fig. 2**.

Auxiliary Heater Blower Motor Replacement



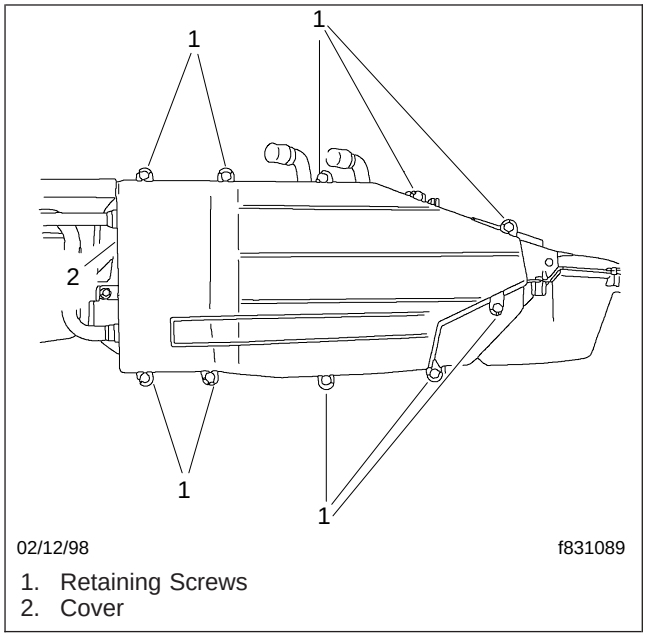
1. Retaining Screws
2. Blower Motor

Fig. 4, Auxiliary Heater Blower Motor

11. Connect the auxiliary air conditioning control module electrical connector. See **Fig. 1**.
12. Connect the battery ground cable.

Replacement

1. Remove the auxiliary air conditioning and heating assembly.
2. Remove the heater/evaporator core cover retaining screws, then remove the heater/evaporator core cover. See **Fig. 1**.



1. Retaining Screws
2. Cover

Fig. 1, Heater/Evaporator Core Cover

3. Remove the evaporator core. See **Fig. 2**.

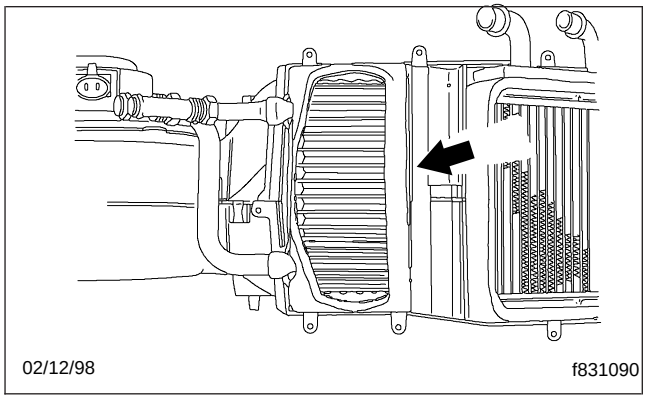


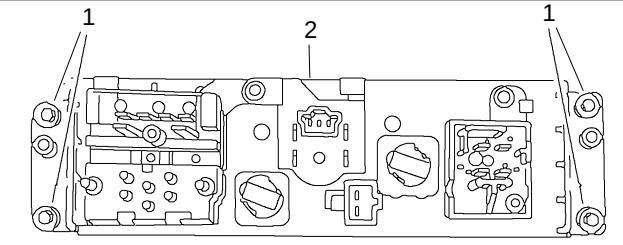
Fig. 2, Evaporator Core

4. Install the evaporator core. See **Fig. 2**.
5. Install the heater/evaporator core cover retaining screws, then install the heater/evaporator core cover. See **Fig. 1**.
6. Install the auxiliary air conditioning and heating assembly.

Auxiliary A/C-Heater Control Assembly Replacement

Replacement

1. Disconnect the battery ground cable.
2. Remove the auxiliary A/C-heater control back cover.
3. Disconnect the auxiliary A/C-heater control assembly electrical connectors.
4. Remove the auxiliary A/C-heater control assembly retaining screws, then remove the auxiliary A/C-heater control assembly. See **Fig. 1**.



1. Retaining Screws
2. Control

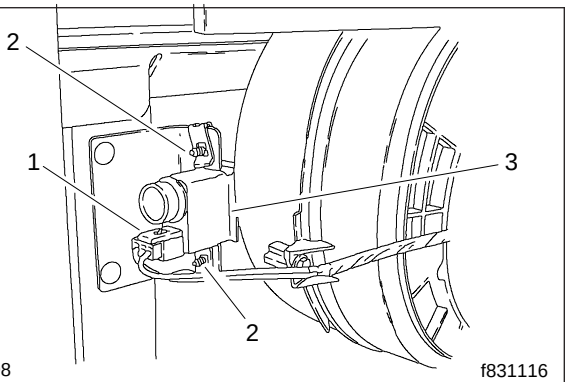
Fig. 1, Auxiliary A/C-Heater Control Assembly

5. Install the auxiliary A/C-heater control assembly retaining screws, then install the auxiliary A/C-heater control assembly. See **Fig. 1**.
6. Connect the auxiliary A/C-heater control assembly electrical connectors.
7. Install the auxiliary A/C-heater control back cover.
8. Connect the battery ground cable.

Automatic Temperature Sensor Control Assembly Replacement

Replacement

1. Remove the blower motor. For instructions, see **Subject 120**.
2. Remove the automatic temperature control sensor. See **Fig. 1.**



1. Electrical Connector
2. Screws
3. Sensor

Fig. 1, Automatic Temperature Control Sensor

2.1 Disconnect the electrical connector.

2.2 Remove the screws.

2.3 Remove the sensor.

3. Install the automatic temperature control sensor. See **Fig. 1**.

3.1 Install the sensor.

3.2 Install the screws.

3.3 Connect the electrical connector.

4. Install the blower motor.

Auxiliary Heater Hose Replacement

Replacement

1. Place a suitable container under the sleeper to collect the coolant.
2. Clamp off the auxiliary heater jumper hoses. See **Fig. 1**.

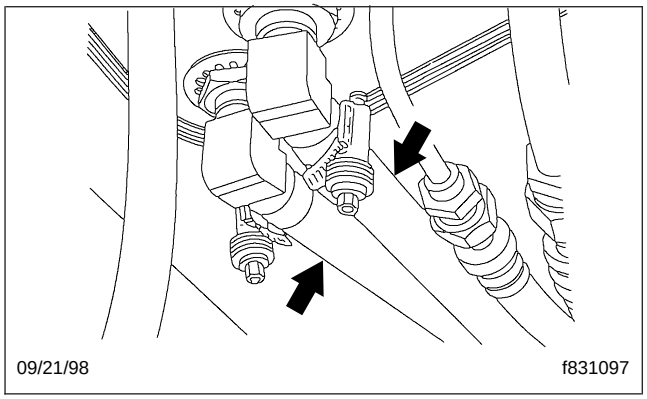


Fig. 1, Auxiliary Heater Jumper Hoses

⚠ WARNING

The engine must be off and fully cool and the cooling system fully depressurized before attempting to disconnect any heater hoses. Failure to comply with these warnings can result in serious injury and burns from hot liquid escaping from the engine cooling system.

3. Disconnect the auxiliary heater jumper hoses from the bulkhead elbows and allow the coolant to drain from the heater core and auxiliary heater hoses.
4. Disconnect the auxiliary air conditioning control module electrical connector. See **Fig. 2**.
5. Remove the retaining screws, then remove the auxiliary air conditioning and heating assembly shield. See **Fig. 3**.
6. Disconnect the auxiliary heater hoses from the heater core. See **Fig. 4**.
7. Disconnect the auxiliary heater hoses from the bulkhead elbows.
8. Remove the auxiliary heater hoses.
9. Connect the auxiliary heater hoses from the bulkhead elbows. See **Fig. 4**.

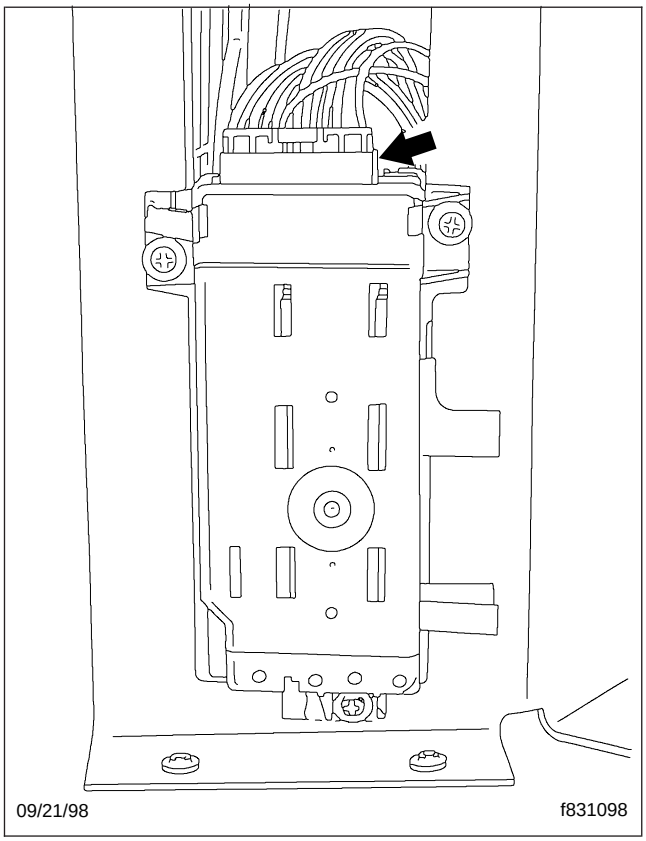
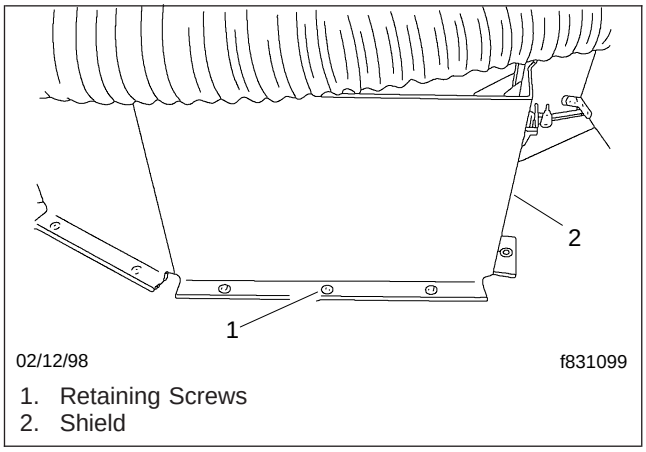


Fig. 2, Auxiliary Air Conditioning Control Module Electrical Connector

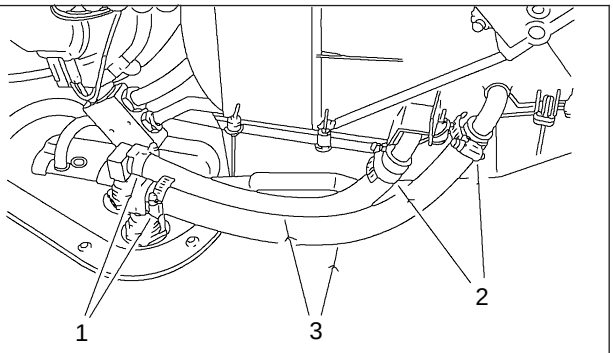


1. Retaining Screws
2. Shield

Fig. 3, Auxiliary Air Conditioning and Heating Assembly Shield

10. Connect the auxiliary heater hoses to the heater core.

Auxiliary Heater Hose Replacement



1. Heater Hoses (heater core side)
2. Heater Hoses (bulkhead side)
3. Heater Hoses

Fig. 4, Auxiliary Heater Hoses

11. Install the auxiliary air conditioning and heating assembly shield, then Install the retaining screws. See **Fig. 3**.
12. Connect the auxiliary air conditioning control module electrical connector. See **Fig. 2**.
13. Connect the auxiliary heater jumper hoses to the bulkhead elbows.
14. Remove clamps from the auxiliary heater jumper hoses. See **Fig. 1**.

⚠ CAUTION

Make certain that the auxiliary heater hose connections are installed correctly and that the auxiliary heater hoses cannot become pinched.

15. Refill and bleed the cooling system. For instructions, refer to **Group 20**.

Auxiliary Heater Jumper Hose Replacement

Rear Hose Replacement

1. Close the supply heater water control valve. See **Fig. 1**.

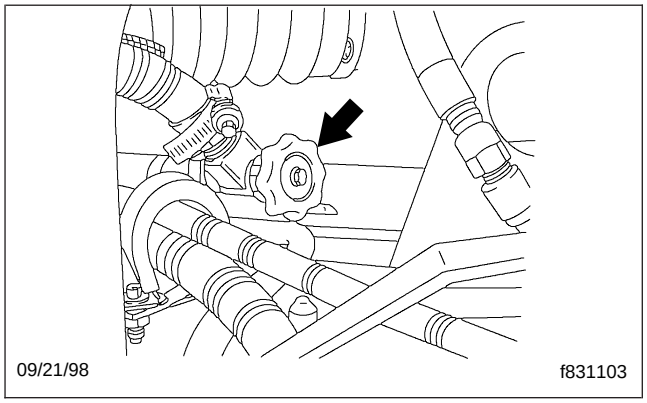


Fig. 1, Supply Heater Water Control Valve

2. Close the return water control valve. See **Fig. 2**.

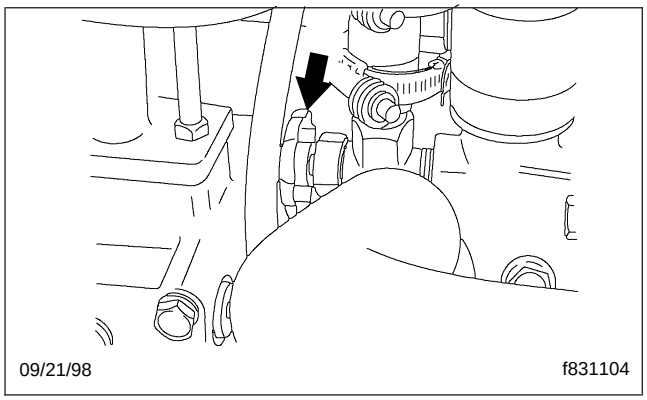


Fig. 2, Return Water Control Valve

3. Place a suitable container under the sleeper to collect the coolant.
4. Disconnect the auxiliary air conditioning control module electrical connector. See **Fig. 3**.
5. Remove the retaining screws, then remove the auxiliary air conditioning and heating assembly shield. See **Fig. 4**.
6. Clamp off the auxiliary heater hoses. See **Fig. 5**.

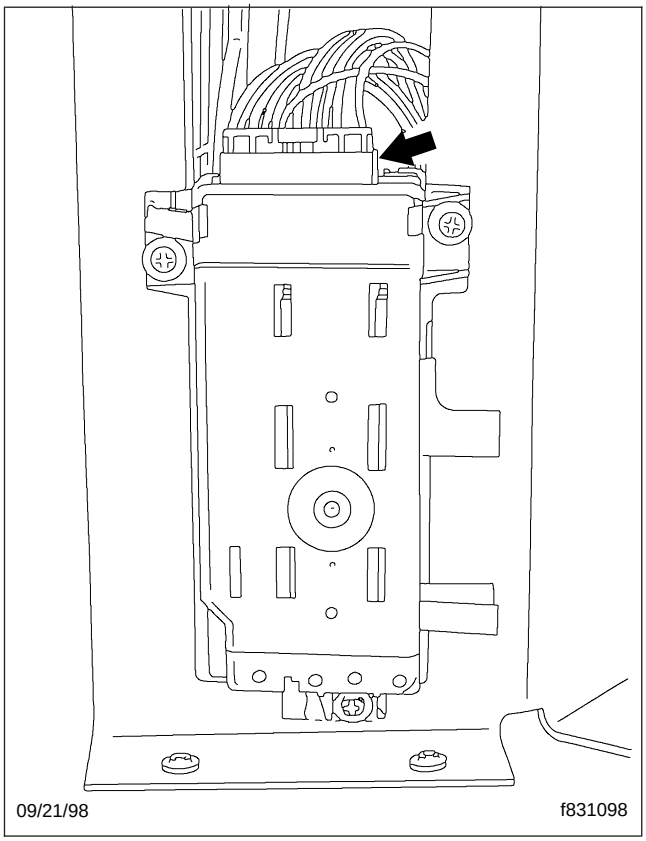
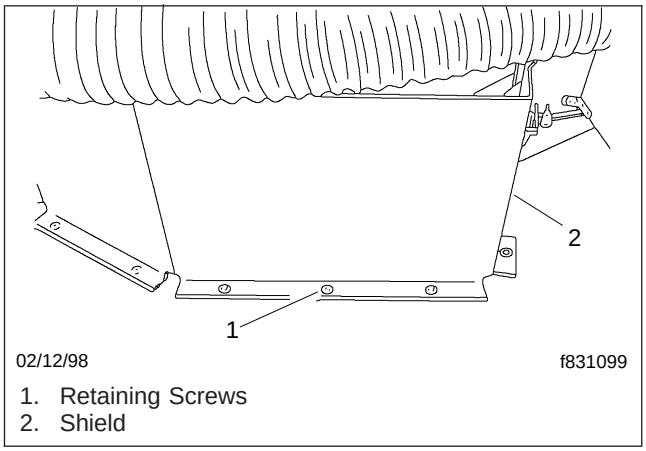


Fig. 3, Auxiliary Air Conditioning Control Module Electrical Connector



1. Retaining Screws
2. Shield

Fig. 4, Auxiliary Air Conditioning and Heating Assembly Shield

Auxiliary Heater Jumper Hose Replacement

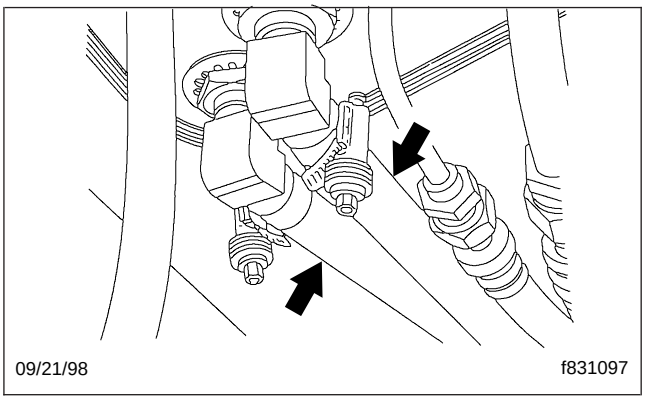


Fig. 5, Auxiliary Heater Hoses

WARNING

The engine must be off and fully cool, and the cooling system fully depressurized before attempting to disconnect any heater hoses. Failure to comply with these warnings can result in serious injury and burns from hot liquid escaping from the engine cooling system.

7. Disconnect the auxiliary heater jumper hoses from the bulkhead elbows.
8. Remove the auxiliary heater jumper hose retaining clamps. See **Fig. 6**.

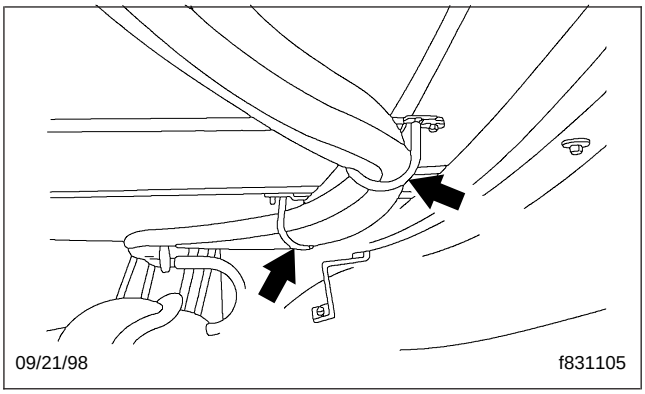


Fig. 6, Auxiliary Heater Jumper Hose Retaining Clamps

9. Remove the body side trim, under the passenger door.
10. Remove the auxiliary heater jumper hoses. See **Fig. 7**.

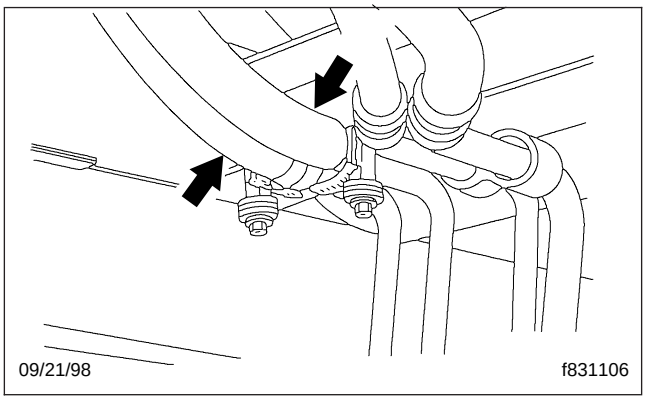


Fig. 7, Auxiliary Heater Jumper Hoses

11. Install the auxiliary heater jumper hoses. See **Fig. 7**.
12. Install the body side trim, under the passenger door.
13. Install the auxiliary heater jumper hose retaining clamps. See **Fig. 6**.
14. Connect the auxiliary heater jumper hoses to the bulkhead elbows.
15. Remove clamps from the auxiliary heater hoses. See **Fig. 5**.
16. Install the auxiliary air conditioning and heating assembly shield, then install the retaining screws. See **Fig. 4**.
17. Connect the auxiliary air conditioning control module electrical connector. See **Fig. 3**.
18. Open the return water control valve. See **Fig. 2**.
19. Open the supply heater water control valve. See **Fig. 1**.

CAUTION

Make certain that the auxiliary heater jumper hose connections are installed correctly and that the auxiliary heater jumper hoses cannot come in contact with any part of the exhaust system, or cannot become pinched.

20. Refill and bleed the cooling system. For instructions, refer to **Group 20**.

Auxiliary Heater Jumper Hose Replacement

Front Hose Replacement

NOTE: The following procedure is a typical procedure and may vary slightly depending on the engine and transmission application.

1. Close the heater water control supply valve. See **Fig. 1**.
2. Close the heater water control return valve. See **Fig. 2**.
3. Position a drain pan below the vehicle to catch any coolant which may escape.
4. Clamp off the auxiliary rear heater coolant jumper line. See **Fig. 8**.

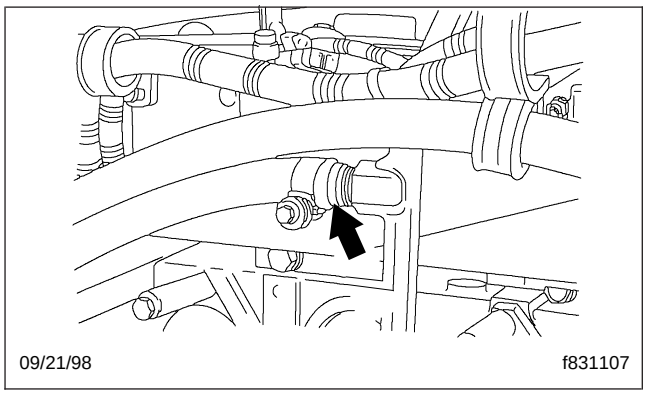


Fig. 8, Auxiliary Rear Heater Coolant Jumper Line

⚠ WARNING

The engine must be off and fully cool, and the cooling system fully depressurized before attempting to disconnect any heater hoses. Failure to comply with these warnings can result in serious injury and burns from hot liquid escaping from the engine cooling system.

5. Disconnect the heater supply hose and retainers from the heater water control supply valve line.
6. Disconnect the heater return hose and retainers from the heater water control return valve line. See **Fig. 9**.
7. Remove the front auxiliary heater jumper hoses. See **Fig. 10**.
8. Install the front auxiliary heater jumper hoses. See **Fig. 10**.

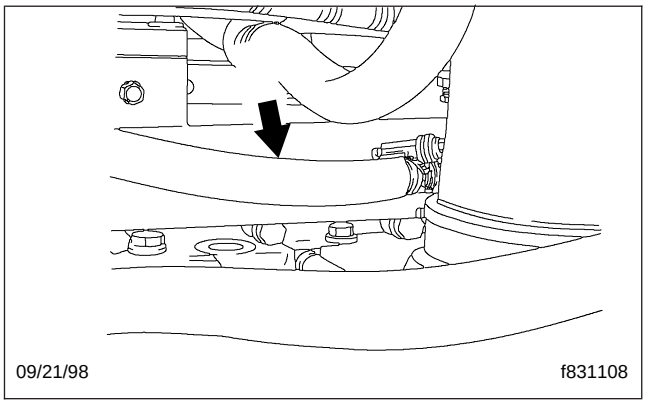


Fig. 9, Heater Return Hose and Retainers

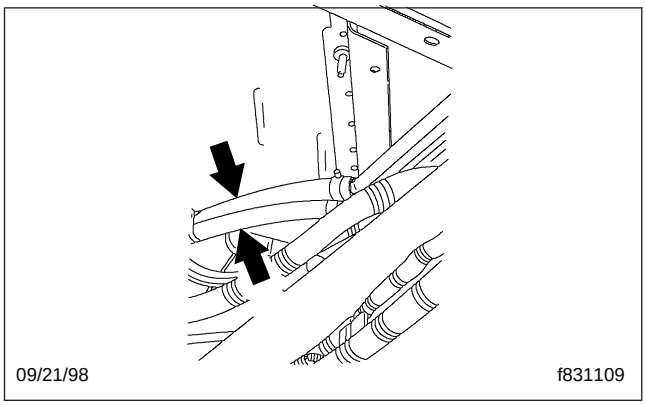


Fig. 10, Front Auxiliary Heater Jumper Hoses

9. Connect the heater return hose and retainers from the heater water control return valve line. See **Fig. 9**.
10. Connect the heater supply hose and retainers to the heater water control supply valve line.
11. Remove clamp from the auxiliary rear heater coolant jumper line. See **Fig. 8**.
12. Open the heater water control return valve. See **Fig. 2**.
13. Open the heater water control supply valve. See **Fig. 1**.

⚠ CAUTION

Make certain that the auxiliary heater jumper hose connections are installed correctly and that the auxiliary heater jumper hoses cannot come in contact with any part of the exhaust system, or cannot become pinched.

Auxiliary Heater Jumper Hose Replacement

14. Refill and bleed the cooling system. For instructions, refer to **Group 20**.

Replacement

1. Disconnect the flexible duct. See **Fig. 1**.

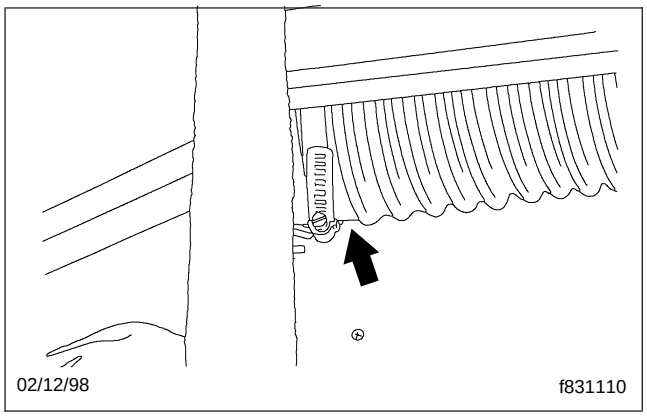
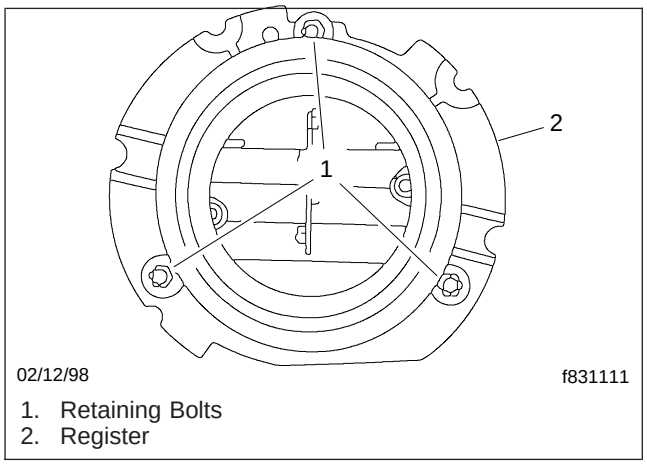


Fig. 1, Flexible Duct

2. Remove the lower register retaining bolts, then remove the lower register. See **Fig. 2**.



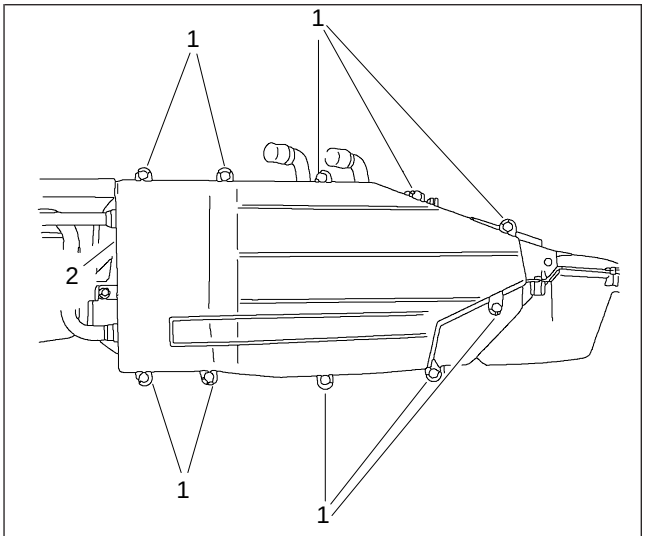
1. Retaining Bolts
2. Register

Fig. 2, Lower Register

3. Install the lower register, then install the lower register retaining bolts. See **Fig. 2**.
4. Connect the flexible duct. See **Fig. 1**.

Replacement

1. Remove the auxiliary air conditioning and heating assembly.
2. Remove the heater/evaporator core cover retaining screws, then remove the cover. See **Fig. 1**.



1. Retaining Screws
2. Cover

Fig. 1, Heater/Evaporator Core Cover

3. Remove the heater core. See **Fig. 2**.

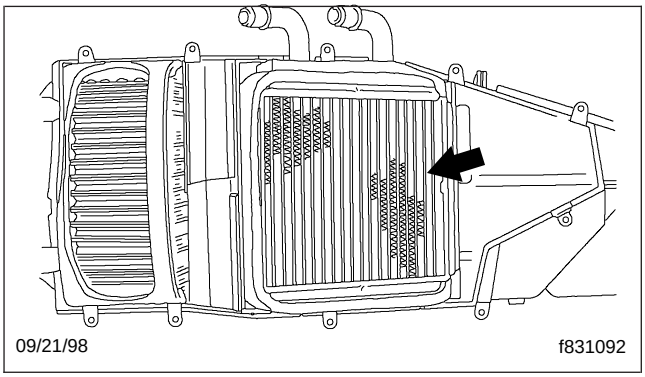


Fig. 2, Heater Core

4. Install the heater core. See **Fig. 2**.
5. Install the heater/evaporator core cover, then install the retaining screws. See **Fig. 1**.
6. Install the auxiliary air conditioning and heating assembly.

Auxiliary Air Conditioning Jumper Line Replacement

Replacement

NOTE: The following procedure is typical and may vary with engine and transmission application.

1. Recover the air conditioning refrigerant from the system. For instructions, refer to **Section 83.00**.
2. Disconnect the battery ground cable.
3. Disconnect the auxiliary air conditioning jumper lines from the bulkhead elbows. See **Fig. 1**.

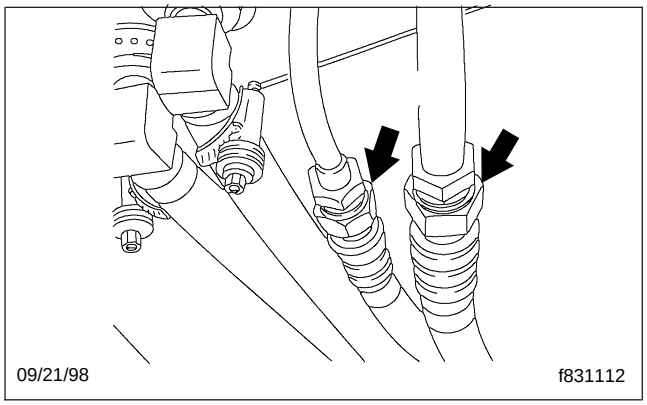


Fig. 1, Auxiliary Air Conditioning Jumper Lines

4. Disconnect the auxiliary air conditioning jumper suction line and the hose retainer from the evaporator-to-compressor line. See **Fig. 2**.
5. Disconnect the auxiliary air conditioning jumper liquid line and all the retainers from the condenser-to-evaporator line. See **Fig. 3**.
6. Remove the auxiliary air conditioning jumper lines.
7. Install the auxiliary air conditioning jumper lines.
8. Connect the auxiliary air conditioning jumper liquid line and all the retainers to the condenser-to-evaporator line. See **Fig. 3**.
9. Connect the auxiliary air conditioning jumper suction line and the hose retainer to the evaporator-to-compressor line. See **Fig. 2**.
10. Connect the auxiliary air conditioning jumper lines to the bulkhead elbows. See **Fig. 1**.
11. Connect the battery ground cable.

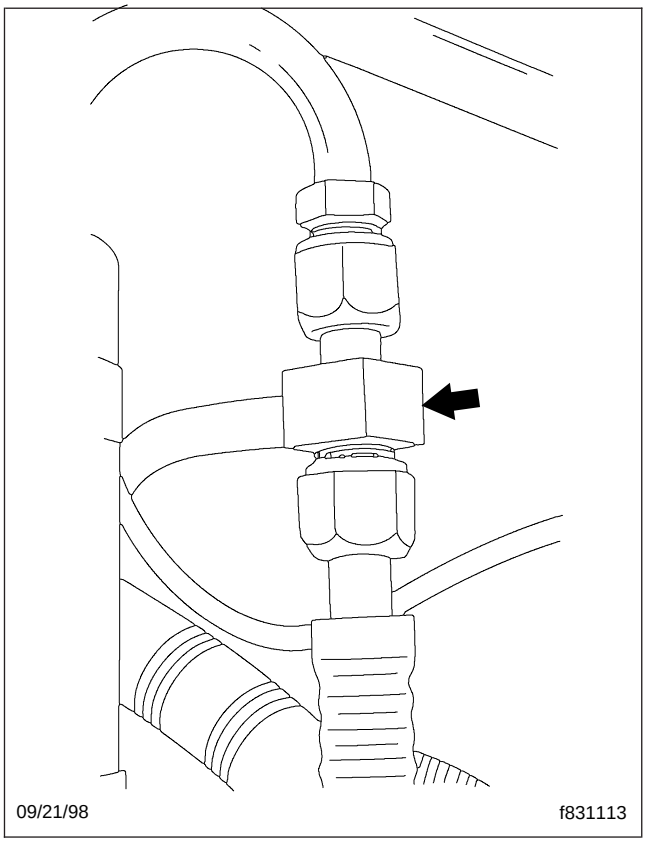


Fig. 2, Auxiliary Air Conditioning Jumper Suction Line

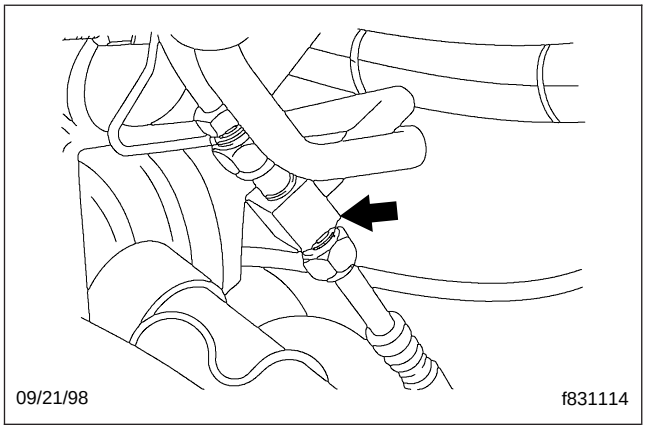


Fig. 3, Auxiliary Air Conditioning Jumper Liquid Line

12. Evacuate, charge and leak-test the air conditioning system. For instructions, refer to **Section 83.00**.

Evaporator Core Expansion Valve Replacement

Replacement

1. Recover the air conditioning refrigerant from the system. For instructions, refer to **Section 83.00**.
2. Disconnect the battery ground cable.
3. Disconnect the auxiliary air conditioning control module electrical connector. See **Fig. 1**.

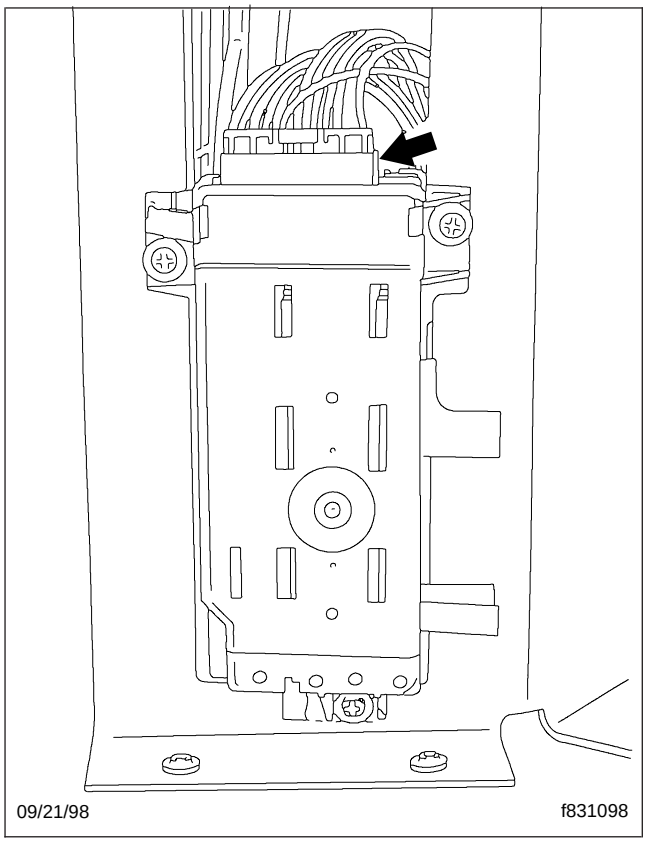
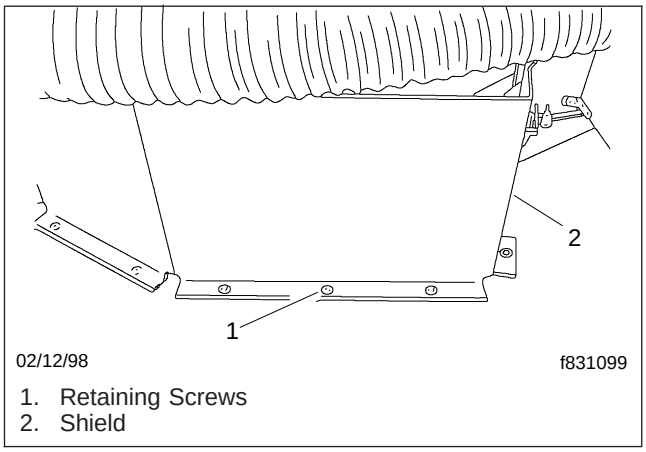


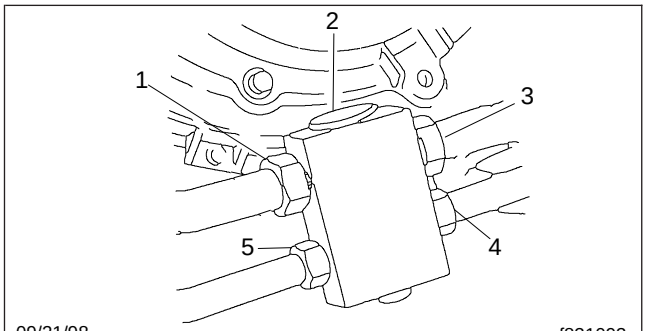
Fig. 1, Auxiliary Air Conditioning Control Module Electrical Connector

4. Remove the auxiliary air conditioning and heating assembly shield. See **Fig. 2**.
   - 4.1 Remove the retaining screws.
   - 4.2 Remove the auxiliary air conditioning and heating assembly shield.
5. Remove the floor pan opening plate.
6. Remove the thermal expansion valve. See **Fig. 3**.



1. Retaining Screws
2. Shield

Fig. 2, Auxiliary Air Conditioning and Heating Assembly Shield



1. Evaporator Inlet
2. Valve
3. Evaporator Outlet
4. Evaporator Core Inlet
5. Evaporator Core Outlet

Fig. 3, Thermal Expansion Valve

   - 6.1 Disconnect the floor pan opening plate evaporator inlet and outlet tube assemblies from the thermal expansion valve.
   - 6.2 Disconnect the evaporator core from the thermal expansion valve.
   - 6.3 Remove the thermal expansion valve.
7. Install the thermal expansion valve. See **Fig. 3**.
   - 7.1 Install the thermal expansion valve.
   - 7.2 Connect the evaporator core to the thermal expansion valve.

Evaporator Core Expansion Valve Replacement

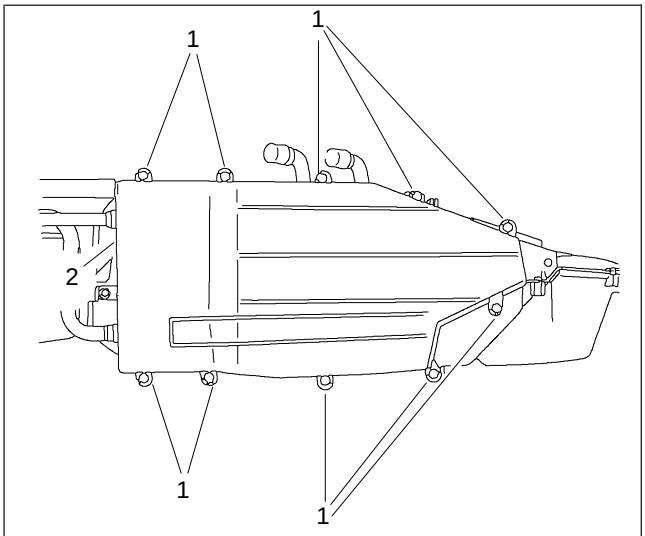
7.3 Connect the floor pan opening plate evaporator inlet and outlet tube assemblies to the thermal expansion valve.

8. Install the floor pan opening plate.
9. Install the auxiliary air conditioning and heating assembly shield. See **Fig. 2**.
   - 9.1 Install the auxiliary air conditioning and heating assembly shield.
   - 9.2 Install the retaining screws.
10. Connect the auxiliary air conditioning control module electrical connector. See **Fig. 1**.
11. Connect the battery ground cable.
12. Evacuate, charge and leak-test the air conditioning system. For instructions, refer to **Section 83.00**.

Auxiliary Air Conditioning Temperature Blend Door Removal and Installation

Removal

1. Remove the auxiliary air conditioning and heating assembly.
2. Remove the auxiliary air conditioning temperature blend door actuator.
3. Remove the heater/evaporator core cover retaining screws, then remove the cover. See **Fig. 1**.



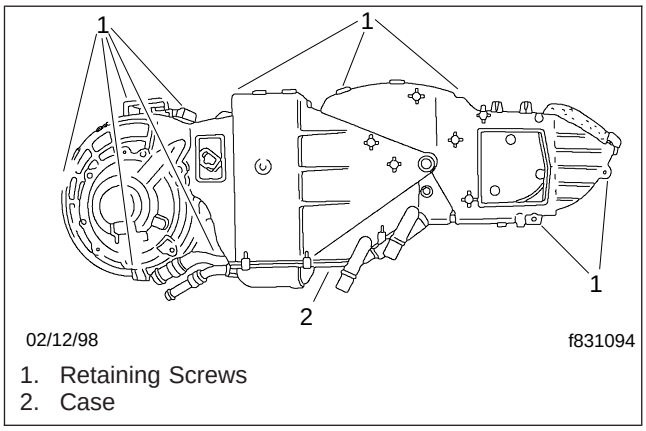
1. Retaining Screws
2. Cover

Fig. 1, Heater/Evaporator Core Cover

4. Remove the retaining screws, then separate the auxiliary air conditioning and heating assembly case halves. See **Fig. 2**.
5. Remove the auxiliary air conditioning temperature blend door. See **Fig. 3**.

Installation

1. Install the auxiliary air conditioning temperature blend door. See **Fig. 3**.
2. Assemble the auxiliary air conditioning and heating assembly case halves, then install the retaining screws. See **Fig. 2**.
3. Install the heater/evaporator core cover, then install the retaining screws. See **Fig. 1**.



1. Retaining Screws
2. Case

Fig. 2, Auxiliary Air Conditioning and Heating Assembly Case

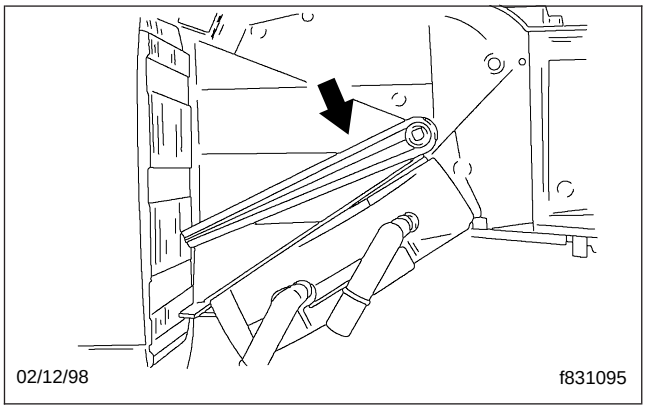


Fig. 3, Auxiliary Air Conditioning Temperature Blend Door

4. Install the auxiliary air conditioning temperature blend door actuator.
5. Install the auxiliary air conditioning and heating assembly.

Auxiliary Air Conditioning Temperature Blend Door Actuator Removal and Installation

Removal

1. Disconnect the battery ground cable.
2. Raise the lower bunk.
3. Disconnect the auxiliary air conditioning control module electrical connector. See **Fig. 1**.

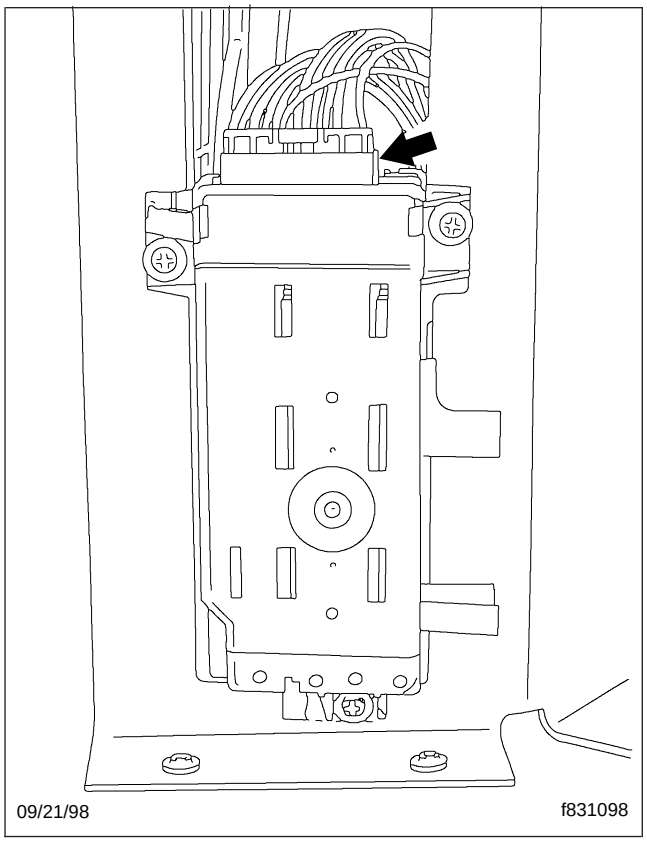


Fig. 1, Auxiliary Air Conditioning Control Module Electrical Connector

4. Remove the retaining screws, then remove the auxiliary air conditioning and heating assembly shield. See **Fig. 2**.
5. Disconnect the right-hand side air distribution duct.
6. Disconnect the auxiliary air conditioning temperature blend door actuator electrical connector.
7. Remove the retaining screws, then remove the auxiliary air conditioning temperature blend door actuator. See **Fig. 3**.

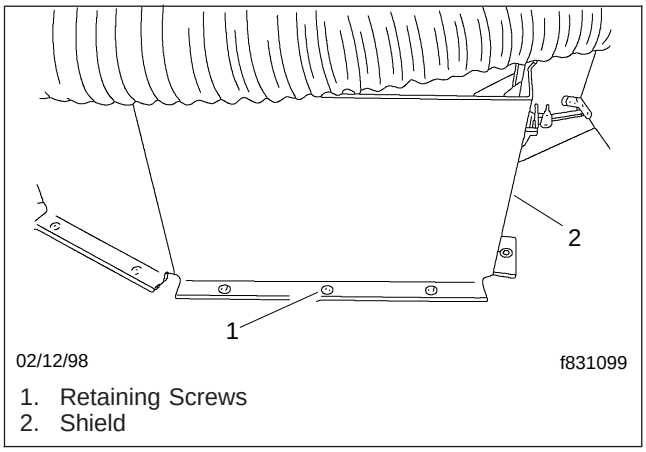


Fig. 2, Auxiliary Air Conditioning and Heating Assembly Shield

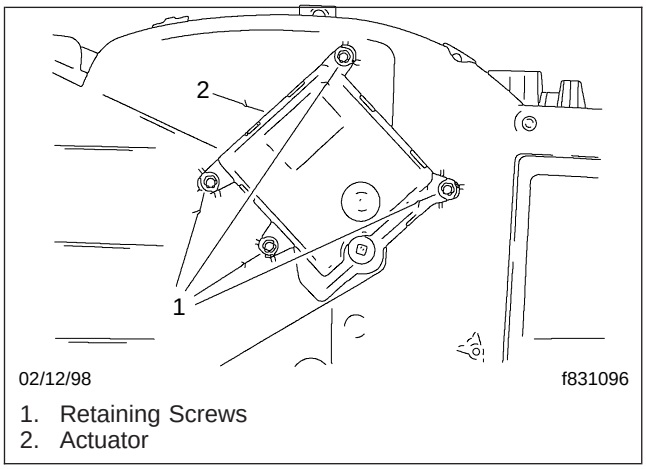


Fig. 3, Temperature Blend Door Actuator

Installation

NOTE: Make sure that the auxiliary air conditioning temperature blend door actuator is properly engaged with the auxiliary air conditioning temperature blend door.

1. Install the auxiliary air conditioning temperature blend door actuator, then install the retaining screws. See **Fig. 3**.
2. Connect the auxiliary air conditioning temperature blend door actuator electrical connector.
3. Connect the right-hand side air distribution duct.

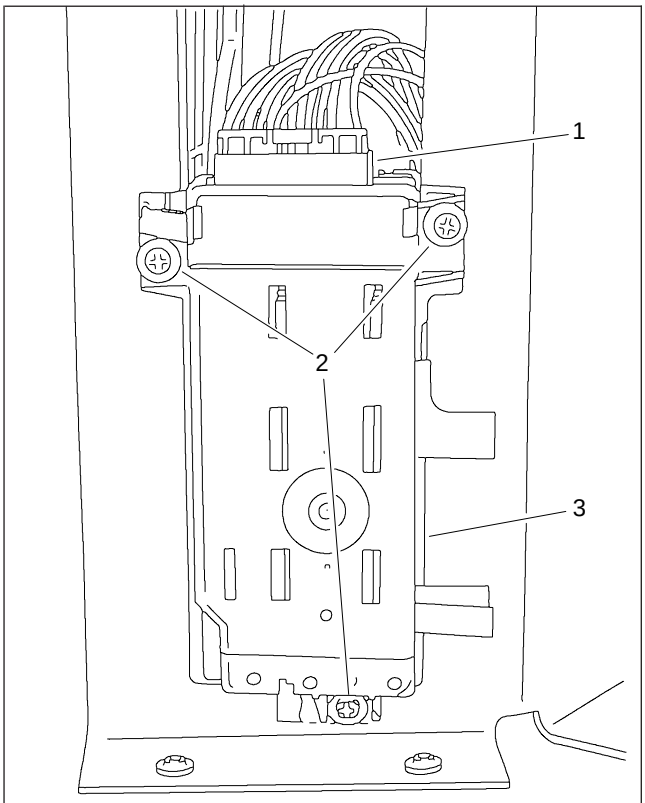
Auxiliary Air Conditioning Temperature Blend Door Actuator Removal and Installation

4. Install the auxiliary air conditioning and heating assembly shield, then install the retaining screws. See **Fig. 2**.
5. Connect the auxiliary air conditioning control module electrical connector. See **Fig. 1**.
6. Lower the lower bunk.
7. Connect the battery ground cable.

Auxiliary Air Conditioning Control Module Replacement

Replacement

1. Disconnect the auxiliary air conditioning control module electrical connector.
2. Remove the auxiliary air conditioning control module retaining bolts.
3. Remove the auxiliary air conditioning control module. See **Fig. 1**.



1. Electrical Connector
2. Retaining Screws
3. Module

Fig. 1, Auxiliary Air Conditioning Control Module

4. Install the auxiliary air conditioning control module. See **Fig. 1**.
5. Install the auxiliary air conditioning control module retaining bolts.
6. Connect the auxiliary air conditioning control module electrical connector.

Air Conditioning

Inspection and Verification

⚠ WARNING

Never attempt to remove the radiator cap while the vehicle is warm and the cooling system is under pressure. Severe burns and injury can occur.

Carbon monoxide is a colorless, odorless and dangerous gas. If it is necessary to operate the engine with the vehicle in a closed area such as a garage, always use an exhaust collector to vent the exhaust gases outside of the closed area.

Do not stand in line with, or near, the fan blade when the engine is running.

The inlet and outlet water hose will become too hot to handle if the system is working properly. Serious burns and injury can occur if caution is not used.

NOTE: Before doing any testing on the auxiliary air conditioning system, make sure that the front air conditioning and heating system and the engine cooling system are functioning properly. Refer to **Group 20** for diagnosis and testing of the engine cooling system.

Diagnosis and testing of the auxiliary air conditioning and heating evaporator core and heater core is the same as the front air conditioning and heating evaporator core and heater core.

1. Verify the owner's original concern by operating the system to duplicate the concern.
2. Visually inspect the system for obvious signs of mechanical or electrical damage. See **Table 1**.

Visual Inspection Chart	
Mechanical	**Electrical**
Damaged evaporator core	Open fuse: sleeper fuse junction panel Fuse 11 (30 A) or Fuse 12 (4 A)
Damaged heater core	Damaged blower motor relay
Kinked, bent or damaged A/C lines	Damaged circuitry
Kinked, bent or damaged heater hoses	Damaged connector(s)
Damaged blower motor housing	Loose or corroded connectors
Damaged ductwork	Damaged control panel components
Damaged air conditioning and heating assembly	
Coolant leak	
Refrigerant leak	

Table 1, Visual Inspection Chart

3. If the concern is not visually evident, determine the problem and proceed to the troubleshooting tables.

Troubleshooting

Problem—Insufficient, Erratic, or No Heat, Auxiliary SilverStar System

Problem—Insufficient, Erratic, or No Heat, Auxiliary SilverStar System	
Possible Cause	**Remedy**
Low engine coolant level	Check for proper engine coolant level. Turn the ignition switch to the "Off" position. Check the engine coolant level. If the engine coolant is not at the proper level, check the coolant system including the radiator cap for leaks. Turn the ignition switch to the "Off" position. Fill the engine coolant system to the specified level. Refer to **Group 20**. NOTE: It is not necessary to check each of the engine coolant system components separately at this time. Perform a pressure check on the engine coolant system. Refer to **Group 20**. If the engine cooling system, including the radiator cap, does not hold pressure, repair the engine cooling system. Refer to **Group 20**. Test the system for normal operation. If the engine cooling system, including the radiator cap, holds pressure, check for hot water to the heater core inlet hose. Start the engine and bring it to the normal operating temperature. Lightly touch the inlet heater water hose. If the inlet heater water hose is not hot, go to **Group 20**. If the inlet heater water hose is hot, check the heater core outlet hose for hot water. Run the engine until it reaches normal operating temperature. Lightly touch the outlet heater water hose. If the outlet heater water hose is cool or cold, repair or replace the heater core. Test the system for normal operation. If the outlet heater water hose is not cool or cold, refer to the "Problem—Auxiliary Controls are Operational With the Function Selector Off" chart in this subject.
Engine overheating	
Plugged or partially plugged heater core	
Damaged/inoperative auxiliary A/C temperature blend door actuator or A/C control module	

Problem—Insufficient A/C Cooling, Auxiliary SilverStar System

Problem—Insufficient A/C Cooling, Auxiliary SilverStar System	
Possible Cause	**Remedy**
Incorrect front A/C-heater function selector switch setting	Check the front climate control system. Check the front climate control panel A/C-heater function selector switch setting. If the front climate control panel A/C-heater function selector switch is not set to MAX A/C or NORM A/C, set the front climate control panel A/C-heater function selector switch to MAX A/C or NORM A/C. Test the system for normal operation. If the front climate control panel A/C-heater function selector switch is set to MAX A/C or NORM A/C, check the refrigerant system. Perform the refrigerant system tests. If the refrigerant system does not test OK, repair the refrigerant system as necessary. Test the system for normal operation. If the refrigerant system tests OK, refer to the "Problem—Temperature Control Does Not Operate Using the Rear Auxiliary Climate Control" chart in this subject.
Low refrigerant level	
Damaged/inoperative thermal expansion valve	
Damaged/inoperative auxiliary A/C temperature blend door actuator or A/C control module	

Problem—Blower Motor Does Not Operate Properly, Auxiliary SilverStar System

Problem—Blower Motor Does Not Operate Properly, Auxiliary SilverStar System	
Possible Cause	**Remedy**
Damaged/inoperative auxiliary blower motor resistor	Check the auxiliary blower motor resistor. Perform the "SilverStar Auxiliary Blower Motor Resistor" test. Refer to "Component Tests" in this subject. If the auxiliary blower motor resistor is not OK, replace the auxiliary blower motor resistor. Test the system for normal operation. If the auxiliary blower motor resistor is OK, check the auxiliary blower motor switch. Perform the "SilverStar Auxiliary Blower Motor Switch" test. Refer to "Component Tests" in this subject. If the auxiliary blower motor switch is not OK, replace the auxiliary blower motor switch. Test the system for normal operation. If the auxiliary blower motor switch is OK, check the auxiliary blower motor operation.
Damaged circuitry	Turn the ignition switch to the "On" position. Rotate the auxiliary blower motor switch through all speed positions. If the auxiliary blower motor operates at all speeds, wiggle the wires and check for intermittent operation. Repair as necessary. Test the system for normal operation. If the auxiliary blower motor does not operate at LO, MED-LO or MED-HI speed, refer to the "Problem—No Operation in Lower Speeds, Auxiliary SilverStar System" chart in this subject. If the auxiliary blower motor does not operate at HI speed, refer to the "Problem—No Operation in High Blower Setting, Auxiliary SilverStar System" chart in this subject.

Problem—Blower Motor Operates Continuously in High Speed, Auxiliary SilverStar System

Problem—Blower Motor Operates Continuously in High Speed, Auxiliary SilverStar System (See Fig. 1)	
Possible Cause	**Remedy**
Damaged/inoperative auxiliary blower motor switch	Check the auxiliary blower motor switch. Turn the ignition switch to the "Off" position. Disconnect the auxiliary blower motor switch C758 harness connector. Turn the ignition switch to the "On" position. Check the blower motor operation. If the blower motor still does not operate continuously in high speed, replace the blower motor switch. Test the system for normal operation. If the blower motor still operates continuously in high speed, check Circuit 515 (O) for short to ground. Turn the ignition switch to the "Off" position. Disconnect the auxiliary blower motor C743 harness connector. Disconnect the auxiliary A/C control module C746 harness connector. Disconnect the auxiliary blower motor resistor C742 harness connector. Measure the resistance of Circuit 515 (O) between the auxiliary blower motor connector C743 and chassis ground. If the resistance is more than 5 ohms, replace the auxiliary blower motor. Test the system for normal operation. If the resistance is less than 5 ohms, repair the short to ground in Circuit 515 (O). Test the system for normal operation.
Damaged circuitry	
Damaged/inoperative auxiliary blower motor	

Troubleshooting

Problem—No Operation in High Blower Setting, Auxiliary SilverStar System

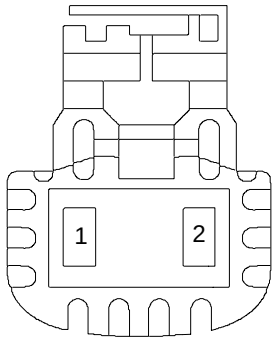


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Fig. 1, Auxiliary Blower Motor Connector Pin Identification

Problem—No Operation in High Blower Setting, Auxiliary SilverStar System (See Fig. 1, Fig. 2 and Fig. 3)	
Possible Cause	**Remedy**
Damaged/inoperative auxiliary blower motor switch	Check the auxiliary blower motor switch. Perform the "SilverStar Auxiliary Blower Motor Switch" test. Refer to "Component Tests" in this subject. If the auxiliary blower motor switch is not OK, replace the auxiliary blower motor switch. Test the system for normal operation.
Damaged circuitry	Check Circuit 277 (GN) for an open. Turn the ignition switch to the "Off" position. Disconnect the auxiliary blower motor switch C758 harness connector. Disconnect the auxiliary A/C-heater function selector switch C760 harness connector. Disconnect the auxiliary blower motor resistor C742 harness connector. Measure the resistance of Circuit 277 (GN) between the auxiliary blower motor switch connector C758 and the auxiliary A/C-heater function selector switch connector C760. If the resistance is more than 5 ohms, repair the open in Circuit 277 (GN). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 515 (O) for an open. Disconnect the auxiliary blower motor C743 harness connector. Disconnect the auxiliary A/C control module C746 harness connector. Measure the resistance of Circuit 515 (O) between the auxiliary blower motor switch connector C758 and the auxiliary blower motor connector C743. If the resistance is less than 5 ohms, wiggle the wires and check for intermittent operation. Repair as necessary. Test the system for normal operation. If the resistance is more than 5 ohms, repair the open in Circuit 515 (O). Test the system for normal operation.

Problem—No Operation in Lower Speeds, Auxiliary SilverStar System

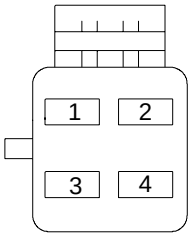

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Fig. 2, Auxiliary Blower Motor Switch Connector Pin Identification

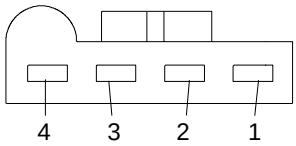

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Fig. 3, Auxiliary Function Selector Switch Connector Pin Identification

Problem—No Operation in Lower Speeds, Auxiliary SilverStar System (See Fig. 2 and Fig. 4)	
Possible Cause	**Remedy**
Damaged/inoperative auxiliary blower motor resistor	Check the auxiliary blower motor resistor. Perform the "SilverStar Auxiliary Blower Motor Resistor" test. Refer to "Component Tests" in this subject. If the auxiliary blower motor resistor is not OK, replace the auxiliary blower motor resistor. Test the system for normal operation.
Damaged/inoperative auxiliary blower motor switch	Perform the "SilverStar Auxiliary Blower Motor Switch" test. Refer to "Component Tests" in this subject. If the auxiliary blower motor switch is not OK, replace the auxiliary blower motor switch. Test the system for normal operation. If the auxiliary blower motor switch is OK, check the auxiliary blower motor operation. Turn the ignition switch to the "On" position. Rotate the auxiliary blower motor switch through all speed positions. If the auxiliary blower motor operates at all speeds, wiggle the wires and check for intermittent operation. Repair as necessary. Test the system for normal operation.

Troubleshooting

Problem—No Operation in Lower Speeds, Auxiliary SilverStar System (See Fig. 2 and Fig. 4)	
Possible Cause	**Remedy**
Damaged circuitry	If the auxiliary blower motor does not operate at LO speed, MED-LO speed, or at MED-HI speed, check Circuit 277 (GN) for an open. Turn the ignition switch to the "Off" position. Disconnect the auxiliary A/C-heater function selector switch C760 harness connector. Disconnect the auxiliary blower motor switch C758 harness connector. Disconnect the auxiliary blower motor resistor C742 harness connector. Measure the resistance of Circuit 277 (GN) between the auxiliary blower motor switch connector C758 and the auxiliary blower motor resistor connector C742. If the resistance is less than 5 ohms, wiggle the wires and check for intermittent operation. Repair as necessary. Test the system for normal operation. If the resistance is more than 5 ohms, repair the open in Circuit 277 (GN). Test the system for normal operation. Check Circuit 260 (R/BK) for an open. Turn the ignition switch to the "Off" position. Disconnect the auxiliary blower motor switch C758 harness connector. Disconnect the auxiliary blower motor resistor C742 harness connector. Measure the resistance of Circuit 260 (R/BK) between the auxiliary blower motor switch connector C758 and the auxiliary blower motor resistor connector C742. If the resistance is less than 5 ohms, wiggle the wires and check for intermittent operation. Repair as necessary. Test the system for normal operation. If the resistance is more than 5 ohms, repair the open in Circuit 260 (R/BK). Test the system for normal operation. Check Circuit 269 (BL/R) for an open. Turn the ignition switch to the "Off" position. Disconnect the auxiliary blower motor switch C758 harness connector. Disconnect the auxiliary blower motor resistor C742 harness connector. Measure the resistance of Circuit 269 (BL/R) between the auxiliary blower motor switch connector C758 and the auxiliary blower motor resistor connector C742. If the resistance is less than 5 ohms, wiggle the wires and check for intermittent operation. Repair as necessary. Test the system for normal operation. If the resistance is more than 5 ohms, repair the open in Circuit 269 (BL/R). Test the system for normal operation.

Problem—Auxiliary Blower Motor Does Not Operate

Problem—Auxiliary Blower Motor Does Not Operate (See Fig. 1, Fig. 2, Fig. 3 and Fig. 5)	
Possible Cause	**Remedy**
Open Fuse 11 (30 A) or Fuse 12 (4 A) Damaged/inoperative blower motor relay Damaged/inoperative auxiliary blower motor switch Damaged/inoperative auxiliary blower motor	Check the auxiliary blower motor. Perform the "Blower Motor" component test. Refer to "Component Tests" in **Section 83.00, Subject 300**. If the blower motor is not OK, replace the auxiliary blower motor. Test the system for normal operation. If the blower motor is OK, check Circuit 371 (R) for power. Turn the ignition switch to the "Off" position. Disconnect the auxiliary blower motor C743. Turn the ignition switch to the "On" position. Measure the voltage of Circuit 371 (R) between the auxiliary blower motor connector C743 and chassis ground. If the voltage is less than 10 volts, check the blower motor relay. Perform the "Blower Motor Relay" test. Refer to "Component Tests" in this subject. If the blower motor relay is not OK, replace the blower motor relay. Test the system for normal operation. If the blower motor relay is OK, check the blower motor relay Circuit 57 (BK) for an open. Turn the ignition switch to the "Off" position. Remove the sleeper fuse junction panel blower motor relay. Measure the resistance of Circuit 57 (BK) between the sleeper fuse junction relay panel blower motor relay connector C768, Pin 85 and chassis ground. If the resistance is more than 5 ohms, repair the open in Circuit 57 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 150 (R) for power. Remove the sleeper fuse junction panel Fuse 11 (30 A). Turn the ignition switch to the "On" position. Measure the voltage of Circuit 150 (R) between the sleeper fuse junction panel input side of Fuse 11 (30 A) and chassis ground. If the voltage is less than 10 volts, repair the open in Circuit 150 (R). Test the system for normal operation. If the voltage is more than 10 volts, check Circuit 16 (R/GN) for power at relay connector. Reinstall the sleeper fuse junction panel Fuse 11 (30 A). Measure the voltage of Circuit 16 (R/GN) between the sleeper fuse junction relay panel blower motor relay connector C768, Pin 86 and chassis ground. If the voltage is less than 10 volts, repair the open in Circuit 16 (R/GN). Test the system for normal operation. If the voltage is more than 10 volts, check Circuit 371 (R) for an open. Turn the ignition switch to the "Off" position. Disconnect the auxiliary blower motor C743. Measure the resistance of Circuit 371 (R) between the sleeper fuse junction relay panel blower motor relay connector C768, Pin 87 and the auxiliary blower motor connector C743. If the resistance is more than 5 ohms, repair the open in Circuit 371 (R). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 50 (GN/W) for power. Turn the ignition switch to the "On" position. Measure the voltage of Circuit 50 (GN/W) between the sleeper fuse junction relay panel blower motor relay connector C768, Pin 30 and chassis ground. If the voltage is less than 10 volts, check Circuit 16 (R/GN) for power. Remove the sleeper fuse junction panel Fuse 12 (4 A). Measure the voltage of Circuit 16 (R/GN) between the sleeper fuse junction panel input side of Fuse 12 (4 A) and chassis ground. If the voltage is less than 10 volts, repair the open in Circuit 16 (R/GN). Test the system for normal operation. If the voltage is greater than 10 volts, check Circuit 50 (GN/W) for an open. Turn the ignition switch to the "Off" position. Reinstall the sleeper fuse junction panel Fuse 12 (4 A). Remove the sleeper fuse junction panel Fuse 11 (30 A). Measure the resistance of Circuit 50 (GN/W) between the sleeper fuse junction relay panel output side of Fuse 11 and the sleeper fuse junction relay panel blower motor relay connector C768, Pin 30. If the resistance is less than 5 ohms, wiggle the wires and Check for intermittent operation. Repair as necessary. Test the system for normal operation. If the resistance is greater than 5 ohms, repair the open in Circuit 50 (GN/W). Test the system for normal operation.

Troubleshooting

Problem—Auxiliary Blower Motor Does Not Operate	
Possible Cause	**Remedy**
Damaged circuitry	Check Circuit 277 (GN) for power. Reinstall the sleeper fuse junction panel Fuse 11 (4 A). Reinstall the sleeper fuse junction panel blower motor relay. Disconnect the auxiliary A/C-heater function selector switch C760. Turn the ignition switch to the "On" position. Measure the voltage of Circuit 277 (GN) between the auxiliary A/C-heater function selector switch connector C760 and chassis ground. If the voltage is greater than 10 volts, check the auxiliary A/C-heater function selector switch. Perform the "Auxiliary A/C-Heater Function Selector Switch" test. Refer to "Component Tests" in this subject. If the auxiliary A/C-heater function selector switch is not OK, replace the auxiliary A/C-heater function selector switch. Test the system for normal operation. If the auxiliary A/C-heater function selector switch is not OK, check the auxiliary A/C-heater function selector switch Circuit 57 (BK) for an open. Turn the ignition switch to the "On" position. Measure the resistance of Circuit 57 (BK) between the auxiliary A/C-heater function selector switch connector C760 and chassis ground. If the resistance is less than 5 ohms, wiggle the wires and check for intermittent operation. Repair as necessary. Test the system for normal operation. If the resistance is more than 5 ohms, repair the open in Circuit 57 (BK). Test the system for normal operation.
Damaged/inoperative auxiliary A/C-heater function selector switch	Check Circuit 277 (GN) for an open. Disconnect the auxiliary blower motor switch C758 harness connector. Measure the resistance of Circuit 277 (GN) between the auxiliary A/C-heater function selector switch connector C760 and the auxiliary blower motor switch connector C758. If the resistance is not less than 5 ohms, repair the open in Circuit 277 (GN). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 515 (O) for power. Turn the ignition switch to the "On" position. Measure the voltage of Circuit 515 (O) between the auxiliary blower motor switch connector C758 and chassis ground. If the voltage is greater than 10 volts, check Circuit 515 (O) for an open. Turn the ignition switch to the "Off" position. Measure the resistance of Circuit 515 (O) between the auxiliary blower motor connector C743 and the auxiliary blower motor switch connector C758. If the resistance is more than 5 ohms, repair the open in Circuit 515 (O). Test the system for normal operation. If the resistance is less than 5 ohms, check auxiliary blower motor switch. Perform the "Auxiliary Blower Motor Switch" test. Refer to "Component Tests" in this subject. If the auxiliary blower motor switch is OK, wiggle the wires and check for intermittent operation. Repair as necessary. Test the system for normal operation. If the auxiliary blower motor switch is not OK, replace the auxiliary blower motor switch. Test the system for normal operation.

Problem—Temperature Control Does Not Operate Using the Rear Auxiliary Climate Control

Problem—Temperature Control Does Not Operate Using the Rear Auxiliary Climate Control (See Fig. 6, Fig. 7 and Fig. 8)	
Possible Cause	**Remedy**
Damaged/inoperative auxiliary temperature potentiometer switch	Check the auxiliary temperature potentiometer switch. Perform the "SilverStar Auxiliary Temperature Potentiometer Switch " test. Refer to "Component Tests" in this subject. If the auxiliary temperature potentiometer switch is not OK, replace the auxiliary A/C-heater function selector switch. Test the system for normal operation. If the auxiliary temperature potentiometer switch is OK, check Circuit 182 (BR/W) for an open. Turn the ignition switch to the "Off" position. Disconnect the auxiliary temperature potentiometer C759 from the harness connector. Disconnect the auxiliary A/C control module C746 from the harness connector. Measure the resistance of Circuit 182 (BR/W) between the auxiliary temperature potentiometer connector C759 and the auxiliary A/C control module connector C746, Pin 9. If the resistance is more than 5 ohms, repair the open in Circuit 182 (BR/W). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 184 (R) for an open.
Damaged/inoperative return air temperature sensor	Measure the resistance of Circuit 184 (R) between the auxiliary temperature potentiometer connector C759 and the auxiliary A/C control module connector C746, Pin 10. If the resistance is more than 5 ohms, repair the open in Circuit 184 (R). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 185 (BK) for an open. Measure the resistance of Circuit 185 (BK) between the auxiliary temperature potentiometer connector C759 and the auxiliary A/C control module connector C746, Pin 2. If the resistance is more than 5 ohms, repair the open in Circuit 185 (BK). Test the system for normal operation. If the resistance is less than 5 ohms, check the auxiliary A/C temperature blend door actuator drive.
Damaged/inoperative auxiliary A/C temperature blend door actuator	Turn the ignition switch to the "On" position. Jumper Pin 5, Circuit 883 (O) to Pin 3, Circuit 884 (Y) and Pin 4, Circuit 882 (W) to Pin 1, Circuit 57 (BK) on the auxiliary A/C control module connector C746. Jumper Pin 4, Circuit 882 (W) to Pin 3, Circuit 884 (Y) and Pin 5, Circuit 883 (O) to Pin 1, Circuit 57 (BK) on the auxiliary A/C control module connector C746. If the auxiliary A/C temperature blend door actuator drives in both directions, check auxiliary A/C temperature blend door actuator resistance. Drive the auxiliary A/C temperature blend door actuator to the full heat position.
Damaged/inoperative auxiliary A/C control module	Turn the ignition switch to the "Off" position. Measure the resistance between Pin 7, Circuit 827 (Y/R) and Pin 6, Circuit 828 (BR/GN) of the auxiliary A/C control module connector C746. Measure the resistance between Pin 8, Circuit 830 (GN/W) and Pin 7, Circuit 827 (Y/R) of the auxiliary A/C control module connector C746. Measure the resistance between Pin 8, Circuit 830 (GN/W) and Pin 6, Circuit 828 (BR/GN) of the auxiliary A/C control module connector C746. If the resistance value of the first measurement is 250 to 1500 ohms, the second measurement 3500 to 6000 ohms and the third measurement 5000 to 7000 ohms, replace the auxiliary A/C control module. Test the system for normal operation. If the resistance value of the first measurement is not 250 to 1500 ohms, the second measurement 3500 to 6000 ohms and the third measurement 5000 to 7000 ohms, check Circuit 830 (GN/W) for an open.

