PREVOST

COACH MANUFACTURER

MAINTENANCE MANUAL

LE MIRAGE XLII

BUS SHELLS & COACHES

PA1216

SECTION 00 : GENERAL INFORMATION

CONTENTS

ILLUSTRATIONS

1. FOREWORD

This manual includes procedures for diagnosis, service, maintenance and repair for components of the XL2 series coach or bus shell model listed on the front cover page. This manual should be kept in a handy place for ready reference by the technician. If properly used, it will meet the needs of the technician and owner.

Information provided in Section 1 through 24 pertains to standard equipment items, systems and components as well as the most commonly used optional equipment and special equipment offered on the coach models covered by this manual.

At the beginning of each section: a Table of Contents and a list of illustrations give the page number on which each subject begins and where each figure is located. Coach operating information is provided in a separate Operator's Manual. Audio/Video system operator instructions are also included in a separate manual.

More specific information on engine and transmission operating, maintenance, and overhaul information is contained in the applicable engine or transmission service manual published by the engine or transmission manufacturer. Engine and transmission parts information is contained in the applicable engine or transmission parts catalog published by the engine or transmission manufacturer.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication approval. The right is reserved to make product changes at any time without notice.

Note: *Typical illustrations may be used; therefore minor illustration difference may exist when compared to actual parts or other publications.*

Prévost Car occasionally sends Maintenance Information, Warranty Bulletins, Safety Recalls or other literature to update users with the latest service procedures. They are issued, when required, to supplement or supersede information in this manual. Update sheet should be filled out and bulletins should be filed at the end of their respective section for future reference.

2. SCHEMATICS

Vehicle AIR SCHEMATICS are provided at the end of Section 12, "Brake". SUSPENSION AIR SCHEMATICS are provided at the end of Section 16, "Suspension". Moreover, ELECTRICAL SCHEMATICS are provided in the technical publications box. Refer to those schematics for detailed circuit information or during diagnosis.

STEEL – STEEL WELDING

3. PRECAUTIONS TO BE OBSERVED BEFORE WELDING

Caution: *Cut off battery power in main power compartment using battery safety switch.*

1. Disconnect *“Ground”* cables from battery terminals.

Note: *Disconnect “Ground” cables only.*

2. If welding must be done near the dashboard i.e. steering column, you must disconnect all electronic control modules (radio & control head, HVAC, TTLT cluster Volvo). You must also disconnect alternator module located in front service compartment.
3. Disconnect three wiring harness connectors from ECM (Electronic Control Module). The ECM is mounted on the starter side of the engine.
4. For vehicles equipped with an Allison automatic transmission, disconnect three wiring harness connectors from ECU (Electronic Control Unit). The ECU is located in front service compartment.
5. For vehicles equipped with WCL system, disconnect electronic controller connector.
6. For vehicles equipped with ABS (Anti-Lock Brake System), disconnect wiring harness connectors from ABS Electronic Control Unit. The ABS Electronic Control Unit is located in front service compartment.
7. Cover electronic control components and wiring to protect from hot sparks, etc.
8. Do not connect welding cables to electronic control components.
9. Do the appropriate welding on vehicle.

Caution: *Position welding machine ground clamp as close as possible to the work.*

10. When welding is complete, reconnect ECM, ECU, ABS electronic control units, etc.
11. Terminate by reconnecting *“Ground”* cables to battery terminals.

Caution : *Before welding, disconnect electronic modules and battery terminals.*

Warning : *Welding surfaces must be free of scale, slag, rust, paint, grease, humidity or other foreign material that would render welding impossible.*

Warning : *Only a qualified and experienced person must do welding.*

- FCAW (Flux Cored Arc Welding) process ;
- Electrode wire conforms to A5.20 AWS (American Welding Society) specifications ;
- E4801T-9-CH, type electrode wire with 0,045" diameter (1,14 mm) ;

Material Thickness	Voltage	Current	Wire Feed Rate	Shielding Gas
1/8" to ½"	26 ± 2 volts	260 Amps	450 ipm. approx.	75% argon – 25% CO_2 or 100% CO_2

If necessary and with great care to prevent perforating the material, it is possible to use a conventional electric arc welding machine according to the following specifications :

- SMAW (Shielded Metal-Arc Welding) process ;
- Welding rod conforms to A5.1 of AWS (American Welding Society) specifications ; E 7018 type welding rod with 1/8" diameter (3,2 mm).
- Current: 100 amperes to 150 amperes; optimum at 120 amps.

It is important to grind weld bead starts and stops and also to grind arc strikes from surfaces.

STEEL - STAINLESS STEEL OR STAINLESS STEEL - STAINLESS STEEL WELDING

Caution : *Before welding, disconnect electronic modules and battery terminals.*

Warning : *Welding surfaces must be free of scale, slag, rust, paint, grease, humidity or other foreign material that would render welding impossible.*

Warning : *Only a qualified and experienced person must do welding.*

- GMAW (Gas Metal-Arc Welding) process;
- Welding wire conforms to AWS (American Welding Standards) A5.9 specifications;
- 308LSi type welding wire with 0.035" diameter (0,9 mm);

STEEL - STAINLESS STEEL WELDING

Steel Thickness	SS Thickness	Voltage	Current	Wire Feed Rate	Shielding Gas
Less than 1/8"	Any type	20±1.5 volts	130±15 Amps	290 ipm approx.	90% He, 7.5% Ar, 2.5% CO_2
1/8" and more	Any type	22±1.5 volts	160±15 Amps	330 ipm approx.	90% He, 7.5% Ar, 2.5% CO_2

STAINLESS STEEL - STAINLESS STEEL WELDING

SS Thickness	Voltage	Current	Wire Feed Rate	Shielding Gas
Any type	20 ± 1.5 volts	130 ± 15 Amps	290 ipm approx.	90% He – 7.5% Ar, 2.5% CO_2

If necessary and with great care to prevent perforating the material, it is possible to use a conventional electric arc welding machine according to the following specifications :

- SMAW (Shield Metal-Arc Welding) process;
- Welding rod conforms to AWS (American Welding Standards) A5.4 specifications; 308L-17 type welding rod with 3/32" diameter (2,4 mm);
- Current: - 50 amperes to 90 amperes, optimum at 60 amperes.

It is important to grind weld bead starts and stops and also to grind arc strikes from surfaces.

4. SAFETY NOTICE

This maintenance manual has been prepared in order to assist skilled mechanics in the efficient repair and maintenance of PRÉVOST vehicles.

This manual covers only the procedures as of manufacturing date.

Safety features may be impaired if other than genuine PRÉVOST parts are installed.

Torque wrench tightening specifications must be strictly observed. Locking devices must be installed or replaced by new ones, where specified. If the efficiency of a locking device is impaired, It must be replaced.

This manual emphasizes particular information outlined by the wording and symbols:

***Warning**: Identifies an instruction which, if not followed, could cause personal injuries.*

***Caution**: Outlined an instruction which, if not followed, could severely damage vehicle components.*

***Note:** Indicates supplementary information needed to fully complete an instruction. Although, the mere reading of such information does not eliminate the hazard, understanding of the information will promote its correct use.*

4.1 DATA PLATES AND CERTIFICATIONS

Delay and confusion can be avoided by placing the complete vehicle identification number of the coach and the serial numbers of the engine on parts orders and correspondence. Also, the transmission, axles, power steering pump chassis and other major components are identified by serial numbers.

4.1.1 Engine

The engine serial and model numbers are stamped on the cylinder block (as viewed from the flywheel end) on the left side just below the fire deck and above the cast-in Detroit Diesel logo (Fig. 1).

In addition, option plates made of laminated paper are located on the rocker cover (starter side). The engine serial and model number and a list of the optional engine equipment is written on the option plate. Refer to this information when ordering replacement parts (Fig. 1).

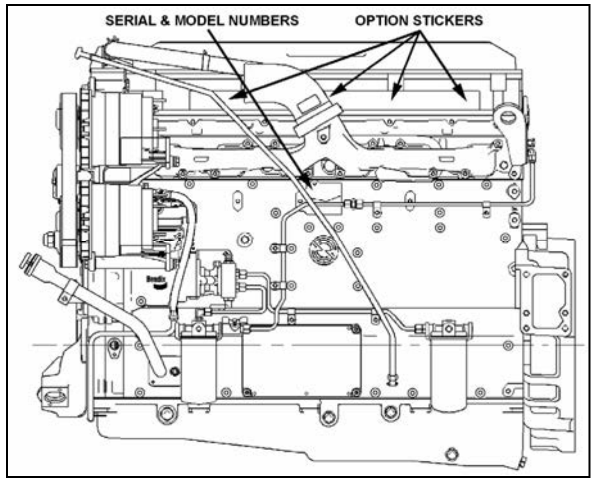


FIGURE 1 : DETROIT DIESEL SERIES 60 00034

4.1.2 Transmission

The transmission identification plate is located on the fluid level dipstick side of the transmission (WT) or on transmission, on the vehicle R.H. side (ZF) (Fig. 2 & 3). The identification plate shows the transmission serial number, part number (assembly number), and model number. Use all three numbers when ordering parts.

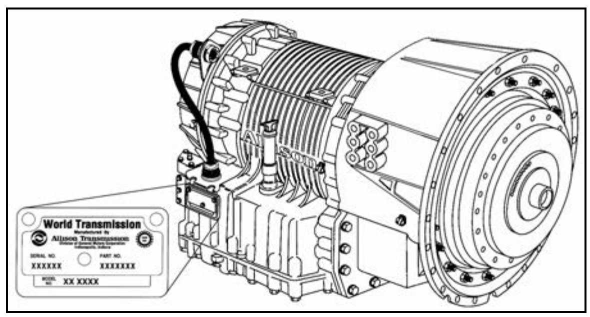


FIGURE 2: WORLD TRANSMISSION 07076

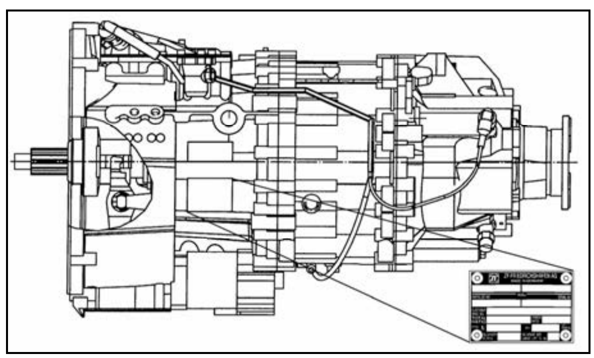


FIGURE 3: ZF-ASTRONIC TRANSMISSION 00040

4.1.3 Drive Axle

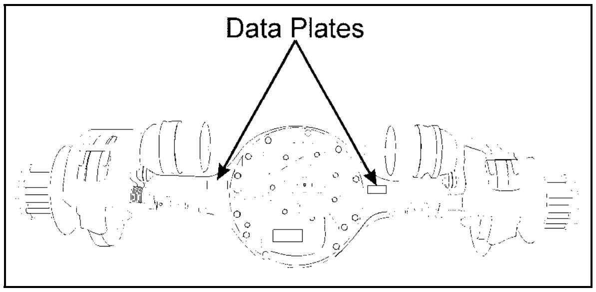


FIGURE 4: TYPICAL SERIAL & MODEL NUMBERS 11019

4.1.4 Front Axle

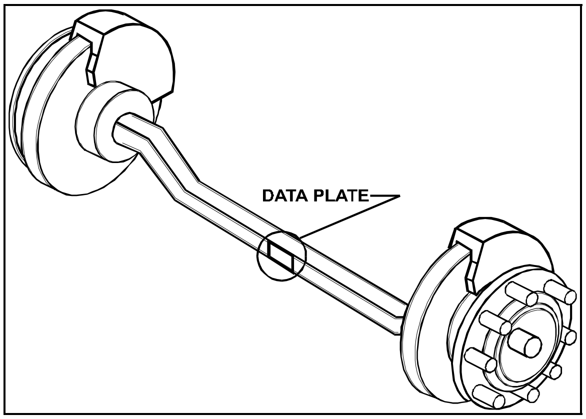


FIGURE 5: TYPICAL SERIAL & MODEL NUMBERS 10024

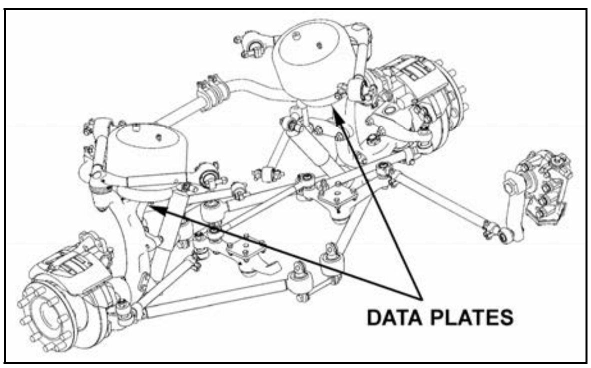


FIGURE 6: ISS TYPICAL SERIAL & MODEL NUMBERS

4.1.5 Power Steering Pump

Power steering pump serial number is located on a tag on the pump (Fig. 7). The pump is mounted on the engine beside the crankshaft pulley.

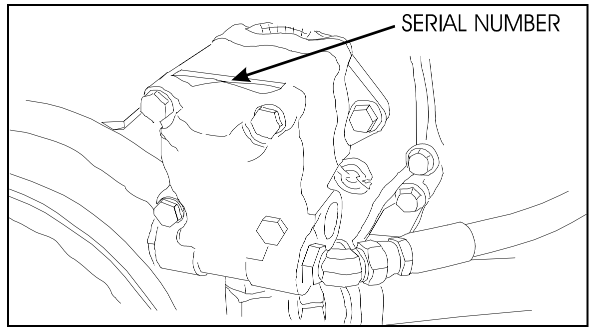


FIGURE 7 : POWER STEERING PUMP NAMEPLATE 00035

4.1.6 Coach Final Record

The Coach Final Record is a record of all data pertaining to the assembly of the coach. This record is included in the technical publication package supplied with the coach. Retain this record in the company records office for reference and safe-keeping.

4.1.7 Safety Certification

Coach components meet specifications and standards as follows:

- Material and parts conform to ASTM and/or SAE standards in effect at the time of manufacture.

- All factory-installed interior materials meet FMVSS 302 for fire resistance.

- Certified according to Provincial, State and Federal Safety standards (Canadian and US) BMCSS, FMVSS, and CMVSS.

Other applicable certification labels are affixed to the component.

4.1.8 DOT Certification Label

This certifies that coaches manufactured by Prevost Car Inc., comply with all Federal Motor Vehicle Safety Standards at the time of manufacture. Information such as date of manufacture, model year, gross vehicle weight rating, tire types and inflation pressure is also etched on this plate. The DOT Certification plate is affixed to L.H. control panel.

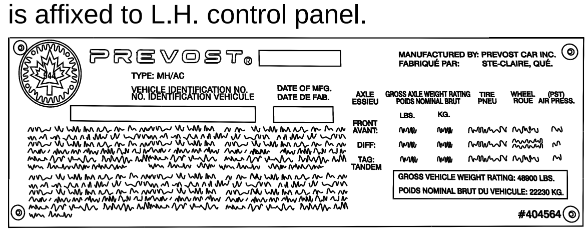


FIGURE 8: DOT CERTIFICATION PLATE 00016

4.1.9 EPA Engine Label

The exhaust emission certification label affixed to the rear junction box certifies that the engine conforms to federal and any state exhaust emission regulations (Fig. 9). It gives the operating conditions under which certification was made.

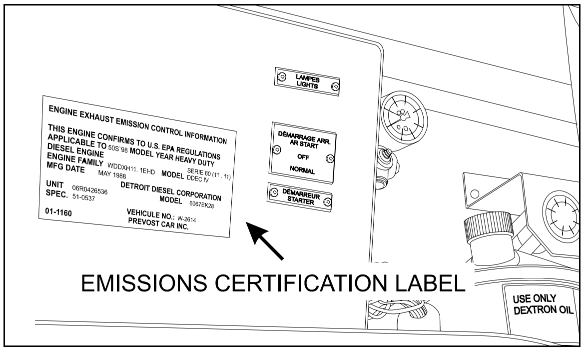


FIGURE 9 : ENGINE COMPARTMENT 00019

4.1.10 Fuel Tank Label

The fuel tank label is molded on the side of the fuel tank. To read this label, unscrew the fuel tank access panel nuts located at the left in the condenser compartment.

4.1.11 Vehicle Identification Number (VIN)

The seventeen digit vehicle identification number (VIN) is located on a plate (Fig. 10 & 11) located on the windshield frame pillar (driver's side). The VIN is visible from the outside of the coach. Make sure the correct vehicle identification number is given when ordering replacement parts. Using the VIN when ordering parts will facilitate processing.

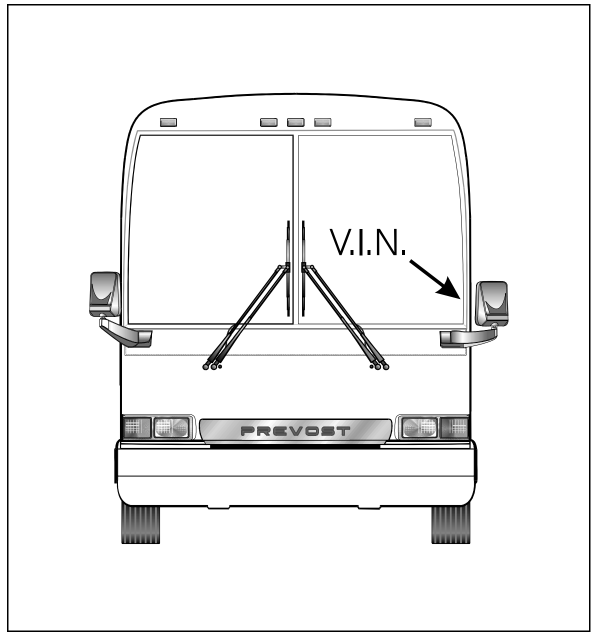
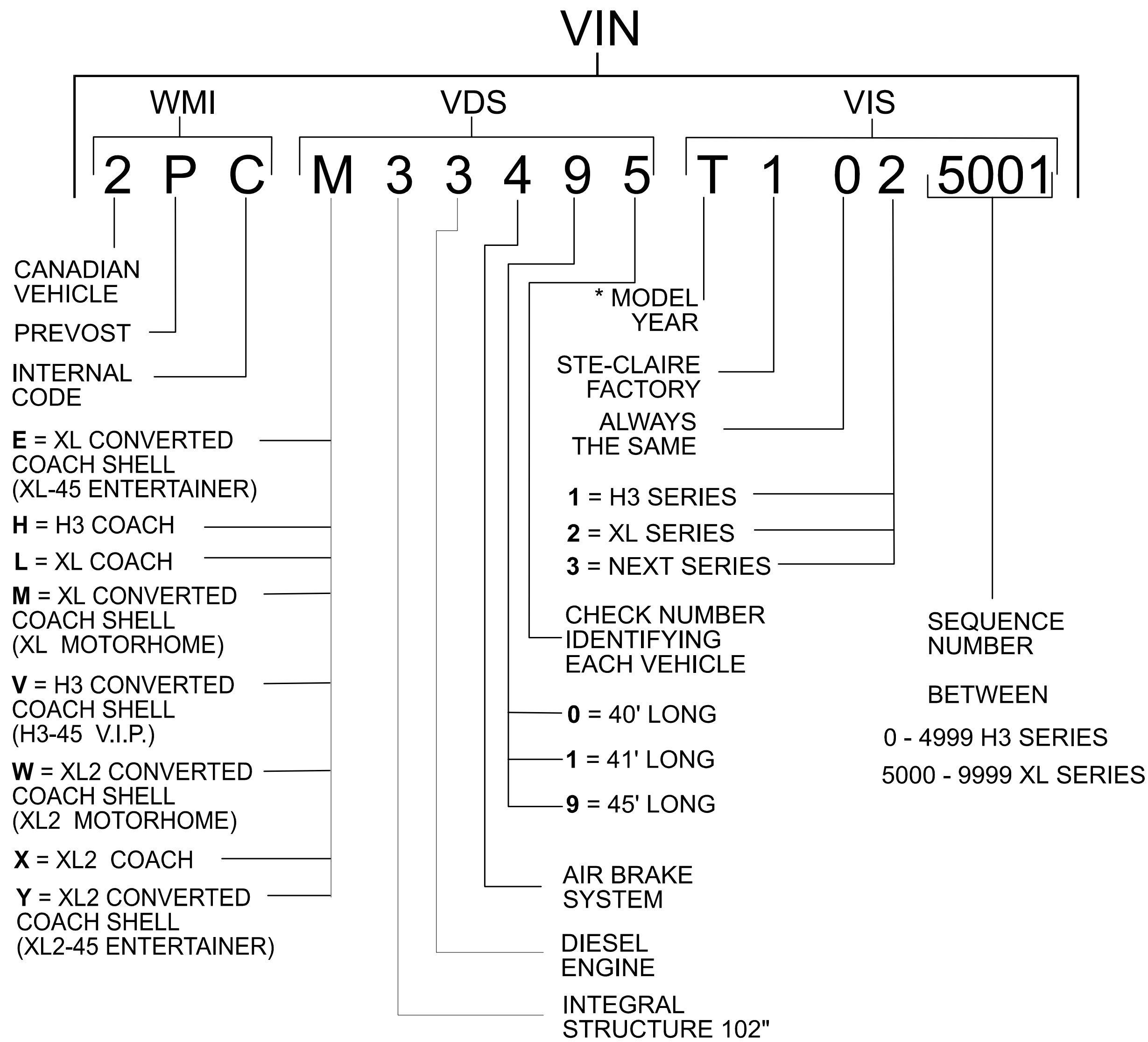


FIGURE 10 : VEHICLE I.D. 00020

Note: *Record the VIN in the coach documentation and keep with company records. The VIN will normally be used for vehicle registration and for obtaining vehicle insurance coverage.*



VIN Vehicle Identification Number: a structured combination of characters assigned to a vehicle by the manufacturer for identification purposes.

WMI World Manufacturer Identifier: Designating the manufacturer of the vehicle.

VDS Vehicle Descriptor Section: Provides information describing the general attributes of the vehicle.

VIS Vehicle Indicator Section: Combination of characters assigned by the manufacturer to distinguish one vehicle from another.

FIGURE 11 : VEHICLE IDENTIFICATION NUMBER VIN1

YEAR	CODE	YEAR	CODE
1993	P	1999	X
1994	R	2000	Y
1995	S	2001	1
1996	T	2002	2
1997	V	2003	3
1998	W	2004	4

5. FASTENER STRENGTH IDENTIFICATION

Most commonly used metric fastener strength property classes are 9.8 and 10.9 with the class identification embossed on the head of each bolt. Customary (inch) strength classes range from grade 2 to 8 with radial line identification embossed on each bolt head actual grade (i.e., a grade 7 bolt will have 5 embossed radial lines on the bolt head). Some metric nuts will be marked with single digit strength identification numbers on the nut face. Fig. 13 shows the different strength markings. When replacing metric fasteners, be careful to use fasteners of the same or greater strength than the original fasteners (the same number marking or higher). It is also important to select replacement fasteners of the correct size. Correct replacement fasteners are available through the parts division. Some metric fasteners available in after-market parts sources were designed to metric standards of countries other the United States and may be of a lower strength, may not have the numbered head marking system, and may be of a different thread pitch.

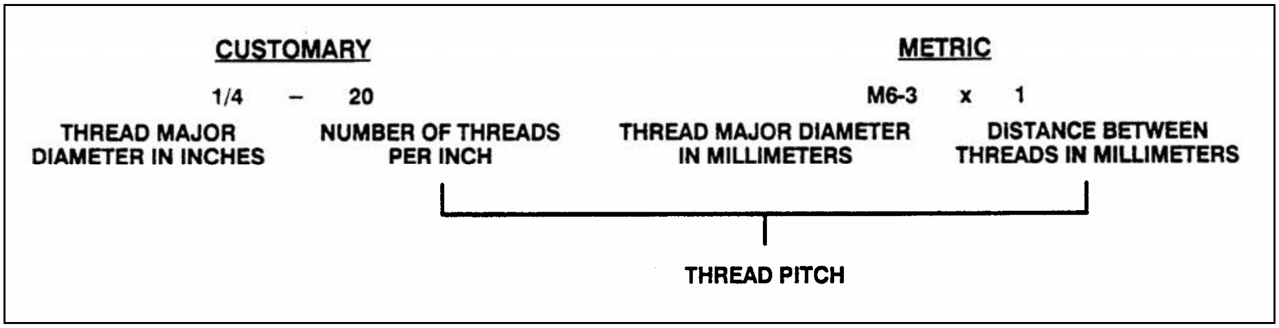


FIGURE 12 : THREAD NOTATION 00002

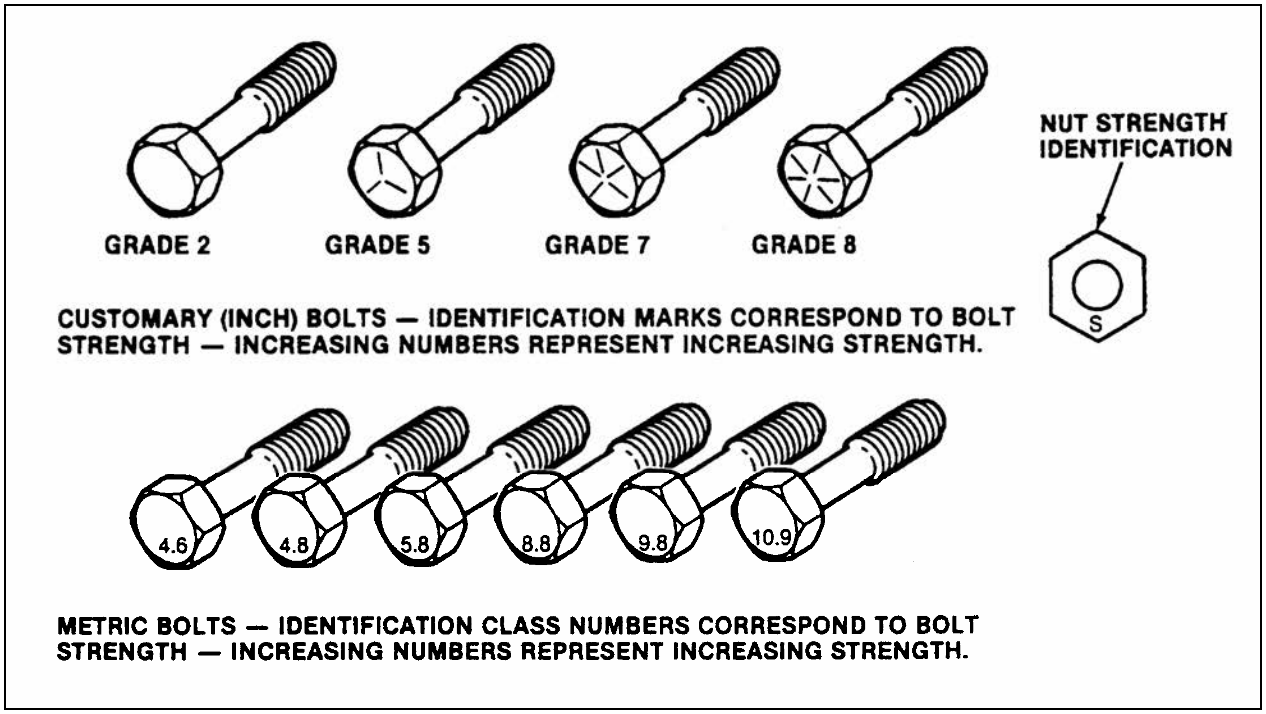


FIGURE 13: BOLT STRENGTH MARKINGS 00003

The metric fasteners used on the coach are designed to new standards and may not yet be manufactured by some non-domestic fastener suppliers. In general, except for special applications, the common sizes and pitches are :

- M 8 X 1.25;
- M 10 X 1.5;
- M 12 X 1.75;
- M 14 X 2;

5.1 SELF-LOCKING FASTENERS

A self-locking fastener is designed with an interference fit between the nut and bolt threads. This is most often accomplished by distortion of the top thread of an all-metal nut or bolt or by using a nylon patch on the threads. A nylon insert or the use of adhesives may also be used as a method of interference between nut and bolt threads (Fig. 14).

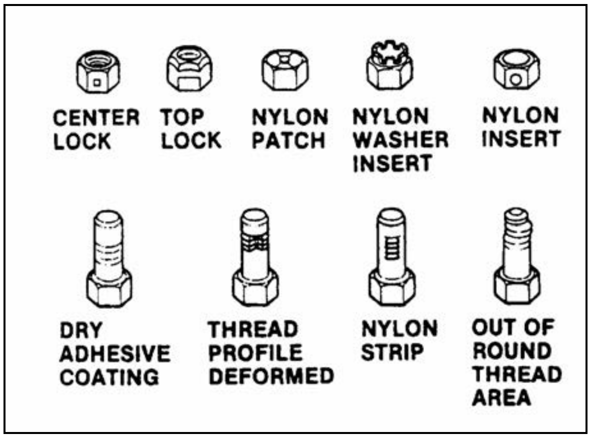


FIGURE 14 : SELF-LOCKING FASTENERS 00004

5.2 RECOMMENDATIONS FOR REUSE

Clean, unrusted self-locking fasteners may be

reused as follows :

a) Clean dirt and other foreign matter from the fastener;

b) Inspect the fastener to ensure there is no crack, elongation, or other sign of fatigue or overtightening. If there is any doubt, replace with a new self-locking fastener of equal or greater strength;

c) Assemble parts and hand start fastener;

d) Observe that, before the fastener seats, it develops torque per the chart in table two. If there is any doubt, replace with a new self-locking fastener of equal or greater strength;

e) Tighten the fastener to the torque specified in the applicable section of this manual;

Fasteners which are rusty or damaged should be replaced with new ones of equal or greater strength.

SELF-LOCKING FASTENER TORQUE CHART

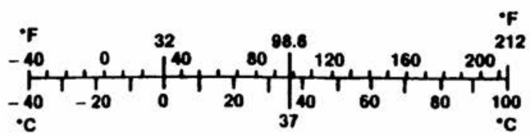
METRIC		6 & 6.3	8	10	12	14	16	20
NUTS AND ALL-METAL BOLTS	N•m	0.4	0.8	1.4	2.2	3.0	4.2	7.0
	lbf•in	4.0	7.0	12	18	25	35	57
ADHESIVE OR NYLON COATED BOLTS	N•m	0.4	0.6	1.2	1.6	2.4	3.4	5.6
	lbf•in	4.0	5.0	10	14	20	28	46

US STANDARD		.250	.312	.375	.437	.500	.562	.625	.750
NUTS AND ALL-METAL BOLTS	N•m	0.4	0.6	1.4	1.8	2.4	3.2	4.2	6.2
	lbf•in	4.0	5.0	12	15	20	27	35	51
ADHESIVE OR NYLON COATED BOLTS	N•m	0.4	0.6	1.0	1.4	1.8	2.6	3.4	5.2
	lbf•in	4.0	5.0	9.0	12	15	22	28	43

5.3 SIX LOBED SOCKET HEAD

Six lobed socket head (Torx) fasteners are used in some applications on vehicles covered in this manual. The tools designed for these fasteners are available commercially. However, in some cases, if the correct tool is not available, a hex socket head wrench may be used.

Multiply	by	to get equivalent number of:
	LENGTH	
Inch	25.4	millimeters (mm)
Foot	0.305	meters (m)
Yard	0.914	meters
Mile	1.609	kilometers (km)
	AREA	
$Inch^2$	645.2	$millimeters^2$ (mm^2)
	6.45	$centimeters^2$ (cm^2)
$Foot^2$	0.093	$meters^2$ (m^2)
$Yard^2$	0.836	$meters^2$
	VOLUME	
$Inch^3$	16 387.0	mm^3
	16.387	cm^3
	0.016	liters (l)
Quart	0.946	liters
Gallon	3.785	liters
$Yard^3$	0.765	$meters^3$ (m^3)
	MASS	
Pound	0.453	kilograms (kg)
Ton	907.18	kilograms (kg)
Ton	0.907	ton (t)
	FORCE	
Kilogram	9.807	newtons (N)
Ounce	0.278	newtons
Pound	4.448	newtons
	TEMPERATURE	
Degree Fahrenheit	(†0F − 32) ÷ 1.8	Degree Celsius (C)



Multiply	by	to get equivalent number of:
	ACCELERATION	
$Foot/sec^2$	0.305	$meter/sec^2$ (m/s^2)
$Inch/sec^2$	0.026	$meter/sec^2$
	TORQUE	
Pound-inch	0.113	newton-meters (N·m)
Pound-foot	1.35	newton-meters
	POWER	
Horsepower	0.746	kilowatts (kW)
	PRESSURE OR STRESS	
Inches of water	0.249	kilopascals (kPa)
Pounds/sq. in.	6.895	kilopascals
	ENERGY OR WORK	
BTU	1 055.0	joules (J)
Foot-pound	1.356	joules
kilowatt-hour	3 600 000.0 or 3.6×10^6	joules (J = one W's)
	LIGHT	
Foot candle	1.076	$lumens/meter^2$ (lm/m^2)
	VELOCITY	
Miles/hour	1.609	kilometers/hr (km/h)

FIGURE 15: METRIC - US STANDARD CONVERSION TABLE

00005

DECIMAL AND METRIC EQUIVALENTS

FRACTIONS	DECIMAL IN.	METRIC MM	FRACTIONS	DECIMAL IN.	METRIC MM
1/64	.015625	.39688	33/64	.515625	13.09687
1/32	.03125	.79375	17/32	.53125	13.49375
3/64	.046875	1.19062	35/64	.546875	13.89062
1/16	.0625	1.58750	9/16	.5625	14.28750
5/64	.078125	1.98437	37/64	.578125	14.68437
3/32	.09375	2.38125	19/32	.59375	15.08125
7/64	.109375	2.77812	39/64	.609375	15.47812
1/8	.125	3.1750	5/8	.625	15.87500
9/64	.140625	3.57187	41/64	.640625	16.27187
5/32	.15625	3.96875	21/32	.65625	16.66875
11/64	.171875	4.36562	43/64	.671875	17.06562
3/16	.1875	4.76250	11/16	.6875	17.46250
13/64	.203125	5.15937	45/64	.703125	17.85937
7/32	.21875	5.55625	23/32	.71875	18.25625
15/64	.234375	5.95312	47/64	.734375	18.65312
1/4	.250	6.35000	3/4	.750	19.05000
17/64	.265625	6.74687	49/64	.765625	19.44687
9/32	.28125	7.14375	25/32	.78125	19.84375
19/64	.296875	7.54062	51/64	.796875	20.24062
5/16	.3125	7.93750	13/16	.8125	20.63750
21/64	.328125	8.33437	53/64	.828125	21.03437
11/32	.34375	8.73125	27/32	.84375	21.43125
23/64	.359375	9.12812	55/64	.859375	21.82812
3/8	.375	9.52500	7/8	.875	22.22500
25/64	.390625	9.92187	57/64	.890625	22.62187
13/32	.40625	10.31875	29/32	.90625	23.01875
27/64	421875	10.71562	59/64	.921875	23.41562
7/16	.4375	11.11250	15/16	.9375	23.81250
29/64	.453125	11.50937	61/64	.953125	24.20937
15/32	.46875	11.90625	31/32	.96875	24.60625
31/64	.484375	12.30312	63/64	.984375	25.00312
1/2	.500	12.70000	1	1.00	25.40000

FIGURE 16: CONVERSION CHART 00006

CONTENTS

ILLUSTRATIONS

1. ENGINE

This vehicle is powered by a 6-cylinder, four-cycle, Detroit Diesel series 60 engine equipped with an electronic control system (DDEC IV).

Two engine displacements are used in the Series 60 engines: 12.7 and 14.0 liters. Summary information on the Electronic Control System is given in this section.

Complete maintenance and repair information on the engine will be found in the current DDEC IV Service Manual #6SE483. This maintenance manual covers engine accessories, controls and related components.

Procedures for engine removal and installation are given at the end of this section. The DDEC system is self-diagnostic. It can identify faulty components and other engine-related problems by providing the technician with a diagnostic code.

Refer to DDEC Troubleshooting Guide #6SE492 published by Detroit Diesel for more complete information on diagnosis of components and system problems.

DDEC IV (**D**etroit **D**iesel **E**lectronic **C**ontrol) controls the timing and quantity of fuel injected by the electronic unit injectors (EUI). The system also monitors several engine functions using electrical sensors, which send electrical signals to the Electronic Control Module (ECM). The ECM computes the electrical signals and determines the correct fuel output and timing for optimum power, fuel economy and emissions. The ECM also has the ability to display warnings or shut down the engine completely (depending on option selection) in the event of damaging engine conditions, such as low oil pressure, low coolant level, or high oil temperature.

Two categories divide system components: engine-mounted components and engine-related components.

2. ENGINE-MOUNTED COMPONENTS

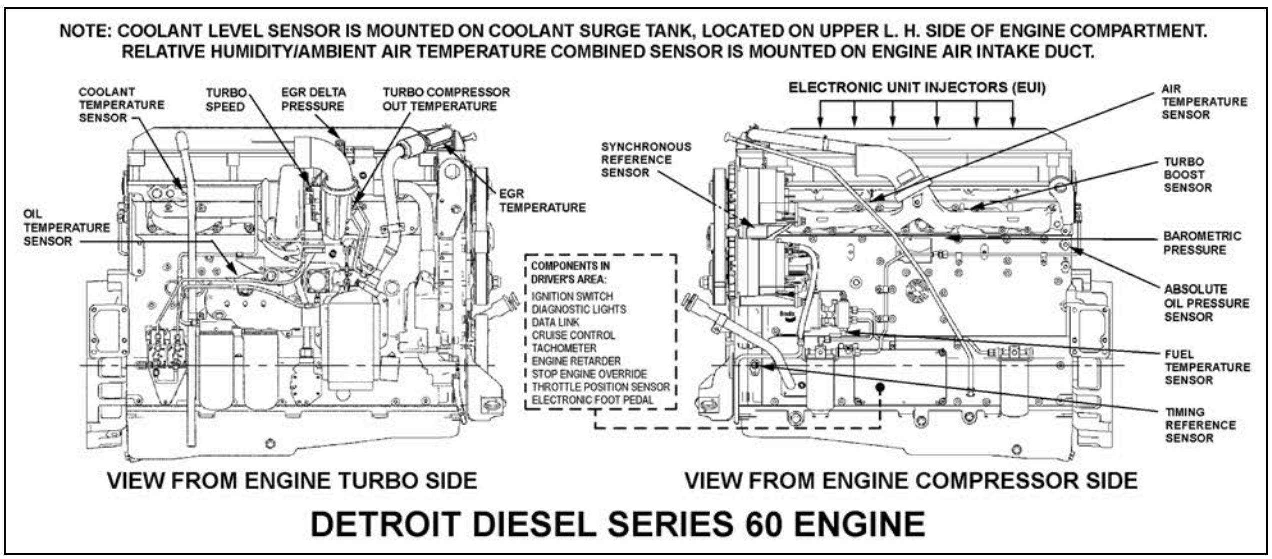


FIGURE 1: DETROIT DIESEL SERIES 60 ENGINE (TYPICAL) 01113

Engine-mounted components are as follows:

- Electronic Control Module
- Electronic Unit Injector
- Synchronous Reference Sensor
- Timing Reference Sensor
- Turbo Boost Pressure Sensor
- Coolant Temperature Sensor
- Fuel Temperature Sensor
- Air Temperature Sensor
- Absolute Oil Pressure Sensor
- Oil Temperature Sensor
- Barometric Pressure
- EGR Delta Pressure
- EGR Temperature
- Turbo Speed
- Turbo Compressor Out Temperature

2.1 ELECTRONIC CONTROL MODULE

The Electronic Control Module is mounted, on the starter side of the engine (Fig. 2). Considered the *"Brain"* of the DDEC IV system, it provides overall monitoring and control of the engine. It does so by comparing input data from the various sensors to a set of calibration data stored in the EEPROM (**E**lectrically **E**rasable, **P**rogrammable, **R**ead-**O**nly **M**emory) within the Electronic Control Module. After comparing the input data with the calibration data, the ECM sends high-current command pulses to the Electronic Unit Injectors (EUI) to initiate fuel injection. The ECM also receives feedback regarding the start and end of injection for a given cylinder. The EEPROM within the Electronic Control Module is factory programmed by Detroit Diesel. Reprogramming must be done at a Detroit Diesel authorized service center. However, some changes may be performed to the cruise control and road speed limiter using a diagnostic data reader (see paragraph "DDEC IV Diagnostic Codes" in this section).

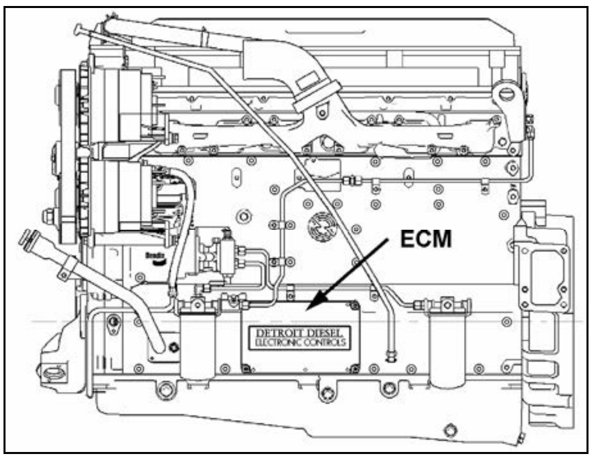


FIGURE 2: ELECTRONIC CONTROL MODULE (ECM) 01064

2.2 ELECTRONIC UNIT INJECTOR

The Electronic Unit Injector (EUI) is a compact device that injects diesel fuel directly into the combustion chamber (Fig. 3). The amount of fuel injected and injection timing is determined by the Electronic Control Module (ECM). The ECM sends a command pulse, which activates the injector solenoid. The EUI performs four functions:

- Creates the high-fuel pressure required for efficient injection;
- Meters and injects the exact amount of fuel required to handle the load;
- Atomizes the fuel for mixing with the air in the combustion chamber;
- Permits continuous fuel flow for component cooling**.**

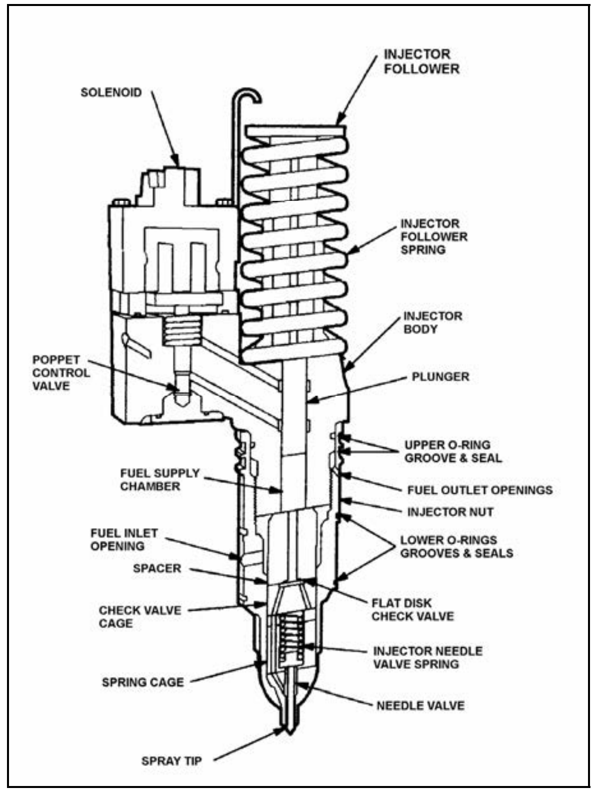


FIGURE 3: UNIT INJECTOR CROSS SECTION 01106

2.3 VPOD

There are two air-operated Variable Pressure Output Devices (VPOD) that control the Variable Geometry Turbo (VGT) and the Exhaust Gas Recirculation (EGR) system. The location of the VPODs is to the left of the engine oil filters (Fig. 4). Pneumatic system supplies air pressure.

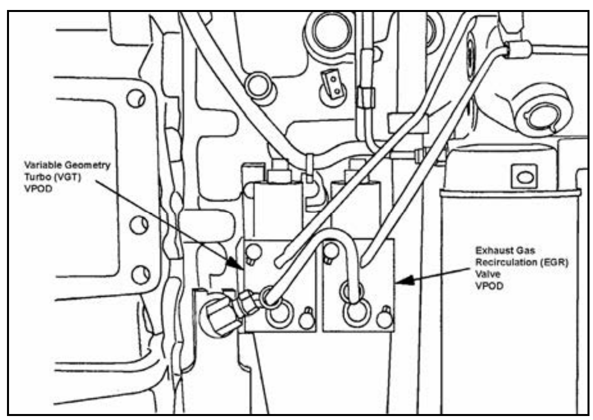


FIGURE 4: VPOD LOCATION

2.4 SYNCHRONOUS REFERENCE SENSOR

The Synchronous Reference Sensor (SRS) is an electronic component, mounted to the rear of the gear case (Fig. 1). The SRS senses a raised metal pin on the rear of the camshaft idler gear and sends a signal to the ECM via a black connector wire. The SRS sensor extends through a hole in the gear case. It is positioned near the rear of the idler gear. A bolt, inserted through a hole in the SRS bracket, secures the SRS assembly to the gear case.

The idler gear pin passes by the SRS as piston number one crank pin reaches 45° before Top-Dead-Center. The ECM uses this information to determine engine speed.

The SRS is non-serviceable and must be replaced as a unit. No adjustment is required.

2.5 TIMING REFERENCE SENSOR

The Timing Reference Sensor (TRS) is an electronic component mounted on the left side of the gear case (right side of coach), near the crankshaft centerline. The TRS is positioned near the timing wheel gear teeth and extends through an opening in the gear case. A bolt, inserted through a hole in the TRS bracket, secures the TRS assembly to the gear case. The TRS connector is gray. The TRS sends a signal to the ECM, this signal is generated by a series of evenly spaced special teeth on the timing wheel. A tooth passes by the TRS as each cylinder crank pin reaches 10° before Top-Dead-Center.

The ECM uses these signals to determine injector solenoid operation time. The TRS is non-serviceable and must be replaced as a unit. No adjustment is required.

2.6 TURBO BOOST PRESSURE SENSOR

The Turbo Boost Pressure Sensor is located on the intake manifold. This device is a pressure sensor that sends an electrical signal to the ECM. The ECM uses this information to compute the volume of air entering the engine. Turbo boost sensor information regulates fuel supply to control engine exhaust.

The turbo boost pressure sensor is non-serviceable and must be replaced as an assembly. No adjustment is required.

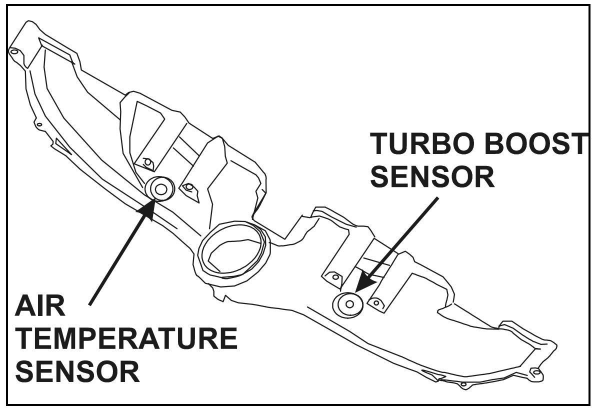


FIGURE 5: TURBO BOOST PRESSURE SENSOR 01023

2.7 COOLANT TEMPERATURE SENSOR

The coolant temperature sensor (Fig. 1) is mounted on the engine's radiator side (turbo side). The sensor helps protect the engine against overheating by sensing coolant temperature.

2.8 FUEL TEMPERATURE SENSOR

The Fuel Temperature Sensor (FTS) is installed underneath the fuel pump (Fig. 6).

The FTS sends an electrical signal to the ECM indicating fuel inlet temperature. The ECM uses this information to calculate fuel consumption.

The FTS is non-serviceable and must be replaced as a unit. No adjustment is required.

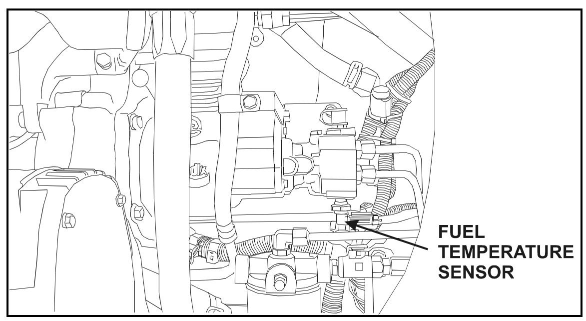


FIGURE 6: FUEL TEMPERATURE SENSOR 01024

2.9 AIR TEMPERATURE SENSOR

The Air Temperature Sensor (Fig. 1 & 5) located on the intake manifold provides input data to vary hot idle speed and injection timing. This helps to improve cold starts and reduces white exhaust smoke.

2.10 ABSOLUTE OIL PRESSURE SENSOR

The Absolute Oil Pressure Sensor (OPS) is installed in the main engine-oil gallery. A typical location is the left rear corner of the cylinder block (Fig. 7). The OPS sends an electrical signal to the ECM indicating the engine oil pressure at any given speed. A low oil pressure signal exceeding seven seconds is used by the ECM to begin the stop engine or warning function. The OPS is non-serviceable and must be replaced as a unit. No adjustment is required.

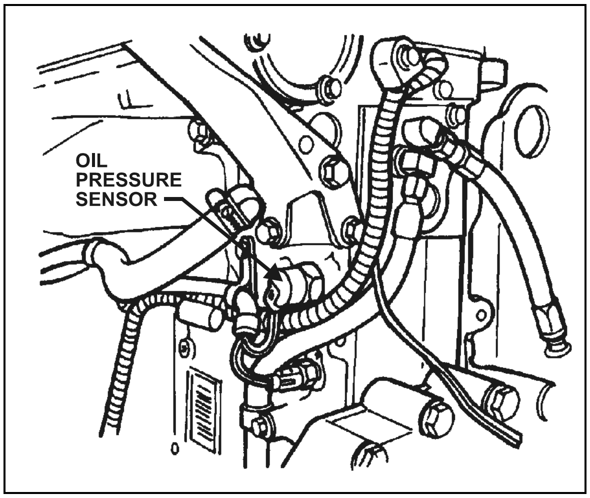


FIGURE 7: ENGINE OPS AND OTS 01025B

2.11 OIL TEMPERATURE SENSOR

The Oil Temperature Sensor (OTS) is installed behind the engine oil filters manifold (Fig. 1). The OTS sends an electrical signal to the ECM indicating engine oil temperature. The ECM uses this information to modify engine speed for better cold weather starts and faster warm-ups. Oil temperatures exceeding engine specifications for two seconds or more will illuminate the Check Engine Light.

The OTS is non-serviceable and must be replaced as a unit. No adjustment is required.

3. ENGINE-RELATED COMPONENTS

Engine-related components include:

- Coolant Level System (CLS)
- Electronic Foot Pedal Assembly (EFPA) and Throttle Position Sensor
- Cruise Control Switch (CCS)
- Diagnostic System Accessories (DSA)

3.1 COOLANT LEVEL SYSTEM (CLS)

The coolant level system consists of a conductivity probe mounted in the surge tank and an electronic interface module located inside the rear junction box. Coolant level is determined by the change in impedance of the probe and its brass mount when immersed in coolant. The electronic device in the module conditions the signal to levels compatible with DDEC. A low coolant level will trigger the engine warning functions.

The probe and electronic interface module are non-serviceable items and should be replaced as units, if found defective. No adjustment is required.

3.2 ELECTRONIC FOOT PEDAL ASSEMBLY (EFPA) & THROTTLE POSITION SENSOR

The Electronic Foot Pedal Assembly (EFPA) connects the accelerator pedal to a Throttle Position Sensor (TPS). The (TPS) is a device, which sends an electrical signal to the Electronic Control Module (ECM). The TPS signal varies in voltage depending on how far the pedal is depressed. The system is installed in the space normally occupied by a mechanical foot pedal. The (EFPA) has maximum and minimum stops that are built into the unit during manufacturing (Fig. 10). The (TPS) converts the operator's foot pedal input into a signal for the ECM. The (EFPA) is shown in Figure 10.

When installed by the equipment manufacturer, the TPS should not require adjustment. If the TPS is suspected of being misadjusted, confirm that the sensor is installed in accordance with the manufacturer's specifications. It is recommended that the idle count be at 50 or higher with a full throttle count of up to 200.

The TPS is self-calibrating and therefore has no optimum closed throttle or wide open throttle count value. If the counts are within the 50 to 200 range, the sensor is properly set.

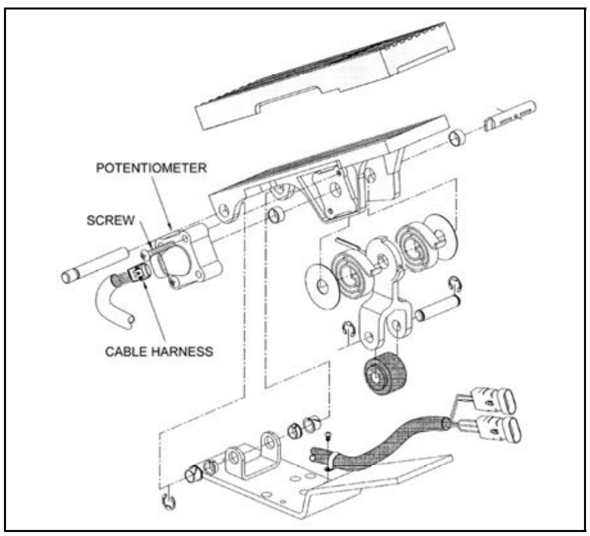


FIGURE 8: ELECTRONIC FOOT PEDAL ASSEMBLY 03035

Monitor the (TPS) at the controls as you move it through its full stroke. Be sure there is no misalignment or obstruction preventing the smooth movement of the TPS through the full stroke. Using a diagnostic data reader, check that the idle and full throttle position counts do not fall within the error zones. The error zones occur when the idle position is less than 14 counts, or when the full throttle position is more than 233 counts. Should these conditions occur, the ECU will signal diagnostic codes of 21-12 for idle error and 21-23 for wide-open throttle error.

3.3 CRUISE CONTROL SWITCHES (CCS)

The four cruise control switches are located in the driver's area on the L.H. side control panel.

1. **Cruise:** This is the main switch that actuates the ECM memory in order to use the speed-regulating mode.
2. **Set:** This switch is used to set the cruise control speed or to decrease the set speed by 2 MPH at each application.

Note: *Cruise control system will not accept speed settings, nor will the "Resume" switch operate below 20 mph (32 km/h) and the engine speed must be above 1100 RPM.*

3. **Resume:** Each time this switch is actuated, the speed will be increased by 2 mph (3,5 km/h). This switch allows the driver return to the last regulated speed following a brake or *"DECEL"* switch application.

Note: *On-off switch must be in the "ON" position in order to return to the last regulated speed.*

4. **Decel:** Will cancel the cruise temporarily and let the vehicle coast. Set speed is still in memory for resume.

For additional information, see the "Operator's Manual" or the "Owner's Manual".

3.4 DIAGNOSTIC SYSTEM ACCESSORIES (DSA)

The DDEC IV engine Diagnostic System Accessories include the following:

- Check Engine telltale light;
- Stop Engine telltale light;
- Stop Engine Override switch;
- Diagnostic Data Link (DDL) connectors.

3.4.1 Check Engine Telltale Light

The Check Engine telltale, mounted on the telltale light panel indicates that a problem has been detected and that a code has been stored in the ECM memory. This light also has a 5-second bulb check when the ignition is first turned on. The Check Engine telltale illuminates when the temperature at coolant sensors exceeds 217°F (103°C) and the temperature at oil sensors exceeds 260°F (127°C). When sensors reach those temperatures, DDEC starts to decrease engine power linearly.

3.4.2 Stop Engine Telltale Light

This light, also mounted on the telltale light panel, illuminates to indicate that a major engine problem is occurring (with the exception of a 5-second bulb check when the ignition is first turned on). The Stop Engine Light illuminates when the temperature at coolant sensors exceeds 222°F (106°C) and the temperature at oil sensors exceeds 239°F (115°C). When sensors detect such temperatures, DDEC shuts the engine down after a 30 seconds grace period. This 30-second delay may be extended another 30 seconds (if absolutely necessary) by using the STOP ENGINE OVERRIDE switch.

Note: *Once engine is stopped, it can not be restarted until the malfunction is corrected.*

3.4.3 Stop Engine Override Switch

This switch, mounted on the dashboard, may be used to extend the 30-second delay period before engine shutdown when the Stop engine telltale light is illuminated. This switch can be repeatedly depressed in order to move the vehicle out of traffic.

Note: *The stop engine override switch will be operative only if it has been depressed before the end of the 30 second delay period.*

Caution: *The OVERRIDE switch must be used only in emergency cases, such as to move the vehicle out of traffic. Excessive use of this switch can cause serious damage to the engine.*

This switch is also used for DDEC diagnostic code requests. Press this switch with the engine at idle or off but with the ignition in the "ON" position and active codes will be flashed on the CHECK ENGINE and STOP ENGINE telltale lights alternately. Refer to “DDEC IV DIAGNOSTIC CODES” in this section for more information.

3.4.4 Diagnostic Data Link (DDL) Connectors

A connector is mounted on the L.H. footwell wall. Another connector is located in the rear electric compartment. They allow the connection of the Diagnostic Data Reader (DDR) to read the codes or to access pertinent data on the condition of the engine. This enables a more complete analysis of any defect found in the DDEC system operation. For more information, see Detroit Diesel Troubleshooting Guide #6SE492.

4. DDEC IV DIAGNOSTIC CODES

4.1 READING DIAGNOSTIC CODES - FLASHING LIGHT METHOD:

DDEC IV makes use of two types of codes: Active and inactive. The difference between the two types of codes is as follows:

Active Codes: Codes that are currently keeping the Check Engine or Stop Engine telltale light illuminated. Active codes are flashed via the Stop Engine Light when checked with the stop-engine-override switch.

Inactive Codes: These are all the codes logged in the ECM (whether or not they are currently turning on the Stop or Check Engine Light). Inactive codes are flashed via the Check Engine telltale light when checked with the stop-engine-override switch. In most instances, only the DDR can provide the information necessary for a quick diagnosis of the problem.

If you just need to read out codes, however, and do not have a DDR available, the following procedure will let you read out codes. Make sure the rear-starting switch (located in the engine compartment) is in the normal position. With the ignition ON, the engine idling or engine shut-off, momentarily depress the Stop Engine Override switch. Active codes will be flashed on the stop engine telltale, followed by the inactive codes being flashed on the check-engine telltale panel. The cycle repeats itself until the operator depresses the stop engine override switch again. A code "43" consists of four flashes, followed by a short pause, then three flashes in quick succession.

Refer to DDEC Troubleshooting Manual 6SE497 for more information and SAE codes.

Note: *Active codes are flashed in ascending numerical flash code order. Inactive codes are flashed in most recent to least recent order.*

Note: *Fault codes can only be cleared using the DDR.*

Note: *The listed codes may not be used in all applications. A default value in the normal operating range is used by the ECM to provide for engine operation if a sensor failure is present.*

DDEC Code # (Flashed)	PID	SID	FMI	DESCRIPTION
11	187	--	4	Variable Speed Governor Sensor Voltage Low
11	187	--	7	Variable Speed Governor Switch System Not Responding
12	187	--	3	Variable Speed Governor Sensor Voltage High
13	111	--	4	Coolant Level Sensor Input Voltage Low
13	111	--	6	Add Coolant Level Sensor Input Voltage Low
14	52	--	3	Intercooler Coolant Temperature Sensor Input Voltage High
14	110	--	3	Coolant Temperature Sensor Input Voltage High
14	175	--	3	Oil Temperature Sensor Input Voltage High
15	52	--	4	Intercooler Coolant Temperature Sensor Input Voltage Low
15	110	--	4	Coolant Temperature Sensor Input Voltage Low
15	175	--	4	Oil Temperature Sensor Input Voltage Low
16	111	--	3	Coolant Level Sensor Input Voltage High
16	111	--	5	Add Coolant Level Sensor Input Voltage High
17	51	--	3	Throttle Plate Position Sensor Input Voltage High
17	72	--	3	Blower Bypass Position Input Voltage High
18	51	--	4	Throttle Plate Position Sensor Input Voltage Low
18	72	--	4	Blower Bypass Position Input Voltage Low
21	91	--	3	Throttle Position Sensor Input Voltage High
22	91	--	4	Throttle Position Sensor Input Voltage Low
23	174	--	3	Fuel Temperature Sensor Input Voltage High
23	--	65	3	Oxygen Content Circuit Input Voltage High
24	174	--	4	Fuel Temperature Sensor Input Voltage Low

DDEC Code # (Flashed)	PID	SID	FMI	DESCRIPTION
24	--	65	4	Oxygen Content Circuit Input Voltage Low
25	--	--	--	Reserved for “No Codes"
26	--	25	11	Aux. Shutdown #1 Active
26	--	61	11	Aux. Shutdown #2 Active
27	105	--	3	Intake Manifold Temperature Sensor Input Voltage High
27	171	--	3	Ambient Air Temperature Sensor Input Voltage High
27	172	--	3	Air Temperature Sensor Input Voltage High
28	105	--	4	Intake Manifold Temperature Sensor Input Voltage Low
28	171	--	4	Ambient Air Temperature Sensor Input Voltage Low
28	172	--	4	Air Temperature Sensor Input Voltage Low
29	351	—	4	TCI Temperature Circuit Failed Low (Release 33.0 or later)
29	404	—	4	Turbo Compressor Temperature Out Sensor Input Voltage Low (Release 32.0 or later)
31	--	51	3	Aux. Output #3 Open Circuit (High Side) - S3
31	--	51	4	Aux. Output #3 Short To Ground (High Side) - S3
31	--	51	7	Aux. Output #3 Mechanical System Fail - S3
31	--	52	3	Aux. Output #4 Open Circuit (High Side) - T3
31	--	52	4	Aux. Output #4 Short to Ground (High Side) - T3
31	--	52	7	Aux. Output #4 Mechanical System Failure - T3
32	--	238	3	SEL Short to Battery (+)
32	--	238	4	SEL Open Circuit
32	--	239	3	CEL Short to Battery (+)
32	--	239	4	CEL Open Circuit
33	102	--	3	Turbo Boost Pressure Sensor Input Voltage High
34	102	--	4	Turbo Boost Pressure Sensor Input Voltage Low
35	19	--	3	High Range Oil Pressure Sensor Input Voltage High
35	100	--	3	Oil Pressure Sensor Input Voltage Low
36	19	--	4	High Range Oil Pressure Sensor Input Voltage High
36	100	--	4	Oil Pressure Sensor Input Voltage Low
37	18	--	3	High Range Fuel Pressure Sensor Input Voltage High
37	94	--	3	Fuel Pressure Sensor Input Voltage High
37	95	--	3	Fuel Restriction Sensor Input Voltage High
38	18	--	4	High Range Fuel Pressure Sensor Input Voltage Low
38	94	--	4	Fuel Pressure Sensor Input Voltage Low
38	95		4	Fuel Restriction Sensor Input Voltage Low
39	—	146	2	EGR Leak- Boost Power (Release 33.0 or later)
39	—	146	12	EGR Leak- Boost Jake (Release 33.0 or later)
39	—	146	7	EGR Valve Not Responding (release 33.0 or later)
39	—	147	2	VNT Vanes Not Responding – Boost Power (Release 33.0 or later)
39	—	147	11	VNT Vanes at Max – Jake (Release 33.0 or later)
39	—	147	12	VNT Vanes Not Responding – Boost Jake (Release 33.0 or later)
39	—	147	14	EGR Flow too low (Release 33.0 or later)
39	—	147	7	VNT Vanes Not Responding – EGR (Release 33.0 or later)
41	--	21	0	Too Many SRS (missing TRS)
42	--	21	1	Too few SRS (missing SRS)
43	111	--	1	Coolant Level Low
44	52	--	0	Intercooler Coolant Temperature High
44	105	--	0	Intake Manifold Temperature High
44	110	--	0	Coolant Temperature High
44	172	--	0	Air Inlet Temperature High

DDEC Code # (Flashed)	PID	SID	FMI	DESCRIPTION
44	175	--	0	Oil Temperature High
45	19	--	1	High Range Oil Pressure Low
45	100	--	1	Oil Pressure Low
46	168	--	1	ECM Battery Voltage Low
46	--	214	1	RTC Backup Battery Voltage Low
46	--	232	1	Sensor Supply Voltage Low
47	18	--	0	High Range Fuel Pressure High
47	94	--	0	Fuel Pressure High
47	102	--	0	Turbo Boost Pressure High
47	106	--	0	Air Inlet Pressure High
47	164	--	0	Injection Control Pressure High
48	18	--	1	High Range Fuel Pressure Low
48	94	--	1	Fuel Pressure Low
48	106	--	1	Air Inlet Pressure Low
48	164	--	1	Injection Control Pressure Low
48	351	--	1	TCI Temperature Below Range (Release 33.0 or later)
48	404	—	1	Turbo Compressor Temperature Out High (Release 33.0 or later)
48	411	--	1	EGR Differential Pressure Low (Release 33.0 or later)
48	412	--	1	EGR Temperature Low (Release 33.0 or later)
49	351	--	0	TCI Temperature Above Range (Release 33.0 or later)
49	404	--	0	Turbo Compressor Out Temperature High (Release 32.0 or later)
51	351	--	3	TCI Temperature Circuit Failed High (Release 33.0 or later)
51	404	--	3	Turbo Compressor Out Temperature Sensor Input Voltage High (Release 32.0 or later)
52	--	254	12	A/D Conversion Fail
53	--	253	2	Nonvolatile Checksum Incorrect
53	--	253	12	EEPROM Write Error
53	--	253	13	Out of Calibration
54	84	--	12	Vehicle Speed Sensor Fault
55	--	216	14	Other ECU Fault (Release 27.0 or later) (This fault is logged in conjunction with another fault to indicate missing information from another ECU.)
55	--	231	12	J1939 Data Link Fault
55	--	248	8	Proprietary Data Link Fault (Master)
55	--	248	9	Proprietary Data Link Fault (Receiver)
56	--	250	12	J1587 Data Link Fault
57	--	249	12	J1922 Data Link Fault
58	92	--	0	Torque Overload
61	--	xxx	0	Injector xxx Response Time Long
62	--	26	3	Aux. Output #1 Short to Battery (+) - F3
62	--	26	4	Aux. Output #1 Open Circuit - F3
62	—	26	7	Aux. Output #1 Mechanical System Not Responding Properly - F3
62	--	40	3	Aux. Output #2 Short to Battery (+) - A2
62	--	40	4	Aux. Output #2 Open Circuit - A2
62	—	40	7	Aux. Output #2 Mechanical System Not Responding Properly - A2
62	--	53	3	Aux. Output #5 Short to Battery (+) - W3
62	--	53	4	Aux. Output #5 Open Circuit - W3
62	—	53	7	Aux. Output #5 Mechanical System Not Responding Properly - W3
62	--	54	3	Aux. Output #6 Short to Battery (+) - X3
62	--	54	4	Aux. Output #6 Open Circuit - X3

DDEC Code # (Flashed)	PID	SID	FMI	DESCRIPTION
62	--	54	7	Aux. Output #6 Mechanical System Not Responding Properly - X3
62	--	55	3	Aux. Output #7 Short to Battery (+) - Y3
62	--	55	4	Aux. Output #7 Open Circuit - Y3
62	—	55	7	Aux. Output #7 Mechanical System Not Responding Properly - Y3
62	--	56	3	Aux. Output #8 Short to Battery (+) - A1
62	--	56	4	Aux. Output #8 Open Circuit - A1
62	--	56	7	Aux. Output #8 Mechanical System Not Responding Properly - A1
63	--	57	0	PWM #1 Above Normal Range
63	--	57	1	PWM #1 Below Normal Range
63	--	57	3	PWM #1 Short to Battery (+)
63	--	57	4	PWM #1 Open Circuit
63	--	58	0	PWM #2 Above Normal Range
63	--	58	1	PWM #2 Below Normal Range
63	--	58	3	PWM #2 Short to Battery (+)
63	--	58	4	PWM #2 Open Circuit
63	--	59	0	PWM #3 Above Normal Range
63	--	59	1	PWM #3 Below Normal Range
63	--	59	3	PWM #3 Short to Battery (+)
63	--	59	4	PWM #3 Open Circuit
63	--	60	0	PWM #4 Above Normal Range
63	--	60	1	PWM #4 Below Normal Range
63	--	60	3	PWM #4 Short to Battery (+)
63	--	60	4	PWM #4 Open Circuit
64	103	--	0	Turbo Overspeed
64	103	--	8	Turbo Speed Sensor Input Failure – Abnormal Period
65	51	--	0	Throttle Plate Position Above Normal Range
65	51	--	1	Throttle Plate Position Below Normal Range
65	51	--	2	Throttle Plate Position Erratic
65	51	--	7	Throttle Plate Not Responding
65	107	--	3	Air Filter Restriction Sensor Voltage High
65	107	--	4	Air Filter Restriction Sensor Voltage Low
66	99	--	3	Oil Filter Restriction Sensor Voltage High
66	99	--	4	Oil Filter Restriction Sensor Voltage Low
66	--	76	0	Engine Knock Level Above Normal Range
66	--	76	3	Engine Knock Level Sensor Input Voltage High
66	--	76	4	Engine Knock Level Sensor Input Voltage Low
66	--	76	7	Engine Knock Level Sensor Not Responding
67	20	--	3	High Range Coolant Pressure Sensor Input Voltage High
67	20	--	4	High Range Coolant Pressure Sensor Input Voltage Low
67	106	--	3	Air Inlet Pressure Sensor Input Voltage High
67	106	--	4	Air Inlet Pressure Sensor Input Voltage Low
67	109	--	3	Coolant Pressure Sensor Input Voltage High
67	109	--	4	Coolant Pressure Sensor Input Voltage Low
68	--	230	5	TPS Idle Validation Circuit Fault (open circuit)
68	--	230	6	TPS Idle Validation Circuit Fault (short to ground)
71	--	xxx	1	Injector xxx Response Time Short
72	84	--	0	Vehicle Overspeed
72	84	--	11	Vehicle Overspeed (Absolute)
72	--	65	0	Oxygen Content Too High
72	--	65	1	Oxygen Content Too Low
73	107	--	0	Air Filter Restriction High
73	--	77	0	Gas Valve Position Above Normal Range
73	--	77	1	Gas Valve Position Below Normal Range

DDEC Code # (Flashed)	PID	SID	FMI	DESCRIPTION
73	--	77	3	Gas Valve Position Input Voltage High
73	--	77	4	Gas Valve Position Input Voltage Low
73	--	77	7	Gas Metering Valve Not Responding
73	--	151	14	ESS Transmission Stuck in Gear
73	--	226	11	Transmission Neutral Switch Failure (ESS Transmission)
73	--	227	2	Aux Analog Input Data Erratic, Intermittent, or Incorrect (ESS Transmission)
73	--	227	3	Aux Analog Input #1 Voltage High (ESS Transmission)
73	--	227	4	Aux Analog Input #1 Voltage Low (ESS Transmission)
74	70	--	4	Optimized Idle Safety Loop Short to Ground
74	99	--	0	Oil Filter Restriction High
75	168	--	0	ECM Battery Voltage High
75	--	214	0	RTC Backup Battery Voltage High (Release 29.0 or later)
75	--	232	0	Sensor Supply Voltage High
76	121	--	0	Engine Overspeed With Engine Brake
77	19	—	0	High Range Oil Pressure High
77	20	—	0	High Range Coolant Pressure High
77	72	—	0	Blower Bypass Door Position High
77	72	—	1	Blower Bypass Door Position Low
77	73	—	1	Fire Pump Pressure Low
77	81	—	0	Exhaust Back Pressure High
77	81	—	1	Exhaust Back Pressure Low
77	81	—	3	Exhaust Back Pressure Sensor Voltage High
77	81	—	4	Exhaust Back Pressure Sensor Voltage Low
77	81	—	12	Exhaust Back Pressure at Rampdown Threshold
77	95	—	1	Fuel Filter Differential Pressure Low
77	99	—	1	Oil Filter Differential Pressure Low
77	100	—	0	0 Engine Oil Pressure High
77	102	—	1	Turbo Boost Pressure Low
77	105	—	1	Inlet Manifold Temperature Low
77	107	—	1	Air filter Restriction Pressure Low
77	108	—	0	Barometric Pressure High
77	108	—	1	Barometric Pressure Low
77	109	—	0	Coolant Pressure High
77	110	—	1	Coolant Temperature Low
77	111	—	0	Coolant Level High
77	171	—	0	Ambient Air Temperature High
77	171	—	1	Ambient Air Temperature Low
77	172	—	1	Air Inlet Temperature Low
77	174	—	0	Fuel Temperature High
77	174	—	1	Fuel Temperature Low
77	175	—	1	Engine Oil Temperature Low
77	222	—	14	Anti-Theft Fault Present
77	251	—	10	Clock Module Abnormal Rate of Change
77	251	—	13	Clock Module Failure
77	252	—	10	Clock Module Abnormal Rate of Change
77	252	—	13	Clock Module Failure
77	354	—	0	Relative Humidity Above Range (Release 33.0 or later)
77	354	—	1	Relative Humidity Below Range (Release 33.0 or later)
77	446	—	0	Cylinder Head Temperature Above Range (Release 33.0 or later)
77	—	151	11	Service Now Lamp Fault Expiration

DDEC Code # (Flashed)	PID	SID	FMI	DESCRIPTION
				(Release 32.0 or later)
78	86	--	14	Cruise Control/Adaptive Cruise Control Fault (Release 27.0 or later
81	98	--	3	Oil Level Sensor Input Voltage High
81	101	--	3	Crankcase Pressure Sensor Input Voltage High
81	153	--	3	Extended Crankcase Pressure Input Voltage High (Release 27.0 or later
81	164	--	3	Injection Control Pressure Sensor Input Voltage High
81	173	--	3	Exhaust Temperature Sensor Input Voltage High
81	411	—	3	EGR Differential Pressure Sensor Circuit Failed High (Release 33.0 or later)
81	412	—	3	EGR Temperature Circuit Failed High (Release 33.0 or later)
81		20	3	Timing Actuator Failed High
81		20	4	Timing Actuator Failed Low
81	--	129	3	Exhaust Port Temperature #1 Sensor Voltage High (Release 32.0 or later)
81	--	130	3	Exhaust Port Temperature #2 Sensor Voltage High (Release 32.0 or later)
81	--	131	3	Exhaust Port Temperature #3 Sensor Voltage High (Release 32.0 or later)
81	--	132	3	Exhaust Port Temperature #4 Sensor Voltage High (Release 32.0 or later)
81	--	133	3	Exhaust Port Temperature #5 Sensor Voltage High (Release 32.0 or later)
81	--	134	3	Exhaust Port Temperature #6 Sensor Voltage High (Release 32.0 or later)
81	--	135	3	Exhaust Port Temperature #7 Sensor Voltage High (Release 32.0 or later
81	--	136	3	Exhaust Port Temperature #8 Sensor Voltage High (Release 32.0 or later)
81	--	137	3	Exhaust Port Temperature #9 Sensor Voltage High (Release 32.0 or later)
81	--	138	3	Exhaust Port Temperature #10 Sensor Voltage High (Release 32.0 or later)
81	--	139	3	Exhaust Port Temperature #11 Sensor Voltage High (Release 32.0 or later)
81	--	140	3	Exhaust Port Temperature #12 Sensor Voltage High (Release 32.0 or later)
81	--	141	3	Exhaust Port Temperature #13 Sensor Voltage High (Release 32.0 or later)
81	--	142	3	Exhaust Port Temperature #14 Sensor Voltage High (Release 32.0 or later)
81	--	143	3	Exhaust Port Temperature #15 Sensor Voltage High (Release 32.0 or later)
81	--	144	3	Exhaust Port Temperature #16 Sensor Voltage High (Release 32.0 or later)
81	—	277	9	EGR Mass Flow Smart Sensor not Responding (Release 33.0 or later)
81	—	277	12	EGR Mass Flow Smart Sensor not Responding (Release 33.0 or later)
82	98	--	4	Oil Level Sensor Input Voltage Low
82	101	--	4	Crankcase Pressure Sensor Input Voltage Low
82	153	--	4	Extended Crankcase Pressure Input Voltage Low (Release 27.0 or later)
82	164	--	4	Injection Control Pressure Sensor Input Voltage Low
82	173	--	4	Exhaust Temperature Sensor Input Voltage Low
82	411	—	4	EGR Differential Pressure Sensor Circuit Failed Low (Release

DDEC Code # (Flashed)	PID	SID	FMI	DESCRIPTION
				33.0 or later)
82	412	—	4	EGR Temperature Circuit Failed Low (Release 33.0 or later)
82	--	129	4	Exhaust Port Temperature #1 Sensor Voltage Low (Release 32.0 or later)
82	--	130	4	Exhaust Port Temperature #2 Sensor Voltage Low (Release 32.0 or later)
82	--	131	4	Exhaust Port Temperature #3 Sensor Voltage Low (Release 32.0 or later
82	--	132	4	Exhaust Port Temperature #4 Sensor Voltage Low (Release 32.0 or later)
82	--	133	4	Exhaust Port Temperature #5 Sensor Voltage Low (Release 32.0 or later)
82	--	134	4	Exhaust Port Temperature #6 Sensor Voltage Low (Release 32.0 or later)
82	--	135	4	Exhaust Port Temperature #7 Sensor Voltage Low (Release 32.0 or later)
82	--	136	4	Exhaust Port Temperature #8 Sensor Voltage Low (Release 32.0 or later)
82	--	137	4	Exhaust Port Temperature #9 Sensor Voltage Low (Release 32.0 or later
82	--	138	4	Exhaust Port Temperature #10 Sensor Voltage Low (Release 32.0 or later)
82	--	139	4	Exhaust Port Temperature #11 Sensor Voltage Low (Release 32.0 or later)
82	--	140	4	Exhaust Port Temperature #12 Sensor Voltage Low (Release 32.0 or later)
82	--	141	4	Exhaust Port Temperature #13 Sensor Voltage Low (Release 32.0 or later)
82	--	142	4	Exhaust Port Temperature #14 Sensor Voltage Low (Release 32.0 or later)
82	--	143	4	Exhaust Port Temperature #15 Sensor Voltage Low (Release 32.0 or later)
82	--	144	4	Exhaust Port Temperature #16 Sensor Voltage Low (Release 32.0 or later)
82	412	—	9	EGR Temperature Smart Sensor not Responding (Release 33.0 or later)
82	412	—	12	EGR Temperature Smart Sensor failed (Release 33.0 or later)
83	73	—	0	Pump Pressure High
83	98	--	0	Oil Level High
83	101	--	0	Crankcase Pressure High
83	153	--	0	Extended Crankcase Pressure High (Release 27.0 or later)
83	173	--	0	Exhaust Temperature High
83	411	—	0	EGR Differential Pressure High (Release 33.0 or later)
83	412	—	0	EGR Temperature High (Release 33.0 or later)
83	--	129	0	Exhaust Port Temperature #1 Sensor Voltage High (Release 32.0 or later)
83	--	130	0	Exhaust Port Temperature #2 Sensor Voltage High (Release 32.0 or later
83	--	131	0	Exhaust Port Temperature #3 Sensor Voltage High (Release 32.0 or later)
83	--	132	0	Exhaust Port Temperature #4 Sensor Voltage High (Release 32.0 or later)
83	--	133	0	Exhaust Port Temperature #5 Sensor Voltage High (Release 32.0 or later)
83	--	134	0	Exhaust Port Temperature #6 Sensor Voltage High

DDEC Code # (Flashed)	PID	SID	FMI	DESCRIPTION
				(Release 32.0 or later)
83	--	135	0	Exhaust Port Temperature #7 Sensor Voltage High (Release 32.0 or later)
83	--	136	0	Exhaust Port Temperature #8 Sensor Voltage High (Release 32.0 or later)
83	--	137	0	Exhaust Port Temperature #9 Sensor Voltage High (Release 32.0 or later)
83	--	138	0	Exhaust Port Temperature #10 Sensor Voltage High (Release 32.0 or later)
83	--	139	0	Exhaust Port Temperature #11 Sensor Voltage High (Release 32.0 or later)
83	--	140	0	Exhaust Port Temperature #12 Sensor Voltage High (Release 32.0 or later)
83	--	141	0	Exhaust Port Temperature #13 Sensor Voltage High (Release 32.0 or later)
83	--	142	0	Exhaust Port Temperature #14 Sensor Voltage High (Release 32.0 or later)
83	--	143	0	Exhaust Port Temperature #15 Sensor Voltage High (Release 32.0 or later)
83	--	144	0	Exhaust Port Temperature #16 Sensor Voltage High (Release 32.0 or later)
84	98	--	1	Oil Level Low
84	101	--	1	Crankcase Pressure Low
84	153	--	1	Extended Crankcase Pressure Low (Release 27.0 or later)
85	190	--	0	Engine Overspeed
85	190	--	14	Engine Overspeed Signal (Release 28.0 or later)
86	73	--	3	Pump Pressure Sensor Input Voltage High
86	108	--	3	Barometric Pressure Sensor Input Voltage High
87	73	--	4	Pump Pressure Sensor Input Voltage Low
87	108	--	4	Barometric Pressure Sensor Input Voltage Low
88	20	--	1	High Range Coolant Pressure Low
88	109	--	1	Coolant Pressure Low
89	95	--	0	Fuel Restriction High
89	111	--	12	Maintenance Alert Coolant Level Fault

5. ENGINE OIL LEVEL

Check the oil level daily with the engine stopped. If the engine has just been stopped and is warm, wait at least 10 minutes to allow the oil to drain back to the oil pan before checking. Wipe the dipstick clean then check oil level. The level should always be within the safe range on the dipstick (Fig. 11). Add the proper grade of oil to maintain the correct level on the dipstick. All diesel engines are designed to consume some oil, so a periodic addition of oil is normal.

***Warning**: Touching a hot engine can cause serious burns.*

***Caution**: Do not overfill. Oil may be blown out through the crankcase breather if the crankcase is overfilled.*

***Caution:** Clean end of tube before removing the dipstick to prevent oil contamination.*

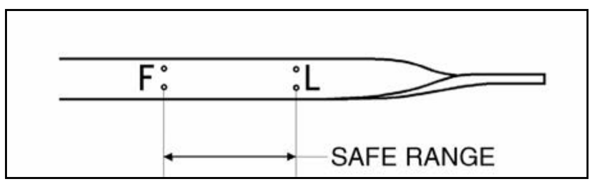


FIGURE 9: ENGINE OIL LEVEL DIPSTICK 01027

***Caution:** If the oil level is constantly above normal and excess lube oil has not been added to the crankcase, consult with an authorized Detroit Diesel service outlet for the cause. Fuel or coolant dilution of lube oil can result in serious engine damage.*

The vehicle may be provided with an oil reserve tank in the engine compartment. To adjust oil level, open the oil reserve tank drain valve and allow oil to discharge into the engine until the "Full" mark on the dipstick is reached then close the valve. Check oil reserve tank level and pour oil in the reserve tank if necessary (Fig. 12).

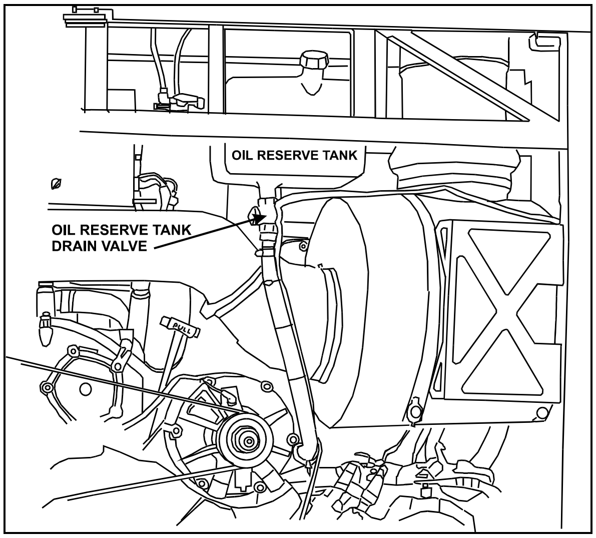


FIGURE 10: OIL RESERVE TANK 01063

6. ENGINE OIL AND FILTER CHANGE

Both the oil and filter should be changed every 12,500 miles (20,000 km) or once a year, whichever comes first. However, changes that are more frequent may be required when the engine is subject to high levels of contamination and/or overheating. Change intervals may be decreased or gradually increased with experience on specific lubricants until the most practical service condition has been established. Always refer to the lubricant manufacturer's recommendations (analysis of drained oil can be helpful).

Caution: *Do not use solvents to dilute the engine oil when draining. Dilution of fresh oil can occur which may be detrimental to the engine.*

Change engine oil with the vehicle on a flat and level surface and with the parking brake applied. It is best to drain the oil when the engine is still warm.

1. From under the vehicle, remove the engine drain plug on the oil pan. Allow oil to drain (Fig. 11).

Warning: *Hot engine oil can cause serious burns. Wear coveralls with sleeves pulled down and gloves to protect hands.*

2. Reinstall the drain plug.
3. Remove the spin-on filter cartridge using a ½" drive socket wrench and extension.

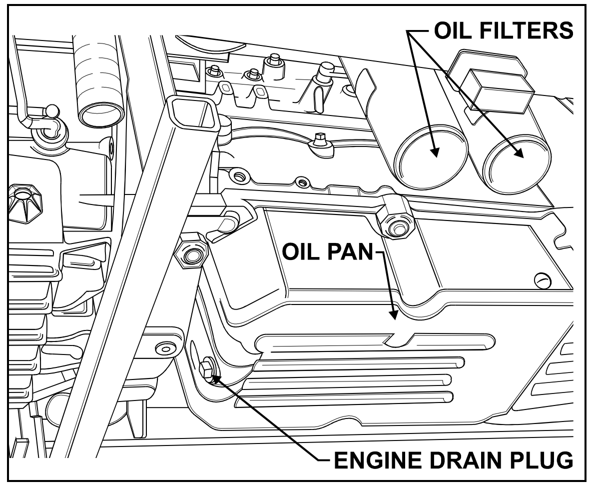


FIGURE 11: ENGINE DRAIN PLUG AND OIL FILTERS 01029

4. Dispose of the used oil and filter in an environmentally responsible manner in accordance with state and/or federal (EPA) recommendations.
5. Clean the filter adapter with a clean rag.
6. Lightly coat the filter gasket (seal) with clean engine oil.
7. Install the new filter on the adapter and tighten manually until the gasket touches the mounting adapter head. Tighten full-flow filters an additional two-thirds of a turn manually. Then, manually tighten bypass filter one full turn.

Caution: *Overtightening may distort or crack the filter adapter.*

8. Remove the engine-oil filler cap and pour oil in the engine until it reaches the "FULL" mark on the dipstick (Fig. 11).
9. Start and run the engine for a short period and check for leaks. After any leaks have been corrected, stop the engine long enough for oil from various parts of the engine to drain back to the crankcase (approximately 20 minutes).
10. Add oil as required to bring the level within the safe range on the dipstick (Fig. 11).

7. RECOMMENDED ENGINE OIL TYPE

To provide maximum engine life, lubricants shall meet the following specifications: SAE Viscosity Grade: 15W-40 API Classification: CI-4.

Note: *Monograde oils should not be used in these engines regardless of API Service Classification.*

Note: *The use of supplemental oil additives is discouraged from use in Detroit Diesel Engines.*

Synthetic oils: Synthetic oils may be used in Detroit Diesel engines provided they are API-licensed and meet the performance and chemical requirements of non-synthetic oils outlined previously. Synthetic oils do not permit extension of recommended oil drain intervals.

Lubricant Selection World Wide: Oils meeting API CD or CC specifications may be used if they also meet military specification MIL-L-2104 D or E. Oils which meet European CCMC D4 specifications may also be used.

Modification of drain interval may be necessary, depending on fuel quality. Contact Detroit Diesel Corporation for further guidance.

8. POWER PLANT ASSEMBLY REMOVAL

To access the engine or engine-related components, the vehicle power plant assembly must be removed as a whole unit by means of a slide-out cradle. The power plant assembly includes the engine, transmission (including retarder if so equipped), air compressor, alternator and transmission oil cooler.

Remove the power plant assembly as follows:

Caution: *Tag hoses and cables for identification before disconnecting in order to facilitate reinstallation. Plug all openings to prevent dirt from entering the system.*

Note: *No parts within the ECM are serviceable. If found defective, replace the complete ECM unit.*

1. Disconnect the battery or batteries from the starting system by removing one or both of the battery cables from each battery system. With the electrical circuit disrupted, accidental contact with the starter button will not produce an engine start. In addition, the Electronic Unit Injectors (EUI) will be disabled, preventing any fuel delivery to the injector tips.

Warning: *Due to the heavy load of the rear bumper assembly, it must be adequately supported before attempting to remove it.*

2. Remove the rear bumper assembly from the vehicle. Refer to Section 18, BODY, under "REAR BUMPER REMOVAL ".
3. Drain the engine cooling system. Refer to Section 05, COOLING under "DRAINING COOLING SYSTEM".

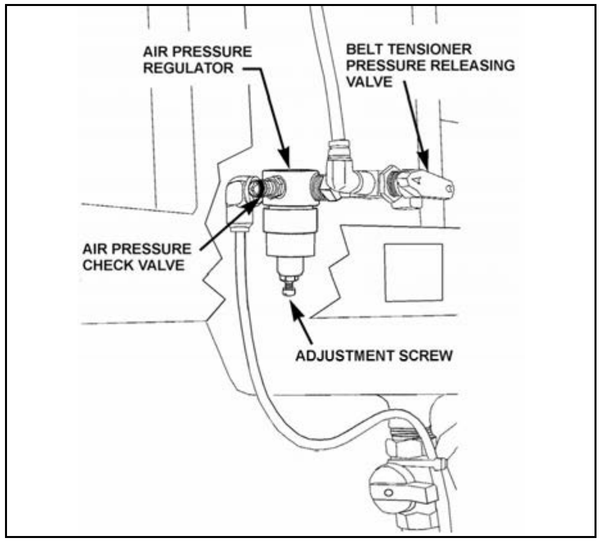


FIGURE 12: BELT TENSIONER VALVE 12200

4. Locate the belt tensioner pressure releasing valve (Fig. 12). Turn pressure releasing valve handle counterclockwise in order to release pressure in belt-tensioner air bellows and loosen belts. Remove the belts.
5. To release all pressure from the air system. Refer to Section 12, BRAKES & AIR SYSTEM for instructions.
6. Disconnect and remove the engine-air intake duct mounted between air cleaner housing and turbocharger inlet (1, Fig.14).

Caution: *To avoid damage to turbocharger, cover the turbocharger inlet opening to prevent foreign material from* entering.

7. Disconnect and remove the air intake duct mounted between the air cooler outlet and the engine intake (2, Fig.14).
8. Disconnect and remove section of coolant pipe assembly mounted between the radiator outlet and the water pump inlet (3, Fig.14).
9. Disconnect the coolant delivery hose located close to the water pump.
10. Disconnect the electric fan-clutch connector, close to the water pump (Fig. 14).
11. Dismantle the air bellows from the upper bracket of the fan-drive assembly tensioner. Remove the upper bracket (4, Fig.14).
12. If necessary, remove the fan drive from the engine compartment by removing the four retaining bolts, washers and nuts securing the fan drive to the floor.

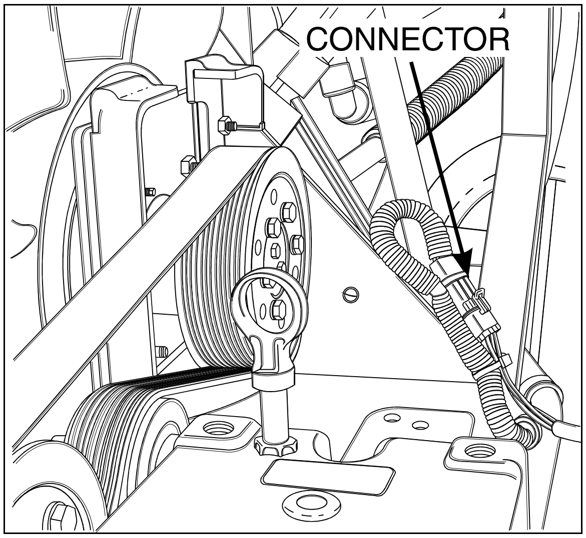


FIGURE 13: ELECTRIC FAN-CLUTCH CONNECTOR 010XX

13. Disconnect and remove the air intake duct mounted between the turbocharger outlet and the air cooler inlet (5, Fig. 14).

14. Disconnect two vent hoses from the thermostat housing and from the coolant pipe assembly.

15. Disconnect and remove a section of coolant pipe assembly mounted between the thermostat housings and the radiator inlet.

16. Disconnect and remove the small hose connected to the heater line valve and to the water pump.

17. Disconnect the small heater hose located on the cylinder head at the back of the engine.

18. Disconnect and remove the exhaust pipe mounted between the turbocharger outlet and the exhaust bellows. If necessary, refer to Section EXHAUST SYSTEM under MUFFLER REMOVAL AND INSTALLATION".

Caution: *To avoid damage to turbocharger, cover the turbocharger outlet opening to prevent foreign material from entering.*

19. Disconnect the steel-braided airline from the A/C compressor air bellows.

20. Disconnect the power steering pump supply and discharge hoses. Cap hose openings immediately to limit fluid loss. Remove retaining clips from cradle (6, Fig. 14).

21. Disconnect the oil delivery hose from the valve located at the reserve tank drain (7, Fig. 14).

22. Disconnect the block heater connector from the power steering pump if applicable (8, Fig. 16).

23. Close engine fuel supply shutoff valve on primary fuel filter. Disconnect the fuel line connected to inlet port. On vehicles equipped with the optional water-separator-fuel-filter, disconnect the connector and remove cable ties from cradle.

24. Disconnect the air compressor discharge, governor steel-braided airlines and manual filling airlines from compressor. Remove retaining clips.

25. Disconnect the hose connecting the compressor head to the sump tank.

26. Disconnect ground cables from rear subframe ground-stud located close to the starter motor.

27. Disconnect positive cable (red terminal) from starting motor solenoid.

28. Disconnect the power plant wiring-harness main connectors from ECM and remove retaining clips from engine compartment backwall.

29. On vehicles equipped with an automatic transmission provided with a hydraulic output retarder, disconnect steel-braided airline from pressure regulator output. The pressure regulator is mounted in the upper section of engine compartment backwall and is accessible through the engine compartment R.H. side door.

30. Disconnect fuel return line from bulkhead fixed on engine cylinder head end.

31. On vehicles equipped with an electrically operated cold-starting aid, disconnect the delivery hose from the starting-aid cylinder solenoid valve. Remove cable ties securing hoses.

32. Disconnect turbo boost pressure gauge airline from engine air intake.

33. Only if the vehicle is equipped with a retarder, remove the transmission rubber-damper assembly above transmission by removing: nut, bushing, rubber damper, rubber damper guide, bolt and washer. Remove the rubber damper bracket from transmission.

34. Disconnect connectors from transmission. On the left side: four on rear side with one close to yoke. On right side: close to the solenoid valve of the output retarder.

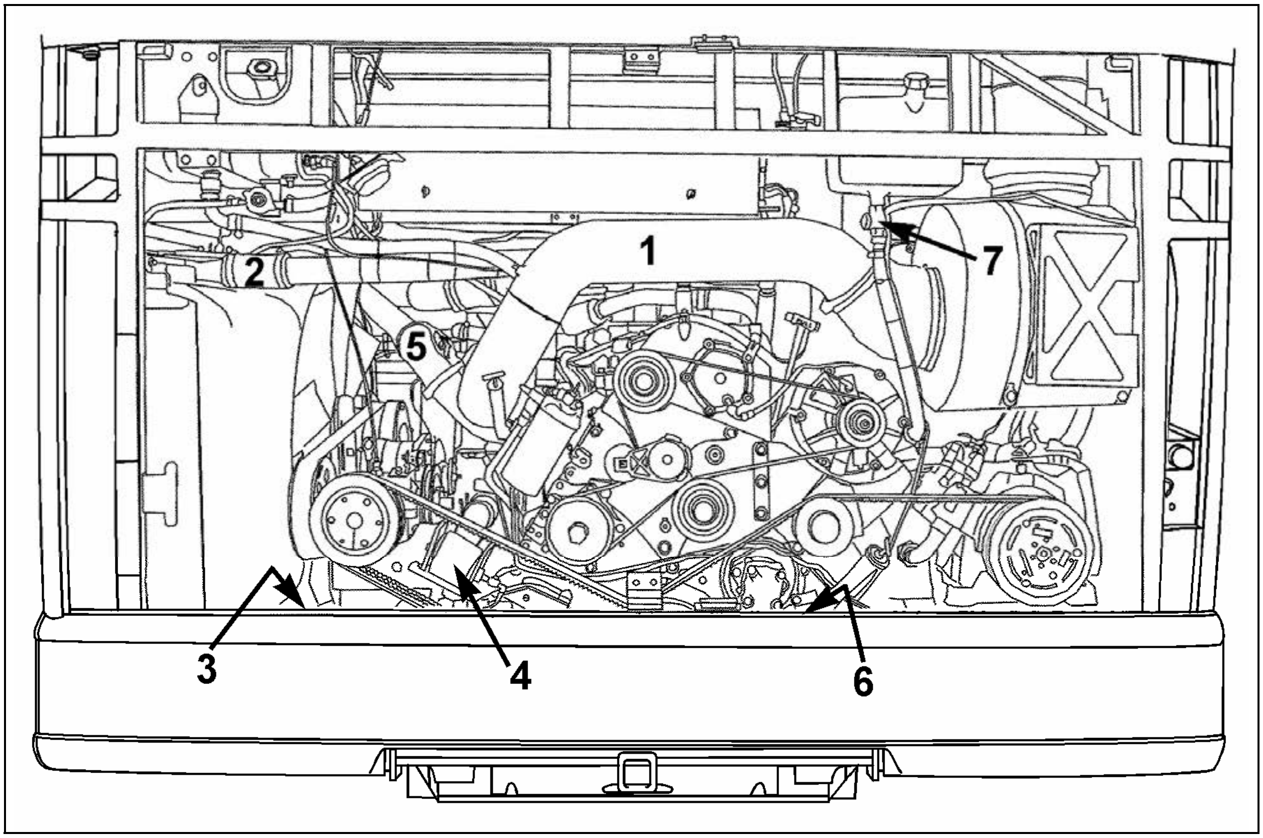


FIGURE 14: ENGINE COMPARTMENT XL2 MTH (TYPICAL) 01112

35. From under the vehicle, disconnect the propeller shaft as detailed in Section 09, under heading "Propeller Shaft Removal".

36. Inspect the power plant assembly to ensure that nothing will interfere when sliding out the cradle. Check for connections or hoses not mentioned in this list as some vehicles are equipped with special or aftermarket components.

37. Remove the six retaining bolts, washers and nuts securing the power plant cradle to the vehicle rear subframe (Fig. 16).

***Note**: Check if any spacer(s) have been installed between power plant cradle and vehicle rear subframe, and if so, note position of each washer for reinstallation purposes.*

38. Using a forklift, with a minimum capacity of 4,000 lbs (1 800 kg), slightly raise the power plant cradle.

39. Pull engine out slowly from the engine compartment. Make sure all lines, wiring and accessories are disconnected and are not tangled.

***Caution**: Due to the minimum clearance between the power plant equipment and the top of the engine compartment, extreme care should be used to raise the power plant cradle, just enough to free the cradle. Clearance between power plant cradle and mounting rail should range between ¼" and ½" (6-12 mm).*

9. POWER PLANT ASSY. INSTALLATION

To install a power plant assembly, follow the same procedure as in "Power Plant Assembly Removal" except in reverse order, then proceed with the following:

1. Torque the power plant cradle mounting bolts to 113-144 lbf•ft (153-195 N•m).

- For vehicles equipped with an Allison automatic transmission and a retarder:

  a) Install transmission bracket (Fig. 15), tighten to 71-81 lbf•ft (96-110 N•m).

  b) Install the transmission's rubber damper assembly above transmission by assembling: bolt, washer, rubber damper guide, rubber damper, bushing nut.

  c) Respect damper tolerance of 58 mm (Fig. 15)

2. If fan drive has been removed, reinstall and align as per Section 05, COOLING SYSTEM, under "FAN DRIVE ALIGNMENT".
3. Refill cooling system with saved fluid (refer to Section 05, COOLANT SYSTEM).
4. Once engine fuel system has been drained, it will aid restarting if fuel filters are filled with fuel oil (refer to Section 03, FUEL SYSTEM).

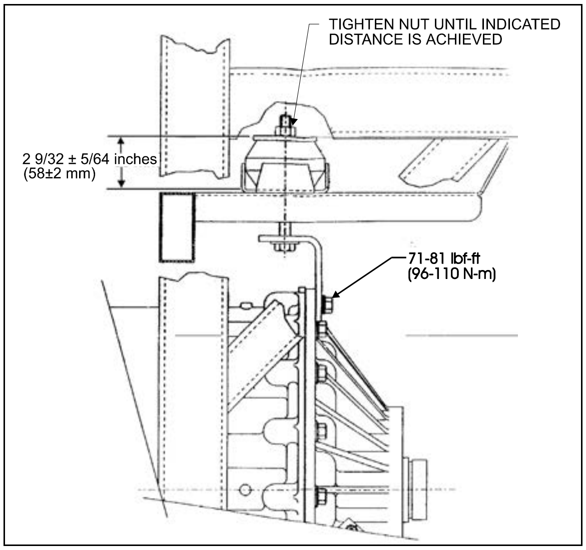


FIGURE 15: RUBBER DAMPER TOLERANCE 07014

5. Start engine for a visual check. Check fuel, oil, cooling, pneumatic and hydraulic system connections for leakage. Test operation of engine controls and accessories.

10. VALVE COVER REMOVAL

Refer to the series 60 detroit diesel service manual for injectors and valves adjustment. Access to engine cover differs depending on vehicle model.

Wait until engine is cold prior to working on vehicle.

10.1 XL2-45 COACHES AND MOTORHOMES

1. Remove air intake pipe.
2. Remove the after CAC (Charger-Air-Cooler) air pipe.
3. Disconnect ventilation pipe from valve cover.
4. Remove trap door located in the middle rear end of vehicle.

Note : *On coaches, last seat has to be removed to access trap door. On motorhomes, it will depend on interior design.*

5. Remove engine cover.
6. Adjust Jake brakes (if applicable), injectors and valves using Detroit Diesel service manual for series 60 engines.
7. Verify engine cover gasket and replace if necessary.

Note : *New gasket must be ordered directly from Detroit Diesel.*

8. Reinstal engine cover with a tightening torque of 18-22 Lbf·ft (25-30 N·m).
9. Connect ventilation pipe to engine cover.
10. Reinstall air intake and after CAC air pipes.
11. Reinstall trap door, seats or interior finish for motorhomes.

11. JAKE BRAKE

Refer to both "The Jake Brake Troubleshooting and Maintenance Manual" and "Installation Manual for Model 790 Engine Brakes" for troubleshooting and installation procedures. They are annexed at the end of this section.

12. ENGINE MOUNTS

The power plant assembly is mounted to the cradle by means of four rubber mounts.

Two rubber mounts are used at the front of the engine while two others are mounted on each side of the flywheel housing on vehicles equipped with an automatic transmission (Fig. 16).

It is recommended that new rubber mounts be installed at each major overhaul.

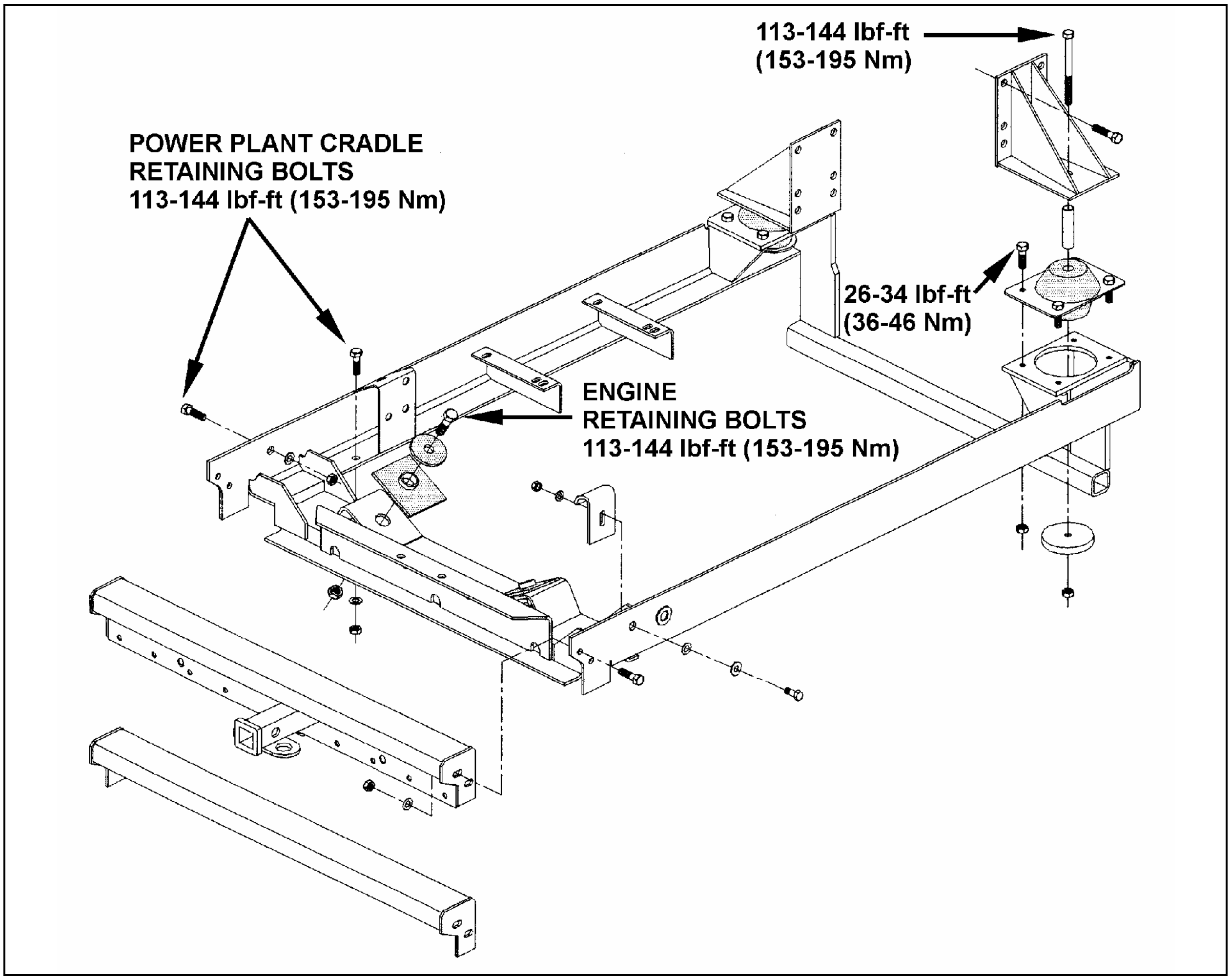
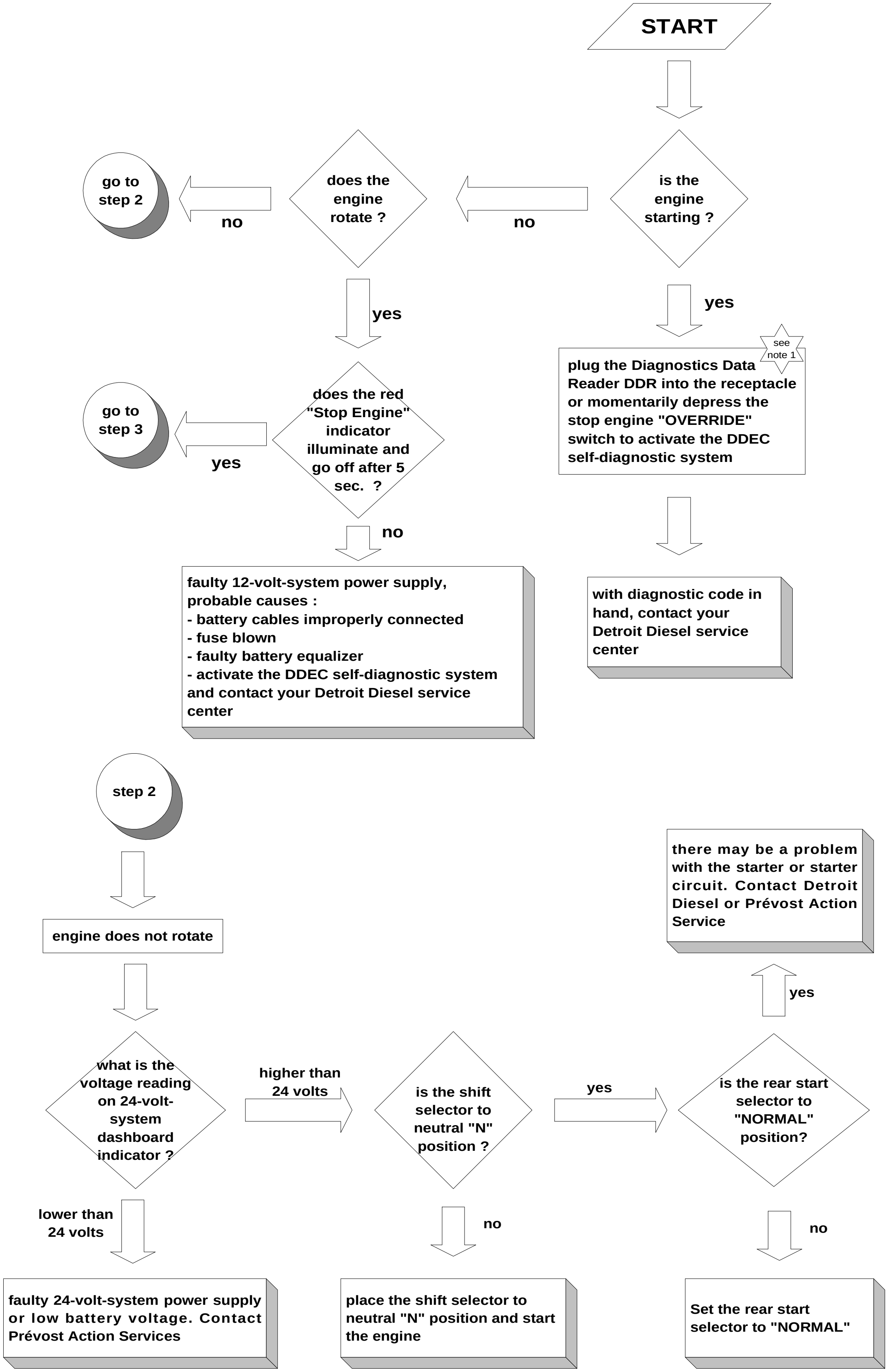
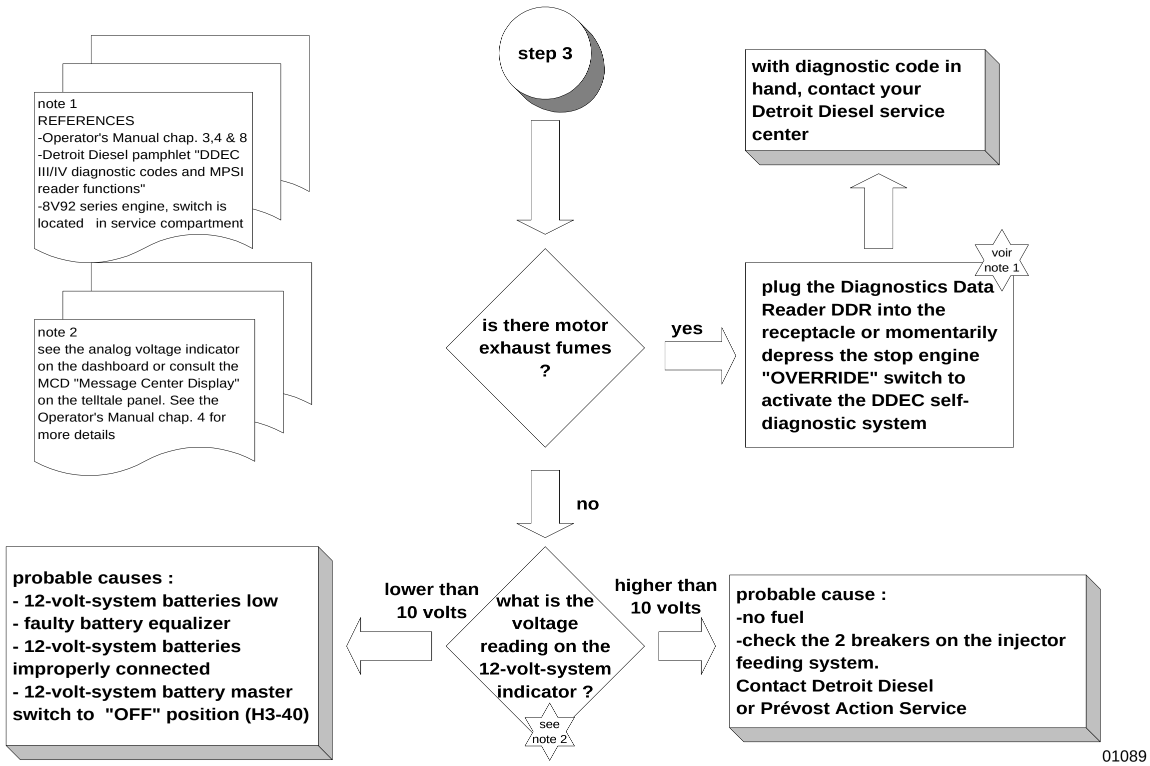


FIGURE 16: POWER PLANT CRADLE INSTALLATION 01107

13. ENGINE TROUBLESHOOTING GUIDE





14. SPECIFICATIONS

Series 60 Engine

Make	Detroit Diesel
Type	Diesel four cycle/in-line engine
Description	Turbo/Air to air charge cooled
No. of cylinders	6
Operating range	1200-2100 RPM
Maximum RPM	2100

Lubricant

Heavy-duty engine oil SAE Viscosity Grade 15W-40, API Classification CI-4. Synthetic oil may be used if it meets the performance and chemical requirements of non-synthetic oils outlined previously. Some engine operating conditions may require exceptions to this recommendation.

Caution*: To avoid possible engine damage, do not use single grade (Monograde) lubricants in Detroit Diesel four-cycle Series 60 engines, regardless of API classification.*

Detroit Diesel Series 60 engine ratings

Series 60 engine ratings used in Prevost Car Models are listed in the following tables. The standard engine ratings are written in bold, customer may easily switch from one rating to another within the same table by having the DDEC IV system reprogrammed.

Coach Base Engine (12.7L)	
350 HP	**@2100 rpm; 1350 lb-ft @1200 rpm**

Coach Standard Engine (12.7L)	
375 HP	@2100 rpm; 1450 lb-ft @1200 rpm
400 HP	**@2100 rpm; 1450 lb-ft @1200 rpm**
430 HP	@2100 rpm; 1450 lb-ft @1200 rpm
375/430 HP	@2100 rpm; 1450 lb-ft @1200 rpm

XL2 Entertainer & 40' MTH Engine (12.7L)	
375 HP	@2100 rpm; 1550 lb-ft @1200 rpm
400 HP	@2100 rpm; 1550 lb-ft @1200 rpm
430 HP	**@2100 rpm; 1550 lb-ft @1200 rpm**
375/430 HP	@2100 rpm; 1550 lb-ft @1200 rpm

XL2 45' & VIP 45' MTH Engine (14.0L)	
435 HP	@2100 rpm; 1650 lb-ft @1200 rpm
475 HP	@2100 rpm; 1650 lb-ft @1200 rpm
500 HP	**@2100 rpm; 1650 lb-ft @1200 rpm**
435/500 HP	@2100 rpm; 1650 lb-ft @1200 rpm

Capacity

Oil reserve tank....................8.4 US qts (8.0 L)

Engine oil level quantity

Oil Pan Capacity, Low Limit.................... 26 quarts/25 liters

Oil Pan Capacity, High Limit.................... 32 quarts/30 liters

Total Engine Oil Capacity with Filters.................... 38 quarts/36 liters

Lubricating oil filter elements

Make .... AC Rochester Div. GMC # 25014505

Make ....A/C Filter # PF-2100

Type .... Full Flow

Prévost number 510458

Torque specification

Engine oil filter ....Tighten 2/3 of a turn after gasket contact

Filters

Engine Air Cleaner Filter

Make....................Nelson # 70337-N

Prévost number 530197

Engine Coolant Filter/Conditioner

Make.................... Nalco Chemical Company # DDF3000

Make....................Detroit Diesel # 23507545

Prévost number 550630

Note: *For primary and secondary fuel filters, refer to Specifications in section 03.*

4. Install the bolts that secure the accessory drive housing to the gear case cover and tighten to 30–38 N·m (22–28 lb·ft) torque using the pattern shown. See Figure 1–413.

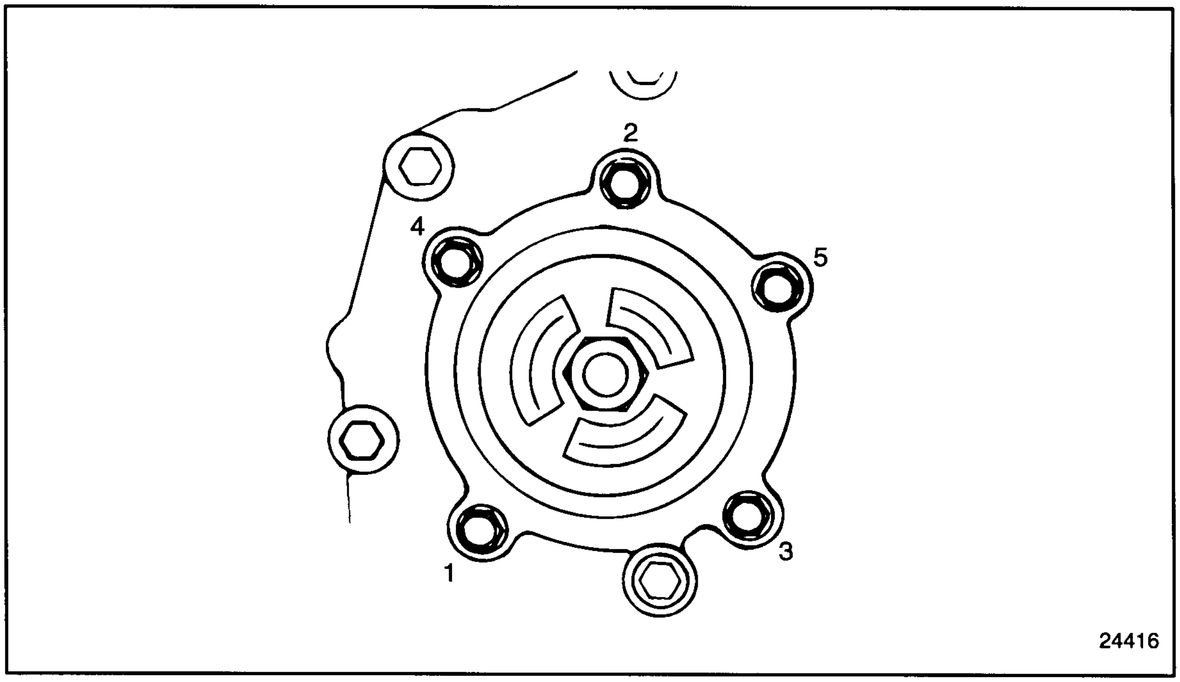


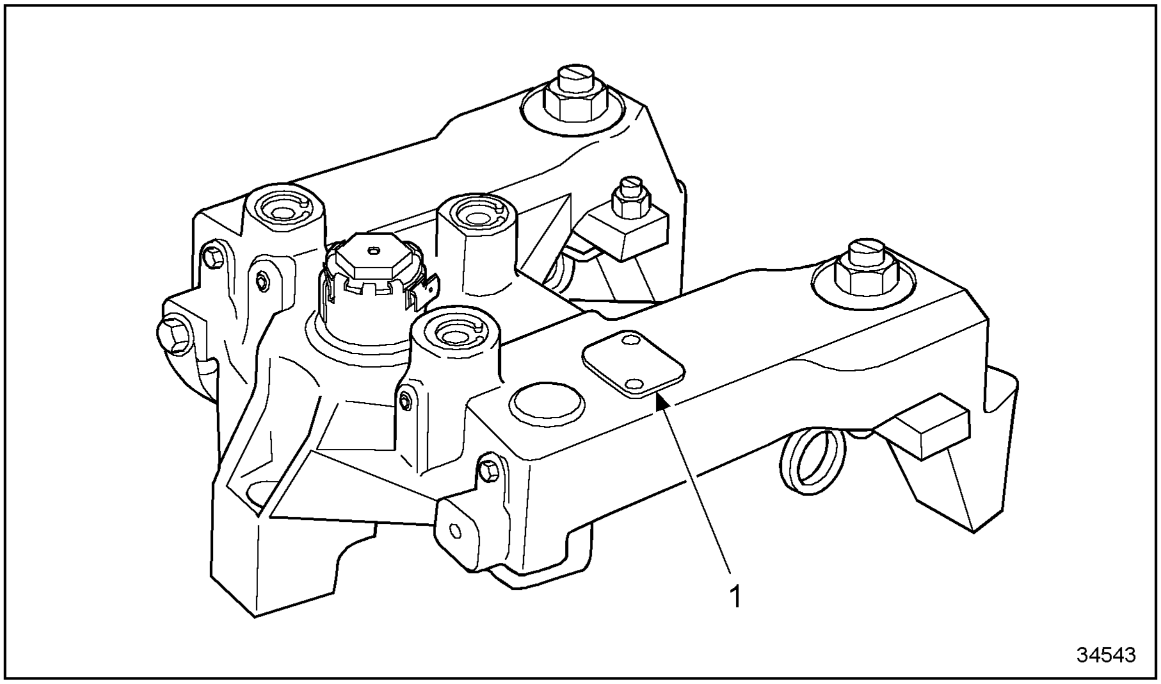
Figure 1-413 Accessory Drive Housing Bolt Torque Sequence

5. Check the bull gear-to-accessory drive gear backlash. Refer to section 1.21.2.1.
6. Adjust the alternator belts. Refer to section 13.12.10.
7. Tighten the alternator mounting bolts.
8. Install any other components removed for this procedure.
9. Refer to section 11.3 for verification of proper accessory drive installation.

1.29 JAKE BRAKE

The engine brake has been designed to fit on the Series 60 engine with no additional valve cover spacers. There are three styles of valve covers for the Series 60 engine. On engines equipped with a two-piece aluminum valve cover, it is NOT necessary to remove the lower valve cover to install the engine brake. However, one style of upper valve cover may require modification at the breather housing location (inside) for engine brake clearance.

The model, part number and serial number are located on the nameplates at the top of each housing. See Figure 1-414.



1. Identification Plate

Figure 1-414 Nameplate Location on Housing

NOTICE:
Only the specific brake model can be used with the engine model it was designed for. Also, the correct slave piston adjustment specification must be used. Failure to follow these instructions may result in serious engine or engine brake damage.

Listed in Table 1-9 are the different Jake Brake models used and the slave piston adjustment specification.

Model Number	Model Year	Engine Displacement	Engine Brake	Slave Piston Adjustment
6067WU40	Pre-1991	11.1L	760/760A	0.660 mm (0.026 in.)
6067GU40	Pre-1991	12.7L	760/760A	0.508 mm (0.020 in.)
6067WU60	1991	11.1L	760/760A	0.660 mm (0.026 in.)
6067GU40	1991	12.7L	765	0.660 mm (0.026 in.)
6067GU28	1991	12.7L	765	0.660 mm (0.026 in.)
6067GU91	1991	12.7L	765	0.660 mm (0.026 in.)
6067WK60	1994	11.1L	760A	0.660 mm (0.026 in.)
6067GK60	1994	12.7L	765	0.660 mm (0.026 in.)
6067GK28	1994	12.7L	765	0.660 mm (0.026 in.)
6067EK60	1998	11.1L	760B	0.584 mm (0.023 in.)
6067PK60	1998	12.7L	765A	0.584 mm (0.023 in.)
6067TK60	1998	12.7L	765A	0.584 mm (0.023 in.)
6067TK45	1998	12.7L	765A	0.584 mm (0.023 in.)
6067MK60	1998	12.7L	770	0.660 mm (0.023 in.)
6067BK60	1998	12.7L	770	0.660 mm (0.023 in.)
6067HKXX	1998 (Non-Line Haul)	14L	770	0.660 mm (0.023 in.)
6067MK28, 6067MK45, 6067MK57, 6067MK60	2000	12.7L Standard	790	0.660 mm (0.026 in.)
6067BK28, 6067BK45, 6067BK57, 6067BK60	2000	12.7L Premium	790	0.660 mm (0.026 in.)
6067HK45, 6067HK60	2000	14L U.S.	790A	0.660 mm (0.026 in.)
6067WK28, 6067WK60	2000	11.1L	790B	0.660 mm (0.026 in.)
6067LK28, 6067LK45, 6067LK60	2000	11.1L	790B	0.660 mm (0.026 in.)
6063GK60, 6067GK28, 6067GK45, 6067GK91, 6067PK62, 6067TK28, 6067TK60, 6067TK62	2000	12.7L	790B	0.660 mm (0.026 in.)
6067HK62	2000	14L Australian	790C	0.660 mm (0.026 in.)

All slave piston adjustments shown here are current as of the date of this manual and supersede all previous adjustments.

XXXX = Model numbers to be determined.

Table 1-9 Jake Brake Model Information

NOTE:
All engines built after serial number 06R0004455 have the correct engine parts for engine brake installation. The model numbers have changed because of design changes in the engine brakes.

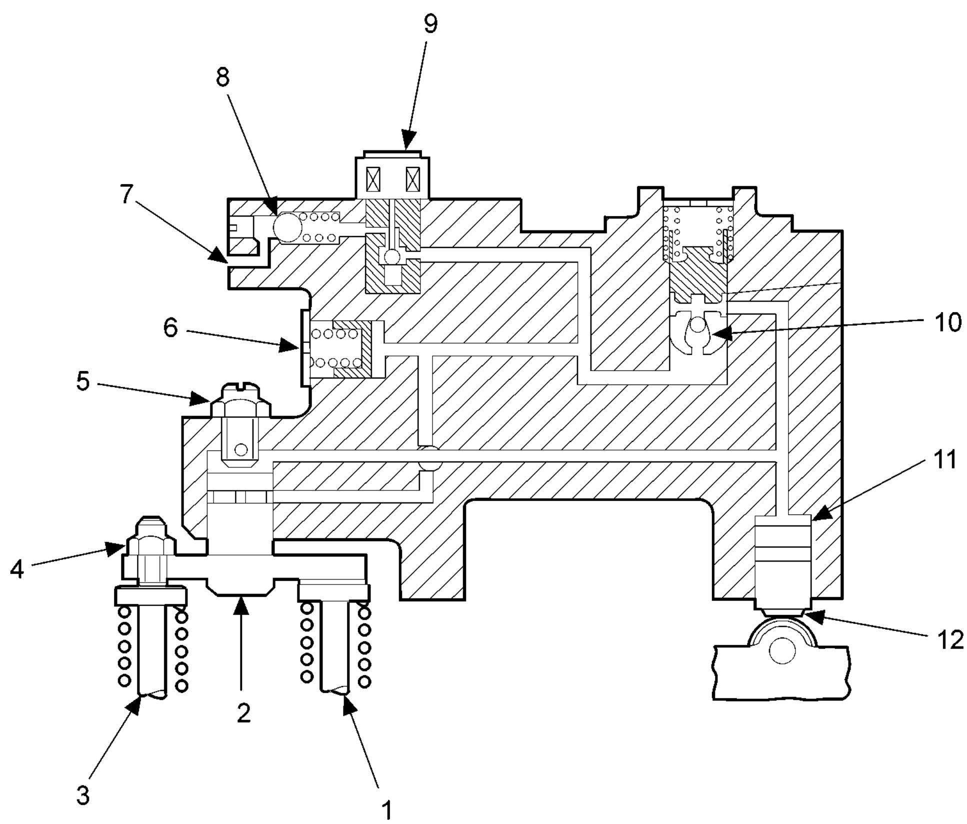
NOTE:
All Series 60 engines with serial numbers 06R0004455 or higher are Jake Brake ready. Do not install a Jake Brake on engines with lower serial numbers.

Effective December 16,1999, Model 790 Jake Brakes are used on all Series 60 engines requiring an engine brake.