Troubleshooting

Problem—Temperature Control Does Not Operate Using the Rear Auxiliary Climate Control	
Possible Cause	**Remedy**
Damaged/inoperative auxiliary temperature potentiometer switch	Disconnect the auxiliary A/C temperature blend door actuator C744 harness connector. Measure the resistance of Circuit 830 (GN/W) between Pin 8 of the auxiliary A/C control module connector C746 and Pin 8 of the auxiliary A/C temperature blend door actuator connector C744. If the resistance is more than 5 ohms, repair the open in Circuit 830 (GN/W). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 827 (Y/R) for an open.
Damaged/inoperative return air temperature sensor	Measure the resistance of Circuit 827 (Y/R) between Pin 7 of the auxiliary A/C control module connector C746 and Pin 4 of the auxiliary A/C temperature blend door actuator connector C744. If the resistance is more than 5 ohms, repair the open in Circuit 827 (Y/R). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 828 (BR/GN) for an open.
Damaged/inoperative auxiliary A/C temperature blend door actuator	Measure the resistance of Circuit 828 (BR/GN) between Pin 6 of the auxiliary A/C control module connector C746 and Pin 7 of the auxiliary A/C temperature blend door actuator connector C744. If the resistance is more than 5 ohms, repair the open in Circuit 828 (BR/GN). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 883 (O) for an open.
	Measure the resistance of Circuit 883 (O) between Pin 5 of the auxiliary A/C control module connector C746 and Pin 6 of the auxiliary A/C temperature blend door actuator connector C744. If the resistance is more than 5 ohms, repair the open in Circuit 883 (O). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 882 (W) for an open.
Damaged/inoperative auxiliary A/C control module	Measure the resistance of Circuit 88R (W) between Pin 4 of the auxiliary A/C control module connector C746 and Pin 5 of the auxiliary A/C temperature blend door actuator connector C744. If the resistance is less than 5 ohms, replace the auxiliary A/C control module. Test the system for normal operation. If the resistance is more than 5 ohms, repair the open in Circuit 882 (W). Test the system for normal operation.

Problem—Auxiliary Controls are Operational With the Function Selector Off

Problem—Auxiliary Controls are Operational With the Function Selector Off (See Fig. 2, Fig. 3 and Fig. 4)	
Possible Cause	**Remedy**
Damaged/inoperative auxiliary A/C-heater function selector switch	Check the auxiliary A/C-heater function selector switch. Perform the "A/C-Heater Function Selector Switch" test. Refer to "Component Tests" in this subject. If the auxiliary A/C-heater function selector switch is not OK, replace the auxiliary A/C-heater function selector switch. Test the system for normal operation. If the auxiliary A/C-heater function selector switch is OK, check Circuit 277 (GN) for short to ground. Disconnect the harness connector. Disconnect the auxiliary blower motor resistor C742 harness connector. Disconnect the auxiliary blower motor switch C758 harness connector. Disconnect the auxiliary A/C-heater function selector switch C760 harness connector. Measure the resistance of Circuit 277 (GN) between the auxiliary A/C-heater function selector switch connector C760 and chassis ground. If the resistance is less than 5 ohms, repair the short to ground in Circuit 277 (GN). Test the system for normal operation. If the resistance is more than 5 ohms, check Circuit 269 (BL/R) for short to ground. Measure the resistance of Circuit 269 (BL/R) between the auxiliary blower motor switch connector C758 and chassis ground. If the resistance is less than 5 ohms, repair the short to ground in Circuit 269 (BL/R). Test the system for normal operation. If the resistance is more than 5 ohms, check Circuit 260 (R/BK) for short to ground.
Damaged circuitry	Measure the resistance of Circuit 260 (R/BK) between the auxiliary blower motor switch connector C758 and chassis ground. If the resistance is less than 5 ohms, repair the short to ground in Circuit 260 (R/BK). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 515 (O) for short to ground. Disconnect the auxiliary blower motor C743 harness connector. Disconnect the auxiliary A/C control module C746 harness connector. Measure the resistance of Circuit 515 (O) between the auxiliary blower motor switch connector C758 and chassis ground. If the resistance is less than 5 ohms, repair the short to ground in Circuit 515 (O). Test the system for normal operation. If the resistance is more than 5 ohms, wiggle the wires and check for intermittent operation. Repair as necessary. Test the system for normal operation.

Troubleshooting

Problem—Rear Auxiliary Blower Motor Switch Operates Only in High

Problem—Rear Auxiliary Blower Motor Switch Operates Only in High	
Possible Cause	**Remedy**
Damaged/inoperative auxiliary blower motor switch	Check the auxiliary blower motor resistor. Perform the "SilverStar Auxiliary Blower Motor Resistor" test. Refer to "Component Tests" in this subject. If the auxiliary blower motor resistor is not OK, replace the auxiliary blower motor resistor. Test the system for normal operation. If the auxiliary blower motor resistor is OK, check the auxiliary blower motor switch. Perform the "SilverStar Auxiliary Blower Motor Switch" test. Refer to "Component Tests" in this subject. If the auxiliary blower motor switch is not OK, replace the auxiliary blower motor switch. Test the system for normal operation. If the auxiliary blower motor switch is OK, check Circuit 269 (BL/R) for an open.
Damaged/inoperative auxiliary blower motor resistor	Disconnect the auxiliary blower motor switch C758 and the auxiliary blower motor resistor C742. Measure the resistance of Circuit 269 (BL/R) between the auxiliary blower motor switch connector C758 and the auxiliary blower motor resistor connector C742. If the resistance is more than 5 ohms, repair the open in Circuit 269 (BL/R). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 260 (R/BK) for an open. Measure the resistance of Circuit 260 (R/BK) between the auxiliary blower motor switch connector C758 and the auxiliary blower motor resistor connector C742. If the resistance is more than 5 ohms, repair the open in Circuit 260 (R/BK). Test the system for normal operation. If the resistance is less than 5 ohms, check Circuit 277 (GN) for an open.
Damaged circuitry	Measure the resistance of Circuit 277 (GN) between the auxiliary blower motor switch connector C758 and the auxiliary blower motor resistor connector C742. If the resistance is less than 5 ohms, wiggle the wires and check for intermittent operation. Repair as necessary. Test the system for normal operation. If the resistance is more than 5 ohms, repair the open in Circuit 277 (GN). Test the system for normal operation.

Component Tests

SilverStar Auxiliary Blower Motor Resistor (See Fig. 9)

Resistance Check		
To Test	**Measure Resistance Between**	**Resistance Should Be**
MED-HI Speed	Terminal 3 and Terminal 1	0.25 ohms ± 10%
MED-LO Speed	Terminal 3 and Terminal 4	0.80 ohms ± 10%
LO Speed	Terminal 3 and Terminal 2	2.70 ohms ± 10%

Table 2, Resistance Check

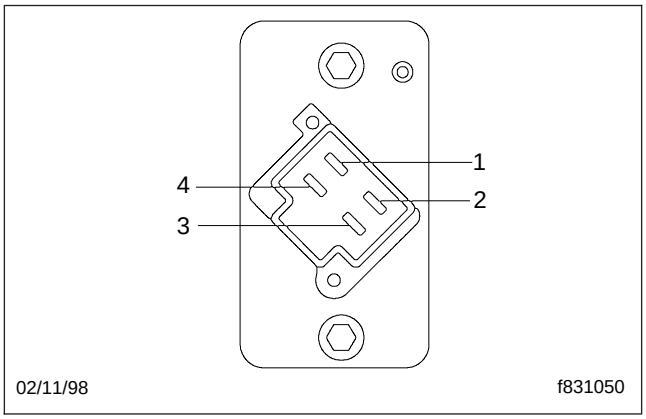


Fig. 9, SilverStar Auxiliary Blower Motor Resistor Pin Identification

A/C-Heater Function Selector Switch (See Fig. 10)

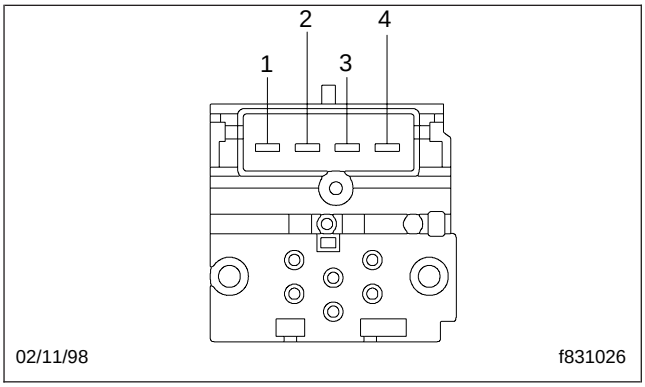


Fig. 10, A/C-Heater Function Selector Switch Pin Identification

Resistance Check			
To Test	**Measure Resistance Between**	**Set The Switch Position To**	**Resistance Should Be**
Blower Motor Circuit	Terminal 3, Circuit 277 (GN) and Terminal (1, Circuit 57 (BK)	"Off"	Greater than 10,000 ohms
		"On"	Less than 5 ohms

Table 3, Resistance Check

SilverStar Auxiliary Blower Motor Switch (See Fig. 11)

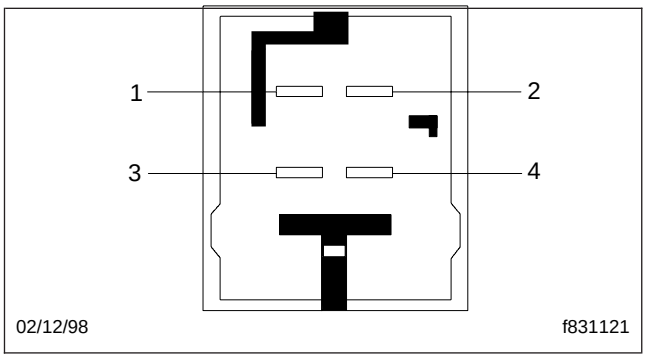


Fig. 11, SilverStar Auxiliary Blower Motor Switch Pin Identification

Resistance Check			
To Test	**Measure Resistance Between**	**Set The Switch Position To**	**Resistance Should Be**
HI Speed	Terminal 1, Circuit 515 (O) and Terminal 2, Circuit 277 (GN)	LO	Greater than 10,000 ohms
		MED-LO	Greater than 10,000 ohms
		MED-HI	Greater than 10,000 ohms
		HI	Less than 5 ohms
MED-HI Speed	Terminal 3, Circuit 269 (BL/R) and Terminal 2, Circuit 277 (GN)	LO	Greater than 10,000 ohms
		MED-LO	Greater than 10,000 ohms
		MED-HI	Less than 5 ohms
		HI	Greater than 10,000 ohms
MED-LO Speed	Terminal 4, Circuit 260 (R/BK) and Terminal 2, Circuit 277 (GN)	LO	Greater than 10,000 ohms
		MED-LO	Less than 5 ohms
		MED-HI	Greater than 10,000 ohms
		HI	Greater than 10,000 ohms

Table 4, Resistance Check

Troubleshooting

SilverStar Auxiliary Temperature Potentiometer Switch (See Fig. 12)

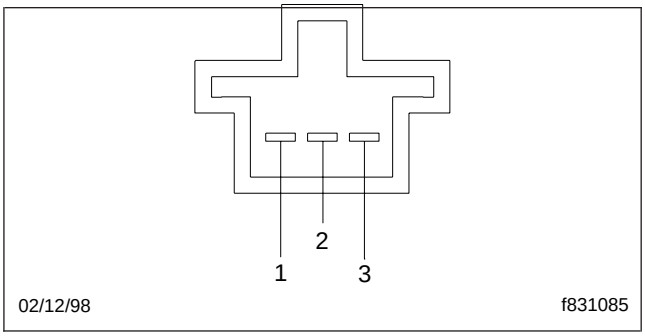


Fig. 12, SilverStar Auxiliary Temperature Potentiometer Switch Pin Identification

Resistance Check			
To Test	**Measure Resistance Between**	**Set The Switch Position To**	**Resistance Should Be**
Temperature Potentiometer Switch	Terminal 1, Circuit 185 (BK) and Terminal 2, Circuit 184 (R)	Full COOL	Less than 100 ohms
		Full WARM	4-6 kohms

Table 5, Resistance Check

Blower Motor Relay

1. Using two No. 10 (or larger gauge) jumper wires, connect the relay Terminals 86 and 30 directly to the positive battery terminal. See **Fig. 13**.

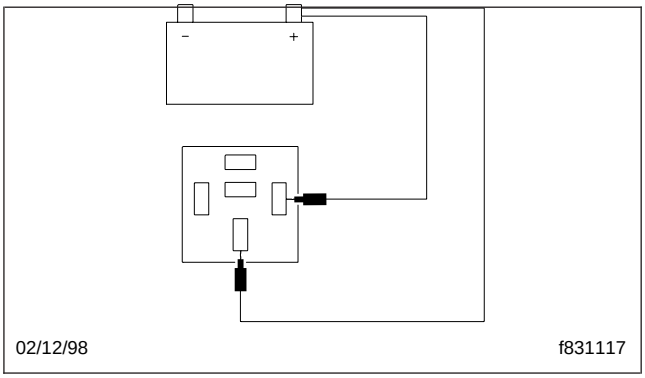


Fig. 13, Blower Motor Relay

2. Connect a voltmeter to Terminal 87A; 10 volts or greater should be present. If 10 volts or greater is not present, replace the relay. If 10 volts or greater is present, continue with the test. See **Fig. 14**.

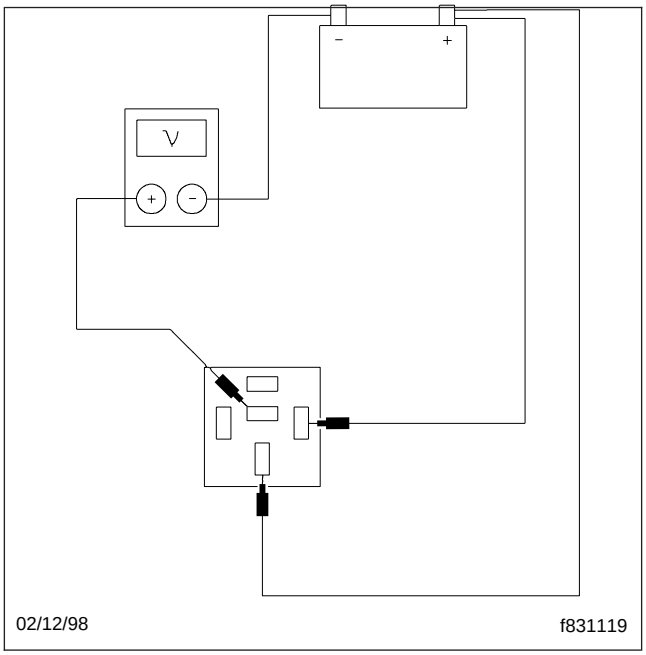


Fig. 14, Testing the Relay

3. Connect a third jumper wire to Terminal 85 and chassis ground. See **Fig. 15**.

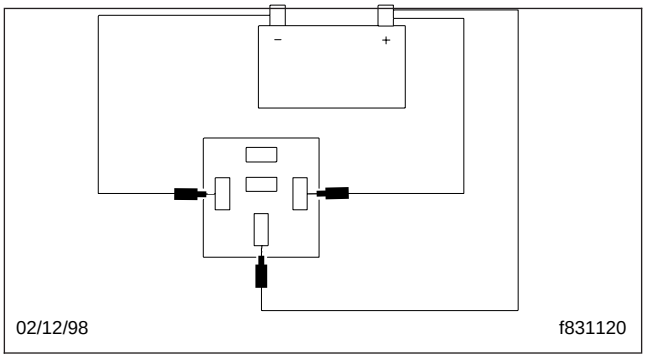


Fig. 15, Testing the Relay

4. Check for voltage at Terminal 87; 10 volts or greater should be present. If 10 volts or greater is not present, replace the relay. See **Fig. 16**.

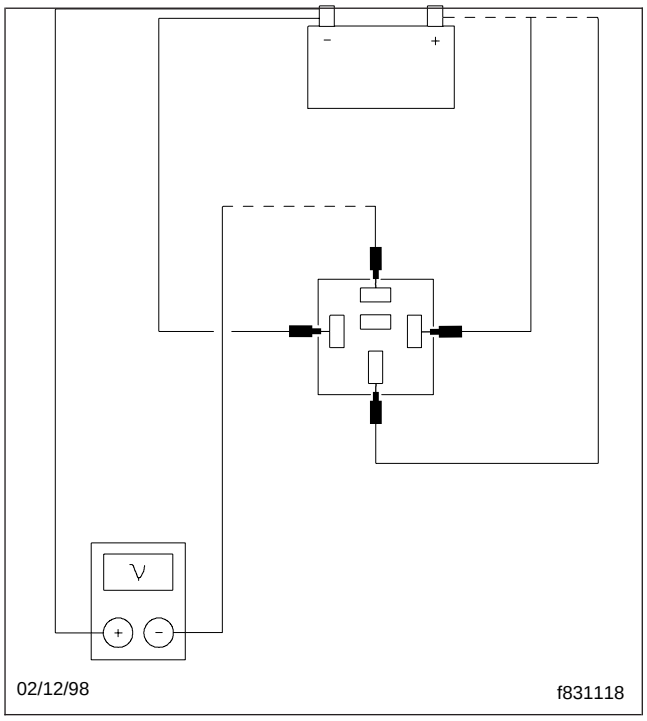


Fig. 16, Testing the Relay

Specifications

General Specifications	
Item	**Specifications**
Calibration Procedure	Start the engine and allow it to reach normal operating temperature.
	Rotate the temperature control to the full WARM position for two minutes.
	Rotate the temperature control to the full COOL position for two minutes.

Table 1, General Specifications

Thermodynamic Principles

Air conditioning is the cooling or refrigeration of the air in the passenger compartment. Refrigeration is accomplished by making practical use of three thermodynamic principles. These principles and their practical application are described below.

Heat Transfer

If two objects of different temperatures are placed near each other, the heat in the warmer object will always travel to the cooler object until both are of equal temperature.

For example, a block of ice in a refrigerator does not transfer its coldness to a nearby carton of milk. Rather, the heat in the warm milk automatically flows to the ice.

The British Thermal Unit (BTU) is used to determine the amount of heat transferred from one object to another. One BTU is the amount of heat required to raise the temperature of 1 pound (0.45 kg) of water 1°F (0.55°C).

For example, to raise the temperature of 1 pound (0.45 kg) of water from 32°F to 212°F (0°C to 100°C), one BTU of heat must be added for 1°F (0.55°C) rise in temperature or a total of 180 BTUs of heat. Conversely, in order to lower the temperature of 1 pound (0.45 kg) of water from 212°F to 32°F (100°C to 0°C), 180 BTUs of heat must be removed from the water.

Latent Heat of Vaporization

When a liquid boils, it absorbs heat without raising the temperature of the resulting gas. When the gas condenses (changes back to a liquid), it gives off heat without lowering the temperature of the resulting liquid.

For example, when 1 pound (0.45 kg) of water at 32°F (0°C) is placed in a container over a flame, the temperature of the water rises 1°F (0.55°C) with each BTU of heat that the water absorbs from the flame. Thus, after it has absorbed 180 BTUs of heat, the water reaches a temperature of 212°F (100°C).

Even though the flame continues to give its heat to the water, the temperature of the water remains at 212°F (100°C). The water however starts to boil or change from a liquid to a gaseous state. It continues to boil until the water has passed off into the atmosphere as vapor. If this vapor were checked with a thermometer, it also would show a temperature of 212°F (100°C).

In other words, there was a rise of only 180°F (from 32°F to 212°F or 0°C to 100°C) in the water and vapor temperature even though the flame applied many more than 180 BTUs of heat. In this case, the heat is absorbed by the liquid in the process of boiling and disappears in the vapor. If the vapor were brought in contact with cool air, the hidden heat would flow into the cooler air and the vapor condensed back to water. Scientists refer to this principle as the latent (hidden) heat of vaporization.

Water has a latent heat of vaporization of 970 BTUs and a boiling point of 212°F (100°C). This means that 1 pound (0.45 kg) of water at 212°F (100°C), will absorb 970 BTUs of heat when changing to vapor at 212°F (100°C). Conversely, the vapor will give off 970 BTUs of heat when condensing back to water at 212°F (100°C).

This heat transfer, occurring when a liquid boils or a vapor condenses, forms the basic principle of all conventional refrigerant systems.

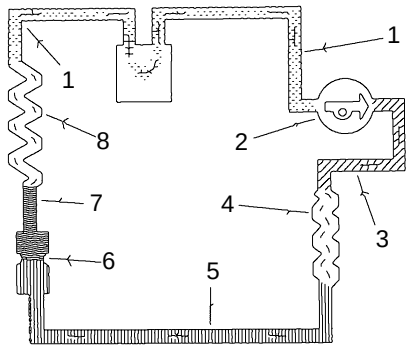
For a liquid to be a refrigerant, it must also have a low boiling point. That is, the temperature at which it boils must be lower than the substance to be cooled.

R–134a is a non-CFC refrigerant. Its temperature/pressure relationship makes it suitable for mobile air conditioning systems.

Effect of Pressure on Boiling or Condensation

As refrigerant passes through an air conditioning system, it flows under high-pressure conditions, first as a high-pressure vapor between the refrigerant compressor and the condenser, then as a high-pressure liquid between the condenser and the evaporator orifice. It expands to a low-pressure vapor between the evaporator orifice and the refrigerant return port in the refrigerant compressor. As pressures in the closed refrigerant circuit vary, temperatures will also vary. As pressure increases, temperatures also increase; as the pressure decreases, temperatures also decrease. The refrigerant flow diagram highlights the changes that take place. See **Fig. 1**.

General Information



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1. Low-Pressure Vapor
2. Refrigerant Compressor
3. High-Pressure Vapor
4. Condenser
5. High-Pressure Liquid
6. Restriction
7. Low-Pressure Liquid
8. Evaporator

Fig. 1, Refrigerant Flow

General Information

The heater and air conditioner assembly is mounted behind the passenger dash panels and on the engine side of the frontwall. The heater and air conditioner assembly contains the following major components:

- accumulator
- blower motor
- climate control panel
- condenser
- electric actuators
- evaporator
- heater core
- orifice tube
- refrigerant compressor
- refrigerant compressor cycling switch

The heating, air conditioning, and ventilating functions of the cab heater and air conditioner system are controlled by the cab climate control panel mounted on the dashboard. Refer to the *L-Line and A-Line Driver's Manual* for operating instructions.

Description of Components

Accumulator

When entering the inlet of the accumulator, the refrigerant contacts the liquid diverter dome and flows to the bottom of the housing. The refrigerant completes vaporization and passes into the suction inlet. A small, screened bleed hole in the bottom allows oil to be sucked into the suction tube to return to the compressor.

A desiccant bag inside the accumulator absorbs any moisture that may be in the system. A fitting on the accumulator is used to mount the refrigerant compressor cycling switch. The fitting prevents refrigerant loss when the cycling switch is removed.

Blower Motor

The blower motor forces air through the HVAC assembly and through the duct work.

Climate Control Panel

The fan switch, temperature control switch, and air selection switch are mounted on the climate control panel, which is also called the control head. The fan switch is used to control the rate of airflow through the outlets. The temperature control switch is used to select the desired temperature. The air selection switch is used to select the direction of warm or cool air through the air outlets.

Condenser

A condenser turns hot refrigerant gas coming from the refrigerant compressor into liquid. The condenser is mounted in front of the radiator. 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.

Electric Actuator

The electric actuator is a combined motor and gearbox that is used to control the position of the doors within the HVAC assembly. The position of the doors is controlled by the settings on the climate control panel. There are five electric actuators on the HVAC assembly:

- the temperature/blend air actuator

- the defrost/panel actuator
- the right-side panel/demist actuator
- fresh air/recirculation actuator
- panel/floor actuator

Evaporator

The evaporator is located in the evaporator housing on the engine side of the frontwall. Because the evaporator is an area of low pressure in the refrigerant system, the boiling point of refrigerant lowers, which causes it to absorb heat from the tubing walls and fins. As it absorbs heat, liquid refrigerant quickly boils and turns into a gas.

As heat is absorbed from the outside surfaces of the evaporator, air passing over the unit loses its heat to these cooler surfaces. Moisture in the air condenses on the outside of the evaporator and drains off as water; the air becomes dehumidified.

Heater Core

When the engine is on, coolant flows through the heater core tubes heating the tubes and fins. The heat is absorbed by air that is forced through the heater core by the blower motor.

Orifice Tube

The orifice tube separates the high- and low-pressure sides of the HVAC system and meters the flow of refrigerant into the evaporator. The orifice tube is located in the inlet tube to the evaporator. The orifice tube has screens on the inlet and outlet ends of the tube. The inlet screen is a strainer for the liquid refrigerant flowing through the opening. The outlet screen reduces the noise of the refrigerant flowing through the orifice tube. O-rings on the orifice tube prevent the high pressure liquid refrigerant from bypassing the orifice tube. The orifice tube cannot be adjusted or repaired; it must be replaced.

Refrigerant Compressor

Heat in the low-pressure gas of the evaporator 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 evaporator is very cold. As a result, there is the problem of how to remove heat from cool 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.

Refrigerant Compressor Cycling Switch

The refrigerant compressor cycling switch is mounted on the accumulator. The electrical contacts within the cycling switch are normally open below an operating pressure of about 23 psi (159 kPa). The electrical contacts close to allow compressor operation when internal pressure rises above approximately 40 to 47 psi (275 to 324 kPa). Lower ambient air temperatures (below 50°F or 10°C) during cold seasons will also open the contacts due to the pressure/temperature relationship of the refrigerant in the system.

The electrical contacts control the circuit to the compressor clutch field coil. When the contacts are closed, the compressor clutch field is energized and the clutch engages to drive the compressor. When the contacts are open, the compressor clutch field coil is de-energized and the compressor does not operate. The cycling switch, when operating properly, will control the refrigerant pressure within the evaporator at a point when the plate/fin surface of the evaporator will be maintained slightly above freezing to prevent icing and blockage of airflow.

Definition of Terms

Refer to the following terms for a better understanding of the HVAC system.

Accumulator A combination desiccant, filter, and storage container for liquid refrigerant.

Air Conditioner A system used to control the temperature, humidity, and movement of air in the cab.

Ambient Air Temperature The temperature of air around an object or the outside temperature.

Binary Switch See high-pressure switch and low-pressure switch.

General Information

Blower Motor A blower motor forces air through the HVAC assembly and through the duct work.

Blower Resistor Block Assembly Inline resistors that control the amount of voltage going to the blower motor. By controlling the voltage, you can control the fan speed.

Boiling Point The temperature at which a liquid changes to a gas. The boiling point varies with pressure.

Bulk Charging Use of large containers of refrigerant for charging a refrigerant system. Normally used for charging empty systems.

Charge A specific amount of refrigerant or oil by volume or weight. Also, the act of placing an amount of refrigerant or oil in the air conditioning system.

Clutch Cycling Switch Engages or disengages the refrigerant compressor depending on changes in system pressure on the low side. Same as low-pressure switch.

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. Typically the condenser is mounted in front of the radiator.

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, dirt, or air in the system.

Cycling Clutch System A system that 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.

Dehydrate To remove all traces of moisture from the refrigerant system. This process occurs during evacuation.

Desiccant A drying agent used in the accumulator to remove water and create an extremely dry condition.

Discharge Line Connects the refrigerant compressor outlet to the condenser inlet.

Discharge Pressure High-side pressure or condensing pressure being discharged from the compressor.

Drive Pulley A pulley attached to the front of the engine crankshaft. It drives the compressor clutch pulley with a belt.

Duct A passageway for the transfer of air from one point to another.

Electric Actuator The actuator is a combined motor and gearbox used to drive the doors within the HVAC assembly.

Evacuate To place a high vacuum in the refrigerant system to remove air and dehydrate or remove traces of moisture.

Evaporate To change state from a liquid to a gas.

Evaporator A component in which liquid refrigerant changes to a gas after it absorbs heat from the air. It 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 normal condition in the evaporator of an orifice tube system. The evaporator operates flooded and evaporates only the liquid closest to the outlet.

Flushing A process of passing liquid refrigerant through an air-conditioner component to remove dirt and water from the part. Liquid refrigerant removes heavy contamination, such as gritty dirt and large dirt buildup.

Freeze-Up Failure of a unit to operate properly because of ice forming at the expansion valve orifice or on the evaporator.

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 before the expansion device. It allows high-side pressure to be checked and other service operations to be performed.

High-Pressure Switch Located on the discharge side of the refrigerant compressor, the high-pressure switch signals the fan on and the refrigerant compressor off in the event of a high pressure condition.

Humidity The amount of water vapor in the air.

Hydraulic Lock The return of liquid refrigerant to the compressor, which could destroy the unit.

Leak Detector Any device used to detect refrigerant leaks in a refrigerant system.

Liquid Pressure Pressure of refrigerant in the liquid line from the condenser to the expansion device.

Low-Pressure Switch Located on the suction side of the refrigerant compressor, the low pressure switch signals the clutch to cycle or shut down in extremely cold temperatures, or if there is a loss of charge.

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 A device to control refrigerant flow for system test purposes. It is 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. The unit of measure is used to measure vacuum drawn from a refrigerant system by a vacuum pump.

Nitrogen A colorless, odorless, dry, inert gas.

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.

Orifice Tube Fixed expansion device located in the cab evaporator inlet that controls the amount of refrigerant that passes into the evaporator.

Overcharge Too much refrigerant or oil in the system.

Polyalkylene Glycol (PAG) Highly refined synthetic refrigerant oil that is used in R–134a air conditioning systems.

psia Pounds per square inch, absolute pressure. 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.

Recovery Removal of the refrigerant from the air conditioning system.

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.

Refrigerant 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.

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 accumulator outlet to the compressor inlet.

Suction Pressure Compressor inlet pressure or the system's low-side pressure.

Suction Service Valve A device located on the suction hose near the accumulator 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 device 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 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.

General Information

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.

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, 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.

R–134a refrigerant 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 in 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 (38 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 that could cause personal injury or property damage.

You must work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

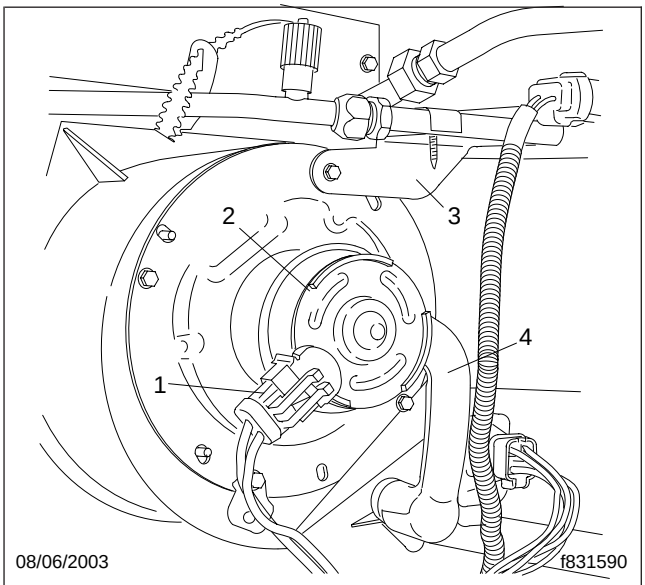
Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

Polyalkylene glycol (PAG) refrigerant oil is the **only** refrigerant oil recommended for use in the refrigerant compressors. When handling refrigerant oil, observe the following:

- Keep the oil free of contaminants.
- Do not expose the air conditioning system or the oil container to air for long periods of time; refrigerant oil absorbs 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 PAG oil with other types of refrigerant oil.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Disconnect the batteries.
4. Disconnect the electrical connector from the blower motor. See **Fig. 1**.



1. Electrical Connector
2. Blower Motor
3. Support Bracket
4. Blower Motor Tube

Fig. 1, Electrical Connector

5. Disconnect the blower motor tube from the blower motor.
6. Remove the screw that attaches the support bracket to the blower motor and remove the support bracket.
7. Remove the screws that secure the blower motor and remove the blower motor.
8. Remove and discard the retaining clip that secures the blower motor fan to the blower motor. See **Fig. 2**.

NOTE: The retaining clip that secures the blower motor fan to the blower motor is a single-use item. If the blower motor and blower motor fan are separated, a new retaining clip must be used.

9. Using a new retaining clip, install the blower motor fan.

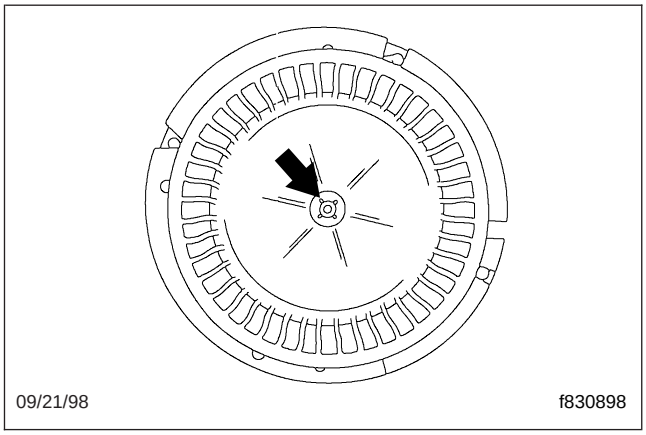
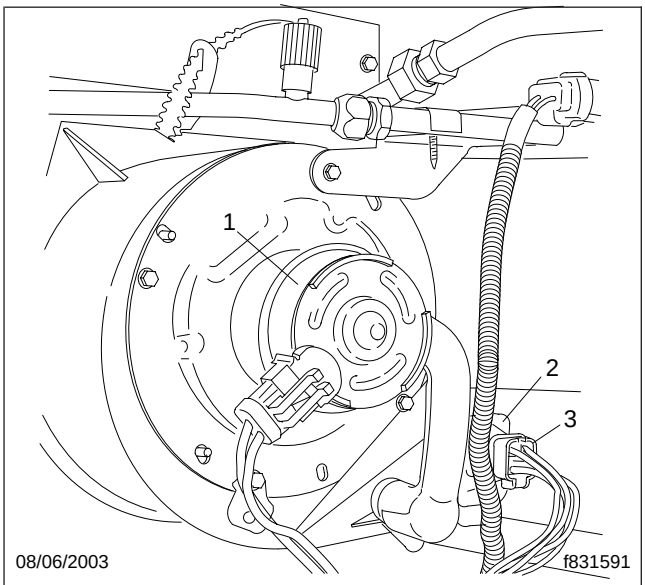


Fig. 2, Retaining Clip

10. Using screws, install the blower motor.
11. Using a screw, install the support bracket on the blower motor.
12. Install the blower motor tube on the blower motor.
13. Connect the electrical connector to the blower motor.
14. Return the hood to the operating position.
15. Connect the batteries.
16. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Open the hood.
4. Disconnect the electrical connector from the resistor. See **Fig. 1**.



1. Blower Motor
2. Resistor
3. Electrical Connector

Fig. 1, Blower Motor Resistor

5. Remove the screws that secure the resistor, and remove the resistor.
6. Inspect the gasket on the blower motor resistor flange before installing the resistor. If the gasket is damaged, replace the resistor, or seal the resistor mounting flange using silicone rubber.
7. Using screws, install the resistor. Torque the screws 18 to 27 lbf·in (170 to 280 N·cm).
8. Connect the electrical connector to the resistor.
9. Connect the batteries.
10. Return the hood to the operating position.
11. Remove the chocks from the tires.

Required Equipment

You will need a machine, or machines, to identify the refrigerant and to recover, evacuate, flush, and charge the refrigerant system. Ideally, one machine can perform all the following functions:

- Identification–The machine must be able to verify the purity of the refrigerant in the refrigerant system and the presence of hydrocarbon-based refrigerants or other unapproved refrigerants.
- Recovery–The machine must be able to fully recover the refrigerant from the refrigerant system.
- Evacuation–Ideally, the machine should have a vacuum pump rated at 6 cfm and be maintenance free. A machine that requires maintenance is acceptable as long as it is properly maintained.
- Charging–The scale used in charging should be accurate to within ±1 ounce (30 mL).
- Flushing–Adaptors for the compressor(s), expansion device(s), and accumulator-drier should be purchased or fabricated to flush the system with refrigerant.

Refrigerant Identification

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

IMPORTANT: Identify the refrigerant in the refrigerant system if you suspect one of the following conditions:

- an excess noncondensable gas, such as nitrogen or air, is in the system
- an unapproved refrigerant is in the system
- the history of refrigerant system repairs is unknown

1. Using a high-quality refrigerant identifier and the manufacturer's instructions, attach the identifier to the vehicle and perform the test.
2. If the vehicle passed the test, it is safe to recover the refrigerant.
3. If the vehicle failed the test due to an excessive amount of noncondensable gas, recover the refrigerant system, then purge the recovery tank of the noncondensable gas.
4. If the vehicle failed the test due to the presence of a hydrocarbon-based refrigerant or a refrigerant other than R-134a, **do not recover the refrigerant into the general-use machine.** To recover the refrigerant system, recover the refrigerant into a separate container that contains refrigerant that must be recycled by a qualified recycling center. It is best to refer the customer to the place where the vehicle was last serviced.

Recovery

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against 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. Turn off the engine, apply the parking brakes, chock the tires, and open the hood.
2. Remove the caps from the suction and discharge service valves.
3. If the history of refrigerant system repairs is unknown, or if you suspect that the system is charged with an unapproved refrigerant, identify the refrigerant using the "Refrigerant Identification" procedures.
4. Wearing protective goggles and nonleather gloves, attach the refrigerant recovery and charging machine 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.

5. Follow the refrigerant recovery and charging machine manufacturer's instructions and recover all of the refrigerant from the refrigerant system.

IMPORTANT: Always comply with all federal and local regulations regarding refrigerant recovery and disposal. You may be subject to substantial penalties for improper procedures.

6. Measure the oil recovered during the recovery process. The refrigerant system will have to be filled 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 accumulator-drier, and flush the condenser and evaporator(s). After the system is charged, perform a performance check to ensure that the heat exchangers are not plugged.

Evacuating

The main purpose in evacuating the refrigerant system is to remove noncondensable gases (NCG), such as nitrogen and air. The secondary purpose is to boil off free water molecules.

In rare cases, water forms ice crystals at the expansion valve. Ice crystals retard or stop the flow of refrigerant, causing a reduction or complete loss of cooling. As the expansion valve warms due to the lack of refrigerant, the ice melts and passes through the expansion valve. Then refrigerant will flow again until the ice crystals re-form. The result is intermittent cooling.

Refrigerant oil has an extremely high moisture absorption capacity. Typically, the moisture picked up by the oil is passed on to the accumulator-drier. If excessive moisture exists in the system, the lubricating ability of the oil is reduced, which could damage the compressor and other components.

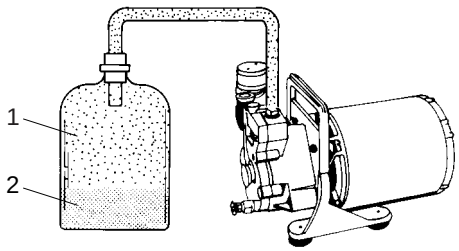
Effects of Pressure on the Boiling Point of Water

⚠ WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

Water boils at 212°F (100°C) at an atmospheric pressure of 14.7 psi (101 kPa) at 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 you 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 lowest at the pump, NCG and water vapor are pulled out of the system. This process is called evacuation or dehydration. See **Fig. 1**.



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1. Vapor 2. Water

Fig. 1, Water to Vapor

Measuring Vacuum

Vacuum should be measured with an electronic thermistor vacuum gauge, which is designed for use with high vacuum pumps and can accurately read as low as 100 microns. This gauge can have an analog scale or a digital (LED or LCD) display.

The location of the vacuum gauge will affect the reading. The closer to the vacuum source, the lower the reading will be. Follow the manufacturer's instructions for proper use of the vacuum gauge.

If the pressure will not stabilize, it is an indication of a leak. If it does stabilize at a vacuum that is too high, for example 1500 microns Hg, it is an indication of moisture and more evacuation is required.

Boiling Temperatures of Water at Converted Pressures		
Boiling Temperature of Water: °F (°C)	**Absolute Pressure: psi (microns Hg)**	**Vacuum: inHg (mmHg)**
212 (100)	14.696 (759993.4)	0 (0)
205 (96)	12.770 (660400.0)	3.92 (99.6)
194 (90)	10.169 (523881.6)	9.22 (234.2)
176 (80)	6.8699 (355269.8)	15.93 (404.6)
158 (70)	4.5207 (233786.7)	20.72 (526.3)
140 (60)	2.8900 (149580.7)	24.04 (610.6)
122 (50)	1.7987 (92555.1)	26.28 (667.5)
104 (40)	1.0700 (55336.4)	27.74 (704.6)
89 (30)	0.61540 (31826.2)	28.67 (728.2)
86 (27)	0.57010 (26220.4)	28.89 (733.8)
76 (24)	0.44435 (22979.9)	29.02 (737.1)
72 (22)	0.38856 (20094.7)	29.13 (739.9)
69 (21)	0.35084 (18143.7)	29.21 (741.9)
64 (18)	0.29505 (15258.5)	29.32 (744.7)
59 (15)	0.24720 (12783.8)	29.42 (747.3)
53 (12)	0.19888 (10285.0)	29.52 (749.8)
45 (7)	0.14746 (7625.8)	29.62 (752.3)
32 (0)	0.08858 (4579.6)	29.74 (755.4)
21 (–6)	0.05293 (2738.1)	29.81 (757.2)
6 (–14)	0.02521 (1304.0)	29.87 (758.7)
–24 (–31)	0.004905 (253.7)	29.911 (759.74)
–35 (–37)	0.002544 (131.6)	29.915 (759.84)
–60 (–51)	0.0004972 (25.7)	29.9200 (759.968)
–70 (–57)	0.0002443 (12.69)	29.92050 (759.9807)
–90 (–68)	0.0000526 (2.72)	29.92089 (759.9906)

Table 1, Boiling Temperatures of Water at Converted Pressures

Holding a vacuum is only an indication that there are not any leaks that are present under a vacuum. Other leaks may exist when the system is pressurized, so a proper leak test must be performed in conjunction with holding a vacuum.

Maintaining an Oil-Lubricated Vacuum Pump

Maintenance is important for a high-vacuum pump. The oil must be changed at regular intervals to prevent moisture buildup, which will cause decreased pump performance and eventual pump failure.

Pumping down for extremely wet air conditioning systems can completely saturate the pump oil, which will require the replacement of the vacuum pump oil.

⚠ CAUTION

Flush the vacuum pump every fourth time it is used, and before storing for long periods of time.

Acid will form and corrode the pump, if water-laden oil remains in the pump for an extended period.

Vacuum pump oil is water soluble. This aids the pump in reaching a high vacuum by absorbing water and sealing the pump.

Use only vacuum pump oil 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 refrigerant compressor filled with the correct amount of refrigerant oil. Replace the accumulator-drier if the system conditions require it.
2. Make sure the vacuum pump has been properly maintained.
3. Wearing protective goggles and nonleather gloves, attach the refrigerant recovery and charging machine hoses, or a vacuum pump, 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.

4. Follow the refrigerant recovery and charging machine manufacturer's instructions and evacuate the refrigerant system.
5. A minimum of 10 minutes with a 6-cfm pump should be used to evacuate the system. Evacuate the system for a longer period of time if using a smaller pump. Make sure that the vacuum level reaches a point where water would boil and does not go back toward zero, then proceed with charging and leak testing the system.

Flushing

⚠ WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

Flushing removes moisture-laden oil and some contamination, such as dirty oil and some particles. When a part is flushed, liquid refrigerant is forced through it. The liquid picks up the contaminants and flushes them out.

Whether to flush, or replace a part depends on how much contamination there is as previously described.

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 parts show signs of internal corrosion and grit, the system is contaminated.

If the system is contaminated with moisture, flush all sections of the system. Then change the oil in the compressor and replace the accumulator-drier prior to evacuating and charging the system.

If the system is heavily contaminated or if desiccant has circulated through the system, replace the accumulator-drier, expansion valve(s), and inspect the compressor.

Do not flush the accumulator-drier or the compressor.

Flush the system in segments to lessen the chance of blowing deposits against a port.

Flush the system in the opposite direction of refrigerant flow. In other words, backflush the sections.

Flushing parts with refrigerant requires a refrigerant recovery and charging machine.

Flushing Procedure

Method 1

NOTE: Use this method when the recovery and charging machine is equipped with a flush cycle.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), accumulator-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter and follow the instructions from the manufacturer of the recovery and charging machine to perform the flush. When flushing the entire system, use an adaptor that fits where the compressor was located and backflush.
4. Remove the adaptors and bypass devices and install the expansion device(s), the compressor, and a new accumulator-drier.
5. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
6. Charge the system with refrigerant and check the system performance.

Method 2

NOTE: Use this method when two recovery and charging machines are available.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), accumulator-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter. When flushing the entire system, use an adaptor that fits where the compressor was located and backflush.
4. Charge the part with 2 pounds (0.9 kg) of refrigerant or the system with 5 pounds (2.3 kg) of refrigerant, then recover the refrigerant with a second machine. It is desirable to start the recovery slightly before the charge cycle is done since this helps to push fluid through the system. Repeat the process several times until you think that all the oil has been removed.
5. Remove the adaptors and bypass devices and install the expansion device(s), the compressor(s), and a new accumulator-drier.
6. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
7. Charge the system with refrigerant and check the system performance.

Charging

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against 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 charging machine connected to the service and discharge port connections.

1. Obtain enough refrigerant to fully charge the system. To determine the amount of refrigerant needed to fully charge the system, read the Air Conditioner label on the vehicle or see **Specifications 400**.
2. Charge the system on the high side following the refrigerant recovery and charging machine manufacturer's instructions.
3. While the compressor is engaged, check the duct temperature and operating pressures at the suction and discharge ports. Compare the temperature and pressures to those in **Specifications 400**. If the operating pressures are not acceptable, see **Subject 300** for troubleshooting procedures.
4. Disconnect the hoses.
5. Shut down the engine.
6. Recover the refrigerant that is in the hoses.

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 nearly 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. 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 refrigerant system: UV (ultraviolet) dye leak detection and electronic leak detection. Daimler Trucks North America 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 the workshop manual. Visible dye on the front of the compressor clutch **does not** verify that there is a repairable 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.

UV Dye Leak Detection

IMPORTANT: When using the UV dye leak detection method, always wear protective eyewear that blocks UV rays and enhances the appearance of the dye. Always wear nonleather gloves and protective eyewear when servicing the air conditioning system.

1. Inspect the refrigerant system for leaks using a UV lamp.
   - 1.1 Inspect the entire refrigerant 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 refrigerant 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 over time.

3. See **Table 2** for a list of products that have been tested and approved for use by Freightliner dealers.
4. Close the hood and remove the chocks from the tires.

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 2, Approved Products for UV Dye Leak Detection

Electronic Leak Detection

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.

When checking for leaks, move the probe all the way around the fitting or suspected leak.

Daimler Trucks North America recommends using only certain makes of the heated diode and infrared (IR) types of electronic leak detectors.

Recommended electronic heated diode type leak detectors are available from their manufacturers. See **Table 3**.

Another type of detector, the corona discharge type, is specifically **not recommended**.

Use the following procedures to locate refrigerant system refrigerant gas leaks using an electronic leak detector.

1. Operate the electronic leak detector in accordance with the manufacturer's instructions. Occasionally use a leak reference bottle of R-134a to ensure that the detector is working properly.
2. Leak test with the engine turned off.

Refrigerant Service Operations

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 3, Electronic Leak Detectors

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. Typically, one-half pound (0.22 kg) of refrigerant is sufficient to create 50 psi (345 kPa) of pressure. 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 does not 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. 2**. Inspect two-cylinder reciprocating type compressors (Climate Control) by placing the probe between the clutch coil and the compressor. See **Fig. 3**.

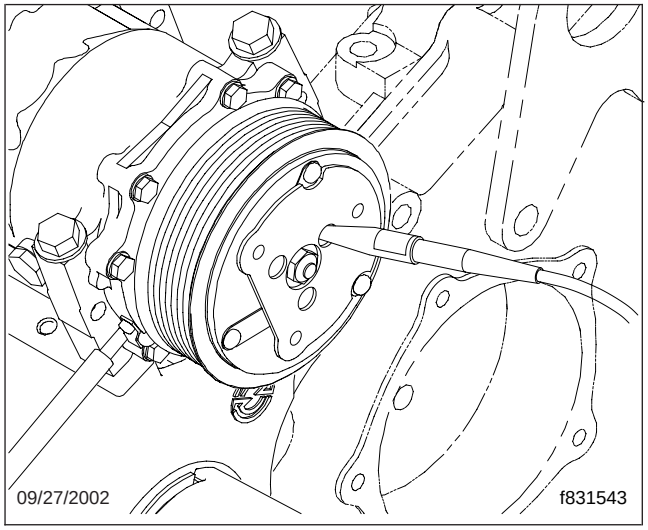


Fig. 2, Axial Type Compressor

IMPORTANT: Be careful not to damage the clutch bearing seal with high pressure shop air.

11. Leak test repaired areas of the system after repairs have been performed. Leak test the service ports (with caps installed) after any service which disturbs the refrigerant system.

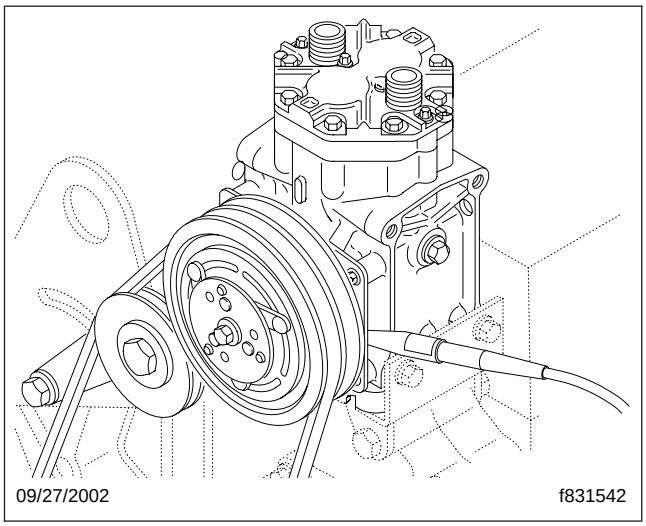


Fig. 3, Two-Cylinder Reciprocating Compressor

Evaporator Housing Removal and Installation

Removal

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Disconnect the batteries.
4. If equipped with air conditioning, recover the refrigerant from the air conditioning system. For instructions, see **Subject 130**.

WARNING

The engine must be off and fully cooled, and the cooling system fully depressurized before disconnecting any heater water hoses. Failure to comply with these warnings can result in serious personal injury from hot liquid escaping from the engine cooling system.

5. If necessary, remove the blower motor. For instructions, see **Subject 110**.
6. From inside the vehicle, remove the bolts and nuts that attach the dash panel support brace to the vehicle, and remove the support brace. See **Fig. 1**.
7. Remove the nuts that attach the evaporator housing to the dash panel.
8. Disconnect all electrical connectors from the blower motor and resistor.
9. Remove the nut that attaches the evaporator housing to the frontwall.
10. Remove the capscrews that attach the evaporator bracket to the frontwall. See **Fig. 2**.
11. Remove the evaporator housing. See **Fig. 3**.

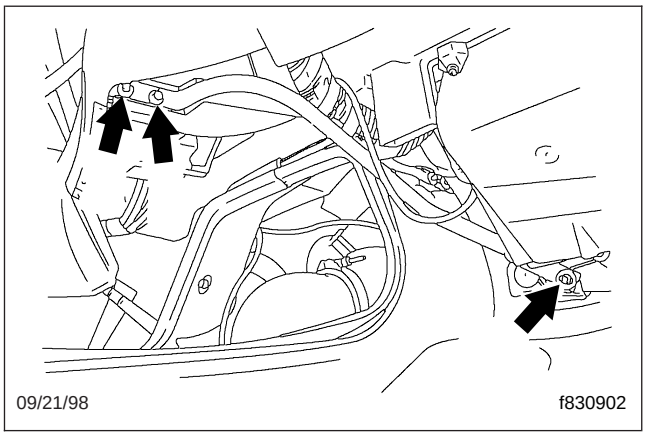


Fig. 1, Support Brace Fasteners

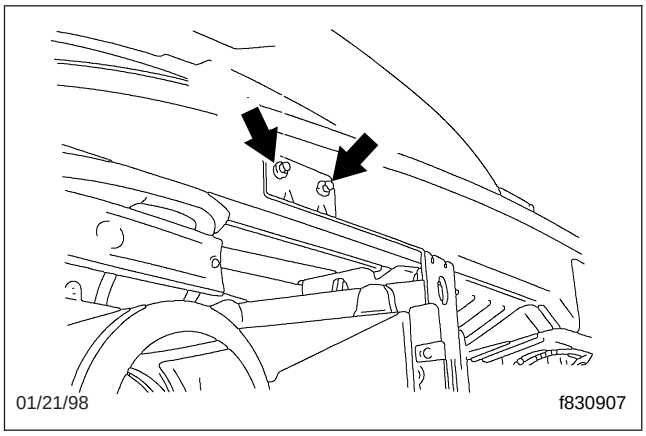


Fig. 2, Evaporator Bracket Capscrews

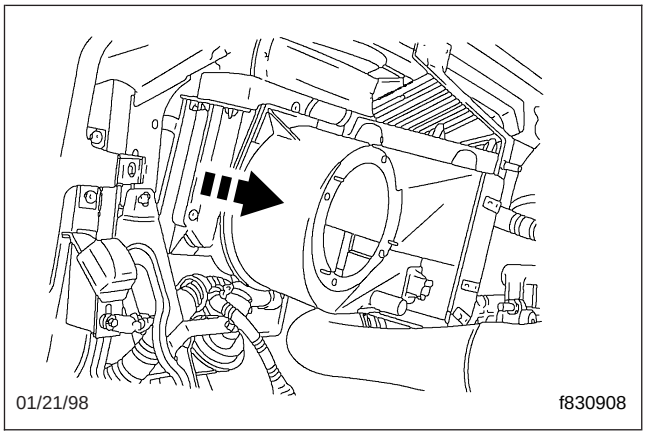


Fig. 3, Evaporator Housing

Evaporator Housing Removal and Installation

Installation

NOTE: If a new evaporator housing is to be installed, the blower motor and wheel, blower motor tube, blower motor resistor, evaporator bracket, fresh air filter, and evaporator must be transferred to the new evaporator housing. To ease installation, install these components prior to installing the evaporator housing.

1. Install the evaporator housing.
2. Install the capscrews that attach the evaporator bracket to the frontwall.
3. Install the nut that attaches the evaporator housing to the frontwall.
4. Connect the electrical connectors to the blower motor and resistor.
5. Install the nuts that attach the evaporator housing to the dash panel.
6. Using bolts and nuts, attach the dash panel support brace to the vehicle.
7. If the blower motor was removed, install the blower motor. For instructions, see **Subject 110**.
8. If equipped with an air conditioner, charge the air conditioning system. For instructions, see **Subject 130**.
9. Connect the batteries.
10. Close the hood.
11. Remove the chocks from the tires.

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

Replacement

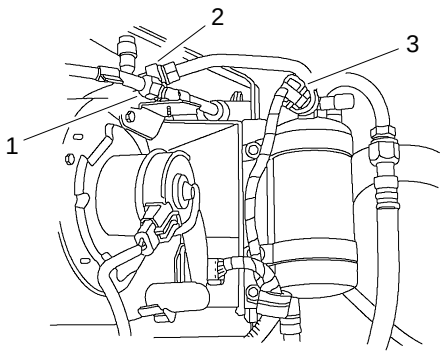
WARNING

The engine must be off and fully cooled, and the cooling system fully depressurized before disconnecting any heater water hoses. Failure to comply with these warnings can result in serious personal injury from hot liquid escaping from the engine cooling system.

1. Recover the refrigerant from the air conditioning system. For instructions, see Subject 130.

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

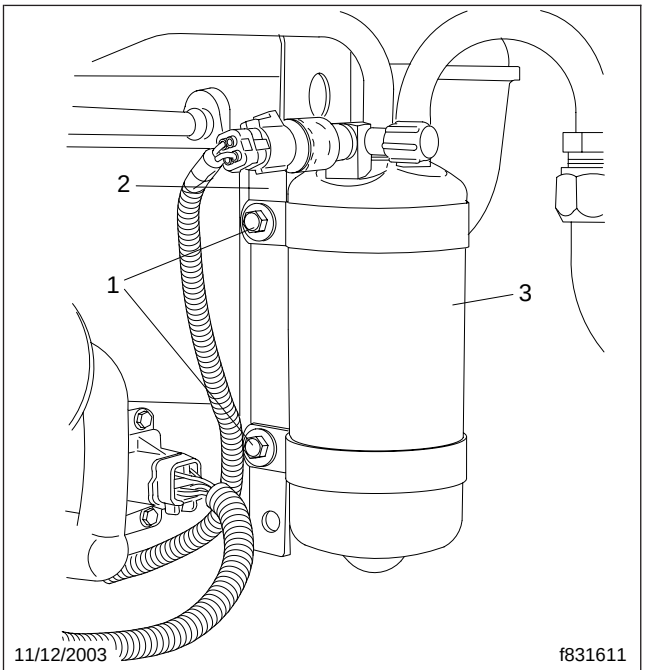
2. Disconnect the refrigerant lines from the evaporator. See Fig. 1.



1. Refrigerant Inlet Line
2. Refrigerant Outlet Line
3. Electrical Connector

Fig. 1, Disconnect the Refrigerant Lines

3. Disconnect the electrical connector from the refrigerant compressor cycling switch on the accumulator.
4. Remove the screws that attach the accumulator to the bracket, and remove the accumulator. See Fig. 2.

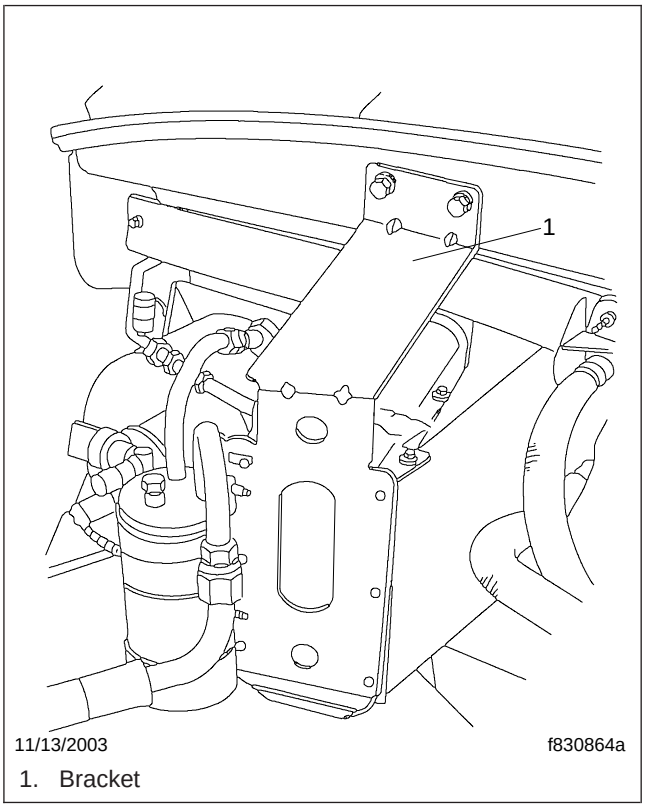


1. Screw
2. Bracket
3. Accumulator

Fig. 2, Accumulator

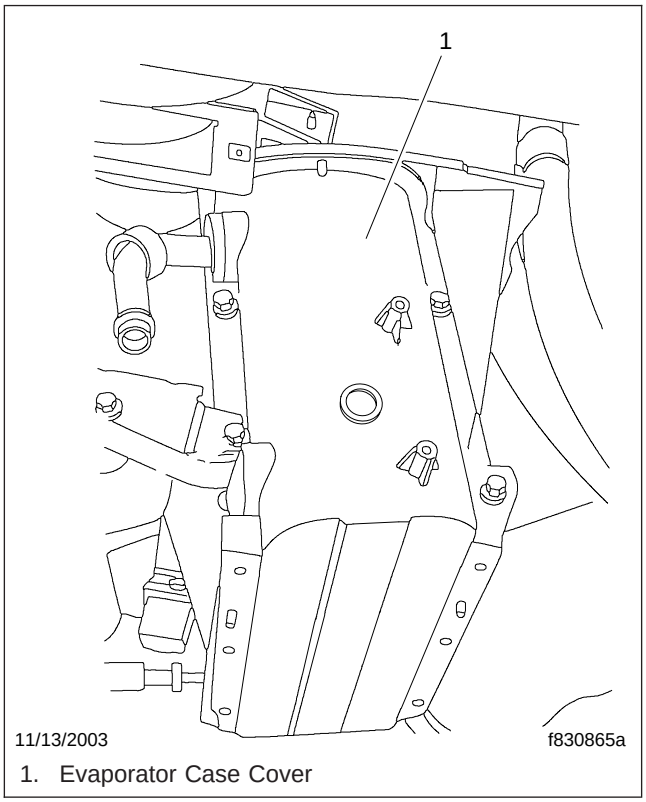
5. Remove the screws that attach the bracket to the evaporator case cover and the frontwall, and remove the bracket. See Fig. 3.
6. Remove the screws on top of the evaporator case cover and remove the case cover. See Fig. 4.
7. Remove the evaporator and O-rings.
8. Install a new evaporator and new O-rings. Lubricate the O-rings with mineral oil before installing.
9. Using screws, install the evaporator case cover.
10. Using screws, attach the accumulator and bracket to the evaporator case cover.
11. Connect the refrigerant lines to the evaporator.

Evaporator Replacement



1. Bracket

Fig. 3, Bracket



1. Evaporator Case Cover

Fig. 4, Evaporator Case Cover

12. Connect the electrical connector to the refrigerant compressor cycling switch on the accumulator.
13. Evacuate, leak check, and charge the air conditioning system. For instructions, see **Subject 130**.

⚠ WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 130**.

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through the refrigerant lines since shop air is wet (humid).

3. Disconnect the refrigerant line at the orifice tube fitting. See **Fig. 1**.

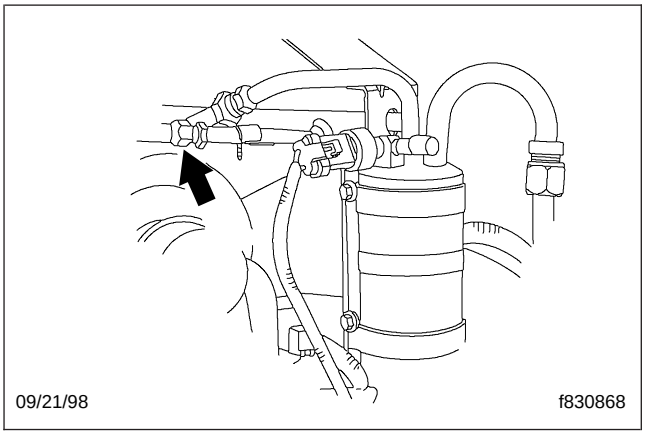


Fig. 1, Orifice Tube Fitting

4. Remove the orifice tube.
5. Install a new orifice tube.
6. Replace the O-ring in the fitting. Lubricate the O-ring with mineral oil before installing the O-ring.
7. Connect the refrigerant line to the orifice tube fitting. Torque the fitting 15 to 20 lbf·ft (20 to 27 N·m).
8. Evacuate and charge the air conditioning system. For instructions, see **Subject 130**.
9. Leak check the orifice tube fitting.
10. Remove the chocks from the tires.

Accumulator Replacement

Replacement Guidelines

NOTE: The accumulator/drier contains a desiccant bag to absorb any moisture that may be in the system. It is important to protect the accumulator/drier by capping any open lines when performing service work on the refrigerant system. Replacement of the accumulator/drier is necessary anytime a major component of the refrigerant system is replaced. Major components include the condenser, the refrigerant compressor, the evaporator, or a refrigerant hose or line. An orifice tube or an O-ring is not considered a major component. However, the orifice tube must be replaced whenever the compressor is replaced.

In addition, the accumulator/drier must be replaced if:

- The accumulator/drier is leaking;
- There has been a complete loss of charge in the refrigerant system;
- There is evidence of moisture in the system, such as internal corrosion of metal refrigerant lines or the refrigerant oil is thick and dark.

NOTE: When replacing the accumulator/drier, this procedure must be followed to make sure that the total oil charge in the system is correct after the new accumulator/drier is installed.

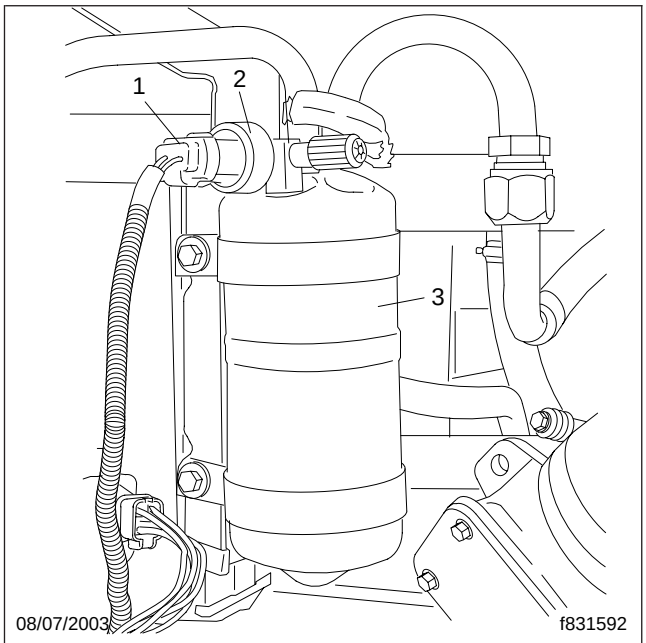
1. Drain the oil from the removed accumulator/drier into a measuring container. It may be necessary to drill one or two 1/2-inch (12.7-mm) holes in the bottom of the accumulator/drier to make sure all the oil has been drained out.
2. Add the same amount of new, clean refrigerant oil, plus the amount of oil that was removed from the system during refrigerant recovery, to the new accumulator/drier. Use only the oil specified for the specific vehicle being serviced.

Replacement

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 130**.
4. Disconnect the electrical connector and the refrigerant compressor cycling switch from the accumulator. See **Fig. 1**.



1. Electrical Connector
2. Refrigerant Compressor Cycling Switch
3. Accumulator

Fig. 1, Accumulator

5. Disconnect the refrigerant lines from the accumulator. Quickly cap the refrigerant lines.

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

6. Remove the capscrews that attach the accumulator to the mounting bracket and remove the accumulator.

Accumulator Replacement

7. Drain the refrigerant oil from the accumulator.
   - 7.1 Drill one or two 1/2-inch (13-mm) holes in the bottom of the accumulator that was just removed.
   - 7.2 Drain the refrigerant oil from the accumulator into a calibrated container. Record the amount of oil recovered and properly dispose of the recovered oil.
8. Add the same amount of clean refrigerant oil that was drained from the accumulator, plus the amount of oil that was removed from the system during refrigerant recovery, to the new accumulator.
9. Using capscrews, install the new accumulator to the mounting bracket.
10. Uncap the refrigerant lines.
11. Replace the O-rings on the refrigerant lines. Lubricate the O-rings with mineral oil before installing.
12. Connect the refrigerant lines to the accumulator. Torque the fittings on the refrigerant lines 25 to 30 lbf·ft (34 to 41 N·m).
13. Connect the refrigerant compressor cycling switch and the electrical connector to the accumulator. Tighten the cycling switch by hand only.
14. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 130**.
15. Return the hood to the operating position.
16. Remove the chocks from the tires.

Removal

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 130**.
4. Disconnect the refrigerant lines from the condenser. Quickly cap the condenser inlet and outlet ports if the condenser will be reinstalled, and cap the refrigerant lines.

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

5. Remove the fasteners that attach the condenser to the radiator, and remove the condenser.

Installation

1. Using fasteners, install the condenser on the radiator. Torque the fasteners 26 to 34 lbf·ft (35 to 46 N·m).
2. Uncap the inlet and outlet ports on the condenser and uncap the refrigerant lines.
3. On refrigerant line connections that have a Mini Stat-O-Seal assembly, replace the Mini Stat-O-Seals. **Do not** lubricate Mini Stat-O-Seals prior to installation. Use **only** a Mini Stat-O-Seal on a Mini Stat-O-Seal assembly.

   On refrigerant line connections that have threaded fittings, replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.
4. Connect the refrigerant lines to the condenser.

   On refrigerant lines that have a Mini Stat-O-Seal assembly, torque the bolt on the retaining plate 11 to 15 lbf·ft (15 to 20 N·m).

   On refrigerant lines that have threaded fittings, torque the fittings 10 to 15 lbf·ft (14 to 20 N·m).
5. Evacuate, leak test, and charge the air conditioning system with refrigerant. For instructions, see **Subject 130**.
6. Return the hood to the operating position.
7. Remove the chocks from tires.

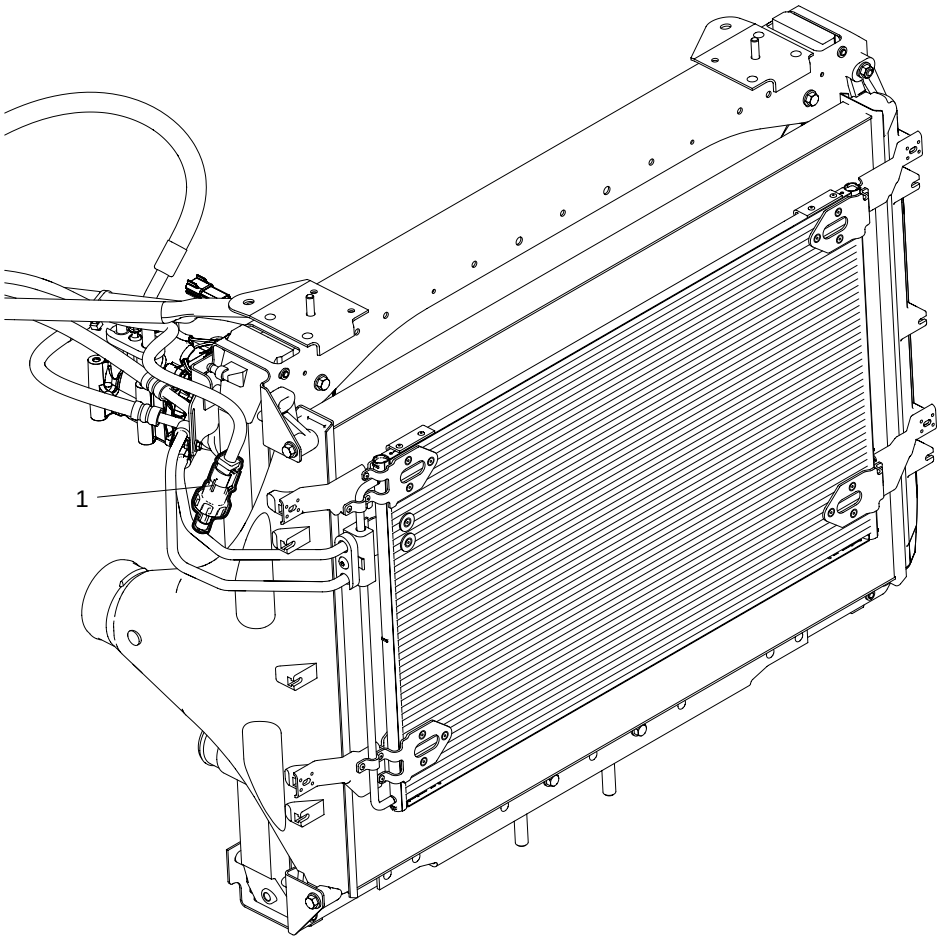
Replacement

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Disconnect the electrical connector from the engine fan cycling switch. See **Fig. 1**.
4. Remove the cycling switch.
5. Check the condition of the O-ring before installing the cycling switch. If necessary, replace the O-ring. Lubricate the O-ring with mineral oil before installing.
6. Install a new engine fan cycling switch. Tighten the switch by hand only.
7. Connect the electrical connector to the cycling switch.
8. Return the hood to the operating position.
9. Remove the chocks from the tires.

Engine Fan Cycling Switch Replacement



1. Engine Fan Cycling Switch

Fig. 1, Engine Fan Cycling Switch

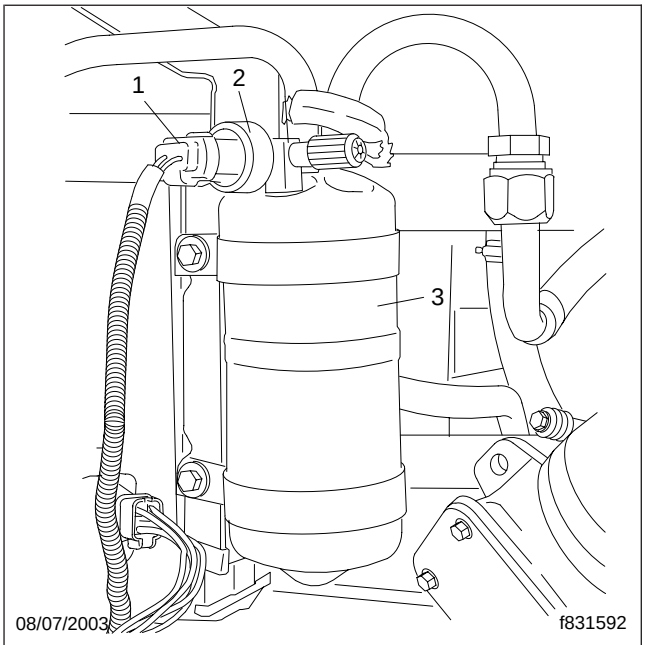
Refrigerant Compressor Cycling Switch Replacement

Replacement

WARNING

Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Disconnect the electrical connector from the refrigerant compressor cycling switch. See **Fig. 1**.
4. Remove the cycling switch.



1. Electrical Connector
2. Refrigerant Compressor Cycling Switch
3. Accumulator

Fig. 1, Refrigerant Compressor Cycling Switch

5. Check the condition of the O-ring before installing the cycling switch. If necessary, replace the O-ring. Lubricate the O-ring with mineral oil before installing.
6. Install a new cycling switch. Tighten the switch by hand only.
7. Connect the electrical connector to the cycling switch.
8. Return the hood to the operating position.
9. Remove the chocks from the tires.

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the auxiliary finish panel. For instructions, see **Group 60**.
4. Remove the screws that attach the climate control panel to the dash panel.
5. Pull the climate control panel away from the dash panel and disconnect the electrical connectors.
6. Remove the climate control panel.

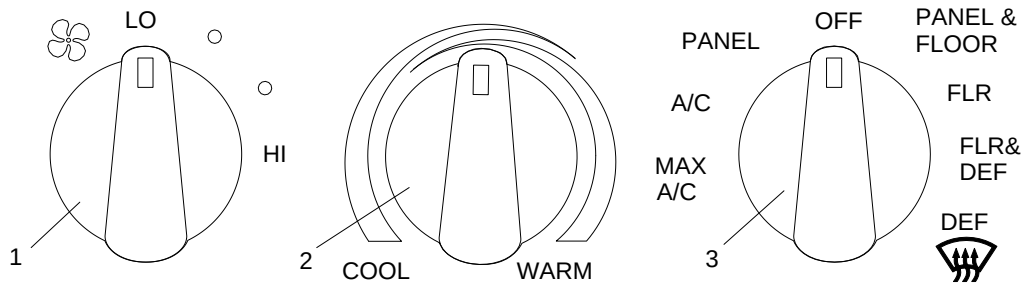
Installation

1. Connect the electrical connectors to the climate control panel.
2. Using screws, attach the climate control panel to the dash panel.
3. Install the auxiliary finish panel. For instructions, see **Group 60**.
4. Connect the batteries.
5. Remove the chocks from the tires.

Fan, Temperature Control, and Air Selection Switches Replacement

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the fan switch, temperature control switch, or air selection switch knob by pulling it off the climate control panel. See **Fig. 1**.
4. Remove the climate control panel. For instructions, see **Subject 210**.
5. Remove the screw that attaches the switch to the climate control panel. Rotate and remove the switch.
6. Using a screw, install a new switch on the climate control panel.
7. Install the climate control panel. For instructions, see **Subject 210**.
8. Install the fan switch, temperature control switch, or air selection switch knob by pushing it on the switch.
9. Connect the batteries.
10. Remove the chocks from the tires.



1. Fan Switch Knob
2. Temperature Control Switch Knob
3. Air Selection Switch Knob

Fig. 1, Climate Control Panel

Temperature/Blend Air Actuator Replacement

NOTE: The temperature/blend air actuator is referred to as the blend door actuator on the wiring schematic, drawing number D06-39579.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the screws that attach the heater core cover to the heater core housing, and remove the cover. See **Fig. 1**.
4. Disconnect the electrical connector from the temperature/blend air actuator. See **Fig. 2**.
5. Remove the screws that attach the temperature/blend air actuator to the HVAC assembly, and remove the actuator.
6. Using screws, install a new temperature/blend air actuator on the HVAC assembly.
7. Connect the electrical connector to the actuator.
8. Using screws, attach the heater core cover to the heater core housing.
9. Connect the batteries.
10. Remove the chocks from the tires.

Defrost/Panel Actuator Replacement

NOTE: The defrost/panel actuator is referred to as mode #3 module on the wiring schematic, drawing number D06-39579.

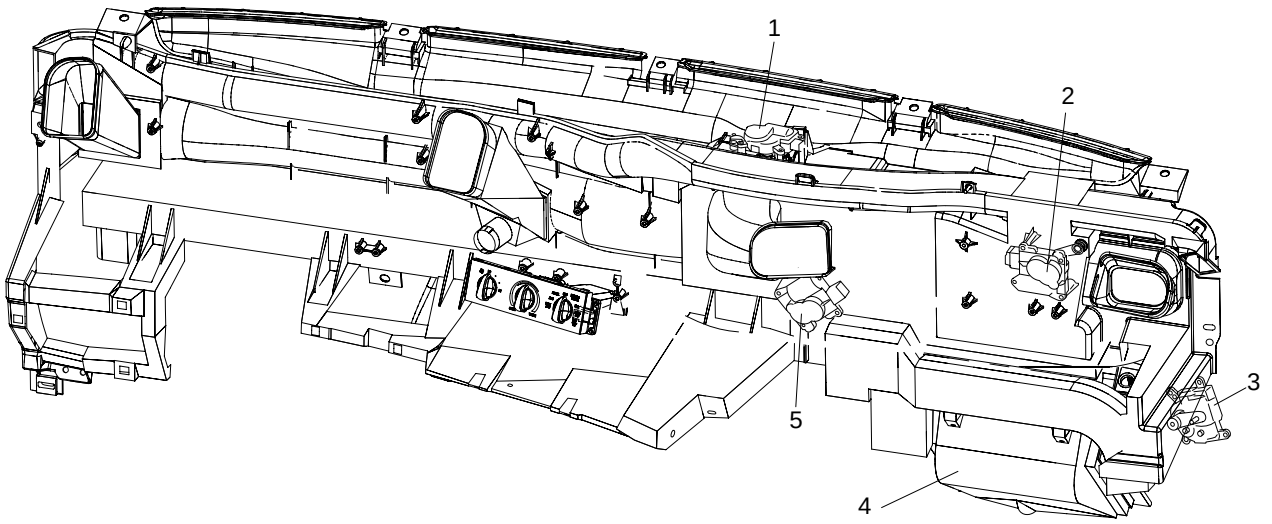
1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the actuator trim cover from the instrument panel. See **Fig. 3**.
4. Disconnect the control arms from the defrost/panel actuator.
5. Disconnect the electrical connector from the actuator.
6. Remove the screws that attach the defrost/panel actuator to the HVAC assembly, and remove the actuator. See **Fig. 1**.
7. Connect the electrical connector to a new defrost/panel actuator and position the actuator where it is to be installed on the HVAC assembly.
8. Connect the control arms to the actuator.
9. Using screws, attach the actuator to the HVAC assembly.
10. Install the actuator trim cover on the instrument panel.
11. Connect the batteries.
12. Remove the chocks from the tires.

Fresh Air/Recirculation Actuator Replacement

NOTE: The fresh air/recirculation actuator is referred to as re-circ on the wiring schematic, drawing number D06-39579.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the screws that attach the heater core cover to the heater core housing, and remove the cover. See **Fig. 1**.
4. Disconnect the control arms from the fresh air/recirculation actuator.
5. Disconnect the electrical connector from the actuator.
6. Remove the screws that attach the fresh air/recirculation actuator to the HVAC assembly, and remove the actuator. See **Fig. 1**.
7. Connect the electrical connector to a new fresh air/recirculation actuator and position the actuator where it is to be installed on the HVAC assembly.
8. Connect the control arms to the actuator.
9. Using screws, attach the actuator to the HVAC assembly.
10. Using screws, attach the heater core cover to the heater core housing.
11. Connect the batteries.

Actuator Replacement



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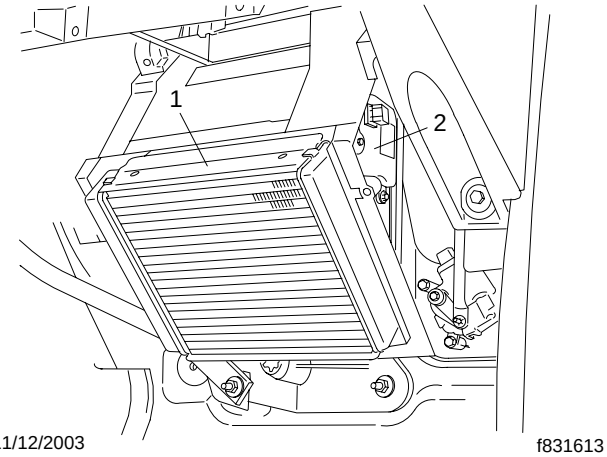
1. Defrost/Panel Actuator
2. Right-Side Panel/Demist Actuator
3. Fresh Air/Recirculation Actuator
4. Heater Core Cover
5. Panel/Floor Actuator

Fig. 1, Actuator Locations



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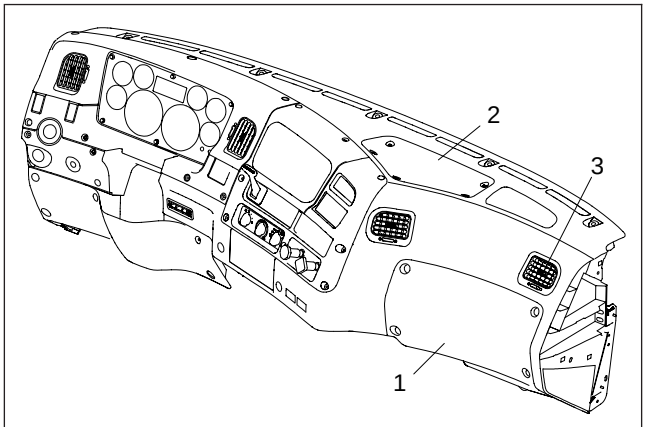
1. Heater Core
2. Temperature/Blend Air Actuator

Fig. 2, Location of Temperature/Blend Air Actuator



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1. Power Distribution Module Cover
2. Actuator Trim Cover
3. Louvers and Louver Housing

Fig. 3, Instrument Panel

12. Remove the chocks from the tires.

Panel/Floor Actuator Replacement

NOTE: The panel/floor actuator is referred to as mode #2 module on the wiring schematic, drawing number D06-39579.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the power distribution module cover from the instrument panel. See **Fig. 3**.
4. Remove the screws that attach the power distribution module separator to the instrument panel, and remove the separator.
5. Remove the screws that attach the power distribution module to the instrument panel, and move the module to the cab floor.
6. Disconnect the electrical connector from the panel/floor actuator. See **Fig. 1**.
7. Remove the screws that attach the panel/floor actuator to the HVAC assembly, and remove the actuator.
8. Using screws, install a new panel/floor actuator on the HVAC assembly.
9. Connect the electrical connector to the actuator.
10. Using screws, install the power distribution module.
11. Using screws, install the power distribution module separator.
12. Install the power distribution module cover on the instrument panel.
13. Connect the batteries.
14. Remove the chocks from the tires.

Right-Side Panel/Demist Actuator Replacement

NOTE: The right-side panel/demist actuator is referred to as mode #1 module on the wiring schematic, drawing number D06-39579.

NOTE: The right-side panel/demist actuator can be removed by removing the right-side louvers and the louver housing, or by removing the power distribution module cover.

Louver Removal Method

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Access the tabs on the lower portion of the louver housing by moving the bottom of the louvers back. Use a screwdriver to release the tabs and pull the louvers and louver housing out of the dash panel. See **Fig. 3**.
4. Remove the screws that attach the actuator to the HVAC assembly, and remove the actuator. See **Fig. 1**.
5. Disconnect the electrical connector from the right-side panel/demist actuator.
6. Connect the electrical connector to the new actuator.
7. Using screws, install a right-side panel/demist actuator on the HVAC assembly.
8. Install the louvers and louver housing in the instrument panel.
9. Connect the batteries.
10. Remove the chocks from the tires.

Power Distribution Module Cover Removal Method

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the power distribution module cover from the instrument panel. See **Fig. 3**.
4. Disconnect the electrical connector from the right-side panel/demist actuator. See **Fig. 1**.
5. Remove the screws that attach the actuator to the HVAC assembly, and remove the actuator.
6. Using screws, install a new right-side panel/demist actuator on the HVAC assembly.
7. Connect the electrical connector to the actuator.

Actuator Replacement

8. Install the power distribution module cover on the instrument panel.
9. Connect the batteries.
10. Remove the chocks from the tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.

WARNING

The engine must be off and fully cooled, and the cooling system fully depressurized before disconnecting any heater water hoses. Failure to comply with these warnings can result in serious personal injury from hot liquid escaping from the engine cooling system.

3. Drain the coolant from the cooling system. For instructions, see **Group 20**.
4. Loosen the hose clamps on the heater hoses.
5. Remove the heater hose.

CAUTION

Install the heater hoses so that they are not pinched and do not contact any part of the exhaust system. Doing so will prevent the hoses from being damaged.

NOTE: Cut a new hose of the same diameter to the same length as the old hose.

6. Install the heater hose.
7. Tighten the hose clamps on the heater hoses.
8. Fill the cooling system with coolant. For instructions, see **Group 20**.
9. Return the hood to the operating position.
10. Remove the chocks from the rear tires.

Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.

WARNING

The engine must be off and fully cooled, and the cooling system fully depressurized before disconnecting any heater water hoses. Failure to comply with these warnings can result in serious personal injury from hot liquid escaping from the engine cooling system.

3. Drain the coolant from the cooling system. For instructions, see **Group 20**.

NOTE: There are two heater core shutoff valves on the vehicle.

4. Loosen the heater hose clamp and remove the heater hose from the heater core shutoff valve.
5. Remove and discard the shutoff valve.
6. Apply pipe sealant with Teflon® (D8AZ-19554-A or equivalent) to the threads on the new shutoff valve.
7. Install the heater hose on the shutoff valve.
8. Tighten the hose clamp on the heater hose.
9. Fill the cooling system with coolant. For instructions, see **Group 20**.
10. Return the hood to the operating position.
11. Remove the chocks from the tires.

Replacement

1. Remove the heater core. For instructions, see **Subject 270**.
2. Remove the evaporator housing. For instructions, see **Subject 140**.
3. Disconnect the electrical connector.
4. Remove the nuts that attach the heater core housing to the firewall, and remove the heater core housing. See **Fig. 1** and **Fig. 2**.

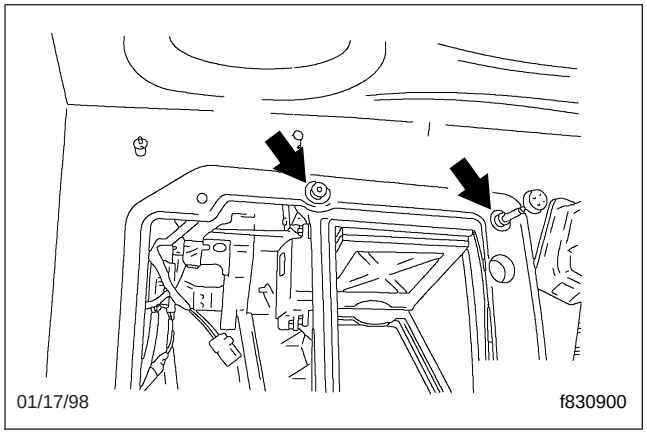


Fig. 1, Heater Core Housing Nuts

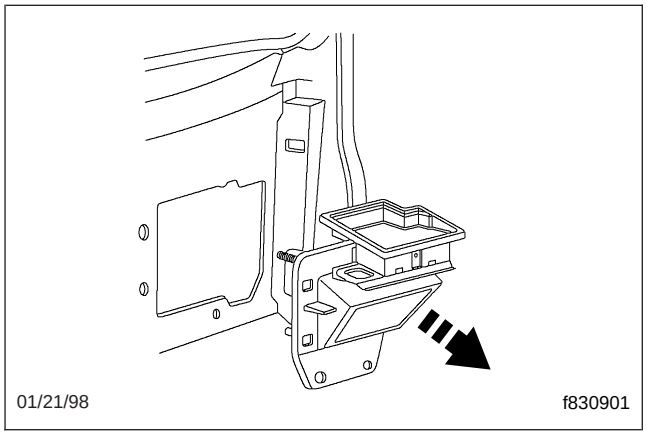


Fig. 2, Heater Core Housing

5. Using nuts, install a new heater core housing on the firewall.
6. Connect the electrical connector.
7. Install the evaporator housing. For instructions, see **Subject 140**.
8. Install the heater core. For instructions, see **Subject 270**.

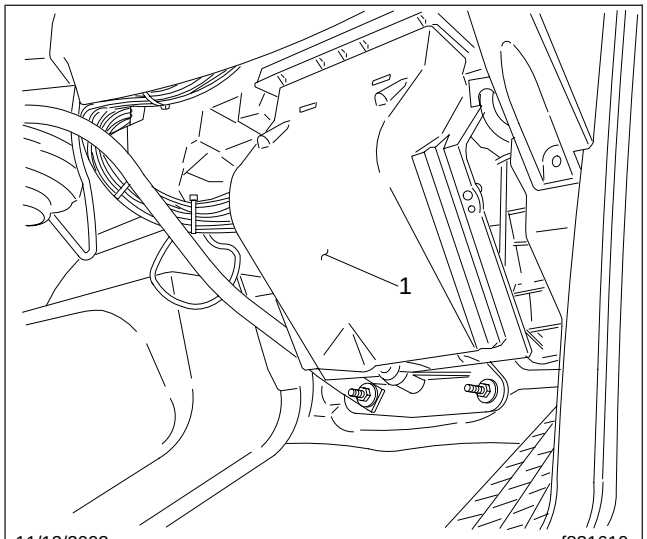
Replacement

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.

⚠ WARNING

The engine must be off and fully cooled, and the cooling system fully depressurized before disconnecting any heater water hoses. Failure to comply with these warnings can result in serious personal injury from hot liquid escaping from the engine cooling system.

3. Close the heater core shutoff valves or clamp the heater hoses.
4. Loosen the heater hose clamps and remove the heater hoses from the heater core.
5. Remove the screws that attach the heater core cover to the heater core housing, and remove the cover. See **Fig. 1**.

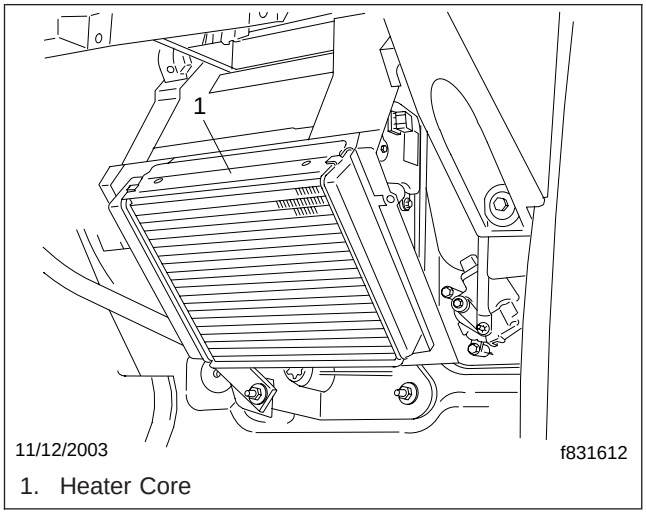


1. Heater Core Cover

Fig. 1, Heater Core Cover

IMPORTANT: A small amount of antifreeze may be present in the heater core. Protect the interior of the vehicle to prevent any damage from an antifreeze spill.

6. Wearing protective gloves, remove the heater core and drain any remaining coolant from the heater core. See **Fig. 2**.



1. Heater Core

Fig. 2, Heater Core

7. Apply rubber suspension insulator lube or its equivalent to the heater core tubes and to the frontwall seals to allow the heater core tubes to pass easily through the frontwall during installation.
8. Wearing protective gloves, install a new heater core in the heater core housing.
9. Using screws, attach the heater core cover to the heater core housing.
10. Attach the heater hoses to the heater core and tighten the hose clamps.
11. Open the heater core shutoff valves or remove the clamps from the heater hoses.
12. Add coolant to the cooling system to replace the amount that was lost during the replacement procedure. For instructions, see **Group 20**.
13. Return the hood to the operating position.
14. Remove the chocks from the tires.

General Information

The cab heating, ventilating, and air conditioning (HVAC) system is an electrically-controlled blend air system. This type of system began being installed on vehicles in July 2000.

On vehicles equipped with air conditioning, all airflow is routed through the evaporator. A blend air door is used to control the amount of air that is routed through the heater core. The amount of air directed through the heater core is dependent on the temperature control switch setting. Electric actuators control the position of the four mode doors, and thus the airflow, within the HVAC system. The actuators are controlled by the control panel module located on the back of the climate control panel. The speed of the blower motor is controlled by reducing the current through a resistor block.

The cab heater and air conditioner consists of a blower motor, evaporator, heater core, and five electric actuators that control the temperature control doors, the air selection mode doors, and the recirculation door. All electric actuators, except the temperature/blend air actuator, are controlled by the control panel module. The temperature/blend air actuator is controlled by a potentiometer on the climate control panel.

- The temperature/blend air actuator controls temperature by controlling the airflow through the heater core.
- The fresh air/recirculation actuator allows fresh air into the cab or allows the air in the cab to be recirculated.
- The panel/floor actuator controls the airflow to the floor outlets and to the instrument panel outlets, with the exception of the right-side instrument panel outlet.
- The right-side panel/demist actuator controls the airflow to the right-side instrument panel outlet and demist outlet.
- The defrost/panel actuator controls the airflow to the defrost outlets and to the instrument panel outlets, with the exception of the right-side instrument panel outlet.

See **Table 1** for the location of the air selection switch positions.

Air Selection Switch Positions

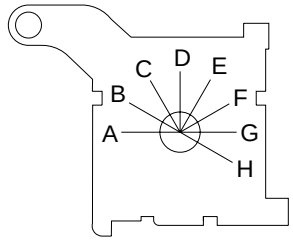
Figure	Switch Position	HVAC Option		
		Heater (–000)	A/C (–001)	Max A/C (–002)
 05/14/2004 f544451	A	Not Available	MAX A/C	MAX A/C
	B	PANEL	A/C	MAX A/C
	C	PANEL & FLOOR	PANEL	PANEL
	D	OFF	OFF	OFF
	E	FLR	PANEL & FLOOR	PANEL & FLOOR
	F	FLR & DEF	FLR	FLR
	G	DEF	FLR & DEF	FLR & DEF
	H	Not Available	DEF	DEF

Table 1, Air Selection Switch Positions

HVAC System Troubleshooting Tables

See **Table 2** to determine which troubleshooting table to refer to for the problem area of the HVAC system.

Troubleshooting the HVAC System

General Diagnosis	
General Problem Area	**Action**
Air Distribution	See **Table 6**.
Blower	See **Table 9** and **Table 10**.
Little or No Cooling	See **Table 3**.
Little or No Heating	See **Table 4**.
Fresh Air/Recirculation	See **Table 12**.
Backlighting	See **Table 5**.
A/C Clutch Not Engaging	See **Table 16**.
CHECK A/C Indicator Illuminated*	See **Table 17**.

* Only vehicles built with pre-2004 engines have a CHECK A/C indicator.

Table 2, General Diagnosis

Little or No Cooling Diagnosis			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Does A/C clutch engage?	Yes	**Go to test no. 2.**
		No	See **Table 16** for diagnosis.
2	Temporarily pinch off the hoses going to the heater core. Is the outlet temperature now acceptable?	Yes	See **Table 7** for diagnosis of temperature/ blend air actuator.
		No	See **Subject 310** for the Refrigerant System Diagnosis procedures.

Table 3, Little or No Cooling Diagnosis

Little or No Heating Diagnosis			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Check engine coolant level.	OK	**Go to test no. 2.**
		Not OK	Check for coolant leaks. Repair as necessary. If vehicle still has a heating problem, **go to test no. 2.**
2	Check heater hose temperatures entering and exiting the heater core: • Set the temperature control switch to full hot. • Set the blower speed to HI. • Set the mode control to PANEL. • Bring engine to operating temperature. Feel both heater hoses going in to and out of the heater core.	Both hot	Check for possible blend door malfunction. See **Table 7** for diagnosis of temperature/ blend air actuator.
		One hot, one cool	Possible plugged heater core. Flush or replace as necessary.
		Both cool to lukewarm	Check engine thermostat for proper operation. Check for closed heater hose valves, if equipped.

Table 4, Little or No Heating Diagnosis

Backlighting Diagnosis			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Check power and ground to control panel: • Gain access to back of control panel. • Remove the AC2 connector. See **Subject 400** for wiring diagrams. • Turn headlight switch ON. Measure voltage across pins 1 and 2 of the AC2 connector.	Approx. 12V	Replace bulb(s). If backlightling still does not work, replace the control panel.
		0V	Check backlighting circuit 29A and ground for open.

Table 5, Backlighting Diagnosis

Air Distribution Diagnosis	
Symptom	**Action**
No air flow from defrost outlets	Does air come out of floor outlets in defrost mode? Yes—**go to Table 14** for diagnosis. No—**go to Table 13** for diagnosis.
No airflow from floor outlets	**Go to Table 14** for diagnosis.
No airflow from panel outlets, except right-side outlet	Does air come out of the floor outlets in PANEL mode? Yes—**go to Table 14** for diagnosis. No—**go to Table 13** for diagnosis.
No airflow from right-side outlet	**Go to Table 15** for diagnosis.
Airflow from floor outlets in all mode positions	**Go to Table 14** for diagnosis.
Airflow from defrost and panel outlets in all mode positions, except floor	**Go to Table 13** for diagnosis.
No recirc or fresh air	**Go to Table 12** for diagnosis.

Table 6, Air Distribution Diagnosis

Temperature/Blend Air Actuator Electrical Diagnosis			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Check fuse/circuit breaker no. 18.	OK	**Go to test no. 2**.
		Not OK	Check circuit 220 for short to ground. Repair as necessary. If OK, replace actuator.

Troubleshooting the HVAC System

Temperature/Blend Air Actuator Electrical Diagnosis			
Test No.	**Test Procedure**	**Test Result**	**Action**
2	Disconnect the temperature potentiometer connector AC3. • Turn ignition ON. Measure voltage across pins 1 and 3 of the temperature potentiometer connector (harness side). NOTE: Connect electrical connector when test is complete. Leave connector accessible. It may require removal in later tests.	Approx. 10V	**Go to test no. 4**.
		Much less than 10V	**Go to test no. 3**.
3	Disconnect the connector to the temperature/blend air actuator. See **Fig. 7**. • Turn ignition ON. Measure voltage across pins 1 and 2 at the actuator connector (harness side). NOTE: Connect electrical connector when test is complete.	Approx. 12V	Check circuits 98K1 and 98K2 for open. Repair as necessary. See **Subject 400** for wiring diagrams. If circuits are okay, replace actuator.
		Much less than 12V	Check circuit 220 and actuator ground circuit for open. Repair as necessary. See **Subject 400** for wiring diagrams.
4	Disconnect the temperature potentiometer connector AC3. • Turn ignition OFF. Measure resistance across pins 1 and 2 of the temperature potentiometer connector (harness side). NOTE: Connect electrical connector when test is complete. Leave connector accessible. It may require removal in later tests.	Approx. 195k ohms	**Go to test no. 6**.
		Much greater than 195k ohms	**Go to test no. 5**.
5	Remove the temperature/blend air actuator. See **Fig. 7**. Measure resistance across pins 5 and 6 at the actuator connector (actuator side).	Approx. 195k ohms	Check circuits 98K2 and 98K3 for open. Repair as necessary. See **Fig. 1**. See **Subject 400** for wiring diagrams.
		Much greater than 195k ohms	Replace actuator.
6	Disconnect the temperature potentiometer connector AC3. • Turn ignition OFF. Measure resistance between harness side of pin 1 and a known good ground. NOTE: Connect electrical connector when test is complete. Leave connector accessible. It may require removal in later tests.	Less than 1 ohm	**Go to test no. 7**.
		More than 1 ohm	Check actuator ground circuit. Repair as necessary. See **Subject 400** for wiring diagrams.

Temperature/Blend Air Actuator Electrical Diagnosis			
Test No.	**Test Procedure**	**Test Result**	**Action**
7	Temperature potentiometer resistance check: • Disconnect the temperature control potentiometer connector AC3 (back of HVAC control panel). Measure resistance at the potentiometer as follows. See **Fig. 1**. • Across pins 1 and 3: should be approx. 5000 ohms • Across pins 1 and 2: should be approx. 80 ohms (cold) and approx. 5150 ohms (hot).	OK	**Go to test no. 8**.
		Not OK	Replace temperature potentiometer.
8	Remove the temperature/blend air actuator. See **Fig. 7**. Move the temperature door arm and check for obstruction or mechanical problem, such as binding.	OK	Replace actuator.
		Not OK	Mechanical problem. Repair as necessary.

Table 7, Temperature/Blend Air Actuator Electrical Diagnosis

Actuator Function Logic						
Air Selection Switch Setting*	**Actuator†**				**A/C 001 and 002 only**	**Blower**
	No. 1 Right-Side Panel/Demist	**No. 2 Panel/Floor**	**No. 3 Defrost/Panel**	**No. 4 Fresh Air/ Recirc‡**		
MAX A/C	CW	CCW	CCW	CW	X	On
A/C	CW	CCW	CCW	CCW§	X	On
PANEL	CW	CCW	CCW	CCW	§	On
OFF	Middle§	Middle§	CCW	CW§		Off§
PANEL & FLOOR	Middle	Middle	CCW	CCW§	X§	On§
FLR	CCW§	CW§	CW§	CCW	§	On
FLR & DEF	CCW	Middle§	CW	CCW	X§	On
DEF	CCW	CCW§	CW	CCW	X	On

* Use this table by starting with the switch at MAX A/C and moving through the settings as listed in the column.
† See **Fig. 7**.
‡ With the ignition off, the fresh air/recirc actuator drives recirc clockwise from any mode.
§ A change in state has occurred.

Table 8, Actuator Function Logic

Troubleshooting the HVAC System

Blower Motor Diagnosis—Blower Does Not Operate at Any Speed			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Before proceeding, perform test in **Table 18**. If this does not correct the problem, return to this table, step 2.		
2	Check if blower relay is switching on: • Disconnect the blower motor connector. • Set the blower speed switch to any speed. • Set the mode control switch to any position except OFF. • Turn ignition ON. Measure voltage between pin 1 (circuit 98FA) of the blower motor connector (harness side) and a known good ground. See **Subject 400** for wiring diagrams.	Approx. 12V	**Go to test no. 8**.
		Less than 1V	**Go to test no. 3**.
3	Check voltage to the coil side of the blower motor relay: • Remove blower motor relay (relay 8). • Turn ignition ON. Measure voltage between the relay cavity in the PDM that mates with pin 1 of the relay and a known good ground.	Approx. 12V	**Go to test no. 4**.
		Less than 1V	Check circuit breaker 18 in cab PDM. Check circuit 220 (305 on vehicles with a 2004 engine) for open or short. Repair as necessary. See **Subject 400** for wiring diagrams.
4	Check if the control panel is providing ground to switch the blower motor relay on: • Turn ignition ON. Measure voltage between relay cavities in the PDM that mate to pins 1 and 2 of the blower motor relay. Check for the following: • When the mode control switch is in the OFF position, the voltage reading should be approx. 6V. • When the mode control switch is in any position except OFF, the voltage reading should be approx. 12V.	OK	**Go to test no. 5**.
		Not OK	Check circuit 98Z for open, check power and ground circuits to HVAC control panel. Repair as necessary. See **Subject 400** for wiring diagrams. If circuits are okay, replace the control panel.

Blower Motor Diagnosis—Blower Does Not Operate at Any Speed			
Test No.	**Test Procedure**	**Test Result**	**Action**
5	Check relay coil resistance. Check resistance across pins 1 and 2 of the blower motor relay. NOTE: If the resistance is approximately 680 ohms, the relay coil is open. If the resistance is approximately 70 ohms, the surge suppression resistor is open. In either case the relay should be replaced.	Approx. 62 to 64 ohms	**Go to test no. 6**.
		Greater than 64 ohms	Replace the relay.
6	Check for voltage at the high side of the blower motor relay. Measure voltage between the relay cavity in the PDM that mates to pin 3 of the blower motor relay (relay 8) and a known good ground.	Approx. 12V	**Go to test no. 7**.
		Less than 1V	Check circuit breaker G in the engine compartment PDM. Check for open/short in circuit 210G that supplies power to the high side of the blower motor relay. Repair as necessary. See **Subject 400** for wiring diagrams.
7	Check continuity in circuit 98FA between blower motor relay and blower motor: • Disconnect blower motor connector. Check continuity between relay cavity in the PDM that mates to pin 5 of the blower motor relay, and pin 1 of the blower motor connector.	Continuity	Check for stuck relay contacts. If OK, check same circuit 98FA using a voltage drop test to confirm circuit. Voltage drop should be less than 1V. Repair as necessary.
		No continuity	Circuit 98FA is open. Repair as necessary.
8	Check voltage drop across blower motor: • Install blower motor relay (relay 8). • Connect blower motor connector. • Turn ignition ON. • Turn fan to HI. • Set mode control switch to any position except OFF. Measure the voltage drop across the blower motor connector (leave connector plugged in) by backprobing the two pins.	More than 10V	Replace blower motor.
		Less than 10V	Check circuit 98FA using a voltage drop test to confirm circuit between blower motor relay and the blower motor. Voltage drop should be less than 1V. If circuit 98FA is OK, perform same check on ground circuit between the blower motor and splice S2. Repair as necessary. See **Subject 400** for wiring diagrams.

Table 9, Blower Motor Diagnosis—Blower Does Not Operate at Any Speed

Blower Motor Diagnosis—Blower Does Not Work in One or Multiple Speed Settings			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Does the blower motor work in one or more speed settings?	Yes	**Go to test no. 2**.
		No	See **Table 9**, Blower Motor Diagnosis—Blower Does Not Operate at Any Speed.

Troubleshooting the HVAC System

Blower Motor Diagnosis—Blower Does Not Work in One or Multiple Speed Settings			
Test No.	**Test Procedure**	**Test Result**	**Action**
2	Does the blower operate in LO speed?	Yes	**Go to test no. 6**.
		No	**Go to test no. 3**.
3	Check the blower resistor block: • Unplug resistor block. Measure resistance across the following pins. See **Fig. 2**. Pins 1 and 3: approx. 0.4 ohm Pins 3 and 4: approx. 1 ohm Pins 2 and 3: approx. 3 ohms If any of the readings are significantly higher than the values shown (meter reads OL), or if any of the readings are zero, then the result is not OK. NOTE: Plug connector back into resistor block when test is complete.	OK	**Go to test no. 4**.
		Not OK	Replace blower resistor block.
4	Check circuit 98F between blower motor and resistor block: • Turn ignition ON. • Set blower speed to MED-HI. • Set mode control switch to any position except OFF. Measure voltage drop between pin 2 (circuit 98F) of the blower motor connector and pin 3 (circuit 98F) of the resistor block by backprobing the connectors. NOTE: Connectors must be plugged in when performing this test.	Less than 0.25V	**Go to test no. 5**.
		More than 0.25V	Repair circuit 98F between blower motor and resistor block.
5	Check resistor block ground circuit: • Turn ignition ON. • Set blower speed to LO. • Set mode control switch to any position except OFF. Measure voltage drop between pin 2 of the resistor block (by backprobing) and the battery negative terminal. NOTE: Connectors must be plugged in when performing this test.	Less than 0.25V	No problem found. Repeat tests.
		More than 0.25V	Locate open or source of high resistance in resistor block ground circuit. Repair as necessary.

Blower Motor Diagnosis—Blower Does Not Work in One or Multiple Speed Settings			
Test No.	**Test Procedure**	**Test Result**	**Action**
6	Check blower motor switch: • Remove blower motor switch connector from the control panel. Check continuity of the switch as follows. See **Fig. 3**. LO: pin 1 to pins 2 through 4—No continuity MED-LO: pin 1 to pin 3—Continuity MED-HI: pin 1 to pin 4—Continuity HI: pin 1 to pin 2—Continuity NOTE: Connect blower switch connector when test is complete.	OK	**Go to test no. 7**.
		Not OK	Replace blower speed switch.
7	Check blower speed switch ground circuit: • Turn ignition ON. • Set blower speed to HI. • Set mode control switch to any position except OFF. Measure voltage drop between pin 1 (GND) of the blower switch (by backprobing) and the battery negative terminal. NOTE: Connectors must be plugged in when performing this test.	Less than 0.25V	Depending on which speed does not work, check the following circuits: For MED-LO: 98A For MED-HI: 98B For HI: 98F between splice S2 and blower switch
		More than 0.25V	Repair blower switch ground circuit.

Table 10, Blower Motor Diagnosis—Blower Does Not Work in One or Multiple Speed Settings

HVAC Control Panel Pinout		
Pin	**Description**	**Circuit**
1	Not used	—
2	Mode no. 1 and no. 2 actuator position sensor ground	GND1
3	Mode no. 2 actuator position sensor feedback	338F2
4	Recirc actuator–open	338E
5	Mode no. 3 actuator–open	338C–
6	Mode no. 2 actuator–CW	338B–
7	Mode no. 1 actuator–CW	338A–
8	Blower motor relay control	98Z
9	Ground	GND2
10	+12V battery	97A
11	Mode no. 2 actuator position sensor +5V reference	338H

Troubleshooting the HVAC System

HVAC Control Panel Pinout		
Pin	**Description**	**Circuit**
12	Mode no. 1 actuator position sensor +5V reference	338G
13	Mode no. 1 actuator position sensor feedback	338F1
14	Recirc actuator–closed	338D
15	Mode no. 3 actuator–closed	338C+
16	Mode no. 2 actuator–CCW	338B+
17	Mode no. 1 actuator–CCW	338A+
18	A/C clutch relay control	97
19	Not used	—
20	+12V ignition switched	220

Table 11, HVAC Control Panel Pinout

Fresh Air/Recirculation Actuator No. 4 Circuit Diagnosis			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Check for signal from control panel: • Disconnect the fresh air/recirc actuator connector. See **Fig. 7**. • Turn ignition ON. Set DMM to read voltage, then place meter leads in harness side of actuator connector as follows: • (+) lead in pin 4 (circuit 338D) • (–) lead in pin 2 (circuit 338E) Start with the mode control switch in the OFF position. Then set the mode switch as follows and observe the voltage readings: MAX A/C: –10.5V± then 0V A/C: +10.5V± then 0V PANEL: +10.5V± then 0V OFF: –10.5V± then 0V PANEL & FLOOR: +10.5V± then 0V FLR: 0V FLR & DEF: 0V DEF: 0V If working correctly, the voltages listed should be present for a few seconds, then go to zero. For example, when the mode is switched to MAX A/C, the voltage should be approximately –10.5 V for a few seconds, then it will go to zero. NOTE: The voltage readings listed may range from approximately ±9 to 11V.	OK	Check for mechanical problem, such as binding. Repair as necessary If no mechanical problem is present, replace the fresh air/recirc actuator.
		Not OK	Check circuits 338D and 338E between control panel and recirc actuator for open or short circuit. Repair as necessary. If circuits 338D and 338E are OK, replace the control panel. NOTE: Assumes control panel is getting power/ground.

Table 12, Fresh Air/Recirculation Actuator No. 4 Circuit Diagnosis

Troubleshooting the HVAC System

Defrost/Panel Actuator No. 3 Circuit Diagnosis			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Check for signal from control panel: • Disconnect the defrost/panel actuator connector. See **Fig. 7**. • Turn ignition ON. Set DMM to read voltage, then place meter leads in actuator connector as follows: • (+) lead in pin 4 (circuit 338C+) • (–) lead in pin 2 (circuit 338C–) Start with the mode control switch in the OFF position. Then set the mode switch as follows and observe the voltage readings: MAX A/C: 0V A/C: 0V PANEL: 0V OFF: 0V PANEL & FLOOR: 0V FLR: –10.5V± then 0V FLR & DEF: 0V DEF: 0V OFF: +10.5V± then 0V If working correctly, the voltages listed should be present for a few seconds, then go to zero. For example, when the mode is switched to FLOOR, the voltage should be approximately –10.5 V for a few seconds, then it will go to zero. NOTE: The voltage readings listed may range from approximately ±9 to 11V.	OK	Check for mechanical problem, such as binding. Repair as necessary If no mechanical problem is present, replace the defrost/panel actuator.
		Not OK	Check circuits 338C+ and 338C– between control panel and defrost/panel actuator no. 3 for open or short circuit. Repair as necessary. If circuits 338C+ and 338C– are OK, replace the control panel. NOTE: Assumes control panel is getting power/ground.

Table 13, Defrost/Panel Actuator No. 3 Circuit Diagnosis

Panel/Floor Actuator (Mode No. 2) Circuit Diagnosis			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Check for actuator position sensor reference voltage and ground: • Disconnect the electrical connector at the actuator. See **Fig. 7**. • Turn ignition ON. Measure voltage across pins 2 and 3 of the actuator connector. See **Fig. 4**.	Approx. 5V	**Go to test no. 2**.
		Approx. 0V	Check circuit 338H (5V ref.) and actuator sensor ground circuit for open or short. Repair as necessary. If the circuits are OK, check power and ground circuits to control panel. If these are also OK, replace the control panel.
2	Check for actuator drive signal from the control panel: • Disconnect the electrical connector at the actuator. See **Fig. 7**. • Turn mode control switch to OFF. • Turn ignition ON. Measure voltage across pins 1 and 6 as follows. See **Fig. 4**. • (–) lead on pin 1 • (+) lead on pin 6 Observe the voltage. The voltage should briefly read approximately 10 to 12V, then go to zero. This repeats approximately every 10 seconds. If the meter observation is as listed, then the signal is OK.	OK	**Go to test no. 4**.
		Not OK	**Go to test no. 3**.
3	Check actuator drive circuit: • Turn ignition OFF. • Gain access to the back of the control panel and disconnect the electrical connector. • Disconnect the actuator connector. See **Fig. 7**. Check continuity in circuit 338B+ between control panel connector pin 16 and the actuator connector pin 6. See **Fig. 4** and **Fig. 5**. Check continuity in circuit 338B– between control panel connector pin 6 and the actuator connector pin 1.	OK	Check power and ground circuits to control panel. Repair as necessary. If the power and ground circuits are OK, replace the control panel.
		Not OK	Repair circuit 338B+ or 338B– as necessary.

Troubleshooting the HVAC System

Panel/Floor Actuator (Mode No. 2) Circuit Diagnosis			
Test No.	**Test Procedure**	**Test Result**	**Action**
4	Check actuator position sensor feedback voltage: • Make sure actuator and mode module connectors are plugged in. • Turn ignition ON. Measure voltage between mode module connector pin 3 (by backprobing) and a known good ground. The voltage should be approx. between 0.5V and 4.5V. See **Fig. 5**.	OK	**Go to test no. 5**.
		Not OK	Check circuit 338F2 for open or short. Repair as necessary. If circuit 338F2 is OK, replace the actuator.
5	Check actuator drive motor resistance: • Remove actuator. See **Fig. 7**. Measure resistance across pins 1 and 6 of the actuator. See **Fig. 4**.	Approx. 96 ohms	**Go to test no. 6**.
		Approx. 0 ohm or meter reads OL	Replace actuator.
6	Check for mechanical problem: • Remove actuator. See **Fig. 7**. Attempt to turn the panel/floor door by hand. Check for binding or obstruction.	OK	Replace actuator.
		Not OK	Repair mechanical problem as necessary.

Table 14, Panel/Floor Actuator (Mode No. 2) Circuit Diagnosis

Right-Side Panel/Demist Actuator (Mode No. 1) Circuit Diagnosis			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Check for actuator position sensor reference voltage and ground: • Disconnect the electrical connector at the actuator. See **Fig. 7**. • Turn ignition ON. Measure voltage across pins 2 and 3 of the actuator connector. See **Fig. 6**.	Approx. 5V	**Go to test no. 2**.
		Approx. 0V	Check circuit 338G (5V ref.) and actuator sensor ground circuit for open or short. Repair as necessary. If the circuits are okay, check power and ground circuits to control panel. If these are also okay, replace the control panel.

Right-Side Panel/Demist Actuator (Mode No. 1) Circuit Diagnosis			
Test No.	**Test Procedure**	**Test Result**	**Action**
2	Check for actuator drive signal mode module: • Disconnect the electrical connector at the actuator. See **Fig. 7**. • Turn mode control switch to OFF. • Turn ignition ON. Measure voltage across pins 1 and 6 as follows. See **Fig. 6**. • (–) lead on pin 1 • (+) lead on pin 6 Observe the voltage. The voltage should briefly read between approximately –10 to –12V, then go to zero. This repeats approx. every 10 seconds. If the meter observation is as listed, then the signal is okay.	OK	**Go to test no. 4**.
		Not OK	**Go to test no. 3**.
3	Check actuator drive circuit: • Turn ignition OFF. • Gain access to the back of the control panel and disconnect the electrical connector. • Disconnect the actuator connector. See **Fig. 7**. Check for continuity in circuit 338A+ between control panel connector pin 17 and the actuator connector pin 6. Check for continuity in circuit 338A– between control panel connector pin 7 and the actuator connector pin 1.	OK	Check power and ground circuits to control panel. Repair as necessary. If the power and ground circuits are OK, replace the control panel.
		Not OK	Repair circuit 338A+ or 338A– as necessary.
4	Check actuator position sensor feedback voltage: • Make sure actuator and control panel connectors are plugged in. • Turn ignition ON. Measure voltage between control panel connector pin 13 (by backprobing) and a known good ground. The voltage should be approx. between 0.5V and 4.5V.	OK	**Go to test no. 5**.
		Not OK	Check circuit 338F1 for open or short. Repair as necessary. If circuit 338F1 is okay, replace the actuator.

Troubleshooting the HVAC System

Right-Side Panel/Demist Actuator (Mode No. 1) Circuit Diagnosis			
Test No.	**Test Procedure**	**Test Result**	**Action**
5	Check actuator drive motor resistance: • Remove actuator. See **Fig. 7**. Measure resistance across pins 1 and 6 of the actuator. See **Fig. 6**.	Approx. 96 ohms	**Go to test no. 6**.
		Approx. 0 ohm or meter reads OL	Replace actuator.
6	Check for mechanical problem: • Remove actuator. See **Fig. 7**. Attempt to turn the right-side panel/demist door by hand. Check for binding or obstruction.	OK	Replace actuator.
		Not OK	Repair mechanical problem as necessary.

Table 15, Right-Side Panel/Demist Actuator (Mode No. 1) Circuit Diagnosis

A/C Compressor Clutch Circuit Diagnosis (clutch does not engage)			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Does the blower also not work?	Yes	See **Table 18**. If this does not correct the problem, return to this table, step no. 2, or to **Table 9**.
		No	**Go to test no. 2**.
2	Check for voltage to A/C compressor clutch: • Disconnect the A/C clutch 2-pin electrical connector. • Turn ignition ON. • Set the mode control switch to MAX A/C. Measure voltage across the two A/C clutch connector pins (harness side).	Approx. 12V	**Go to test no. 3**.
		0V	**Go to test no. 4**.
3	Check voltage drop at A/C clutch: • Connect the A/C clutch 2-pin connector. • Turn ignition ON. • Set the mode control switch to MAX A/C. Measure voltage across the two A/C clutch connector pins by backprobing.	10.5V or more	Replace A/C compressor
		Less than 10.5V	Check entire circuit between A/C clutch and A/C relay and A/C clutch ground circuit for source of high resistance. Use voltage drop measurements to isolate problem. Repair as necessary. See **Subject 400** for wiring diagrams.

A/C Compressor Clutch Circuit Diagnosis (clutch does not engage)			
Test No.	**Test Procedure**	**Test Result**	**Action**
4	Check for voltage to A/C compressor upstream of thermal switch: • Disconnect 4-pin connector near A/C compressor. • Turn ignition ON. • Set the mode control switch to MAX A/C. Measure voltage across pins 1 and 4 of the 4-pin connector (harness side). NOTE: Connect 4-pin connector when test is complete.	Approx. 12V	Thermal switch or wiring between 4-pin and 2-pin connector is open. Replace compressor.
		0V	**Go to test no. 5**.
5	Check for voltage on 97C at A/C clutch: • Disconnect the A/C clutch 2-pin connector. • Turn ignition ON. • Set mode control switch to MAX A/C. Measure voltage between pin B (circuit 97C) and a known good ground.	Approx. 12V	Check ground circuit to A/C clutch. Repair as necessary.
		0V	**Go to test no. 6**.
6	Check continuity across the low pressure (clutch cycling) switch: • Disconnect low pressure switch. See **Fig. 8**. Measure continuity across low pressure switch terminals. NOTE: See **Subject 400** for A/C Clutch Cycling Pressure Switch Specifications.	Continuity	**Go to test no. 7**.
		No continuity	Check refrigerant temperature/pressure relationship. If pressure is low, check refrigerant charge and repair as necessary. If temperature/pressure relationship is okay and pressure is above 42 psi (290 kPa), replace the low pressure switch (clutch cycling switch).
7	Check voltage to low pressure (clutch cycling) switch: • Disconnect low pressure switch. See **Fig. 8**. • Turn ignition on. • Set mode control switch to MAX A/C. Measure voltage between low pressure switch connector pin 2 (circuit 97F) and a known good ground.	Approx. 12V	**Go to test no. 8**.
		0V	**Go to test no. 9**.

Troubleshooting the HVAC System

A/C Compressor Clutch Circuit Diagnosis (clutch does not engage)			
Test No.	**Test Procedure**	**Test Result**	**Action**
8	Check continuity across the high pressure switch: • Disconnect high pressure switch. See **Fig. 9**. Measure continuity across high pressure switch terminals. NOTE: See **Subject 400** for High Pressure Cutout and Fan Cycling Pressure Switch Specifications.	Continuity	Check circuits 97C and 97E between the low pressure switch and A/C clutch for open. Repair as necessary. See **Subject 400** for wiring diagrams.
		No continuity	Replace high pressure switch.
9	Check for control voltage to A/C clutch relay: • Disconnect the A/C clutch relay. • Turn ignition ON. • Set mode control switch to MAX A/C. Measure voltage across the connector pins that correspond to relay pins 1 and 2 (circuits 220 and 97).	Approx. 12V	**Go to test no. 11**.
		0V	**Go to test no. 10**.
10	Check for ignition supply voltage to control side of A/C clutch relay: • Disconnect the A/C clutch relay. • Turn ignition ON. Measure voltage between connector pin that corresponds to relay pin 1 and a known good ground.	Approx. 12V	Check circuit 97 between relay and control panel. Repair as necessary. If circuit 97 is okay, replace the control panel. See **Subject 400** for wiring diagrams.
		0V	Check circuit 220 (ignition supply) for open. Repair as necessary. See **Subject 400** for wiring diagrams.
11	Check voltage to common pin of relay: • Disconnect the A/C clutch relay. Measure voltage between connector pin that corresponds to relay pin 3 (circuit 97A) and a known good ground.	Approx. 12V	**Go to test no. 12**.
		0V	Check circuit 97A and fuse. Repair as necessary. See **Subject 400** for wiring diagrams.
12	Bypass relay: • Disconnect the A/C clutch relay. Insert a jumper wire between connector pins that correspond to pins 3 and 5 of the relay (circuits 97A and 97F).	Clutch engages	Replace relay.
		Clutch does not engage	Check connections and wiring between relay and low pressure switch for open or high resistance. Repair as necessary. See **Subject 400** for wiring diagrams.

Table 16, A/C Compressor Clutch Circuit Diagnosis (clutch does not engage)

CHECK A/C Indicator Illuminated*			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	Does the CHECK A/C indicator come on intermittently, or does it stay on all the time?	Stays on all the time	Check compressor clutch ground circuit for open or poor connections. Repair as necessary. If OK, thermal switch is probably stuck open. If thermal switch is stuck open, replace the compressor. See **Subject 400** for wiring diagrams.
		Comes on intermittently	System is probably low on refrigerant, thus causing thermal switch to open intermittently. Check refrigerant charge. If low, repair all leaks. NOTE: See **Subject 400** for Compressor Thermal Protection Switch Specifications.

* Vehicles with 2004 engines do not have a CHECK A/C indicator.

Table 17, CHECK A/C Indicator Illuminated

Troubleshooting Control Panel Software Lockup

On vehicles built from July 2000 through May 2004 the software for the HVAC control panel may lock up. This is most likely to occur when the battery voltage is low and the weather is cold. When the software locks up, the blower motor will not run and the refrigerant compressor clutch will not engage. Beginning June 1, 2004, production made a change to the HVAC control panel to protect it from the effects of a low-voltage start up.

The following control panel part numbers are known to be prone to software lockup:

- A22-51035-000 through -002
- A22-52746-000 through -002
- A22-57400 through -002

Use the test procedure in **Table 18** to determine if the control panel software is locked up. If software lockup is confirmed, replace the control panel with the latest version available.

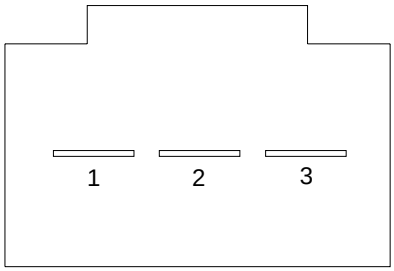
Troubleshooting the HVAC System

Checking for Control Panel Software Lockup			
NOTE: Control panels may exhibit software lockup which results in the following symptoms: blower is inoperable, and, if equipped with A/C, the A/C compressor clutch will not engage.			
Test No.	**Test Procedure**	**Test Result**	**Action**
1	If blower does not work at all, and the A/C compressor clutch does not engage (if equipped with A/C), do the following: Turn ignition OFF. Remove the fuse that supplies constant battery power to the control panel for at least 5 seconds, then install it. NOTE: For fuse location, see **Table 19**. Turn ignition ON. Start engine only if equipped with A/C. Does the blower now work and the A/C clutch engage (if equipped with A/C)?	Yes	Replace the existing control panel with the most current version available. For instructions, see **Subject 210**.
		No	For blower not working, see **Table 9**. For blower not working **and** A/C clutch not engaging, see **Table 9** and **Table 16** for diagnosis.

Table 18, Checking for Control Panel Software Lockup

Fuse Location–Constant Battery Supply to Control Panel			
Model	**Build Date**	**Fuse ID**	**Fuse Location**
Acterra	Built through February 22, 2001	G	Under hood PDM
	Built from February 23, 2001, through September 14, 2003	3	Cab PDM
	Built on or after September 15, 2003	31	
L-Line and A-Line	Built from July 1, 2000 through September 14, 2003	3	
	Built on or after September 15, 2003	31	

Table 19, Fuse Location–Constant Battery Supply to Control Panel

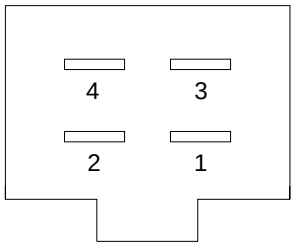


04/15/2004 f544452

NOTE: As seen looking toward the potentiometer.

1. Pin 1, Ground, 98K2
2. Pin 2, Wiper, 98K3
3. Pin 3, +12V, 98K1

Fig. 1, Temperature Potentiometer Connector AC3 Pinout

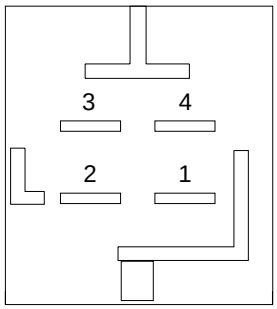


04/15/2004 f544453

NOTE: As seen looking toward the resistor block.

1. Pin 1, 98B
2. Pin 2, GND
3. Pin 3, 98F
4. Pin 4, 98A

Fig. 2, Blower Motor Resistor Block Pinout

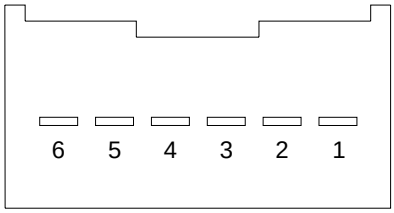


04/15/2004 f544454

NOTE: As seen looking toward the switch.

1. Pin 1, GND
2. Pin 2, 98F
3. Pin 3, 98A
4. Pin 4, 98B

Fig. 3, Blower Motor Switch Pinout

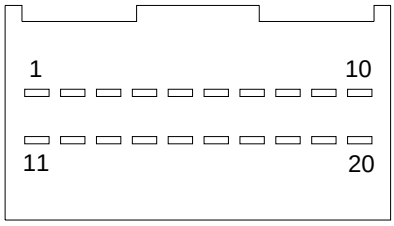


07/27/2004 f544457

NOTE: As seen looking toward the actuator.

1. Pin 1, Motor (–), 338B–
2. Pin 2, Position Sensor 5V Reference, Pot (+), 338H
3. Pin 3, Position Sensor Ground, Pot (–), GND1
4. Pin 4, Position Sensor Feedback, 338F2
5. Pin 5, Not Used
6. Pin 6, Motor (+), 338B+

Fig. 4, Panel/Floor Actuator (Mode No. 2) Pinout

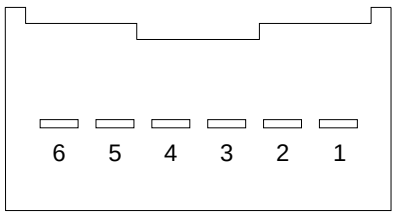


04/15/2004 f544455

NOTE: As seen looking toward the control panel. See **Table 11** for pin numbers, circuit numbers, and descriptions.

Fig. 5, HVAC Control Panel Module Pinout

Troubleshooting the HVAC System

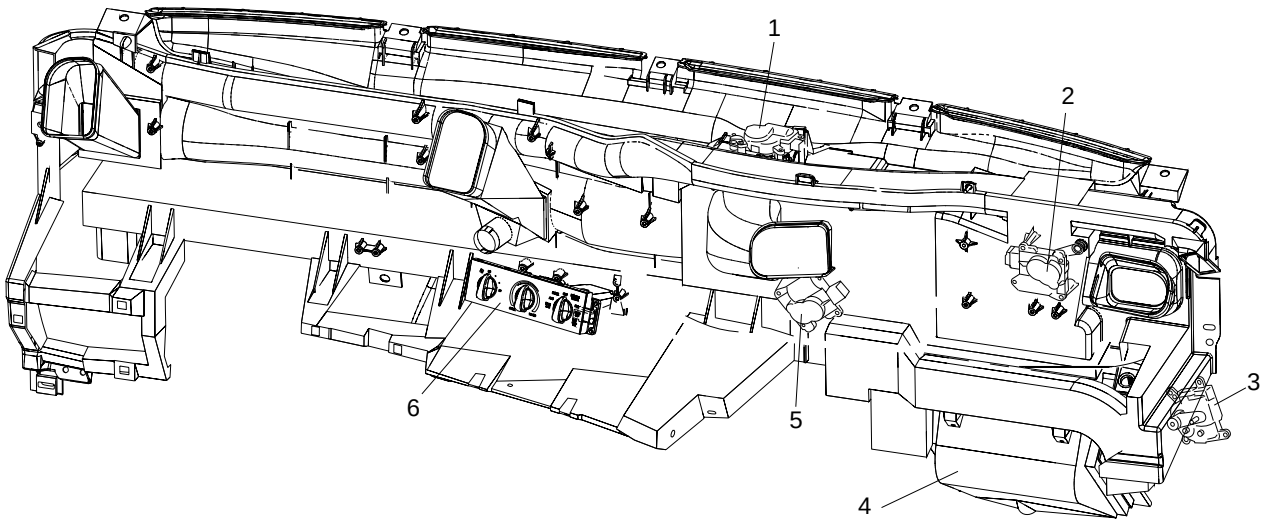


07/27/2004 f544457

NOTE: As seen looking toward the actuator.

1. Pin 1, Motor (–), 338A–
2. Pin 2, Position Sensor 5V Reference, Pot (+), 338G
3. Pin 3, Position Sensor Ground, Pot (–), GND1
4. Pin 4, Position Sensor Feedback, 338F1
5. Pin 5, Not Used, NA
6. Pin 6, Motor (+), 338A+

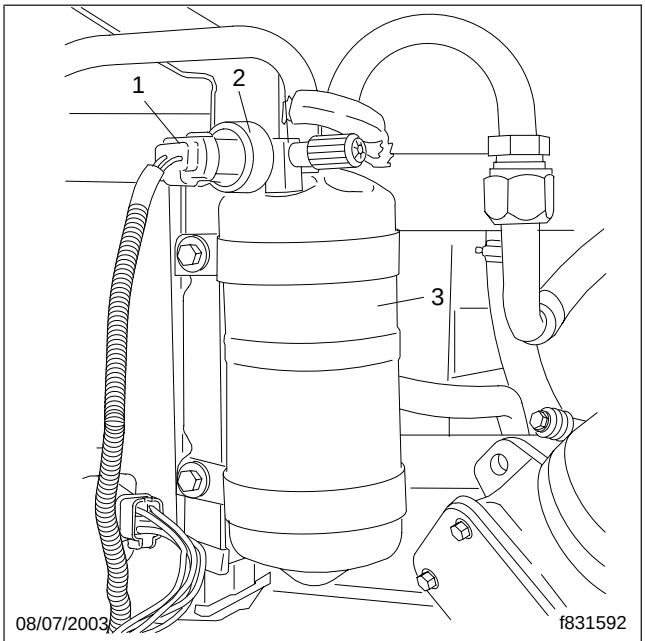
Fig. 6, Right-Side Panel/Demist Actuator (Mode No. 1) Pinout



08/09/2004 f831402c

1. Defrost/Panel Actuator
2. Right-Side Panel/Demist Actuator
3. Fresh Air/Recirculation Actuator
4. Heater Core Cover
5. Panel/Floor Actuator
6. Climate Control Panel

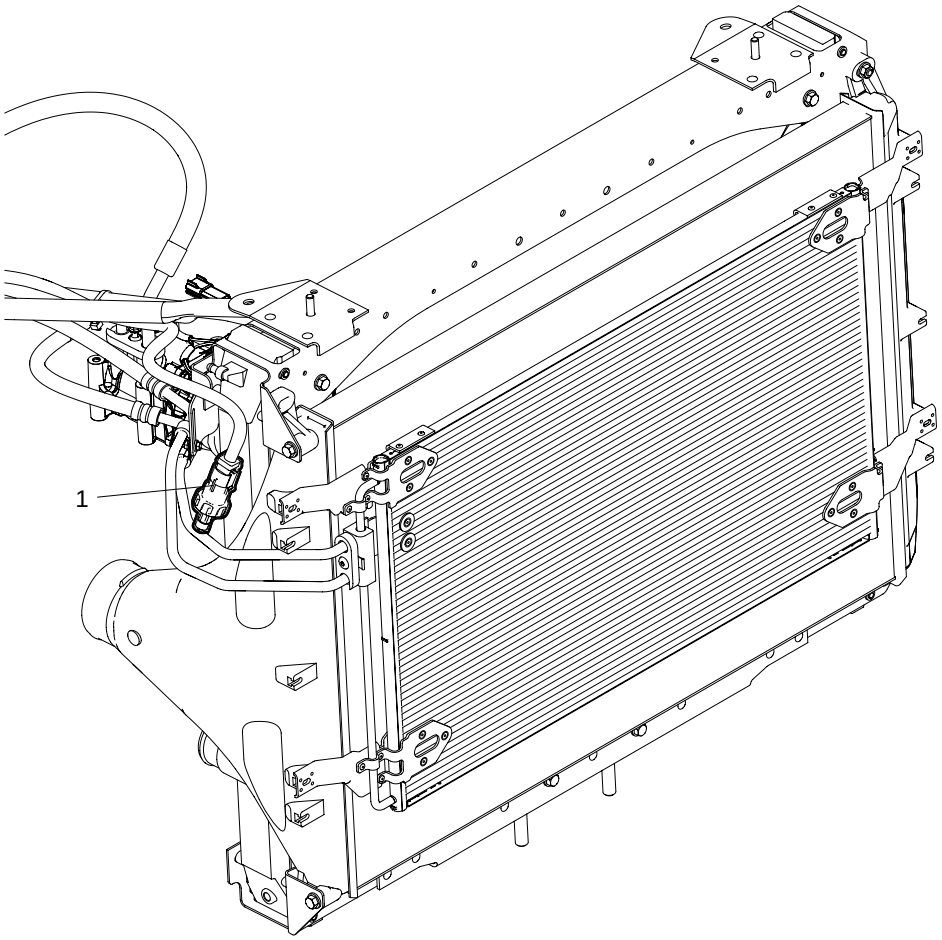
Fig. 7, Actuator Locations



1. Electrical Connector
2. Low Pressure (clutch cycling) Switch
3. Accumulator

Fig. 8, Low Pressure (clutch cycling) Switch

Troubleshooting the HVAC System



1. High Pressure Cut-out/Fan Cycling Switch

Fig. 9, High Pressure Cut-out/Fan Cycling Switch

General Information

Before testing the A/C system performance, check the following conditions and correct any problems before proceeding with performance testing:

- A/C compressor drive belt worn or slipping
- A/C clutch slipping

Connect pressure gauges to the service ports and insert a thermometer into the center dash outlet. Operate the A/C system until the engine is warm and the temperature on the thermometer stabilizes. Then compare the test data with the temperature pressure specifications in the appropriate table in **Subject 400**.

When performance testing the refrigerant system, be sure the test conditions are the same as those that were used when the temperature pressure specifications were developed. The test conditions are stated at the bottom of the temperature pressure specifications tables.

If the dash outlet temperature or service port pressures do not agree with the specified values, do the following:

- For a vehicle with a Visteon scroll compressor, see **Table 1** for possible cause and correction.
- For a vehicle with a Sanden compressor, see **Table 2** for possible cause and correction.

Refrigerant System Troubleshooting Tables

Refrigerant System Diagnosis for a Vehicle With a Visteon Scroll Compressor			
Test Result	**Possible Symptoms**	**Probable Cause(s)**	**Correction**
High side pressure abnormally high	Line to condenser is excessively hot	Restricted refrigerant flow (restricted discharge line or condenser)	Locate and remove the restriction.
		Air in the system	Recover, evacuate, and charge the system.
		Engine overheating	Check engine cooling system and repair as necessary.
		Reduced airflow across condenser	Clear or clean cause of restriction.
		Engine fan not operating correctly	Check engine cooling fan and repair as necessary.
High pressure side abnormally low	Evaporator outlet not cold and low pressure gauge indicates vacuum	Faulty orifice tube	Replace orifice tube.
	None	Moisture in the system	Recover, evacuate, and charge the system.
	Clutch cycles off rapidly after engagement	Low refrigerant charge	Recover system. If amount of refrigerant recovered indicates low charge, leak check entire system and repair leaks. Then evacuate and charge.
	High side pressure is lower than normal	Faulty A/C compressor	Replace the compressor.

Troubleshooting the Refrigerant System

Refrigerant System Diagnosis for a Vehicle With a Visteon Scroll Compressor			
Test Result	**Possible Symptoms**	**Probable Cause(s)**	**Correction**
Low side pressure abnormally low	Suction line not cold, and low pressure gauge indicates vacuum	Frozen orifice tube (moisture in system)	Recover, evacuate, and charge the system.
	None	Cycling switch low cutout is too low or switch is sticking	Check cycling switch and replace as necessary.
	Discharge temperature is cool, but airflow is less than normal	Frozen evaporator core	Run fan with A/C off to thaw the evaporator. Check cycling switch operation.
	Accumulator outlet is cool, inlet is warm during operation. Both should be cool when operating.	Clogged or restricted accumulator	Replace the accumulator.
High and low side pressures abnormally high	Low side pressure drops when condenser is cooled by water spray	System overcharged	Recover, evacuate, and charge the system.
Rapid compressor cycling		System undercharged	Recover system. If amount of refrigerant recovered indicates low charge, leak check entire system and repair leaks. Then evacuate and charge the system.
Refrigerant leaks	Compressor clutch is dirty	Compressor shaft seal leak	Replace the compressor.
	Compressor seam is wet with oil	Compressor gasket leak	

Table 1, Refrigerant System Diagnosis for a Vehicle With a Visteon Scroll Compressor

Refrigerant System Diagnosis for a Vehicle With a Sanden Compressor				
High Side Pressure	**Low Side Pressure**	**Possible Symptoms**	**Probable Cause(s)**	**Correction**
High	High	Compressor running continuously	Inadequate airflow across condenser	Check engine fan operation, and repair as necessary.
			Restricted airflow across condenser	Clean or remove debris from condenser.
High	Normal to High	Compressor running continuously	Engine overheating	Check engine cooling system and repair as necessary.
Normal to High	Normal	Compressor running continuously	Air in refrigerant	Recover, evacuate, and charge the system.
			High ambient temperature or humidity	Not a problem.
Normal	High	Compressor running continuously	Missing orifice tube	Replace the orifice tube.
		Compressor cycling, excessive on and off time	A/C clutch cycling switch cut in pressure too high	Check A/C clutch cycling switch and replace as necessary.

Troubleshooting the Refrigerant System

Refrigerant System Diagnosis for a Vehicle With a Sanden Compressor				
High Side Pressure	**Low Side Pressure**	**Possible Symptoms**	**Probable Cause(s)**	**Correction**
Normal to Low	High	Compressor running continuously	Low compressor performance	Replace the compressor.
Normal	Low	Compressor cycling, excessive on and off time	A/C clutch switch cutout pressure too low	Check A/C clutch cycling switch and replace as necessary.
Normal to Low	Normal to High	Compressor running continuously	Restriction between evaporator and compressor inlet (lines or accumulator)	Locate restriction and replace as necessary.
Normal to Low	Normal	Compressor cycling on and off quickly, shorter than normal run time	Low airflow across evaporator	Check evaporator for debris accumulation, frozen core, or faulty blower motor. Repair as necessary.
			Restriction	Locate restriction and repair as necessary.
		Compressor cycling on and off quickly, shorter than normal run and off time	Low refrigerant charge	Recover system. If amount of refrigerant recovered indicates low charge, leak check entire system and repair leaks. Then evacuate and charge the system.
		Compressor cycling on and off quickly, longer than normal off time	Restricted or plugged evaporator core	Locate restriction and repair as necessary.
Normal to Low	Low	Compressor running continuously	Restriction between evaporator and compressor inlet (lines or accumulator)	Locate restriction and repair as necessary.
			A/C clutch cycling switch sticking closed	Check A/C clutch cycling switch and repair as necessary.
Low	Normal	Compressor cycling on and off quickly, shorter than normal run and off time	A/C clutch cycling switch cut in cutout pressure range too close	Check A/C clutch cycling switch and replace as necessary.
Normal	Normal	Compressor running continuously or run time excessively long if cycling	Moisture in system	Recover, evacuate, and charge the system.
			Excessive refrigerant oil in the system	Flush system with refrigerant to remove oil. Add proper quantity of oil, evacuate and charge the system.
		Compressor cycling on and off quickly, shorter than normal run and off time	A/C clutch cycling switch cut in cutout pressure range too close	Check A/C clutch cycling switch and replace as necessary.

Table 2, Refrigerant System Diagnosis for a Vehicle With a Sanden Compressor

Specifications

⚠ WARNING

R–134a is the only refrigerant that is approved for use on Sterling vehicles. Several companies offer less expensive, hydrocarbon-based refrigerant, such as propane and methane. Use of these refrigerants will void the warranty on the 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. No vehicle built by Sterling Trucks can be safely charged with hydrocarbon-based refrigerants, regardless of what the refrigerant supplier states.

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.

Refrigerant recover/charge stations can be purchased from:

SPX Kent-Moore
28635 Mound Road
Warren, Michigan 48092-3499
(800) 328-6657

See **Fig. 1** for a partial view of the heater and air conditioner system wiring diagram. See **Fig. 2**, **Fig. 3** and **Fig. 4** for details of the heater and air conditioner system wiring diagram.

See **Fig. 5** for a partial view of the heater and air conditioner system wiring diagram. See **Fig. 6** and **Fig. 7** for details of the heater and air conditioner system wiring diagram.

See **Fig. 8** for a partial view of the heater and air conditioner system wiring diagram. See **Fig. 9** and **Fig. 10** for details of the heater and air conditioner system wiring diagram.

The amount of refrigerant needed to fully charge the air conditioning system is printed on the "Air Conditioner" label on the air intake plenum located under the hood. See **Fig. 11**.

See **Fig. 12** for an illustration of the Behr and Modine condensers.

A/C Clutch Cycling Pressure Switch Specifications*				
Color	**Type of A/C Compressor**	**Part No.**	**Contacts Open Pressure psi (kPa)**	**Contacts Close Pressure psi (kPa)**
White	Sanden and Visteon Scroll	VST95BW19E561AA	36 to 42 (248 to 290)	21 to 23 (145 to 159)

* Some early production vehicles with 2004 engines were equipped with a blue, YC2H 19D561 AA pressure switch. If the vehicle has this switch and is having a problem with A/C performance, replace it with a VST95BW19E561AA pressure switch.