Former Jake Brake production models for the Series 60 engine were the 760A (which replaced model 760), 760B, 765, 765A, and 770.

Detroit Diesel engine model Nos. 6067GU28 and 6067GK28 are for bus/coach applications. Due to interference fits on some coach chassis, a two-housing Jake Brake kit may be required. Contact your Detroit Diesel Distributor for information on these kits.

Energizing the engine brake effectively converts a power-producing diesel engine into a power-absorbing air compressor. This is accomplished through motion transfer using a master-slave piston arrangement which opens cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust. See Figure 1-415.



1. Exhaust Valve
2. Slave Piston Assembly
3. Exhaust Valve
4. Leveling Screw
5. Slave Piston Adjusting Screw
6. Accumulator
7. Oil In
8. Check Valve (Model 760)
9. Solenoid Valve
10. Control Valve
11. Master Piston
12. Injector Pin and Roller

Figure 1-415 Jake Brake Schematic

The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion stroke, the effect being a net energy loss, since the work done in compressing the cylinder charge is not returned during the expansion process.

Exhaust blowdown occurs as the energized solenoid valve permits engine lube oil to flow under pressure through the control valve to both the master piston and the slave piston. See Figure 1-415.

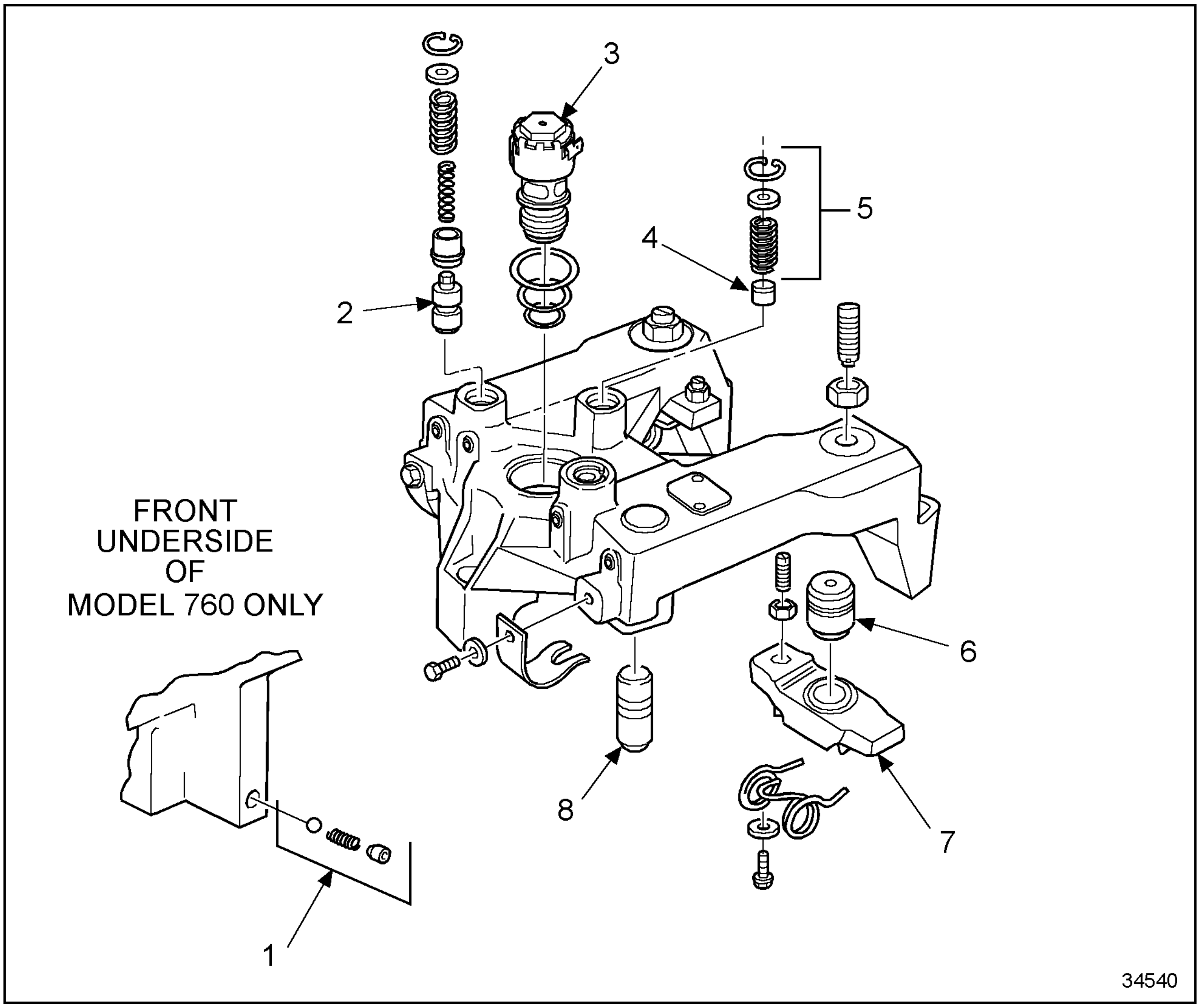
Oil pressure causes the master piston to move down, coming to rest on the injector rocker arm roller.

The injector rocker arm begins its travel as in the normal injection cycle, moving the master piston upward and directing high-pressure oil to the slave piston. The ball check valve in the control valve traps high-pressure oil in the master-slave piston system.

High pressure oil causes the slave piston to move down, momentarily opening the exhaust valves, while the engine piston is near its top-dead-center position, releasing compressed cylinder air to the exhaust manifold.

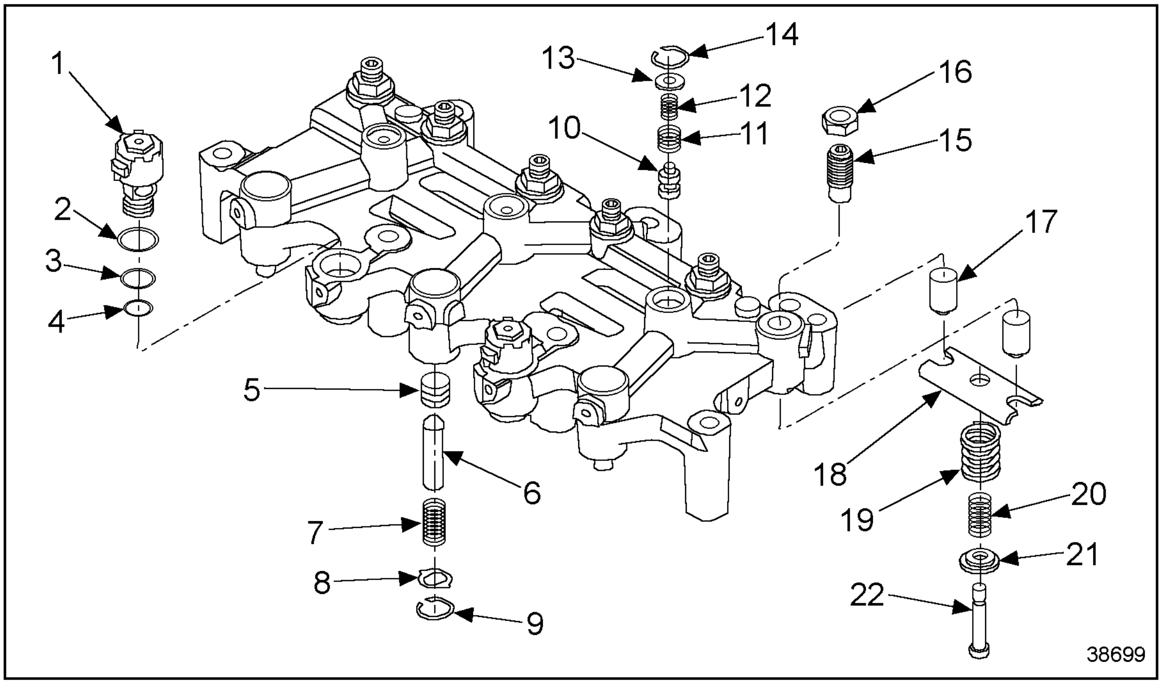
At the bottom of its stroke, the slave piston separates from the valve in the slave piston adjusting screw, allowing high pressure oil to flow into the accumulator. This reduces the pressure in the high pressure circuit, permitting the slave piston to retract and the exhaust valves to close in preparation 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. Compressed air escapes to the atmosphere, completing a compression braking cycle.

The Jake Brake is electronically controlled. Jake Brake control system wiring will vary depending on the vehicle manufacturer. For a general overview of the Jake Brake, see Figure 1-416 and see Figure 1-416a.



1. Ball Check Valve (Model 760 Only)
2. Control Valve
3. Solenoid Valve
4. Accumulator Piston
5. Power Lash Assembly
6. Slave Piston
7. Bridge
8. Master Piston

Figure 1-416 Typical Model 760, 765, or 770 Jake Brake Assembly



1. Solenoid Valve
2. Upper Seal
3. Center Seal
4. Lower Seal
5. Master Piston
6. Master Piston Pushrod
7. Master Piston Spring
8. Washer
9. Retaining Ring
10. Control Valve
11. Outer Control Valve Spring
12. Inner Control Valve Spring
13. Washer
14. Retaining Ring
15. J-Lash® Screw
16. Locknut
17. Slave Piston
18. Slave Piston Bridge
19. Outer Slave Piston Spring
20. Inner Slave Piston Spring
21. Slave Piston Spring Seat
22. Shoulder Bolt

Figure 1-416a Typical Model 790 Jake Brake Assembly

NOTICE:
This application and adjustment information must be strictly followed. Failure to follow these instructions may result in serious engine or engine brake damage.

1.29.1 Repair or Replacement of Jake Brake

To determine if repair is possible or replacement is necessary, perform the following procedure. See Figure 1-417.

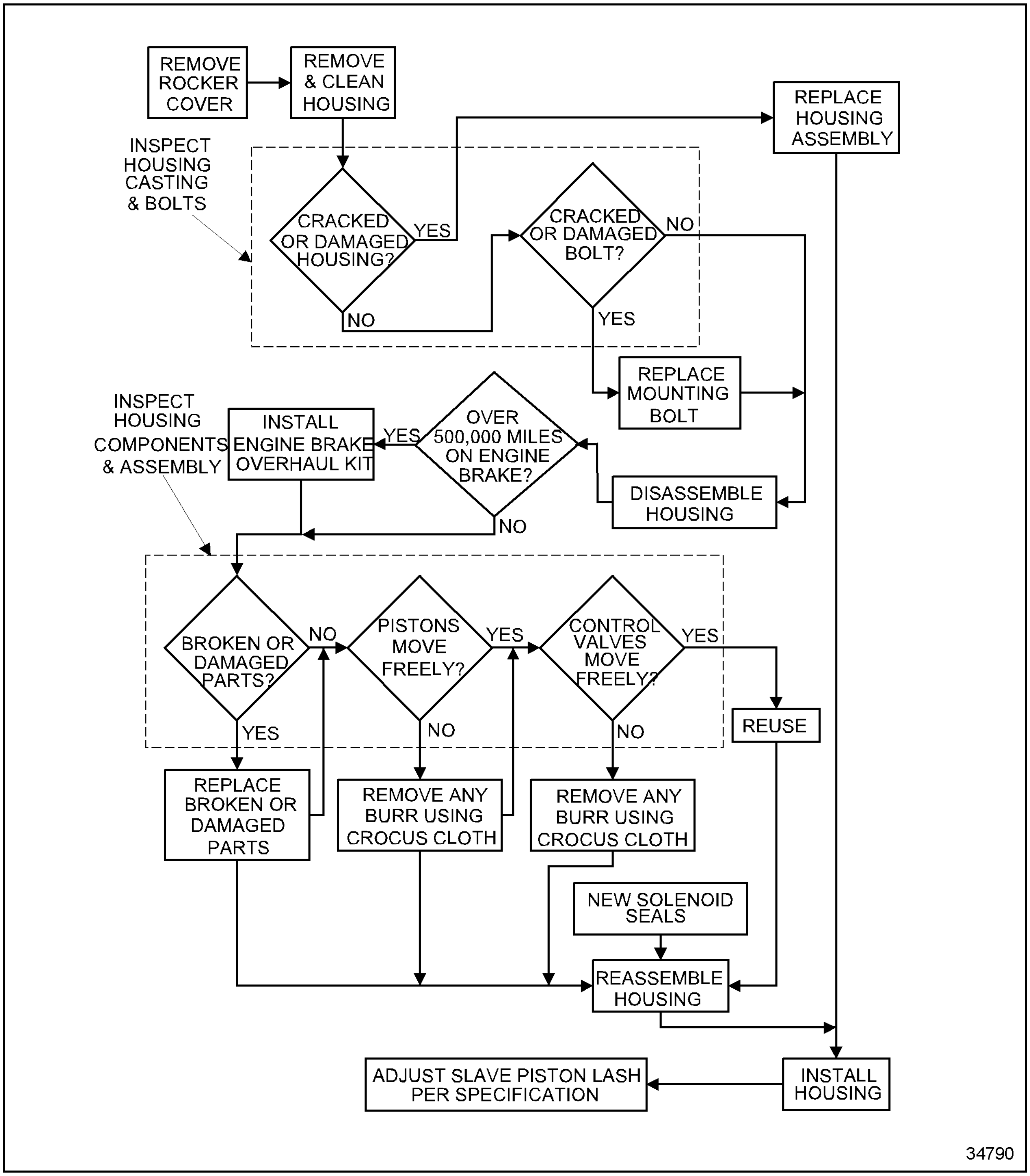


Figure 1-417 Jake Brake Repair or Replacement Flowchart

1.29.2 Removal of Model 760, 765, or 770 Jake Brake

Remove the model 760, 765, or 770 Jake Brake as follows:

NOTE:
The following procedures apply to Model 760, 765, and 777 Jake Brakes. For Model 790 Jake Brake removal procedures, refer to section 1.29.6.

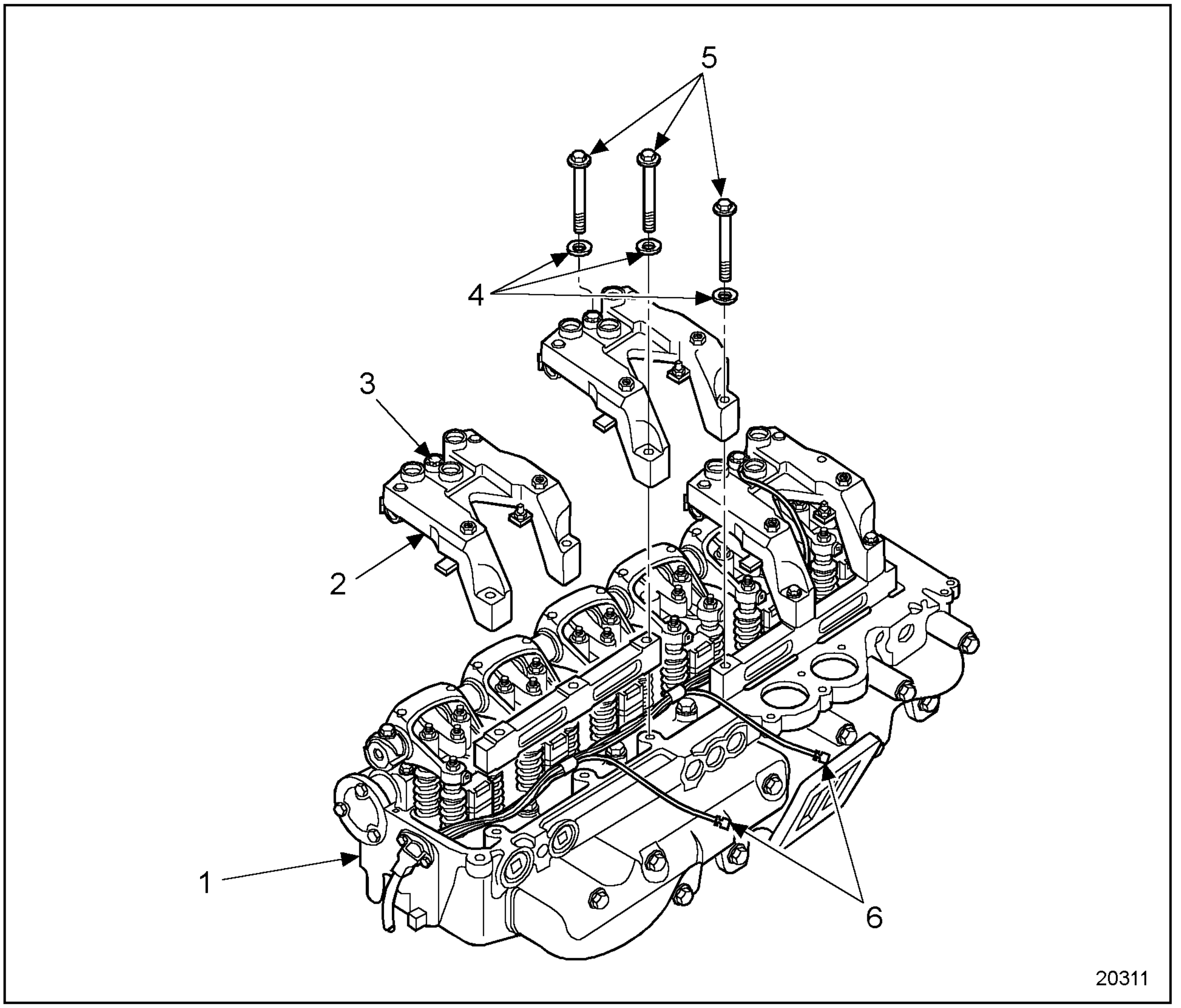
CAUTION:

To avoid possible personal injury, never remove any engine brake component with engine running.

1. Disconnect starting power for engine. Refer to OEM guidelines.
2. Remove the engine rocker cover. Refer to section 1.6.2 for one-piece, refer to section 1.6.3 for two-piece and refer to section 1.6.5 for three-piece.

NOTE:
If the engine is equipped with an aluminum two-piece valve cover, remove only the upper valve cover when installing the engine brake.

3. Note the location of the rocker arm shaft, the exhaust valve rocker arm, the fuel injector rocker arm, and the intake valve rocker arm.
4. Disconnect the solenoid wiring harness connectors from the engine brake solenoids. See Figure 1-418.



1. Cylinder Head
2. Jake Brake Assembly
3. Solenoid
4. Washers (3 each)
5. Mounting Bolts (3 each)
6. Engine Brake Harness

Figure 1-418 Jake Brake Assembly

5. Remove the nine mounting bolts and washers that secure the engine brake assemblies to the cylinder head. See Figure 1-418.

NOTE:

Only the Model 760 Jake Brake uses two different length mounting bolts. Six bolts, 120 mm (4.72 in.) long, are used on the exhaust side of the engine. Three bolts, 110 mm (4.33 in.) long, are used on the intake side of the engine. These bolts must be reinstalled in their correct positions.

6. Remove the engine brake assemblies and the spacer bar.

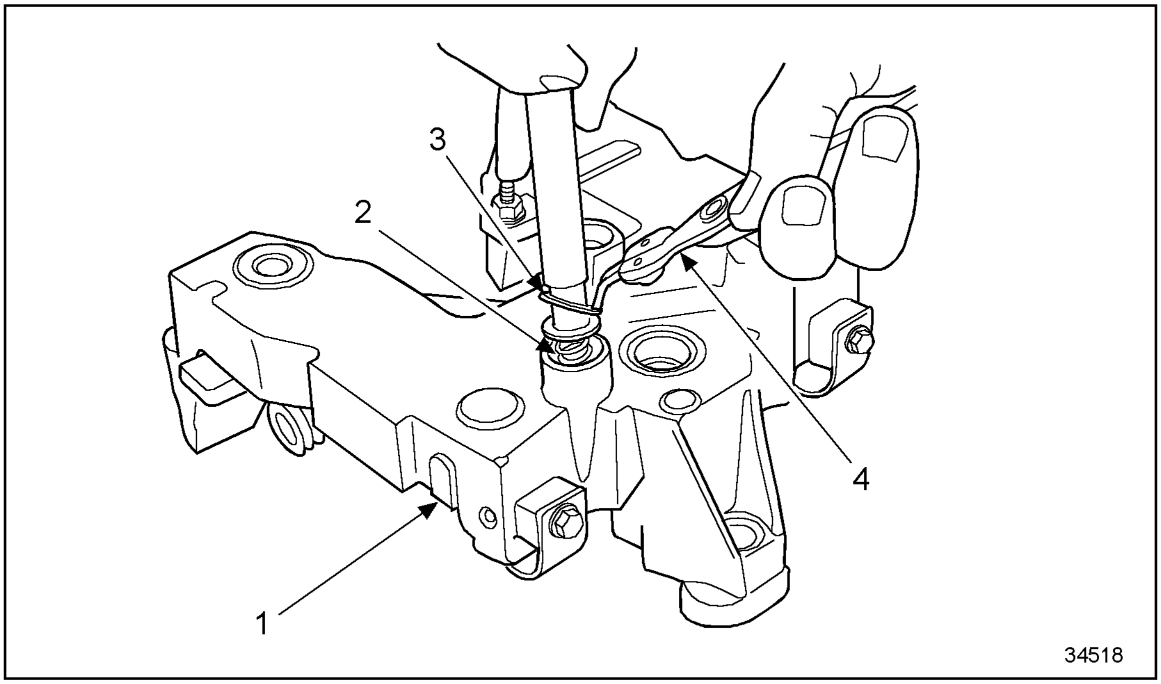
1.29.3 Disassembly of Model 760, 765, or 770 Jake Brake

Remove the control valve as follows:

CAUTION:

To avoid personal injury, remove control valve covers carefully. Control valve covers are under load from the control valve springs.

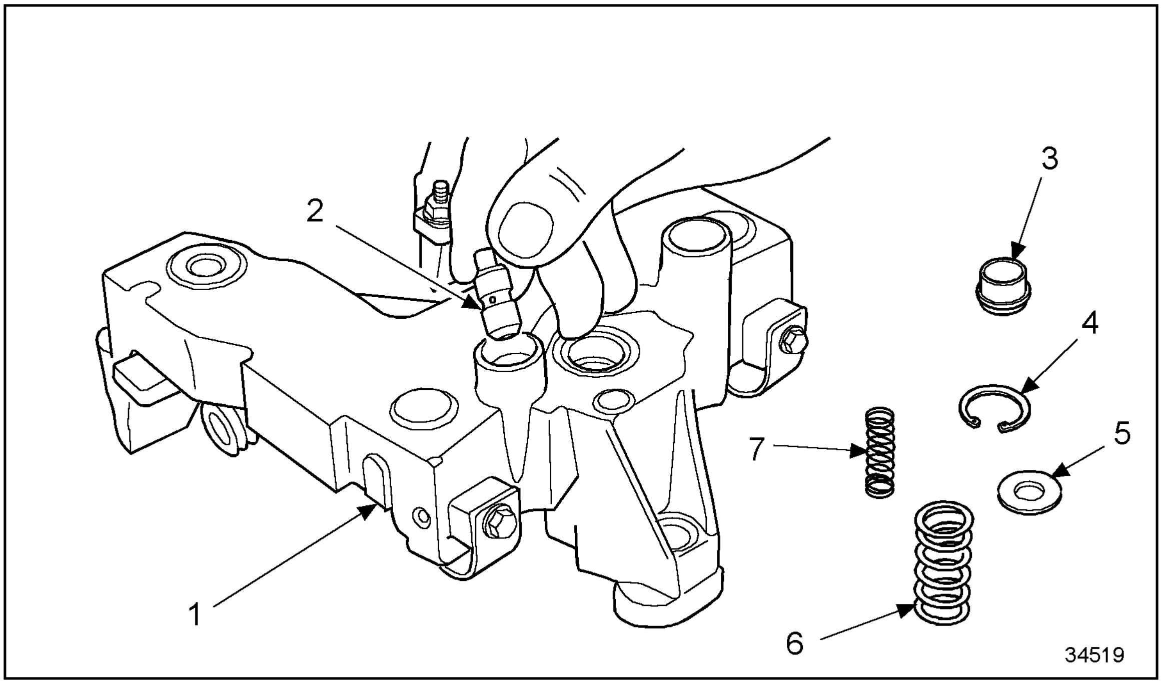
1. Press down on control valve washer using an appropriate diameter rod to relieve spring pressure. See Figure 1-419.



1. Jake Brake Assembly
2. Spring
3. Snap Ring Retainer
4. Snap Ring Pliers

Figure 1-419 Relieving Spring Pressure

2. Using retaining ring pliers, remove retaining ring.
3. Slowly remove cover until spring pressure ceases, then remove the two control valve springs and collar. See Figure 1-420.



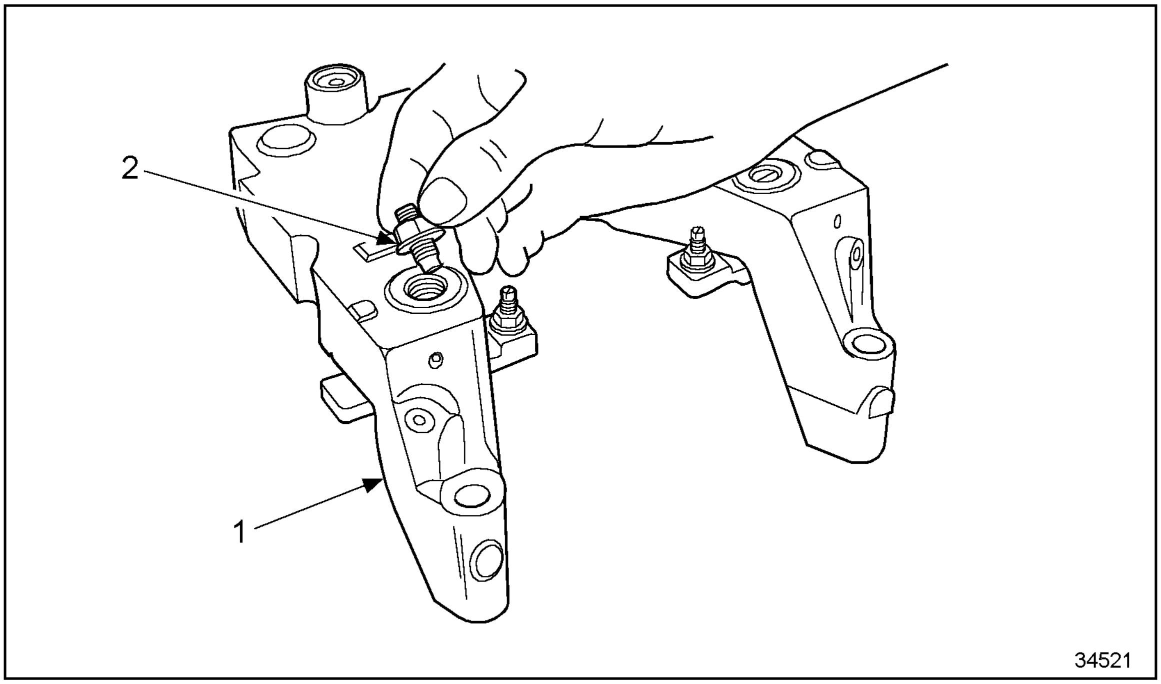
1. Jake Brake Assembly
2. Control Valve
3. Collar
4. Snap Ring Retainer
5. Washer
6. Collar Spring
7. Control Valve Spring

Figure 1-420 Removing Control Valve Springs and Collar

4. Using needle-nose pliers, reach into the bore and grasp the stem of the control valve. Remove control valve.

Remove the slave piston adjusting screw as follows:

1. Loosen slave piston adjusting screw locknut.
2. Remove adjusting screw from housing. See Figure 1-421.



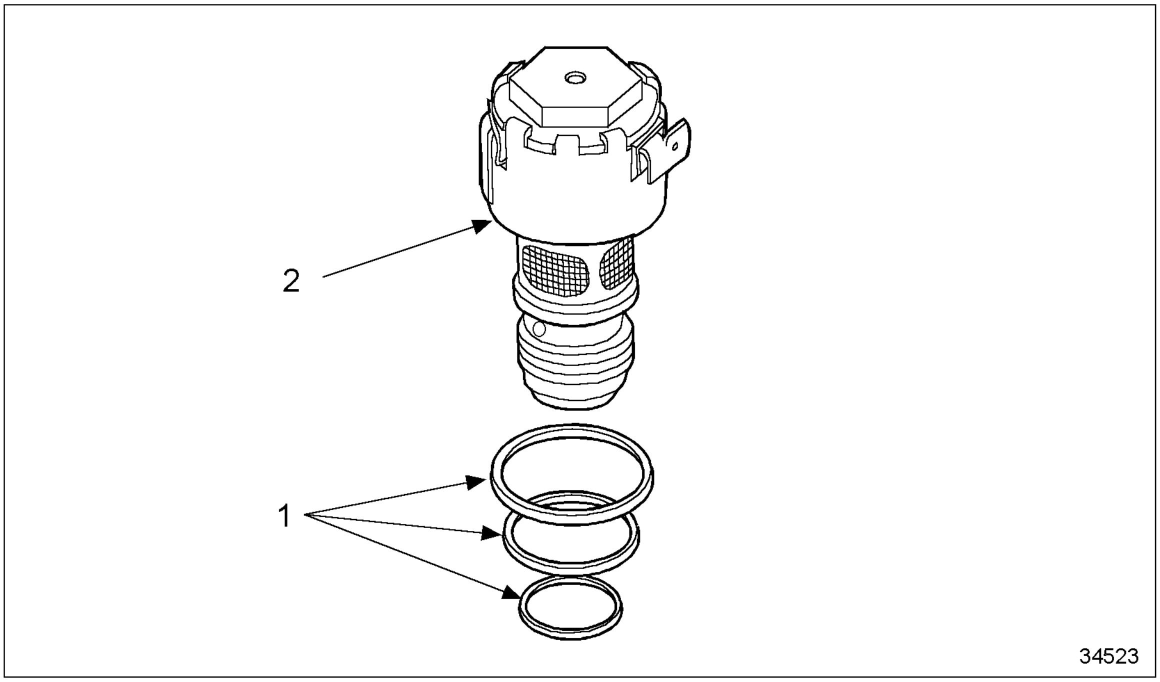
1. Jake Brake Assembly
2. Slave Piston Adjusting Screw

Figure 1-421 Removing Slave Piston Adjusting Screw

Remove the solenoid valve as follows:

NOTICE:
To avoid possible engine damage, do not disassemble or tamper with the solenoid valve.

1. Disconnect solenoid valve harness.
2. Using a 7/8 in. socket and extension for former solenoids or a 3/4 in., 6 point socket and extension for current solenoids, unscrew solenoid valve.
3. Remove and discard the three rubber seal rings. See Figure 1-422.



1. Seal Rings (3)
2. Solenoid

Figure 1-422 Removing Rubber Seal Rings

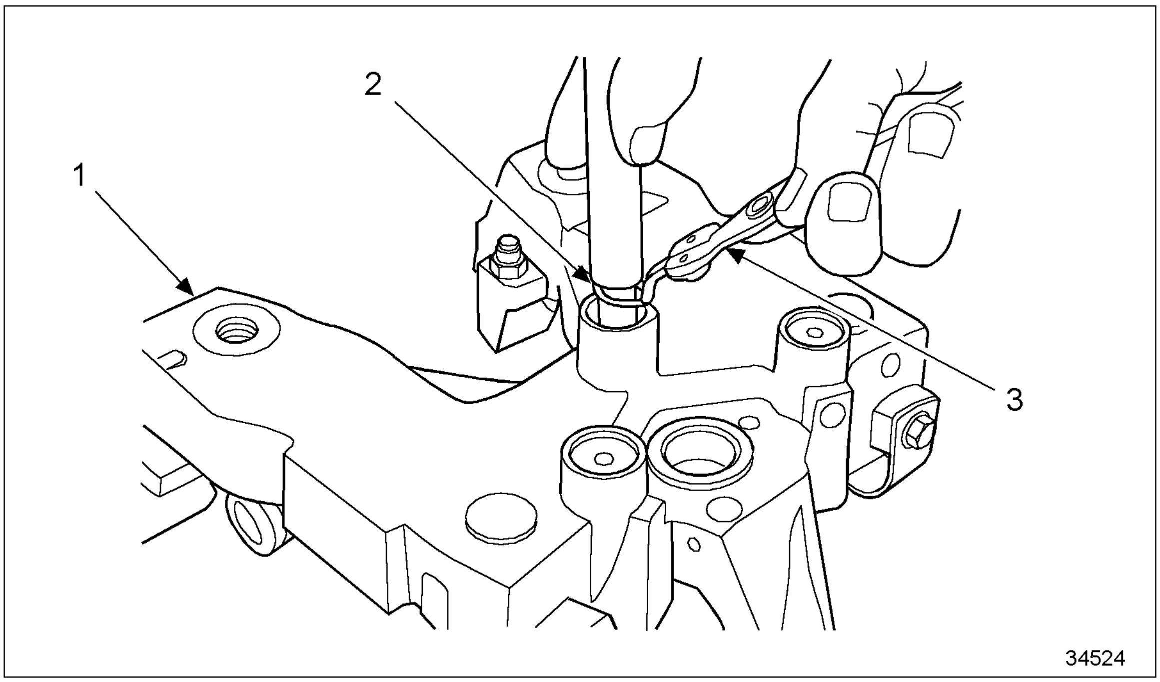
4. If the lower ring stays in the bottom of the housing bore, remove with a piece of wire.

Remove the accumulator as follows:

CAUTION:

The accumulator spring is under strong compression. To avoid possible personal injury if the accumulator spring is discharged, wear safety glasses and use caution when removing the retaining ring and cover.

1. Push down on the accumulator cover using the appropriate diameter rod, and remove the retaining ring. See Figure 1-423.

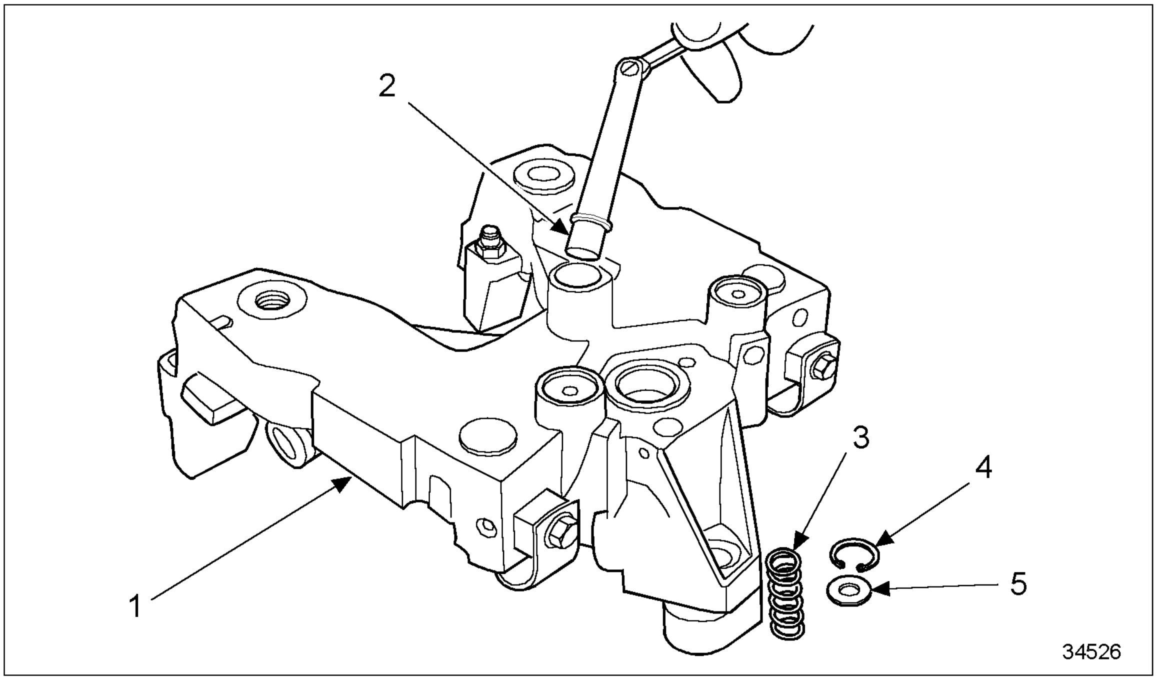


1. Jake Brake Assembly
2. Retaining Ring
3. Retaining Ring Pliers

Figure 1-423 Removing Retaining Ring

2. Relieve pressure on the accumulator cover.
3. Remove the cover and spring.

4. Use a magnet to remove the piston from the accumulator bore. See Figure 1-424.



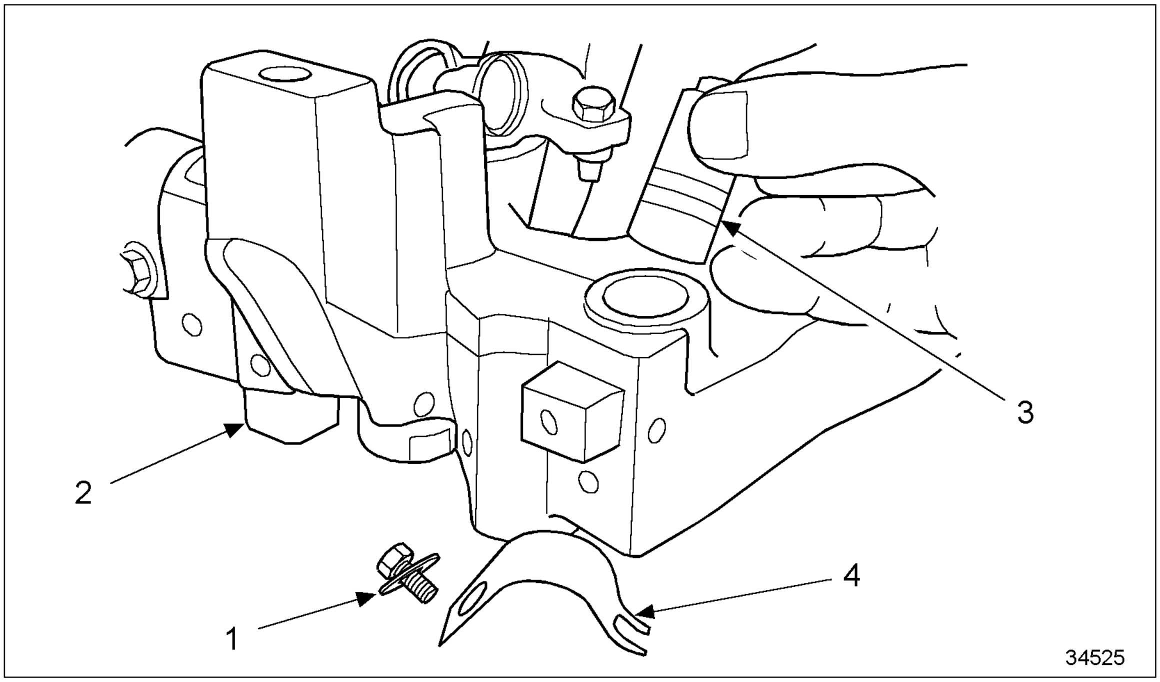
1. Jake Brake Assembly
2. Piston
3. Spring
4. Retaining Ring
5. Washer

Figure 1-424 Removing Piston from Accumulator Bore with Magnet

Remove the master piston as follows:

1. Remove the screw, washer, and master piston spring from the housing.
2. Remove the master piston. See Figure 1-425.

NOTE:
Use needle-nose pliers, if necessary.



1. Washer and Screw Assembly
2. Jake Brake Assembly
3. Master Piston
4. Master Piston Spring

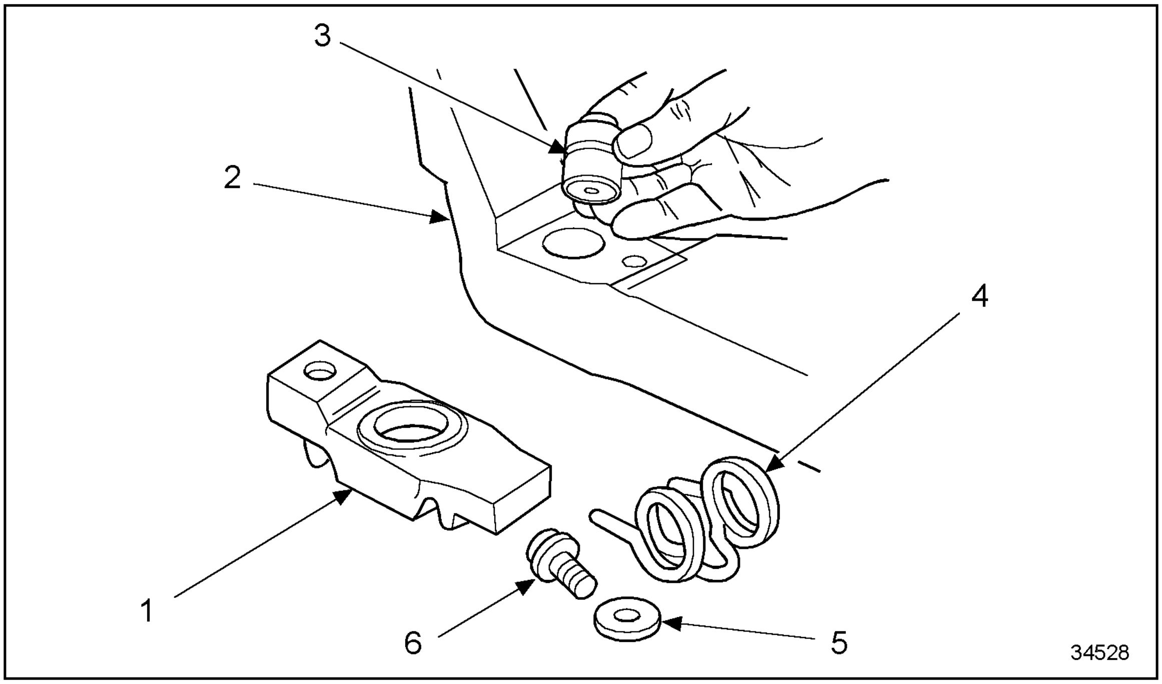
Figure 1-425 Removing The Master Piston

On Model 760 only, remove the ball check valve as follows:

1. Remove the plug.
2. Remove the ball check valve and spring.

Remove the slave piston as follows:

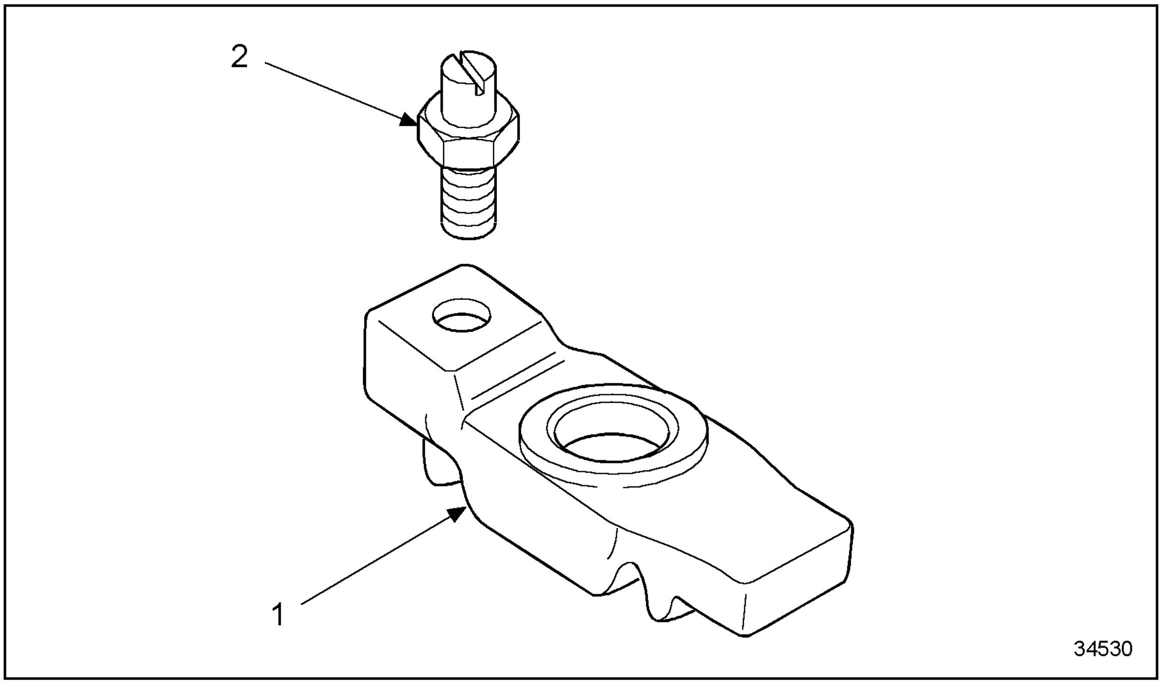
1. Remove the screw and spring that retains the slave piston return spring.
2. Remove the bridge and the slave piston. See Figure 1-426.



1. Slave Piston Bridge
2. Jake Brake Housing
3. Slave Piston
4. Return Spring
5. Washer
6. Screw

Figure 1-426 Removing Bridge and Slave Piston

3. Loosen the leveling screw locknut and remove the leveling screw from the bridge. See Figure 1-427.



1. Slave Piston Bridge
2. Slave Piston Leveling Screw

Figure 1-427 Removing the Leveling Screw from the Bridge

The injector rocker arm contains a pin and roller for actuating the engine brake master piston. If excessive wear or damage to the roller is present, replace the rocker arm assembly. Refer to Section 1.6.2.

1.29.3.1 Cleaning of Model 760, 765, or 770 Jake Brake

Clean the Jake Brake as follows:

NOTE:
Use an OSHA-approved cleaning solvent when washing parts. Be sure to coat parts with clean engine oil when reinstalling them.

1. Wash the control valves with approved cleaning solvent.
2. Push a wire through the hole in the base of the valve to the distance required to ensure that the ball check is free.

NOTE:
The ball should lift with light pressure on the wire.

CAUTION:

To prevent possible personal injury when using compressed air, wear adequate eye protection (face plate or safety glasses) and do not exceed 40 psi (276 kPa) air pressure.

3. Dry the valve with compressed air, and wipe clean with a paper towel.
4. Thoroughly clean the control valve bore in the housing using clean paper towels.
5. Clean slave piston adjusting screw in an approved cleaning solvent.
6. Clean out the solenoid valve bore in the housing.

NOTICE:

Use clean paper towels to clean the solenoid valve bore. Never use rags, as they may leave lint and residue which can plug the oil passageways, causing Jake Brake malfunction.

7. Clean the master piston in approved cleaning solvent.

1.29.3.2 Inspection of Model 760, 765, or 770 Jake Brake

The Jacobs engine brake is typically a trouble-free device. However, inspections are necessary and some maintenance is required. Use the following procedures to keep the engine brake in top condition.

Inspect the Jake Brake as follows:

1. Inspect slave piston adjusting screw for protrusion, spring pressure and freedom of movement.

NOTE:
The plunger should protrude from the bottom of the screw, have light spring pressure apparent when depressed, and move freely. Be sure the retaining ring is fully engaged in its groove (groove is located on the bottom of the reset screw and top of the POWER-LASH assembly).

   [a] If the plunger does not protrude, the spring does not have light pressure or does not move freely, replace the entire screw assembly. Refer to Section 1.29.4

   [b] If the slave piston adjusting screw meets specifications, continue with inspection.

2. Inspect the accumulator for wear or damage.

   [a] If worn or damaged, replace the accumulator. Refer to Section 1.29.4.

   [b] If accumulator is not worn or damaged, continue with inspection.

3. Inspect the master piston bore for wear or damage.

NOTE:
Some wear marks are permissible.

   [a] If worn or damaged, replace the master piston. Refer to Section 1.29.4.

   [b] If not worn or damaged, continue with inspection.

4. Apply clean lube oil to the piston, and insert into bore.

NOTE:
Master piston should move in and out freely with no binding.

   [a] If binding occurs, replace master piston and/or housing. Refer to Section 1.29.4.

   [b] If no binding occurs, continue with inspection.

5. Inspect master piston spring for relaxation.

NOTE:
The spring should hold the master piston completely in the housing.

   [a] If relaxed, replace the spring. Refer to Section 1.29.4.

   [b] If spring holds tightly, continue with inspection.

6. Inspect the ball check valve (Model 760 only) for wear or damage.
   [a] If worn or damaged, replace ball check valve. Refer to Section 1.29.4.
   [b] If not worn or damaged, proceed with inspection.
7. Inspect slave piston components for excessive wear or damage.
   [a] If worn or damaged, replace slave piston component.
   [b] If not worn or damaged, proceed with inspection.

1.29.3.3 Inspection of Control Valve

Inspect the control valve as follows:

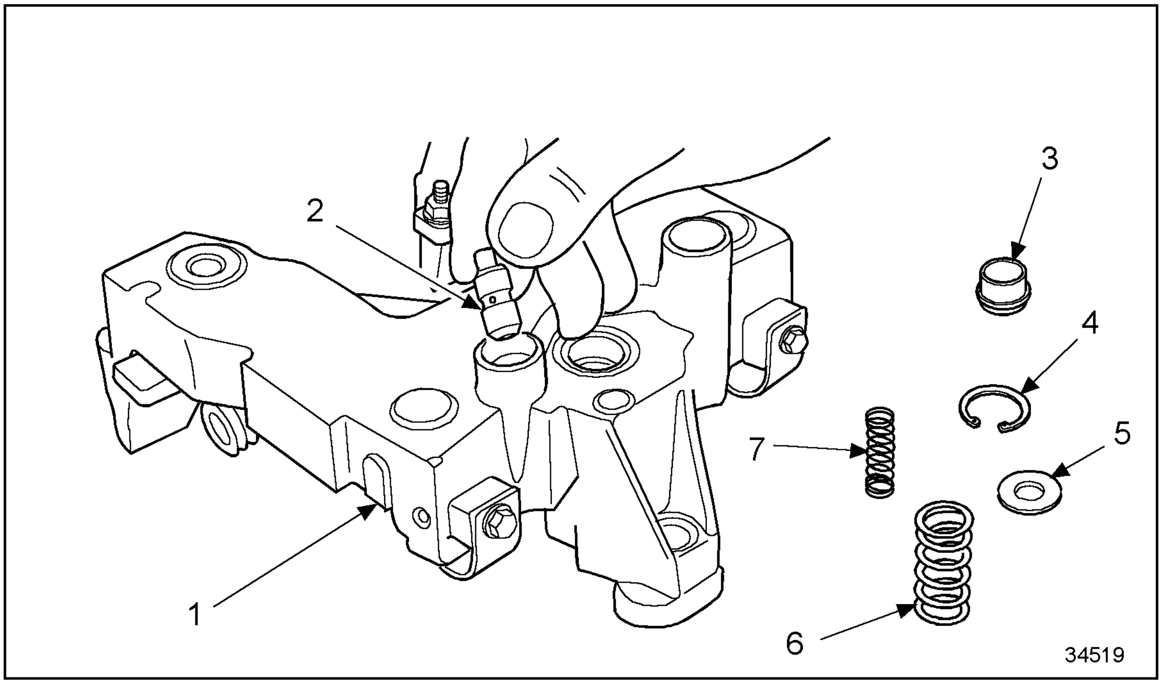
1. Dip the control valves in clean lube oil.
2. Holding the control valve by the stem, let it drop into the bore.
   [a] If binding occurs or if the ball sticks in the valve, replace the control valve. Refer to Section 1.29.4.
   [b] If no binding occurs and the ball does not stick in the control valve, assemble the Jake Brake. Refer to Section 1.29.4.

1.29.4 Assembly of Model 760, 765, or 770 Jake Brake

Install the control valve as follows:

1. Slip the control valve into the bore. See Figure 1-428.

NOTE:
Make sure the control valve collar is installed with the longer sleeve area facing up. If the collar is installed upside down, the engine brake cylinder will not operate.



1. Jake Brake Assembly
2. Control Valve
3. Collar
4. Snap Ring Retainer
5. Washer
6. Collar Spring
7. Control Valve Spring

Figure 1-428 Installing the Control Valve

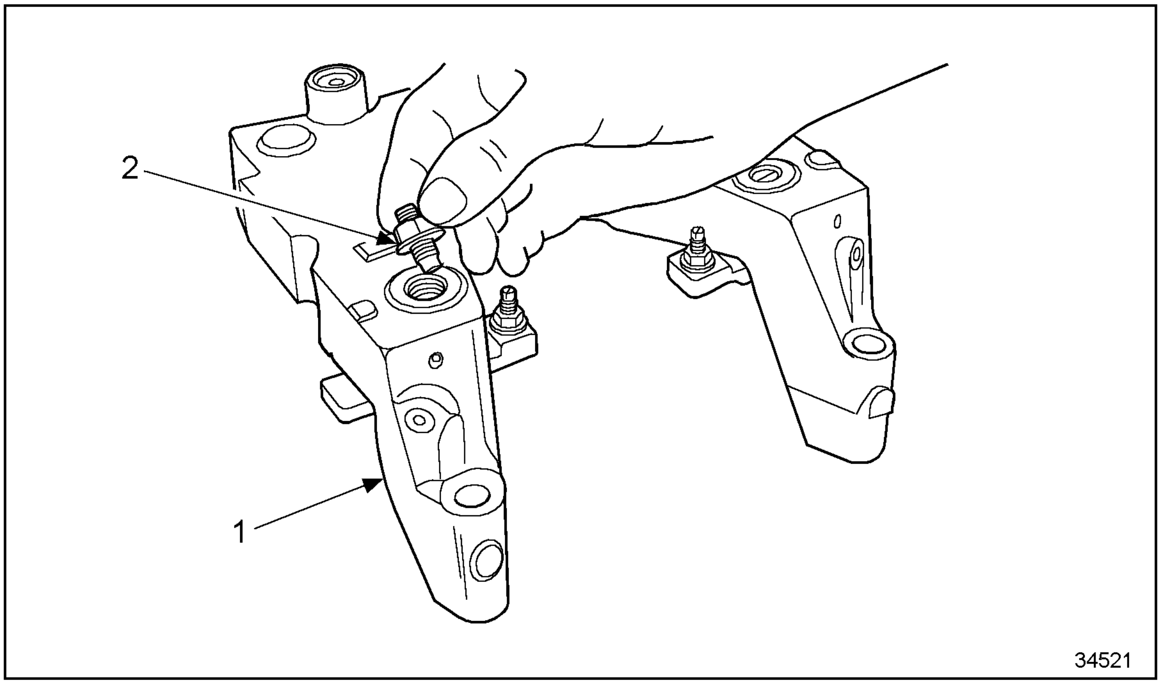
2. Install the control valve collar and two springs.

NOTE:
Ensure the collar is installed with the longer sleeve area facing up. If the collar is installed upside down, the engine brake cylinder will not operate.

3. Press the cover (washer) into place.
4. While holding the cover tightly in place, install the retaining ring.
5. Rotate retaining ring ears 90 degrees to assure ring is seated in groove.

Install the slave piston adjusting screw as follows:

1. Place the screw in the housing. See Figure 1-429.



1. Jake Brake Assembly
2. Slave Piston Adjusting Screw

Figure 1-429 Installing the Slave Piston Adjusting Screw

2. Torque the slave piston adjusting screw locknut to 35 N·m (25 lb·ft).

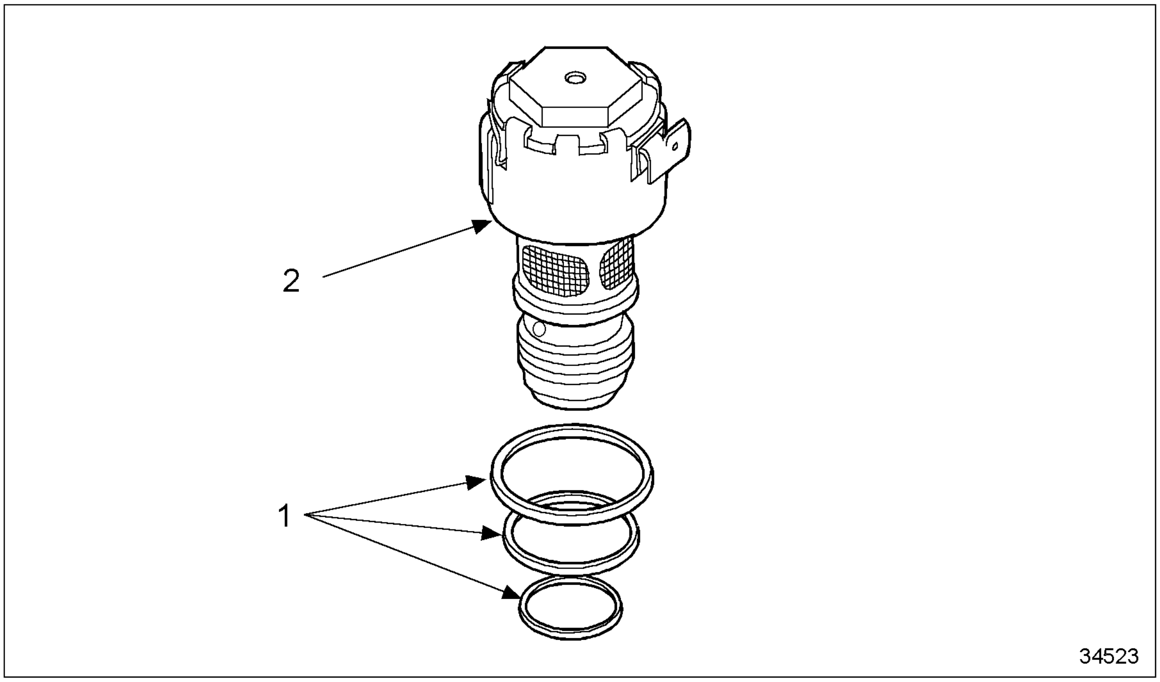
Install the solenoid valve as follows:

NOTE:
As of October 19, 1997, former solenoids have been replaced with the current improved solenoids. The current solenoids have an increased installation torque and improved durability. The current solenoid is interchangeable with the former.

1. Coat new solenoid valve seal rings with clean lube oil.

NOTE:
Use current upper seals when installing current solenoids. New seals are identified with yellow stripes.

2. Install the upper and center seal rings on the solenoid valve body and the lower seal ring into the bottom of the bore in the housing. See Figure 1-430.



1. Seal Rings (3)
2. Solenoid

Figure 1-430 Installation of Solenoid Valve Seal Rings

3. Make sure the seals are seated properly.
4. Using a 7/8 in. socket and extension for former solenoids or a 3/4 in., 6 point socket and extension for current solenoids, carefully screw the solenoid valve into the housing without unseating the seals.
5. Torque the former solenoid to 12.4 N·m (9 lb·ft). Torque the current solenoid to 20 N·m (15 lb·ft.)

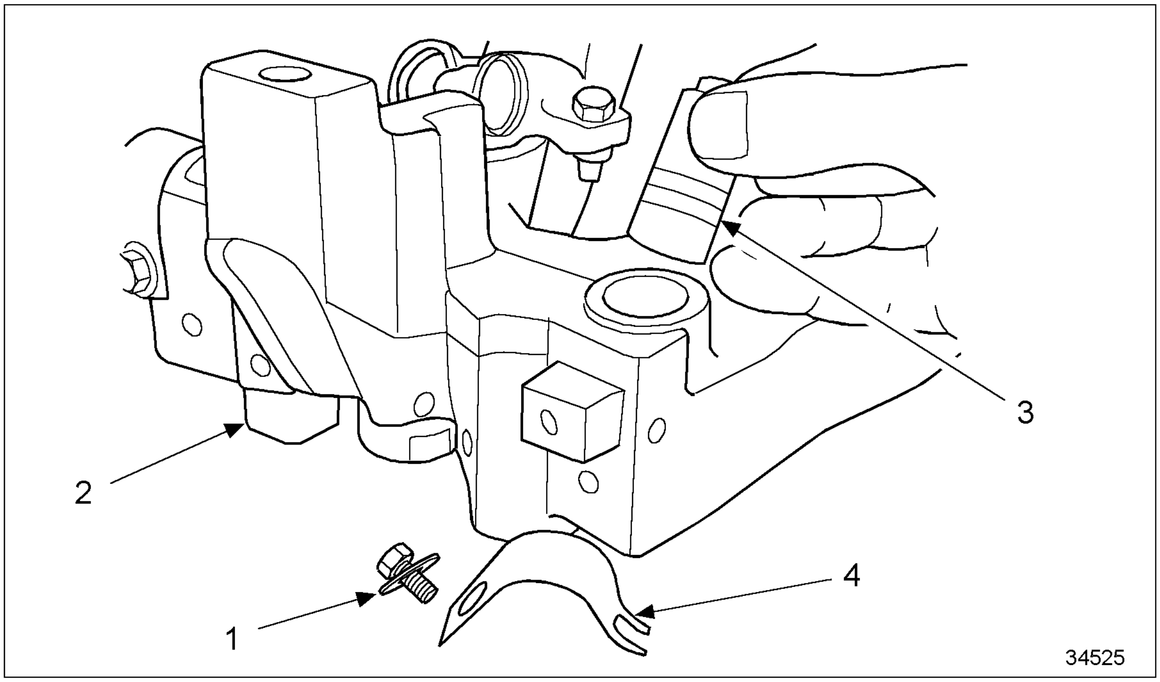
NOTE:
Be careful not to twist the seals while installing.

Install the accumulator as follows:

1. Place the piston into the accumulator bore.
2. Insert the spring, and install the cover.
3. Push down the accumulator cover, and insert retaining ring.

Install the master piston as follows:

1. Apply clean lube oil to the piston.
2. Insert master piston into bore. See Figure 1-431.



1. Washer and Screw Assembly
2. Jake Brake Assembly
3. Master Piston
4. Master Piston Spring

Figure 1-431 Inserting Master Piston into Bore

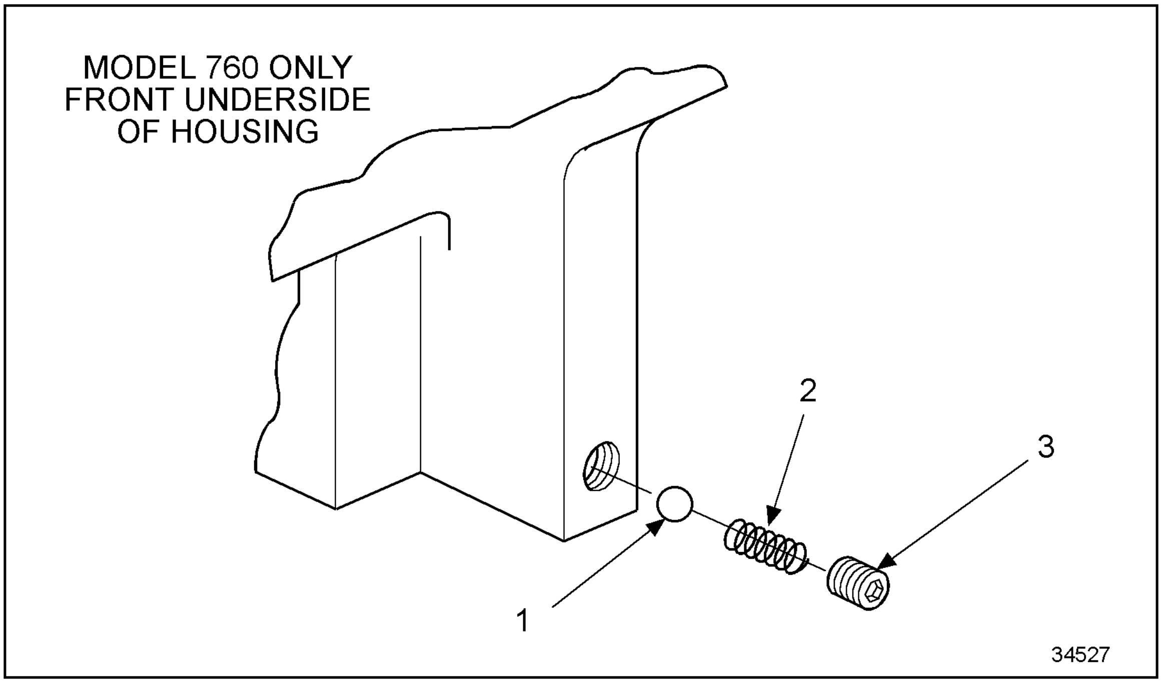
3. Install spring, washer, and screw.

NOTE:
Make sure spring legs are centered around master piston boss.

4. Torque screw to 10 N·m (7.4 lb·ft).

On model 760 only, install the ball check valve as follows:

1. Install the ball check valve and spring. See Figure 1-432.



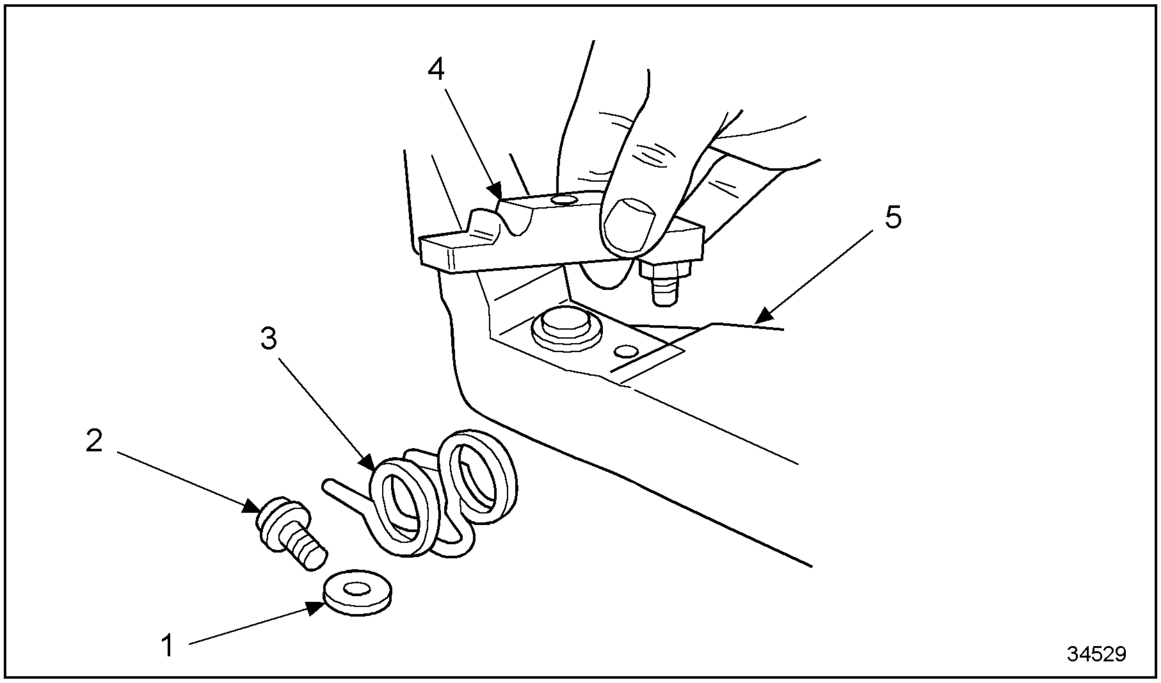
1. Ball Check Valve
2. Spring
3. Pipe Plug

Figure 1-432 Installation of Ball Check Valve

2. Insert the plug. Torque pipe plug to 11.2 N·m (8.3 lb·ft).

Install the slave piston as follows:

1. Install the screw from the slave piston side of the bridge.
2. Install the leveling screw locknut.
3. Install the bridge with the leveling screw toward the center of the housing. See Figure 1-433.



1. Washer
2. Screw
3. Torsion Spring
4. Bridge Assembly
5. Jake Brake Housing

Figure 1-433 Installing Bridge with Leveling Screw Toward Center of Housing

4. Install the slave piston assembly torsion spring with the ends over the bridge. See Figure 1-434.

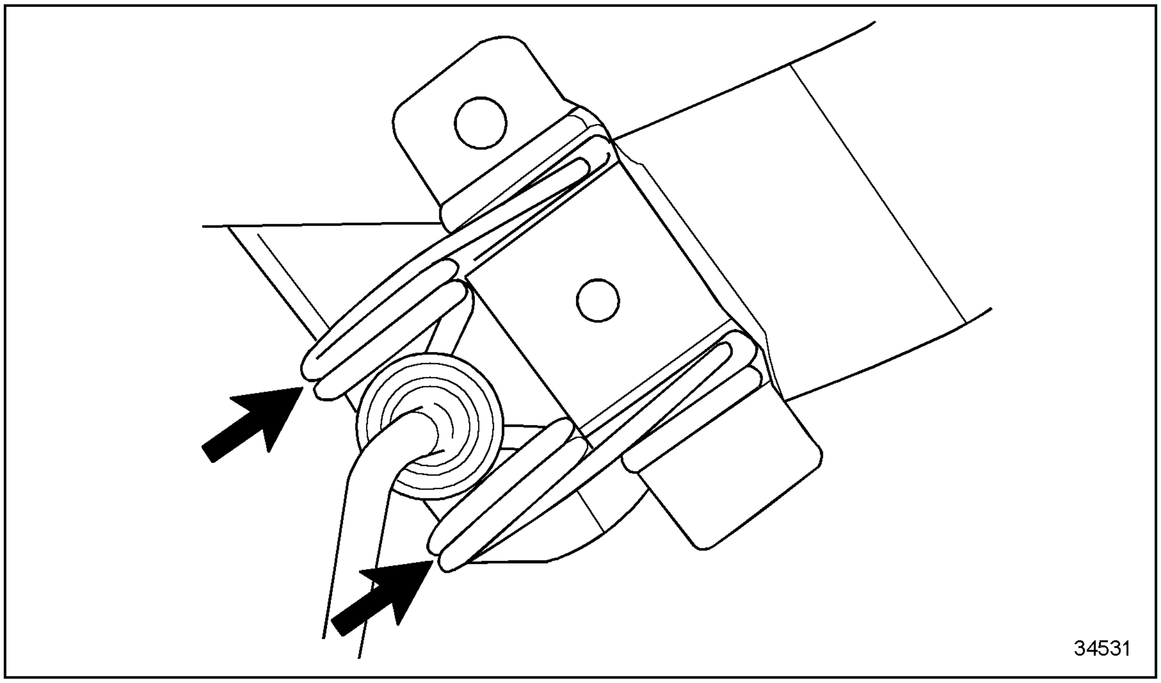


Figure 1-434 Installing the Slave Piston Assembly Torsion Spring

5. Install the screw over the center part of the spring.

NOTICE:
While tightening the screw on the torsion spring, push the spring toward the slave piston assembly. Failure to do so may result in contact between the intake valve adjusting screw and torsion spring. Serious engine damage may result.

6. Torque the screw to 20 N·m (15 lb·ft.).
7. Torque the slave piston leveling screw locknut to 47 N·m (35 lb·ft.).

1.29.5 Installation of Model 760, 765, or 770 Jake Brake

Install the model 760, 765, or 770 Jake Brake as follows:

NOTE:
The following procedures apply to Model 760, 765, and 770 Jake Brakes. For Model 790 Jake Brake installation procedures, refer to section 1.29.10.

1. Adjust the intake and exhaust valve clearances and set the injector heights. Refer to section .

CAUTION:

To prevent possible personal injury when using compressed air, wear adequate eye protection (face plate or safety glasses) and do not exceed 40 psi (276 kPa) air pressure.

2. Attach the length of tubing to a blow gun nozzle, and blow out the oil from the bolt holes.
3. Cover the holes with hand towels to minimize oil spray.

NOTE:
Removing the oil from the bolt holes prevents the cylinder head from cracking when tightening the bolts.

4. Place the spacer bar on the exhaust manifold side of the cylinder head with the "OUT" markings adjoining each other and facing the exhaust manifold. See Figure 1-435, and see Figure 1-436.

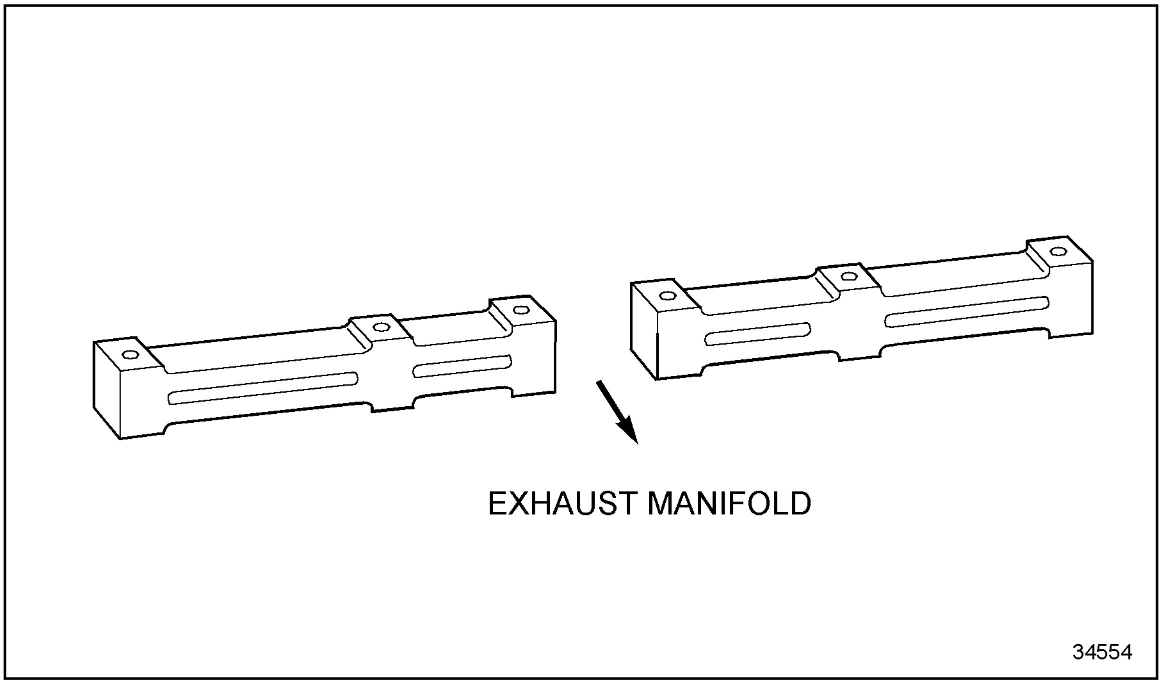


Figure 1-435 Spacer Bars with "Out" Marks Adjoined

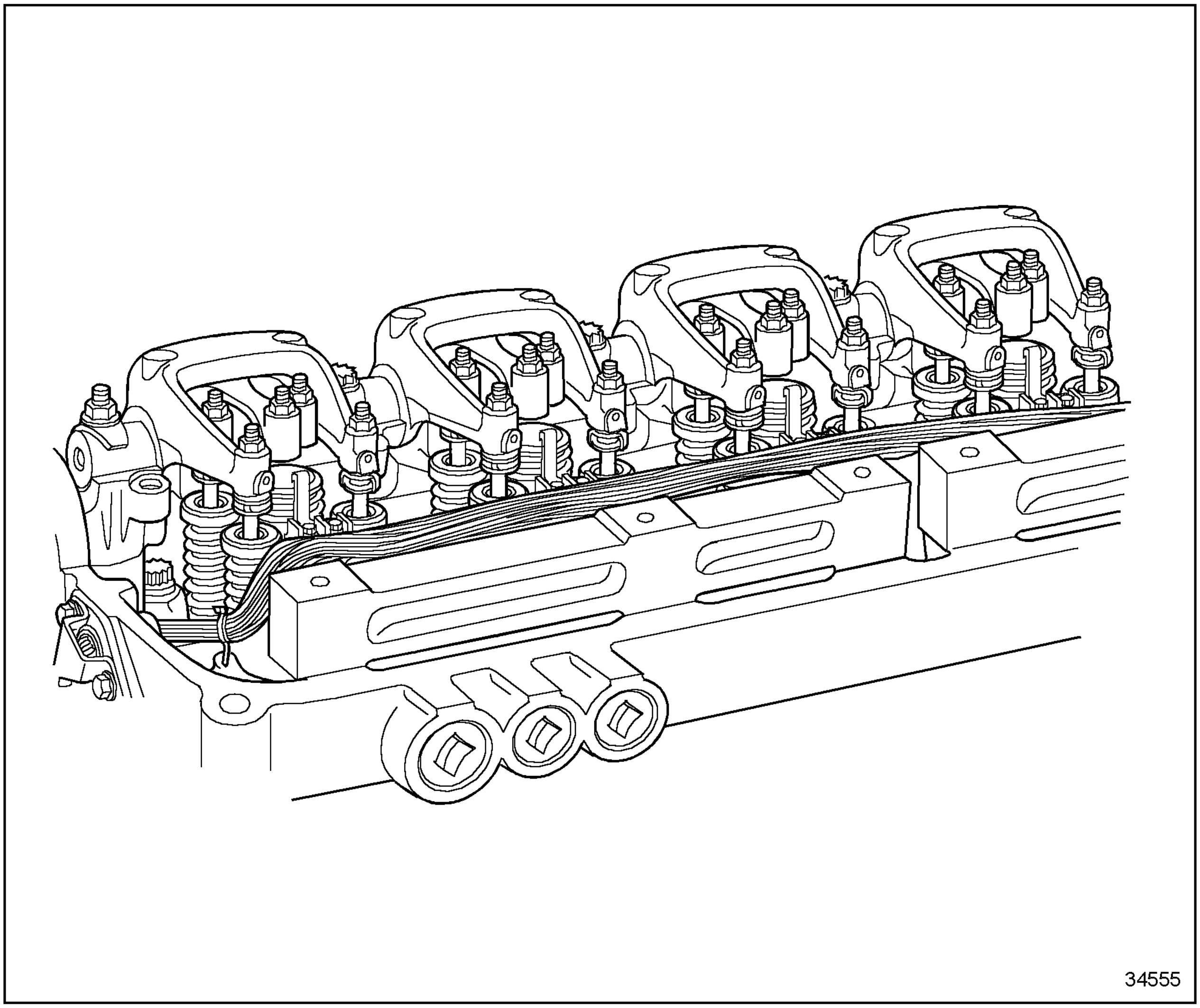


Figure 1-436 Location of Spacer Bars

5. Place the three engine brake housings over the rocker shafts with the solenoid valves toward the camshaft side of the engine.

NOTE:
Be sure housings do not interfere with wiring harness.

NOTICE:
Do not mix the rocker arm shaft bolts and the Jake Brake mounting bolts. If the rocker arm shaft bolt is mistakenly used to mount the Jake Brake housing, the longer shoulder on the bolt will block the oil supply to the Jake Brake on the camshaft side of the housing. The brake will not retard the engine as designed. This condition could cause loss of vehicle braking control on downgrades, which may create a risk of personal injury to the vehicle operator or other persons and damage to the vehicle or property of others.

NOTE:
The rocker arm shaft mounting bolt and Jake Brake mounting bolt, part of the Jake Brake assembly, are similar in appearance. Both are M12 x 110 mm (4.33 in.) long and have 12–point heads.

NOTE:
In the event of a housing hold down bolt failure on a Jacobs engine brake housing, replace all bolts on that particular housing.

NOTICE:
Use bolts that have the Jacobs logo, circled "J". Installation of bolts that do not have the circled "J" may result in damage to the engine, engine brake or both.

[a] The Jake Brake bolt has the Jacobs logo (circled "J") and the letters "EF" marked on the head. The bolt length is no longer marked atop the bolt head.

[b] The DDC rocker arm shaft bolt has the DDC logo (spinning arrows) and the vendor I.D. (F-C) on its head.

[c] Jake Brake model 760 requires two bolts along with one bolt and new washers.

NOTE:
Be sure that only Jake Brake bolts, see Figure 1-437, are installed in the Jake Brake housing.

[d] The DDC bolt shoulder is much longer, 17.0 mm (0.669 in.) versus 4 mm (0.157 in.) than the Jake Brake bolt. See Figure 1-437.

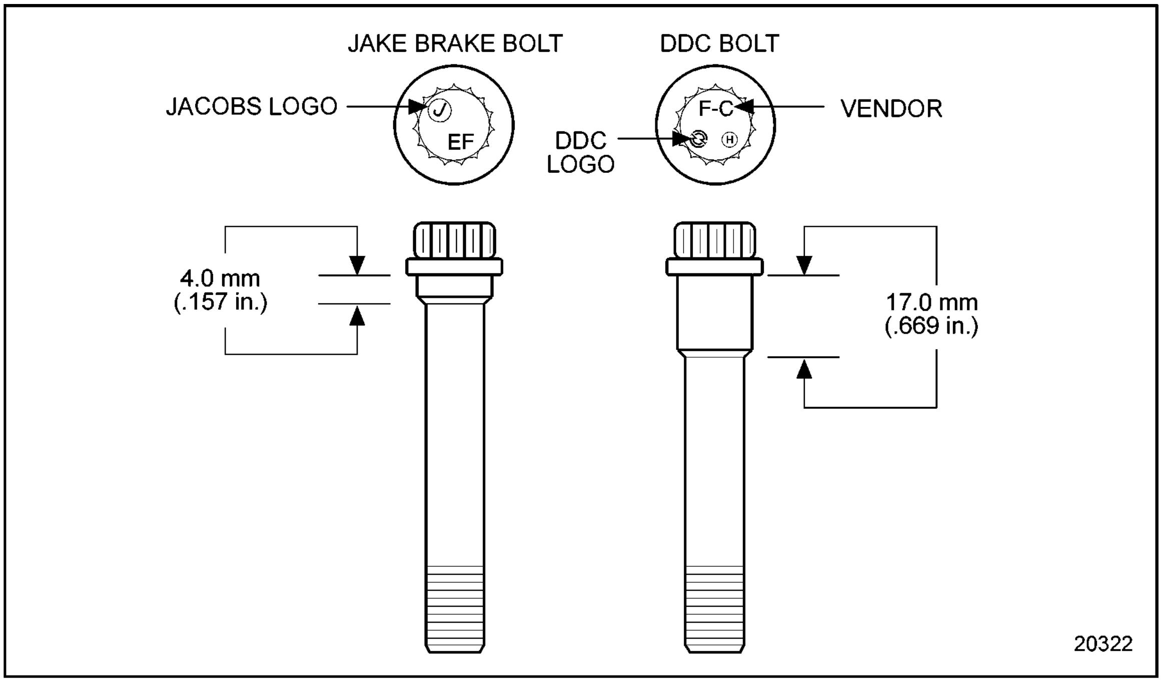
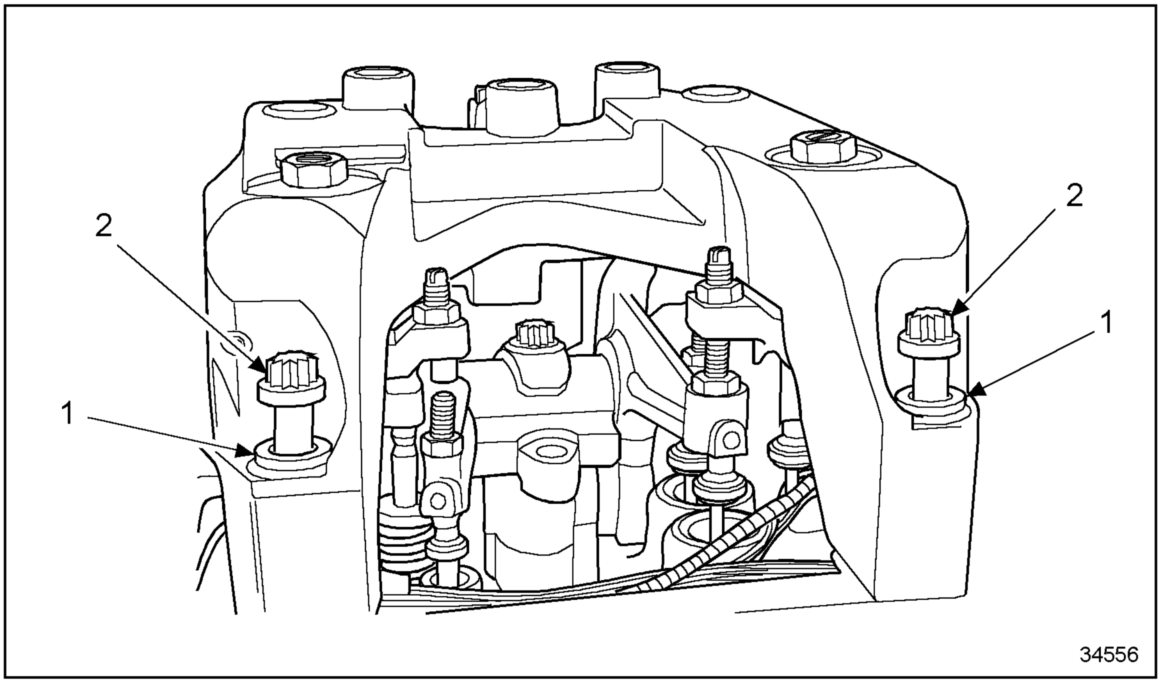


Figure 1-437 Jake Brake and DDC Bolt Identification

NOTICE:

The model 760 uses two lengths of mounting bolts. Six 120 mm bolts should be installed on the exhaust side of the engine. Three 110 mm bolts should be installed on the camshaft side of the engine. Failure to do so will result in engine damage.

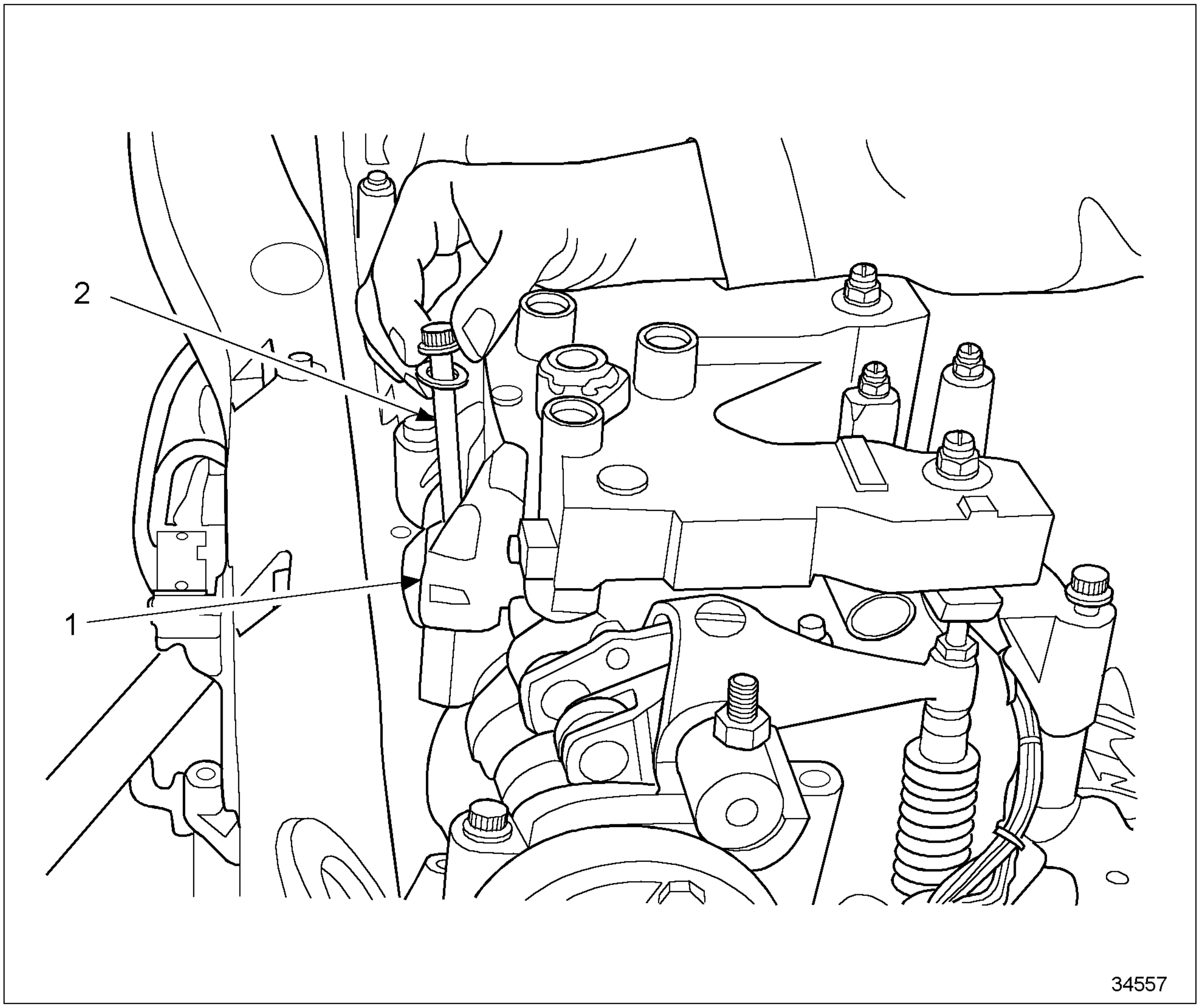
6. On model 760, install one washer onto each 120 mm (4.75 in.) bolt, and insert into brake housing on the exhaust manifold side (two per housing). See Figure 1-438.



1. Washer
2. Long Bolt

Figure 1-438 Installation of Brake Housing Bolts on Exhaust Manifold Side

7. On model 760, install one washer on the 110 mm (4.375 in.) bolt, and insert into brake housing at the camshaft side (one per housing). See Figure 1-439.



1. Jake Brake Housing Assembly
2. Mounting Bolt

Figure 1-439 Installation of Brake Housing Bolts on Camshaft Side

8. On models 760A, 760B, 765, and 765A, lubricate each hold down bolt with clean engine oil.

NOTE:
All the housing mounting bolts for these models are the same length of 110 mm (4.375 in.).

9. On models 760A, 760B, 765, and 765A, install a washer on each bolt, and install into housings (three bolts per housing).

10. On models 760A and 765, move the housing from side to side, and locate the housing in the center position of the movement. See Figure 1-440.

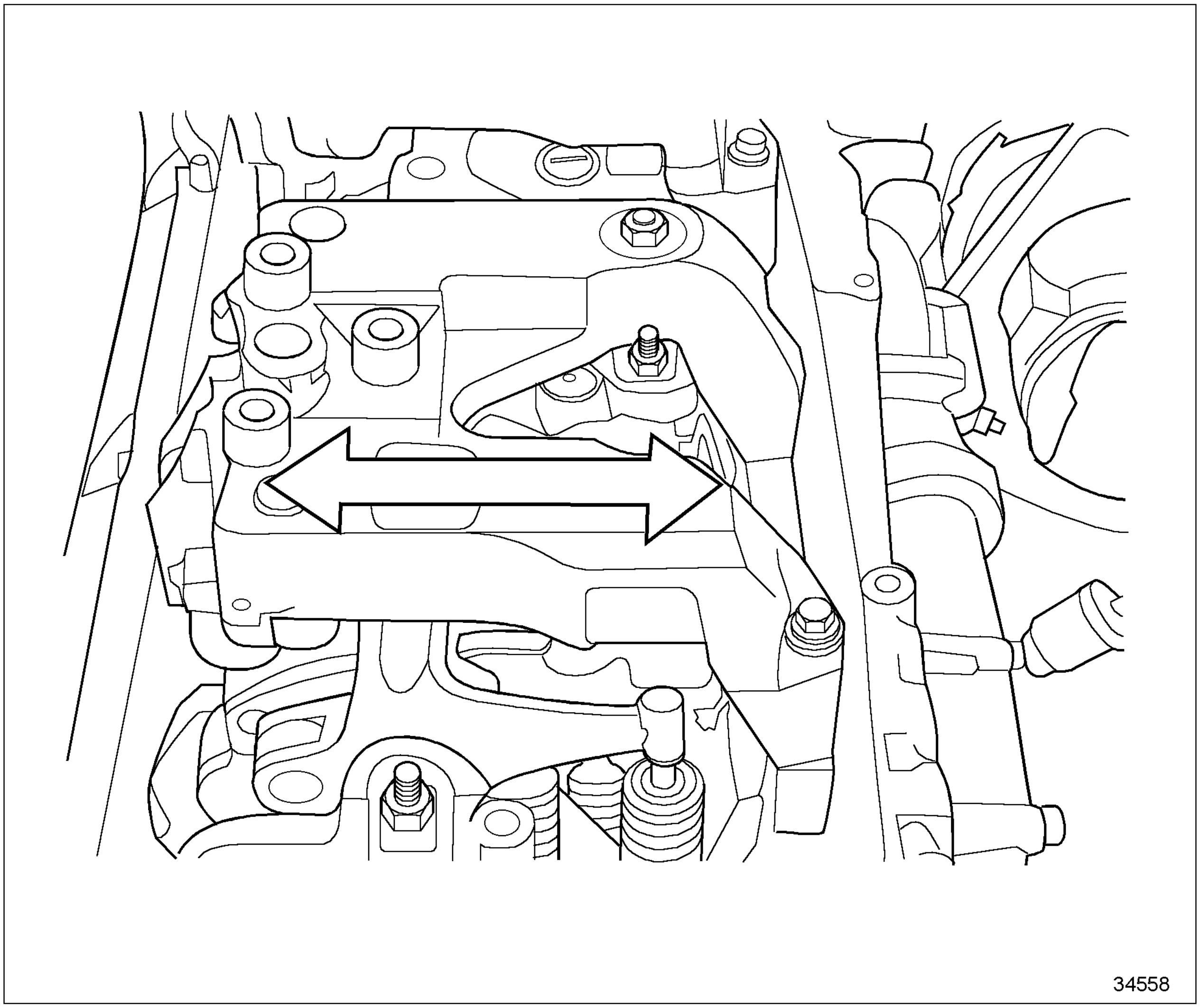


Figure 1-440 Locating Center Position of Housing

11. On models 760B and 765A, move the housing from side to side, and locate as far toward the camshaft side of the engine as possible.
12. On all models, torque the engine brake mounting bolts using the following sequence:
    [a] Torque the three bolts on the camshaft side of the engine to 55 N·m (40 lb·ft).
    [b] Torque the six bolts on the exhaust manifold side of the engine to 55 N·m (40 lb·ft).
    [c] Repeat the tightening sequence and re-torque all bolts to 136 N·m (100 lb·ft).
    [d] Check the torque to 136 N·m (100 lb·ft).
13. Secure wire harness to spacer bars with plastic ties.
14. Connect wiring harness solenoid connectors to solenoids.

1.29.5.1 Adjustment of Slave Piston on Model 760, 765, or 770 Jake Brake

Make the following adjustment with the engine stopped and cold, and the oil temperature at 60°C (140°F) or below. The exhaust valves on the cylinder *must* be in the closed position (rocker arm roller on the base circle of the camshaft). When setting the engine brake lash, the exhaust valves must be in the closed position. Adjust the slave piston on all models as follows:

NOTE:
The following procdures apply to Model 760, 765, and 770 Jake Brakes. For Model 790 Jake Brake slave piston lash setting procedures, refer to section 1.29.10.1.

NOTE:
Model 770 Jacobs engine brake requires a special procedure for adjusting the slave piston. The procedure is clearly indicated in the following adjustment steps.

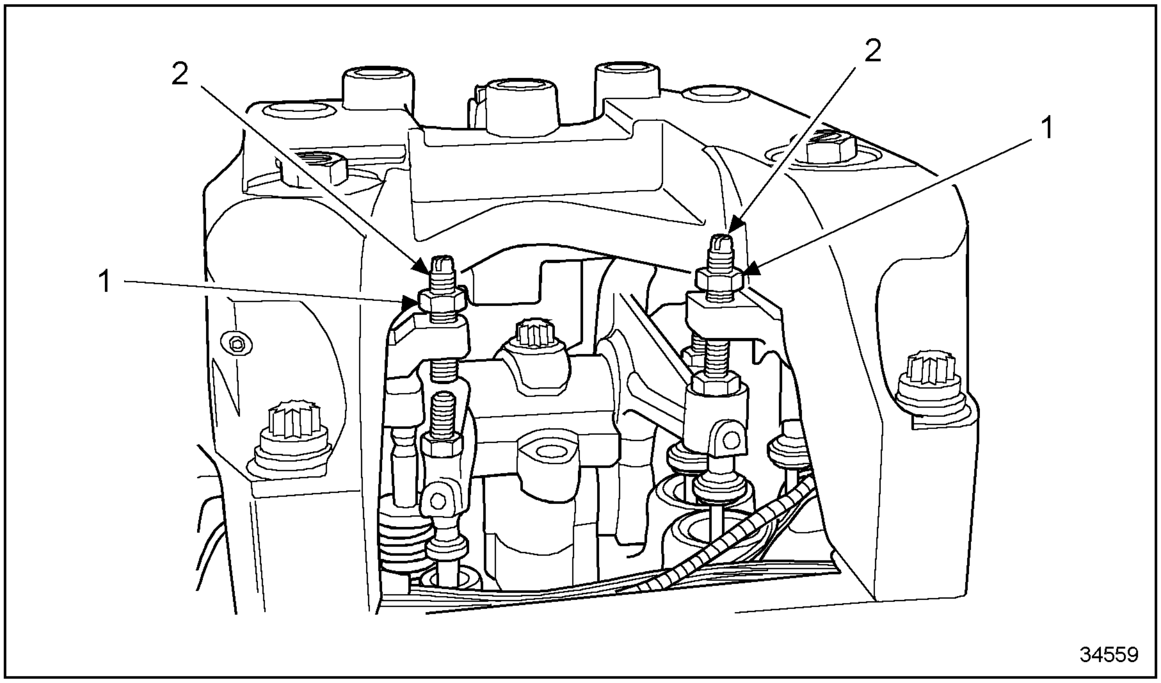
NOTICE:
Improper slave piston adjustment can result in engine or brake housing damage.

NOTICE:
Strictly follow the slave piston adjustment procedure. Failure to use the proper adjustment procedure will result in poor engine brake performance and/or serious engine damage.

1. Refer to section 1.29 for proper slave piston clearance setting.

2. 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 Figure 1-441.

NOTE:
The leveling screw is located in the bridge member of the slave piston assembly.

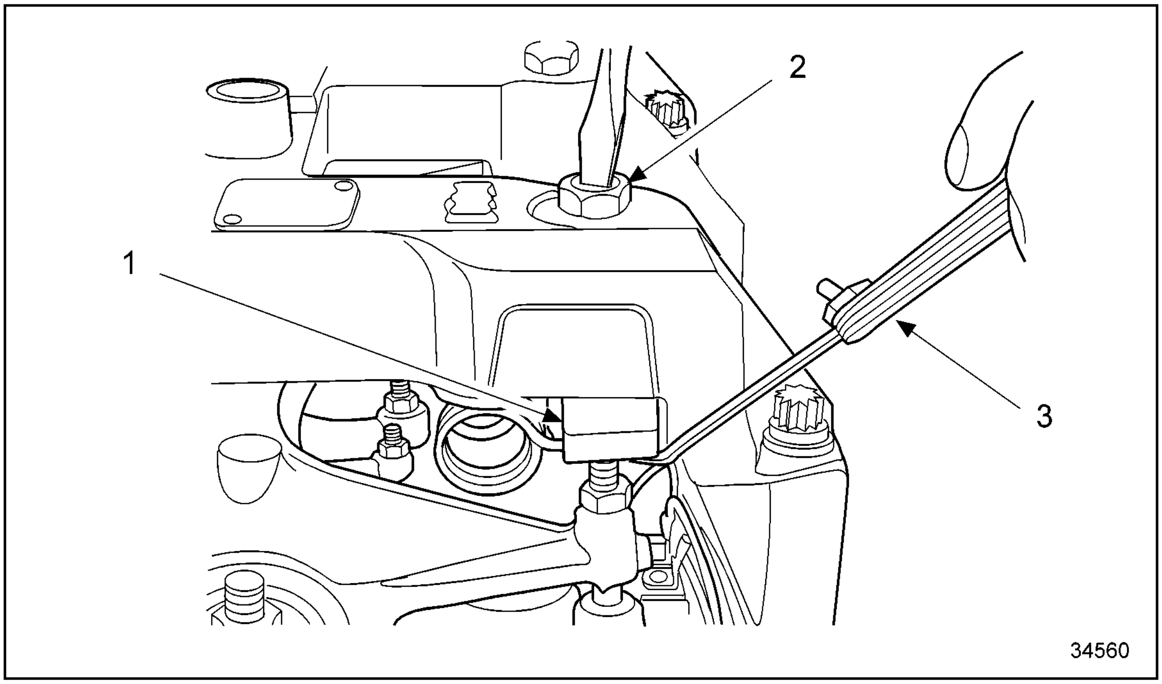


1. Leveling Screw
2. Locknut

Figure 1-441 Location of Leveling Screw

3. On models 760, 760A, 760B, 765, and 765A, place the correct size feeler gage between the solid side of the slave piston (the side without the leveling screw) and the exhaust rocker arm adjusting screw. Feeler gage sizes are listed in Table 1-9.

4. On models 760, 760A, 760B, 765, and 765A, turn the slave piston adjusting screw clockwise until a slight drag is felt on the feeler gage. See Figure 1-442.



1. Slave Piston Bridge
2. Slave Piston Adjusting Screw
3. Feeler Gage

Figure 1-442 Turn Slave Piston Adjusting Screw Clockwise

5. Perform the following additional steps on model 770:

   [a] Turn in the J-Lash® adjusting screw until the solid side of the slave piston bridge assembly contacts the exhaust valve and the valve springs begin to compress. Turn in one additional turn.

NOTICE:
All oil must be purged from the J-Lash adjusting screw. Oil remaining in the J-Lash screw will cause inaccurate clearance adjustment, resulting in possible engine or engine brake damage. If oil is below room temperature (below 60°F), wait at least two minutes for oil to be purged from the J-Lash adjusting screw.

NOTE:
Wait at least 30 seconds for oil to be purged from the J-Lash adjusting screw.

   [b] Back out the adjusting screw **only** until the correct size feeler gage can be inserted between the solid side of the slave piston bridge assembly and the exhaust valve.

   [c] Adjust the J-Lash so that a light drag is felt on the feeler gage.

NOTE:
Do not back out the J-Lash more than required to obtain a light drag on the feeler gage.

   [d] Use a screwdriver to hold the J-Lash in place, and torque the lock nut to 34 N·m (25 lb·ft).

NOTE:
If the J-Lash screw is backed out until it no longer compresses the slave piston spring, oil will enter the screw and the adjustment will be incorrect. If this occurs, repeat the J-Lash adjustment procedure.

   [e] Recheck the lash settings. If clearance setting is incorrect, repeat the J-Lash adjustment procedure.

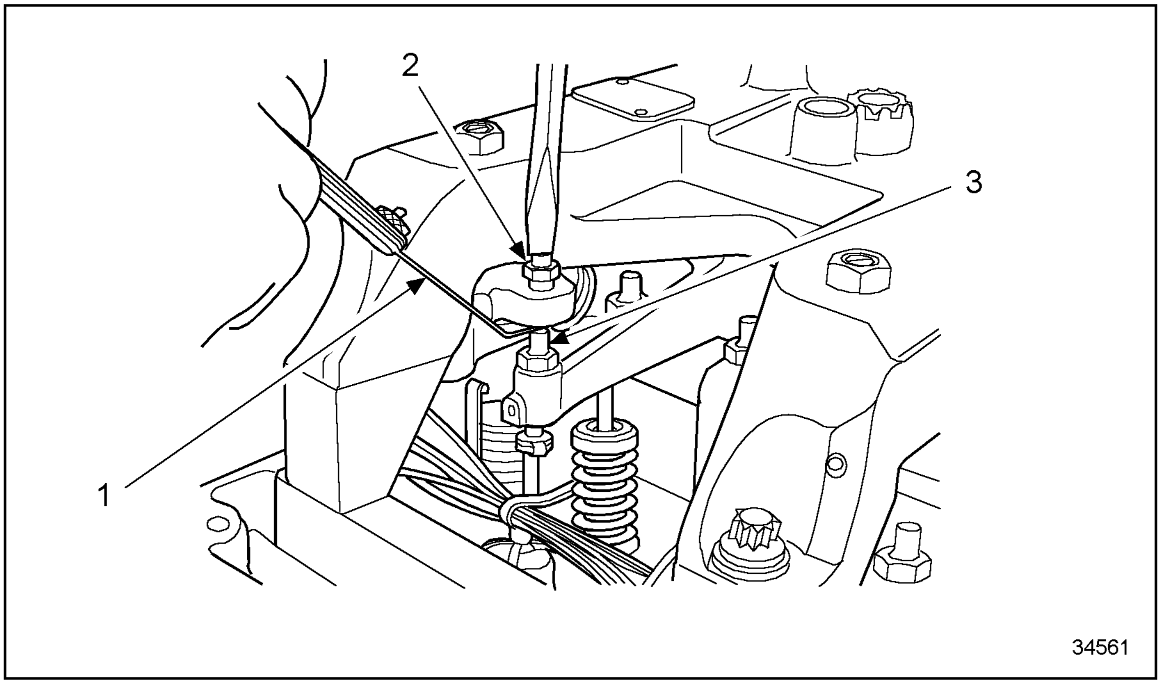
NOTE:
Once the engine brake has been run, oil enters the J-Lash screw making the engine brake adjustment unreadable. If unsure of the adjustment, repeat the J-Lash adjustment procedure.

6. On all models, hold the screw in position, and torque the locknut to 35 N·m (26 lb·ft).
7. Check the adjustment, and repeat if necessary.

NOTE:
Do not disassemble the slave piston adjusting screws.

8. Place the correct feeler gage between the leveling screw and the rocker arm adjusting screw.

9. Turn the leveling screw clockwise until a slight drag is felt on the feeler gage. See Figure 1-443.



1. Feeler Gage
2. Slave Piston Leveling Screw
3. Rocker Arm Adjusting Screw

Figure 1-443 Setting Clearance on Leveling Screw and Rocker Arm Adjusting Screw

10. Hold the leveling screw in position, and torque the locknut to 47 N·m (35 lb·ft).
11. Check adjustment, and repeat if necessary.
12. Repeat the adjustment procedures for the remaining cylinders. Refer to step 2 through step 11.

NOTE:
Bar over the engine when necessary to place the exhaust valves in the closed position for slave piston adjustment.

13. Install the engine rocker cover. Refer to section 1.6.2 for one-piece, refer to section 1.6.3 for two-piece, and refer to section 1.6.5 for three-piece.
14. Install all remaining components that were removed for this procedure.
15. Connect starting power for the engine.
16. Verify proper Jake Brake installation by driving the vehicle, then checking engine brake performance.

1.29.6 Removal of Model 790 Jake Brake Assembly

Remove the Model 790 Jake Brake as follows:

CAUTION:

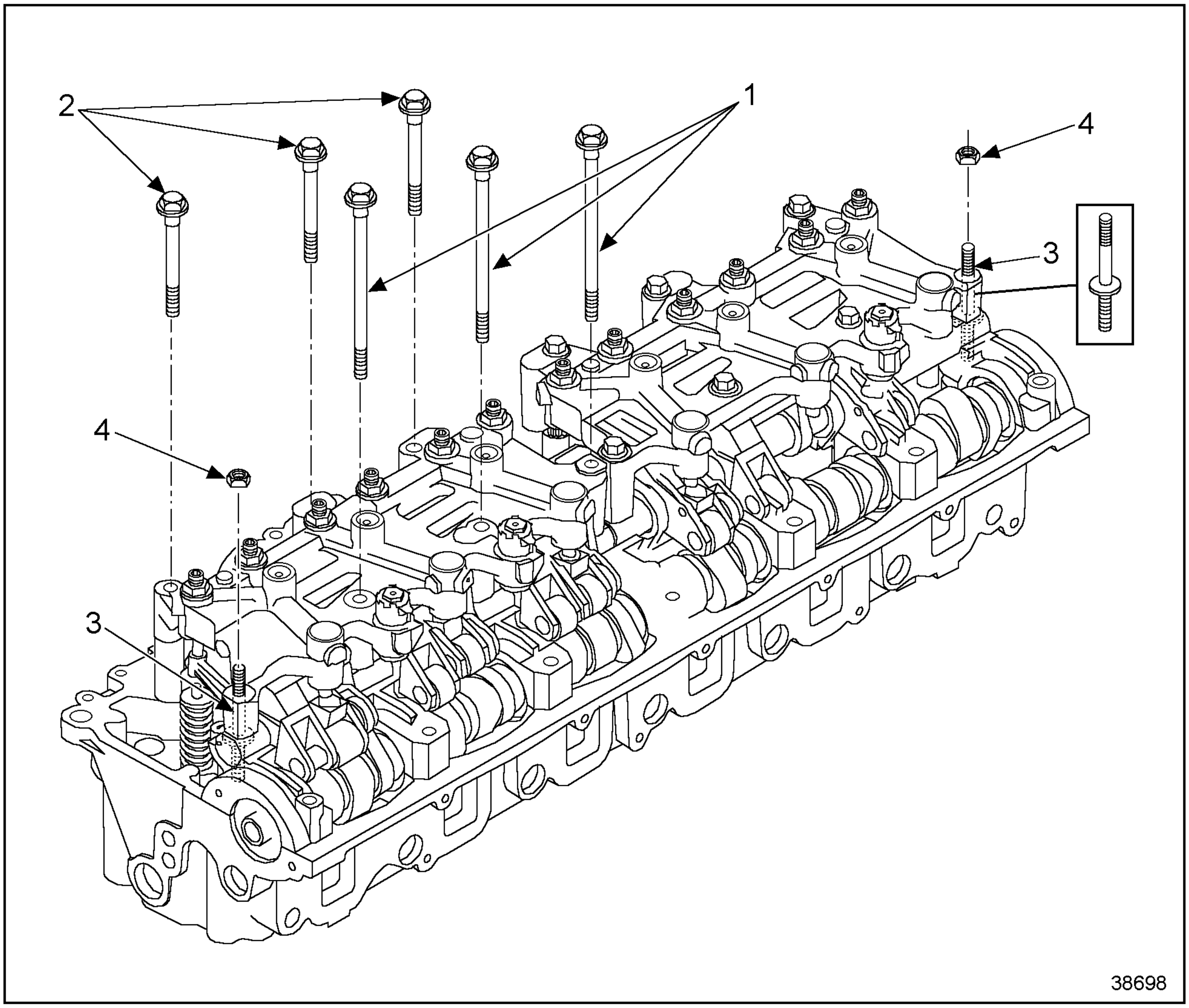
To avoid injury from hot engine surfaces, stop the engine and allow it to cool ambient temperature before working on it.

CAUTION:

To avoid injury from accidental engine start-up, disable/disconnect power to the engine starting system.

1. With the engine at ambient temperature and power to the starting system disconnected, Refer to section of the *Series 60 Service Manual,* 6SE483 and remove the engine rocker cover.
2. Note the location of the rocker arm shaft, the exhaust valve rocker arm, the fuel injector rocker arm, and the intake valve rocker arm.
3. Disconnect the solenoid wiring harness connectors from the Jake Brake solenoids.

4. Remove the three (3) 140 mm long mounting bolts that secure the engine brake to the cylinder head. See Figure 1-443a.



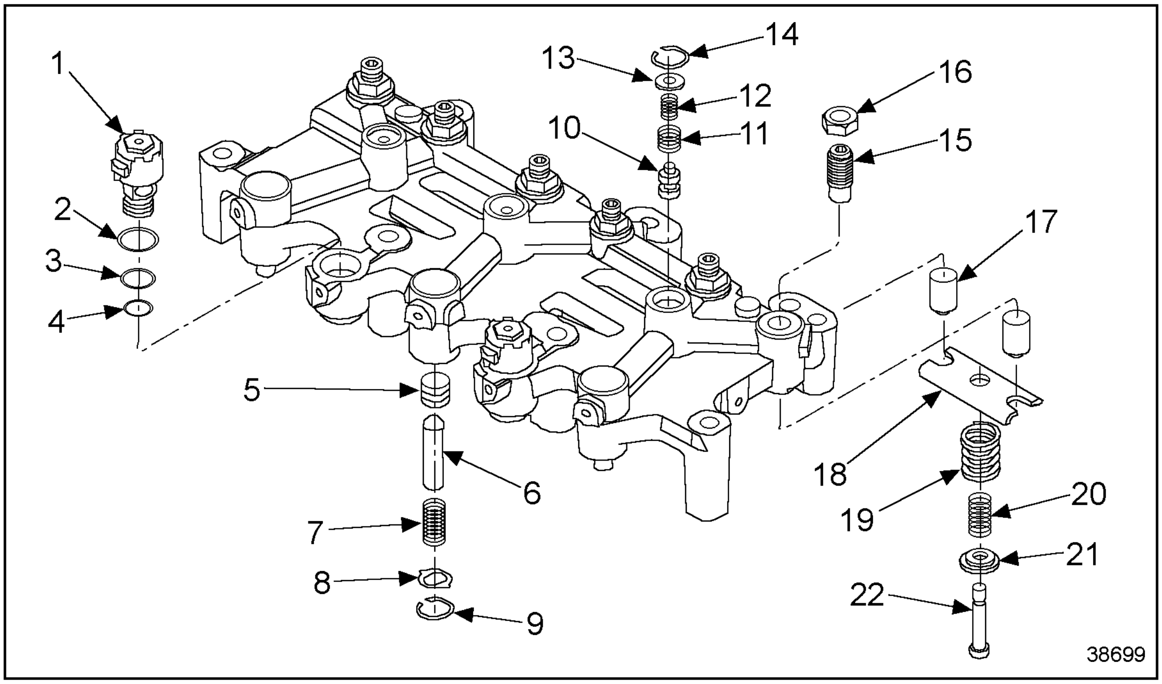
1. Mounting Bolt — 170 mm Long
2. Mounting Bolt — 140 MM Long
3. Stud Bolt
4. Nut

Figure 1-443a Model 790 Jake Brake Fasteners

5. Remove the three (3) 170 mm long mounting bolts and the two (2) nuts that secure the engine brake to the cylinder head.
6. Remove the engine brake assembly.
7. Repeat steps 1 through step 5 and remove the second Jake Brake assembly from the engine.

1.29.6.1 Disassembly of Model 790 Jake Brake

Instructions for disassembly of Model 790 Jake Brakes are incomplete at time of publication, but will be provided at a future date. For components of Model 790 Jake Brakes, see Figure 1-443b.



1. Solenoid Valve

3.Center Seal

4. Lower Seal

5. Master Piston

6. Master Piston Pushrod

7. Master Piston Spring

8. Retaining Ring

9.Control Valve

10. Outer Control Valve Spring

11. Inner Control Valve Spring

12. Washer

13. Retaining Ring

14.J-Lash® Screw

15. Locknut

16. Slave Piston

17. Slave Piston Bridge

18. Outer Slave Piston Spring

19. Inner Slave Piston Spring

20. Slave Piston Spring Seat

21. Shoulder Bolt

22. Shoulder Bolt

Figure 1-443b Typical Model 790 Jake Brake Assembly

1.29.7 Cleaning of Model 790 Jake Brake

Instructions for cleaning of Model 790 Jake Brake are incomplete at the time of publication, but will be provided at a future date.

1.29.8 Inspection of Model 790 Jake Brake

Instructions for inspection of Model 790 Jake Brake are incomplete at the time of publication, but will be provided at a future date.

1.29.9 Assembly of Model 790 Jake Brake

Instructions for assembly of Model 790 Jake Brake are incomplete at the time of publication, but will be provided at a future date.

1.29.10 Installation of Model 790 Jake Brake Assembly

The installation procedures for the model 790 Jake Brake assemblies differ slightly from the former engine brakes. Two brake housings are used, instead of three, and spacer bars are not required. Install the model 790 Jake Brake assemblies as follows:

1. With the engine at ambient temperature, install front Jake Brake housing (with two solenoids) over the front three cylinders. Position with solenoids on camshaft side of engine.
2. Install the rear housing (with one solenoid) over the rear three cylinders. Position with solenoid on camshaft side of engine.

NOTE:
There is one extra mounting hole drilled on the slave piston side of each housing. These holes are for manufacturing purposes only and are not used for installation.

3. Install six (6) 170 mm bolts through the housings into the rocker shafts in locations 1 through 6, and install two (2) nuts in locations 7 and 8. See Figure 1-443c.

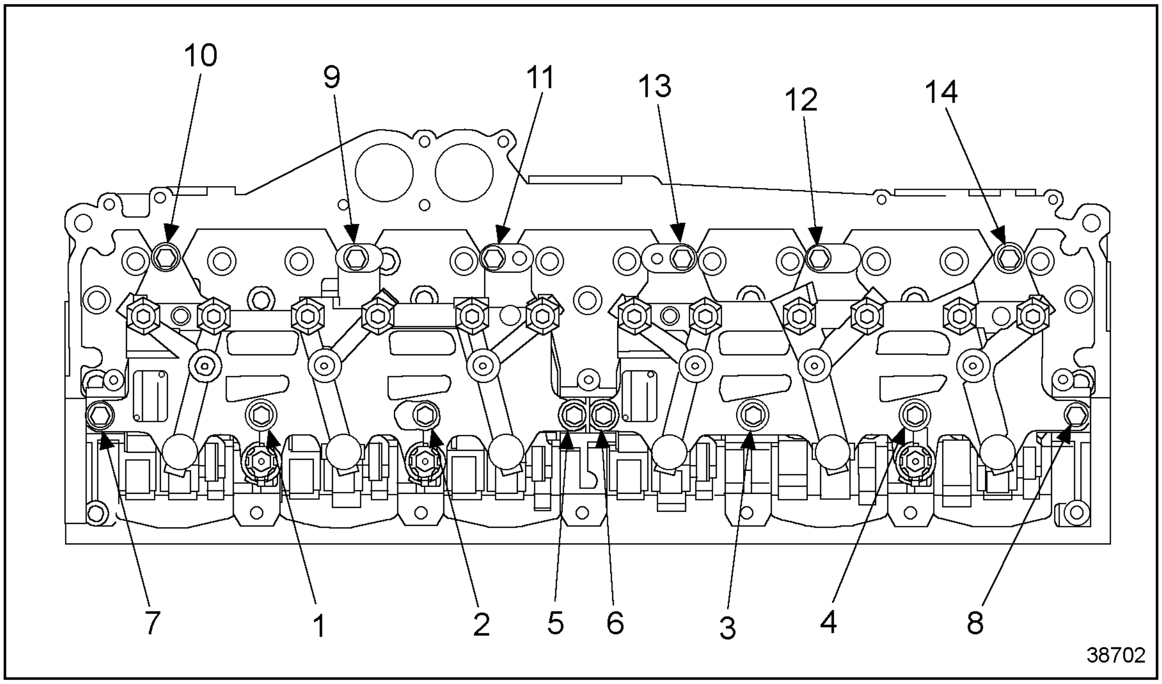


Figure 1-443c Housing Hold-Down Bolt Locations

NOTICE:
To ensure proper engine brake housing installation, Jake Brake mounting bolts (identified by a circle "J" on the heads) and required one-piece spacers *must* be used when mounting the brake assemblies.

4. Install six (6) 140 mm bolts into each housing and through the spacers in locations 9 through 14.
5. Torque all mounting bolts to 136 N·m (100 lb-ft) in bolt location number sequence shown. See Figure 1-443c.
6. Route the wire to the solenoid for cylinder 1 through the front retaining clip on the front housing and connect to the solenoid. Torque screw to 1.13 N·m (10 lb·in.).
7. Route wire to the solenoid for cylinders 3 and 4 through the rear retaining clip on the front housing and connect to the solenoid. Torque screw to 1.13 N·m (10 lb·in.).
8. Route wire to the solenoid for cylinders 4, 5 and 6 through the single retaining clip on the rear housing and secure to the terminal screw on the solenoid. Torque screw to 1.13 N·m (10 lb·in.).
9. Secure any excess wire to the injector harness with wire ties.

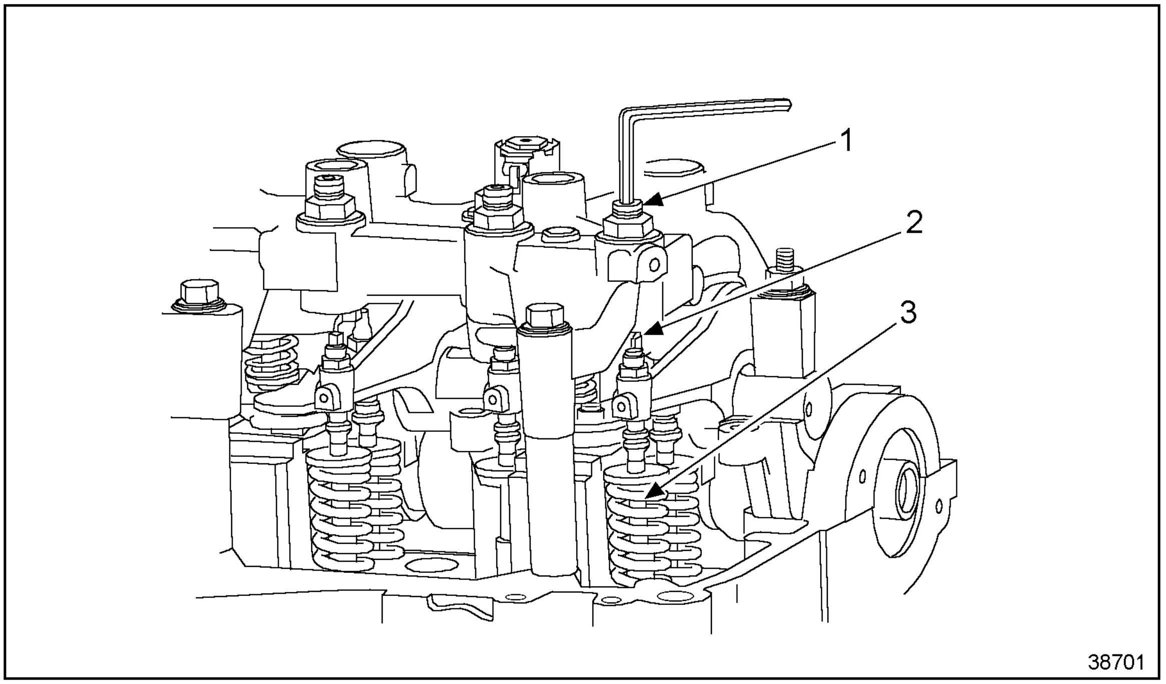
1.29.10.1 Set Slave Piston Lash

The slave piston lash must be set after Jake Brake housings are installed. Adjustments must be made with the engine stopped and cold and the oil temperature at 60°C (140°F) or below. Exhaust valves on the cylinder must be in the closed position (rocker arm roller should be on the base circle of the camshaft).

NOTICE:
The slave piston adjustment procedure *must* be followed exactly. Failure to properly adjust Jake Brakes will result in inefficient engine brake performance and may lead to severe engine or Jake Brake damage.

Adjust Jake Brake Model 790 slave piston lash as follows:

1. Loosen the locknut. Then, using a 5/16 in. Allen wrench, turn the J-Lash adjusting screw counter-clockwise until a 0.660 mm (0.026 in.) feeler gauge can be inserted between the slave piston and the exhaust rocker adjusting screw. Insert the feeler gauge.
2. Using the 5/16 in. Allen wrench, turn the J-Lash adjusting screw in (clockwise) until the slave piston contacts the feeler gauge and the exhaust rocker adjusting screw. When the valve spring begins to compress, turn the screw clockwise *one* additional turn. *Wait at least 30 seconds for oil to be purged from the J-Lash adjusting screw.* See Figure 1-443d.



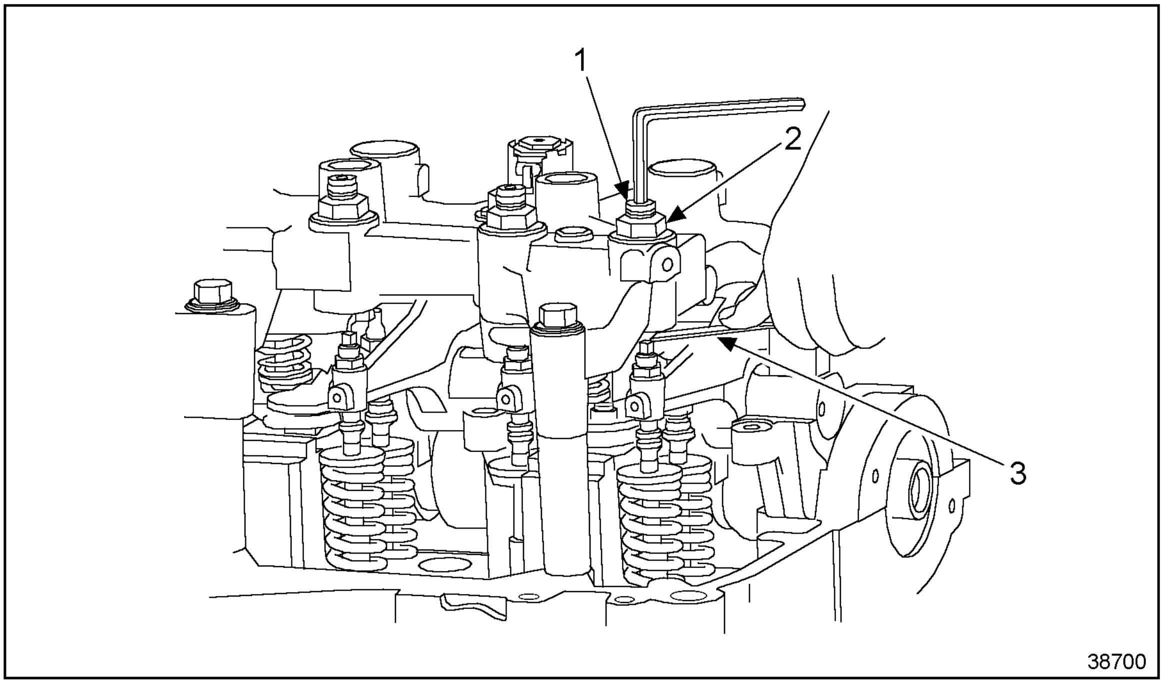
1. J-Lash Adjusting Screw
2. Slave Piston
3. Exhaust Valve Spring

Figure 1-443d Turn the Adjusting Screw Until the Valve Spring Compresses

NOTICE:

Oil *must* be purged from the J-Lash adjusting screw. Oil remaining in the J-Lash screw will cause inaccurate clearance adjustment, which could result in damage to the engine or Jake Brake. ***If oil is below room temperature (below 16° C or 60° F), wait at least two minutes for oil to be purged from the J-Lash adjusting screw.***

3. After waiting the required interval to purge oil from the J-Lash adjusting screw, back out the adjusting screw (turn counter-clockwise) ***only*** until a 0.660 mm (0.026 in.) feeler gage can be moved with a slight resistance. See Figure 1-443e. *Do not back out the J-Lash adjusting screw more than required to obtain a light drag on the feeler gage.* Using the Allen wrench to hold the J-Lash adjusting screw in place, torque the lock nut to 35 N·m (25 lb-ft).



1. J-Lash Adjusting Screw
2. Locknut
3. Feeler Gage

Figure 1-443e Adjusting Slave Piston Lash

NOTE:

If the J-Lash adjusting screw is backed out until it no longer compresses the slave piston spring, oil will enter the screw and the adjustment will be incorrect. If this occurs, repeat step 1 and step 2.

4. After torquing the adjusting screw lock nut, recheck lash setting. If lash is incorrect, repeat step 1 and step 2.

NOTE:
Once the engine brake has been run, you will not be able to check Jake Brake adjustment. This is because of oil retained in the J-Lash adjusting screw. If unsure of the adjustment, you must repeat step 1 through step 3.

5. Repeat step 1 through step 3 for the remaining slave piston on the same cylinder.
6. Repeat step 1 through step 4 for the remaining cylinders.
7. Complete the installation by installing the rocker cover. Refer to section 1.6 of the service manual.
8. Install all remaining components that were removed for this procedure.
9. Connect starting power for the engine.
10. Start and drive the vehicle to verify proper Jake Brake performance.

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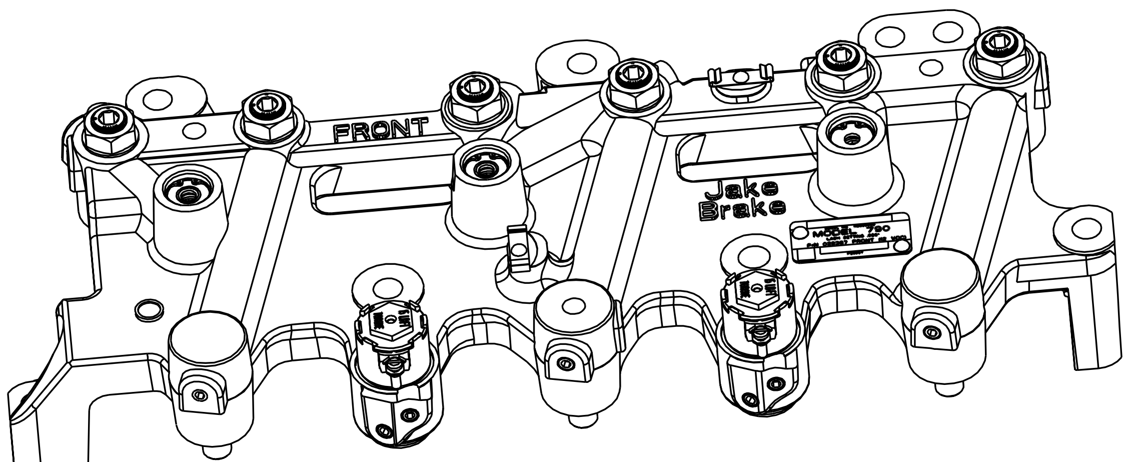
Jacobs Vehicle Systems™

Jacobs Engine Brake™

Tune-Up Kit
790/795 Series
P/N 29013



Information in this manual was current at time of printing and is subject to change without notice or liability.