Table 1, A/C Clutch Cycling Pressure Switch Specifications

High Pressure Cut Out and Fan Cycling Pressure Switch Specifications						
Color	**Part No.**	**Type of Fan**	**Engine Cooling Fan psi (kPa)**		**High Pressure Cut Out psi (kPa)**	
			Fan On	**Fan Off**	**Cut Out**	**Cut In**
Green	06-35209-000	On/Off Fan	310 to 340 (2137 to 2344)	255 to 295 (1758 to 2034)	435 to 475 (2999 to 3275)	220 to 280 (1517 to 1931)

Specifications

High Pressure Cut Out and Fan Cycling Pressure Switch Specifications						
Color	Part No.	Type of Fan	Engine Cooling Fan psi (kPa)		High Pressure Cut Out psi (kPa)	
			Fan On	Fan Off	Cut Out	Cut In
Black/Yellow	F3AH 19D594 CA	Viscous	—	—	460 to 490 (3172 to 3378)	230 to 290 (1586 to 1999)

Table 2, High Pressure Cut Out and Fan Cycling Pressure Switch Specifications

Compressor Thermal Protection Switch Specifications*	
Thermal Switch Cut Out Temperature	Thermal Switch Reset Temperature
235.4 to 246.2°F (113 to 119°C)	203 to 224.6°F (95 to 107°C)

* All vehicles have a thermal protection switch. Only vehicles with a pre-2004 engine have a CHECK A/C indicator.

Table 3, Compressor Thermal Protection Switch Specifications

Temperature/Pressure Specifications for a Day Cab With a 2004 Engine and a Visteon Scroll Compressor					
Ambient Air Temp.	Relative Humidity	Left Center Outlet Temperature	Service Port Pressures		A/C Compressor Status
			High Side psi (kPa)	Low side psi (kPa)	
70°F (21°C)	25%	40.0 to 46.5°F (4 to 8°C)	No data	No data	Cycling
	50%	39.5 to 46.0°F (4 to 8°C)	85 to 98 (586 to 676)	19 to 25 (131 to 172)	On
80°F (27°C)	25%	43.5 to 50.0°F (6 to 10°C)	101 to 115 (696 to 793)	21 to 27 (145 to 186)	On
	50%	45.0 to 51.5°F (7 to 11°C)	104 to 117 (717 to 807)	21 to 27 (145 to 186)	On
90°F (32°C)	25%	47.0 to 53.5°F (8 to 12°C)	128 to 141 (883 to 972)	23 to 29 (159 to 200)	On
	50%	50.5 to 57.0°F (10 to 14°C)	140 to 153 (965 to 1055)	24 to 30 (165 to 207)	On
	70%	51.5 to 58.0°F (11 to 14°C)	151 to 164 (1041 to 1131)	27 to 33 (186 to 228)	On

Specifications

Temperature/Pressure Specifications for a Day Cab With a 2004 Engine and a Visteon Scroll Compressor					
Ambient Air Temp.	Relative Humidity	Left Center Outlet Temperature	Service Port Pressures		A/C Compressor Status
			High Side psi (kPa)	Low side psi (kPa)	
100°F (38°C)	25%	50.5 to 57.0°F (10 to 14°C)	171 to 184 (1179 to 1269)	26 to 32 (179 to 221)	On
	50%	56.0 to 62.5°F (13 to 17°C)	193 to 206 (1331 to 1420)	28 to 34 (193 to 234)	On
	70%	59.5 to 66.0°F (15 to 19°C)	212 to 225 (1462 to 1551)	31 to 37 (214 to 255)	On
Test conditions: • Engine running at 1500 rpm • Engine fan locked on • Normal A/C mode, outside air • Blower on HI • Cab doors open • Hood open • No solar load, no wind speed					

Table 4, Temperature/Pressure Specifications for a Day Cab With a 2004 Engine and a Visteon Scroll Compressor

Temperature/Pressure Specifications for a Vehicle With a Sanden Compressor and a Modine Condenser but Without an Auxiliary HVAC Unit*						
Ambient Air Temp.	Humidity (approximate)	Dash Outlet Temperature	Service Port Pressures		A/C Compressor Status	A/C Compressor Status Comments
			High Side psi (kPa)	Low Side psi (kPa)		
70°F (21°C)	Low 25%	42-47°F (6-8°C)	80-119 (552-820)	20-39 (138-269)	Cycling	On for about 6 seconds, off for about 8 seconds.
	Medium 50%	42-48°F (6-9°C)	77-122 (531-841)	19-40 (131-276)	Cycling	On for about 7 seconds, off for about 7 seconds.
	High 70%	43-50°F (6-10°C)	77-130 (531-896)	19-39 (131-269)	Cycling	On for about 10 seconds, off for about 5 seconds.
80°F (27°C)	Low 25%	44-49°F (7-9°C)	95-141 (655-972)	19-39 (131-269)	Cycling	On for about 9 seconds, off for about 6 seconds.
	Medium 50%	44-49°F (7-9°C)	97-150 (669-1034)	20-40 (138-276)	Cycling	On for about 13 seconds, off for about 5 seconds.
	High 70%	44-47°F (7-8°C)	144-149 (993-1027)	21 (145)	On	On steady

Specifications

Temperature/Pressure Specifications for a Vehicle With a Sanden Compressor and a Modine Condenser but Without an Auxiliary HVAC Unit*						
Ambient Air Temp.	**Humidity (approximate)**	**Dash Outlet Temperature**	**Service Port Pressures**		**A/C Compressor Status**	**A/C Compressor Status Comments**
			High Side psi (kPa)	**Low Side psi (kPa)**		
90°F (32°C)	Low 25%	45-49°F (7-9°C)	113-166 (779-1145)	20-39 (138-269)	Cycling	On for about 12 seconds, off for about 5 seconds.
	Medium 50%	47-51°F (8-11°C)	166-170 (1145-1172)	23-24 (159-165)	On	On steady
	High 70%	54-57°F (12-14°C)	181-184 (1284-1269)	29 (200)	On	On steady
100°F (38°C)	Low 25%	50-54°F (10-12°C)	191-195 (1317-1344)	25 (172)	On	On steady
	Medium 50%	59-62°F (15-17°C)	212-214 (1462-1475)	33 (228)	On	On steady
	High 70%	62-65°F (17-18°C)	218-220 (1503-1517)	35 (241)	On	On steady

Test conditions:

- Engine running at 1500 rpm
- Engine fan locked on
- Normal A/C mode, outside air
- Blower on HI
- Cab doors open
- Hood open
- No solar load, no wind speed

* See **Fig. 12** for an illustration of a Modine condenser.

Table 5, Temperature/Pressure Specifications for a Vehicle With a Sanden Compressor and a Modine Condenser but Without an Auxiliary HVAC Unit

Specifications

Temperature/Pressure Specifications for a Vehicle With a Sanden Compressor, a Modine Condenser, and an Auxiliary HVAC Unit*							
Ambient Air Temp.	Humidity (approximate)	Dash Outlet Temperature	Auxiliary Unit Outlet Temperature	Service Port Pressures		A/C Compressor Status	A/C Compressor Status Comments
				High Side psi (kPa)	Low Side psi (kPa)		
70°F (21°C)	Low 25%	42-48°F (6-9°C)	45-50°F (7-10°C)	70-105 (483-724)	20-39 (138-269)	Cycling	On for about 43 seconds, off for about 10 seconds.
	Medium 50%	40-43°F (4-6°C)	47°F (8°C)	107-112 (738-772)	21-22 (145-152)	On	On steady
	High 70%	42-46°F (6-8°C)	49°F (9°C)	107-115 (738-793)	23-24 (159-165)	On	On steady
80°F (27°C)	Low 25%	44-49°F (7-9°C)	51°F (11°C)	124-129 (855-889)	20 (138)	On	On steady
	Medium 50%	47-50°F (8-10°C)	54°F (12°C)	123-126 (848-869)	20 (138)	On	On steady
	High 70%	52-55°F (11-13°C)	60°F (16°C)	133-140 (917-965)	32-33 (221-228)	On	On steady
90°F (32°C)	Low 25%	50-53°F (10-12°C)	61°F (16°C)	148-156 (1020-1076)	29 (200)	On	On steady
	Medium 50%	56-59°F (13-15°C)	66°F (19°C)	157-167 (1082-1151)	35-36 (241-248)	On	On steady
	High 70%	64-67°F (18-19°C)	72°F (22°C)	175-183 (1207-1262)	43-44 (296-303)	On	On steady
100°F (38°C)	Low 25%	58-61°F (14-16°C)	66°F (19°C)	180-191 (1241-1317)	35-36 (241-248)	On	On steady
	Medium 50%	65-68°F (18-20°C)	73°F (23°C)	193-203 (1331-1400)	43-44 (296-303)	On	On steady
	High 70%	70-73°F (21-23°C)	78°F (26°C)	209-215 (1441-1482)	50 (345)	On	On steady

Specifications

Temperature/Pressure Specifications for a Vehicle With a Sanden Compressor, a Modine Condenser, and an Auxiliary HVAC Unit*							
Ambient Air Temp.	Humidity (approximate)	Dash Outlet Temperature	Auxiliary Unit Outlet Temperature	Service Port Pressures		A/C Compressor Status	A/C Compressor Status Comments
				High Side psi (kPa)	Low Side psi (kPa)		
Test conditions: • Engine running at 1500 rpm • Engine fan locked on • Normal A/C mode, outside air • Blower on HI • Cab doors open • Hood open • No solar load, no wind speed							

* See **Fig. 12** for an illustration of a Modine condenser.

Table 6, Temperature/Pressure Specifications for a Vehicle With a Sanden Compressor, a Modine Condenser, and an Auxiliary HVAC Unit

Refrigerant Amounts		
Condenser Make and Type	Vehicle Type and Build Date	Refrigerant Amount
Modine Serpentine	Day cab built prior to July 2002	2.75 lb or 2 lb 12 oz (1.25 kg)
	Sleeper built prior to July 2002	4.31 lb or 4 lb 5 oz (1.95 kg)
Valeo Parallel	Day cab built from July 2002	2.75 lb or 2 lb 12 oz (1.25 kg)
	Sleeper built from July 2002	4.31 lb or 4 lb 5 oz (1.95 kg)
Behr Parallel	Day cab built from January 2004	2.75 lb or 2 lb 12 oz (1.25 kg)
	Sleeper built from January 2004	3.13 lb or 3 lb 2 oz (1.42 kg)
Modine Parallel	Day cab built from June 2005	2.63 lb or 2 lb 10 oz (1.42 kg)
	Sleeper built from June 2005	3.13 lb or 3 lb 2 oz (1.42 kg)

Table 7, Refrigerant Amounts

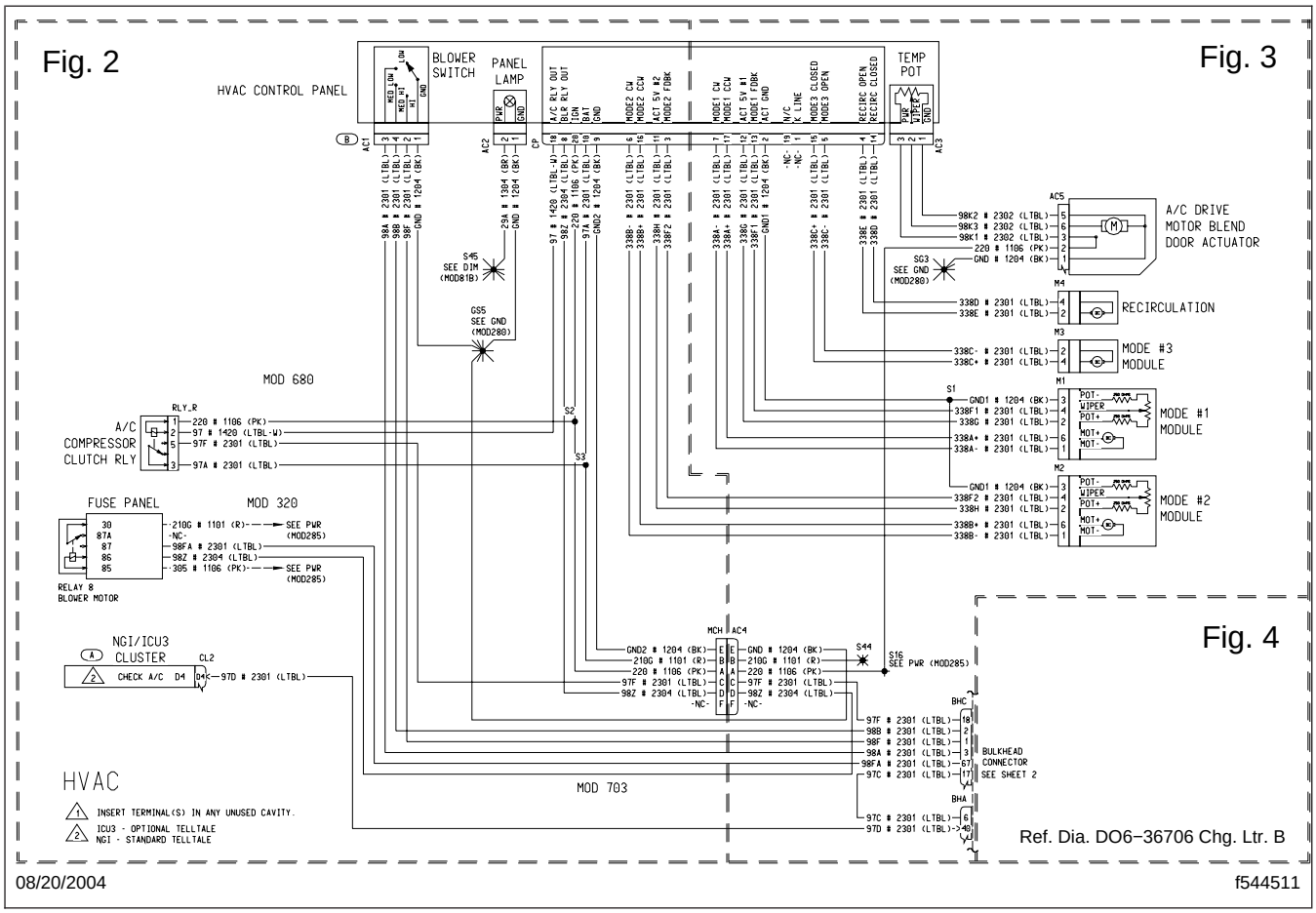


Fig. 1, Heater and Air Conditioner System Wiring Diagram (partial view) for a Vehicle With a 2004 Engine

Specifications

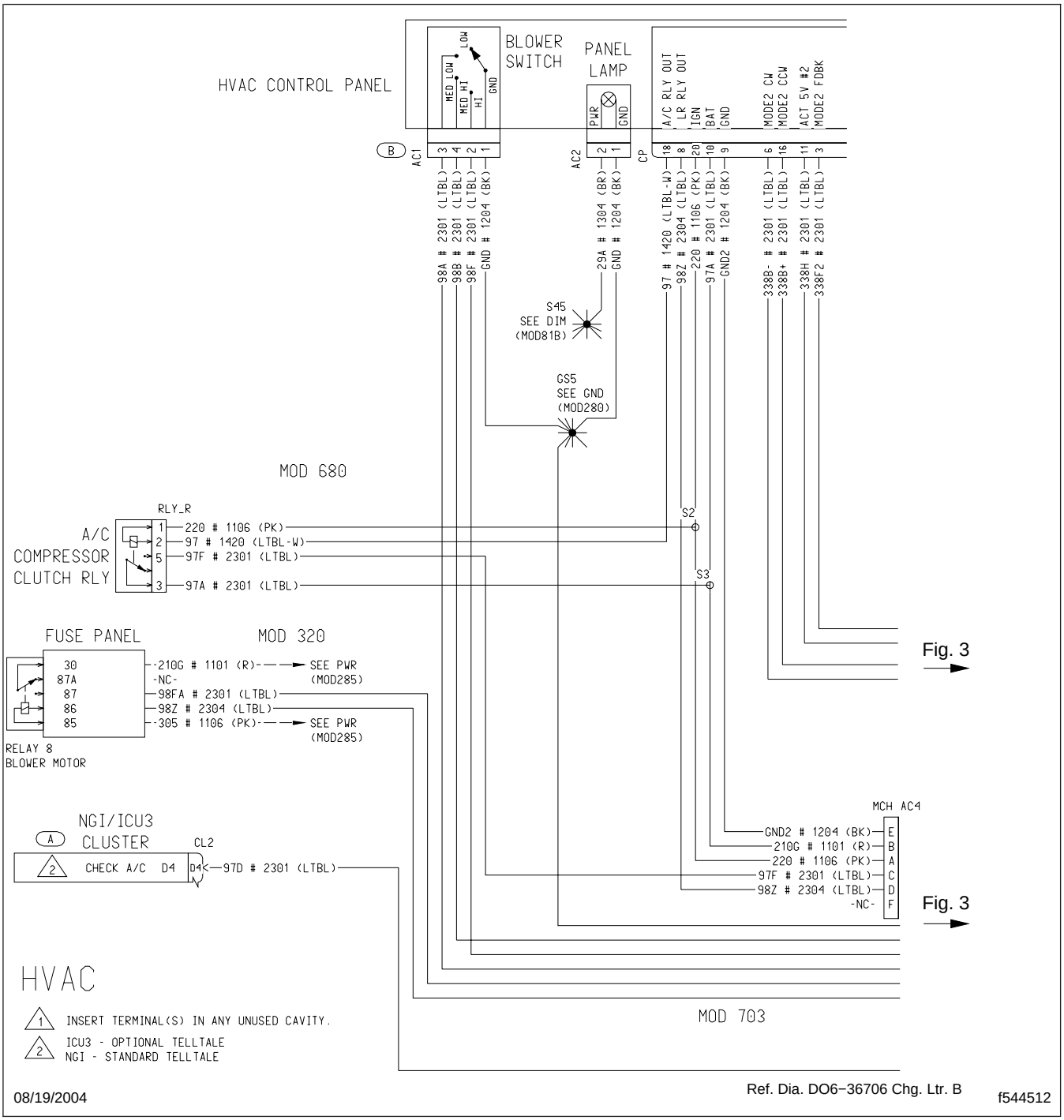


Fig. 2, Heater and Air Conditioner System Wiring Diagram (detail) for a Vehicle With a 2004 Engine

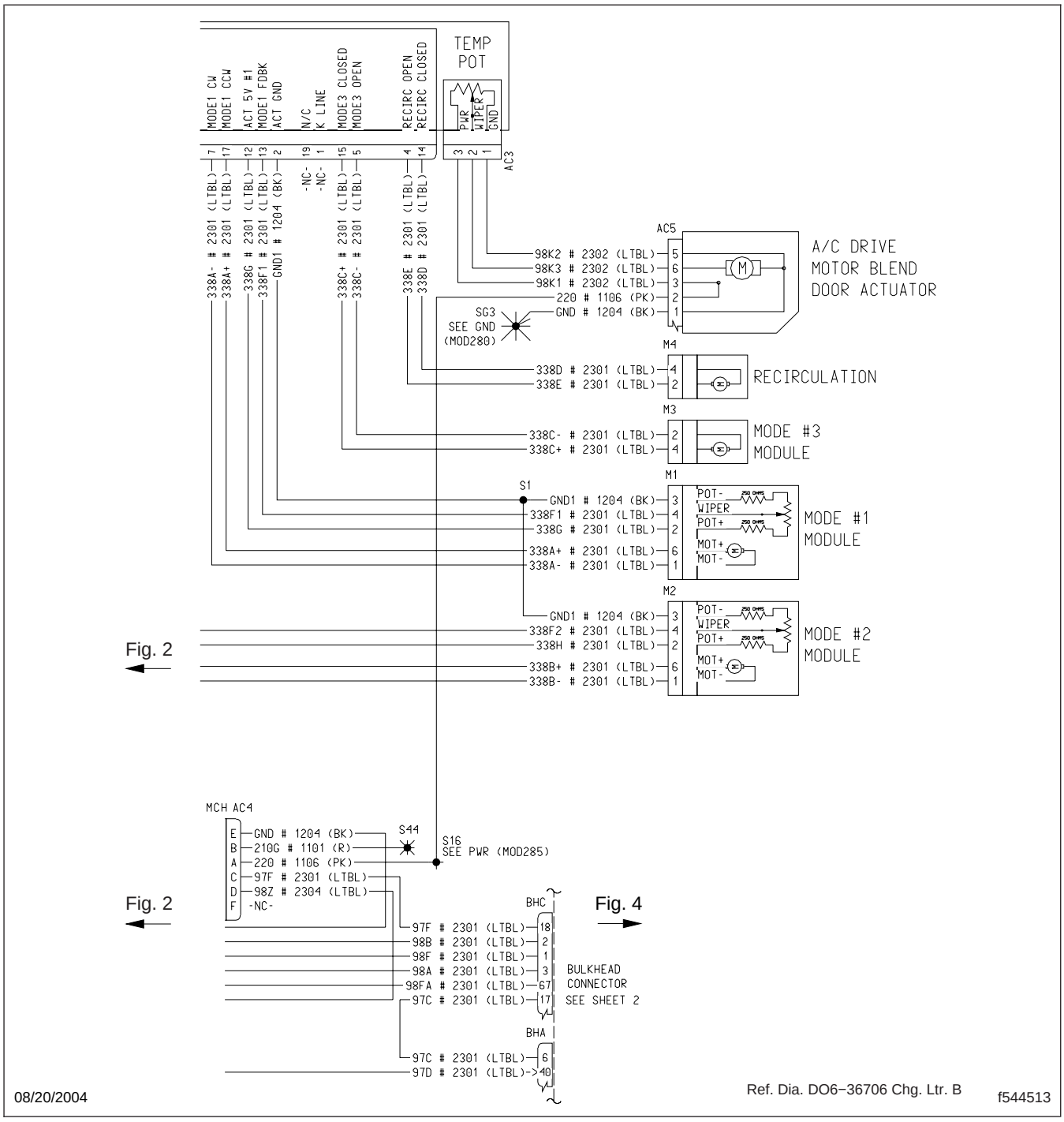


Fig. 3, Heater and Air Conditioner System Wiring Diagram (detail) for a Vehicle With a 2004 Engine

Specifications

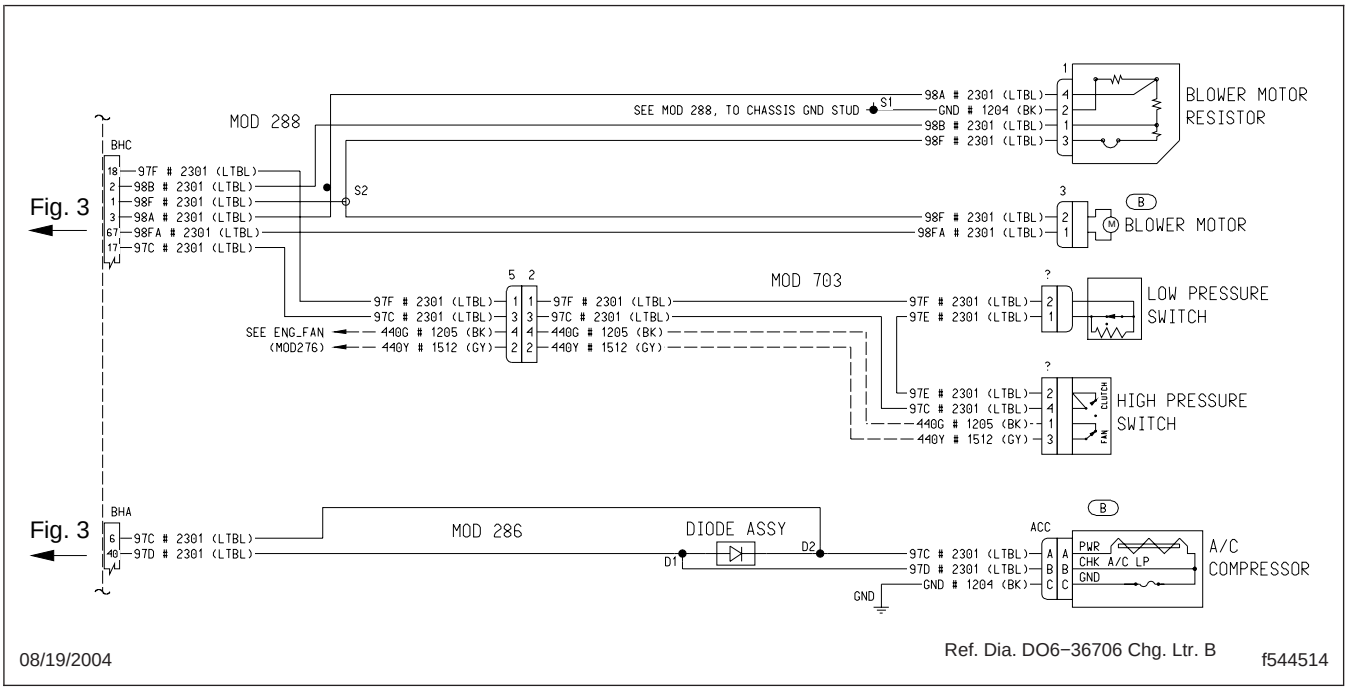


Fig. 4, Heater and Air Conditioner System Wiring Diagram (detail) for a Vehicle With a 2004 Engine

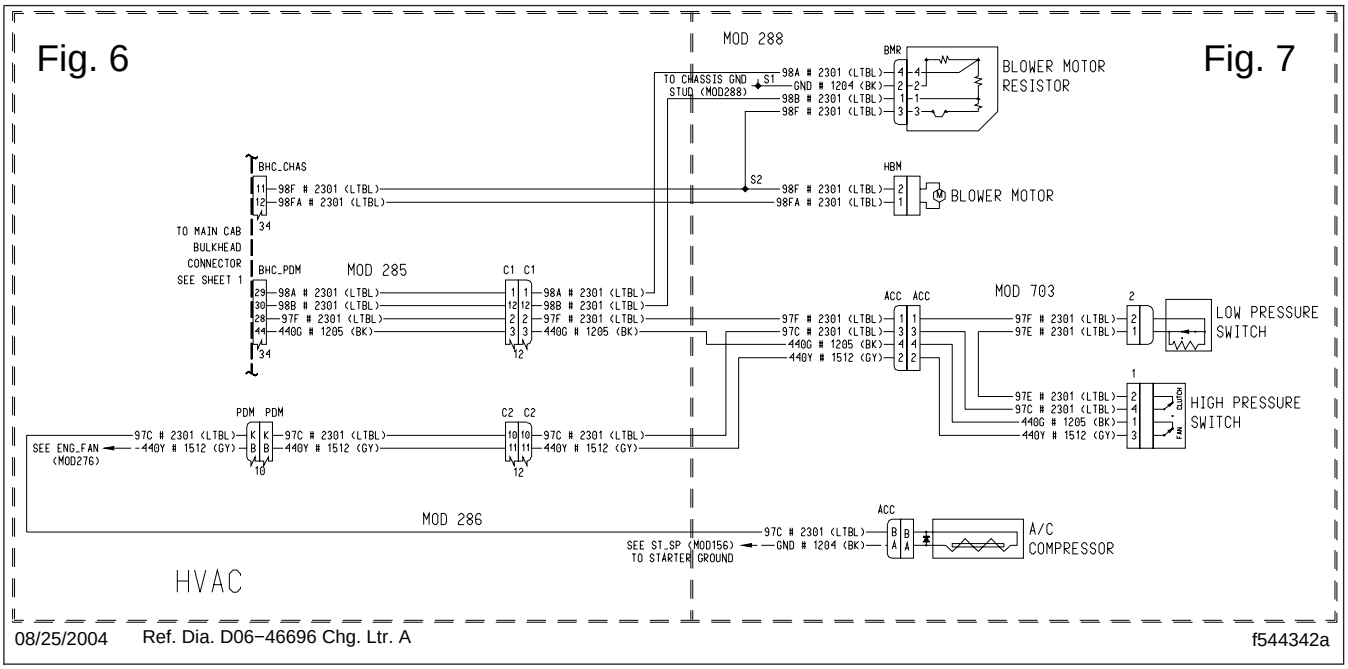


Fig. 5, Heater and Air Conditioner System Wiring Diagram (partial view) for a Vehicle With a 2004 Engine

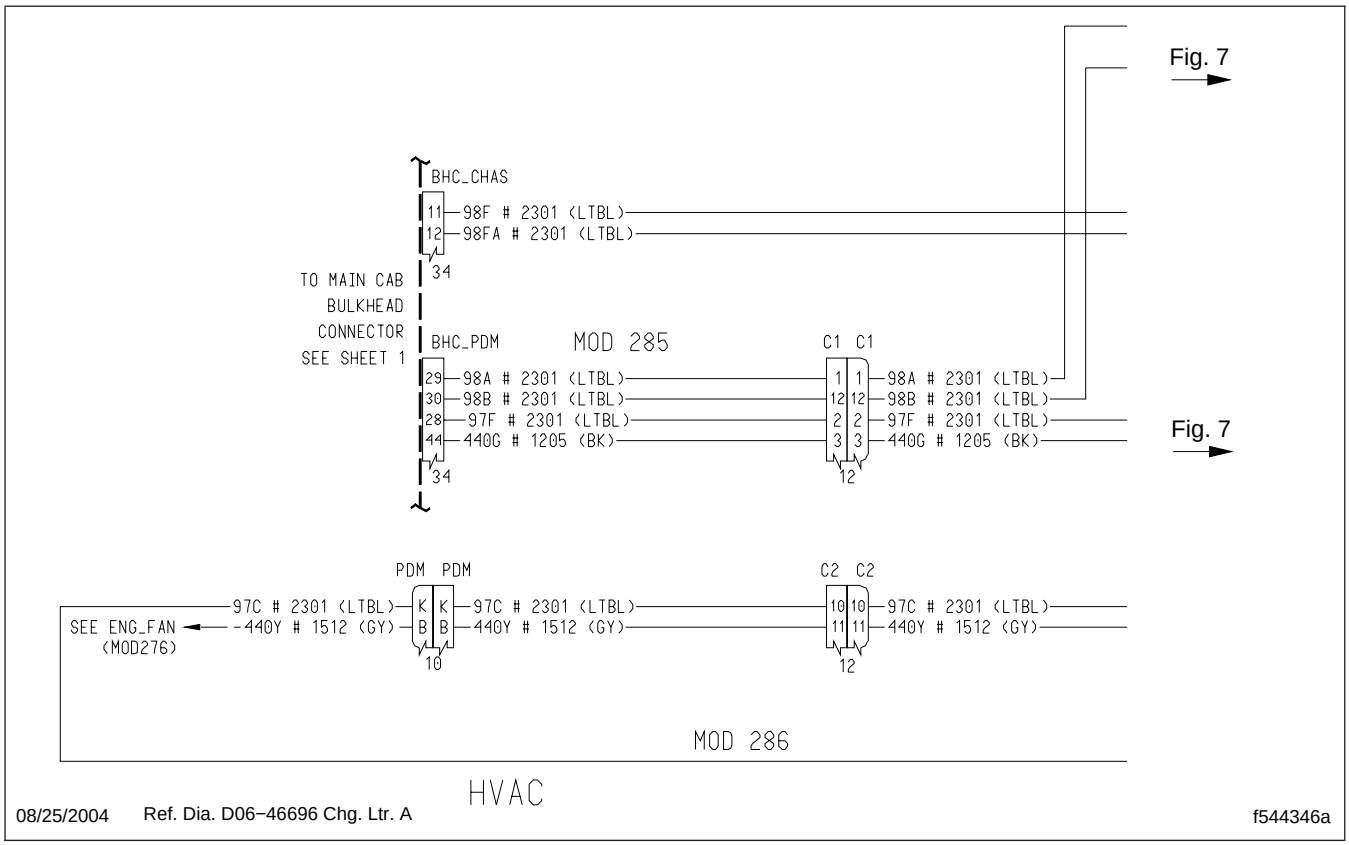


Fig. 6, Heater and Air Conditioner System Wiring Diagram (detail) for a Vehicles With a 2004 Engine

Specifications

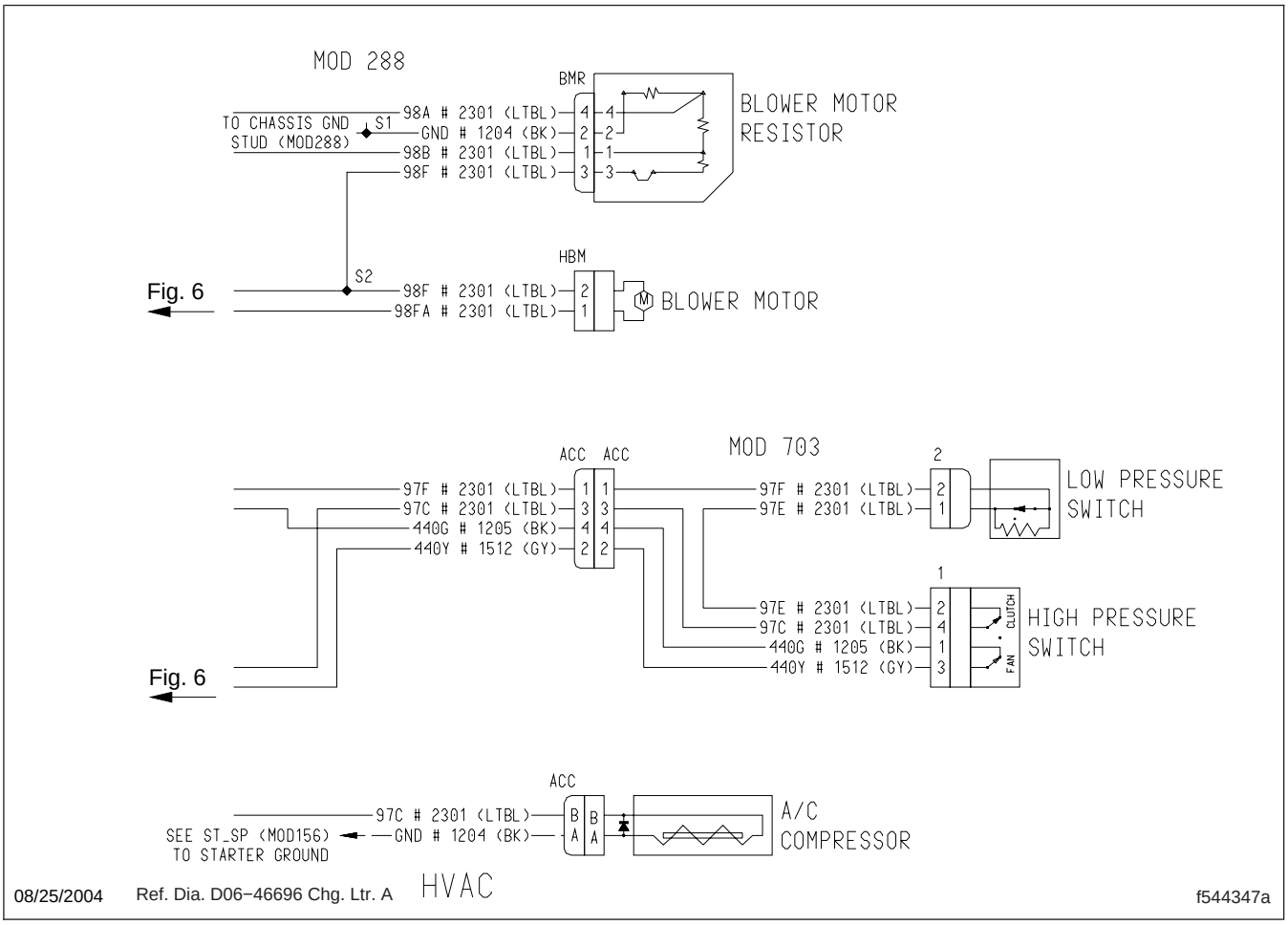


Fig. 7, Heater and Air Conditioner System Wiring Diagram (detail) for a Vehicle With a 2004 Engine

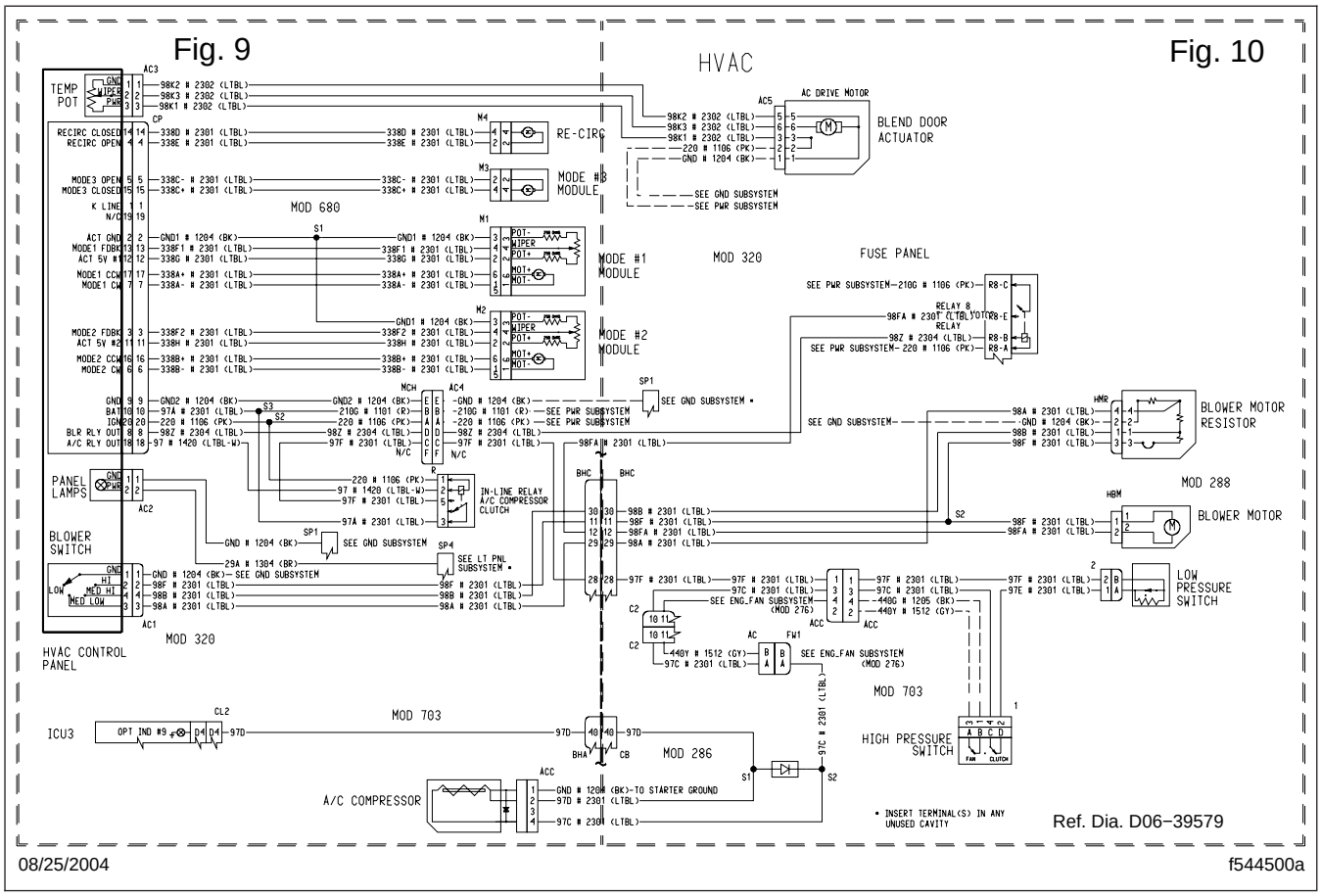


Fig. 8, Heater and Air Conditioner System Wiring Diagram (partial view) for a Vehicle With a Pre-2004 Engine

Specifications

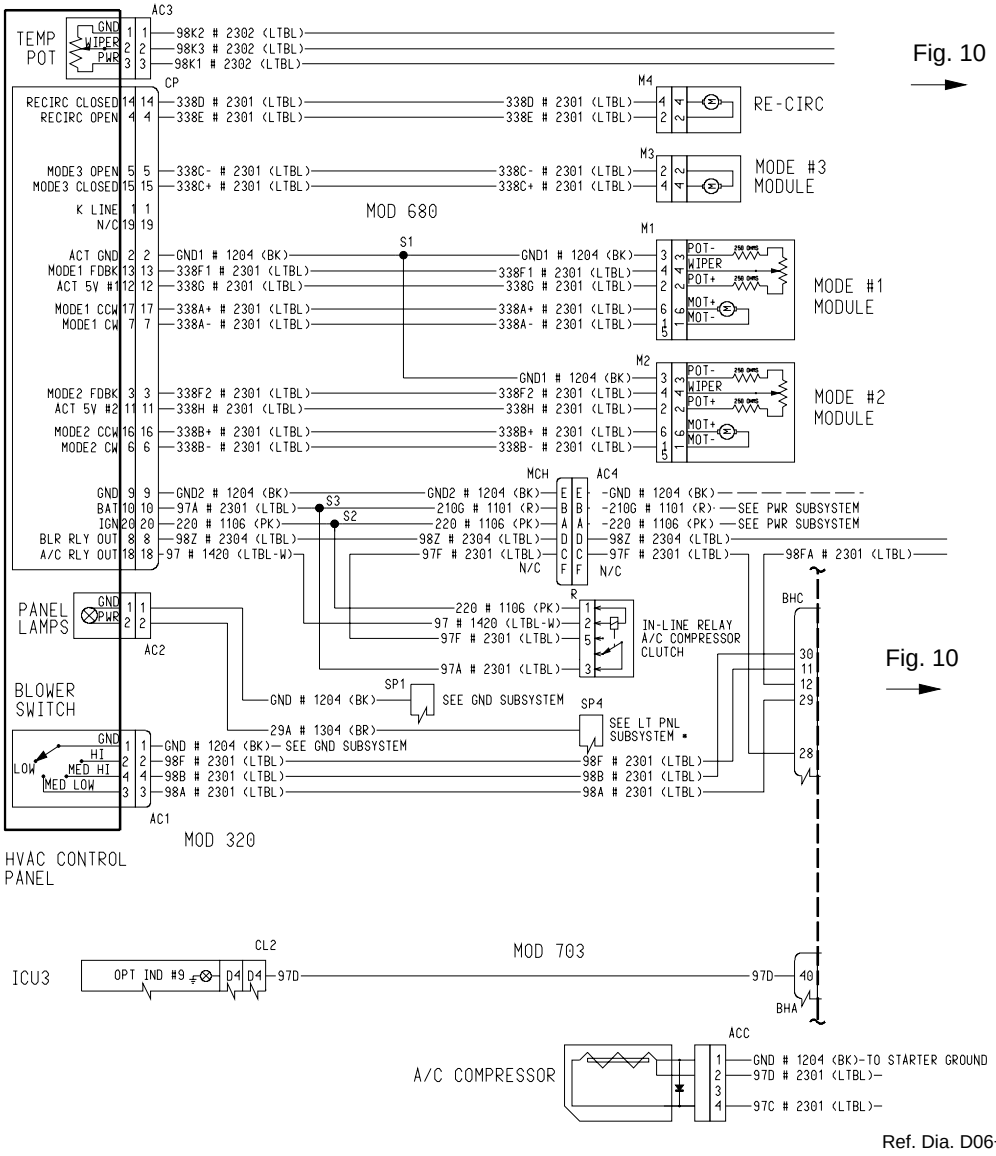


Fig. 9, Heater and Air Conditioner System Wiring Diagram (detail) for a Vehicle With a Pre-2004 Engine

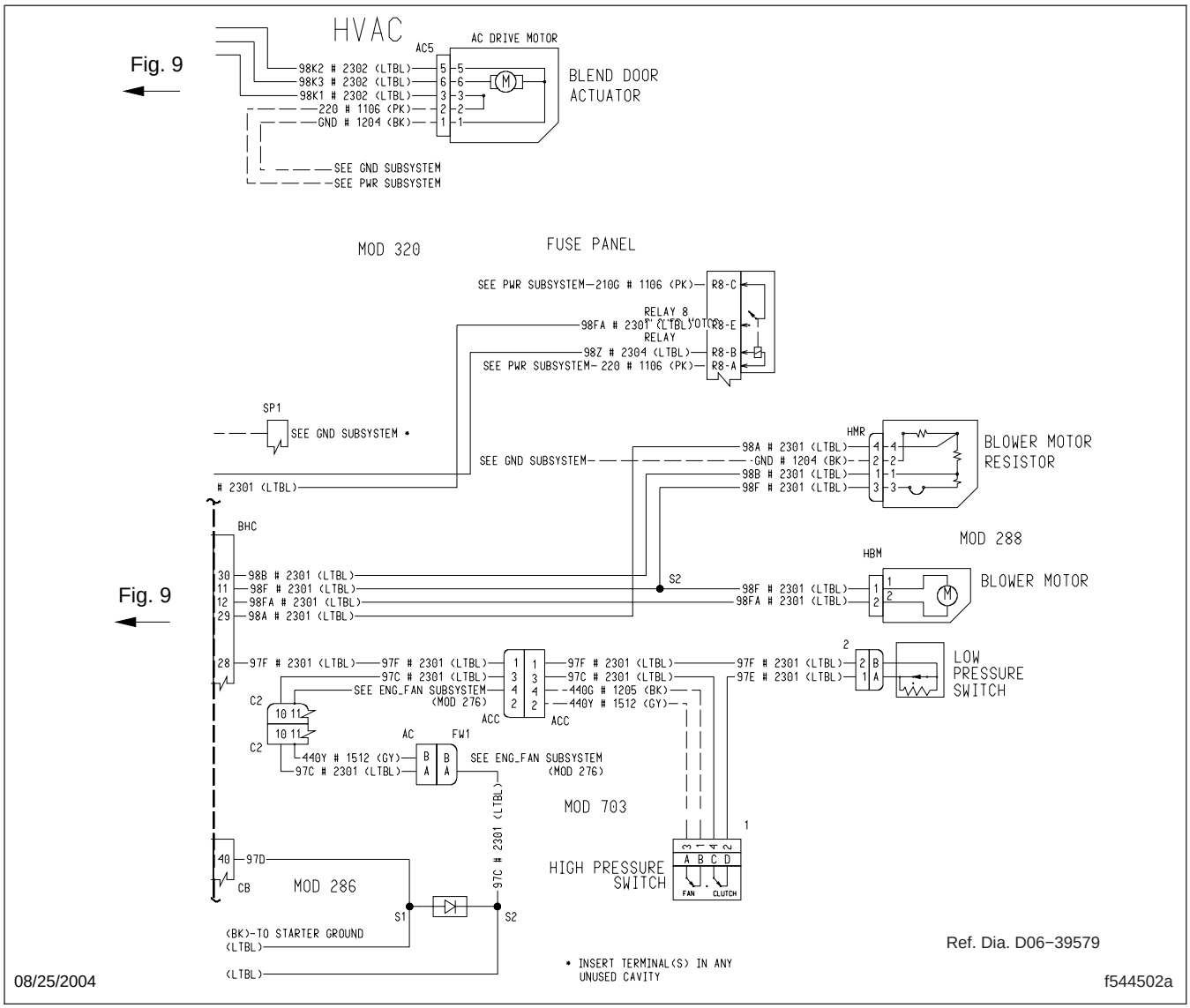
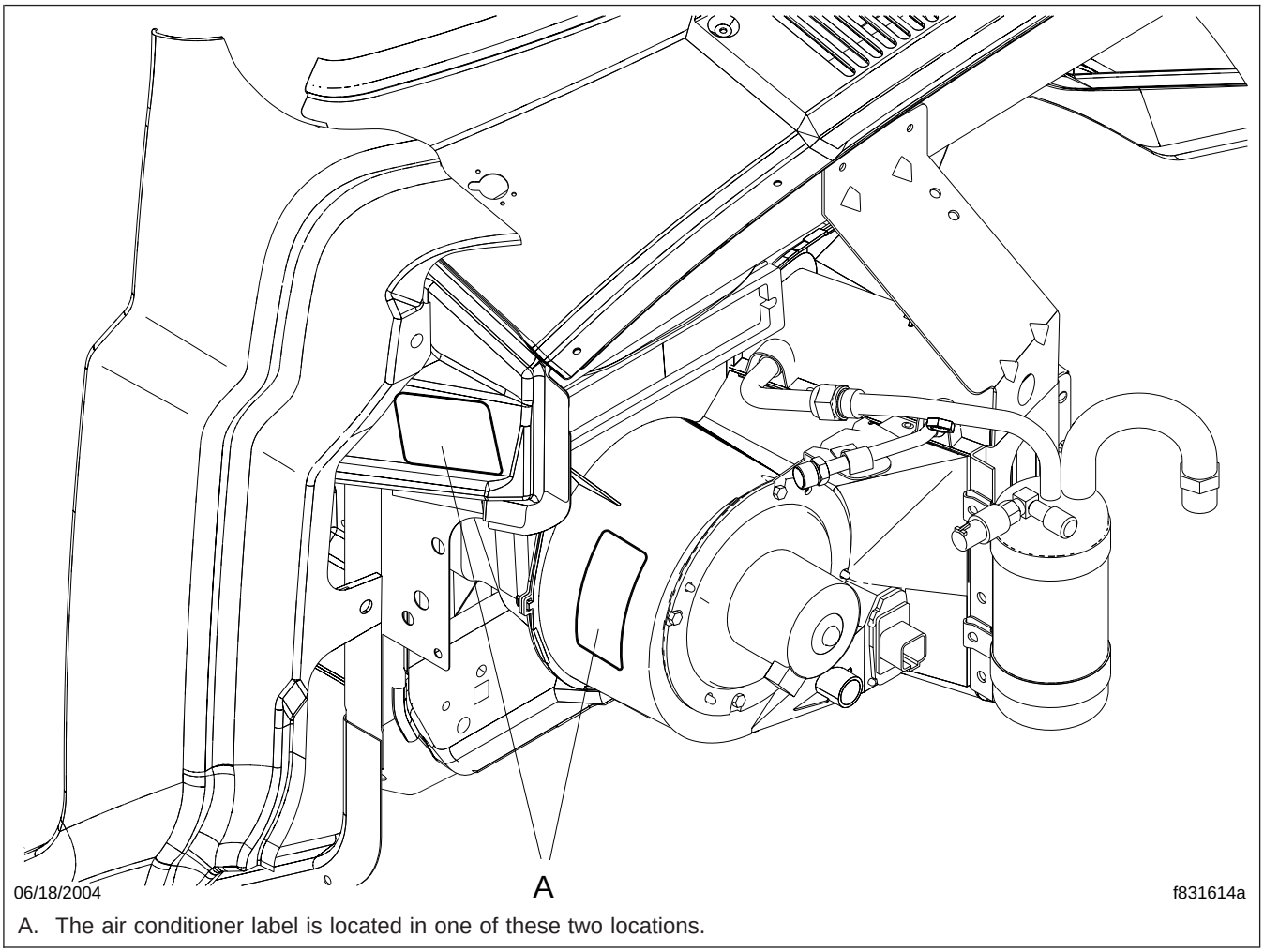


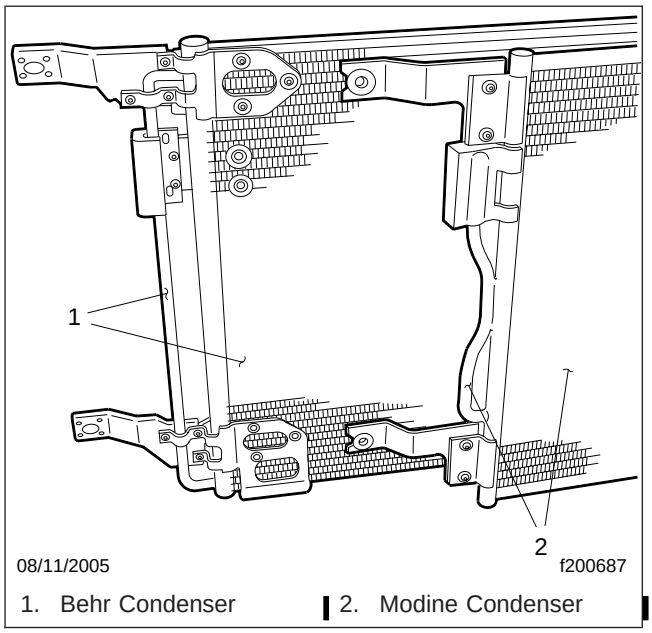
Fig. 10, Heater and Air Conditioner System Wiring Diagram (detail) for a Vehicle With a Pre-2004 Engine

Specifications



A. The air conditioner label is located in one of these two locations.

Fig. 11, Air Conditioning Label Location



1. Behr Condenser
2. Modine Condenser

Fig. 12, Behr and Modine Condensers

General Information

The primary purpose of the refrigerant compressor is to draw refrigerant gas from the evaporator and compress it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid so that it can be used for cooling again. The secondary purpose of the compressor is to move refrigerant through the air conditioning system.

Safety Precautions

Whenever repairs are made to any air conditioner components 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 (38 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 that could cause personal injury or property damage.

Always work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG) oil is used in the compressor. When handling PAG oil, observe the following guidelines:

- Keep the oil free of contaminants.
- Do not expose the air conditioning system or the PAG oil container to air for more than five minutes. PAG oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use.
- Use care when handling. Spilled oil could damage painted surfaces, plastic parts, and drive belts.
- Never mix PAG oil with other types of refrigerant oil.

Pre-Service Checks |

⚠ WARNING

Before doing any work, read the information in 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.

Compressor problems usually show in one of four ways:

- abnormal noise
- seizure
- leakage
- 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 with the engine shut off and see if the drive plate can be turned. If it cannot be turned, the compressor has seized.

Do the following checks whenever the air conditioner system is not cooling enough and the causes are unknown.

1. Check the drive belt and mounting.
   - 1.1 On the drive belt look for wear, damage, or oil. If worn, oil-soaked, or damaged, remove it and install a new one. See **Section 01.03**, Subject 100, for instructions.
   - 1.2 Check the compressor mounting components for loose fasteners, cracks, or other damage. Tighten loose fasteners to the correct torque specification. Repair or replace cracked or damaged brackets.
2. Check the wiring and connections to the compressor clutch. Replace damaged wiring and tighten loose connections.
3. Check for road debris buildup on the condenser coil fins. Using air pressure and a whisk broom or a solution of soap and water, carefully clean the condenser. Be careful not to bend the fins.
4. Check the refrigerant charge in the air conditioner system. For instructions, see **Section 83.05**, Subject 130.

Refrigerant Compressor Removal and Installation

Removal

WARNING

Before doing any work, read the information in 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. Turn off the engine, apply the brakes, and chock the tires.
2. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.05, Subject 130**.
3. Remove the serpentine belt. Do not pry or roll the belt off the pulleys.
4. Disconnect the wiring harness from the compressor.
5. Disconnect the discharge and suction lines from the compressor. Quickly cap the discharge and suction ports and the refrigerant lines.

IMPORTANT: Under no circumstances should the ports on the compressor or the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

6. Being careful not to spill any refrigerant oil, remove the capscrews and washers that attach the refrigerant compressor to the engine and remove the compressor.

Installation

1. If installing a new compressor, adjust the refrigerant oil level in the new compressor. For instructions see, **Subject 130**.
2. Using capscrews and washers, install the compressor on the mounting bracket. Torque the capscrews 15 to 19 lbf·ft (20 to 26 N·m).
3. Uncap the discharge and suction ports and the refrigerant lines. Check the refrigerant lines and the discharge and suction ports. They must be clean and free of nicks, gasket residue, and other foreign material.
4. Replace the O-rings on the refrigerant lines. Lubricate the O-rings with mineral oil prior to installation.
5. Connect the refrigerant lines to the compressor. Torque the retaining plate 11 to 15 lbf·ft (15 to 20 N·m).
6. Connect the wiring harness to the compressor.
7. Install the serpentine belt.
8. If installing a new compressor or if the system was without any refrigerant pressure before repairs were started, replace the accumulator. For instructions, see **Section 83.05, Subject 170**.
9. Evacuate, charge, and leak test the refrigerant system. For instructions, see **Section 83.05, Subject 130**.
10. Turn the compressor shaft several times by hand to distribute the refrigerant oil that has settled.
11. Lower the hood.
12. Run the air conditioning system for several minutes to circulate the refrigerant oil.
13. Check the performance of the air conditioning system by turning on the air conditioning and checking the temperature at the air outlets in the cab. See **Section 83.05, Subject 400** for the correct temperatures. If the temperatures are not correct, see **Section 83.05, Subject 300** for troubleshooting procedures.
14. Remove the chocks from the tires.

Adjustment

If the compressor is being replaced, drain the refrigerant oil from the old compressor to determine the amount of oil to add to the new compressor.

1. Remove the caps (if present) from the suction and discharge ports.
2. Drain the refrigerant oil from the suction and discharge ports into a suitable container while turning the shaft clockwise with a socket wrench on the compressor clutch retaining nut.
3. Measure and record the amount of refrigerant oil drained from the compressor.
4. Inspect the refrigerant oil for signs of contamination such as discoloration or foreign material. If there is contamination, flush the system using the instructions in **Section 83.05, Subject 130**.
5. Add Visteon polyalkylene glycol (PAG) refrigerant oil to the refrigerant compressor.
   - 5.1 If the amount of oil drained from the refrigerant compressor is less than 3 ounces (0.10 mL), add an additional 3 ounces (0.10 mL) to the amount of oil that was recovered during refrigerant recovery.
   - 5.2 If the amount of oil drained from the refrigerant compressor is between 3 to 5 ounces (0.10 to 0.17 mL), add the same amount of oil that was drained in addition to the amount recovered during refrigerant recovery.
   - 5.3 If the amount of oil drained from the refrigerant compressor is more than 5 ounces (0.17 mL), add only 5 ounces (0.17 mL) in addition to the amount recovered during refrigerant recovery.
   - 5.4 If the system was flushed, add 7 ounces (0.24 mL) of oil to the new accumulator, and 7 ounces (0.24 mL) of refrigerant oil to the refrigerant compressor.
6. To determine the amounts of refrigerant oil to add to the refrigerant compressor when other components have been replaced, follow the replacement instructions in this subject.

Adding Oil After Suction Accumulator/Drier Replacement

1. Drill a hole in the bottom of the old suction accumulator/drier.
2. Drain the refrigerant oil into a suitable oil measuring container.
3. Using the type of refrigerant oil recommended by the refrigerant compressor manufacturer, pour the same amount of new refrigerant oil plus 2 oz (60 ml) into the suction accumulator/drier.

Adding Oil After Component Replacement

NOTE: If a refrigerant line or component bursts with a fully charged system, the addition of refrigerant oil may be necessary, with the amount determined by the technician.

Using the type of refrigerant oil recommended by the refrigerant compressor manufacturer, pour new oil into the component in the following amounts:

- Evaporator: add 3 oz (90 ml)
- Condenser: add 1 oz (30 ml)
- Evaporator orifice: add 2 oz (59 ml)
- Refrigerant lines: add 2 oz (59 ml)

Adding Oil After Refrigerant Compressor Replacement

IMPORTANT: If the refrigerant compressor is being replaced due to failure, the suction accumulator/drier must be replaced at the same time. For instructions for a Sanden compressor, see **Section 83.02, Subject 150**. For instructions for a Visteon compressor, see **Section 83.06, Subject 130**.

Specifications

Use only Visteon polyalkylene glycol (PAG) refrigerant oil, part number EXM 920029, in the Visteon refrigerant compressor.

General Information

Hood

The hood is molded using the SMC process. SMC, which stands for sheet molding compound, is a fiberglass and thermosetting polyester material. SMC hoods are easily recognized by their smooth inner surface. To make each part, SMC sheets are first placed between matching mold halves. Heat and pressure are applied to the mold in order to cure (solidify) the SMC resin. At the end of the process, an in-mold coating is injected onto the part to prepare it for priming and topcoating.

Hood Mounting and Components

The hood assembly is hinged at the front mounts. Depending on the vehicle configuration, the hinges are located on a crossbar at the bottom of the grille opening, or at the sides of the grille opening. The hood pivots work in conjunction with the tilt-assist and tilt-limiting mechanisms to allow a forward hood tilt of approximately 65 degrees for vehicle service. Some hoods are equipped with butterfly, or transverse access openings for ease of service.

In the closed position, the rear of the hood is supported by hood mounting brackets, which are attached to the cab. The rear brackets hold the hood in the correct position for operation. The hood is held in place with elastomeric latches; one on each side.

The hood hinge brackets are adjustable fore-and-aft, and depending on the hood configuration, side-to-side and/or up-and-down. The rear hood mounting brackets are adjustable side-to-side and up-and-down.

The hood is equipped with headlight assemblies, which feature a headlight and turn signal/parking light combination on each fender.

Grille

The grille is mounted to the hood or the radiator, depending on the vehicle configuration and options. Hood-mounted grilles are chrome-plated or painted plastic. Radiator-mounted grilles, of aluminum, are bright anodized or painted silver metallic.

Hood Removal and Installation, Vehicles With an Engine Manufactured Through 2006

Procedures under these headings apply to the following vehicles, with engines manufactured through 2006, as specified:

- 101-inch BBC vehicles
- 111-inch BBC vehicles
- 113-inch and 122-inch BBC vehicles

CAUTION

On vehicles using aluminum cab construction, use only original equipment manufacturer replacement parts, including fasteners. This must be strictly adhered to in order to reduce the possibility of galvanic corrosion.

101-Inch BBC Vehicles

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Open the hood.
3. Place a support between the floor and the front of the hood. The support should be as wide and as long as the front of the hood, and should be the same height as the lowest edge of the hood. Pad the support and the front bumper.
4. Disconnect the front lamps electrical connector; see **Fig. 1**.
5. Have an assistant close the hood one-fourth of the way, and support it in that position from the front. Disconnect the hood check cable by removing the retainer spring and the clevis pin from the hood support bracket; see **Fig. 2**.

CAUTION

Do not support the hood by the grille or the headlamp surface; this could cause damage to the grille or the headlamp surface.

6. Tilt the hood fully open, and rest it on the support so that most of the weight is on the hood structure.
7. On each side of the vehicle, pull the hood hinge retainer spring out of the clevis pin. See **Fig. 3**.
8. With two assistants holding the hood, one per side, push out both hood hinge clevis pins.

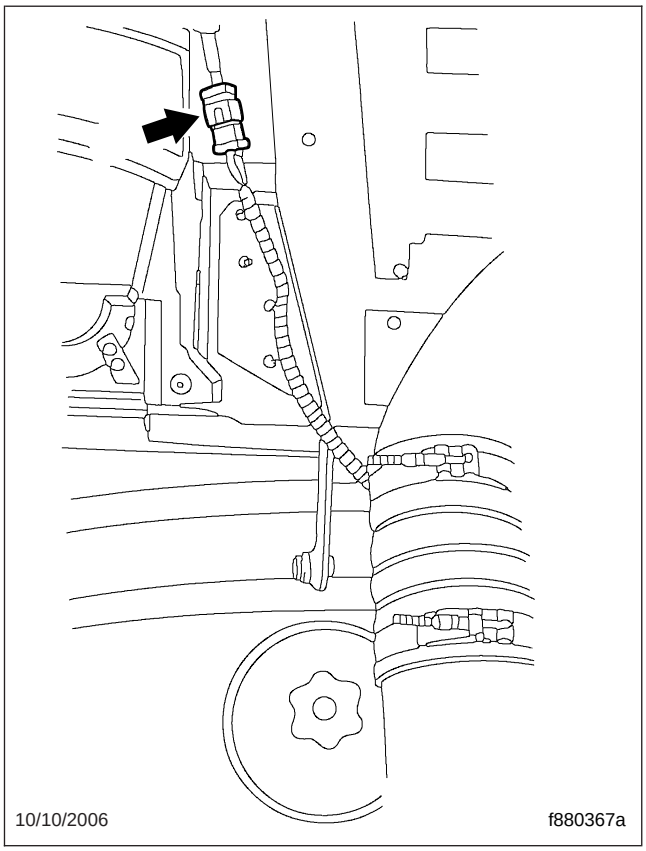


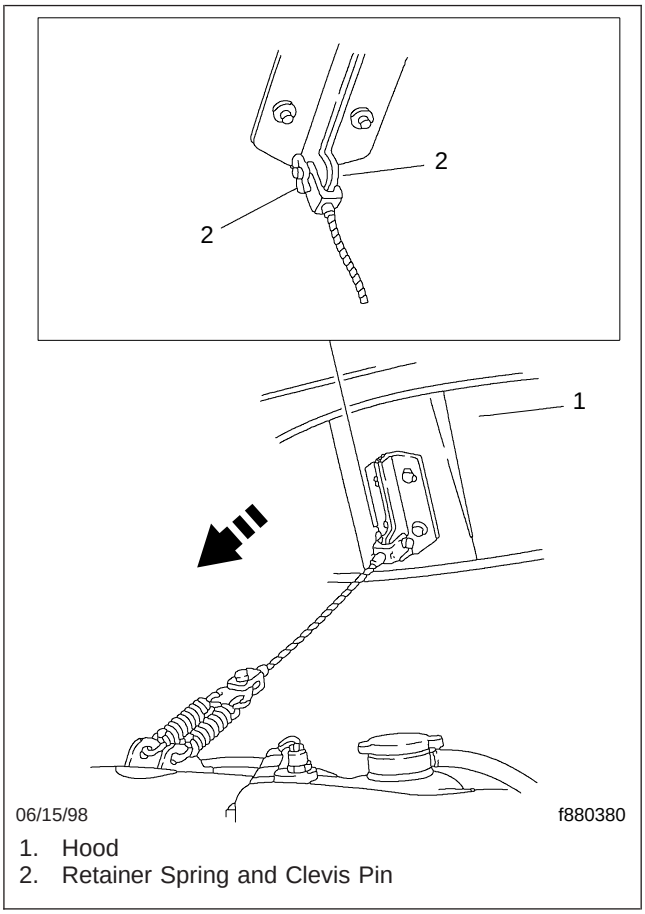
Fig. 1, Front Lamp Electrical Connector (101-inch, 113-inch, and 122-inch BBC vehicles)

9. Position the hood carefully on the support.

Installation

1. With the tires chocked, and two assistants holding the hood, one per side, install the hood hinge clevis pins; see **Fig. 3**.
2. Install new retainer springs in the clevis pins on both sides of the vehicle.
3. Have an assistant close the hood one-fourth of the way, and support it in that position from the front. Attach the hood check cable to the hood with the clevis pin and retainer spring; see **Fig. 2**.
4. Connect the front lamps electrical connector; see **Fig. 1**.
5. Close and latch the hood.

Hood Removal and Installation, Vehicles With an Engine Manufactured Through 2006



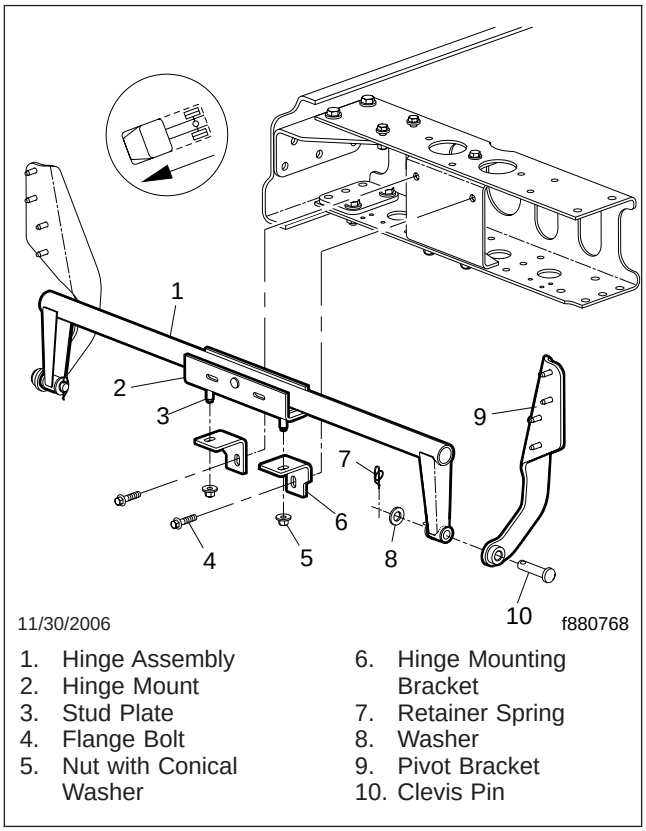
1. Hood
2. Retainer Spring and Clevis Pin

Fig. 2, Hood Check Cable (101-inch and 111-inch BBC vehicles)

6. Align the hood, if necessary; see "Hood Alignment" below. For hood alignment clearances, see **Specifications 400**.
7. Remove the chocks.

Hood Alignment

NOTE: The frame-mounted portion of the hood hinge assembly, hidden behind the front bumper, provides adjustment along three axes, fore-and-aft, up-and-down, and side-to-side. See **Fig. 3**. The cab-mounted hood stabilizers provide up-and-down adjustment and side-to-side adjustment at the rear of the hood. See **Fig. 4**. To correct a misaligned hood, measure the clearances between the panels to determine in which directions, and how far, to move the hood.



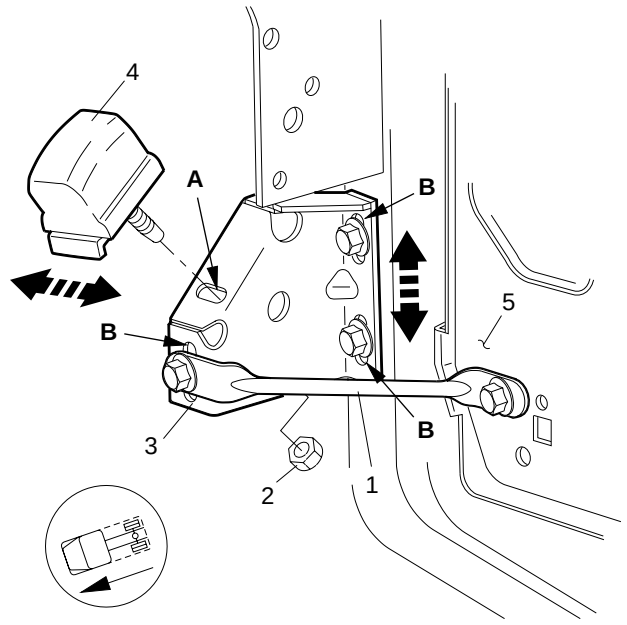
1. Hinge Assembly
2. Hinge Mount
3. Stud Plate
4. Flange Bolt
5. Nut with Conical Washer
6. Hinge Mounting Bracket
7. Retainer Spring
8. Washer
9. Pivot Bracket
10. Clevis Pin

Fig. 3, Hood Hinge Assembly (101-inch BBC vehicles)

For hood alignment clearances, see **Specifications 400**.

1. Drive the vehicle back and forth to settle the frame and suspension. Park the vehicle on a flat, level surface. Shut down the engine, apply the parking brakes, and chock the tires.
2. For hood adjustment at the rear of the hood, loosen the hood stabilizer bracket bolts and slide the bracket up-and-down, or loosen the isolator and slide it side-to-side. See **Fig. 4**.
3. Lubricate the top face of the hood stabilizer isolator with fluorinated grease.
4. If further hood adjustments are necessary, remove the front bumper (except extended frame or extended bumper); see **Section 31.00**.

Hood Removal and Installation, Vehicles With an Engine Manufactured Through 2006



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NOTE: Right-hand side shown.

A. Slot for Side-to-Side Adjustment
B. Slots for Up-and-Down Adjustment

1. Hood Stabilizer Brace
2. Nut
3. Hood Stabilizer Bracket
4. Isolator
5. Cab Front Wall

Fig. 4, Hood Alignment at Cab-Mounted Hood Stabilizer

5. Loosen the bolts (item 4 in **Fig. 3**) on the two hinge mounting brackets, move the hood up-and-down as far as required, then tighten the bolts.
6. Loosen the two nuts (item 5 in **Fig. 3**) that secure the hood hinge mounting brackets to the hinge assembly, move the hood side-to-side or front-and-back as far as required, then tighten the nuts.
7. If the hood cannot be adjusted to the specified clearances, the hood hinges may be damaged. Inspect the hood hinge assembly and the pivot brackets, and replace any damaged components.
8. Remove the chocks.

111-Inch BBC Vehicles

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Open the hood.
3. Place a support between the floor and the front of the hood. The support should be as wide and as long as the front of the hood, and should be the same height as the lowest edge of the hood. Pad the support and the front bumper.
4. Disconnect the front lamps electrical connector; see **Fig. 5**.

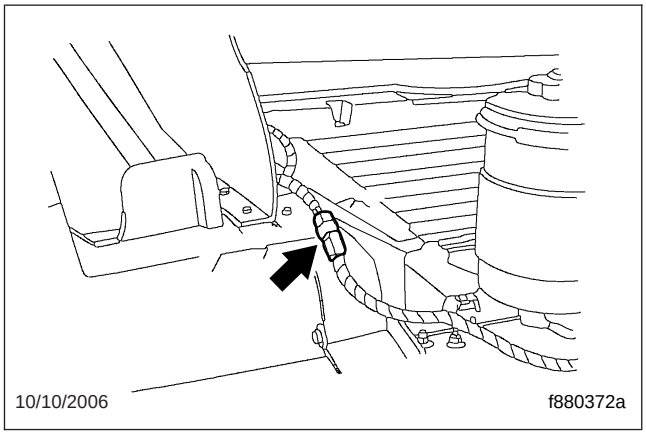

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Fig. 5, Front Lamps Electrical Connector (111-inch BBC vehicles)

5. Have an assistant close the hood one-fourth of the way, and support it in that position from the front. Disconnect the hood check cable by removing the retainer spring and the clevis pin from the hood support bracket; see **Fig. 2**.

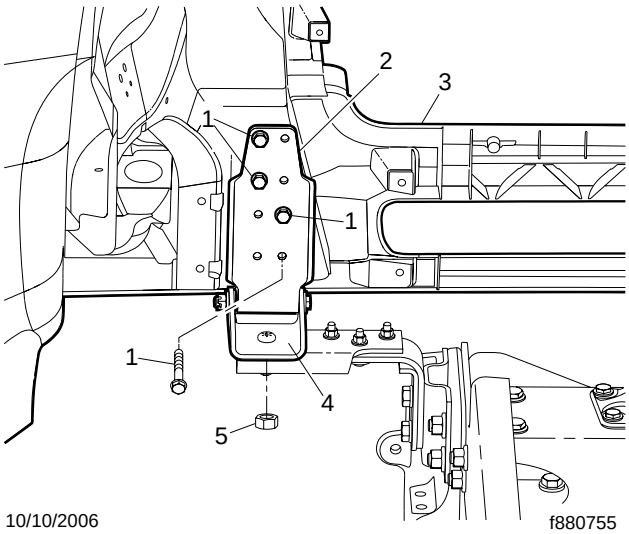
CAUTION

Do not support the hood by the grille or the headlamp surface; this could cause damage to the grille or the headlamp surface.

6. Tilt the hood fully open, and rest it on the support so that most of the weight is on the hood structure.
7. With two assistants holding the hood, one per side, remove the capscrews (item 1 in **Fig. 6**)

Hood Removal and Installation, Vehicles With an Engine Manufactured Through 2006

that attach the hood hinge assembly to the hood on both sides of the vehicle.



NOTE: Left side shown.

1. Capscrew
2. Hood-Mounted Hinge Bracket
3. Hood
4. Frame-Mounted Hinge Bracket
5. Nut

Fig. 6, Hood Hinge (111-inch BBC vehicles)

8. Position the hood carefully on the support.

Installation

1. With the tires chocked, and two assistants holding the hood, one per side, position the hood against the hinge brackets, and install the capscrews that attach the brackets to the hood; see **Fig. 6**.
2. Have an assistant close the hood one-fourth of the way, and support it in that position from the front. Attach the hood check cable to the hood with the clevis pin and retainer spring; see **Fig. 2**.
3. Close and latch the hood.
4. Connect the front lamps electrical connector; see **Fig. 5**.
5. Align the hood, if necessary; see "Hood Alignment" below. For hood alignment clearances, see **Specifications 400**.
6. Remove the chocks.

Hood Alignment

NOTE: The hood hinges provide fore-and-aft adjustment and side-to-side adjustment. The nut at both hinges must be loosened for adjustment. See **Fig. 6**. The cab-mounted hood stabilizers provide up-and-down adjustment and side-to-side adjustment at the rear of the hood. See **Fig. 4**. To correct a misaligned hood, measure the clearances between the panels to determine in which directions and how far to move the hood.

For hood alignment clearances, see **Specifications 400**.

1. Drive the vehicle back and forth to settle the frame and suspension. Park the vehicle on a flat, level surface. Shut down the engine, apply the parking brakes, and chock the tires.
2. For hood adjustment at the rear of the hood, loosen the hood stabilizer bracket bolts and slide the bracket up-and-down, or loosen the isolator and slide it side-to-side. See **Fig. 4**.
3. Lubricate the top face of the hood stabilizer isolator with fluorinated grease.
4. Loosen the nut (item 5 in **Fig. 6**) that secures the hood hinge bracket on each side of the vehicle, move the hood front-and-back or side-to-side as required, then tighten the nuts.
5. If the hood cannot be adjusted to the specified clearances, the hood hinges may be damaged. Inspect the hood hinges and replace, if required.
6. Remove the chocks.

113-Inch and 122-Inch BBC Vehicles

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Remove the bumper; see **Section 31.00, Subject 100**.

Hood Removal and Installation, Vehicles With an Engine Manufactured Through 2006

WARNING

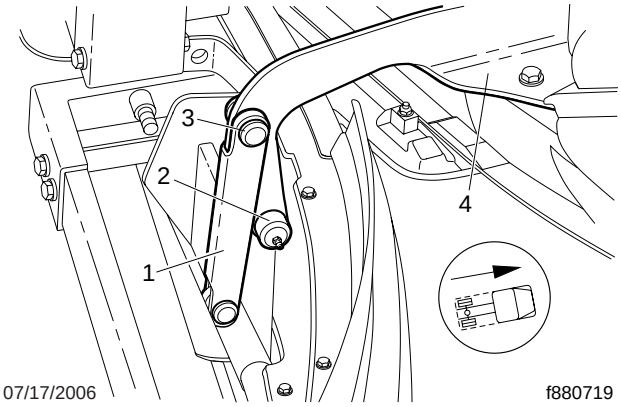
Do not attempt to lift the hood; it weighs about 150 lb (68 kg). Lifting the hood could result in personal injury or damage to the hood assembly and other components.

3. Open the hood.
4. Remove the grille; see **Subject 150**.
5. Place a support between the floor and the front of the hood. The support should be as wide and as long as the front of the hood, and should be the same height as the lowest edge of the hood. Place cardboard, carpet, rags, or other padding on top of the support to protect the hood.
6. Disconnect the front lamps electrical connector; see **Fig. 1**.
7. On vehicles built before December 2003, while an assistant is supporting the hood closed one-fourth of the way, disconnect the hood hinge links from the hood hinge mounting plate assemblies, as follows. See **Fig. 7**.
   - 7.1 Remove the left hood hinge link retaining spring.
   - 7.2 Remove the left hood hinge link pin.
   - 7.3 Remove the right hood hinge link retaining spring.
   - 7.4 Remove the right hood hinge link pin.

CAUTION

Do not support the weight of the hood with the grille support bracket or the chrome headlamp bezels. The weight of the hood will damage these components.

8. With an assistant supporting the hood closed one-fourth of the way, disconnect the hood-check cables by removing the nuts and bolts that attach the cables to the left and right mounting brackets. See **Fig. 8**. Lower the hood onto the support.
9. On each side of the vehicle, remove the spring clip and the washer from the hood hinge clevis pin. See **Fig. 9**.
10. On each side of the vehicle, push out and remove the hood hinge clevis pin.



1. Hood Hinge Link
2. Hood Hinge Pivot Pin
3. Hood Hinge Link Pin
4. Hood Mounting Plate Assembly

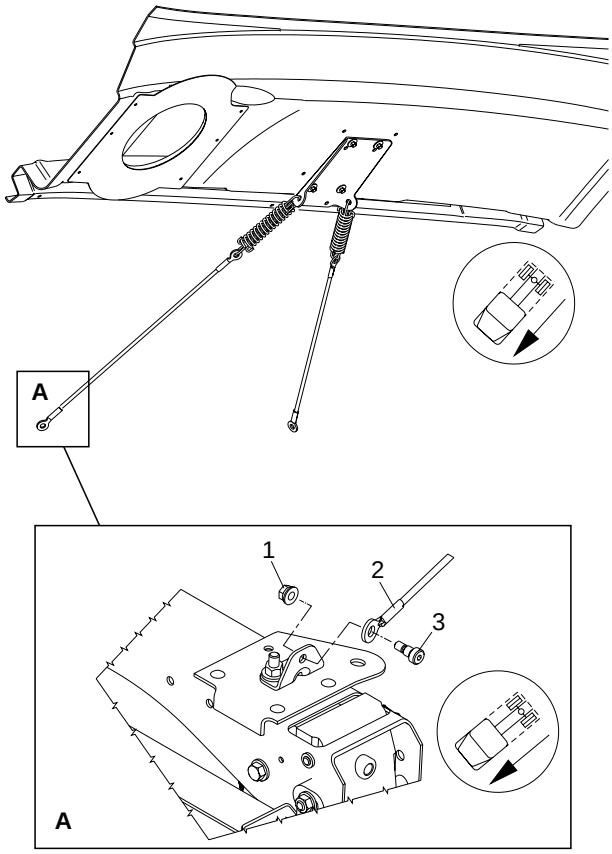
Fig. 7, Hood Hinge Link (113-inch and 122-inch BBC vehicles built before December 2003)

11. Position the hood carefully on the support.

Installation

1. With the tires chocked, install the hood hinge clevis pins on each side of the vehicle. See **Fig. 9**.
2. Install a washer and spring clip on each hood hinge clevis pin.
3. On vehicles built before December 2003, while an assistant is supporting the hood closed one-fourth of the way, connect the hood hinge links to the hood hinge mounting plate assemblies, as follows. See **Fig. 7**.
   - 3.1 Install the right hood hinge link pin.
   - 3.2 Install the right hood hinge link retaining spring.
   - 3.3 Install the left hood hinge link pin.
   - 3.4 Install the left hood hinge link retaining spring.
4. With an assistant supporting the hood closed one-fourth of the way, position the hood-check cables on the left and right mounting brackets, and install the nuts and bolts. Tighten the nuts securely. See **Fig. 8**.
5. Connect the front lamps electrical connector; see **Fig. 1**.

Hood Removal and Installation, Vehicles With an Engine Manufactured Through 2006



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A. Disconnect the hood-check cable.

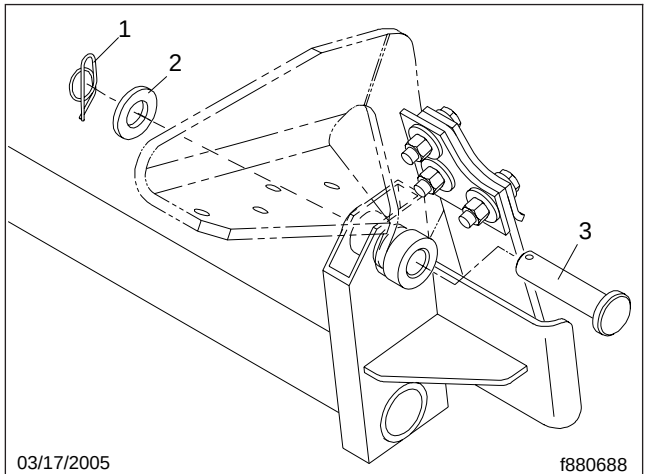
1. Nut
2. Hood-Check Cable
3. Bolt

Fig. 8, Hood-Check Cable Assembly (113-inch and 122-inch BBC vehicles)

6. Install the grille; see **Subject 150**.
7. Close and latch the hood.
8. Install the bumper; see **Section 31.00, Subject 100**.
9. Align the hood, if necessary; see "Hood Alignment" below. For hood alignment clearances, see **Specifications 400**.
10. Remove the chocks.

Hood Alignment

NOTE: The frame-mounted portion of the hood hinge assembly, hidden behind the front



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NOTE: Left side shown.

1. Spring Clip
2. Washer
3. Hood Hinge Clevis Pin

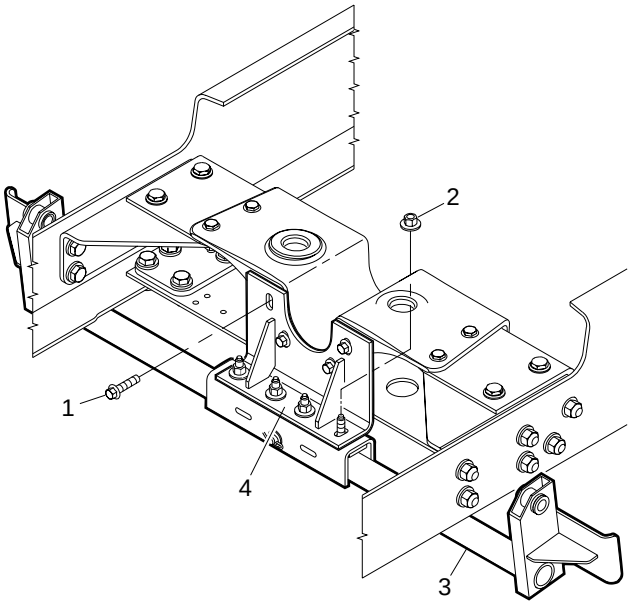
Fig. 9, Hood Hinge Mounting Bracket (113-inch and 122-inch BBC vehicles)

bumper, provides adjustment along three axes: fore-and-aft, up-and-down, and side-to-side. See **Fig. 10**. The cab-mounted hood stabilizers provide side-to-side and up-and-down adjustment at the rear of the hood. See **Fig. 4**. To correct a misaligned hood, measure the clearances between the panels to determine which directions, and how far, to move the hood.

For hood alignment clearances, see **Specifications 400**.

1. Drive the vehicle back and forth to settle the frame and suspension. Park the vehicle on a flat, level surface. Shut down the engine, apply the parking brakes, and chock the tires.
2. For hood adjustment at the rear of the hood, loosen the hood stabilizer bracket bolts and slide the bracket up-and-down, or loosen the isolator and slide it side-to-side. See **Fig. 4**.
3. Lubricate the top face of the hood stabilizer isolator with fluorinated grease.
4. If further adjustments are necessary, remove the front bumper (except extended frame or extended bumper); see **Section 31.00**.
5. Loosen the bolts in the front face of the hood hinge center mounting brackets, and move the

Hood Removal and Installation, Vehicles With an Engine Manufactured Through 2006



1. Bolt
2. Nut
3. Torsion Bar
4. Pivot Bracket

Fig. 10, Hood Alignment at Hood Hinge (113-inch and 122-inch BBC vehicles)

hood up-and-down as required, then tighten the bolts. See **Fig. 10**.

6. Loosen the nuts that retain the hood hinge to the center mounting bracket, and move the hood side-to-side or fore-and-aft as required, then tighten the nuts.
7. If the hood cannot be adjusted to the specified clearances, the hood hinge may be damaged. Inspect the hood hinge crosstube and arms that attach to the hood, and replace any damaged components.
8. Remove the chocks.

Hood Removal and Installation, Vehicles With an EPA07 Engine

Procedures under these headings apply to the following vehicles, with EPA07 engines, as specified:

- 101-inch and 111-inch BBC vehicles
- 113-inch and 122-inch BBC vehicles

CAUTION

On vehicles using aluminum cab construction, use only original equipment manufacturer replacement parts, including fasteners. This must be strictly adhered to in order to reduce the possibility of galvanic corrosion.

101-Inch and 111-Inch BBC Vehicles

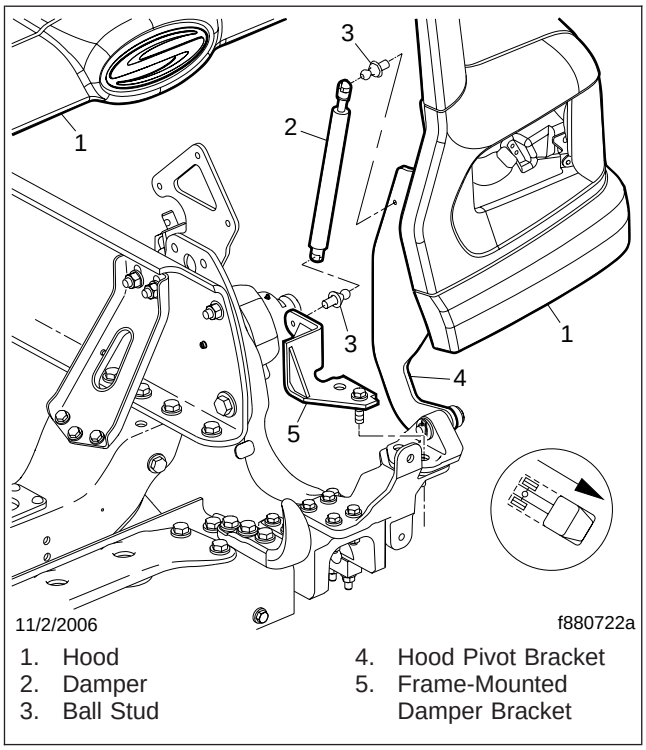
Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Open the hood.
3. Place a support between the floor and the front of the hood. The support should be as wide and as long as the front of the hood, and should be the same height as the lowest edge of the hood. Pad the support and the front bumper.
4. Disconnect the front lamps electrical connector, located next to the left-side hood hinge.
5. For a 101-inch BBC vehicle, disconnect the hood damper from the hood; see **Fig. 1**.

   For a 111-inch vehicle, disconnect the hood tilt-assist strut by removing the fasteners that attach the strut to the hood; see **Fig. 2**.
6. Disconnect the hood check cables, as follows.

   6.1 Have an assistant close the hood one-fourth of the way, and support it in that position from the front.

   6.2 With the assistant supporting the hood in position, remove the shoulder bolts and flange nuts that attach the check cables to the brackets on the radiator; see **Fig. 3**.



1. Hood
2. Damper
3. Ball Stud
4. Hood Pivot Bracket
5. Frame-Mounted Damper Bracket

Fig. 1, Hood Damper Installation

CAUTION

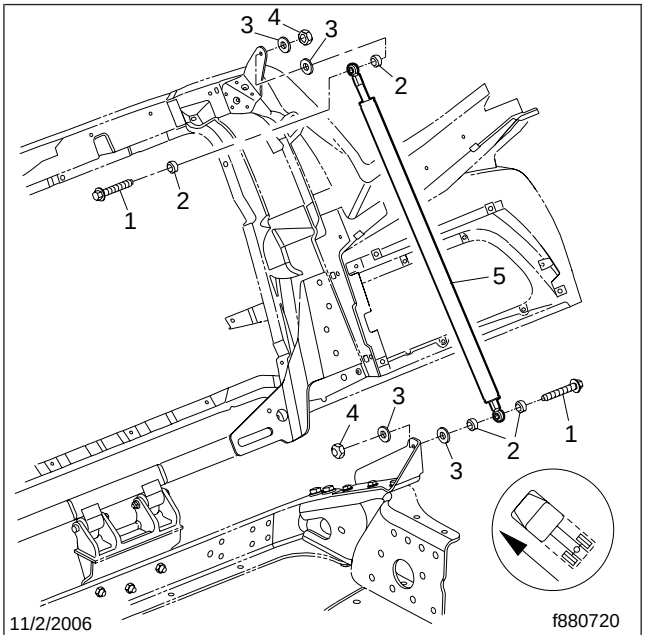
Do not support the hood by the grille or the headlamp surface; this could cause damage to the grille or the headlamp surface.

7. Tilt the hood fully open, and rest it on the support so that most of the weight is on the hood structure.
8. On each side of the hood, pull the retainer spring out of the clevis pin; see **Fig. 4**.
9. With two assistants holding the hood, one per side, remove both hood hinge clevis pins and washers.
10. Position the hood carefully on the support.

Installation

1. With the tires chocked, and two assistants holding the hood, one per side, install hood hinge clevis pins and washers; see **Fig. 4**.
2. Install new retainer springs in the clevis pins on both sides of the vehicle.

Hood Removal and Installation, Vehicles With an EPA07 Engine



NOTE: 113/122-inch BBC shown; 111-inch BBC similar.

1. Bolt
2. Spacer
3. Washer
4. Nut
5. Strut

Fig. 2, Hood Tilt-Assist Strut Installation

3. Connect the hood check cables, as follows.
   - 3.1 Have an assistant close the hood one-fourth of the way, and support it in that position from the front.
   - 3.2 With the assistant supporting the hood in position, attach the hood check cables to the brackets on the radiator with the shoulder bolts and flange nuts; see **Fig. 3**.
4. For a 101-inch BBC vehicle, connect the hood damper to the hood; see **Fig. 1**.

   For a 111-inch vehicle, connect the hood tilt-assist strut to the hood; see **Fig. 2**.
5. Connect the front lamps electrical connector.
6. Close and latch the hood.
7. Align the hood, if necessary. For hood alignment clearances, see **Specifications 400**. For hood alignment instructions, see "Hood Alignment" in this subject.
8. Remove the chocks.

Hood Alignment

NOTE: Hood alignment is adjusted at both hinges for fore-and-aft and side-to-side movements. The fasteners at both hinges must be loosened for adjustment; see **Fig. 5**. The cab-mounted hood stabilizers provide side-to-side adjustment at the rear of the hood only; see **Fig. 6**. To correct a misaligned hood, measure the clearances between the panels to determine in which directions and how far to move the hood.

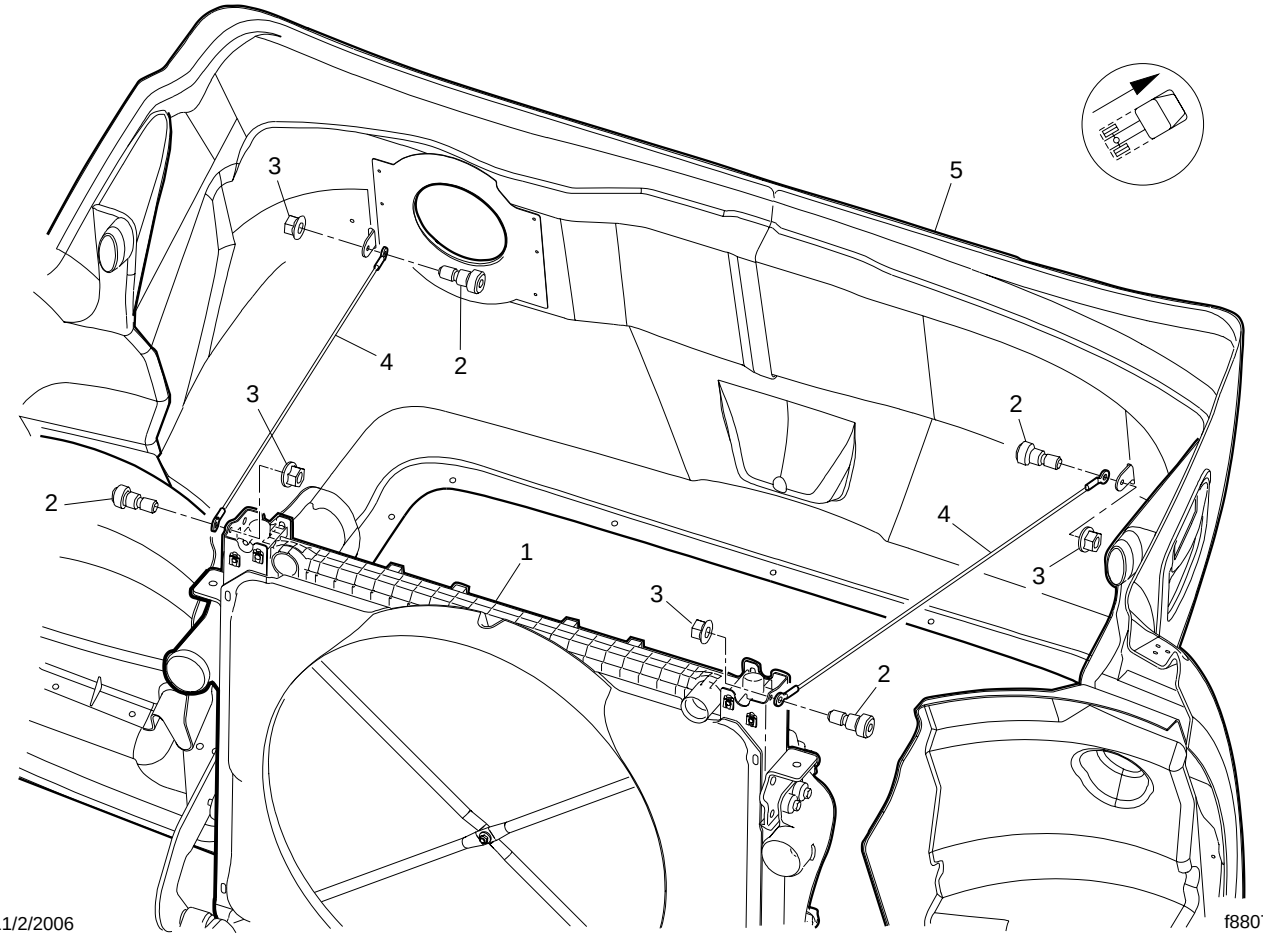
1. Drive the vehicle back and forth to settle the frame and suspension. Park the vehicle on a flat, level surface. Shut down the engine, apply the parking brakes, and chock the tires.
2. Loosen the stabilizer receptacle bracket bolts and slide the bracket up or down or side-to-side for hood adjustment at the rear of the hood only; see **Fig. 6**. For clearances, refer to **Specifications 400**.
3. Lubricate the hood stabilizer on the top face with fluorinated grease.
4. Loosen the bolts on the hood-mounted pivot bracket, move the hood up or down as far as required, and tighten the bolts. For clearances, refer to **Specifications 400**.
5. Loosen the bolts that secure the hinge brackets to the frame, move the hood left to right or front to back as far as required and tighten the nuts. For clearances, refer to **Specifications 400**.
6. If the hood cannot be adjusted to the specified clearances, the hood hinge may be damaged. Inspect the hood hinge brackets, and replace any damaged components.
7. Remove the chocks.

113-Inch and 122-Inch BBC Vehicles

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Open the hood.
3. Remove the grille; see **Subject 150**.

Hood Removal and Installation, Vehicles With an EPA07 Engine



NOTE: 101-inch BBC vehicle with a chassis-mounted radiator is shown. 111-inch BBC vehicles have springs attached to the cables at the hood end. For vehicles with an engine-mounted radiator, the cables attach to an intermediate bracket at the radiator end.

1. Radiator
2. Shoulder Bolt
3. Flange Nut
4. Check Cable
5. Hood

Fig. 3, Hood Check Cables (101-inch and 111-inch BBC vehicles)

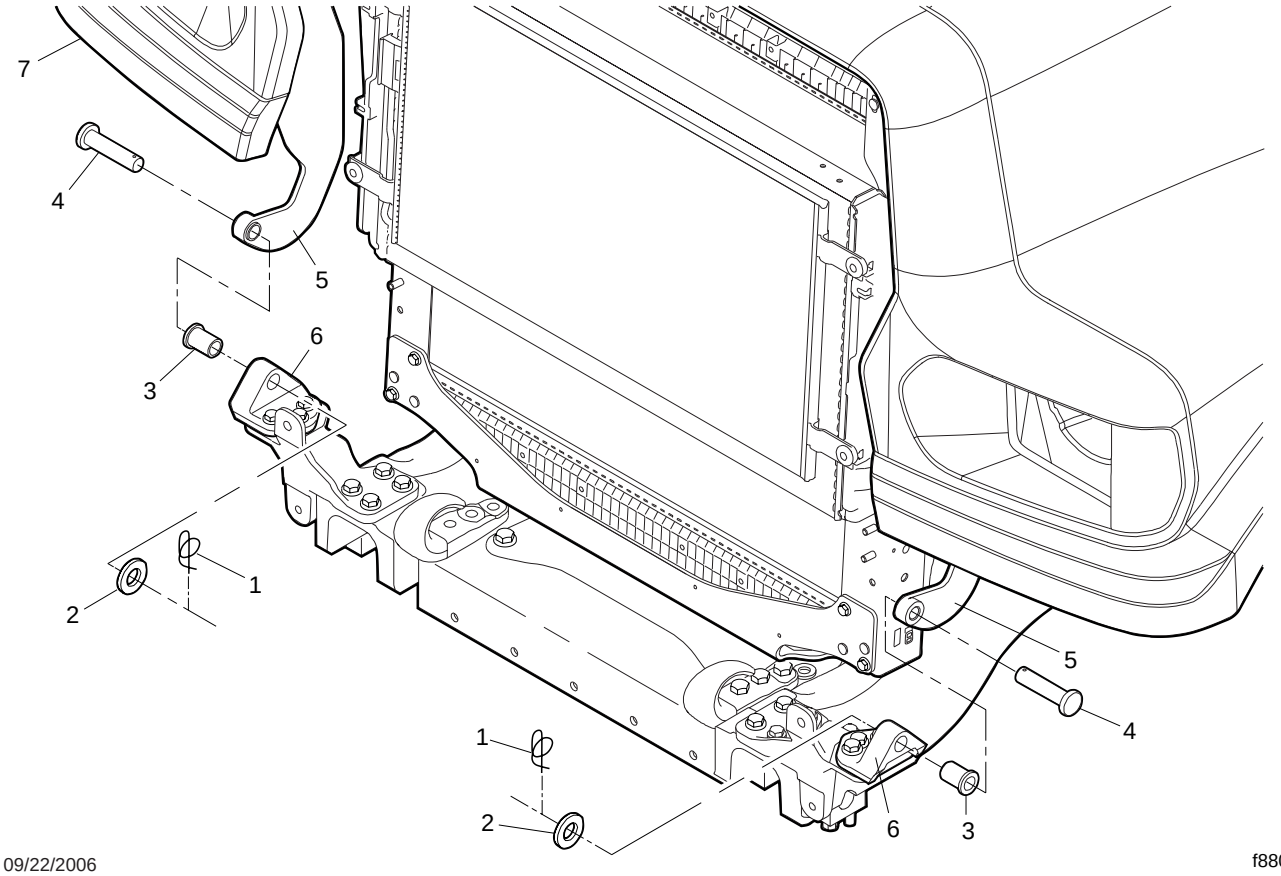
4. Place a support between the floor and the front of the hood. The support should be as wide and as long as the front of the hood, and should be the same height as the lowest edge of the hood. Pad the support and the front bumper.
5. Disconnect the front lamps electrical connector.
6. Disconnect the hood tilt-assist strut by removing the fasteners that attach the strut to the hood; see **Fig. 2**.

⚠ CAUTION

Do not support the hood by the grille or the headlamp surface; this could cause damage to the grille or the headlamp surface.

7. With an assistant supporting the hood closed one-fourth of the way, disconnect the hood-check cables by removing the nuts and bolts that attach the cables to the left and right mounting brackets; see **Fig. 7**. Tilt the hood fully open, and

Hood Removal and Installation, Vehicles With an EPA07 Engine



1. Retainer Spring
2. Washer
3. Bushing
4. Clevis Pin
5. Pivot Bracket
6. Chassis-Mounted Hinge Bracket
7. Hood

Fig. 4, Hood Hinge Installation (101-inch and 111-inch BBC vehicles)

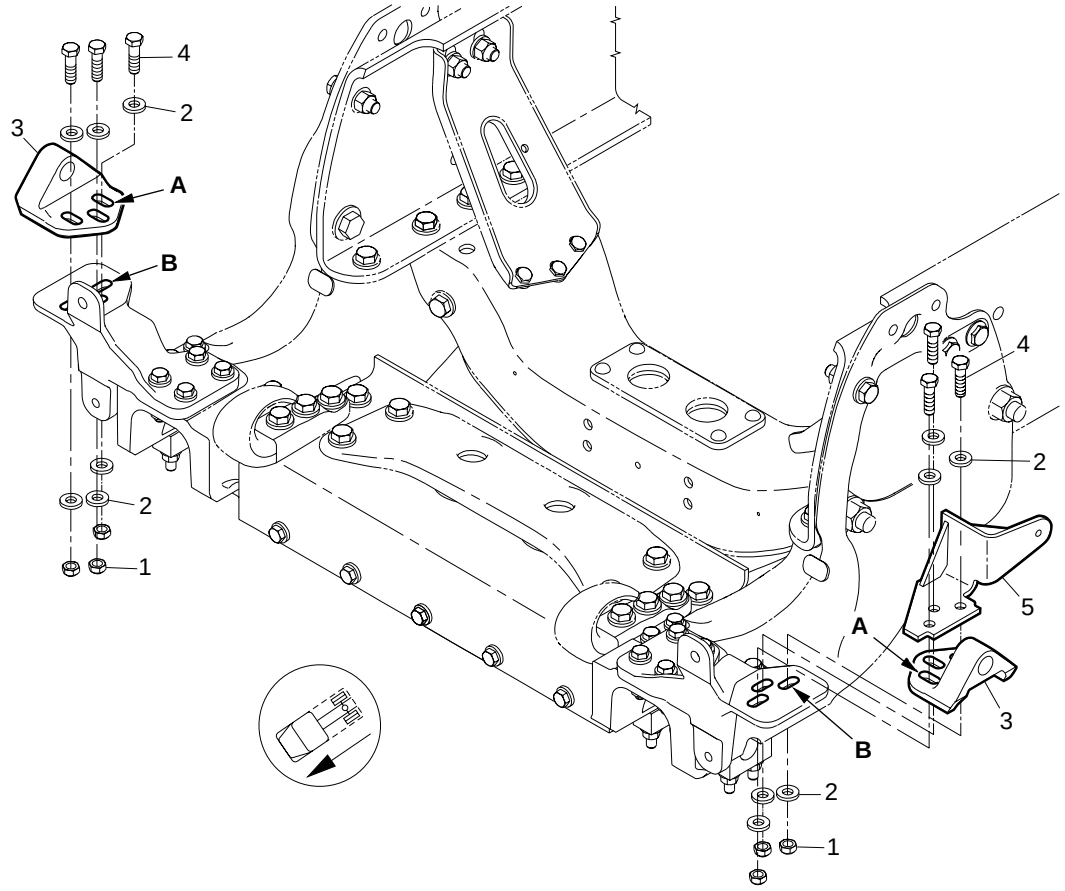
rest it on the support so that most of the weight is on the hood structure.

8. With two assistants holding the hood, one per side, remove both shoulder bolts and locking flange nuts; see **Fig. 8**.
9. Position the hood carefully on the support.

Installation

1. With the tires chocked, and two assistants holding the hood, one per side, install the shoulder bolts and locking flange nuts in the hood hinge; see **Fig. 8**.
2. Have an assistant close the hood one-fourth of the way, and support it in that position from the front. Connect the hood-check cables to the left and right mounting brackets; see **Fig. 7**.
3. Connect the hood tilt-assist strut to the hood; see **Fig. 2**.
4. Connect the front lamps electrical connector.
5. Install the grille, see **Subject 150**.
6. Close and latch the hood.
7. Align the hood, if necessary. For hood alignment clearances, see **Specifications 400**. For hood alignment instructions, see "Hood Alignment" below.

Hood Removal and Installation, Vehicles With an EPA07 Engine



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A. Slots for Side-to-Side Adjustment
B. Slots for Fore-and-Aft Adjustment

1. Nut
2. Washer
3. Chassis-Mounted Hinge Bracket
4. Bolt
5. Chassis-Mounted Damper Bracket (101-inch BBC only)

Fig. 5, Hood Alignment at Frame-Mounted Hinge Bracket (101-inch and 111-inch BBC, non-FFE vehicles)

8. Remove the chocks.

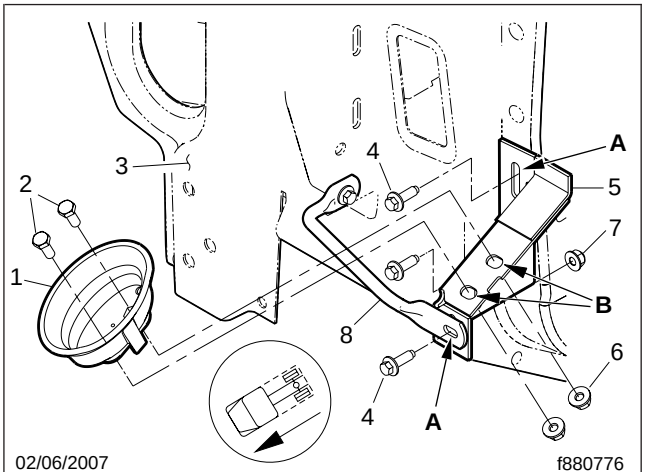
Hood Alignment

NOTE: The frame-mounted portion of the hood hinge assembly provides adjustment along two axes: fore-and-aft, up-and-down; see **Fig. 9**. The cab-mounted hood receptacle brackets provide up-and-down adjustment at the rear of the hood; see **Fig. 10**. To correct a misaligned hood, measure the clearances between the panels to determine which directions, and how far, to move the hood.

For hood alignment clearances, see **Specifications 400**.

1. Drive the vehicle back and forth to settle the frame and suspension. Park the vehicle on a flat, level surface. Shut down the engine, apply the parking brakes, and chock the tires.
2. For hood adjustment at the rear of the hood, loosen the hood receptacle bracket bolts, and

Hood Removal and Installation, Vehicles With an EPA07 Engine



A. Slots for Up-and-Down Adjustment
B. Slots for Side-to-Side Adjustment

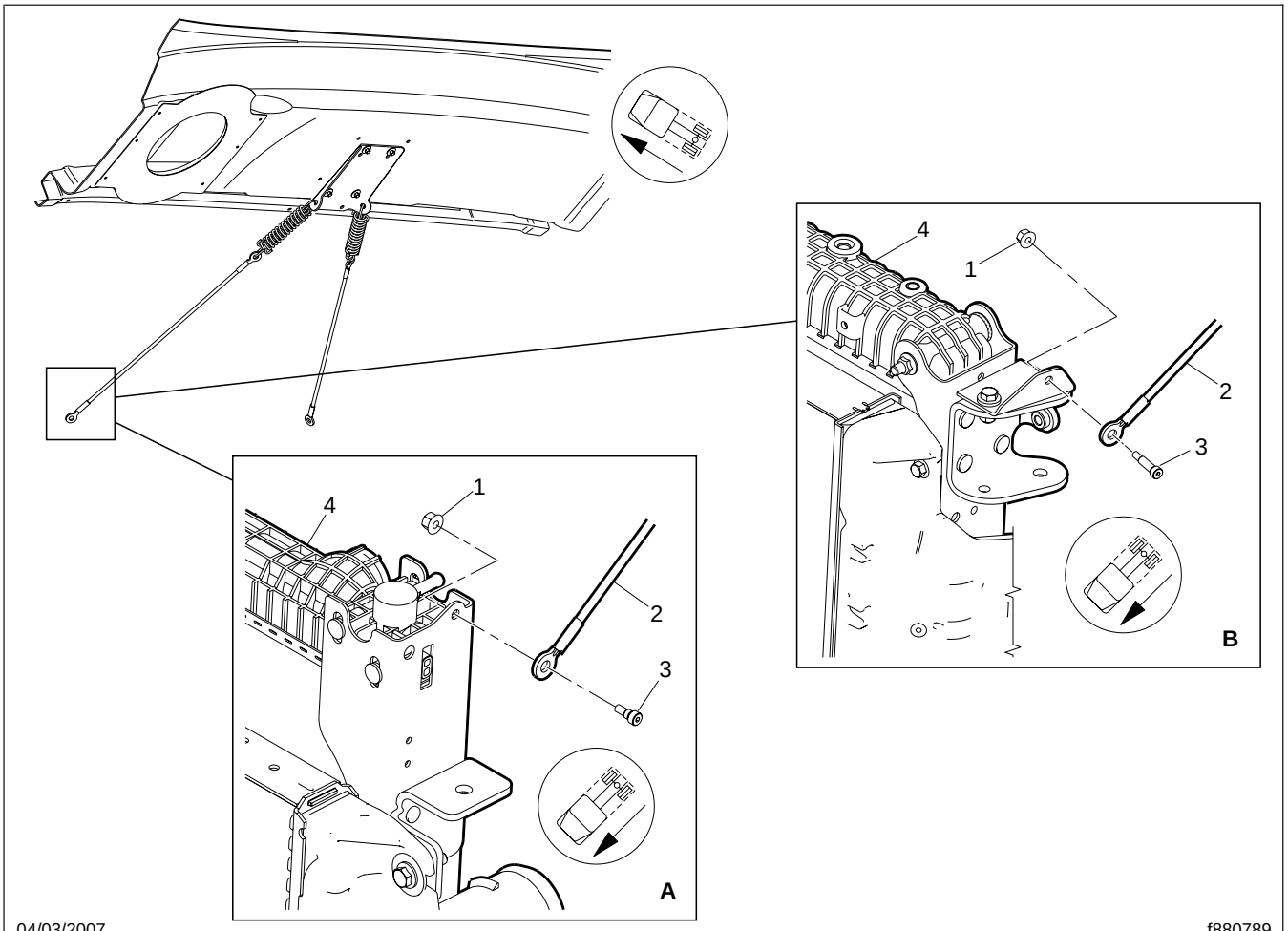
1. Receptacle
2. Bolt
3. Front Wall
4. Bolt
5. Bracket
6. Nut
7. Nut
8. Brace

Fig. 6, Hood Alignment at Cab-Mounted Stabilizer Receptacle Bracket (101-inch and 111-inch BBC vehicles)

slide the bracket up or down, or side-to-side, then tighten the bolts; see **Fig. 10**.

3. Using fluorinated grease, lubricate the flat face of the hood-mounted stabilizer.
4. For hood adjustment at the front of the hood, loosen the capscrews that attach the hood support bracket to the front closing crossmember, move the hood up or down, then tighten the capscrews. To adjust the front of the hood fore-and-aft, loosen the nuts that attach the hood hinge bracket to the support bracket, move the hood as required, then tighten the nuts; see **Fig. 9**.
5. If the hood cannot be adjusted to the specified clearances, the hood hinge may be damaged. Inspect the hood hinge brackets and the hood crossbar, and replace any damaged components.
6. Remove the chocks.

Hood Removal and Installation, Vehicles With an EPA07 Engine

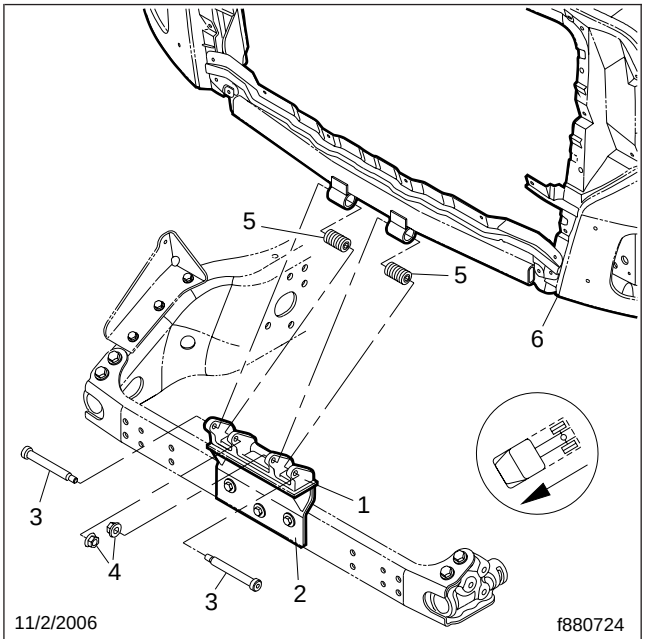


A. Chassis-Mounted Radiator
B. Engine-Mounted Radiator

1. Nut
2. Hood-Check Cable
3. Bolt
4. Radiator

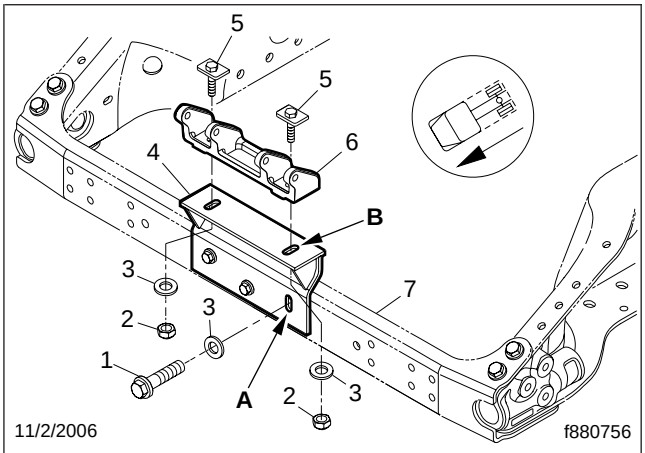
Fig. 7, Hood-Check Cable Assembly (113-inch and 122-inch BBC vehicles)

Hood Removal and Installation, Vehicles With an EPA07 Engine



1. Hinge Bracket
2. Support Bracket
3. Shoulder Bolt
4. Locking Flange Nut
5. Bushing
6. Hood

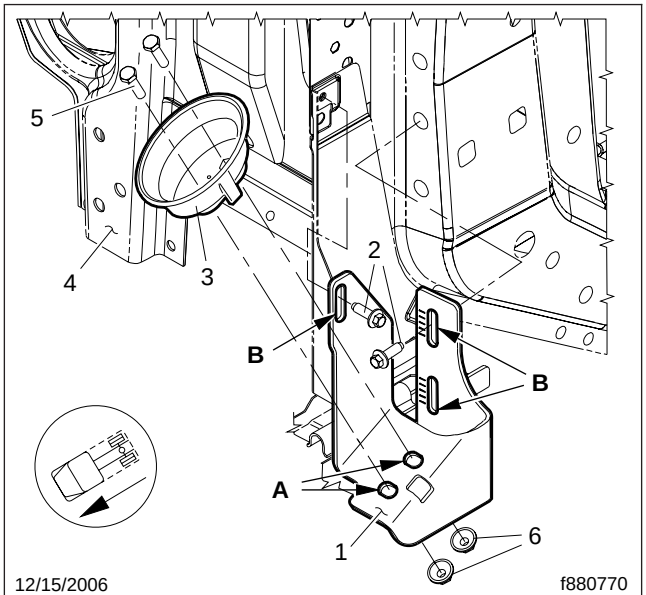
Fig. 8, Hood Hinge Installation (113-inch and 122-inch BBC vehicles)



A. Slots for Up-and-Down Adjustment
B. Slots for Fore-and-Aft Adjustment

1. Capscrew
2. Nut
3. Washer
4. Support Bracket
5. Plate Stud
6. Hood Hinge Bracket
7. Front Crossmember

Fig. 9, Hood Alignment at Hood Hinge (113-inch and 122-inch BBC vehicles)



NOTE: Left-hand mount is shown; right-hand is similar.

A. Slots for Side-to-Side Adjustment
B. Slots for Up-and-Down Adjustment

1. Bracket
2. Capscrew
3. Receptacle
4. Front Wall
5. Bolt
6. Nut

Fig. 10, Hood Alignment at Cab-Mounted Receptacle Bracket (113-inch and 122-inch BBC vehicles)

Cowl Panel Removal and Installation

Removal

CAUTION

On vehicles using aluminum cab construction, use only original equipment manufacturer replacement parts, including fasteners. This must be strictly adhered to in order to reduce the possibility of galvanic corrosion.

1. Open the hood.

IMPORTANT: Remove the bracket bolts from the A-pillar, since the bracket bolts to the cowl panel are thread-locked during assembly.

2. Remove the cowl panel upper inner door bolts. See **Fig. 1**.

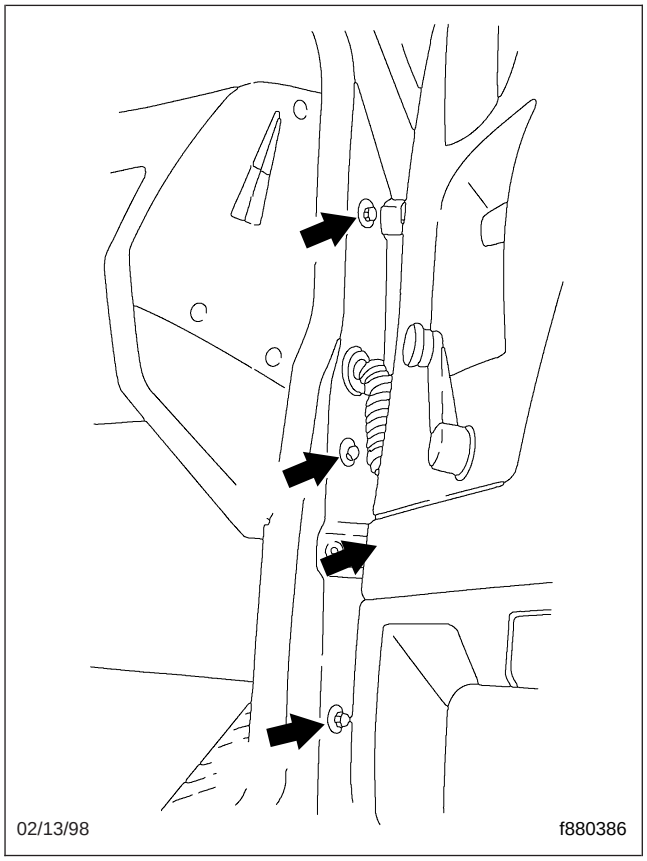


Fig. 1, Cowl Panel Upper Inner Door Bolts

3. Remove the cowl panel lower inner door bolts. See **Fig. 2**.
4. Remove the cowl front panel bolts. See **Fig. 3**.

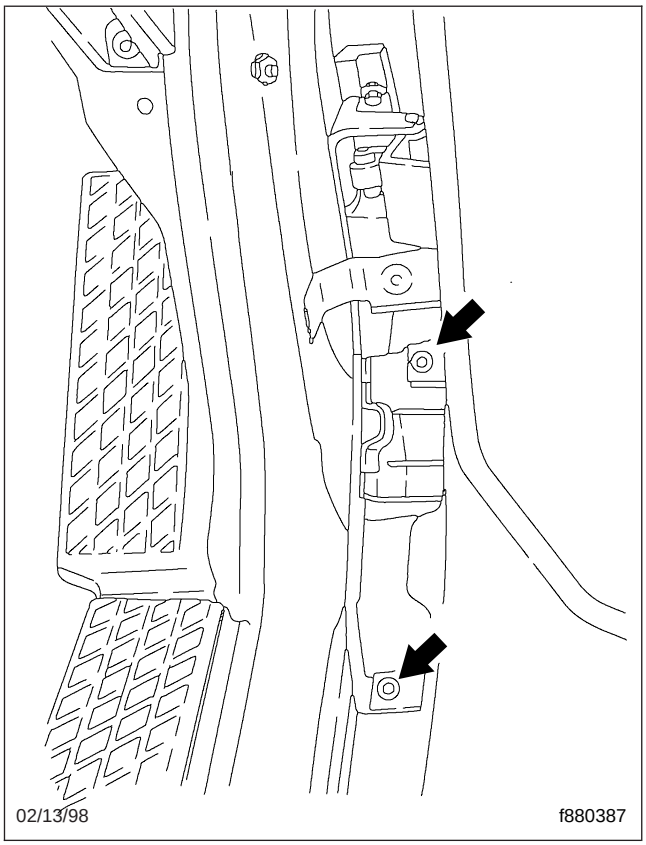


Fig. 2, Cowl Panel Lower Inner Door Bolts

5. Remove the hood latch bracket bolts. See **Fig. 4**.
6. Pull the cowl panel from the installed position.

Installation

1. Place the cowl panel into position.
2. Install the hood latch bracket bolts. See **Fig. 4**.
3. Install the cowl front panel bolts. See **Fig. 3**.
4. Install the cowl panel lower inner door bolts. See **Fig. 2**.
5. Install the cowl panel upper inner door bolts. See **Fig. 1**.
6. Close the hood.

Cowl Panel Removal and Installation

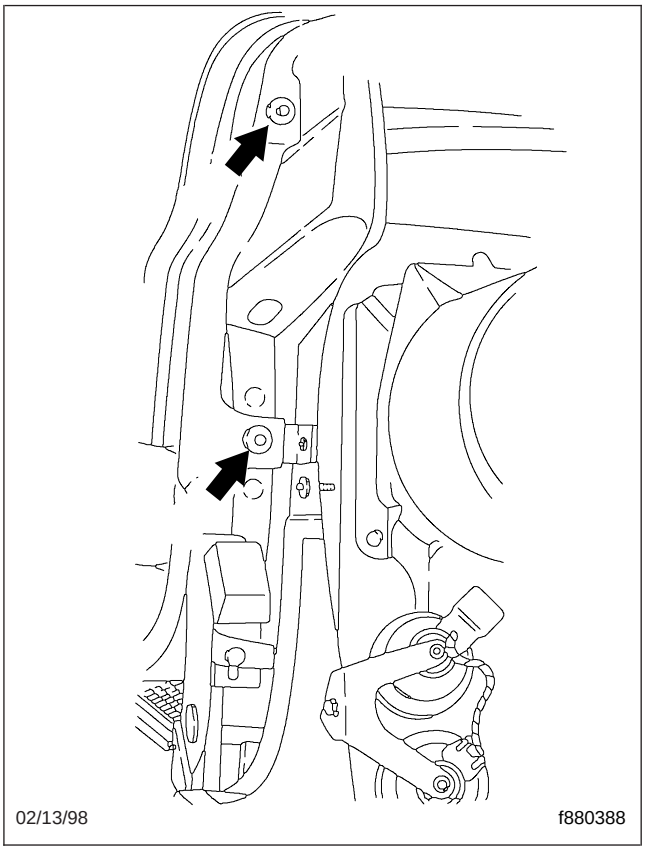


Fig. 3, Cowl Front Panel Bolts

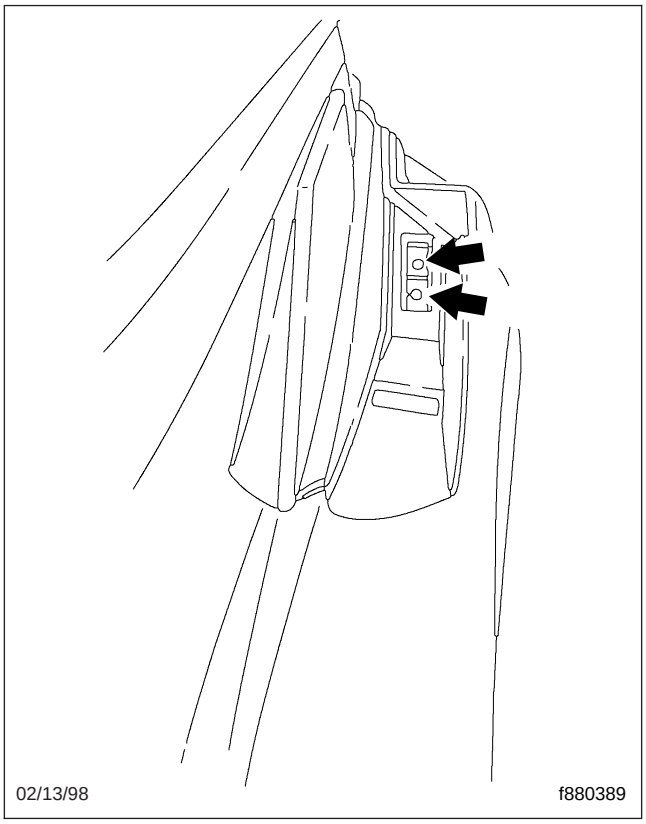


Fig. 4, Hood Latch Bracket Bolts

Fender Removal and Installation

Removal

CAUTION

On vehicles using aluminum cab construction, use only original equipment manufacturer replacement parts, including fasteners. This must be strictly adhered to in order to reduce the possibility of galvanic corrosion.

1. Open the hood.
2. Remove the cowl panel lower inner door bolts. See **Fig. 1**.

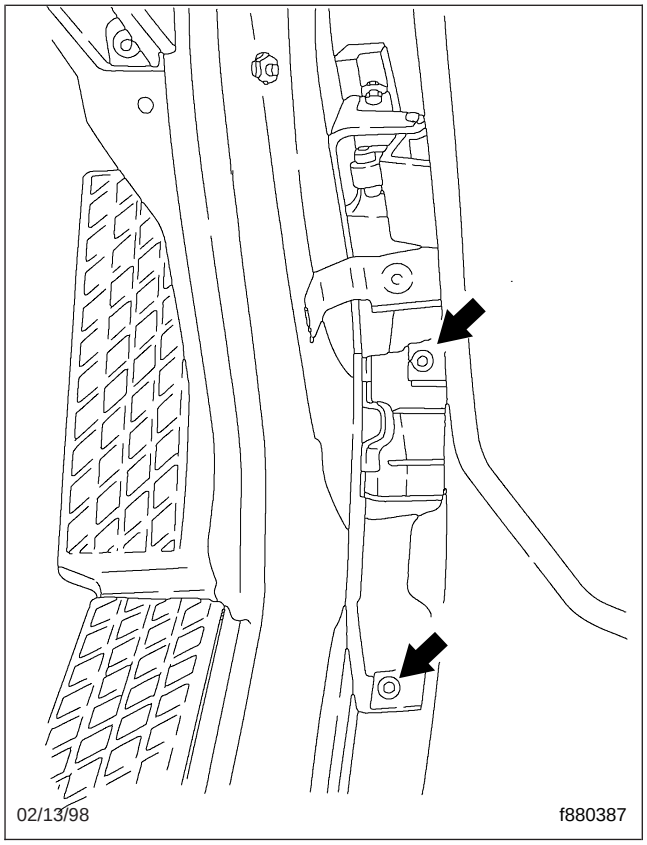


Fig. 1, Cowl Panel Lower Inner Door Bolts

3. Remove the hood latch bracket bolts. See **Fig. 2**.
4. Remove the upper fender bracket bolt. See **Fig. 3**.
5. Remove the inner fender bracket lower bolts. See **Fig. 4**.

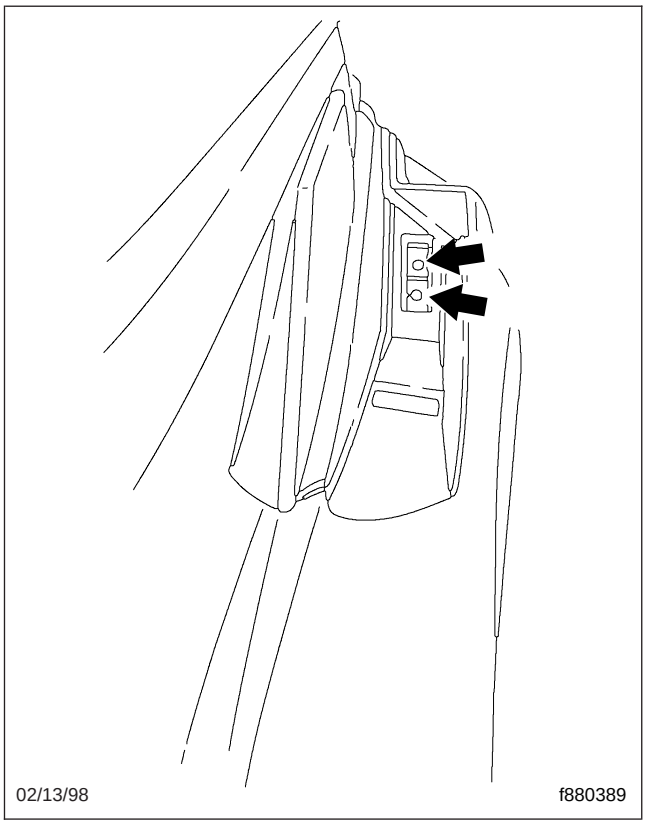


Fig. 2, Hood Latch Bracket Bolts

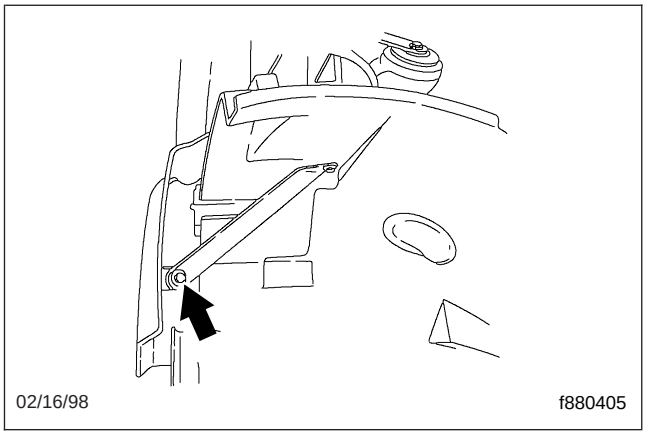


Fig. 3, Upper Fender Bracket Bolt

6. Remove the fender support bracket bolt. See **Fig. 5**.
7. Pull the fender towards the rear of the vehicle and remove.

Fender Removal and Installation

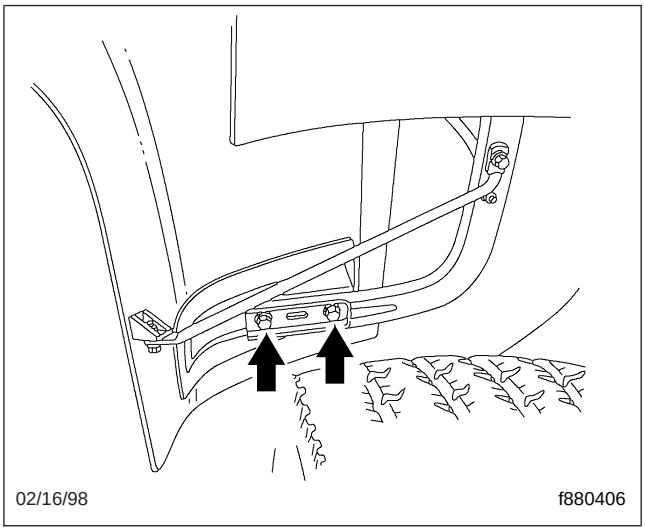


Fig. 4, Inner Fender Bracket Lower Bolts

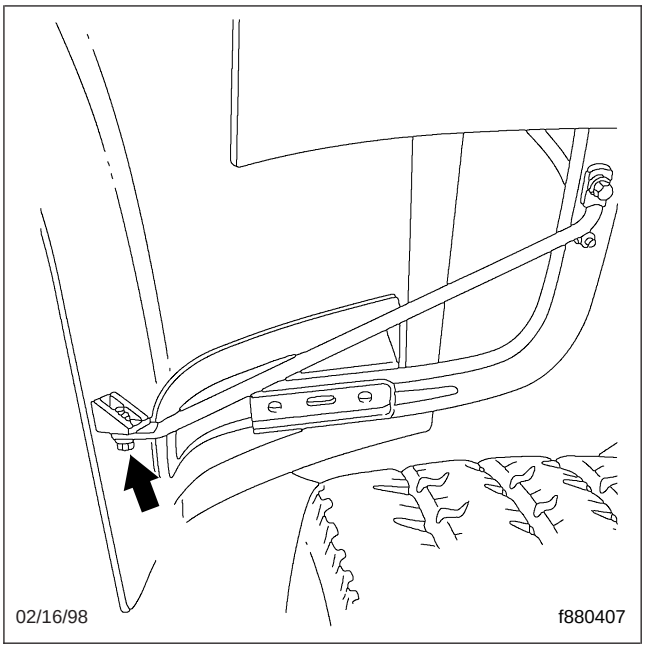


Fig. 5, Fender Support Bracket Bolt

8. Remove the cowl panel lower inner door bracket bolt and the bracket. See **Fig. 6**.

Installation

1. Position the fender on the vehicle.

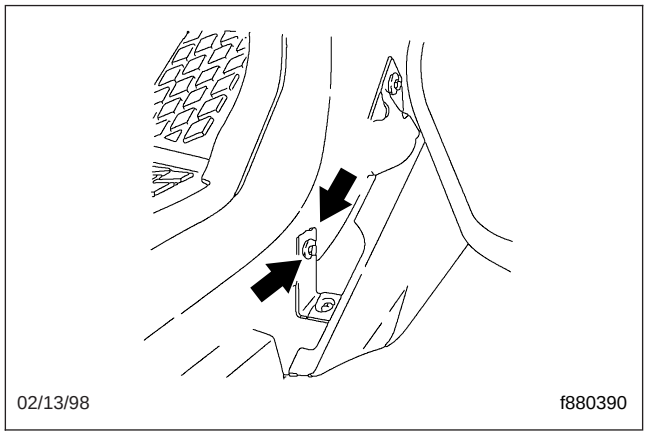


Fig. 6, Cowl Panel Lower Inner Door Bracket Bolt

2. Install the hood latch bracket and the bolts, but do not tighten the bolts. See **Fig. 2**.
3. Install the upper fender bracket bolt. See **Fig. 3**.
4. Install the fender support bracket bolt. See **Fig. 5**.
5. Install the inner fender bracket lower bolts. See **Fig. 4**.

CAUTION

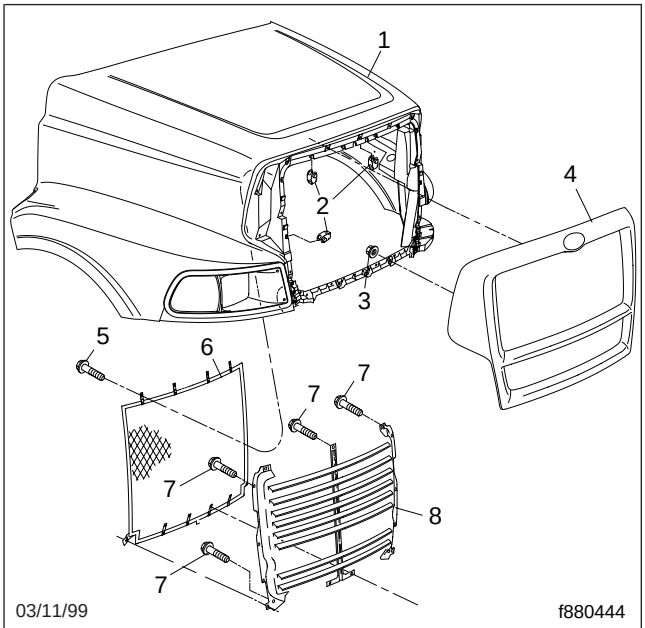
A clearance smaller than specified may result in door-to-fender contact and damage.

6. Align the fender, then tighten the hood latch bracket bolts. Refer to **Subject 170**. See **Fig. 2**.
7. Align the cowl panel lower inner door bracket and tighten the bolt. See **Fig. 6**.
8. Install the cowl panel lower inner door bolts. See **Fig. 1**.

Hood-Mounted One-Piece Grille

Removal

For a grille with a full bezel, see **Fig. 1**. For a grille without a bezel, see **Fig. 2**. For a grille with a partial bezel, see **Fig. 3**.



1. Hood
2. Grille Retaining Clips
3. Bezel Retaining Clips
4. Bezel
5. Screen Fasteners
6. Screen
7. Grille Fasteners
8. Grille

Fig. 1, Hood-Mounted One-Piece Grille With Bezel

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Open the hood.
3. From under the hood, remove the fasteners around the screen, if so equipped. Remove the screen.
4. Remove the fasteners from the grille. Remove the grille.
5. If the vehicle is equipped with a full bezel, remove the fasteners from the bezel. Remove the bezel.

   If the vehicle is equipped with a partial bezel, remove the fasteners from the hood molding. Remove the molding.

Installation

1. With the tires chocked, attach the bezel or hood molding (if so equipped) to the hood with the fasteners.
2. Attach the grille to the hood with the fasteners. Do not install the fasteners in the holes used to attach the screen to the grille.
3. Install the screen, if so equipped, and tighten the fasteners.
4. Close the hood.
5. Remove the chocks.

Radiator-Mounted One-Piece Grille

Removal

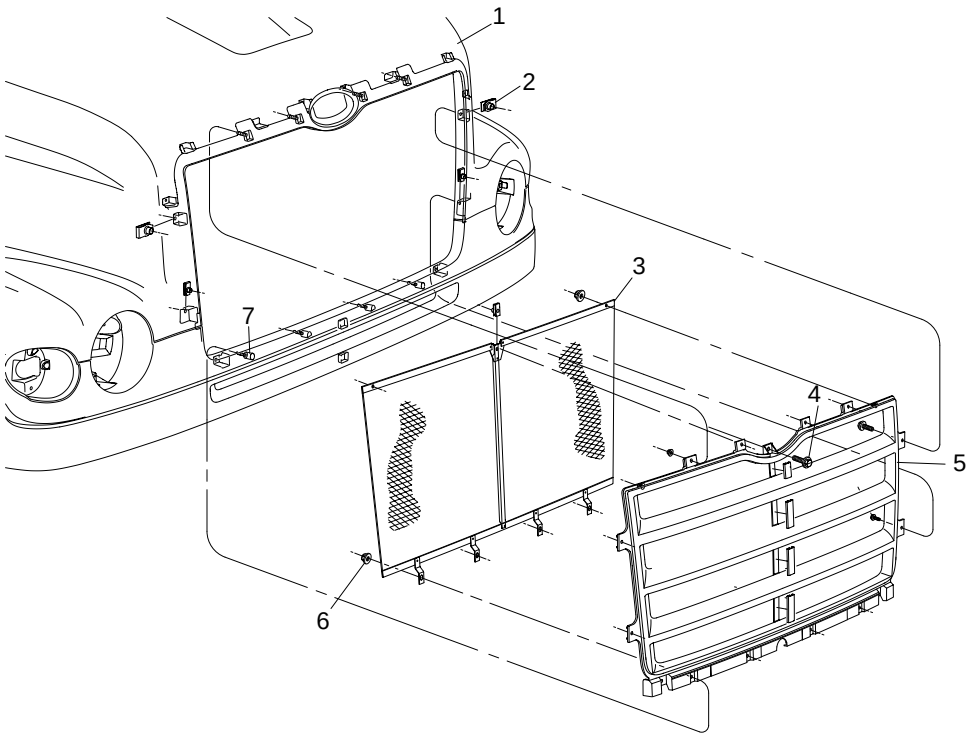
For a grille without a bezel, see **Fig. 4**. For a grille with a partial bezel, see **Fig. 5**.

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. If the vehicle is equipped with a screen, remove the fasteners around the screen. Remove the screen.
3. Open the hood.
4. If the vehicle is equipped with hood moldings, remove the fasteners from the moldings (upper and lower). Remove the moldings.
5. Remove the fasteners from the grille. Remove the grille.

Installation

1. With the tires chocked, attach the grille to the radiator with the fasteners.
2. Attach the hood moldings (if so equipped) to the hood with the fasteners.
3. Close the hood.
4. Install the screen, if so equipped, and tighten the fasteners.
5. Remove the chocks.

Grille Removal and Installation



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1. Hood
2. Locknut
3. Screen
4. Screw and Washer
5. Grille
6. Nut and Washer
7. Stud

Fig. 2, Hood-Mounted One-Piece Grille Without Bezel

Hood-Mounted Two-Piece Grille

Removal

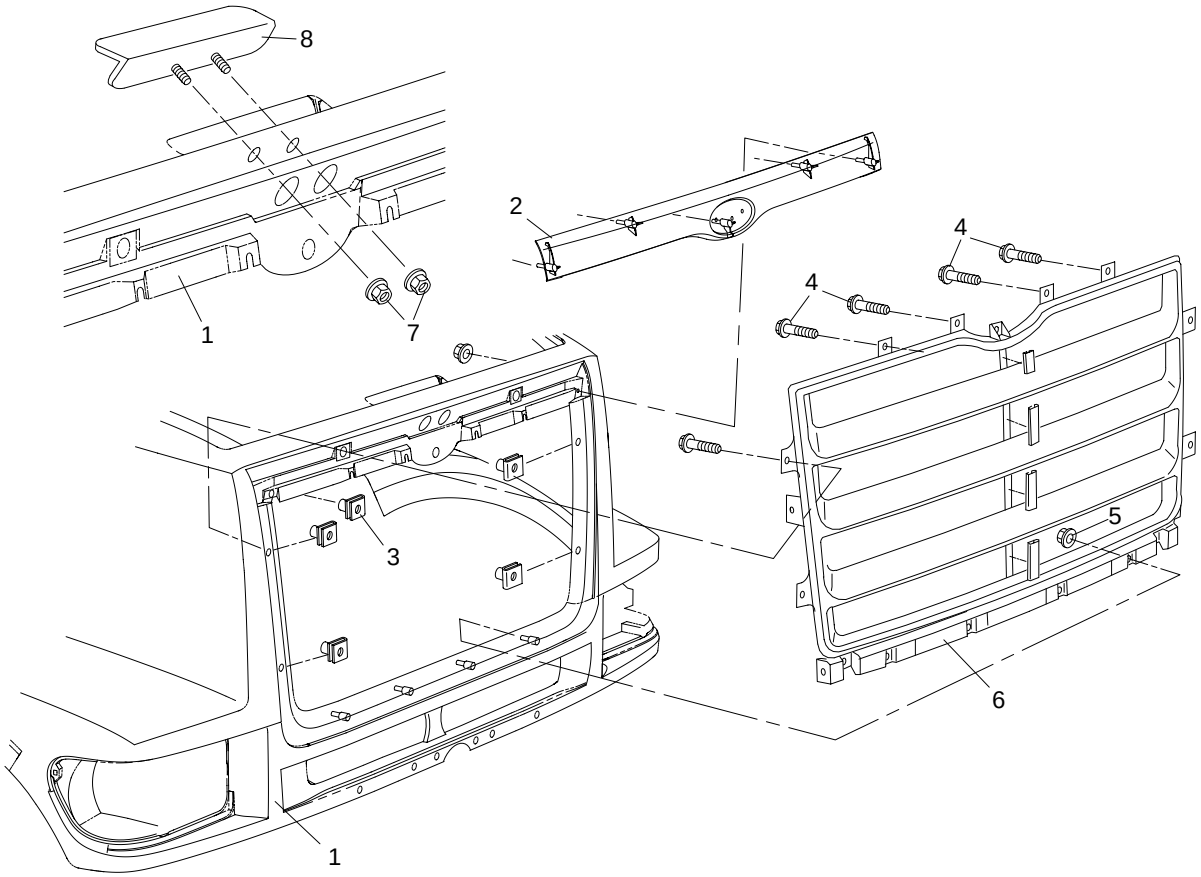
1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Open the hood.
3. From under the hood, remove the fasteners around the screen, if so equipped; see **Fig. 6**. Remove the screen.

NOTE: Support the upper and lower grille so they do not fall.

4. From under the hood, remove the 10 fasteners and washers from the lower grille. Remove the lower grille.
5. From under the hood, remove the 12 fasteners and washers from the upper grille. Remove the upper grille.
6. Remove the fasteners from the bezel, and remove the bezel.

Installation

1. With the tires chocked, attach the bezel to the hood with the fasteners.
2. Position the upper grille under the hood. Align the 12 fasteners and washers with the holes, and tighten the fasteners.
3. Position the lower grille under the hood. Align the 10 fasteners and washers with the holes, and tighten the fasteners.
4. Install the screen, if so equipped, and tighten the fasteners.