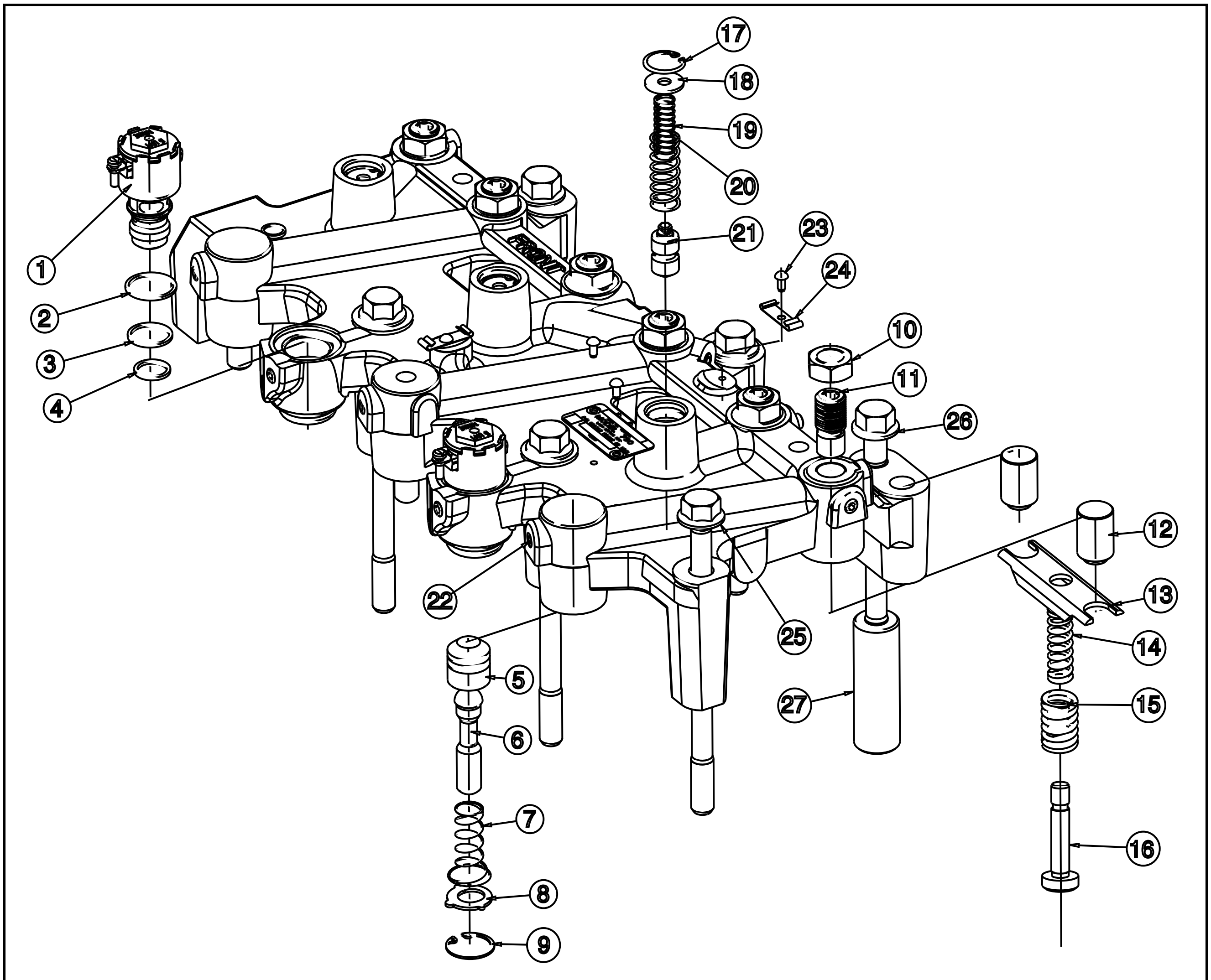
Refer to the Application guide, P/N 24770 for specific application information. Also refer to the Install Manual, P/N 29901 and the engine manual for specific installation instructions.

TUNE-UP KIT INSTRUCTIONS

Tune-up Kit Contents Model 790/795

Illus. No.	P/N	Part Name	Quantity per kit
1	1024612	Solenoid, 12VDC S/L	0
1	1024619	Solenoid, 24VDC S/L	0
2	20229	Seal, Solenoid Upper	3
3	1082	Seal, Solenoid Center	3
4	1083	Seal, Solenoid lower	3
5	26932	Master Piston	0
6	28791	Push Rod, Master Piston	0
7	28768	Spring, Master Piston	6
8	29944	Retainer, Master Piston	6
9	26555	Ring, Retainer	6
10	19987	Nut, Hex (790 series)	0
10	29908	Nut, Hex (795)	0
11	28341	J-lash™ assembly (790)	0
11	29300	J-lash™ assembly (790A)	0
11	29317	J-lash™ assembly (790B)	0
11	29310	J-lash™ assembly (790C)	0
11	29908	Solid Screw 3/8-24 (795)	0

Illus. No.	P/N	Part Name	Quantity per kit
12	26142	Slave Piston	0
13	28379	Bridge, Slave Piston	0
14	28372	Spring, Inner Slave Piston	6
15	28373	Spring, Outer Slave Piston	6
16	29295	Bolt, Shoulder-Slave Piston	6
17	12991	Ring, Retainer	6
18	16505	Washer	6
19	18179	Spring, Inner Control Valve	6
20	10843	Spring, Outer Control Valve	6
21	11930	Control Valve	6
22	18485	Pipe Plug	0
23	17303	Drive Screw	0
24	29127	Clip, Wire Harness	0
25	28346	CapScrew, M12X1.75X170	0
26	29132	CapScrew, M12X1.75X140	0
27	29118	Spacer Tube	0
NI	29015	Instructions	0



General Information

These instructions describe how to properly remove, clean and reinstall Jacobs Engine Brake™ components. For additional information on the 790/795 Series engine brakes, refer to the Series 60 Engine Service Manual, P/N 6SE483.

For slave piston clearance refer to the Jacobs Application Guide for Detroit Diesel Engines, P/N 24770.

Use OSHA-approved cleaning solvent for cleaning parts. Original parts to be reused should be inspected for wear and replaced as required. Be sure to coat parts with clean engine oil when reinstalling them.

The standard Jacobs Vehicle Systems Service Parts Warranty applies to the components of this Tune-up Kit. The warranty is administered by Detroit Diesel Corporation.

Safety Precautions

The following symbols in this manual signal conditions potentially dangerous to the mechanic or equipment. Read this manual carefully. Know when these conditions can exist. Then take necessary steps to protect personnel as well as equipment.

⚠ WARNING THIS SYMBOL WARNS OF POSSIBLE PERSONAL INJURY.

⚠ CAUTION THIS SYMBOL REFERS TO POSSIBLE EQUIPMENT DAMAGE.

NOTE: INDICATES AN OPERATION, PROCEDURE OR INSTRUCTION THAT IS IMPORTANT FOR CORRECT SERVICE.

Fuels, electrical equipment, exhaust gases and moving engine parts present potential hazards that could result in personal injury. Take care when installing equipment or parts. Always wear safety glasses. Always use correct tools and follow proper procedures as outlined in this manual.

Instructions

⚠ WARNING NEVER REMOVE OR ADJUST ANY ENGINE BRAKE OR COMPONENT WITH THE ENGINE RUNNING.

Access Engine Brake

1. Thoroughly clean engine.

2. Remove valve rocker cover and gasket.

NOTE: IF THE ENGINE HAS A TWO-PIECE COVER, THE LOWER VALVE COVER BASE DOES NOT HAVE TO BE REMOVED TO GAIN ACCESS TO THE ENGINE BRAKE HOUSINGS.

3. Disconnect the lead wires from each of the solenoid valves (1) and detach them from the wire clips (24).

4. Remove the six capscrews (25&26) and nut securing each engine brake housing. Remove the housings.

5. Retain six spacer tubes (27).

Disassemble Housings

1. Remove the solenoid valve (1) and discard the three seal rings (2,3,4).

⚠ WARNING WEAR SAFETY GLASSES. REMOVE CONTROL VALVE COVERS CAREFULLY TO AVOID PERSONAL INJURY. COVERS ARE UNDER LOAD FROM CONTROL VALVE SPRINGS (19,20).

2. Hold down the control valve cover while removing the retaining ring (17). Remove and discard all parts.

3. Loosen the locknut (10) and remove the adjusting screws (11) and locknuts. Retain the adjusting screws and locknuts.

4. Remove the retaining rings (9), retainers (8) and springs (7) that retains the master pistons; discard the springs, retainers and retaining rings. Remove and save the master pistons (5) and the push rods (6).

5. Remove the shoulder bolt (16) and springs (14,15) that retain the slave piston; discard springs only. Remove and save the bridge (13) and slave piston (12).

Assemble Housings

1. Clean all parts in an approved cleaning solvent. Dry with compressed air.

2. Coat all parts to be installed into housings with clean lube oil.

3. Reinstall the original slave piston (12) and bridge (13), reversing the removal procedure.

4. Install the new shoulder bolts (16) and springs (14,15). Tighten the bolt to 23 N•m (200 lb-in).

5. Reinstall the master pistons (5) and push rods (6). Install the new springs (7), retainers (8) and retaining rings (9). Rotate the retaining rings 90° to ensure that the ring is seated in the groove.

6. Install the adjusting screw (11) and locknut (10). Do not tighten the locknut at this time.

7. Install the new control valves (21), springs (19,20), washers (18) and retaining rings (17). Rotate the retaining ring 90° to ensure that the ring is seated in the groove.

8. Install the lower (smallest) solenoid seal ring (4) into the bottom of the solenoid valve bore. Install the upper (2) and center (3) seal rings on the solenoid valve. Coat the seals with engine oil prior to assembly.

NOTE: NEW UPPER SEAL RINGS CAN BE IDENTIFIED BY A YELLOW STRIPE.

9. Insert the solenoid valve and torque to 20 N•m (15 lb-ft).

NOTE: INSTALL THE SOLENOID CAREFULLY TO AVOID CUTTING OR TWISTING THE SEAL RINGS. IMPROPER INSTALLATION COULD RESULT IN POOR ENGINE BRAKE PERFORMANCE.

Install Engine Brake Housings

⚠ CAUTION REMOVING THE OIL FROM THE BOLT HOLES PREVENTS THE CYLINDER HEAD FROM CRACKING WHEN BOLTS ARE TIGHTENED. ATTACH A LENGTH OF TUBING TO AN AIR GUN NOZZLE AND BLOW OUT THE OIL FROM THE HOUSING HOLD-DOWN BOLT HOLES. COVER THE HOLES WITH HAND TOWELS TO MINIMIZE OIL SPRAY.

⚠ WARNING WEAR SAFETY GLASSES WHILE BLOWING THE OIL FROM THE BOLT HOLES.

1. Place the engine brake housings on the rocker shafts and spacer tubes with the solenoids on the camshaft side of the engine and the slave pistons over the exhaust valves.

2. Lubricate each hold-down capscrew with clean engine oil prior to installation.

3. Install three M12x170 capscrews (25) on solenoid side of brake. Install three M12x140 capscrews (26) on the exhaust side of the engine.

⚠ CAUTION INSTALLING 170 MM CAPSCREWS (25) ON THE EXHAUST SIDE OF THE ENGINE CAN RESULT IN SERIOUS ENGINE DAMAGE.

4. Before tightening the capscrews, move the housing from side to side. Position housing in the center of the range of motion.

5. Tighten the capscrews in the following sequence:

   a. Starting with the middle capscrew, tighten the three capscrews on the camshaft side of the engine to 55 N•m (40 lb-ft).

   b. Starting with the middle bolt, tighten the three bolts on the exhaust manifold side of the engine to 55 N•m (40 lb-ft).

   c. Tighten the nut at the end of the rocker shaft to 55 N•m (40 lb-ft)

   d. Repeat the tightening sequence and torque all capscrews to 136 N•m (100 lb-ft).

   e. Follow the same sequence for the other brake.

6. Connect the lead wires to the solenoid valves passing the wires through the wire clips. Torque solenoid screw to 1 N•m (9 lb-ft) and pull the lead wires away from the housing.

Adjust Slave Piston Clearance

⚠ CAUTION FAILURE TO FOLLOW ADJUSTMENT PROCEDURES CAN RESULT IN ENGINE OR ENGINE BRAKE DAMAGE.

NOTE: MAKE SLAVE PISTON ADJUSTMENT WITH THE ENGINE STOPPED AND COLD. ADJUST EACH CYLINDER WITH THE EXHAUST VALVES IN THE CLOSED POSITION.

1. Back out the adjusting screws on the slave pistons until the slave piston does not touch the rocker arm.

2. Insert the proper feeler gage between the slave piston and the exhaust rocker adjusting screw. Using a 3/16 inch hex wrench turn in the adjusting screw until the slave piston contacts the exhaust rocker adjusting screw through the feeler gage. For Model 795 applications, skip to step 4, For J-Lash installation only, continue turning in the adjusting screw until the valve springs begin to compress, then turn in one (1) additional turn. Wait at least 30 seconds for oil to be purged from the J-Lash adjusting screw.

NOTE: ALL OIL MUST BE PURGED FROM THE J-LASH ADJUSTING SCREW. IF OIL IS BELOW 60 °F, 16 °C, WAIT AT LEAST TWO MINUTES FOR OIL TO BE PURGED FROM THE J-LASH ADJUSTING SCREW.

⚠ CAUTION SERIOUS ENGINE DAMAGE MAY OCCUR FROM IMPROPER LASH SETTING.

3. After the time interval specified in step (2), back out the adjusting screw ONLY until a light drag is felt on the feeler gage. Do not retract more than required to obtain a light drag on the feeler gage.

NOTE: IF THE J-LASH ADJUSTING SCREW IS BACKED OUT UNTIL IT NO LONGER COMPRESSES THE SLAVE PISTON SPRING, OIL WILL ENTER THE SCREW AND THE ADJUSTMENT WILL BE INCORRECT. IF THIS OCCURS, REPEAT STEPS (1) AND (2).

4. Hold the J-Lash adjusting screw in place and torque the lock nut to 38 N•m (336 lb-in). Recheck lash settings. If lash setting is incorrect, repeat steps (1) through (3) above.

NOTE: ONCE THE ENGINE BRAKE HAS BEEN RUN YOU WILL NOT BE ABLE TO CHECK THE ENGINE BRAKE ADJUSTMENT FOR ENGINES USING J-LASH ADJUSTING SCREWS. THIS IS BECAUSE OF OIL RETAINED IN THE J-LASH ADJUSTING SCREW. IF UNSURE OF THE ADJUSTMENT, YOU MUST REPEAT STEPS (1) THROUGH (4) ABOVE.

Engine Brake Operational Check

⚠ WARNING WEAR EYE PROTECTION AND DO NOT EXPOSE YOUR FACE OVER THE ENGINE AREA. TAKE PRECAUTIONS TO PREVENT OIL LEAKAGE ONTO THE ENGINE. COVER CONTROL VALVE AREAS SUFFICIENTLY TO PREVENT OIL SPLASH.

Bleed the engine brake housings.

1. Be sure wires are away from moving parts.

2. Start the engine and allow to run for a few minutes.

3. Manually activate the solenoid valve several times to allow the housing to be filled with oil.

NOTE: THE SOLENOID VALVE IS MANUALLY ACTIVATED BY DEPRESSING THE ARMATURE. THE ARMATURE IS LOCATED IN THE CENTER OF THE TOP OF THE SOLENOID.

Check for proper operation.

1. Manually activate the solenoid valve and watch the master piston to be sure it is moving down onto the roller in the injector rocker arm.

2. Watch the slave piston assembly. It should move down to contact the exhaust valve rocker arm adjusting screws.

3. Check each housing to be sure it is functioning.

4. Shut down engine.

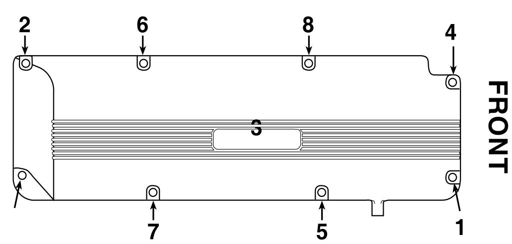
Rocker Cover Installation

1. Make sure the seal is in place in the rocker cover base and set the cover in place on the cover base.

2. Install the bolt with a flat washer, isolator and limiting sleeve into the cover holes.

3. Tighten the bolts to 14 N•m (10 lb-ft) in the sequence shown in Fig. 1.

4. Torque the bolts to 27 N•m (20 lb-ft).



SERIES 60 ROCKER COVER

FIG. 1

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www.jakebrake.com

P/N 29015 Rev. A

Printed in U.S.A.

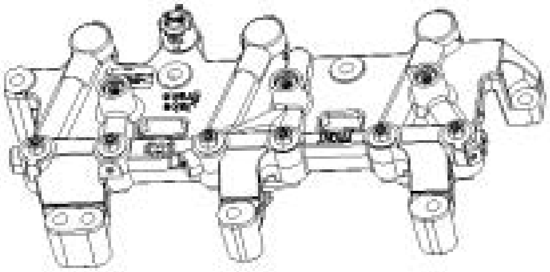
Rev. 10/00

SPECIFICATIONS - 790/795/797

Jake Brake® Models 790, 795 & 797

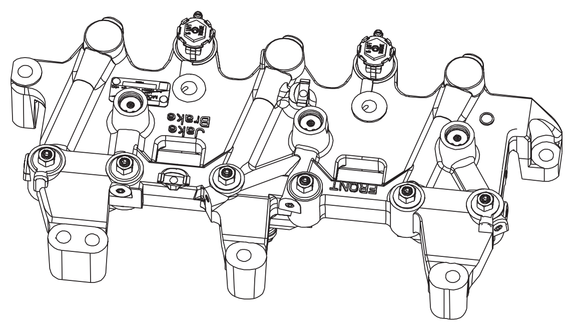
for Detroit Diesel Series 60® Engines

Year 2000 Production Engines and Beyond



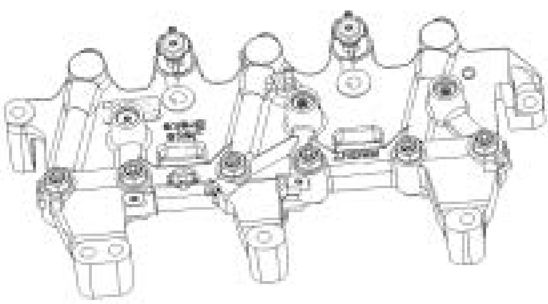
797 Series

For engines manufactured 10/01/02-



Model 795

For engines manufactured 8/10/00-9/30/02



790 Series

For engines manufactured 12/15/99-8/10/00

Features & Benefits

Designed in partnership with Detroit Diesel to yield a more simplified design, reducing weight while increasing performance & reliability:

- *Significant low & mid-range RPM performance improvements*
- *Respected Jake Brake® reliability & durability*

Jake Brake is the only engine brake brand installed at Detroit Diesel

Backed by Detroit Diesel's worldwide distributor & dealer network

2-year/unlimited mileage standard warranty

OVER 40 YEARS Since 1961 OF LEADERSHIP

Engineered for the Road Ahead™

Jake Brake® Models 790, 795 & 797

for Detroit Diesel Series 60® Engines

Technical Specifications

Height	4.2"	107 mm
Length	19.6"	498 mm
Width	4"	102 mm
Kit Added Weight	75 lbs.	34 kg.
Housings Per Engine	2	

Application Information

For the most accurate application information, refer to the Detroit Diesel Application Guide (Jacobs P/N 24770), available from your Detroit Diesel Distributor or online at www.jakebrake.com.

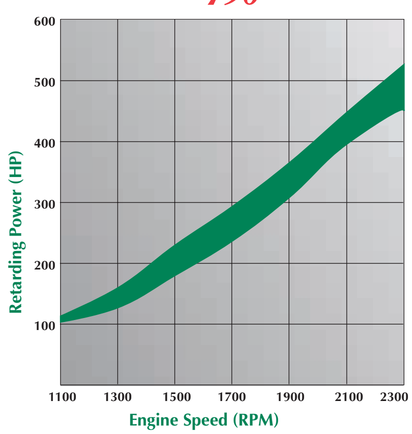
How The Jake Brake® Works:

Energizing the engine brake effectively converts a power-producing diesel engine into a power-absorbing air compressor. This is accomplished through motion transfer using a master/slave piston arrangement which opens cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust.

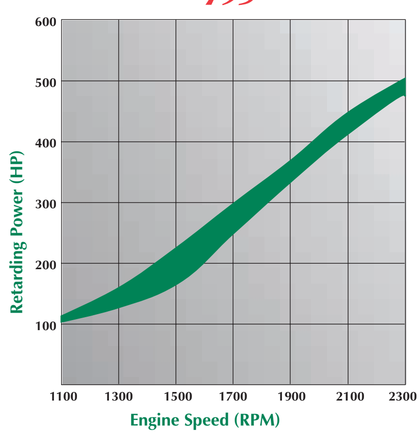
The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion stroke, the effect being a net energy loss since the work done in compressing the cylinder charge is not returned during the expansion process.

Retarding Performance

790



795



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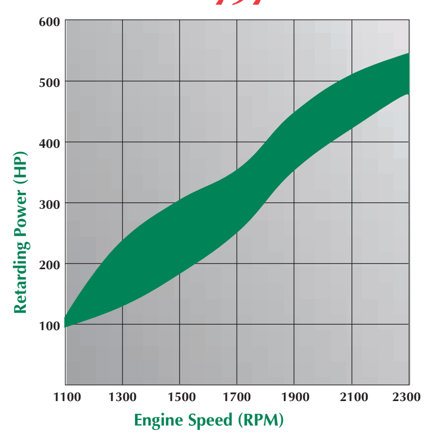


RPM	790				
	12.7L 330-350	12.7L Std	12.7L Prem	14L US Hwy	14L Australia
1100	101	101	105	105	110
1300	138	136	142	143	163
1500	193	194	190	185	235
1700	267	273	251	241	294
1900	342	351	323	308	368
2100	406	413	397	401	455
2300	465	470	480	483	525

RPM	795			
	12.7L 330-350	12.7L Std	12.7L Prem	14L US Hwy
1100	110	108	102	109
1300	157	150	135	140
1500	220	215	165	193
1700	299	280	250	253
1900	359	363	340	333
2100	419	445	420	412

RPM	797					
	12.7L 426	12.7L 433	12.7L Australia	14L 430	14L 489	14L 500
1100	111	104	99	116	113	109
1300	156	150	135	233	238	151
1500	226	229	191	285	302	221
1700	307	320	262	324	348	305
1900	366	382	359	404	448	404
2100	426	433	439	443	510	489
2300	475	479	496	492	564	552

Important Note: The performance data shown above is measured in accordance with SAE J1621 power measurement standard, up to engine manufacturer's rated engine speed of 2100 RPM.

Others may claim higher retarding performance. Only the Jacobs Engine Brake® is designed and tested in cooperation with Detroit Diesel to provide the highest performance available while maintaining or improving engine brake system reliability and durability.

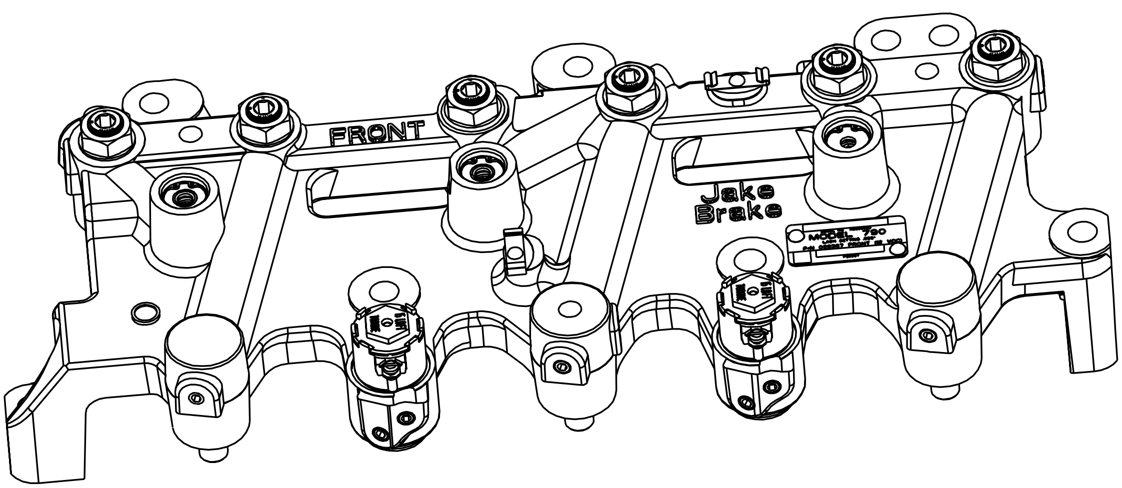
Jacobs Vehicle Systems™

P/N 030562 Rev. B 3/03

Jacobs Vehicle Systems™

Jacobs Engine Brake®

Models 790/795/797



Information in this manual was current at time of printing and is subject to change without notice or liability.

Refer to the Application guide, P/N 24770 for specific application information. Also refer to the Installation Manual, P/N 29901 and the Engine Manual for specific installation instructions.

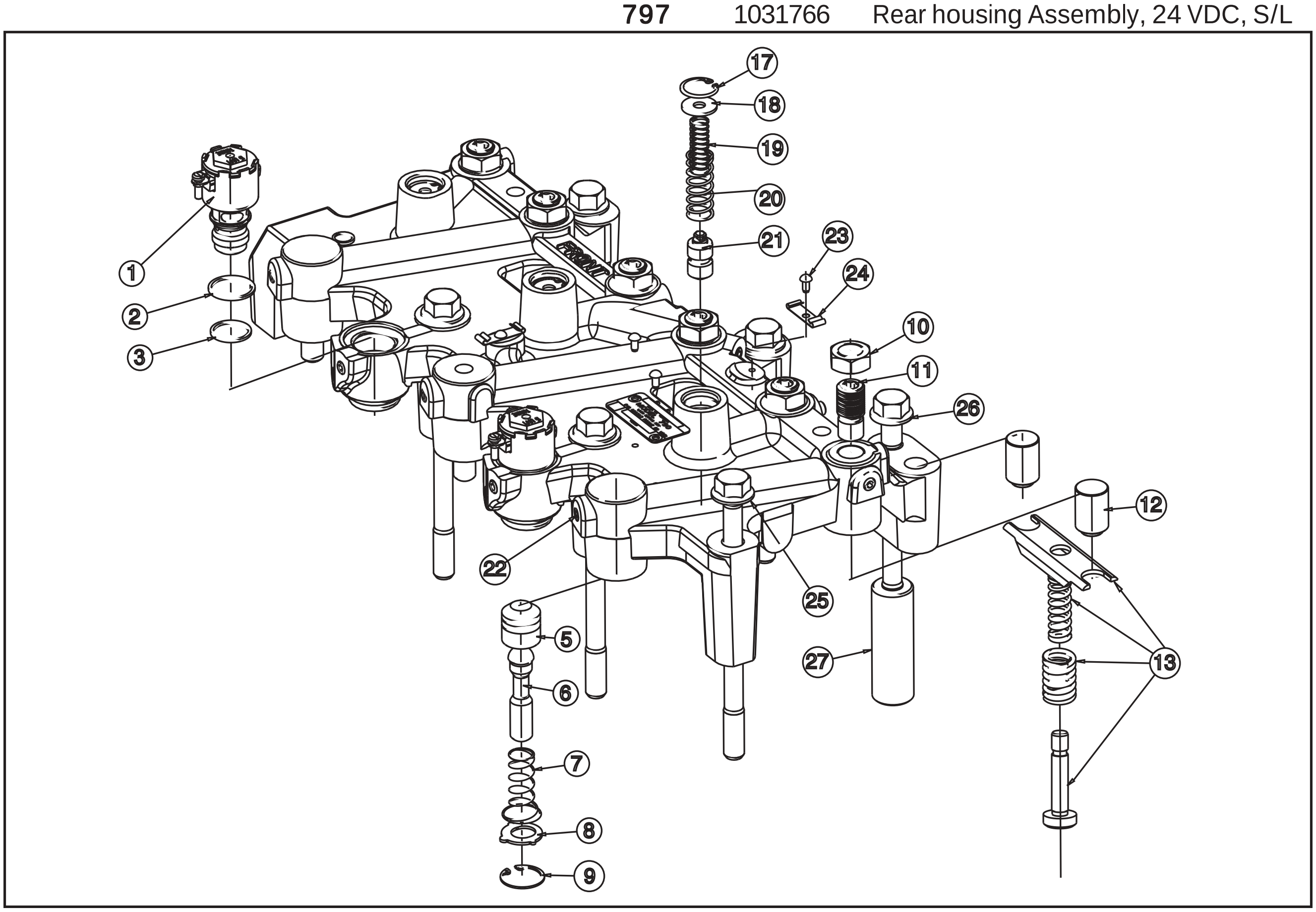
PARTS MANUAL

790/795/797 KITS

Model No.	P/N	Description
790	29240	Engine Brake Kit, 12 VDC
790	29020	Engine Brake Kit, 24 VDC
790A	29123	Engine Brake Kit, 12 VDC
790A	29232	Engine Brake Kit, 24 VDC
790B	29302	Engine Brake Kit, 12 VDC
790B	29304	Engine Brake Kit, 24 VDC
790C	29321	Engine Brake Kit, 12 VDC
790C	29323	Engine Brake Kit, 24 VDC
795	30505	Engine Brake Kit, 12 VDC
795	30506	Engine Brake Kit, 24 VDC
797	31361	Engine Brake Kit, 12 VDC
797	31860	Engine Brake Kit, 24 VDC

790/795/797 HOUSING ASSEMBLIES

Model No.	P/N	Description
790	28367	Front housing Assembly, 12 VDC, S/L
790	28368	Rear housing Assembly, 12 VDC, S/L
790	29017	Front housing Assembly, 24 VDC, S/L
790	29018	Rear housing Assembly, 24 VDC, S/L
790A	29029	Front housing Assembly, 12 VDC, S/L
790A	29030	Rear housing Assembly, 12 VDC, S/L
790A	29124	Front housing Assembly, 24 VDC, S/L
790A	29125	Rear housing Assembly, 24 VDC, S/L
790B	29128	Front housing Assembly, 12 VDC, S/L
790B	29129	Rear housing Assembly, 12 VDC, S/L
790B	29130	Front housing Assembly, 24 VDC, S/L
790B	29131	Rear housing Assembly, 24 VDC, S/L
790C	29148	Front housing Assembly, 12 VDC, S/L
790C	29149	Rear housing Assembly, 12 VDC, S/L
790C	29150	Front housing Assembly, 24 VDC, S/L
790C	29151	Rear housing Assembly, 24 VDC, S/L
790D	1031226	Front housing Assembly, 12 VDC, S/L
790D	1031227	Rear housing Assembly, 12 VDC, S/L
790D	1031228	Front housing Assembly, 24 VDC, S/L
790D	1031229	Rear housing Assembly, 24 VDC, S/L
795	29902	Front housing Assembly, 12 VDC, S/L
795	29903	Rear housing Assembly, 12 VDC, S/L
795	29904	Front housing Assembly, 24 VDC, S/L
795	29905	Rear housing Assembly, 24 VDC, S/L
797	1031322	Front housing Assembly, 12 VDC, S/L
797	1031323	Rear housing Assembly, 12 VDC, S/L
797	1031765	Front housing Assembly, 24 VDC, S/L
797	1031766	Rear housing Assembly, 24 VDC, S/L



HOUSING ASSEMBLY 790/795/797

Illus. No.	Part Name	790	795	797	Qty per housing
1	**Solenoid**		1024612(12VDC) -or- 1024619(24VDC)		2*
2	**Seal, Solenoid Upper**		20229		2*
3	**Seal, Solenoid Middle**		1082		2*
4	Seal, Solenoid Lower	not required		not required	2*/***
5	Master Piston	26932		31282	3
6	**Pushrod - Master Piston**		28791		3
7	**Spring, Master Piston**		28768		3
8	Washer- MP Retainer	29944		31854	3
9	Ring, Retainer	26555		31331**	3
10	Nut, Hex	19987	29908		6
11	Adjusting Screw	(See 790 J-Lashes)	29864	31270	6
12	Slave Piston	26142		31324	6
13	Slave Piston Spring Group	32160		32127	3
	Bridge, Slave Piston	n/a		n/a	-
	Spring, Inner Slave Piston	n/a		n/a	-
	Spring, Outer Slave Piston	n/a		n/a	-
	Shoulder Bolt, Slave Piston	n/a		n/a	-
17	**Ring, Retainer**		12991		3
18	**Washer**		16505		3
19	**Spring, Inner Control Valve**		18179		3
20	**Spring, Outer Control Valve**		10843		3
21	**Control Valve Assembly**		11930		3
22	**Pipe Plug**		18485		-
23	**Drive Screw**		17303		-
24	**Clip, Wire Harness**		29127		-

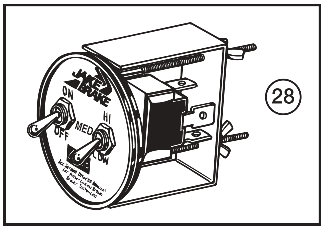
Notes: **Bold** text deplicts parts that are common to all brake models listed.
*For 790/795, front housing has two solenoid and the rear housing has one;
For 797, both front and rear housings have only one solenoid.
**Requires assembly tool part #J-45976
***Reference Technical Service Letter 02TS-17

790 J-lash™ Assemblies & Groups

Illus. No.	Part Name	790	790A	790B&D	790C	Qty per housing
11	J-lash™ Assembly	28341	29300	29317	29310	6
	J-lash™ Assy Group (12 pack)	29019	29414	29415	29416	-

ATTACHING PARTS

Illus. No.	P/N	Part Name	Quantity per kit
NI	**29133**	**Attaching Parts Group**	1
25	28346	CapScrew, M12X1.75X170	6
26	29132	CapScrew, M12X1.75X140	6
27	29118	Spacer Tube	6



CAB CONTROL GROUP

Illus. No.	P/N	Part Name	Quantity per kit
NI	**20220**	**Cab Control Group**	
NI	20244	Harness, 6ft	1
28	20035	Switch	1

SERVICE PARTS 790/795/797

P/N	Part Name
17671	Feeler gauge 0.026 IN. (0.660 mm)
16590	Screw, Rocker Adjusting
29013	Tune up kit - 790/795 Series
29589	Wire Clip Kit - Model 790
30503	Solid Screw Group (12 pack), 795
32128	Solid Screw Group (12 pack), 797
32146	Tune up kit - 797 Series
J-45976	Master Piston Assembly Tool, 797
29901	Installation Manual

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22 East Dudley Town Road
Bloomfield, CT 06002

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P/N 29900 Rev. B

Rev. 10/02

SECTION 03: FUEL SYSTEM

CONTENTS

ILLUTRATIONS

1. FUEL SYSTEM DESCRIPTION

Figure 1 shows a schematic of the fuel system. Fuel is drawn from the fuel tank through a manual shut-off valve, a primary fuel filter or a fuel filter/water separator (optional) before it enters the fuel pump. If the vehicle is equipped with the optional “Davco Fuel Pro 382”, it is designed to be the only fuel filter in the system, no secondary fuel filter is necessary. Leaving the pump under pressure, the fuel flows through a secondary fuel filter and a shut-off valve, then to the cylinder head. The fuel reaches the injectors in the cylinder head through passages within the head. Excess fuel exits at the rear of the head just above the inlet, through a restrictive return fitting which maintains fuel pressure in the system. Finally, the fuel flows through the check valve and the fuel cooler before it returns to the fuel tank. One preheater is available: 104 000 BTU. If the vehicle is equipped with the 104 000 BTU preheater, the fuel is drawn from the fuel tank through the fuel filter to the preheater. Excess fuel returns to the fuel tank.

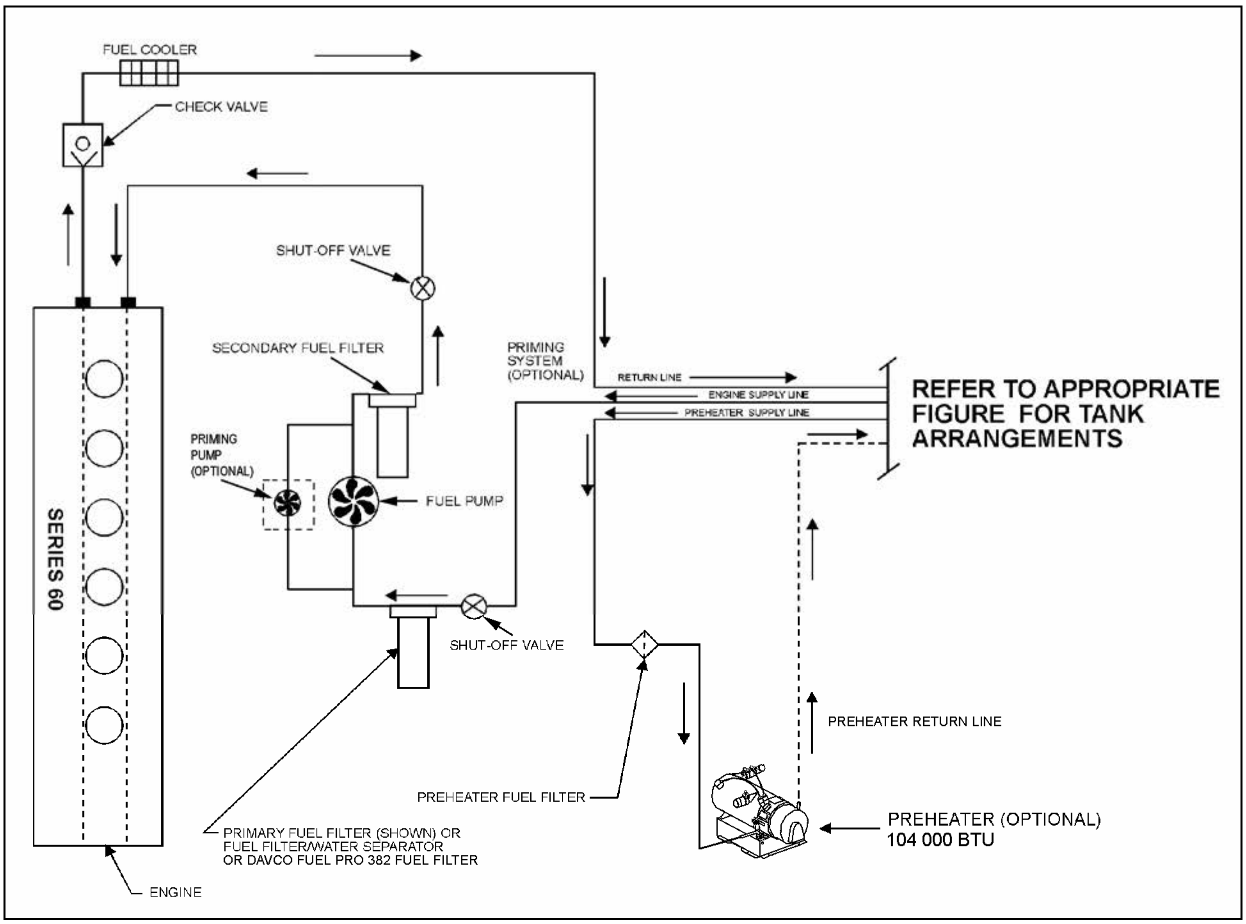


FIGURE 1: FUEL SYSTEM SCHEMATIC 03055

2. FUEL LINES AND FLEXIBLE HOSES

Make a visual check for fuel leaks at all engine-mounted fuel lines and connections and at the fuel tank suction and return lines. Since fuel tanks are susceptible to road hazards, leaks in this area may best be detected by checking for accumulation of fuel under the tank. Engine performance and auxiliary equipment is greatly dependent on the ability of flexible hoses to transfer lubricating oil, air, coolant and fuel oil. Diligent maintenance of hoses is an important step in ensuring efficient, economical and safe operation of engine and related equipment.

Check hoses daily as part of the pre-start-up inspection. Examine hoses for leaks and check all fittings, clamps and ties carefully. Make sure that the hoses are not resting on or touching shafts, couplings, and heated surfaces, including exhaust manifolds, any sharp edges or other obviously hazardous areas. Since all machinery vibrates and moves to a certain extent, clamps and ties can fatigue with age. To ensure continued proper support, inspect fasteners frequently and tighten or replace them as necessary. Refer to the schematic diagram of the fuel system (Fig. 1).

Caution: *Oil level above the dipstick full mark or a decrease in lube oil consumption may indicate internal fuel leaks. Check oil level frequently.*

3. FUEL VALVES

Manual shut-off valves on engine fuel-supply line are located on the R.H. side of engine compartment (Fig. 2). A manual shut-off valve is located at the inlet side of the primary fuel filter (fuel filter/water separator, if vehicle is so equipped) under the starter. Another manual shut-off valve is located at the outlet side of the secondary fuel filter, under the air compressor. No manual valve is required on preheater fuel-supply line, since the positive-displacement fuel pump (located close to the fuel tank) prevents fuel flow when not activated.

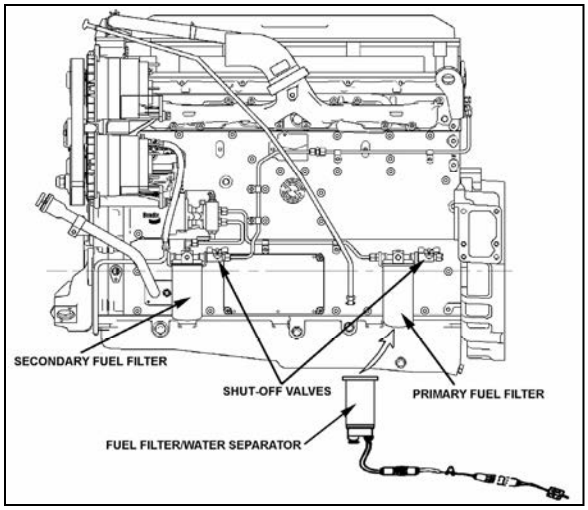


FIGURE 2: MANUAL SHUT-OFF VALVES 03052

4. FILTERS AND WATER SEPARATOR

The fuel system is equipped with primary and secondary fuel filters for additional protection of the injectors. A fuel-filter/water-separator may be installed in primary fuel-filter location, to prevent water infiltration in engine fuel system (Fig. 2). It should be drained periodically, or when the water separator telltale light on the dashboard illuminates. To drain, loosen positive seal drain valve below separator, and tighten after water has been flushed out.

Note: *The operating conditions and cleanliness of type of fuel used determine the service intervals of the filter/water separator element and the secondary fuel filter cartridge.*

4.1 FUEL FILTER/WATER SEPARATOR SERVICING

The fuel filter/water separator is located on the starter side of the engine, below the starter. The water separator must be drained periodically or when the telltale light on the dashboard illuminates.

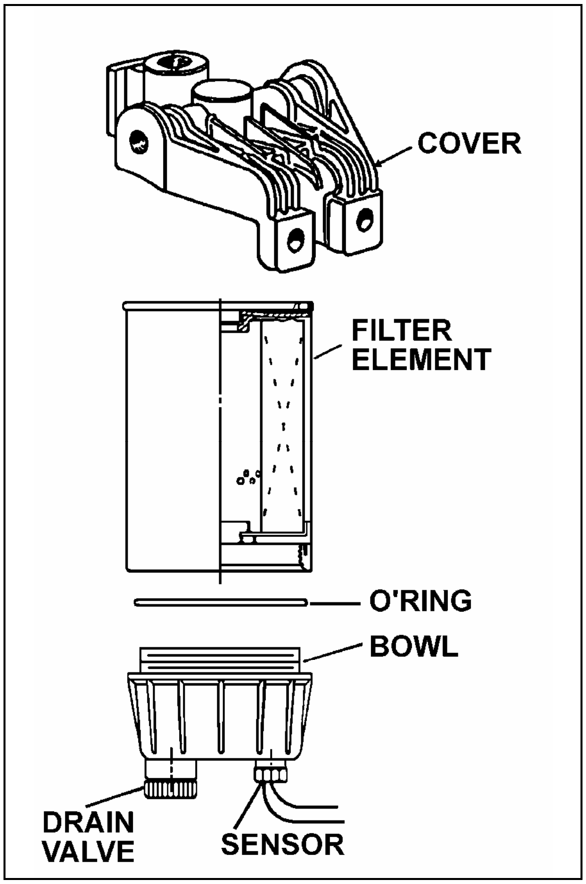


FIGURE 3: FUEL FILTER/WATER SEPARATOR 03025

Replace the water separator element as follows:

1. Drain the fuel filter/water separator as stated previously.
2. With engine "OFF" and engine fuel supply line valves closed; remove the filter element/bowl assembly from cover (for valve location, see *"3. FUEL VALVES"* in this section).
3. Separate bowl from filter element. Clean bowl and O-ring groove.

Note: *Bowl is reusable, do not discard.*

4. Lubricate O-ring with clean diesel fuel or motor oil and place it in bowl groove.
5. Screw new filter element onto bowl snugly by hand.

Caution: *Do not use tool to tighten. Tighten by hand only.*

6. Lubricate filter seal with clean diesel fuel or motor oil.
7. Fill filter element/bowl assembly with clean diesel fuel and attach onto cover. Hand tighten an additional 1/3 to 1/2 turn after making full seal contact.
8. Open valves of the engine fuel supply line.
9. Run the engine and check for leaks.

Caution*: If the water separator continuously requires draining, it is possible that water or sediment has accumulated in the fuel tank. To correct this situation, open the drain plug under the tank when the fuel gauge indicates tank is 1/4 full in order to drain any contaminant.*

4.2 FUEL FILTER SERVICING (PRIMARY AND SECONDARY)

The primary and secondary fuel filters are located on the R.H. side of the engine. The primary filter is located below the starter, and the secondary fuel filter is below the air compressor. They are of a spin-on type and must be replaced every 12,500 miles (20 000 km) or once a year, whichever comes first. The primary fuel filter is equipped with a positive seal drain-valve to prevent water infiltration in engine fuel system. To drain, loosen positive seal drain-valve below filter and tighten after water has been flushed out.

A method of determining when filters are clogged to the extent that they should be changed is based on the fuel pressure at the cylinder head fuel inlet fitting and the inlet restriction at the fuel pump. In a clean system, the maximum pump-inlet restriction should not exceed 6 inches of mercury (20.3 kPa) and must not exceed 12 inches of mercury (41 kPa) with a dirty system.

At normal operating speeds and with the standard 0.080" restriction fittings, the fuel pressure at the cylinder head inlet is 50-75 psi (345-577 kPa). Change the fuel filters whenever the inlet restriction at the fuel pump reaches 12 inches of mercury (42 kPa) at normal operating speeds. Also, change whenever the fuel pressure at the cylinder head inlet fitting falls to the minimum fuel pressure given above.

Change the filter cartridge(s) as follows:

Note: *Use a suitable band wrench or filter wrench, such as J22775, to remove the filters.*

1. Stop engine, shut off the engine fuel supply line valves (for valve location, See *"3. FUEL VALVES").* Unscrew and discard filters.
2. Fill new filter replacement cartridge(s) with clean fuel oil, about two thirds (2/3). Apply a thin coat of clean fuel oil on gasket.
3. Install new filters. Tighten until filter is snug against the gasket, with no side movement. Rotate an additional 1/2 turn by hand.
4. Open engine fuel supply line valves.

Caution: *Mechanical tightening of the fuel filters is not recommended and may result in seal and/or cartridge damage. Tighten the fuel filters by hand only.*

5. Start the engine and check for leaks.

Note: *There is a fuel system shut-off valve on the discharge side of the secondary fuel filter. This check valve is designed to prevent fuel loss at time of filter replacement.*

4.3 DAVCO FUEL PRO 382

The optional Fuel Pro 382 diesel fuel filter system consists of a permanently mounted fuel processor, a replaceable filter element, a filter element cover and collar and a fluid filter base assembly. This system is installed between the fuel tank and the fuel pump and is designed to be the only fuel filter in the fuel system. The filter serves as a water separator as well as a fuel filter (refer to figure 4).

When new, the fuel level as seen through the clear cover in the 382 filter is very low. It rises as dirt collects on the filter from the bottom up. Restriction remains consistently low because fuel always flows through clean, new media. Change filter when fuel level reaches the top of filter element (refer to figure 5).

Filter renewal:

1. Stop engine;
2. Drain fuel by opening the drain valve;
3. Untighten upper collar, remove cover;
4. Replace filter element;
5. Check O-Rings and components for wear;
6. Replace cover, hand tighten collar;
7. Pour fuel up to bottom of filter element through spin off cap located on top of cover.
8. Start engine, raise rpm for 2-3 minutes, hand tighten collar again.

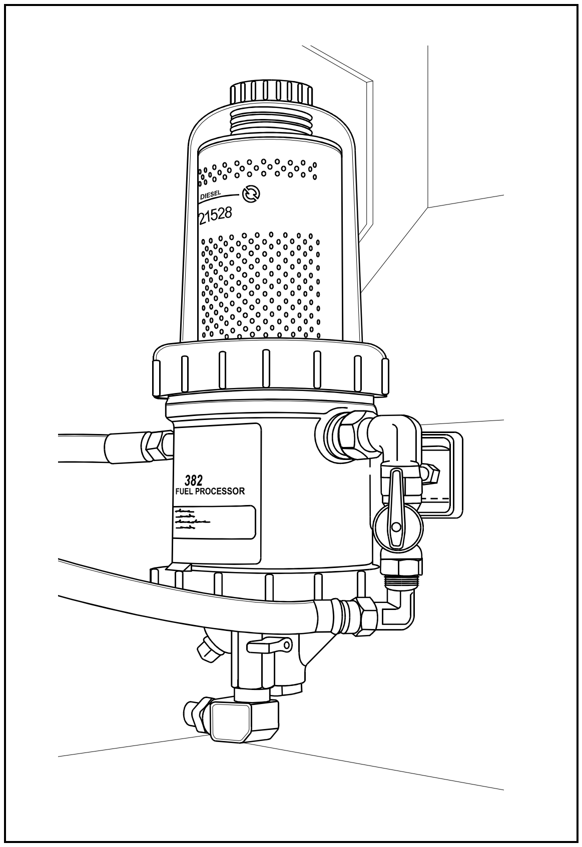


FIGURE 4: DAVCO FUEL PRO 382 FUEL FILTER 03032

Note*: Fuel Pro 382 also accepts standard secondary spin-on fuel filters.*

Environmental Notice*: Diesel fuel is an environmentally hazardous product. Dispose in an environmentally friendly manner.*

4.4 PREHEATER FUEL FILTER

The preheater fuel filter is located above the preheater, in the L.H. side rear service compartment. Replace the filter every 50,000 miles (80 000 km) or once a year, whichever comes first.

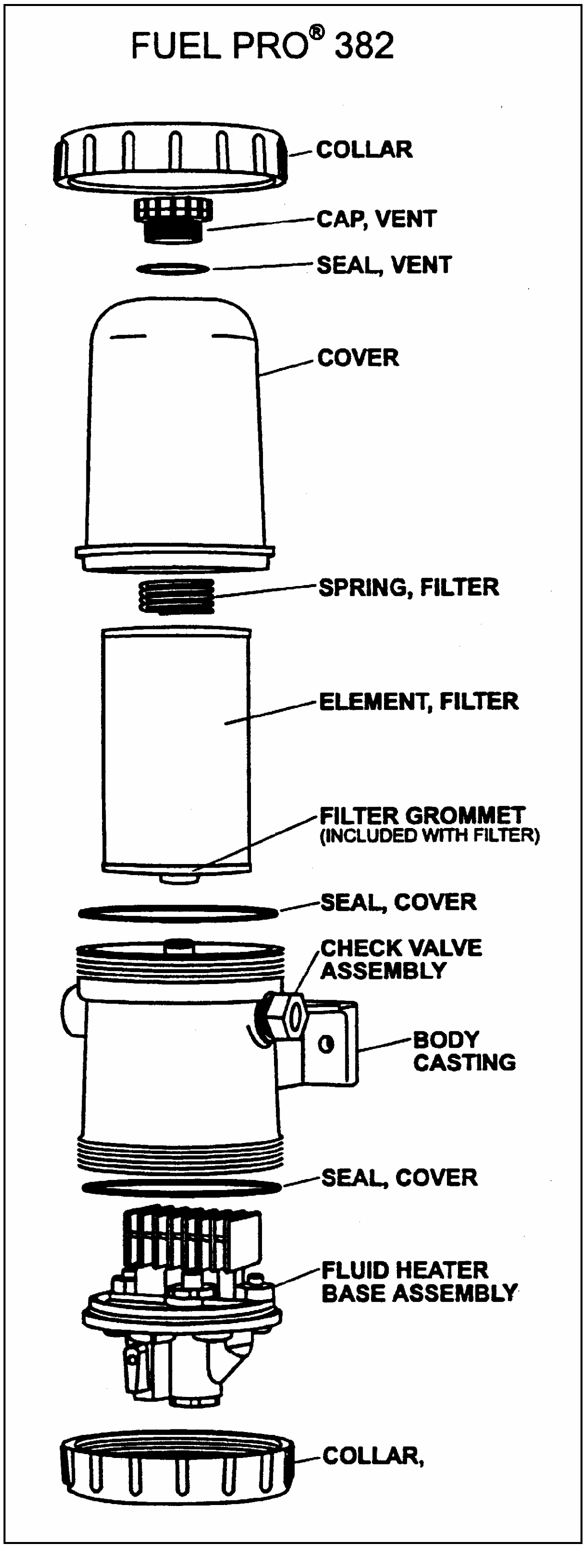


FIGURE 5: DAVCO FUEL PRO 382 EXPLODED VIEW03034

5. FUEL TANK

All XL2 series vehicles are equipped with a high-density cross-link polyethylene fuel tank. XL2-45 coach has a capacity of 208 US gallons (787 liters). MTH 40 and MTH 45E fuel tanks have a total capacity of 250 US gallons (945 liters) while MTH 45 can be equipped with an optional 90 US gallons (341 Liters) auxiliary stainless steel tank forward of the standard 208 US gallons (787 liters) fuel tank. The main tank is located just forward of the rear baggage compartment, between the A/C condenser and evaporator. The auxiliary tank is located in the baggage compartment just forward of the main tank.

On all vehicles, fuel filling access doors on both sides of vehicle provide direct access to filler necks; offering the added advantage of refueling from either side of vehicle.

A pressure relief valve on the fuel tank connection-panel relieves high-pressure buildup and an overflow tube allows offset air in the tank to escape during filling. For 95% of the tank volume, 5% of tank inside space is kept filled with air with no exit opening, allowing for a fuel expansion safety margin. A drain plug, accessible from under the vehicle, is fitted at the bottom of the tank(s).

5.1 TANK REMOVAL

Warning: *Park vehicle safely, apply parking brake, stop engine and set battery master switch (es) to the OFF position before working on the vehicle.*

Before working under an air-suspended vehicle, it is strongly recommended to support the body at the recommended jacking points.

Note: *Before removal, the fuel tank should be completely drained by unscrewing the drain plug. Ensure that the container used has a capacity equal to the amount of fuel remaining in the tank(s).*

For vehicles equipped with a transverse tank or an auxiliary tank, drain it as well since it is directly connected to the main tank.

It is possible to drain both tanks through only one plug, but the other tank will not drain completely since the connecting hose is not on the bottom.

5.1.1 Main Fuel Tank

1. Open the condenser door and remove the fuel tank access panel. The rear baggage compartment fuel tank access panel may also be removed to facilitate access to components.
2. If applicable, unscrew clamps retaining L.H. side filler tube to the fuel tank, then disconnect tube and remove it.
3. Unscrew clamps retaining R.H. side filler tube to fuel tank and filler neck. Disconnect tube and remove it.
4. If applicable, unscrew preheater supply line, preheater return line, auxiliary return line and/or auxiliary return line from fuel tank connection-panel.
5. Unscrew engine supply and return lines from fuel tank connection-panel, identify them for reinstallation.

Note : *For vehicles equipped with a transverse tank or an auxiliary tank, the two hoses joining the tanks should be disconnected.*

6. Disconnect electrical wiring from tank on connection plate.

Warning: *Before removing the bolts securing the tank support to the frame, make sure the tank is supported adequately. Failure to do so could result in injury as well as damage to the tank.*

7. From under the vehicle, on R.H. side, unscrew the 4 bolts (2 in front, 2 in back) retaining the tank support to the frame.
8. From under the vehicle, on the L.H. side, unscrew the 2 bolts (1 in front, 1 in back) retaining the tank support to the frame.
9. Carefully remove tank from under the vehicle.

5.1.2 Auxiliary Fuel Tank (if so equipped)

1. Open the baggage compartment just forward of condenser compartment, disconnect the (2) hoses previously joining the tanks.
2. From underneath vehicle, unscrew the two (2) bolts retaining the tank strap (one on each side).
3. From inside the baggage compartment just forward of condenser compartment, slightly raise the strap and pull out auxiliary fuel tank using the same care as for the main fuel tank.

Caution : *Protective cushions or rags should be placed on the baggage compartment floor to prevent it from being scratched by the fuel tank during removal.*

5.1.3 Transverse Fuel Tank

1. The transverse fuel tank must be removed from R.H. side. The stainless steel panel must be removed by first removing the adhesive.
2. From underneath the vehicle, unscrew the bolt on left and right hand side securing the tank foot. Unscrew the two screws at the center of the tank then disconnect the two hoses previously joining the tanks.
3. Unscrew clamps retaining L.H. side filler tube to the fuel tank, then disconnect tube and remove it.
4. Unscrew clamps retaining R.H. side filler tube to fuel tank and filler neck. Disconnect tube and remove it.
5. Remove plastic molded panel from inside baggage compartment located forward of A/C & Heating compartment.
6. Slide the tank out carefully.

5.2 TANK INSTALLATION

To install Main, Auxiliary and Transverse Fuel Tanks, simply reverse the *"Tank Removal"* procedure.

5.3 FUEL TANK VERIFICATION

Inspect fuel tank from under vehicle for leaks or fuel traces. If a leak is detected, repair immediately as per "Polyethylene Fuel Tank Repair" in this section.

Warning: *Park vehicle safely, apply parking brake, stop engine and set battery master switch(es) to the OFF position before working on the vehicle.*

Before working under an air-suspended vehicle, it is strongly recommended to support the body at the recommended jacking points.

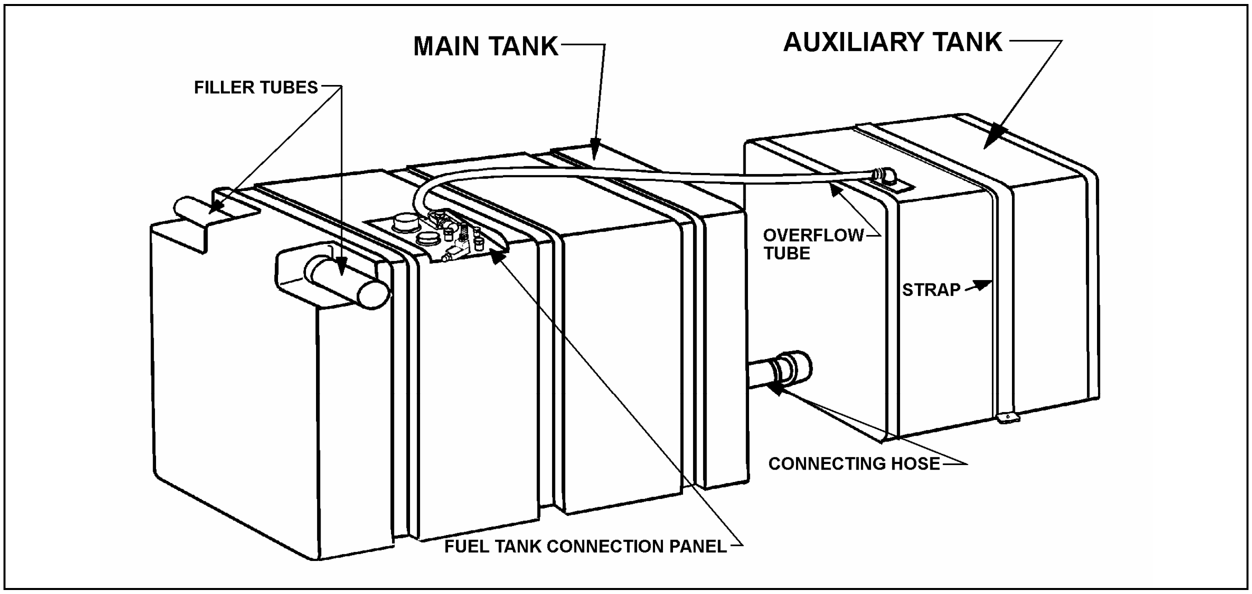


FIGURE 6: 208 US GAL. MAIN FUEL TANK (XL2-45) & 90 US GAL. AUXILIARY FUEL TANK (OPTIONAL) (MTH 45) 03028

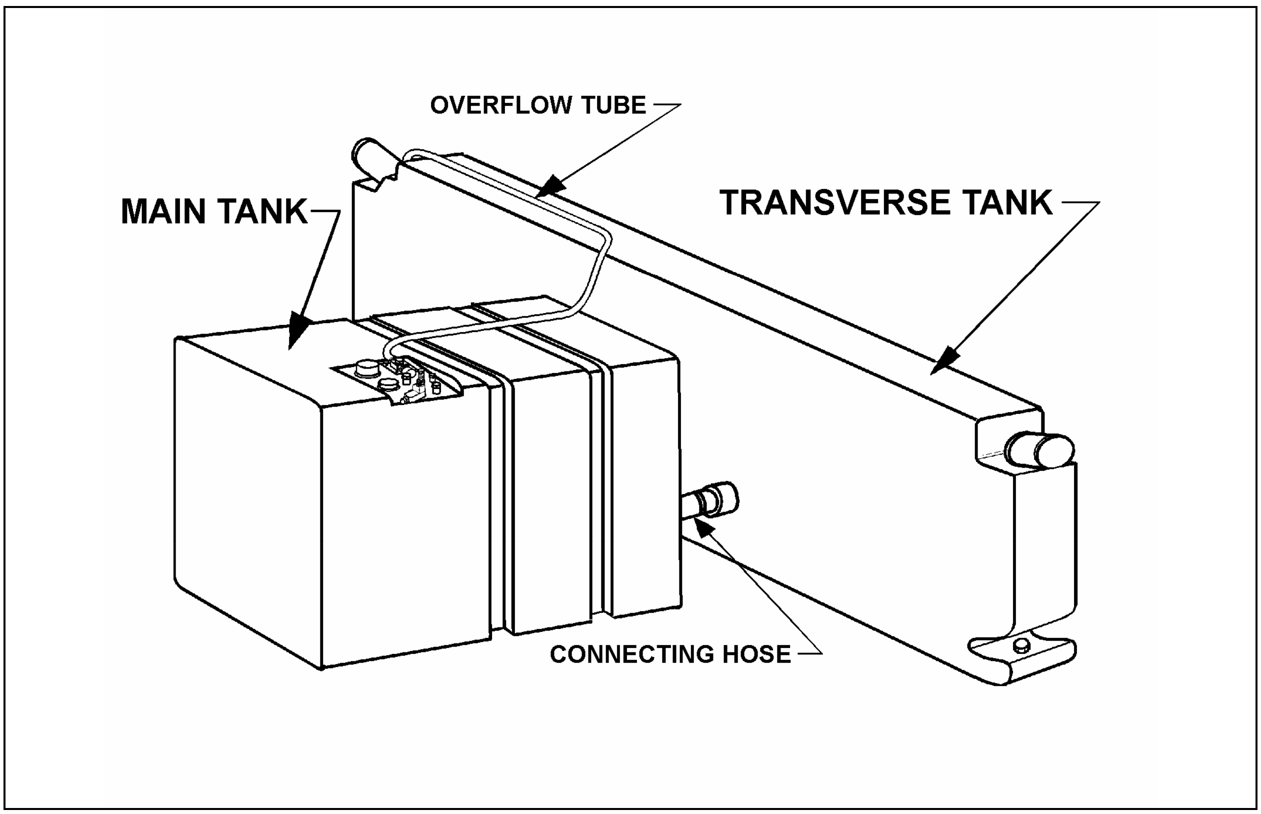


FIGURE 7: 250 US GALLONS FUEL TANKS (MAIN TANK & TRANSVERSE FUEL TANK) (MTH 40 & MTH 45E) 03029

5.4 POLYETHYLENE FUEL TANK REPAIR

***Note**: Fuel level must be lower than perforation to carry out this procedure.*

***Warning**: Park vehicle safely, apply parking brake, stop engine and set battery master switches to the OFF position before working on the vehicle.*

1. Locate perforation on fuel tank.
2. If necessary, remove fuel tank as per instructions in this section.
3. Drill perforation with a 23/64" bit. Make sure drill hole is perfectly round.
4. Insert a screw (Prevost #500196) and a washer (Prévost #5001244) into anchor nut (Prévost #500331).
5. Place assembly in drill hole. tighten screw by 10 complete turns. Refer to Fig. 9.
6. Apply sealant on head plug (Prévost #507300) and seal hole with the head plug.

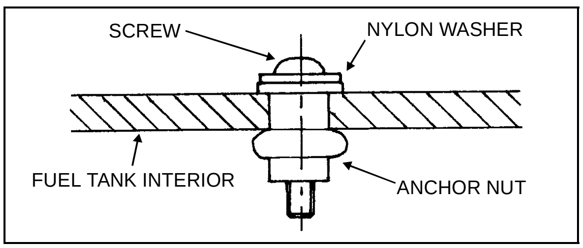


FIGURE 8: FUEL TANK REPAIR 03014

6. PRIMING FUEL SYSTEM

The problem with restarting a diesel engine that has run out of fuel, is that after the fuel is exhausted from the tank, it is pumped from the primary fuel filter or the fuel filter/water separator (if vehicle is so equipped), and sometimes partially removed from the secondary filter. This results in an insufficient fuel supply to sustain engine firing. The primary fuel filter or fuel filter/water separator and secondary filter must be free of air in order for the systems to provide adequate fuel for the injectors. When the engine runs out of fuel, the following operations must be performed before restarting:

Fill fuel tank with the recommended fuel oil. If only partial filling is possible, add a minimum of 10 gallons (38 liters) of fuel.

- If the vehicle is equipped with a Fuel Pro 382 fuel filter/water separation, pour fuel through spin on cap as per "4.3 DAVCO FUEL PRO 382".
- If the vehicle is equipped with an optional priming pump **(**see Figure 10).

Press the priming switch, located in the engine compartment rear junction box just below the switches and cables. Start the engine and check for leaks.

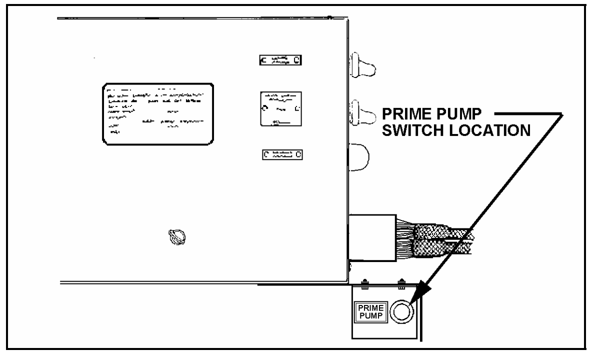


FIGURE 9: PRIME PUMP SWITCH LOCATION 01037

If the vehicle is not equipped with a priming pump:

1. Unscrew the cap on the priming valve located on the secondary filter;
2. Direct fuel under pressure 25 psi (172 kPa) to the priming valve using a quick coupling;
3. Start the engine and check for leaks.

7. FUEL PUMP INSTALLATION

The fuel pump is driven off the rear of the air compressor.

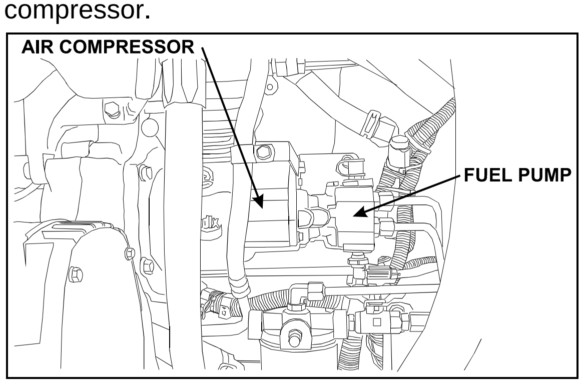


FIGURE 10: FUEL PUMP LOCATION 03053

1. If removed, install inlet and outlet fittings in the cover of the fuel pump.

Note: *New fittings have sealant already applied. When reusing fittings, coat the threads lightly with Locktite Pipe Sealant, Detroit Diesel number J 26558-92, or equivalent, before installing. To prevent sealant from entering fuel system, do not apply to the first two threads of the fitting. Do not use Teflon tape or paste on the fittings.*

2. Install drive coupling in drive hub of the fuel pump. Install a new gasket to the mounting flange of the pump.
3. Index the drive coupling with the drive hub on the end of the air compressor crankshaft and align the pump mounting boltholes with those in the air-compressor rear cover.

Note*: When correctly positioned, the outlet fitting on the pump should be in approximately an 8 o'clock position when viewed from the rear, and the drain opening in the pump body facing down.*

4. Seat the fuel pump squarely against the air compressor. Pilot the flange on the pump body, in the opening in the rear cover of the compressor. Install three mounting bolts and tighten them to 22-28 lbs•ft (30-38 N•m).
5. Connect the fuel inlet and outlet lines to the fuel pump and tighten.
6. Prime engine fuel system before starting engine to ensure pump seal lubrication and prompt engine starting.

8. FUEL OIL SPECIFICATIONS

The quality of fuel oil used for high-speed diesel engine operation is a very important factor in obtaining satisfactory engine performance, long engine life and acceptable exhaust emission levels. The fuel oil should meet ASTM designation D 975. Grade 1-D is recommended, however grade 2-D is acceptable.

Note: *These fuel grades are very similar to grade DF-1 or DF-2 of Federal Specifications VV-F-800. For detailed fuel recommendations, refer to publication "Engine Requirements-Lubricating Oil, Fuel, and Filters" #7SE270 available from Detroit Diesel Distributors.*

9. AIR CLEANER (DRY TYPE)

The vehicle is equipped with a dry-type replaceable element air cleaner, located in the engine compartment. Access the air cleaner through the engine R.H. side door. Engine air enters the air cleaner through (2) two intake ducts located just above engine side doors. It then flows through a pre-cleaner and finally through the air cleaner. The pre-cleaner removes dust and moisture by means of a discharge tube at the bottom of the element. It is in series with a replaceable impregnated paper filter element (air cleaner).

9.1 PRE-CLEANER SERVICING

The pre-cleaner is designed to be self-cleaning ; however, it should be inspected and any accumulated foreign material removed during the periodic replacement of the impregnated paper filter element.

9.2 AIR CLEANER SERVICING

Stop the engine, open the R.H. side engine compartment door, and loosen the wing nut retaining the air cleaner element to the air cleaner. Remove the element by pulling on the handle in the center of the air cleaner element.

Install cleaner element as follows:

1. Inspect the gasket-sealing surface inside the air cleaner. It must be smooth, flat and clean;
2. Install the air cleaner element;
3. Make sure that the element seals securely;
4. Inspect element cover gasket and replace if necessary.

Whenever it becomes necessary to remove the air cleaner assembly (dry type) for maintenance or other repair in this area, great care should be taken when installing air cleaner assembly.

The pre-filter should be installed snugly in the air duct and clamped tightly to the air cleaner inlet to prevent any dust infiltration into the air cleaner.

9.3 GENERAL RECOMMENDATIONS

The following maintenance procedures will ensure efficient air cleaner operation:

1. Keep the air cleaner housing tight on the air intake pipe;
2. Make sure the correct filters are used for replacement;
3. Keep the air cleaner properly assembled so the joints are air-tight;

4. Immediately repair any damage to the air cleaner or related parts;
5. Inspect, clean or replace the air cleaner or elements as operating conditions warrant. Whenever an element has been removed from the air cleaner housing the inside surface of the housing must be cleaned with a soft clean cloth;
6. Periodically inspect the entire system. Dust-laden air can pass through an almost invisible crack or opening which may eventually cause damage to an engine;
7. Never operate the engine without an element in the air cleaner assembly;

Caution : *Do not ignore the Warning given by the air restriction indicator. This could result in serious engine damage.*

8. Store new elements in a closed area free from dust and possible damage.

9.4 AIR CLEANER RESTRICTION INDICATOR

A resettable restriction indicator may be installed on the engine air-intake duct, clearly visible from the rear engine compartment. The indicator monitors the vacuum level between the air filter and the engine. A red marker is displayed when the air filter is clogged and must be replaced. Reset by pressing on the indicator's extremity.

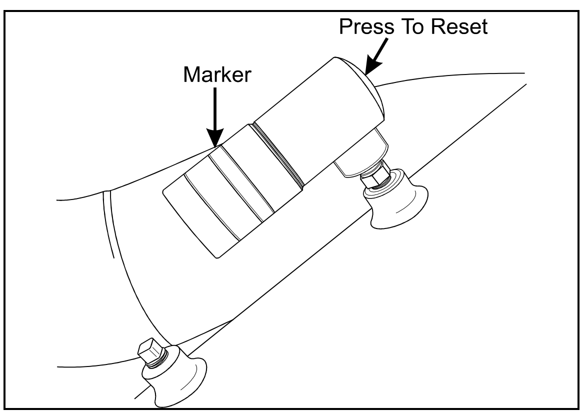


FIGURE 11: RESTRICTION INDICATOR 01052

10. FUEL COOLER

The fuel cooler serves to cool the surplus diesel fuel after it has exited the cylinder head, on its way back to the fuel tank. It is accessible through the engine radiator door, and it is located just in front of the coolant radiator (Fig. 13).

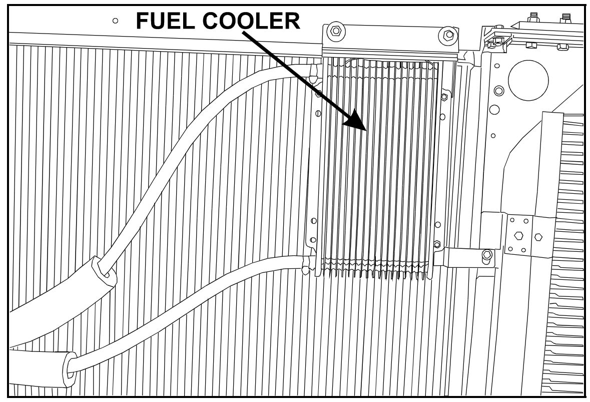


FIGURE 12: FUEL COOLER LOCATION 03054

11. FUEL PEDAL

The EFPA (Electronic Foot Pedal Assembly) connects the accelerator pedal to a potentiometer (a device that sends an electrical signal to the ECM, which varies in voltage, depending on how far down the pedal is depressed). The EFPA is installed in the space normally occupied by a mechanical foot pedal. It has maximum and minimum stops that are built into the unit during manufacturing.

11.1 FUEL PEDAL ADJUSTMENT

The EFPA contains a throttle position sensor that varies the electrical signal sent to the ECM. The sensor must be adjusted whenever an EFPA is serviced. In addition, the sensor should be adjusted any time codes 21 and 22 are flashed.
With the ignition "ON" and the proper diagnostic tool (DDR) (for information regarding the DDR, see *"01 ENGINE"* in this manual), check the throttle counts at idle and full throttle positions.
Proper pedal output should be 20/30 counts at idle and 200/235 at full throttle. If adjustment is necessary, remove the potentiometer retaining screws and rotate the potentiometer clockwise to increase counts or counterclockwise to decrease. When correct output is confirmed, tighten retaining screws.

11.2 POTENTIOMETER REPLACEMENT

1. Disconnect cable harness connector.

***Caution:** Note the routing and clamping locations of the cable before disassembly. Proper cable routing and fastening is critical to the operation of this system. Marking the foot pedal assembly to record cable routing is recommended.*

2. Loosen the two screws and remove potentiometer. Retain for re-assembly.
3. Discard potentiometer (Fig. 14).
4. Position new potentiometer. Press potentiometer onto the potentiometer shaft, matching cutouts in shaft to drive tangs of potentiometer. Apply hand pressure until potentiometer has bottomed out in housing. Reinstall screws (Fig. 12) and tighten just enough to secure potentiometer lightly. Tighten screws to 10 - 20 lbf•in (1.5 - .2 N•m).
5. Reconnect electronic foot pedal assembly's cable harness to the ECM connector. If potentiometer calibration is necessary (see *"FUEL PEDAL ADJUSTMENT"* in this section).

***Caution:** Make sure the cable harness is routed correctly, and securely installed so that it does not become pinched, stretched, or otherwise damaged during vehicle operation.*

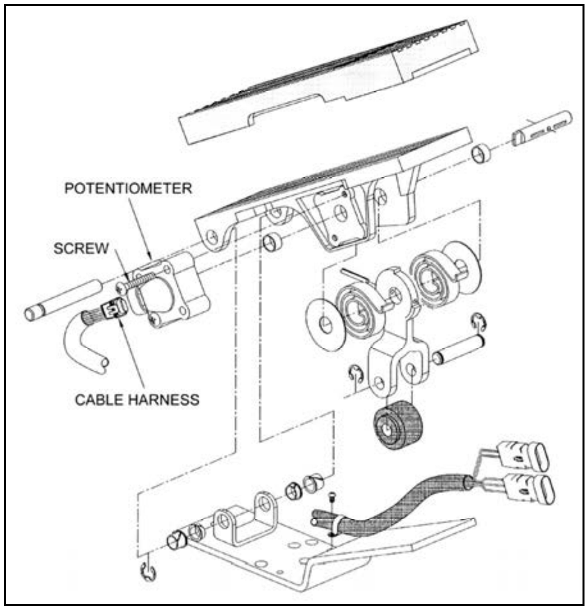


FIGURE 13: ELECTRONIC FOOT PEDAL ASSEMBLY 03035

12. SPECIFICATIONS

Davco FuelPro 382 Fuel Filter / Water Separator Element
Supplier number 23521528
Prévost number 531437

Primary Fuel Filter / Water Separator (optional)
(May be used instead of primary filter (never use with a primary filter).
Make ....Racor
Type ....Spin-on

ELEMENT
Supplier number ....S 3202
Prévost number 531390

BOWL
Supplier number RK30051
Prévost number 531389

DRAIN VALVE AND SEAL
Supplier number RK30058
Prévost number 531397

O-RING
Supplier number RK30076
Prévost number 531398

PROBE/WATER SENSOR

Supplier number RK21069
Prévost number 531391

Primary Fuel Filter
Make .... AC
Type .... Spin-on
Filter No. T-915D
Service Part No. 25014274
Prévost number 510137
OR
Service Part No (Type with Water Separator) 23512317
Prévost number 531407
Element torque .... 1/2 turn after gasket contact

Secondary Fuel Filter
Make .... AC
Type .... Spin-on
Filter No. T-916D
Service Part No. 25014342
Prévost number 510128
Element torque .... 1/2 turn after gasket contact

Fuel tank(s) Capacity (ies)
Standard (XL2-45 & MTH 45) .... 208 US gallons (787 liters)
Standard (MTH 40 & MTH 45E) .... 250 US gallons (945 liters)
Optional (MTH 45) .... 90 US gallons (341 liters)

Air Cleaner
Make .... Nelson
Prevost Number 530206
Service Part No 7182 8N
Supplier number (element cartridge) 70337N
Prévost number (element cartridge) 530197

Air Cleaner Restriction Indicator
Make .... Donaldson
Model RBX00-2220
Indicates .... at 20" (508 mm) of water
Prévost number 530161

Preheater Fuel Filter
Make .... Webasto
Supplier number 603.359
Prévost number 871037

Fuel Cooler
Make .... Berendsen
Supplier number DB-1240
Prévost number 950109

CONTENTS

ILLUSTRATIONS

1. DESCRIPTION

The muffler is rubber mounted on the vehicle frame. This feature reduces the transmission of vibrations to the muffler thus resulting in extended life of muffler, brackets and other components.

2. MAINTENANCE

The exhaust system should be inspected periodically for restrictions and leaks. The exhaust systems are shown on figures 1 & 2 (fig. 1 = XL2-40 & 45E and fig. 2 = XL2-45). Restrictions such as kinked or crimped pipes result in excessive back pressure that can lead to increased fuel consumption, power loss, and possible damage to engine combustion chamber components. Exhaust leaks are commonly the result of loose clamp bolts, corroded pipes, or a punctured muffler. In addition to objectionable noise, a leaking exhaust system could allow toxic gases to enter the vehicle. Inspect the exhaust system as follows :

- At vehicle inspection intervals ;
- Whenever a change is noticed in the sound of the exhaust system ; and
- Whenever the exhaust system is damaged.

Replace damaged or corroded exhaust system components without delay.

When operating the engine in a service garage or in a closed area, the exhaust must be vented to the outside. Place the shop vent hose over the exhaust outlet pipe.

Warning: *Avoid breathing exhaust gases since they contain carbon monoxide which is odorless and colorless but harmful. Carbon monoxide is a dangerous gas that can cause unconsciousness and can be lethal. If, at any time you suspect that exhaust fumes are entering the vehicle, locate and correct the cause(s) as soon as possible.*

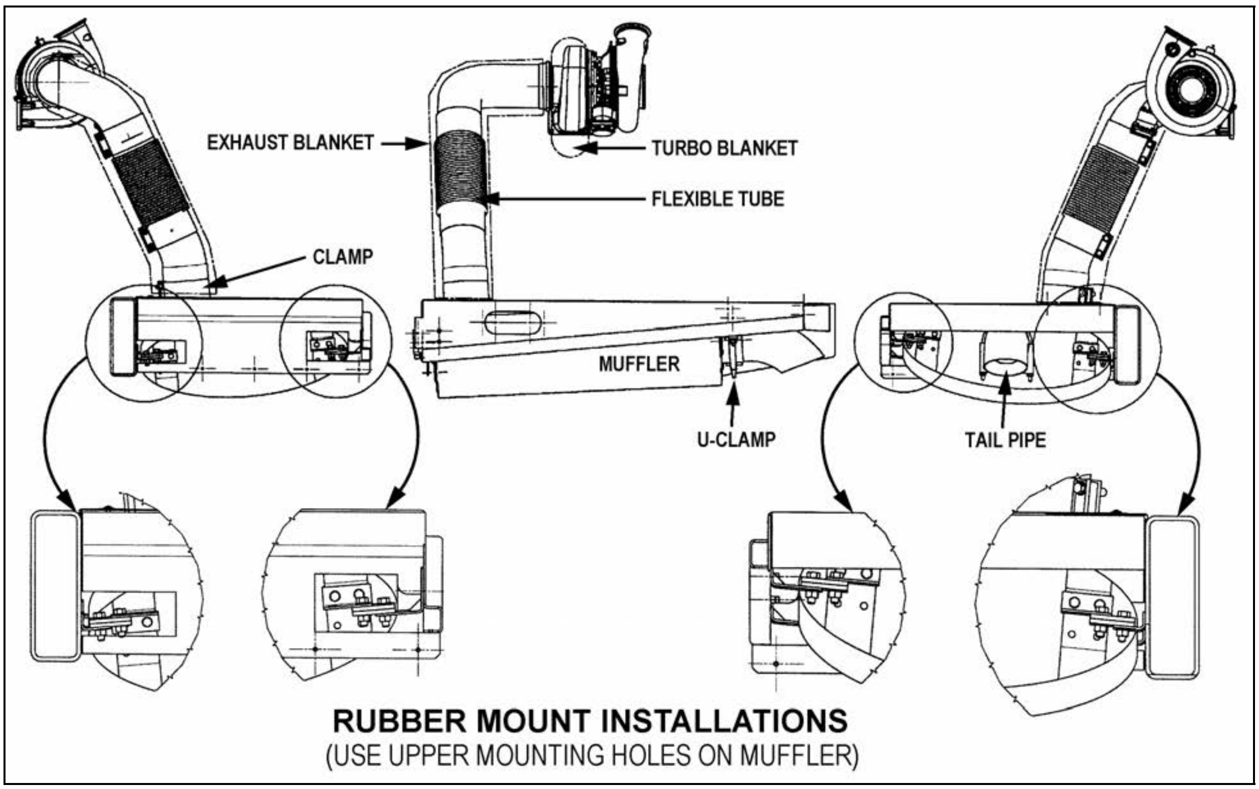


FIGURE 1: EXHAUST SYSTEM - XL2-40 & 45E (SHELL) INSTALLATION 04006

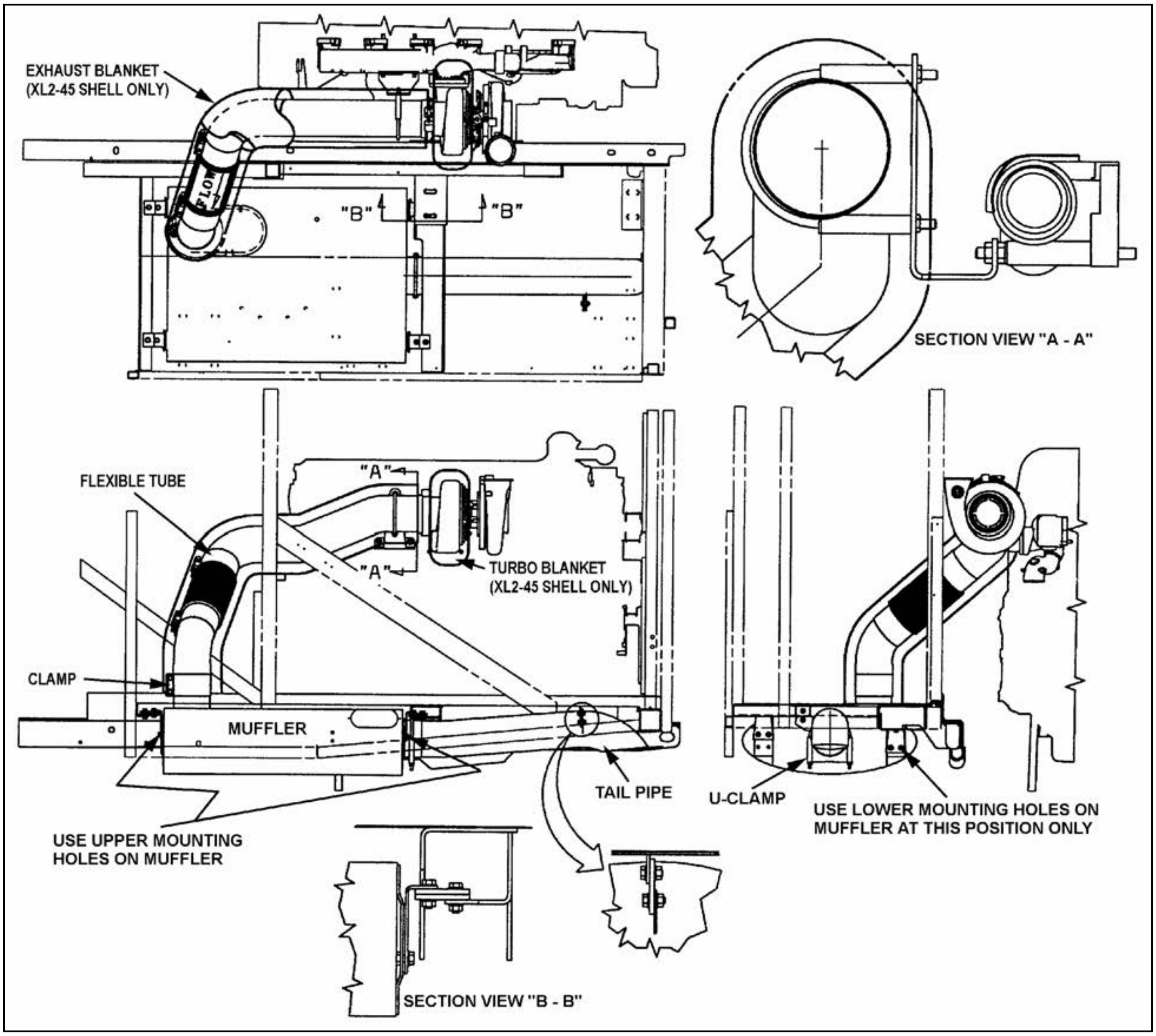


FIGURE 2: EXHAUST SYSTEM - XL2-45 (COACH & SHELL) INSTALLATION 04007

3. MUFFLER REMOVAL & INSTALLATION

Warning: *Make sure that muffler and components are cold before handling.*

1. Remove bolts and clamps securing exhaust pipe bellows to the muffler.
2. Support the muffler from underneath vehicle.
3. Remove U-clamp retaining the tail pipe to the muffler.
4. Remove bolt holding the tail pipe to the frame bracket.
5. Remove the tail pipe.
6. Remove the fasteners holding the four rubber mounts to the frame brackets.
7. Remove the fasteners securing the rubber mounts to the muffler brackets.
8. Remove rubber mounts then muffler from underneath vehicle.
9. Remove parts which are attached to the muffler such as brackets and collar.
10. Inspect and replace parts if necessary. Reinstall parts on the new muffler.

For installation, reverse the removal procedure.

Warning: *Check connections for tightness and fasteners for proper assembly.*

4. FLEXIBLE TUBE INSTALLATION

The flexible exhaust tube contains an inside rigid pipe. To allow appropriate flexibility for assembly, make sure that the rigid pipe is concentric to the flexible part.

To maintain the pipe centered at the time of installation, cardboard spacers must be inserted at four places at equal distance around tubing (Fig. 3). These spacers may be left in place and will deteriorate over time.

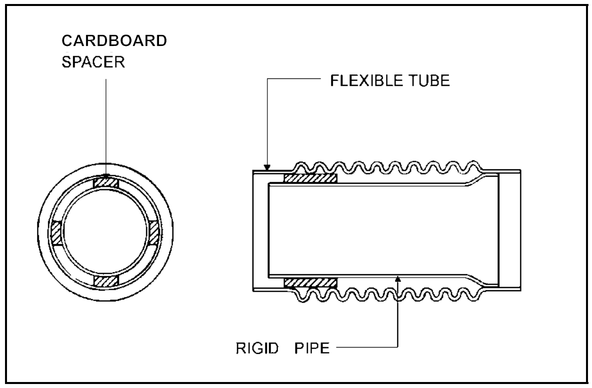


FIGURE 3: FLEXIBLE TUBE INSTALLATION 04003

5. HEAT BLANKETS (CONVERTED VEHICLES ONLY)

5.1 EXHAUST

5.1.1 Installation on XL2-45 Shells

1. Remove L.H. side tag axle wheel.
2. Locate splash guard panel located at rear of vehicle (behind L.H. side tag axle wheel), then remove, cover bellows and exhaust pipe with 2-piece blanket #040553 (Fig. 4). Use velcro to secure blanket in place.

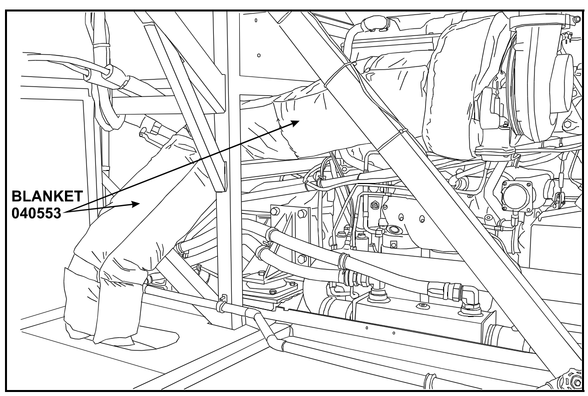


FIGURE 4: EXHAUST BLANKET INSTALLATION 04009

3. Install the turbo blanket as described further in this section.

5.1.2 Installation on XL2-40 & XL2-45E Shells

1. Remove L.H. side tag axle wheel.
2. Locate splash guard panel located at rear of vehicle (behind L.H. side tag axle wheel), then remove, cover bellows and exhaust pipe with 2-piece blanket #040565. Refer to figure 4 showing installation on XL2-45 shells. Use velcro to secure blanket in place.
3. Install the turbo blanket as described further in this section.

5.2 TURBO (ALL SHELLS)

Install turbo blanket #040557, then cover turbine housing (Fig. 5). Use velcro to secure blanket in place.

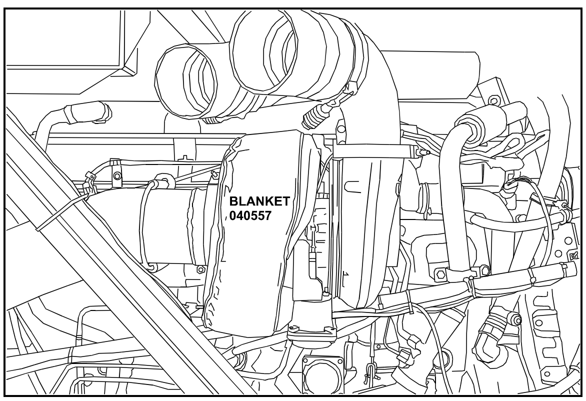


FIGURE 5: TURBO BLANKET INSTALLATION 04010

Note: *The compressor housing does not require a blanket.*

CONTENTS

ILLUSTRATIONS

1. DESCRIPTION

A radiator and thermo-modulated fan are used to effectively dissipate the heat generated by the engine. A centrifugal-type water pump is used to circulate the engine coolant (Fig. 1).

Two full blocking-type thermostats are used in the water outlet passage to control the flow of coolant, providing fast engine warm-up and regulating coolant temperature.

The engine coolant is drawn from the lower portion of the radiator by the water pump and is forced through the transmission cooler before going through the oil cooler and into the cylinder block.

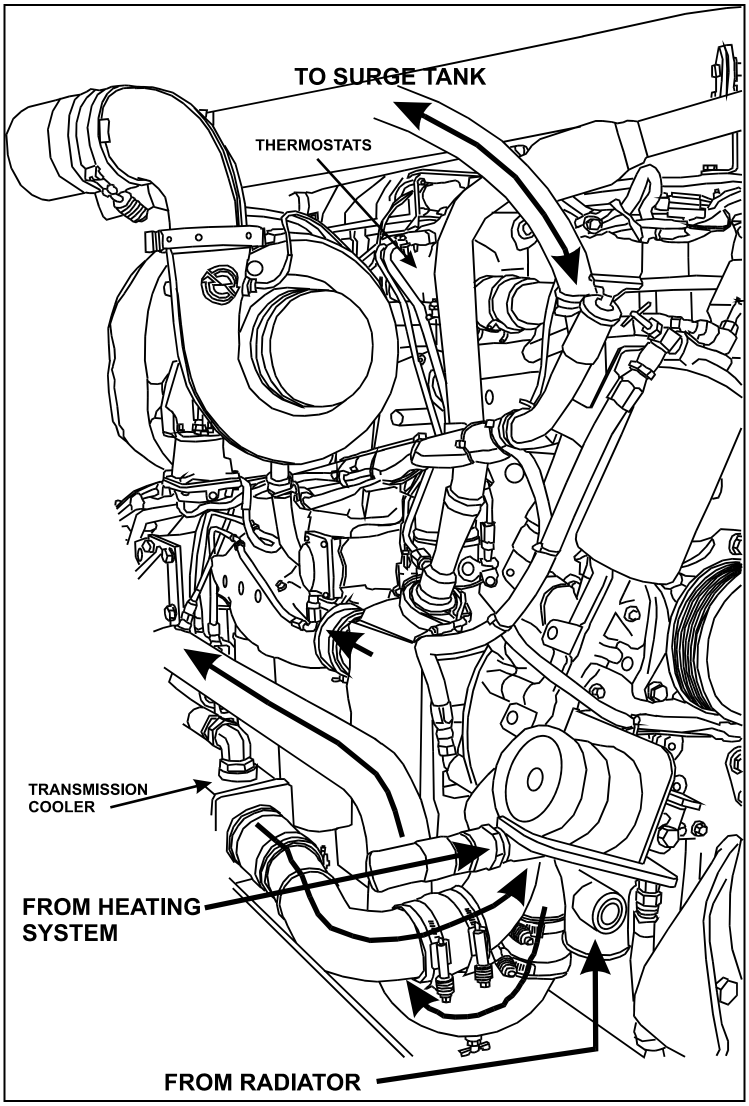


FIGURE 1: COOLING SYSTEM 05087

From the cylinder block, the coolant passes up through the cylinder head and, when the engine is at normal operating temperature, it goes through the thermostat housing and into the upper portion of the radiator. The coolant then passes through a series of tubes where its heat is dissipated by air streams created by the revolving fan and the motion of the vehicle.

Upon starting a cold engine or when the coolant is below normal operating temperature, the closed thermostats direct coolant flow from the thermostat housing through the by-pass tube to the water pump. Coolant is recirculated through the engine to aid engine warm up. When the thermostat opening temperature is reached, coolant flow is divided between the radiator inlet and the by-pass tube. When the thermostats are completely open, all of the coolant flow is to the radiator inlet.

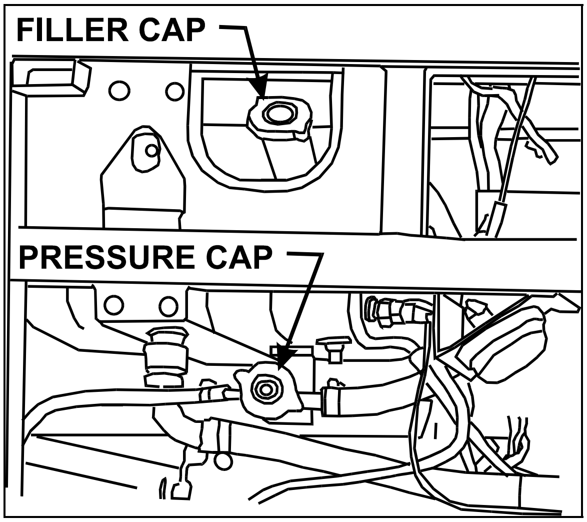


FIGURE 2: SURGE TANK - ENGINE COMP'T 05079

The cooling system is filled through a filler cap on the surge tank (Fig. 2). A pressure cap underneath the surge tank is used to maintain pressure within the system. When system exceeds normal pressure rating (14 psi - 96.53 kPa), the cap releases air and if necessary, coolant through the overflow tube (Fig. 2). Two thermostats are located in the housing attached to the right side of the cylinder head (Fig. 1). Furthermore, a water temperature sensor mounted on the cylinder head (radiator side) is also supplied for engine protection purposes.

The engine cooling system also provides hot coolant fluid for the vehicle heating system. Refer to section 22, *"”HEATING AND AIR CONDITIONING"* in this manual for information relating to heating system water circulation.

2. MAINTENANCE

A systematic routine inspection of cooling system components is essential to ensure maximum engine and heating system efficiency.

- Check coolant level in the surge tank daily, and correct if required. Test antifreeze strength.
- Maintain the prescribed inhibitor strength levels as required. Coolant and inhibitor concentration must be checked at each oil change, every 12,500 miles (20 000 km) or once a year, whichever comes first to ensure inhibitor strength. For vehicles equipped with coolant filters replace precharge element filter with a maintenance element filter as per *“COOLANT FILTER”* in this section. If the vehicle is not equipped with a filter, add the recommended inhibitor concentration to the antifreeze/water solution.
- Drain, flush, thoroughly clean and refill the system every two years or every 200,000 miles (320 000 km), whichever comes first. For vehicle equipped with coolant filters, change the precharge element filter or the existing maintenance element filter for a new maintenance element filter. If the vehicle is not equipped with filters add the recommended inhibitor concentration to the antifreeze/water solution.

Note: *Do not add inhibitors to the antifreeze / water solution if vehicle is equipped with a coolant filter.*

Coolant must be discarded in an environmentally safe manner.

2.1 VEHICLES WITHOUT COOLANT FILTERS

Refer to Nalcool 3000 with Stabil-Aid bulletin annexed to the end of this section for preventive maintenance (at each oil change) and initial treatment instructions (each time the cooling system is drained and flushed).

2.2 VEHICLES WITH COOLANT FILTERS

Change the coolant precharge element filter for a maintenance element filter at initial oil change (see *"Specifications"* at the end of this section) and replace existing maintenance element filter with a new one as per *"COOLANT FILTER"* in this section. A precharge element filter must be installed each time the cooling system is drained and flushed prior to installing a maintenance element filter.

- Check belts for proper tension; adjust as necessary and replace any frayed or badly worn belts.
- Check radiator cores for leaks and make sure the cores are not clogged with dirt or insects. To avoid damaging the fins, clean cores with a low-pressure air hose. Steam clean if required.
- Inspect the water pump operation. A leaky pump sucks in air, increasing corrosion.

- Repair all leaks promptly. Unrepaired leaks can lead to trouble. Inspect and tighten radiator mounts periodically. Test and replace thermostats regularly.

Note: *In order to ensure the integrity of the system, it is recommended that a periodic cooling system pressure check be made. Pressurize the cooling system to 103-138 kPa (15-20 psi) using Radiator and Cooling System Tester, J24460-1. Do not exceed 138 kPa (20 psi).*

Any measurable drop in pressure may indicate a leak. Whenever the oil pan is removed, the cooling system should be pressure checked as a means of identifying any incipient coolant leaks. Make sure the cause of the internal leak has been corrected before flushing the contaminated system.

Leaks at the thermostat housing hose connections may be caused by deformation of connections or by rough surfaces on the castings of the hose mounting surfaces. It is recommended that *"Dow Corning RTV-102 Compound"* or any equivalent product be applied on cast surfaces prior to hose installation.

Caution: *Castings should be clean and free of oil and grease before applying compound. No other sealer should be used with RTV-102 compound.*

3. HOSES

Rotten, swollen, and worn out hoses or loose connections are frequent causes of cooling system problems.

Serious overheating is often caused by an old hose collapsing or from rotten rubber shedding from hoses and clogging the coolant passages.

Connections should be inspected periodically and hose clamps tightened. Replace any hose found to be cracked or swollen.

When installing a new hose, clean pipe connections and apply a thin layer of a non-hardening sealing compound. Replace worn out clamps or clamps that pinch hoses.

3.1 CONSTANT-TORQUE HOSE CLAMPS

All hose clamps of 1 3/8" ID and over, used on the heating and cooling systems, are of the *"Constant-torque"* type. These clamps are worm-driven, made of stainless steel, and supplied with a series of Belleville spring washers. They also feature an extended integral liner that covers the band slots to protect soft/silicone hoses from damage, and help maintain consistent sealing pressure.

This type of clamp is designed to automatically adjust its diameter to compensate for the normal expansion/contraction of a hose and metal connection that occurs during vehicle operation and shutdown. The constant-torque clamp virtually eliminates coolant losses due to *"Cold flow"* leakage and greatly minimizes clamp maintenance.

3.1.1 Installation

A torque wrench should be used for proper installation. The recommended torque is 90 to 100 lbf·in. (10 to 11 N·m). The Belleville spring washer stacks should be nearly collapsed flat and the screw tip should extend ¼" (6 mm) beyond the housing (Fig. 3).

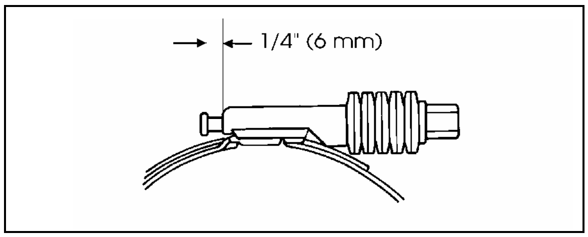


FIGURE 3: CONSTANT-TORQUE CLAMP 05037

Caution: *The hose clamps will break if over-torqued. Do not over-tighten, especially during cold weather when hose has contracted.*

3.1.2 Maintenance

The constant-torque clamps contain a *"Visual torque check" feature.* When the tip of the screw is extending ¼" (6 mm) out of the housing, the clamp is properly installed and maintains a leak-proof connection. Since the constant-torque clamp automatically adjusts to keep a consistent sealing pressure, there is no need to re-torque hose clamps on a regular basis. During vehicle operation and shutdown, the screw tip will adjust according to the temperature and pressure changes. **Checking for proper torque should be done at room temperature.**

4. COOLANT

4.1 COOLANT LEVEL VERIFICATION

Coolant level is correct when cold coolant is visible through the surge tank sight glass (Fig. 4). If coolant level is low, fill cooling system.

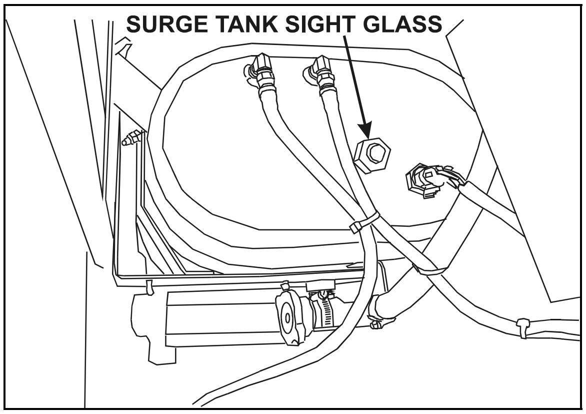


FIGURE 4: SURGE TANK SIGHT GLASS 05094

4.2 COOLANT LEVEL SENSOR

This warning device consists of a fluid level probe mounted on the surge tank. The probe sends a signal to the ECM to indicate coolant level. If the coolant level drops below the probe, the *"Check Engine"* light flashes and a diagnostic code is registered (see section 01" *ENGINE"*).

Caution: *Do not run engine with the "Check Engine" light flashing.*

The level probe is mounted on the R.H. side of the surge tank while the electronic module is mounted inside the rear electric junction box.

4.3 THAWING COOLING SYSTEM

If the cooling system becomes frozen solid, place the coach in a warm area until the ice is completely thawed. Under no circumstances should the engine be operated when the cooling system is frozen, as it will result in engine overheating due to insufficient coolant.

Once thawed, check engine, radiator and related components for damage caused by expansion of frozen coolant fluid.

4.4 COOLANT REQUIREMENTS

The coolant provides a medium for heat transfer and controls the internal temperature of the engine during operation. In an engine having proper coolant flow, some of the combustion heat is conveyed through the cylinder walls and the cylinder head into the coolant. Without adequate coolant, normal heat transfer cannot take place within the engine, and engine temperature rapidly rises. Coolant must therefore be carefully selected and properly maintained.

Select and maintain coolant in order to meet the following basic requirements:

- Provide for adequate heat transfer.
- Provide protection from cavitation damage.
- Provide a corrosion and erosion resistant environment within the cooling system.
- Prevent formation of scale or sludge deposits in the coong system.
- Be compatible with the cooling system hose and seal materials.
- Provide adequate freeze protection during cold weather operation.

Combining suitable water with reliable inhibitors satisfies the first five requirements. When freeze protection is required, a solution of suitable water and antifreeze containing adequate inhibitors will provide a satisfactory coolant fluid. Ethylene glycol-based antifreeze is recommended for use in Series 60 engines. The cooling system capacity is 24 US gal (91 liters).

Note: *In general, antifreeze does not contain adequate inhibitors. For this reason, supplemental coolant additives are required.*

For a complete overview of engine coolants used with Detroit Diesel Engines, refer to *"Specifications"* in the Detroit Diesel Series 60 *"Engine Operator's Guide"*.

4.5 COOLING SYSTEM RECOMMENDATIONS

Always maintain cooling system at the proper coolant level. Check daily.

The cooling system must be pressurized to prevent localized boiling of coolant. The system must be kept clean and leak-free. The filler and pressure caps must be checked periodically for proper operation.

4.6 INHIBITORS

A coolant solution, which has insufficient inhibitors or no inhibitors at all, invites the formation of rust, scale, sludge and mineral deposits within the cooling system. These deposits can cause water pump seal wear and coat the interior of coolant system passages. Heat transfer is reduced as deposits build up, leading to an overheating condition. Continued operation with this condition can lead to serious engine damage: liner scuffing, scoring, piston seizure and cylinder head cracking. These damages can occur quickly or over a longer period of time, depending of location and amount of deposits. Improperly inhibited coolants can become corrosive enough to "eat away" coolant passages and seal ring grooves and cause leaks to develop. Hydrostatic lock can occur if leak is internal and accumulates on top of a piston. The result may be a bent connecting rod. Cavitation erosion may occur in improperly inhibited coolants. Cavitation erosion is caused by the implosion of tiny bubbles against localized surfaces of the system. Such implosion causes pinpoint pressures high enough to erode pump impellers, cylinder liners and cylinder blocks. In extreme cases, their surfaces are so deeply pitted that they appear to be spongy, and holes can develop completely through them.

4.6.1 Inhibitor Test Procedures

Test Kits are commercially available to check engine coolant for nitrite concentration. Nitrite concentration is an indication of Supplemental Coolant Additive (SCA) level. Nitrite must be maintained within recommended levels. Coolant must be tested at each oil change to insure that inhibitor levels are maintained within the ranges shown hereafter:

Detroit Diesel Selected Products System		
	Min. PPM	**Max PPM**
Boron (B)	1000	1500
Nitrite (NO2)	800	2400
Nitrates (NO3)	1000	2000
Silicon (Si)	50	250
Phosphorous (P)	300	500
pH	8.5	10.5

***Note**: Above SCA values with GM6038-M or ASTM 4985. Use Nalco Chemical Company nitrite test kits (CO-318). A factory coolant analysis program is available through Detroit Diesel distributors under part number 23508774.*

4.7 COOLANT RECOMMENDATIONS

1. Always use recommended antifreeze, inhibitor and water at proper concentration levels. A 50% coolant/water solution is normally used as factory fill. Antifreeze concentration over 70% is not recommended because of poor heat transfer capability, adverse freeze protection and silicate dropout. Antifreeze concentration below 30% offers little freeze, boilover or corrosion protection.
2. Use only ethylene glycol antifreeze meeting the GM 6038-M or ASTM D 4985 formulation or an equivalent antifreeze with a 0.15% maximum silicate content meeting GM 1899-M performance specifications.
3. Use an antifreeze solution year-round for freeze and boil-over protection. Seasonal changing of coolant from an antifreeze solution to an inhibitor/water solution is recommended.
4. Pre-mix coolant makeup solutions at proper concentrations before adding to the cooling system.
5. Maintain the prescribed inhibitor strength levels as required.
6. Do not mix different base inhibitor packages.
7. Always maintain proper coolant level.

***Caution:** Always test the solution before adding water or antifreeze.*

8. If cooling system is not at the proper protection level. Mix coolant/water solution to the proper concentration before adding to the cooling system
9. Use only non-chromate inhibitors.
10. Distilled water is recommended.

DO NOT USE THE FOLLOWING:

- Soluble oil
- Chromate inhibitor

- Methoxy propanol-base antifreeze
- Methyl alcohol-base antifreeze
- Sealer additives or antifreezes containing sealer additives

Warning: *Never remove filler cap while coolant is hot. When coolant is at ambient temperature, release pressure from system by turning the pressure cap counterclockwise 1/4 turn; then remove filler cap slowly. A sudden release of pressure from the heated cooling system can result in severe burns from the expulsion of hot coolant fluid.*

4.7.1 Vehicles Without Coolant Filters

Refer to Nalcool 3000 with Stabil-Aid bulletin annexed to the end of this section for preventive maintenance (at each oil change) and initial treatment instructions (each time the cooling system is drained and flushed).

4.7.2 Vehicles With Coolant Filters

Change the coolant precharge element filter for a maintenance element filter at initial oil change (see Specifications at the end of this section) and replace existing maintenance element filter with a new one as per *"COOLANT FILTER"* in this section. A precharge element filter must be installed each time the cooling system is drained and flushed before installing a maintenance element filter.

Note: *The coolant filter contains inhibitors.*

5. DRAINING COOLING SYSTEM

Use the following procedures to drain the cooling system partially or completely.

To drain engine and related components:

1. Stop engine and allow engine to cool. Close both heater line shutoff valves.

On XL2-40 & 45E vehicles, the valves are located in engine compartment. One is on the R.H. side of compartment and is accessible through engine compartment R.H. side door (Fig. 5).

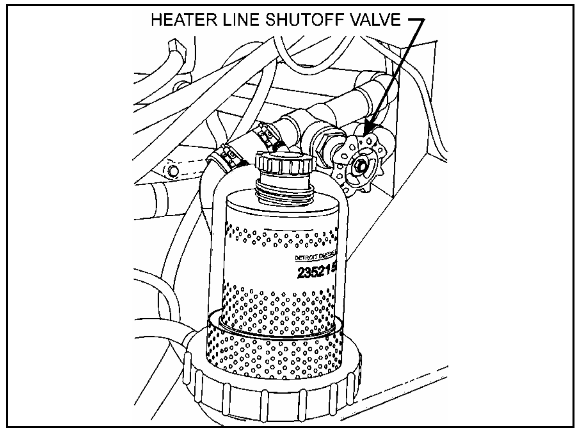


FIGURE 5: HEATER LINE SHUT-OFF VALVE 05070

Another valve is located in the engine compartment under the radiator fan gearbox (Fig. 6).

Note*: Refer to section 22 under "Preheating System" for information about preheater access and heater line shutoff valve.*

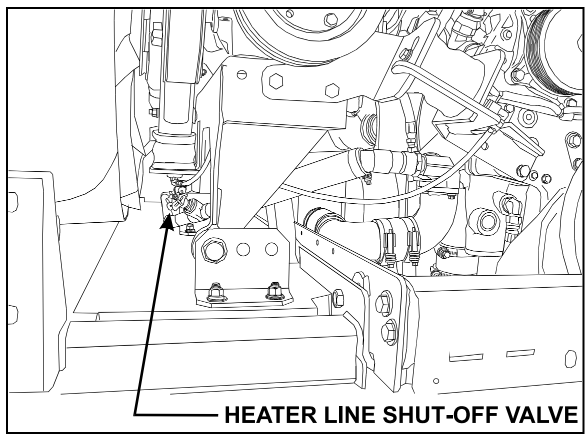


FIGURE 6: ENGINE COMPARTMENT 05078

On XL2-45 vehicles, one valve is located in the engine compartment, under the radiator fan gearbox (Fig. 6), another valve is located in the engine compartment behind splash guard panel at rear of vehicle (behind L.H. side tag axle wheel) (Fig. 7).

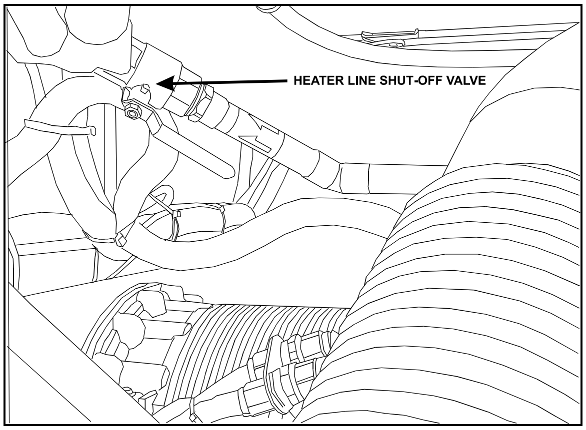


FIGURE 7: HEATER LINE SHUT-OFF VALVES 05067

Warning: *Before proceeding with the following steps, make sure the coolant has cooled down. The sudden release of pressure from a heated cooling system can result in loss of coolant and possible personal injury (scalding) from the hot liquid.*

2. Unscrew the surge tank pressure cap counterclockwise, ¼ turn to let air enter the system and permit the coolant to drain completely from system.

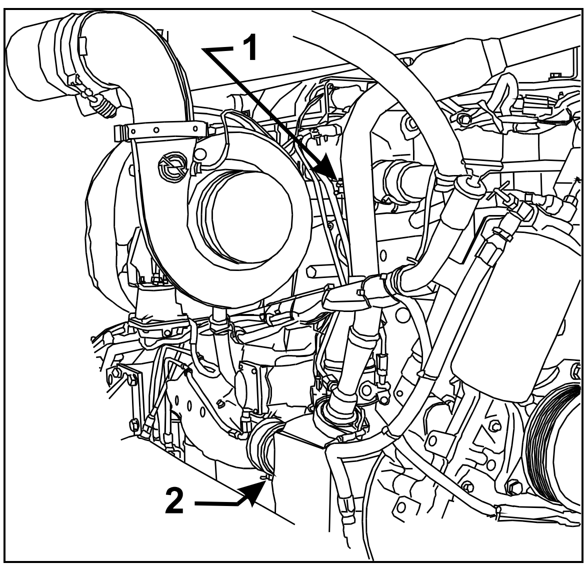


FIGURE 8: ENGINE COOLANT DRAIN COCKS 05088

3. Unscrew the water pump housing inlet line drain plug (Fig. 9).

4. Open drain cock at bottom of thermostat housing to drain the coolant trapped above the thermostats (1, Fig. 8).

5. Open the radiator drain cock.

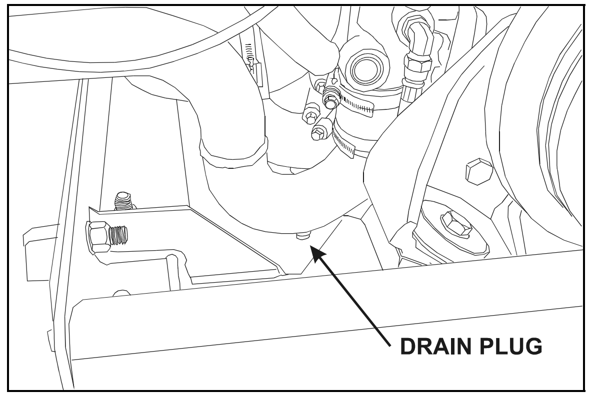


FIGURE 9: WATER PUMP DRAIN COCK 05072

6. Open engine drain cock (2, Fig. 8).

7. Remove the transmission oil cooler. Drain, flush and inspect. Refer to Section 7, “TRANSMISSION” for oil cooler maintenance or preventive replacement.

Caution: *Drain water pump completely before extended storage to avoid possible water pump damage.*

Caution: *If freezing weather is anticipated and the engine is not protected with antifreeze, drain the cooling system completely when vehicle is not in use. Trapped water in the cylinder block, radiator or other components may freeze and expand resulting in damages. Leave the drain plugs open until the cooling system can be filled with coolant fluid. Do not run engine with cooling system empty.*

To drain the entire system, do the previous steps while maintaining the shutoff valves in the open position; then follow the procedure under *“9.2 Draining Heating System”* in Section 22.

6. FILLING COOLING SYSTEM

If only the engine and related components were drained, maintain the two heater line shutoff valves in their closed position, then proceed as follows.

1. Close all drain cocks. Refer to draining procedure for the location of draining points.

2. Refill cooling system from the surge tank filler cap inlet with a recommended ethylene glycol-based antifreeze and water solution of the required concentration. Add Detroit Diesel selected product cooling system inhibitors (if required).

Note: *The coolant level should remain within two inches of the surge tank filler neck.*

Note: *Make sure the vent line at top of thermostat housing is properly connected and not obstructed. The vent line (thermostat housing dome to radiator top tank) is required to ensure complete engine fill and proper venting of air in the system.*

3. Install the filler and pressure caps, then start the engine and run it at fast idle until reaching normal operating temperature. Check for leaks.

Note: *If for any reason, the coolant level drops below the surge tank level probe, the Check Engine light will flash.*

4. Stop engine and allow to cool.
5. Open the two heater line shutoff valves, check the coolant level in the surge tank, and then add as required.

Caution: *Never pour cold coolant into a hot engine. The sudden change in temperature may crack the cylinder head or block.*

If the entire system has been drained, redo the previous steps while maintaining the two heater line shutoff valves in the "Open" position. With engine running, activate the driver's and central heating systems to permit coolant circulation. Complete the procedure by bleeding the heater cores as explained in Section 22, under *"9.4 Bleeding Heating System".*

7. FLUSHING

If the cooling system is contaminated, flush the cooling system as follows:

1. Drain the coolant from the engine.
2. Refill with clean water.

Caution: *If the engine is hot, fill slowly to prevent rapid cooling and distortion of the engine castings.*

3. To thoroughly circulate the water, start and run the engine for 15 minutes after the thermostats have opened.
4. Fully drain system.
5. Refill with clean water and operate for 15 minutes after the thermostats have opened.
6. Stop engine and allow to cool.
7. Fully drain system.

Vehicles without coolant filters:

Fill with a 50/50-antifreeze/water solution and add required inhibitors.

Vehicles with coolant filters:

Replace the coolant filter with a precharge element filter; in this case do not mix inhibitors with antifreeze/water solution.

Dispose of spent fluids in an environmentally responsible manner according to regulations in effect in your area.

7.1 COOLING SYSTEM DESCALERS

If the engine overheats and the fan belt tension, coolant level and thermostat operation have been found to be satisfactory, it may be necessary to de-scale and flush the entire cooling system.

Remove scale formation by using a reputable and safe de-scaling solvent. Immediately after using the de-scaling solvent, neutralize with a neutralizing agent. It is important that product directions be thoroughly read and followed.

After using the solvent and neutralizer, fully drain the system, then reverse flush the engine and radiator (see *"Reverse Flushing" in this section)* before filling the system with coolant solution.

7.2 REVERSE FLUSHING

After the engine and radiator have been thoroughly de-scaled, they should be reverse-flushed. The water pump should be removed and the radiator and engine reverse-flushed separately to prevent dirt and scale deposits from clogging the radiator tubes or being forced through the pump. Reverse flushing is accomplished by hot water, under pressure, being forced through the cooling system in a direction opposite to the normal flow of coolant, loosening and forcing deposits out.

The radiator is reverse flushed as follows:

1. Remove the radiator inlet and outlet hoses and replace existing radiator cap with a new one.
2. Attach a hose to the top of the radiator to lead water away from the engine.

3. Attach a hose at the bottom of the radiator and insert a flushing gun in the hose.
4. Connect the water hose of the gun to the water outlet and the air hose to the compressed air outlet.
5. Turn on the water and when the radiator is full, turn on the air in short blasts, allowing the radiator to fill between blasts.

Note: *Apply air gradually. Do not exert more than 138 kPa (20 psi) air pressure. Too great a pressure may rupture a radiator tube.*

6. Continue flushing until only clean water is expelled from the radiator.

The cylinder block and cylinder head water passages are reverse flushed as follows:

1. Remove the thermostats and the water pump.
2. Attach a hose to the water inlet of oil cooler housing to drain water away from engine.
3. Attach a hose to the water outlet at the top of the cylinder head (thermostat housing) and insert the flushing gun in the hose.
4. Turn on the water until the jackets are filled, and then turn on the air in short blasts. Allow jackets to fill with water between air blasts.
5. Continue flushing until the water from the engine runs clean.

If scale deposits in the radiator cannot be removed by chemical cleaners or reverse flushing as outlined above, it may be necessary to remove the upper tank and rod out the individual radiator tubes with flat steel rods. Circulate the water through the radiator core from the bottom to the top during this operation.

8. SPIN-ON COOLANT FILTER

The optional engine cooling system filter is used to filter out impurities such as scale or sand from the coolant and it also eliminates the process of adding inhibitors to the antifreeze/water solution. The filter is located beside the belt tensioning arm (Fig. 10).

The precharge element filter lasts for 12,500 miles (20 000 km) or one year, whichever comes first. Replace the precharge element filter with a maintenance element filter, which lasts for 200,000 miles (320 000 km) or two years, whichever comes first. Each time the coolant is renewed, a precharge element filter must be installed before installing a maintenance element filter.

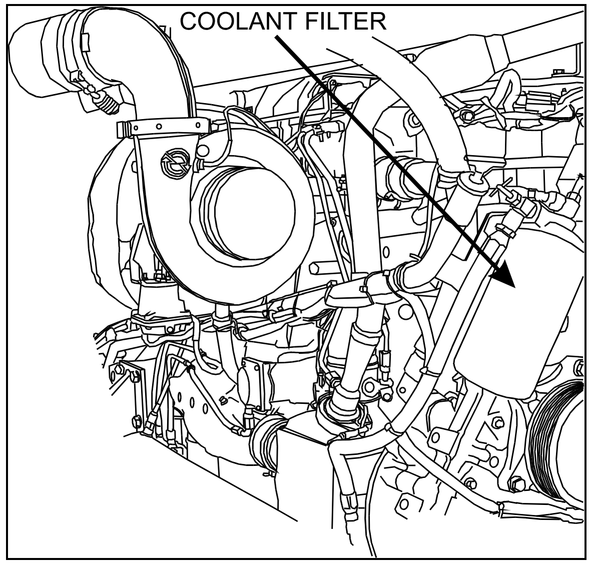


FIGURE 10: COOLANT FILTER 05089

Note: *If a coolant filter is to be installed on an engine already in service, drain and flush the cooling system before installing the filter.*

To replace a filter:

1. Close the two filter shutoff cocks on the filter mounting head and unscrew the old filter from mounting.

Warning: *Failure to relieve cooling system pressure may result in personal injury.*

2. Remove and discard the filter.
3. Clean the filter adapter with a clean, lint-free cloth.
4. Coat surface of gasket with oil, tighten 2/3 to 1 turn after gasket makes contact with head.
5. Open the two filter shutoff cocks.
6. Start engine and check for leaks.

Caution: *Do not exceed recommended service intervals.*

9. RADIATOR

The radiator is mounted on the L.H. side of engine compartment. It is designed to reduce the temperature of the coolant under all operating conditions. It is essential that the radiator core be kept clean and free from corrosion and scale at all times.

9.1 MAINTENANCE

Inspect the exterior of the radiator core every 25,000 miles (40 000 km) or once a year, whichever comes first. Clean with a quality grease solvent, such as a mineral spirits and dry with compressed air. Do not use fuel oil, kerosene, gasoline, or any caustic material. It may be necessary to clean the radiator more frequently if the vehicle is operated in extremely dusty or dirty areas. Refer to coolant system flushing and reverse flushing in this section for maintenance of radiator interior.

10. VARIABLE SPEED RADIATOR FAN

The radiator fan has two thermostatically controlled speeds. The ECM controls the speed by comparing data from engine coolant temperature, charge air cooling temperature, engine oil temperature, A/C condenser temperature, transmission retarder state, manual switch to a set of calibration data. Once fan switches to a state, it stays at that state for 30 seconds long before changing, to reduce clutch cycling. The fan drive clutch is electromagnetic; the ECM sends an electric current to regulate speed by activating one magnetic coil for the first speed and two magnetic coils for the second speed.

The settings are:

- 190°F (87.5°C) Thermostat starts to open
- 192°F (89°C) Fan medium speed, descending, off
- 196°F (91°C) Fan medium speed, rising, on
- 199.5°F (93°C) Fan high speed, descending, off
- 203°F (95°C) Fan high speed, rising, on
- 205°F (96°C) Thermostats fully open

Note: *In case of an electrical power failure: remove the bolt from the end of the shaft and screw it into the locking plate. This procedure will prevent engine from overheating by forcing fan rotation (Fig. 11). On certain models, the mechanical locking device consists of two threaded bushings fixed on the pulley and two drilled metal plates fixed on the rotor. Use the two screws located on the face of the clutch to fasten the metal plates and the bushings (Fig.12).*

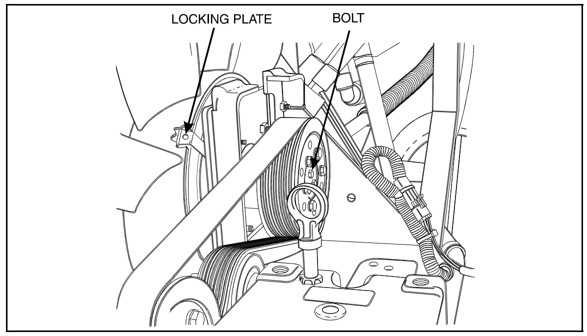


FIGURE 11: MECHANICAL LOCKING DEVICE 05061

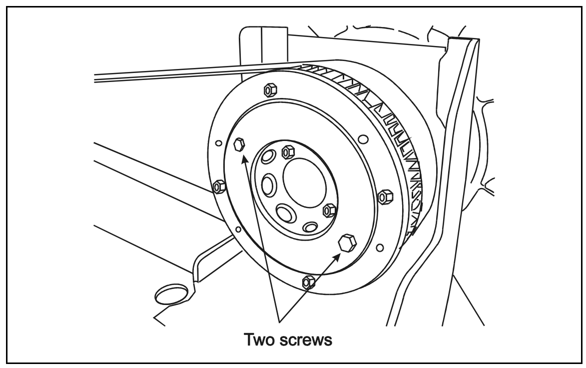


FIGURE 12: SCREWS LOCATION

10.1 MAINTENANCE

1. Clean the fan and related parts with clean fuel oil and dry them with compressed air. Do not clean with steam or high-pressure jet.
2. Check the fan blades for cracks or other damage. Replace the fan if the blades are cracked or deformed.
3. Remove any rust or rough spots in the grooves of the fan pulley. If the grooves are damaged or severely worn, replace the pulley.
4. Do not add any fluids or lubricants to the fan driving mechanism.
5. Do not restrict fan rotation during engine operation for any reason.

6. Do not operate fan-driving mechanism with a damaged fan assembly. Replace a damaged fan as soon as the fault is noted.
7. Immediately investigate and correct any operator complaint involving driving mechanism or cooling system performance.
8. When questions arise, obtain answers before proceeding. Assistance is available through the authorized Field Sales distributor serving your area.

10.2 INSPECTION

Warning: *Set the starter selector switch in engine compartment to the "Off" position to prevent accidental starting of the engine.*

- Check security of fasteners securing fan blade assembly to fan driving mechanism.
- Check coupling installation between fan blade assembly and gearbox.
- Visually inspect fan driving mechanism, fan blade assembly, shroud, radiator, and surrounding area for evidence of contact between rotating and non-rotating parts.
- Check fan transfer belt for fraying, cracking, and proper tension.
- Turn fan through at least 360° of rotation. It should turn smoothly with no resistance.

10.3 THERMOSTAT OPERATION

Coolant temperature is controlled by two blocking-type thermostats located in a housing attached to the cylinder head, on the turbo side of the engine (Fig. 12).

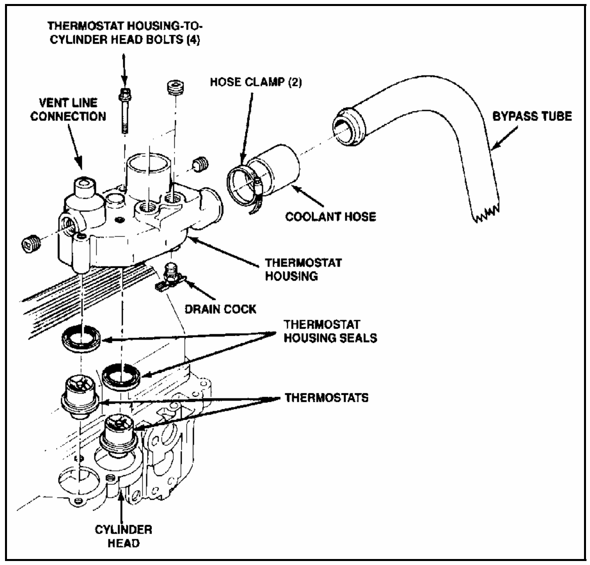


FIGURE 13: THERMOSTAT AND RELATED PARTS 05034

At coolant temperature below approximately 190°F (88°C), the thermostat valves remain closed and block the flow of coolant from the engine to the radiator. During this period, all of the coolant in the system is recirculated through the engine and directed back to the suction side of the water pump via a bypass tube. As the coolant temperature rises above 190°F (88°C) the thermostat valves start to open, restricting the bypass system, and allowing a portion of the coolant to recirculate through the radiator. When the coolant temperature reaches approximately 205-207°F (96-97°C) thermostat valves are fully open, the bypass system is blocked off and the coolant is directed through the radiator.

11. FAN GEARBOX

The radiator fan is belt driven from the engine crankshaft pulley through a standard gearbox, which is designed with two output shafts.

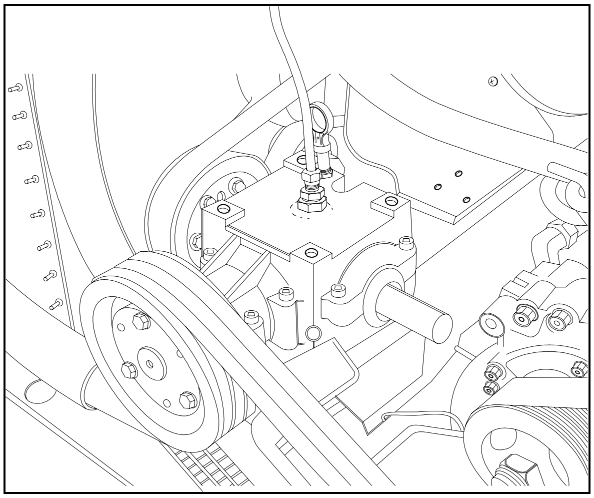


FIGURE 14: FAN GEARBOX 05062

11.1 MAINTENANCE

Change the gearbox oil at 3,000 miles (4,800 km) and subsequently every 50,000 miles (80,000-km) or once a year, whichever comes first.

11.2 OIL CHANGE

1. Stop engine and make sure that all engine safety precautions have been observed.
2. Remove the drain plug located underneath the gearbox case.
3. Drain gearbox.
4. Replace drain plug.
5. Remove the dipstick located on top of gearbox and wipe with a clean rag (Fig. 13).
6. Adjust level to ″Full″ mark using Mobil SHC 630 (Prévost #180217) synthetic oil.
7. Insert dipstick in gearbox case, then remove again to check mark.
8. Reinsert the dipstick.

12. RADIATOR FAN BELT REPLACEMENT

Locate the belt tensioner pressure-releasing valve (Fig. 14), then turn handle counter-clockwise in order to release pressure in belt tensioner air bellows, thus releasing tension on belts.

Remove existing belts (3″V″belts & 1 Poly) from fan assembly and replace with new ones.

Turn the pressure-releasing valve clockwise to its initial position to apply tension on the new belts.

***Note:** For proper operation of the belts, adjust the air bellows tensioner pressure regulating valve (located next to control valve) to 50 psi (345 kPa) for XL2 Coaches and to 45 psi (310 kPa) for XL2 MTH.*

12.1 BELT TENSION ADJUSTMENT

The regulator is located in the engine compartment behind the belt tension pressure releasing valve panel. Turn the screw located under the regulator assembly to change the tension pressure. Check proper pressure using the pressure check valve (Fig. 14).

Use Belt Tension Gauge #68-2404 to measure tension of engine belts. For proper operation of air tensioners, adjust upper tensioning bracket to provide a ¼" (7 mm) gap between stopper and bracket under normal pressure of 50 psi - 345 kPa or 45 psi - 310 kPa. Refer to figure 15 for more information.

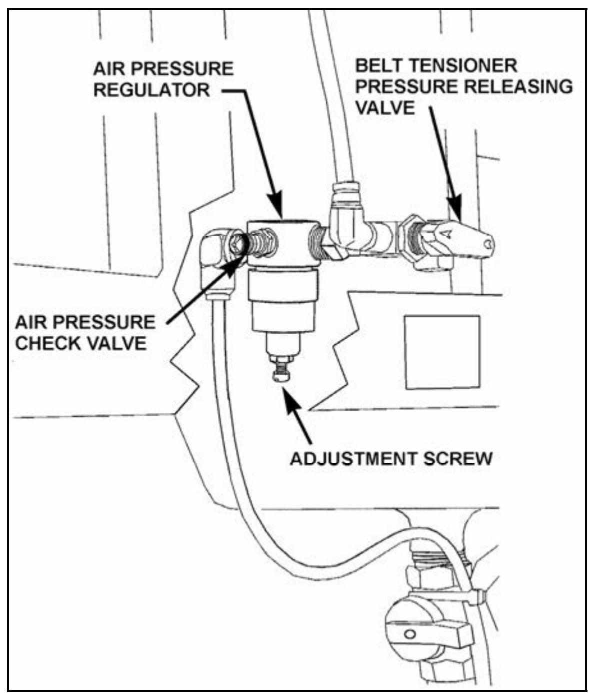


FIGURE 15: REGULATOR VALVE 12200

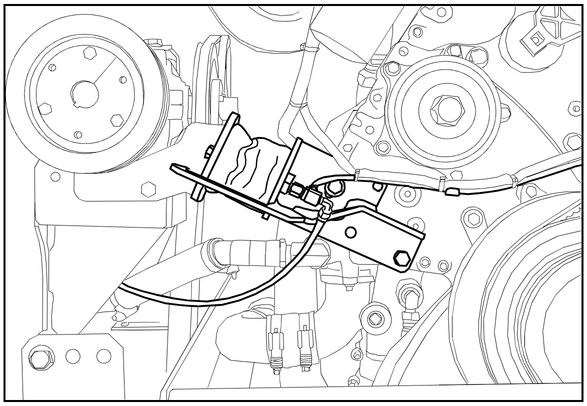


FIGURE 16: BELT TENSIONER 01059

13. FAN DRIVE ALIGNMENT

1. Install both attachment assembly plates (P/N 051779) (48, Fig. 16) through lower plating and secure with four spring nuts (P/N 500666), (70, Fig. 16). Then install one spacer (P/N 050705), (49, Fig. 16) on each spring nut at both anchoring locations (Fig. 16).

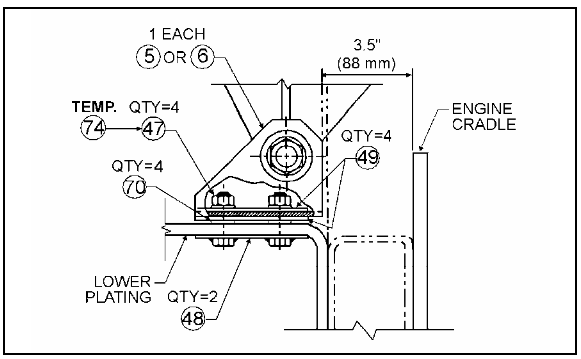


FIGURE 17: ANGLE SUPPORT 05014

2. Center seat assembly in the fan shroud using the horizontal displacement of the fan driving mechanism support. Center with the slots in the floor at anchoring angle support (on some vehicles only). Vertical displacement of the fan clutch is made possible by slots at the base of the fan clutch (on some vehicles only) or by shimming with additional spacers at anchoring locations. Temporarily secure assembly with two nuts (P/N 500709), (74, Fig. 16) at both anchoring locations.

Caution: *Tilt fan and check for clearance.*

3. Using a straight edge, align the 3"V"pulley on gearbox central shaft pulley with engine pulley, while taking pulleys outer edge thickness under consideration i.e. 3"V"pulley's outer edge is thicker than that of engine pulley's (Fig. 17).

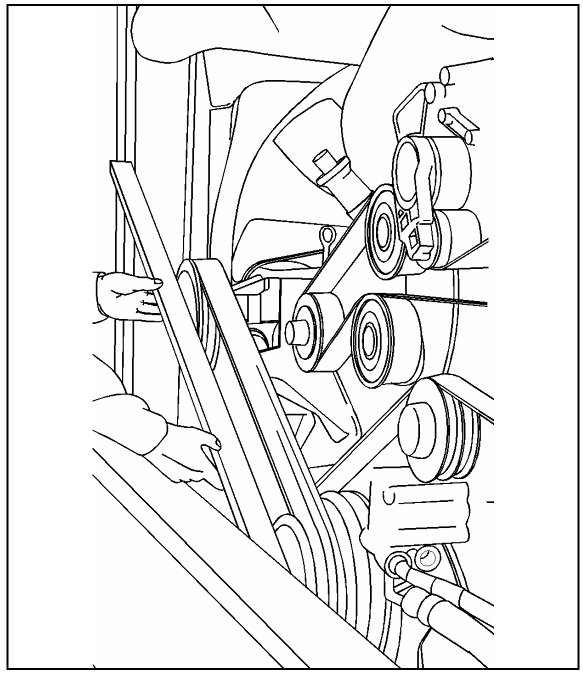


FIGURE 18: PULLEY ALIGNMENT 05064

4. Using a universal protractor, check 3"V" pulley's vertical angle with that of engine pulleys. If angles do not correspond, raise seat assembly by shimming with additional spacers (#49 - P/N 050705).

Note: *Use a straight edge to measure engine pulley's vertical angle (Fig. 18).*

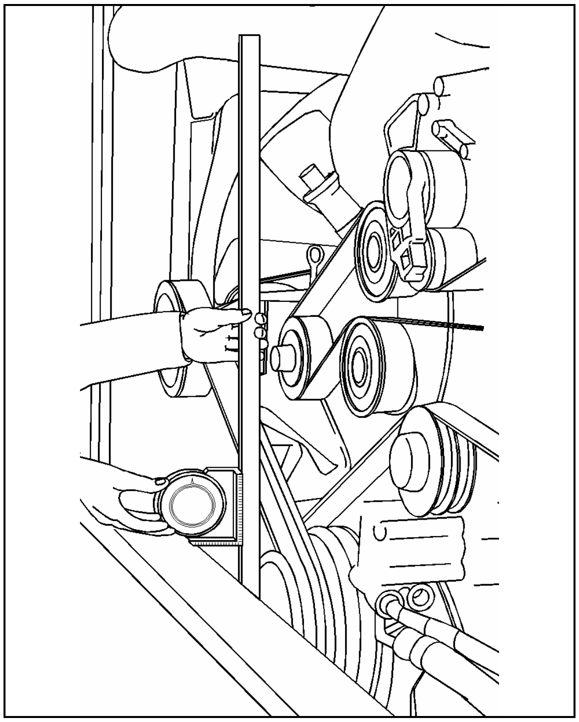


FIGURE 19: PULLEY VERTICAL ANGLE 05063

5. Check alignments again (steps 2, 3 & 4) then replace temporary anchoring nuts (P/N 500709) (74, Fig. 16) with four nuts (P/N 500714) (47, Fig. 16) and tighten using a wrench.
6. Align multi "V" pulley with fan pulley. Adjust the depth of the pulley on the gearbox shaft.
7. Set belt tensioner pressure regulating valve to 50 PSI - 345 kPa.

Caution: *In order for tensioning system to work properly, adjust upper tensioning bracket to provide a ¼" (7 mm) gap between stopper and bracket. Otherwise, release tension on system and readjust distance using bolts securing upper tensioning bracket (Fig. 15).*

.

14. SPECIFICATIONS

Cooling System Capacity (Approximation)

Includes heating system.. 24 US gal (91 liters)

Thermostat

Number used...2
Start to open ....186-193°F (86-89°C)
Fully open .... 207°F (97°C)

Radiator

Make...Valeo
Location .... Rear L.H. side
<u>XL2 Coaches, W0 & WE MTH</u>
Supplier number.......... 1040153
Prevost number.......... 550820
<u>W5 MTH</u>
Supplier number.... 1040149
Prevost number.......... 550819

Surge Tank Filler Cap

Make .... Stant
Model R3
Prevost number 052355

Pressure Cap

Make .... Stant
Pressure setting.. 14 psi (96.53 kPa)
Supplier number R12
Prevost number 550606

Fan Clutch

Make .... Linnig
Type ....3 speed
<u>XL2 Buses</u>
Supplier number LA1.2.0118
Prevost number 550837
<u>XL2 MTH</u>
Supplier number.... ....LA1.2.0131Y
Prevost number.......... 550839

Note: *The fan clutch is controlled by DDEC (not by thermoswitch).*

Fan Gearbox

Make ....Superior Gearbox
Ratio...1:1
Supplier number 411ACF-097-6
Prevost number 550789
Lubricating Oil.. MOBIL SHC 630
Prevost number (Oil) 683666

Fan Belt (gearbox-fan)

Make .... Dayco
Type .... Poly-V
Qty 1

XL2 Coaches, W0 & WE XL2 MTH:

Supplier number .... 10-55"
Prevost number 506684

W5 XL2 MTH:

Supplier number 12 PK-2100
Prevost number 507627

Fan Belt (gearbox-motor)

Make .... Dayco
Type .... V belt
Qty 3

XL2 Coaches:

Supplier number AX-71
Prevost number 505522

W0 & WE XL2 MTH:

Supplier number AX-73
Prevost number 506691

W5 XL2 MTH:

Supplier number 3/BX-77
Prevost number 509822

Corrosion Inhibitor and Coolant Stabilizer

Supplier number.......Detroit Diesel 23507857
Supplier number.......Nalco DD3000-15

Coolant Filter

Number used 1
Make .... Nalco
Type .... Spin-on

MAINTENANCE ELEMENT FILTER

Supplier number. ....Detroit Diesel 23507545
Supplier number......Nalco DDF3000
Prevost number 550630

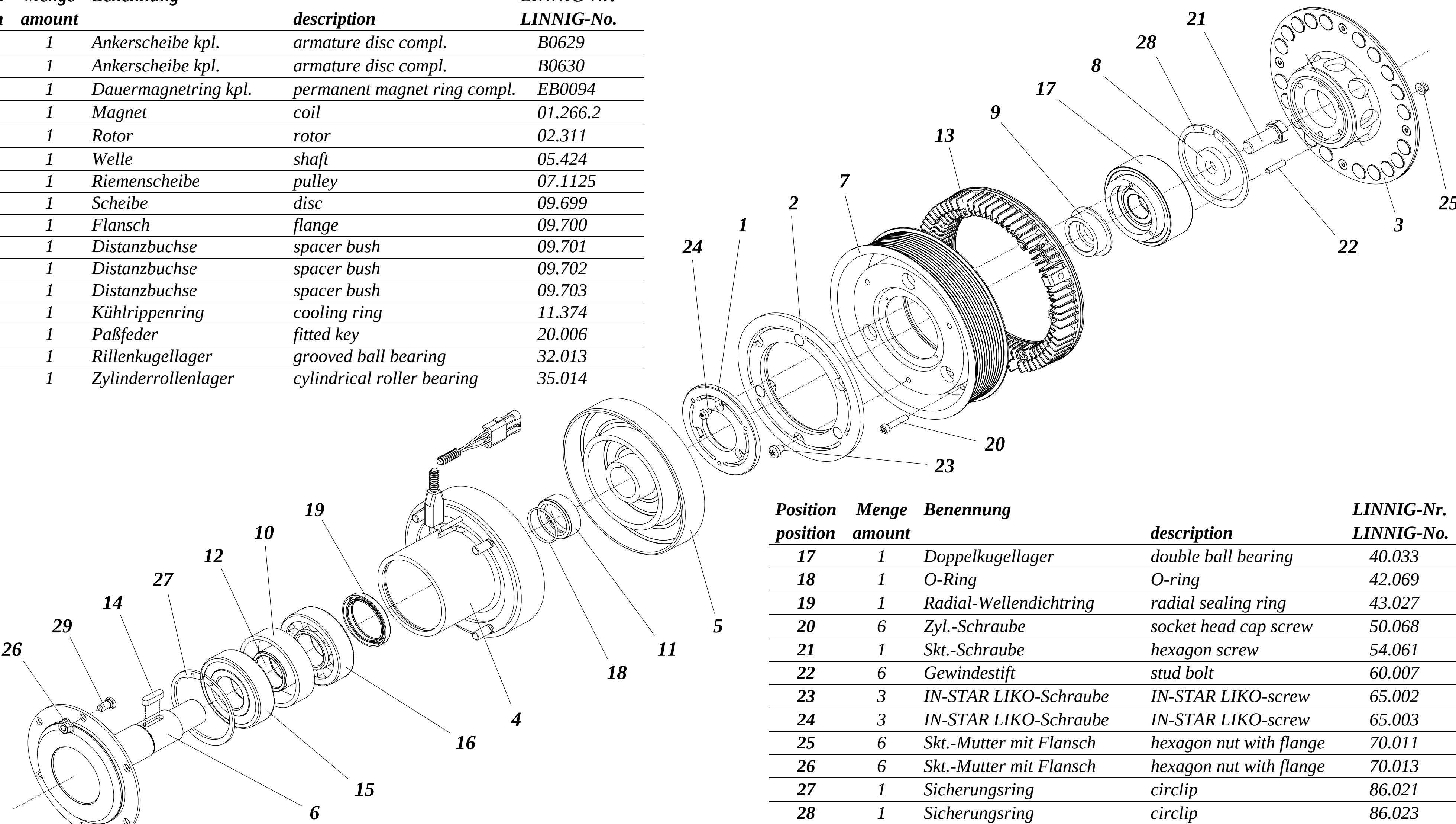
PRECHARGE ELEMENT FILTER

Supplier number. ....Detroit Diesel 23507189
Supplier number......Nalco DDF60
Prevost number 550629

LINNIG
Antriebstechnik GmbH
Riedheimer Str.5
D - 88677 Markdorf

Ersatzteilliste / spare part list LA1.2.0131Y

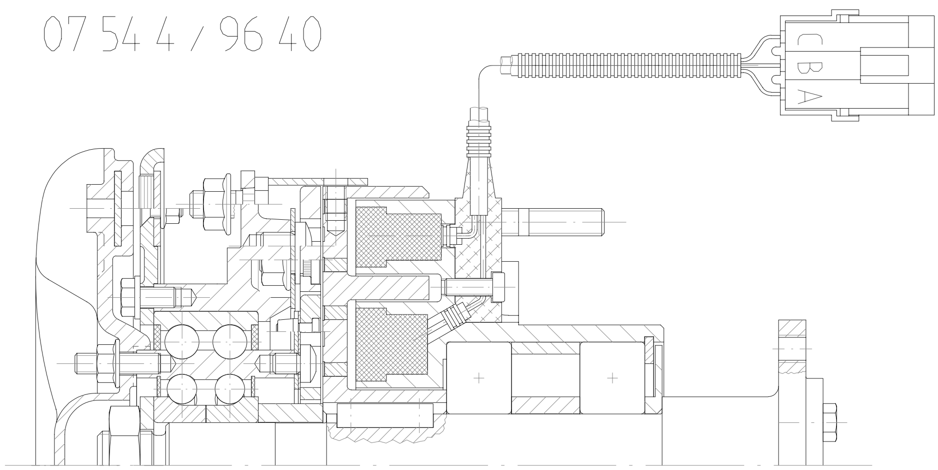
Position / position	Menge / amount	Benennung	description	LINNIG-Nr. / LINNIG-No.
1	1	Ankerscheibe kpl.	armature disc compl.	B0629
2	1	Ankerscheibe kpl.	armature disc compl.	B0630
3	1	Dauermagnetring kpl.	permanent magnet ring compl.	EB0094
4	1	Magnet	coil	01.266.2
5	1	Rotor	rotor	02.311
6	1	Welle	shaft	05.424
7	1	Riemenscheibe	pulley	07.1125
8	1	Scheibe	disc	09.699
9	1	Flansch	flange	09.700
10	1	Distanzbuchse	spacer bush	09.701
11	1	Distanzbuchse	spacer bush	09.702
12	1	Distanzbuchse	spacer bush	09.703
13	1	Kühlrippenring	cooling ring	11.374
14	1	Paßfeder	fitted key	20.006
15	1	Rillenkugellager	grooved ball bearing	32.013
16	1	Zylinderrollenlager	cylindrical roller bearing	35.014

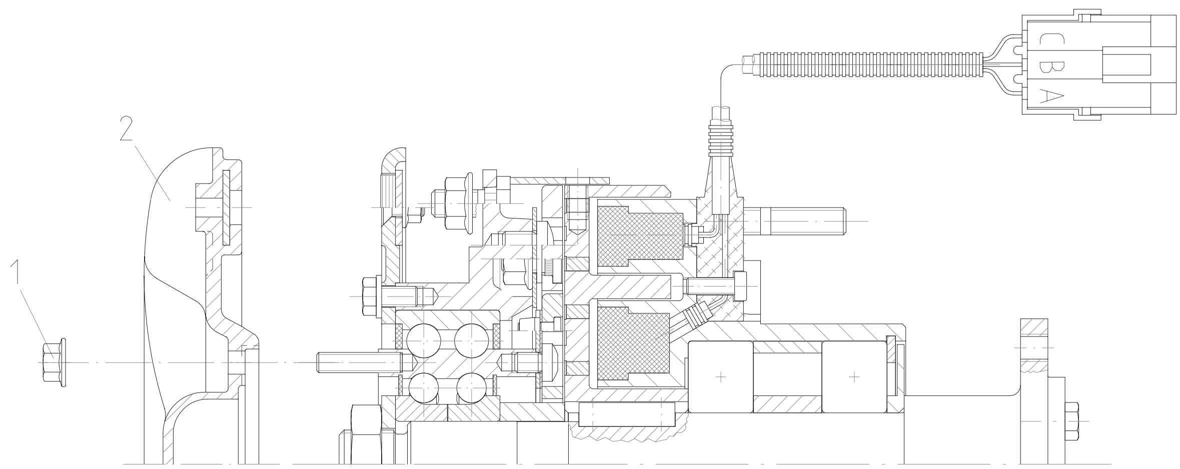


Position / position	Menge / amount	Benennung	description	LINNIG-Nr. / LINNIG-No.
17	1	Doppelkugellager	double ball bearing	40.033
18	1	O-Ring	O-ring	42.069
19	1	Radial-Wellendichtring	radial sealing ring	43.027
20	6	Zyl.-Schraube	socket head cap screw	50.068
21	1	Skt.-Schraube	hexagon screw	54.061
22	6	Gewindestift	stud bolt	60.007
23	3	IN-STAR LIKO-Schraube	IN-STAR LIKO-screw	65.002
24	3	IN-STAR LIKO-Schraube	IN-STAR LIKO-screw	65.003
25	6	Skt.-Mutter mit Flansch	hexagon nut with flange	70.011
26	6	Skt.-Mutter mit Flansch	hexagon nut with flange	70.013
27	1	Sicherungsring	circlip	86.021
28	1	Sicherungsring	circlip	86.023
29	6	Einpress-Gewindebolzen	press-in bolt	120.017

Repair instructions for LA1.2.0118Y and LA1.2.119Y

LINNIG
Antriebstechnik GmbH
Box 1430
88672 Markdorf
07 54 4 / 96 40

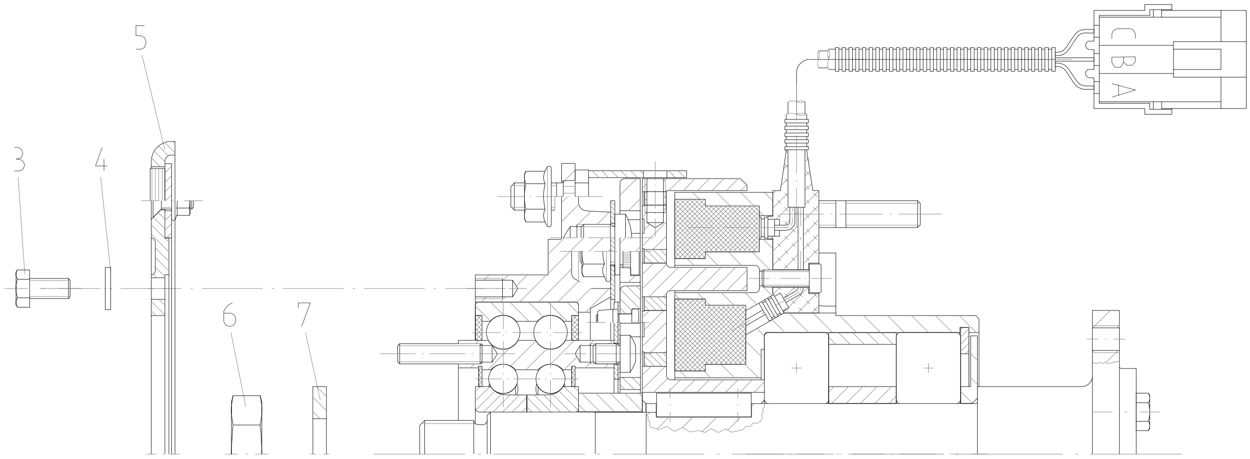




1) Loose hexagon head nut M6 (1).

2) Remove aluminium fan (2) by hand.
Mind the acceleration of the permanent magnets.

142.181
11.11.02
Meckes

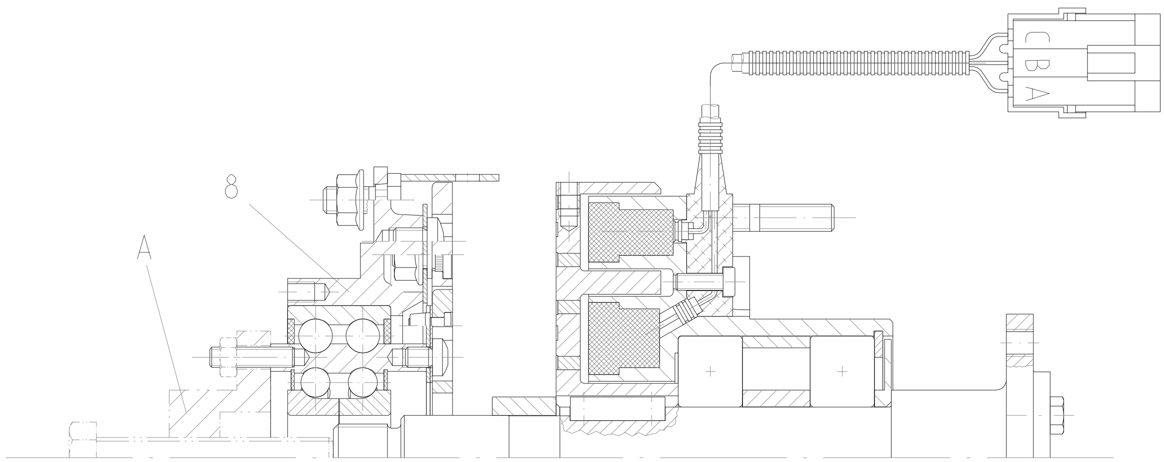


3) Loose hexagon head screw (3)
and remove washers (4).

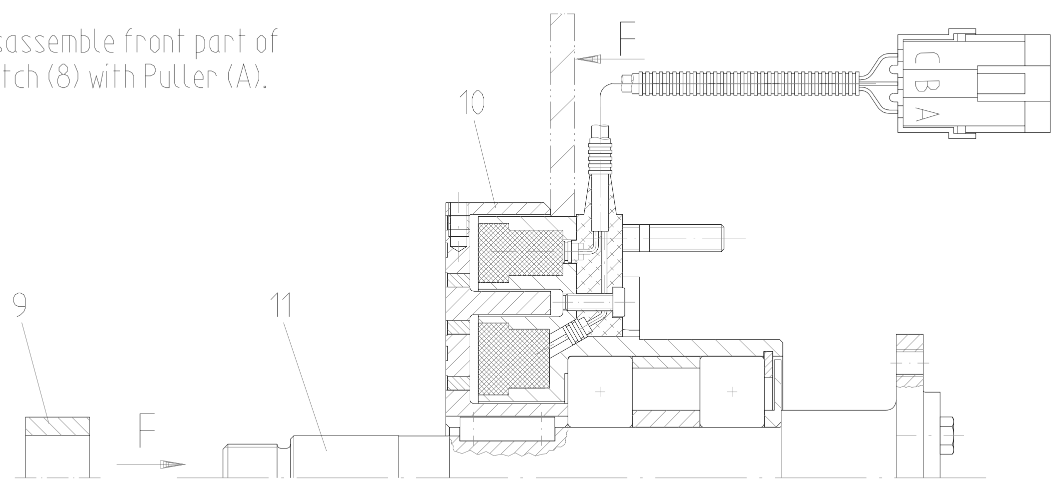
4) Dismantle the permanent magnet ring (5).

5) Remove fan.

6) Remove hexagon head nut M20×1.5 (6).
Remove washer (7).



7) Disassemble front part of
clutch (8) with Puller (A).

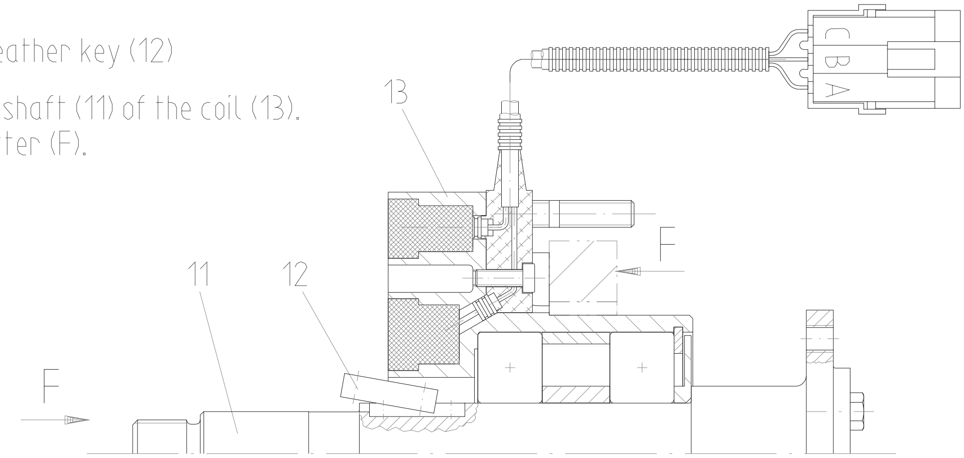


8) Remove spacer (9).

9) Press the shaft (11) of the rotor (10).
Follow the letter (F).

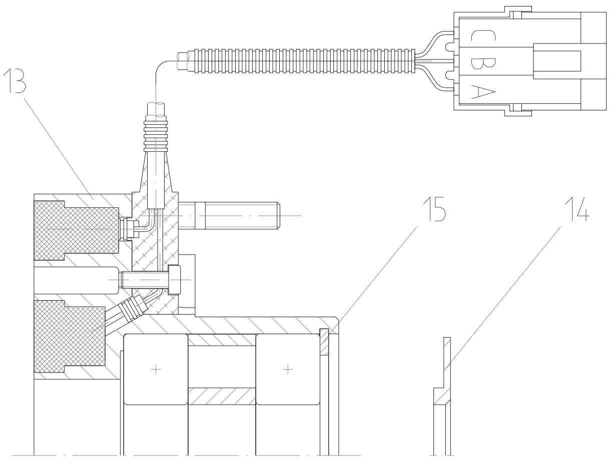
10) Remove feather key (12)

11) Press the shaft (11) of the coil (13).
Follow letter (F).



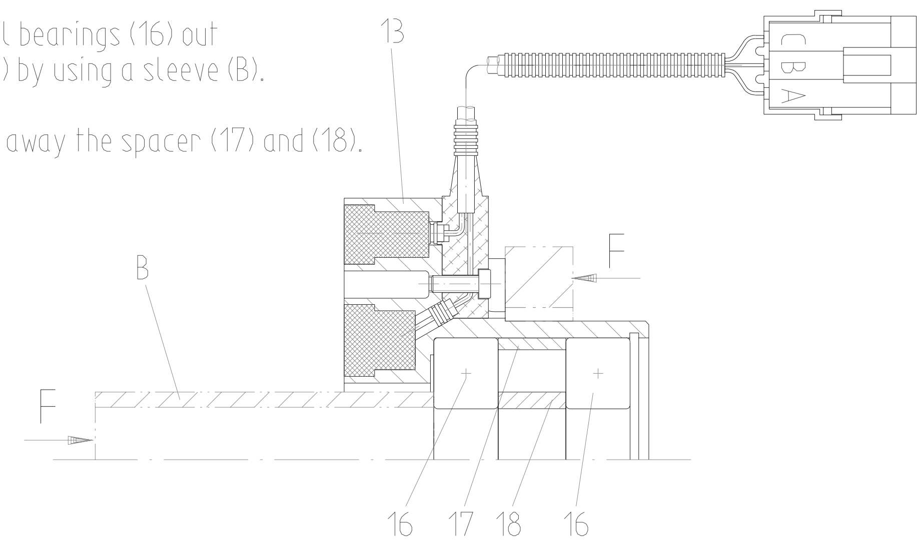
12) Remove gasket (14) from shaft.

13) Take out circlip (15) from coil (13).



14) Press the ball bearings (16) out
of the coil (13) by using a sleeve (B).

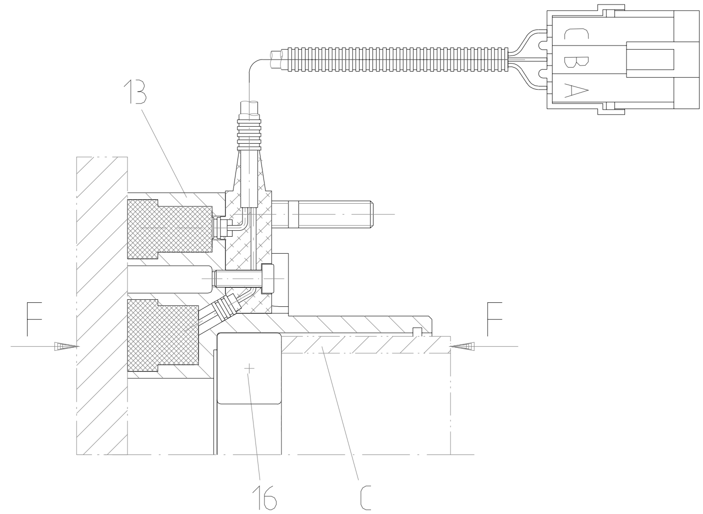
15) Don't through away the spacer (17) and (18).



Renew the following parts when reassemble the clutch:	clutch-front-part (8)	LINNIG No. EB0095
	rotor (10)	LINNIG No. 02.264
	2 × ball bearings (16)	LINNIG No. 32.005

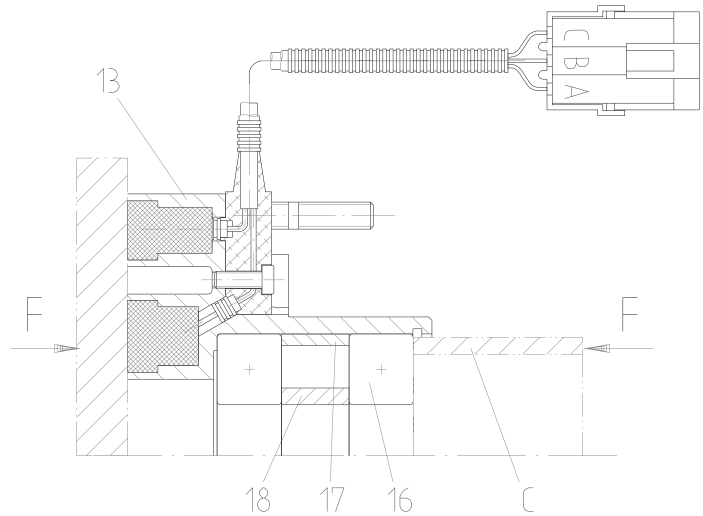
Assembly instruction

16) Press the ball bearing (16)
into the coil (13).
(Note: Press only the outer ring
of the bearing. See (F).

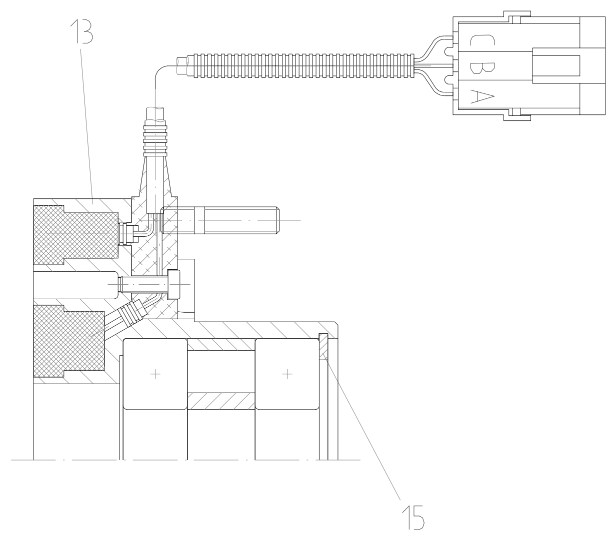


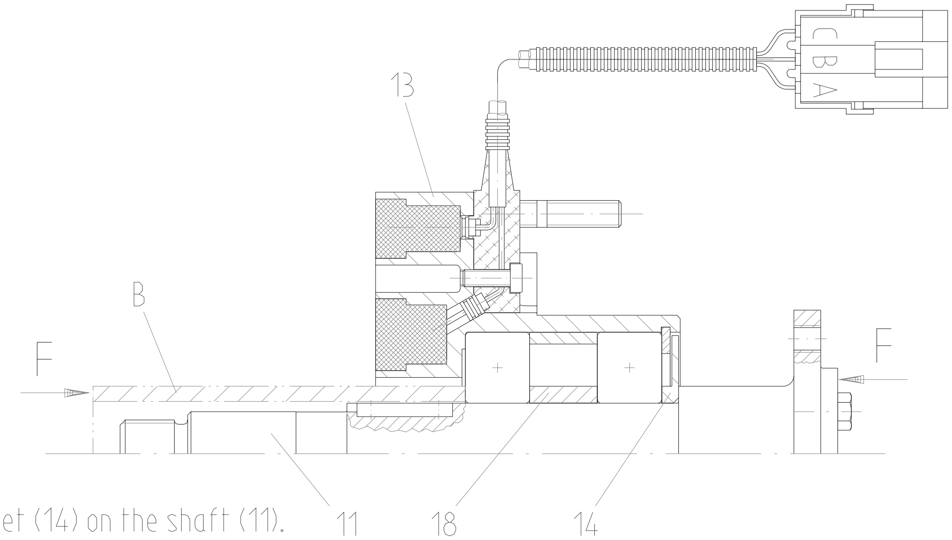
17) Insert spacer (17) and (18)
into the coil (13).

18) Press the ball bearing (16)
into the coil (13).
(Note: Press only on the
outer ring of the bearing.
See (F).



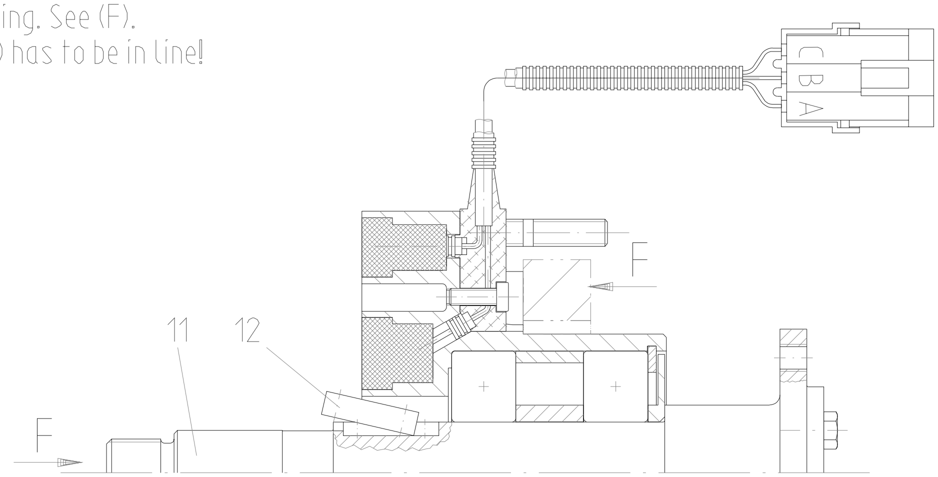
19) Replace circlip (15)
into the coil (13).



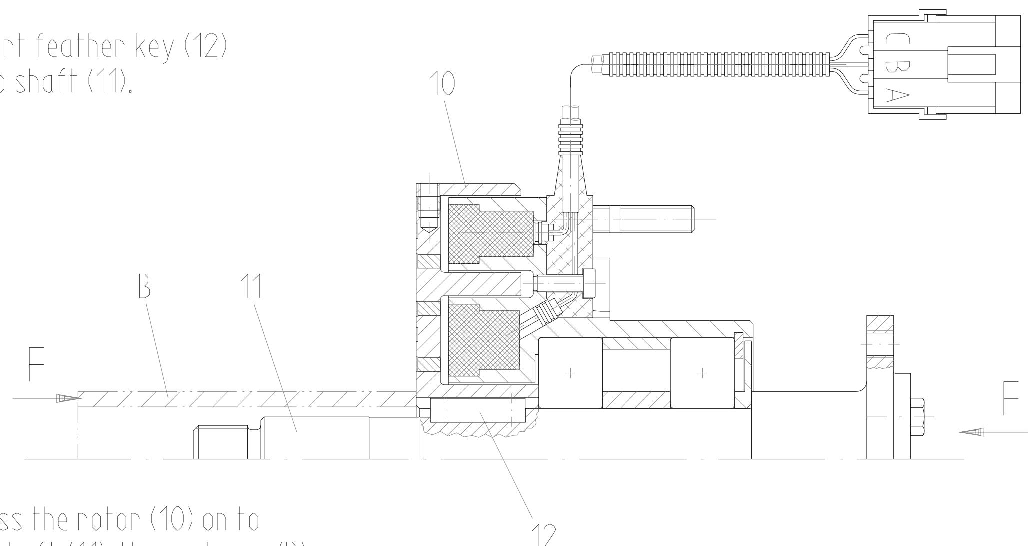


20) Push gasket (14) on the shaft (11).
(Take care for the right position)

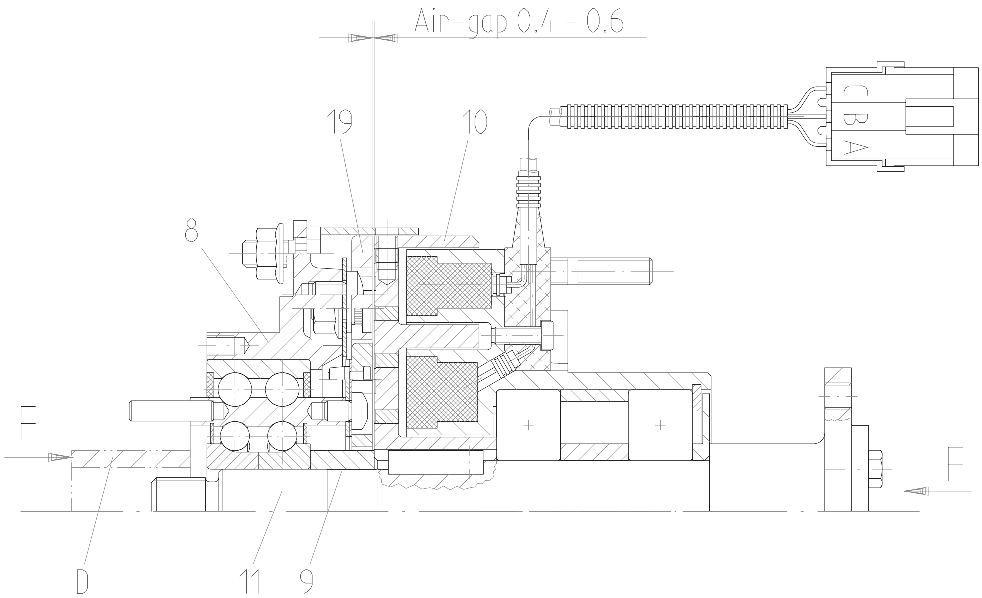
21) Press the coil (13) onto the shaft (11).
(Note: Press only the inner ring
of the bearing. See (F).
Spacer (18) has to be in line!



22) Insert feather key (12)
into shaft (11).



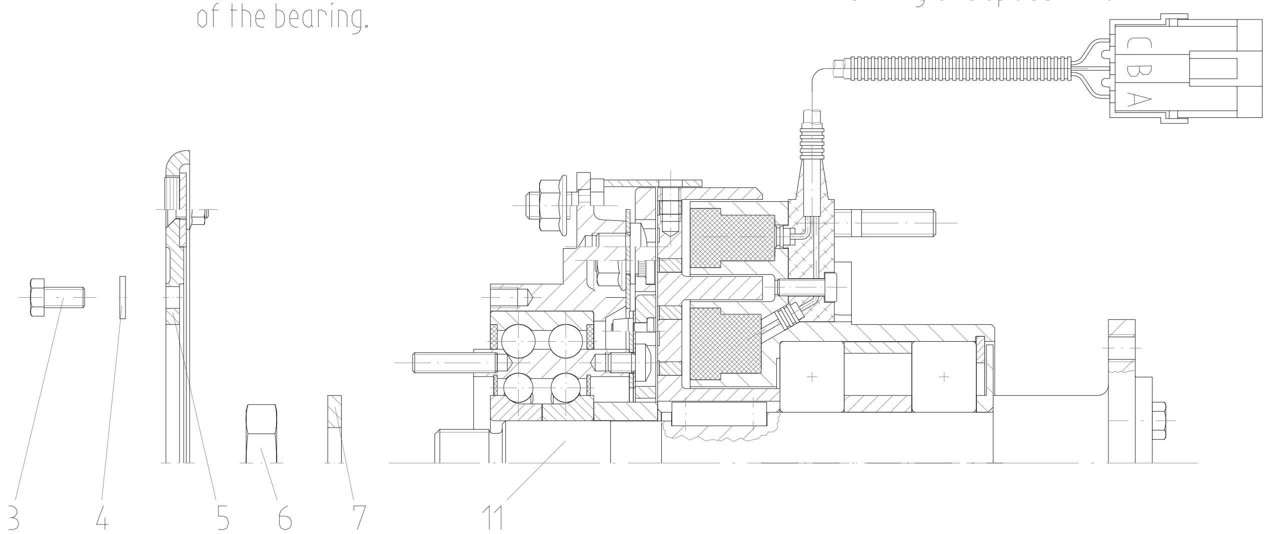
23) Press the rotor (10) on to
the shaft (11). Use a sleeve (B).
Look after the position of the feather key (12).



24) Push spacer (9) on to the shaft (11).

25) Press the clutch front part (8) with sleeve on to the shaft. Press only on the inner ring of the bearing.

26) Check the air-gap 0.4 - 0.6 mm between rotor (10) and core disc (19). If necessary put toleranced washers between bearing inner ring and spacer (9).



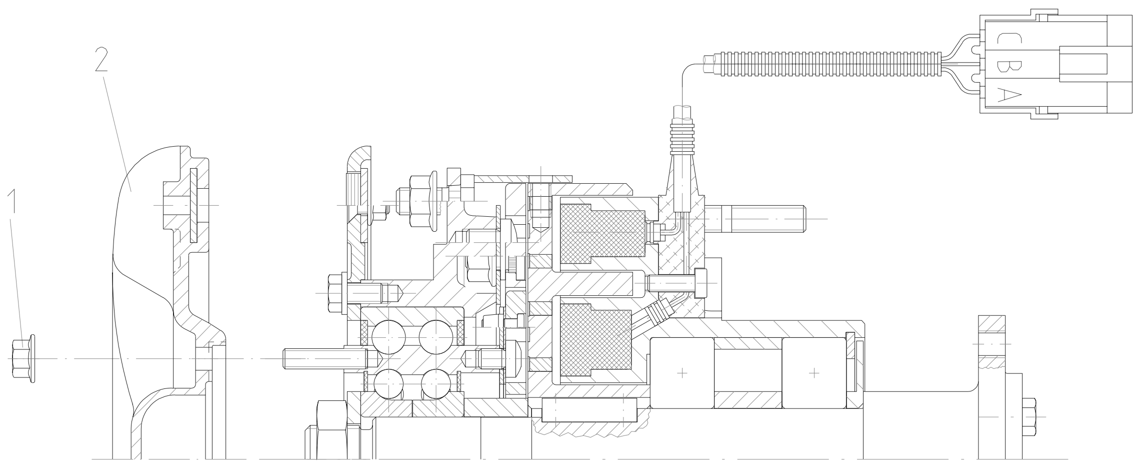
27) Push washer (7) on to the shaft (11).

28) Assemble hexagon head nut M20×1.5 (6). Torque Ma = 90 Nm Secure hexagon head nut with locking paint

29) Assemble fan.

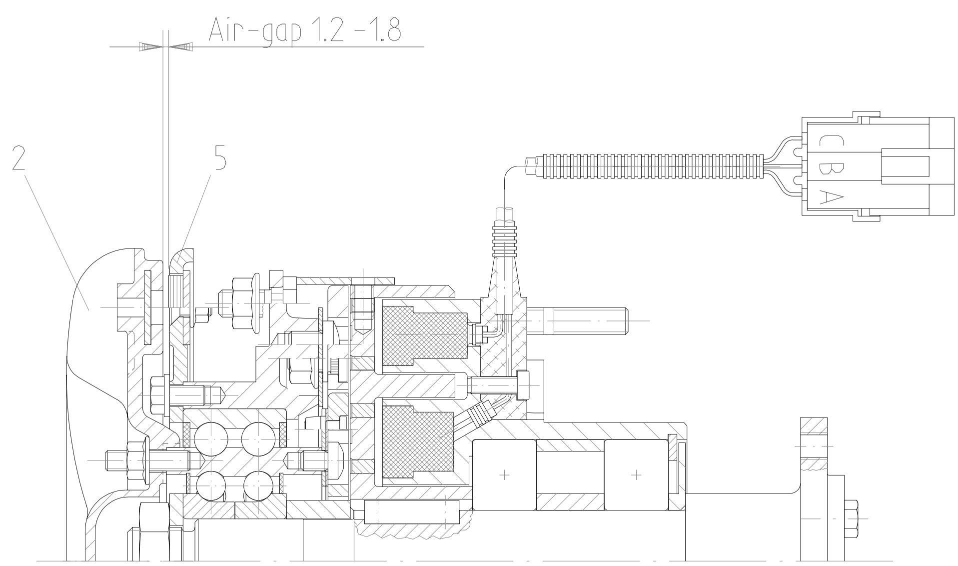
30) Assemble permanent magnet ring (5)

31) Bolt the permanent magnet ring (5) with three hexagon head screws M6×12-8.8 and washers (4) on to the clutch front part. Torque Ma = 10 Nm



32) Assemble aluminium fan (2).

33) Screw the aluminium fan (2)
on to the clutch front part
with hexagon head nut M6-8 (1).
Torque Ma = 10 Nm



34) Check air-gap 1.2 - 1.8 mm between
fan (2) and permanent magnet ring (5).

SECTION 06: ELECTRICAL

CONTENTS

ILLUSTRATIONS

1. GENERAL DESCRIPTION

This vehicle uses a dual voltage system to obtain two different voltages (12 and 24 volts) for various electrical controls and accessories. The main power source incorporates four maintenance-free “Delco” model 1150 batteries connected in parallel-series. All batteries are kept uniformly charged by means of a 100 amp battery equalizer (standard), giving a maximum possible output supply of 100 amps on the 12 volt system. Both the 12 and 24 volt systems are controlled through individual main battery relays. One or two 24 volt self-rectified alternators are belt driven from the engine, and can be reached through the engine compartment door.

1.1 WIRING DIAGRAMS

A master wiring diagram of the electric circuits, covering standard and optional accessories and systems, is located in the technical publications box. Usually, a separate wiring diagram page is provided for each major function or system. In some cases, more than one circuit may appear on one wiring diagram page; when this occurs, each circuit covered in this page is listed in the wiring diagram index. Moreover, a circuit may appear on several pages; in such case, the number(s) at the extremity of the diagram title will indicate the sheet reference number. Refer to the *"Wiring Diagram Index*" to ensure that the correct diagram is being used to trace the circuit in question.

1.1.1 Wiring Diagram Keys

Various symbols are used on the wiring diagrams to depict different types of electrical components. It is essential to become familiar with these symbols in order to understand the diagrams. The major symbols shown on the diagrams are identified under *"Wiring Diagram keys"* (page **K** of wiring diagrams).

1.1.2 Using Wiring Diagrams

Two methods are used to *"work"* with electric wiring diagrams.

Situation: You have identified the defective part (breaker, diode, relay, etc.), and you wish to locate its corresponding circuit.

Problem: Circuit breaker #56 is released (open circuit) and you don't know which circuit is affected.

a) Refer to wiring diagram index, and look for *"Circuit breaker code"*, pages **F**.

b) At item CB #56, in the first column, you will find the page on which to find the corresponding diagram, in the second column the breaker ampere rating, and in the third column, the Prévost number. The other columns give you the location and the function of the breaker.

c) Refer to page 4, keeping in mind the function of the breaker, i.e. emergency exit lights.

d) When you have located *“emergency exit lights”,* follow the wiring until you come across CB #56 and its circuit.

Situation: You have a problem with a specific system and you want to find the corresponding diagram.

Problem: The last three (3) speakers on the R.H. side of vehicle are inoperative and you must trace the electric circuit.

a) Refer to wiring diagram index and look for *“Sound system”.*

b) You will find on page 26 the components as well as the electric wiring, thus providing you with a complete understanding of this circuit.

1.1.3 Testing Circuits

A careful study of the wiring diagrams should be made to determine the source and flow of current through each circuit. When a circuit is thoroughly understood, a point-to-point check can be made with the aid of the applicable wiring diagrams. Any circuit can be tested for continuity or short circuits with a multimeter or a suitable voltmeter.
All electrical connections must always be kept clean and adequately tight. Loose or corroded connections can result in discharged batteries, difficult starting, dim lights and improper functioning of other electric circuits. Inspect all wiring connections at regular intervals. Make sure knurled nuts on all amphenol-type plugs are securely tightened. Knurled nuts on the plastic amphenol-type connectors will click into a detent when properly tightened. Line connectors, who have the side locking tabs, must have the locks latched in place to ensure a proper electrical connection.

1.2 WIRE SIZES AND COLORS

Each wire in the electrical system has a specific size as designated on the wiring diagram. When replacing a wire, the correct size must be used. Never replace a wire with one of a smaller size.
The vehicle electrical system is provided with different voltages. The insulation on each wire is distinctly colored in order to determine visually

the wiring voltage and to assist in making connectors. The wires are color coded as follows:

Red	24 volt system
Yellow	12 volt system
Black	grounded wire
Blue	110 V ac system (live)
White	110 V ac system (neutral)
Green	110 V ac system (ground)
Orange	speakers (+)
Brown	speakers (-)
Grey	spare wire

Note: *Wires are identified at each 2-4 inch (5-10 cm) intervals by a printed number.*

Each wire on a diagram is patterned to assist in tracing and testing circuits. The wire number identifies the voltage rating, the wire identification number and the basic wire gauge as illustrated in figure 1.

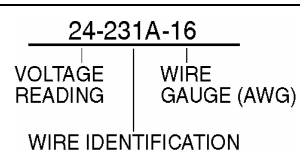


FIGURE 1: WIRE IDENTIFICATION 06048

1.3 SPARE WIRES

When the vehicle leaves the factory, and even in the case of a fully-equipped vehicle, an important number of unconnected spare wires are routed between the junction boxes. Consequently, for any connection of an additional accessory, refer to page D *"Spare wires"* in master wiring diagram to determine the number, the gauge and location of these wires.

Note: *Spare wires are identified by a wire identification number and by the letters "SP", to designate "spare".*

1.4 CLEANING CONNECTORS

When the pins and sockets of connectors become dirty, clean them with a good quality solvent containing HFC 134A refrigerant as its active ingredient. HFC 134A has two qualities that recommend it. First, it does not conduct electricity and therefore, will not cause shorting between connector pins and sockets. Second, it evaporates quickly, eliminating the possibility of condensation within the connectors.

Always shake out or gently blow out any excess HFC 134A before assembling a connector to its mating connector or hardware. HFC 134A trapped in the connector can affect the connector seal.

Warning: *HFC 134A is toxic. HFC 134A bases compounds should always be used in a well-ventilated area, never in a confined space. Use outdoor whenever possible.*

1.5 CIRCUIT BREAKERS

Most electric circuits are protected by circuit breakers of the "Manual Reset" type. The main circuit breakers, as well as those protecting the A/C system, are located in the engine compartment, on R.H. side of the vehicle or in the main power depending on type of vehicle. The remaining are located in the evaporator compartment, inside the A/C junction box.

CIRCUIT BREAKERS			
CB1	A/C Full Air	24 volts	200 amps
CB2	Hot Wire	12 volts	40 amps
CB3	Rear Junction Box	12 volts	70 amps
CB4	Front Junction Box	12 volts	90 amps
CB5	Hot Wire	24 volts	30 amps
CB6	Rear Junction Box	24 volts	90 amps
CB7	Front Junction Box	24 volts	90 amps
CB8	Condenser Fan Motor L.H.	24 volts	40 amps
CB9	Evaporator Fan Motor	24 volts	120 amps
CB11	Condenser Fan Motor R.H.	24 volts	40 amps

The smaller circuit breakers are accessible in the front service compartment and rear junction box. This type of circuit breaker deenergizes the circuit without disconnecting any wire. Simply press down the red tab on breaker to open the circuit, repair defective circuit, and afterwards depress black button in center of breaker to close the circuit.

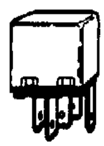
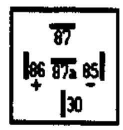
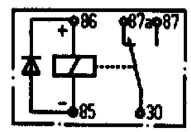
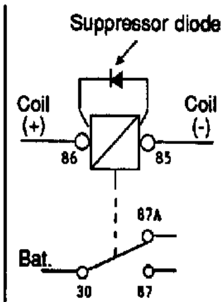
1.6 RELAYS

Relays are used to automatically energize or deenergize a circuit from a remote location. The relay draws a very low current to energize its coil. Once the coil is energized, it develops a magnetic field that pulls a switch arm closed or open, to either energize or deenergize a given component. As the control current required for the coil is very low, the relay allows a remote station to control a high energy circuit without running great lengths of costly high capacity cable, and also eliminates the need for high amperage switches and heavy connectors.

Many systems on this vehicle are provided with control relays, which are all, located in or on the junction boxes, figure 2.

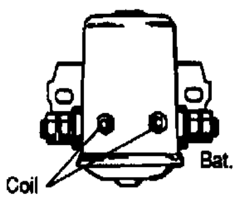
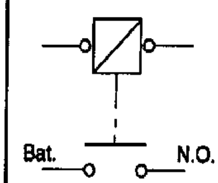
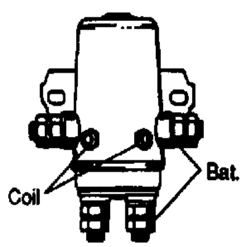
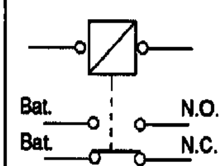
Note: *Each relay is identified with "12V" or "24V" printed on its casing in order to identify the coil operating voltage.*

Caution: *The magnetic relays for the starting motor, evaporator and both condenser motors and condenser speed controls should have the 5/16" stud nuts torqued to 50 ± 5 In-lbs (5,5 ± 0,5 Nm).*

		Configuration on base	Key printed on casing	Key used on wiring diageam	Example
Cubic relay (Steel or plastic casing) Type: S.P.D.T.					R #5

NOTE: This relay is provided with an internal suppressor diode; never reverse wiring terminals #85 and 86 at base as a direct short circuit will result.

The relay coils connected to the alternator "relay terminal" should never be provided with a suppressor diode as the output current at this terminal is not rectified, thus rendering relay inoperative.

		Configuration on base	Key printed on casing	Key used on wiring diageam	Example
Magnetic relay (Round steel casing) Type: S.P.S.T.		None	None		R #4
Magnetic relay (Round steel casing) Type: D.P.D.T.		None	None		R #40

LEGEND

Bat.	Battery
N.O.	Normally Open
N.C.	Normally Closed
S.P.D.T.	Single Pole Double Throw
S.P.S.T.	Single Pole Single Throw
D.P.D.T.	Double Pole Double Throw

FIGURE 2: TYPES OF RELAYS

06050

2. XL2 COACHES ELECTRICAL COMPARTMENTS AND JUNCTION BOXES

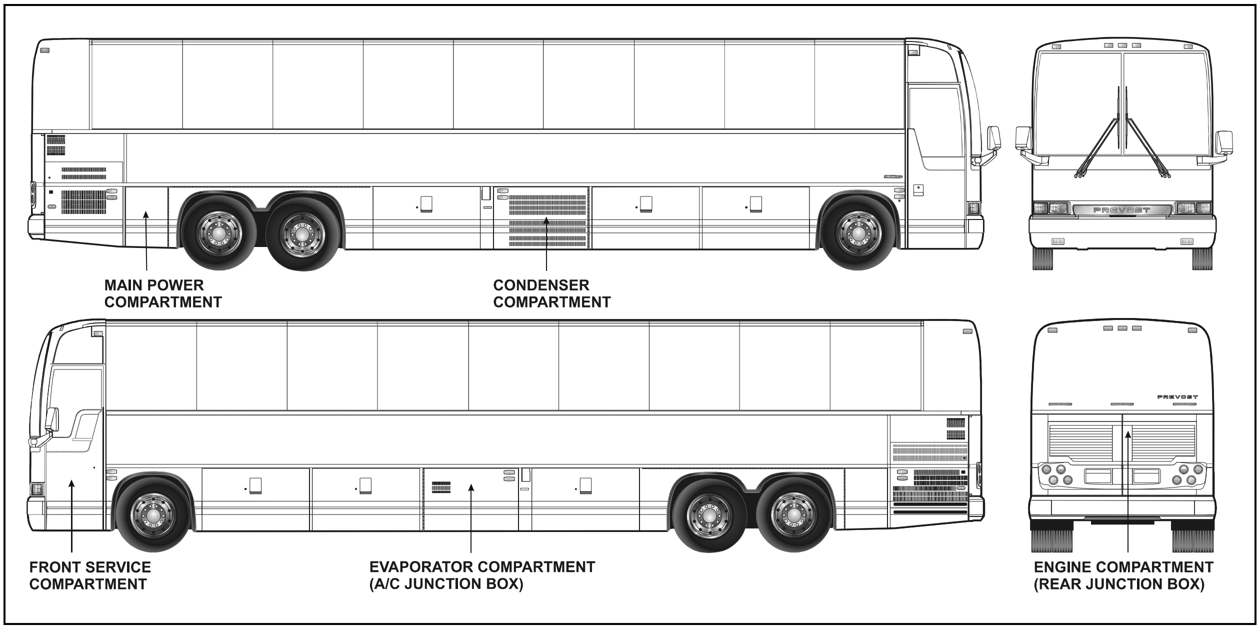


FIGURE 3: ELECTRICAL COMPARTMENT (XL2-45 COACH) 06329

2.1 MAINTENANCE

A Cortec VCI-238 corrosion inhibitor has been sprayed in all electrical compartments to protect components from corrosion. The life expectancy of this product is five years, so it is recommended to reapply it every five years. It is also recommended to spray it on new components when added or replaced.

Warning: *Use VIC-238 in a well ventilated area. Do not smoke. Avoid prolonged contact with skin and breathing of spray mist. Harmful or fatal if swallowed. Do not induce vomiting. Call physician immediately.*

2.2 BOOSTER BLOCK

On XL2-45 coaches, booster block is located in the main power compartment (Fig. 4).

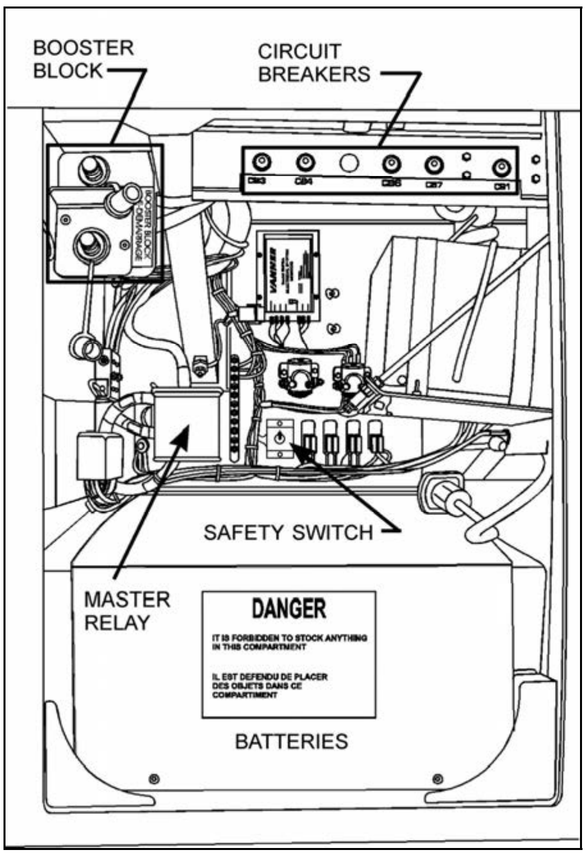


FIGURE 4: MAIN POWER COMPARTMENT (XL2-45) 06316

2.3 BATTERY SAFETY SWITCH

This switch disconnects both the 12 and 24 volts. This toggle switch is located in the main power compartment (XL2-45).

Caution: *During repair or maintenance periods, set battery safety switch to the "OFF" position in order to avoid personal injury. This ensures that power is cut off even if master key switch is set to the "ON" position by mistake. When master key switch is set to the "OFF" position, electrical supply from the batteries is automatically cut off.*

Note: *When battery safety switch or master key switch is set to the "OFF" position, the electrical supply from the batteries is cut off, with the exception of the Fire Detection System, the Engine & Transmission Electronic Controls, the Auxiliary Heating System, the Battery Equalizers and the Digital Clock.*

2.4 BATTERIES

The batteries are located in the main power compartment on the XL2-45 coach.

Electric Circuit Protection

Two type of cutoff mechanisms are installed to protect the vehicle's electrical system; fuses and manually-resettable circuit breakers. If an electrical device is inoperative, check the corresponding cutoff mechanism.

Caution: *Never replace a fuse with a higher rated one because it will cause severe damage to the electric system.*

2.5 CIRCUIT BREAKERS

Most of the manually-resettable circuit breakers are located in the: A/C junction box, rear junction box, front service compartment, and in the main power compartment. An identification decal is affixed on the inside face of each door.

XL2-45 coaches are equipped with eight (8) main breakers; they are installed in the main power compartment and in the A/C junction box in the evaporator compartment, they can be identified as follows (Fig. 4, 5, 6 and 7):

1. A/C full air (CB1) 200 A - 24 volts;
2. Front junction box (CB7) 90 A - 24 volts;
3. Rear junction box (CB6) 90 A - 24 volts;
4. Direct (CB4) 90 A - 12 volts;
5. Rear junction box (CB3) 70 A - 12 volts;
6. Condenser fan motor L.H. (CB8) 40 A - 24 volts;
7. Evaporator fan motor (CB9) 120 A - 24 volts;
8. Condenser fan motor R.H. (CB11)40 A - 24 volts.

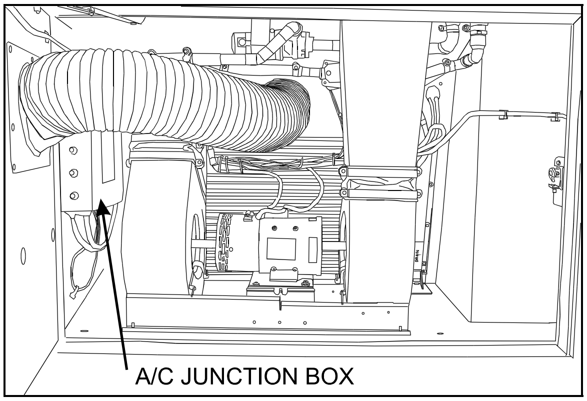


FIGURE 5: LOCATION OF A/C JUNCTION BOX IN EVAPORATOR COMPARTMENT 22244B

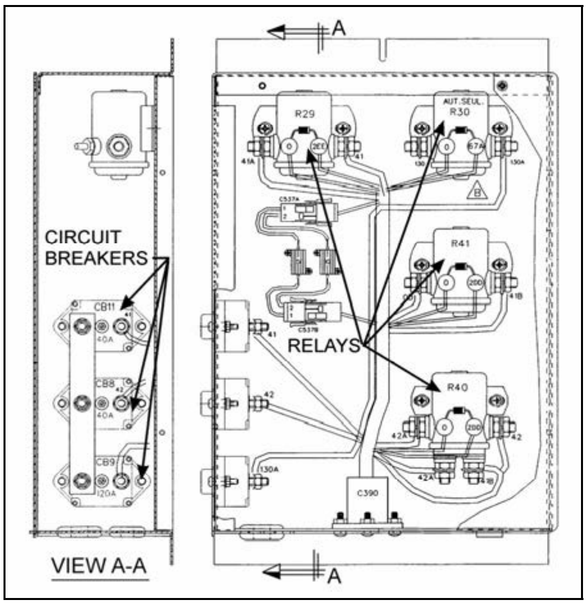


FIGURE 6: A/C JUNCTION BOX 06317

2.6 FRONT SERVICE COMPARTMENT

The front service compartment is located on L.H. side of vehicle, under the driver's window. It contains the following components (Fig. 7 and 8):

- relays;
- breakers;
- alternator module
- diodes;
- World Transmission ECU;
- electronic control unit for ABS.

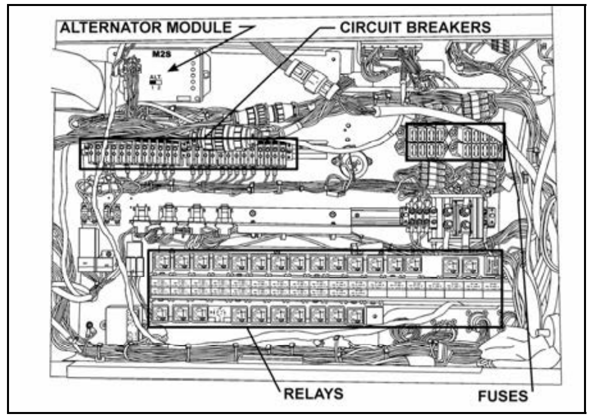


FIGURE 7: TOP SECTION OF FRONT SERVICE COMPARTMENT 06319

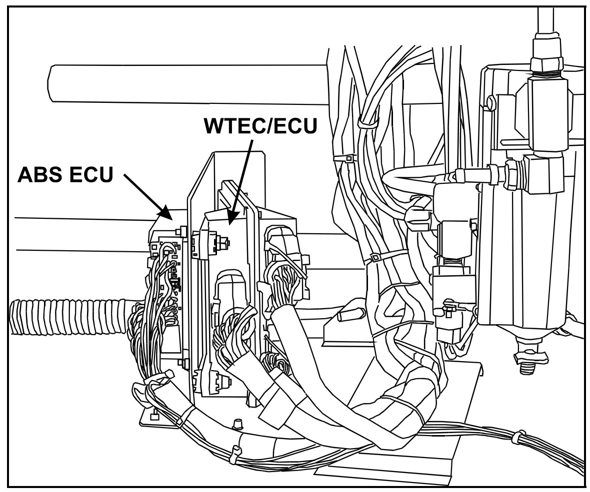


FIGURE 8: BOTTOM SECTION OF FRONT SERVICE COMPARTMENT 06394

DDR connector

To enhance troubleshooting and to allow interrogation of the ECU for valuable service information, a DDR (diagnostic data reader) can be used. To use it, plug the appropriate connector (not furnished by the manufacturer) in the terminal located in the rear junction box or the connector located on L.H. console (refer to fig. 9 and 11). You can also use your push-button shifter to perform certain maintenance operations (see Section 01, Engine, under paragraph "4. DDEC IV Diagnostic codes").

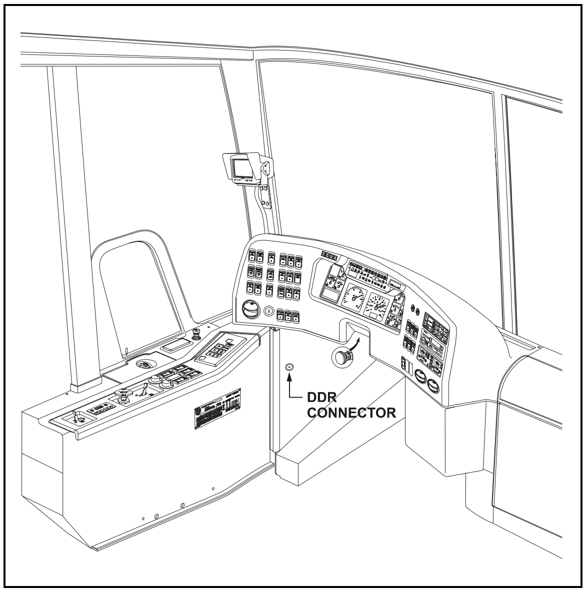


FIGURE 9: DDR CONNECTOR LOCATION IN DRIVER'S AREA 18558

2.6.1 L.H. SIDE OF FRONT BAGGAGE COMPARTMENT (Vehicle Equipped With Video System)

This compartment may contain the following components:

- protective screen (with video system);
- video inverter (with video system);
- electronic system monitor.

Battery Equalizers

On XL2-45 coach the battery equalizers are located in the main power compartment (Fig. 4).

2.7 ENGINE COMPARTMENT (REAR JUNCTION BOX)

The rear junction box is located in the engine compartment. Switches are located on R.H. side of rear junction box (Fig.10):

- engine compartment light switch;
- starter selector switch;
- rear start (push button switch).

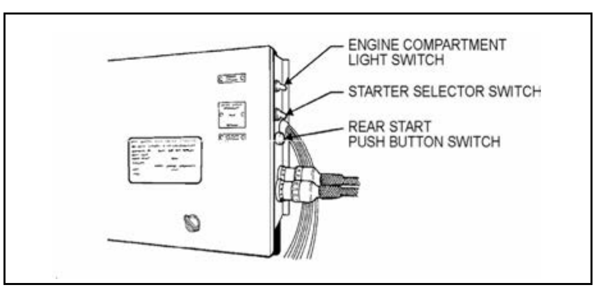


FIGURE 10: REAR JUNCTION BOX SWITCHES 01017

The rear junction box contains the following components (Fig. 11):

- relays;
- breakers;
- diodes;
- time delay relay;
- DDR connector.

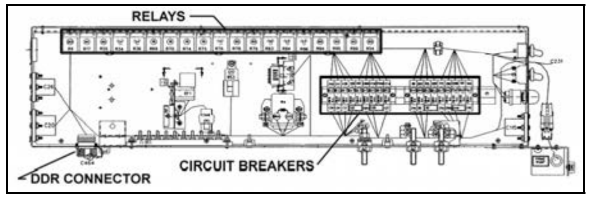


FIGURE 11: REAR JUNCTION BOX 06318

3. XL2 MOTORHOMES ELECTRICAL COMPARTMENTS AND JUNCTION BOXES

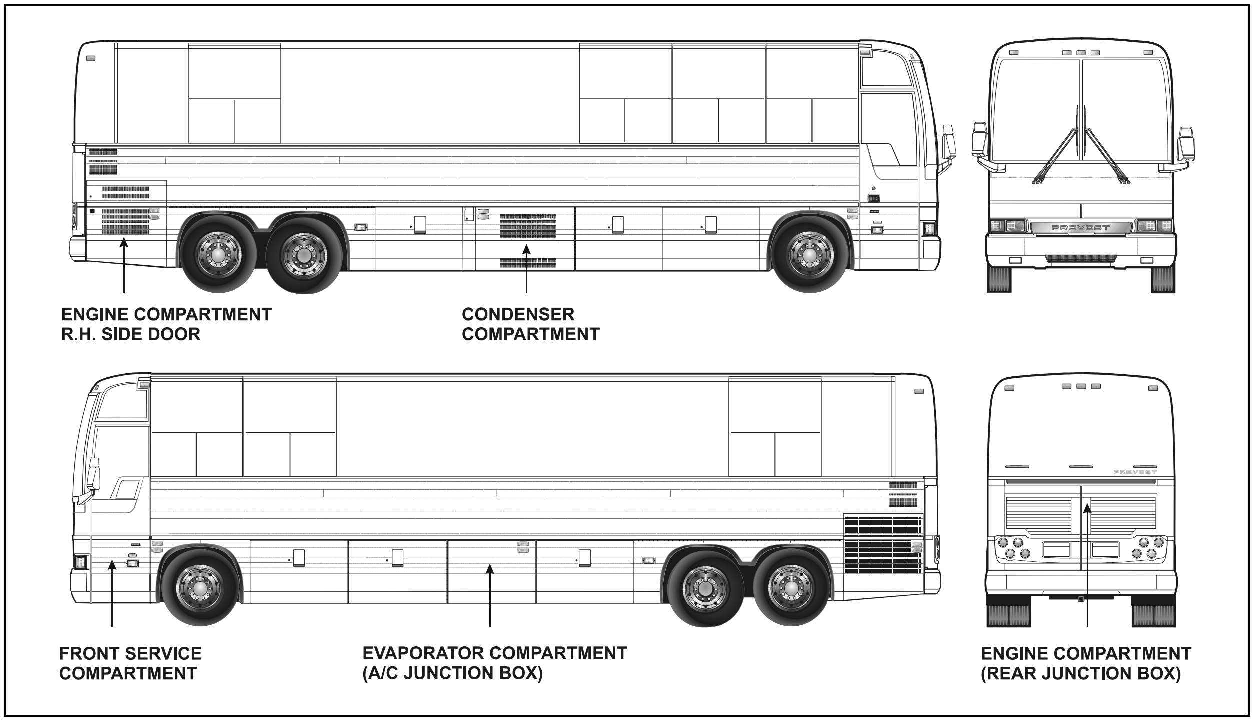


FIGURE 12: ELECTRICAL COMPARTMENTS (XL2-40 BUS SHELLS) 06330

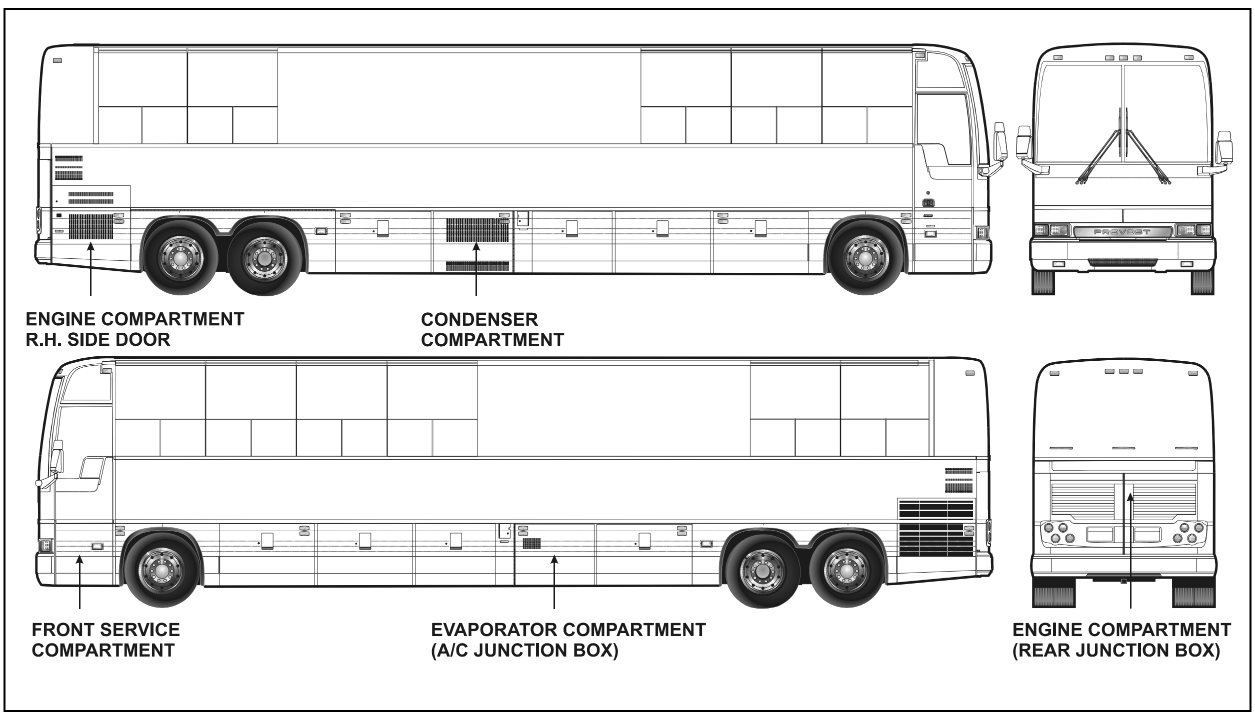


FIGURE 13: ELECTRICAL COMPARTMENTS (XL2-45E BUS SHELLS) 06324

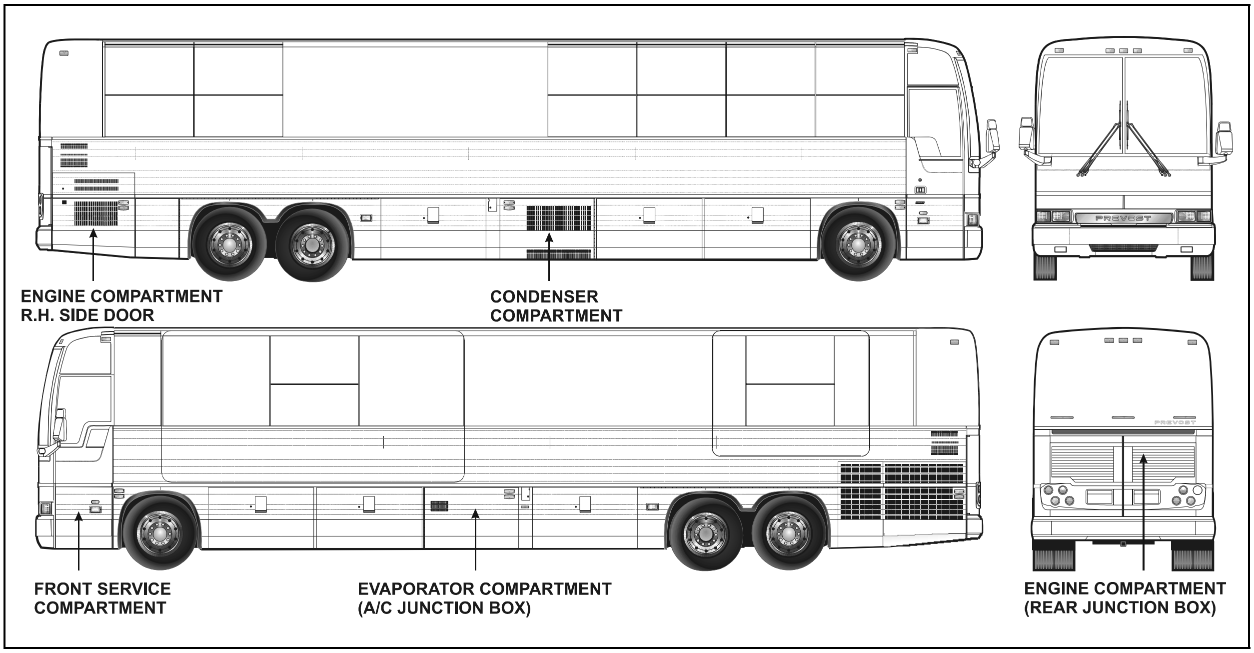


FIGURE 14: ELECTRICAL COMPARTMENTS (XL2-45 BUS SHELLS) 06323

3.1 MAINTENANCE

A Cortec VCI-238 corrosion inhibitor has been sprayed in all electrical compartments to protect components from corrosion. The life expectancy of this product is five years, so it is recommended to reapply it every five years. It is also recommended to spray it on new components when added or replaced.

Warning: *Use VIC-238 in a well ventilated area. Do not smoke. Avoid prolonged contact with skin and breathing of spray mist. Harmful or fatal if swallowed. Do not induce vomiting. Call physician immediately.*

3.2 BOOSTER BLOCK

On all XL2 MTH, booster block is located on the breaker panel in the engine compartment on the R.H. side and is accessible through engine R.H. side door (Fig. 15).

3.3 BATTERY SAFETY SWITCH

This switch disconnects both the 12 and 24 volts. This toggle switch is located on the breaker panel in the engine compartment on the R.H. side and is accessible through engine R.H. side door (Fig. 15).

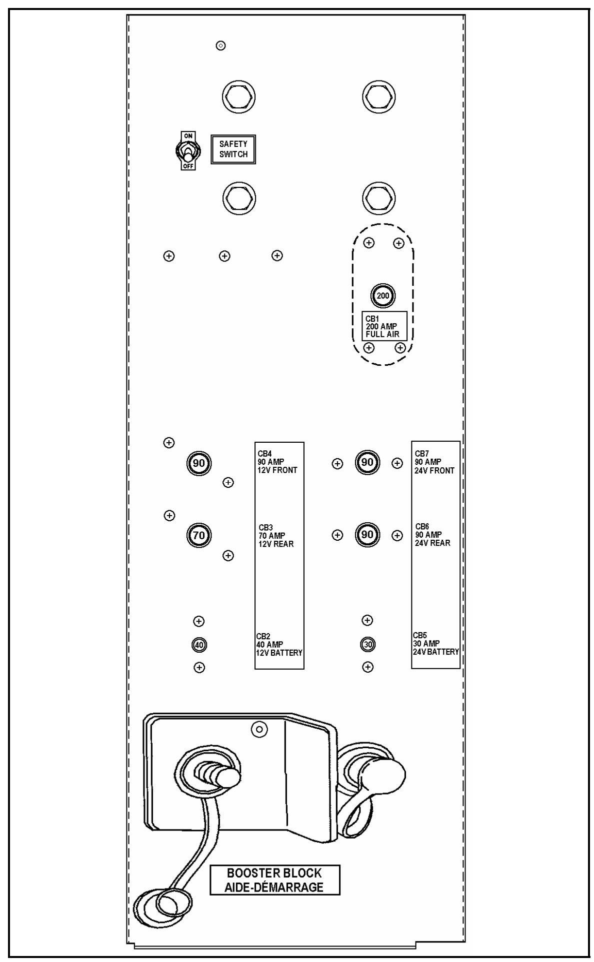


FIGURE 15: BREAKER PANEL 06508

Caution: *During repair or maintenance periods, set battery safety switch to the "OFF" position in order to avoid personal injury. This ensures that power is cut off even if master key switch is set to the "ON" position by mistake. When master key switch is set to the "OFF" position, electrical supply from the batteries is automatically cut off.*

Note: *When battery safety switch or master key switch is set to the "OFF" position, the electrical supply from the batteries is cut off, with the exception of the Fire Detection System, the Engine & Transmission Electronic Controls, the Auxiliary Heating System, the Battery Equalizers and the Digital Clock.*

3.4 BATTERIES

The batteries are located in the engine compartment R.H. side (Fig. 16). The battery arrangement may differ between vehicle types due to available space.

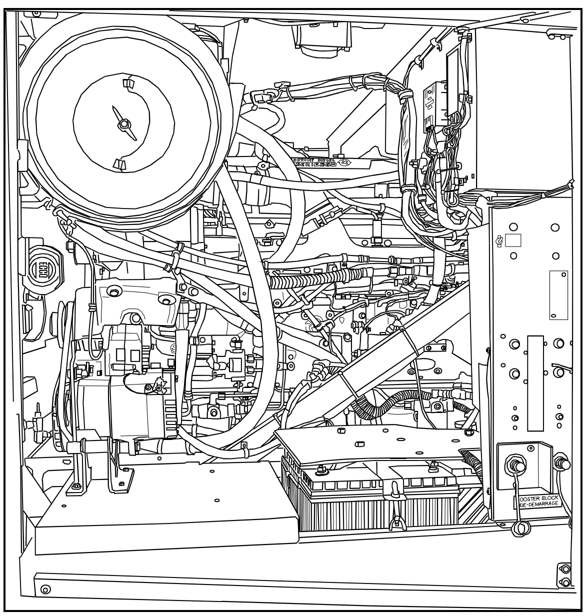


FIGURE 16: ENGINE COMPARTMENT R.H. SIDE 18513

Electric Circuit Protection

Two type of cutoff mechanisms are installed to protect the vehicle's electrical system; fuses and manually-resettable circuit breakers. If an electrical device is inoperative, check the corresponding cutoff mechanism.

Caution: *Never replace a fuse with a higher rated one because it will cause severe damage to the electric system.*

3.5 CIRCUIT BREAKERS

Most of the manually-resettable circuit breakers are located in the: A/C junction box, rear junction box, front service compartment and in the engine compartment R.H. side. An identification decal is affixed on the inside face of each door.

MTH XL2-40, XL2-45E and XL2-45 may be equipped with ten (10) main breakers; six (6) of which are standard and four (4) are supplied only on vehicles equipped with central A/C system. CB2 to CB7 breakers are standard and CB1, CB8, CB9 and CB11 breakers are optional.

On all vehicles, breakers CB1 to CB7 are installed on breaker panel in engine compartment R.H. side (Fig. 15 & 16). They are accessible through engine R.H. side door and can be identified as follows:

1. A/C full air (CB1) 200 A - 24 volts;
2. Front junction box (CB7) 90 A - 24 volts;
3. Rear junction box (CB6) 90 A - 24 volts;
4. Direct (CB4) 90 A - 12 volts;
5. Rear junction box (CB3) 70 A - 12 volts;
6. Battery CB2) 40 A - 12 volts;
7. Battery (CB5) 30 A - 24 volts;

On all vehicles equipped with central A/C, breakers CB8, CB9 and CB11 are installed in the A/C junction box in the evaporator compartment (Fig. 17 and 18), and are identified as follows:

1. Condenser fan motor L.H. (CB8) 40 A - 24 volts;
2. Evaporator fan motor (CB9) 120 A - 24 volts;
3. Condenser fan motor R.H. (CB11)40 A - 24 volts.

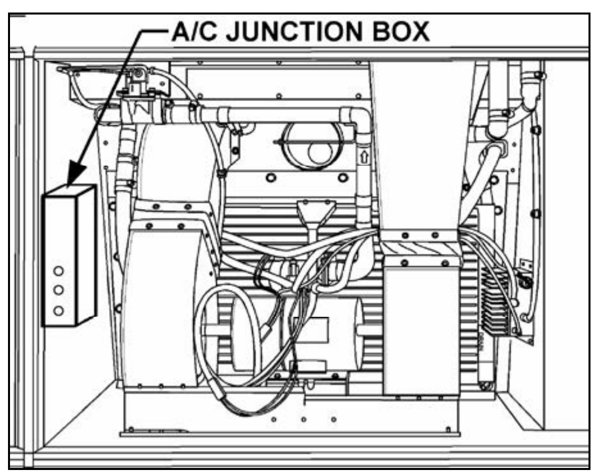


FIGURE 17: LOCATION OF A/C JUNCTION BOX IN EVAPORATOR COMPARTMENT 06414

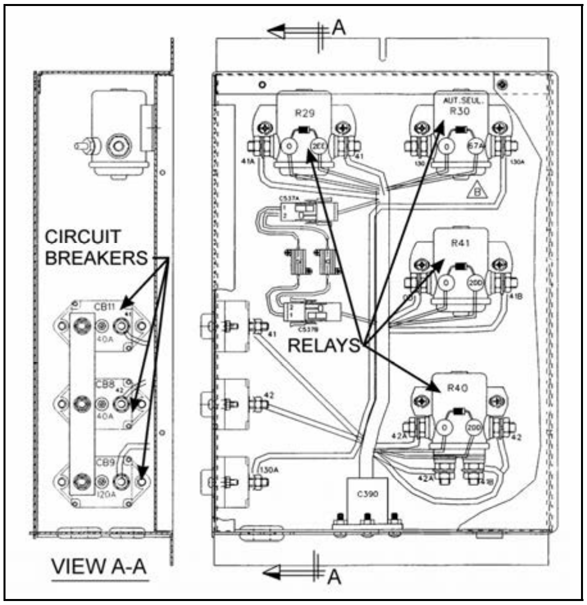


FIGURE 18: A/C JUNCTION BOX 06317

3.6 FRONT SERVICE COMPARTMENT

The front service compartment is located on L.H. side of vehicle, under the driver's window. It contains the following components (Fig. 19 and 20):

- relays;
- breakers;
- alternator module
- diodes;
- World Transmission ECU;
- electronic control unit for ABS.

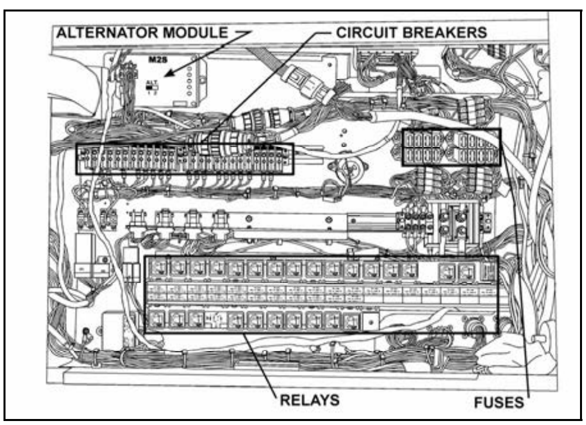


FIGURE 19: TOP SECTION OF FRONT SERVICE COMPARTMENT 06319

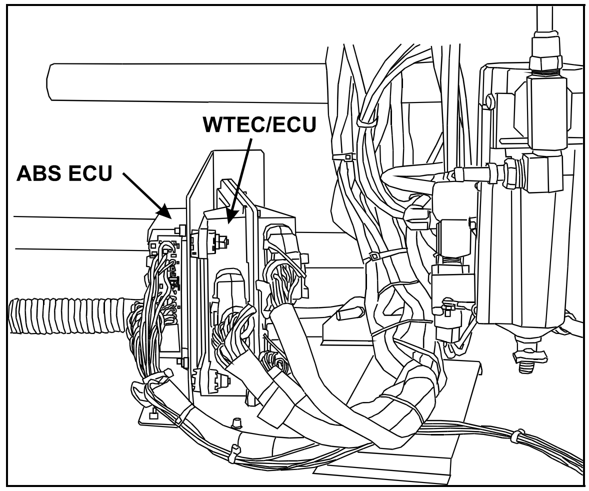


FIGURE 20: BOTTOM SECTION OF FRONT SERVICE COMPARTMENT 06394

DDR connector

To enhance troubleshooting and to allow interrogation of the ECU for valuable service information, a DDR (diagnostic data reader) can be used. To use it, plug the appropriate connector (not furnished by the manufacturer) in the terminal located in the rear junction box or the connector located on L.H. console (refer to fig. 21 and 22). You can also use your push-button shifter to perform certain maintenance operations (see Section 01, Engine, under paragraph "4. DDEC IV Diagnostic codes").

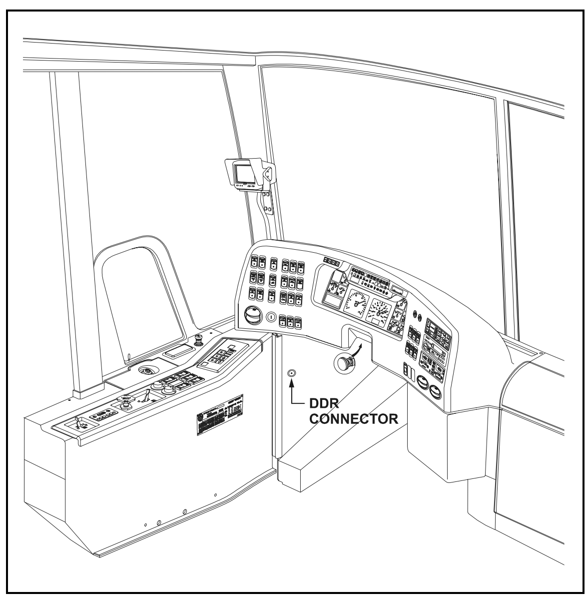


FIGURE 21: DDR CONNECTOR LOCATION IN DRIVER'S AREA 18558

3.7 ENGINE COMPARTMENT (REAR JUNCTION BOX)

The rear junction box is located in the engine compartment. Switches are located on R.H. side of rear junction box (Fig.22):

- engine compartment light switch;
- starter selector switch;
- rear start (push button switch).

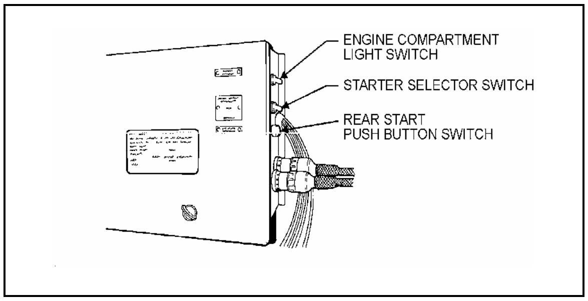


FIGURE 22: REAR JUNCTION BOX SWITCHES 01017

The rear junction box contains the following components (Fig. 23):

- relays;
- breakers;
- diodes;
- time delay relay;
- DDR conector.

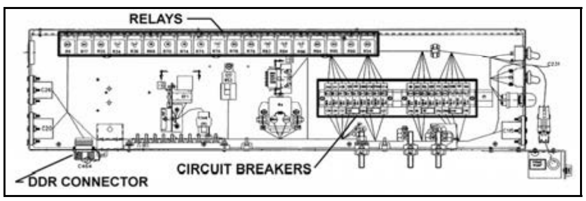


FIGURE 23: REAR JUNCTION BOX 06318

4. BATTERIES

The vehicle is provided with four (4) maintenance-free 12 volt heavy-duty batteries connected in series-parallel (Fig. 24). The top-mounted negative and positive terminals are tightly sealed to prevent leaks. Water never needs to be added to this type of battery. There are no filler caps in the cover. The battery is sealed, except for small vent holes in the cover. The vents must not be restricted as they allow small amounts of gases produced in the battery to escape. The special chemical composition inside the battery reduces gassing to a very small amount at normal charging voltages. Besides reducing gassing, the special chemistry greatly reduces the possibility of overcharge damage.

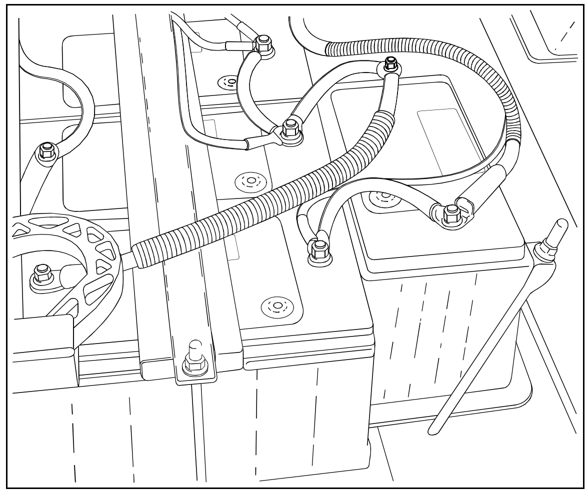


FIGURE 24: BATTERIES (TYPICAL) 06343

The vents require keeping the battery in an upright position to prevent electrolyte leakage. Tipping the battery beyond a 45^O angle in any direction can allow a small amount of electrolyte to leak out of the vent holes.

Warning: *DO NOT tip battery by more than 45^O when carrying or installing the battery.*

Note: *Evidence of electrolyte leakage does not necessarily mean the battery is defective.*

With special cables properly attached to batteries, the metal surfaces that carry the current are completely sealed from the atmosphere. This prevents terminal oxidation and corrosion that may cause starting and charging problems. If new cables are required, sealed terminal cable replacements should be used to retain the reliability of the original maintenance-free connections.

Warning: *All lead-acid batteries generate hydrogen gas, which is highly flammable. If ignited by a spark or flame, the gas may explode violently, causing spraying of acid, fragmentation of the battery, which may result in severe personal injuries. Wear safety glasses and do not smoke when working near batteries. In case of contact with acid, flush immediately with water.*

The battery has four (4) major functions:

1. Providing a source of current for starting the engine.
2. Stabilizing the voltage in the electrical system;

3. Supplying current for a limited time, when electrical demands of the equipment exceed the power output of the alternator;
4. Providing a limited source of power for connected accessories, when the engine is not running.

4.1 BATTERY REMOVAL AND INSTALLATION

4.1.1 XL2-45 Coach

The batteries are located in the main power compartment.

1. Remove the two screws at the bottom of the plastic protective cover, then unscrew the two quarter turn nuts to remove the protective cover (Fig. 4)

Warning: *To prevent possible electric shocks or sparking, the battery master switch should be in the "Off" position before disconnecting cables from the batteries (see paragraph "2.3 Battery master switch").*

2. Remove the supports, and unscrew terminal nuts of each defective battery.
3. Remove battery cables from the batteries.
4. Remove batteries.
5. Installation is the reverse of removal.

Note: *When the battery cables have been removed from the batteries, wrap the battery terminals and cable ends with electric tape to prevent accidental grounding. The ground cables should always be disconnected first and replaced last.*

Note: *In replacing batteries, only batteries of the same specification should be used. Refer to "Specifications" at the end of this section for further details.*

Caution: *Ensure that connections are not reversed when reinstalling batteries, since damage to electrical system components will result.*

When reinstalling batteries, battery connections must be tightened to 13-15 Ft-lbs (18-20) Nm) and the nut on top of sliding tray to 45-55 In-lbs (5-6 Nm). A torque wrench is required to ensure an accurate tightening torque.

Warning: *To prevent possible electric shock or sparking, the battery master switch must be set to the "Off" position before tightening an electrical connection.*

Note: *A protective silicone free, coating should be applied on all terminals that have been disconnected. We recommend the use of Cortec VCI-238 (Prévost #682460) on all electrical connections.*

4.1.2 XL2-40, XL2-45E and XL2 45 Bus Shells

The batteries are located in the engine compartment R.H. side (Fig. 16).

1. Remove the tree (3) plastic protective cover retaining bolts. Remove the plastic protective cover.
2. Remove the support retaining bolt.

Warning: *To prevent possible electric shocks or sparking, the 12 and 24 volts battery master switch should be in the "Off" position before disconnecting cables from the batteries (see paragraph "3.3 Battery Master Switch").*

3. Remove the support (if necessary, remove battery cables). To remove battery cables, unscrew terminal nuts and remove cables.
4. Remove battery cables from defective batteries.

Note: *When the battery cables have been removed from the batteries, wrap the battery terminals and cable ends with electric tape to prevent accidental grounding. The ground cables should always be disconnected first and replaced last.*

5. Remove defective batteries.
6. Installation is the reverse of removal.

Note: *In replacing batteries, only batteries of the same specification should be used. Refer to "Specifications" at the end of this section for further details.*

Caution: *Ensure that connections are not reversed when reinstalling batteries, since damage to electrical system components will result.*

When reinstalling batteries, battery connections must be tightened to 13-15 Ft-lbs (18-20) Nm) and the nut on top of sliding tray to 45-55 In-lbs (5-6 Nm). A torque wrench is required to ensure an accurate tightening torque.

Warning: *To prevent possible electric shock or sparking, the battery master switch must be set to the "Off" position before tightening an electrical connection.*

Note: *A protective silicone free, coating should be applied on all terminals that have been disconnected. We recommend the use of Cortec VCI-238 (Prévost #682460) on all electrical connections.*

4.2 BATTERY RATING

Each of the 12 volt batteries used on the vehicle has the following rating:

- Reserve capacity: 195 minutes
- Cold cranking (amps): 950 @ 0°F (-18°C)
- Cold cranking (amps): 745 @ -20°F (-29°C)
- Weight (filled): 59 lb. (26,7 kg)

The reserve capacity is defined as the number of minutes a new, fully charged battery at 80 F (26,6 C) can be discharged at 25 amperes and maintain a minimum of 1.75 volts per cell (10.5 volts total for one 12 volts battery). This rating can be used as a basis for determining how long a vehicle might run after an alternator failure. The cold cranking rating is defined as the minimum discharge current a battery will deliver in amperes for 30 seconds at 0 F (-18 C) while maintaining a minimum of 1.2 volts per cell (7.2 volts total for one 12 volts battery). This rating can be used as a basis for comparing starting performance.

4.3 BATTERY TESTING

The maintenance-free battery has a strong ability to withstand the damaging effects of overcharge. The test indicator in the cover is used only to determine if the battery can be tested in case of a cranking problem.
The test indicator in the battery cover is to be used with accepted diagnostic procedures only. It must not be used to determine if the battery is good or bad, charged or discharged. The test indicator is a built-in hydrometer in one cell that provides visual information for battery testing (Fig. 25).
It is important when observing the test indicator, that the battery be relatively level and has a clean indicator top to see the correct indication. Some lighting may be required in poorly lit areas. Under normal operation, two indications can be observed.

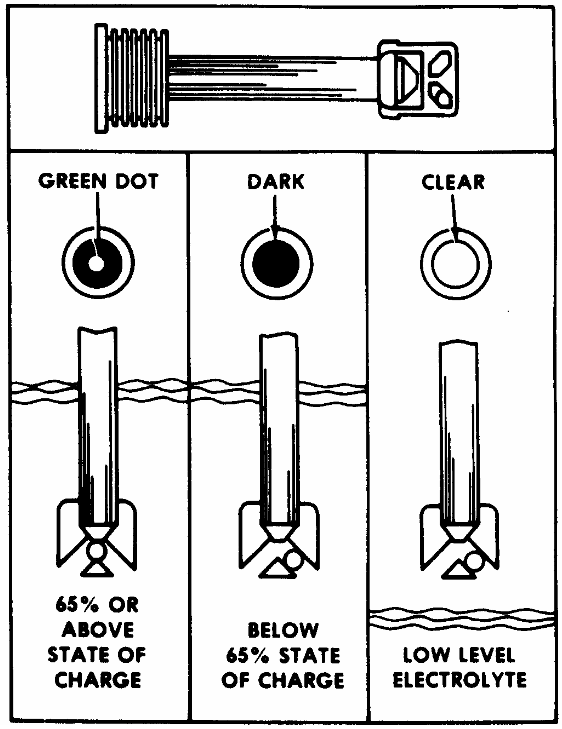


FIGURE 25: TEST INDICATOR 06096

Green Dot Visible

Any green appearance is interpreted as a *"green dot"*, and the battery is ready for testing. On rare occasions, following prolonged cranking, the green dot may still be visible when the battery is obviously discharged. Should this occur, charge the battery as described under *"Charging Procedure"* in *"Battery Charging"* later in this section.

Dark - Green Dot Not Visible

If there is difficulty cranking the engine, the battery should be tested as described in this section. On rare occasions, the test indicator may turn light yellow. In this case, the integral charging system should be checked. Normally, the battery is capable of further service; however, if difficult start has been reported, replace the battery. **DO NOT CHARGE, TEST, OR JUMP-START.**

4.3.1 Visual Inspection

1. Check the outside of the battery for a broken or cracked cover or case that could permit loss of electrolyte. If obvious physical damage is noted, replace the battery.
2. Check for loose terminal posts, cable connections, damaged cables, and for evidence of corrosion. Correct conditions as required before proceeding with tests.

4.3.2 Removing Surface Charge

Disconnect cables from the battery and attach alligator clamps to the contact lead pad on the battery as shown in figure 27. Connect a 300 ampere load across the terminal for 15 seconds to remove surface charge from the battery.

4.3.3 Load Test

This test is one means of checking the battery to determine its ability to function as required in the vehicle.
To make this test, use test equipment that will withstand a heavy electrical load from the battery, such as a carbon pile resistor or other suitable means.

1. Connect a voltmeter, ammeter, and a variable load resistance as illustrated in figure 26.

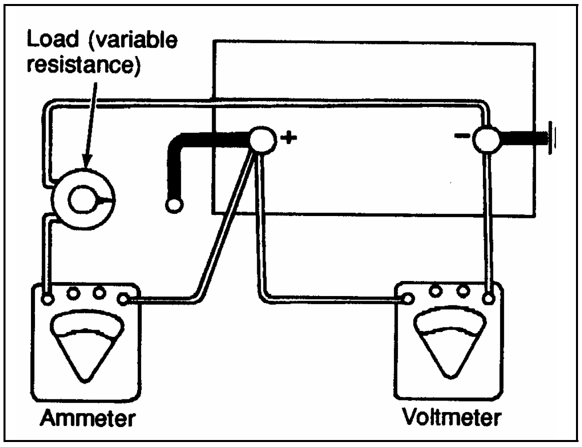


FIGURE 26: LOAD TEST 06064

Caution: *Observe polarity of the meters and the battery when making connections, and select the correct meter range.*

2. Apply a 290 amperes load to the battery for 15 seconds.
3. With an ammeter reading specified load, read voltage. The voltage should be at least 9.6 volts. Disconnect the load. If the voltmeter indicates 9.6 volts or more, the battery is good. If the voltmeter reading is less than 9.6 volts, replace the battery. This voltage is to be used for battery ambient temperatures of 70ºF (21ºC) and above. For temperatures below 70ºF (21ºC), refer to the following *"Voltage and Temperature Chart"*.

Voltage and Temperature Chart

Ambient Temperature	Minimum Voltage
70ºF (21ºC) and above	9.6
60ºF (16ºC)	9.5
50ºF (10ºC)	9.4
40ºF (4ºC)	9.3
30ºF (-1ºC)	9.1
20ºF (-7ºC)	8.9
10ºF (-12ºC)	8.7
0ºF (-18ºC)	8.5

Note: *The accuracy of this test procedure is dependent upon close adherence to the proper load, time and temperature specifications.*

4.3.4 Testing Battery Cables

Check all cable ring terminals and connections to determine if they are in good condition. Excessive resistance, generally caused by poor connections, produces an abnormal voltage drop which may lower voltage at the starter to such a low value that normal operation of the starter will not be obtained. An abnormal voltage drop can be detected with a low-reading voltmeter as follows:

Warning: *To prevent the engine from starting, the DDEC engine circuits, which are protected by breakers (CB-19, CB-20 and CB-21) located in the rear junction box, must be deenergized during these tests; afterward, depress black button to close circuit.*

1. Check voltage drop between grounded (negative) battery terminal and vehicle frame by placing one prod of the voltmeter on the battery terminal and the other on a good ground (unpainted surface) on the vehicle. With the starter cranking the engine at a temperature of 70ºF (21ºC), voltage reading should be less than 0.3 volt. If the voltage reading exceeds 0.3 volt, there is excessive resistance in this circuit.
2. Check voltage drop between the positive battery terminal and the starter positive terminal stud while the motor is operated. If the reading is more than 2.5 volts, there is excessive resistance in this circuit.

Note: *If it is necessary to extend the voltmeter lead for this test, use a #16 (AWG) or larger wire.*

3. Check voltage drop between the starter housing and a good ground on the vehicle. The reading should be less than 0.2 volt.

Warning: *Any procedure other than the following could cause personal injury or damages to the charging system resulting from battery explosion or electrical burns.*

Wear adequate eye protection when working on or near the batteries. Ensure that metal tools or jumper cables do not contact the positive battery terminal (or a metal surface in contact with it) as a short circuit will result. Do not attempt to jump start a vehicle suspected of having a frozen battery because the battery may rupture or explode. Both the booster and discharged batteries must be treated carefully when using jumper cables. Follow exactly the procedure outlined later in this section, being careful not to cause sparks.

4.4 BATTERY CHARGING

Warning: *During charging of the batteries, an explosive gas mixture forms in each cell. Part of this gas escapes through the vent holes and may form an explosive atmosphere around the battery itself if ventilation is poor. This explosive gas may remain in or around the battery for several hours after it has been charged. Sparks or flames can ignite this gas causing an internal explosion, which may shatter the battery.*

1. *Do not smoke near a battery which is being charged or which has been recently charged.*
2. *Do not break live circuits at battery terminals because a spark usually occurs at the point where a live circuit is broken. Care must always be taken when connecting or disconnecting booster leads or cable clamps on chargers. Poor connections are a common cause of electric arcs, which cause explosions.*
3. *The electrical system on this vehicle is negative ground. Installing the batteries with the positive terminals grounded or incorrect use of the booster battery and jumper cables will result in serious damage to the alternator, batteries and battery cables.*

The batteries used on this vehicle can be charged either on or off the vehicle; however, when they are removed from the vehicle, it is recommended that an adapter kit, which is available from any "A/C DELCO" dealer, be used in charging sealed-terminal batteries. Use the booster block to charge the batteries when they are left on vehicle and **make sure that the main battery disconnect switch is set to the *"On"* position.**

The alligator clamps of the tester or charger must be placed between the terminal nuts and the lead pads of the terminal studs (Fig. 27) after the vehicle cables are detached. The alligator clamps should make firm contact with the lead pads.

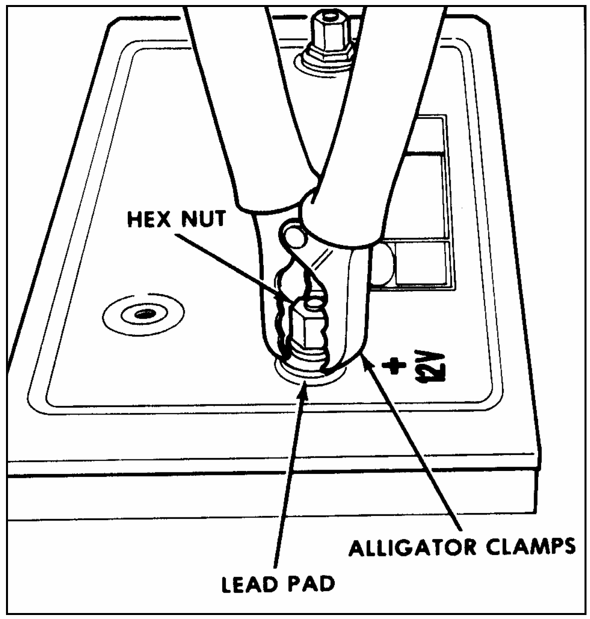


FIGURE 27: ALLIGATOR CLAMPS AND BATTERY 06065

Note: *If this connection cannot be made because of the alligator clamp design, the load value for testing must be reduced from 290 to 260 amperes.*

On rare occasions, such as those that occur following prolonged cranking, the green dot in the test indicator may still be visible when the battery is obviously discharged. Should this occur, a boost charge of 20 amperes-hour is recommended. Under normal operating conditions, do not charge battery if the green dot is visible. The battery should never be charged if the test indicator (hydrometer) is clear or light yellow. If this occurs, replace the battery.

A charge rate between 3 and 50 amperes is generally satisfactory for any maintenance-free battery as long as spewing of electrolyte does not occur or the battery does not feel excessively hot (over 125ºF (52ºC)). If spewing or violent gassing of electrolyte occurs or battery temperature exceeds 125ºF (52ºC), the charging rate must be reduced or temporarily stopped to allow cooling and to avoid damaging the battery. Battery temperature can be estimated by touching or feeling the battery case. The battery is sufficiently charged when the green dot in the built-in hydrometer is visible. No further charging is required. Shake or tilt the battery at hourly intervals during charging to mix the electrolyte and see if the green dot appears.

Warning: *Always turn off the charger before connecting or disconnecting to a battery.*

Note: *The charge rate must be doubled when the batteries are charged by the booster block, because of the series-parallel circuit.*

Battery charging consists of a charge current in amperes for a period of time in hours. Thus, a 25 ampere charging rate for 2 hours would be a 50 ampere-hour charge to the battery. Most batteries, whose load test values are greater than 200 amperes, will have the green dot visible after at least a 75 ampere-hour charge. In the event that the green dot does not appear, replace the battery.

4.4.1 Battery Charging Guide

Fast Charging Rate
20 amps @ 3-¾ hours
30 amps @ 2-½ hours
40 amps @ 2 hours
50 amps @ 1-½ hours

Slow Charging Rate
5 amps @ 15 hours
10 amps @ 7-½ hours
The time required for a charge will vary according to the following factors:

Size of Battery
For example, a completely discharged large heavy-duty battery requires more than twice the recharging time of a completely discharged small passenger car battery.

Temperature
For example, a longer time will be needed to charge any battery at 0°F (-18°C) than at 80°F (27°C). When a fast charger is connected to a cold battery, the current accepted by the battery will be very low at first, then in time, the battery will accept a higher rate as it warms.

State of Charge
For example, a completely discharged battery requires more than twice as much charge than a half-charged battery. Since the electrolyte is nearly pure water and a poor conductor in a completely discharged battery, the current accepted is very low at first. Later, as the charging current causes the electrolyte acid content to increase, the charging current will likewise increase.

Charger Capacity
For example, a charger which can supply only 5 amperes will require a much longer period of charging than a charger that can supply 30 amperes or more.

4.4.2 Emergency Jump Starting With Auxiliary (Booster) Battery

Warning: *Do not jump start vehicles equipped with maintenance-free batteries if the test indicator is light yellow.*

Both booster and discharged batteries should be treated carefully when using jumper cables. A vehicle with a discharged battery may be started by using energy from a booster battery or the battery from another vehicle.

Warning: *Jump starting may be dangerous and should be attempted only if the following conditions are met:*

The booster battery or the battery in the other vehicle must be of the same voltage as the battery in the vehicle being started, and must be negative grounded.

If the booster battery is a sealed-type battery without filler openings or caps, its test indicator must be dark or a green dot must be visible. Do not attempt jump starting if the test indicator of the booster battery or the discharged battery has a light or bright center.

Warning: *Follow the procedure exactly as outlined hereafter. Avoid making sparks.*

1. Wear eye protection and remove rings, watches with metal bands and other metal jewelry.
2. Apply parking brake and place the transmission shift lever or push-button pads in Neutral (N) position in both vehicles. Turn off lights, heater and other electrical loads. Observe the charge indicator. If the indicator in the discharged battery is illuminated, replace the battery. **Do not** attempt jump starting when indicator is illuminated. If the test indicator is dark and has a green dot in the center, failure to start is not due to a discharged battery and the cranking system should be checked. If charge indicator is

dark but the green dot does not appear in center, proceed as follows:

3. Connect one end of one red jumper cable to the positive (+) terminal of the booster power source and the other end to the positive (+) post of the booster power block, located in the main power compartment or in the engine compartment R.H. side (refer to fig. 4 and 15).
4. Connect one end of the remaining negative jumper cable (black) to the negative (-) terminal of the booster power source, and the other end of the black jumper cable to the negative (-) post of the booster power block.
5. Make sure the clips from one cable do not inadvertently touch the clips on the other cable. Do not lean over the battery when making connections. The ground connection must provide good electrical conductivity and current carrying capacity.
6. Start the engine in the vehicle that is providing the jump start. Let the engine run for a few minutes, then start the engine in the vehicle that has the discharged batteries.
7. When removing the jumper cables, perform the above procedure exactly in reverse order, and replace protective caps on booster block terminals.

Warning*: Any procedure other than the above could result in personal injury, property damage due to battery explosion, or damage to the charging system of the booster vehicle or of the boosted vehicle.*

Note: *Jumper cables must withstand 500 cranking amperes. If cable length is 20 feet (6m) or less, use 2/0 (AWG) gauge wires. If cable length is between 20-30 feet (6-9m), use 3/0 (AWG) wires.*

4.5 CLEANING AND INSPECTION

The external condition of the battery and the battery cables should be checked periodically. The top of the battery should be kept clean and the battery hold-down clamp bolts should be kept properly tightened. For best results when cleaning the battery, wash first with a diluted solution of ammonia or soda to neutralize any acid present, then wash out with clean water. The battery hold-down bolts should be kept tight enough to prevent the batteries from moving, but they should not be tightened to the point that excessive strain is placed on the battery hold-down cover (proper tightening torque: 45-55 In-lbs (5-6 Nm).

To insure good contact, the battery cable ring terminals should be tight on the battery posts. If the posts or cable ring terminals are corroded, the cables should be disconnected and the posts and clamps cleaned separately with a soda solution and a wire brush. Install cable ring terminals on battery posts and tighten to a torque of 10-15 Ft-lbs (13-20 Nm). Replace protective caps to prevent corrosion and sparks.

4.6 COMMON CAUSES OF BATTERY FAILURE

When a battery fails, the cause of failure may be related to something other than the battery. For this reason, when a battery failure occurs, do not be satisfied with merely recharging or replacing the battery. Locate and correct the cause of the failure to prevent recurrence. Some common external causes of battery failure are as follows:

1. A defect in charging system such as high resistance or a faulty alternator or regulator.
2. A malfunction within the 12 volts system (equalizer).
3. Overloads caused by a defective starter or excessive use of accessories.
4. Dirt and electrolyte on top of the batteries causing a constant drain.
5. Hardened battery plates, due to battery being in a low state of charge over a long period of time.
6. Shorted cells, loss of active material from plates.
7. Driving conditions or requirements under which the vehicle is driven for short periods of time.
8. A constant drain caused by a shorted circuit such as an exposed wire or water infiltration in junction boxes causing ground fault.
9. Extended operation of preheating system with engine not running.
10. Failing to close disconnect switches during the night.

4.7 TROUBLESHOOTING

If a battery is known to be good and then has not performed satisfactorily in service for no apparent reason, the following factors may reveal the cause of trouble:

1. Vehicle accessories and disconnect switches inadvertently left on overnight.
2. Defects in the charging system, such as high wiring resistance, faulty alternator, regulator or battery equalizer.
3. A vehicle electrical load exceeding the alternator (or battery equalizer) capacity, with the addition of electrical devices, such as CB radio equipment, a cellular phone or additional lighting systems.
4. Defects in the electrical system, such as shorted or pinched wires.
5. Extended driving at a slow speed while using many accessories.
6. Loose or poor battery cable-to-post connections, previous improper charging of a run-down battery, or loose hold-down clamp bolts.
7. High-resistance connections or defects in the cranking system.

5. ELECTRICAL SYSTEM MONITOR

This vehicle is equipped with an electronic device that monitors and detects abnormal alternator, voltage regulator, battery banks or battery equalizers conditions. The monitor is installed in the main power compartment (XL2-45) (refer to fig. 4), or in the engine compartment R.H. side (MTH). The *“Battery balance”* and *“Battery Hi/Lo”* warning lamps connected to this module are mounted in the dashboard (refer to *“Operator’s Manual”* for location). If a malfunction should occur, the monitor sends a signal to the driver through the warning light of the malfunctioning component. If the *“Battery Hi/Lo”* warning light is illuminated, check the 24 volt voltmeter to determine if the battery voltage is too high or too low.

Note: *According to the battery charging condition, it is normal that "Battery Hi/Lo" warning light illuminates upon starting the engine and stays illuminated for a few seconds. This is caused by the normal voltage drop of the battery during starting.*

5.1 TELLTALE LIGHT DEFINITIONS

Battery Hi/Lo

Voltmeter drops below 24 V dc

- Check alternator output.
- Check voltage regulator.
- Check battery connections.
- Check battery cells.
- Check battery equalizer connections.

Voltmeter exceeds 30 V dc

- Check alternator output.
- Check voltage regulator.
- Check battery connections.

Battery Balance

Note: *Allow at least 15 minutes to balance batteries after any corrective measure has been taken.*

1. Batteries out of balance (difference greater than 1.5 volts between the two battery banks).
    - Check battery equalizer connections.
    - Check equalizer cables for proper gauge.
    - Check battery connections.
2. Demand for 12 volt power exceeding rated amperage output of battery equalizers causing batteries to go out of balance.
    - Reduce 12 volt load or install additional battery equalizer(s).

“Battery” Warning Light

This warning light is not controlled by the electronic monitor, but by the "R" terminal of the alternator using the normally-closed contact of relay R-33. If a voltage drop should occur in the charging system, the *“Battery”* telltale light will immediately illuminate to warn the driver. The *“Battery Hi/Lo”* telltale light will illuminate if voltage drops below 24 V dc.

Refer to heading *"Diagnosis of Charging System Problems"* later in this section, to determine weather the alternator or the voltage regulator is defective. Should the *"Battery"* telltale light illuminate while the 24 volt voltmeter keeps on giving a normal reading and the *"Battery Hi/Lo"* telltale light does not illuminate, the relay R-33 or its wiring is probably defective.

Caution: *The relay R-33 should never be replaced with a relay provided with a suppressor diode on its coil as the output current (between 12 and 14 volts) at the alternator "R" terminal is not rectified, thus rendering the relay inoperative.*

Note: *When the "Battery" warning light illuminates, the "A/C & Heating" system shuts off in order to prevent battery discharge.*

6. BOSCH ALTERNATOR

One or two 24 volt 140 amp., self regulated, belt driven, air-cooled BOSCH alternators may be used in the 24 volt electrical system (instead of the DELCO 24 volt 270 amp. alternator).

Change the brushes as per “Repair and Testing Instructions for T1 Alternator 0120 69 552” every 100,000 miles (160 000 fm) or once every two years, whichever comes first.

Replace bearings as per “Repair and Testing Instructions for T1 Alternator 0120 69 552” every 200,000 miles (320 000 fm) or once every four years, whichever comes first.

Refer to Bosh T1 Alternator Maintenance Manual Annexed at the end of this section.

7. DELCO ALTERNATOR

The 24 volt charging system consists of a belt driven, oil-cooled, brushless alternator, a 24 volt voltage regulator, an alternator relay and a 12 volt system that includes a 12 volt, 100 amp equalizer. The components used in this system are described under the applicable headings hereafter.