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1. Hood
2. Upper Molding
3. Locknut
4. Screw and Washer
5. Nut and Washer
6. Grille
7. Hexnut and Washer
8. Hood Handle

Fig. 3, Hood-Mounted One-Piece Grille With Partial Bezel

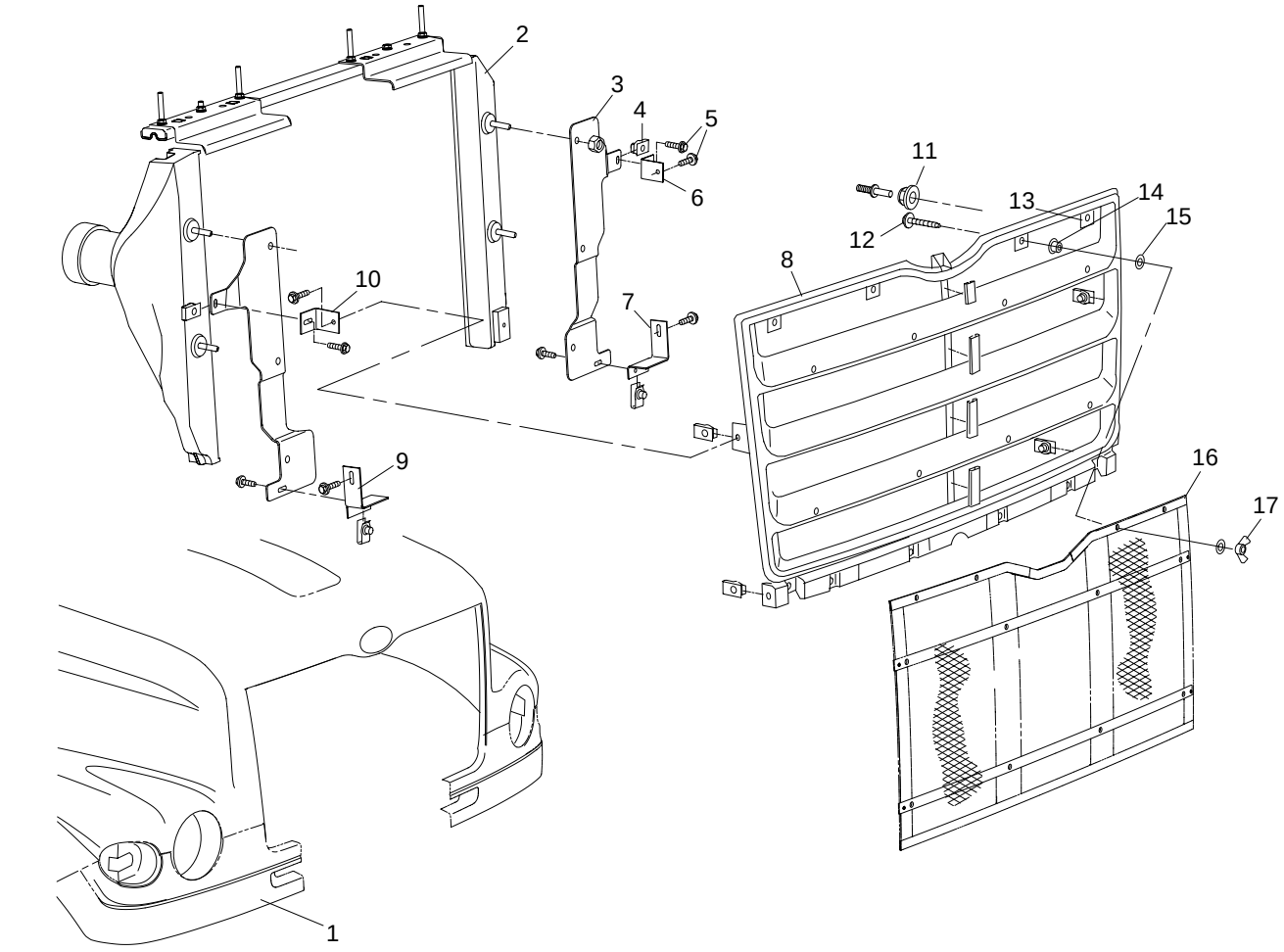
5. Close the hood.
6. Remove the chocks.

Radiator-Mounted Grille with Surround, 113-Inch and 122-Inch BBC Vehicles

Removal

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Open the hood.
3. If the vehicle is equipped with a screen, remove the fasteners around the screen. Remove the screen; see **Fig. 7**.
4. Remove the fasteners around the nameplate. Remove the nameplate from the grille.
5. Remove the fasteners from the grille. Remove the grille from the radiator.
6. Remove the lower grille surrounds from the nameplate surrounds.
7. Remove the nameplate surrounds from the grille surround.

Grille Removal and Installation



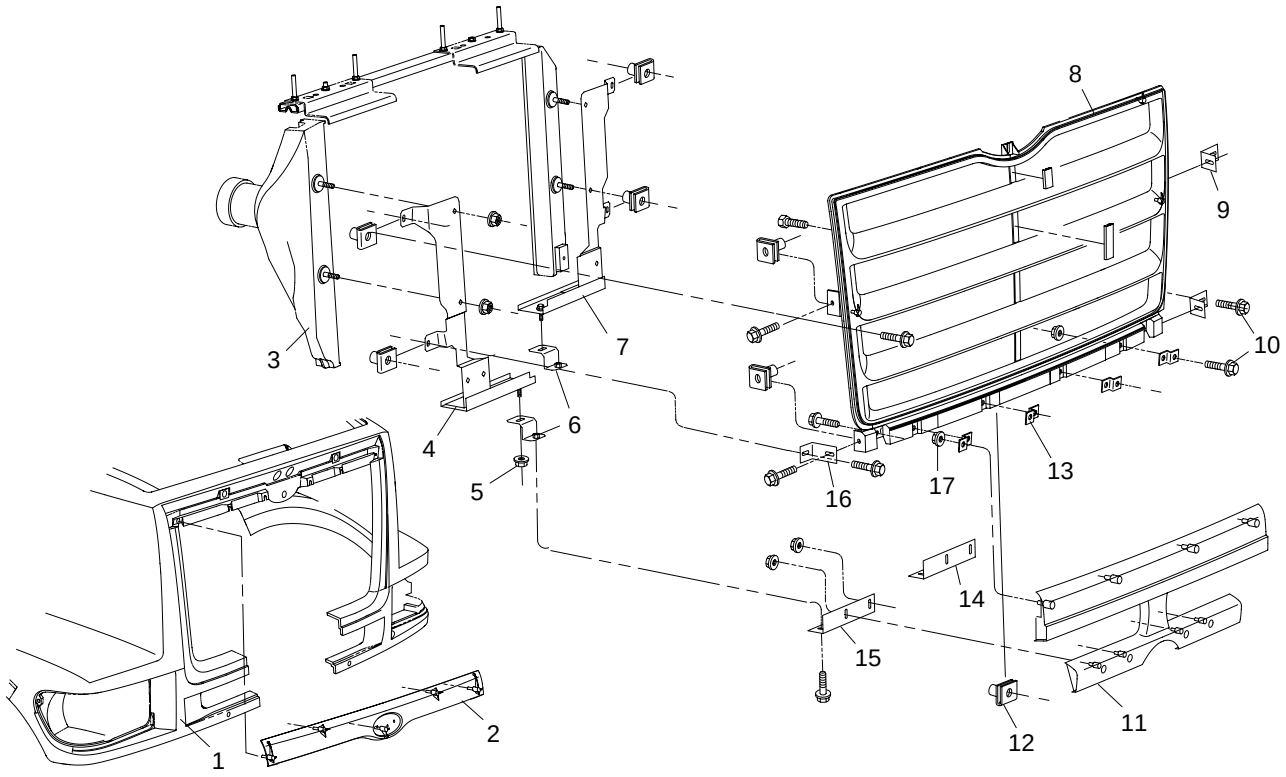
1. Hood
2. Radiator
3. Bracket Assembly
4. Nut
5. Screw and Washer
6. Support
7. Bracket
8. Grille
9. Bracket
10. Support
11. Nut and Washer
12. Screw and Washer
13. Tab
14. Nut
15. Washer
16. Screen
17. Wingnut

Fig. 4, Radiator-Mounted One-Piece Grille Without Bezel

8. Remove the fasteners that attach the grille cutout to the grille surround. Remove the grille cutout; see **Fig. 8**.
9. Remove the fasteners that attach the grille surround to the hood. Remove the grille surround.

Installation

1. With the tires chocked, attach the grille surround to the hood.
2. Attach the grille cutout to the grille surround.
3. Attach the nameplate surround to the grille surround.



11/12/1999 f880476

1. Hood
2. Upper Molding
3. Radiator
4. Upper Bracket, RH
5. Nut and Washer
6. Center Bracket
7. Upper Bracket, LH
8. Grille
9. Support Bracket, LH
10. Screw and Washer
11. Lower Molding
12. Locknut
13. Center Bracket
14. Lower Bracket, LH
15. Lower Bracket, RH
16. Support Bracket, RH
17. Nut and Washer

Fig. 5, Radiator-Mounted One-Piece Grille With Partial Bezel

4. Attach the lower grille surrounds to the nameplate surrounds.
5. Attach the grille to the radiator with the fasteners.
6. Attach the nameplate to the grille.
7. Install the screen, if so equipped, and tighten the fasteners.
8. Close the hood.
9. Remove the chocks.

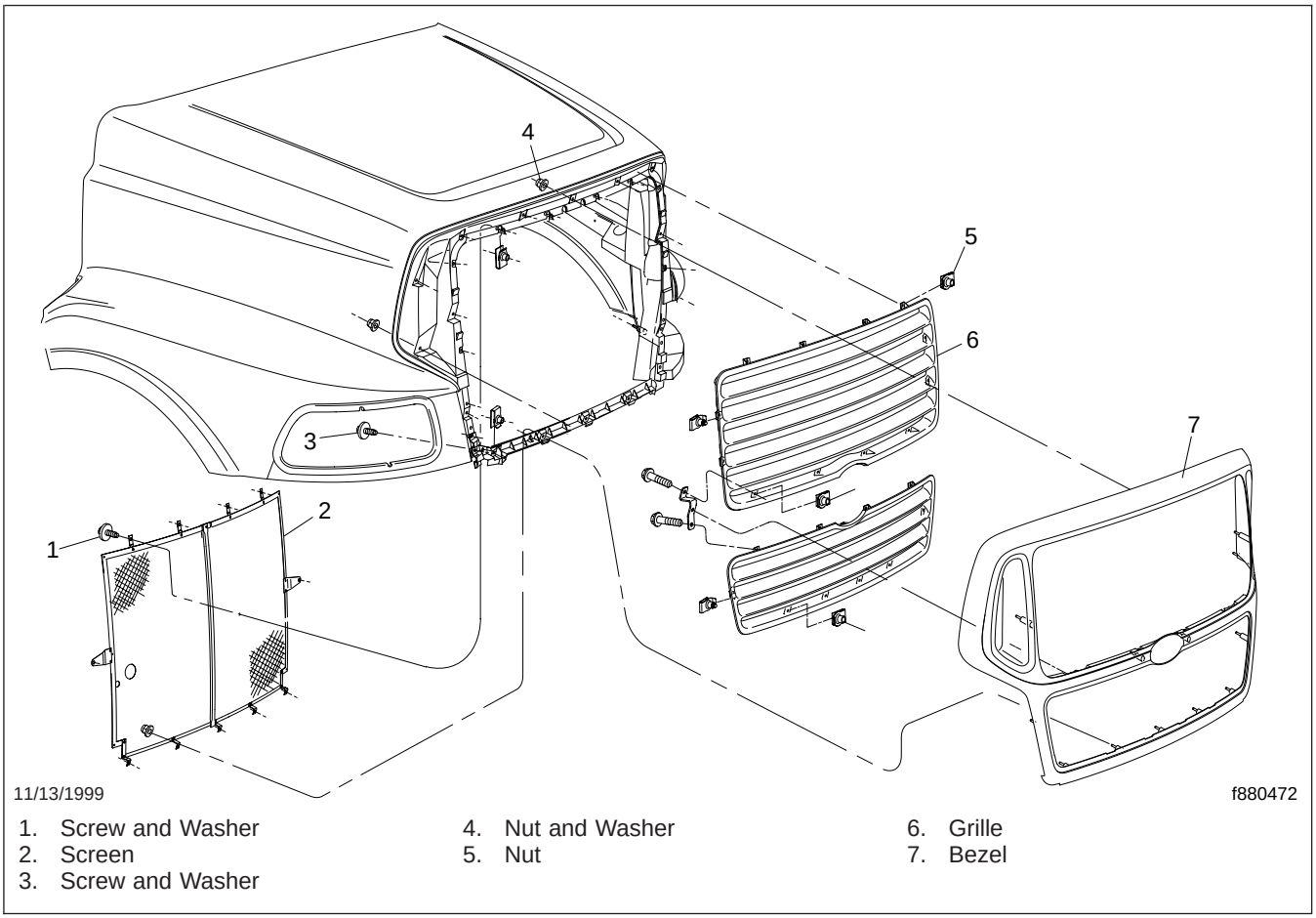
Radiator-Mounted Grille with Bezel, Built From April, 2007

Removal

For 101-inch and 111-inch vehicles without forward frame extension, see **Fig. 9**. For 101-inch and 111-inch BBC vehicles with forward frame extension, see **Fig. 10**.

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Remove the fasteners that attach the grille and the lower grille panel (if so equipped) to the radiator. Remove the grille.

Grille Removal and Installation



1. Screw and Washer
2. Screen
3. Screw and Washer
4. Nut and Washer
5. Nut
6. Grille
7. Bezel

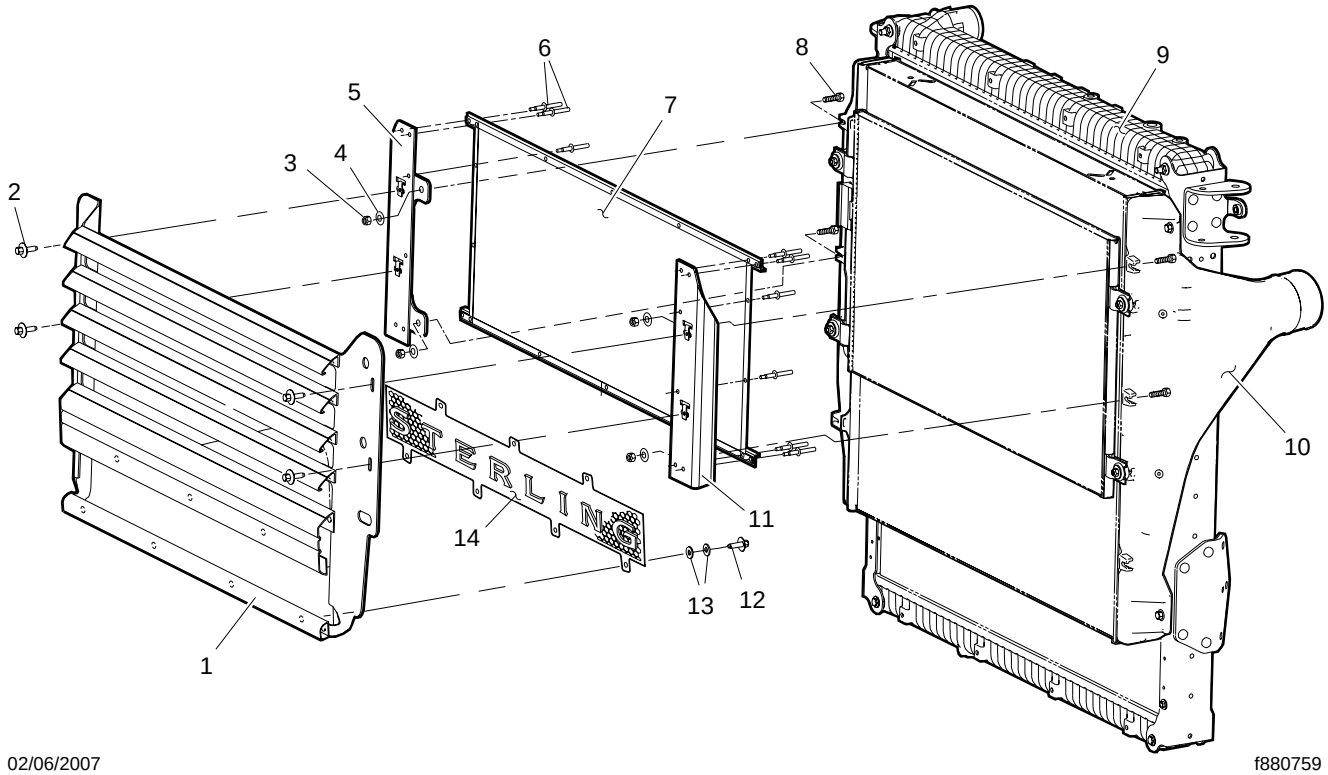
Fig. 6, Hood-Mounted Two-Piece Grille

3. Open the hood.
4. Remove the capscrews that attach the bezel to the hood above the headlamp surrounds; see **Fig. 11**.
5. Pull the bezel up to disengage the clips from the hood. Remove the bezel.

Installation

1. With the tires chocked, lower the bezel into position on the hood, engaging the clips that attach it to the hood; see **Fig. 11**.
2. Using the capscrews, attach the bezel to the hood above the headlamp surrounds.
3. Close the hood.
4. Attach the grille and the lower grille panel (if so equipped) to the radiator with the fasteners.
5. Remove the chocks.

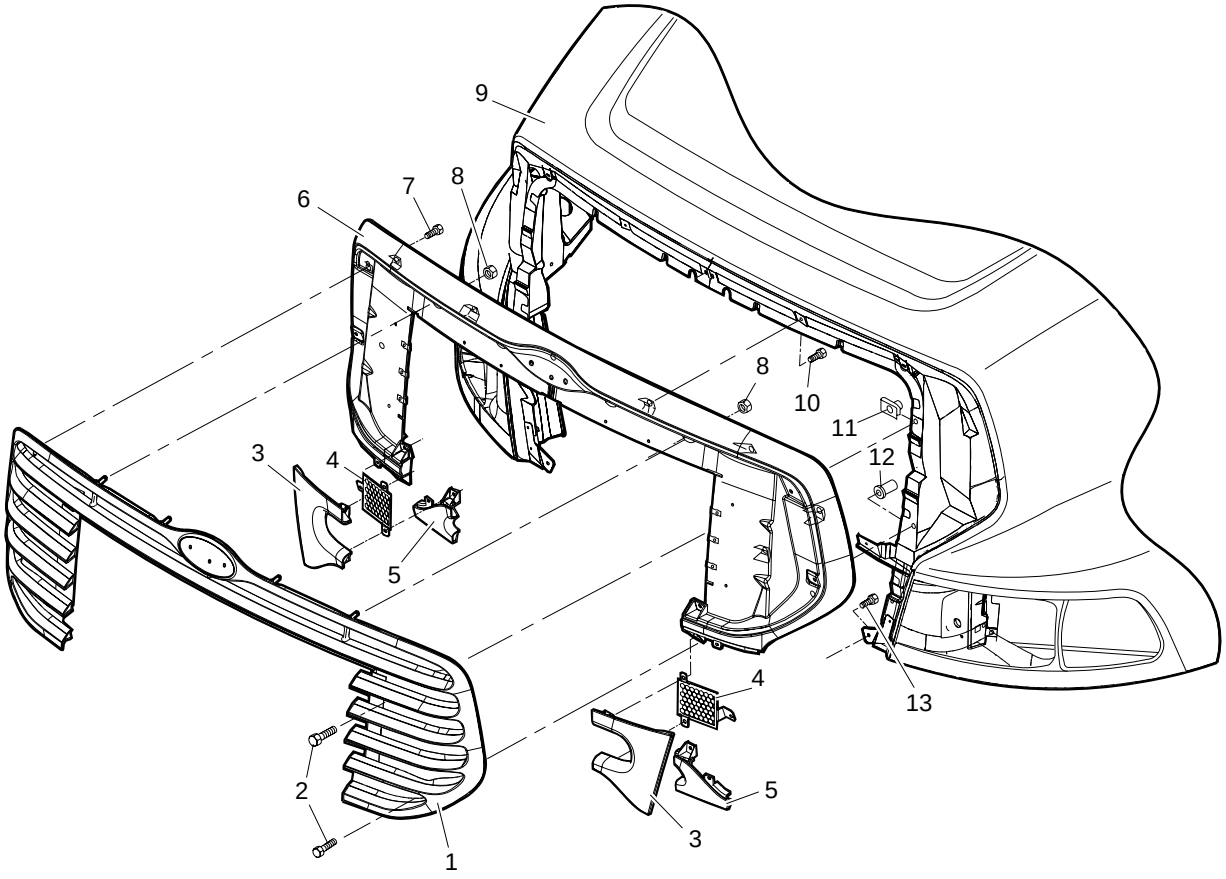
Grille Removal and Installation



1. Grille
2. Capscrew
3. Locknut
4. Flatwasher
5. Grille Bracket, RH
6. Stud
7. Bug Screen
8. Capscrew
9. Radiator
10. Charge Air Cooler
11. Grille Bracket, LH
12. Capscrew, M6 X 1
13. Nylon Washer
14. Nameplate

Fig. 7, Radiator-Mounted Grille (113-inch and 122-inch BBC vehicles)

Grille Removal and Installation



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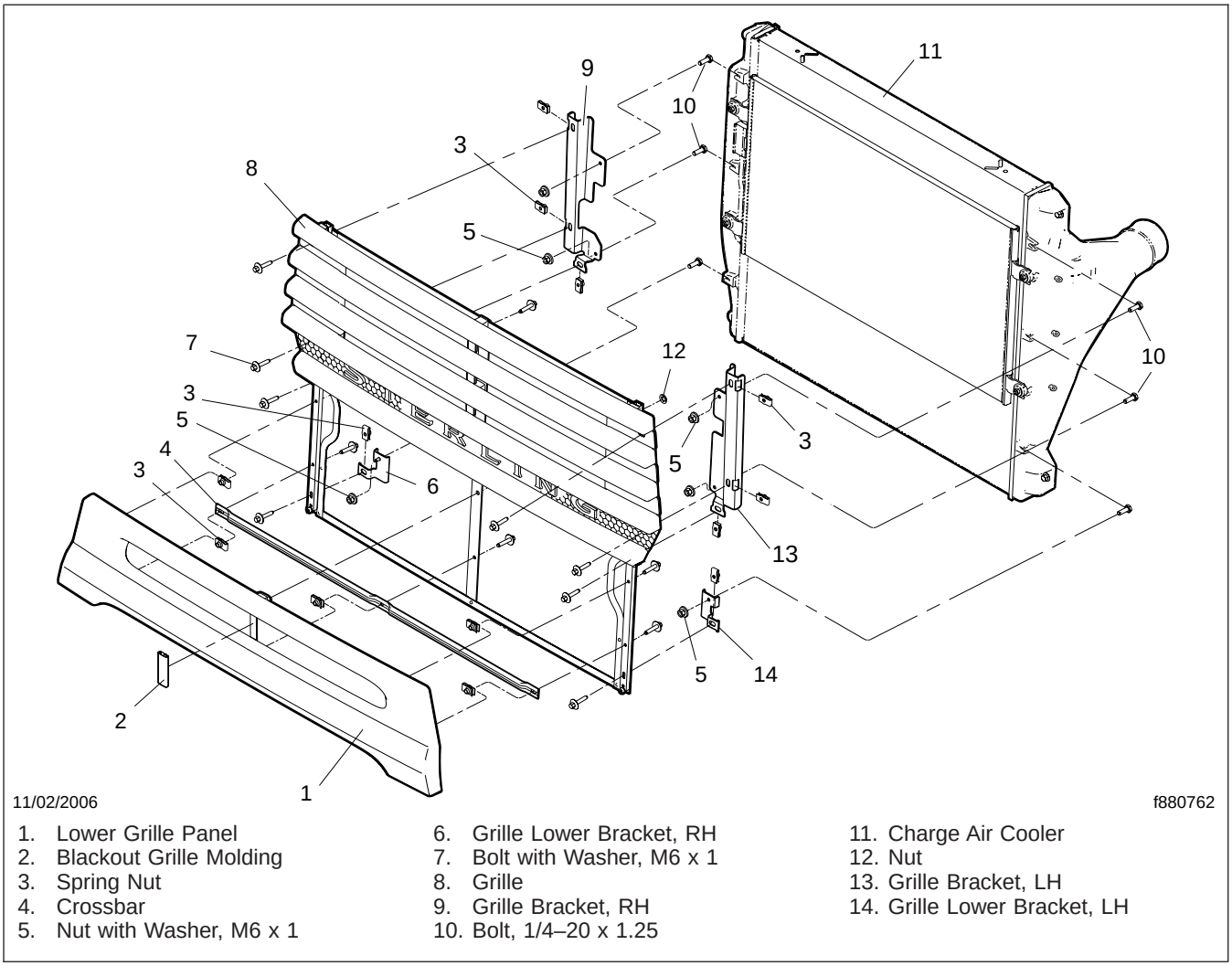
1. Grille Cutout
2. Capscrew
3. Nameplate Surround
4. Nameplate Screen
5. Lower Grille Surround
6. Grille Surround
7. Capscrew
8. Nut
9. Hood
10. Capscrew
11. Spring Nut
12. Expansion Nut
13. Capscrew

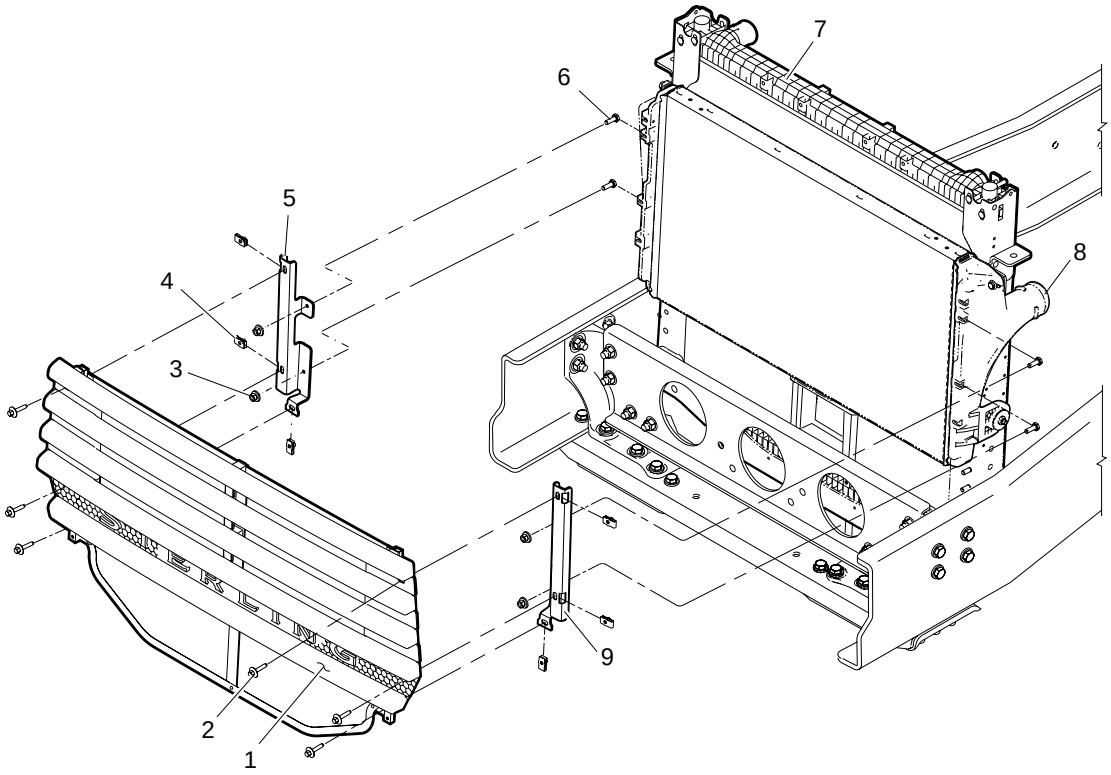
Fig. 8, Grille Cutout and Surround Installation (113-inch and 122-inch BBC vehicles)



1. Lower Grille Panel
2. Blackout Grille Molding
3. Spring Nut
4. Crossbar
5. Nut with Washer, M6 x 1
6. Grille Lower Bracket, RH
7. Bolt with Washer, M6 x 1
8. Grille
9. Grille Bracket, RH
10. Bolt, 1/4–20 x 1.25
11. Charge Air Cooler
12. Nut
13. Grille Bracket, LH
14. Grille Lower Bracket, LH

Fig. 9, Radiator-Mounted Grille (101-inch and 111-inch BBC vehicles built from April, 2007)

Grille Removal and Installation



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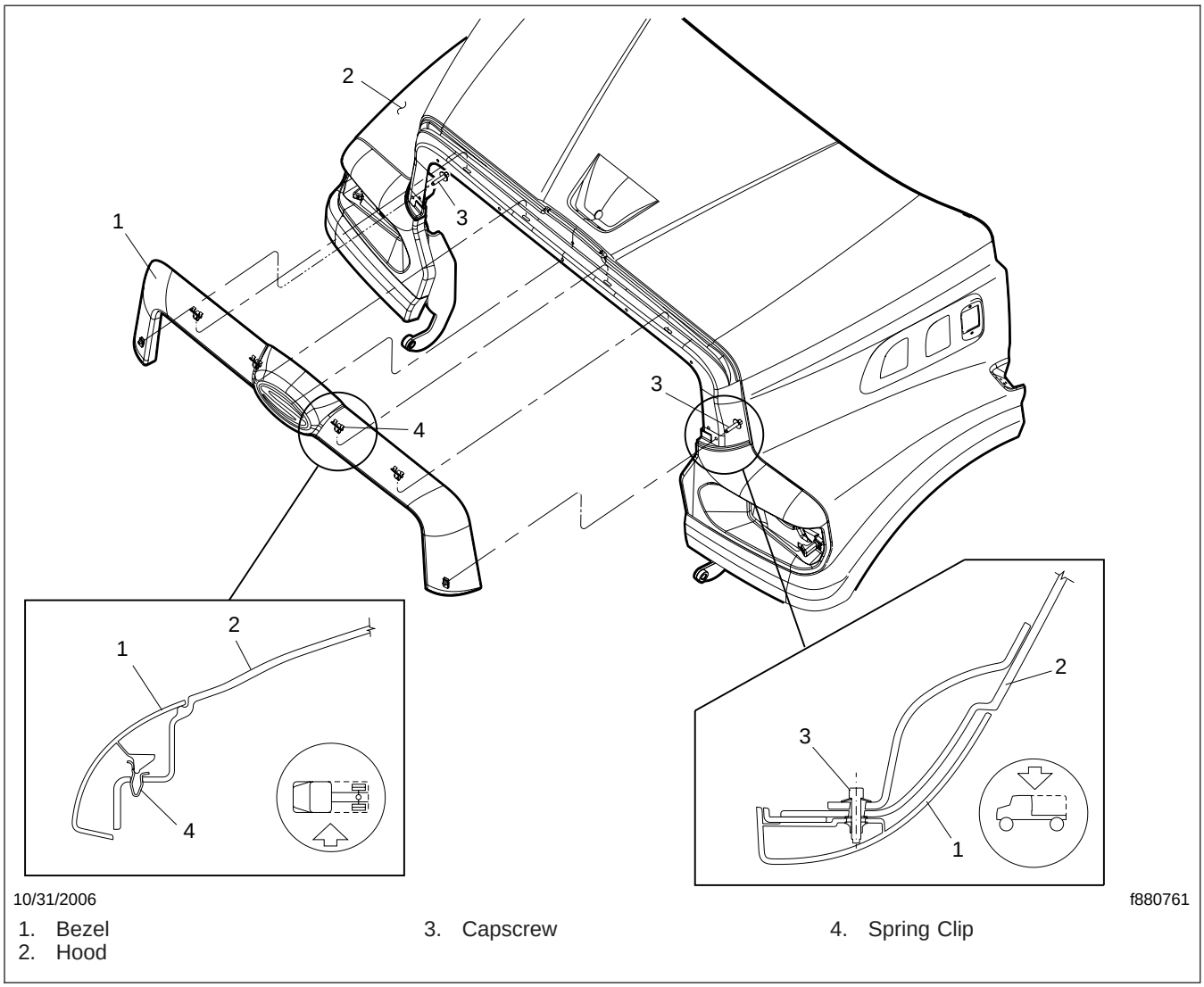
1. Grille
2. Bolt with Washer, M6 x 1
3. Nut with Washer, M6 x 1
4. Spring Nut
5. Grille Bracket, RH
6. Bolt, 1/4–20 x 1.25
7. Radiator
8. Charge Air Cooler
9. Grille Bracket, LH

Fig. 10, Radiator-Mounted Grille (101-inch and 111-inch BBC vehicles with forward frame extension, built from April, 2007)

Grille Removal and Installation

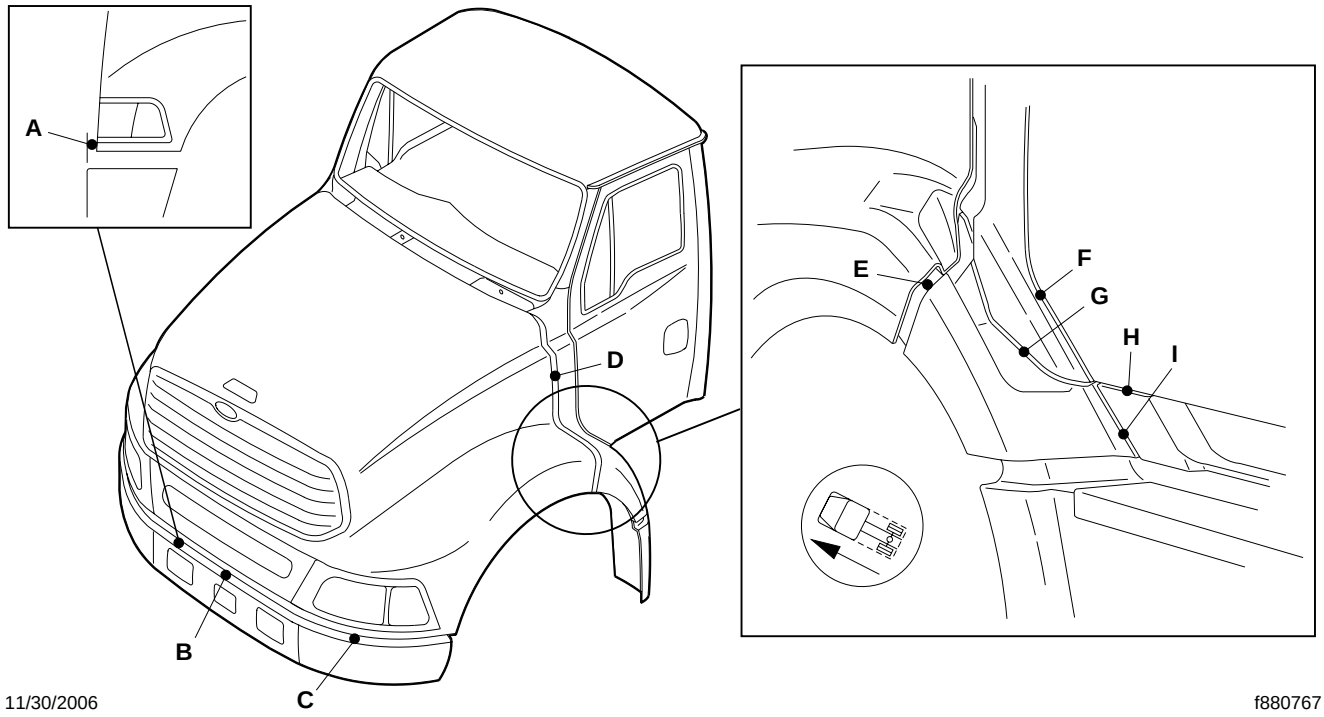


1. Bezel
2. Hood
3. Capscrew
4. Spring Clip

Fig. 11, Bezel Installation (101-inch and 111-inch BBC vehicles built from April, 2007)

Hood Alignment Clearances

See **Fig. 1** and **Table 1** for hood alignment clearance specifications.



See **Table 1** for clearance measurements.

Fig. 1, Clearance Measurement Locations

Hood Alignment Clearances				
Ref.*	Clearance Location	Vehicle Application	Specification	
			Target Value	Range
A	Bumper-to-Hood Front-to-Back	111" BBC	3/4 inch (19 mm)	—
B	Grille-to-Bumper at Center	101", 113", and 122" BBC	2-1/2 inch (64 mm)	2-3/8 to 2-5/8 inch (60 to 67 mm)
		111" BBC	2-1/2 inch (64 mm)	—
C	Grille-to-Bumper Under Headlamp (L-Line)	101", 113", and 122" BBC	2-1/2 inch (64 mm)	2-3/8 to 2-5/8 inch (60 to 67 mm)
D	Hood-to-Cowl Panel	All	2-1/4 inch (57 mm)	1-7/8 to 2-3/8 inch (48 to 60 mm)
E	Hood-to-Fender at Latch Pocket	101", 113", and 122" BBC	1-1/4 inch (32 mm)	1-1/8 to 1-3/8 inch (29 to 35 mm)
F	Door-to-Cowl Panel	All	3/16 inch (5 mm)	5/32 to 1/4 inch (4 to 6 mm)
G	Cowl Panel-to-Fender	All	3/16 inch (5 mm)	5/32 to 1/4 inch (4 to 6 mm)

Specifications

Hood Alignment Clearances				
Ref.*	Clearance Location	Vehicle Application	Specification	
			Target Value	Range
H	Door-to-Valance Panel	111", 113", and 122" BBC	3/16 inch (5 mm)	5/32 to 1/4 inch (4 to 6 mm)
I	Fender-to-Valance Panel	111" BBC	3/16 inch (5 mm)	5/32 to 1/4 inch (4 to 6 mm)
		113" and 122" BBC	3/16 inch (5 mm)	3/32 to 9/32 inch (2 to 7 mm)

* See **Fig. 1** for measurement locations.

Table 1, Hood Alignment Clearances

Lubricant Specifications

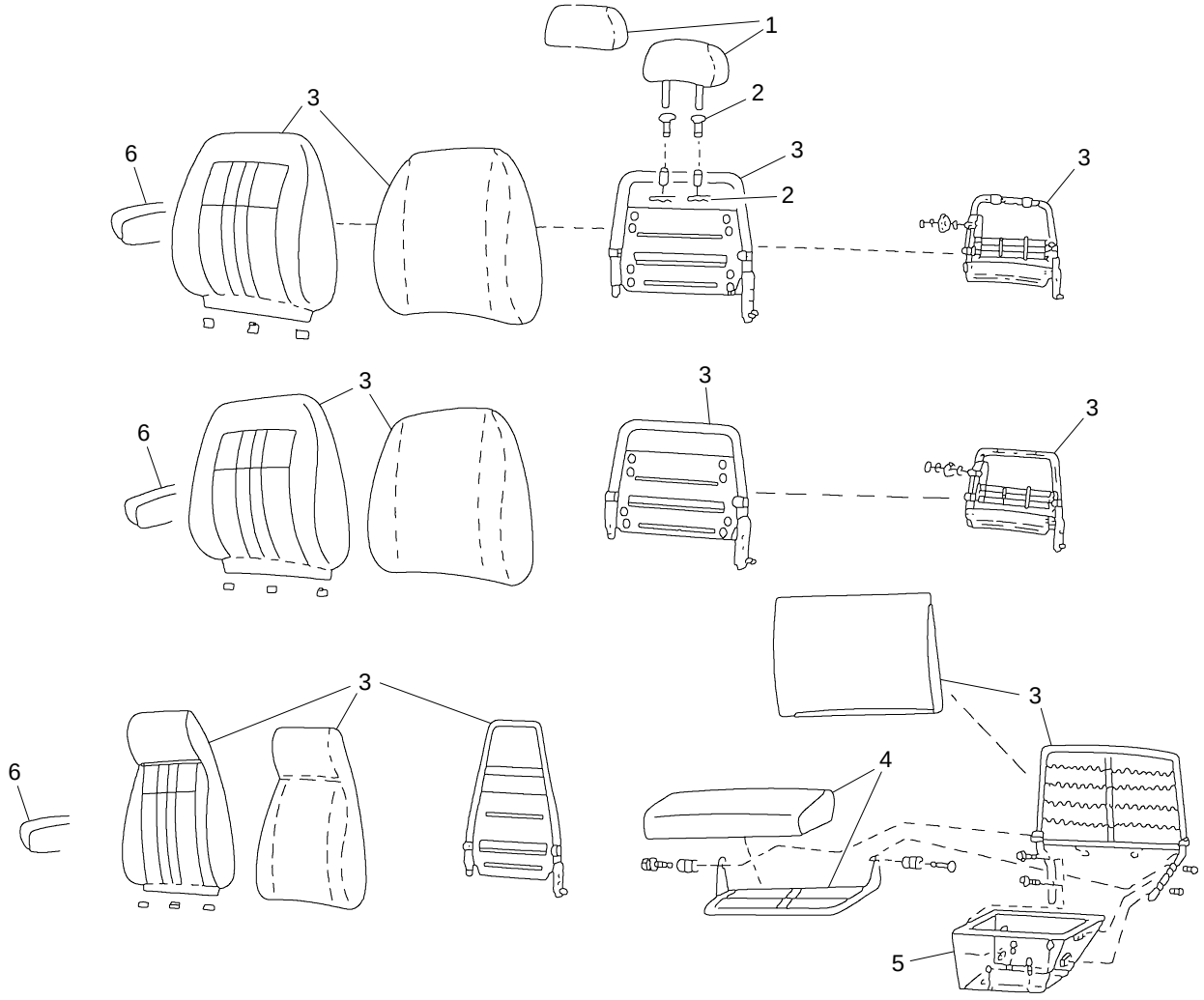
See **Table 2** for lubricant specifications.

Lubricant Specifications	
Item	Specification
Hood Stabilizer Lubricant	Fluorinated Grease ESF–M1C229–A

Table 2, Lubricant Specifications

Seats

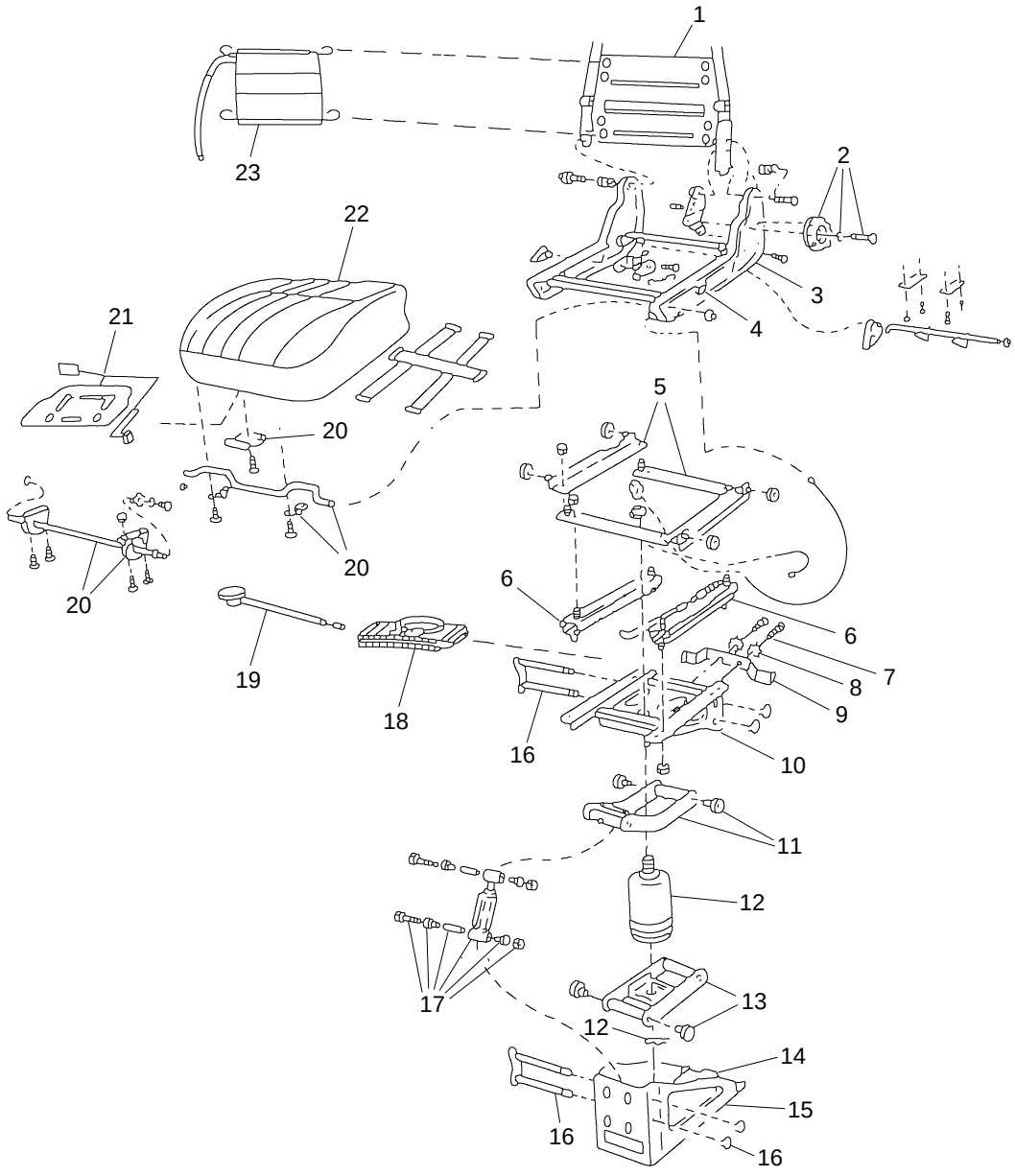
See **Fig. 1** for the disassembled view of the National Cush-N-Aire II Single Seat and Passenger Bench. See **Fig. 2** for the disassembled view of the National Cush-N-Aire II Single Seat. See **Fig. 3** for the National Cush-N-Aire II Lumbar System.



1. Head Restraint
2. Bushing and Retainer
3. Seat Back
4. Seat Bottom
5. Seat Base
6. Armrest

Fig. 1, National Cush-N-Aire II Single Seat and Passenger Bench, Disassembled View

General Information



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1. Seat Back
2. Seat Back Recliner Assembly
3. Seat Frame
4. Seat Switch
5. Seat Chugger
6. Track Assembly
7. Bolt
8. Star Washer
9. Safety Belt Bar
10. Upper Base Assembly
11. Upper Arm Assembly with Bushings
12. Air Spring Assembly
13. Lower Arm Assembly with Bushings
14. Rubber Stop
15. Lower Base Assembly
16. Shaft Kit
17. Shock Absorber Kit
18. Swivel Base
19. Seat Swivel Latch Cable
20. Seat Adjuster Kit
21. Seat Heater
22. Seat
23. Lumbar Support

Fig. 2, National Cush-N-Aire II Single Seat, Disassembled View

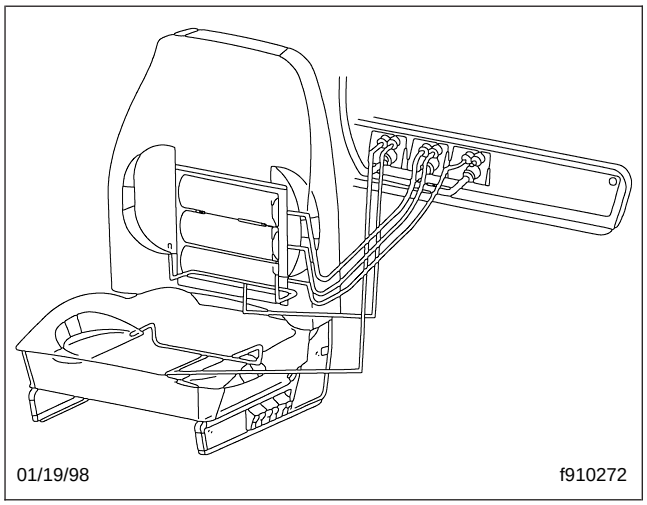


Fig. 3, National Cush-N-Aire II Lumbar System

Replacement

WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the seating system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

1. Drain the vehicle air reservoirs.
2. Apply inward pressure on the quick release collar, and pull the air line out of the connector. See **Fig. 1**.

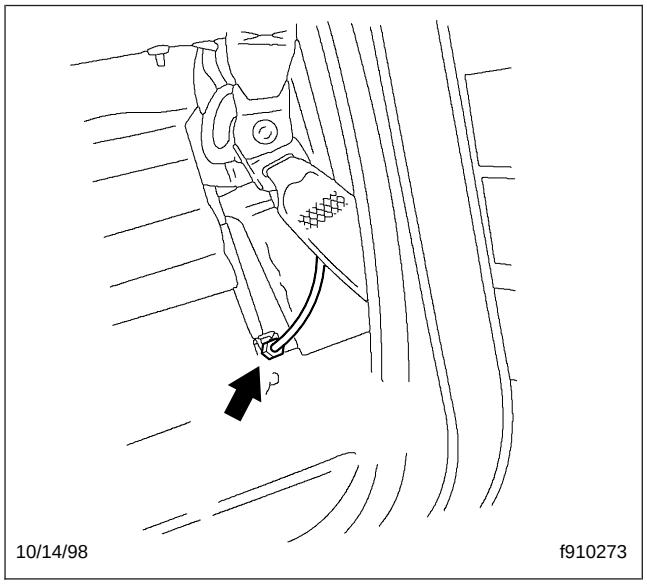


Fig. 1, Quick Release Collar

3. Compress the air switch retaining tabs, and push the air switch from the seat frame. See **Fig. 2**.
4. Remove the air lines from the air switch. See **Fig. 3**.
   - 4.1 Apply inward pressure on the quick release collar, and pull the air line out of the connector.
   - 4.2 Pull the air lines from the air switch fittings.
5. Install the air lines into the air switch.
6. Install the air switch into the seat frame.

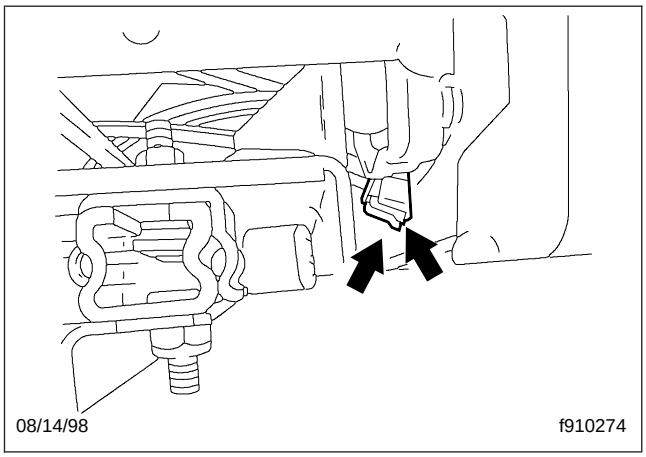
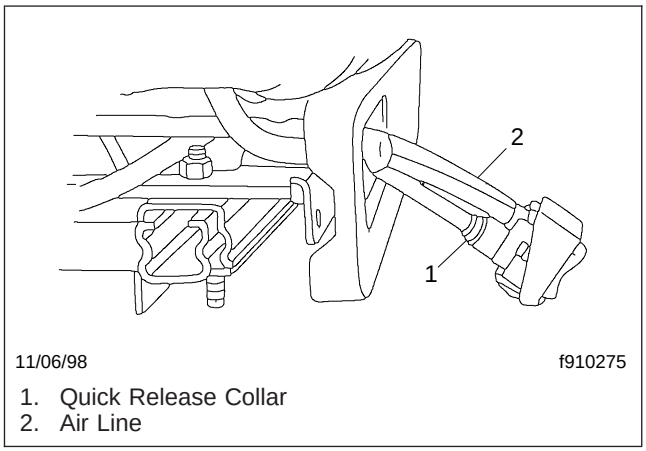


Fig. 2, Air Switch



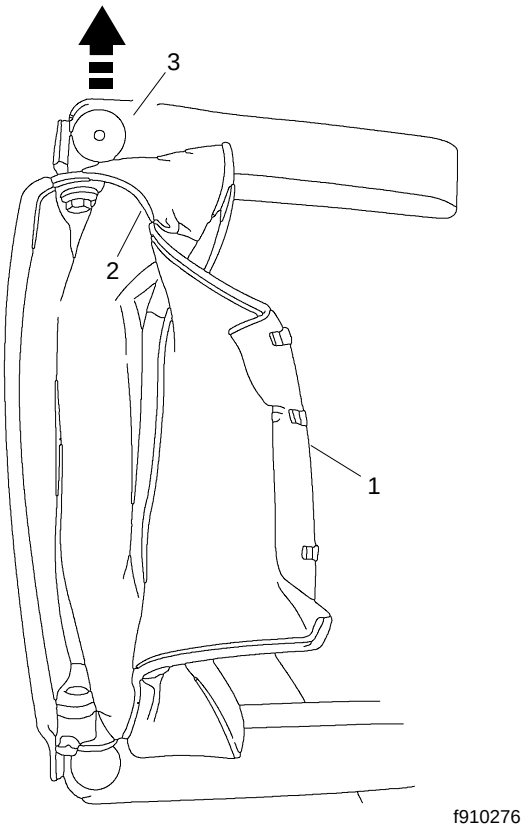
1. Quick Release Collar
2. Air Line

Fig. 3, Air Switch

7. Recharge the air reservoirs by starting the vehicle.

Replacement

1. Remove the seat back. Refer to **Subject 120**.
2. Remove the armrest. See **Fig. 1**.



1. Seat Back Cover
2. Armrest Tube Locking Button, Under Seat Cover
3. Armrest

Fig. 1, Armrest Removal

   2.1 Pull the seat back cover from the back of the seat back.

   2.2 Reach a hand in from the front of the seat back and press the armrest tube locking button.

   2.3 Pull the armrest from the seat back.

3. Position the armrest on the seat back.
4. Pull the seat back cover back into place.
5. Install the seat back. Refer to **Subject 120**.

Replacement

1. Remove the right-side bolt. See **Fig. 1**.

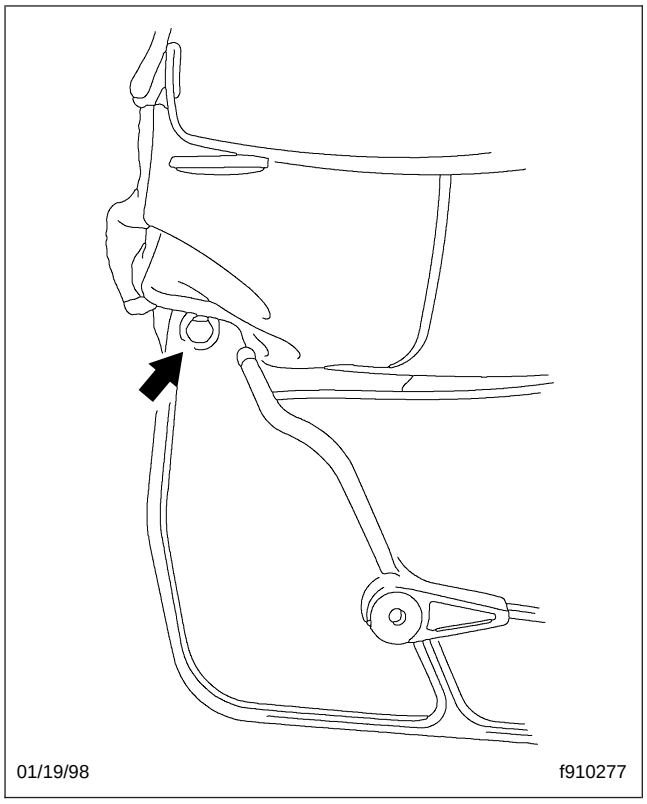


Fig. 1, Right-Side Bolt

2. Remove the left-side bolt. See **Fig. 2**.
3. Remove the recline limit bolt.
4. Remove the recline bolt. See **Fig. 3**.
5. Remove the nut and stud, and lift the seat back from the seat. See **Fig. 4**.

⚠ WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the seating system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

6. Remove the seat back air line from the air switch. See **Fig. 5**.
7. Install the seat back air line onto the air switch.

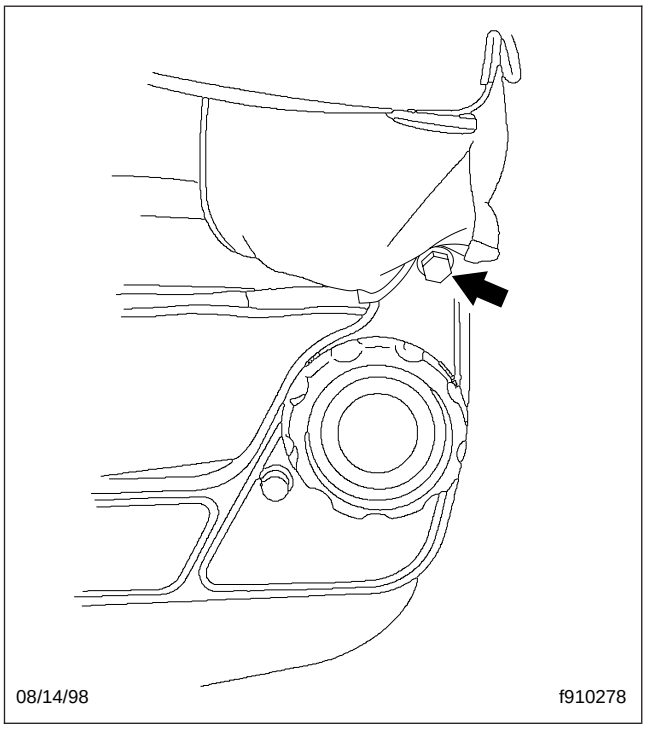


Fig. 2, Left-Side Bolt

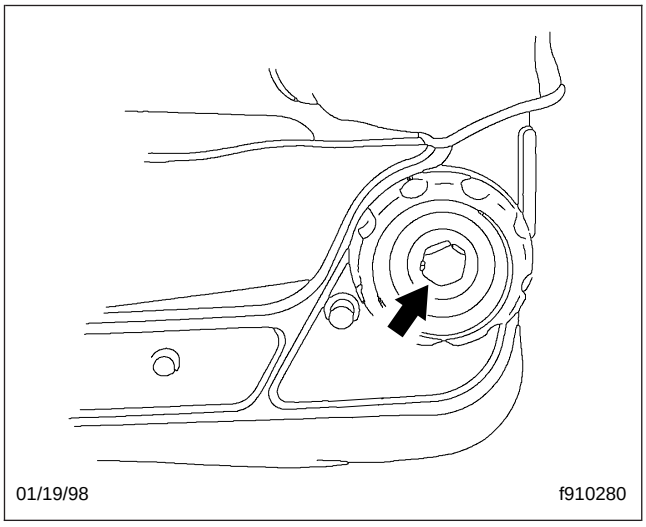


Fig. 3, Recline Bolt

8. Position the seat back on the seat, and install the stud and nut.
9. Install the recline bolt.
10. Install the recline limit bolt and tighten until firm.

Seat Back Replacement

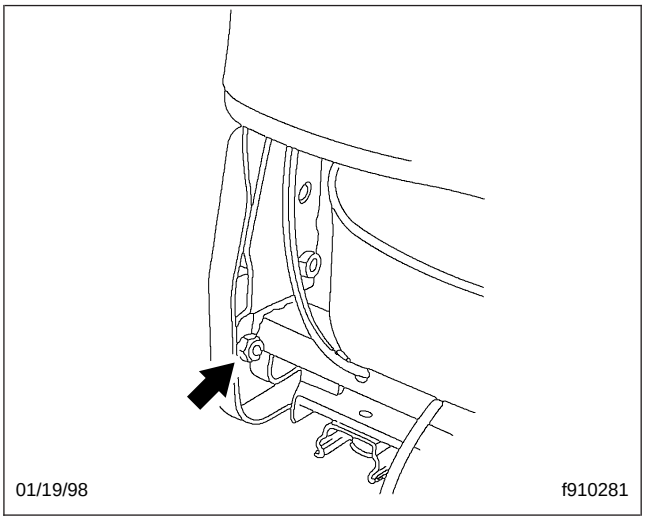


Fig. 4, Nut and Stud

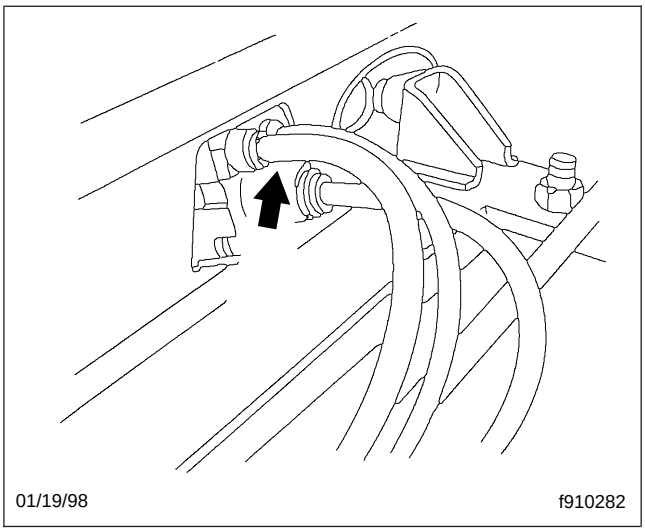


Fig. 5, Seat Back Air Line

11. Install the left-side bolt and tighten until firm.
12. Install the right-side bolt and tighten until firm.

Replacement

1. Remove the left-side nuts. See **Fig. 1**.

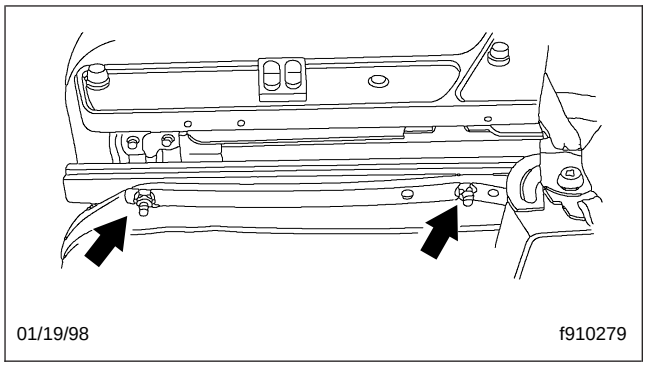


Fig. 1, Left-Side Nuts

2. Remove the right-side nuts. See **Fig. 2**.

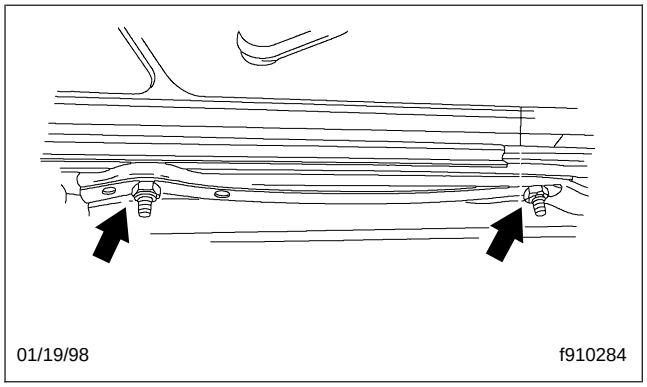


Fig. 2, Right-Side Nuts

WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the seating system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

3. Apply inward pressure on the quick release collar, and pull the airline out of the connector. See **Fig. 3**.
4. Remove the air spring air line from the air switch. See **Fig. 4**.
5. Remove the seat.
6. Install the new seat.

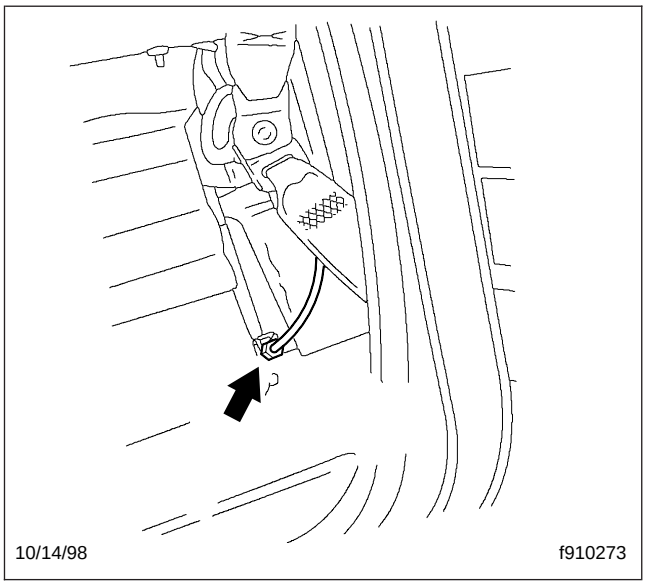


Fig. 3, Quick Release Collar

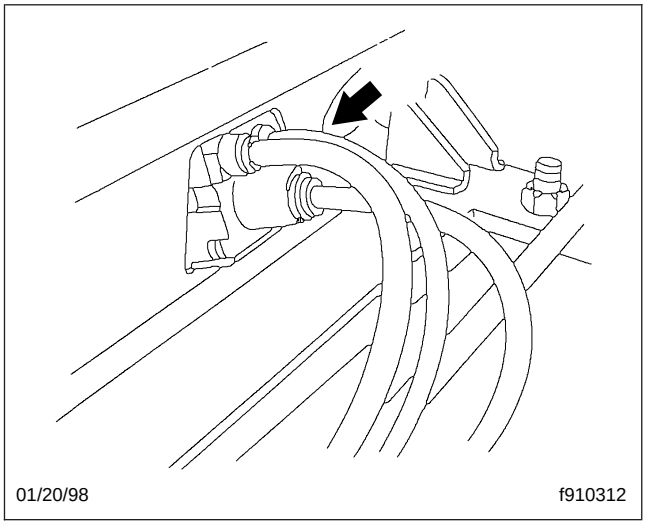


Fig. 4, Air Spring Air Line

7. Install the air spring air line from the air switch.
8. Install the right- and left-side nuts and tighten until firm.

Disassembly

WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the seating system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

1. Apply inward pressure on the quick release collar, and pull the airline out of the connector. See **Fig. 1**.

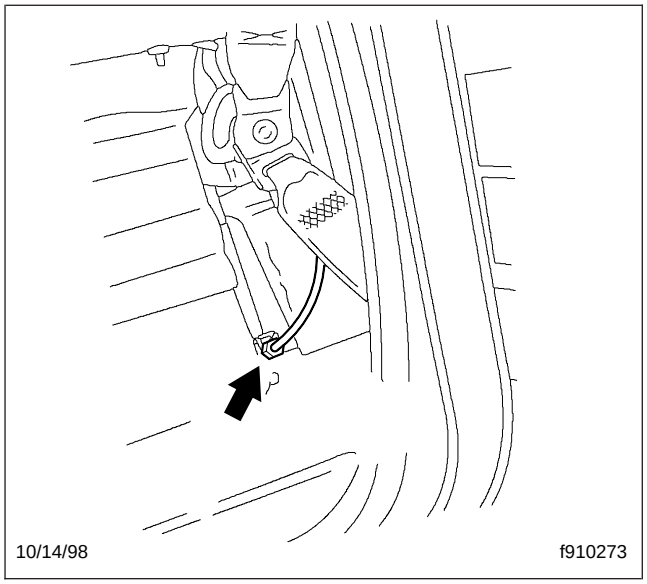


Fig. 1, Quick Release Collar

2. Remove the seat and base from the vehicle.
3. Remove the seat-to-base nuts. See **Fig. 2**.
4. Remove the air spring air line. See **Fig. 3**.
5. Support the base in the full up position with a suitable brace. See **Fig. 4**.
6. Remove the air spring retaining ring. See **Fig. 5**.
7. Push the air spring fitting through the seat base retaining hole. See **Fig. 6**.
8. Pull the air spring retaining clip from the air spring, and remove the air spring. See **Fig. 7**.
9. Remove the shock absorber top nut and bolt. See **Fig. 8**.

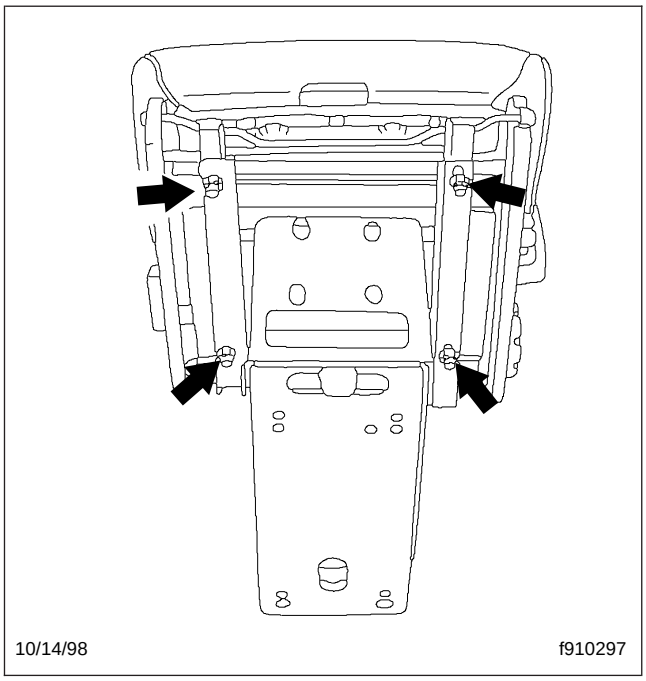


Fig. 2, Seat-to-Base Nuts

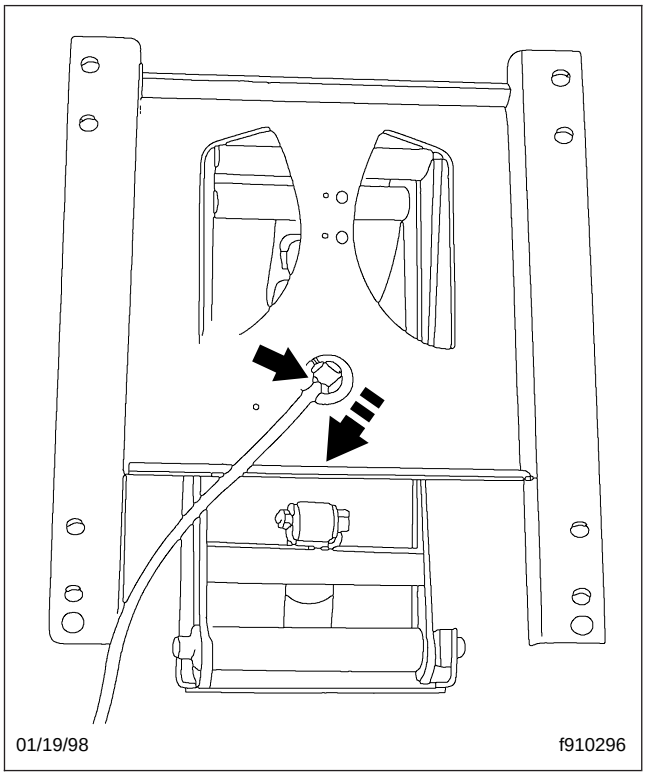


Fig. 3, Air Spring Air Line Remove/Install

Seat Base Disassembly and Assembly

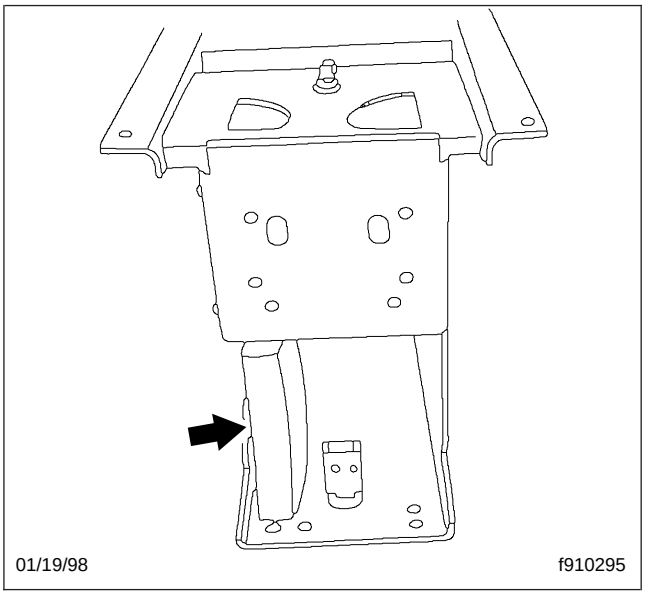


Fig. 4, Supporting the Base

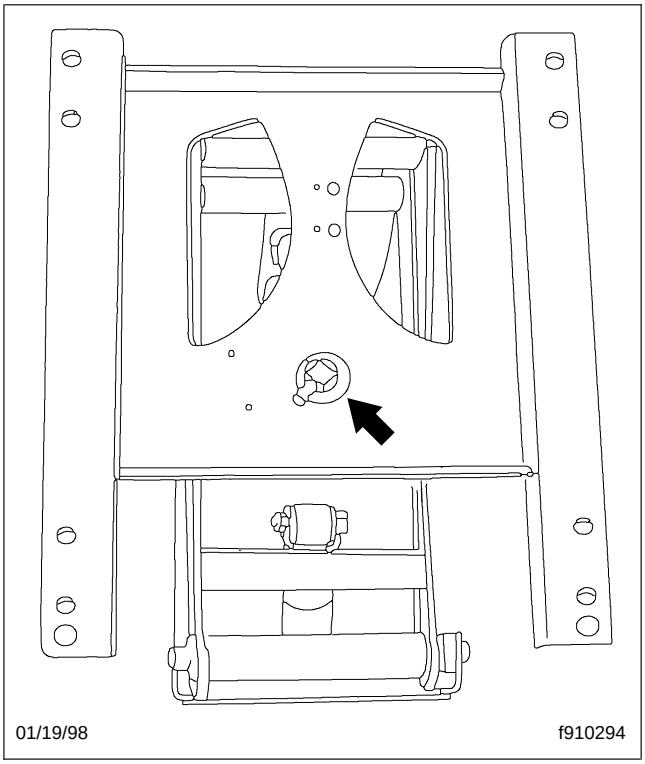


Fig. 5, Air Spring Retaining Ring Remove/Install

10. Remove the shock absorber bottom nut and bolt, and remove the shock absorber. See **Fig. 9**.

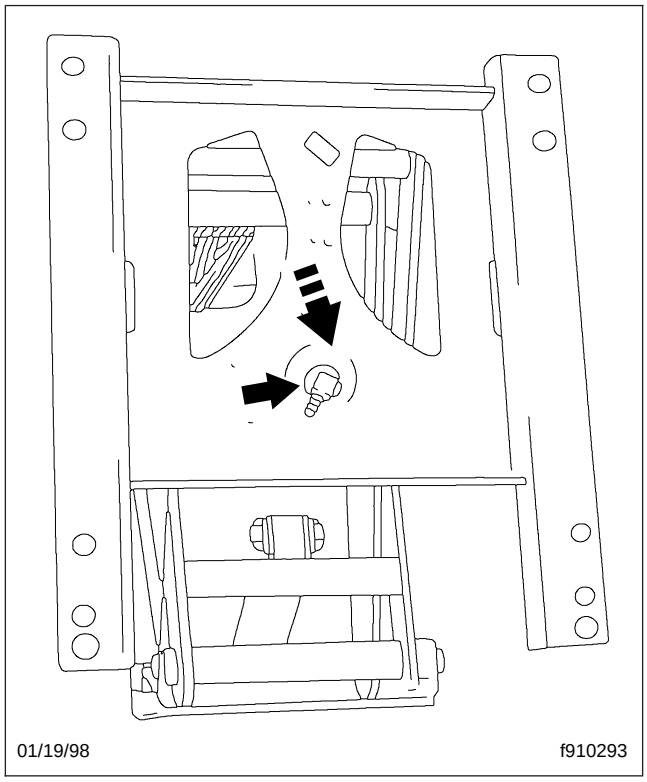


Fig. 6, Air Spring Fitting

11. Remove the snap rings. See **Fig. 10**.
12. Drive the shafts out of the base using a drift pin. The two shafts are connected at the opposite end. To prevent binding, drive the shafts out of the base evenly. See **Fig. 11**.
13. Remove the snap rings. See **Fig. 12**.
14. Drive the shafts out of the base using a drift pin. The two shafts are connected at the opposite end. To prevent binding, drive the shafts out of the base evenly. See **Fig. 13**.
15. Remove the shaft bushings with a drift pin. Repeat for the other side. See **Fig. 14**.