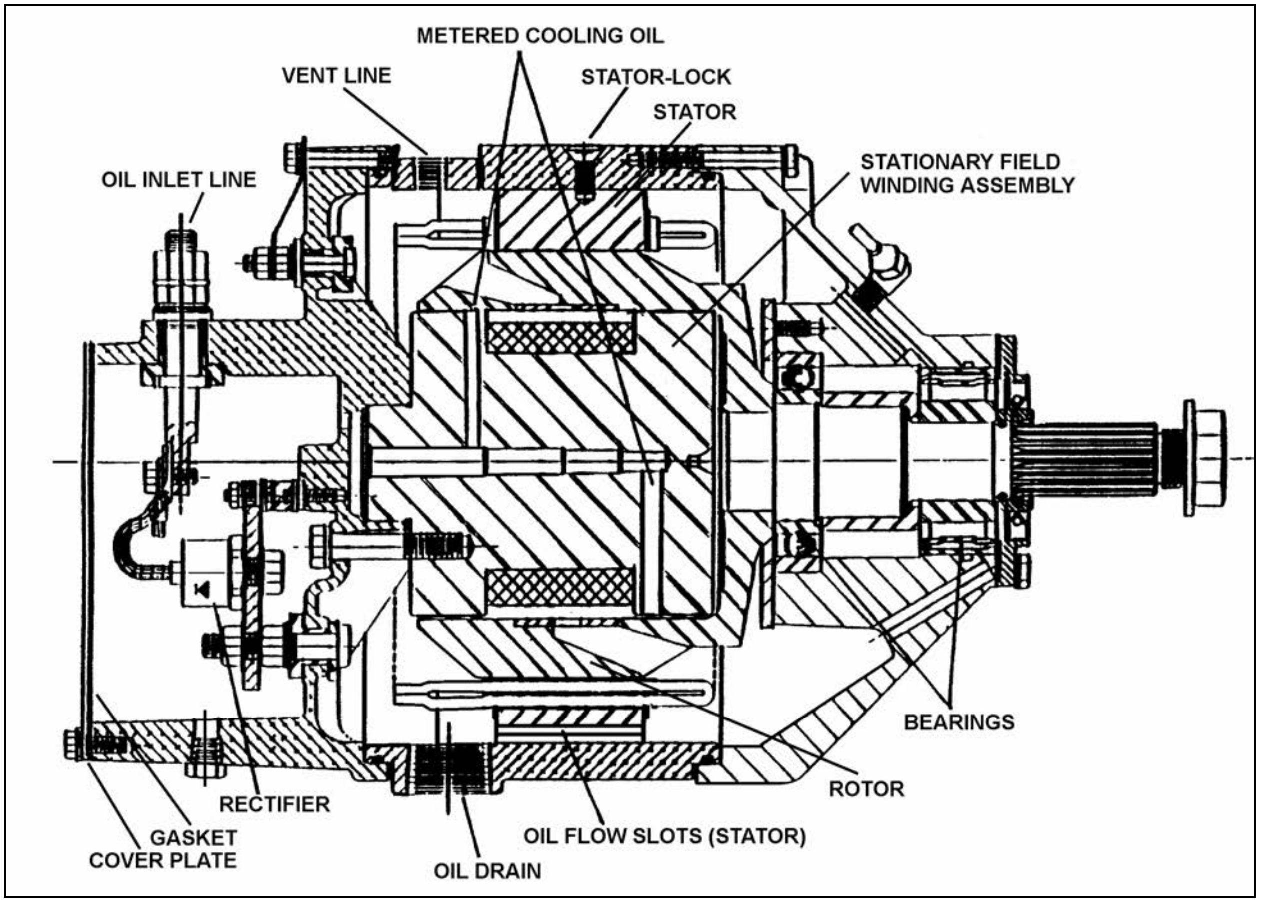


FIGURE 28: 50DN DELCO ALTERNATOR SECTIONAL VIEW 06493

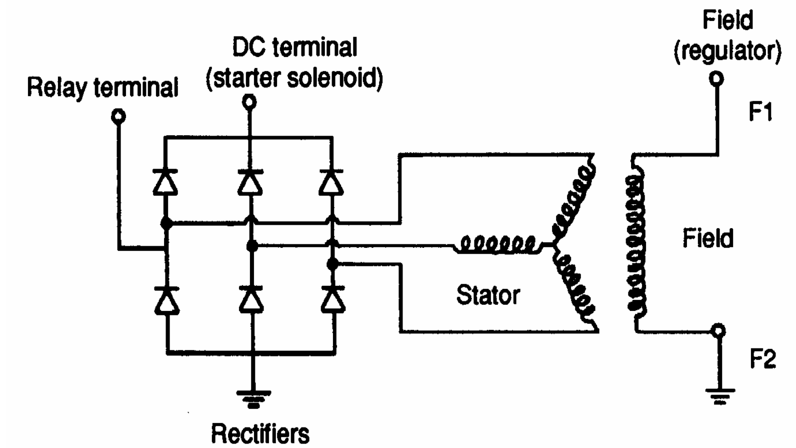


FIGURE 29: ALTERNATOR WIRING DIAGRAM (DELCO) 06067

This oil-cooled alternator is self rectifying. All current carrying members, windings, built-in diodes, and field coils are stationary. The only moving component is the rotor. The alternator is a totally-enclosed unit, cooled and lubricated by engine oil. The oil inlet is on the diode end cover. The oil drains back into the engine crankcase through the drive end frame and drive adapter housing.

This alternator should never be operated with the oil supply line disconnected. A continuous flow of engine oil through the alternator lubricates the bearings and cools the assembly. Four terminals are used on this alternator: the DC output terminal, two field terminals, and a 12 volt relay terminal. The alternator output voltage is regulated by a separate 24 volt regulator that controls the alternator field current (Fig. 28 and 29).

Note: *The relay coils connected to the alternator "relay terminal" SHOULD NEVER BE PROVIDED WITH A SUPPRESSOR DIODE as the output current at this terminal is not rectified, thus rendering relay inoperative.*

Caution: *The electrical system is NEGATIVE GROUNDED. Connecting the batteries or a battery charger with the positive terminal grounded will endanger the alternator diodes and vehicle wiring by a high current flow. Burned wiring harnesses and burned "open" diodes will result. Always ensure that the alternator and battery polarities are matched prior to installation. THE ALTENATOR WILL NOT REVERSE TO ACCEPT INVERSE POLARITY. Also, do not ground or short across any of the alternator or regulator terminals.*

Since there are no brushes, slip rings, or rubbing seals, the alternator requires no periodic maintenance other than the following:

Check alternator-to-engine mounting bolts for looseness and tighten to the proper torque.

Check all electrical connections for tightness and corrosion. Clean and tighten connections as necessary. Be sure wiring insulation is in good condition and that all wiring is securely clipped to prevent chafing of the insulation.

With the engine running, listen for noise and check the alternator for vibration. If the alternator is noisy or vibrates excessively, it should be removed for inspection and repair.

Ensure that battery terminals are clean and tight.

8. CHARGING SYSTEM TROUBLESHOOTING

The troubleshooting of the charging system is made easier by the use of a 12 and a 24 volt voltmeter, "*Battery*", *"Battery balance"* and *"Battery Hi/Lo"* telltale lights mounted in the dashboard (for location refer to the *"Operator's Manual"*). The definition of each warning light is explained under the "ELECTRICAL SYSTEM MONITOR"

8.1 ALTERNATOR OR VOLTAGE REGULATOR

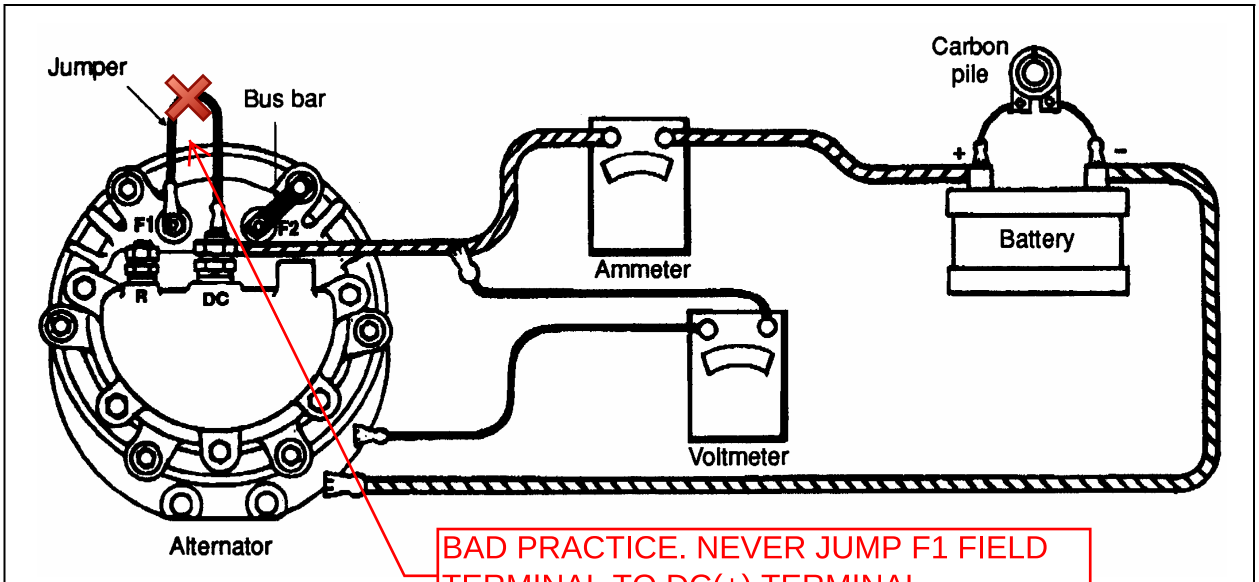


FIGURE 30: CONNECTIONS FOR CHECKIN 06068

8.2 ALTERNATOR DIAGNOSIS

Caution: *Before checking the alternator, set the battery master switch to the OFF position.*

It is not necessary to disassemble completely the alternator to make electrical checks. All electrical checks are made at the diode end of the assembly without having to remove the rotor, drive end frame or bearing. If the electrical components are not defective but bearing replacement is necessary, this can be done at the drive end without having to disassemble the diode end of the unit.
The components in the alternator that require electrical checks are the field winding, the six diodes, and the stator winding.

8.2.1 Diode Checks

Each diode may be checked for shorts and opens as follows:

1. Ensure the battery master switch is set to the “OFF” position.
2. Remove the pipe plug from underneath the end housing to drain the oil in the rectifier engine oil supply.
3. Remove the cap screws (7) and lock washers that attach the diode end cover to the end housing. Remove the end cover from the end housing.

Note: *Do not operate the alternator unless this unit is completely reassembled.*

4. Remove seal from the end housing, detach and remove “DC” and relay terminals, stud, insulating sleeves and O-rings.
5. Disconnect all diode flexible leads; i.e. three from the output terminal stud and three from the diode supports. See figure 31 for more details.

Each diode may be checked for short or open circuits with an ohmmeter.

Note: *The ohmmeter polarity may be determined by connecting its leads to the voltmeter leads. The voltmeter will read up-scale when the negative leads are connected together and the positive leads are connected together. The polarity of the voltmeter leads may be determined by connecting the leads to the identified terminals on a battery.*

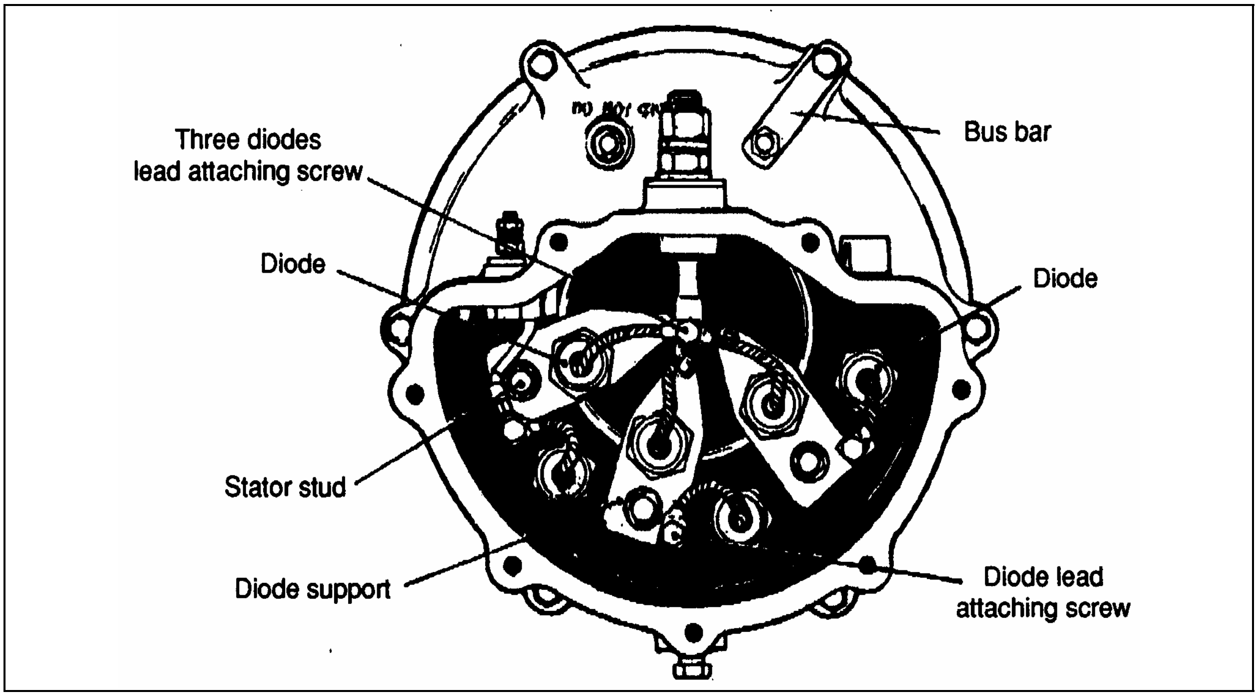


FIGURE 31: VIEW OF RECTIFIER END FRAME WITH COVER REMOVED 06069

Note: *Use an ohmmeter with a single 1.5 volts cell. Most accurate reading will be determined when the 300 ohms value is calibrated to the center one-third of the scale. DO NOT USE high voltage, such as a 110 volts test lamp to check diodes.*

To check diodes mounted in the supports for short fields, connect the positive ohmmeter lead to each diode lead and the ohmmeter negative lead to each support as shown in "A", "B", and "C" of figure 32. To check diodes mounted in the end frame for shorts, connect the ohmmeter positive lead to each diode lead and the ohmmeter negative lead to the end frame as shown in parts "D", "E", "F". The ohmmeter readings may vary considerably when checking diodes for shorts, but if the reading is 300 ohms or less, the diode is probably defective and should be replaced. A diode that reads 300 ohms or less will allow excessive reverse current from the battery. Replace defective diodes as explained later in this section.

To check the diodes mounted in the diode supports for open fields, connect the ohmmeter negative lead to each diode lead and the ohmmeter positive lead to each support as shown in parts “A”, “B”, and “C” of figure 33. To check the diodes mounted in end frame for shorts, connect the ohmmeter negative lead to each diode lead and the ohmmeter positive lead to the end frame as shown in parts “D”, “E” and “F”. An infinite resistance reading indicates an open diode. Diodes can be replaced by following the procedure outlined under DIODE REPLACEMENT”.

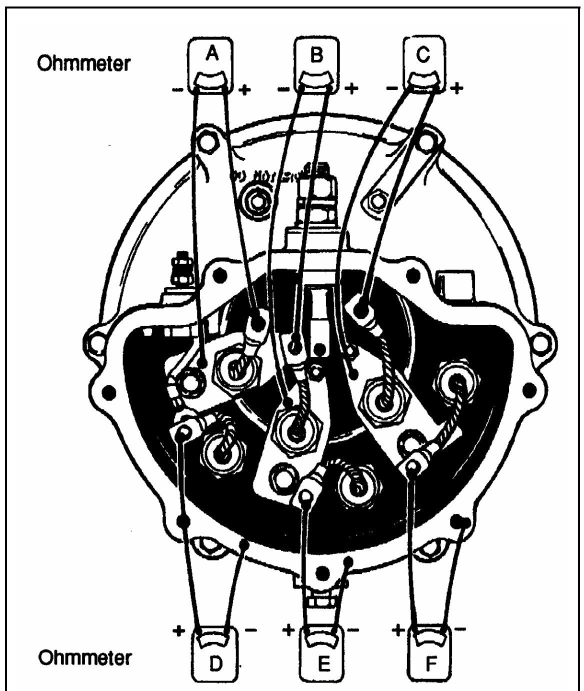


FIGURE 32: DIODE TESTING 06070

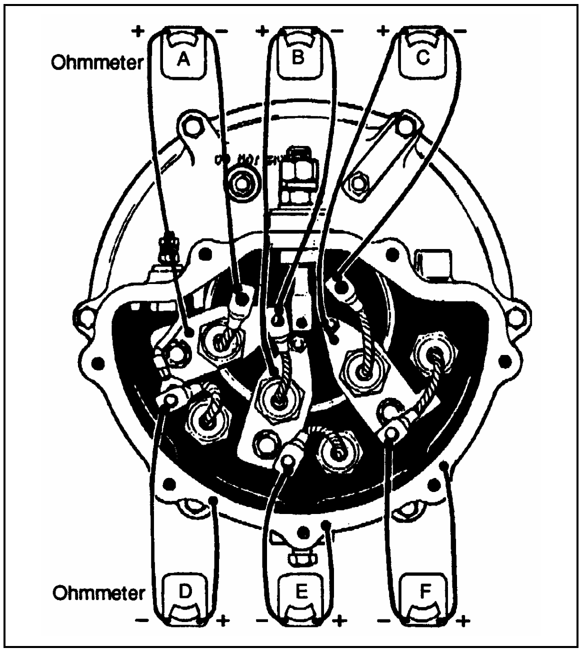


FIGURE 33: DIODE TESTING 06071

When reinstalling diodes, torque to 9-11 Ft-lbs (12-15 Nm). Re-stake next to the threads in an arbor press with an 1/8 inch (3,2 mm) round punch. Press the punch with gradual pressure. Do not strike as the shock may damage the diodes.

8.2.2 Field Winding Check

The field winding may be checked for shorts and opens with an ohmmeter. To check the field winding, connect the ohmmeter to field terminal and to ground. A resistance reading above normal indicates an open, and a reading less than normal indicates a short field. The normal resistance value is 3.0 to 3.3 ohms at 80°F (27°C). An alternate method of checking is to place a battery of specified voltage, and an ammeter in series with the field winding. The current should register 7.2 to 8.3 amperes at 24 volts. Coil resistance is approximately 3.1 ohms. Amperage readings, other than the above, indicate an open, grounded, or shorted field. A defective field coil can be replaced by removing the end frame on which the field terminal is located and then removing the four field coil mounting screws. See FIELD REPLACEMENT" for a detailed procedure.

8.2.3 Stator Winding Check

The stator winding may be checked for open and short fields with an ohmmeter as follows:

Open Fields

Connect the ohmmeter leads to two pairs of diode supports as shown in parts "A", "B", and "C" of figure 34. Correct polarity of the leads must be observed. The ohmmeter should indicate a low resistance. If an infinite or a high resistance is measured in either one or both checks, the stator windings are open.

Ground

To check the stator windings for ground, connect an ohmmeter to the diode support and diode end frame as shown in part "C" of figure 34. The ohmmeter should indicate a very high or infinite resistance. If zero, or a very low resistance is measured, the windings are grounded.

Shorts

The stator windings are difficult to check for shorts without finely calibrated laboratory test equipment due to the very low resistance values of the windings. However, if all other alternator checks are satisfactory, yet the unit fails to perform to specifications, shorted stator windings are probable.

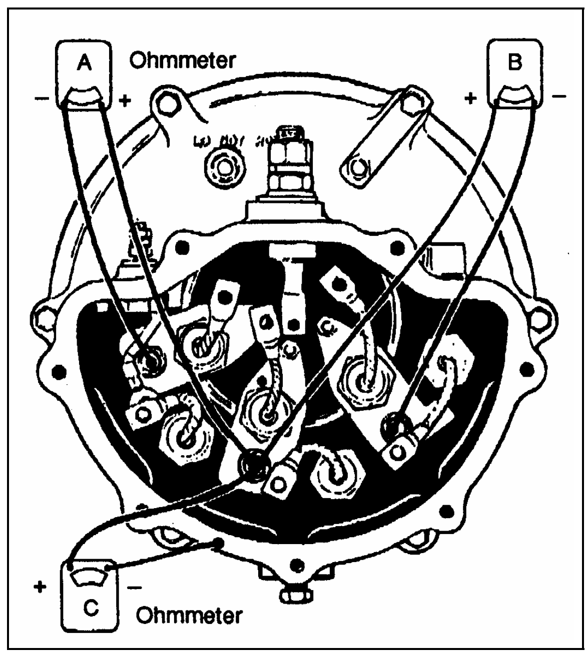


FIGURE 34: STATOR WINDING TEST 06072

8.3 DIODE REPLACEMENT

The following replacement procedures are based on the assumption that the diode end cover is still off and diode leads were disconnected as explained earlier in this section.

Note: *When replacing a diode, make sure it is designed for a negative ground system. The diode can be identified by the symbol stamped on the diode case. The arrow must point toward the diode flexible lead.*

To replace the three diodes that are mounted in the supports attached to the stator lead studs, it is necessary to remove the diode and support assembly. The two outer diode and support assemblies are identical and can be installed on either side. The center unit has a different support, with 2 inches (50,8 mm) between the mounting hole centers.

Note*: The outer supports are provided with 2 ¼" (57,15 mm) center holes.*

8.3.1 Diode Replacement (in Support)

1. Remove nut with lock washer attaching the diode support to the stator lead stud.
2. Remove nut, lock washer, and flat washer attaching support to the small stud in the end frame.
3. Remove the diode and support assembly. Then remove insert from small hole in support or from small stud in the end frame.
4. Remove nut and flat washer from diode mounting stud, then remove diode from the support.
5. Place a new diode in the support and install a flat washer and nut on the diode mounting stud. Hold the diode with a wrench placed over flats on the diode, while tightening nut on the mounting stud to a torque of 160-180 In-lbs (18-20 Nm).
6. Place diode and support assembly over the stator lead stud and the small mounting stud. Place insert over small stud inside the hole in the support. Install flat washer, lock washer, and nut on the small stud, and tighten to a torque of 22-25 In-lbs (2-3 Nm). Install nut with lock washer on stator lead stud and tighten firmly.

8.3.2 Diode Replacement (in End Frame)

To remove diode, use a thin 1 inch open end wrench on flats of the diode case to unscrew diode from the end frame. Thread the new diode into the end frame and tighten to a torque of 160-180 In-lbs (18-20 Nm). If no other parts are to be replaced, refer to "DIODE END COVER INSTALLATION" in this section.

8.4 FIELD REMOVAL

1. Remove three diode and support assemblies from the end frame to provide access to the two lower field to end frame bolts.
2. Remove nut with lock washer and flat washer from three stator lead studs.
3. Remove the six bolts and lock washers attaching the diode end frame to the stator frame.
4. Separate the end frame from the stator frame, and remove the end frame and field assembly from the rotor while pushing the stator lead studs out of the end frame.
5. Remove nut, lock washer, flat washer, and insulating washer which secure the field lead terminal stud in the end frame. Push the stud out of the end frame.
6. Remove field terminal stud insulating bushing and seal from the end frame. Remove insulating sleeve from the field terminal stud.
7. Remove the four bolts and lock washers attaching the field to the end frame.
8. To separate the field from the end frame, install four 3/8-24 x 3 inch bolts in place of the 3/8-24 x 2 inch bolts removed in step 7. Thread bolts in to even heights. Support the end frame in an arbor press. Then, using a suitable press plate to exert pressure on all four bolt heads, press the field out of the end frame.

8.5 FIELD INSTALLATION

1. Position the field assembly on the end frame. Insert four 3/8-24 x 3 inch bolts through the end frame and thread into the field to keep holes aligned.
2. Support the end frame on an arbor press bed so that the diodes will not be damaged, and press the field into the end frame. Press in until shoulder on field coil bottoms against the end frame.
3. Remove the four guide bolts. Install four 3/8-24 x 2 inch bolts, using new lock washers to attach the field to the end frame. Tighten bolts securely.
4. Place insulating sleeve in inner side of the field terminal stud hole in the end frame, and insert the terminal stud through the sleeve. Place two O-rings and insulating bushing

over the terminal stud and push into hole in the end frame. Install insulating washer, flat washer, toothed lock washer, and nut on terminal stud. Tighten firmly.

5. Install each stator lead stud in the end frame as follows: Place insulating washer over the stud and insert the stud through the end frame. Place the insulating bushing over the stud and position in end frame hole. Install flat washer, lock washer, and nut on the stud. Tighten firmly.
6. Install three diode and support assemblies on the end frame as previously directed under “DIODE REPLACEMENT”.
7. Install a new seal in notch around end of the stator frame. Insert field into the rotor and position the end frame against the stator frame. Attach end frame to the stator frame with six bolts and lock washers. Tighten bolts firmly.
8. If no other parts require replacement, refer to "DIODE END COVER INSTALLATION" in this section to complete the assembly.

8.6 STATOR REPLACEMENT

If tests performed under “Stator Winding Checks” earlier in this section indicated an open circuit or short in the stator, the stator and frame assembly must be replaced.

8.6.1 Removal

1. Remove diode end frame and field assembly as previously directed in steps 1 through 4 under “Field Removal”.
2. Remove the six bolts and lock washers attaching the stator frame to the drive end frame.
3. Separate the stator frame from the drive end frame and remove the stator frame from the end frame and rotor.

8.6.2 Soldering Stator Terminal Leads

1. Using a wire brush, thoroughly clean the wire and terminal.
2. Silver solder the stator lead to the terminal using a torch.
3. Thoroughly clean the silver solder connection with a wire brush.
4. Using a high grade energized rosin flux, coat the silver soldered connection with a 80-20 tin-lead solder or pure tin solder to prevent deterioration of the silver solder by engine oil.

Note: *The silver solder will provide the required mechanical strength, which will not be affected by temperature. The tin-lead solder will protect the silver solder connection from deterioration by engine oil.*

8.6.3 Installation

1. Position new seal in notch around the drive end of the stator frame.
2. Position the stator and frame assembly over the rotor against the drive end frame. Attach the stator frame to the drive end frame with six bolts and lock washers. Tighten bolts firmly.
3. Install diode end frame and field assembly as directed in steps 5, 6 and 7 under “installation”.
4. Install rectifier end cover as directed later.

8.7 DIODE END COVER INSTALLATION

1. Make sure all diodes are properly installed and securely tightened. Leads from diodes threaded into the end frame must be securely attached to the diode supports. The relay terminal lead must also be attached to the left diode support.
2. Connect leads from the three diodes mounted in supports to the output terminal stud. Tighten the attachment screw firmly. Place insulating bushing over relay terminal stud.
3. Place a new seal in the diode end frame.
4. With the end cover in place against the end frame, install the cap screws and lock washers. Tighten the cap screws evenly and firmly.
5. Make sure the drain plug is installed in bottom of the end cover and securely tightened.

8.8 ALTERNATOR REMOVAL (DELCO)

1. Place *"Starter Selector Switch"* in engine compartment to the *"OFF"* position.
2. Place the battery master switch to the “OFF” position.
3. Remove alternator drive belt (see “ALTERNATOR DRIVE BELT”).

Note: *When reinstalling drive belt, it is important to set the belt tension correctly. (refer to the appropriate heading later in this section).*

4. Scratch off protective sealer from electrical connections (relay, field and positive terminals). Refer to figure 35.

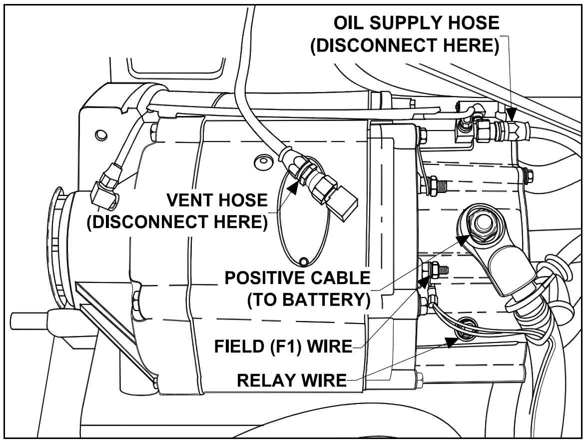


FIGURE 35: ALTERNATOR (HOSES AND WIRES) 06341

Note: *After reconnecting electrical wires, it is important to cover terminals with protective sealer (Prévost #680745).*

5. Disconnect wire #25 from the relay terminal, wire #107 from the field “F1” terminal and disconnect battery cable from the positive “+” terminal on the diode end cover. Tag wires removed to ease identification at time of installation. Refer to figure 35.
6. Disconnect oil supply line and vent hose from top of alternator (Fig. 35) and tape lines to prevent entry of foreign matter. Disconnect oil drain hose from bottom of alternator (Fig. 36) and tape line to prevent entry of foreign matter.

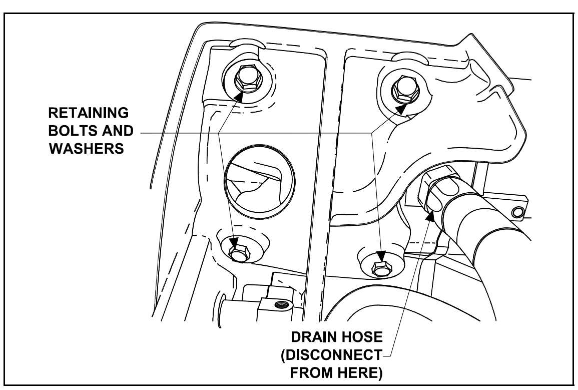


FIGURE 36: ALTERNATOR RETAINING BOLTS AND WASHERS 06350

7. Remove the four bolts and lock washer retaining alternator (refer to fig. 36).

Warning: *Alternator weights approximately 154 lbs (70 kg). Another person is required to take the alternator out of the engine compartment.*

8.8.1 Disassembly of Alternator

After diode, field and stator winding checks, the alternator can be disassembled to repair a faulty component, such as field or stator, or to proceed with bearing or rotor replacement. Perform the following steps to disassemble the alternator:

1. Remove nuts and washers from "DC" terminal on diode end frame.
2. Separate the diode cover plate from the diode end frame by removing the mounting screws.
3. Remove the washer, nut and lock washer attaching the diode supports to the end frame, the three screws connecting the diode leads to the diode supports, and the three nuts which attach the stator studs to the diode supports.
4. Separate the diode support assemblies from the diode end frame, and the three nuts that connect the studs to the diode end frame.
5. Mark the position of the drive end frame and diode frame with respect to the stator assembly so that the parts can be reassembled in the same position.
6. Detach the diode end frame and field assembly from the stator assembly by removing the attachment screws.
7. Separate the field assembly from the diode end frame by removing the four attachment screws.
8. Separate the rotor assembly and drive end frame from the stator assembly by removing the attaching screws.
9. Remove the shaft nut and washer, and the pulley. Press the rotor shaft out of the drive end frame.
10. Remove the retainer plate and pull the bearings from the drive end frame.

8.8.2 Alternator Cleaning and Inspection

Whenever the alternator is disassembled, it should be cleaned and inspected.

Cleaning

If sludge has accumulated on the stator, a light mineral oil should be used to clean it.

Inspection

When the alternator has been disassembled to the extent that the stator is exposed, the stator should be checked for the following:

a) Adequate varnish.

b) Proper spacing of conductors so that “near shorts” do not exist.

c) Proper phase lead placement.

d) Strong conductor and cross-over welds

8.8.3 Bearing or Rotor Replacement

Whenever the rotor and drive end frame are disassembled for any reason, the single-row ball bearing must be replaced with a new one due to the probability of damage during disassembly.

Removal and Disassembly

1. If the pulley was not removed from the rotor shaft at time of alternator removal, remove the nut and flat washer from the shaft and pull the pulley off the shaft.
2. Remove the six bolts and lock washers attaching the drive end frame to the stator frame. Separate the drive end frame from the stator frame. Remove the drive end frame and support assembly.
3. Support the drive end frame in an arbor press so that the rotor can be pressed down out of the end frame. Using a suitable adapter against the end of the rotor shaft that will pass through the inner race of the double-row ball bearing, press the rotor down out of the end frame and bearings. Since the single-row bearing outer race is held in the end frame by the retainer plate, and the inner race is a press fit on to the rotor shaft, the bearing will probably be damaged when the shaft is pressed out and need to be replaced with a new part.
4. Remove the six screws attaching the bearing retainer plate to the drive end frame. Remove the retainer plate, the single-row bearing and the bearing spacer from the end frame.
5. Support the drive end frame in an arbor press with the double-row bearing down, so that the bearing can be pressed down out of the end frame. Using a suitable driver that will exert a force on the bearing outer race, press the bearing out of the end frame.
6. Remove the rubber bearing clamp from groove in the end frame.

Assembly and Installation

1. Install a new single-row ball bearing into inner side of the drive end frame. Install the bearing retainer plate and attach with six screws. Stake screws in place after tightening.
2. Position the rubber bearing clamp in the groove in bearing bore of the drive end frame. Lubricate the clamp to permit the bearing to be pressed in without dislodging or damaging the clamp.
3. Position the rotor in an arbor press with the shaft end up. Install the drive end frame and single-row bearing assembly over the rotor shaft. Using a driver over the rotor shaft, which will exert a force on the bearing inner race, press the bearing onto the shaft until it bottoms against the rotor.
4. Install bearing spacer over the rotor shaft. Position the double-row bearing over the rotor shaft at end frame bore. Using an adapter that will exert a force on both the inner and outer races of the bearing, press the bearing onto the shaft and into the end frame until the inner race bottoms against the bearing spacer.
5. Place a new seal around the drive end of the stator frame.
6. Insert the rotor between the stator and field, and position the drive end frame against the stator frame. Attach the end frame to the stator frame with six bolts and lock washers. Tighten the bolts to a torque of 5 to 5.4 Ft-lbs (6-7 Nm).

Caution: *When replacing the alternator on the vehicle, ensure that an alternator with the proper drive ratio is used. Installation of an alternator with any other drive ratio will result in severe and costly damage to the alternator and engine.*

8.8.4 Alternator Reassembly

Reassembly is the reverse of disassembly.

Note: *When tightening the outside nut on the "DC" output terminal, torque the nut to 30-35 Ft-lbs (41-47 Nm). The lower nut should be supported while doing so.*

When reinstalling diodes, tighten to a torque of 9-11 Ft-lbs (12-15 Nm).

8.8.5 Output check

When removed from the engine, the alternator may be checked without circulating oil on a test bench, providing the output is limited to 100 amperes or less. The alternator may be bench tested without circulating oil at outputs exceeding 100 amperes, as long as the period of operation is limited to less than 15 seconds.

Caution: *Operating the alternator at outputs greater than 100 amperes without adequate oil circulation for periods exceeding 15 seconds, will cause the alternator to overheat, resulting in damage to the winding and diodes.*

If the alternator is to be operated at an output greater than 100 amperes for longer than 15 seconds, circulating oil must be provided. SAE 30 engine oil must be applied to the connection on the diode end cover at a pressure of 35 psi and at a temperature of 60°F to 220°F (16°C to 104°C). This will provide an oil flow of about one gallon per minute.
To check the alternator on a test bench, make electrical connections as shown in figure 30. Make sure the negative battery terminal is connected to the alternator frame.

8.9 ALTERNATOR DRIVE BELT

Removal

1. Insert a ¾'' socket drive into the tensioning arm opening (Fig. 37).
2. Twist the tensioning arm to slacken belt.
3. Remove belt.

Installation

Installation of the alternator drive belt is the reverse of removal.

8.9.1 Adjustment

Correct belt tension is required to maximize belt life. The tensioning arm maintains proper belt tension, no adjustment is required.
Check for wear and proper tension every 6,250 miles (10 000 km) or twice a year, whichever comes first.

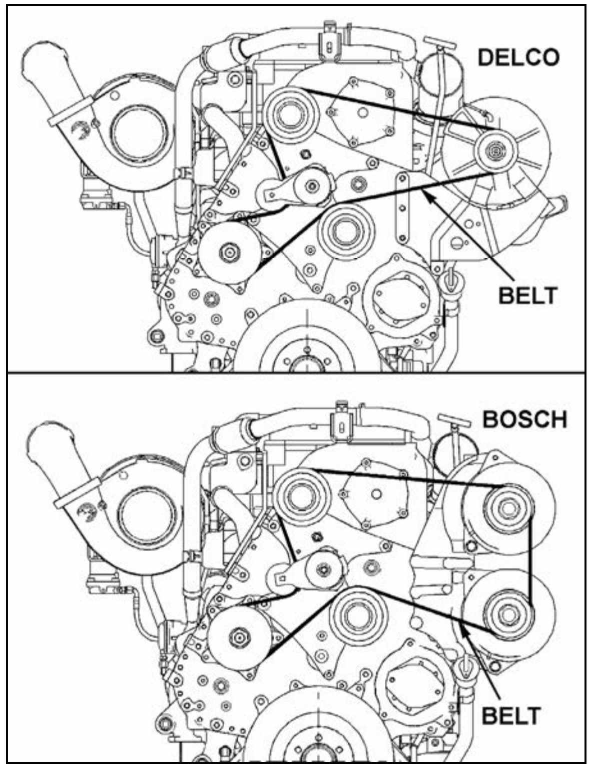


FIGURE 37: ALTERNATOR DRIVE BELT 06509

9. VOLTAGE REGULATOR (DELCO)

The 24 volt regulator used with Delco alternator is located in the engine compartment R.H. side (MTH).

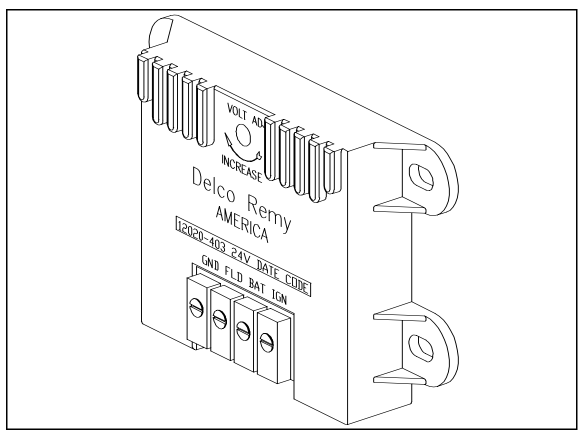


FIGURE 38: VOLTAGE REGULATOR 06408

The transistor regulator illustrated in figure 38 is an assembly mainly consisting of diodes, capacitors, resistors and transistors. These components are mounted on a printed circuit panel board to form a completely static unit containing no moving parts. Regulators of this type have only four terminals which are identified "GND." (ground), "FLD" (field) "BAT" (battery) and "IGN" (ignition).

The regulator components work together to limit the alternator voltage to the preset value by controlling the alternator field current. This is the only function that the regulator performs in the charging system.

The voltage at which the alternator operates is determined by the regulator adjustment. Once adjusted, the alternator voltage remains constant. The regulator is unaffected by length of service, changes in temperature, or changes in alternator output and speed.

A typical wiring diagram of a negative ground system is illustrated in figure 39. This diagram shows only the basic charging system components. It does not show any components such as the control relays. Refer to *"Charging system"* wiring diagram, in *"Wiring diagrams"* for the electric circuits and connections.

Voltage regulator maintenance

The voltage regulator is a service-free electronic unit. When it fails, it should be replaced. The following procedure must be used:

Caution: *Set the battery master switch to the "OFF" position.*

- Open the engine compartment R.H. side door in order to get access to the voltage regulator;
- Unscrew the electrical cable connectors;
- Unscrew the voltage regulator unit;
- Install a new voltage regulator by reversing the procedure.

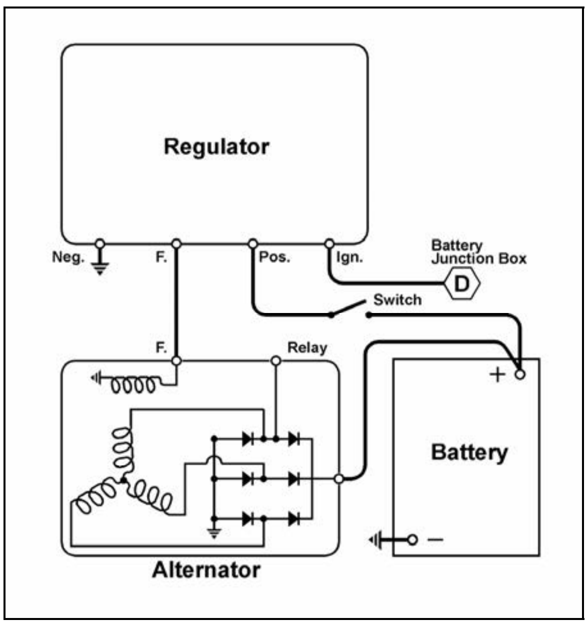


FIGURE 39: TYPICAL WIRING DIAGRAM OF A NEGATIVE GROUND SYSTEM 06415

Note: *For information about BOSCH alternator and voltage regulator, refer to technical publication "Repair and Testing Instructions for T1 Alternator 0120 689 552".*

9.1 TROUBLESHOOTING PROCEDURES

Trouble in the electrical system will usually be indicated by one of two conditions: an undercharged or an overcharged battery. Either condition can result from an improper voltage regulator setting:

Checking Battery Voltage

The absence of gas production during the continuous appearance of the green dot in the battery's built-in hydrometer indicates that the voltage setting is satisfactory. Check the following conditions:

Checking Voltage Regulator Setting

1. To check the voltage setting, connect a voltmeter across the "POS" and "NEG" terminals on the regulator, and an ammeter to the "C" terminal on the alternator. Refer to figure 40.

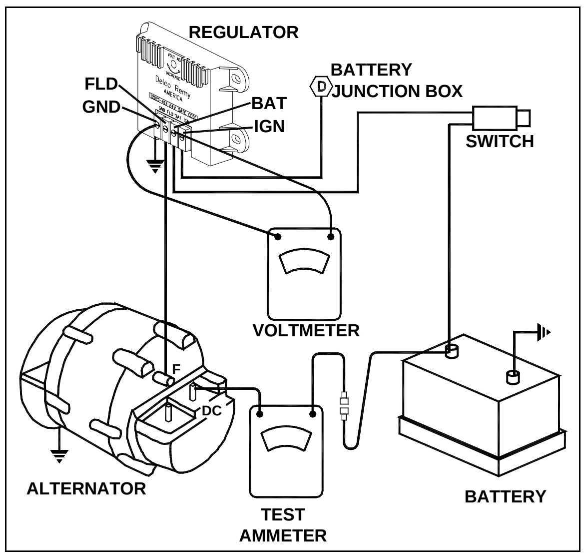


FIGURE 40: REGULATOR VOLTAGE SETTING 06416

2. Operate the engine at approximately 1000 rpm (about 2300 alternator rpm), with accessories on, to obtain an alternator output of 20-200 amperes.
3. Note the voltage setting. It should be steady at 27.5 volts.
4. If not, the desired setting can be obtained by removing the plug from the voltage regulator cover and slightly turning the adjusting screw inside the regulator. Turn the adjusting screw clockwise to increase the

voltage setting or counterclockwise to decrease it. See figure 41 for details.

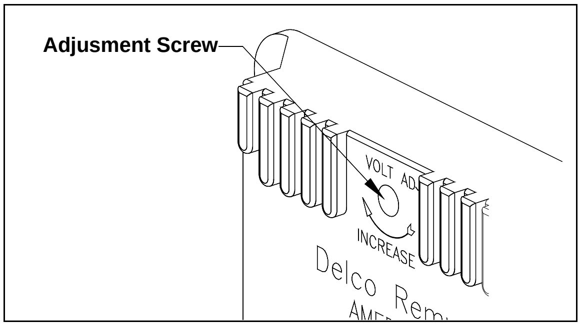


FIGURE 41: ADJUSTING REGULATOR VOLTAGE SETTING 06418

Note: *If regulator voltage cannot be adjusted to the specified setting, remove the regulator and repair or replace it as necessary.*

9.1.1 Undercharged Battery

If the voltage setting is steady and reasonably close to the specified value and the battery is undercharged, raise the setting by 0.3 volt, then check for an improved battery condition over a minimum service period of 48 hours. If the voltage cannot be adjusted to the desired value, the alternator should be checked as follows:

1. Stop alternator, turn off all accessories and disconnect battery ground cable.
2. Disconnect all leads from the regulator and from the alternator field. **Do not allow leads to touch ground.**
3. Connect a voltmeter and an ammeter in the circuit at the alternator "DC" terminal.
4. Connect a jumper lead from the alternator "DC" terminal to the alternator field terminal.

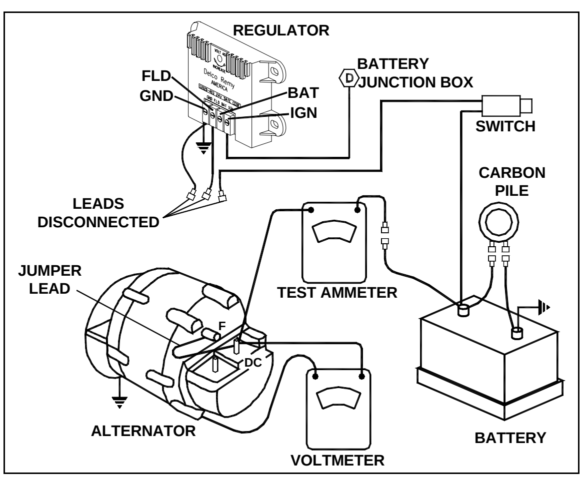


FIGURE 42: REGULATOR VOLTAGE TEST (UNDERCHARGED BATTERY) 06417

5. Connect a carbon pile resistor load across the battery. Turn to the *"Off"* position.
6. See figure 42 for wiring connections.
7. Reconnect battery ground cable
8. Turn on all vehicle accessories.
9. Operate alternator and adjust carbon pile resistor load as required to check for rated output as given in Delco-Remy Service Bulletin 1G-187 or 1G-188.
10. Check the alternator field winding as follows: Disconnect the lead from the field terminal and connect an ohmmeter from the field terminal to ground. A resistance reading above normal indicates an open field, and a resistance reading less than normal indicates a shorted or grounded field. The normal resistance can be calculated by dividing the voltage by the field current published in Delco-Remy Service Bulletin 1G-186, 1G-187, or 1G-188. The normal resistance value should be at or near midscale on the ohmmeter for accuracy. An alternate method of checking is to connect a battery of specified voltage and an ammeter in series with the field winding, and compare readings with published specifications in Delco-Remy Service Bulletin 1G-186, 1G-187, or 1G-188. An alternator is defective if it does not produce rated output or if field windings are faulty. If the alternator provides rated output, and field windings check satisfactorily, the regulator should be checked as covered under "Regulator Checks".

9.1.2 Overcharged Battery

If the voltage setting as checked above is steady and reasonably close to the specified value, lower the setting by 0.3 volt and check for an improved battery condition over a minimum service period of 48 hours. If the voltage cannot be adjusted to the desired value, proceed as follows: where the alternator field is grounded internally in the alternator as shown in figure 39 a shorted or grounded field or a defective regulator can cause an overcharged battery. The field winding can be checked as covered in paragraph “Undercharged Battery”. If the field winding is found to be correct, the alternator is not defective, and the regulator should be checked as covered under “Regulator Checks”.

9.2 REGULATOR CHECKS

Separate the cover from the base, and remove the panel assembly from the cover. Carefully note the location of all washers and lock washers.

The component parts are keyed to figure 39. Before making electrical checks, visually inspect the components and make sure all soldered connections are secure. Various electrical checks with an ohmmeter can be made to determine which components are defective.

The ohmmeter **must** be accurate, and should be a scale-type meter with a 1.5 or 3 volt cell. Most digital ohmmeters cannot be used to check semiconductors. However, some digital ohmmeters are specially designed to test semiconductors and can be used to test components in the regulator. Consult the ohmmeter's manufacturer for specifications concerning the capabilities of the ohmmeter.

It is important that all of the following checks be made. If a defective part is found, replace it before proceeding with the remaining checks. Be sure to make all the checks since more than one component may be defective.

A defective regulator can be repaired according to the following methods:

A) By changing the printed circuit board in the regulator. Unscrew the retaining screws on the printed circuit and remove it. Install a new printed circuit board. This method is the most commonly used.

B) By removing any retaining screws involved and unsoldering the connections. When resoldering, limit solder time to a minimum as excessive heat may damage the printed circuit board and component parts. However good soldered connections are essential for satisfactory operation. A resin core 63% tin 37% lead solder with a 360°F (182°C) melting point is recommended along with a soldering iron rated at 50 watts or less. Use extreme care to avoid overheating. Before checking the printed circuit board, remove transistor TR1, which must be checked separately. Connect the ohmmeter as shown in figure 46, and then reverse the ohmmeter leads to obtain two readings on the same component. Use the middle scale on scale-type meters on which the 300 ohm value should be within, or nearly within, the middle third of scale.

Capacitors C1 and C2 = The ohmmeter should read high and low on each capacitor. If not, replace capacitor.

Diodes D1, D2 and D3 = Each diode should give one high and one low reading. If not, replace diode.

Resistor R2 = Turn voltage adjustment screw (identified in figure 41) with ohmmeter connecting each way. Reading should change as slotted screw is turned. If not, replace R2.

Transistor TR1 = See figure 43. Use the low scale. Each of the three checks should read low and high. If not, replace TR1.

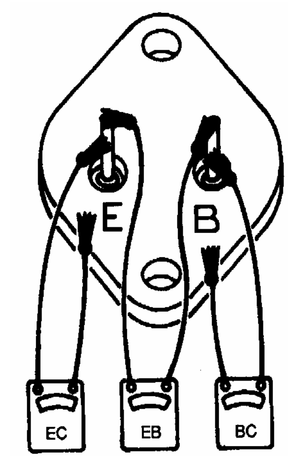


FIGURE 43: CHECKING TRANSISTOR TR1 06081

Transistor TR2 = Change the ohmmeter to use the low scale. EB should read low and high. BC should read low and high. EC should both read high. If not, replace TR2. See figure 44.

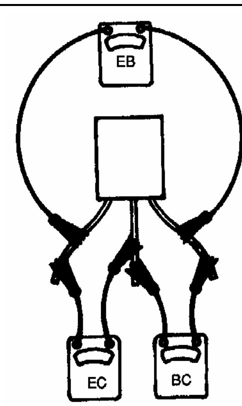


FIGURE 44: CHECKING TRANSISTOR TR2 06081

9.3 ADJUSTING VOLTAGE

After repair, the regulator must be adjusted to the desired voltage setting. Follow the procedure under "Checking Voltage Regulator Setting". Slowly turn the adjusting screw full range and observe the voltmeter to ensure that the voltage is being controlled, then, while still turning, slowly adjust to the desired setting.

10. BATTERY EQUALIZER

VoltMaster Battery Equalizer Owner's Manual (100 amps) is annexed at the end of this section.

Refer to "Electrical Compartments and Junction Box" of this section, for location.

11. STARTER

Refer to Mitsubishi Electric Corporation (MELCO) Service bulletin ME003-P annexed at the end of this section for information and maintenance instruction on MELCO 105P70 starter.

12. ENGINE BLOCK HEATER

The vehicle may be equipped with an engine immersion-type electric block heater to assist cold weather starting. The heater male electric plug is easily accessible through the engine compartment R.H. side door (Fig. 45). To use it, connect the female plug of an electrical extension cord to the heater plug. The extension cord must be plugged into a 110-120 V AC power source only. The engine block heater should be used whenever the vehicle is parked for an extended period of time in cold weather and a suitable power source is available.

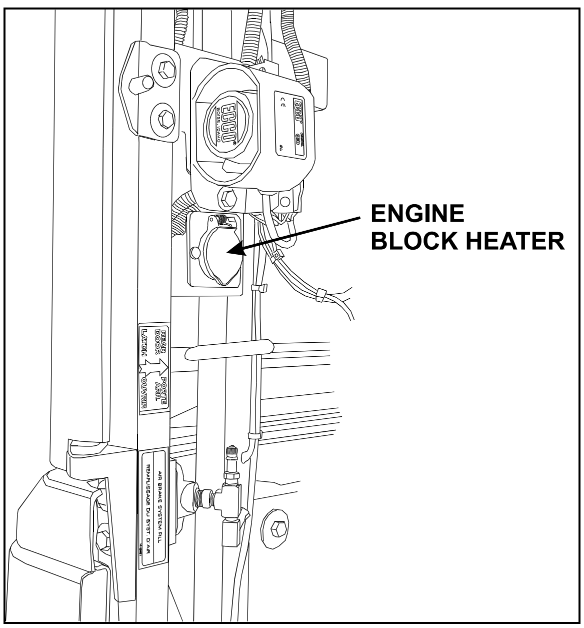


FIGURE 45: ELECTRIC HEATER PLUG LOCATION 18354

12.1 MAINTENANCE

This heater is non-serviceable except for the cord, and if faulty, must be replaced as a unit.

13. EXTERIOR LIGHTING

The circuit for exterior lights, as well as their control switches, relays and circuit breakers are shown on the applicable wiring diagrams. Wiring diagrams are located in the technical publication box.

13.1 HEADLIGHTS

Each headlight assembly consists of a 12 volt halogen rectangular lamp unit and a front turn signal light. Headlight lamps are double-filament units, having high and low beams.

13.1.1 Headlight Beam Toggle Switch

The multifunction lever located on the steering column is used to select proper lighting. High beams or low beams can be selected by pulling the lever rearward. A high beam indicator on the central dashboard panel is illuminated when the high beam circuit is energized.

Note: *Pulling the lever rearward while the lights are off will flash the headlights.*

13.1.2 Maintenance

Clean headlights with soap and water and a good glass cleaner whenever dirty. For maximum illumination, headlight connections must be coated with a dielectric grease to prevent oxidation and proper voltage must be maintained. Low battery voltage, loose or dirty contacts in wiring system and poor ground contribute to a decrease in voltage. Check wiring and connections regularly and keep battery properly charged. When a headlight burns out, a new bulb must be installed. Headlight aiming is not necessary after a bulb replacement.

Headlights must be properly aimed to provide maximum allowable road illumination. When using mechanical aiming devices, follow manufacturer's instructions.

Headlight aim should be checked after installing a new headlight unit. Aiming can be performed without removing headlight assembly. Horizontal and vertical aiming of each headlight unit is provided by two adjusting screws that move the headlight unit within its support (fig. 52). There is no adjustment for focus since the headlight unit is set for proper focus during manufacturing assembly.

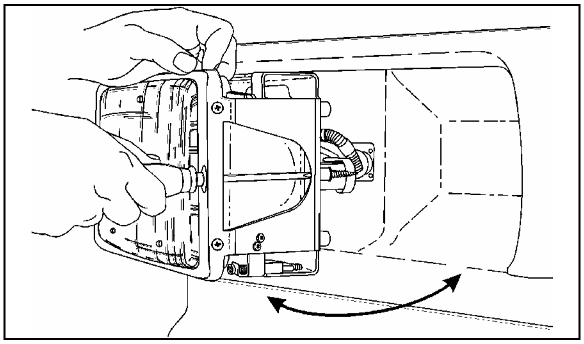


FIGURE 46: HEADLIGHT ASSEMBLY 06405

13.1.3 Headlight Adjustment

The following is a general procedure for headlight adjustment using a mechanical equipment, such as a *"Bear 47-132 headlight aligner".* If your mechanical equipment is different, refer to the manufacturer's instruction manual.

Setting aligner according to slope

The floor level offset dial must match with slope to ensure a precise alignment.

1. Park vehicle on a level floor.
2. Fix one (1) calibration fixture to each aligner.
3. Install aligner in center of each wheel on one side of vehicle. Unit B must be installed beside the front axle wheel with its viewing port facing rearward, and unit A beside the drive axle wheel with its viewing port facing forward. See figure 48 for more details.

Note: *Check that the three indicators on each module are set to zero.*

4. Level each unit with the thumb adjusting screw on the fixture until level-vial bubble is centered.
5. Look through the top port hole of unit A, and turn horizontal knob until split images are aligned. See figure 47.

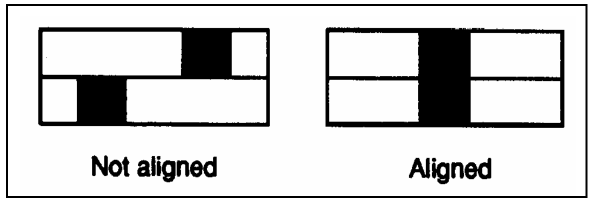


FIGURE 47: HEADLIGHT ALIGNMENT 06088

6. Set according to floor slope. Transfer positive (+) or negative (-) reading of horizontal dial to the floor level offset dial to offset floor slope on each aligner (Fig. 49). Push on the floor level offset dial to register reading.
7. Remove calibration fixture from each unit.

Note: *If vehicle remains stationary during the headlight alignment procedure, it is not necessary to check floor slope each time.*

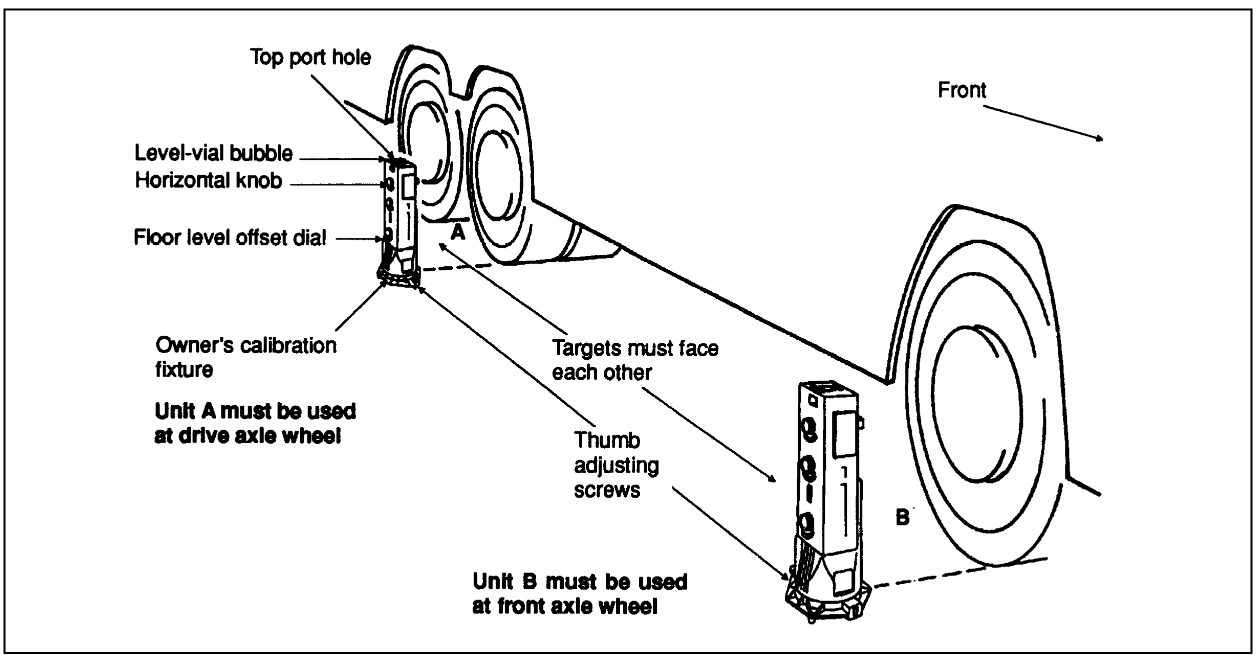


FIGURE 48: HEADLIGHT ALIGNMENT 06087

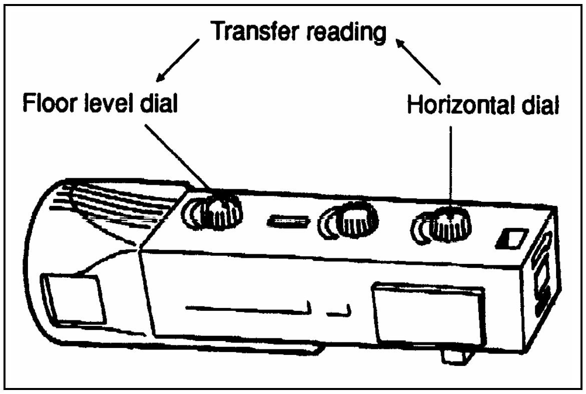


FIGURE 49: HEADLIGHT ALIGNER 06089

Headlight Alignment

The aligner is provided with adapters for different sizes of headlights that are always aligned in pairs.

1. Fix the adequate adapter on each headlight.

Note: *The adapters are equipped with steel inserts, thus providing a good seating for precise headlight adjustment.*

2. Install aligners on headlights (unit A on driver's side and unit B on other side with the sight openings facing each other) by pushing the handle forward to secure rubber suction disc. Pull handle until it locks. Refer to figure 50.

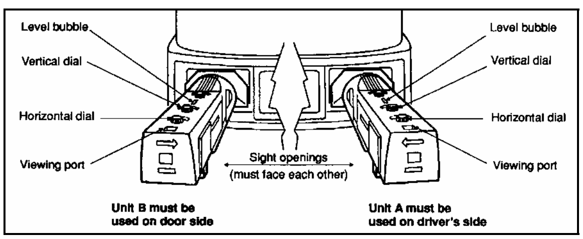


FIGURE 50: HEADLIGHT ALIGNMENT 06090

Note: *Ensure that floor level offset dial is set correctly before aligning headlights.*

Horizontal Alignment

1. Reset horizontal dial to zero.
2. Check that split image is visible in the viewing port. If not, reposition aligner by turning it.
3. Turn the horizontal aim adjusting screw of each headlight until split image is aligned (Fig. 51 and 52).

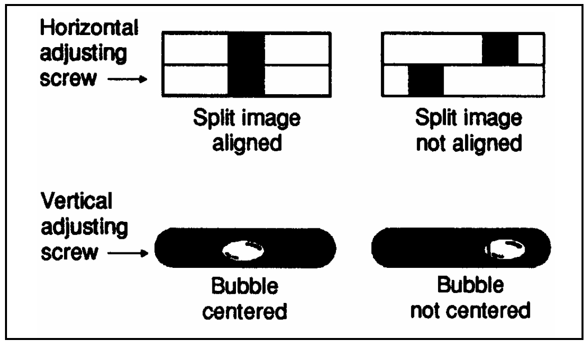


FIGURE 51: HEADLIGHT ALIGNMENT 06091

Vertical Alignment

1. Reset vertical dial to zero.
2. Turn the adjusting screw of the headlight vertical aim until bubble is centered (Fig. 51 and 52). Repeat operation on other headlight.
3. Recheck the horizontal alignment.

Remove aligners by pressing on vacuum release button.
Repeat the same procedure for the high beams.

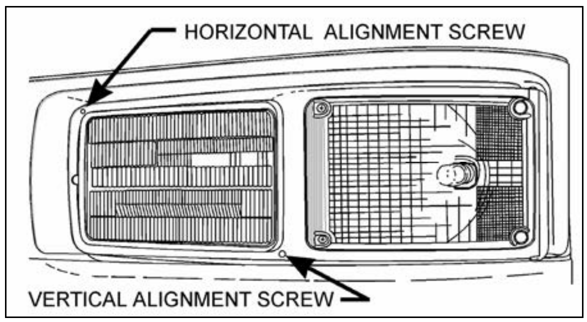


FIGURE 52: ALIGNMENT SCREWS 06413

If proper mechanical equipment is not available, perform adjustments as described below:

1. Park vehicle on level floor so headlights are 25 feet (7,6 m) from a smooth surface preferably of light color. A door or wall is suitable. Centerline of vehicle should be perpendicular to this vertical surface.
2. Draw a horizontal line on vertical surface at height of light center. Locate point on this horizontal line at which projected centerline of vehicle intersects. Measure distance between light centers and divide this distance equally on either side of center mark. Then draw two vertical lines directly ahead of each light center.
3. Switch on high beams and cover one headlight while adjusting the other.

4. When aiming headlights, beam may appear distorted. A new headlight unit must be installed to correct this condition.
5. After headlight is properly aligned, cover it and proceed in the same manner as above with opposite headlight.

13.1.4 Headlight Unit Replacement

Removal

1. Remove screw fixing headlight assembly to its housing (Fig. 46) and pivot assembly out.
2. Remove socket from headlight lamp connector.
3. Remove six mounting screws attaching headlight unit to support.

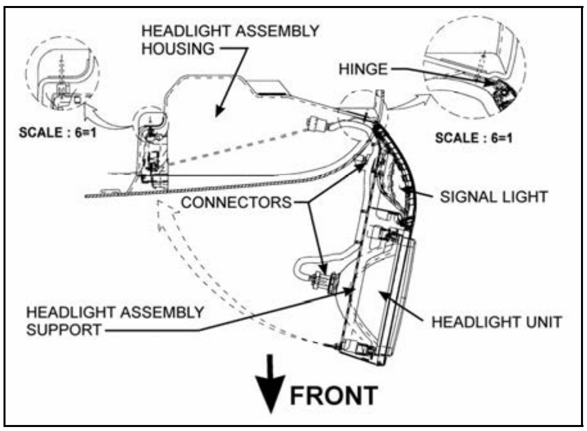


FIGURE 53: TOP VIEW OF HEADLIGHT ASSEMBLY 06421

Installation

1. Install wiring connector on back of new headlight unit. Position unit in support with molded lens number at top.
2. Secure headlight unit using six mounting screws.
3. Pivot headlight assembly back into its housing then secure using fixing screw.
4. Perform alignment procedure.

Note: *The headlight aim must be checked and adjusted even if it was properly adjusted before the headlight unit was replaced.*

13.1.5 Headlight Bulb Removal and Replacement

1. Remove the headlight screw fixing the headlight assembly, then pivot headlight assembly out.
2. Remove socket from headlight lamp.
3. Remove the bulb by pushing and rotating it out of the socket.
4. Install the new bulb by reversing the previous procedure.

13.2 FRONT TURN SIGNAL

The front turn signal is part of the headlight assembly. The turn signal lens is located on each front corner and shares a common support with the headlights. Turn signal is visible from both front and side.

13.2.1 Front Turn Signal Light Replacement

Removal

1. Remove screw fixing headlight assembly to its housing (Fig. 46) and pivot assembly out.
2. Remove socket from front turn signal light lamp connector.
3. Remove four mounting screws attaching front turn signal light to support.

Installation

1. Install wiring connector on back of new front turn signal light. Position unit in support with molded lens number at top.
2. Secure front turn signal light using four mounting screws.
3. Pivot headlight assembly back into its housing then secure using fixing screw.

13.2.2 Front Turn Signal Light Bulb Removal and Replacement

1. Remove the headlight screw fixing the headlight assembly, then pivot headlight assembly out.
2. Remove socket from front turn signal light.
3. Remove the bulb by pushing and rotating it out of the socket.
4. Install the new bulb by reversing the previous procedure.

13.3 STOP, TAIL, DIRECTIONAL, BACK-UP, AND HAZARD WARNING LIGHTS

A combination stoplight, taillight, directional signal light and back-up light assembly is mounted at the rear, on each side of the vehicle. Furthermore, when braking, two center stoplights (LED) and a cyclops light (LED) will illuminate simultaneously with the stoplights on the sides for increased safety. The L.H. and R.H. side center stop lights are also used as directional signal and marker lights.

The stop, tail, directional signal and back-up lights consist of individual LED lights mounted on the engine rear door, and each light is serviced individually as a complete unit. The back-up light uses a regular tungsten bulb.

The hazard warning flashing system uses the front, side and rear directional lights simultaneously. This system is energized by a switch on the L.H. dashboard.

13.3.1 Lamp Removal and Replacement

1. Open engine compartment rear door.
2. Remove the lamp support retaining screws (2), then from the outside, remove the lamp and its support.
3. From the outside, install the new lamp with its support then fasten the retaining screws.

13.3.2 Center Stoplights and Cyclops Light Removal and Replacement

These (LED) lights are sealed unit and should be replaced as an assembly in accordance with the following procedure:

1. Unscrew both "Phillips" light screws then remove the light assembly.
2. Install new light assembly and secure using screws.

13.4 LICENSE PLATE LIGHT

Two LED units are mounted above the rear license plate(s) of vehicle. In case of burn out, the LED unit must be changed according to the following procedure.

1. Pry out the rubber seal with a small screwdriver. Pull on the LED unit and disconnect it.
2. Reconnect new LED unit, place rubber seal, and press on it until it is seated in position.

13.5 CLEARANCE, IDENTIFICATION AND MARKER LIGHTS

The vehicle is equipped with marker, identification and clearance lights (LED). The clearance lights are mounted at each corner of the coach near the top and the identification lights are in the upper center of rear and front sections. The rear clearance and identification lights are red and the front ones are amber.

The amber marker lights are mounted along the sides of vehicle.

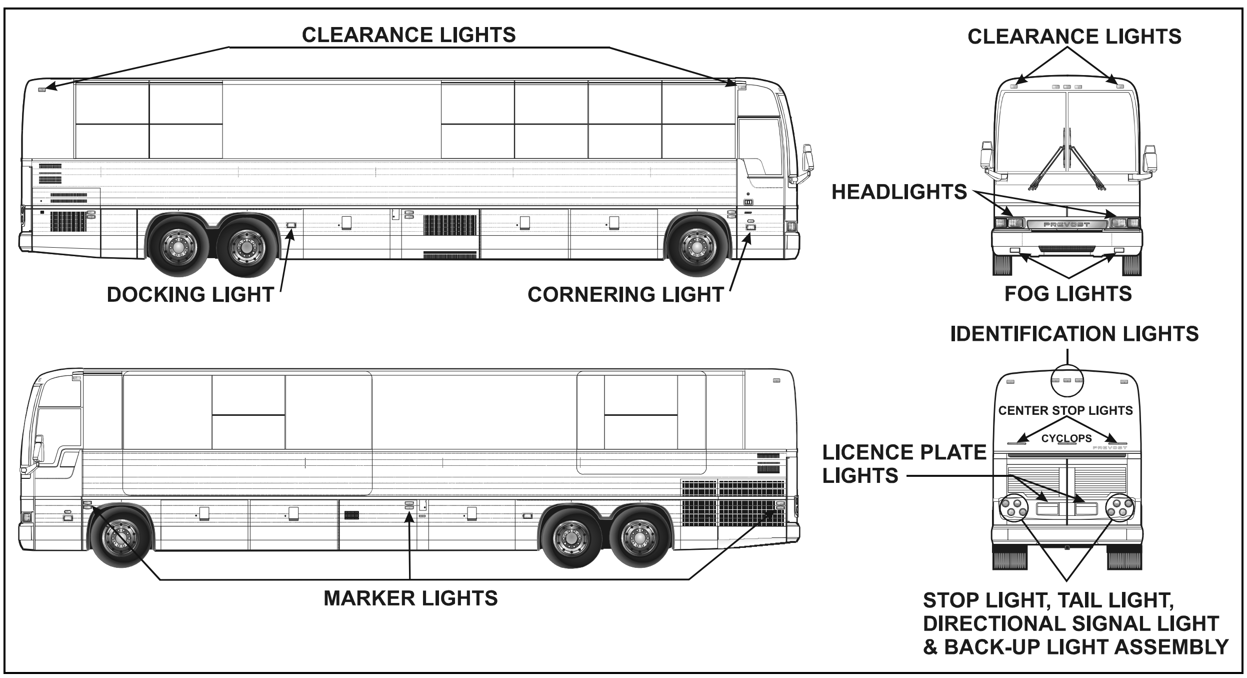


FIGURE 54: VARIOUS LIGHTS LOCATION 06412

13.5.1 Marker Light Removal and Replacement

The side marker light is a sealed unit (LED) and should be replaced as an assembly in accordance with the following procedure:

1. Unscrew both *"Phillips"* light screws, then remove the light assembly.
2. Position the new light assembly and install the "Phillips" screws.

13.5.2 Clearance and Identification Light Removal and Replacement

The clearance and identification light are sealed units (LED) and can be replaced in accordance with the following procedure:

1. Unscrew both "Phillips" light screws, then remove the light assembly.
2. Position the new light assembly, then install the "Phillips" screws.

13.6 DOCKING AND CORNERING LIGHTS

MTH vehicles are provided with two halogen sealed-beam units that serve as cornering lights. They are mounted on the vehicle as follows: one is mounted on the front L.H. side service compartment door, while the other is located on the entrance door on the R.H. side. The main function of these lights is to increase lateral visibility when turning a corner. These lights are energized simultaneously with the directional lights. A dashboard-mounted rocker switch may be actuated to cancel this system in special situations.

Two additional halogen sealed-beam units are installed aft of the rear baggage compartment. These lights are used as docking lights and both will illuminate automatically when reverse range is selected to facilitate back-up or docking procedure. These lights do not operate automatically when the reverse range is selected, but by means of a dashboard-mounted rocker switch. When actuated, the docking as well as the cornering lights illuminate.

13.6.1 Lamp Removal and Replacement

Both docking and cornering sealed-beam units can be changed in accordance with the following procedure:

1. Remove the two "Phillips" screws attaching the retaining ring.
2. Disconnect the light unit connection.
3. Remove the lamp.
4. Position new lamp.
5. Connect and position the light unit.
6. Finally, install the retaining ring.

13.7 FOG LIGHTS

Standard halogen fog lights (MTH) or optional (coaches), can be mounted on this vehicle to give the driver better visibility in foggy weather, or to improve the range of vision just ahead of the coach.

13.7.1 Bulb Removal and Replacement

1. Pull on the release handle located in the front service compartment, near the door lower hinge. The bumper will lower gradually.
2. Remove the protector cover on light unit (if so equipped). Unfasten the glass retainer screw and remove the glass.
3. Remove retaining clip from its notches, then lift the retaining clip and remove the bulb.
4. Install the new bulb, then replace the retaining tab of clip to its position into the notches.

Caution: *During this step, avoid contacting the bulb with your fingers. This could alter the bulb life.*

5. Reinstall the glass and secure using screw.
6. Replace the light unit cover (if so equipped).

14. INTERIOR LIGHTING EQUIPEMENT

14.1 CONTROL PANEL LIGHTING

The instrument gauges and switches mounted on all control panels are energized whenever the exterior light switch is pushed to the first position. A control dimmer located on the dashboard is used to vary the brightness of the panel gauges, switches and indicator lights.
The gauge lights, panel lights, switch lights and indicator lights have a different bulb arrangement. Thus, the procedure to change a defective bulb can vary according to the application.

14.1.1 Switch Lighting

1. Slightly pull the switch with a defective LED away from the control panel.
2. Disconnect the electric cable from the switch.
3. To install a new switch, reverse the procedure (Fig. 55).

Note: *Switches are lighted by the use of LED. When lighting on a switch fails, replace defective switch as a unit.*

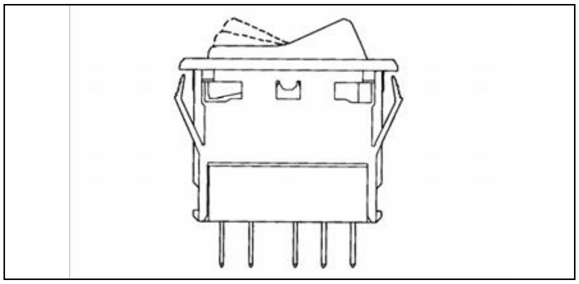


FIGURE 55: SWITCH 06321

14.1.2 Telltale Light Replacement

Telltale module is non-serviceable and must be replaced as a unit.

1. Unscrew and remove the top dashboard panel.
2. Remove the telltale back wire electric connectors.
3. Unscrew and remove the telltale module.
4. To replace the telltale module, reverse the procedure.

14.1.3 Gauge Light Bulb Replacement

1. For any gauge light bulb replacement, the dashboard panel must be removed in order to have access to the rear of gauges.
2. Remove bulb socket from the gauge, turn the defective bulb counterclockwise and pull it out of the gauge.
3. Push a new bulb and socket ASM and turn clockwise to lock in place.
4. Replace the rear dashboard housing.

14.2 STEPWELL LIGHTS (COACHES ONLY)

Two Stepwell lights are illuminated when the door opening system is activated.

14.2.1 Bulb Removal and Replacement

Proceed as follows to replace a defective bulb:

1. Unscrew the two Phillips-head screws retaining the lens to the wall, and remove it.
2. With the light lens removed, pull bulb from the lamp while applying lateral pressure.
3. Install the new bulb into the lamp.
4. Position the light lens and install it.

14.3 LAVATORY NIGHT-LIGHT

The lavatory night-light is illuminated as soon as the ignition switch is set to the *“ON”* position.

14.3.1 Bulb Removal and Replacement

1. Unscrew the two Phillips-head screws retaining the lens to the wall, and remove it.
2. With the light lens removed, pull bulb from the lamp while applying lateral pressure.
3. Install the new bulb into the lamp.
4. Position the light lens and install it

14.4 DRIVER’S AREA LIGHTS

Two halogen ceiling lights are installed over the stepwell and the driver’s area. These lights are frequently used for night-time operation when passengers board or leave coach.

14.4.1 Bulb Removal and Replacement

1. Unsnap the lamp with a flat head screwdriver and remove it.
2. Pull the defective bulb out of the socket.
3. Install the new bulb by pushing it in position
4. Replace the lamp by snapping it back in place.

Caution: *Do not touch halogen bulbs with bare hands as natural oils on skin will shorten bulb life span.*

14.5 PASSENGER SECTION LIGHTING

The passenger section of coach is lit by two types of fluorescent tube lamps installed on the parcel racks.
The aisle or indirect lights are located on front of parcel racks, and provide soft, indirect cabin lighting and parcel rack interior lighting. More powerful lighting for general and in-station applications is provided by fluorescent tubes located under the parcel racks, close to the windows. A dual power system is available for this lighting either from the 24 volt vehicle power supply or from a 110 volt outlet supply. In order to save batteries during extended periods of in-station lighting, no current is drawn from the batteries as soon as the 110 volt circuit is connected.

Moreover, adjustable reading lamps are installed under the parcel racks for passenger accommodation.

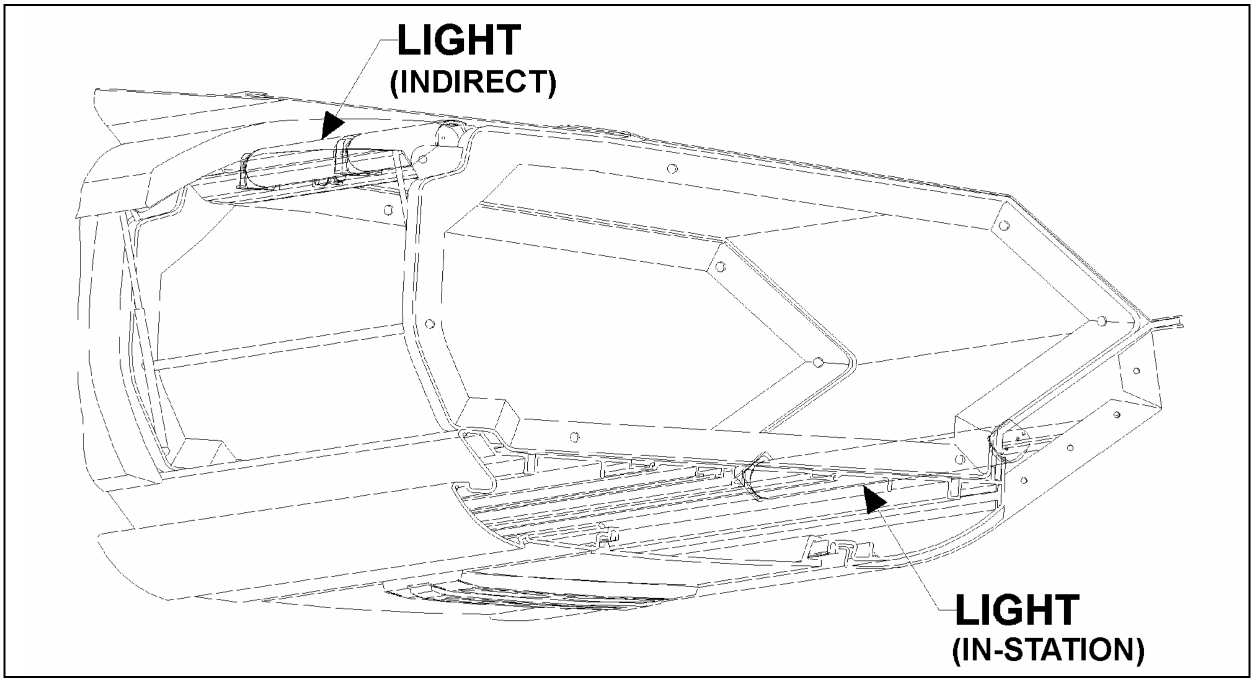


FIGURE 56: PARCEL RACK LIGHTING 06419

14.5.1 Fluorescent Tube Replacement

Indirect Fluorescent Light

1. Open the parcel rack access door, if so equipped, unscrew the two Phillips screws (one each end). Let the hinged cover down.
2. Remove fluorescent tube from light socket.
3. Install a new fluorescent tube.
4. Lift the hinged cover and replace the two retaining screws (Fig. 56).

Parcel Rack Interior Lighting

1. Open the parcel rack access door, if so equipped, unscrew the two Phillips screws (one each end). Pull the hinged cover down.
2. Push on the bulb, turn and then, pull it from the socket.
3. Install a new bulb.
4. Lift the hinged cover and replace the two retaining screws.

14.5.2 Removal and Replacement of In-Station Fluorescent Tubes

1. Start by pulling out the corner of the lens then delicately peeling it out of its seat.

Caution: *The lens is fragile. Be very careful when removing and handling.*

2. Rotate and pull the fluorescent tube from its sockets.
3. Install a new fluorescent tube, rotating the tube to secure it in the sockets.
4. Replace the screen lens by first inserting one side in the seat, then push the other side in and snap it in place by running it in from one corner to the next.

14.5.3 Removal and Replacement of Reading Lamp Bulb

1. Engage the tool (#830164) over the lamp and turn one quarter turn counterclockwise. Then, remove the tool slowly.
2. Pull the bulb socket off the reading lamp unit.
3. Push and turn bulb counterclockwise, then pull it out of the socket.
4. Install new bulb in the socket, then push and turn clockwise to lock bulb in position.
5. Push the bulb socket in the reading lamp unit.
6. Position the reading lamp with the tool (#830164), turn one quarter turn clockwise.

14.6 ENGINE COMPARTMENT LIGHTING

A switch located on R.H. side of rear junction box can be used to actuate the two oval engine compartment lights.

Each light is sealed and can be replaced as follows:

1. Disconnect the light unit connection.
2. Remove the lamp.
3. Position new lamp.
4. Connect the light unit.
5. Make sure the retaining ring is installed properly.

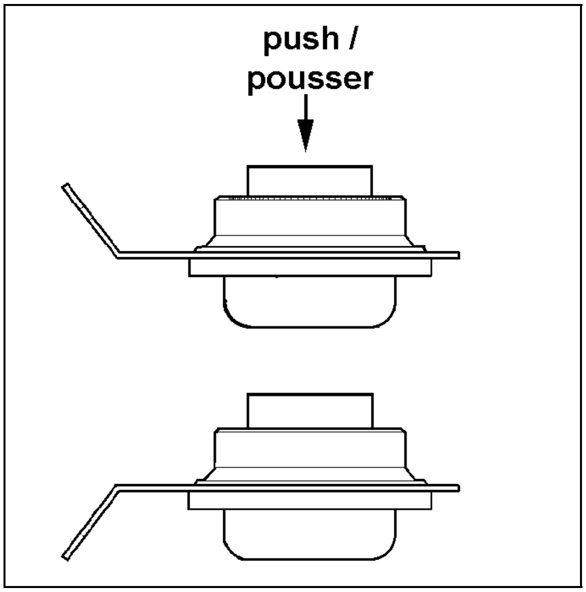


FIGURE 57: ENGINE COMPARTMENT LIGHT

14.7 LAVATORY LIGHT

The halogen lavatory light is installed on ceiling. A microswitch, mounted in the door exterior frame, is activated by the door lock mechanism upon locking to energize the circuit. This switch is readily serviced by removing the two Phillips-head screws securing the mounting plate to the door exterior frame.

Bulb removal and replacement:

1. Unsnap the lamp with a flat head screwdriver and remove it.
2. Pull the defective bulb out of the socket.
3. Install the new bulb by pushing it into position.
4. Replace the lamp by snapping it back in place.

Caution: *Do not touch halogen bulbs with bare hands as natural oils on skin will shorten bulb life span.*

15. LIGHT BULB DATA

When replacing a light bulb, special attention must be paid to the voltage rating (refer to light bulb data hereafter).

LIGHT BULB DATA					
APPLICATION	**PREVOST PART NO.**	**TRADE OR SAE NUMBER**	**WATTS OR CANDLE POWER**	**VOLTS**	**QTY**
EXTERIOR LIGHTING					
Hi/Lo-beam	930291	9004	65/45 W	12	2
Docking & cornering	930319	9415	37.5W	12	4
Fog	561882	H3 (OSRAM)	55 W	12	2
License plate (sealed)	930266	TL 15206	---	12	2
Marker Light (red)	930340	Grote 47072-3	---	12	2
Marker Light (amber)	930341	Grote 47073	---	12	10
Identification (red)	930334	TL 25420R	---	12	3
Clearance (red)	930334	TL 25420R	---	12	4
Identification (amber)	930337	TL 25450Y	---	12	3
Clearance (amber)	930337	TL 25450Y	---	12	4
Front directional (hazard & marker)	562135	3057	32/3W	12	2
Rear directional	560589	1156	32 W	12	4
Stop	560589	1156	32 W	12	8
Back-up	560589	1156	32 W	12	4
Center stop	930330	HELLA 96208	---	12	2
Cyclops	930330	HELLA 96208	---	12	1
Tail	560123	67	4 W	12	4
Exterior compartment (except engine)	562278	6429	10 W	24	12
Engine compartment	930383	SEALED	25 W	12	2

LIGHT BULB DATA					
APPLICATION	**PREVOST PART NO.**	**TRADE OR SAE NUMBER**	**WATTS OR CANDLE POWER**	**VOLTS**	**QTY**
INTERIOR LIGHTING					
Instrument cluster lights	562838	2721 MFX	---	12	---
Telltale panel assy.	562907	---	---	---	1
Step light (Coaches)	562278	6429	10 W	24	2
Lavatory	830176	Q20MR16	20 W	12	1
Parcel rack	560144	1820	1.6 W	12	A R
Driver's area	830176	Q20MR16	20 W	12	2
"EMERGENCY EXIT" decal	560601	456	2 W	24	A R
"LAVATORY OCCUPIED"	563108	168	3 W	12	1
"WATCH YOUR STEP"	561166	1820	1.6 cp	24	2
Aisle	560141	1251	3 W	24	A R
Reading	563260	303	6 W	24	A R
Fluorescent (In-Station)	830153	F32T8/SP41	32 W	---	A R
Destination sign fluorescent	830120	F30T8CW4	30 W	---	1
Fluorescent (Indirect)	830152	F13T5/CW	13 W	---	A R

16. SPECIFICATIONS

Battery

Make .... Volvo
Model 20359831
Type .... Maintenance-free
Terminal type .... Top Stud
Group size 31
Volts 12
Load test amperage 290
Reserve capacity (minutes) 195

Cold cranking (in amps)
-At 0°F (-18°C) .... 950 (each battery)

Maximum dimensions (inches/mm)
-Length (including flange) 13.0/330,2
-Width 6.7/169,3
-Height (including top posts) 9.3/237,0
-Approximate weight (lbs/kg) 59/26,7

❖ *Battery tester cable clamps should be between terminal nuts and lead pads of terminals. If not possible, load value should be 210 amperes.*

Torque specifications

Battery cable to post .... 10-15 Ft-lbs (13-20 Nm)
Battery cover .... 45-50 Ft-lbs (5-6 Nm)

Electrical system monitor

Make .... Vanner
Model EM-70
Input .... 24 V dc
System high .... Greater than 30 V dc
System low .... Less than 24 V dc
Trip level .... + 0.75 V dc
Prévost Number 562058

Alternator

Make .... Delco Remy
Model Number 1117702
Series 50DN
Type 600

Field current at 80°F (27°C)
-Amperes .... 7.2 – 8.0
-Volts 24

Hot output

-Amperes .... 270 at 80°F (27°C) ambient

-Volts 28

-Approximate rpm 3000

Ground .... negative

Prévost number 561723

Alternator

Make.. BOSCH
Model Number..0120689552
Series T1

Hot output

-Amperes.. 140 at 25°C (AMBIENT)
-Volts 28
-Approximate rpm.. 6000
Ground .... negative
Prevost Number 562752

Regulator

Make.. Delco-Remy
Model Number...
Type ....Transistor
Voltage adjustment .... External screw
Prévost number.. 562775

Battery equalizer

Make.. Vanner
Model... 60-100D
Amperes.. 100 amps
Prévost Number 563334

Starter

Make..Mitsubishi Electric Corporation (MELCO)
Model Number..M009T82479
Type 105P70
Voltage 24
Prévost Number 510752

No-load test
-Volts 23.5
-Max. current draw .... 125 amperes
-Min. rpm ....3000 rpm

Starter solenoid

Make..Mitsubishi Electric Corporation (MELCO)
Model Number.. 1115557
Pull In Voltage ....16 volts max.

Mitsubishi Electric Corporation (MELCO)

STARTER MOTORS (105P70)

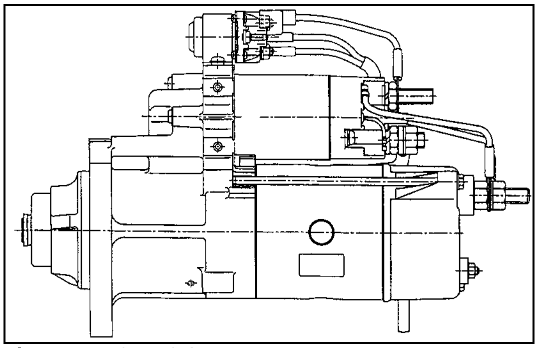


Figure 1 - 105P70 STARTER

A starter is one of the parts installed to the flywheel housing. MELCO's 105P70 starter uses the planetary gear reduction system, actualizing a compact and high-power starter. This starter weighs approximately 30 pounds (13.5 kg), extremely lightweight, and excels in handling.

In addition, this starter uses an overhung mechanism in the output shaft supporting structure designated to protect the inner starter parts from dust or water/oil splash.

1. Principle of operation

* When handling the starting system, be sure to refer to the wiring diagrams issued by the vehicle manufacturer to insure an understanding of the whole starting circuit.

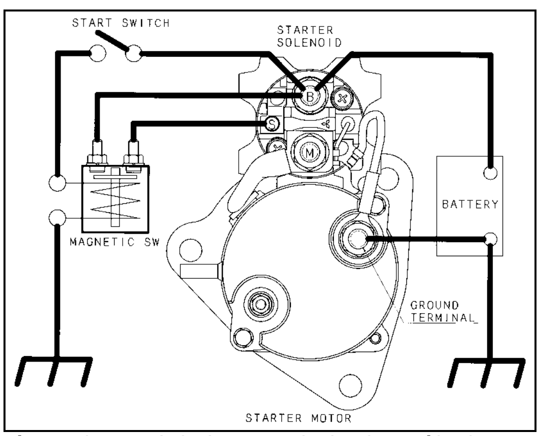


Figure 2 - BASIC STARTING CIRCUIT (GROUND-FLOAT TYPE)

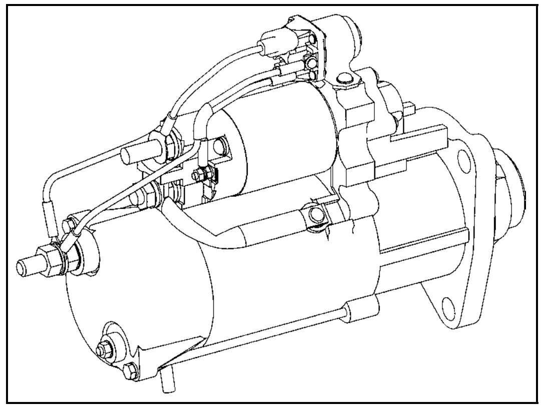


Figure 2 shows the circuit diagram for the 105P70 Ground-float type (sometimes referred to as Insulated or Isolated Ground).

The circuit diagram contains a start switch, a magnetic switch, and a starter solenoid.

When the start switch is closed, the current flows through the magnetic switch windings. The magnetic switch contacts are closed, enabling the current to flow through the windings in the starter solenoid. The clutch is thrust forward with the movement of the plunger and the lever (shown in figures 3), the pinion starts to rotate slowly by the above-mentioned current to engage with the ring gear. When the secure engagement is made, the main contacts in the starter solenoid are closed, and cranking takes place.

When the engine does not start during the initial cranking attempt, the start switch must be turned off within 30 seconds to protect the starter from excessive heat. If the starter motor is operated continuously for 30 seconds, it is necessary to allow the starter motor to be cooled off for at least 2 minutes before the next operation.

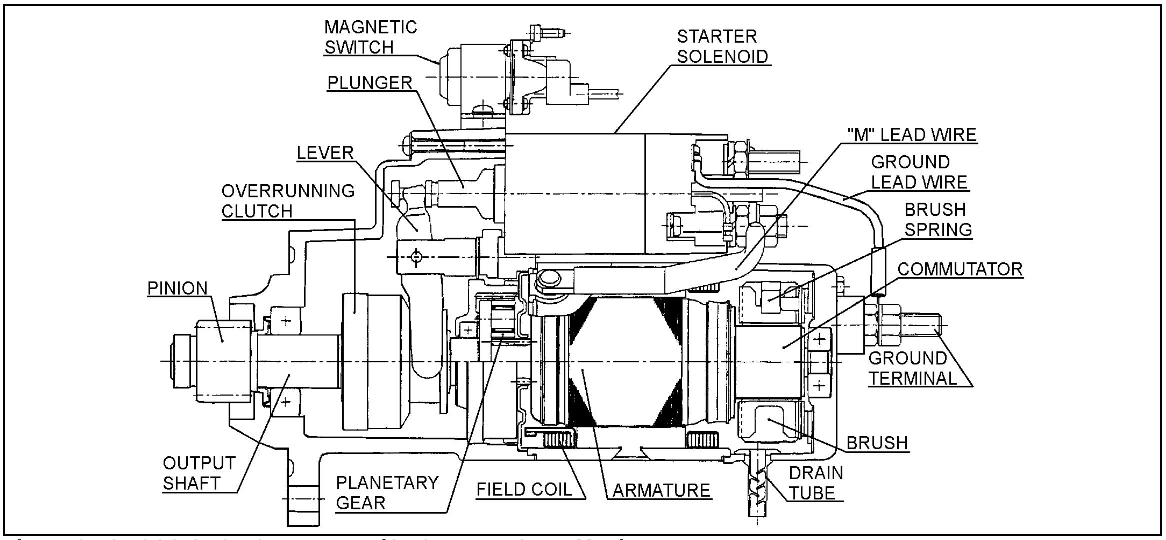


Figure 3 - CROSS-SECTIONAL VIEW (GROUND-FLOAT TYPE)

When the engine starts, the clutch prevents excessive overrun of the armature. Because the clutch is for a short-time rating, the start switch must be turned off immediately after the engine starts.

2. Troubleshooting the starting circuit

If the starting system is not functioning correctly, the following checks will assist in determining which part of the circuit is at fault.

2.1 Battery

To determine the condition of the battery, follow the testing procedure specified by the vehicle manufacturer. Ensure that the battery is fully charged. (If the battery is faulty, the other starting systems cannot be checked.)

2.2 Wiring

Inspect the wiring relating to the starting system for damage. Inspect all connections to the battery, start switch, magnetic switch, and starter solenoid for contact failure due to looseness or rust.

2.3 Magnetic switch (Directly attached to the starter)

Inspect the magnetic switch for its function with the start switch closed (i.e. key switch in the start position) by measuring the voltage between the S-terminal in the starter solenoid and the ground. The switch should not be closed for more than 3 seconds. If this time is exceeded, the starter solenoid may be damaged.

2.4 Ring gear and pinion

If the battery, wiring, and magnetic switch are in satisfactory condition, it is assumed that a "stuck" condition may be found (this condition is the phenomenon caused when the pinion is caught by the ring gear, thereby resulting in neither pinion rotation nor thrust movement). This only occurs in very rare cases when the ring gear and pinion teeth are damaged on their end faces. Therefore, remove the starter and check the end faces on the ring gear and pinion for damage (burr). If necessary, replace the ring gear and starter.

2.5 Starter

2.5.1 Pinion movement and starter solenoid operation test

As described in figure 4, inspect that the pinion advances forward (no rotation will occur) when a voltage of 16 to 24 V is applied to between the S-terminal in the starter solenoid and the ground. Inspection must be done within 3 seconds for voltage application. If the pinion does not advance forward, replace the starter. The P-coil in the starter solenoid may be layer-shorted, or the pinion sliding area may be clogged.

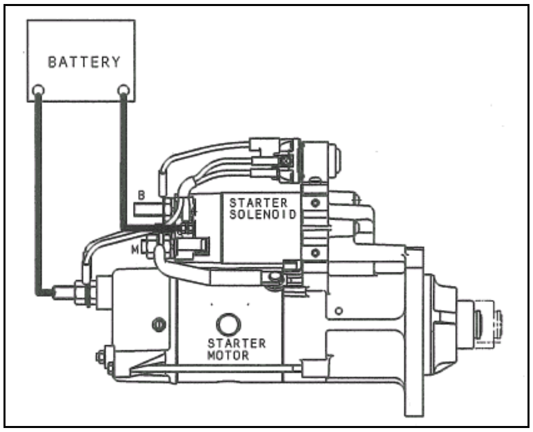


Figure 4 - TESTING PINION MOVEMENT AND PULL-IN WINDINGS (GROUND-FLOAT TYPE)

For the starter switch coils, refer to the switch circuit diagrams for the ground-wire type (ground-float type) shown in figures 5.

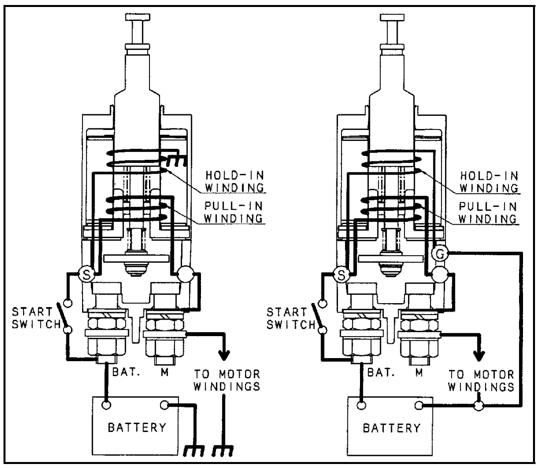


Figure 5 - SOLENOID CIRCUIT (GROUND-FLOAT TYPE)

If the pinion is performing properly, follow the procedure as described below to inspect the H-coil in the starter solenoid.
Remove the M-terminal nut as described in figure 6 and keep the lead wire end in contact with the M-terminal. Apply voltage between the S-terminal and the ground to let the pinion advance forward. Immediately after that, separate the lead wire from the M-terminal and check if the pinion stays in the advanced forward position while voltage is applied to the H-coil only. If the pinion returns, replace the starter. The H-coil is assumed to be layer-shorted.

* M-terminal nut tightening torque: 20 to 30 N·m

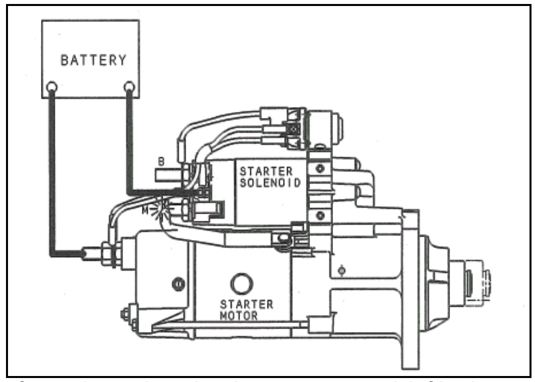


Figure 6 - TESTING HOLD-IN WINDINGS (GROUND-FLOAT TYPE)

Below are the resistance values for the P- and H-coils for reference.

Coil	Resistance (reference)
P-coil	0.072ohm at 68° F
H-coil	1.300 ohm at 68° F

2.5.2 No-load test

The no-load test makes it easy to inspect the starter for functional failure without disassembling. This test can also identify an open/short circuit that is difficult to check when disassembled.

As shown in figure 7, connect the starter, fully charged battery, ammeter, and voltmeter. If possible, connect a resistor suitable for voltage control in parallel with the battery. In addition, use an rpm indicator to measure the revolution speed of the output shaft.

Note: *Attention should be given to the output shaft which advances forward to approximately 0.8" (20 mm) and rotates at that position when the starter is operated.*

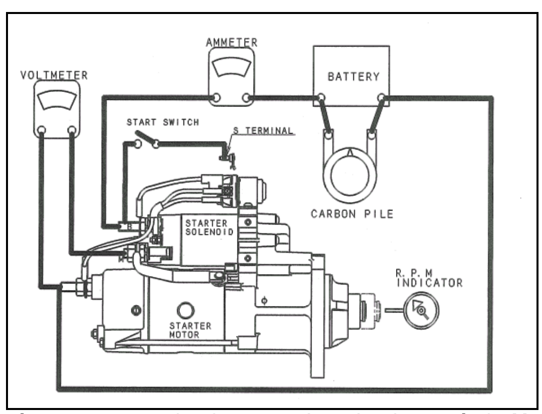


Figure 7 - NO-LOAD TEST CIRCUIT (BODY-GROUND TYPE)

* If the output shaft does not move, stop voltage application. If voltage continues to be applied, excessive heat will occur in the starter solenoid and give thermal damage to the coil, thereby making it unserviceable.

Inspect that the current and revolution speed satisfy the following standards when the start switch is closed.

Voltage	Current	Speed
23.5 V	125 A max.	3000 rpm min.

It is not necessary to adjust the voltage to the exact value of 23.5 V. If the voltage is slightly higher, the rpm will be proportionately higher, while if the voltage is lower, the rpm will be proportionately lower. The current is independent of the voltage, and can be judged using the above standard.

* Note that the starter solenoid will not operate unless the voltage between the S-terminal and the ground exceeds 16 V.

<u>Test result and possible cause</u>

1. Rated current draw and revolution speed indicate normal condition of the starter.
2. Low revolution speed and high current draw indicate:
   a. Too much friction inside starter motor such as clogging, dirt, wearing, faulty bearings
   b. Shorted circuit inside starter
3. No revolution of the output shaft indicates:
   a. Grounded M-lead wire or field coils
   b. Frozen bearings
4. No current draw indicates:
   a. Open field coils
   b. Open armature coils
   c. Broken brush springs, worn brushes, or high insulation resistance between brushes and commutator
5. Extremely low revolution speed and low current draw indicate:

   Poor connection between M-terminal and lead wire, or between bracket and brush holder screws (body-ground type only), damaged M-lead wire, damaged brush pig tails, or poor contact between commutator and brushes
6. High revolution speed and high current draw indicate:

   Shorted field coils

* In case of symptoms 2 to 6, replace the starter, because of the possible failures mentioned above.

<u>2.5.3 Output shaft play</u>

Before reinstalling the starter to the engine, follow the procedure below to inspect the output shaft clearance.

1. Remove the M-terminal nut and keep the lead wire end in contact with the M-terminal.
2. Apply voltage to between the S-terminal and the ground to let the pinion advance forward. Immediately after that, separate the lead wire from the M-terminal. The pinion stays in the advanced forward position until the battery is disconnected.
3. As described in figure 8, measure the distance between the shaft pressed-in and pulled-out positions. The play should be within 0.004" to 0.118" (0.1 to 3.0 mm). If the measured value does not satisfy the standard, replace the starter.

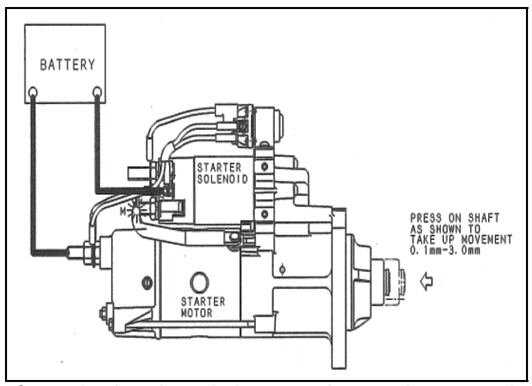


Figure 8 - CHECKING OUTPUT SHAFT CLEARANCE (GROUND-FLOAT TYPE)

Repair and Testing Instructions for T1 Alternator

0120 689 552

Modifications

Edition	Date	Name	Modifications
001	8/28/98	I. Serra	Original
002	12/4/98	I. Serra	Update 8.98 Instructions

Table of contents

1 General

This manual contains repair and testing instructions with corresponding test specifications for the 0 120 689 5... series alternators.

T1 (RL) 28V 70/140A

Note: Alternator 0 120 689 543 was utilized in preparing these instructions.

2 Safety Precautions

2.1 Special Tool Usage

The use of incorrect or unsuitable tools and test equipment can lead to personal injury and may damage the alternator or its component parts. Only use tools that are specified in this instruction or meet the specification of the recommended tools.

2.2 Fire Risk

To provide radio interference suppression, the alternator is equipped with capacitors with a long storage time. Cleaning of alternator components may cause and electrical discharge when they are immersed in cleaning fluid. This discharge may cause combustible liquids to ignite.

2.3 Skin Protection

To avoid skin irritation when handling oils and greases, apply protective gloves or creams before starting work and wash off hands with soap and water when servicing has been completed.

2.4 Compressed Air

Only use compressed air regulated to a maximum of 4 Bar (60 PSI), and a clean cloth for cleaning of the armature, excitation windings and alternator plates.

2.5 Explosion Risk

Avoid exposure to fire, open flame and sparks. Thoroughly dry all cleaned parts as gases could form from the cleaning process and may cause an explosion.

3 Specifications

3.1 Electrical Test Specifications

Interference suppression capacitor	1.8 … 2.6 μF (microfarad)
Load current less than/equal to 10A	27.6 … 28.4 V (volts, regulated)
Damping Resistance	3.1 … 3.5 kΩ (kilohms)
Stator Resistance	0.036 Ω (-0/+10%) T1 (RL) 28V70/140A
Rotor Resistance	7.5 Ω (-0/+10%) T1 (RL) 28V70/140A

Power Output Test

Alternator	Speed (RPM)	Load Current - Inductive (A)	Test Duration (Min)
T1 (RL) 28V70/140 A	1500	76	30
	6000	136	10

Following completion of the output test, allow alternator to run at 7000 rpm for one minute.

Oscilloscope Pattern

This image represents a properly functioning alternator. The D.C. voltage produced has a small harmonic wave.

Small spikes may be superimposed on the oscilloscope screen if the voltage regulator is regulating. Applying a load to the alternator output terminals can turn off the regulator.

In order to be able to compare oscilloscope images, the oscilloscope so the pattern fits between two vertical 10x divisions.

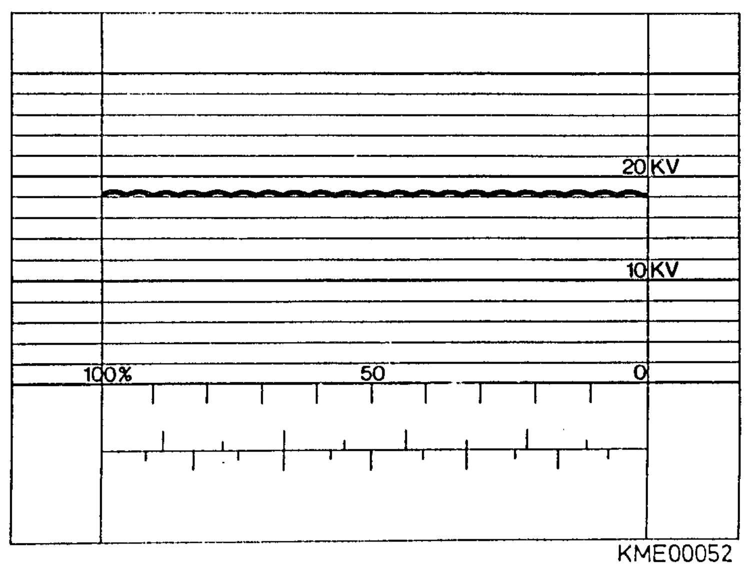


Figure 1 Normal Oscilloscope Pattern

3.2 Mechanical Test Specifications

Rotor to Stator Air Gap (Between any side of stator and rotor)		Greater than 0.3 mm (0.012 in)
Eccentricity (Rotor mounted at bearing points)	Outer Diameter Of Rotor	0.05 mm (0.002 in) maximum
	Outer Diameter Of Collector Rings	0.03 mm (0.0012 in) maximum
Collector ring diameter	New	32.5 mm (1.279 in)
	Used	31.5 mm (1.240 in) minimum
Carbon Brush Projection	New	16.0 mm (0.630 in) minimum
	Used	7.0 mm (0.275 in) minimum

3.3 Tightening Torques

Item Number	Description	Metric (Nm)	SAE
55	Air Intake Stud	3.0 … 3.4	26.5 … 30.1 in. lbs.
66	D+ Terminal	2.4 … 3.2	21.2 … 28.3 in. lbs.
29	B+ Terminal, B- Terminal	10.0 … 13.0	88.5 … 115 in. lbs.
37	W Terminal	4.1 … 5.5	36.3 … 48.7 in. lbs.
15	Voltage Regulator	1.3 … 1.7	11.5 … 15.0 in. lbs.
43	Capacitor Mounting Screw	4.3 … 5.7	38.0 … 50.4 in. lbs.
23	Rectifier Mounting Screw	1.3 … 1.7	11.5 … 15.0 in. lbs.
21	Drive End Shield to Collector Ring Shield	7.2 … 9.7	63.7 … 85.9 in. lbs.
5	Drive End Shield Bearing Cover Plate	4.1 … 5.5	36.3 … 48.7 in. lbs.
52	Pulley Retaining Nut	135 … 170	99.5 … 125.4 ft. lbs.

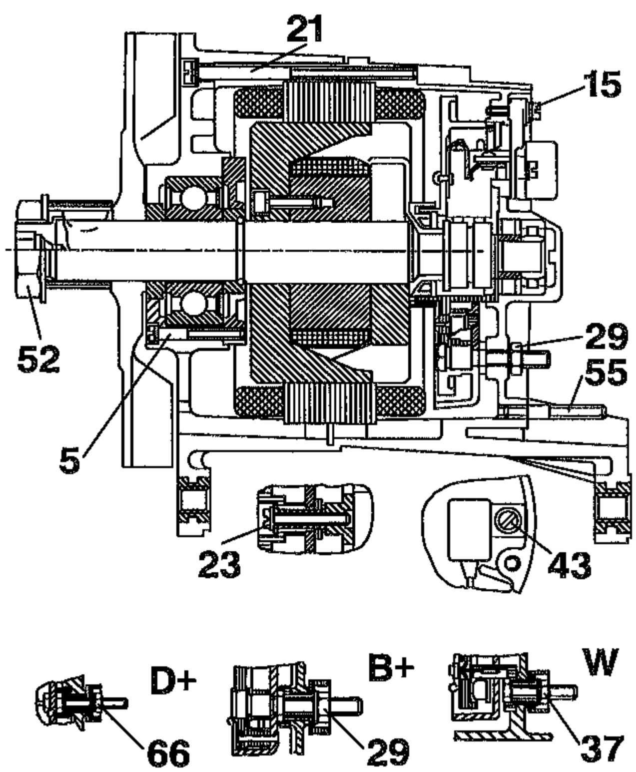


Figure 2 Fastener Torque Chart

4 Alternator Schematic

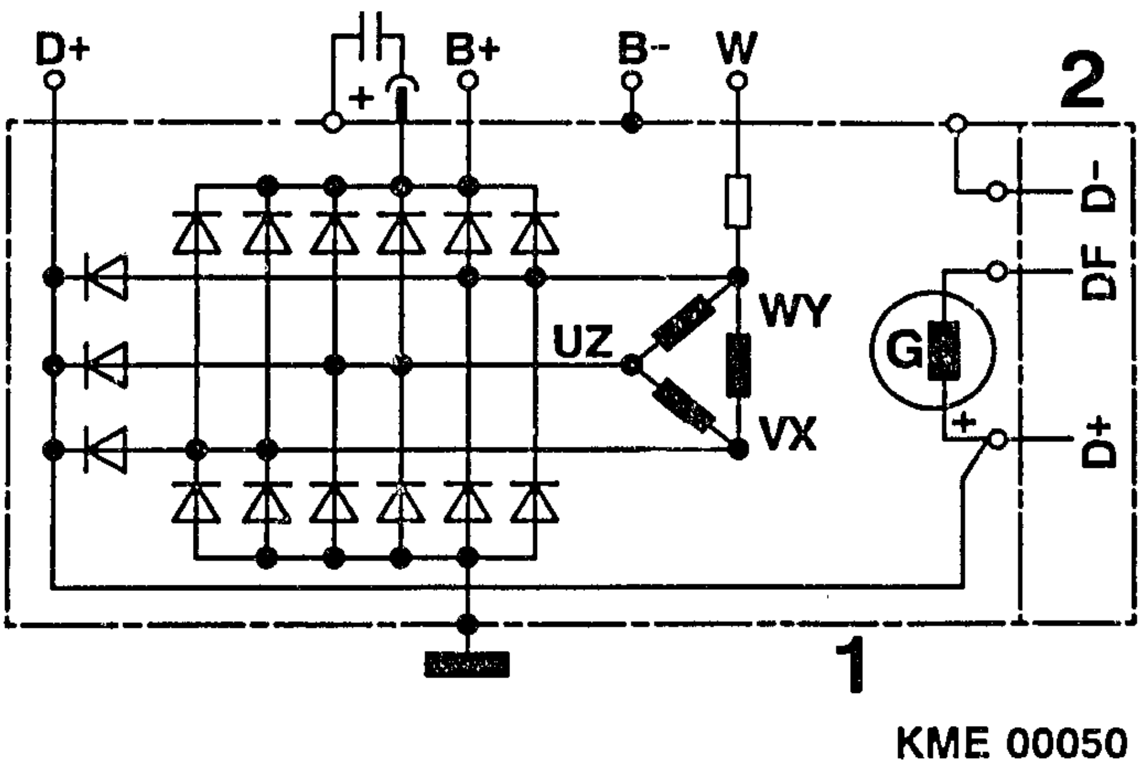


Figure 3 Alternator/Voltage Regulator Schematic

1 Alternator

B+ Battery Positive
B- Battery Negative
D+ Dynamo + (Warning Lamp Output)
W Tachometer Output

2 Voltage Regulator

D+ Dynamo + (Alternator Output)
DF Dynamo Field
D- Dynamo -

5 Alternator Coding

T 1 R 28V 70/ 140A

Rated current in amps measured at 6000 rpm

Rated current in amps measured at 1500 rpm

Alternator Voltage

Direction of Rotation

(→) Or R	Clockwise
(←) Or L	Counter Clockwise
(↔) Or RL	Multidirectional

1 Claw Pole Alternator
2 Salient Pole Alternator
3 Windingless Rotor Alternator

Outer Diameter of Alternator

G	100 … 109 mm
K	120 … 129 mm
N	130 … 139 mm
T	170 … 199 mm
U	more than 200 mm

6 Parts Cleaning

Caution: Fire Risk

To provide radio interference suppression, the alternator is equipped with capacitors with a long storage time. Cleaning of alternator components may cause and electrical discharge when they are immersed in cleaning fluid. This discharge may cause combustible liquids to ignite.

Alternator components with capacitors should only be cleaned with a non-combustible cleaner such as HAKU 1025/6.

Caution: Compressed Air

Only use compressed air regulated to a maximum of 4 Bar (60 PSI), and a clean cloth for cleaning of the armature, excitation windings and alternator plates.

Caution: Explosion Risk

Avoid exposure to fire, open flame and sparks. Thoroughly dry all cleaned parts as gases could form from the cleaning process and may cause an explosion.

7 Tools, Test Equipment Lubricants and Adhesives

7.1 Test Equipment

Description	Bosch Number	
Alternator Test Bench	Commercially Available	
Internal Short-Circuit Tester (Flash Tester)	KDAW 9978	0 986 619 110
Universal Multi-Meter	MMD 302	0 684 500 302
Alternator Tester	WPG 012.00	0 684 201 200

7.2 Special Tools

Description	Bosch Number	
Arbor Press	Commercially Available	
Soldering Iron	Commercially Available	
Universal Bearing Puller	Commercially Available	
V-Block *Note: 2 Required*	Commercially Available	
14mm Hex, 1/2" Drive Socket	Commercially Available	
Clamping Support	KDAW 9999	0 986 619 362
Die Spigot for Arbor Press (Used with KDLJ 6011, KDLJ 6012, KDLJ 6015)	KDLJ 6010	0 986 618 124
Bearing Remover	KDLJ 6009	0 986 618 121
Press Tool for Roller Bearing	KDLJ 6021	0 986 618 139
Bearing and Seal Installer	KDLJ 6011	0 986 618 125
Collector Ring Installer	KDLJ 6012	0 986 618 126
Drive End Shield Support Ring for Rotor Pressing	KDLJ 6013	0 986 618 127
Press Tool - Spacer Ring, Roller Bearing Inner Race and Collector Rings	KDLJ 6018	0 986 618 134
Alignment Pin - Drive End Shield and Collector Ring End Shield	KDLJ 6014	0 986 618 128
Removal Tool - Sliding Bushing	KDLJ 6015	0 986 618 129
Holding Tool - Sliding Bushing	KDLJ 6016	0 986 618 130
Inner Bearing Race Removal Tool	KDAW 9996	0 986 619 269
Puller Receiver Cup	KDAW 9995/0/1	0 986 619 214
Threaded Pin with Cone	KDAW 9995/14	0 986 619 250
Bearing Puller Spring Collet	KDAW 9995/6	0 986 619 233
Feeler Gauge 0.15 … 0.6 mm (.005 … .024 in) *Note: 4 required*	KDZV 7399	0 986 618 378
Dial Indicator	EFAW 7	1 687 233 011
Magnetic Indicator Stand	T-M 1	4 851 601 124

7.3 Lubricants and Adhesives

Description	Manufacturer Number	Bosch Number
Roller Bearing Grease	UNIREX N3	5 975 560 125
	Ft1 v 34	5 700 009 000
	VS 15164-Ft	5 975 560 000
Molycote Paste	Ft 70 v 1	5 700 040 000
Adhesive Dispersant	KK57v1	5 703 151 000
Silicon Paste	Ft2v4	5 700 083 005

7.3.1 Lubricant Quantities

Bottom of Roller Bearing	2 g (0.07 oz.)
Collector End Shield Radial Seal	2 g (0.07 oz.)
Roller Bearing	2…2.5 g (0.07…0.09 oz.)

8 Exploded View

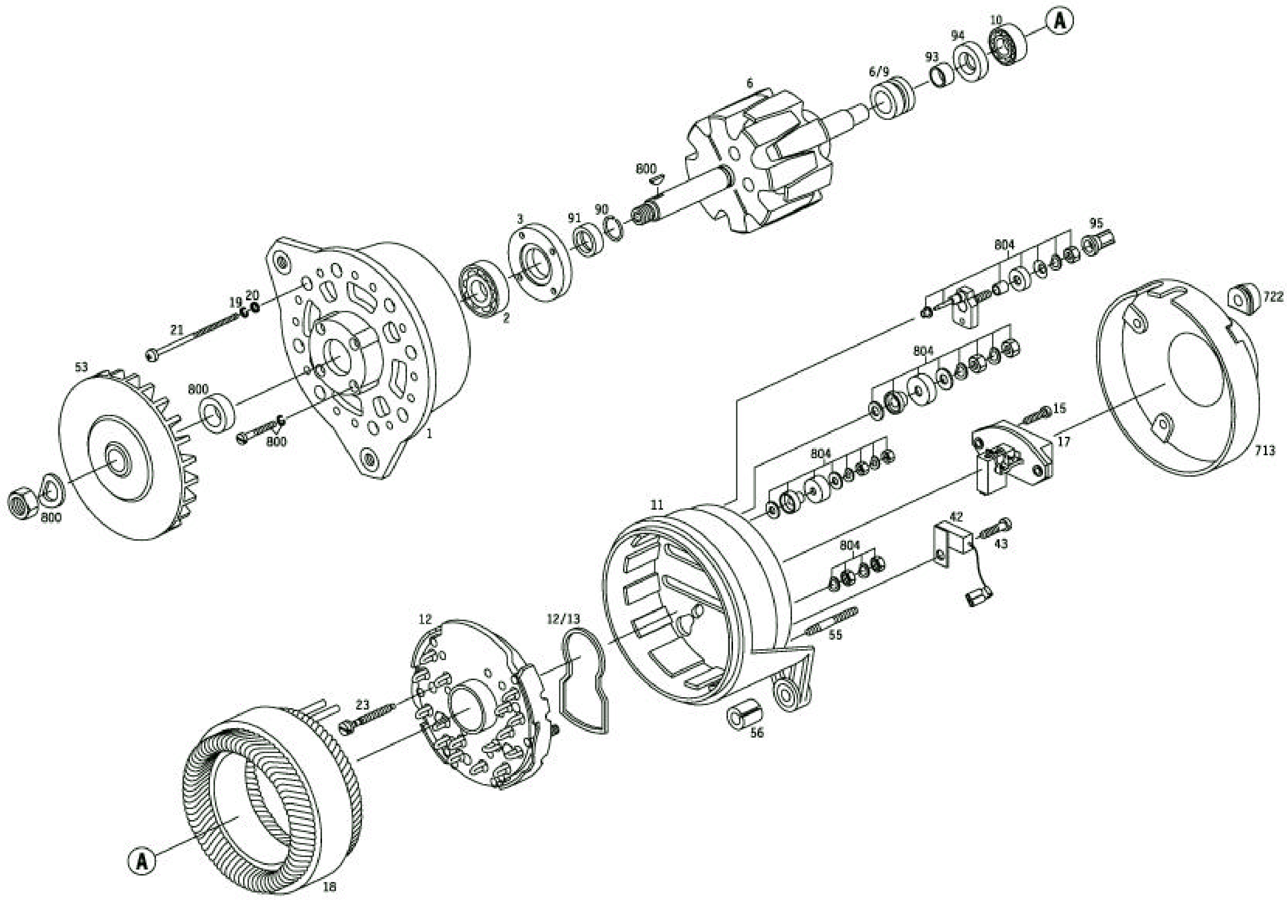


Figure 4 Alternator Exploded View

Item	Designation	Item	Designation
1	Drive End Shield	20	Plain Washer
2	Ball Bearing	21	Oval-Head Screw
3	Cover Plate	23	Washer & Screw Assembly
6	Rotor	42	Suppression Capacitor
6/9	Collector Ring	43	Oval-Head Screw
10	Roller Bearing	53	Fan
11	Collector-Ring End Shield	55	Stud
12	Rectifier	56	Expansion Bushing
12/13	Seal	90	Retainer
15	Washer & Screw Assembly	91	Support Ring
17	Transistor Regulator	93	Spacer Ring
17/3/8	Compression Spring	94	Radial Seal
17/3/801	Carbon-Brush Set	95	Protective Cap
17/10	Gasket	713	Air-Intake Cover
18	Stator	722	Grommet
19	Spring Lock Washer		

9 Alternator Disassembly and Testing

9.1 Rear Cover Removal

1. Clamp alternator in clamping fixture KDAW 9999 (Bosch Number 0 986 619 362).

2. Remove four nuts holding on the air intake cover. (Figure 5)

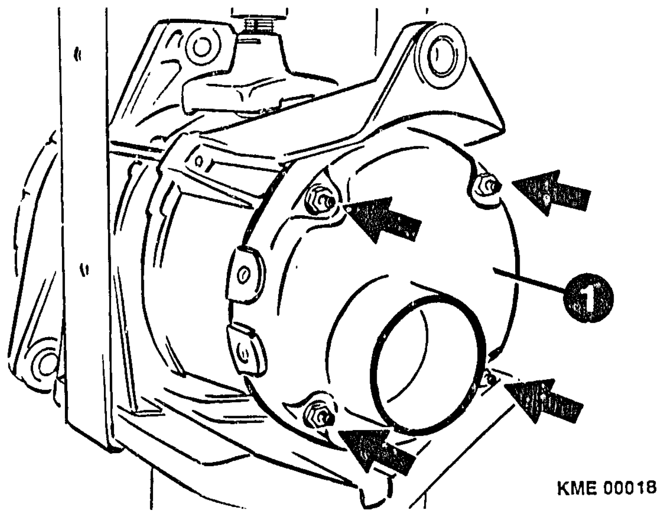


Figure 5 Air Intake Cover Removal (1)

Note: The voltage regulator must be removed before any further disassembly of the alternator takes place. The brushes of the regulator can break if the regulator is not removed before any other disassembly takes place.

9.2 Voltage Regulator Removal

1. Remove the three (3) screws that secure the regulator to the collector ring end shield. (Figure 6)

2. Carefully remove the voltage regulator from the collector ring end shield.

Note: The brushes of the regulator will break if the regulator is not removed before any other disassembly of the alternator takes place.

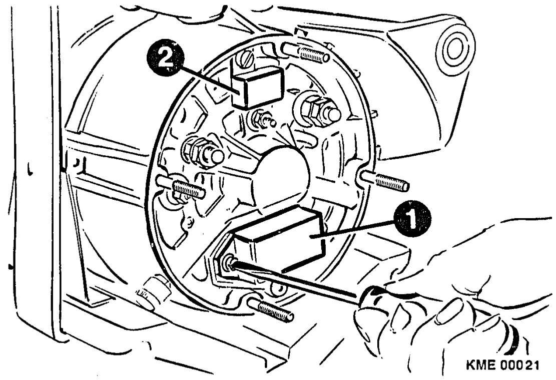


Figure 6 Voltage Regulator (1) and Suppression Capacitor (2)

9.2.1 Brush Replacement

1. The exposed length of the carbon brushes must be measured to determine if they require replacement. Measure the length of each brush. If the exposed brush length is less than 7 mm (0.276"), the brush must be replaced. (Figure 7)

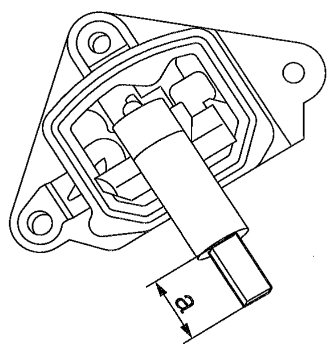


Figure 7 Brush Length Measurement

2. To replace the brushes, the brush lead must be unsoldered and the brush removed from the regulator.

3. Insert the new brush into the regulator and solder the brush lead to the regulator.

Note: Use only rosin-core solder to attached the brush lead.

4. Check the brushes for freedom of movement after they are soldered.

5. Measure the exposed length of the new brushes. The exposed length should be 16 mm (0.630")

9.3 Noise Suppression Capacitor Testing and Removal

1. Disconnect the suppression capacitor from terminal B+.

2. Connect Multimeter MMD 302 (Bosch Number 0 684 500 302) or equivalent to the lead of the suppression capacitor and the B- terminal of the alternator. (Figure 8)

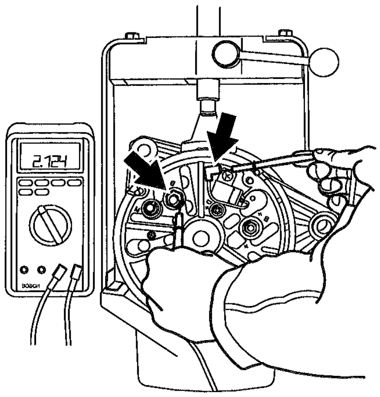


Figure 8 Testing of Suppression Capacitor

3. Measure the capacitance of the suppression capacitor. If the capacitance does not read between 1.8 and 2.6 μF (microfarad), the capacitor must be replaced.

4. Remove the screw that secures the suppression capacitor and remove capacitor.

Note: After removing the suppression capacitor from the alternator, the capacitor lead should be shorted to the capacitor-mounting strip to discharge the capacitor. Failure to do so may cause the capacitor to discharge while being cleaned.

9.4 Pulley and Fan Removal

1. Using a 14-mm hex socket to hold the rotor shaft. Loosen and remove pulley-retaining nut with a box wrench. (Figure 9)

Note: Do not use an air impact gun to remove the nut as the force of the impact may cause damage to the alternator bearings.

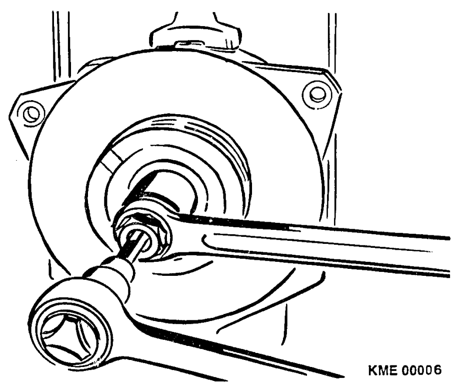


Figure 9 Pulley and Fan Removal

2. Remove the pulley and cooling fan from the alternator.

9.5 Separation of Drive Shield and Collector End Shield

Note: With a scribe, mark the relationship between the drive end shield and the collector ring end shield. This will assist in the realigning of the two shields upon reassembly.

1. Loosen and remove the four (4) outer Oval-head screws which hold the end shields together. (Figure 10)

2. Slide the drive end shield and rotor out of the collector end shield.

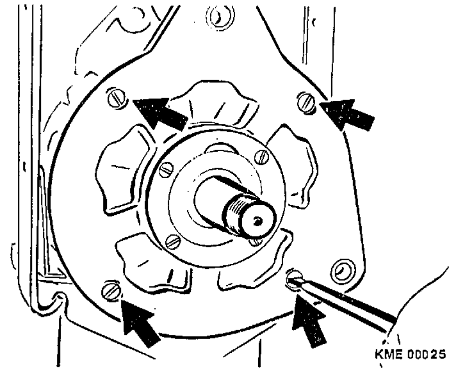


Figure 10 Drive End Shield Removal

9.6 Rectifier Assembly Testing

Note: The following testing of the rectifier is to be performed with the rectifier assembly installed and wired in to the stator.

1. With the rectifier assembly still installed in the collector end shield, testing of the rectifier is to be performed.

   a. Using tester WPG 012.00 (Bosch Number 0 684 201 200) (Figure 11)

   i) Connect the negative (black) lead of the tester to the collector end shield and the positive (red) lead to each of the stator connection solder joints.

   ii) Connect the positive (red) lead of the tester to the B+ Terminal and the negative (black) lead to each of the stator connection solder joints.

   iii) Connect the positive (red) lead of the tester to the D+ Terminal and the negative (black) lead to each of the stator connection solder joints.

The rectifier assembly is reusable if the tester remains in green zone. If the rectifier assembly fails any test, one or more of the diodes are defective and the whole assembly must be replaced.

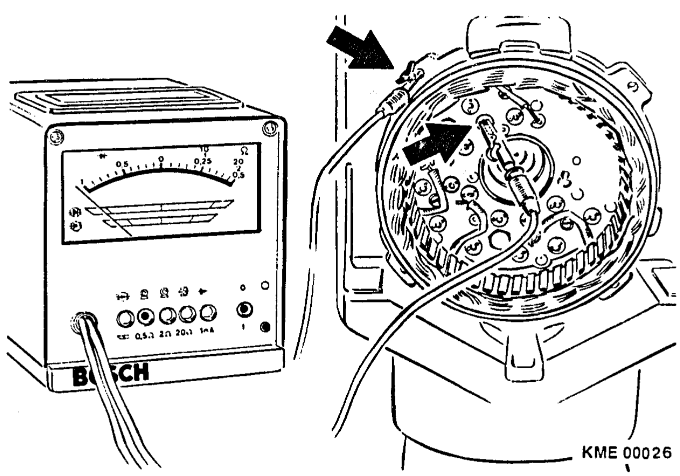


Figure 11 Testing of Rectifier Assembly

b. Using a Diode Tester

i) Connect the negative (black) lead of the tester to the collector end shield and the positive (red) lead to each of the stator connection solder joints. No current should pass through the rectifier assembly.

ii) Connect the positive (red) lead of the tester to the collector end shield and the negative (black) lead to each of the stator connection solder joints. Current should pass through the rectifier assembly.

iii) Connect the positive (red) lead of the tester to the B+ Terminal and the negative (black) lead to each of the stator connection solder joints. No current should pass through the rectifier assembly.

iv) Connect the negative (black) lead of the tester to the B+ Terminal and the positive (red) lead to each of the stator connection solder joints. Current should pass through the rectifier assembly.

v) Connect the positive (red) lead of the tester to the D+ Terminal and the negative (black) lead to each of the stator connection solder joints. No current should pass through the rectifier assembly.

vi) Connect the negative (black) lead of the tester to the D+ Terminal and the positive (red) lead to each of the stator connection solder joints. Current should pass through the rectifier assembly.

If the rectifier assembly fails any test, one or more of the diodes are defective and the whole assembly must be replaced.

9.7 Removal and Testing of Stator Assembly

1. With tester WPG 012.00 or Multimeter MMD 302 set to read 0 to 0.5 Ω, test the resistance of the stator while it is still attached to the rectifier assembly. Connect the test leads between the phase outputs of the stator. Repeat the test until all three phases of the stator has been tested. A good stator will read between 0.036 Ω and 0.040 Ω. (Figure 12)

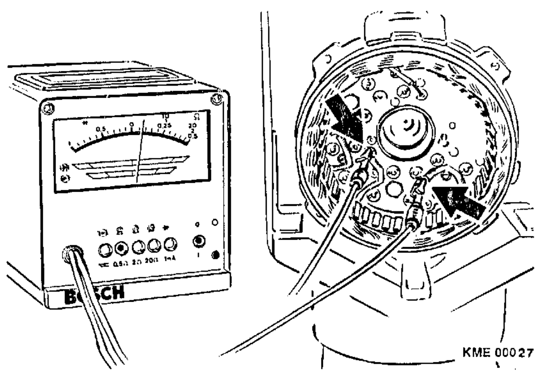


Figure 12 Stator Resistance Testing

2. Unsolder the stator phase connections from the rectifier assembly with a soldering gun or iron.

3. Bend open any bent-over lead connections with a screwdriver or pliers and pull the stator leads from the rectifier eyelets.

Note: The insulation tester applies a voltage of 80 VAC to the stator. Voltages of 80V can be fatal. When performing this test, observe care is used in handling the stator and any component or surface that is exposed to the stator. Use insulated gloves and do not touch the work surface until all tests are completed.

4. Using insulation tester KDAW 9983 (Bosch Number 0 986 619 110) or equivalent, apply 80 VAC to each of the stator phase leads with one probe while the other probe is in contact with the exterior of the stator. (Figure 13)

   No continuity should be present. Any continuity between the stator phase leads and the exterior of the stator indicates a breakdown of the stator insulation and a short to ground. If continuity is present, the stator must be replaced.

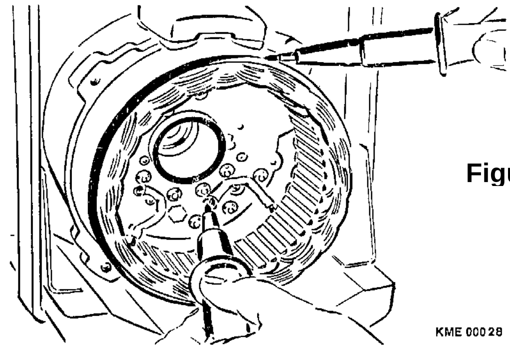


Figure 13 Stator Insulation Testing

9.8 Rectifier Assembly Removal

1. Loosen and remove the three screws that hold the rectifier to the collector end shield. (Figure 14)
2. Unsolder the W terminal from the rectifier assembly.

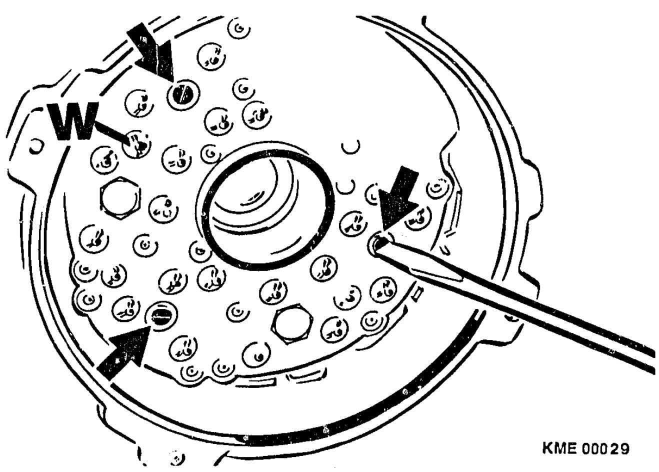


Figure 14 Rectifier Assembly Removal

3. Remove the nuts holding terminals B+, B- and D+ to the collector end shield.

   Note: Do not attempt to remove the studs from the rectifier assembly. Terminals B+, B- and D+ are permanently attached to the rectifier assembly. Terminal W is attached to the collector end shield. Do not loosen Terminal W.

4. Remove the rectifier assembly from the collector end shield.

9.9 Dampening Resistor Testing and Removal

1. The W Terminal incorporates a dampening resistor. Using a Multimeter MMD 302, connect one lead to the exterior portion of the W terminal and connect the other lead to the other side of the W Terminal. The Multimeter should read between 3.1 and 3.5 k (kilohm). If the resistance is above or below this range, the W terminal is to be replaced as an assembly. (Figure 15)

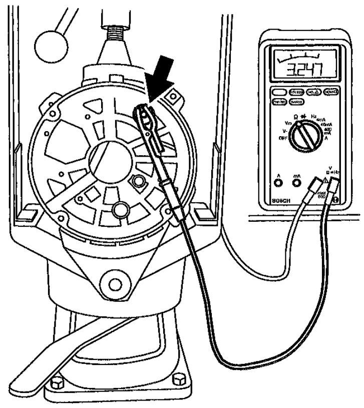


Figure 15 Testing of W Terminal Dampening Resistor

2. Loosen the nut retaining terminal W to the collector end shield.

3. Remove terminal W.

9.10 Removal of Collector End Shield Bearing and Seal

1. Insert extractor KDLJ 6009 (Bosch Number 0 986 618 121) into bearing.

2. Screw threaded rod KDAW 9995/14 (Bosch Number 0 986 618 214) into extractor KDLJ 6009.

3. Slide the receiver cup KDAW 9995/0/5 (Bosch Number 0 986 619 250) onto threaded rod.

4. Screw on the handle, rotate until the bearing, and seal come out of the collector end shield. (Figure 16)

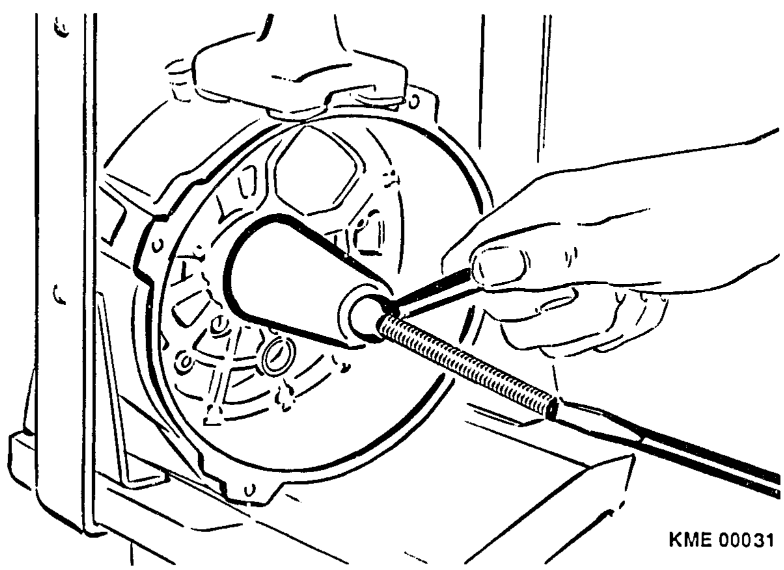


Figure 16 Bearing and Seal Removal

5. If the roller bearing is stuck in end shield, proceed as follows:

   a. Remove extractor KDLJ 6009 from the bearing.
   b. Destroy the bearing cage with a screwdriver or similar tool.
   c. Remove rollers from bearing.
   d. Insert spring collet KDAW 9995/6 (Bosch Number 0 986 619 233) into bearing outer race.
   e. Screw threaded rod KDAW 9995/14 into extractor KDAW 9995/6.
   f. Slide the receiver cup KDAW 9995/0/5 onto threaded rod.
   g. Screw on handle and rotate until the bearing race comes out of the collector end shield.

9.11 Removal of Sliding Bushing in Collector End Shield

1. Place collector end shield in an arbor press, support mounting/pivot boss on mandrel KDLJ 6016 (Bosch Number 0 986 618 130). (Figure 17)

2. Place bushing mandrel KDLJ 6015 (Bosch Number 0 986 618 219) on sliding bushing.

3. Press sliding bushing out of collector end shield into mandrel KDLJ 6016.

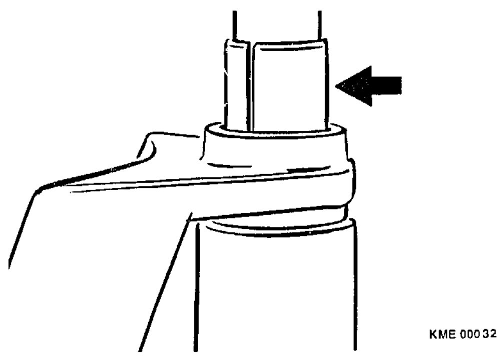


Figure 17 Sliding Bushing Removal

9.12 Removal of Rotor from Drive End Shield

1. Place drive end shield onto pressing ring KDLJ 6013 (Bosch Number 0 986 618 127).

2. Place pressing ring into an arbor press. (Figure 18)

3. Press out rotor.

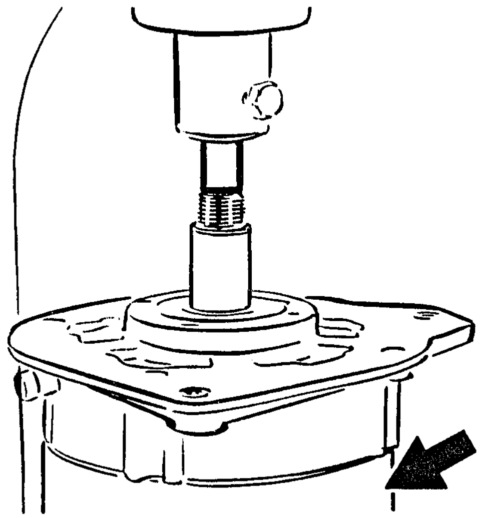


Figure 18 Pressing out Rotor

4. Remove spacer ring from rotor shaft.

Notes: Protect the threads of the rotor from damage prior to pressing. Always replace the drive end bearing if the rotor has been pressed out. Therefore, only remove the rotor if;

- *the rotor is to be replaced*
- *the excitation winding of the rotor is to be replaced*
- *the drive end bearing/spacer ring is to be serviced*
- *the rotor collector rings are to be replaced*

9.13 Removal of Bearing and Seal from Drive End Shield

1. Loosen and remove the four (4) screws holding the bearing cover plate. (Figure 19)

2. Remove the spacer ring (Refer to arrow in Figure 19).

3. Remove the bearing from the drive end shield.

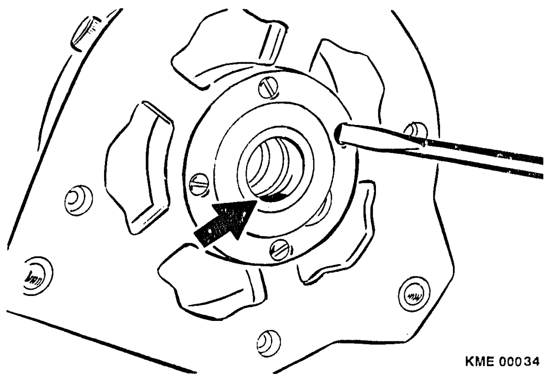


Figure 19 Drive End Bearing Removal

9.14 Removal of Collector Ring End Inner Bearing Race from Rotor

1. With a universal bearing puller, remove the inner race of the endshield bearing. (Figure 20)

Notes: *Place jaws of the puller yoke behind the inner-bearing race and pull the bearing race only. Do not place the yoke behind the spacer ring. Pulling both the bearing and the spacer ring at the same time may damage the rotor. The inner bearing race must be replaced anytime the collector end shield bearing is replaced.*

2. Reposition the puller and remove the spacer ring from the rotor shaft.

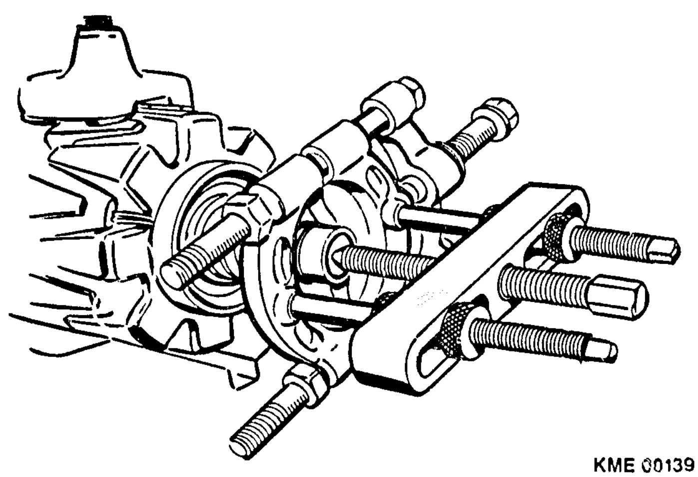


Figure 20 Inner Bearing Race Removal

9.15 Rotor Inspection

1. Using electric tester ETE 014.00 or Multimeter MMD 302, measure the resistance between the two collector rings of the rotor. The resistance measured should be between 7.5 and 8.3 . (Figure 21)

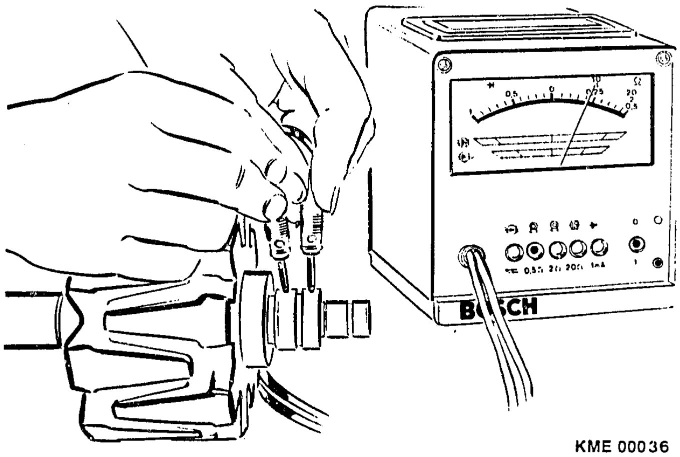


Figure 21 Rotor Resistance Testing

2. Using insulation tester KDAW 9983 or equivalent, apply 80 VAC to the rotor claw poles and each of the collector rings. If the insulation tester lights, there is a short to ground within the rotor. (Figure 22)

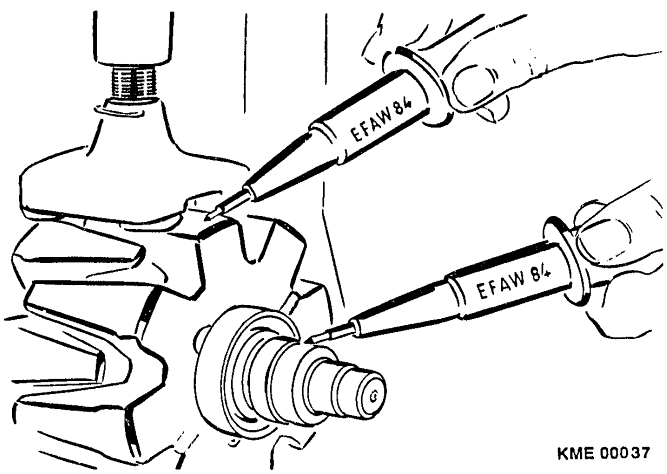


Figure 22 Rotor Insulation Testing

Note: The insulation tester applies a voltage of 80 VAC to the rotor. Voltages of 80V can be fatal. When performing this test, observe care is used in handling the rotor and any component or surface that is exposed to the rotor. Use insulated gloves and do not touch the work surface until all tests are completed.

3. Mount the rotor in a pair of V-Blocks at the rotor bearing points.

4. Position dial indicator (Magnetic Base T-M 1 (Bosch Number 4 851 601 124) and Dial Indicator EFAW 7 (Bosch Number 1 687 233 011)) to measure the concentricity of the rotor at:: (Figure 23)

   a. Outer diameter of rotor, maximum run-out 0.05 mm (0.002 in). If the run-out of the rotor exceeds the maximum, the rotor must be replaced.

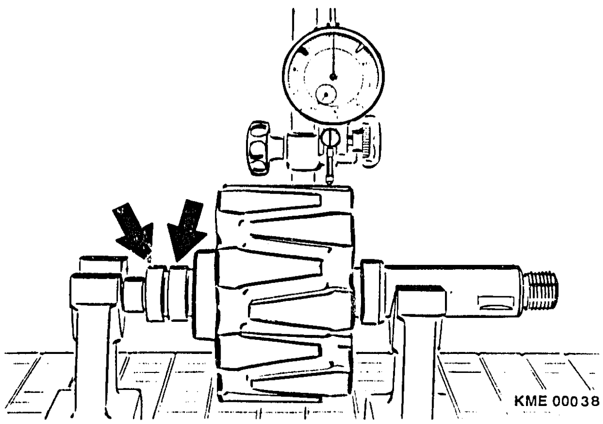


Figure 23 Rotor Concentricity Measurement

   b. Each collector ring, maximum run-out 0.03 mm (0.0012 in). If the run-out exceeds the maximum, the collector rings can be machined down to a minimum of 31.5 mm (1.240 in) diameter. If the required machining causes the collector ring diameter to drop below the minimum dimension, the collector ring(s) must be replaced.

9.16 Collector Ring Replacement

1. Before the collector rings can be removed, the spacer ring from the end of the rotor must be removed. Refer to Section 9.14 *"Removal of Inner Bearing Race from Rotor."*

2. Unsolder the rotor leads from each collector ring.

3. With a universal bearing puller, remove each collector ring one at a time from the rotor. (Figure 24)

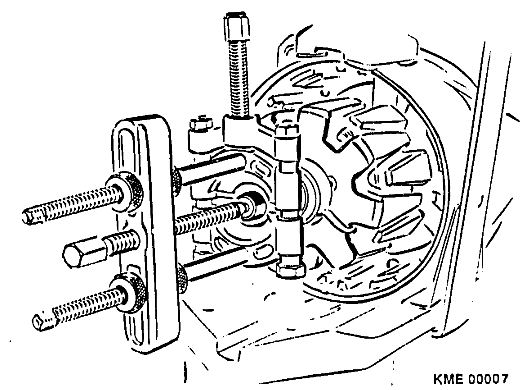


Figure 24 Collector Ring Removal

10 Alternator Assembly

10.1 Rotor Assembly

1. Position rotor in arbor press with the drive end pointing down.

2. Press the lead for the rotor winding into the slot of the rotor.

3. Slide the collector rings onto the rotor shaft as far as possible by hand. Make sure the lead for the rotor windings does not become damaged while sliding the collector rings over the lead.

4. Lining up the slot in tool KDLJ 6012 (Bosch Number 0 986 618 126) with the rotor lead, press the collector rings onto the rotor as far as possible. (Figure 25)

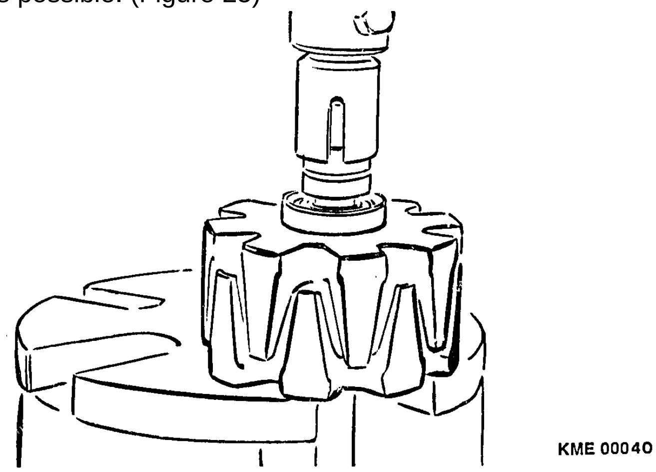


Figure 25 Pressing on Collector Rings

5. Solder each of the rotor winding leads to one of the collector rings with rosin core solder.

6. After soldering, touch up surface of collector ring to remove any excess solder from the brush contact surface.

7. Press on collector end shield bearing spacer ring with tool KDLJ 6018 (Bosch Number 0 986 618 134) until it contacts the stop on the rotor and no air gap is present. (Figure 26)

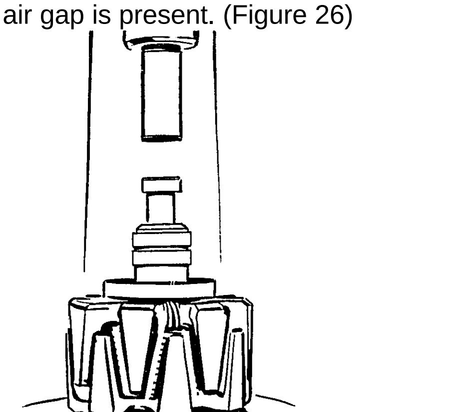


Figure 26 Spacer Ring

Note: Do not allow the spacer ring to twist while pressing onto the rotor.

8. Place the inner bearing race of the collector end shield bearing onto the rotor shaft.
9. Press the bearing onto the rotor shaft with tool KDLJ 6018. (Figure 26)

10.2 Drive End Shield Assembly

1. Insert sealed ball bearing into the drive end shield.
2. Align the holes of the bearing cover plate with the holes in the drive end shield.
3. Start the four screws which hold the bearing cover plate and tighten to 4.1 … 5.5 Nm (36.3 … 48.7 in. lbs.) (Figure 27)

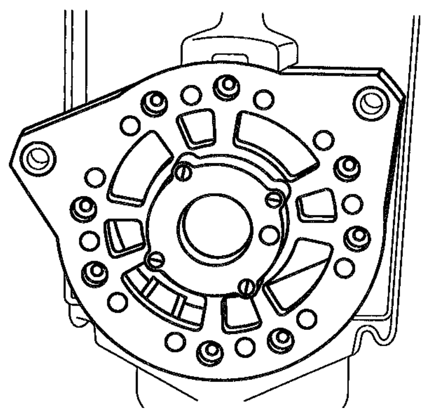


Figure 27 Drive End Bearing Retaining Screws

4. Insert bearing/fan spacer ring into the drive end shield from the fan side of the shield.
5. Place drive end shield on to an arbor press with the bearing/fan spacer ring pointed down. (Figure 28)
6. Slide support ring onto the drive end of the rotor. Make sure the under cut side of the ring faces the retaining ring on the rotor.

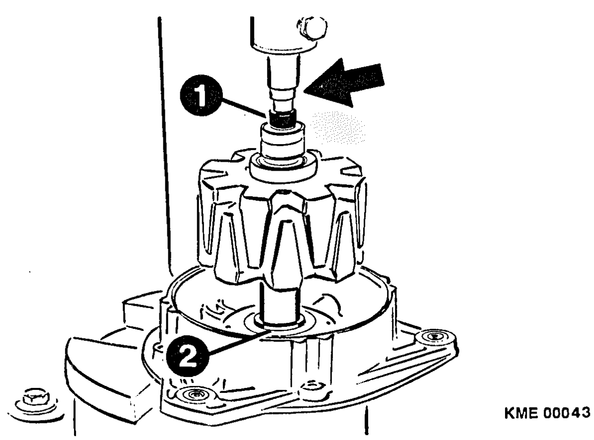


Figure 28 Installing Rotor into Drive End Shield
(1) Tool KDLJ 6018 (2) Support Ring

7. Place rotor into the drive end bearing.

8. Place tool KDLJ 6018 onto the end of the rotor and press the rotor into the drive end bearing until the bearing seats against the support ring.

10.3 Collector Ring End Shield Assembly

1. Pack the collector end roller bearing with 2 to 2.5 g (0.07 to 0.09 oz.) of UNIREX N3 grease.

2. Place the end shield on an arbor press.

3. Place tool KDLJ 6011 (Bosch Number 0 986 618 125) into bearing and press bearing into collector end shield. (Figure 29)

4. Pack the bottom of the collector end housing bearing bore with an additional 2 g (0.07 oz.) of UNIREX N3 grease.

5. Coat the sealing lip of the radial lip seal and pack the seal with 2 g (0.07 oz.) of UNIREX N3 grease.

Notes: Do not assemble the alternator with a dry radial seal as this will lead to seal failure and contamination of the brushes and collector rings.

Make sure there is no excess grease on the exterior of the seal before installation in the collector end shield. Excess grease on the exterior of the seal will cause contamination of the collector rings and brushes.

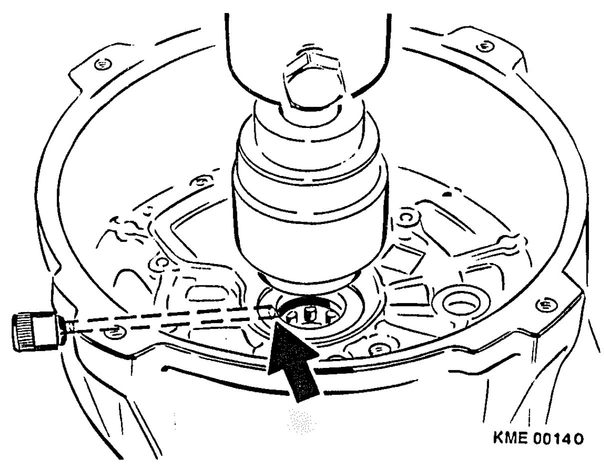


Figure 29 Installation of Bearing and Seal

6. Place seal onto tool KDLJ 6011 and press the seal into the collector end shield. (Figure 29)

7. Place collector end shield in an arbor press, support mounting/pivot boss on tool KDLJ 6016. (Figure 30)

8. Coat the inside of the collector end shield bore with Molycote.

9. Place sliding bushing into place on collector end shield.

10. With tool KDLJ 6015, press sliding bushing into end shield until the bushing is flush with the inner surface of the mounting/pivot boss. (Figure 30)

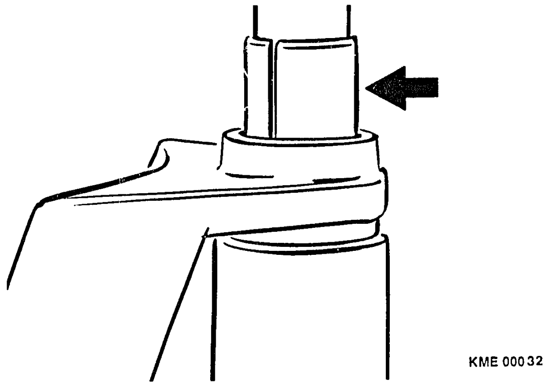


Figure 30 Sliding Bushing Installation

11. Insert terminal W into collector end shield in location marked W. Make sure the locating lug of the terminal assembly indexes the end shield correctly.

12. Place insulator and flat washer onto terminal W.

13. Install nut and torque to 4.1 to 5.5 Nm (36.3 to 48.7 in. lbs.)

14. Install protective cap onto terminal W. (Figure 31)

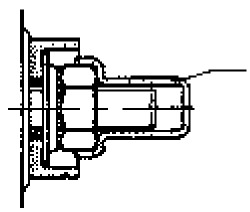


Figure 31 Terminal W Insulator, Washer, Nut and Cap

10.4 Rectifier Assembly

1. Place flat washer and insulator (a) onto terminal B+ and D+ studs of the rectifier assembly. (Figure 32)

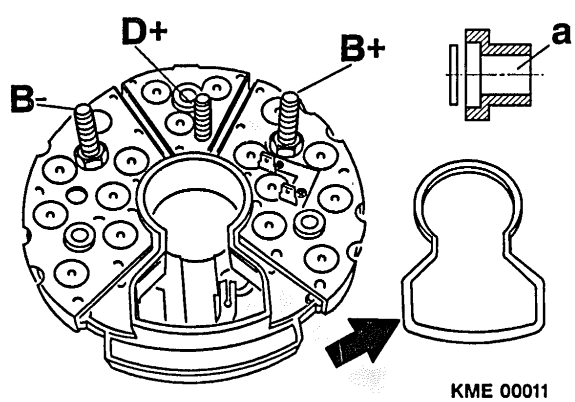


Figure 32 Rectifier Insulators and Seal

2. Coat the keyhole shaped surface of the rectifier with adhesive. (Figure 32)

3. Place the rectifier seal ring onto the keyhole shaped surface of the rectifier. Make sure the seal conforms to the shape of the keyhole.

4. Once the adhesive has cured, place the rectifier into the collector end shield. Make sure the solder lug of the W Terminal passes into the correct position of the rectifier assembly.

5. Install the insulating washer, flat washer and nut to terminal studs B+ and D+. (Figure 33)

6. Install flat washer and nut onto terminal stud B-. (Figure 33)

7. Check that the soldering lug of terminal W is still in the proper location of the rectifier assembly.

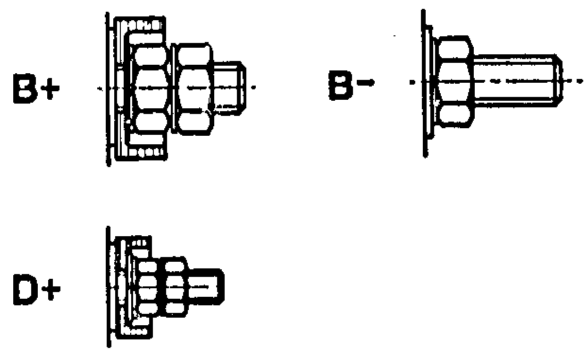


Figure 33 Terminal B+, B- and D+ Assembly

8. Torque terminal stud nuts B+, D+ and B- to:
   a. Terminal B+ and B-........ 10 to 13 Nm (88.5 to 115 in. lbs.)
   b. Terminal D+................... 2.4 to 3.2 Nm (21.2 to 28.3 in. lbs.)

9. Install the flat washer and second nut to terminal studs B+, D+ and B- and torque to:
   a. Terminal B+ and B-........ 10 to 13 Nm (88.5 to 115 in. lbs.)
   b. Terminal D+................... 2.4 to 3.2 Nm (21.2 to 28.3 in. lbs.)

10. Install the three (3) rectifier mounting screws and torque to 1.3 to 1.7 Nm (11.5 to 15 in. lbs.).

11. Solder the soldering lug of terminal W to the solder pad of the rectifier assembly with rosin core solder. (Figure 34)

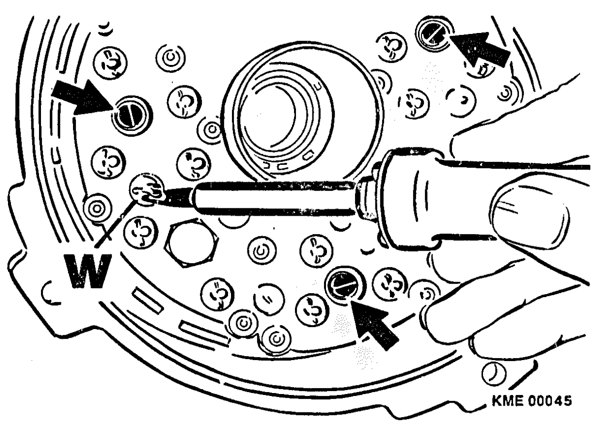


Figure 34 Rectifier Mounting and Soldering of Terminal W

10.5 Stator Assembly

1. Position the stator on the collector end shield. The side of the stator with the winding leads should be closest to the collector end shield.
2. Line up the scribed mark of the stator with the scribed mark of the collector end shield. If either the stator or collector end shield was replaced, a new mark should be scribe across the new part using the replaced component as a reference.

3. Place each of the stator leads into a corresponding soldering lug of the rectifier assembly. After the lead is through the soldering lug, bend the lead so it forms a U around the lug. (Figure 35)

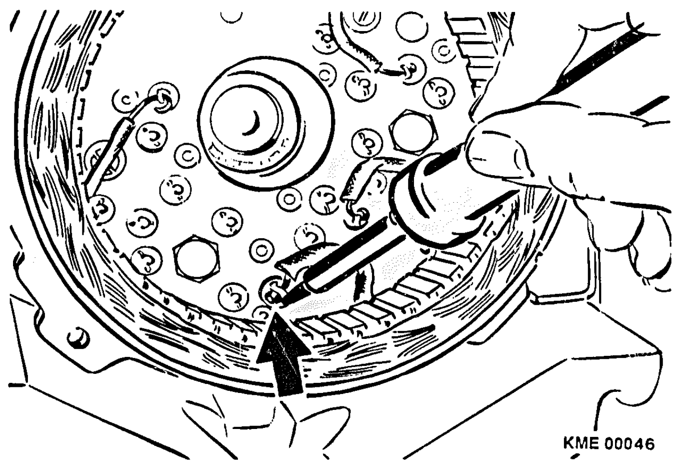


Figure 35 Soldering of Stator Leads

4. Solder each of the stator leads to the rectifier assembly with rosin core solder.

10.6 Rotor and Drive End Shield Installation

1. Place collector end shield and stator assembly on a suitable surface so the rotor and drive end shield assembly can be lowered into place

2. Guide the rotor and drive end shield assembly until the inner bearing race of the collector end bearing enters the roller bearing. Once the inner race enters the bearing, lower the assemblies completely into the collector end shield.

3. Insert guide pin KDLJ 6014 (Bosch Number 0 986 618 128) through the sliding bushing of the collector end shield and the bushing of the drive end shield. (Figure 36)

4. Start the four (4) drive end shield to collector end shield screws.

5. Place the alternator assembly into clamping fixture KDAW 9999.

6. Insert four (4) 0.3 mm (0.012 in) feeler gauges between the stator and the rotor. The feeler gauges should be place in four diametrically opposed positions. (Figure 36)

7. Torque the drive end shield to collector end shield screws to 7.2 to 9.7 NM (21.2 to 28.3 in. lbs.).

8. Remove the four feeler gauges from between the stator and rotor.

9. Turn the rotor by hand. The rotor should rotate freely by hand. If the rotor does not turn freely, loosen the drive end shield to collector end shield screws and repeat steps 6, 7, 8 and 9.

10. While rotating the rotor by hand, listen for contact between the rotor and the stator or stator leads. If any contact sound is heard, the rotor and drive end shield assembly must be removed, the cause determined and repaired before continuing. Once the problem has been corrected, start at step 1 of this section.

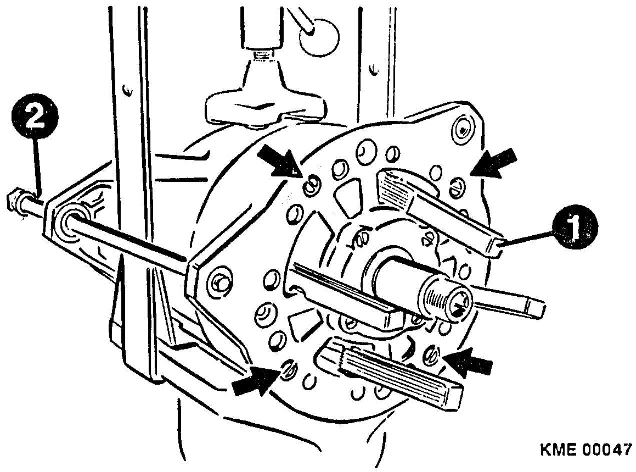


Figure 36 Drive End Shield, Stator and Collector End Shield Assembly
(1) Feeler Gauge (2) Tool KDLJ 6015

11. Remove the alignment pin KDLJ 6014 from the alternator.

10.7 Regulator and Capacitor Installation

1. Depress the carbon brush closest to the regulator into the regulator/brush holder.

2. Insert a straightened paper clip (1 to 1.3 mm dia. x 40mm) into the hole of the regulator until the pin holds the brush in place.

3. Pivot the regulator into the opening of the alternator. Once the brush holder is inside the alternator cavity, slowly remove the paper clip and allow the brushes to extend from the holder. (Figure 37)

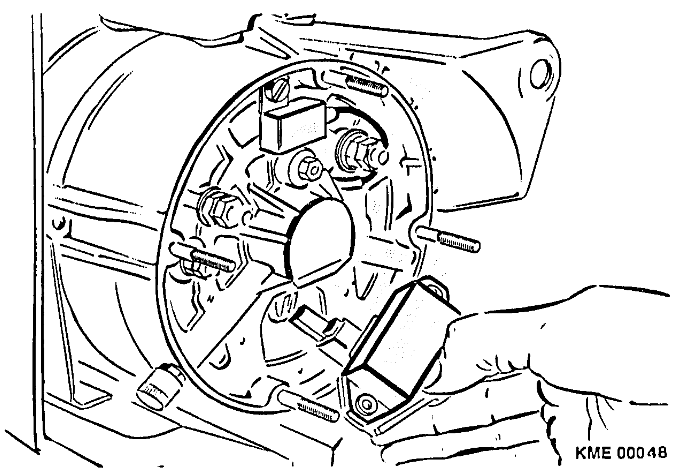


Figure 37 Regulator Installation

4. Align the mounting holes of the regulator to holes of the alternator housing.

Note: When aligning the mounting holes, pay attention to the force used as damage can occur to the brushes.

5. Install the three (3) regulator mounting screws and torque to 1.3 to 1.7 Nm (11.5 to 15 in. lbs.). (Figure 38)

6. Install capacitor on collector end shield and tighten mounting screw to 4.3 to 5.7 Nm (38.0 to 50.4 in. lbs.). (Figure 38)

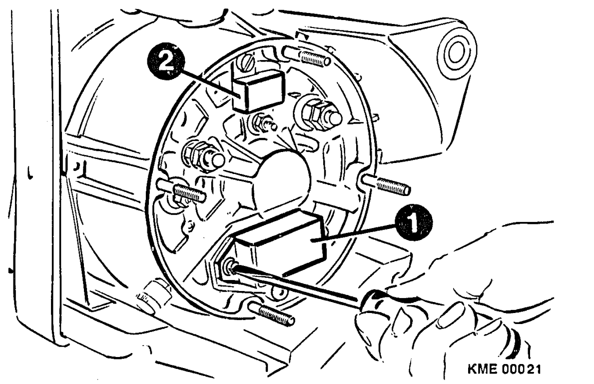


Figure 38 Capacitor Installation
(1) Voltage Regulator (2)

7. Connect lead of capacitor to spade terminal +.

8. Install air intake cover onto alternator. Do not torque cover until it has been installed on the vehicle/engine.

11 Functional Testing

11.1 General Information

The functional testing of the alternator is broken into two categories, Power Output and Voltage Trace Evaluation. All of the tests describe here are performed with the voltage regulator installed on the alternator.

11.1.1 Power Output Tests

The power output tests verify the capability of the alternator to produce rated current and voltage at different speeds. This test requires a test bench of sufficient horsepower to turn a fully loaded alternator at a given speed. Additionally, the test bench must have the ability to inductively load the alternator to its rated amperage for an extended amount of time.

The power output test is to be performed anytime the alternator is suspected of being defective or if the alternator has been disassembled.

11.1.1.1 Test Bench Requirements

To perform the power output test of this series alternator, a test bench must meet the following minimum criteria.

Characteristic	Minimum Specification
Variable Speed Control	0 - 12,000 RPM
Drive Motor	4 kW (5.4 hp)
Load Bank Capability	170 A @ 28 V for 10 minutes 80 A @ 28 V for 30 minutes
Output Voltage Capability	28 V

11.1.2 Voltage Trace Evaluation

The voltage trace evaluation compares the output of the alternator as viewed on an oscilloscope to know oscilloscope patterns. The voltage trace evaluation is an important tool for diagnostics of an alternator that cannot meet the criteria of the power output test. Proper interpretation of the waveforms obtained can lead a technician to the defective component of a failed alternator. The voltage trace evaluation is done while the alternator is still mounted to the alternator test bench. Most any oscilloscope, which is capable of accepting the alternator voltage output, is useable for this evaluation.

11.2 Power Output Testing

11.2.1 Test Bench Mounting

1. Mount the alternator to the test bench per the operating instructions of the test bench manufacturer.

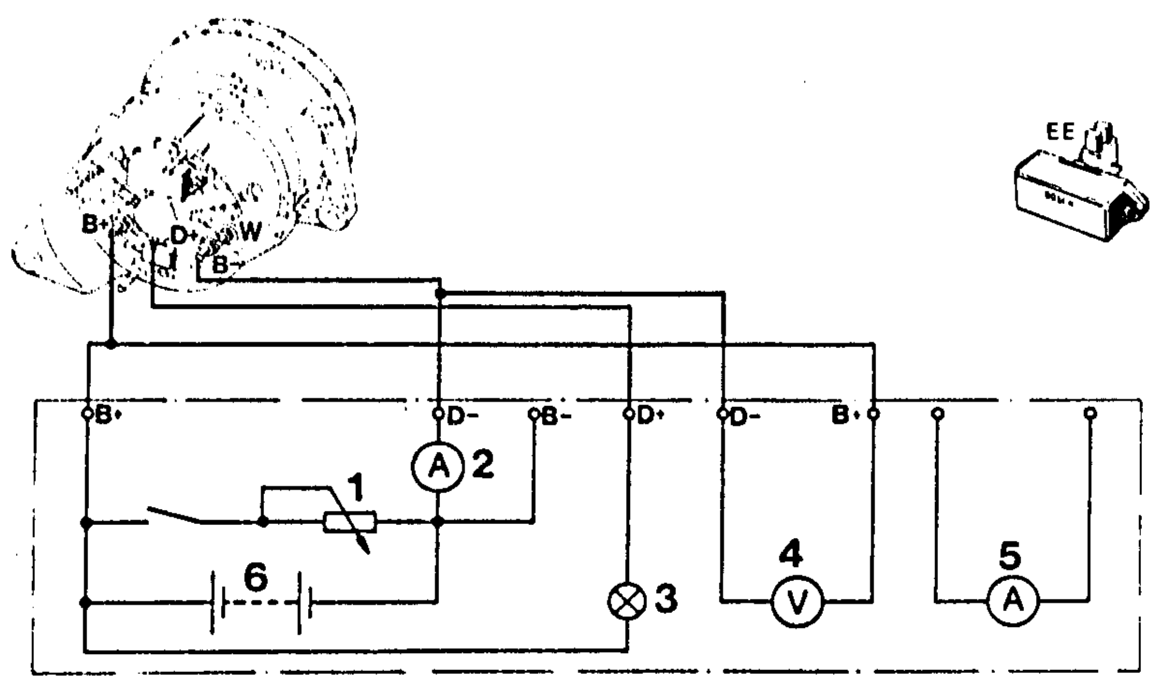
2. Connect the drive system of the test bench to the alternator as per the instructions of the test bench manufacturer.

Note: Only perform the power output tests with the fan pulley installed on the alternator. Failure to test the alternator with the correct fan installed can cause the alternator to overheat and damage the internal components of the alternator.

3. Connect the test leads of the test bench to the alternator as follows:

a. Connect the +24 v lead of the test bench to the B+ terminal of the alternator.
b. Connect the -24 v lead of the test bench to the B- terminal of the alternator.
c. Connect the charging indicator lamp of the test bench to the D+ terminal of the alternator.

Note: Refer to test bench manufacturers operating instructions for correct terminology of test leads
Refer to figure 39 for a schematic outline of alternator to test bench connections. Compare this schematic to the hook-up schematic of your test bench.



KME 00049

Figure 39 Alternator Test Bench Hook-up Schematic

(1) Variable Load Resistor
(2) Ammeter (Alternator Output)
(3) Charging Indicator Lamp
(4) Voltmeter (Regulated Voltage)
(5) Ammeter
(6) Test Bench Battery

4. Make sure the test bench is set for the correct voltage and rotation before starting tests.

11.2.2 Power Output Test

1. Start test bench and increase speed to 1500 rpm, alternator speed.

2. Increase inductive load on the alternator until 76A output is achieved. As load is increased, monitor test bench speed and correct if speed drops while applying load.

3. Hold test bench at this speed and load for 30 minutes. Monitor alternator output and speed during the test period.

4. Remove load and operate the alternator at 7000 rpm for one minute to allow the alternator to cool.

5. Refer to the test bench operating instructions and allow the load bank to cool the required amount of time before proceeding to the next test.

6. After the load bank has cooled, increase the test bench until the alternator has reached 6000 rpm.

7. Increase inductive load on the alternator until 136A alternator output is achieved. As load is increased, monitor test bench speed and correct if speed drops while applying load.

8. Hold test bench at this speed and load for 10 minutes. Monitor alternator output and speed during the test period.

9. Remove load and operate the alternator at 7000 rpm for one minute to allow the alternator to cool.

10. Refer to the test bench operating instructions and allow the load bank to cool the required amount of time before proceeding to the next test.

11. Apply a minimum load of 10A to the alternator.

12. Measure the regulated voltage of the alternator. The correct regulated voltage is between 27.6 and 28.4 volts.

13. If the alternator passes the three output tests, no further testing is required. If the alternator failed any of the three tests, proceed with the voltage trace evaluation.

11.3 Voltage Trace Evaluation

The voltage trace evaluation is a comparison of the voltage output of the alternator to know patterns. These know patterns will help identify different failed components.

11.3.1 Oscilloscope Hook-up

1. Following the manufacturer's instructions for your oscilloscope, connect the scope to the B+ and B- terminals of the alternator.

2. Adjust the oscilloscope to read 28 volts.

3. Turn on test bench and operate the alternator with a 10A load.

4. Compare oscilloscope display to the following test patterns.

11.3.2 Normal Pattern

This image represents a properly functioning alternator. The D.C. voltage produced has a small harmonic wave.

Small spikes may be superimposed on the oscilloscope screen if the voltage regulator is regulating. Applying a load to the alternator output terminals can turn off the regulator.

In order to be able to compare oscilloscope images, the oscilloscope so the pattern fits between two vertical 10x divisions.

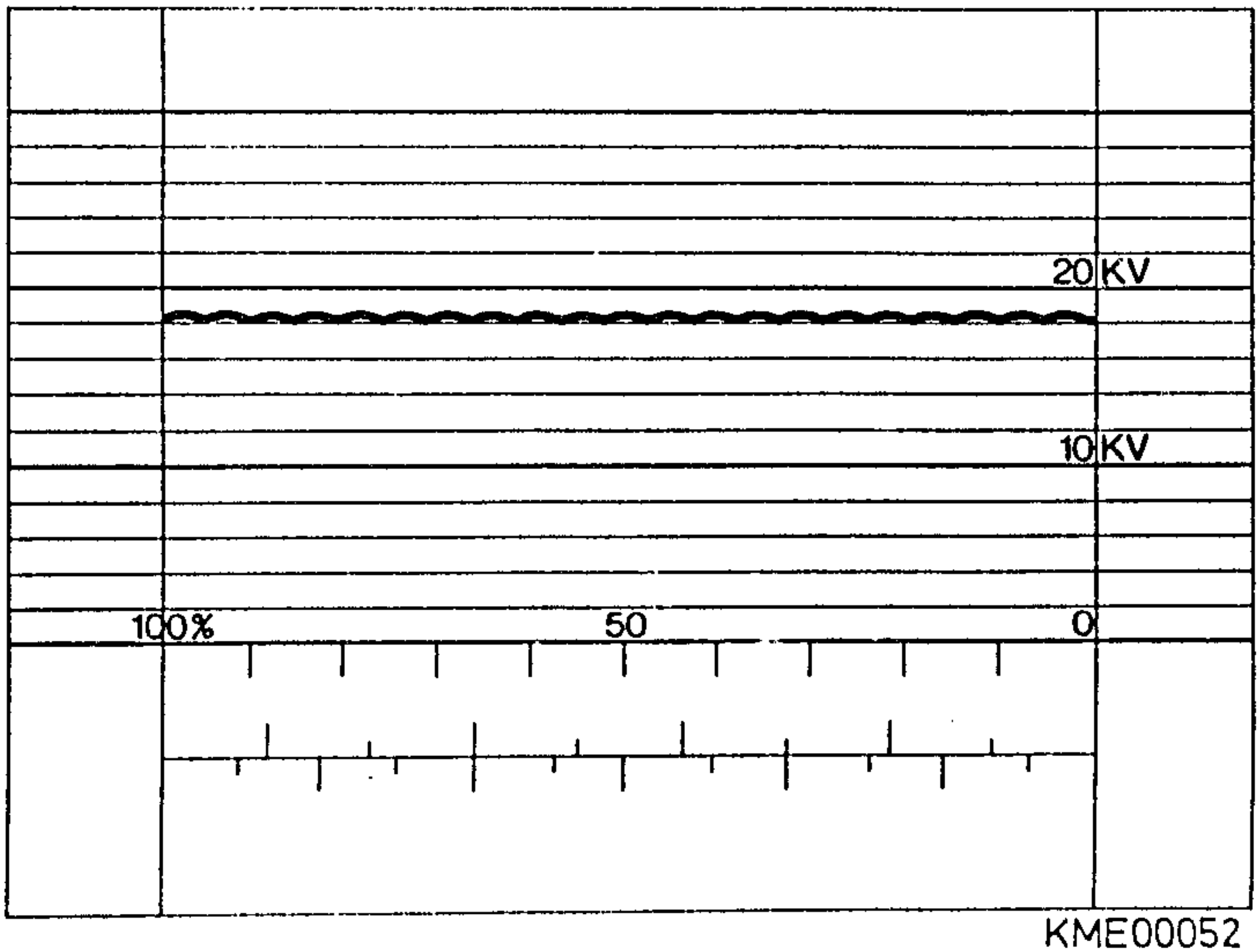


Figure 40 Normal Pattern

11.3.3 Open Exciter Diode

This pattern displays a characteristic dip in the normally smooth wave characteristic of a defective exciter diode. This would require disassembly of the alternator and replacement of the rectifier assembly.

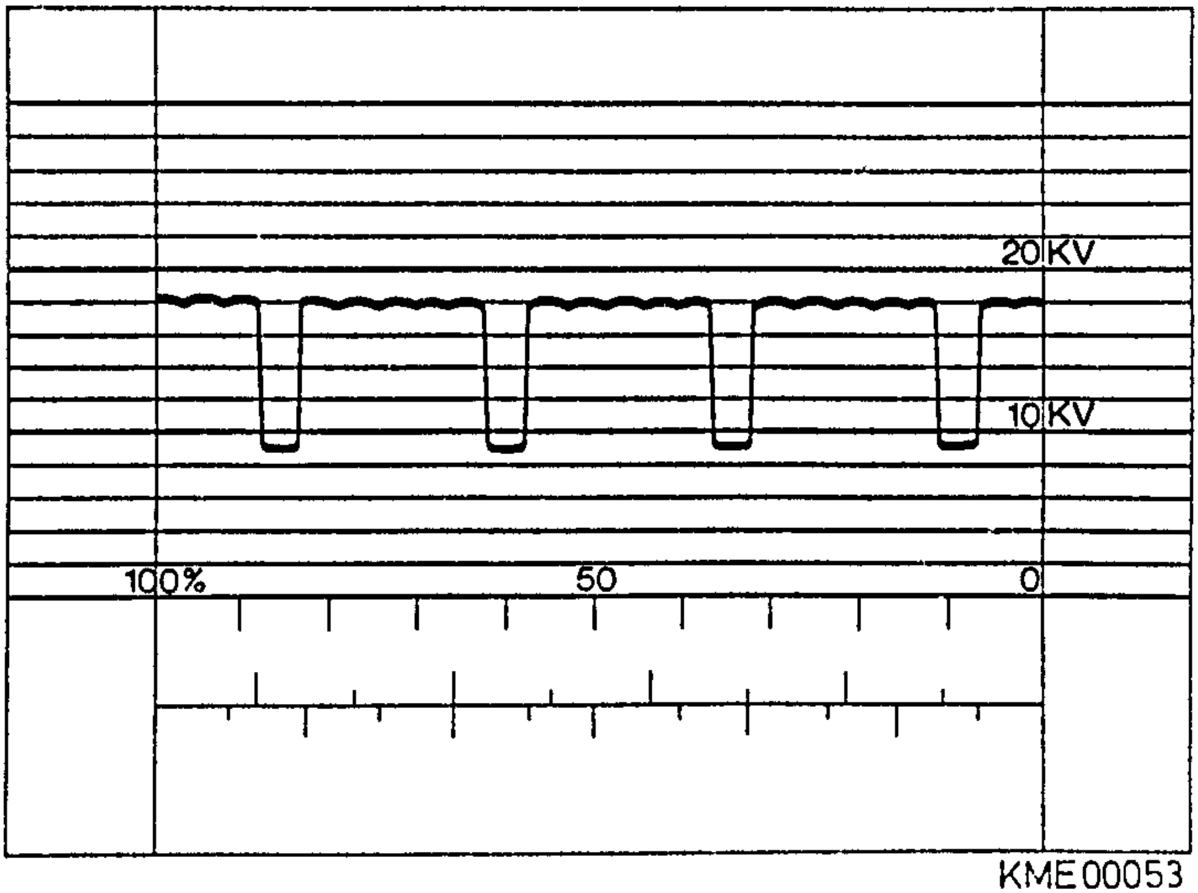


Figure 41 Open Exciter Diode

11.3.4 Open Positive Rectifier Diode

This pattern identifies an open positive rectifier diode. In the case of multiple diodes in parallel, all of the diodes on the circuit must be open. An example is:

There are two diodes in the rectifier for each phase of the stator. Both diodes must be open for this pattern to appear.

With this type of defect, the rectifier assembly must be replaced.

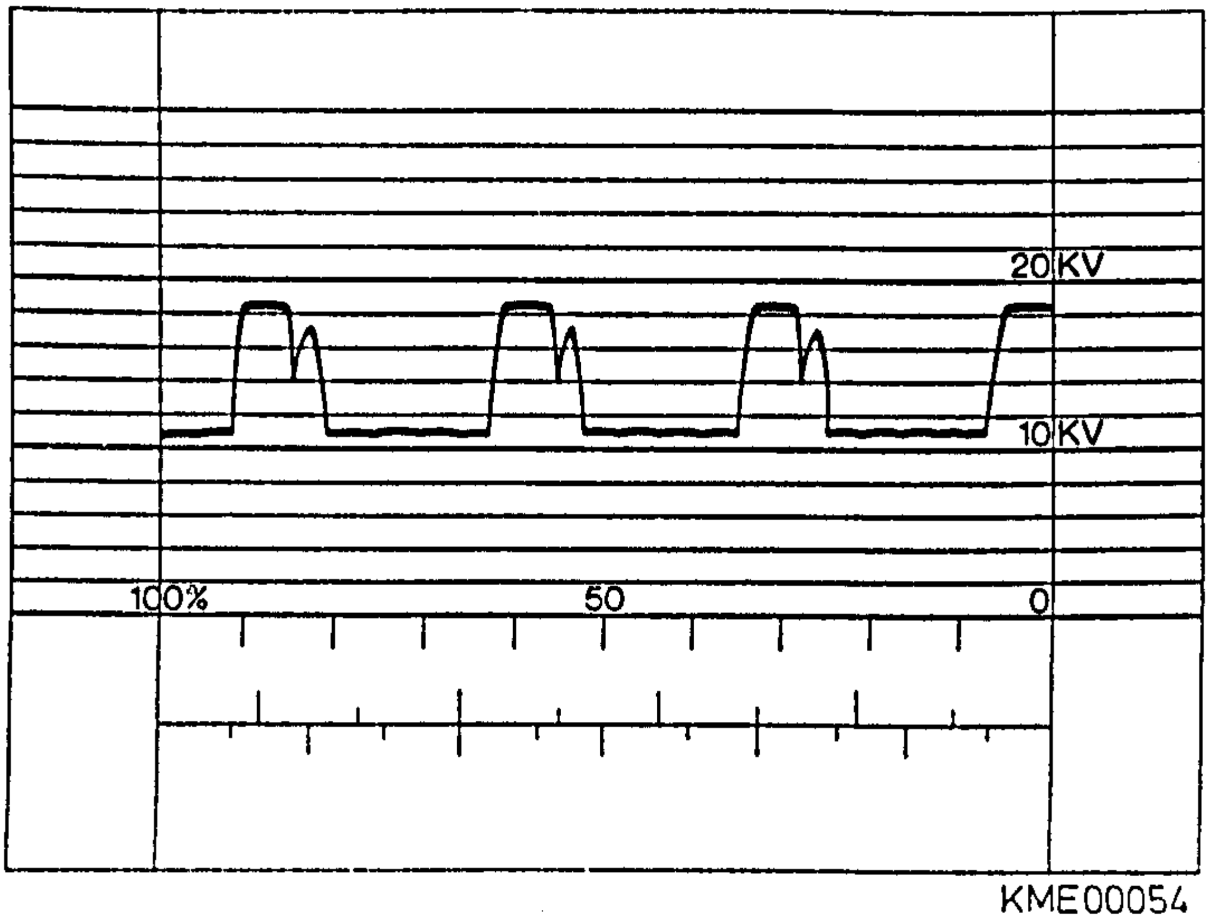


Figure 42 Open Positive Rectifier Diode

11.3.5 Open Negative Rectifier Diode

This pattern identifies an open negative rectifier diode. In the case of multiple diodes in parallel, all of the diodes on the circuit must be open. An example is:

There are two diodes in the rectifier for each phase of the stator. Both diodes must be open for this pattern to appear.

With this type of defect, the rectifier assembly must be replaced.

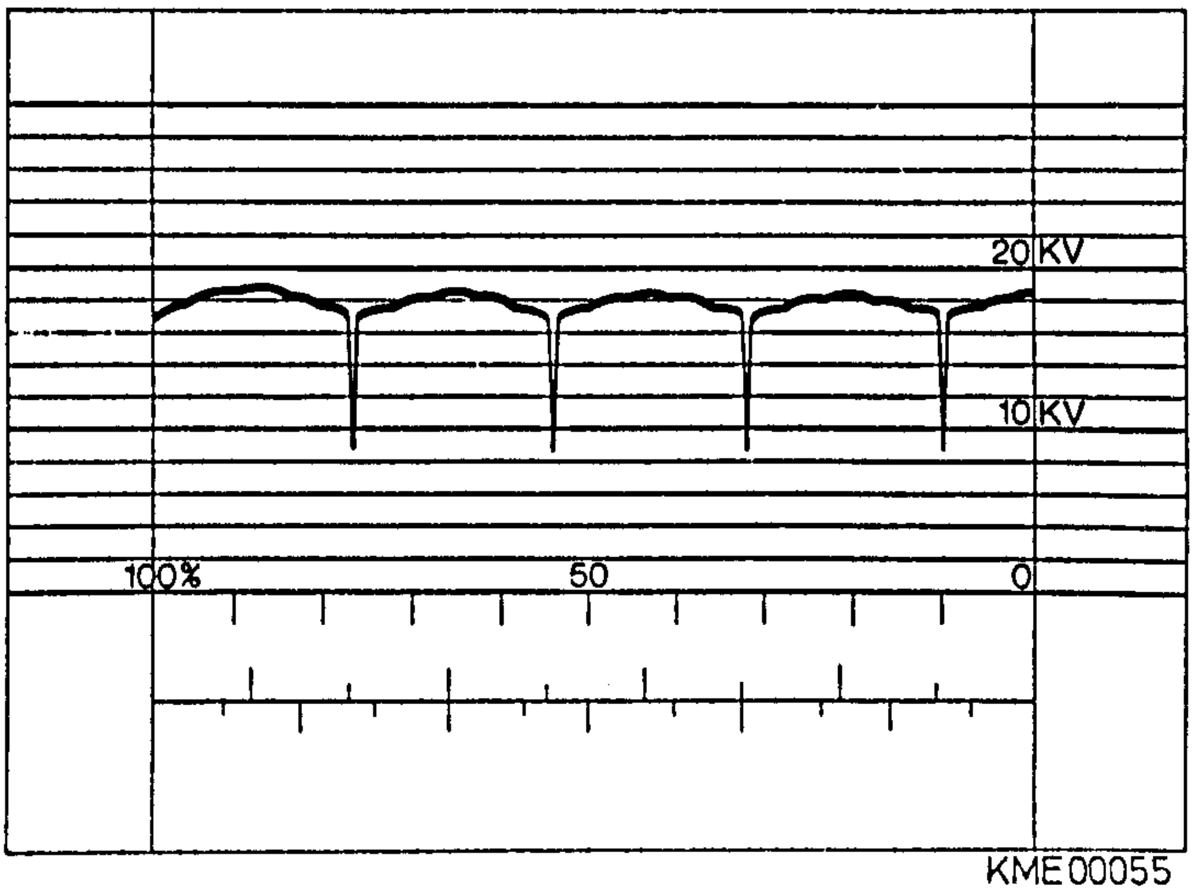


Figure 43 Open Negative Rectifier Diode

11.3.6 Shorted Exciter Diode

This pattern identifies a shorted exciter diode. This would require disassembly of the alternator and replacement of the rectifier assembly.

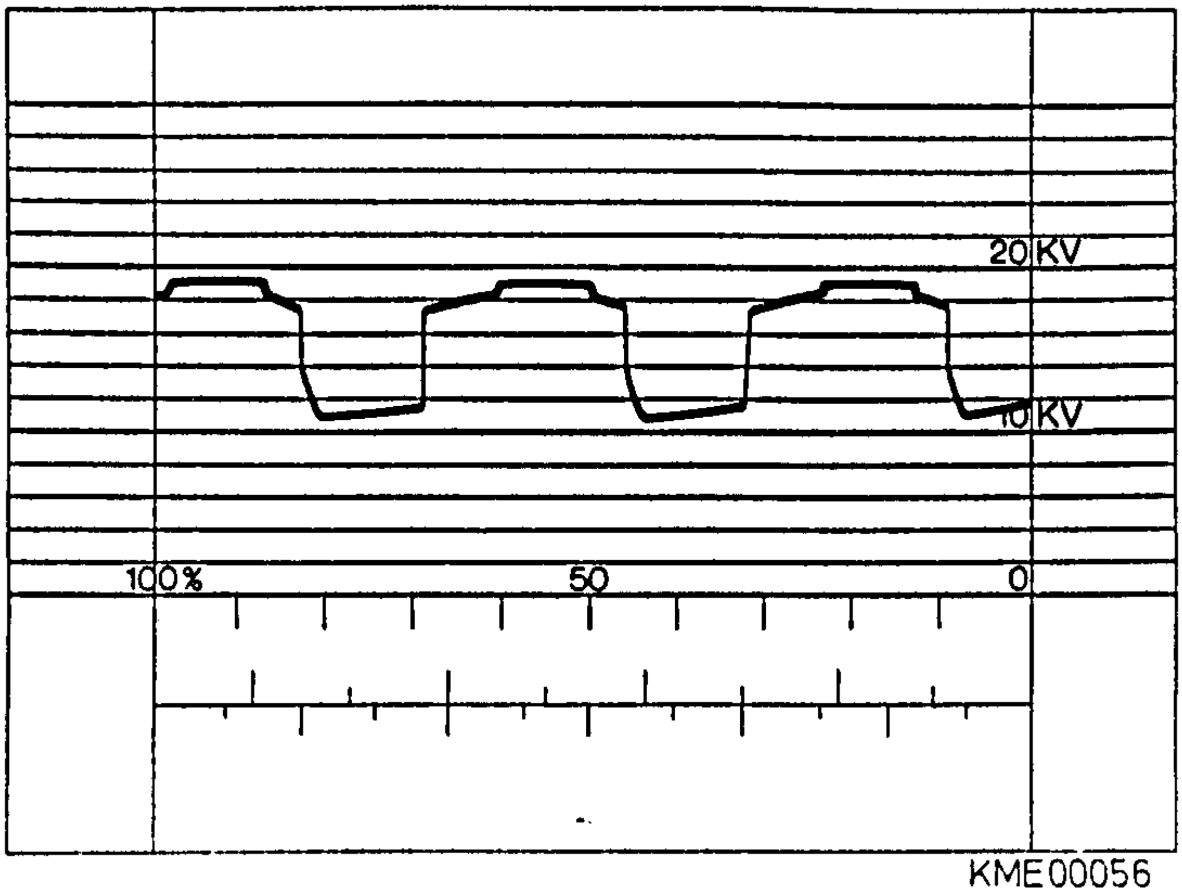


Figure 44 Shorted Exciter Diode

11.3.7 Shorted Positive Rectifier Diode

This pattern identifies a positive rectifier diode that is shorted. This defect requires replacement of the rectifier assembly.

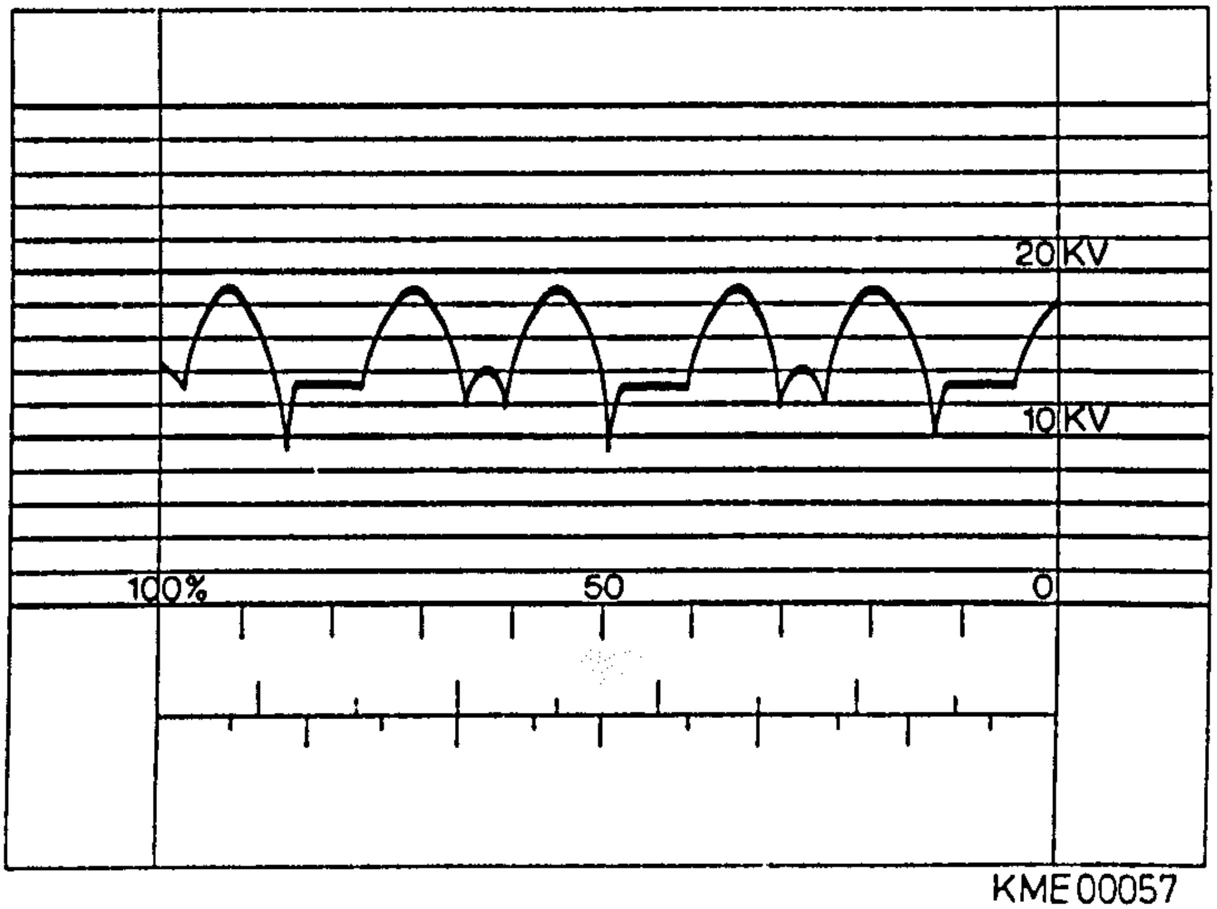


Figure 45 Shorted Positive Rectifier Diode

11.3.8 Shorted Negative Rectifier Diode

This pattern identifies a negative rectifier diode that is shorted. This defect requires replacement of the rectifier assembly.

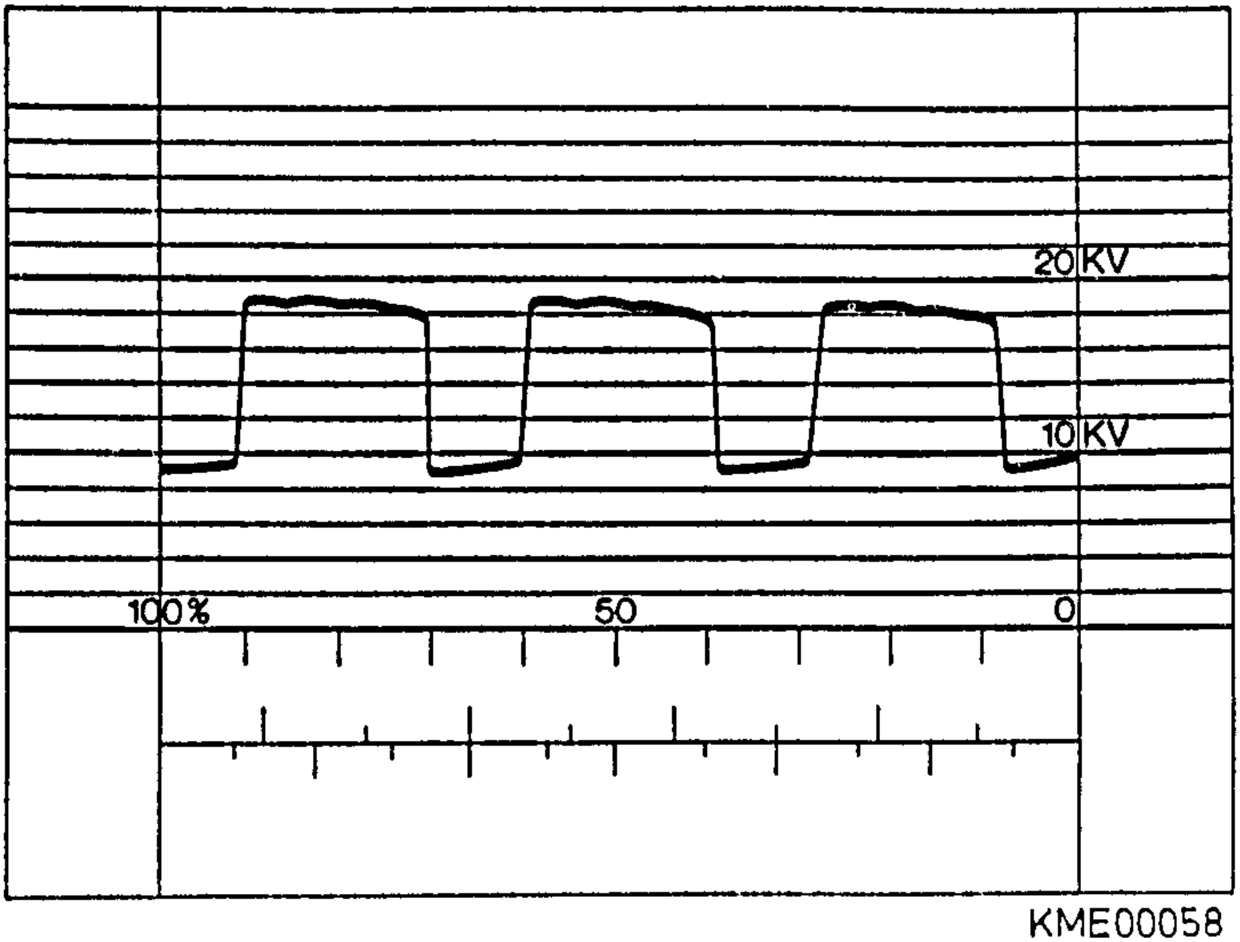


Figure 46 Shorted Negative Rectifier Diode

11.3.9 Open Phase of Stator

This pattern illustrates a stator with an open phase winding. This type of defect would require replacement of the stator.

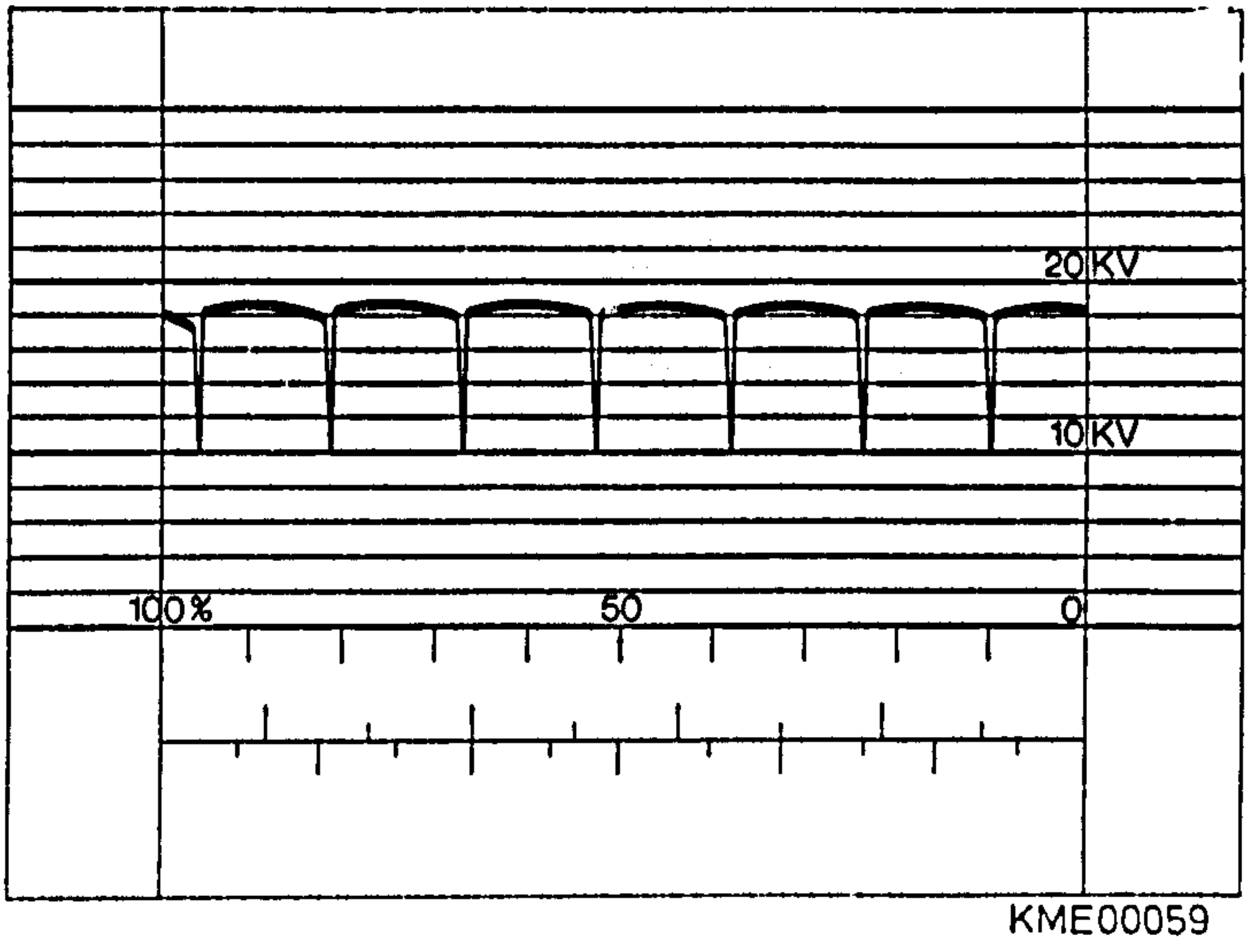
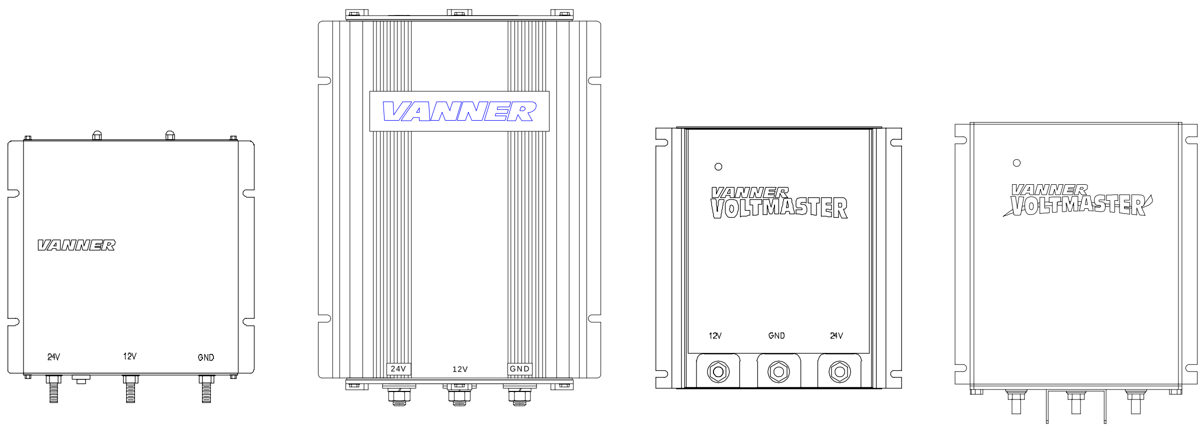


Figure 47 Open Stator Phase

VoltMaster Battery Equalizer



Family 1	Family 2	Family 3	Family 4
60-10B	60-100C	60-60	65-60
60-20A	60-100D	60-60M	65-60M
60-50A	60-100E	60-80	65-80
60-50E		60-100	65-100
60-50M			

Table of Contents

Introduction

Thank you for purchasing a Vanner *VoltMaster* Battery Equalizer. We are confident that you will be very pleased with its performance because our Battery Equalizers are designed and manufactured by skilled professionals using the highest standards in workmanship. With minimum maintenance and care, you can be assured of many years of trouble free service.

General Description

The Vanner *VoltMaster* Battery Equalizer is an efficient and highly reliable method of obtaining a 12 volt DC power source from a 24 volt DC electrical system. The equalizer makes the batteries look like they are in series and parallel at the same time. In addition to providing regulated 12 volt power, the system ensures that battery voltages remain equal which significantly extends battery life. Ideally suited for vehicle and alternate energy applications, the *VoltMaster* Battery Equalizer is designed to save your batteries and the money you would spend replacing them. Users of the Vanner *VoltMaster* Battery Equalizer know that it is the most cost effective and dependable solution for dual voltage systems.

A typical system would include a 24VDC power source, such as an alternator or solar array, two 12 volt battery banks in series, and the *VoltMaster* Battery Equalizer. The Battery Equalizer connects to the 24 volt, 12 volt and ground terminals of the battery system. When the 12 volt loads require power, the Battery Equalizer ensures that the current is taken equally from both batteries, and that the voltages of the two batteries are kept equal. This equalization ensures extended battery life and provides a stable 12 volt supply for operating accessories.

Parallel Equalizers: Models are available which provide 10, 20, 60, 80 and 100 amps of 12 volt DC power. *VoltMaster* Battery Equalizers may also be operated in parallel to provide more power. For example, two 60 amp units can be installed to provide 120 amps of 12 volt DC power. Family 1, Family 3 and Family 4 models may be paralleled in any combination. Family 2 models may be paralleled with other Family 2 models only.

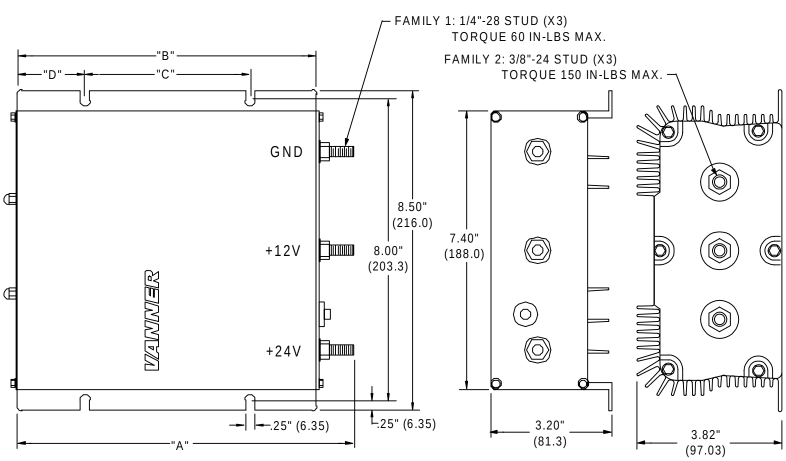
NOTE: The Vanner *VoltMaster* Battery Equalizer is an extremely reliable device and, when installed according to the instructions, will provide reliable operation for an indefinite period of time. However, if a system abnormality should develop that would cause a Battery Equalizer malfunction, damage to the battery system could result if 12 volt loads are present. If your system application is critical you may consider installing a Vanner **Model EM-70 Electrical System Monitor**. This module monitors the battery system's voltages and balance, and provides fault signals that can be wired to warning lights, buzzers or other control/warning devices. Models 60-50M , 60-60M and 65-60M have the EM-70 built in. Call Vanner for more details.

Specifications

	Family 1			Family 2*	Family 3* / Family 4		
Model Number	60-10B	60-20A	60-50A*	60-100E*	60-60*	60-80*	60-100*
					65-60	65-80	65-100
Input Voltage 24v	20 to 35v	20 to 35v	20 to 35v	18 to 36v	18 to 32v	18 to 32v	18 to 32v
Efficiency (Peak)	>91%	>92%	>92%	>94%	>97%	>97%	>97%
Max 24vdc Input	6 amps	12 amps	28 amps	55 amps	32 amps	43 amps	53 amps
Output Voltage	(Input Voltage/2) ±2% - 50mv						
Output Amps (12v)	0-10	0-20	0-50	0-100	0-60	0-80	0-100
Standby Current	17 milliamps nominal at 28.4V						
Operating Temp.	-40°C to +71°C (-40°F to 160°F)				-40°C to +75°C (-40°F to 167°F)		
Storage Temp.	-54°C to +85°C (-65°F to 185°F)				-54°C to +95°C (-65°F to 203°F)		
Serviceable	Yes	Yes	Yes	Yes	No	No	No
Environmental Considerations	Anodized aluminum enclosure provides protection against salt, fungus, dust, water, fuel vapors and all fluids associated with commercial and off-highway vehicle operations. Continuous exposure to splashes and spills should be avoided.						
Mounting Location	Mount on a flat surface close to the batteries to allow short cable runs. Vertical mounting with terminals down is recommended. Location should be protected from battery acid and gases.						
Weights	2.3 lbs	5.0 lbs	7.0 lbs	9.5 lbs	6.0 lbs	6.6 lbs	6.6 lbs
					7.0 lbs	7.6 lbs	7.6 lbs

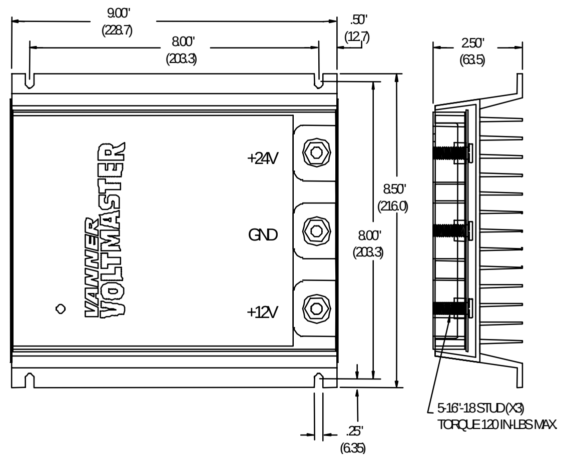
Unlisted models: Model 60-60M and 65-60M have built-in EM-70 Electrical System Voltage Monitor. Model 60-50M is a 60-50A with built-in EM-70. Model 60-50E is a 60-50A with weather resistant gasket. Model 60-100C is an early 60-100E. Model 60-100D is a 60-100C with circuit breakers instead of internal fuses. Older models not mentioned should be tested as Family 1 and should be considered non-repairable.
*Obsolete.

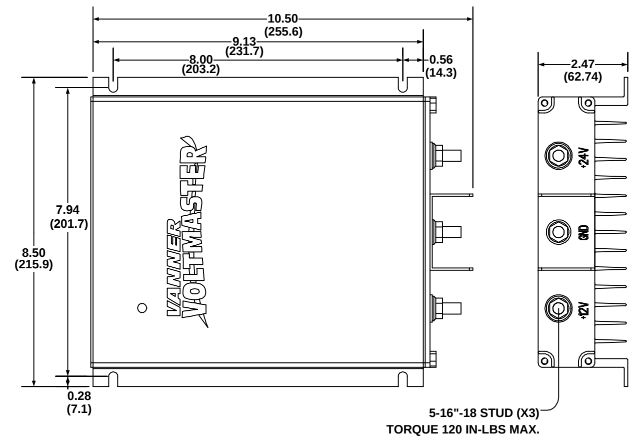
Family 1 and Family 2 Equalizer Dimensions



Model	"A"	"B"	"C"	"D"
60-10B	4.25 (107.9)	3.00 (76.3)	2.00 (50.80)	0.50 (12.7)
60-20A	9.38 (238.2)	8.00 (203.2)	4.50 (114.3)	1.75 (44.4)
60-50A	13.38 (339.8)	12.00 (304.8)	8.00 (203.2)	2.00 (50.8)
60-100C	13.46 (341.88)	12.00 (304.8)	8.00 (203.2)	2.00 (50.8)

Family 3 Equalizer Dimensions **Family 4 Equalizer Dimensions**

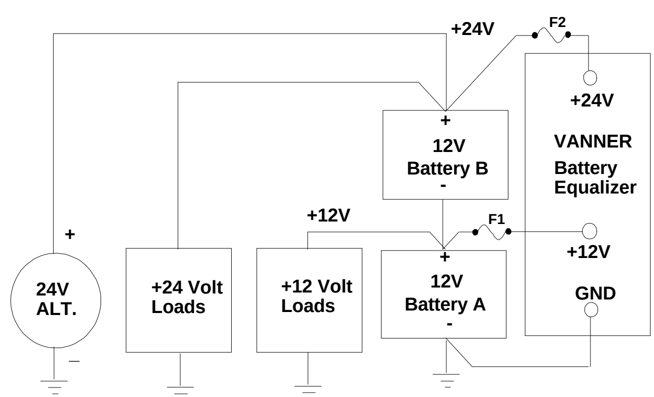




Theory of Operation

In many 24 volt electrical systems it is desirable to tap into the battery system to obtain power for 12 volt loads. This method, while seemingly simple, causes a charge imbalance resulting in Battery B (see diagram) being overcharged, and possibly boiling, while Battery A discharges.

To solve this application problem the Vanner *VoltMaster* Battery Equalizer is connected to the battery system at the +24 volt, +12 volt, and ground points. The Battery Equalizer makes the batteries look like they are in series and in parallel at the same time. The Battery Equalizer maintains the voltage balance and therefore the charge acceptance rate of each battery. Family 3 and Family 4 Equalizers hold Battery A and B voltages to within 0.05 volts under light loads and to within 0.1 volts at full rated load. Family 1 and Family 2 models hold Battery A and B voltages to within 0.10 volts under light loads and to within 0.50 volts under full rated load.



Note-Battery Banks A and B should have the same amp-hour capacity.

When the voltage of Battery A is higher than or equal to Battery B the Battery Equalizer is in the standby mode, i.e., it is not transferring power from its 24 volt input to its 12 volt output. When a 12 volt load is present, and Battery A's voltage decreases to just below the voltage of Battery B, the Battery Equalizer activates and transfers sufficient current from Battery B to Battery A to satisfy the load and maintain an equal voltage and charge in both batteries.

A key advantage of a system containing a Vanner *VoltMaster* Battery Equalizer, compared to a DC to DC converter, is that if the 12 volt load requires a momentary surge current which exceeds the rated capacity of the Battery Equalizer, Battery A will supply the extra current to the load. The Battery Equalizer will then replenish the energy to Battery A after the surge has passed.

The *VoltMaster* Battery Equalizer is a completely automatic device that requires no human intervention when installed according to the recommended procedures. Family 1 Equalizers and some Family 2 Equalizers have a manually resetable circuit breaker. If the circuit breaker trips, due to a system overload or abnormality, it can be reset by pushing the white button. Note that on some units the white circuit breaker button may protrude slightly in its normal (non-tripped) position. A blown fuse on Family 2 Equalizers requires factory repair. There are no user operational devices on Family 3 or Family 4 models.

The following scenarios describe the *VoltMaster* Battery Equalizer's system operation.

Scenario #1 - 24 volt load present, no 12 volt load present. The system operates as a system would without the Battery Equalizer whether the alternator is ON or OFF. The Battery Equalizer is in the standby mode except for making small adjustments to keep the batteries in balance.

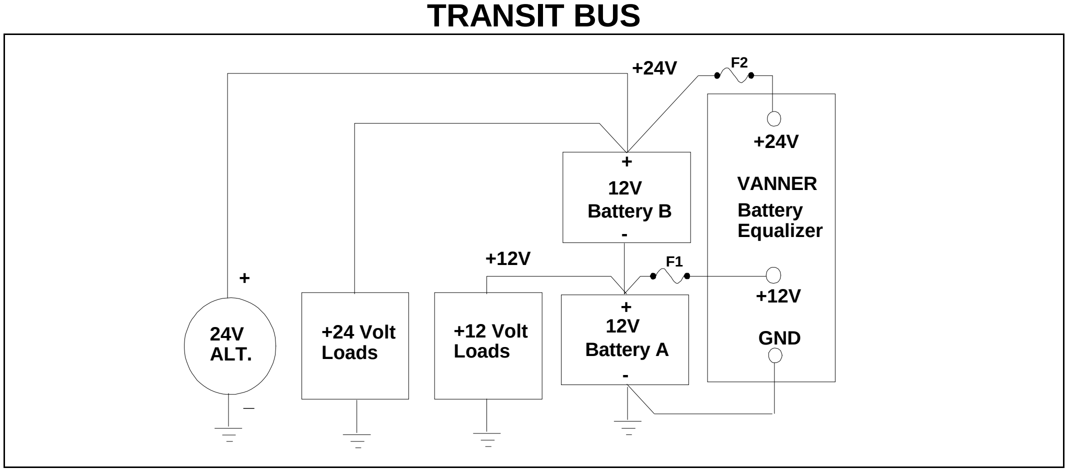
Scenario #2 - Both 24 volt and 12 volt loads present, alternator is OFF. The Battery Equalizer will insure that both batteries will discharge at the same rate even if different loads are present.

Scenario # 3 - Both 24 volt and 12 volt loads present, alternator is ON. The alternator provides 24 volt power to the battery system and to the 24 volt loads. The Battery Equalizer transfers power from the 24 volt source to the 12 volt load by converting 24 volt power to 12 volts. It will supply sufficient 12 volt power to satisfy the 12 volt load and to maintain battery voltage balance.

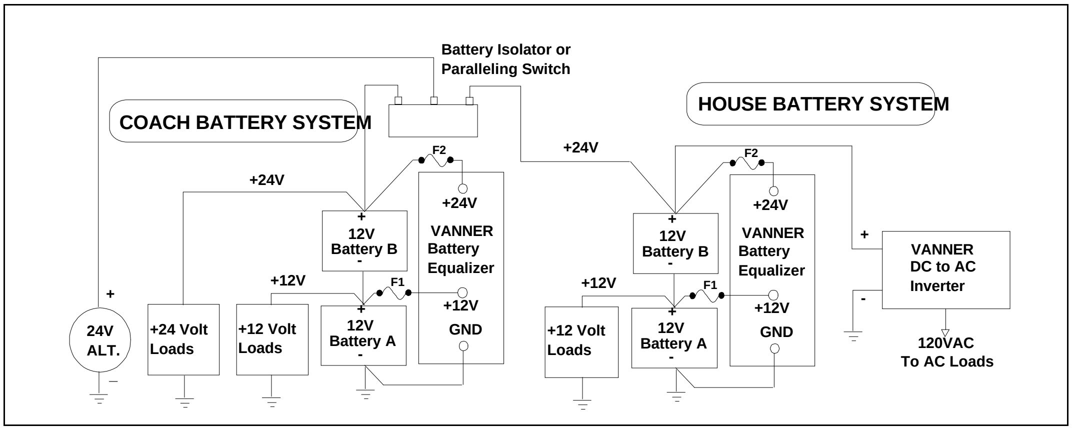
Typical Applications

Vanner *VoltMaster* Battery Equalizer are used in many types of applications including transit and tour buses, private coaches, heavy trucks and off highway equipment, yachts, and alternative energy systems such as solar powered homes. In addition to Battery Equalizers, Vanner manufactures a wide range of complementary products such as DC to DC converters, DC to AC inverters, battery charger/conditioners, and battery isolators. The following system diagrams illustrate how these products are used in various applications.

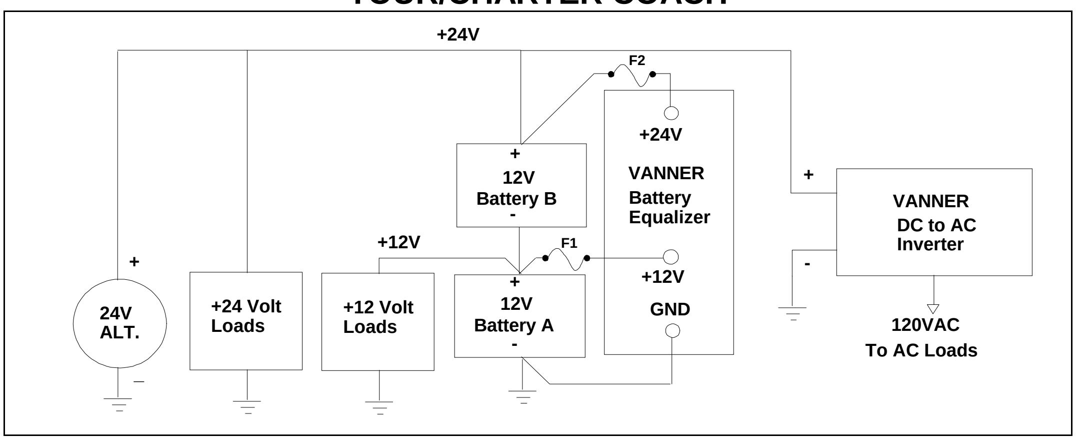
TRANSIT BUS



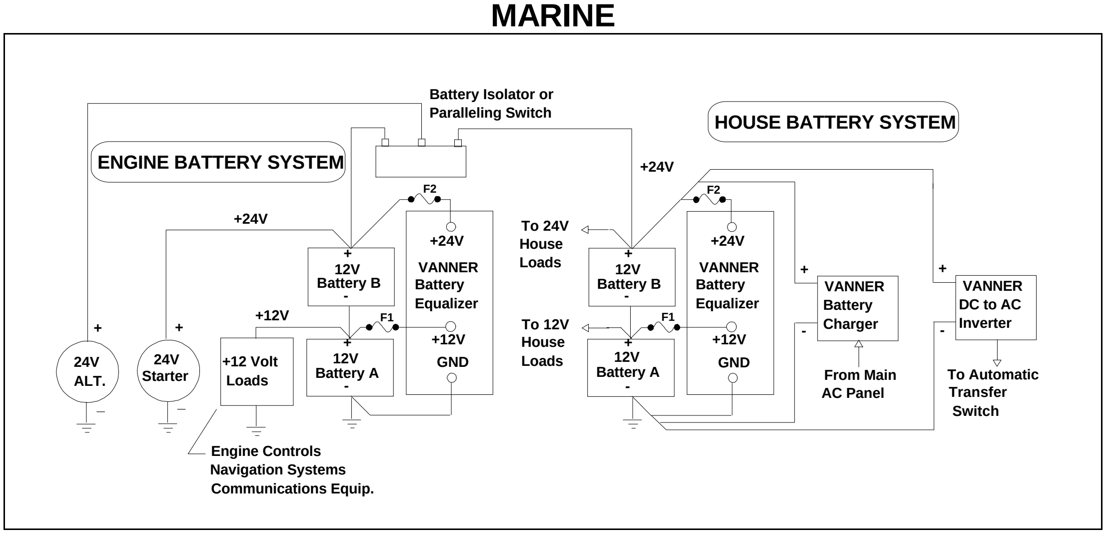
PRIVATE COACH



TOUR/CHARTER COACH



MARINE



Installation Instructions

When connecting wires or cables to the available post (+24, GND, +12) when installing Vanner Equalizer Models 60-60, 60-80, 60-100, do not exceed the specified torque of 120 in-lbs. This information is printed on the Product Label just above the connection post. Torque values higher than specified may damage the product, reducing performance or creating hazardous conditions. Products damaged by improper torque may not be covered by warranty.

Do not connect more than one conductor per available post on any model of Vanner Equalizer. Multiple wires and cables may overstress internal components, resulting in poor performance or creating hazardous conditions. Products damaged by the installation of multiple conductors per post may not be covered by warranty.

Fault protection devices must be installed between the Equalizer and the power source (battery). A fault protection device would be any fuse or circuit breaker properly rated for the maximum DC current obtainable. This advisory is in accordance with SAE, NEC and UL, for mobile power applications. Install per applicable codes or within 18" of the battery. See Wire and Fuse Sizing Chart on page 9 of this manual or contact Vanner at 1-800-227-6937 or pwrsales@vanner.com if assistance is needed in sizing fault protection devices.

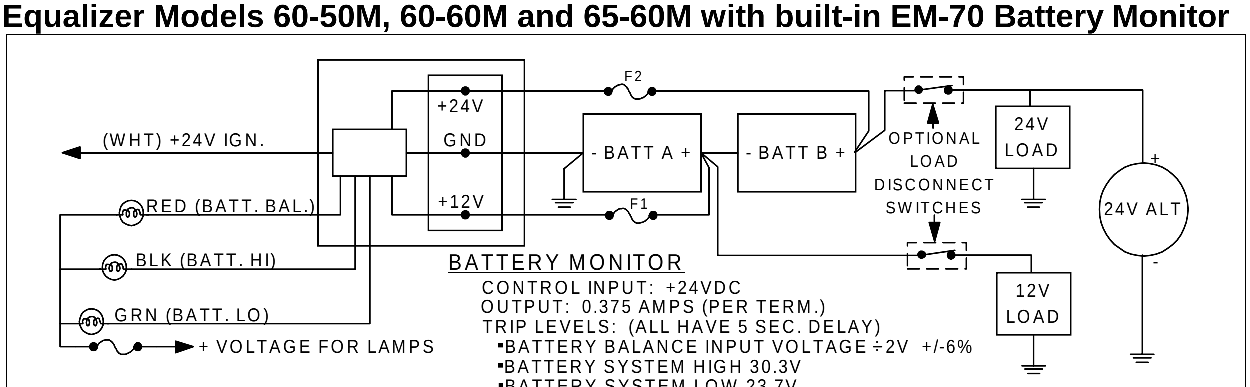
Caution: This equipment employs components that tend to produce arcs and sparks. To prevent fire or explosion, do not install in compartments containing batteries or flammable materials. Safety goggles should always be worn when working near batteries

Mounting Location –The Equalizer may be mounted in any orientation, however, the recommended orientation for optimum heat dissipation is vertical. It is recommended that the wiring terminals be down to prevent the possibility of a falling metal object shorting the terminals. Do not mount in zero-clearance compartment that may result in the Equalizer overheating. Locate so that contact by people is unlikely.

Environmental Protection – Do not expose to rain or moisture. The unit should be located in an area that will protect it from direct exposure to moisture such as high pressure washing, rain, etc.

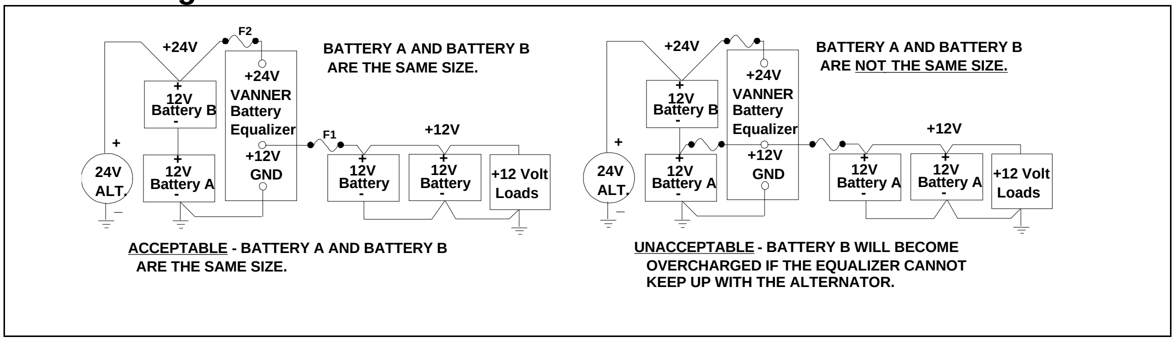
Wiring Sequence– To prevent reverse polarity damage on Family 1 and Family 2 models when connecting/disconnecting battery terminals: ALWAYS 1) Remove Equalizer ground terminal first, and 2) Replace Equalizer ground terminal last. The wiring sequence is not an issue with Family 3 or 4 models.

Equalizer Models 60-50M, 60-60M and 65-60M with built-in EM-70 Battery Monitor



The EM-70 Battery Monitor provides the following ground signals: Battery HI when +24 rises above 30.3V, Battery LO when +24 falls below 23.7V, Battery BALANCE when +12 is not within 6% of (+24 ÷ 2). Each ground signal is rated 0.375 amps and should be protected by a 1 amp fuse.

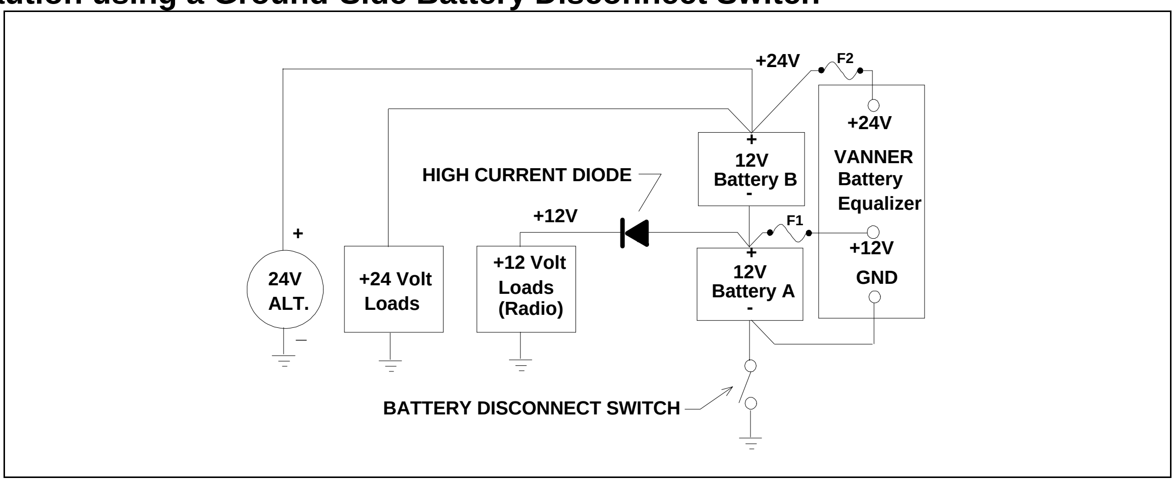
Caution adding 12volt batteries



In certain applications, such as private coach or alternate energy applications, it may be desirable to have additional 12 volt “House Batteries” to operate heavy 12 volt (inverter) loads. Use the Equalizer to charge the additional batteries.

Connect the Equalizer 12V terminal to the additional batteries only. Do not connect the Equalizer 12V terminal to both battery banks as this would make Battery A larger than Battery B. **Damage to Battery B may occur during charging** due to overcharging, if the equalizer cannot keep up with the charging system.

Caution using a Ground-Side Battery Disconnect Switch



The system must be wired as shown to prevent Reverse Polarity Damage to polarity sensitive12 volt loads and Family 1 and Family 2 Equalizers while the ground-side disconnect switch is open. The equalizer's GND terminal <u>must</u> be wired to the battery side of the ground-side disconnect switch circuit for the equalizer to work properly.

Install the external High Current Diode, such as Vanner Model 52-75 (45 amp continuous rating) to protect polarity sensitive 12 volt loads if these loads do not already contain input diode protection. This prevents a reverse polarity on the 12 volt equipment when the battery switch is open. The reverse polarity does not come from the Equalizer but from any 24 volt equipment that may be turned ON.

Wire Size and temperature rating

Cables connecting the Battery Equalizer to the batteries must be sufficiently large to prevent unwanted voltage drops. These voltage drops (loss) must be less than 0.05 VDC between the Equalizer's +24 volt terminal and the battery +24 volt terminal (Battery B positive terminal), less than 0.10 VDC between the Equalizer's +12 volt terminal and the battery +12 volt terminal (the jumper between Battery A and Battery B), and less than 0.05 VDC between the Equalizer's GND terminal and the battery ground terminal (Battery A negative terminal that is connected to chassis ground). In most installations, the Battery Equalizer's terminals are wired directly to the battery terminals to prevent voltage loss that could occur in switch contacts, connections, and long wire runs. Since the equalizer can be operated in temperatures up to 71º or 75ºC, use wire rated at least 90ºC. See Wire and Fuse Size Chart.

Wire and Fuse Size Chart

Wire Size AWG	Ring Terminal Molex or UL recognized equal	Max wire length, in feet, between Equalizer and battery to keep voltage drop under 0.1 volt. The chart assumes wire carries no other load and wire temperature is below 80ºC.						
		60-10	60-20	60-50	60-60	60-80	60-100	2 x 60-100
					65-60	65-80	65-100	2 X 65-100
#14	191930072	3.2	XXX	XXX	XXX	XXX	XXX	XXX
#12	191930134	5.0	2.5	XXX	XXX	XXX	XXX	XXX
#10	191930134	7.7	3.8	XXX	XXX	XXX	XXX	XXX
#8	191930157	12.8	6.4	2.6	2.1	XXX	XXX	XXX
#6	191930251	19.4	9.7	3.9	3.2	2.4	XXX	XXX
#4	191930278	35.2	17.6	7.0	5.9	4.4	3.5	XXX
#2	191930309	51.9	26.0	10.4	8.7	6.5	5.2	2.6
#1	191930333	65.4	32.7	13.1	10.9	8.2	6.5	3.3
#1/0	191930333	82.9	41.4	16.6	13.8	10.4	8.3	4.1
#2/0	191930346	105.5	52.7	21.1	17.6	13.2	10.5	5.3
Fuse F1		20 amp	30 amp	80 amp	80 amp	100 amp	125 amp	250 amp
Fuse F2		10 amp	15 amp	35 amp	40 amp	50 amp	80 amp	150 amp

Crimp the ring terminals using *Molex* tool 192840002 (14ga), 192840001 (10 -12ga), 192840035 (2 - 8ga) (phone 813-521-2700) and *AC Terminal* tool model 0280 (6 ga and larger) (phone 614-868-9828).

Testing and Troubleshooting

All Vanner equalizers fall into one of three distinct families. The three families operate differently and must be tested differently. The following three test procedures apply **only** to the equalizer family listed.

CAUTION
Servicing of electrical systems should only be performed by trained and qualified technical personnel.

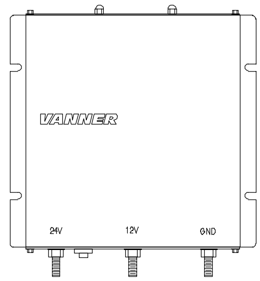
Equipment Required

VoltMeter having 0.01 volt resolution. (Fluke Model 87 Multimeter recommended).
Clamp-on amp meter (Fluke Model 36 Clamp-on Meter recommended).

Vanner Repair Service

Vanner offers a quick turn around factory repair service for Family 1 and Family 2 models. (Family 3 and 4 models are non-repairable.) Send the unit to the address below with a note instructing us to repair it. Include your name, phone number, shipping address (not a P.O. Box Number), and your purchase order number.

Test Procedure for Family 1 Battery Equalizers



Models 60-10B, 60-20A, 60-50A

CAUTION

To avoid Reverse Polarity Damage to Family 1 and Family 2 Equalizers when servicing the electrical system or when performing any work which involves making battery connections always:

1. Remove Equalizer Ground terminal first.
2. Replace Equalizer Ground terminal last.

Family 1 Battery Equalizer Test Procedure:

1. Carefully remove the ground (GND) cable from the Equalizer. Do not allow this cable to touch any other connection on the Equalizer because the other terminals are connected to the batteries.
2. Make sure there is approximately 12 volts between the +24 and +12 terminals of the Equalizer by momentarily connecting the two terminals of a 12 volt light (headlight, marker light, etc.) to the +24 and +12 terminals of the Equalizer. The light should light and stay lit.
3. Next, connect that same 12 volt lamp between the +12 and GND terminals of the Equalizer. The lamp should light and stay lit. If the lamp does not light, the light then goes out, or the light dims, the Equalizer requires repair.
4. Further verification may be made by measuring the voltages on the Equalizer terminals. Be certain that the lamp used earlier is connected between the +12 and GND terminals.
5. Measure the voltage between +24 and +12 terminals. Note this reading.
6. Measure the voltage from the +12 terminal to GND. Note this reading.
7. Compare the two readings by subtracting the +12 to GND reading from the +24 to +12 reading. A properly functioning Equalizer is one where the difference is between -0.5 and +0.13 volts. For example, the +24 to +12 reading might be 12.85 volts. The +12 to GND voltage might read 12.75 volts. This Equalizer would be functioning properly with a 0.10 difference (12.85 minus 12.75 volts) which is within specs.

Common Questions for Family 1 Battery Equalizers

Q) Will operating loads which exceed the output rating of the Battery Equalizer cause the circuit breaker (white button near the wiring terminals on Family 1 or Family 2 equalizers) to trip?

A) No, the Battery Equalizer electronically limits the output current to a value less than the amount required to trip the circuit breaker. (Extreme conditions, such as 28 VDC input with 8 VDC output at very high ambient temperatures, may cause the circuit breaker to trip.)

Q) Why is the Battery Equalizer's circuit breaker value lower than its output current rating (35 amp circuit breaker in model 60-50A)?

A) The circuit breaker is in the ground circuit. Due to the equalizer's two to one (24/12 VDC) voltage conversion, the model 60-50A requires 25 amps at 24VDC input to produce about 50 amps output at 12 VDC. Therefore, a 35 amp circuit breaker in the GND circuit will properly protect for the maximum 25 amp rating.

Q) What causes the circuit breaker to trip on a Battery Equalizer?

A1) The Battery Equalizer's circuit breaker is designed to trip when the +12 volt to GND terminals are exposed to reverse polarity.

A2) With the Battery Equalizer's GND terminal connected to chassis and the battery negative terminal disconnected, a short between a +24 volt circuit and chassis will pull the chassis up to +24 volts, causing a reverse polarity on the +12 volt to GND circuits. The circuit breaker trips to protect the Battery Equalizer.

A3) With the Battery Equalizer's GND terminal connected to chassis and the battery negative cable disconnected, 24 volt loads (e.g., starter motor) will pull the chassis up to +24 volt causing a reverse polarity on the Battery Equalizer's +12 Volt to GND circuits. The circuit breaker will trip to protect the Battery Equalizer.

A4) Since the above reverse polarity conditions may occur during bus maintenance it is recommended that the service personnel verify the circuit breaker is IN before releasing the bus for service and the tour bus operator do the same in his “walk around”.

Q) What are some known conditions that could cause Battery Equalizer problems?

A1) Corrosive liquids or water forced into the Battery Equalizer's case from high pressure spray cleaning could shorten the normal life expectancy.

A2) Drilling into the case (except for the mounting flanges) can shorten the life or prevent the unit from operating. The installer may not realize the Battery Equalizer is not operating correctly unless a 12 volt load is applied to the system and the Battery Equalizer 12 volt current is measured.

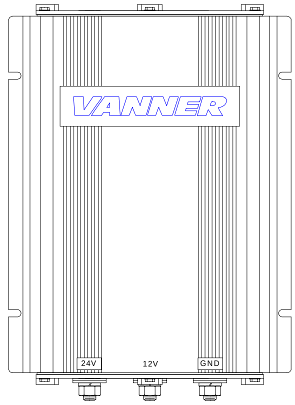
A3) Too small of wire or bad connections will allow the Battery balance to be less than optimum. Voltage loss in wire from the battery's +24 volt terminal to the Battery Equalizer's +24 volt terminal should be 0.05 VDC maximum; from the battery's +12 volt terminal to the Battery Equalizer's +12 volt terminal should be 0.10 VDC maximum, and from the battery ground terminal to the Battery Equalizer's GND terminal should be 0.05 VDC maximum, when the +12 volt load is causing the Battery Equalizer to operate at 100% capacity.

A4) Installing the Battery Equalizer in a location where it will be exposed to battery fumes will shorten its normal life. Acid fumes are heavier than air. Installation of Battery Equalizers on the battery mounting surface near the bottom of the batteries have caused severe corrosion to the Battery Equalizers. However, installation of Battery Equalizers 3 or more inches above the top of the batteries have not caused problems.

Q) Can different models of equalizers be paralleled?

A) Yes, any combination of models from Family 1, Family 3 and Family 4 may be paralleled. Family 2 models may only be paralleled with other Family 2 models.

Test Procedure for Family 2 Battery Equalizers



Models 60-100C, 60-100D and 60-100E

General: Family 2 Equalizers were designed to be more energy conservative during low power requirements compared to Family 1 models. This along with unique protection circuitry require Family 2 models to be tested differently than Family 1, Family 3 or Family 4 models.

CAUTION

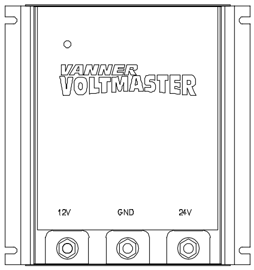
To avoid Reverse Polarity Damage to Family 1 and Family 2 Equalizers when servicing the electrical system or when performing any work which involves making battery connections always:

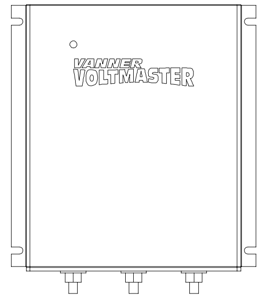
1. Remove Equalizer Ground terminal first.
2. Replace Equalizer Ground terminal last.

Family 2 Battery Equalizer Test Procedure:

1. With the coach engine and vehicle loads OFF measure the voltage of Battery A. Replace or recharge Battery A if less than 11.5 volts.
2. Start the engine and turn ON a 12 volt load such as headlights.
3. Measure the input voltage between the +24 and GND posts of the equalizer. This voltage should be between 25.5 volts and 29.0 volts. If it isn't then check the alternator and 24 volt voltage regulator circuits.
4. Zero the DC Clamp-on ammeter as needed.
5. Put the jaws of the clamp-on ammeter around all wires connected to the equalizer +12 volt terminal stud.
6. Observe the DC amperage out of the equalizer with the clamp-on ammeter. If there are 3 amps or more showing on the ammeter, the equalizer is functioning and no further tests are needed.
7. Continue with the following steps ONLY if the ammeter shows less than 3 amps.
8. Measure the voltage between the +24 terminal (meter positive lead) and the +12 terminal (meter negative lead) of the equalizer. Record this voltage.
9. Subtract 0.60 volts from the number recorded in Step 8.
10. Measure the voltage between the equalizer +12 terminal (meter pos) and the GND terminal (meter neg).
11. Wait for this voltage to drop below the voltage calculated in Step 9 or the clamp-on ammeter reading jumps from approximately 0 to more than 3 amps. More than 3 amps means the equalizer is functioning.
12. If the voltage drops below the calculated value from Step 9 and the clamp-on ammeter has not jumper from approximately 0 to more than 3 amps of current wait for an additional 30 seconds.
13. If the equalizer does not turn ON after 30 seconds the unit is defective and should be sent in for repair.

Test Procedure for Family 3 and 4 Battery Equalizers





Models 60-60, 60-80 and 60-100

Models 65-60, 65-80, 65-100

General: Family 3 and Family 4 Equalizers contain an indicator light. If the indicator light is ON the equalizer is working.

The Equalizer is working properly if:

1. The Indicator Light is ON and;
2. The 12 volt DC loads are being operated continuously and are within the rated capacity of the equalizer and;
3. Battery A voltage is lower than Battery B by no more than 0.05 to 0.10 volts (measured at the equalizer +24, +12 and GND terminals).

Family 3 and Family 4 Battery Equalizers are electronically protected against reverse polarity damage therefore the DC connection sequence is not an issue.

Family 3 and Family 4 Equalizers will not function properly unless all three battery connections are made. Battery A and Battery B voltages both must be above 8 volts for the unit to turn ON.

Any combination of Family 1, Family 3 and Family 4 models may be operated in parallel.

Please note that the 24V, 12V and GND stud position and orientation are different on Family 3 and Family 4 models than on Family 1 or Family 2 models.

Family 3 and Family 4 Battery Equalizer Test Procedure:

1. Field test the equalizer while fully connected to the vehicle batteries. For bench testing, two 12 volt batteries, or two 12 volt power supplies are required. Family 3 and Family 4 Equalizers must be connected to the batteries at GND, 12V and 24V to function properly.
2. If battery voltage is below 24 volts start the vehicle or apply a 24 volt battery charger to the batteries.
3. Turn ON 12 volt DC loads up to the equalizer rated capacity. Measure DC amps on the equalizer +12 cable to verify load amperages.
4. **At the equalizer** measure and record:
   a. Battery A voltage (voltage between the equalizer +12 and GND terminals)
   b. Battery B voltage (voltage between the equalizer +24 and +12 terminals)
   c. Equalizer Indicator Light status (ON or OFF)

5. Subtract Battery A voltage from Battery B voltage and compare readings.

Voltage Comparison		Indicator Light	Equalizer Status	
a.	Battery A is lower than Battery B but within 0.05 volt.	OFF	OFF	Stand-by Mode. The equalizer will not turn ON until Battery A is lower than Battery B by more than 0.05 volts.
b.	Battery A is lower than Battery B by 0.05 to 0.10 volts.	ON	ON	Normal Operating Mode
c.	Battery A is lower than Battery B by more than 0.10 volts	ON	ON	Self-Protection Mode due to Overload Condition. See below.
d.	Battery A is lower than Battery B by more than 0.10 volts	OFF	OFF	The Equalizer is not functioning properly.
e.	Battery A is <u>higher</u> than Battery B	Abnormal condition. Suspect Battery B is defective or a 12 volt load is connected to Battery B.		

<u>Overload Condition</u> on Family 3 and Family 4 Equalizers

An overload condition exists when the 12 volt loads exceed the equalizer's rated capacity. The overload condition will not damage the equalizer but may cause damage to the batteries.

During the overload, the equalizer output is limited by internal protection circuits to its Rated Output Amps. The 12 volt amps exceeding the equalizer output are drawn from Battery A which will begin to draw the batteries out of balance. The equalizer full Rated Output Amps are maintained as long as Battery A and Battery B remain balanced within 0.10 volt. The internal protection circuits will reduce equalizer output as the batteries become further out-of-balance. If Battery A voltage falls below approximately 8 volts the equalizer will shut itself OFF.

To correct the overload condition the 12 volt load must be reduced or the equalizer capacity must be increased.

<u>Trouble Shooting an Engine No-Start Situation</u>

<u>Situation:</u>
A coach has dead batteries and won't start while jump starting. The coach is equipped with a 24 volt starting and charging system, a 12 volt electronic diesel engine control, a Model 60-80 (Family 3) Battery Equalizer, and a moderate 12 volt load which cannot be turned OFF. The coach sits for several days and the batteries run completely dead. During jump starting the engine cranks but does not start due to low voltage on the 12 volt supply. Electrical testing reveals there is no 12 volt output from the equalizer while jump starting even though the equalizer separately tests OK.

<u>Cause:</u>
The 12 volt load which could not be turned OFF first ran both batteries down until the equalizer shut itself OFF due to low voltage. (Family 3 and Family 4 Equalizers will shut OFF if system voltage falls below 16 volts or if voltage on either battery falls below 8 volts.) Then Battery A alone was drained to near zero volts.
As the bus is being jumped, 12 volt loads hold Battery A voltage too low for the equalizer to turn ON and Battery A is too weak to support the 12 volt electronic engine control.

<u>Solution:</u>
Turn OFF all 12 volt loads (turning the battery disconnect switch OFF may accomplish this). Connect the jumper cables but do not crank the engine for two or three minutes or until the equalizer indicator light has turned ON which means the equalizer is ON. (Both batteries must rise above 8 volts.) The battery disconnect switch can then be turned ON and the bus should have adequate 12 volt power to start.

NORTH AMERICAN LIMITED WARRANTY

Vanner Inc., doing business as The Vanner Power Group, referred to herein as Vanner, warrants that this product is free from defects in materials and workmanship for a period of two (2) years from date of installation or two and one half (2 1/2) years from date of manufacture, whichever is less if and only if the following requirements are complied with:

1. The product is installed and checked out properly according to all guidelines, instructions, and checkout procedures set forth in the product Installation and Operating Manual.
2. The installer records all checkout data required and completes, signs, and returns the warranty registration card to Vanner within ten (10) days after installation.
3. The product was purchased after January 1, 2000.

Vanner does not warrant its products against any and all defects when: defect is a result of material or workmanship not provided by Vanner; normal wear and tear, or defects caused by misuse or use in contrary to instructions supplied, neglect, accident, reversed polarity, unauthorized repairs and/or replacements.

All warranties of merchantability and fitness for a particular purpose: written or oral, expressed or implied, shall extend only for a period of two (2) years from date of installation or two and one half (2 1/2) years from date of manufacture, whichever is first. There are no other warranties that extend beyond those described on the face of this warranty. Some states do not allow limitation on how long an implied warranty lasts, so the above limitations may not apply to you.

Vanner does not undertake responsibility to any purchaser of its product for any undertaking, representation, or warranty made by any dealers or distributors selling its products beyond those herein expressed unless expressed in writing by an officer of Vanner.

Vanner does not assume responsibility for incidental or consequential damages, including, but not limited to, responsibility for loss of use of this product, removal or replacement labor, loss of time, inconvenience, expense for telephone calls, shipping expense, loss or damage to property, or loss of revenue. Some states do not allow the exclusion or limitation of incidental or consequential damages, so these limitations may not apply to you.

Vanner reserves the right to repair, replace, or allow credit for any material returned under this warranty. Any damage caused by the customer will be charged or deducted from the allowance.

All warranty work will be performed at Vanner’s factory, or authorized repair facility utilizing a valid Warranty Authorization Number (WAN) prior to repair. Products shall be delivered to Vanner’s facility, freight prepaid and fully insured. Products repaired under warranty, or replacement parts or products will be returned to North American location prepaid via same transportation means and level of service as received, unless directed otherwise. Prepaid freight policy does not apply to locations outside North America.

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ELECTRONIC MONITOR EM-70D
Owner's Manual

GENERAL

The EM-70D Electronic Monitor is a device designed to monitor several critical functions in the electrical system of a vehicle that operates on a 24 volt system. It will also monitor the 12 volt service when using a Vanner VoltMaster Battery Equalizer which supplies 12 volt service from a 24 volt source.

CHARACTERISTICS

The EM-70D can function in a variety of ways:

1. The monitor functions as an alternator monitor when the battery balance lamp output and +12 volt monitor input terminals are not in use.
2. The monitor functions as a device to control a field current relay, shutting down the field current if the voltage regulator fails in the full field mode. This function is accomplished by connecting the EM-70D as normal and installing a latching field current relay to the battery high lamp output terminal.

In all cases the lamp outputs in the EM-70D are designed to provide the ground connection for the lamps (or buzzers, beepers, relays) under a fault condition. The lamp outputs have also been designed so they may be paralleled should the installer wish to have fewer than three (3) indicator lamps in service. If this is done, the output current remains at 0.375 (375 milliamps). It is possible to install momentary light test switches (or just one (1) light test switch provided three (3) isolating diodes are installed) so as to enable the operator to check the lamps to determine if they are functioning.