Assembly

Lubricate the shaft housings. Refer to **Specifications, 400**.

1. Install the shaft bushings with a drift pin. Repeat for the other side. See **Fig. 14**.

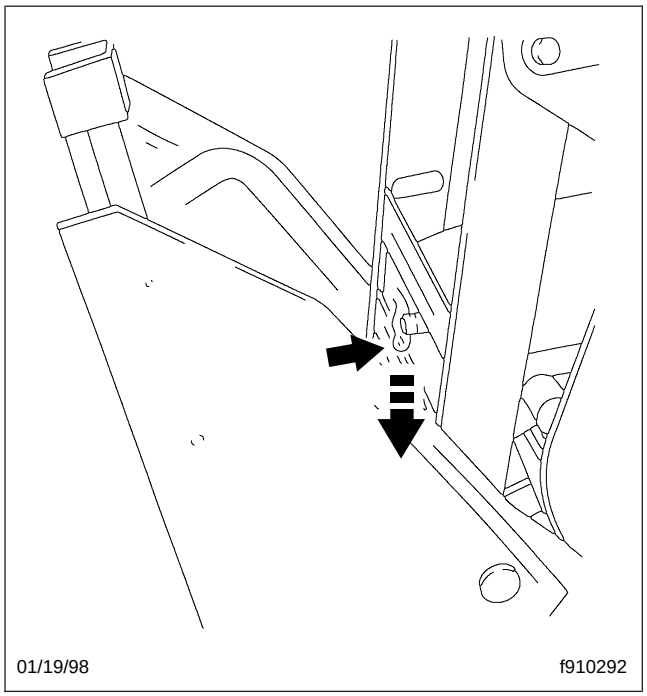


Fig. 7, Air Spring Retaining Clip Removal/Installation

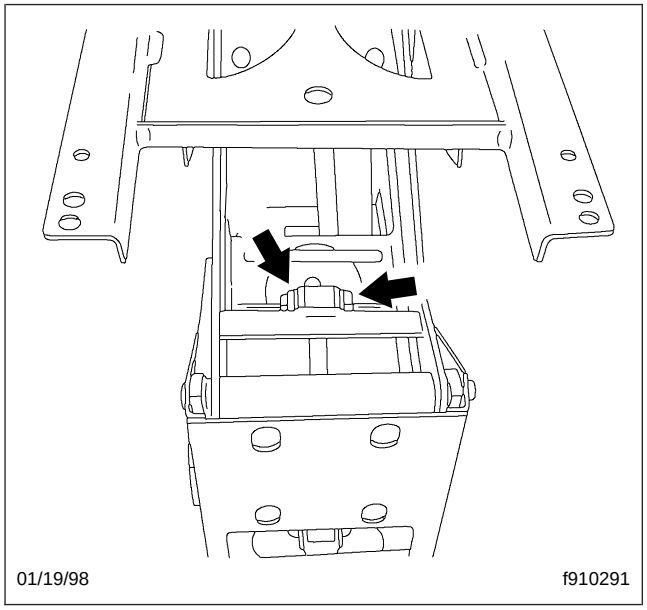


Fig. 8, Shock Absorber Nut and Bolt Removal/ Installation

2. Drive the shafts into the base using a drift pin. The two shafts are connected at the opposite end. To prevent binding, drive the shafts into the base evenly. See **Fig. 13**.
3. Install the snap rings. See **Fig. 12**.
4. Drive the shafts into the base using a drift pin. The two shafts are connected at the opposite end. To prevent binding, drive the shafts into the base evenly. See **Fig. 11**.
5. Install the snap rings. See **Fig. 10**.
6. Position the shock absorber and install the bottom bolt and nut. See **Fig. 9**.
7. Install the shock absorber top bolt and nut. See **Fig. 8**.

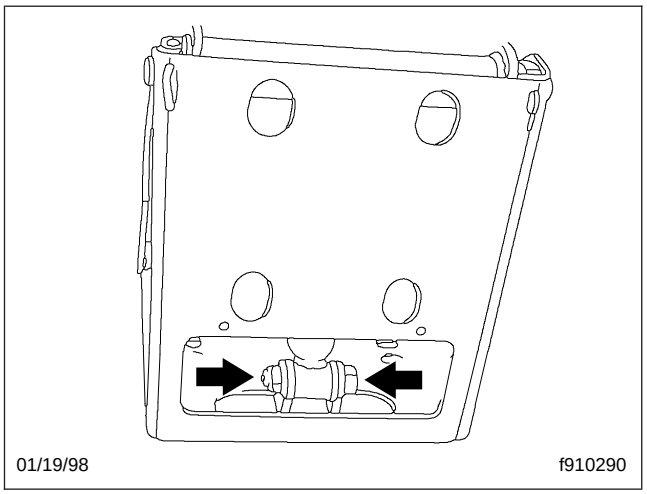


Fig. 9, Shock Absorber Bottom Nut and Bolt Removal/ Installation

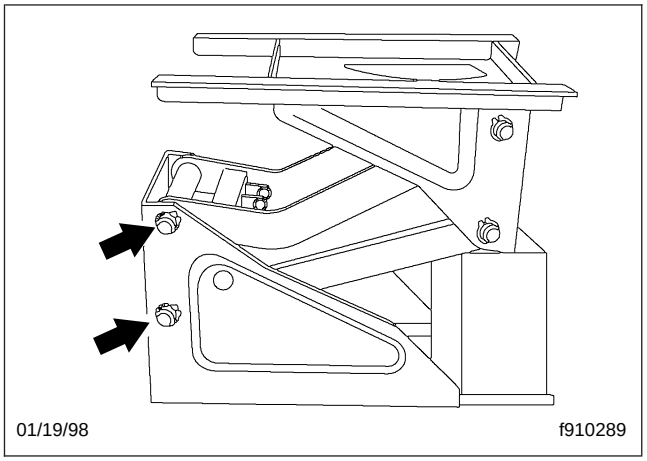


Fig. 10, Snap Rings Removal/Installation

Seat Base Disassembly and Assembly

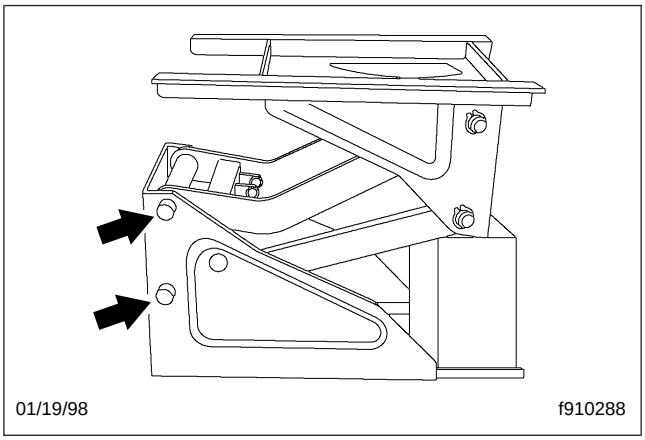


Fig. 11, Driving Out the Shafts

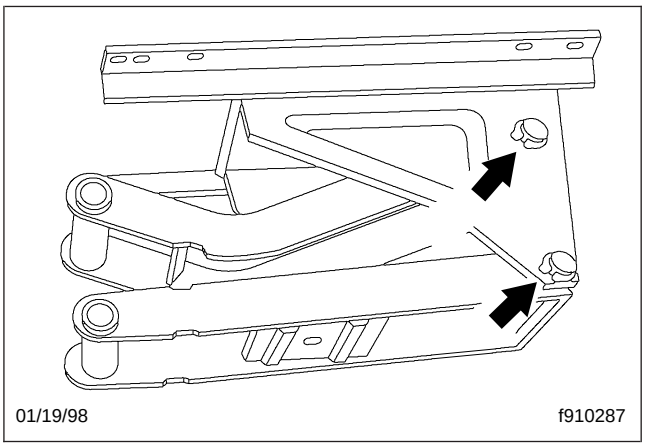


Fig. 12, Snap Rings Removal/Installation

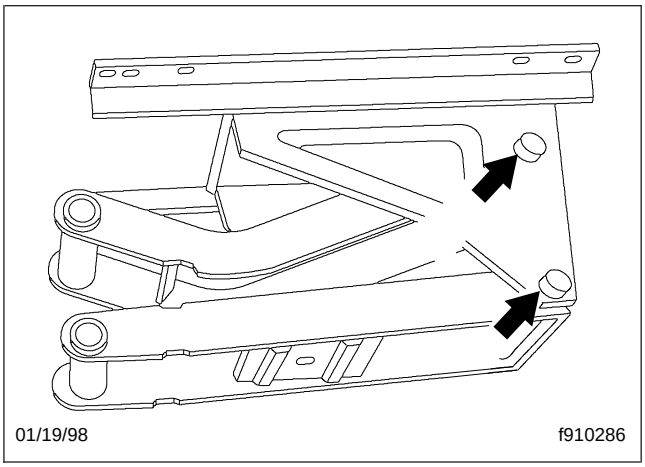


Fig. 13, Driving Out the Shafts

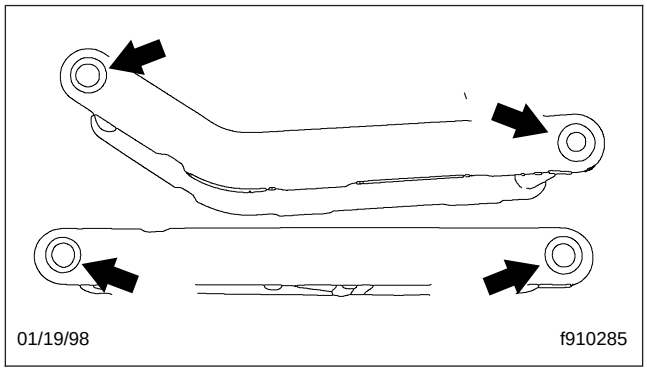


Fig. 14, Removing the Shaft Bushings

8. Position the air spring, and install the air spring retaining clip. See **Fig. 7**.
9. Install the air spring air line. See **Fig. 3**.
10. Install the seat-to-base nuts. See **Fig. 2**.
11. Install the seat and base into the vehicle.
12. Install the airline into the quick connector. See **Fig. 1**.

Disassembly

1. Remove the seat back.
2. Remove the armrests.
3. Pull the seat back cover from the back of the seat back, and pull the seat back cover to the headrest region of the seat back. See **Fig. 1**.

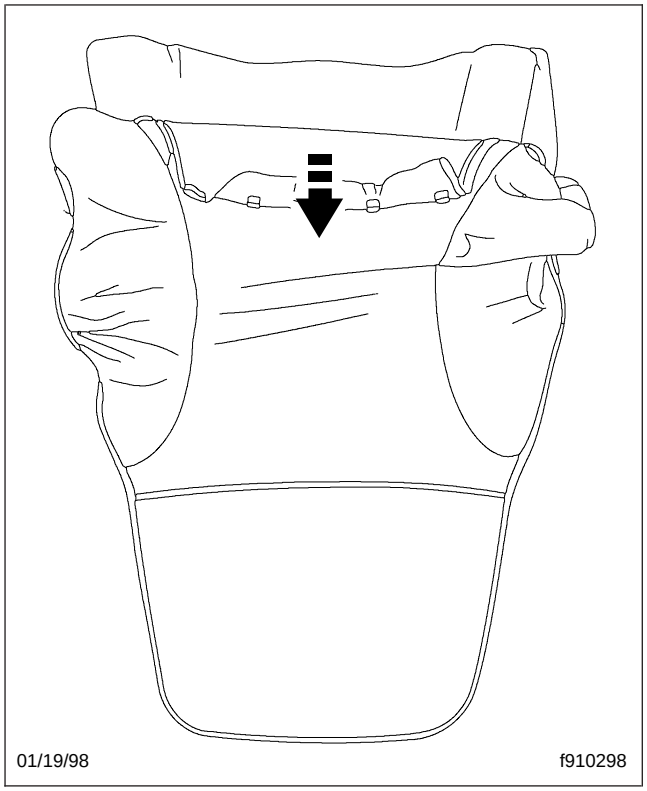


Fig. 1, Pull the Seat Back Cover from the Back of the Seat Back

4. Remove the clips, and pull the seat back cover from the seat back. See **Fig. 2**.
5. Slide the lumbar retainers out of the seat back, and remove the lumbar assembly. See **Fig. 3**.
6. Pull the seat back frame from the seat back cushion. See **Fig. 4**.

Assembly

1. Pull the seat back frame onto the seat back cushion. See **Fig. 4**.

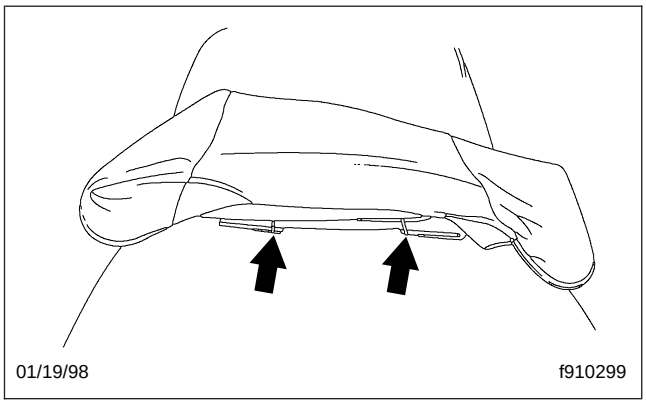


Fig. 2, Remove the Clips

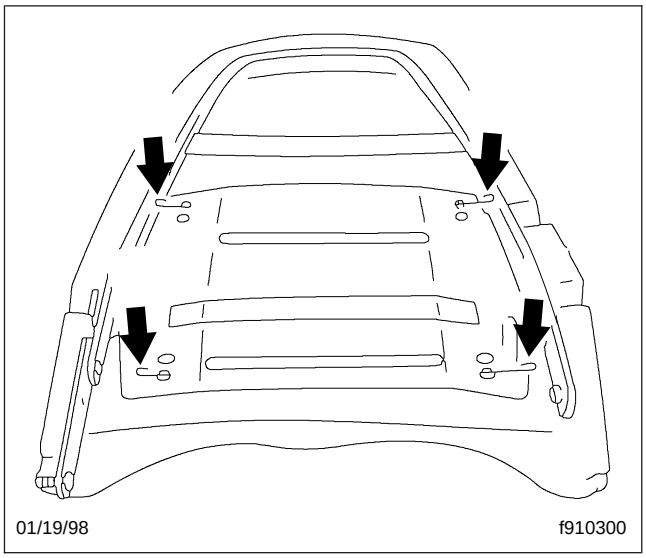
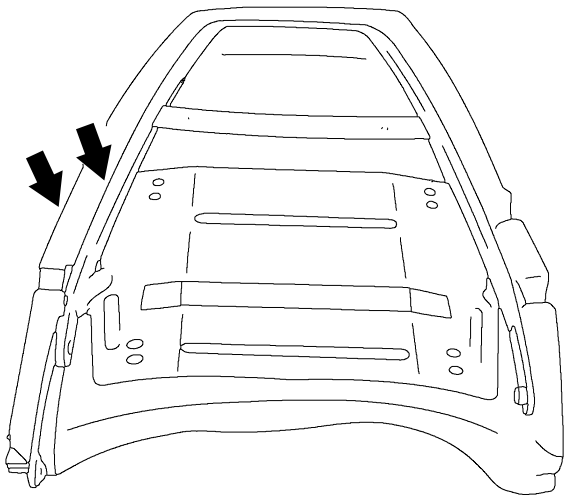


Fig. 3, Remove the Lumbar Assembly

2. Position the lumbar assembly and install the lumbar retainers into the seat back. See **Fig. 3**.
3. Pull the seat back cover onto the seat back and install the clips. See **Fig. 2**.
4. Pull the seat back cover onto the headrest region of the seat back. See **Fig. 1**.

Seat Back Disassembly and Assembly



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1. Seat Back Frame
2. Seat Back Cushion

Fig. 4, Pull the Seat Back Frame from the Seat Back Cushion

Disassembly

1. Cut the tie strap. See **Fig. 1**.

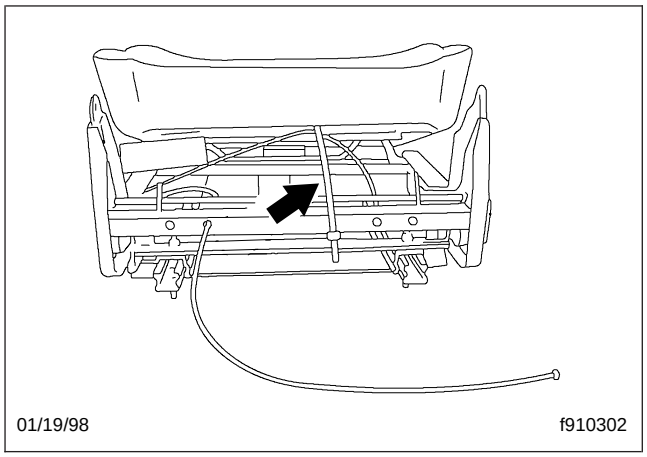


Fig. 1, Cut the Tie Strap

2. Remove the screws and brackets retaining the seat. See **Fig. 2**.

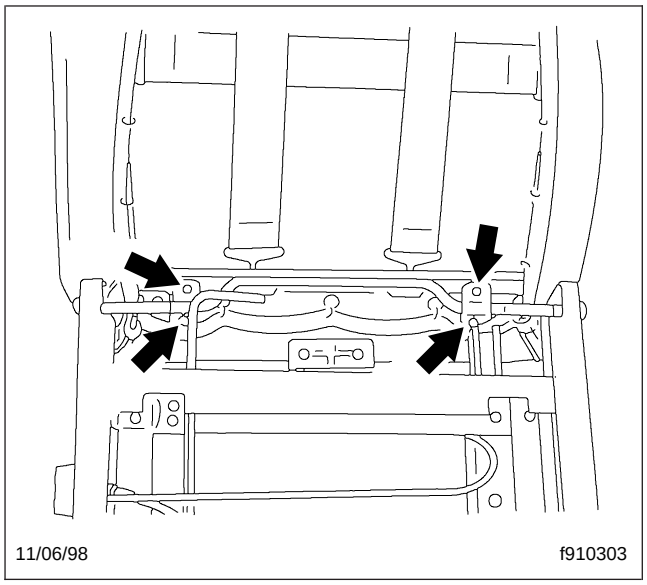


Fig. 2, Seat Retaining Screws and Brackets

3. Remove the seat cover screws. See **Fig. 3**.
4. Remove the seat cover. See **Fig. 4**.
   - 4.1 Remove the clips on the seat straps.

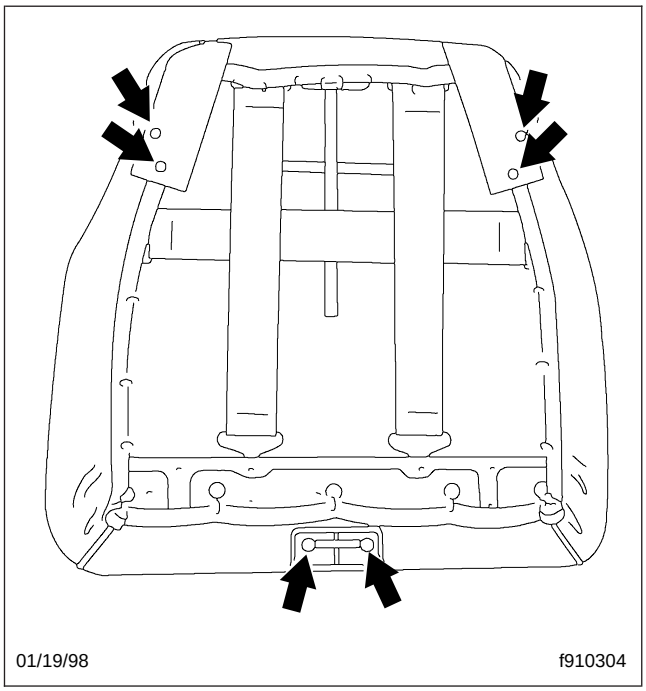


Fig. 3, Seat Cover Screws

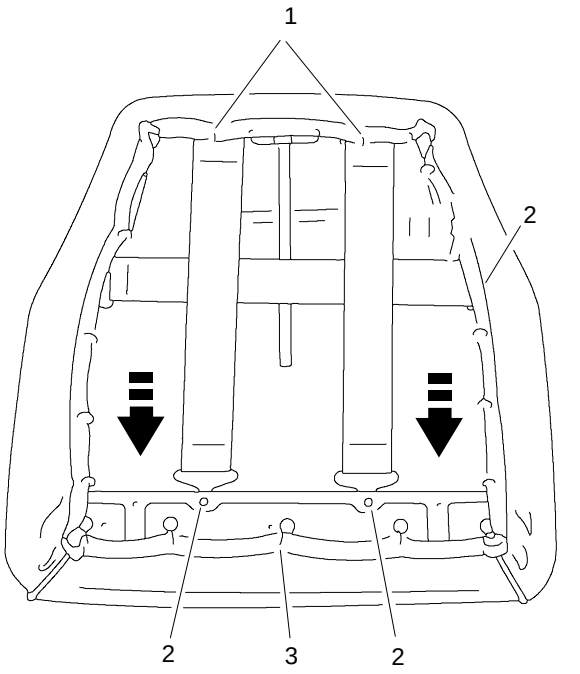
   - 4.2 Remove the seat straps by pulling from the retaining holes.
   - 4.3 Remove the clips retaining the seat cover, and remove the seat cover.
5. Pull the seat frame from the seat cushion. See **Fig. 5**.

Assembly

NOTE: Seal the seat frame to the seat cushion.

1. Install the seat cover. See **Fig. 4**.
   - 1.1 Pull the seat straps through the retaining holes.
   - 1.2 Install the clips on the seat straps.
   - 1.3 Position the seat cover and install the retaining clips.
2. Install the seat cover screws and tighten until firm. See **Fig. 3**.
3. Install the brackets and screws retaining the seat and tighten until firm. See **Fig. 2**.
4. Install a new tie strap. See **Fig. 1**.

Seat Cushion Disassembly and Assembly



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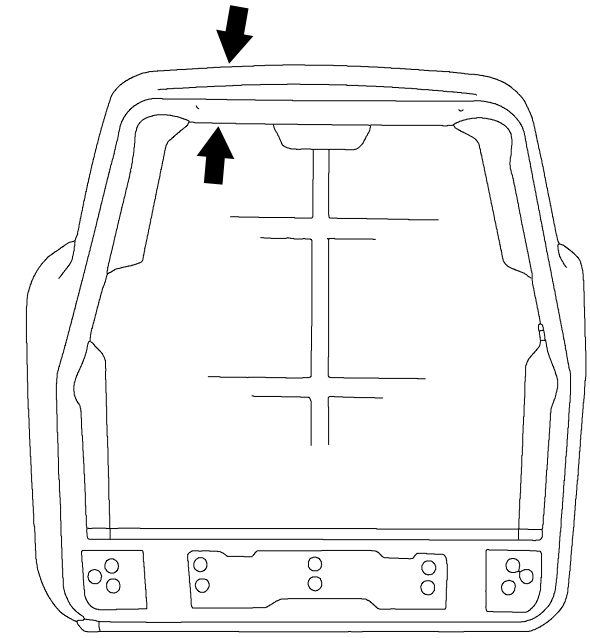
1. Seat Strap Clips
2. Seat Straps
3. Seat Cover Retaining Clips

Fig. 4, Seat Cover



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1. Seat Frame
2. Seat Cushion

Fig. 5, Seat Frame

Disassembly

1. Remove the seat track retaining nuts, and remove the seat tracks. See **Fig. 1**.

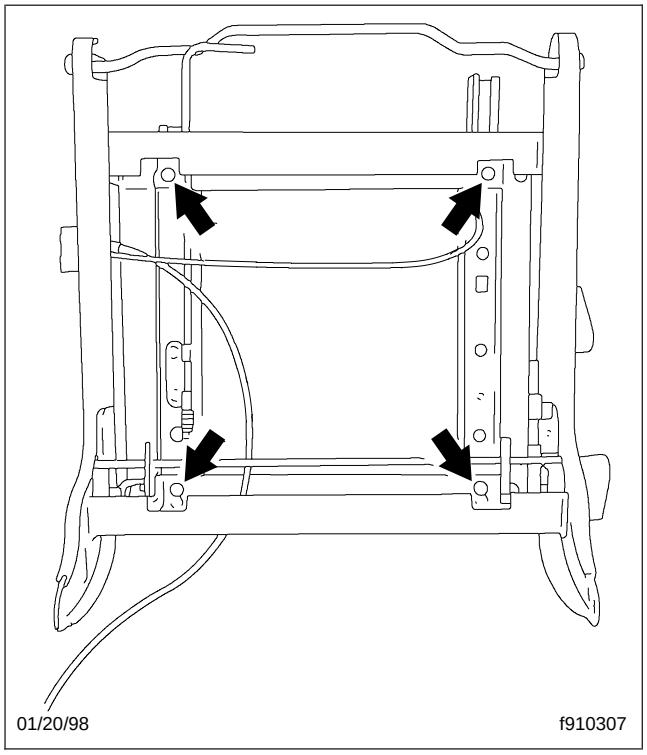


Fig. 1, Seat Track Retaining Nuts

2. Compress the air switch retaining tabs, and push the air switch from the seat frame. See **Fig. 2**.

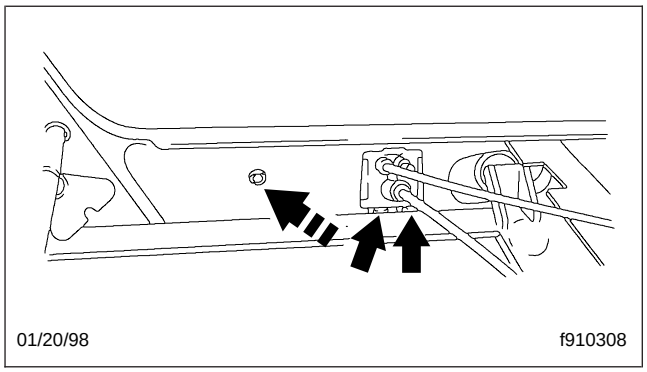


Fig. 2, Compress the Air Switch Retaining Tabs

3. Remove the seat chugger nuts, and carefully remove the right seat chugger assembly. See **Fig. 3**.

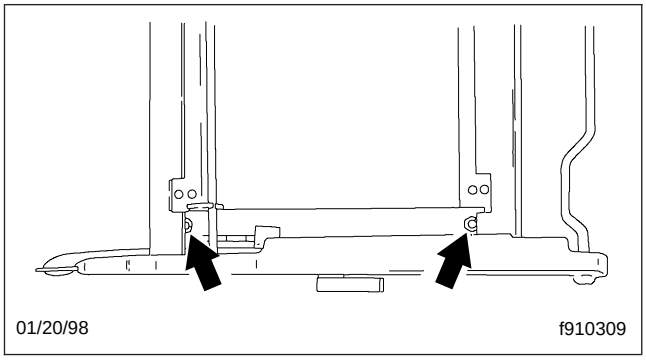


Fig. 3, Right-Side Chugger Assembly Removal/ Installation

4. Carefully pull the left seat chugger from the seat frame. See **Fig. 4**.

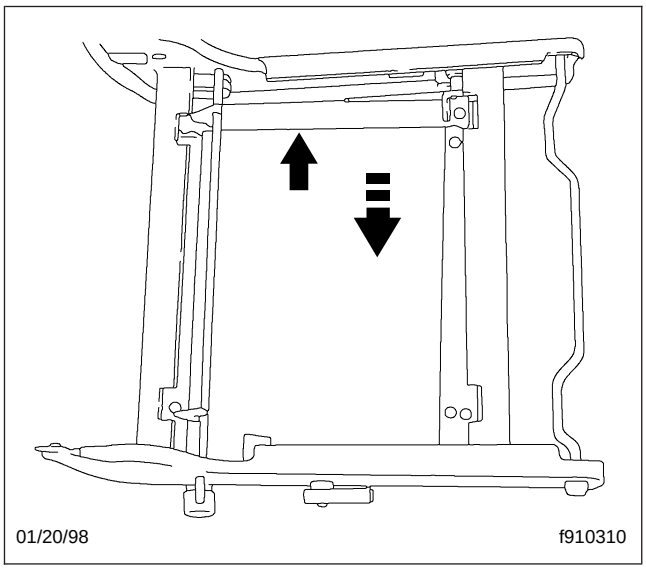


Fig. 4, Left-Side Chugger Assembly Removal/ Installation

5. Remove the nut, and remove the seat chugger latch assembly. See **Fig. 5**.

Assembly

NOTE: Lubricate the seat chugger bearings and the seat tracks. For approved lubricants, refer to **Specifications, 400**.

Seat Mid-Section Disassembly and Assembly

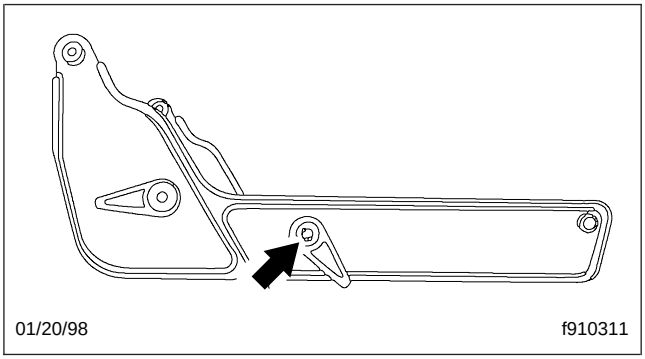


Fig. 5, Seat Chugger Latch Assembly Removal/ Installation

1. Position the seat chugger latch assembly and install the nut. See **Fig. 5**.
2. Install the left seat chugger. See **Fig. 4**.
3. Install the right seat chugger assembly. See **Fig. 3**.
4. Install the air switch. See **Fig. 2**.
5. Install the seat tracks. See **Fig. 1**.

Troubleshooting

INSPECTION AND VERIFICATION

Verify the customer's concern by operating the seat to duplicate the condition.

MECHANICAL AND PNEUMATIC SEAT MALFUNCTION CAUSES

Inspect the seat system to determine if one of the following mechanical or pneumatic concerns applies:

- seat track obstructions
- missing parts
- obvious breaks in parts
- operation of the shock absorber
- broken seat adjusting cable
- broken, disconnected or chafed air lines
- leaking valve and connections
- leaking or damaged air spring
- damage to the lumbar support system

Problem—Air Suspension Seat Will Not Move Vertically

Problem—Air Suspension Seat Will Not Move Vertically	
Possible Source	**Remedy**
Binding seat track(s)	Check for loose or broken parts. Replace or repair as necessary.
Disconnected pneumatic line	Reconnect the pneumatic line.
Leaking pneumatic line	Replace the pneumatic line.
Leaking air spring	Replace the air spring.
Damaged seat switch	Replace the seat switch.

Specifications

General Specifications	
Item	**Specification**
Silicone Rubber	ESB–M4G92–AESE–M4G195–A
Premium Long-Life Grease	ESA–M1C75–B

Table 1, General Specifications

Seats

L-Line and A-Line vehicles are available with Bostrom seating in both a mid-back and high-back configuration. Both of these seating systems are of an air suspension design.

Replacement

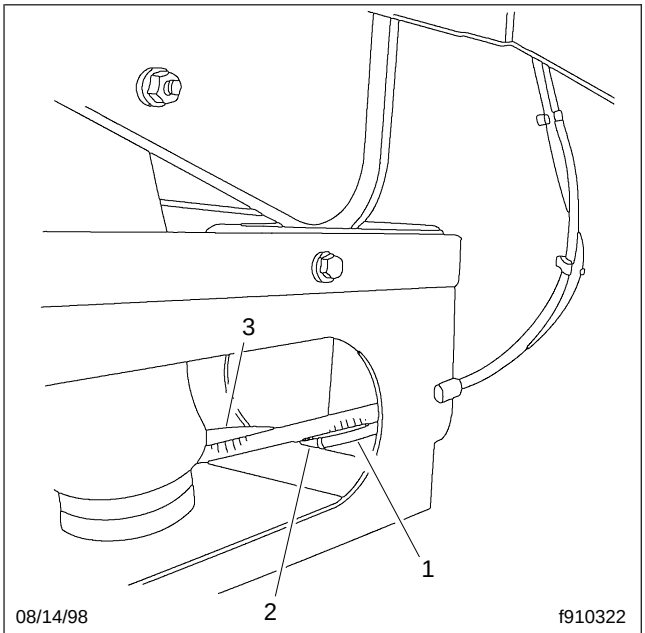
WARNING

All air pressure must be relieved from the air reservoirs before disconnecting any pneumatic lines or hoses from the seating system. Failure to relieve air pressure could cause the lines to whip, resulting in personal injury.

1. Drain the vehicle air reservoirs.

NOTE: The pneumatic lines are of the quick-release type.

2. Disconnect the pneumatic lines. See **Fig. 1**.



1. Quick-Release Pneumatic Line Connector
2. Quick-Release Collar Right-Side
3. Quick-Release Collar Left-Side

Fig. 1, Pneumatic Lines

2.1 Push the line toward the quick-release pneumatic line connector.

2.2 Apply inward pressure on the quick-release collar, and pull the line out of the connector.

2.3 Repeat for the second quick-release connector.

3. Cut the retaining clips. See **Fig. 2**.

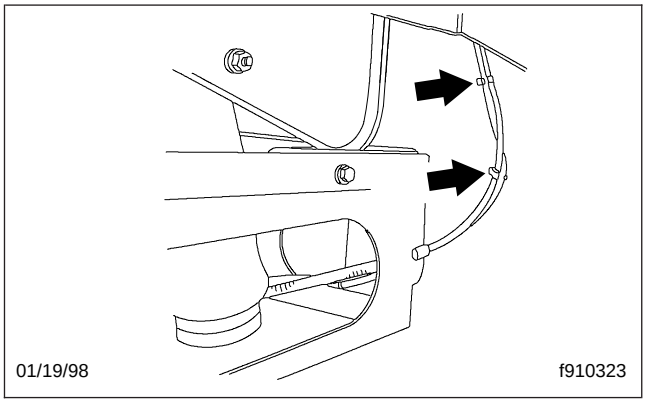


Fig. 2, Retaining Clips

4. Apply slight outward pressure on the switch retaining tabs, and slide the switch forward and off the seat.
5. Install the air switch.
6. Connect the pneumatic lines. See **Fig. 1**.
7. Install new retaining clips.
8. Recharge the air reservoirs by starting the vehicle.

Replacement

1. Remove the bolts that attach the seat to the seat base. See **Fig. 1**.

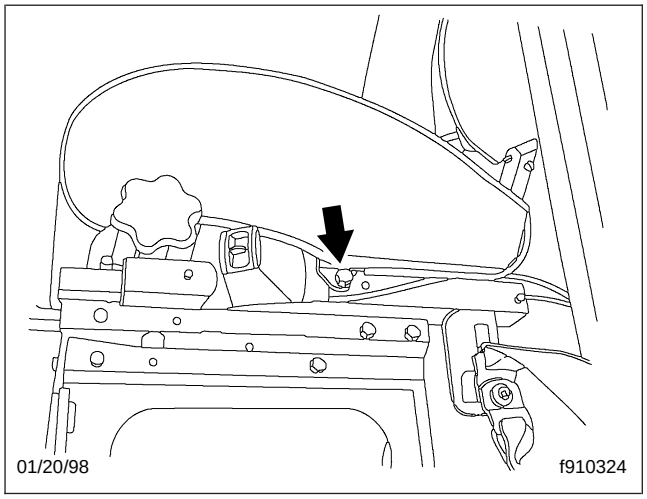


Fig. 1, Seat to Seat Base Bolt, Left-Side Shown

2. Move the seat to the rearmost position. Remove the nuts below the seat, and remove the seat.
3. Position the seat and install the nuts and bolts. Tighten the nuts 18 to 21 lbf·ft (25 to 29 N·m).

Replacement

1. Remove the switch.
2. Remove the bolts that retain the seat to the seat pedestal. See **Fig. 1**.

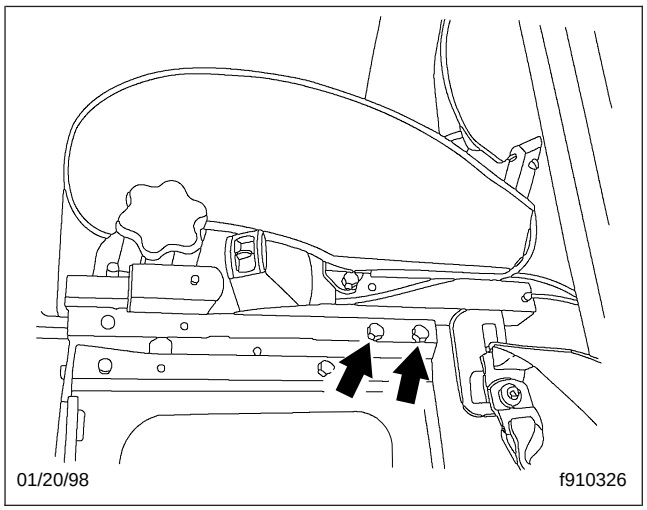


Fig. 1, Bolts Removal/Installation, Left-Side Shown

3. Remove the nuts, and remove the seat and pedestal. See **Fig. 2**.

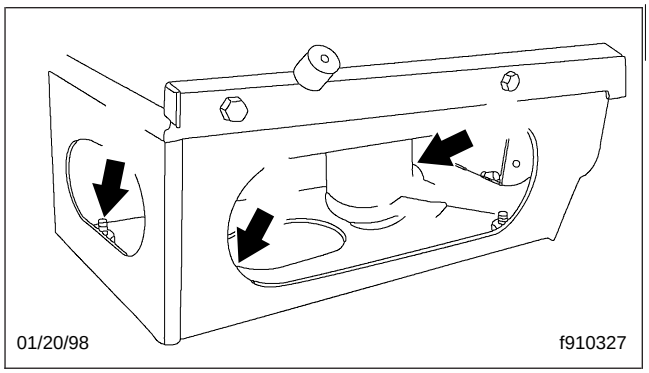


Fig. 2, Seat and Pedestal Removal/Installation

4. Position the seat and pedestal and install the nuts. See **Fig. 2**.
5. Install the bolts and tighten until firm. See **Fig. 1**.

Replacement

1. Remove the seat.
2. Remove the switch.
3. Remove the bolts that retain the seat to the seat pedestal. See **Fig. 1**.

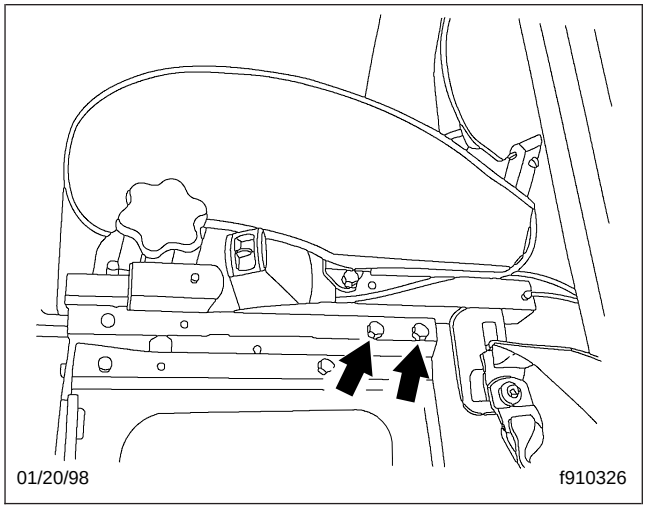
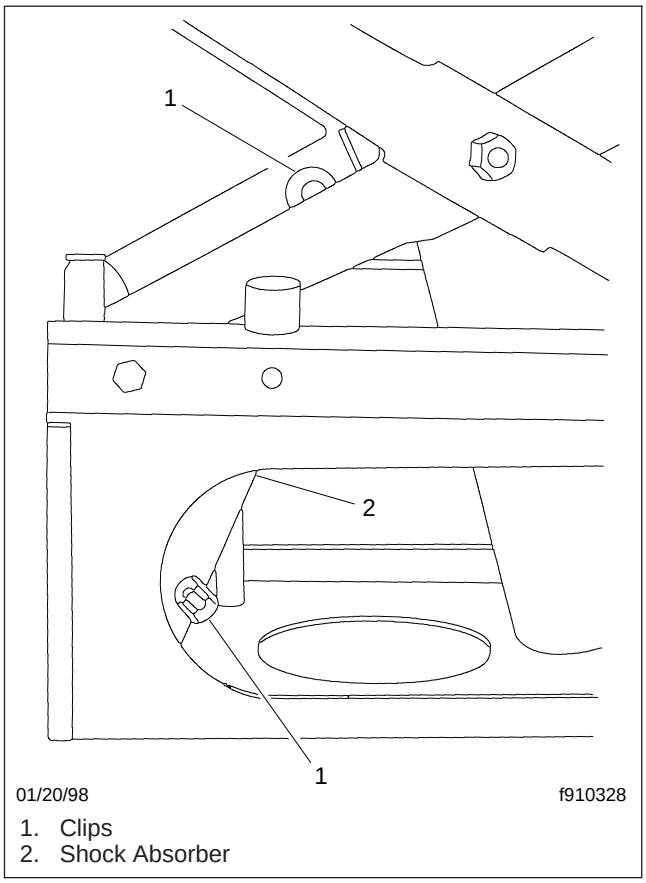


Fig. 1, Bolts Removal/Installation, Left-Side Shown

4. Remove the shock absorber. See **Fig. 2**.
   - 4.1 Remove the clips.
   - 4.2 Remove the shock absorber.
5. Remove the seat adjuster stop bolts, and remove the stop. See **Fig. 3**.

NOTE: The seat height adjuster must be fully extended to remove the seat adjuster.

6. Remove the seat adjuster. See **Fig. 4**.
   - 6.1 Remove the bolts.
   - 6.2 Fully extend the height adjuster, and remove the seat adjuster assembly.
7. Remove the front inner spring. See **Fig. 5**.
8. Remove the rear inner spring. See **Fig. 6**.
9. Remove the latch. See **Fig. 7**.
   - 9.1 Remove the spring.
   - 9.2 Remove the nut.
   - 9.3 Remove the bolt.



1. Clips
2. Shock Absorber

Fig. 2, Shock Absorber

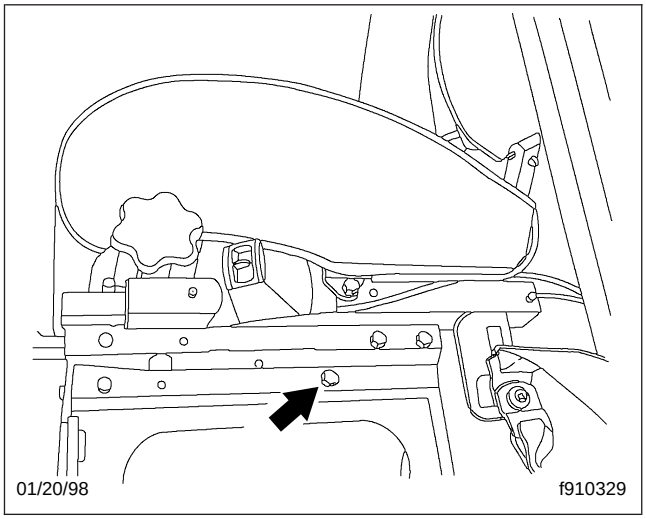
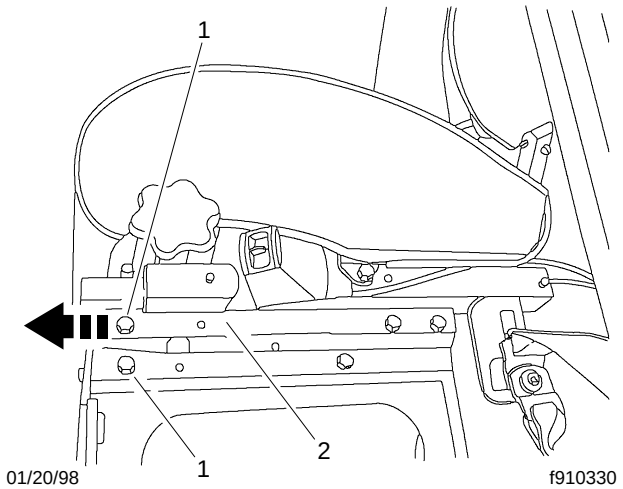


Fig. 3, Seat Adjuster Stop Bolt, Left-Side Shown

- 9.4 Remove the springs.

Latch Replacement



1. Bolts
2. Seat Adjuster Assembly

Fig. 4, Seat Adjuster

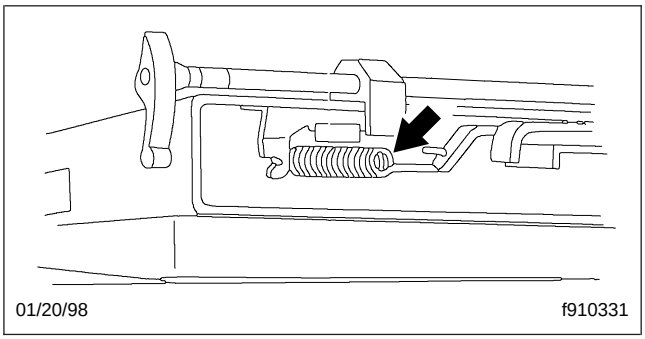


Fig. 5, Front Inner Spring

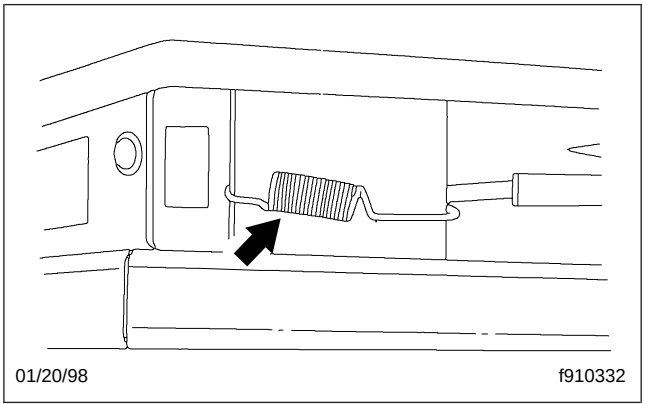
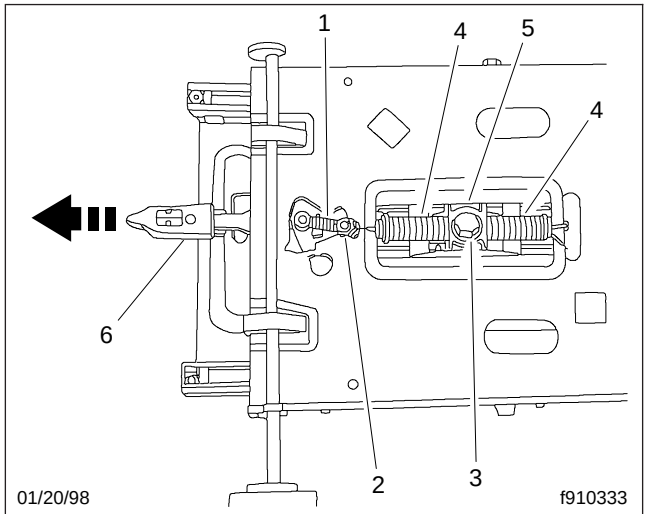


Fig. 6, Rear Inner Spring

9.5 Remove the spring isolator.



1. Spring
2. Nut
3. Bolt
4. Springs
5. Spring Isolator
6. Latch

Fig. 7, Latch Removal/Installation

9.6 Remove the latch.

10. Install the latch.
    - 10.1 Position the latch.
    - 10.2 Install the spring isolator.
    - 10.3 Install the springs.
    - 10.4 Install the bolt.
    - 10.5 Install the nut.
    - 10.6 Install the spring.
11. Tighten the middle bolt 27 to 35 lbf·ft (36 to 47 N·m). Tighten the spring nut 12 to 15 lbf·ft (16 to 20 N·m). See **Fig. 1**.
12. Tighten the three bolts 22 to 27 lbf·ft (30 to 36 N·m). See **Fig. 3** and **Fig. 4**.

SilverStar Sleeper Non-Retractable Safety Belt Buckle Replacement

Replacement

1. Remove the lower bunk mattress.
2. Remove the safety belt buckle bunk anchor bolts, and remove the safety belt buckle assembly. See **Fig. 1**.

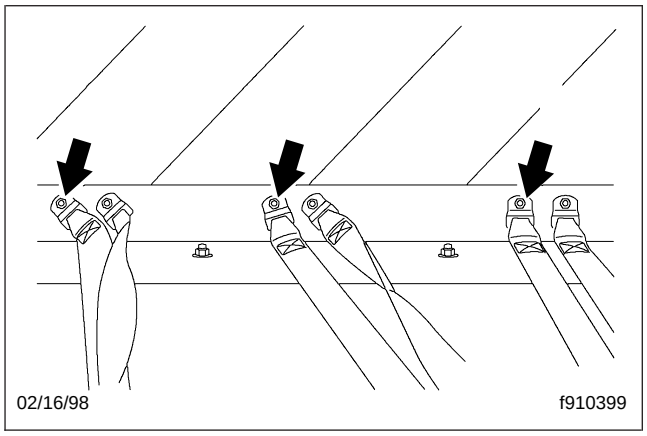


Fig. 1, Safety Belt Buckle Bunk Anchor Bolts

3. Position the safety belt buckle assembly and install the safety belt buckle bunk anchor bolts. Tighten 22 to 32 lbf·ft (30 to 43 N·m).
4. Install the lower bunk mattress.

Troubleshooting

INSPECTION AND VERIFICATION

Verify the customer's concern by operating the seat to duplicate the condition.

Mechanical and Pneumatic Seat Malfunction Causes

Inspect the seat system to determine if one of the following mechanical or pneumatic concerns applies:

- seat track obstructions
- missing parts
- obvious breaks in parts
- operation of the shock absorber
- broken seat adjusting cable
- broken, disconnected or chafed air lines
- leaking valve and connections
- leaking or damaged air spring
- damage to the lumbar support system

Problem—Air Suspension Seat Will Not Move Vertically

Problem—Air Suspension Seat Will Not Move Vertically	
Possible Cause	**Remedy**
Binding seat track(s)	Check for loose or broken parts. Replace or repair as necessary.
Disconnected pneumatic line	Reconnect the pneumatic line.
Leaking pneumatic line	Replace pneumatic line.
Leaking air spring	Replace the air spring.
Damaged seat switch	Replace the seat switch.

Specifications

Torque Specifications	
Description	**lbf·ft (N·m)**
Seat Mount Shoulder Bolt (M8)	18–21 (25–29)
Spring Mount Shoulder Bolt	27–35 (36–47)
Pivot Mount Nut (M8 x 1.25 Self-Locking)	12–15 (16–20)
Self Adjuster Bolt (M8)	22–27 (30–36)

Table 1, Torque Specifications

Occupant Restraint System

⚠ WARNING

Inspect and maintain seat belts. When any part of a seat belt system needs replacement, the entire seat belt must be replaced, both retractor and buckle side. Any time a vehicle is involved in an accident, and the seat belt system was in use, the entire vehicle seat belt system must be replaced before operating the vehicle. Do not attempt to modify the seat belt system; doing so could change the effectiveness of the system. Failure to replace worn or damaged seat belts, or making any modifications to the system, may result in personal injury or death.

Although the three-point seat belts installed in Sterling vehicles appear similar to the seat belts used in passenger cars, there are some important differences that can affect service life:

- A heavy truck can travel more miles in a year than a car might go in its lifetime.
- There is more movement in a truck seat belt system, especially with air ride seats.
- Trucks often operate in more severe environments than cars, such as gravel pits, cement plants and grain elevators, where the belts are exposed to abrasive dirt and dust.

Because of these factors, truck seat belt systems need to be inspected regularly to ensure that they are in proper condition.

The safety belts are factory installed. If the safety belts are removed for any reason, follow the "Removal and Installation" procedures in **Subject 100**. Sealer must be placed around all safety belt anchor bolt holes in the floorpan.

IMPORTANT: When any part of a seat-belt system needs replacement, the entire seat-belt system must be replaced—both the retractor side and the buckle side and, if equipped, both tether belts.

Safety Belt Buckle

The safety belt buckle ends are designed to lock onto the safety belt tongue and to serve as an anchor for both the lap and shoulder portions of the safety belt.

Lap Safety Belt

On some right-hand-drive vehicles, a lap safety belt with a retractor is fitted on the driver and passenger side seats. The inboard lap belt is retractable. To secure the safety belt, the belt tongue is inserted into an outboard, floor-anchored buckle assembly. See **Fig. 1**.

Lap/Shoulder Safety Belt

The outboard combination lap and shoulder belt is a continuous loop system which uses a common sliding tongue. To secure the safety belt, the tongue is inserted into an inboard buckle.

The shoulder harness retractor is designed to let the webbing move freely in or out at all times, except during a vehicle deceleration rate sufficient enough to activate a mechanically-actuated inertia sensor. When the inertia sensor is activated, it will cause the shoulder harness retractor to lock, preventing further extension of the shoulder harness.

On bench seat installations, the inboard belt with the buckle passes through the seat before being anchored to the floor. On air suspension bucket seats, it attaches to the bottom rear of the seat before being anchored to the floor. Attaching the tongue and buckle secures the occupant with both lower and upper restraints. This tongue and buckle attachment can be accomplished by a single continuous movement.

Center Safety Belt

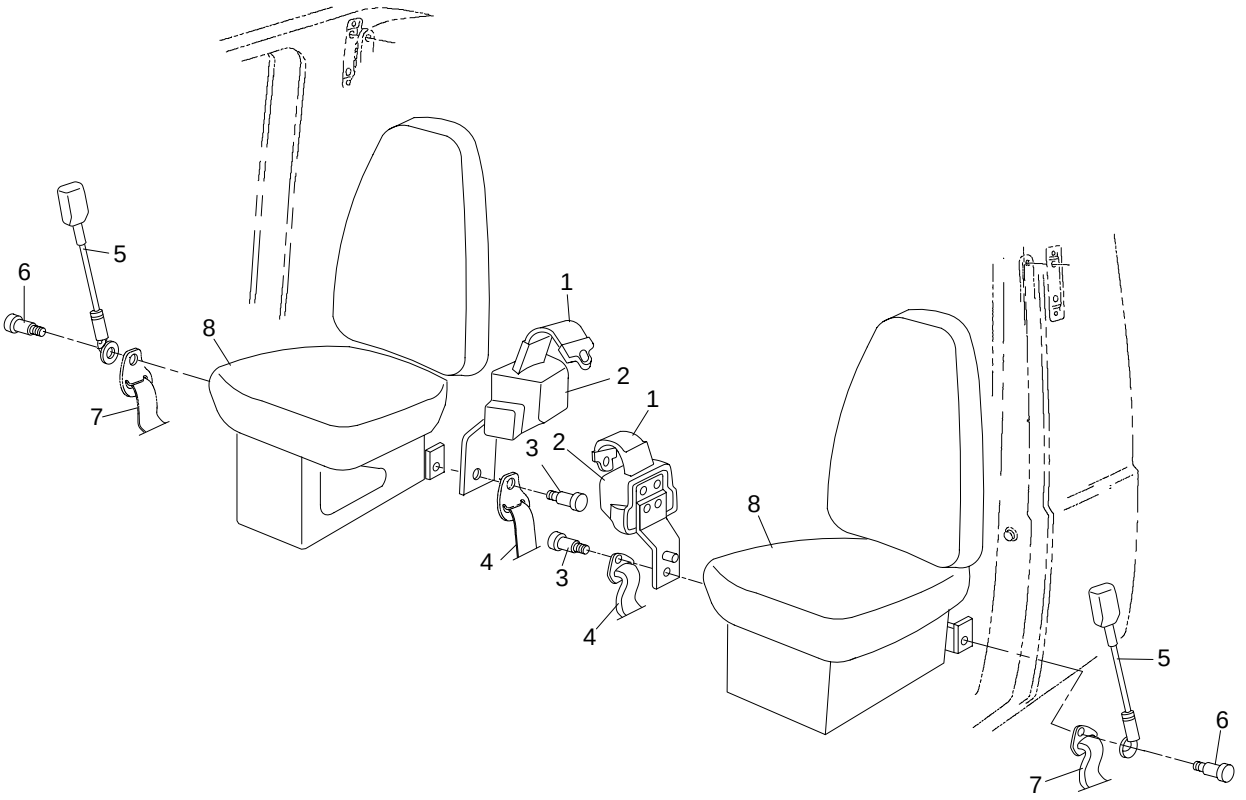
The center safety belts (if equipped) do not have retractors. To lengthen the belt, tip the tongue until the ends can be joined over the lap.

To fasten the belt, insert the tongue into the open end of the buckle until a snap is heard. Shorten the belt, if necessary, by pulling on the loose end of the webbing.

Shoulder Strap Adjuster

The D-ring is the upper anchor point for the shoulder portion of the safety belt. An adjustable D-ring (if equipped) can be positioned at four different points to adapt to individual driver or passenger preferences. The D-ring is adjusted by pushing the release button down and sliding the D-ring to the desired po-

General Information



1. Retractor Belt
2. Retractor Assembly
3. Retaining Bolt
4. Retractor Assembly Anchor
5. Buckle Assembly
6. Retaining Bolt
7. Buckle Assembly Anchor
8. Seat

Fig. 1, Lap Safety Belts, Right-Hand-Drive Vehicles

sition. It is not necessary to use the release button to raise the D-ring.

Komfort® Latch

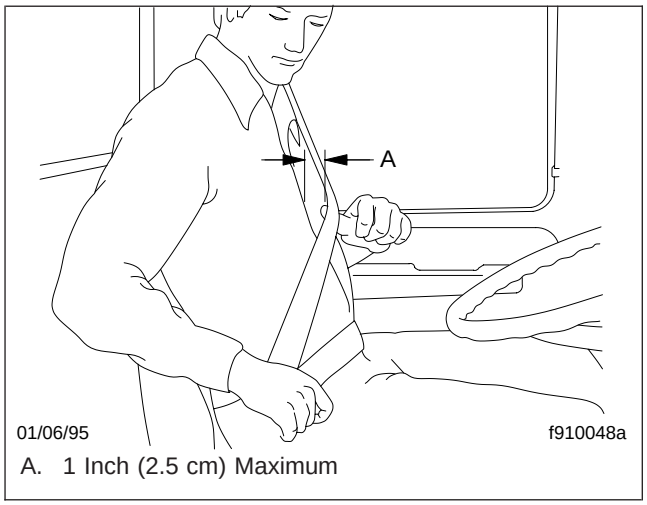
If the constant pressure of the engaged belt system causes discomfort, the driver or passenger can elect to engage the Komfort® latch as follows:

⚠ WARNING

Never adjust the Komfort® latch so that more than 1 inch (2.5 cm) of slack is apparent when measured from the chest to the belt. Failure to follow these precautions can increase the chance and severity of injury in an accident.

NOTE: If at any time when the Komfort® latch is latched and the driver or passenger is required to lean forward quickly, the Komfort® latch will automatically release.

1. Pull on the webbing of the safety belt shoulder strap, permitting only enough slack in the shoulder belt to allow slight pressure on the shoulder and chest. The maximum amount of slack must not exceed 1 inch (2.5 cm) when measured from the chest to the belt. See **Fig. 2**.
2. While holding the slack, lift the lever on the Komfort® latch upward, clamping the safety belt webbing in place. See **Fig. 3**.



A. 1 Inch (2.5 cm) Maximum

Fig. 2, Slack Amount

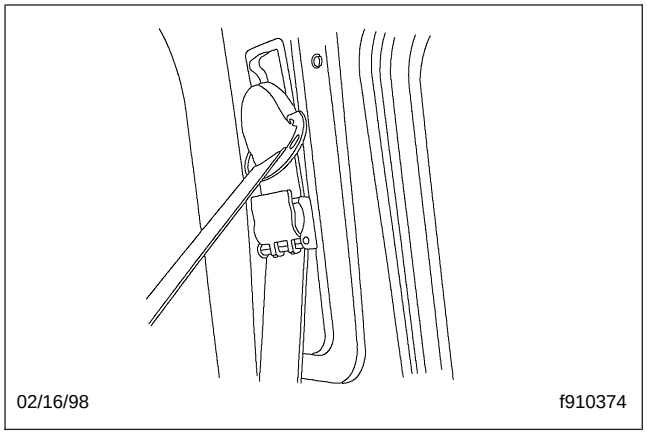


Fig. 3, Komfort® Latch Engaged

3. Push the release button on the safety belt buckle. This allows the tongue to unlatch from the buckle.
4. Give the shoulder strap a quick pull, which will release the Komfort® latch and allow the safety belt to retract into the retractor.

IMPORTANT: If an emergency release from the safety belt is needed, release the buckle by pushing the release button. In the event of an emergency, the Komfort® latch does not have to be released.

5. While the safety belt retracts, guide the tongue to its original position to prevent it from striking an individual or the vehicle.

Unfastening Safety Belts With Retractors

Push the release button in the buckle and allow the outboard belts to retract to the fully stowed position. After unbuckling the belt, it is recommended to guide the tongue during retraction to prevent it from causing injury or damage.

Safety Belt Extension Assembly

A safety belt assembly that is too short when fully extended over the lap of a vehicle occupant can be lengthened approximately 8 inches (20.3 cm) with a safety belt extension assembly. The safety belt extension assembly is only available with black webbing and a standard buckle and must be of the same manufacture as the belt to which it is attached.

Retractor Removal and Installation

Removal

IMPORTANT: When any part of a seat-belt system needs replacement, the entire seat-belt system must be replaced—both the retractor side and the buckle side and, if equipped, both tether belts.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. For vehicles with air suspension seats, remove the retractor-side safety belt seat anchor bolt. See **Fig. 1**.

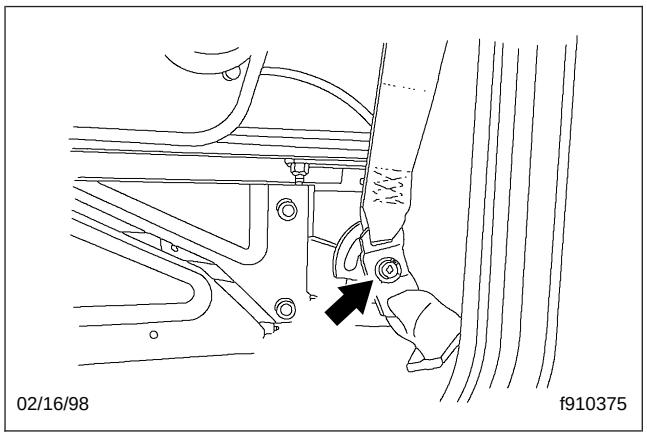
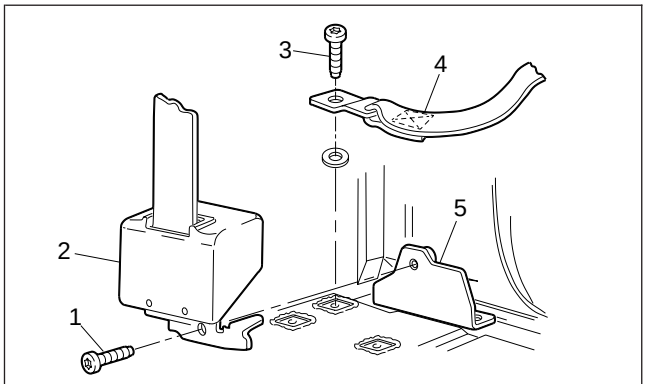


Fig. 1, Safety Belt Seat Anchor Bolt

3. Remove the retractor-side floor anchor bolt. See **Fig. 2**. Remove the tether, if so equipped.
4. Remove the safety belt retractor bolt.
5. Remove the shoulder strap guide cover. See **Fig. 3**.
6. Remove the shoulder strap guide nut.
7. Remove the safety belt retractor assembly.

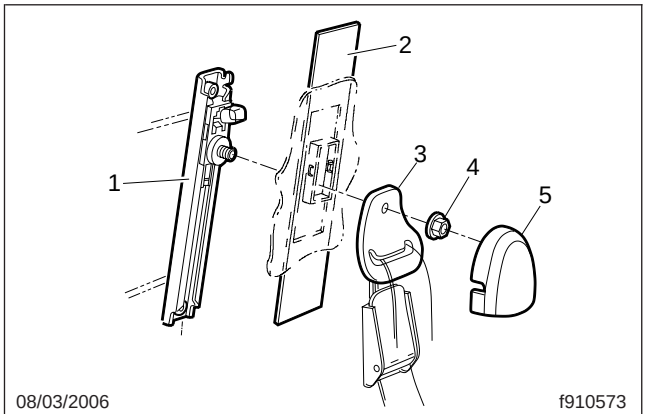
Installation

1. With the tires chocked, position the shoulder strap guide in place. Install the guide nut. See **Fig. 3**. Tighten the nut 22 to 32 lbf·ft (30 to 43 N·m).
2. Install the shoulder strap guide cover.



1. Retractor Bolt
2. Retractor
3. Floor Anchor Bolt
4. Safety Belt or Tether (if so equipped)
5. Retractor Mounting Bracket

Fig. 2, Safety Belt Retractor and Floor Anchor



1. Height Adjuster
2. Dust Cover
3. Shoulder Strap Guide
4. Guide Nut
5. Cover

Fig. 3, Shoulder Strap Guide Installation

3. Position the safety belt retractor in place, and install the bolt. See **Fig. 2**. Tighten the bolt 22 to 32 lbf·ft (30 to 43 N·m).
4. For vehicles with air suspension seats, attach the safety belt and tether to the seat with the seat anchor bolt. See **Fig. 1**. Tighten the bolt 22 to 32 lbf·ft (30 to 43 N·m).
5. Attach the safety belt or the tether (if so equipped) to the cab floor with the floor anchor

Retractor Removal and Installation

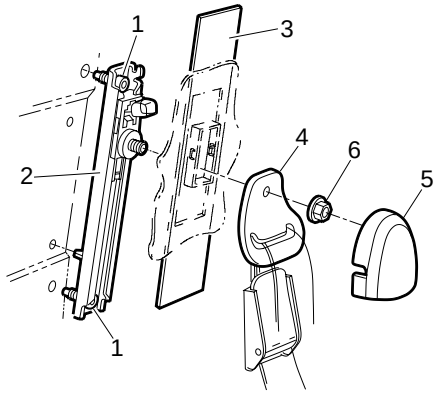
bolt. See **Fig. 2**. Tighten the bolt 22 to 32 lbf·ft (30 to 43 N·m).

Height Adjuster Removal and Installation

Removal

IMPORTANT: When any part of a seat-belt system needs replacement, the entire seat-belt system must be replaced—both the retractor side and the buckle side and, if equipped, both tether belts.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the shoulder strap guide cover. See **Fig. 1**.



1. Height Adjuster Screw
2. Height Adjuster
3. Dust Cover
4. Shoulder Strap Guide
5. Cover
6. Guide Nut

Fig. 1, Height Adjuster Installation

3. Remove the shoulder strap guide nut.
4. Remove the height adjuster trim cover, if so equipped. See **Fig. 2**.
5. Remove the height adjuster dust cover. See **Fig. 1**.
6. Remove the height adjuster by removing the height adjuster screws.

Installation

1. With the tires chocked, position the height adjuster in place, and install the height adjuster screws. See **Fig. 1**. Tighten the screws 22 to 30 lbf·ft (30 to 40 N·m).

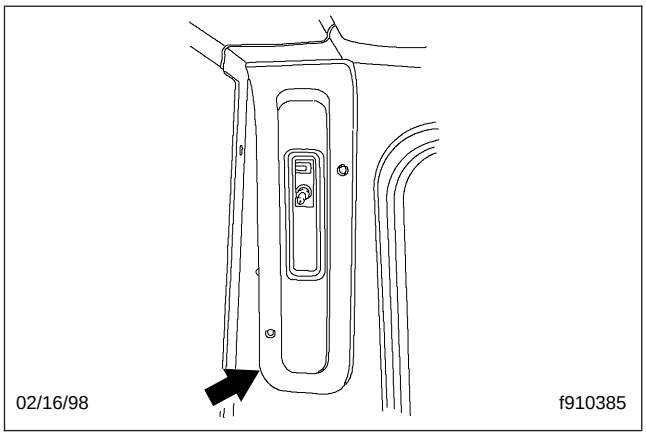


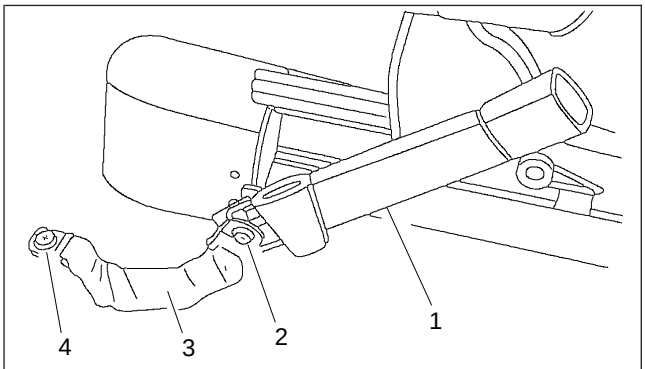
Fig. 2, Height Adjuster Trim Cover

2. Install the height adjuster dust cover.
3. Install the height adjuster trim cover. See **Fig. 2**.
4. Install the shoulder strap guide and nut. See **Fig. 1**. Tighten the nut 22 to 32 lbf·ft (30 to 43 N·m).
5. Install the shoulder strap guide cover.

Replacement

IMPORTANT: When any part of a seat-belt system needs replacement, the entire seat-belt system must be replaced—both the retractor side and the buckle side and, if equipped, both tether belts.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. If the vehicle is equipped with air suspension seats, remove the seat anchor bolt. See **Fig. 1**.
3. Remove the floor anchor bolt.
4. Remove the safety belt buckle, and if so equipped, the tether.
5. If the vehicle is equipped with air suspension seats, attach the new safety belt buckle and tether to the seat with the seat anchor bolt. Tighten the bolt 22 to 32 lbf·ft (30 to 43 N·m).
6. Attach the safety belt buckle or tether (if so equipped) to the cab floor with the floor anchor bolt. Tighten the bolt 22 to 32 lbf·ft (30 to 43 N·m).



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1. Safety Belt Buckle
2. Seat Anchor Bolt
3. Safety Belt Tether
4. Floor Anchor Bolt

Fig. 1, Safety Belt Buckle Mounting (air suspension seat shown)

Able Body Sleeper Non-Retractable Safety Belt Buckle Replacement

Replacement

IMPORTANT: When any part of a safety belt system needs replacement, the entire safety belt system must be replaced—both the retractor side and the buckle side and, if equipped, tether belts.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the safety belt buckle floor anchor bolt located under the vehicle carpeting. See **Fig. 1**.

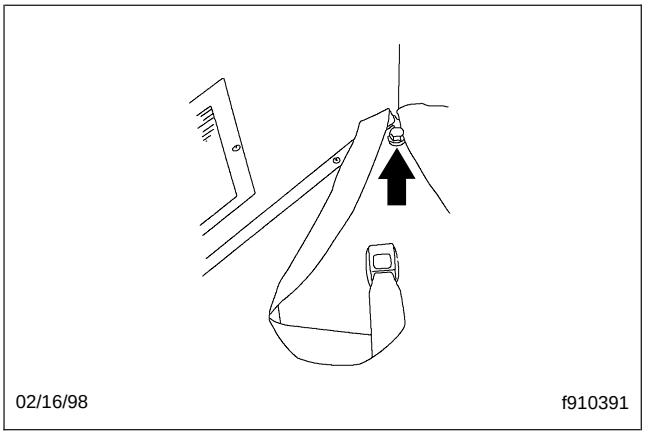


Fig. 1, Safety Belt Buckle Floor Anchor Bolt

3. Install the safety belt buckle floor anchor bolt. Tighten 22 to 32 lbf·ft (30 to 43 N·m). See **Fig. 1**.

SilverStar Sleeper Non-Retractable Safety Belt Buckle Replacement

Replacement

IMPORTANT: When any part of a safety belt system needs replacement, the entire safety belt system must be replaced—both the retractor side and the buckle side and, if equipped, tether belts.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the lower bunk mattress.
3. Remove the safety belt buckle bunk anchor bolts, and remove the safety belt buckle assembly. See **Fig. 1**.

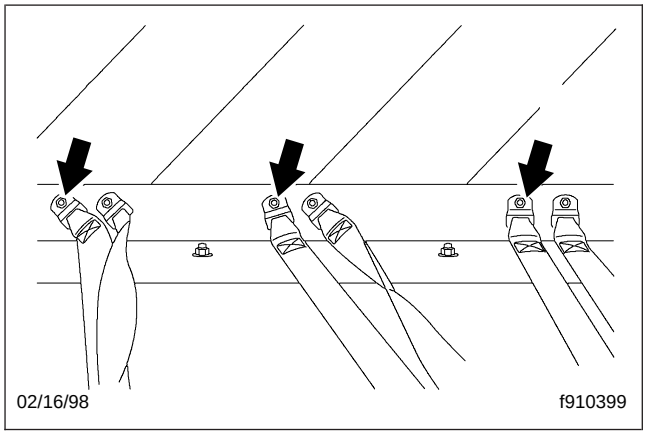


Fig. 1, Safety Belt Buckle Bunk Anchor Bolts

4. Position the safety belt buckle assembly and install the safety belt buckle bunk anchor bolts. Tighten 22 to 32 lbf·ft (30 to 43 N·m). See **Fig. 1**.
5. Install the lower bunk mattress.

Able Body Sleeper Non-Retractable Safety Belt Tongue Replacement

Replacement

IMPORTANT: When any part of a safety belt system needs replacement, the entire safety belt system must be replaced—both the retractor side and the buckle side and, if equipped, tether belts.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the lower bunk mattress.
3. Drill out the rivets. See **Fig. 1**.