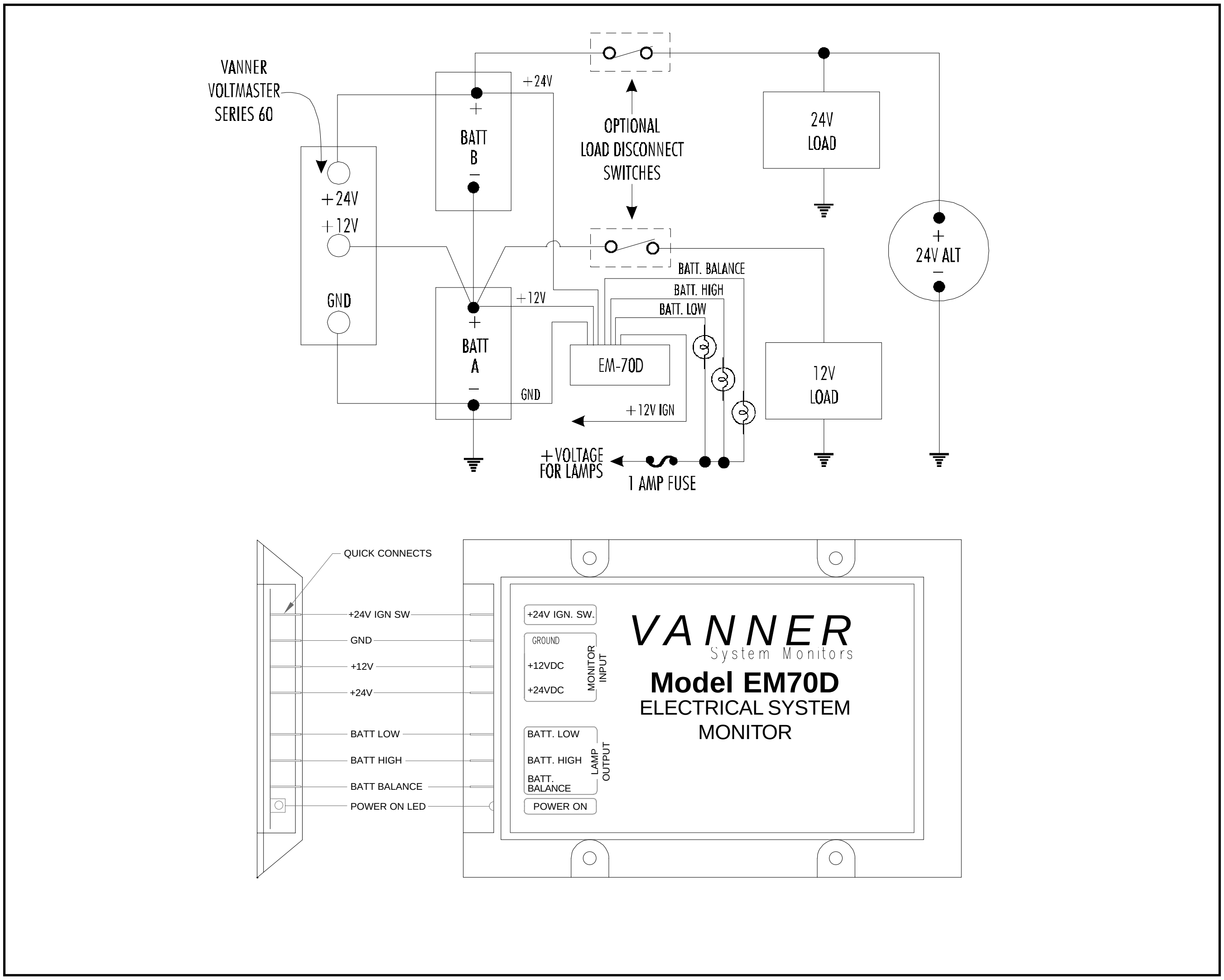
INSTALLATION

When installing the EM-70D, locate a dry, flat surface that will accommodate the four mounting holes. Even though the unit is potted and completely sealed, it is preferable to locate the monitor in as clean a location as possible. Since the current levels are in the milliamp range, it is permissible to use 18 gauge wire at all seven spade terminals. When connecting the three (3) monitor input leads to the system, it is important to note that the connections should be made to the wiring system as close to the battery terminals as possible. This will allow the EM-70D to monitor the condition of the wiring and terminals in the system and alert the operator if a problem develops. Should these three (3) wires be connected to the three terminals on the equalizer, the EM-70D will only monitor the equalizer voltages and will not respond to wiring or termination problems.

SPECIFICATIONS

IGNITION SYSTEM INPUT:	24 VDC (Minimum 18 VDC, Maximum 35 VDC)
WARNING LAMP TRIP LEVELS:	Battery System High - greater than 30 VDC Battery System Low - less than 24 VDC Battery Balance - greater than $\frac{\text{INPUT}}{2}$ + 6% OR less than $\frac{\text{INPUT}}{2}$ - 6%
WARNING LAMP* OUTPUT:	Open collector style, 0.375 amps (375 milliamps) maximum *Also applies to buzzers, beepers, relays, etc.

INSTALLATION SCHEMATIC



WARNING LAMP DEFINITIONS—LAMPS WILL GLOW UNDER FOLLOWING CONDITIONS:

BATTERY LOW

1. Battery voltage drops below 24 VDC
   - Check alternator output
   - Check alternator regulator
   - Check battery connections
   - Check battery cells
   - Check Battery Equalizer connections

BATTERY HIGH

1. Battery voltage exceeds 30 VDC
   - Check alternator output
   - Check alternator regulator
   - Check battery connections

BATTERY BALANCE

1. Batteries out of balance (greater than 1.5 volt difference between the two batteries)
   - Check circuit breaker on Battery Equalizer (if applicable)
   - Check Battery Equalizer connections
   - Check Equalizer cables for proper gauge
   - Check battery connections

2. Demand for 12 volt power exceeding rated amperage output of Battery Equalizer; causing batteries to go out of balance
   - Reduce 12 volt loads
   - Install larger or additional Battery Equalizer

3. Equalizer not functioning properly
   - Perform on-vehicle tests from troubleshooting guide (see Equalizer Owner's Manual).
   - If inoperable, replace Battery Equalizer and return inoperable unit to Vanner for repairs.

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Part #A94319

SECTION 07: TRANSMISSION

CONTENTS

ILLUSTRATIONS

1. DESCRIPTION

XL2 Series vehicles may be provided with either an Allison World automatic transmission or a ZF-AsTronic transmission.

1.1 ALLISON AUTOMATIC TRANSMISSION

The B500(R) World Transmission has 6 speeds with two top range (fifth and sixth) overdrives. Total coverage is determined by dividing the highest gear ratio by the lowest gear ratio. Total coverage expresses the transmission gear ratio versatility. Transmissions with larger total coverage number have a wider variety of available ratios.

An electronic control allows the transmission to shift at exactly the right point on the engine's fuel consumption curve for best economy. Early lockup maintains the highest possible mechanical efficiency through the closely-spaced gear steps, culminating in two overdrive ratios. This combination allows progressive shifting techniques, where engine speeds are reduced for higher efficiency and lower fuel consumption.

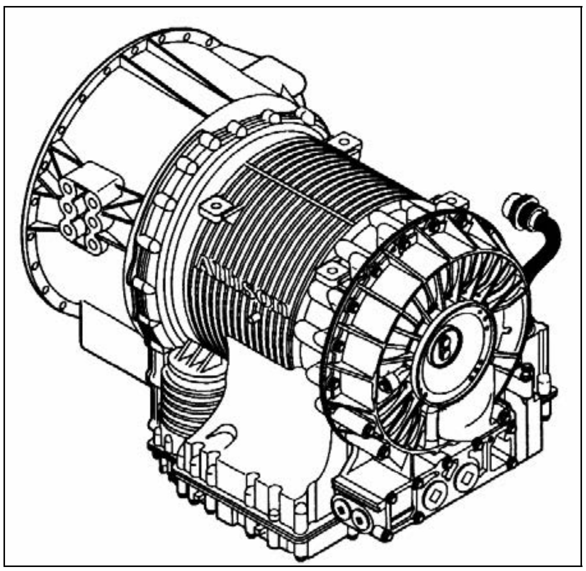


FIGURE 1: WORLD TRANSMISSION 07075

Gear selection and torque converter modes are controlled by a microcomputer-based electronic transmission management system. It is fed information regarding throttle position, operator range selection, engine speed, turbine speed, transmission output speed and various system pressures from special electronic sensors. With this information, it computes shift points and clutch pressures to meet immediate needs. Using closed loop adaptive logic, the electronic control looks at a number of parameters during the shift, and makes minute adjustments to match the shift to desired profile stored in its memory. It then looks at these adjustments and resets the parameters, which allow the transmission to quickly compensate for variations in load, terrain or environment and to adjust for clutch wear and engine power changes. A Diagnostic Data Reader can be connected to the electronic control unit to provide a self-check of all systems in the transmission. Four-digit trouble codes greatly reduce the time it takes to pinpoint potential problems. (Refer to heading *"10. TROUBLESHOOTING"* in this section).

1.1.1 Retarder (if applicable)

This optional auxiliary braking device for the automatic transmission is integrated into the basic envelope of the transmission and transmits its braking force directly to the propeller shaft. It requires no additional length and adds only 75 pounds (34 kg) of weight. Operation of the retarder is controlled electronically by the driver's use of the brake and/or by hand control lever.

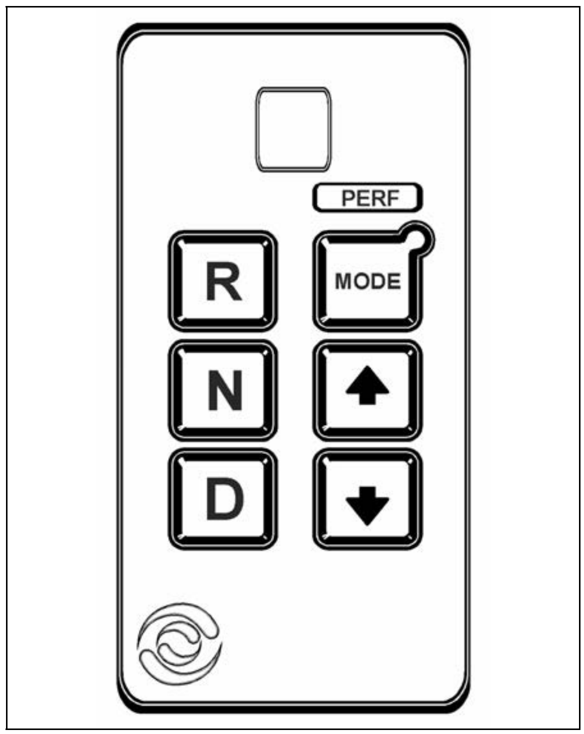


FIGURE 2: WORLD TRANSMISSION CONTROL PAD 07025

When activated, fluid enters a cavity and provides resistance to the turning of rotor blades revolving with the output shaft. This effectively slows the vehicle to the point where the service brakes are needed only for final stopping. The retarder is fully modulated and is compatible with ABS.

1.2 ZF-ASTRONIC TRANSMISSION

The *AS* TRONIC gear shift system is a combination of an electro-pneumatically shifted constant-mesh gearbox and an automated dry clutch.

If the *AS* TRONIC transmission system is to be used, the vehicle must have an electronic engine control unit as well as CAN communication. Since the clutch is automated (clutch pedal no longer fitted), the driver no longer has to activate the clutch.

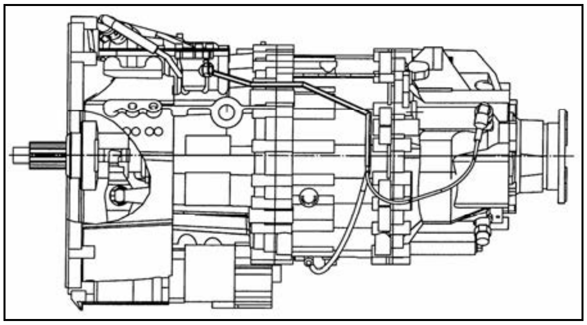


FIGURE 3: ZF-ASTRONIC TRANSMISSION 07078

The actual shift procedure is performed by the electronic transmission control unit. The driver has the option of driving the vehicle in both semi-automatic mode as well as fully automatically. When in semi-automatic mode, manual shifting with the range selector is made easier.

When in fully automatic mode, gears are selected and shifts made by the electronic control unit. The driver can still intervene if he wishes to. All system functions required are shown on the display, e.g. neutral, gear change, clutch overload and diagnosis information.

2. WELDING PROCEDURES

These procedures are intended only for vehicles equipped with transmission electronic controls. When frame or other welding is required on the vehicle, precautions are to be taken to protect the electronic control components. Refer to section 00: GENERAL INFORMATION, paragraph 3: “Precautions to be observed before welding” for complete procedure.

3. MAINTENANCE

3.1 WORLD TRANSMISSION

To gain access to the dipstick, open the engine compartment rear doors ; dipstick is located on the radiator side of the engine (Fig. 4).

To check the transmission oil level, a cold check and a hot check must be performed. A cold check must be made between 60ºF (16ºC) and 140ºF (60ºC). The transmission oil temperature gauge indicates the operating temperature; it is located in the MCD dashboard integrated Liquid Crystal Display and can be viewed when selecting the Gauge Mode (refer to ‘’Operator’s Manual’’ for added information).

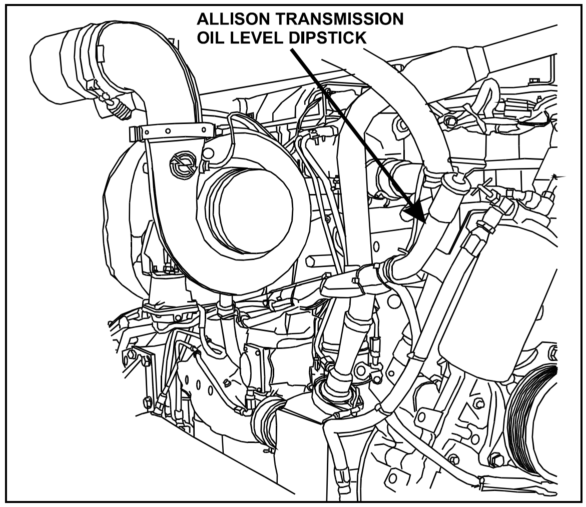


FIGURE 4: OIL LEVEL DIPSTICK (AUTO. TRANS.) 07033

Note: *Perform the cold check first to verify the transmission oil level before performing the hot check.*

The hot check can be performed when the transmission oil reaches the normal operating temperature of 160ºF (71ºC) to 200ºF (93ºC).

Clean all dirt from around the end of the oil filler tube before removing the dipstick. Dirt or foreign matter must not be permitted to enter the oil system since it will cause valves to stick, undue wear of transmission parts, and clogged passages. Check the oil level in accordance with the following procedures and record any abnormal level on your *"Maintenance Records".*

Warning: *When checking the oil level, be sure that the parking brake and/or emergency brakes* *are set and properly engaged, and the wheels are choked. Unexpected and possible sudden vehicle movement may occur if these precautions are not taken.*

Special care must be taken not to touch the engine coolant tubing and/or exhaust pipe, since this could cause severe burns.

Do not wear loose clothing and, stay away from rotating parts during procedure; personal injury could occur.

Always check the oil level reading at least twice when the engine is running. Consistency is important in maintaining the accuracy of the reading. If inconsistent readings persist, check the transmission breather to ensure it is clean and free of debris.

3.1.1 Cold Check

The purpose of the **Cold Check** is to determine if the transmission has enough fluid to be operated safely until a **Hot Check** can be made.

1. If the engine has been shut down for an extended period of time, park the vehicle on a level surface and apply the parking brake.

Caution: *The oil level rises as sump temperature increases. DO NOT fill above the "Cold Run" band if the transmission oil is below normal operating temperature.*

2. Run the engine for at least one minute. Shift to Drive (D) and operate the engine for 30 seconds at 1000-1500 rpm; then shift to Reverse (R) to clear the hydraulic system of air. Finally shift to Neutral (N) and allow the engine to idle (500 - 800 rpm).
3. While the engine is running, remove the dipstick from the tube and wipe it clean (Figs. 4 & 5).

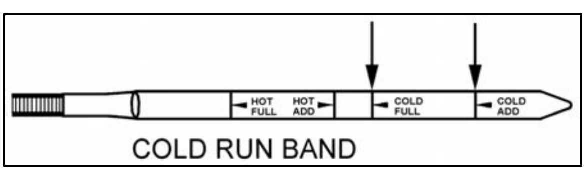


FIGURE 5: COLD CHECK 07050

4. Insert the dipstick into the tube and then remove, checking the oil level reading (Fig. 4). Repeat the check procedure to verify the reading. If the oil reading is within the "Cold Run" band, the level is satisfactory for operating the transmission until the oil is hot enough to perform a "Hot Run" check. If the oil reading is not within the "Cold Run" band, add or drain oil as necessary to bring the level within the "Cold Run" band.
5. Perform a **Hot Check** at the first opportunity after the normal operating temperature of 160ºF (71ºC) to 200ºF (93ºC) is attained.

Caution: *An accurate fluid level check cannot be made unless the engine is idling (500-800 rpm) in Neutral, the transmission fluid is at the proper temperature, and the vehicle is on a level surface.*

3.1.2 Hot Check

Caution: *The oil must be hot to ensure an accurate check for this procedure. The oil level rises as temperature increases.*

1. Operate the transmission in Drive (D) range until normal operating temperature is reached 160ºF (71ºC) to 200ºF (93ºC).
2. Park the vehicle on a level surface and shift to Neutral (N). Apply the parking brake and allow the engine to idle (500 - 800 rpm).
3. While the engine is running, remove the dipstick from the tube and wipe it clean.
4. Insert the dipstick into the tube and then remove, checking the oil level reading. Repeat the check procedure to verify the reading.

The safe operating level is anywhere within the "Hot Run" band on the dipstick (Fig. 5).

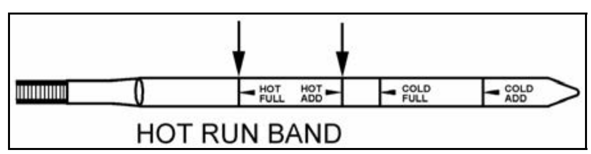


FIGURE 6: HOT CHECK 07049

1. If the oil level is not within the "Hot Run" band, add or drain oil as necessary to bring the oil level within the band.

Note: *The* Cold Check *is more appropriate for verifying the oil level after the first fill-up. In case of conflict, the* Hot Check *has priority over the* Cold Check*; the automatic system of verification via the shift selector has priority over the* Hot Check*.*

3.1.3 Readout of the Oil Level Sensor

The optional Oil Level Sensor (OLS) is designed to measure transmission oil level only when the following combination of operating conditions exist:

1. Engine must be at idle;
2. **NEUTRAL** must be selected;
3. Zero output speed;
4. Transmission oil must be within a "normal" temperature band (160-250°F; 70-120°C), and;
5. Once the first four (4) conditions are met, there must be a "waiting" period (approx. 2 min., to facilitate consistent oil drainback) before oil level measurement begins.

To enter OLS readout mode (after meeting the conditions noted above), simultaneously press the UPSHIFT and DOWNSHIFT arrows on the shifter. If the five (5) conditions noted above are present, the display will immediately enter the reading mode. If the "waiting" period has not elapsed, the left digit of the display will become a "chasing" digit and the right digit will count down from (8) to (1) until the waiting period is complete.

After attaining the reading mode, the display will flash *"OL-OK"*, *"LO-01"*, *"HI-02"*, etc., where the suffix *"01"* or *"02"* indicates the volume of oil (in quarts) either low or high.

At any time in this sequence, simultaneously pressing the UPSHIFT and DOWNSHIFT arrows directs the ECU to enter the transmission diagnostic mode as described under *"10. Troubleshooting"* in this section.
D, N, or R may also be selected on the shifter at any time - the OLS mode will abort and normal transmission will commence. Shifts are not inhibited.

Oil Level Sensor (OLS) Codes

CODE	CAUSE OF CODE
OL-OK	Oil Level Is Correct
LO-01	One Quart Low
LO-02	Two Quarts Low
HI-01	One Quart High
HI-02	Two Quarts High
OL-50	Engine Speed (RPM) Too Low
OL-59	Engine Speed (RPM) Too High
OL-65	Neutral Must Be Selected
OL-70	Sump Oil Temperature Too Low
OL-79	Sump Oil Temperature Too High
OL-89	Output Shaft Rotation
OL-95	Sensor Failure

3.1.4 Keeping Oil Clean

Oil must be handled in clean containers, fillers, etc., to prevent foreign material from entering the transmission. Place the dipstick on a clean surface area while filling the transmission.

Caution: *Containers or fillers that have been used to handle antifreeze or engine coolant must NEVER be used for handling transmission fluid. Antifreeze and coolant solutions contain ethylene glycol that, if introduced into the transmission, can cause the clutch plates to fail.*

3.1.5 Oil Recommendations

Hydraulic oils used in the transmission have an important influence on transmission reliability and durability. In order of preference Castrol TranSynd Synthetic Fluid, DEXRON-III and DEXRON-IIE, MIL-L-2104D, and type C-4 oils (Allison approved SAE 10W or SAE 30) are recommended. Type C-4 oil is the only oil approved for use in off-highway applications. Use type SAE 30 where ambient temperature is consistently above 86ºF (30ºC). Some DEXRON-II oils are also qualified as type C-4 oils and may be used in off-highway applications. However, a DEXRON-II fluid which is not a qualified type C-4 oil must never be used in off-highway applications. Consult your local Allison dealer or distributor to determine if a DEXRON-II oil is also a qualified type C-4 oil.
Before using type C-4 oils, consult the vehicle manufacturer to ensure that materials used in tubes, hoses, seals, etc., are compatible with type C-4 oils. Also, consult your local Allison dealer or distributor to determine if the oil you have selected is an approved type C-4 oil. Ford Motor Company specification oils M2C33-F, M2C138-CJ and M2C166-H may be used and may be intermixed with DEXRON-II oil.

OIL SPECIFICATIONS AND AMBIENT TEMPERATURE OPERATING CONDITIONS	
Oil type	Ambient temperature
MIL-L-2104D, DEXRON-II, TranSynd TES 295, C-4	120ºF (48ºC) to -25ºF (-32ºC)
MIL-L-46167	-25ºF (-32ºC) to -60ºF (-51ºC)

The use of an arctic preheat kit is recommended at temperatures below -25ºF (-32ºC). If a preheat kit is not available, the ECU will restrict full operation until the sump temperature is increased. The chart below shows the temperature ranges in which the transmission will operate. It should be noted that at lower sump temperature, the transmission's operation may be restricted.

Transmission Oil Temperature	**"DO NOT SHIFT" Light**	**Operation**
Below -26ºF (-32ºC)	ON	Neutral only
-24ºF (-31ºC) to +19ºF (-7ºC)	OFF	Start with neutral and reverse, normal upshifts
+20ºF (-6ºC) to 260ºF (126ºC)	OFF	Full operation in all ranges
Above 260ºF (126ºC)	ON	Inhibits 5th and 6th ranges

3.1.6 Oil Contamination

At each oil change, examine the drained oil for evidence of dirt or water. A nominal amount of condensation will emulsify during operation of the transmission. However, if there is evidence of water, check the cooler (heat exchanger) for other signs of leakage. This, however, may also indicate leakage from the engine oil system.

3.1.7 Metal Particles

Metal particles in the oil (except for minute particles normally trapped in the oil filter) indicate damage has occurred in the transmission. When these particles are found in the sump, the transmission must be disassembled and closely inspected to find the source. Metal contamination will require complete disassembly of the transmission and cleaning of all internal and external circuits, coolers, and all other areas where the particles could lodge.

Caution: *If excessive metal contamination has occurred, replacement of the oil cooler and replacement of all bearings within the transmission is recommended.*

3.1.8 Coolant Leakage

If engine coolant leaks into the transmission oil system, immediate action must be taken to prevent malfunction and possible serious damage. The transmission must be completely disassembled, inspected, and cleaned. All traces of the coolant contamination must be removed. Friction clutch plates contaminated with ethylene glycol must be replaced.

TABLE 1 : Recommended Fluid and Filter change intervals (Non-Transynd Fluid)		
Initial Break-In		5,000 miles (8 000 km)
Coach	Non-Transynd Fluid	12,000 miles (19300 km) or 6 months, whichever comes first
MTH with retarder	Non-Transynd Fluid	12,000 miles (19300 km) or 6 months, whichever comes first
MTH without retarder	Non-Transynd Fluid	25,000 miles (40200 km) or 12 months, whichever comes first

TABLE 2 : HD/B 500/T 400/T 500 Series

2 inch Control Module (1.75 approximately) – Requires filter kit P/N 29540493

Recommended Fluid and Filter Change Intervals (TranSynd^{TM}/TES 295 Fluid)

Coaches and MTH with retarder				MTH without retarder			
Initial Break-in				5,000 Miles (8 000 km)			
Fluid	Filters			Fluid	Filters		
	Main	Internal	Lube/Auxiliary		Main	Internal	Lube/Auxiliary
50,000 Miles (80 000 km) 24 Months	50,000 Miles (80 000 km) 24 Months	Overhaul	50,000 Miles (80 000 km) 24 Months	150,000 Miles 240 000 km 48 Months	50,000 Miles (80 000 km) 24 Months	Overhaul	50,000 Miles (80 000 km) 24 Months

3.1.9 Oil and Filter Change

Allison transmissions are now factory fill with TranSynd fluid. Oil change must be performed with the vehicle on a flat and level surface and with parking brake applied. Oil and oil filter change frequency is determined by the severity of service and operating conditions of the transmission and by the filter equipment installed. See *"Table 1 and 2"* for oil and filter change intervals. More frequent changes may be required when operations are subject to high levels of contamination or overheating.

The procedure for changing the transmission oil and oil filters is as follows:

Drain

1. The transmission should be at an operating temperature of 160ºF (71ºC) to 200ºF (93ºC) when the oil is drained. This will ensure quicker and more complete fluid drainage.

Note: *Remove transmission protective panel located underneath transmission for easier access.*

2. Remove the drain plug from under the transmission (Fig. 6) and allow the oil to drain into a suitable container. Check the condition of the oil as described previously.
3. To replace the integral filters, remove twelve bolts (6 on each cover), two filter covers, two O-rings, two square cut seals and the two filters from the bottom of the control module (Fig. 6).
4. To install filters, pre-lube and install the two O-rings, the two square cut seals followed by the filters (lube the O-ring in filter cartridge only) into the filter compartment. Index each filter/cover assembly to holes in channel plate/sump. Push the cover assembly in by hand to seat the seals.

Caution: *Do not use bolts to draw the cover to sump. This can damage the cover, seal, or sump.*

5. Install twelve bolts and both covers, and then tighten to 38-45 Ft-lbs (51-61 Nm).
6. Inspect the drain plug and O-ring. Replace if necessary. Reinstall the drain plug and tighten to 18-24 Ft-lbs (25-32 Nm).
7. Reinstall transmission protective panel

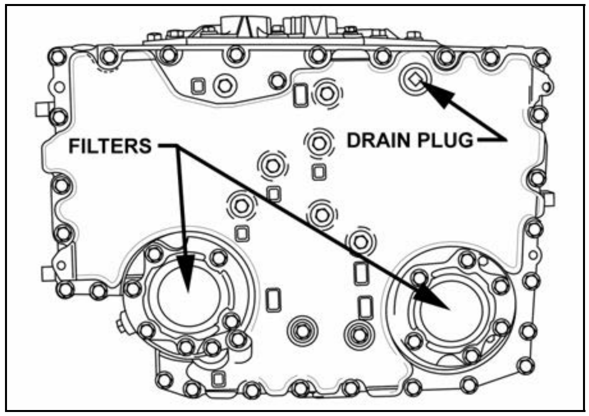


FIGURE 7: DRAIN PLUG AND FILTERS 07052

Refill

Using the oil level dipstick filler tube, refill with 24 US qts (23 liters) [28 US qts (26.5 liters) if equipped with retarder] and check the oil level using the previously described procedure. The refill amount is less than the initial filling because some of the oil remains in the external circuits and transmission cavities.

3.2 ZF AS-TRONIC TRANSMISSION

All information needed for the removal /installation or maintenance of the ZF transmission are included in the documents annexed at the end of this section.

3.2.1 ZF AS-TRONIC / SACHS Clutch Installation Procedure

Important Note:

The clutch hub splines, input shaft, release bearing, clutch fork, and clutch push rod ends all come pre-lubed from the factory.

- Clean the flywheel, clutch disc, and pressure plate surfaces, removing any grease prior to assembly.
- Slide the clutch disk onto the transmission input shaft to check for smooth engagement. Remove clutch disk.
- Apply a very thin coating of Optimal Olista Longtime synthetic grease to the transmission input shaft. Slide the clutch disk along the full length of the input shaft to transfer grease to the clutch hub splines. Remove clutch disc, and remove any excess grease from the exterior of the clutch disc hub. **It is very important that no**

excess grease is left on the exterior of the clutch hub or clutch disk!

- Install two temporary pilot studs (7/16-14, 3” long), placing them on the same diameter, 180^o apart. These are used to aid in the alignment of the clutch pressure plate.
- Verify that the pilot bearing is seated properly in the flywheel. Insert a clutch alignment tool (SAE 2” DIA, 10 Spline) through the clutch disc and into the pilot bearing. PLEASE NOTE: the direction matters – the large side of the hub should face the clutch pressure plate. The clutch disc hub should be marked “flywheel side” – this side should face the flywheel.
- Use the clutch alignment tool to keep the clutch disc in the proper position and align the clutch cover with the two studs. Push the cover in place in the direction of the flywheel and start installing the clutch bolts. Use Lock-Tite for each bolt. Install, but do not torque, the 10 bolts. Remove the two pilot studs and in their place install the remaining 2 bolts.
- When the bolts are hand tight, be sure that the clutch cover fits into the flywheel centering ring. Tighten each bolt a little at a time, in a crisscross pattern, until the pressure plate cover contacts the flywheel face. Once the cover has touched the face of the flywheel, torque the clutch bolts to 55 ft-lbs, again in a crisscross fashion.
- Remove the clutch alignment tool. If the installation was successful, it should slide out smoothly.
- Ensure that the release bearing retaining clip (located on the “fingers” of the pressure plate) is closed. Refer to figure 8.
- Remove the Clutch Inspection Cover from the bottom of the transmission.
- The transmission should have been shipped in gear. This will allow the installer to rotate the output shaft in order to align the input shaft with the clutch disc hub. If the transmission is in neutral, a “strap wrench” (with a rubber or leather strap) can be used to align the input shaft. Do not use a wrench of the “chain” variety, as damage to the input shaft may result. When aligned, push the transmission towards the engine. Be sure that the bell housing contacts the flywheel housing.

Warning!

- Insure that the transmission moves in a straight line. It can very easily go off center relative to the clutch disc and pilot bearing.
- Insure that the bell housing interfaces evenly with the flywheel housing. Even surface contact should be attained before tightening bolts.
- Do not try to correct relative position of the bell housing and flywheel housing by pulling the transmission into place with the bell housing bolts. The transmission bell housing should seat into the flywheel housing freely.

- When the bell housing and flywheel housing surfaces and bolt holes are aligned, install the transmission bolts. Only hardened steel flat washers should be used, **SERRATED LOCK WASHERS ARE NOT ALLOWED**. Torque the transmission bolts to 55 ft-lbs. in a crisscross fashion.
- From underneath, push the clutch release bearing forward (in the direction of flywheel) using the release fork. Use force to snap the bearing into the retaining clip located on the “fingers” of the pressure plate. The installer should be able to both hear and feel the bearing seat into place. Refer to figure 8.

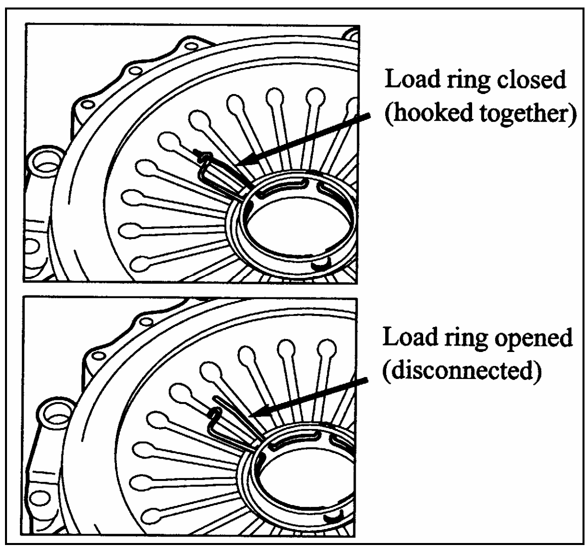


FIGURE 8: RELEASE BEARING RETAINING CLIP 07081

- Install the Clutch Actuator inspection cover.

- The clutch/transmission installation is now complete.

4. ALLISON TRANSMISSION REMOVAL

The following procedure deals with the removal of the Allison transmission without removing the power plant cradle from vehicle. The methods used to support the transmission and engine depend upon conditions and available equipment.

1. Select transmission's "NEUTRAL" position, apply parking brake, then set battery master switch to the "OFF" position.
2. Jack up vehicle, then place safety supports underneath body.

Caution: *Only the recommended jacking points must be used as outlined in Section 18,* "BODY".

Note: *For more clearance between the tag axle and transmission, the tag axle may be unloaded and jacked up or retracted (if applicable).*

2. Remove engine splash guards and protective panels surrounding transmission.
4. Remove cross member from under transmission.
5. Remove the transmission drain plug and allow oil to drain. Inspect the drain plug washer and replace it if necessary. Reinstall the drain plug and tighten to 33-41 Ft-lbs (45-56 Nm) (see *"3.2.9 Oil and Filter Change"* in this section.

Warning: *It is better to drain oil when it is still warm. Avoid contact with oil since it can be very hot and cause personal injury.*

6. Remove transmission dipstick and filler tube.
7. Disconnect propeller shaft from transmission and remove its safety guard. Refer to Section 09, *"PROPELLER SHAFT".*
8. Disconnect the two oil cooler hoses from transmission. Cover hose ends and fittings to prevent fluid contamination.

Warning: *A significant amount of oil may drain from oil lines when they are disconnected.*

9. Disconnect all sensors on L.H. side of the transmission.
10. Disconnect main wiring harness.
11. Disconnect the air supply line (steel-braided hose) from retarder control valve (if applicable).
12. Remove any locking tie, clamp and bracket that may interfere with the removal of transmission.
13. Support transmission using a suitable transmission jack.
14. Remove the access plug from the flywheel housing on the R.H. side below starter. From access plug, remove the 12 converter-to-flexible plate attaching screws. Cranking the engine to gain access to the attaching screws may be done by turning the crankshaft pulley using a suitable adapter (fig. 7).

Caution: *Do not rotate alternator shaft clockwise to avoid removing tension on belt.*

15. Remove the 12 screws retaining the torque converter housing to the flywheel housing.

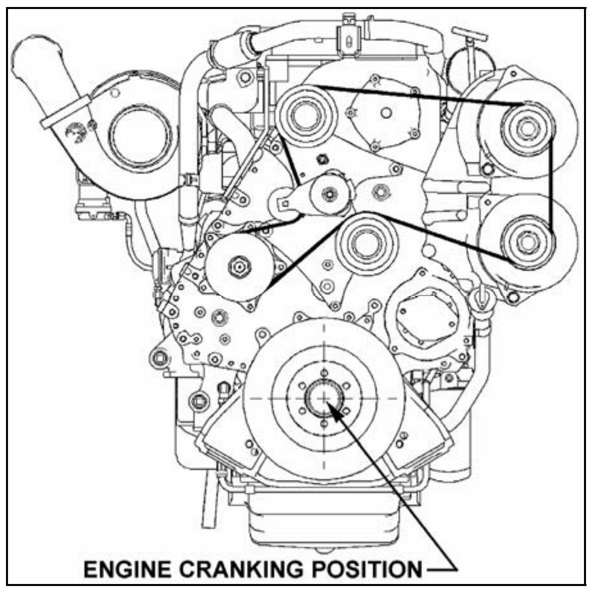


FIGURE 9: ENGINE CRANKING POSITION 01116

Caution: *Make sure transmission-to-engine alignment is maintained when removing screws to avoid damaging torque converter housing.*

16. Remove the transmission rubber mount above transmission by removing the nut, bolt and washer over the rubber and its support. Remove the bracket from transmission (only if the vehicle is equipped with a retarder).
17. Slowly pull transmission straight out to clear the engine.

18. Remove the transmission.

5. TRANSMISSION OIL COOLER REMOVAL

5.1 TRANSMISSION WITHOUT RETARDER

Stop engine and allow engine to cool. Close both heater line shutoff valves (refer to Section 05 *''Cooling''*).

To drain the cooling system, proceed as per Section 05 *''Cooling''*, paragraph 5: Draining. If the cooling system is contaminated, flush system as per Section 05 *''Cooling''*, paragraph 7: Flushing.

1. Disconnect and remove the engine air intake duct mounted between the air cleaner housing and the turbocharger inlet.

Caution: *To avoid damage to turbocharger, cover the turbocharger inlet opening to prevent foreign material from entering.*

2. Disconnect the two transmission hoses from oil cooler. Cover hose ends and fittings to prevent fluid contamination.

Warning: *A significant amount of oil may drain from oil lines when they are disconnected.*

3. Unfasten the constant-torque hose clamps and remove the two hoses.

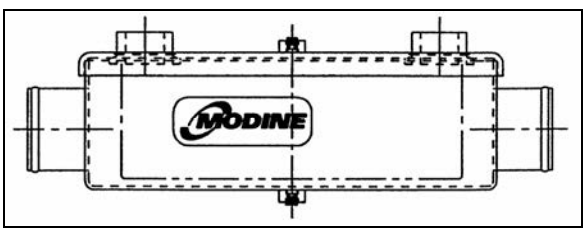


FIGURE 10: MODINE OIL COOLER 07072

4. Unscrew the four holding nuts and remove the U-bolts, remove the oil cooler from engine compartment.
5. Reinstall transmission oil cooler by using reverse procedure.

5.2 TRANSMISSION WITH RETARDER

Stop engine and allow engine to cool. Close both heater line shutoff valves (refer to Section 05 *''Cooling''*).

1. To drain the cooling system, proceed as per Section 05 *''Cooling''*, paragraph 5: Draining. If the cooling system is contaminated, flush system as per Section 05 *''Cooling''*, paragraph 7: Flushing.
2. Disconnect and remove the engine air intake duct mounted between the air cleaner housing and the turbocharger inlet.

Caution: *To avoid damage to turbocharger, cover the turbocharger inlet opening to prevent foreign material from entering.*

3. Disconnect the transmission hoses from oil cooler. Cover hose ends and fittings to prevent fluid contamination.

Warning: *A significant amount of oil may drain from oil lines when they are disconnected.*

4. Unfasten the constant-torque hose clamps and remove the two hoses.
5. Unscrew the holding bolts and nuts and remove the oil cooler from engine compartment.

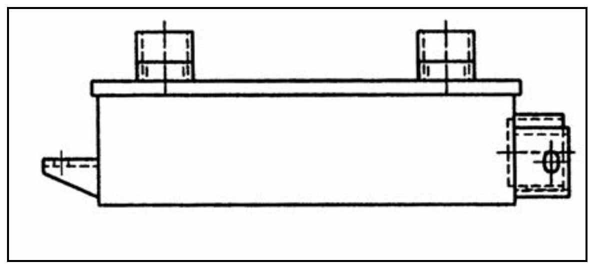


FIGURE 11: COOLER WITH RETARDER 07073

6. Reinstall transmission oil cooler by using reverse procedure.

6. CLEANING AND INSPECTION OF THE TRANSMISSION

6.1 ALLISON AUTOMATIC TRANSMISSION

The exterior of the transmission should be cleaned and inspected at regular intervals. The length of service and severity of operating conditions will determine the frequency of such inspections. Inspect the transmission for:

1. Loose bolts (transmission and mounting components);
2. Oil leaks (correct immediately);
3. Loose, dirty, or improperly adjusted throttle sensor linkage;
4. Damaged or loose oil lines;

5. Worn or frayed electrical harnesses, improper routing;
6. Worn or out of phase drive line U-joint and slip fittings.

Caution: *DO NOT pressure wash the transmission electrical connectors. Water and detergent will cause the contacts to corrode or become faulty.*

6.1.1 Breather

The breather is located on the engine, flywheel side near the valve cover. It serves to prevent pressure build-up within the transmission and must be cleaned to keep the passage opened. The prevalence of dust and dirt will determine the frequency at which the breather requires cleaning. Use care when cleaning the engine. Spraying steam, water or cleaning solution directly at the breather can force the water or solution into the transmission. Always use care when removing the hose connector from transmission to prevent the entry of foreign matter.

7. ALLISON TRANSMISSION INSTALLATION

Note: *For more clearance between the tag axle and transmission, the tag axle may be unloaded and jacked up, or retracted (if applicable).*

1. With the access plug removed, align one of the 12 attaching screw holes in the flexible plate with the access opening (starter side).
2. Place the transmission on a transmission jack.
3. Install a headless guide bolt into one of the 12 threaded holes for flexible plate attaching screws in the flywheel.
4. Lubricate the flywheel center pilot boss with molybdenum disulfide grease (Molycote G, or equivalent).
5. Raise transmission and position the flywheel pilot boss into the flexible plate adapter. Align the guide bolt previously installed in the flywheel with the flexible plate hole facing the access opening in the flywheel housing.

Warning: *Severe damages and/or personal injury can occur if transmission is not adequately supported.*

6. Seat the transmission against the engine flywheel housing. NO FORCE IS REQUIRED. If interference is encountered, move the transmission away from engine, then investigate the cause.

Caution: *The torque converter housing must be seated against the flywheel housing prior to tightening any screws. DO NOT USE SCREWS TO SEAT THE HOUSING.*

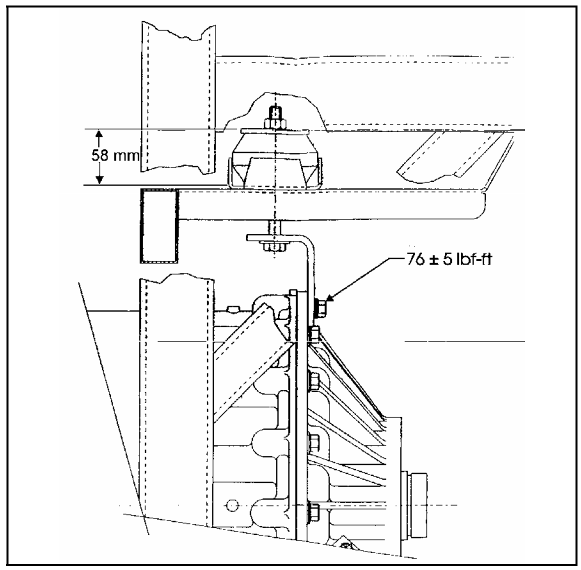


FIGURE 12: NUT TOLERANCE 07014

7. Start all torque converter housing screws, then tighten four of them gradually and in a criss-cross sequence around the housing. Tighten the 12 remaining screws. Recommended torque is between 42-50 Ft-lbs (57-68 Nm).
8. Remove the guide bolt through the access opening in the flywheel housing. Replace it with a self-locking screw, finger-tighten then start the remaining screws; tighten to 17-21 lbf•ft (23-28 N•m). Place a wrench on the crankshaft pulley attaching screw to turn the converter to gain access to the threaded holes.
9. Reinstall the access plug.
10. If the vehicle is equipped with a retarder; install the bracket on the transmission and tighten the bolt to 71-81 Ft-lbs (96-110 Nm). Install the transmission rubber mount between the rubber support and the frame with a bolt, nut and washer. Tighten the nut

until the tolerance of 58 ± 2 mm is met (Fig. 10).

11. Remove jack from under transmission.
12. Connect all sensors.
13. Connect the main wiring harness.
14. Connect the air supply line (steel-braided hose) to the retarder control valve (if applicable).
15. Connect the two transmission oil cooler hoses as they were previously.
16. Reinstall clamps and brackets, and replace locking ties previously removed during removal procedure.
17. Install propeller shaft and its safety guard. Refer to Section 09, *"PROPELLER SHAFT".*
18. Install transmission dipstick and filler tube.
19. Install cross member under transmission.
20. Install engine splash guards.
21. Adjust the retarder pressure to 80 ± 3 psi with the air pressure regulator. For more information refer to Section 12, *"BRAKE AND AIR SYSTEM*", under heading *"AIR PRESSURE REGULATOR".* The air pressure regulator is located at back of engine compartment, on R.H. side (Fig. 11) or in the R.H. side rear service compartment.
22. Make sure that the drain plug is in place, then remove the transmission dipstick and pour approximately 24 US quarts (23 L) of automatic transmission fluid through the filler tube. Check and adjust oil level.

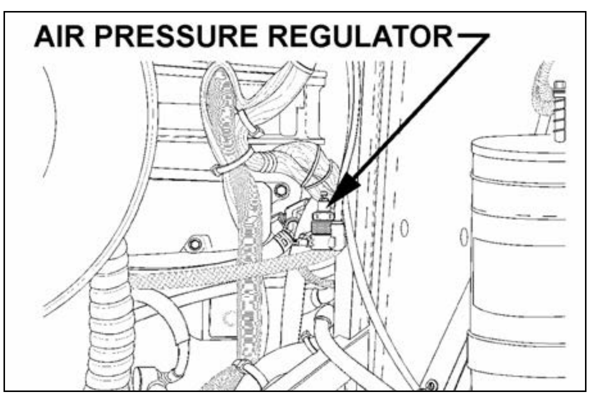


FIGURE 13: AIR PRESSURE REGULATOR (TYPICAL) 07037

Caution: *Do not overfill the transmission. Overfilling can cause oil aeration (milky appearance) and overheating. If overfilling occurs, drain oil as required to bring it to the proper level.*

8. ALLISON TRANSMISSION PRINCIPLES OF OPERATION

Refer to *"Allison Transmission, MD Series, Principles of Operation, SA 2454".*

9. TROUBLESHOOTING

9.1 ALLISON AUTOMATIC TRANSMISSION

Refer to “Allison Transmission, MD Series, Troubleshooting Manual, SA 2158A”.

9.1.1 WTEC/Electronic Control Unit

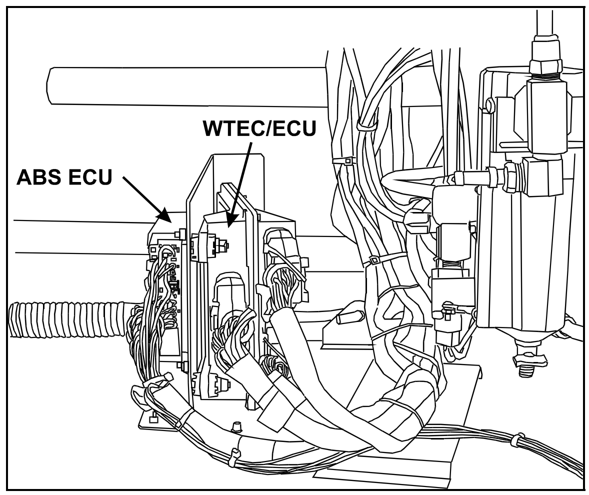


FIGURE 14: WTEC / ELECTRONIC CONTROL UNIT 07075

The ’’World’’ automatic transmission has a new Electronic Control Unit (ECU) which involves specific diagnostic incident codes. The ECU transmission unit is located in the coach front service compartment.

WTEC/ECU Replacement

The automatic transmission ECU is a non-serviceable electronic device. When it fails, it must be replaced using the following procedure:

- open the coach front service compartment in order to get access to the ECU;
- remove the electrical cable connectors;
- unscrew the WTEC/ECU unit;
- replace by reversing the procedure.

Caution: *Place the battery master switch to the ‘’OFF’’ position.*

9.1.2 WTEC/Troubleshooting

For complete information about WTEC /Troubleshooting, refer to ''Allison Transmission, MD Series, Troubleshooting Manual, SA2978'' March 1997, pages D-9 and D-10.

9.1.3 Diagnostic Code Memory

Diagnostic codes are logged in a list in memory (sometimes referred to as the queue), positioning the most recently occurring code first and containing up to five codes. The codes contained in the list have the information recorded as shown in the chart below. Access to the code list position, main code, sub code and active indicator is available through either the shifter display or the Pro-Link Diagnostic Data Reader (DDR). Access to the ignition cycle counter and event counter is obtained through the DDR only.

Code List Position	Main Code	Sub Code	Active Indicator	Ignition Cycle Counter	Event Counter
d1	21	12	YES	00	10
d2	41	12	YES	00	04
d3	23	12	NO	08	02
d4	34	12	NO	13	01
d5	56	11	NO	22	02
Displayed on shifter display and DDR			YES= ACTIVE= "MODE ON"	Ignition cycle counter and event counter are not available on shifter display	

Note: *All information is available with a diagnostic tool (DDR).*

The following paragraphs define the different parts of the code list.

Code List Position

The position (1 through 5) which a code occupies in the code list in memory. Positions are shown as "d1" (Diagnostic Code #1) through "d5."

Main Code

The general condition or area of fault detected by ECU.

Sub Code

The specific area or condition under the main code in which the condition was detected.

Active Indicator

Will be turned "On" when a fault condition is active (shifter will display "MODE ON" or the DDR will display "YES"). Will be set to "Off" when conditions exist to indicate fault condition is gone.

Ignition Cycle Counter

Used to clear diagnostic codes that are inactive from the code list in memory. A counter is incremented each time a normal ECU power down occurs following clearing of the Active Indicator. A code will be cleared from the list when the counter exceeds 25.

Event Counter

Used to count the number of occurrences of a diagnostic code that occurs prior to the incident being cleared from the code list. The most recent code will be in position "d1". If the most recent code is one which is already in the code list, that code will be moved to position "d1", the Active Indicator will be turned "On" (shifter will display "MODE ON" or the DDR will display "YES"), the Ignition Cycle Counter is cleared and "1" is added to the Event Counter.

Clearing the Active Indicator and code Records from the Code List in Memory

If the conditions causing a diagnostic code to be set are cleared, the Active Indicator can be manually cleared by holding the "MODE" button down continuously for 3 seconds until a tone is heard from the shifter.

To clear code records from the list, hold the "MODE" button down continuously for ten seconds until a second tone sounds. All diagnostic records in the list that are not active will then be cleared and the remaining records will be moved up the list.

Code Reading and Code Clearing Procedures

Diagnostic codes can be read and cleared by two methods: by using the Pro-Link 9000 DDR plugged in the receptacle located on L.H. lateral console (Shells)/L.H. side control panel (Coaches) or by using the shifter display. The use of the Pro-Link 9000 DDR is described in the instruction manual supplied with each tool. The method for reading and clearing codes described in this section refers only to entering of the Diagnostic Display Mode by the proper button selection.

The Diagnostic Display Mode may be entered for viewing of codes at any speed. Codes can only be cleared when the output speed = 0 and no output speed sensor failure is active.

The following descriptions explain how to use the shifter to read and clear codes.

9.1.4 Reading Codes

1. Enter the diagnostic display mode by pressing the "⬆" and "⬇" (upshift and downshift arrows) buttons at the same time on the pushbutton shifter.

Note: *If a "DO NOT SHIFT" condition is present at this time, the lever should be in the same position as it was at the time of code detection. If not, this shifter tone will sound continuously.*

Note*: If an Oil Level Sensor (OLS) is present, the oil level will be displayed first. Diagnostic code display is achieved by depressing the UPSHIFT and DOWNSHIFT arrows or display MODE button a second time.*

2. Read the first code in the first of five code positions on the digital display of the shifter. For example, we will read code 25 11 in the first position. The display will change every two seconds as follows:
   a. Code list position --"d1";
   b. Main code --"25";
   c. Sub code --"11"; and
   d. Display will repeat cycle of a., b. and c, above.
3. Press the "MODE" button momentarily to view the second position (d2) in the same way as 2. above.
4. To view the third, fourth and fifth positions (d3, d4 and d5), momentarily press the "MODE" button as explained above.
5. Pressing the "MODE" button momentarily after the fifth position is displayed will cause the sequence of code positions to start over with the first position.
6. Any code that is active will be indicated by the "MODE ON" indicator (Active Indicator) being turned on while in that code position (while in the normal operation).
7. Any code position in the list which does not have a diagnostic code logged will display "- -" for both the main and sub code displays. All positions after a code codes.

9.1.5 Clearing Codes

1. Clearing of the active indicator is automatically done at ECU power down on all but code 69 34.
2. Some codes will clear the active indicator automatically when the condition causing the code is no longer detected by the ECU (see Diagnostic Code List and Description, page 7 - 22).
3. Manual clearing is possible while in the diagnostic display mode and after the condition causing the code is corrected (output speed must be zero).
   a. To clear all active indicators, hold the "MODE" button down continuously for 3 seconds until the shifter tone sounds for 0.5 seconds.
   b. Release the "MODE" button to return to normal operating mode. If the condition causing the code was not active at the time, the active indicator will turn off.

Caution: *If clearing a code while locked in a Forward or Reverse position (fail-to-range), the transmission will still be in Drive or Reverse when the clearing procedure is completed. Neutral must be selected manually.*

Exiting the Diagnostic Display Mode

The diagnostic display mode can be exited by any of the following procedures:

1. Press the "⬆" and "⬇" (upshift and downshift) buttons at the same time on the pushbutton shifter.
2. Press any range button, "D", "N" or "R", on the pushbutton shifter (the shift will be commanded if it is not inhibited by an active code).
3. Do nothing and wait until the calibrated time (approximately 10 minutes) has passed and the system automatically returns to the normal operating mode.
4. Turn off power to the ECU (turn off the vehicle at the ignition switch).
5. After the clearing of a code, the active indicator procedure described above has been performed.

Clearing Records from the Code List in Memory

If the requirements for Manual Clearing the Active Indicator have been satisfied, and the "MODE" button is held down continuously for ten seconds while in the display mode until a tone sounds, then all diagnostic records in the code list that are not active will be cleared and the remaining records will be moved up in the code list.

Abbreviations found in the Code Chart

The following responses are used throughout the following chart to command safe operation when diagnostic codes are set.

1. **DNS** (**D**o **N**ot **S**hift) Response
   a. Turn off lockup clutch and inhibit lockup operation.
   b. Inhibit all shifts.
   c. Turn on the *DO NOT SHIFT* light.
   d. Pulse the tone generator for 8 seconds when the condition is first detected.
   e. Blank the select digit in the display.
   f. Ignore any range selection inputs and disable the button feedback tone for the pushbutton shifter.
2. **SOL OFF** (**Sol**enoid **Off**) Response

   All solenoids are commanded off (turning solenoids "A" and "B" off electrically causes them to be on hydraulically).
3. **RPR** (**R**eturn to **P**revious **R**ange) Response

   When the ratio or C3 pressure switch tests associated with a shift are not passed, the ECU commands the same range as commanded at the beginning of the shift.
4. **NNC** (**N**eutral **N**o **C**lutches) Response

   When certain ratio or C3 pressure switch tests are not passed, the ECU commands a neutral condition with no clutches applied.

Diagnostic code list and description

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
12	12	Oil level, low	No	No upshift above a calibration range
12	23	Oil level, high	No	No upshift above a calibration range
13	12	ECU input voltage, low	Yes	DNS, SOL OFF (Hydraulic default)
13	13	ECU input voltage, medium low	No	None: Shift adaptive feature will not function.
13	23	ECU input voltage, high	Yes	DNS, SOL OFF (Hydraulic default)
14	12	Oil level sensor, low	No	None
14	23	Oil level sensor, high	No	None
21	12	Throttle position sensor, low	No	Use Throttle default value
21	23	Throttle position sensor, high	No	Use Throttle default value
22	14	Engine speed sensor reasonableness test	No	Use default engine speed
22	15	Turbine speed sensor reasonableness test	Yes	DNS, Lock in current range
22	16	Output speed sensor reasonableness or rapid decel test	Yes	DNS, Lock in current range
23	12	Primary Shifter or RSI Link Fault	No	Hold in last valid direction
23	13	Primary Shifter Mode Function Fault	No	Mode change not permitted
23	14	Secondary Shifter or RSI Link Fault	No	Hold in last valid direction
23	15	Secondary Shifter Mode Function Fault	No	Mode change not permitted
24	12	Sump oil temperature, cold	Yes	DNS
24	23	Sump oil temperature, hot	No	No upshifts above a calibration range
25	00	Output speed reasonableness test, detected at 0 speed, (L)	Yes	DNS, Lock in current range (L)
25	11	Output speed reasonableness test, detected at 0 speed, (1st)	Yes	DNS, Lock in current range (1st)
25	22	Output speed reasonableness test, detected at 0 speed 2nd	Yes	DNS, Lock in current range (2nd)

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
25	33	Output speed reasonableness test, detected at 0 speed, 3rd	Yes	DNS, Lock in current range (3rd)
25	44	Output speed reasonableness test, detected at 0 speed, 4th	Yes	DNS, Lock in current range (4th)
25	55	Output speed reasonableness test, detected at 0 speed, 5th	Yes	DNS, Lock in current range (5th)
25	66	Output speed reasonableness test, detected at 0 speed, 6th	Yes	DNS, Lock in current range (6th)
25	77	Output speed reasonableness test, detected at 0 speed, R	Yes	DNS, Lock in current range (R)
32	00	C3 pressure switch open, L range	Yes	DNS, Lock in current range (L)
32	33	C3 pressure switch open, 3rd range	Yes	DNS, Lock in current range (3rd)
32	55	C3 pressure switch open, 5th range	Yes	DNS, Lock in current range (5th)
32	77	C3 pressure switch open, R range	Yes	DNS, Lock in current range (R)
33	12	Sump oil temperature sensor, low	No	Use default value of 200ø F (93ø C)
33	23	Sump oil temperature sensor, high	No	Use default value of 200ø F (93ø C)
34	12	EEPROM, factory cal. compatibility number wrong	Yes	DNS, SOL OFF (Hydraulic default)
34	13	EEPROM, factory calibration block checksum	Yes	DNS, SOL OFF (Hydraulic default)
34	14	EEPROM, Power Off Block checksum	Yes	Use previous location, or factory calibration and reset adaptive
34	15	EEPROM, Diagnostic Queue Block Checksum	Yes	Use previous location, or clear diagnostic queue
34	16	EEPROM, Real Time Block Checksum	Yes	DNS, SOL OFF (Hydraulic default)
35	00	Power interruption (Code set after power restored)	No	NONE (Hydraulic default during interruption)
35	16	Real Time EEPROM Write Interruption	Yes	DNS, SOL OFF (Hydraulic default)
36	00	Hardware/Software not compatible	Yes	DNS, SOL OFF

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
				(Hydraulic default)
41	12	Open or short to ground, A solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
41	13	Open or short to ground, B solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
41	14	Open or short to ground, C solenoid circuit	Yes	DNS. SOL OFF (Hydraulic default)
41	15	Open or short to ground, D solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
41	16	Open or short to ground, E solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
41	21	Open or short to ground, F solenoid circuit	No	Lock-up inhibited
41	22	Open or short to ground, G solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
41	23	Open or short to ground, H solenoid circuit	No	Retarder allowed, differential lock inhibited
41	24	Open or short to ground, J solenoid circuit	No	Low and 1st inhibited
41	25	Open or short to ground, K solenoid circuit	No	K solenoid operation inhibited
41	26	Open or short to ground, N solenoid circuit	No	Low and 1st inhibited
42	12	Short to battery, A solenoid circuit	Yes	DNS, Lock in a range
42	13	Short to battery, B solenoid circuit	Yes	DNS, Lock in a range
42	14	Short to battery, C solenoid circuit	Yes	DNS, Lock in a range
42	15	Short to battery, D solenoid circuit	Yes	DNS, Lock in a range
42	16	Short to battery, E solenoid circuit	Yes	DNS, Lock in a range
42	21	Short to battery, F solenoid circuit	No	Lock-up inhibited
42	22	Short to battery, G solenoid circuit	Yes	DNS, Lock in a range

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
42	23	Short to battery, H solenoid circuit	No	Retarder allowed, differential lock inhibited
42	24	Short to battery, J solenoid circuit	No	Low and 1st inhibited
42	25	Short to battery, K solenoid circuit	No	K solenoid operation inhibited
42	26	Short to battery, N solenoid circuit	No	Low and 1st inhibited
43	21	Low side driver, F solenoid circuit	No	Lock-up inhibited
43	25	Low side driver, K solenoid circuit	No	K solenoid operation inhibited
43	26	Low side driver, N solenoid circuit	No	Low and 1st inhibited
44	12	Short to ground, A solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
44	13	Short to ground, B solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
44	14	Short to ground, C solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
44	15	Short to ground, D solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
44	16	Short to ground, E solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
44	21	Short to ground, F solenoid circuit	No	Lock-up inhibited
44	22	Short to ground, G solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
44	23	Short to ground, H solenoid circuit	No	Retarder allowed. differential lock inhibited
44	24	Short to ground, J solenoid circuit	No	Low and 1st inhibited
44	25	Short to ground, K solenoid circuit	No	K solenoid operation inhibited
44	26	Short to ground, N solenoid circuit	No	Low and 1st inhibited
45	12	Open circuit, A	Yes	DNS, SOL OFF

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
		solenoid circuit		(Hydraulic default)
45	13	Open circuit, B solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
45	14	Open circuit, C solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
45	15	Open circuit, D solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
45	16	Open circuit, E solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
45	21	Open circuit, F solenoid circuit	No	Lock-up inhibited
45	22	Open circuit, G solenoid circuit	Yes	DNS, SOL OFF (Hydraulic default)
45	23	Open circuit, H solenoid circuit	No	Retarder allowed differential lock inhibited
45	24	Open circuit, J solenoid circuit	No	Low and 1st inhibited
45	25	Open circuit, K solenoid circuit	No	K solenoid operation inhibited
45	26	Open circuit, N solenoid circuit	No	Low and 1st inhibited
51	10	Offgoing ratio test (during shift), 1 to L	Yes	Low and 1st inhibited
51	12	Offgoing ratio test (during shift), 1 to 2	Yes	DNS, RPR
51	21	Offgoing ratio test (during shift), 2 to 1	Yes	DNS, RPR
51	23	Offgoing ratio test (during shift), 2 to 3	Yes	DNS, RPR
51	43	Offgoing ratio test (during shift), 4 to 3	Yes	DNS, RPR
51	45	Offgoing ratio test (during shift), 4 to 5	Yes	DNS, RPR
51	65	Offgoing ratio test (during shift), 6 to 5	Yes	DNS, RPR
52	01	Offgoing C3PS test (during shift),	Yes	DNS, RPR

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
		L to 1		
52	08	Offgoing C3PS test (during shift), L to N1	Yes	DNS, NNC
52	32	Offgoing C3PS test (during shift), 3 to 2	Yes	DNS, RPR
52	34	Offgoing C3PS test (during shift), 3 to 4	Yes	DNS, RPR
52	54	Offgoing C3PS test (during shift), 5 to 4	Yes	DNS, RPR
52	56	Offgoing C3PS test (during shift), 5 to 6	Yes	DNS, RPR
52	71	Offgoing C3PS test (during shift), R to 1	Yes	DNS, NNC
52	72	Offgoing C3PS test (during shift), R to 2	Yes	DNS, NNC
52	78	Offgoing C3PS test (during shift), R to N1	Yes	DNS, NNC
52	79	Offgoing C3PS test (during shift), R to 2 (R to NNC to 2)	Yes	DNS, NNC
52	99	Offgoing C3PS test (during shift), N3 to N2	Yes	DNS, RPR
53	08	Offgoing speed test (during shift), L to N1	Yes	DNS, NNC
53	18	Offgoing speed test (during shift), 1 to N1	Yes	DNS, NNC
53	28	Offgoing speed test (during shift), 2 to N1	Yes	DNS, NNC
53	29	Offgoing speed test (during shift), 2 to N2	Yes	DNS, RPR
53	38	Offgoing speed test (during shift), 3 to N1	Yes	DNS, NNC
53	39	Offgoing speed test (during shift), 3 to N3	Yes	DNS, RPR
53	48	Offgoing speed test (during shift), 4 to N1	Yes	DNS, NNC

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
53	49	Offgoing speed test (during shift), 4 to N3	Yes	DNS, RPR
53	58	Offgoing speed test (during shift), 5 to N1	Yes	DNS, NNC
53	59	Offgoing speed test (during shift), 5 to N3	Yes	DNS, RPR
53	68	Offgoing speed test (during shift), 6 to N1	Yes	DNS, NNC
53	69	Offgoing speed test (during shift), 6 to N4	Yes	DNS, RPR
53	78	Offgoing speed test (during shift), R to N1	Yes	DNS, NNC
53	99	Offgoing speed test (during shift), N2 to N3 or N3 to N2	Yes	DNS, RPR
54	01	Oncoming ratio test (after shift), L to 1	Yes	DNS, RPR
54	07	Oncoming ratio test (after shift), L to R	Yes	DNS, NNC
54	10	Oncoming ratio test (after shift), 1 to L	Yes	DNS, RPR
54	12	Oncoming ratio test (after shift), 1 to 2	Yes	DNS, RPR
54	17	Oncoming ratio test (after shift), 1 to R	Yes	DNS, NNC
54	21	Oncoming ratio test (after shift), 2 to 1	Yes	DNS, RPR
54	23	Oncoming ratio test (after shift), 2 to 3	Yes	DNS, RPR
54	27	Oncoming ratio test (after shift), 2 to R	Yes	DNS, NNC
54	32	Oncoming ratio test (after shift), 3 to 2	Yes	DNS, RPR
54	34	Oncoming ratio test (after shift), 3 to 4	Yes	DNS, RPR
54	43	Oncoming ratio test (after shift),	Yes	DNS, RPR

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
		4 to 3		
54	45	Oncoming ratio test (after shift), 4 to 5	Yes	DNS, RPR or SOL OFF (Hydraulic default)
54	54	Oncoming ratio test (after shift), 5 to 4	Yes	DNS,RPR
54	56	Oncoming ratio test (after shift), 5 to 6	Yes	DNS,RPR
54	65	Oncoming ratio test (after shift), 6 to 5	Yes	DNS,RPR
54	70	Oncoming ratio test (after shift), R to L	Yes	DNS,NNC
54	71	Oncoming ratio test (after shift), R to 1	Yes	DNS,NNC
54	72	Oncoming ratio test (after shift), R to 2	Yes	DNS,NNC
54	80	Oncoming ratio test (after shift), N1 to L	Yes	DNS,RPR
54	81	Oncoming ratio test (after shift), N1 to 1	Yes	DNS,RPR
54	82	Oncoming ratio test (after shift), N1 to 2	Yes	DNS,RPR
54	83	Oncoming ratio test (after shift), N1 to 3	Yes	DNS,RPR
54	85	Oncoming ratio test (after shift), N1 to 5	Yes	DNS,RPR
54	86	Oncoming ratio test (after shift), Nl to 6	Yes	DNS, RPR
54	92	Oncoming ratio test (after shift), R to 2 (R to NNC to 2)	Yes	DNS, NNC
54	92	Oncoming ratio test (after shift), N1 to 2 (N1 to NNC to 2)	Yes	DNS, RPR
54	92	Oncoming ratio test (after shift), N2 to 2	Yes	DNS, RPR
54	93	Oncoming ratio test (after shift), N3 to 3	Yes	DNS, RPR

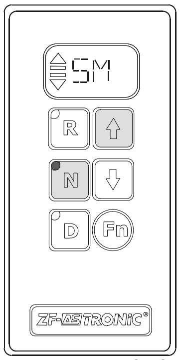
MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
54	95	Oncoming ratio test (after shift), N3 to 5	Yes	DNS, RPR
54	96	Oncoming ratio test (after shift), N4 to 6	Yes	DNS, RPR
54	97	Oncoming ratio test (after shift), 2 to R (2 to NNC to R)	Yes	DNS, NNC
55	17	Oncoming C3PS test (after shift), 1 to R	Yes	DNS, NNC
55	27	Oncoming C3PS test (after shift), 2 to R	Yes	DNS, NNC
55	80	Oncoming C3PS test (after shift), N1 to L	Yes	DNS, RPR
55	87	Oncoming C3PS test (after shift), N1 to R	Yes	DNS, RPR
55	97	Oncoming C3PS test (after shift), 2 to R or NVL to R (2 to NNC to R)	Yes	DNS, NNC
56	00	Range verification test, L	Yes	DNS, 1st, Low, or SOL OFF (Low)
56	11	Range verification test, 1st	Yes	DNS, 6th
56	22	Range verification test, 2nd	Yes	DNS, 6th or 5th
56	33	Range verification test, 3rd	Yes	DNS, 5th or SOL
56	44	Range verification test, 4th	Yes	DNS, 3rd or 5th
56	55	Range verification test, 5th	Yes	DNS, SOL OFF (5th) or 3rd
56	66	Range verification test, 6th	Yes	DNS, 5th, 3rd, or SOL OFF (3rd)
56	77	Range verification test, R	Yes	DNS, N2 or N3
57	11	Range verification C3PS test, 1st	Yes	DNS, SOL OFF (3rd)
57	22	Range verification C3PS test, 2nd	Yes	DNS, 3rd
57	44	Range verification C3PS test, 4th	Yes	DNS, 5th or SOL OFF (3rd)
57	66	Range verification C3PS test, 6th	Yes	SOL OFF (5th), DNS
57	88	Range verification C3PS test, N1	Yes	DNS, N3
57	99	Range verification C3PS test, N2 or N4	Yes	DNS, N3

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
61	00	Retarder oil temperature, hot	No	None
62	12	Retarder oil temperature sensor, low	No	None
62	23	Retarder oil temperature sensor, high	No	None
63	00	Special function input	No	Depends on special function
64	12	Retarder modulation request sensor, low	No	Retarder operation inhibited
64	23	Retarder modulation request sensor, high	No	Retarder operation inhibited
65	00	Engine rating too high	Yes	DNS
66	00	Serial communications interface fault	No	Use default throttle values
69	12	ECU, A solenoid driver open	Yes	DNS, SOL OFF (hydraulic default)
69	13	ECU, B solenoid driver open	Yes	DNS, SOL OFF (hydraulic default)
69	14	ECU, C solenoid driver open	Yes	DNS, SOL OFF (hydraulic default)
69	15	ECU, D solenoid driver open	Yes	DNS, SOL OFF (hydraulic default)
69	16	ECU, E solenoid driver open	Yes	DNS, SOL OFF (hydraulic default)
69	21	ECU, F solenoid driver open	No	Lock-up inhibited
69	22	ECU, G solenoid driver open	Yes	DNS, SOL OFF (Hydraulic default)
69	23	ECU, H solenoid driver open	No	Retarder allowed, differential lock inhibited
69	24	ECU, J solenoid driver open	No	Low and 1 st inhibited
69	25	ECU, K solenoid driver open	No	K solenoid operation inhibited
69	26	ECU, N solenoid driver open	No	Low and 1st inhibited
69	32	ECU, SPI communications link fault	No	Hold in last valid direction
69	33	ECU, Central Operating Processor (COP) time-out	Yes	Reset ECU, Shutdown ECU on 2nd occurrence (power loss: hydraulic defaults)

MAIN CODE	SUB CODE	DESCRIPTION	DO NOT SHIFT LIGHT	INHIBITED OPERATION DESCRIPTION
69	34	ECU, EEPROM write time-out	Yes	DNS, SOL OFF (Hydraulic default)
69	35	ECU, EEPROM checksum	Yes	Induce COP time-out (reset ECU)
69	36	ECU, RAM self test	Yes	Induce COP time-out (reset ECU)
69	41	ECU, I/O ASIC addressing test	Yes	Induce COP time-out (reset ECU)
0	35	Software, minor loop overrun	Yes	Induce COP time-out (reset ECU)
70	35	Software, illegal write to access $0000	Yes	Induce COP time-out (reset ECU)
70	35	Software, major loop overrun	Yes	Induce COP time-out (reset ECU)

10. ZF-ASTRONIC TRANSMISSION SYSTEM FAULTS AND ERROR MESSAGES

10.1 SYSTEM FAULTS (ERROR MESSAGES)



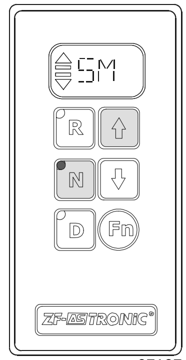
07107

If the "**SM**" symbol appears in the display, a system error has occurred.

- **Stop the vehicle**
- **Vehicle may no longer be driven**

Error messages and the reactions resulting from these errors can be deleted with the vehicle at a standstill and the "Ignition OFF". (Wait until the display goes out). If the display does not go out once the ignition has been turned "OFF", set the battery master switch to the **OFF** position. Switch the ignition back on. If the error message is still in place, the transmission has to be repaired. The transmission is inoperative. The vehicle will have to be taken to a service point. The error number(s) must be specified when the service point is contacted.

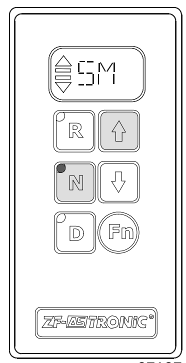
Calling up error numbers



07107

⇨ Switch on ignition
⇨Depress "**N**" key
⇨ Hold down "🡅" key
⇨ One or more error numbers appear on the display. These correspond to the errors presently active in the system.

Calling up error numbers from the error memory:



07107

⇨ Switch on ignition
⇨ Press "**N**" key and at the same time depress the foot-operated brake
⇨ Hold down the foot-operated brake and depress and hold down "🡅" key
⇨ The errors stored in the transmission ECU are shown on the display one after another.

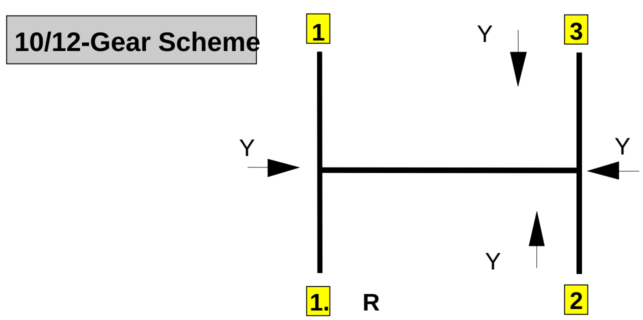
ERROR CODES

Remark to titles in table:

ZF fault number : defined by ZF.
Display SM-Symbol : (0=NO, 1=YES) Display shows "**SM**"(severe failure)
Warning lamp : (0=NO, 1=YES) Telltale panel warning lamp "**check trans**"(less severe failure)

Shift schemes of transmissions:

Y2 Splitter K2
Y3 Splitter K1
Y8 Range (GP) low
Y9 Range (GP)



Failure No.	Fault description	display SM symbol	warning lamp
2	Short circuit to ground at output stage to Y2 (Valve Splitter; DD: high, OD: low)	0	1
3	Short circuit to ground at output stage to Y3 (Valve Splitter; DD: low, OD: high)	0	1
4	Short circuit to ground at output stage to Y4 (Valve Select)	0	1
5	Short circuit to ground at output stage to Y5 (Valve Select)	0	1
6	Short circuit to ground at output stage to Y6 (Valve Shift)	0	1
7	Short circuit to ground at output stage to Y7 (Valve Shift)	0	1
8	Short circuit to ground at output stage to Y8 (Valve Range)	0	1
9	Short circuit to ground at output stage to Y9 (Valve Range)	0	1
10	Short circuit to ground at output stage to Y10 (Main valve)	1	1
11	Short circuit to ground at output stage to warning buzzer (E-Module)	0	0
17	Short circuit to ground at output stage to Y1 (inertia brake valve)	0	1
18	Short circuit to ground at output stage to Y17 (valve clutch disengage slow)	0	1
19	Short circuit to ground at output stage to Y15 (valve clutch engage slow)	0	1
20	Short circuit to ground at output stage to Y16 (valve clutch disengage fast)	0	1
21	Short circuit to ground at output stage to Y14 (valve clutch engage fast)	0	1
22	Short circuit to ground at output ADVP (wakeup control signal for E-module, voltage supply to display, warning lamp, warning buzzer, output speed sensor 1)	1	1
25	Short circuit to ground at output SD to display	0	1
26	CAN engine configuration timeout	0	0
27	Error on ”engine configuration message” (engine configuration)	0	0
31	Error on ”Actual engine retarder - percent torque” signal (ERC1_ER)	0	1
32	Error on ”Engine retarder configuration message” (Engine retarder configuration)	0	1
33	CAN ”Engine retarder configuration” timeout	0	1
34	Interruption at output stage to Y2 (Valve Splitter)	0	1
35	Interruption at output stage to Y3 (Valve Splitter)	0	1
36	Interruption at output stage to Y4 (Valve Select)	0	1
37	Interruption at output stage to Y5 (Valve Select)	0	1
38	Interruption at output stage to Y6 (Valve Shift)	0	1
39	Interruption at output stage to Y7 (Valve Shift)	0	1
40	Interruption at output stage to Y8(Valve Range)	0	1
41	Interruption at output stage to Y9 (Valve Range)	0	1
42	Interruption at output stage to Y10 (Main valve)	1	1
49	Interruption at output stage to Y1 (inertia brake valve)	0	1
50	Interruption at output stage valve Y17 (clutch disengage slow)	0	1
51	Interruption at output stage valve Y15 (clutch engage slow)	0	1
52	Interruption at output stage valve Y16 (clutch disengage fast)	0	1
53	Interruption at output stage to large Y14 (clutch engage fast)	0	1
54	Interruption at output ADVP (wakeup control signal for E-module, voltage supply to display, warning lamp, warning buzzer, output speed sensor 1)	1	1
56	Short circuit to ground at output SDP	1	1
58	Short circuit to positive at output SDP	0	1
66	Short circuit to positive at output stage to Y2 (Valve Splitter)	0	1
67	Short circuit to positive at output stage to Y3 (Valve Splitter)	0	1
68	Short circuit to positive at output stage to Y4 (Valve Select)	0	1
69	Short circuit to positive at output stage to Y5 (Valve Select)	0	1
70	Short circuit to positive at output stage to Y6 (Valve Shift)	0	1

Failure No.	Fault description	display SM symbol	warning lamp
71	Short circuit to positive at output stage to Y7 (Valve Shift)	0	1
72	Short circuit to positive at output stage to Y8 (Valve range low)	0	1
73	Short circuit to positive at output stage to Y9 (Valve range high)	0	1
74	Short circuit to positive at output stage to Y10 (Main valve)	0	1
81	Short circuit to positive at output stage to Y1 (inertia brake valve)	0	1
82	Short circuit to positive at output stage to valve Y17 (clutch disengage slow)	1	1
83	Short circuit to positive at output stage to valve Y15 (clutch engage slow)	1	1
84	Short circuit to positive at output stage to valve Y16 (clutch disengage fast)	1	1
85	Short circuit to positive at output stage to valve Y14 (clutch engage fast)	1	1
86	Short circuit to positive at output ADVP (wakeup control signal for E-module, voltage supply to display, warning lamp, warning buzzer, output speed sensor 1)	0	1
89	Short circuit to positive at output SD to display	0	1
90	Communication error between controller 1 and controller 2 (ECU failure)	1	1
91	CAN EBC1 timeout	0	1
92	Error on ”ABS active” signal (EBC1)	0	0
93	Error on ”ASR engine control active” signal (EBC1)	0	0
94	Error on ”ASR brake control active” signal (EBC1)	0	0
95	Error on ”Cruise control active” signal (CCVS)	0	1
97	Error on ”Engine speed” signal (EEC1)	0	1
98	Error on transmission input speed signal	0	1
99	Error on output speed signal 1	0	1
100	Error on output speed signal 2	0	1
101	Error on both output speed signals	1	1
102	Plausibility error between transmission input speed and out-put speed	0	1
104	High voltage (Vehicle electrical system voltage too high)	0	1
105	Low voltage (Vehicle electrical system voltage too low)	1	1
107	Stabilised voltage supply at output AU (clutch sensor supply) out of valid range	0	1
108	Error in selector lever or tip lever	0	1
110	ZF CAN timeout	0	1
114	Clutch engaged unintentionally in standstill, gear engaged	1	1
117	Error in clutch self-adjustment process	1	1
118	Clutch does not disengage	1	1
119	Clutch does not engage / does not transmit engine torque	1	1
12	Mechanical failure of small disengagement clutch valve	0	1

Failure No.	Fault description	display SM symbol	warning lamp
0			
121	Mechanical failure of large disengagement clutch valve	0	1
122	Mechanical failure of small engagement clutch valve	0	1
123	Mechanical failure of large engagement clutch valve	0	1
124	Error on clutch travel signal	0	1
126	Error on pressure sensor signal	0	1
127	Error on ECU temperature sensor signal	0	1
128	Error on oil temperature sensor signal	0	1
129	No shift sensor signal (Short circuit to positive)	0	1
130	No shift sensor signal (Short circuit to ground)	0	1
131	No shift sensor signal (Interruption)	0	1
132	Self adjustment error of shift sensor	0	1
133	No gate select sensor signal (Short circuit to positive)	0	1
134	No gate select sensor signal (Short circuit to ground)	0	1
135	No gate select sensor signal (Interruption)	0	1
136	Gate select sensor self adjustment error	0	1
137	No range change group (GP) sensor signal (Short circuit to positive)	0	1
138	No range change group (GP) sensor signal (Short circuit to ground)	0	1
139	No range change group (GP) sensor signal (Interruption)	0	1
140	Self adjustment error of range change group sensor in position fast	0	1
141	No splitter group (GV) sensor signal (Short circuit to positive)	0	1
142	No splitter group (GV) sensor signal (Short circuit to ground)	0	1
143	No splitter group (GV) sensor signal (Interruption)	0	1
144	Splitter group (GV) sensor self adjustment error	0	1

Failure No.	Fault description	display SM symbol	warning lamp
145	Range change group (GP) disengagement error	0	1
146	Changeover error during range change group (GP) shifting	0	1
147	Range change group (GP) does not engage	1	1
148	Splitter (GV) does not disengage	0	1
149	Change over error during splitter shifting	0	1
150	Splitter (GV) does not engage	1	1
151	Selector cylinder does not disengage	0	1
152	Change over error during gate selection procedure	0	1
153	Selector cylinder does not engage	1	1
154	Main transmission gear does not disengage	1	1
155	Main transmission gear does not engage	1	1
156	Wrong gear shifting	1	1
158	Shift sensor signal leaves engaged position during driving	0	1
159	Range-change group sensor signal leaves engaged position during driving	0	1
160	Splitter sensor signal leaves engaged position during driving	0	1
161	Easy Start feedback signal permanently active or brake not completely open	1	1
162	Easy Start not available	0	1
163	Engine does not react on torque intervention	0	1
164	Error on ”Drivers demand engine percent torque” (EEC1)	0	1
165	Error on ”Accelerator pedal position” (EEC2)	0	1
166	Permanent idle signal	0	1
168	No idle signal or error on ”idle signal switch” signal (EEC2) or never active "idle signal"	0	1
169	Cut-off relay in ECU does not switch off	1	1
17	No voltage supply at pin 30 or cut-off relay in ECU does not switch on	1	1

Failure No.	Fault description	display SM symbol	warning lamp
0			
171	Error on "Actual engine percent torque" signal (EEC1)	0	1
173	Error on "Brake switch" signal (CCVS)	0	1
175	Error on "Ignition lock" signal (Key 15)	0	1
177	System-CAN Busoff error	1	1
178	CAN Errorwarning	1	1
179	CAN queue overrun	1	1
180	CAN EEC1 timeout	1	1
181	CAN EEC2 timeout	1	1
182	CAN CCVS timeout	0	1
183	CAN ERC1_ER timeout	0	1
188	ECU fault - wrong interrupt	1	1
189	ECU fault - stack watch	1	1
190	EOL EEPROM parameter out of valid range	1	1
191	EOL EEPROM parameter checksum error	1	1
192	ECU fault - EEPROM access failure	0	1
193	ECU temperature too high	1	1
194	Both sources for front axle speed not available	0	1
197	Error on "Front axle speed" (WSI)	0	0
198	Error on "Relative wheel speeds" (WSI)	0	0
199	CAN WSI timeout	0	1
227	Application-Error database for CAN-communication	1	1

11. SPECIFICATIONS

ALLISON AUTOMATIC TRANSMISSION WITH OR WITHOUT RETARDER

<u>XL2 Buses</u>
Gross input power (maximum)....450 hp (335 kW)
Gross input torque (maximum) ....1460 Ft-lbs (1978 Nm)
Rated input speed (minimum-maximum) ....1600-2300 rpm
<u>XL2 MTH</u>
Gross input power (maximum)....525 hp (391 kW)
Gross input torque (maximum) ....1550 Ft-lbs (2102 Nm)
Rated input speed (minimum-maximum) ....1600-2300 rpm

Mounting:
Engine....SAE #1 flywheel housing, flex disk drive

Torque converter:
Type .... One stage, three element, polyphase
Stall torque ratio ....TC 551-1.8
Lockup clutch with torsional damper .... Integral/standard

Gearing:
Type .... Patented, constant mesh, helical, planetary

Ratio:
First 3.51:1
Second....1.91:1
Third....1.43:1
Fourth....1.00:1
Fifth 0.74:1
Sixth 0.64:1
Reverse 4.80:1

Ratio coverage:
6 speed 5.48:1

*** Gear ratios do not include torque converter multiplication.**

Oil System:
Oil type.... TRANSYND, DEXRON-IIE OR DEXRON III
Capacity (excluding external circuits) ....Initial fill 47 US qts (45 liters)
Oil change.... 24 US qts (23 liters)
Oil change (with retarder).... 27.6 US qts (26 liters)

Oil Filters:
Make .... Allison Transmission
Type .... Disposable cartridge
Supplier number 29503829
Prévost number 57-1687

SECTION 09: PROPELLER SHAFT

CONTENTS

ILLUSTRATIONS

1. PROPELLER SHAFT

1.1 DESCRIPTION

The propeller shaft transmits power from the transmission to the differential (Fig. 1). Refer to paragraph *"6. SPECIFICATIONS"* at the end of this section for propeller shaft length. The propeller shaft is "Dana 1810" type with tubular shafts. It is provided with two heavy-duty universal joints (Fig. 1).

The propeller shaft has a full round end yoke at one end and a half round end yoke at the other end. The tube yoke is connected to the differential by a full round end yoke with four needle bearings.

The other extremity (slip yoke assembly) is connected to the transmission by a half round end yoke with two needle bearings.

Furthermore, a slip joint on the propeller shaft compensates for variations in distance between the transmission and the differential, or between the output retarder (optional on the automatic transmission) and differential.

The rise and fall of the drive axle bring about these variations as the vehicle passes over uneven surfaces. The slip joint also eases removal of the transmission or the drive axle.

2. REMOVAL, DISASSEMBLY, REASSEMBLY AND INSTALLATION

Refer to *"SPICER UNIVERSAL JOINTS AND DRIVESHAFTS"* annexed to this section, under headings *"Heavy Duty - removal, disassembly, reassembly and installation".*

Where applicable:

- Remove or install propeller shaft safety guard.
- Screw bolts to the specified torque (Fig. 1).

Note: *Disregard the procedure on "Lock straps" mentioned in the "Spicer Universal Joints and Driveshafts Manual".*

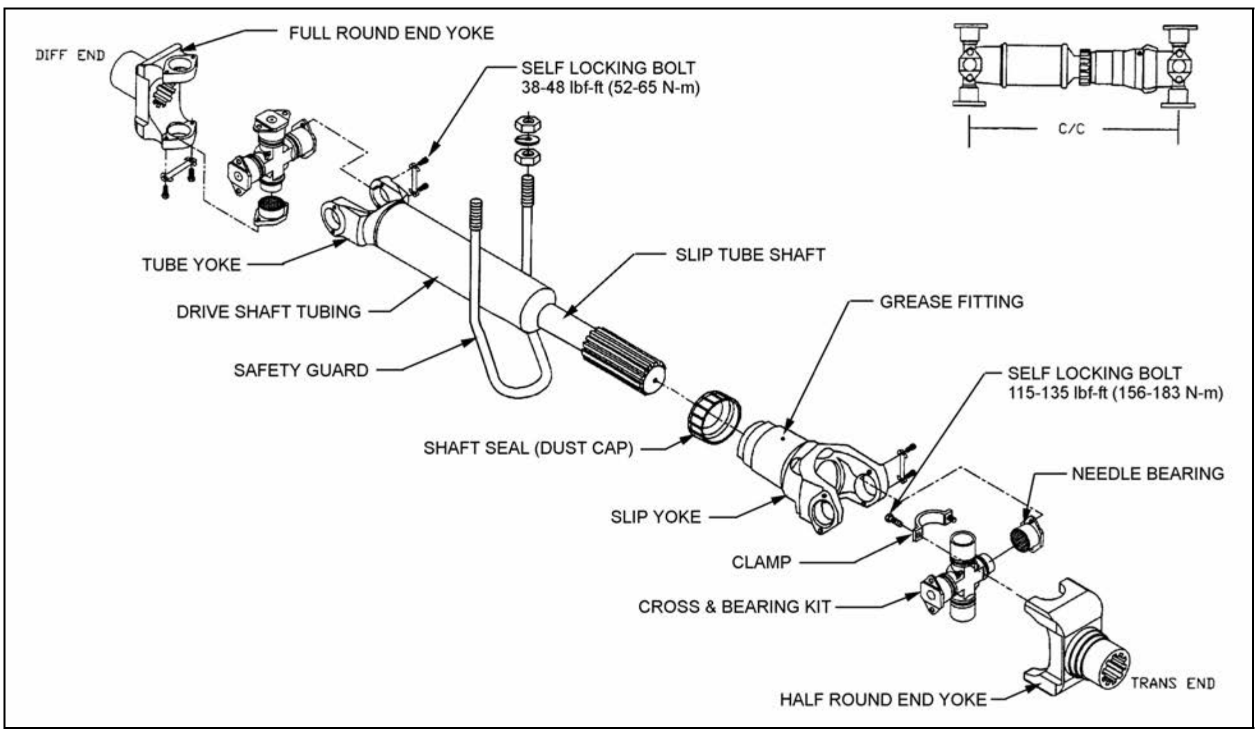


FIGURE 1: PROPELLER SHAFT ASSEMBLY 09002

3. CLEANING, INSPECTION AND LUBRICATION

3.1 CLEANING AND INSPECTION

Thoroughly clean grease from bearings, journal, lubricating grease fittings and other parts. Needle bearing assemblies may be soaked in a cleaning solution to soften hard grease particles. It is extremely important that bearing assemblies be absolutely clean and blown out with compressed air, since small particles of dirt or grit can cause rapid bearing wear. Do not attempt to disassemble needle bearings.

Bearing journal areas should be inspected for roughness or grooving. If light honing does not remove roughness, the entire bearing assembly should be replaced. Excessive wear of the needle bearing is indicated if the needles drop out of the retainer, or if marks are present on the journal bearing surface. In such case, replace bearing assembly. Finally, inspect yokes for cracks, wear or distortion.

Note: *Repair kits are available for overhaul of the propeller shaft assembly. Refer to the paragraph "6. Specifications" of this section.*

3.2 LUBRICATION

Lubricate propeller shaft universal joints and slip yoke periodically, every 6,250 miles (10 000 km) or twice a year, whichever comes first. Apply grease gun pressure to the lube fitting. Use a good quality lithium-base grease such as: NLGI No.2 (suitable for most temperatures) or NLGI No.1 (suitable for extremely low temperatures). Refer to "Spicer Universal Joints and Driveshafts, Service Manual", under heading, "Inspection and Lubrication". See lubrication procedures for U-joints and lubrication for slip splines.

Note: *Do not assume that bearing cavities have been filled with new grease unless it has expelled around all seals.*

4. EXPLANATION OF COMMON DAMAGES

1. Cracks: Stress lines due to metal fatigue. Severe and numerous cracks will weaken the metal until it breaks.

2. Galling: Scraping off of metal or metal displacement due to friction between surfaces. This is commonly found on trunnion ends.

3. Spalling (surface fatigue): Breaking off of chips, scales, or flakes of metal due to fatigue rather than wear. It is usually found on splines and U-joint bearings.

4. Pitting: Small pits or craters in metal surfaces due to corrosion. If excessive, pitting can lead to surface wear and eventual failure.

5. Brinelling: Surface wear failure due to the wearing of grooves in metal. It is often caused by improper installation procedures. Do not confuse the polishing of a surface (false brinelling), where no structural damage occurs, with actual brinelling.

6. Structural Overloading: Failure caused by a load greater than the component can stand. A structural overload may cause propeller shaft tubing to twist under strain or it may cause cracks or breaks in U-joints and spline plugs.

5. TROUBLESHOOTING

Refer to *"Spicer Service Manual - Universal Joints and Driveshafts"* under heading *"Troubleshooting".*

6. SPECIFICATIONS

PROPELLER SHAFT

VEHICLES EQUIPPED WITH ALLISON WORLD TRANSMISSION

XL2-45 COACHES AND W-45 MOTORHOMES

Make .... Hayes-Dana Inc.
Series 1810
Supplier number 819325-2200
Prevost number 580070

W-40 AND Y-45E MOTORHOMES

Make .... Hayes-Dana Inc.
Series 1810
Supplier number 819299-1
Prevost number 580075

XL2-45 COACHES EQUIPPED WITH ZF TRANSMISSION

Make .... Hayes-Dana Inc.
Series 1810
Supplier number 816688-1600
Prevost number 580080

Repair kits

Make .... Hayes-Dana Inc.
U-joint kit (tube yoke), Supplier number 5-281X
U-joint kit (tube yoke), Prevost number 580043
U-joint kit (slip yoke), Supplier number 5-510X
U-joint kit (slip yoke), Prevost number 580062
Cap and bolt kit, bolt torque 115-135 lbf•ft (156-183 N•m), Supplier number 6.5-70-18X
Cap and bolt kit, bolt torque 115-135 lbf•ft (156-183 N•m), Prevost number 580063
Bolts kit, bolt torque 38-48 lbf•ft (52-65 N•m), Supplier number 6-73-209
Bolts kit, bolt torque 38-48 lbf•ft (52-65 N•m), Prevost number 580071

Half Round End Yoke

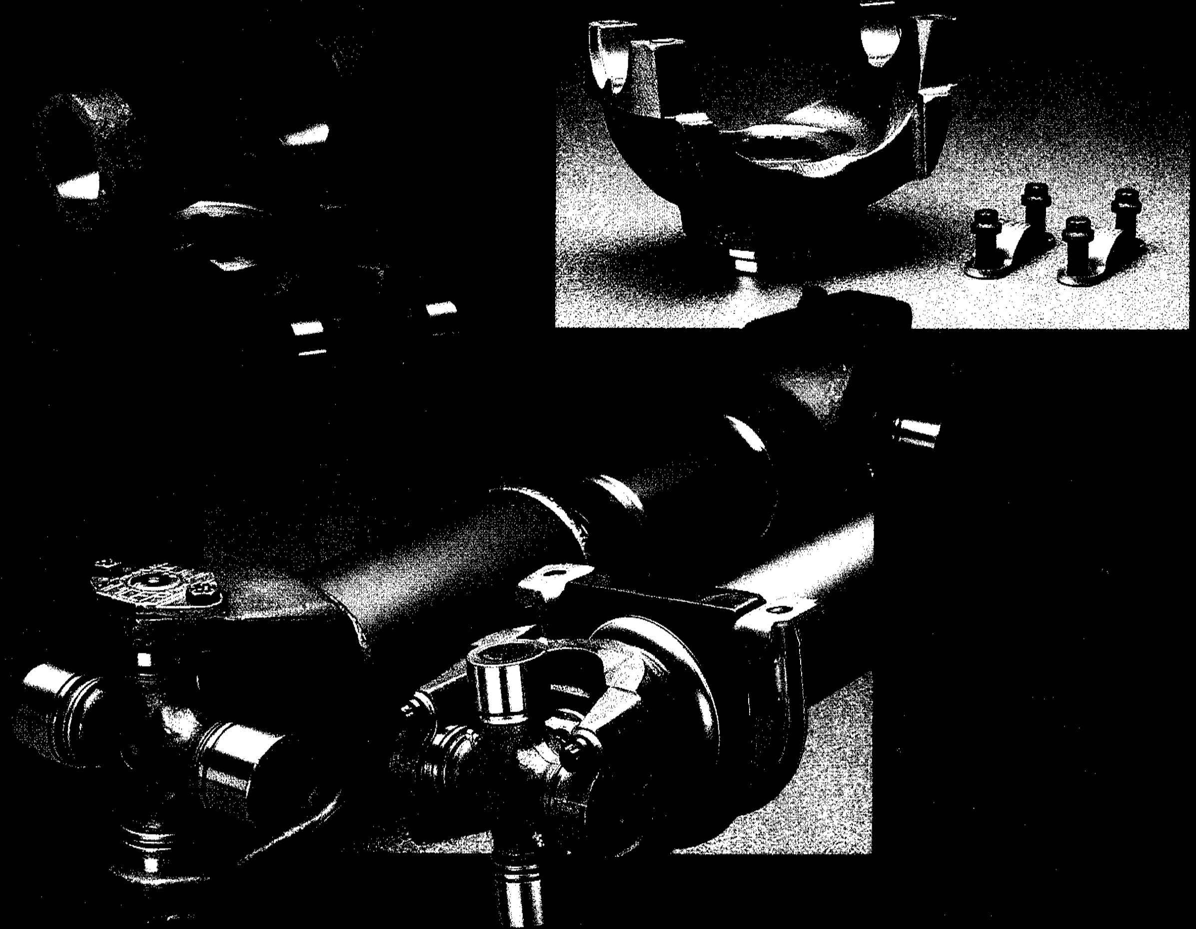
Make .... Covington Detroit Diesel
Supplier number 29511516

Note: *U-joint kits will come equipped with the serrated bolt and lock patch and will no longer contain a lock strap.*

SERVICE MANUAL

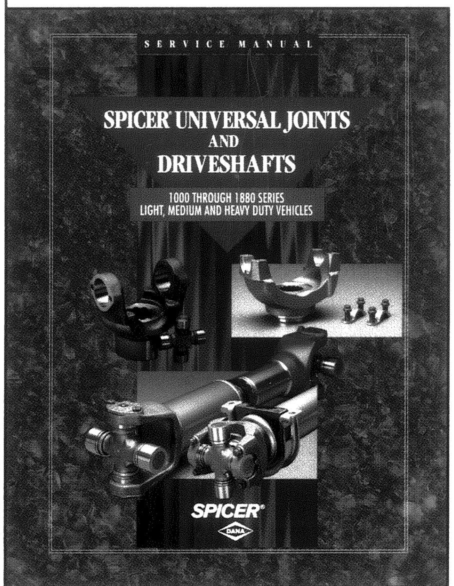
SPICER® UNIVERSAL JOINTS AND DRIVESHAFTS

1000 THROUGH 1880 SERIES
LIGHT, MEDIUM AND HEAVY DUTY VEHICLES



SPICER®

DANA



INDEX

ABOUT THIS MANUAL...

Because of the many similarities between light, medium and heavy duty drivelines, this manual will present information as it relates to all three types. However, there are some basic differences among the three. Where this occurs it will be clearly noted.

Failure to follow procedures, recommendations and caution statements outlined in this manual may void the product warranty and could result in serious personal injury.

SAFETY PRECAUTIONS

Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.

Do not go under the vehicle when the engine is running.

Do not work on the shaft (with or without a guard) when the engine is running.

Do not engage or disengage driven equipment by hand from under the vehicle when the engine is running.

In order to avoid becoming entangled, install the power take-off and/or shaft behind the frame rail, tanks, battery box, etc.

If power take-off and/or shaft are still exposed after installation, install guard.

Install a support strap when servicing a driveshaft to prevent personal injury. See pages 9, 13, 15, & 17.

A serious or fatal injury can occur...
- ▲ if you lack proper training
- ▲ if you fail to follow proper procedures
- ▲ if you do not use proper tools and safety equipment

- ▲ if you assemble driveline components improperly
- ▲ if you use incompatible driveline components
- ▲ if you use worn-out or damaged driveline components
- ▲ if you use driveline components in a non-approved application

This manual contains detailed safety instructions. Read, understand and follow this manual.
- ▲ Get proper training
- ▲ Learn and follow safe operating procedures
- ▲ Use proper tools and safety equipment
- ▲ Use proper components in good condition

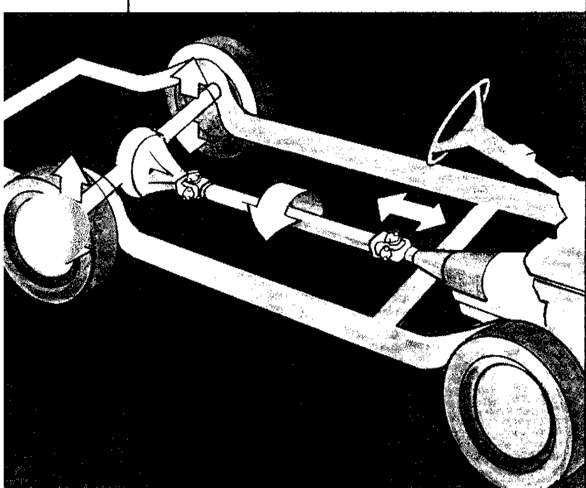
Refer to the pages listed for more detailed instructions.
- ▲ Inspection and Lubrication – See pages 4 - 8
- ▲ Servicing the Driveshaft
  - – heavy duty – pages 8 - 15
  - – light and medium duty – pages 15 - 17
  - – double cardan driveshafts – pages 18 - 21
- ▲ Straightening and Balancing – See page 24

This symbol warns of possible personal injury.

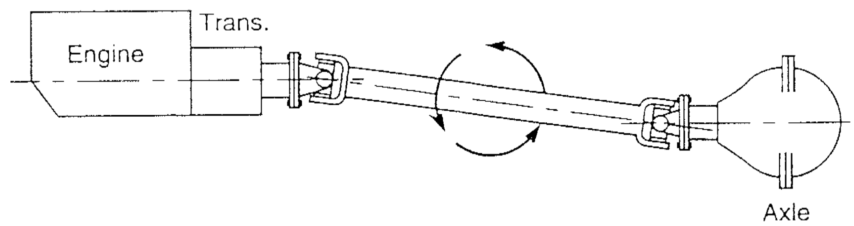
THE FUNCTION OF A DRIVESHAFT

The basic function of a driveshaft is to transmit power from one point to another in a smooth and continuous action. In automobiles, trucks and construction equipment, the drivetrain is designed to send torque through an angle from the transmission to the axle (or auxiliary transmission).

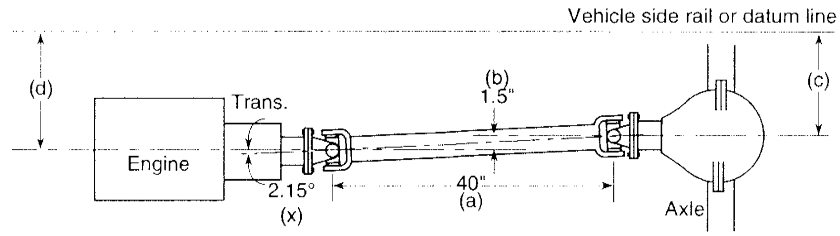
The driveshaft must operate through constantly changing relative angles between the transmission and axle. It must also be capable of changing length while transmitting torque. The axle of a vehicle is not attached directly to the frame, but rides suspended by springs in an irregular, floating motion.



This means the driveshaft must be able to contract, expand and change operating angles when going over bumps or depressions. This is accomplished through universal joints, which permit the driveshaft to operate at different angles, and slip joints, which permit contraction or expansion to take place.



The geometry of a driveshaft in side view – vertical offset

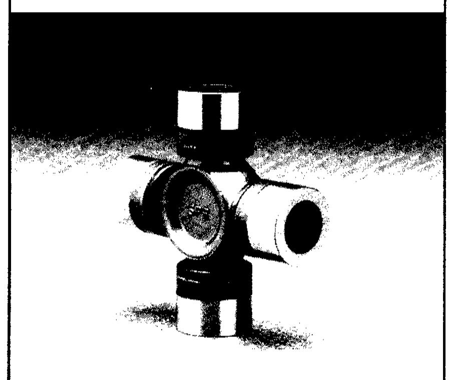


The geometry of a driveshaft in plan view – horizontal offset

CONSTRUCTION OF A DRIVESHAFT (ALL TYPES)

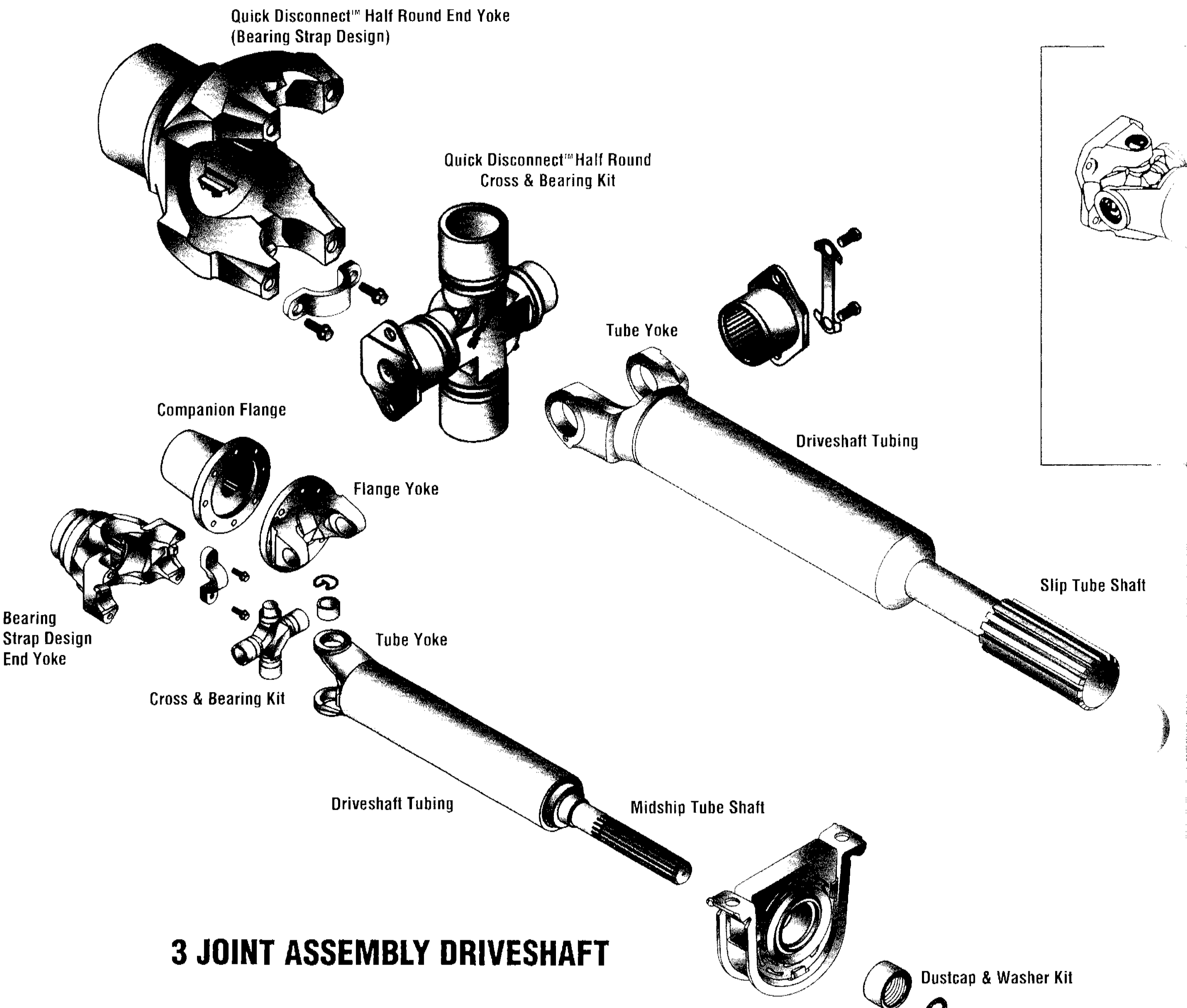
To transmit required torque loads, the driveshaft must be durable and strong. Forged steel and high strength cast yokes, including the Spicer Quick Disconnect™ end yoke for heavy duty vehicles, are used to provide the necessary rigidity required to maintain bearing alignment under torque loads. Spicer heavy-duty u-joint kits and Low Effort™ light-duty u-joint kits are designed to give extended driveshaft life.

Spicer Quick Disconnect™ End Yoke

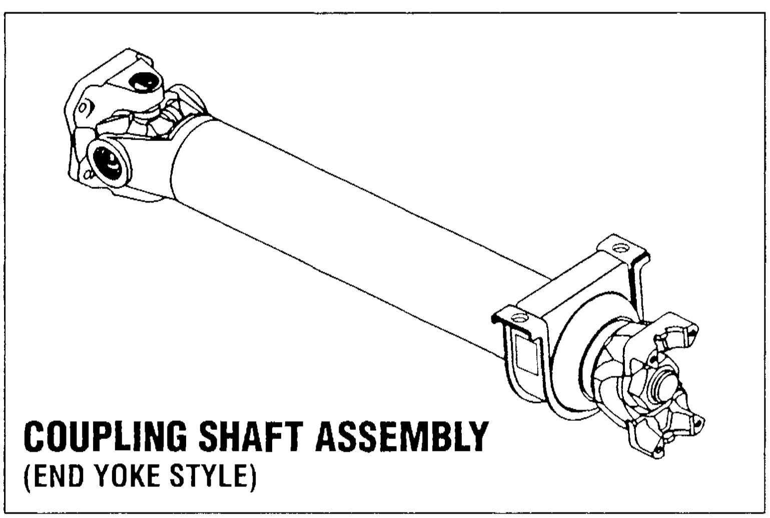


Spicer Low Effort™ U-Joint Kit

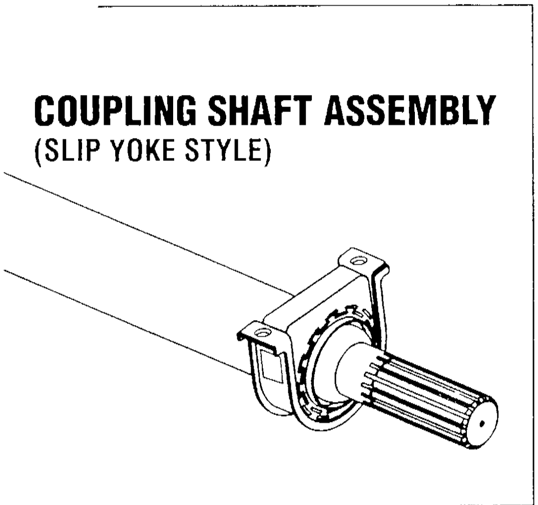
DRIVESHAFT PARTS LISTING

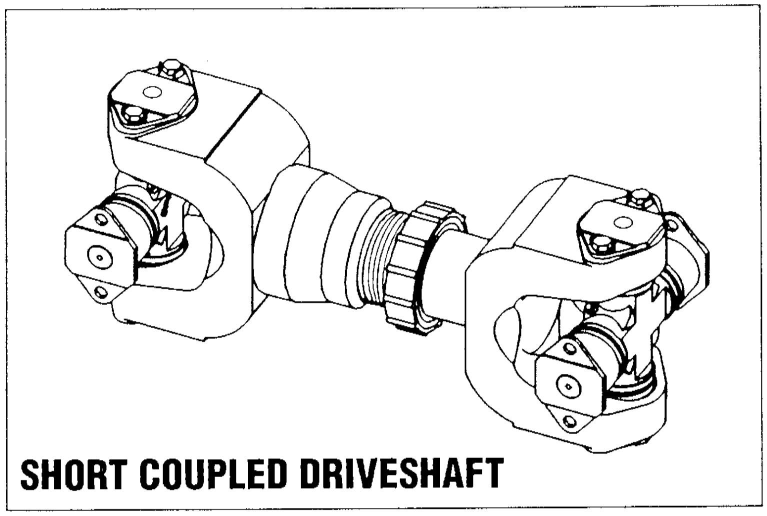


3 JOINT ASSEMBLY DRIVESHAFT



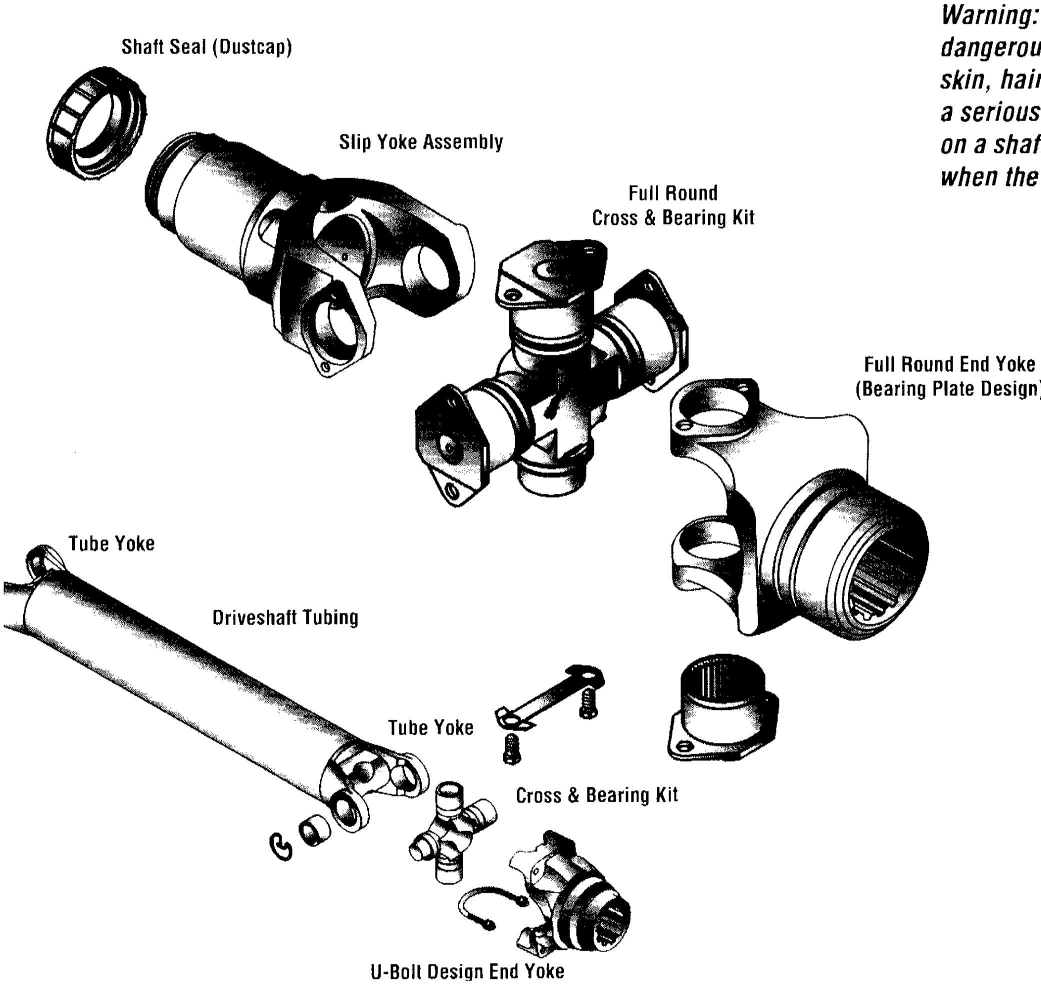
COUPLING SHAFT ASSEMBLY
(END YOKE STYLE)





2 JOINT ASSEMBLY DRIVESHAFT

Warning: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause a serious injury or death. Do not work on a shaft (with or without a guard) when the engine is running.



CONSTRUCTION OF A DRIVESHAFT

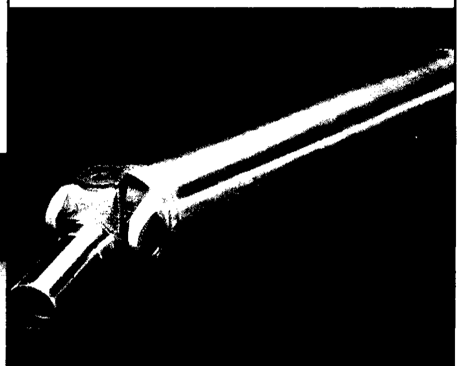
Anti-friction bearings are used to withstand required oscillating loads while the driveshaft is rotating at high speeds. The needle roller bearings on the trunnions of the cross carry large loads and are used because of their high capacity in a limited space.

Spicer Positive Purging valve and exclusive crowned bearing race inside diameter.

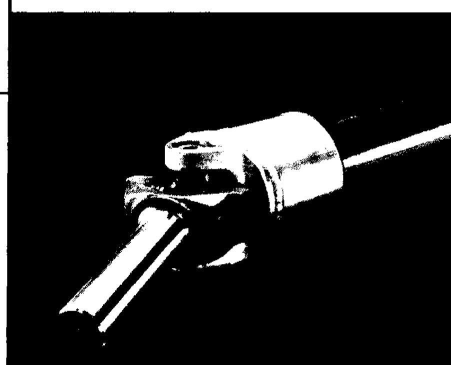
Spicer's exclusive bearing assembly inside diameter crowning and tapered thrust pads distribute loads more evenly on needle roller bearings and cross trunnion ends to significantly reduce end galling. Bearing assemblies are individually sealed to provide retention of lubricants and prevent the entry of foreign material. If lubricants become contaminated with water or abrasive matter, needle roller bearing life is seriously affected.

Abrasive material is a major problem when a vehicle operates under conditions of extreme moisture and dirt. To combat this problem, synthetic rubber seals were developed and resulted in increased life, ability to withstand high temperature and a less critical relubrication cycle for driveshafts.

Special high-strength tubing is used to provide maximum torque carrying capacity at minimum practical weight. In addition to steel tubing in use for many years now, Spicer Lite™ aluminum and Graph-Lite™ composite (aluminum wrapped in graphite) driveshafts have been developed to meet the vehicular industry needs.



Spicer Lite™ Aluminum Driveshaft



Spicer Graph Lite™ Driveshaft

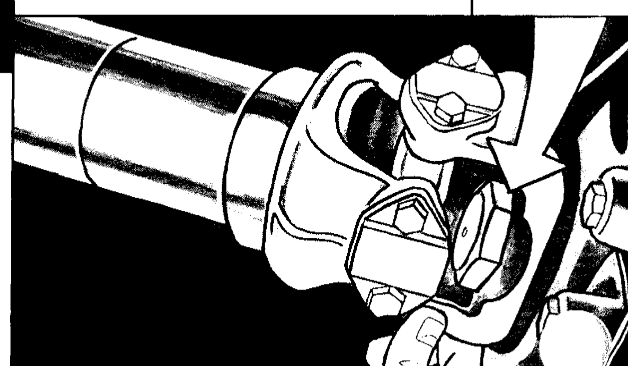
The sliding splines between slip joint and permanent joint must support the driveshaft and be capable of sliding under full torque loads. To aid in this axial or slip movement, Spicer Glidecote™ was developed to reduce sliding friction thereby reducing thrust loads under high torque. This non-metallic coating also prevents spline galling and extends spline life.

INSPECTING AND LUBRICATING THE DRIVESHAFT (All Types)

WARNING: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death. Do not work on a shaft (with or without a guard) when the engine is running.

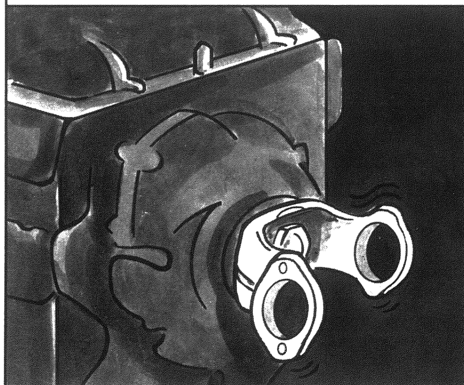
INSPECTION

To keep a vehicle operating smoothly and economically the driveshaft must be carefully inspected at regular intervals. Vibrations and u-joint and shaft support (center) bearing problems are caused by such things as loose end yokes, excessive radial (side to side or up and down) looseness, slip spline radial looseness, bent shaft tubing, or missing plugs in the slip yoke.

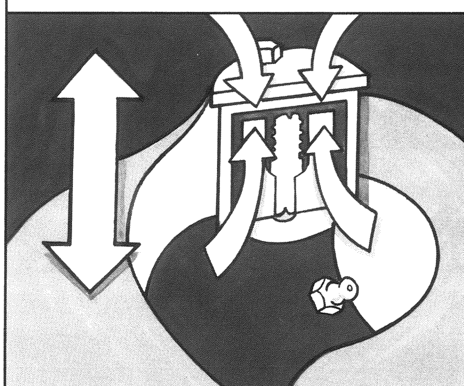


1. Check the output and input end yokes on both the transmission and axle, or axles, for looseness. If loose, disconnect the driveshaft and retorque the end yoke retaining nut to specification. If yoke replacement is required, check for manufacturer's recommendation regarding replacement frequency of the end yoke retaining nut.

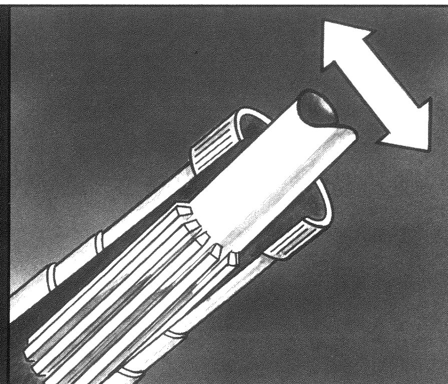
INSPECTING AND LUBRICATING THE DRIVESHAFT (ALL TYPES)



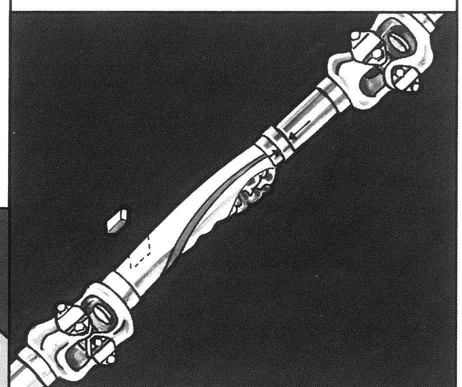
2. If the end yokes are tight, check for excessive radial looseness of the transmission output shaft and axle input and output shafts in their respective bearings. Consult transmission and axle manufacturer's specifications for acceptable radial looseness limits and method of checking.



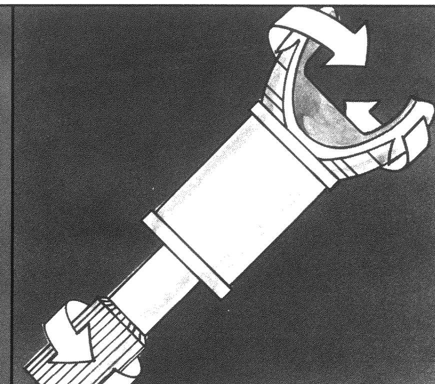
3. Check for excessive looseness across the ends of the bearing assemblies and trunnions. This looseness should not exceed .006 inches maximum.



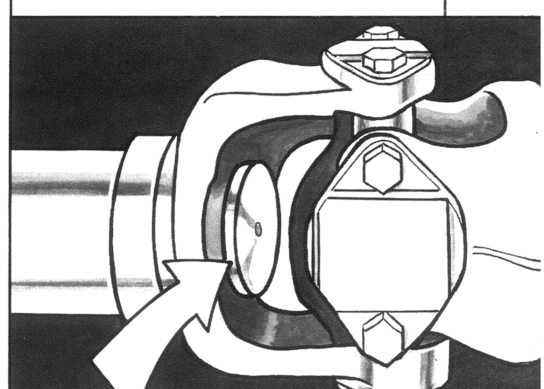
4. Check the slip spline for excessive radial movement. Radial looseness between the slip yoke and the tube shaft should not exceed .007 inches.



5. Check the shaft for damaged, bent tubing or missing balance weights. Make certain there is no build up of foreign material on the shaft, such as undercoat or concrete. If found, they should be removed carefully to avoid damage to the driveshaft.



6. If runout readings are required, they should be taken with the driveshaft mounted in the vehicle, with the transmission in neutral and the axle shafts pulled, or by jacking rear wheels off the ground and placing axles on jack stands. This will allow rotating the driveshaft by hand to check indicator readings. The runout readings taken at the various locations should not exceed an additional 0.010 T.I.R. over the manufacturer's specified runout. (See page 24)



7. For an inboard and outboard slip yoke assembly design, check to be sure the plug is not loose or missing ... if it is, repair or replace it. Loose or missing plugs are commonly caused by not enough driveshaft slip capability.

LUBRICATION

Among the most common causes of joint and slip problems is lack of proper lubrication. Properly sized Spicer U-joints that are adequately relubricated at recommended intervals will normally meet or exceed vehicle operation requirements. Relubrication flushes the joints thus removing abrasive contaminants from the bearings.

LUBRICANTS FOR UNIVERSAL JOINTS

For a standard application, use a good quality E.P. (extreme pressure) grease (Timkin Test Load 45 lbs. min) meeting *N.L.G.I. Grade 2 specifications.

Grease must have an operating range of +325°F/+163°C to -10°F/-23°C and be compatible with commonly used multi-purpose greases such as Lithium Soap Types.

For driveshaft applications involving shaft speeds below 500 RPM, a mineral oil in the SAE 140 to 250 viscosity range should be used.

Consult your local lubricant source for greases that meet these specifications.

N.L.G.I. *E.P. Grade 2 Lubricating Grease

* National Lubricating Grease Institute

INITIAL LUBRICATION AND RELUBE CYCLES

Spicer replacement universal joint kits contain only enough grease to provide needle roller bearing protection during storage. It is therefore necessary to completely lubricate each replacement kit prior to assembly into the yokes. Each cross lube reservoir should be fully packed with a recommended grease and each bearing assembly should also be wiped with the same grease, filling all the cavities between the needle rollers and applying a liberal grease coating on the bottom of each bearing assembly. Too much grease may cause hydraulic "lock-up", making installation difficult. After the kits are installed into the yokes and prior to placing into service, they should be relubed, through the lube fitting, using the same grease.

Relubrication cycles vary depending on the service requirements and operating conditions of the vehicle. A recommended relube cycle for various types of service is shown below.

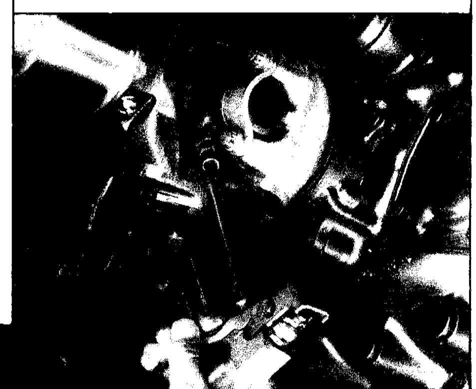
NOTE: On-highway is defined as all applications requiring less than 10% of operating time on gravel, dirt or unimproved roads. If longer than 10% operating time off-highway, use off-highway recommendations.

TYPE OF SERVICE	MILES or	TIME
CITY	5000/8000	3 MONTHS
ON HIGHWAY (MID-RANGE)	10,000/15,000	3 MONTHS
ON HIGHWAY (LINE-HAUL)	10,000/15,000	30 DAYS
ON/OFF HIGHWAY	5,000/8,000	3 MONTHS
OFF HIGHWAY/ INDUSTRIAL		500/200 HRS.*

*Relubrication cycles for off highway and industrial use vary depending on the application and operating conditions. In general, to obtain maximum life, relubrication should occur every 500 hours for normal service and every 200 hours for continuous service or severe environmental conditions.

LUBRICATION PROCEDURE FOR U-JOINTS

(Except Constant Velocity Type Joints)



WARNING: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.

Do not work on a shaft (with or without a guard) when the engine is running.

Do not go under the vehicle when the engine is running.

In order to avoid becoming entangled install power take-off and/or shaft behind the frame rail, tanks, battery box, etc.

If power take-off and/or shaft are still exposed after installation, install a guard.

1. Use the proper lubricant to purge all four seals of each u-joint. This flushes abrasive contaminants from each bearing assembly and assures all four are filled. Pop the seals. Spicer seals are made to be popped.

2. On center twin zerk design or single zerk kits, if any of the seals fail to purge, move the driveshaft from side to side and then apply gun pressure. This allows greater clearance on the thrust end of the bearing assembly that is not purging. On two-zerk kits, try greasing from the opposite lube fitting. For light-duty kits, check for a fully seated snap ring or burrs on the snap ring or snap ring groove.

3. Because of the superior sealing capability of the Spicer Seal design on the 1610, 1710, 1760, 1810 and 1880 Series, there will occasionally be one or more bearing assembly seals that will not purge.

Release seal tension by loosening the bolts holding the bearing assembly that doesn't purge. It may be necessary to loosen the bearing assembly approximately 1/16 inch minimum. If loosening it does not cause purging, remove the bearing assembly to determine cause of blockage.

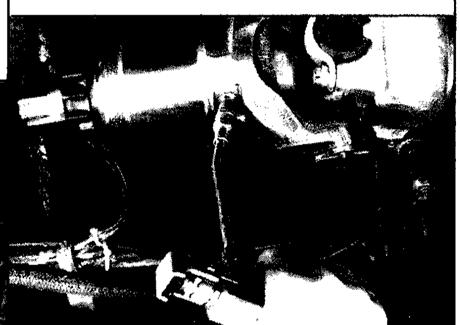
4. Install new bolts and torque to specifications.

CAUTION: *Retaining bolts should not be reused. If loosening or removal of bolts is necessary, install new bolts and torque to specification.*

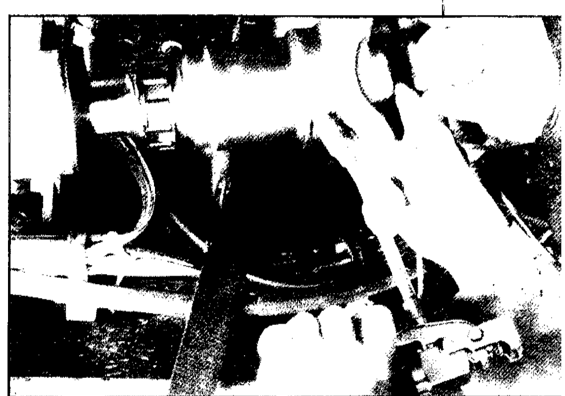
LUBRICATION FOR SLIP SPLINES

The lubricant used for u-joints is satisfactory for slip splines. Glidecote™ and steel splines both use a good E.P. grease meeting N.L.G.I. Grade 2 specifications.

Relube splines at the intervals recommended in the chart for u-joints.



1. Apply grease gun pressure to the lube fitting until lubricant appears at the pressure relief hole in the plug at the slip yoke end of the spline.