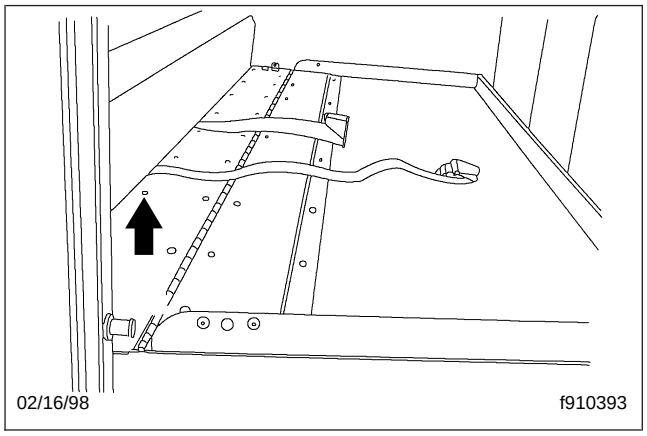


Fig. 1, Lower Bunk Rivets

4. Lift the lower bunk platform and support it in the "Up" position.
5. Disconnect the lower bunk center prop safety latch. See **Fig. 2**.
   - 5.1 Remove the nut and bolt.
   - 5.2 Swing the safety latch down from the bunk platform.

NOTE: Use care not to damage the vehicle interior during bunk platform removal.

6. Remove the lower bunk platform.
7. Drill out the lower bunk fore and aft beam rivets and remove the fore and aft beams.
8. Remove the screws retaining the storage compartment lights and disconnect the electrical connectors. See **Fig. 3**.
9. Disconnect the auxiliary A/C system. See **Fig. 4**.

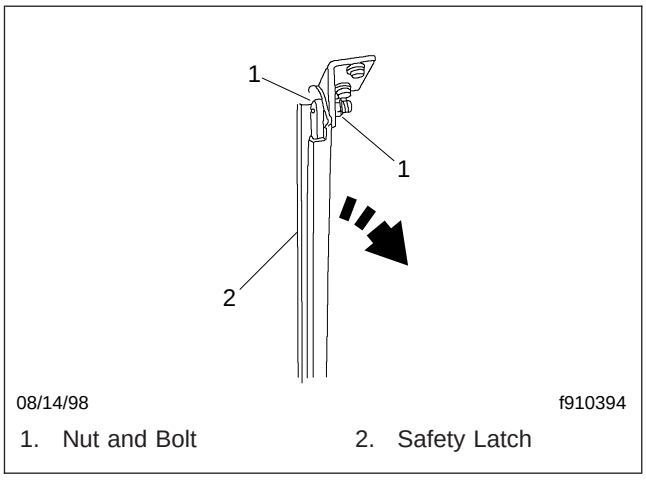


Fig. 2, Lower Bunk Center Prop Latch

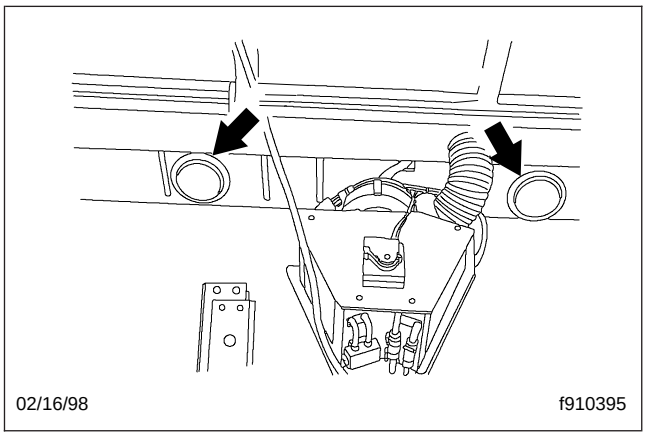


Fig. 3, Storage Compartment Lights

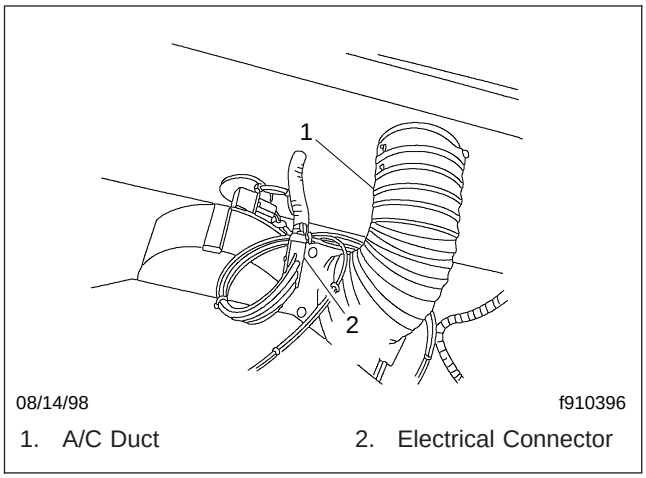


Fig. 4, Auxiliary A/C System

Able Body Sleeper Non-Retractable Safety Belt Tongue Replacement

9.1 Disconnect the A/C duct.

9.2 Disconnect the electrical connector.

10. Remove the mounting screws on the storage compartment rear trim panel.
11. Pull the storage compartment rear trim panel forward at the corners.
12. Disconnect the side A/C ducts located in the left-hand side and right-hand side corners.
13. Remove the storage compartment rear trim panel.
14. Relocate the rear panel insulation.

NOTE: The safety belt tongue nut is located on the vehicle underside.

15. Remove the safety belt tongue nut and bolt.
16. Install the safety belt tongue nut and bolt.
17. Position the rear panel insulation.
18. Install the storage compartment rear trim panel.
19. Connect the side A/C ducts located in the left-hand side and right-hand side corners.
20. Position the storage compartment rear trim panel.
21. Install the storage compartment rear trim panel mounting screws.
22. Connect the auxiliary A/C system.

    22.1 Connect the electrical connector.

    22.2 Connect the A/C duct.

23. Connect the storage compartment lights electrical connectors and install the screws.
24. Install the fore and aft beams with new rivets.

NOTE: Use care not to damage the vehicle interior during bunk platform installation.

25. Install the lower bunk platform.
26. Connect the lower bunk center prop safety latch.

    26.1 Swing the safety latch up towards the bunk platform.

    26.2 Install the nut and bolt.

27. Position the lower bunk platform and install new rivets.
28. Install the lower bunk mattress.

SilverStar Sleeper Non-Retractable Safety Belt Tongue Replacement

Replacement

IMPORTANT: When any part of a safety belt system needs replacement, the entire safety belt system must be replaced—both the retractor side and the buckle side and, if equipped, tether belts.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the lower bunk mattress.
3. Remove the safety belt tongue bunk anchor bolts, and remove the safety belt assembly. See **Fig. 1**.

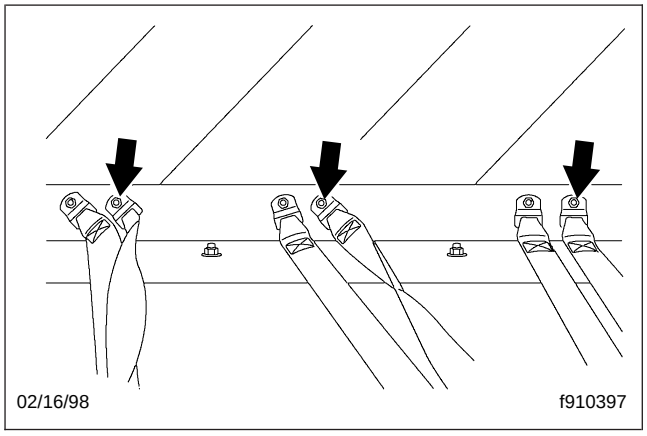


Fig. 1, Safety Belt Tongue Bunk Anchor Bolts

4. Position the safety belt tongue bunk and install the anchor bolts. Tighten 22 to 32 lbf·ft (30 to 43 N·m). See **Fig. 1**.

Safety Belt Webbing

The following procedure is recommended for the removal of spots and stains from safety belts. It is important that proper cleaning techniques and cleaning agents be used to prevent setting the stain or affecting the color or flame resistance of the safety belts. Avoid bleaching or redyeing the webbing as this can hinder the safety belt strength and performance.

NOTE: The following materials are needed to clean the safety belts:

- clean, undyed cotton fabric
- medium-hard bristle brush
- spot and stain remover or equivalent commercial product

NOTE: Prior to selecting a cleaning method, perform the following steps:

⚠ CAUTION

Do not bleach or dye the webbing. This can weaken the safety belt.

1. Remove excess staining material from the fabric by scraping or wiping with a clean cloth.
2. Identify the staining material, if possible.
3. Clean the fabric as described in the following Method A, B or C.

Spot Cleaning Method A

NOTE: Use this procedure for stains from grease, oil, tar, water spotting, crayon and lipstick.

⚠ CAUTION

Care must be used in the application of the spot lifter to prevent it from damaging the vinyl trim.

NOTE: Using other than recommended cleaners or procedures can affect the flammability or fabric appearance of the safety belt webbing.

1. Spray the stain with upholstery cleaner or equivalent commercial product from a distance of 8 to 10 inches (204 to 254 mm) as directed by the instructions on the can.
2. Allow the spot lifter to dry completely, until forming a white powder on the surface of the fabric.
3. Brush and vacuum the white powder from the fabric.
4. If the spot or stain is not removed from the fabric, repeat the procedure as necessary.
5. Wipe the cleaned area with a damp cloth to remove any residual cleaner.

General Cleaning Method B

NOTE: Use this procedure for stains such as grease, oil, tar, adhesive, crayon and lipstick.

1. If the stain is still visible after the spot cleaning procedure (Method A), blot the soiled area with a clean cotton cloth saturated with spot and stain remover or equivalent commercial product.
2. Rub in a circular motion while continuously exposing clean portions of the cloth.
3. Gradually widen the area of application onto the edges of the safety belt(s).
4. Repeat as necessary.
5. Wipe the cleaned area with a clean, damp cloth to remove any residual cleaner.

General Cleaning Method C

NOTE: Use this procedure for stains from soil, food, soda pop and coffee.

NOTE: Spot cleaning as described in Method A will be sufficient when the soiled area is not excessive. In the event of severe soiling or staining, clean the entire safety belt to avoid a cleaning ring condition.

1. Apply Rosenthal, Bissell or equivalent upholstery cleaner with a cloth or brush as directed by the instructions on the container.
2. Rub in a circular motion until the stain is removed.
3. Gradually widen the area of application to the edges of the safety belt(s).

Safety Belt Cleaning

4. Repeat the cleaning as necessary.
5. Rub the cleaned area with a clean, damp cloth to absorb any residual cleaner.
6. Allow the safety belt(s) to dry at room temperature.

Replacement

IMPORTANT: When any part of a safety belt system needs replacement, the entire safety belt system must be replaced—both the retractor side and the buckle side and, if equipped, tether belts.

Safety Belt Anchor Plate Without Thread Damage

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the damaged anchor bolt from the anchor reinforcement and discard.
3. Install a new anchor bolt with the same part number as indicated in the "Parts Replacement" table in **Specifications 400**. Tighten the bolt to specification. Refer to "Torque Specifications" in **Specifications 400**.

Safety Belt Anchor Plate and Bolt With Thread Damage

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the broken or stripped anchor bolt and discard.
3. Drill out the internal threads in the safety belt anchor plate with a 27/64-inch drill.
4. Rethread the anchor plate with a 1/2-13 tap.
5. Blow out any metal chips.
6. Install the attachment parts. Tighten the replacement bolt to specification. Refer to the "Torque Specifications" table in **Specifications 400**. Original parts are to be replaced with the repair parts indicated in the "Parts Replacement" table in **Specifications 400**. Unless specified, use original parts.

Shoulder Safety Belt Height Adjuster Replacement

Replacement

IMPORTANT: When any part of a seat-belt system needs replacement, the entire seat-belt system must be replaced—both the retractor side and the buckle side and, if equipped, both tether belts.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the height adjuster. Refer to "Height Adjuster" in **Subject 110**.
3. Drill out the damaged threads in the upper B-pillar structure, using a 1/2-inch drill. See **Fig. 1**.

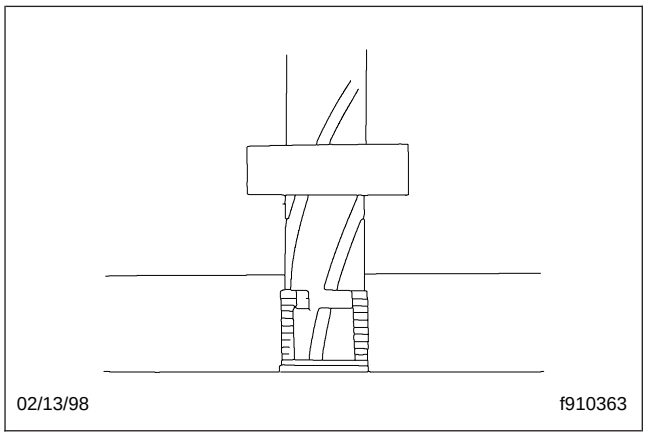


Fig. 1, Drilling Out Damaged Threads

NOTE: After each rotation, back the tap off slightly to remove new cuttings and make sure to blow out any chips.

4. Apply a suitable lubricant to the threads of an M14-1.5 tap and tap new threads.
5. Select thread insert N807170–190 and hand-screw it into the tapped hole until it is slightly below the surface of the hole. See **Fig. 2**.

NOTE: Drive "kees" on the insert will act as an automatic stop.

6. Using a 12-oz hammer, lightly tap the installation tool several times to drive down the insert "kees". See **Fig. 3**.

NOTE: If the height adjuster retaining bolts are stripped, replace the height adjuster and retaining bolts. Refer to "Height Adjuster" in **Subject 110**, and to the applicable "Parts Replacement" table in **Specifications 400**.

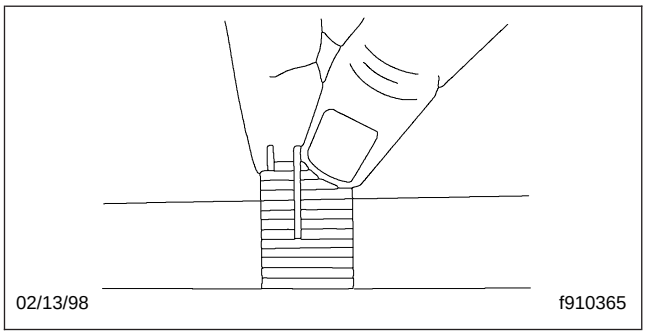


Fig. 2, Installing Thread Insert

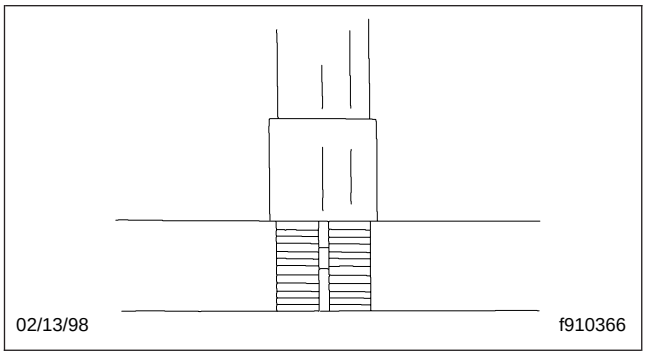


Fig. 3, Inserting the "Kees"

7. Install the height adjuster. Refer to "Height Adjuster" in **Subject 110**.

Safety Belt Procedure After a Collision

⚠ WARNING

Inspect and maintain seat belts. When any part of a seat belt system needs replacement, the entire seat belt must be replaced, both retractor and buckle side. Any time a vehicle is involved in an accident, and the seat belt system was in use, the entire vehicle seat belt system must be replaced before operating the vehicle. Do not attempt to modify the seat belt system; doing so could change the effectiveness of the system. Failure to replace worn or damaged seat belts, or making any modifications to the system, may result in personal injury or death.

1. Safety belt assemblies should be periodically inspected to make sure they have not become damaged and are in proper operating condition, particularly if subjected to severe stress.
2. Before installing a new safety belt assembly, the safety belt attaching areas must be inspected for damage and distortion. If the attaching points are damaged or distorted, the sheet metal must be worked back to its original shape and structural integrity.
3. Install the new safety belt(s). Refer to the appropriate subject in this section. Perform the "Component Function Test" in **Troubleshooting 300**.

Safety Belt Twisted at the Safety Belt Guide (See Fig. 1)

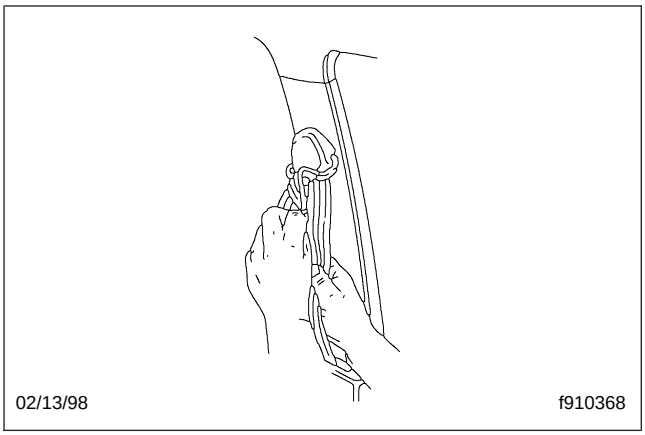


Fig. 1, Safety Belt Guide (D-Ring)

NOTE: These procedures apply to both wire-formed and stamped D-ring designs.

1. Grasp the safety belt webbing at the shoulder belt guide (D-ring).
2. Rotate and fold the belt webbing over itself to remove the twist.
3. Feed the folded portion of the safety belt webbing through the safety belt guide (D-ring).
4. When completed, the safety belt should look like the illustration.

Safety Belt Tongue Rotated on Belt

1. Grasp the safety belt tongue and pull down on the closest belt webbing to form a loop through the upper (narrower and longer) slot in the tongue. See **Fig. 1**.

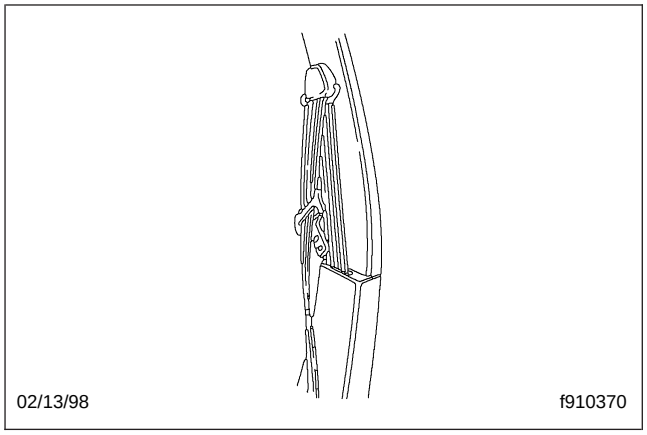


Fig. 1, Safety Belt Tongue

2. Working within the upper slot, rotate and fold the safety belt webbing over itself as required to remove the twist. See **Fig. 2**.

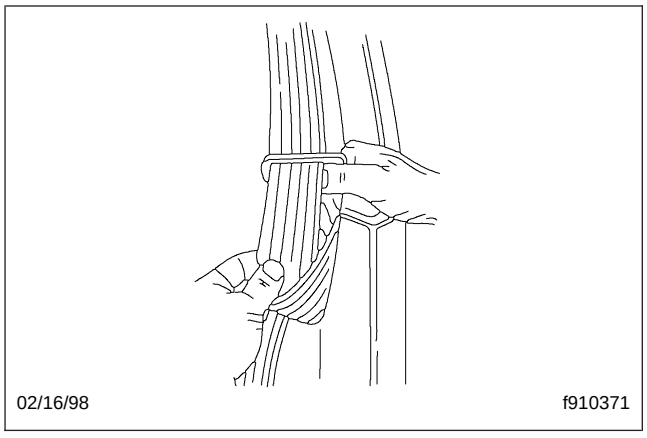


Fig. 2, Rotate to Remove Twist

3. Pull the excess safety 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. See **Fig. 3**.

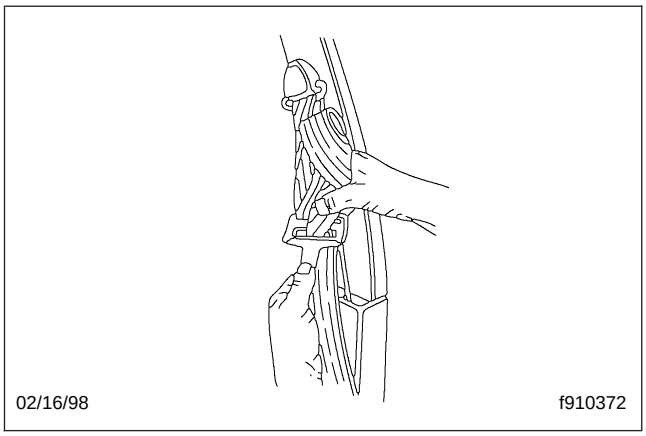
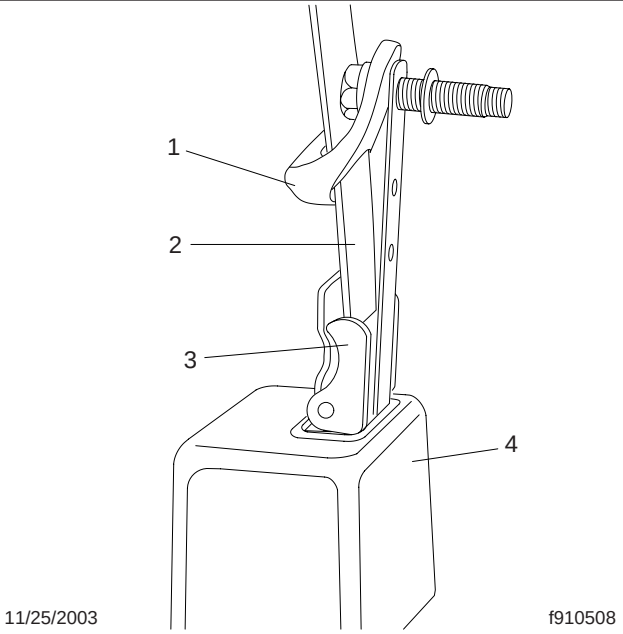


Fig. 3, Removing Twist

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.

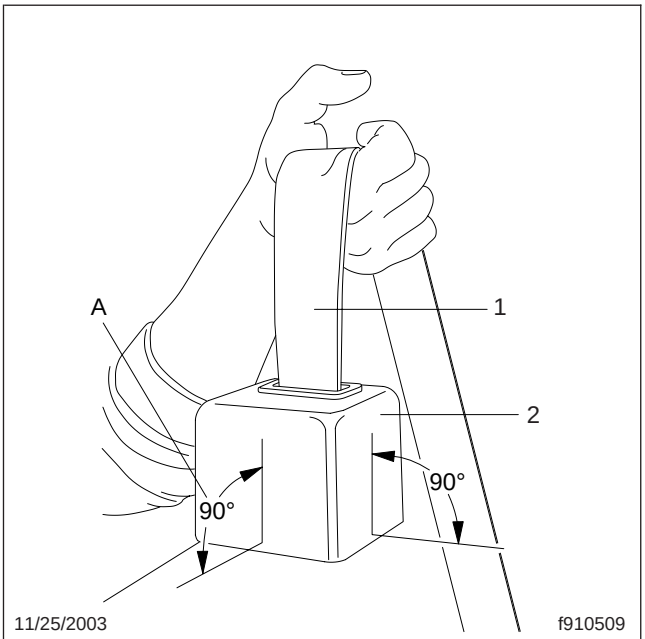
1. Park the vehicle, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Verify that the retractor is mounted in the 90-degree position. See **Fig. 1**.
3. Firmly grasp the web close to the retractor. See **Fig. 2**.



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.



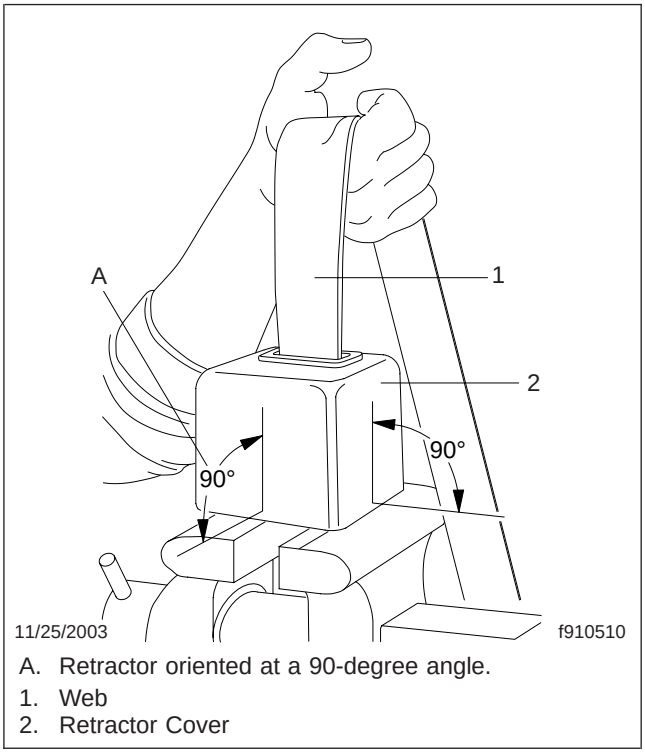
A. Orient the retractor at a 90-degree angle.
1. Web
2. Retractor Cover

Fig. 2, Firmly Grasp the Webbing

Unlocking an Uninstalled Retractor

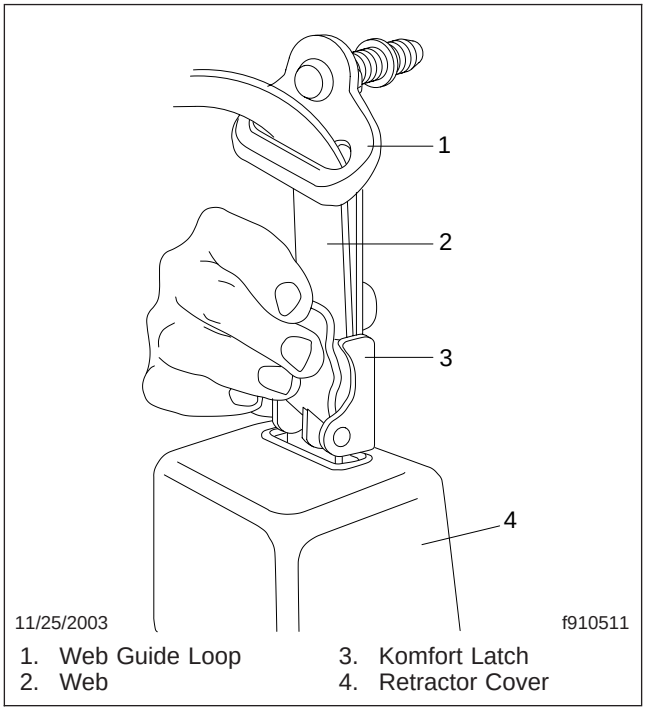
1. Clamp the retractor in a vice at a 90-degree angle. See **Fig. 3**.
2. Pull on the web with enough force to tighten the web onto the spool.
3. Release the web. This allows 1/2-inch (12.7-mm) of the webbing to feed back into the retractor storage housing and unlock the retractor.
4. Pull all the webbing 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

Inspection

⚠ WARNING

Inspect and maintain seat belts. When any part of a seat belt system needs replacement, the entire seat belt must be replaced, both retractor and buckle side. Any time a vehicle is involved in an accident, and the seat belt system was in use, the entire vehicle seat belt system must be replaced before operating the vehicle. Do not attempt to modify the seat belt system; doing so could change the effectiveness of the system. Failure to replace worn or damaged seat belts, or making any modifications to the system, may result in personal injury or death.

Seat belts and tether belts have a finite life which may be much shorter than the life of the vehicle. Regular inspections and replacement as needed are the only assurance of adequate seat belt security over the life of the vehicle.

1. Check the web for fraying, cuts, extreme dirt and dust, or for severe fading from exposure to sunlight, especially near the buckle latch plate and in the D-loop guide area.
2. Check operation of the buckle, latch, Komfort Latch or Sliding Komfort Latch (if equipped), web retractor, and upper seat belt mount on the door pillar. Check all visible components for wear or damage.
3. Check the seat belt and tether belt connection points, and tighten any that are loose.

Troubleshooting

Inspection and Verification

1. Verify the customer complaint by operating the safety belt. Refer to the "Component Function Test" in this subject.
2. Inspect the safety belts for obvious signs of wear or mechanical damage; see **Subject 240**.

Component Function Test

To prevent mistaking a full extension for a safety belt lockup, the safety belt must not be fully extended.

1. Buckle up and proceed to a safe test area. If the passenger safety belt must be tested, a passenger should be buckled into the passenger seat.

NOTE: The passenger safety belt can be tested by the driver, providing the driver has the ability to grasp the passenger shoulder belt and extend it approximately 26 inches (660 mm) with no compromise to safe driving. This method applies to the 5 mph (8 km/h) test only.

2. After reaching a safe area for performing sudden stops, the driver will attain a speed of approximately 5 mph (8 km/h). The driver should inform the passenger, if applicable, that he or she is preparing to make a severe brake application. At this time, both the driver and passenger should grasp their respective shoulder harnesses and prepare to lean slightly forward at the moment the brake application is made.

The driver and passenger must be prepared to brace themselves in the event the safety belt retractor does not lock.

The maximum brake application must be on dry concrete or an equivalent hard road surface, never on a wet or gravel road surface.

3. The driver will make a maximum brake application (approximately 32 ft/sec [9.7 m/sec]) without tire skid. The driver and passenger should lean forward slightly into the shoulder harness. At this instant, the safety belt(s) should lock up without webbing payout.
4. If there is a lockup of the shoulder strap(s), the safety belt assembly(s) is functioning properly. If either or both retractors fail to lock up at the 5 mph (8 km/h) speed, repeat the test at a constant 15 mph (24 km/h). This test must be performed with a passenger if the passenger belt is to be tested.

IMPORTANT: If the retractor of a new belt has been bolted into a damaged or distorted mounting area, the new retractor could warped and may not function. If this is the case, rework the sheet metal back to its original shape and structural integrity and install another new, complete safety belt assembly.

5. If either or both shoulder harnesses do not lock up at the 15 mph (24 km/h) test, the vehicle is to be returned for repair of the malfunctioning safety belt(s). Remove the retractor and rework the sheet metal in the area of the retractor mounting surface back to its original shape and structural integrity. Install the retractor assembly and test the safety belt assembly(s) as previously stated.

Problem—Excessive Pressure on Occupant During Normal Use; Webbing Cannot Be Extracted; Excessive Slack in Webbing Does Not Retract

Problem—Excessive Pressure on Occupant During Normal Use; Webbing Cannot Be Extracted; Excessive Slack in Webbing Does Not Retract	
Possible Cause	**Remedy**
Safety belt retractor	Check and replace, if necessary.

Troubleshooting

Problem—Safety Belt(s) Does Not Function Properly

Problem—Safety Belt(s) Does Not Function Properly	
Possible Cause	**Remedy**
Safety belt retractor	Go to the "Component Function Test" in this subject.

Specifications

Parts Replacement Table		
Original Parts		
Part No.	**Code Letter ***	**Part Name**
386273–S100	1A	Bolt, 7/16–20 x 1.38 Pan Head Tapping
386274–S100	1B	Bolt, 7/16–20 x 1.75 Pan Head Tapping (0.50 Shoulder)
382629–S100	—	Washer, 0.463/0.443 i.d. Plate (1.80 dia., 0.190 thick)
382583–S100	—	Washer,1/2 Serrated (0.18 thick)
386272–S100	IF	Bolt, 7/16–20 x 0.88 Pan Head Tapping
386276–S100	IL	Bolt, 7/16–20 x 1.75 Pan Head Tapping (0.75 shoulder)
386277–S100	1K	Bolt, 7/16–20 x 1.38 Pan Shoulder Tapping (0.50 shoulder)
382580–S100	—	Washer, 7/16
386392–S100	IG	Bolt, 7/16–20 x 2.15 Pan Head Tapping
384966–S100	V	Bolt, 7/16–20 x 1.75 Pan Head Tapping
389547–S190	IR	7/16–20 x 1.54
390775–S190	ID	7/16 x 20 x 2.00

* Identification letter on top of bolt head or face of spacer.

Table 1, Parts Replacement Table

Parts Replacement Table		
Replacement Parts		
Part No.	**Code Letter ***	**Part Name**
383531–S36	X	Bolt,1/2–13 x 1.38 Pan Locking
383753–S36	Y	Bolt,1/2–13 x 1.75 Pan Locking (0.50 Shoulder)
382552–S100	—	Washer, 1/2 Flat (1.30 Dia., 0.190 Thick)
382533–S100	—	Washer,1/2 Flat (0.25 Thick)
383437–S36	W	Bolt,1/2 x 13 Pan Locking

Parts Replacement Table		
Replacement Parts		
Part No.	**Code Letter ***	**Part Name**
383754–S36	Z	Bolt,1/2–13 x 2.25 Pan Locking (0.88 Shoulder)
38709–S	T	Bolt,1/2–13 x 1.38 Pan Head Shoulder Locking
—	—	—
383754–S36	Z	Bolt,1/2–13 x 2.25 Pan Locking (0.88 Shoulder)
—	—	—
389548–S199	S	1/2 x 13 x 1.50
390691–S190	D	1/2 x 13 x 2.0

* Identification letter on top of bolt head or face of spacer.

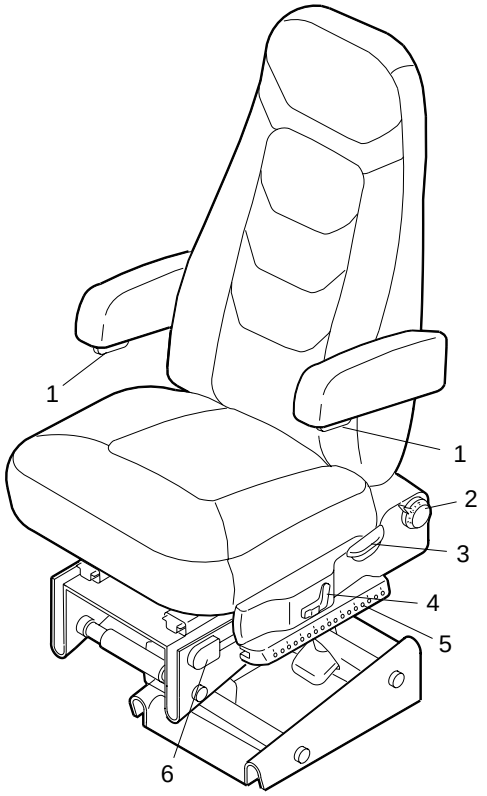
Table 2, Parts Replacement Table

Torque Specifications	
Description	**lbf·ft (N·m)**
Height Adjuster Bolts	22–30 (30–40)
Safety Belt Floor Anchor Bolts	22–32 (30–43)
Safety Belt Retractor Bolts	22–32 (30–43)
Shoulder Strap Guide Nut	22–32 (30–43)
Safety Belt Seat Anchor Bolts	22–32 (30–43)
Safety Belt Buckle Floor Anchor Bolts	22–32 (30–43)
Safety Belt Buckle Seat Anchor Bolts	22–32 (30–43)
Safety Belt Buckle Bunk Anchor Bolts	22–33 (30–44)
Safety Belt Tongue Bunk Anchor Bolts	22–33 (30–44)

Table 3, Torque Specifications

General Information

EzyRider seats (see **Fig. 1**) offer adjustment features for height, fore and aft positioning, back cushion tilt, lumbar support, and seat cushion tilt. The air suspension and height-adjustment features are provided by an air spring that receives air pressure from the vehicle air system; pressure in the air spring is controlled by a switch 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 reduces the amount of road shock by isolating the occupant from the motion of the vehicle. A lockout feature is used whenever the isolator is not desired.



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1. Armrest Adjustment Knob
2. Back Cushion Tilt Position Indicator (if so equipped)
3. Back Cushion Tilt Lever
4. Height Adjustment and Lumbar Support Lever
5. Fore/Aft Seat Position Indicator (if so equipped)
6. Isolator and Fore/Aft Seat Adjustment Lever

Fig. 1

The availability and configuration of the seat adjustment features may vary from those shown. For a complete description of, and operating instructions for, all seat adjustment features, refer to the *L-Line and A-Line Driver's Manual*.

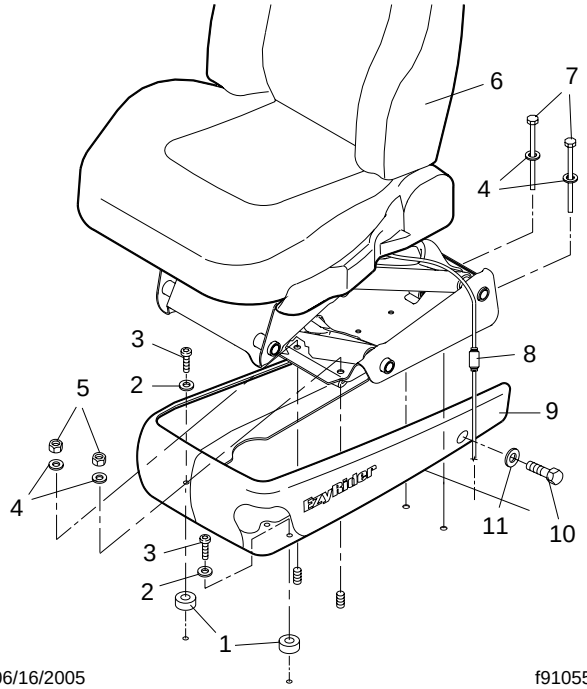
Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Press the seat ride-height rocker switch until the seat is adjusted to its maximum height.
3. If so equipped, remove the seat suspension skirt. It is attached to the seat with 11 upholstery fasteners.

⚠ WARNING

Do not remove the seat without first draining the seat air spring and using a block to keep the seat suspension extended. If not securely blocked, the seat could lower unexpectedly, pinching a hand or finger between the suspension parts, resulting in personal injury.

4. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the air suspension seat base and the rear crosstube of the lower arm.
5. Drain the vehicle air reservoirs. Then press the seat-height adjustment switch until all the air is exhausted from the air spring.
6. Remove the seat heel guard. See **Fig. 1**.
   - 6.1 Remove the two screws and washers that hold the heel guard to the sides of the seat base.
   - 6.2 Remove the two T20 Torx® capscrews and washers that attach the heel guard to the cab deck. Remove the two spacers under the heel guard.
   - 6.3 Loosen the fasteners (two nuts in the front and two capscrews in the rear) that attach the seat base to the cab deck.
   - 6.4 Slide the heel guard forward to unseat the bottom flange from under the outer edges of the seat base. Remove the heel guard.
7. Disconnect the air valve air-supply hose at the quick-connect union behind the seat.
8. Remove the Torx capscrews that attach the seat-belt straps to the intermediate-connecting-point threaded rod.



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1. Spacers
2. Washer
3. Torx Capscrew, T20
4. Washers
5. Nuts
6. Seat
7. Capscrews
8. Air Supply Quick-Connect Union
9. Heel Guard
10. Screw
11. Washer

Fig. 1, EzyRider Seat Installation

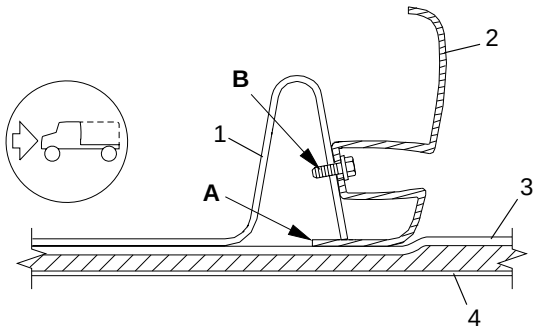
9. Remove the two capscrews and washers that attach the rear of the seat base to the cab deck, and the two nuts and washers that attach the front of the seat base to studs on the cab deck. Remove the seat from the cab.

Installation

1. Position the seat on the cab deck, with the two cab-deck studs inserted through the holes in the front of the seat base. Install the two nuts and washers on the studs. Insert the two capscrews and washers through the holes in the rear of the seat base (see **Fig. 1**). Do not tighten the nuts or the capscrews until the heel guard is installed.
2. Attach the brackets of the seat-belt straps and tether straps to the intermediate-connecting-point threaded rod. Tighten the Torx capscrews 35 to 45 lbf·ft (47 to 61 N·m).

Seat Removal and Installation

3. Connect the air valve air-supply hose by pressing the pneumatic tubing into the quick-connect union behind the seat.
4. Install the seat heel guard.
   4.1 Place the heel guard around the seat base, sliding it backward to seat the bottom flange under the outer edge of the seat base on both sides. See **Fig. 2**.



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A. Slide the bottom flange of the heel guard under the outer edge of the seat base.
B. Attach the heel guard to the seat base with the screws and washers.

1. Seat Base
2. Heel Guard
3. Floor Covering
4. Cab Deck

Fig. 2, Installing the Heel Guard

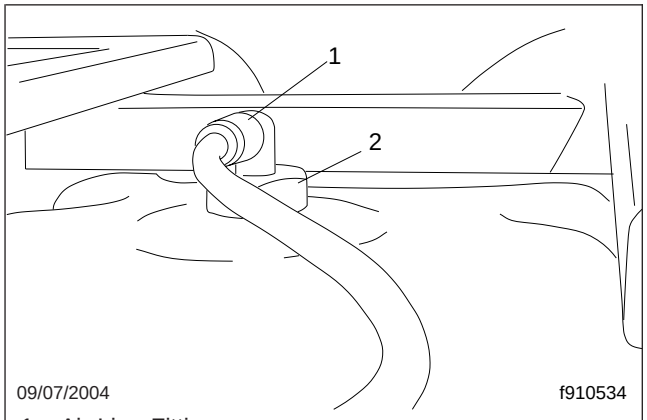
   4.2 Tighten the two capscrews and the two nuts that attach the seat to the cab deck 25 to 29 lbf·ft (34 to 39 N·m).
   4.3 Position the two spacers under the heel guard, then attach the front of the heel guard to the cab deck with the two T20 Torx capscrews and washers.
5. Start the engine and allow the air reservoirs to fill. Press the seat ride-height rocker switch until the seat is adjusted to its maximum height, then remove the wooden block that supports the seat suspension.
6. Install the seat suspension skirt.
7. Remove the chocks from the tires.

Air Spring Replacement

1. Park the vehicle, apply the parking brakes, shut down the engine, and chock the front and rear tires.
2. Inflate the seat suspension to the maximum height.
3. Pull the slide lever, and slide the seat to the forward position.
4. Lift the suspension skirt up and out of the way.
5. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the air suspension seat base and the rear crosstube of the lower arm.

NOTE: The seat must be secured with a block when replacing the air spring.

6. Drain the vehicle air reservoirs. Then push in on the bottom of the seat ride-height rocker switch until all air is exhausted from the air spring.
7. Remove the air line from the air spring. See **Fig. 1**.



1. Air Line Fitting
2. Spring Plate Mounting Nut

Fig. 1, Air Line and Fitting

8. Remove the air fitting from the top of the air spring.
9. Remove the nut that secures the air spring to the spring plate.
10. Use a 9/16-inch socket wrench to remove the lower air spring bolt.
11. Remove the air spring.
12. Install the new air spring.
13. Install the spring plate mounting nut and torque 130 lbf·in (1470 N·cm).
14. Install the air fitting and tighten securely. Make sure that the fitting is oriented forward.
15. Cut 1/4 inch (6 mm) off of the air line using a hose cutter.
16. Insert the air line into the air fitting.
17. Apply Loctite™ 454 to the bottom six threads of the mounting bolt. See **Fig. 2**.

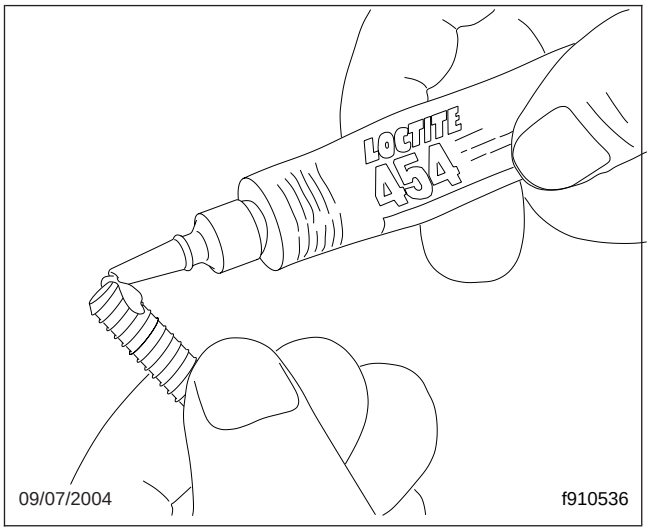


Fig. 2, Apply Loctite 454

18. Install the bolt through the bottom casting of the seat to the air spring and tighten the bolt 45 lbf·in (510 N·cm).
19. Start the engine and allow the air reservoirs to fill. Push in on the top of the seat ride-height rocker switch until the seat is adjusted to its maximum height, then remove the wooden block that supports the seat suspension.
20. Remove the chocks from the tires.

General Information

Sterling currently applies DuPont® single-stage Imron® 5000 or two-stage (base coat and clear coat) Imron 6000 high-solids polyurethane enamel on the vehicle cab at the factory.

Black Standard Urethane or Imron 5000 is used on the vehicle chassis. The chassis includes the frame, spoke spider, running gear, and any components attached to the frame. Aluminum fuel tanks are not painted.

To meet the federal air quality regulations imposed by the EPA and local jurisdictions, these products contain low levels of volatile organic compounds (VOCs) and are formulated free of lead and chrome.

The procedures in this section are for use with DuPont products. Unless otherwise noted, all products are manufactured by E. I. du Pont de Nemours and Company, Inc. Obtain approval from a Freightliner Regional Office for use of topcoats produced by other manufacturers.

Color-Matching

The recommended aftermarket paints for color-matching factory-applied paint are as follows:

- Cab—use Imron 5000 or Imron 6000
- Chassis—use only Imron 5000

To ensure proper gloss, durability, and color-matching of the enamel, use only Imron 5000 on panels that were previously painted with Imron 5000, and use only Imron 6000 on panels painted with Imron 6000.

To determine the correct paint number for color-matching any original finish on a vehicle, refer to the paint specification on the vehicle specification decal. Refer to the vehicle driver's manual for the location of this decal.

NOTE: The high-solids Standard Urethane applied to the chassis at the factory is sold to original equipment manufacturers (OEMs) only, and is not available for aftermarket sale. Use Imron 5000, N0001 Black, for repainting.

General Guidelines

This section provides instructions for preparing large panels or the entire cab for topcoating with DuPont® products. For spot repairs or touch-ups, see **Subject 120**.

Before topcoating, the surface must be thoroughly cleaned and sanded. Any bare areas must also be conditioned and primed.

1. Preparation materials specified for one type of surface should not be used for any other type of surface.
2. Limit intermediate coatings, such as primers, to the brand and type specified by the finish-coat manufacturer.

⚠ CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

Preparation for Prime Coat

Use the cleaners and conditioners specified in each step to prepare the surface for priming. See **Specifications, 400** for a summary of the products used in this procedure.

⚠ WARNING

Do not use solvent-based cleaners on large areas of plastic or fiberglass, such as the hood or air fairing. Wiping down these large areas may cause a buildup of static electricity. The resulting spark could cause a flash fire, which could result in personal injury or property damage.

CAB AND HOOD PREPARATION

1. Wash and dry the entire vehicle with a mild detergent.

⚠ WARNING

Solvents are flammable. Keep them away from heat, sparks, and open flame. Keep the container closed. Use only with adequate ventilation. Avoid breathing the vapor, or headache, nausea, and impaired reaction time and coordination may result.

2. Wipe all surfaces to be painted with a clean cloth soaked with solvent or cleaner. Remove all traces of wax, polish, grease, and silicones.
   - Metal—use DuPont Prep-Sol 3919 S.
   - Plastic—use DuPont Plastic Prep 2319 S.
   - Fiberglass—use DuPont Prep-N-Solv.

   2.1 Work on small areas at a time, wetting the surface liberally.

   2.2 Quickly wipe the surface with a clean cloth before the solvent or cleaner has a chance to dry. Change cloths frequently.
3. Feather the edge of all repaired areas, chipped surfaces, and scratches.

   3.1 Cut down the edges of broken spots with no. 220 sandpaper.

   3.2 Feather the edges by hand, using a sanding block with no. 400 sandpaper.
4. Sand the entire area to be painted. Using a sanding block and no. 400 sandpaper, remove the gloss to improve adhesion of the primer.
5. Using a clean cloth soaked with cleaner, remove any sanding dust.
   - Metal or plastic—use DuPont 3939 S lacquer and enamel cleaner.
   - Fiberglass—use a solution of one part water and one part isopropyl alcohol (IPA).
6. Treat bare metal and rusted areas.
   - Steel—use DuPont 5717 S metal conditioner.
   - Aluminum—use DuPont 225 S aluminum cleaner.

   6.1 Mix one part of the cleaner with two parts of water in a plastic bucket.

6.2 Apply the cleaner with a cloth or sponge. If corrosion is present, work the surface with a stiff plastic brush or 3M Scotch-Brite® pad. Do not use any pads containing iron.

6.3 While the metal is still wet, wipe thoroughly with a clean, dry cloth. Allow the surface to dry before applying a conversion coating.

7. Apply a conversion coating to all bare metal.
   - Steel—use DuPont 5718 S metal conversion coating.
   - Zinc casings or galvanized surfaces (iron or steel)—use DuPont 5718 S metal conversion coating.
   - Aluminum—use DuPont 226 S aluminum conversion coating.

   7.1 Pour the conversion coating into a plastic container (do not dilute). Using a 3M Scotch-Brite or similar non-iron abrasive pad, apply the conversion coating to the metal surface. Work only as much area as can be coated and rinsed before the solution dries.

   7.2 Leave the coating on the surface for 2 to 5 minutes. Then, rinse off the solution with cold water, or mop with a sponge or cloth rinsed frequently in clean water.

   If the metal surface dries before rinsing, reapply the conversion coating, then repeat the previous substep.

   7.3 Wipe the surface dry with a clean cloth, or air dry.

8. With paper and tape, mask all areas that are not to be painted.

AIR FAIRING KIT PREPARATION

Before installing a new air fairing, prepare the surface for topcoating.

1. Wash the air fairing with a mild detergent. Dry with a clean, absorbent, lint-free cloth or paper towels.
2. Using a clean cloth soaked with DuPont Prep-N-Solv®, wipe the entire surface to remove any trace of grease or oil.
3. Scuff-sand the air fairing with no. 320 grit sandpaper.
4. Wipe the air fairing with a clean cloth soaked in a solution of one part water and one part isopropyl alcohol. Allow 10 to 15 minutes for the air fairing to dry.
5. With tape and paper, mask all areas that are not to be painted.

Prime Coat

Prime all bare and feathered areas before topcoating. The specified primers can be used on any surface.

1. Clean all cracks and surfaces with dry compressed air.
2. Using a tack cloth, wipe all surfaces to be painted.

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.

3. Prime all bare metal and feathered areas with DuPont primer.
   - Steel and aluminum—use Corlar 824 S epoxy primer.
   - Fiberglass—use Corlar 825 S epoxy primer.

   3.1 Stir the primer thoroughly.

   3.2 Mix two parts Corlar epoxy primer with one part DuPont 826 S activator.

   3.3 Reduce three parts of this mixture with one part DuPont 3602 S lacquer thinner (viscosity reading is 18 to 22 seconds in a no. 2 Zahn cup). Stir thoroughly.

   3.4 Wait 1 to 2 hours from time of mixing before using. This provides time for complete chemical induction.

   3.5 Set the air pressure at the spray gun at 45 psi (310 kPa). For pressure feed sys-

tems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

3.6 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

3.7 Spray one full wet coat to give a dry film thickness of 0.7 to 1.0 mil (18 to 25 µm).

3.8 Clean the equipment immediately after use with DuPont 3602 S lacquer thinner.

3.9 Air dry 2 hours or force dry 20 minutes.

4. Wet sand the primer with no. 400 grit or finer sandpaper. Feather the edge into the surrounding area.

5. Dry the surface. Using a clean cloth soaked with cleaner, remove any sanding dust.
   - Metal or plastic—use DuPont 3939 S lacquer and enamel cleaner.
   - Fiberglass—use solution of 1 part water and 1 part isopropyl alcohol (IPA).

NOTE: See **Subject 110** for topcoating instructions.

General Guidelines

This section provides instructions for applying a topcoat of DuPont® enamel to full panels or the entire cab. For spot repairs or touch-ups, see **Subject 120**.

⚠ CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

Do not mix additives with the finish coats unless they are specified by the finish-coat manufacturer. See **Specifications, 400** for a summary of the products used in this procedure.

Before applying any topcoat:

1. Prepare the surface for topcoating. See **Subject 100** for instructions.
2. Clean all cracks and surfaces with dry compressed air.
3. Using a tack cloth, wipe all surfaces to be painted.

After topcoating, remove the masking as follows:

- After normal air drying—remove all masking when the surface is reasonably dry.
- After forced drying—remove the masking immediately after the finish has been baked.
- After two-toning—remove the masking used for the first coat as soon as it has set up, usually in about 35 to 40 minutes. Follow the same procedure for the second color.

Imron 5000 Topcoating

Imron 5000 is a single-stage, low VOC, high-solids polyurethane enamel. It provides a durable, high-gloss surface with good chemical resistance. It requires the addition of an activator.

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while spraying Imron 5000, and until the work area has been exhausted of all vapor and spray mist. Breathing paint vapor or spray mist can cause personal injury.

MIXING

1. Stir the Imron 5000 enamel thoroughly.
2. Mix three parts Imron 5000 enamel with one part of DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life of the mixture is about 2 to 4 hours at 70°F (21°C), unless an accelerator is added.

3. If faster curing time is desired, add DuPont 389 S fast-dry accelerator. Add up to 2 ounces (60 mL) to 1 gallon (3.8 L) of mixed material.
4. Mix thoroughly and strain.

NOTE: The viscosity of the mixture is about 9 to 20 seconds in a no. 3 Zahn cup, depending on the color. Adding reducer could affect the color match on some metallics.

APPLICATION

1. Set the air pressure at the spray gun to 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.
2. Apply the topcoating.
   - 2.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.
   - 2.2 Using a cross-coat technique, spray one medium-wet coat in a north-to-south direction
   - 2.3 Allow 5 to 10 minutes drying time between each application. Do not sand.
   - 2.4 Apply a second medium-wet coat in an east-to-west direction.
   - 2.5 A third medium-wet coat may be needed for good coverage of some colors.
3. To air dry, allow 2 to 4 hours with accelerator 389 S, and 6 to 8 hours without the accelerator.

   To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

4. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.
5. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

RECOATING OR DECORATING

Two-toning, striping, or lettering may be applied in 4 to 6 hours if DuPont 389 S accelerator is used. Wait 10 to 12 hours if no accelerator is used.

Decals may be applied in 12 to 16 hours if 389 S accelerator is used. Wait 24 hours if no accelerator is used.

For topcoats cured over 72 hours, scuff-sand with no. 400 grit sandpaper and wipe with a clean tack cloth before recoating, striping, lettering, or applying decals.

Imron 6000 Topcoating

Imron 6000 is a two-stage, high-solids polyurethane enamel. It provides good cover with one cross-coat of the base color followed by one coat of Imron 6000 clear coat. Both the base color and clear coat require the addition of an activator.

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while spraying Imron 6000, and until the work area has been exhausted of all vapor and spray mist. Breathing paint vapor or spray mist can cause personal injury.

MIXING

1. Stir the Imron 6000 base color thoroughly.
2. Mix three parts Imron 6000 base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life of the mixture is about 2 to 4 hours at 70°F (21°C), unless an accelerator is added.

3. If faster curing time is desired, add DuPont 389 S fast-dry accelerator. Add up to 2 ounces (60 mL) to 1 gallon (3.8 L) of mixed material.
4. Mix thoroughly and strain.

NOTE: For solids, the viscosity of the mixture is about 20 seconds in a DuPont M-222 (M-50) cup; for metallics, it is about 18 seconds.

APPLICATION

1. Set the air pressure at the spray gun to 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.
2. Apply the topcoating.
   - 2.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.
   - 2.2 Apply one cross-coat of the Imron 6000 base color.
   - 2.3 Flash 10 minutes minimum. Do not sand.
   - 2.4 Mix three parts DuPont 3440 S or 3480 S clear with one part DuPont 193 S or 194 S activator.
   - 2.5 Apply one coat of the activated DuPont 3440 S or 3480 S clear.
3. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

   To force dry, wait 15 minutes following the application of the clear coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).
4. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.
5. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

RECOATING OR DECORATING

Two-toning, striping, and lettering may be applied in 4 to 6 hours if DuPont 389 S accelerator is used. Wait 10 to 12 hours if no accelerator is used.

Decals may be applied in 12 to 16 hours if 389 S accelerator is used. Wait 24 hours if no accelerator is used.

For topcoats cured over 72 hours, scuff-sand with no. 400 grit sandpaper and wipe with a clean tack cloth before recoating, striping, lettering, or applying decals.

General Guidelines

This section provides instructions for making spot repairs or touch-ups with DuPont® enamels. Buffing may correct minor imperfections; more serious repairs require surface preparation before a topcoating can be applied. For striping, lettering, or decal application after the repair is complete, see **Subject 110**.

1. Preparation materials specified for one type of surface should not be used for any other type of surface. See **Specifications, 400** for a summary of the materials used in this section.
2. Limit intermediate coatings, such as primers, to the brand and type specified by the finish-coat manufacturer.
3. Do not mix additives with the finish coats unless they are specified by the finish-coat manufacturer.

⚠ CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

Buffing Minor Imperfections

1. Clean the area carefully with a mild detergent and rinse.
2. Remove imperfections using ultra-fine or micro-fine sandpaper (1500 or 2000 grit) and water. Rinse the area with clean water, then dry.
3. Buff the area.
   - 3.1 Use a clean foam pad at low speed (about 1600 rpm) with one of the following products:
     - DuPont 1500 S
     - Meguiar's No. 2
     - 3M Finesset Two 5928
   - 3.2 Using medium pressure, buff slowly in an overlapping pattern until the imperfection has been eliminated. Repeat as necessary.
   - 3.3 Rinse the area with clean water, then dry.
4. Polish the area.
   - 4.1 Apply one of the following products with a clean pad (3M Waffle Pad):
     - DuPont 3000 S
     - Meguiar's No. 9
     - 3M 5996
   - 4.2 Using medium pressure, work small areas using an even, overlapping pattern until the gloss is restored. As the polish dries and the gloss appears, ease the pressure on the polishing pad. Repeat as necessary.

Preparing for Topcoating

1. Wash the entire panel with mild detergent. Dry with a clean, lint-free cloth.

⚠ WARNING

Solvents are flammable. Keep them away from heat, sparks, and open flame. Keep the container closed. Use only with adequate ventilation. Avoid breathing the vapor, or headache, nausea, and impaired reaction time and coordination may result.

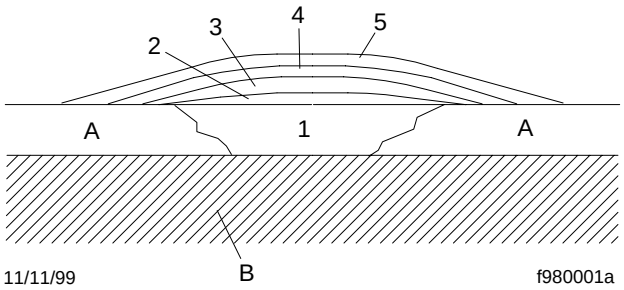
2. Clean the area to be repaired with DuPont 3939 S solvent and quickly wipe the surface with a clean, lint-free cloth before the solvent dries. Remove all traces of wax, polish, grease, and silicones.
3. Sand or grind all dents and scratches.
4. Wet sand and the area being repaired with no. 320 grit or finer sandpaper, or a 3M Scotch-Brite® or similar non-iron abrasive pad. Feather the edge.
5. Remove the sanding dust. Use the same solvent and wipe-on, wipe-off method used earlier to clean the area.
6. Mask all areas that will not be painted.
7. Clean all cracks and surfaces with dry compressed air.
8. Using a tack cloth, wipe all surfaces to be painted.

Spot Repair

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.

9. Prime all bare metal and feathered areas with DuPont primer. See **Fig. 1**.
   - Steel and aluminum — use Corlar 824 S epoxy primer.
   - Fiberglass — use Corlar 825 S epoxy primer.



NOTE: Scale exaggerated for clarity. The number of layers depends on the specific application.

A. Existing Paint
B. Panel Material (substrate)
1. Primer
2. First Color Topcoat
3. Second Color Topcoat
4. Third Color Topcoat
5. Clear Coat

Fig. 1, Spot Repair Cross-Section

9.1 Stir primer thoroughly.

9.2 Mix two parts Corlar epoxy primer with one part DuPont 826 S activator.

9.3 Reduce three parts of this mixture with one part DuPont 3602 S lacquer thinner (viscosity reading is 18 to 22 seconds in a no. 2 Zahn cup). Stir thoroughly.

9.4 Wait 1 to 2 hours from time of mixing before using. This provides time for complete chemical induction.

9.5 Set the air pressure at the spray gun to 45 psi (310 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

9.6 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

9.7 Spray one wet coat to give a dry film thickness of 0.7 to 1.0 mil (18 to 25 µm).

9.8 Clean the equipment immediately after use with DuPont 3602 S lacquer thinner.

9.9 Air dry 2 to 4 hours or force dry 20 minutes.

10. Wet sand the primer with no. 400 grit or finer sandpaper. Feather the edge into the surrounding area.
11. If the original paint was Imron 6000, hand-rub the area around the spot repair with a medium grade compound to ensure a seamless finish.
12. Remove the sanding dust. Use the same solvent and wipe-on, wipe-off method used earlier to clean the area.
13. Wipe the repair area with a tack cloth.
14. If the finish is old, apply one coat of DuPont 222 S adhesion promoter over the entire repair area.

14.1 Set the air pressure to 35 psi (240 kPa) at the spray gun.

14.2 Flash for 5 to 10 minutes at 70°F (21°C) before topcoating.

Topcoating a Spot Repair

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while spraying topcoating, and until the work area has been exhausted of all vapor and spray mist. Breathing topcoating vapor or spray mist can cause personal injury.

Imron 5000 Topcoating

1. Mix the Imron 5000 polyurethane enamel.

1.1 Stir the Imron 5000 enamel thoroughly.

1.2 Mix three parts Imron 5000 base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.

1.3 Mix thoroughly and strain.

2. Set the air pressure at the spray gun at 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

3. For metallic topcoats only, apply one coat of DuPont 500 S urethane clear.

3.1 Mix eight parts of 500 S urethane with one part 193 activator.

3.2 Reduce the activated 500 S urethane mixture 50 percent with 8685 S reducer.

3.3 Apply a medium-wet coat of the reduced 500 S urethane over the entire repair area, and well beyond where the color will be applied.

3.4 Flash 3 minutes before applying the Imron 5000 topcoat.

4. Apply the solid color or metallic topcoating.

4.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

4.2 Spray one medium-wet coat over the primed area.

4.3 Flash 5 to 10 minutes.

4.4 Apply a second medium-wet coat. Extend the spray area slightly to taper the edge and avoid a visible ring.

4.5 A third medium-wet coat may be needed for good coverage of some colors. Allow each coat to flash before applying the next coat.

NOTE: A mist coat of five parts of color to three parts of 8022 S is recommended when applying metallics. Hold the gun about 18 inches (45 cm) from the surface.

5. Blend the repair area into the OEM finish.

5.1 Lower the air pressure to 15 to 20 psi (100 to 140 kPa) at the spray gun.

5.2 Empty the spray cup and refill it with DuPont 8022 S reducer or a blend of 8022 S and 8093 S.

5.3 Carefully blend the edge of the repair with even coats to melt in the overspray.

5.4 Spray one or two medium coats of the reducer over the entire area.

5.5 If a haze appears around the edge after the reducer has dried, lightly rub the edge with DuPont 1500 S one-step polish.

6. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

7. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.

8. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

Imron 6000 Topcoating

1. Mix the Imron 6000 polyurethane enamel.

1.1 Stir the Imron 6000 base color thoroughly.

1.2 Mix three parts Imron 6000 base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.

1.3 Mix thoroughly and strain.

2. Set the air pressure at the spray gun at 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

3. Apply the topcoating.

3.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

3.2 Apply one cross-coat of the Imron 6000 base color over the primed area. No flash time is required before applying a clear coat.

3.3 Flash 10 minutes minimum. Do not sand.

Spot Repair

3.4 Mix three parts DuPont 3440 S or 3480 S clear with one part DuPont 193 S or 194 S activator.

NOTE: For best results, apply the clear coat over the entire panel. If a blend of the repair area is attempted, apply the clear coat only over the repair area, overspraying the edge slightly.

3.5 Apply one coat of the activated DuPont 3440 S or 3480 S clear.

4. Blend the 3440 S or 3480 S clear into the surrounding topcoat.

   4.1 Set the air pressure to 25 psi (170 kPa) at the spray gun.

   4.2 Apply one coat of 3401 S blending clear over the repair area only to the overspray edge.

   4.3 Flash 2 minutes. Repeat if necessary.

5. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

   To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

6. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.

7. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

General Information

If corrosion appears around the rivets on an aluminum cab, the rivets must be replaced as part of the surface corrosion repair.

Use only the DuPont products specified in each step. See **Specifications, 400** for a summary of the products used in this procedure.

⚠ CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying primer or topcoat, and until the work area has been exhausted of all vapor and spray mist. Breathing paint vapor or spray mist can cause personal injury.

Surface Preparation

1. Wash and dry the cab with a mild detergent.
2. Wipe all areas to be repaired with a clean cloth soaked with DuPont Prep-Sol 3919 S.
   - 2.1 Work on small areas at a time, wetting the surface liberally.
   - 2.2 Quickly wipe the surface with a clean cloth before the solvent has a chance to dry. Change cloths frequently.
   - 2.3 Remove all traces of wax, polish, oil, grease, and silicones.
3. Using a no. 11 tool bit (0.191-inch/4.85-mm diameter), drill out the rivet heads in the corroded area. Remove the rivets.
4. Sand the corroded areas.
   - 4.1 Using no. 220 to 320 grit sandpaper, sand the corroded or otherwise exposed areas on the aluminum skin (substrate).
   - 4.2 Feather the edges by hand or with an oscillating sander (DA).
5. Sand the entire area to be painted. Using a sanding block and no. 400 sandpaper, remove the gloss to improve adhesion of the primer and topcoat.
6. Using a clean cloth soaked with DuPont 3939 S lacquer and enamel cleaner, remove any sanding dust.
7. Install new 3/16-inch-diameter rivets in the clean, drilled holes.

IMPORTANT: Make sure both the bare metal and new rivets are treated with metal conditioner.

8. Treat all bare metal and new rivets with metal conditioner.
   - 8.1 Mix one part of DuPont 225 S aluminum cleaner with two parts of water in a plastic container. Do not use a metal container.
   - 8.2 Apply the cleaner with a cloth or sponge. Work the surface with a stiff plastic brush or 3M Scotch-Brite® pad. Do not use any pads containing iron.
   - 8.3 While the metal is still wet, wipe thoroughly with a clean, dry cloth. Allow the surface to dry before applying the conversion coating.
9. Apply a conversion coating to all bare metal.
   - 9.1 Pour DuPont 226 S aluminum conversion coating into a plastic container. *Do not dilute.* Using a 3M Scotch-Brite or similar non-iron abrasive pad, apply the conversion coating to all bare metal surfaces.

     Work only as much area as can be coated and rinsed before the solution dries.
   - 9.2 Leave the coating on the surface for 2 to 5 minutes. Then, rinse off the solution with cold water, or mop with a sponge or cloth rinsed frequently in clean water.

     If the metal surface dries before rinsing, reapply the conversion coating, leave it on for 2 to 5 minutes, then rinse thoroughly.

9.3 Wipe the surface dry with a clean cloth, or air dry.

10. With paper and tape, mask all areas that are not to be painted. Prime immediately.

Prime Coat

1. Clean all cracks and surfaces with dry compressed air.
2. Using a tack cloth, wipe all surfaces to be painted.
3. Prime all bare metal and feathered areas with DuPont Corlar® 824 S epoxy primer.

   3.1 Stir Corlar 824 S primer thoroughly.

   3.2 Mix two parts Corlar 824 S primer with one part DuPont 826 S activator.

   3.3 Reduce three parts of this mixture with one part DuPont 3602 S lacquer thinner (viscosity reading is 18 to 22 seconds in a no. 2 Zahn cup). Stir thoroughly.

   3.4 Wait 1 to 2 hours from time of mixing before using, to provide time for complete chemical induction.

   3.5 Spray one full wet coat to give a dry film thickness of 0.7 to 1.0 mil (18 to 25 µm).

   3.6 Clean equipment immediately after use with DuPont 3602 S lacquer thinner.

   3.7 Air dry 2 to 4 hours or force dry 20 minutes.

Topcoat

Imron 5000® is a single-stage, low VOC, high-solids polyurethane enamel. It provides a durable, high-gloss surface with good chemical resistance. It requires the addition of an activator.

MIXING

1. Stir the enamel thoroughly.
2. Mix three parts Imron 5000 enamel with one part of DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life is about 2 to 4 hours at 70°F (21°C), unless an accelerator is added.

3. If faster curing time is desired, add DuPont 389 S fast-dry accelerator. Add up to 2 ounces (60 mL) to 1 gallon (3.8 L) of activated material.
4. Mix thoroughly and strain.

NOTE: The viscosity of the mixture is about 9 to 15 seconds in a no. 3 Zahn cup, depending on the color. Adding reducer could affect the color match on some metallics.

APPLICATION

1. Set the air pressure at the spray gun at 50 to 60 psi (345 to 414 kPa) for solid colors, and 65 psi (448 kPa) for metallics. For pressure feed systems, set the fluid delivery at 12 to 16 ounces (355 to 473 mL) per minute. See **Specifications, 400**.
2. Apply the topcoating.

   2.1 Hold the spray gun about 8 inches (20 cm) from the surface.

   2.2 Spray one medium-wet coat over the primed area.

   2.3 Allow 5 to 10 minutes drying time between each application.

   2.4 Apply a second medium-wet coat. Extend the second coat beyond the edge of the first coat to provide the correct taper and avoid a visible ring.

   2.5 A third medium-wet coat may be needed for good coverage of some colors.

3. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

   To force dry, wait 15 minutes following the application of the final topcoat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

4. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.
5. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

RECOATING OR DECORATING

Two-toning, striping, or lettering may be applied in 4 to 6 hours if DuPont 389 S accelerator is used. Wait 10 to 12 hours if no accelerator is used.

Decals may be applied in 12 to 16 hours if DuPont 389 S accelerator is used. Wait 24 hours if no accelerator is used.

For topcoats cured over 72 hours, scuff-sand with no. 400 grit sandpaper and wipe with a clean tack cloth before recoating, striping, lettering, or applying decals.

Equipment Application Parameters

Equipment Application Parameters		
Parameter	**English Units**	**Metric Units**
Atomizing Air		
Primer	45 psi	310 kPa
Enamel	60–65 psi	410–450 kPa
Fluid Delivery	12–16 oz/min	350–470 mL/min
Booth Temperature	75°F	23°C
Spray Gun Distance	10–12 in	25–30 cm

DuPont Surface Preparation Materials

Step	**Surface Preparation Materials**			
	Steel	**Aluminum**	**Plastic**	**Fiberglass**
Wash and dry	Mild detergent (such as diswashing detergent)			
Wipe with cleaner	Prep-Sol 3919 S	Prep-Sol 3919 S	Plastic Prep 2319 S	Prep-N-Solv
Sand and feather	220 grit, then 400 grit			320 grit
Remove sanding dust	3939 S lacquer and enamel cleaner			Mix: - 1 part water - 1 part isopropyl alcohol
Treat bare metal	5717 S metal conditioner	225 S aluminum cleaner	—	—
Apply conversion coating to bare metal	5718 S metal conversion coating	226 S aluminum conversion coating	—	—
Apply sealer primer	Mix: - 2 parts Corlar 824 S primer with 1 part DuPont 826 S activator - reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner		Mix: - 2 parts Corlar 825 S primer with 1 part DuPont 826 S activator - reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner	

DuPont Topcoating Materials

Step	**Topcoating Materials**	
	Imron 6000	**Imron 5000**
Mix enamel	Mix: - 3 parts Imron 6000 - 1 part 193 S or 194 S activator	Mix: - 3 parts Imron 5000 - 1 part 193 S or 194 S activator
Add accelerator (optional)	389 S accelerator (up to 2 oz/gal of activated enamel)	
Mix clear coat	Mix: - 3 parts 3440 S or 3480 S clear - 1 part 193 S or 194 S activator	—

Specifications

Step	Topcoating Materials	
	Imron 6000	**Imron 5000**
Pressure at gun	60–65 psi (414–448 kPa)	60 psi (414 kPa)
Equipment cleanup	3939 S lacquer and enamel cleaner or 8685 S reducer	

DuPont Spot Repair Materials

Step	Spot Repair Materials	
	Imron 6000	**Imron 5000**
Cleaning	3939 S lacquer and enamel cleaner	
Sanding	320 grit or finer	
Sealer primer	Mix: - 2 parts Corlar 824 S primer with 1 part DuPont 826 S activator - reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner	
Compound	Medium grade compound	—
Adhesion promoter	222 S adhesion promoter	
Topcoat	1 coat Imron 6000: - 3 parts base color - 1 part 193 S or 194 S activator	2 coats Imron 5000: - 3 parts enamel - 1 part 193 S or 194 S activator
Topcoat viscosity	Solids: 20 sec; Metallics: 18 sec (#2 Zahn cup)	9–20 sec (#3 Zahn cup)
Clear coat	Mix: - 3 parts 3440 S or 3480 S clear - 1 part 193 S or 194 S activator	—
Accelerator (optional)	389 S accelerator	
Blending clear	1 coat 3401 S blending clear	
Equipment cleanup	3939 S lacquer and enamel cleaner or 8685 S reducer	