2. Now cover the pressure relief hole with your finger and continue to apply pressure until grease appears at the slip yoke seal.

CAUTION: *In cold temperatures be sure to drive the vehicle immediately after lubricating. This activates the slip spline and removes the excessive lubricant. Failure to do so could cause the excess lubricant to stiffen in the cold weather and force the plug out. The end of the spline would then be open to collect contaminants and cause the spline to wear and/or seize.*

SHAFT SUPPORT BEARING ASSEMBLIES

Bearing manufacturers do the initial lubrication and all Spicer shaft support (center) bearings are lubed for life. When replacing a shaft support bearing assembly, be sure to fill the entire cavity around the bearing with waterproof grease to shield the bearing from water and contaminants. Enough grease must be put in to fill the cavity to the extreme edge of the slinger surrounding the bearing. Lubricants must be waterproof. The following chart lists recommended waterproof lubricants for use with center bearings.

NOTE: There are numerous instances when special lubrication is required by vehicle specification or customer request. The lubrication recommendations listed in this manual are what Spicer U-Joint engineers suggest. Any alternate lubricants, or lubrication procedures, are the responsibility of the user.

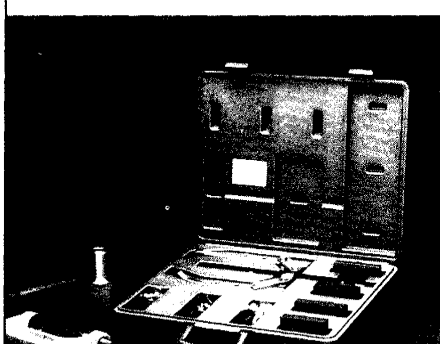
Recommended Lubricants - Source

Rykon Premium No. 3
- Amoco Oil Company

Sun C-34 Grease (Cup No. 4)
- Sun Oil Company

Amolith 8516
- Amoco Oil Company

Van Talgar No. 4
- Exxon Company



SERVICING THE DRIVESHAFT

Heavy Duty Application

Cross and Bearing Kit Replacement
Bearing Plate Design

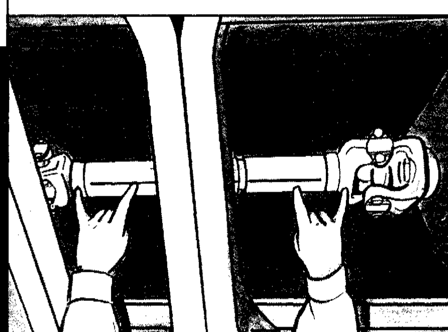
Full Round and Quick Disconnect End Yoke Designs

Special Tools:

Torque wrench (125 lb./ft.)
Journal locator
U-joint press
V-block
* Alignment bar/No Go wear gauge
Common hand tools

One of the following is recommended:
Owatonna tool kit (#7057) (Two-jaw puller)
Tiger tool kit
JJAG tool kit
J & J tool kit

*Available only from Dana Corporation Spicer Service Representatives.



NOTE: Before removal of the driveshaft set the brakes, block the wheels, and mark the slip yoke assembly and tube shaft with a marking stick or paint to assure proper alignment when reassembled. This is known as keeping the driveshaft yokes "In Phase."

CAUTION: Never heat components or use sledge hammers and floor jacks to disassemble driveshafts. This can result in damaged, weakened or bent components.

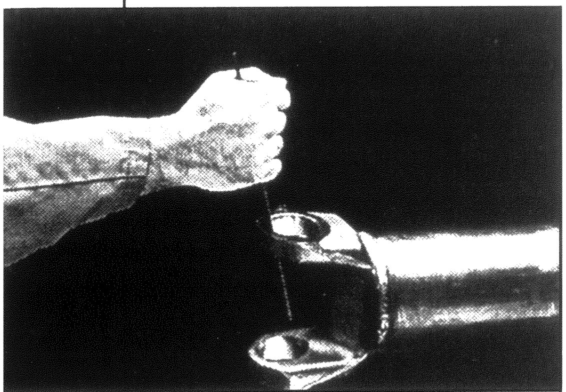
WARNING: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death. Do not work on a shaft (with or without a guard) when the engine is running.

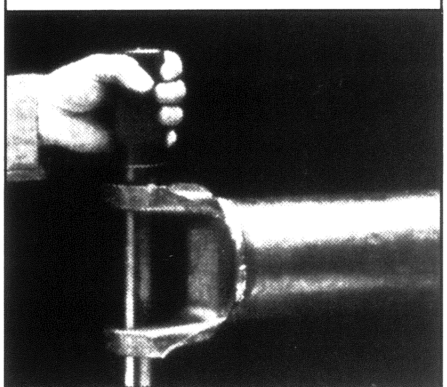
REMOVAL
(Full Round End Yoke Style)

1. The method of driveshaft removal should be one that assures safety and ease of removal to the mechanic without damage to the driveshaft, transmission or axle components. Suggested method is use of a u-joint puller: Owatonna tool kit #7057, Tiger tool kit, JJAG tool kit, or J&J tool kit.

2. Bend tabs of lock straps away from bolt heads with a chisel.

NOTE: The self-locking bolt design for full-round end yokes uses serrated bolts with lock patch and DOES NOT require a lock strap.





3. After removing the cross and bearings, both ends, inspect the cross hole surfaces for damage or raised metal. Raised metal can be removed with a rat tail or half round file and emery cloth. Check the yoke lug crossholes with a No-Go Wear Gauge and then use a Spicer Alignment Bar to inspect for damage by sliding through both cross holes simultaneously. The alignment bar will identify yoke lugs that have taken a set because of excessive torque. The raised metal or distorted lugs can be a cause of premature cross and bearing problems.

At this time, clean the cross holes of the yokes on the transmission and axle and inspect with an alignment bar gauge as described above.

If after proper cleaning of the cross holes the alignment bar will not pass through simultaneously, the yoke lugs are distorted and the yoke or yokes should be replaced.

CAUTION: *Use a journal locator to avoid nicking journal cross trunnions or damaging oil seal slingers.*

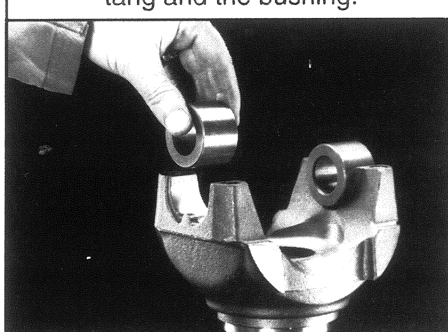
DISASSEMBLY (Quick Disconnect™ Half Round End Yoke Style)

1. Place the driveshaft in v-blocks to remove the cross and bearing assemblies.

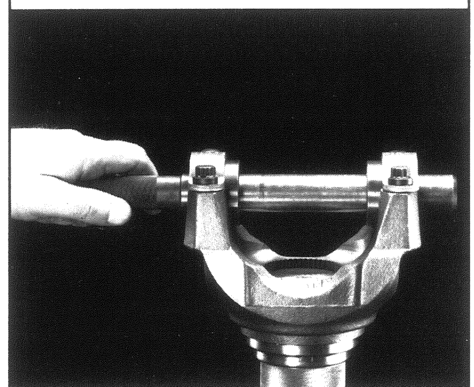
2. Completely remove the cross and bearings from both ends of the driveshaft by removing the bolts and bearing straps.

3. Remove the end yoke from the driveshaft and place in a soft jawed vise to inspect the crosshole surfaces. Raised metal can be removed with a rat tail or half round file. Emery cloth should be used to remove all rust and corrosion from crosshole bores.

4. Check the yoke for crosshole alignment using the Spicer Alignment gauge. Place the correct bushing in each lug ear allowing a .03 to .06 clearance between the tang and the bushing.

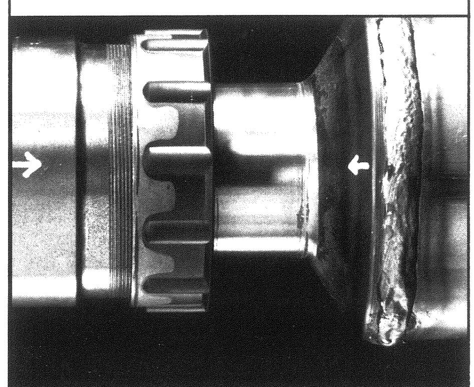


Assemble bearing straps and bolts, tightening bolts a minimum of 30 ft. lbs. Insert the alignment gauge into one crosshole. If the gauge enters and passes through the opposite crosshole, alignment is correct. If the alignment gauge will not enter the opposite crosshole, reinspect for burrs.

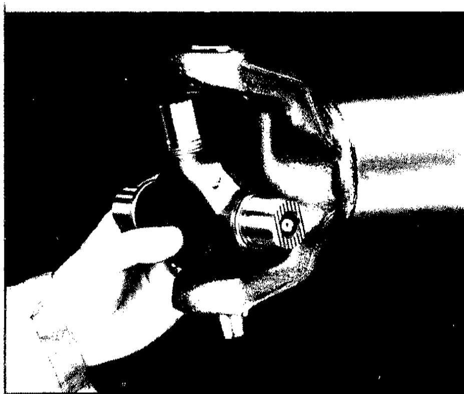


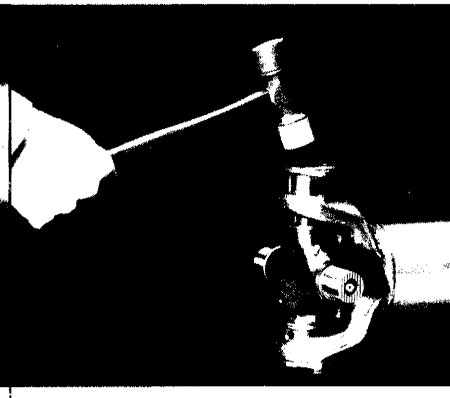
If, after proper cleaning, the alignment gauge still does not pass through both crossholes, the yoke lugs are distorted and the yoke should be replaced.

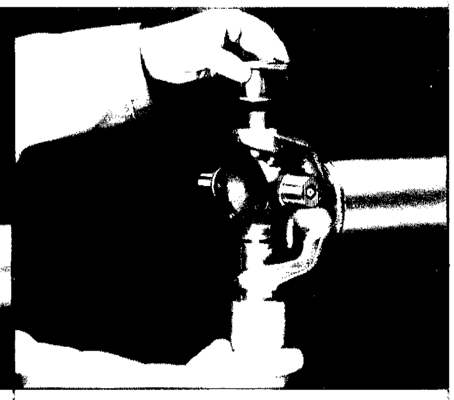
REASSEMBLY



1. Place each end of the driveshaft, less cross and bearing kits, on v-blocks. Check the paint marking placed on the tube and slip yoke assembly prior to removing from the vehicle to be sure they are lined up or "in phase."

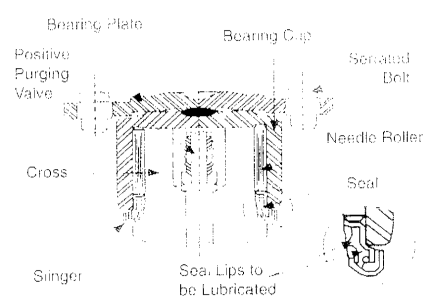






2. Remove the cross and bearings from the box and remove all four bearing assemblies.

   Rotate the cross to inspect for presence of the positive purging valve in each lube hole of all four trunnions. Then position the cross into the end yoke with its lube fitting in line as near as possible with the slip spline lube fitting. Keep the lube fitting on the inboard side.



3. The lips of the seal on the u-joint **must** be lubricated with a light weight oil to prevent the seal from turning inside out upon installation. Also, each cross reservoir must be packed with grease and **each** cap bearing wiped with grease prior to assembly.

4. Move one end of the cross to cause a trunnion to project through the cross hole beyond the outer machined face of the yoke lug. Place a bearing assembly over the trunnion diameter and align it to the cross hole.

   Holding the trunnion in alignment with the cross hole, using the journal locator press bearing assembly flush to face of end yoke by hand.

   A journal locator should be used to prevent damage to the u-joint trunnions and slingers. If the u-joint bearing cap is pressed into place, the bearings and bearing surfaces could be damaged.

   If bearing assembly binds in cross hole, tap with soft hammer directly in center of bearing assembly plate. Do not tap outer edges of bearing plate.

   Exact fit of all driveline components is extremely important. The correct parts and clean mating surfaces are essential for safe operation and good repair.

5. When the bearing assembly is completely seated put the lock plate tab in place and use the "Grade Eight" cap screws that are furnished with the kit and insert them through the cap screw holes in both the lock strap and bearing assembly. Thread with hand or wrench into tapped holes in yoke. Do not torque down bolts.

***NOTE:** The self-locking bolt design for full-round yokes uses serrated bolts with lock patch and DOES NOT require a lock strap. DO NOT reuse ANY retaining bolt. If loosening or removal of a bolt is necessary, replace with a new one.*

6. Move the cross laterally to the opposite side and through the cross hole beyond the machined surface of the yoke lug. Place a bearing assembly over the cross trunnion and slide it into the cross hole, seating the plate to the face of the lug. Put the lock plate tab in place and thread the bolts with hand or wrench into tapped holes in yoke.

SERVICING THE DRIVESHAFT

NOTE: Projecting the trunnion through a cross hole beyond the machined surface of the lug will provide a surface to help align the bearing assembly with the cross hole. This method should also be followed when assembling driveshaft to yokes of vehicle at transmission and axle or axles.

7. Repeat process of installation of cross and bearing kit at opposite end of the driveshaft. Make sure to position the cross in the yoke so that the lube fitting is in line with the lube fitting at the other end.

8. For flange yoke applications, install the flange yoke, bearing assemblies and bolts at this time.

CAUTION: *Worn bearing assemblies used with a new cross or new bearing assemblies used with a worn cross will wear rapidly making another replacement necessary in a short time.*

Always Replace the Cross, Four Bearing Assemblies and Bolts as a Unit.

INSTALLATION IN VEHICLE

The installation of a driveshaft does not present any unusual mechanical difficulties. Before actual installation the driveshaft should be checked for the following items:

✓ Damage or dents on the driveshaft tubing.

✓ Splines should slide freely with slight drag from slip shaft seal.

✓ Cross should flex and be free from excessive bind. A slight drag is the most desirable condition on a new cross and bearing kit. Excessive looseness is not desirable and will result in an unbalanced driveshaft.

✓ Mounting flanges and pilots should be free from burrs, paint and foreign substances which would not allow proper seating at assembly.

When servicing system balanced assemblies it is imperative that the following rules be strictly adhered to:

1. Sleeve yokes to midship shafts, end yokes, companion flanges, etc. must not be rotated from their original position during reassembly.

2. It is strongly recommended that an indexing mark or line be painted down the entire length of all assemblies prior to removal from the vehicle.

3. Upon reassembly, all components must be reinstalled exactly as removed. Do not turn yokes or sleeves from their original position.

   For Spicer slip yoke interaxle applications, the slip yoke should be installed with the yoke ears "up hill" from the seal. In main driveshaft applications, the slip yoke seal should be up hill or with the slip yoke at the transmission in transmission-to-axle applications.

4. If at all possible, do not remove boots or dust caps from sleeve assemblies.

5. Inspect boots for any damage (rips or holes). If boot is damaged, it must be discarded. Do not reuse clamps.

6. Push on dust caps are not serviceable. If dust cap must be removed, replace it with a new one.

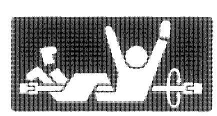
7. If a boot must be disconnected, remove the clamp at the sleeve end and leave the other end attached. Do not reuse clamp.

8. <u>IMPORTANT</u>: If any major component is replaced on any of the assemblies (any component other than boots, dust caps, or u-joints), the entire system balanced assembly must be rebalanced by a competent driveshaft repair facility capable of system balancing.

Failure to adhere to these recommendations can cause excessive driveline vibration and/or premature component failure.

NOTE: The unitized one piece seal now used on Spicer driveshafts is not intended to be removed in service. When servicing driveshafts with the pop on seal, DO NOT remove the seal from the slip yoke. Pull the tube shaft out of the slip yoke and carefully realign the splines on the tube shaft with the slip yoke upon reassembly. To separate the tube shaft from the slip yoke, pull the tube out of the slip yoke, leaving the seal in place. A significant amount of force will be required to remove as well as reinstall the tube shaft through the seal. Removal of the unitized seal causes damage to the seal lip where it contacts the slip yoke. If removal of the seal is absolutely necessary, it should be replaced with a new unit.

To remove the old seal, hold the yoke assembly firmly in a vise. Using a large chisel, drive the seal off of the yoke. To install a new seal, generously lubricate the seal lip and press the new seal into place using a small arbor press or equivalent.



WARNING: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.

Do not go under the vehicle when the engine is running.

Do not work on a shaft (with or without a guard) when the engine is running.

Do not engage or disengage driven equipment by hand from under the vehicle when the engine is running.

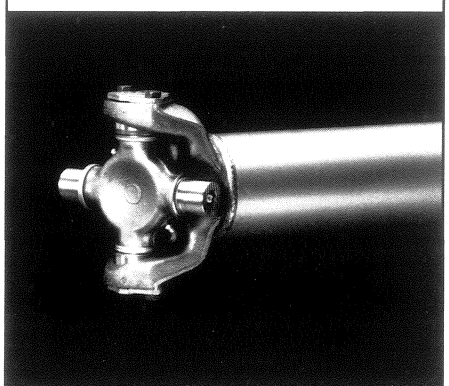
In order to avoid becoming entangled, install the power take-off and/or shaft behind the frame rail, tanks, battery box, etc.

If power take-off and/or shaft are still exposed after installation, install a guard.

Install a support strap when servicing a driveshaft to prevent personal injury.

FULL ROUND END YOKE STYLE

1. Rotate the transmission end yoke by putting the transmission in neutral and the axle end yoke by jacking up one rear wheel, so the cross holes are in a horizontal position.



2. Tilt the cross trunnions of the driveshaft, both ends, with trunnions pointing toward each other from end to end, one side. Install with the slip joint nearest the source of power. Use a nylon support strap to aid in handling the driveshaft.

CAUTION: *Use a journal cross locator to avoid nicking journal cross trunnions or damaging oil seal slingers.*

3. Holding the driveshaft firmly, project a trunnion in an outward position between the lugs of either the axle or the transmission end yoke and through a cross hole. Repeat at opposite end. The driveshaft is being supported at each end by one trunnion surface in a cross hole and the nylon support strap.

   Tilt a cross trunnion until the opposite side can be inserted through a cross hole. Repeat at opposite end. The driveshaft is now being supported at each end by two trunnion surfaces in the cross holes and the nylon support strap.

4. Move one end of the shaft to cause a trunnion to project through the cross hole beyond the outer machined face of the yoke lug. Place a bearing assembly over the trunnion diameter and align it to the cross hole.

   Holding the trunnion in alignment with the cross hole, press bearing assembly flush to face of end yoke by hand.

   If bearing assembly binds in cross hole, tap with soft hammer **directly in center** of bearing assembly plate. Do not tap outer edges of bearing plate.

5. Slide the shaft to project an opposite trunnion through the cross hole beyond the face of the end yoke. Again, place a bearing assembly over the trunnion, align and place hands on opposite bearing assembly, and press both inward flush to yoke faces. If assembly binds, tap with soft hammer as outlined above. Put the lock plate tab in place and insert the "Grade Eight" cap screws through the holes in the lock plates and bearing assemblies. Thread cap screws into end yokes. Tighten with wrench until plates are flush against end yoke faces.

6. Lubricate the cross and bearing assembly until lube appears at all four seals. If any seal fails to purge, see "Lubrication Procedure for U-Joints." Also check slip yoke lubrication.

7. Torque all eight bolts to specification (see chart below). Bend lock plate tabs to flat of cap screwheads to lock in place.

NOTE: *The self-locking bolt design for full-round yokes uses serrated bolts with lock patch and DOES NOT require a lock strap. DO NOT reuse ANY retaining bolts.*

8. Repeat at opposite end. Remove nylon support strap.

FULL ROUND END YOKE

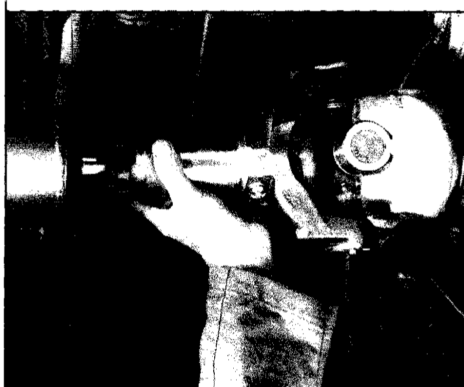
SERIES	THREAD SIZE	TORQUE: LOCK STRAP DESIGN (Lb./Ft.)	(NM)	Bolt P/N	TORQUE: SERRATED BOLT w/LOCK PATCH (Lb./Ft.)	(NM)	Bolt P/N
1610	.312-24	26-35	35-48	5-73-109	26-35	35-48	5-73-709
1710	.375-24	38-48	52-65	6-73-109	38-48	52-65	6-73-209
1760	.375-24	38-48	52-65	6-73-109	38-48	52-65	6-73-209
1810	.375-24	38-48	52-65	6-73-109	38-48	52-65	6-73-209
1880	.438-20	60-70	81-95	7-73-115	60-70	81-95	7-73-315

SERVICING THE DRIVESHAFT

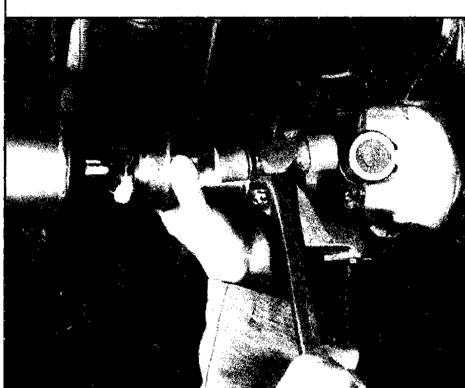
QUICK DISCONNECT™ HALF ROUND END YOKE

SERIES	THREAD SIZE	BOLT P/N	BOLT TORQUE (Lb./Ft.)	BOLT TORQUE (NM)
SPL90	.375-24	6-73-412	45-60	61-81
1610	.375-24	6-73-412	45-60	61-81
1710	.500-20	8-73-316	115-135	156-183
1760	.500-20	8-73-316	115-135	156-183
1810	.500-20	8-73-316	115-135	156-183

On Quick Disconnect applications, the bearing saddles of the end yoke must be clean and free of any contaminants.

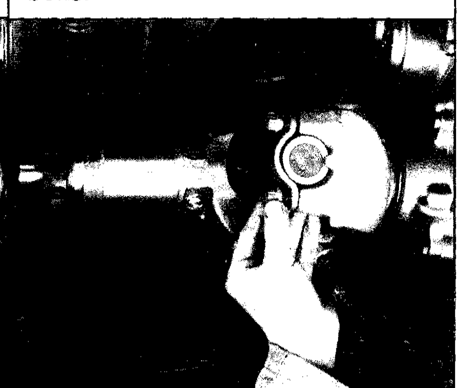


Using a soft hammer, tap the bearing assemblies until they are fully seated into the end yoke. Check to be sure the cups are fully seated in the bearing saddles of the yoke behind the yoke tabs as shown below.



Install the bearing straps and bolts and torque all eight bolts to the proper specification. Bend lock plate tabs to flat of cap screwheads to lock in place.

***NOTE**: The self-locking bolt design for full-round yokes uses serrated bolts with lock patch and DOES NOT require a lock strap. DO NOT reuse ANY retaining bolts.*



Lubricate the cross and bearing assembly until lube appears at all four seals. If any seal fails to purge, see "Lubrication Procedure for U-Joints." Also check slip yoke lubrication.

***CAUTION:** Excessive bearing rotation could cause premature wear of components involved. The causes of rotation are:*

1. Use of non-Spicer parts with Genuine Spicer components.
2. Improper torque on retaining strap bolts.
3. Failure to firmly seat both bearing assemblies in the end yoke saddles before the strap bolts are tightened.
4. Dirty bearing saddles.

***CAUTION:** Half Round self-locking retaining bolts should not be reused. Follow instructions implicitly to prevent danger of serious personal injury or death from loss of driveshaft function.*

FLANGE YOKE

SERIES	THREAD SIZE	BOLT TORQUE (Lb./Ft.)	BOLT TORQUE (NM)
SPL 90	.375-24	40-48	54-65
1610	.375-24	40-48	54-65
1710	.375-24	40-48	54-65
1760	.438-20	63-75	85-102
1810	.438-20	63-75	85-102
1880	.625-18	194-232	263-315

FLANGE YOKE STYLE

With nylon support strap in place and holding the driveshaft firmly, align the (permanent end) flange pilots of the driveshaft flange yoke and axle companion flange with each other. Align bolt holes and install bolts, lock washers and nuts to temporarily secure driveshaft to axle. Compress the slip assembly to position the opposite end of the driveshaft to the transmission companion flange. Align bolt holes and install bolts, lock washers, and nuts. Torque to specifications, both ends.

NOTE: 1650 Series Bearing Assemblies with Locking Flats.

When installing new bearing assemblies into cross holes, the locking flat on the bearing assembly must be aligned with the locking flat in the yoke cross hole. Proper location of locking flats will assure that the bearing assembly will not rotate.

LIGHT AND MEDIUM DUTY APPLICATION

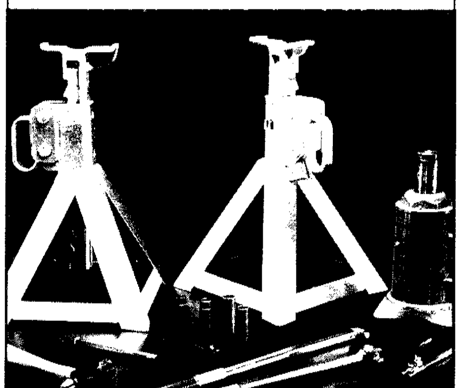
Cross and Bearing Kit Replacement

Inside and Outside Snap Ring, U-Bolt and Bearing Strap Design

WARNING: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death. Do not go under the vehicle when the engine is running.

TOOLS (1000 - 1500 SERIES):

Common Hand Tools
Soft Hammer



REMOVAL

Procedures for removing the driveshaft from light and medium duty vehicles are nearly the same as for heavy duty applications. One difference is that the cross and bearings vary in the method of attaching to the vehicle. Methods of attachment include u-bolt, bearing strap and flange yoke design.

For heavy driveshafts, support with a nylon support strap. Remove the u-bolts or strap cap screws from the end yoke. Slide the slip yoke toward the shaft to free the bearings from their seats between the yoke tabs in the end yokes. Care should be taken to avoid dropping the bearing assemblies. Repeat at opposite end.

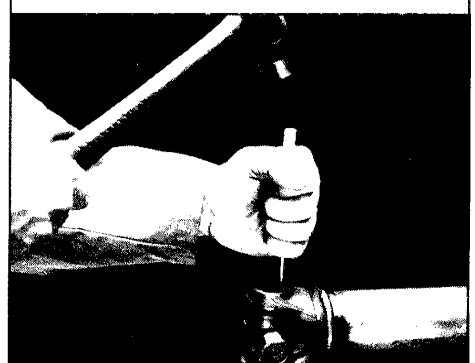
For double flange applications, disassemble as a complete assembly by removing the companion flange bolts.

For flange yoke and end yoke combination-type driveshafts, remove as described above for whatever design applies.

OUTSIDE SNAP RING DESIGN (RELUBABLE)

Disassembly

With the shaft removed, the following procedure should be followed:

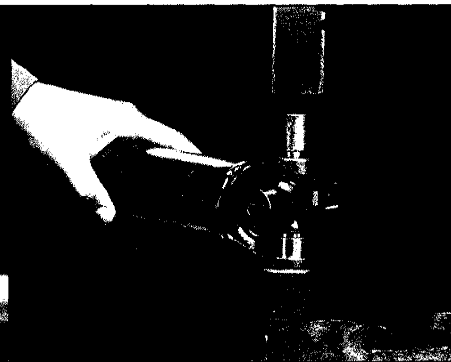


1. Using a soft drift, tap the outside of the bearing assembly to loosen snap ring. Tap bearing only hard enough to break assembly away from snap ring.

2. Remove snap ring from yoke. Turn joint over, tap bearing away from snap ring, then remove opposite snap ring.

3. Set the yoke in the arbor press with a piece of tube stock beneath it. Position the yoke with the lube fitting pointing up to prevent interference during disassembly. Place a solid plug on the upper bearing assembly and press it through to release the lower bearing assembly.

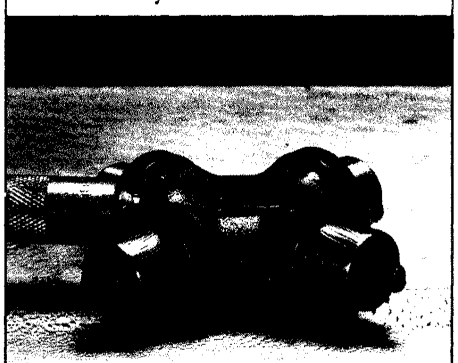
4. If the bearing assembly will not pull out by hand after pressing, tap the base of the lug near the bearing assembly to dislodge it.



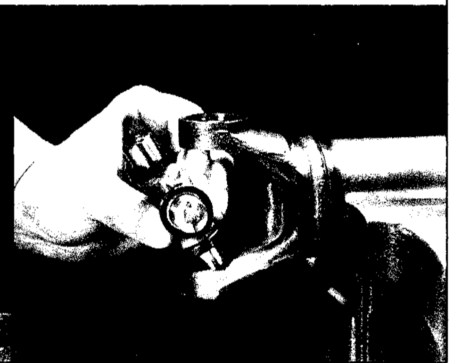
5. To remove the opposite bearing assembly, turn the yoke over and straighten the cross in the open cross hole. Then carefully press on the end of the cross so the remaining bearing assembly moves straight out of the bearing cross hole. If the cross or bearing assembly are cocked, the bearing assembly will score the walls of the cross hole and ruin the yoke.

6. Repeat this procedure on the remaining bearing assemblies to remove the cross from the yoke.

Reassembly



1. Pack the four grease cavities of the cross with a high quality extreme pressure N.L.G.I. Grade 2 grease (refer to page 6). Also pack each bearing assembly approximately 1/4 full with this grease.



2. Position the cross in the yoke with its lube fitting on the inboard side (toward driveshaft).

3. Move one end of the cross to cause a trunnion to project through the cross hole beyond the outer machined face of the yoke lug. Place a bearing assembly over the trunnion diameter and align it to the cross hole. Using an arbor press, hold the trunnion in alignment with the cross hole and place a solid plug on the upper bearing assembly. Press the bearing assembly into the cross hole enough to install a snap ring.

4. Install a snap ring.

5. Repeat steps 3 and 4 to install the opposite bearing assembly. If the joint is stiff, strike the yoke ears with a soft hammer to seat the needle bearings.

CAUTION: *Be sure snap rings are properly seated in grooves.*

6. Repeat steps 2 - 5 at the opposite end of the driveshaft if installing a second kit. Make sure to keep lube fittings at each end of the driveshaft in line.

7. Install the reassembled driveshaft in the vehicle. If bearing straps or u-bolts hold the shaft in vehicle, be certain the bearing assemblies are fully seated between bearing locating shoulders.

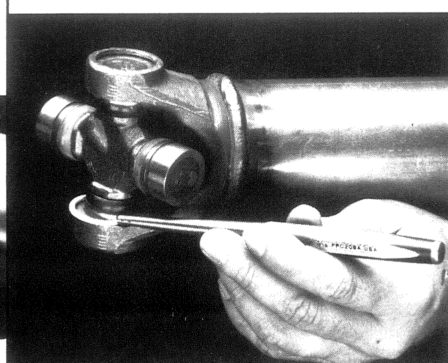
8. Torque bolts to specification.

CAUTION: *Self-locking bolts used with bearing straps should not be reused. Follow instructions implicitly to prevent danger of serious personal injury or death from loss of driveshaft function.*

9. Apply more grease through the lube fitting until grease appears at all four bearing seals.

INSIDE SNAP RING DESIGN (RELUBABLE)

Disassembly

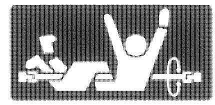


Removing an inside snap ring.

Repeat outside snap ring design disassembly instructions.

Reassembly

Repeat outside snap ring design reassembly instructions.



WARNING: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death. Do not go under the vehicle when the engine is running.

In order to avoid becoming entangled install power take-off and/or shaft behind the frame rail, tanks, battery box, etc.

If power take-off and/or shaft are still exposed after installation, install a guard.

PRELUBE OR LUBE-FOR-LIFE™ DESIGNS

Spicer Prelube or Lube-for-Life™ U-joint Kit

Some Spicer crosses and bearings are prelube or lube-for-life designs and have no lube fittings. Since lubrication is critical, special seals are used to contain the lubricant in the cross/bearings in this design.

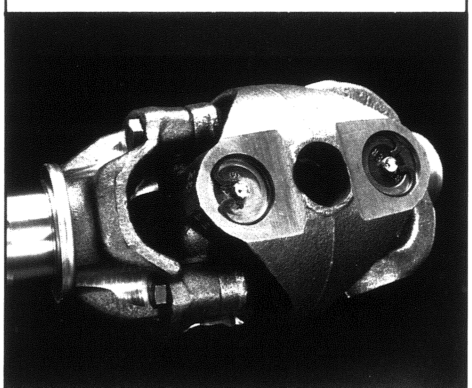
Service instructions are nearly the same for relubable and prelube or lube-for-life design, whether it is inside or outside snap ring, u-bolt or bearing strap design.

The difference is that lifetime lubrication is done by Spicer at the time of manufacture and relubrication should not be necessary. Replacement of the cross and bearing kit rather than relubrication is recommended.

TORQUE SPECS FOR LIGHT AND MEDIUM DUTY

POSITION	BOLT SIZE	TORQUE (Lb./Ft.)	TORQUE (NM)
U-Bolts	(5/16) .312-24	14-17	19-23
	(3/8) .375-24	20-24	27-33
	(7/16) .438-20	32-37	43-50
Bearing Strap	(1/4) .250-28	13-18	18-24
	(5/16) .312-24	25-30	34-41
	(3/8) .375-24	45-60	61-81
Flange Bolts	(5/16) .312-24	22-26	16-35
	(3/8) .375-24	40-48	54-65
	(7/16) .438-20	63-75	85-102
	(1/2) .500-20	97-116	132-157

DOUBLE-CARDAN CONSTANT VELOCITY TYPE JOINT
(Light Duty)



The double-cardan constant velocity (CV) type u-joint is a special design to accommodate necessary installation angles not compatible with single-cardan u-joints. The CV joint also requires special attention. Neglect is its main enemy.

The CV joints need lubrication to live. Some of the older assemblies using flush-type fittings require special lube gun fittings, such as a needle nose attachment. The crosses may or may not have lube fittings.

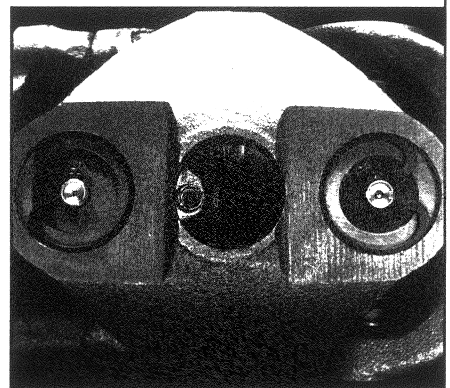
The centering socket and ball is critical to proper function of the CV joint and smooth operation. Without lubrication it will wear out, causing vibration and serious damage. Rebuilding the CV joint will be necessary.

LUBRICATION

The lube fitting for the centering socket in the CV joint can be difficult to reach and requires a special lube technique. It is necessary to rotate the driveshaft to a position with the flush type lube fitting in the centering socket up toward the floor board. The yokes spread or open in this position to allow access with the needle nose tip. It is still an awkward and blind procedure. That explains why neglect is so common.

WARNING: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death. Do not work on a shaft (with or without a guard) when the engine is running.

A more positive, less frustrating approach is to disconnect the driveshaft. The lube fitting will come into view but it may be necessary to jack one front wheel and rotate the driveshaft. This can be done to all 4WD vehicles with the double-cardan u-joint.

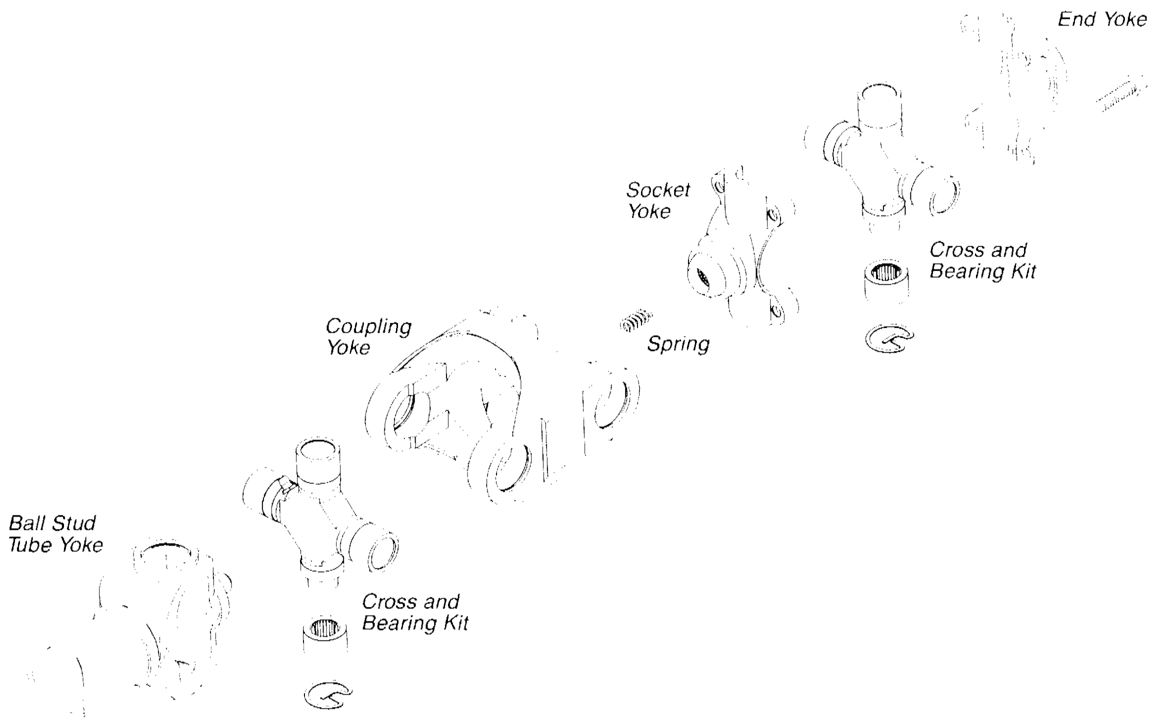


Lubrication access hole in late-design Spicer Double Cardan Joints

The later-design Spicer CV joints simplify lubrication by making easy access to the lube fittings. Service replacement kits have been modified with a lube fitting in one or more bearing assemblies to aid in lubrication access. Also, an access hole has been provided in the center yoke for easy lubrication of the centering ball. This new design eliminates the need to disconnect the shaft and puts the fittings in plain view.

Look for signs of u-joint trouble when lubricating u-joints:

- ✔ Lube spray from a leaky seal indicates need for u-joint replacement.
- ✔ Any looseness or noticeable "slop" at a u-joint in the driveshaft calls for immediate replacement of the u-joint, assuming the snap rings or bolts are already in place or torqued down.



Spicer Double Cardan Constant Velocity Type Joint

SPICER STYLE REPAIR KIT

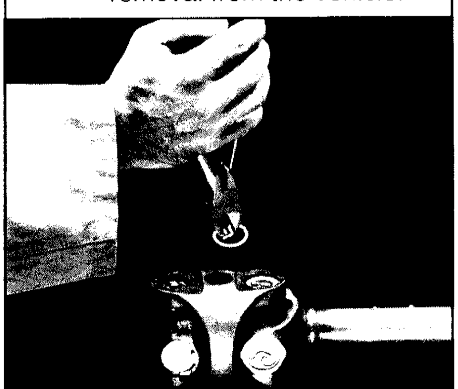
The Spicer style double cardan CV joint has outside snap rings. CV joint repairs should be made whenever inspections show any noticeable sign of loose fit, corrosion or loss/lack of lube at u-joint or centering ball.

Centering socket/ball repair kits are available from Spicer with installation instructions for replacement. The correct repair kit depends on whether the CV joint is the older or newer type. The advantage of easy access lube fittings for the new style center kit would be lost when installed in an old style u-joint. The centering kits have a different location for the lube fitting.

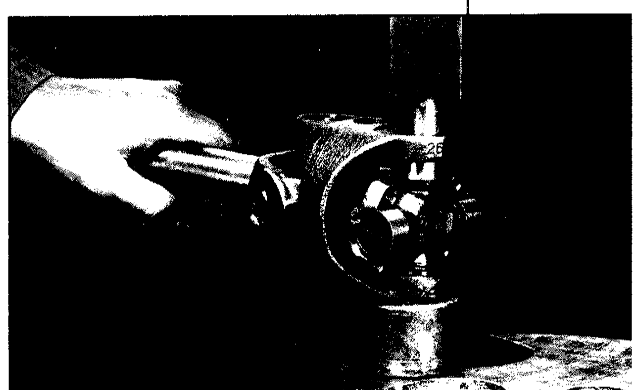
The disassembly and reassembly of both types is basically the same procedure. It is important that both styles be reassembled with all lube fittings aligned on the same side. This will make service lubrication more convenient and reduce the possibility of overlooking lube points.

DISASSEMBLY

1. Disconnect u-bolts or bearing straps at the single-cardan end yoke position. Disconnect cap screws from the CV end yoke or flange bolts from the CV companion flange. This will allow driveshaft removal from the vehicle.



2. Remove all snap rings from the bearing assemblies.



3. Press the bearing assembly partially from the outboard side of the center yoke — enough to grasp by vise jaws. Do not press the bearing assembly completely through.

***NOTE**: Be sure to remove lube fitting if it interferes with bearing assembly press-out.*

SERVICING THE DRIVESHAFT

4. Grasp the protruding bearing assembly by vise jaws. Tap the tube yoke with a mallet and drift to dislodge the bearing assembly from the yoke hole.

5. Flip the assembly and repeat steps 3 and 4 for removing the opposite side bearing assembly. This will then allow removal of the cross centering kit assembly and spring.

6. Press the remaining bearing assemblies out on the other cross as described above to complete disassembly.

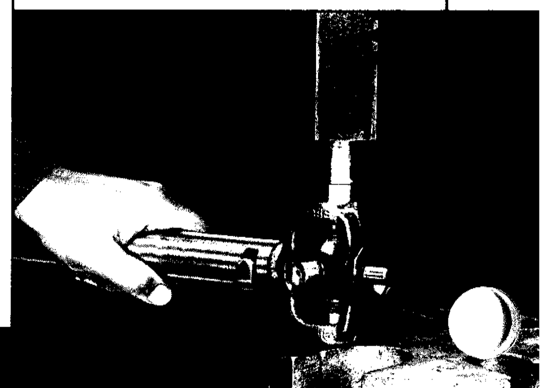
CAUTION: *Tap in the center of the "H" yoke. Never strike the yokes at the bearing assembly holes because the snap ring grooves may collapse and make reassembly impossible.*

REASSEMBLY

1. Fit a cross into the tube yoke.
2. Place a bearing assembly in a tube yoke hole and over a trunnion. Keep the needle rollers upright in the bearing assembly. A needle roller lying at the bottom of the bearing assembly will prevent proper assembly.

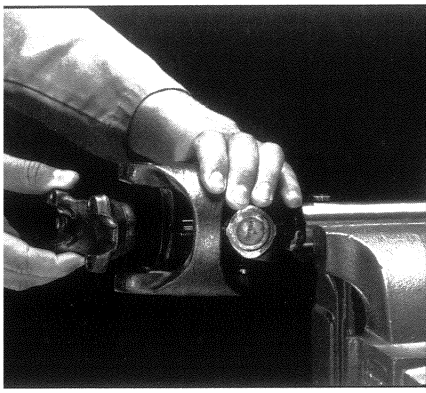
***NOTE**: Be sure to remove the lube fitting if it interferes with bearing assembly press-up.*

3. Press the bearing assembly in place and install a snap ring.

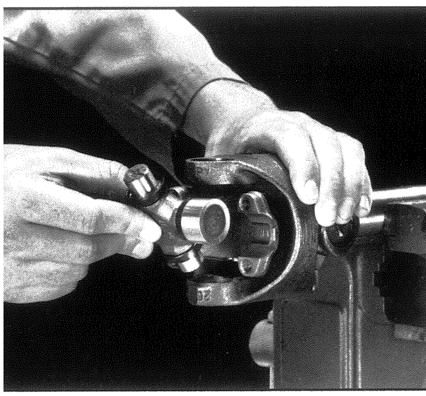


4. Flip the tube yoke and repeat bearing assembly installation on the opposite trunnion. Install a snap ring.

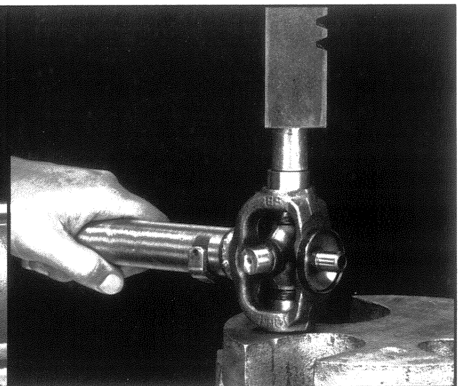
5. Fit the center yoke on the remaining two trunnions and press bearing assemblies in place, both sides. Install snap rings.



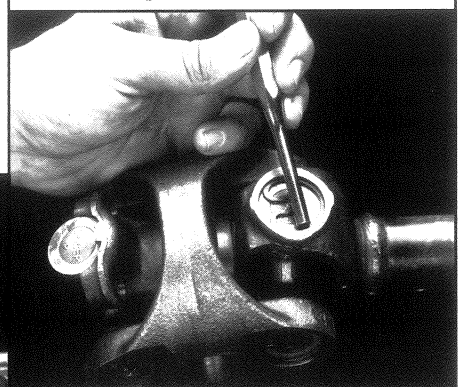
6. Next install the centering kit assembly inside the center yoke making sure the spring in the tube yoke is in place. Align the lube fitting on the centering kit assembly with the lube fitting on the installed cross.



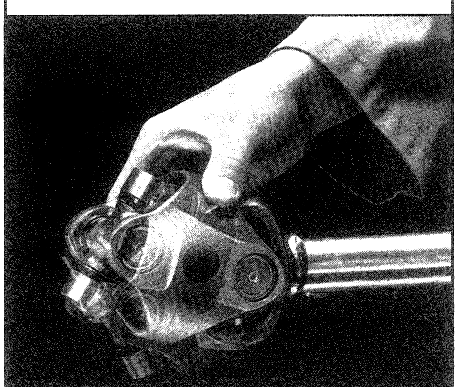
7. Place two bearing assemblies on the remaining cross (opposite sides). Fit the open trunnions into the center yoke holes and the bearing assemblies into the centering kit assembly. Make sure the lube fitting on the cross is in line with the other two lube fittings.



8. Press the remaining two bearing assemblies into place and install snap rings.



9. Tap the snap rings to allow them to set into the grooves. A bearing cup from a used u-joint works well for this.



10. Check for proper assembly. Flex the CV joint beyond center. It should snap "over center" in both directions when all needle rollers and components are correctly assembled.

11. Reinstall in the vehicle.

12. Torque all bolts and cap screws to specifications shown below.

13. Add grease to all three lube fittings.

TORQUE SPECIFICATIONS FOR DOUBLE-CARDAN CONSTANT VELOCITY TYPE JOINTS

1210CV–Standard Grade Eight Bolts
Bolt Torque – 13-18 lb./ft.
(.250-28)

1310/1330CV–Standard Grade Eight Bolts
Bolt Torque - 22-26 lb./ft.
(.312-24)

CAUTION: *Self-locking bolts used with bearing straps should not be reused. Follow instructions implicitly to prevent danger of serious personal injury or death from loss of driveshaft function.*

WARNING: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.

Do not go under the vehicle when the engine is running.

In order to avoid becoming entangled install power take-off and/or shaft behind the frame rail, tanks, battery box, etc.

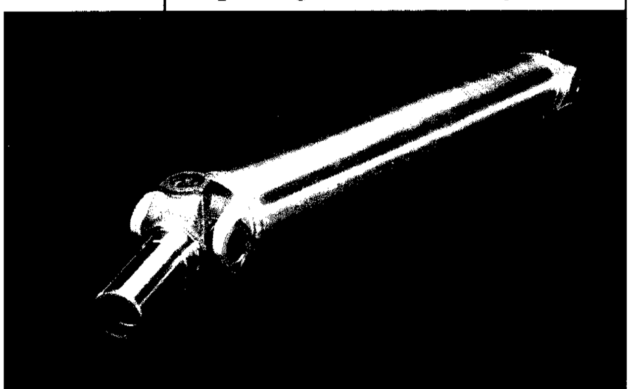
If power take-off and/or shaft are still exposed after installation, install a guard.

SERVICING THE DRIVESHAFT

Assembly and disassembly procedures for Spicer Lite™ aluminum and Spicer Graph-Lite™ driveshafts are similar to those of other driveshafts. However, some unique instructions **must be** followed to service advanced technology materials.

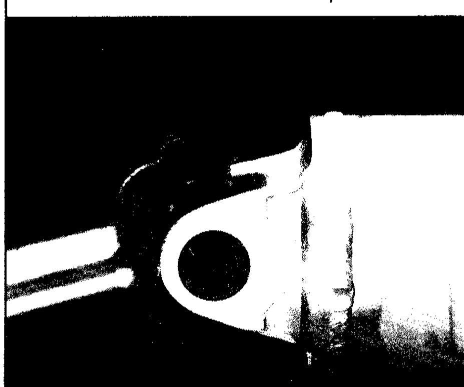
SPICER LITE™ ALUMINUM DRIVESHAFT

Inspecting and Lubricating



1) Inspect Spicer Lite™ aluminum driveshafts following the same procedures for steel driveshafts as outlined on pages 4 - 7.

2) Inspect the aluminum tubing for surface scratches and dents. These scratches may **not** exceed 0.008 inches in depth.



3) Visually inspect the circle welds and end fittings for any signs of cracks or signs of deterioration. If there are any cracks that exceed 0.008 inches in depth, the assembly must be replaced.

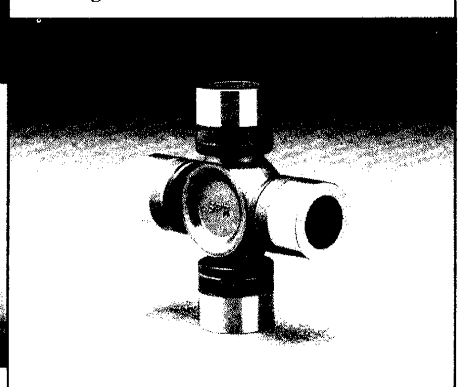
4) Check to be sure there are no missing balance weights. If balance weights are missing and a void has occurred in the aluminum tubing greater than 0.008 inches, the assembly must be replaced.

SERVICING

1) Service Spicer-Lite™ aluminum driveshafts following the same procedure for steel driveshafts as outlined on pages 13 - 15.

2) After removing the cross and bearings from both ends of the driveshaft, inspect the cross hole surfaces for damaged or raised metal. Raised metal can be removed with an emery cloth. The raised metal can cause premature cross and bearing problems.

***CAUTION:** Aluminum is softer than steel. Care must be taken not to remove excessive material or damage cross holes.*



3) If the universal joint kit is replaced, it must be replaced with a kit designed specifically for use with aluminum. The use of non-endurion coated kits will result in damage to the driveshaft through galvanic corrosion.

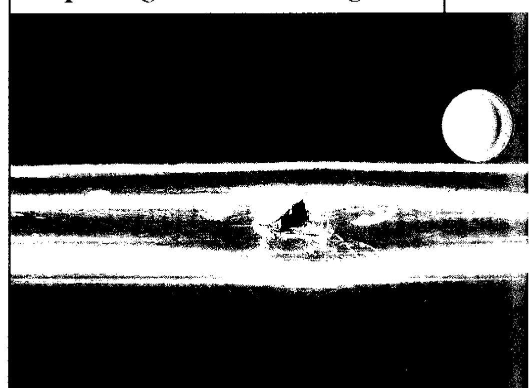
***CAUTION:** When replacing universal joint kits in aluminum driveshafts, use kits designed specifically for aluminum to avoid galvanic corrosion.*

Straightening and Balancing

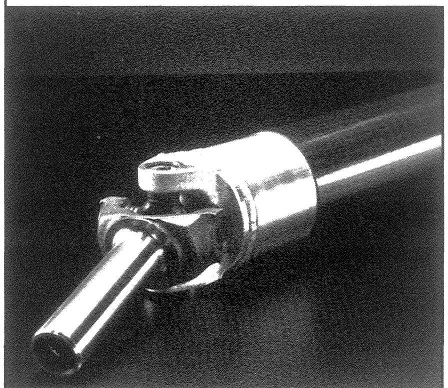
1) Our Spicer Lite™ aluminum driveshaft can be straightened following the same procedure for steel driveshafts as outlined on page 24.

GRAPH-LITE™ DRIVESHAFTS

Inspecting and Lubricating

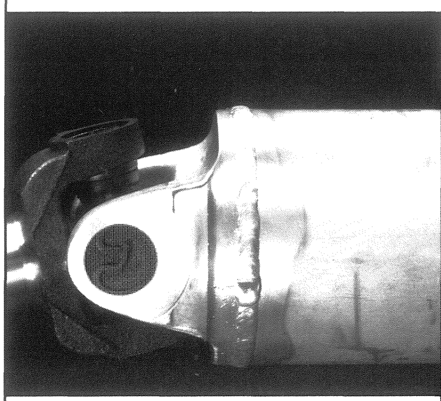


1) Inspect driveshaft for any surface imperfections in the black graphite covering. Look for torn graphite near the ends of the covering and surface scratches or cracks deeper than 0.008 inches along the length of the covering. If any imperfections such as these exist, the assembly must be replaced. The black graphite must be securely attached to the aluminum tubing in all areas. If there is any relative movement between the two materials (aluminum and carbon graphite), the assembly must be replaced.



2) Inspect the driveshaft following the same procedures for steel driveshafts as outlined on pages 4 - 7.

3) Inspect the aluminum tubing for surface scratches and dents deeper than 0.008 inches.



4) Visually inspect the circle welds and end fittings for any signs of cracks or deterioration. If there are any cracks that exceed 0.008 inches in depth, the assembly must be replaced.

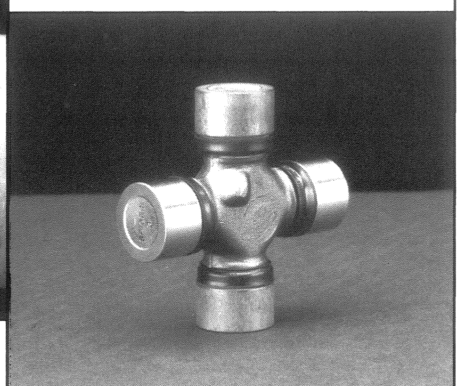
5) Check for any missing balance weights. If balance weights are missing, and a void has occurred in the aluminum tubing greater than 0.008 inches, the assembly must be replaced.

Servicing

1) Service Spicer Graph-Lite™ driveshafts following the same procedure for steel driveshafts outlined on pages 13 - 15.

2) After removing the cross and bearings from both ends of the driveshaft, inspect the cross hole surfaces for damaged or raised metal. Raised metal can be removed with an emery cloth. The raised metal can cause premature cross and bearing problems.

CAUTION: *Aluminum is softer than steel. Care must be taken not to remove excessive material or damage cross holes.*

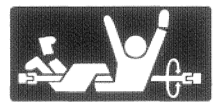


3) If the universal joint kit is replaced, it must be replaced with a kit designed specifically for use with aluminum. The use of non-endurion coated kits will result in damage to the driveshaft through galvanic corrosion.

CAUTION: *When replacing universal joint kits in Graph-Lite™ driveshafts, use kits designed specifically for aluminum to avoid galvanic corrosion.*

Straightening and Balancing

DO NOT, UNDER ANY CIRCUMSTANCES, ATTEMPT TO STRAIGHTEN ALUMINUM GRAPHITE DRIVESHAFTS. Any attempt to do this will cause damage to the carbon graphite covering resulting in decreased performance of the driveshaft. The entire driveshaft assembly must be replaced if the tubing is bent or twisted.



WARNING: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.

Do not go under the vehicle when the engine is running.

Do not work on a shaft (with or without a guard) when the engine is running.

Do not engage or disengage driven equipment by hand from under the vehicle when the engine is running.

In order to avoid becoming entangled, install the power take-off and/or shaft behind the frame rail, tanks, battery box, etc.

If power take-off and/or shaft are still exposed after installation, install a guard.

Install a support strap when servicing a driveshaft to prevent personal injury.

A serious or fatal injury can occur ...
- ▲ if you lack proper training
- ▲ if you fail to follow proper procedures
- ▲ if you do not use proper tools and safety equipment
- ▲ if you assemble driveline components improperly
- ▲ if you use incompatible driveline components
- ▲ if you use worn-out or damaged driveline components
- ▲ if you use driveline components in a non-approved application

This manual contains detailed safety instructions. Read, understand and follow this manual.
- ▲ Get proper training
- ▲ Learn and follow safe operating procedures
- ▲ Use proper tools and safety equipment
- ▲ Use proper components in good condition

STRAIGHTENING AND BALANCING ANGLES AND PHASING

STRAIGHTENING AND BALANCING THE DRIVESHAFT

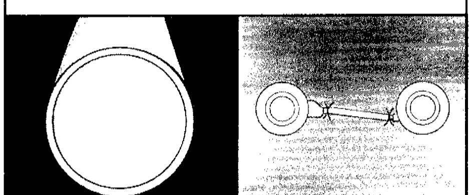
(Excluding Aluminum)

The rebuilding of a driveshaft assembly usually consists of replacing worn cross and bearing assemblies with a new kit. These kits replace the part of a driveshaft most subject to wear in operation. The potential off-center condition present in the cross and bearing assemblies makes it desirable to balance every assembly after installing new cross and bearing kits.

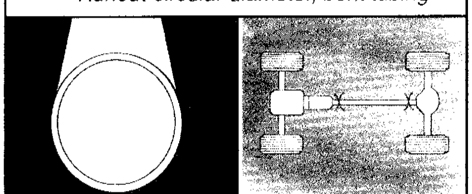
When the tubing is bent or twisted or the tube fittings are distorted, it will be necessary to replace the damaged parts.

Properly assemble the new components into the tube and straighten the shaft assembly before tack welding, to be sure the parts are on center. This can be done by mounting the complete assembly in the appropriate tooling and straightening until the ends of the tube run concentric within 0.005 T.I.R. Recheck for runout.

RUNOUT VERSUS OVALITY



Runout-circular diameter, bent tubing

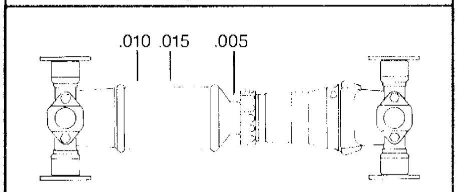


Ovality-oval diameter straight tubing

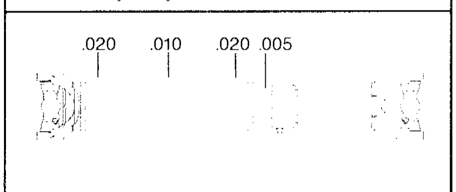
When checking for runout, it is important to distinguish between runout and ovality. Runout is when the tube is slightly bent but still maintains its circularity throughout the tube. During dynamic balancing, a dial indicator will show runout ONCE per revolution.

Ovality occurs when the tube is not circular but oval in shape. During dynamic balancing, a dial indicator will display ovality TWICE per revolution. Even though a tube may be straight, ovality will make it seem bent. A tube with ovality may be used up to a 0.010 T.I.R. runout reading. Beyond this limit the tube must be discarded for driveshaft purposes.

After welding, the entire driveshaft shouid be straightened to the following limits:



Heavy Duty Driveshaft Runout Limits



Light and Medium Duty Driveshaft Runout Limits for Unbalanced Driveshaft

Heavy Duty

0.005 T.I.R. on the neck of the slip tube shaft
0.010 T.I.R. on ends of tubing 3" from welds
0.015 T.I.R. at linear center of the tube

Light and Medium Duty

0.005 T.I.R. on the neck of the slip tube shaft
0.010 T.I.R. on ends of tubing 3" from welds
0.015 T.I.R. at linear center of the tube
0.015 T.I.R. for full length of tube with 30" or less

(T.I.R. — Total Indicator Reading)

These runouts should be taken with entire driveshaft assembly mounted on master tooling which locates on the outboard bearing assemblies of the u-joint kit (light and medium duty), or the trunnions of the outboard u-joint kit (heavy duty) or on selected flange yokes or yokes.

All flange yokes or yokes should be selected for dynamic balance to eliminate as much unbalance as possible. During balancing, the driveshaft again should be mounted on the same master tooling or selected flanges or yokes.

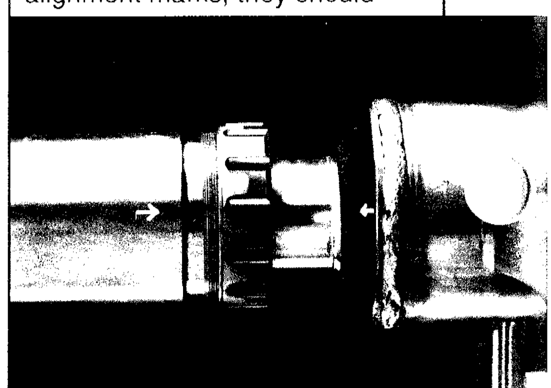
After straightening, balance the entire assembly to Original Equipment Manufacturer specifications.

ANGLES AND PHASING

(All Types)

Proper driveshaft angles and correct phasing of the yokes are very important in maintaining long life and quiet running shafts.

When in phase, the slip yoke lugs (ears) and tube yoke lugs (ears) are in line. Normally, this is the ideal condition and gives the smoothest running shaft. There may be an alignment arrow stamped on the slip yoke and on the tube shaft to assure proper phasing when assembling these components. If there are no alignment marks, they should be added before disassembly of the shaft to assure proper reassembly.

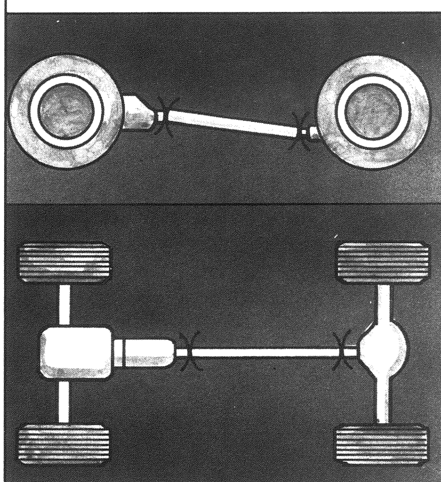


An "In Phase" Driveshaft

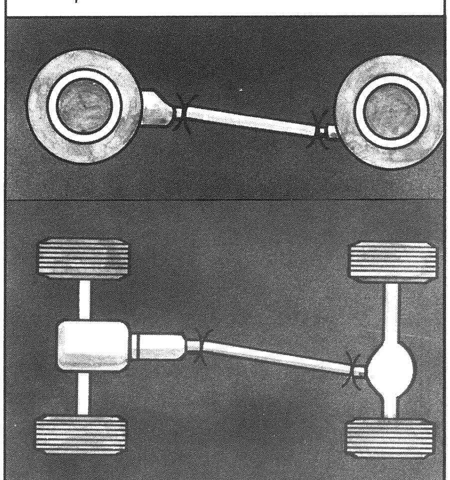
Phasing is relatively simple on a two-joint set ... be sure that the slip yoke lugs and the tube yoke lugs are in line. Driveshaft angles are a little more complicated.

The u-joint operating angle is the angle formed by two yokes connected by a cross and bearing kit. There are two kinds of u-joint angles.

The simple one plane angle found in most installations has all driveline slope confined to one plane, usually the vertical plane. The other type of driveline angle is the compound angle in two planes. This is found in driveline designs where offset exists in both the vertical and horizontal planes. For detailed information on troubleshooting compound angles, contact your Spicer Service Representative.



One Plane Angle Driveshafts, Side and Top View



Two Plane Angle Driveshaft, Side and Top View

High angles combined with high R.P.M. is the worst combination, resulting in reduced u-joint life. Too large and unequal u-joint angles can cause vibrations and contribute to u-joint, transmission and differential problems. The improper u-joint angles must be corrected.

Ideally, the operating angles on each end of the driveshaft should be equal to or within 1 degree of each other, have a 3 degree maximum operating angle and have at least 1/2 of a degree continuous operating angle.

R.P.M. is the main factor though in determining maximum allowable operating angles. As a guide to maximum normal operating angles, refer to the chart listed.

DRIVESHAFT RPM	MAX. NORMAL OPERATING ANGLES
5000	3.25°
4500	3.67°
4000	4.25°
3500	5.0°
3000	5.83°
2500	7.0°
2000	8.67°
1500	11.5°

Tube diameter and normal operating RPM determine maximum allowable tube length. If "critical length" is reached, a three-joint driveshaft with center support or a Spicer Graph-Lite™ driveshaft must be used. Refer to the Spicer "Driveshaft Speed Calculator" — Form M3-11 TRNG.

When the transmission output shaft centerline and axle input shaft centerline are parallel, the u-joint operating angle permissible is length of driveshaft divided by five. Example: A short coupled driveshaft with a 15" length would be limited to 3 degrees maximum operating angle. A 30" shaft would be limited to 6 degrees.

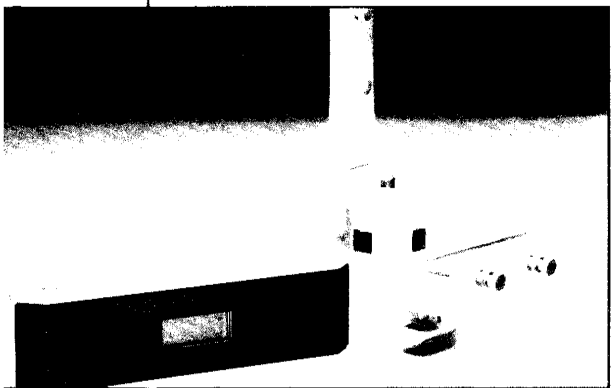
When the transmission output shaft centerline and axle input shaft centerline intersect midway of the driveshaft, the joint angles are equal. However, due to the change to unequal joint angles during up and down axle movement, this is a more undesirable condition than parallel centerlines. In this case, the maximum u-joint operating angle is determined by dividing length of driveshaft by ten. Example: A 30" driveshaft with intersecting angles would have a 3 degree permissible operating angle.

CHECKING DRIVESHAFT ANGLES IN THE VERTICAL OR HORIZONTAL PLANE

WARNING: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death. Do not work on a shaft (with or without a guard) when the engine is running.

Use the following procedure to check driveshaft angles for proper u-joint operating angles.

1. Inflate all tires to the pressure at which they are normally operated. Park the vehicle on a surface which is as level as possible both from front-to-rear and from side-to-side. Do not attempt to level the vehicle by jacking up the front or rear axles. Shift the transmission to neutral and block the front tires. Jack up a rear wheel.
2. Rotate the wheel by hand until the output yoke on the transmission is vertical, and lower the jack. This simplifies measurement later. Check driveshaft angles in the same loaded or unloaded condition as when the vibrations or noise occurred. Always try to check driveline angles in both loaded and unloaded conditions.



Spicer "Anglemaster® II" Electronic Driveline Inclinometer with available attachments

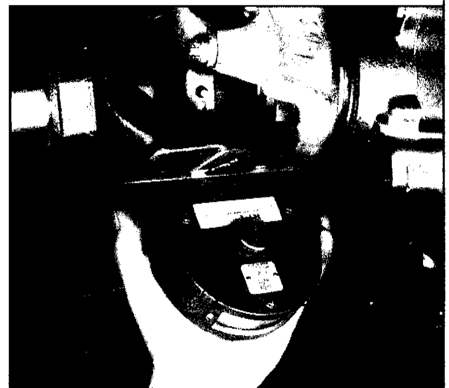
3. To determine driveshaft angles, a spirit level protractor or Spicer Anglemaster® II Electronic Driveline Inclinometer is required. On a protractor, when angles are read from the 0 degree mark (horizontally — on the driveshaft) record and use the angle shown. When angles are read from either of the 90 degree marks (vertically — on the flange) 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 the horizontal plane. Thus, if a vertical reading is 85 degrees, the angle being measured is 5 degrees (90 - 85 = 5 degrees).

   To use the Spicer Anglemaster® II Electronic Driveline Inclinometer, simply place the sensor on the component to be measured. A display module will show what the angle is and in which direction it slopes.

   (Available only from Dana Corporation and your Spicer Service Representative.)

   If using a protractor, all angles should be read within 0.25 degree and they should be measured with the protractor held plumb on a clean flat surface. The Spicer Anglemaster® II Electronic Driveline Inclinometer is automatically accurate to within 1/10 of 1 degree. Always measure the slope of the drivetrain going from front to rear. A component slopes downward if it is lower at the rear than the front. A component slopes upward when it is higher at the rear than it is in front.

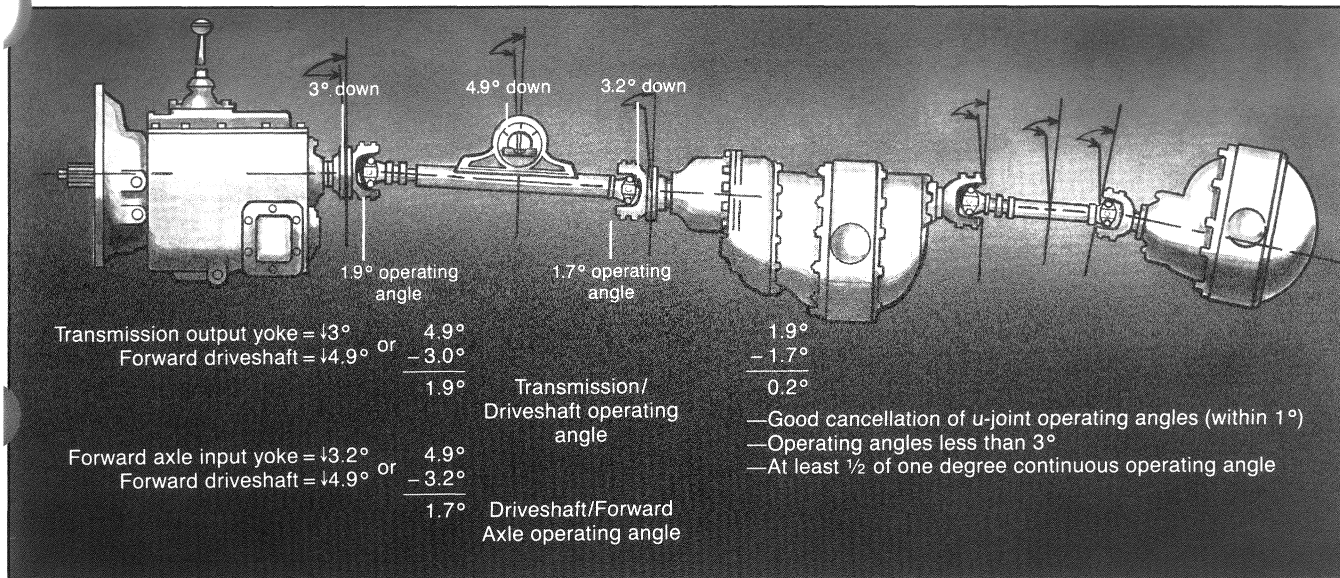
4. Check and record the angle on the main transmission. This reading can be taken on the end yoke lug, with the bearing assembly removed or on a flat surface of the main transmission parallel or perpendicular to the output yoke lug plane. Record your readings on a sketch.



5. Now check the driveshaft angle between the transmission and axle or forward axle. On short tube length driveshafts, check the angle of the driveshaft on either the tube or slip yoke lug with the bearing assembly removed. On long tube length driveshafts, measure the angle on the tube at least 3" away from the circle welds or at least 1" away from any balance weights. Be sure to remove any rust, scale or sound deadening compounds from the tube to obtain an accurate measurement.

A 5 minute videotape that outlines instructions for "Measuring and Calculating Driveline Operating Angles" is available at $60.00 from:

Spicer Universal Joint Division
Dana Corporation
P. O. Box 955
Toledo, Ohio 43695
Attn: Advertising Department



6. Check the forward axle input yoke angle by removing a bearing assembly and measuring the angle on the yoke lugs or on a flat surface of the angle housing parallel or perpendicular to the input yoke lug plane.

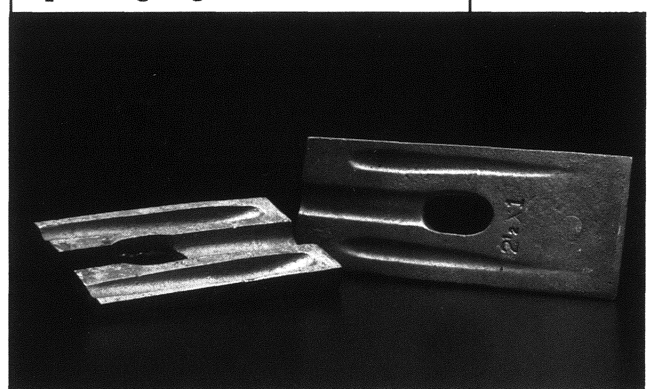
7. If applicable, measure the output yoke angle of the forward axle, the angle of the tandem driveshaft between the forward axle and the rear axle, and the rear axle input yoke angle.

With all of the angles recorded, complete a drawing as shown. There are no u-joint operating angles in your drawing at this time, just the slope of the components and their direction. To determine u-joint operating angles, simply find the difference in the slopes of the components.

When the slopes are in the **Same** direction on two connected components, **Subtract** the smaller number from the larger to find the u-joint operating angle. When the slopes are in the **Opposite** direction on two connected components, **Add** the measurements to find the u-joint operating angle.

Now compare the u-joint operating angles on your drawing to the rules for ideal operating angles mentioned above.

Correcting U-Joint Operating Angles



Axle Shims

The recommended method for correcting severe u-joint operating angles depends on the vehicle suspension or driveline design.

On vehicles with leaf spring suspension, thin wedges called axle shims can be installed under the leaf springs of single axle vehicles to tilt the axle and correct u-joint operating angles. Wedges are available in a range of sizes to change pinion angles.

On vehicles with tandem axles, the torque rods can be shimmed. Torque rod shims rotate the axle pinion to change the u-joint operating angle. A longer or shorter torque rod may be available from the manufacturer if shimming is not practical. Some torque rods are adjustable.

As a general rule, the addition or removal of a 1/4" shim from the rear torque arm will change the axle angle approximately 3/4 of a degree. A 3/4 of a degree change in the pinion angle will change the u-joint operating angle about 1/4 of a degree.

Always take the time to call the vehicle manufacturer if there are unusual u-joint operating angle problems. For detailed information on troubleshooting three u-joint or multiple-shaft driveline arrangements, contact your Spicer Service Representative.

What Causes U-Joint Operating Angles To Change

- ✓ Suspension changes caused by:
  - worn bushings in the spring hangers
  - worn bushings in the torque rods
  - incorrect airbag height
- ✓ Revisions in components of the driveline
- ✓ Stretching or shortening the chassis
- ✓ Adding an auxiliary transmission or transfer case in the main driveline
- ✓ Worn engine mounts

Driveshaft Brake

When a driveshaft brake is used, care must be taken to see that the brake drum is properly piloted, runs true and is in balance.

FIELD PROBLEM ANALYSIS

(All Types)

WARNING: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death. Do not work on a shaft (with or without a guard) when the engine is running.

U-Joint problems, as a rule, are of a progressive nature. They generally accelerate rapidly and result in ruined components.

Some recognizable signs of u-joint deterioration are:

1. Vibration
2. U-joint looseness
3. U-joint discoloration due to excessive heat buildup
4. Inability to purge all four trunnion seals
5. An audible noise or squeal from the driveline

Lubrication-Related Problems

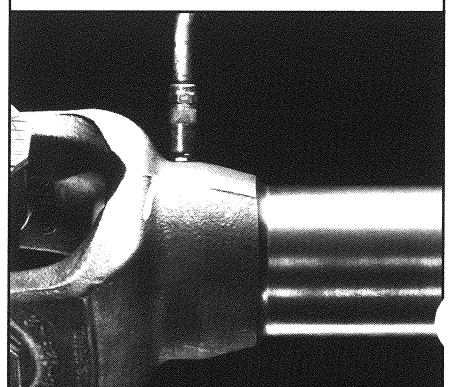
The most common reasons for u-joint wear are lack of lubrication, inadequate lube quality, inadequate initial lubrication or failure to lubricate properly and often enough.

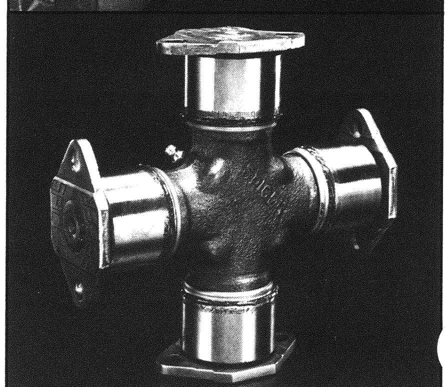
On Quick-Disconnect™ applications, excessive bearing rotation could cause premature wear of components involved. The causes of rotation are:

1. Use of non-Spicer parts with Genuine Spicer components.
2. Improper torque on retaining strap bolts.
3. Failure to firmly seat both bearing assemblies in the end yoke saddles before the strap bolts are tightened.
4. Dirty bearing saddles.

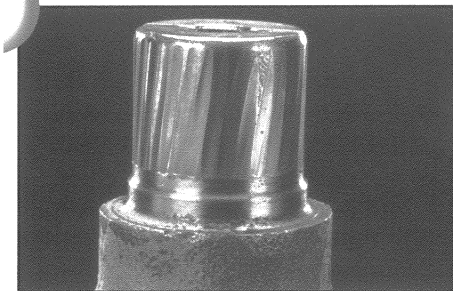
To avoid lubrication-related problems:

1. Lube all fittings including those that are often over looked, out-of-sight, dirt-covered or difficult to reach.
2. Know how some lube fittings appear different from regular chassis lube fittings and require a needle nose attachment for the grease gun.
3. Don't overlook slip yoke lubrication.

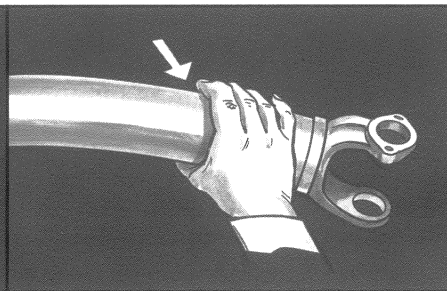




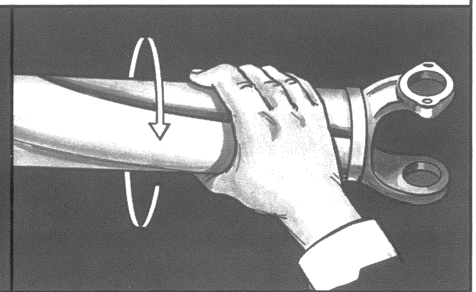
4. Use correct lube technique. **New Lube Must Flow From All Four Bearing Seals.**
5. Use correct lubricant. It should be a recommended type, such as N.L.G.I. Grade 1 or 2 with E.P. additives and high temperature resistance.
6. New u-joints must be lubricated when assembled into the driveshaft yokes.
7. Observe recommended lubrication cycle. See chart on page 6.



Brinelling



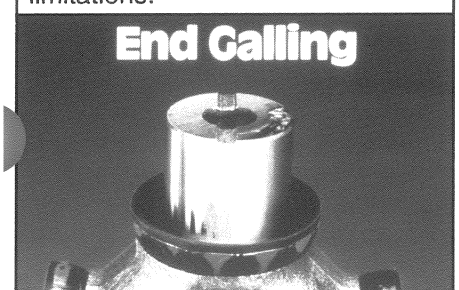
Transverse Vibration



Torsional Vibration

Generally, a lubrication problem is one of two types — brinelling or end galling. The grooves made by the needle roller bearings on the trunnion of the cross are known as brinelling. Brinelling can also be caused by too much torque for the capacity of the u-joint used. End galling is a displacement of metal at the end of the trunnion and can also be related to angularity problems. Both of these problems can be caused by lack of lubrication.

Problems which are not a result of lubrication are associated with the installation, angles and speed of the driveshaft. Fractured parts caused by torque, fatigue and bending are associated with overload, excessively high u-joint angles and driveshaft lengths exceeding critical speed limitations.



End Galling

VIBRATION-RELATED PROBLEMS

Vibration is a driveshaft problem that can be either transverse or torsional.

Transverse vibration is the result of unbalance acting on the supporting shafts as the driveshaft rotates. When a part having an out-of-balance, or heavy side, is rotated an unbalanced force is created that increases with the square of the speed. The faster the shaft turns, the greater the unbalance force acting on the shaft.

The force produced by this out-of-balance condition tends to bend the supporting members. As the supporting members have a natural frequency of vibration similar to a swinging pendulum, a violent vibration may exist at certain periods when the speed of rotation and the natural frequency of supports coincide.

Each end of the shaft must be balanced individually as each support is responsive to an out-of-balance condition in the portion of the shaft it supports. Out-of-balance affects operating conditions only when rotating.

Transverse vibration caused by a driveshaft out-of-balance will usually emit sound waves that you can hear and mechanical shaking that you can feel. The force from out-of-balance increases with speed, not torque load. The driveshaft speed is determined by vehicle speed and the vibration is demonstrated best by road testing the vehicle to operating speed, disengaging engine, and checking vibration while coasting with engine noises eliminated.

Torsional vibration, although similar in effect to transverse vibration, is an entirely different motion. The transverse vibration is a bending movement whereas torsional vibration is a twisting motion.

The energy to produce torsional vibration can occur from the power impulses of the engine or from improper u-joint angles. This type of vibration is difficult to identify in road testing but certain characteristics do exist. It causes a noticeable sound disturbance and can occasionally transmit mechanical shaking.

Torsional vibrations can exist at one or more periods any place in the operating range and tend to be more severe at lower speeds. Changes in torque load (part-to-full throttle) usually affect the vibration. The nonuniform velocity obtained when a u-joint operates at an angle produces torsional vibration. In a driveline having two or more joints in series, it is desirable to have the individual joint angles arranged such that the net result minimizes nonuniform velocity characteristics over the system.

It is practically impossible to maintain the desired joint angles throughout the operating range. Therefore, it is necessary to determine some maximum limit of torsional excitation which can be considered as generally acceptable.

The amount of torsional excitation which can be accepted without causing excessive disturbance depends upon operating speed and characteristics of supporting structures and other units in the driveline and drivetrain system.

Other vibrational problems in a driveshaft could be caused by worn or damaged u-joints. These joints must be constantly maintained according to manufacturer's lubrication specifications.

WARNING: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death. Do not go under the vehicle when the engine is running.

Complaints

VIBRATION

Low gear shudder
At certain speeds under full drive or full coast
Under light loaded conditions

Causes

Secondary couple load reaction at shaft support bearing
Improper phasing
Incompatible driveshaft
Driveshaft weight not compatible with engine-transmission mounting
Driveshaft too long for speed
Loose outside diameter fit on slip spline
Excessively loose u-joint for speed
Driveshaft out of balance; not straight
Unequal u-joint angles
U-joint angle too large for continuous running
Worn u-joint
Inadequate torque on bearing plate cap screws
Torsional and/or inertial excitation

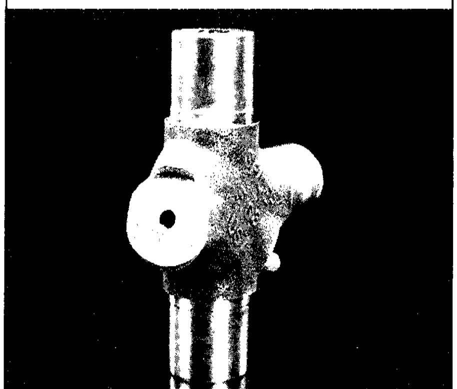
Corrections

Reduce u-joint continuous running angle
Replace u-joint
Install two piece driveshaft with shaft support bearing
Use larger diameter tube
Shim drivetrain components to equalize u-joint angles
Straighten and balance shaft
Check with transmission or axle manufacturer — replace shaft bearing
Inspect u-joint flex effort for looseness — torque to specification
Check driveshaft for correct yoke phasing

Complaints

PREMATURE WEAR

Low mileage u-joint wear
Repeat u-joint wear
End galling of cross trunnion and bearing assembly
Needle rollers brinelled into bearing cup and cross trunnion
Broken cross and bearing assemblies



Broken Cross

Causes

End yoke cross hole misalignment
Excessive angularity
Improper lubrication
Excessive u-bolt torque on retaining nuts
Excessive continuous running load
Continuous operation at high angle/high speed
Contamination and abrasion
Worn or damaged seals
Excessive torque load (shock loading) for u-joint and driveshaft size

Corrections

Use Spicer alignment bar to check for end yoke cross hole misalignment, replace end yoke if misaligned
Check u-joint operating angles with a spirit level protractor or Spicer Anglemaster® II Electronic Driveline Inclinometer, reduce excessive u-joint operating angles
Lubricate according to Spicer specifications
Replace u-joint kit
Reduce u-joint continuous running angle
Replace with higher capacity u-joint and driveshaft
Check u-joint flex effort — replace joint or yoke if necessary
Clean and relubricate u-joint
Realign to proper running angle — minimum 1/2 degree
Torque bearing retention method to specification

Complaints

SLIP SPLINE WEAR

Seizure
Galling
Outside diameter wear at extremities and at 180 degrees
Spline shaft or tube broken in torsion

Causes

Improper lubrication
Worn or damaged part
Tube size inadequate
Excessive torque load for u-joints and driveshaft size
Male spline head engagement length too short for application
Excessive loose outside diameter fit
Slip member working in extreme extended or fully collapsed position
Contamination

Corrections

Lubricate slip spline according to Spicer specifications
Replace with higher capacity u-joint and driveshaft
Check u-joint flex effort — replace joint or yoke if necessary
Clean and relubricate according to Spicer specification
Replace spline — check design for application
Use Spicer Glidecote™ slip spline
Increase driveshaft assembly length to position slip spline head towards u-joint
Check for male slip member with longer spline
Use larger diameter tube

Complaints

SHAFT AND/OR TUBE

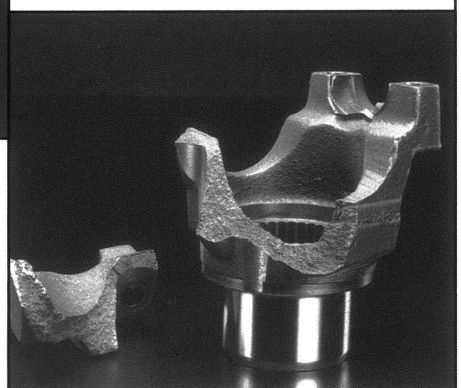
Shaft support bearing wear or fracture
Shaft support rubber insulator wear or fracture
Tube circle weld fracture

Causes

Balance weight located in apex of weld yoke lug area
Balance weight too close to circle weld
Improper circle weld
Bending fatigue due to secondary couple loads
Driveshaft too long for operating speeds
Worn or damaged parts
Excessive torque load (shock loading) for u-joint and driveshaft size
Improper lubrication of bearings
Shaft support bearing misaligned — interferes with slinger

Corrections

Reduce u-joint continuous running angle
Replace with higher capacity u-joint and driveshaft
Install two piece driveshaft with shaft support bearing
Use larger diameter tube
Normal bearing wear — replace
Realign mounting bracket to frame cross member to eliminate interference with slinger



Complaints

YOKE FRACTURE

Yoke broken in hub
Yoke broken at ear tip

Causes

Mating yoke lug interference at full jounce and rebound
Excessive torque load for u-joint and driveshaft size
Improper shaft length and slip
Bending fatigue due to secondary couple loads

Corrections

Reduce u-joint continuous running angles
Replace with higher capacity u-joint and driveshaft
Replace yoke — check design for application
Use wide angle yokes
Check installed lengths and adjust driveshaft length to provide proper slip conditions

WARNING: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.

Refer to safety precaution section on inside front cover.

GLOSSARY

ALIGNMENT BAR — a device (gauge) used to check yoke cross hole alignment.

BEARING ASSEMBLY — a hollow cup containing the needle roller bearings that ride on the cross trunnion.

BRINELLING — grooves from needle rollers marking and burning into trunnion. Usually caused by improper angles, lack of lubrication or too much load.

CARDAN-TYPE U-JOINT — a non-constant velocity u-joint which consists of two yokes connected by a cross through four bearings.

COMPOUND ANGLE — a driveline angle that is offset both vertically and horizontally.

CONSTANT VELOCITY (CV) U-JOINT — a u-joint which uniformly transmits motion at an angle without speed changes in the driven shaft.

CONTINUOUS OPERATING TORQUE — represents the constant torque load that a respective driveshaft or joint series will transmit over long periods of time, such as a direct drive installation.

COUPLING SHAFTS — are essentially extension members to the total drivetrain. In automotive applications these units are inserted ahead of the two joint assemblies and lead out of the power source, usually supported by a shaft support bearing. Used where one piece shafts would be too long.

CRITICAL SPEED — this is a phenomenon associated with any elastic shaft rotating at a high speed. At some specific speed the shaft will start to vibrate and, in some instances, the vibrations are so severe that the shaft will "whip" resulting in premature wear or fracture in the drivetrain system.

CROSS — the central component of the u-joint, connecting the input and output yokes.

CROSS HOLE — two parallel machined holes in the yoke lugs, which accept u-joint bearing assemblies.

DOUBLE-CARDAN CV JOINT — consists of two u-joints connected by a coupling yoke (double yoke) with internal supporting and centering means. The torsional vibrations of the two joints are cancelled so that power is transmitted smoothly.

DRIFT — a soft metal, usually brass, tool used to assist in removal of bearing assemblies from full round cross holes.

GALLING — a displacement of metal, usually caused by lack of lubrication, angularity problems, or over capacity loads.

GLIDECOTE™ — Dana patented coating for slip splines that extends life through reduction of friction.

HORSEPOWER — a unit of measure that denotes the amount of work done in a given period of time. 1 H.P. = 550 lbs./ft. per second. The formula for horsepower is: H.P. = Torque x R.P.M./5252.

INCLINOMETER — an instrument for indicating the inclination of a driveline from the horizontal.

LUBE CYCLE — recommended time period for relubrication.

NEWTON-METERS (nm) — a unit of measurement for torque, comparable to lb./ft. One (1) lb./ft. = 1.355818 nm. One (1) nm = .73756 lb./ft.

PHASING (IN-LINE) — a relationship that exists between the yokes when they are in-line from "ear-to-ear" and their centerlines are parallel.

PHASING (OUT-OF-LINE) — a relationship that exists between the yokes when they are not in-line from "ear-to-ear," but are rotated relative to one another.

POSITIVE PURGING VALVE (PPV)— a lube valve that is pressed into the cross assembly of Genuine Spicer U-Joints. The PPV provides ease of purging and eliminates inadvertent dislocation from the cross when assembling or disassembling.

PURGE — completely flush out the clean, fresh lube at all four seals.

R.P.M. — revolutions per minute. R.P.M. = H.P. x 5252/Torque.

RUNOUT — applies to the allowable off-center limits of a driveshaft.

SERRATED BOLT WITH LOCK PATCH — a bolt, identified by the under-head serrations and the lock patch coating on the threads, that replaces the lock strap design.

SHAFT SUPPORT (CENTER) BEARING ASSEMBLY — a mounted bearing assembly used when two or more driveshafts are required to reduce driveshaft length — supports the coupling shaft.

SHORT COUPLED JOINT — a driveline of yoke shaft and slip yoke construction similar to a two-joint assembly, used where space is restricted.

SHORT DURATION TORQUE — represents the u-joints capability to withstand momentary loading accompanying start-stop service.

SLIP YOKE (ALSO SLEEVE YOKE) — it is that component of the driveshaft that absorbs the axial movement of the vehicle thus allowing for length changes in the driveshaft.

T.I.R. — Total Indicator Reading, a measure of driveshaft runout.

TORQUE — twisting effort caused by the application of force. The formula for torque is: T = H.P. x 5252/R.P.M.

TORSIONAL ELASTIC LIMIT — represents the maximum torque load the u-joint or shaft will transmit instantaneously, without yield in any part.

TRUNNION — the four machined posts of the u-joint cross which serve as the inner bearing race.

TUBE (WELD) YOKE — permanent fitting at one or both ends of a driveshaft designed to fit a specific tube and u-joint assembly.

TWO-JOINT ASSEMBLY — these assemblies are in essence a complete driveshaft. The front end of the unit contains the slip joint while the rear is fitted with a permanent type joint.

U-JOINT COUPLING — consists of two yokes and a cross and bearing kit, a type of flexible coupling which can transmit torque and/or rotary motion from one shaft to another with fixed or changing angular misalignment.

U-JOINT DRIVESHAFT — a rotating shaft used for the transmission of torque and consisting of one or two u-joint couplings and a center section. It is capable of operating at an angle and usually with changes in length.

YOKE AND TUBE ASSEMBLY — a weld yoke and a piece of tubing attached at the factory available in various length and capacities suitable for field specialist tailoring.

Spicer...The name that guarantees you're buying the best.

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SECTION 10: FRONT AXLE

CONTENTS

ILLUSTRATIONS

1. FRONT AXLE

1.1 DESCRIPTION

This front axle is of the ''Reverse Elliot'' type manufactured by Dana Spicer Europe. The front axle consists of a girder section axle bed or beam with stub axles. Each stub axle is carried on a taper kingpin, with a plain phosphor bronze bushing at the top and at the bottom. The unitized hub bearings used on the NDS range of axles, are non-serviceable items. Bearings are pre-adjusted, lubricated and have seals fitted as part of the manufacturing process. The bearings are greased for life and there is no need or facility for re-lubrication. Brakes are manufactured by KNORR-BREMSE. Steering ball joints with hardened balls and rubbing pads incorporate compression springs which automatically take up any wear.

The tie rod simplifies toe-in adjustment. The maximum turning angle is set through stop screws installed on the inner side of the knuckle.

Steering stabilizer (damper) and steering drag link which are mounted on the front axle are described in Section 14; *''Steering''* of this manual.

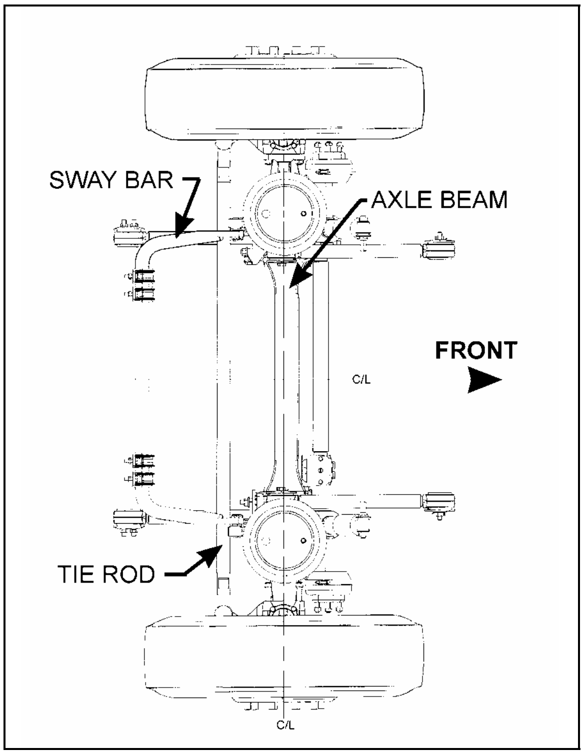


FIGURE 1: FRONT AXLE ASSEMBLY 10026

2. LUBRICATION

Pressure lubricate axle every 6 months or 30,000 miles (48 000 km) whichever comes first (Fig. 2). Tie rod ends and knuckle pins are provided with grease fittings for pressure lubrication. These grease fittings should be serviced every 6,250 miles (10 000 km) or twice a year whichever comes first. Good quality lithium-base roller bearing grease NLGI No.1 and 2 are recommended.

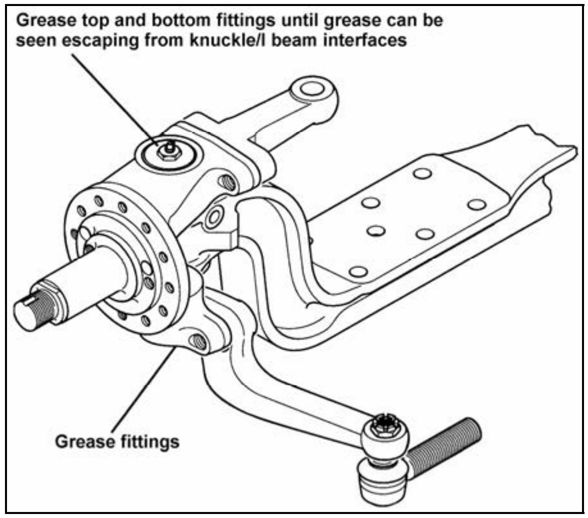


FIGURE 2: FRONT AXLE GREASING POINTS

3. MAINTENANCE

A periodic inspection of the front axle assembly should be made to check that all bolts are tight, and that no damage and distortion have taken place. Suspension support stud nuts, U-bolt nuts, tie rod arms, steering arm nuts and stop screws should be checked and tightened, as required, to the torque specifications given at the end of this section. Also check the condition of the steering knuckle pins and bushings. In case of excessive looseness, the bushings and pins should be replaced.

Any looseness in the steering linkage, under normal steering loads, is sufficient cause to immediately check all pivot points for wear, regardless of accumulated mileage. Steering linkage pivot points should be checked each time the front axle assembly is lubricated. Any looseness can be visually detected while rotating the steering wheel in both directions.

Steering knuckles, knuckle pins and bushings can be overhauled or replaced without removing the axle from the vehicle. However, if extensive overhaul work is necessary, the axle assembly should be removed.

Caution: *Should removal of a locking device be required when undergoing repairs, disassembly or adjustments, always replace with a new one.*

3.1 TIE ROD END PLAY ADJUSTMENT

If end play exceeds 0.047” (1.2 mm), readjustment is necessary.

Remove protective cap, using a suitable tool ie: a 1” x 1/8” x 9” long flat bar, tighten adjuster piece fully home (SOLID) locating thrust cup onto ball pin.

Still with tool located on adjuster piece, back off carefully (LEAST AMOUNT) until adjuster piece cotter pin is allowed to pass through body, then remove tool.

Reinstall protective cap.

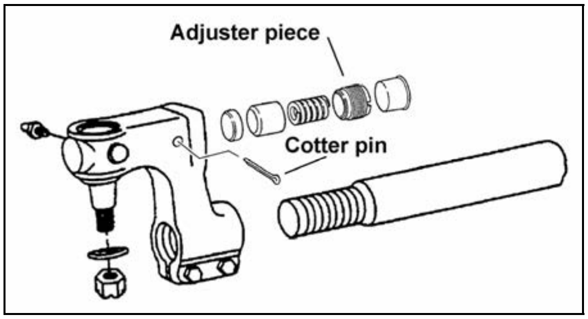


FIGURE 3: TIE ROD END PLAY ADJUSTMENT 10029

4. REMOVAL AND REPLACEMENT

The following procedure deals with the removal of the front axle assembly. The method used to support the axle assembly and suspension components during removal and disassembly depends upon local conditions and available equipment.

4.1 REMOVAL

1. Raise the vehicle by its jacking points on the body (see Section 18, *‘’Body’’* under heading 16; Vehicle Jacking Points) until vehicle body is approximately 30 inches (760 mm) from the floor. Place jack stands under frame. Remove the wheels (if required, refer to Section 13, *‘’Wheels, Hubs and Tires’’*).

Caution : *Use only the recommended jacking points as outlined in section 18 “Body”.*

2. Exhaust compressed air from the air supply system by opening the drain valve of each reservoir.
3. Install jacks under axle jacking points to support the axle weight.

Warning : *To help prevent injury caused by the axle rolling off the jacks, these should be equipped with U-adapters, or similar precautions must be taken.*

4. Disconnect the steering drag link from the steering arm.
5. Remove the ABS sensors from their location in hubs (if applicable).
6. Disconnect the height control valve link from its support on the axle.
7. Disconnect air lines from front brake chambers, and cover line ends and fittings to prevent the entry of foreign matter.

Caution: *Position the air lines and electric wires so they will not be damaged while removing the front axle assembly.*

8. Proceed with steps a, b and c, while referring to Section 16: *‘’Suspension’’.*
   a) Disconnect sway bar links from axle brackets.
   b) Remove shock absorbers.
   c) Disconnect five radius rods: one transversal and two longitudinal from subframe, and two upper rods from axle.
9. Remove the bolts and nuts fixing the axle to the left-hand and right-hand side air bellows mounting supports.
10. Using the jacks, slowly lower the axle assembly, and carefully pull away from underneath vehicle.

4.2 REPLACEMENT

Reverse front axle “*Removal”* procedure. Ensure cleanliness of air bellows support mounting plates.

Note : *Refer to Section 16, ‘’Suspension’’, Section 14, ‘’Steering’’ and to paragraph 8*

''Specifications'' at the end of this section for applicable checks and recommended tightening torques.

5. SERVICE INSTRUCTIONS FOR STEER AXLE

Refer to "DANA SPICER Maintenance Manual Model NDS and Maintenance Manual NDS Axles" annexed at the end of this section.

6. FRONT WHEEL ALIGNMENT

Correct front wheel alignment must be maintained for steering comfort and satisfactory tire life. Road shocks and vibrations, as well as normal stress and strains on the front-end system can, under normal operating conditions, result in loss of front wheel alignment.

Check the front wheel alignment when the following occurs:

1. Every 200,000 miles (320 000 km) or 24 months (normal maintenance);
2. When the vehicle does not steer correctly; or
3. To correct a tire wear condition.

There are two types of front wheel alignment: **minor alignment** and **major alignment**.

6.1 MINOR FRONT WHEEL ALIGNMENT

Perform a minor front wheel alignment for all normal maintenance conditions.

Perform the minor front wheel alignment in the following sequence :

1. Inspect all the systems that affect the wheel alignment. See paragraph 6.3, *''Inspection Before Alignment''* in this section.
2. Check the hub bearings. See section 13, *''Wheels, hubs and Tires''* under heading 8: Front and Tag Axle Wheel Hubs.
3. Check and adjust the toe-in.

6.2 MAJOR FRONT WHEEL ALIGNMENT

Perform a major front wheel alignment to correct steering and tire wear conditions.

Perform the major front wheel alignment in the following sequence:

1. Inspect all systems affecting the wheel alignment. See paragraph 6.3, *''Inspection Before Alignment''* in this section.
2. Check the hub bearings. See section 13, *''Wheels, hubs and Tires''* under heading 8: Front and Tag Axle Wheel Hubs.

Note: *If steering angle stoppers are changed, a special procedure is required for readjusting gearbox steering limiter. See paragraph 6.5 ''Hydraulic Stop'' in this section.*

3. Check and adjust the turning angle adjustment.
4. Check the camber angle.
5. Check and adjust the caster angle.
6. Check and adjust the toe-in.

6.3 INSPECTION BEFORE ALIGNMENT

Check the following before doing a front wheel alignment:

1. Ensure that the vehicle is at normal riding height. See Section 16, *''Suspension''* under heading 7: *''Suspension Height Adjustment''*.
2. Ensure that front wheels are not the cause of the problem. See Section 13, *''Wheels, Hubs and Tires''*. Inspect the tires for wear patterns indicating suspension damage or misalignment.
    a. Make sure the tires are inflated to the specified pressure.
    b. Make sure the front tires are the same size and type.
    c. Make sure the wheels are balanced.
    d. Check wheel installation and straightness.
3. Check the wheel bearing adjustment.
4. Check steering linkage for bending and pivot points for looseness.
5. Check knuckle pins for evidence of excessive wear.
6. Check radius rods for bending and rubber bushings for evidence of excessive wear.

7. Make sure all fasteners are tightened to the specified torque. Use a torque wrench for verification. As soon as the fastener starts to move, record the torque. Correct if necessary. Replace any worn or damaged fasteners.

6.4 TURNING ANGLE ADJUSTMENT

The maximum turning angle is set through the two steering stop screws installed on the axle center. The turning angle is factory adjusted to accommodate the chassis design, and therefore, does not require adjustment on new vehicles. However, it should be checked and adjusted any time any component of the steering system is repaired, disassembled or adjusted.

Check if front tires rub against the frame or if the steering gear has been serviced.

Proceed with the following method to check the steering maximum turning angle :

6.4.1 R.H. Turn Adjustment

Caution : *To prevent the steering damper from interfering with the adjustment of turning angles, make sure its fixing bracket is at the correct location on the axle center (refer to section 14 “Steering”).*

1. Turn steering wheel to the right until the boss on the axle center touches the right stop screw.
2. Verify the nearest point of contact of the ball socket body with the air bellows support assembly. Measure the distance between those two points.
3. The distance between these two points should be approximately 1/8 inch (3 mm). If not, the steering stop screws must be readjusted.
4. Verify the nearest point of contact of the drag link with the tire. Measure the distance between those two points.
5. The distance should be 1 inch (25 mm) or more. If not, the steering stop screws must be readjusted.
6. This must be done for a full right turn.
7. If readjustment is required:
   a. Remove the swivel stop screw.
   b. Add to the stop screw the required number of washers to obtain the proper measure, tighten the stop screw afterwards. Two washers of different thickness are available: 1/16 inch and 3/16 inch.

6.4.2 L.H. Turn Adjustment

1. Turn steering wheel to the left until the boss on the axle center touches the left stop screw.
2. Verify the nearest point of contact of the ball socket body with the air bellows support assembly. Measure the distance between those two points.
3. The distance between these two points should be approximately 1/8 inch (3 mm). If not, the steering stop screws must be readjusted.
4. Check the stroke of the steering stabilizer cylinder (damper). It should not exceed 12.59 inches (320 mm).
5. This must be done for a full left turn.
6. If readjustment is required:
   a. Remove the swivel stop screw.
   b. Add to the stop screw the required number of washers to obtain the proper measure, tighten the stop screw afterwards. Two washers of different thickness are available: 1/16 inch and 3/16 inch.

Note : *If steering angle stoppers are changed, a special procedure is required for readjusting gearbox steering limiter. See paragraph 6.5 ''Hydraulic Stop'' in this section.*

6.5 HYDRAULIC STOP

Note: *Before steering limiter readjustment, verify vehicle wheel alignment and ensure that oil level is checked and that air bleeding is done.*

Refer to *“ZF-Servocom Repair Manual''* annexed at the end of Section 14 *''Steering''* under heading *‘Setting and Functional Test.*

6.6 FRONT WHEEL CAMBER

Wheel camber is the number of degrees the top of the wheel tilts outward (positive) or inward (negative) from a vertical angle (Fig. 4).

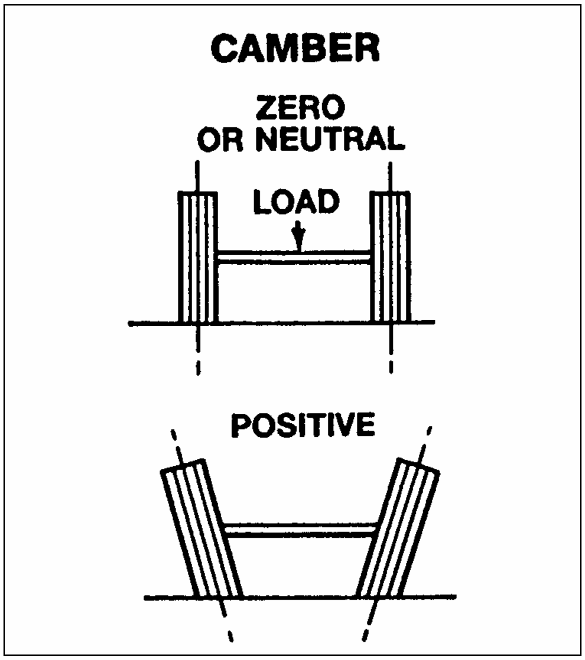


FIGURE 4: CAMBER 10006

The camber angle is not adjustable. Camber variations may be caused by wear at the wheel bearings, steering knuckle pins or by a bent knuckle or sagging axle center. Steering effort is affected by improper camber, and uneven tire wear will result. Excessive positive camber causes an irregular wear of tire at the outer shoulder and excessive negative camber causes wear at the inner shoulder.

6.6.1 Camber Check

For camber specifications, refer to paragraph 8: ''Specifications'' in this section

1. Use an alignment machine to check the camber angle.
2. If camber reading is not in the specifications, check the wheel bearings and repeat the check. If the reading is still not within specifications, verify the steering knuckle pins and axle center.

   See instructions in "DANA SPICER Maintenance Manual Model NDS and Maintenance Manual NDS Axles" annexed at the end of this section.
3. Check the wheel lateral distortion as instructed in Section 13, *''Wheels, Hubs and Tires''* under heading, *''Checking for Distorted Wheel on Vehicle''*. If distortion is excessive, straighten or replace wheel(s).

6.7 FRONT AXLE CASTER

For caster specifications, refer to paragraph 8: ''Specifications'' in this section.

Positive caster is the rearward tilt from the vertical axis of the knuckle pin. Negative caster is the forward tilt from the vertical axis of the knuckle pin (Fig. 5). This vehicle is designed with a positive caster. The purpose of the caster angle is to give a trailing effect. This results in stabilized steering and a tendency for the wheels to return to the straight-ahead position after taking a turn.

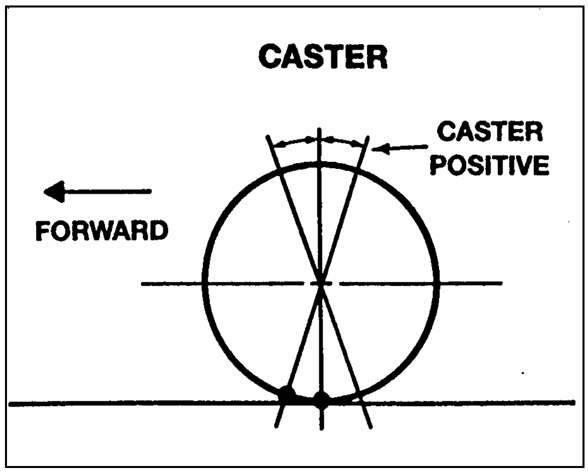


FIGURE 5: CASTER 10007

Excessive caster results in hard steering around corners. A shimmy may also develop when returning to the straight ahead position (pulling out of curves).

Insufficient caster will cause wandering and steering instability. Caster variations may be caused by a bent axle, tilting or distortion of the side suspension supports, damaged radius rod bushings, or unequal tightening of the front and rear suspension support bolts. Incorrect caster must be corrected by replacing the damaged suspension parts. A precision instrument should be used to measure the caster.

Note : *The caster of this vehicle is factory set and is not adjustable. However, if after replacing damaged parts or in case of improper caster due to irregular setting, the front axle caster needs adjustment; it can be adjusted by means of shims (Prévost #110663) on the left-hand side upper radius rod support in order to obtain minor adjustment.*

6.8 FRONT WHEEL TOE-IN

Wheel toe-in is the degree (usually expressed in fractions of an inch) to which the forward part of the vehicle front wheels are closer together than the rear part, measured at wheel centerline height with the wheels in the normal ''straight-ahead'' position of the steering gear.

Incorrect toe-in results in excessive tire wear caused by side slippage and also steering instability with a tendency to wander. Toe-in may be measured from the center of tire tread or from the inside of the tires. Take measurements at both front and rear of axle (see ''A and ''B'' in fig. 6).

When setting toe-in adjustment, the front suspension must be neutralized; that is, all component parts must be in the same relative position when marking the adjustment as they will be when in operation.

To neutralize the suspension, the vehicle must be rolled forward, approximately ten feet.

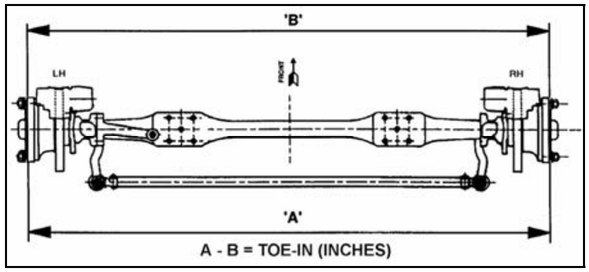


FIGURE 6: TOE-IN MEASUREMENTS

For toe-in specifications, refer to paragraph 8 ''Specifications'' in this section.

By rolling the vehicle forward, all tolerances in the front suspension are taken up and the suspension is then in its normal operating position. Neutralizing the front suspension is extremely important, especially if the vehicle has been jacked up in order to mark the tires. Otherwise, the front wheels will not return to their normal operating position due to the tires gripping the floor surface when the vehicle jack is lowered.

Note: *''Toe-in'' measurements must be taken at the horizontal axis of the wheel centerline.*

6.8.1 Inspection and Adjustment

Before checking front wheel toe-in, first check the camber angles and make the necessary corrections.

1. Measure the toe-in.
2. If the toe-in measurement is not within the specified tolerance, carry out the following procedure :
   a. Loosen the pinch bolt nuts and bolts on each tie rod end.
   b. Turn the tie rod until the specified toe-in measurement is obtained.
   c. Tighten the pinch bolt nuts alternately and progressively to 65-75 Ft-lbs (88-102 Nm), thus securing all tie rod joints.

7. TROUBLESHOOTING

CONDITION	CAUSE	CORRECTION
Tires wear out quickly or have uneven tire tread wear.	1. Tires have incorrect air pressure. 2. Tires out-of-balance. 3. Incorrect tag axle alignment. 4. Incorrect toe-in setting. 5. Incorrect steering arm geometry.	1. Put specified air pressure in tires. 2. Balance or replace tires. 3. Align tag axle. 4. Adjust toe-in specified setting. 5. Service steering system as necessary.
Vehicle is hard to steer.	1. Low pressure in the power steering system. 2. Steering gear not assembled correctly. 3. Steering linkage needs lubrication. 4. King pins binding. 5. Incorrect steering arm geometry. 6. Caster improperly adjusted. 7. Tie rod ends hard to move. 8. Worn thrust bearing.	1. Repair power steering system. 2. Assemble steering gear correctly. 3. Lubricate steering linkage. 4. Replace king pins. 5. Service steering system as necessary. 6. Adjust caster as necessary. 7. Replace tie rod ends. 8. Replace thrust bearing.
Bent or broken steering arm, steering top lever or tie rod assembly.	1. Too much pressure in the power steering system. 2. Cut-off pressure of the power steering system improperly adjusted. 3. Vehicle not powered on correctly. 4. Power steering system not installed correctly.	1. Replace damaged part(s), adjust power steering system to specified pressure. 2. Make sure vehicle is powered on correctly. 3. Correctly install the power steering system. 4. Correctly install the power steering system.
Worn or broken steering ball stud.	1. Drag link fasteners tightened past specified torque. 2. Lack of lubrication or incorrect lubricant. 3. Power steering stops improperly adjusted.	1. Replace damaged part(s), tighten drag link fasteners to specified torque. 2. Lubricate linkage with specified lubricant. 3. Adjust stops to specified dimension.
Worn king pins and knuckle bushings.	1. Worn or missing seals and gaskets. 2. Incorrect lubricant. 3. Axle not lubricated at scheduled frequency. 4. Incorrect lubrication procedures. 5. Lubrication schedule does not match operating conditions.	1. Replace damaged part(s), replace seals and gaskets. 2. Lubricate axle with specified lubricant. 3. Lubricate axle at scheduled frequency. 4. Use correct lubrication schedule to match operating conditions. 5. Change lubrication schedule to match operating conditions.
Vibration or shimmy of front axle during operation.	1. Caster not adjusted properly. 2. Wheels and/or tires out-of balance. 3. Worn steering stabilizer cylinder.	1. Adjust caster. 2. Balance or replace wheels and/or tires. 3. Replace steering stabilizer cylinder.

8. SPECIFICATIONS

Front Axle

Make .... DANA SPICER EUROPE

Model .... NDS

Front Track .... 84.4 inches (2 145 mm)

Rated load capacity .... 16,500 lbs (7 500 kg)

Torque specifications

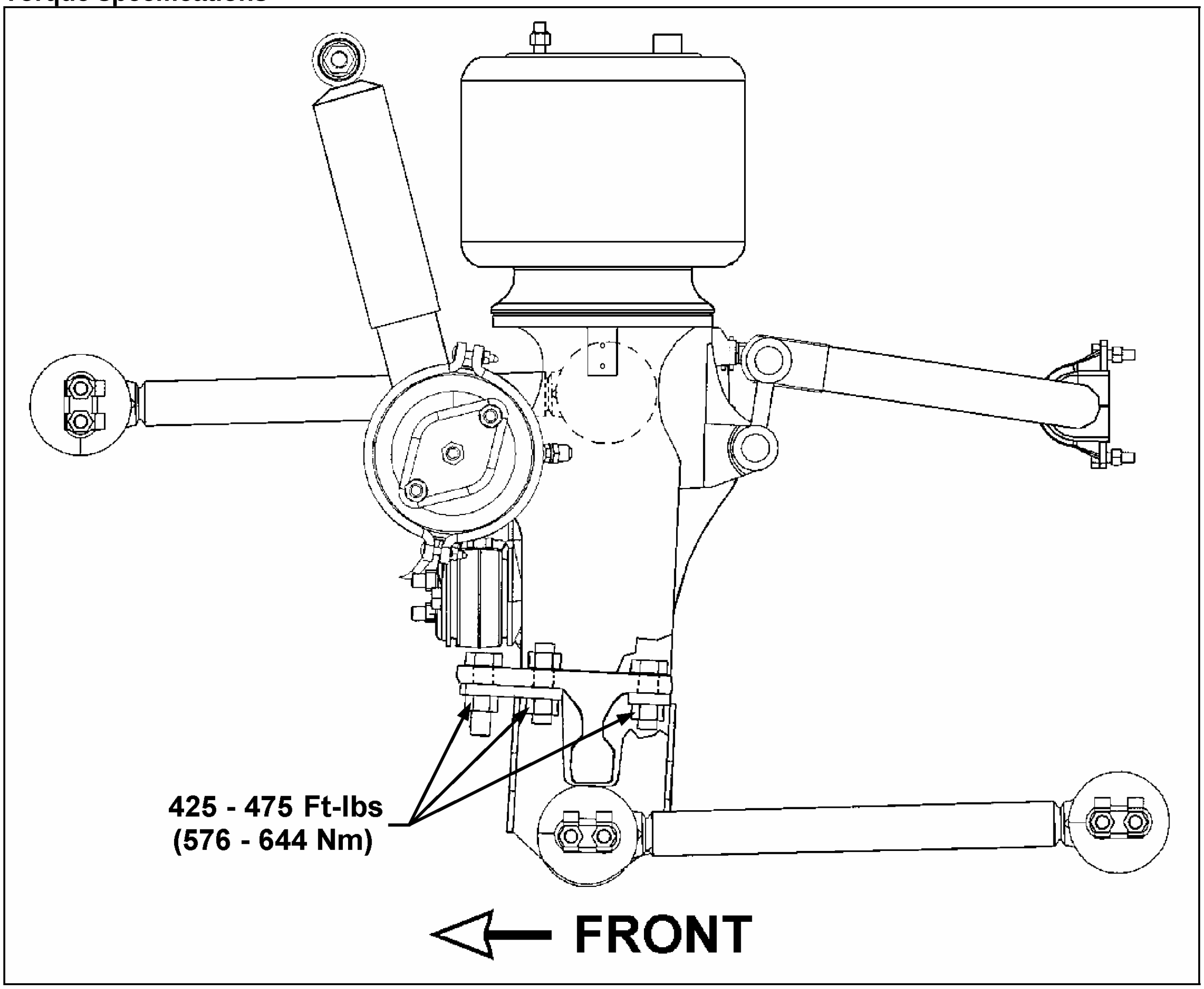


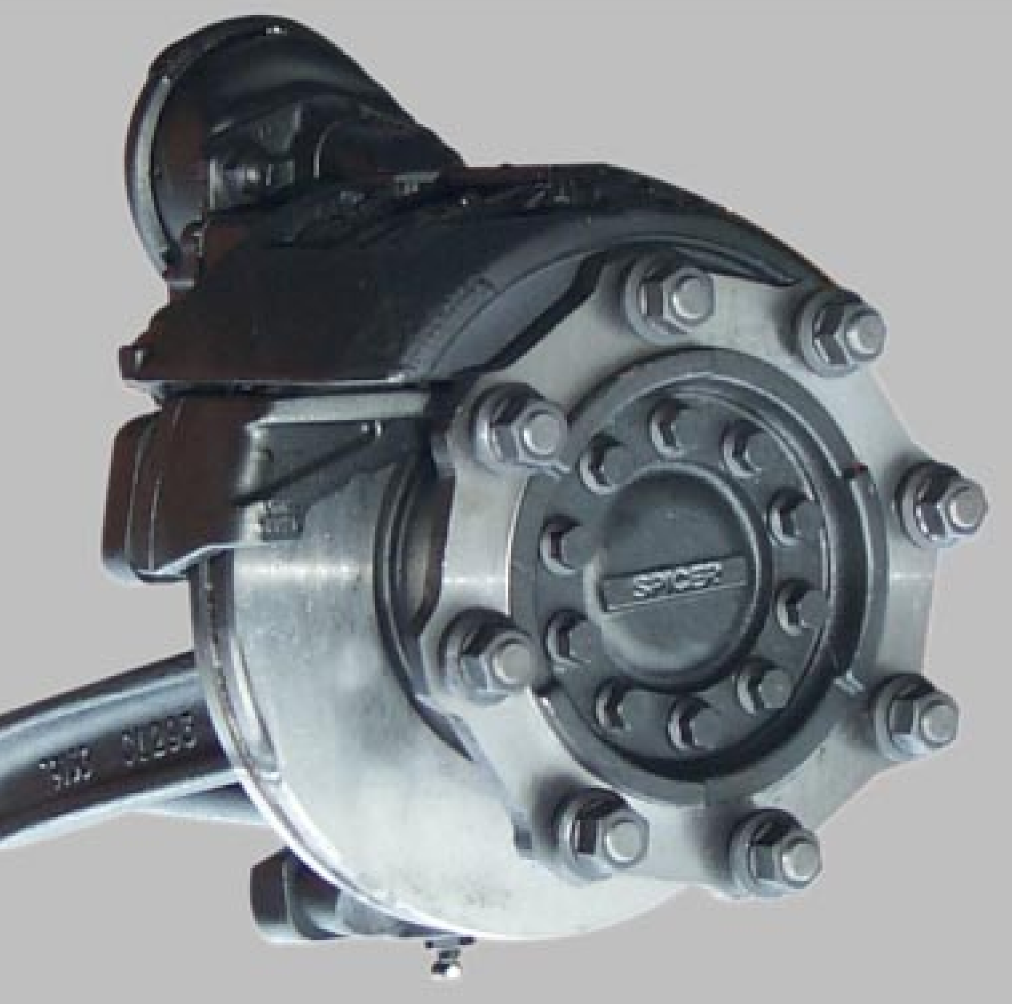
FIGURE 7: AIR BELLOWS MOUNTING SUPPORT AND AXLE 10030

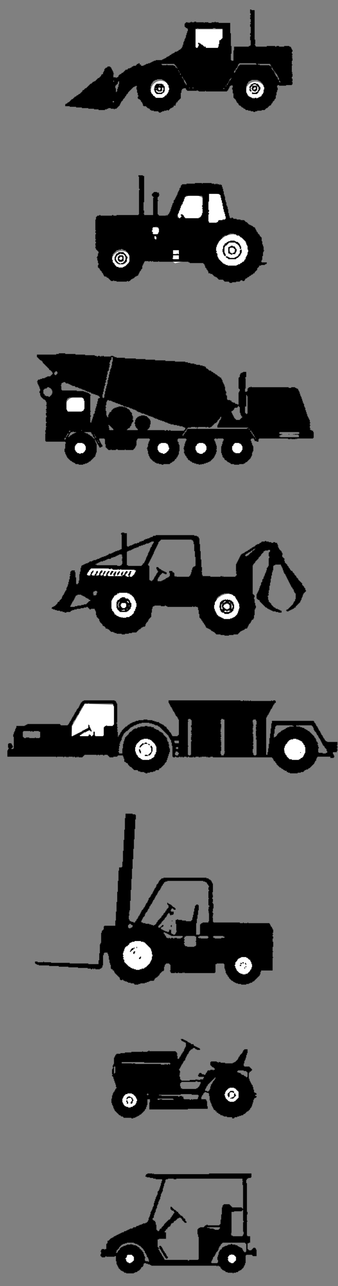
For more torque specifications, see ‘Dana Spicer Maintenance Manual NDS Axles and Maintenance Manual Model NDS’’ annexed at the end of this section.

FRONT WHEEL ALIGNMENT SPECIFICATIONS			
Front Wheel Alignment	**Minimal**	**Nominal**	**Maximal**
Camber, (degrees) R.H. and L.H. *****	-0.250	0.125	0.375
Caster, (degrees) R.H. and L.H.	2	2.75	3.5
Toe-in (A minus B), (degrees)	0.08	0.13	0.17

**** Note :*** *Camber angle changes with loading. The given numbers are for an empty vehicle.*

Maintenance manual
Model NDS
Hub and brake assembly
With Knorr Bremse
Disc brake
Fitted to offset barrel swivel





SPICER SPECIALITY AXLE DIVISION

MANUAL ISSUE SHEET

Page No.	Issue	Description / Alteration	Reason	Date
All	A	New Manual		Mar.2000
11	B	Page added all subsequent pages re numbered	Brake disc checking added	Oct.2000
7	C	Optimol Paste Added	To prevent fretting ECN 8695	Aug.2002

OVERHAUL PROCEDURES

PREPARATION
Prepare for axle overhaul as follows:

1 Set parking brake and block drive wheels to prevent vehicle movement.

2. Raise vehicle until tyres are off the ground. support raised vehicle with safety stands.

WARNING!

NEVER WORK UNDER A VEHICLE SUPPORTED ONLY BY A JACK. ALWAYS USE SAFETY STANDS.

HUB END DISASSEMBLY

1. Disconnect brake connections and ABS sensor from vehicle.
Fit plugs to connections to prevent dirt ingress.

2. Loosen but do not remove, brake caliper retaining bolts

3. Using suitable lifting equipment, support the brake caliper.

4. Remove brake caliper retaining bolts and remove brake caliper from axle.

WARNING!
BRAKE CALIPER IS HEAVY
ENSURE WEIGHT IS FULLY SUPPORTED BEFORE REMOVING RETAINING BOLTS.
TAKE CARE TO AVOID CALIPER SWINGING AND TRAPPING FINGERS.

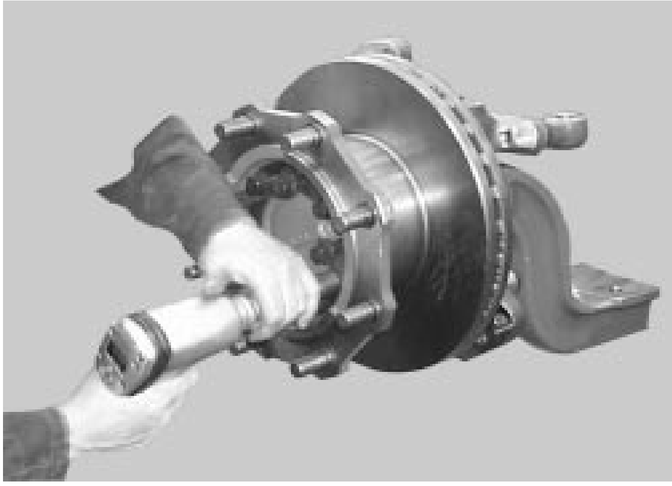
NOTE:-
BRAKE CALIPERS ARE HANDED!
SPICER SPECIALITY AXLE DIVISION RECOMMENDS MARKING CALIPERS WITH PAINT OR MARKER PEN TO FACILITATE CORRECT REFITTING

BRAKE AIR CYLINDERS SHOULD ONLY BE REMOVED IF REPLACEMENT OR REPAIR IS REQUIRED.

REFER TO THE BRAKE MANUFACTURERS MANUAL FOR DETAILS OF CALIPER OR AIR CYLINDER SERVICE.

OVERHAUL PROCEDURES

HUB END DISASSEMBLY

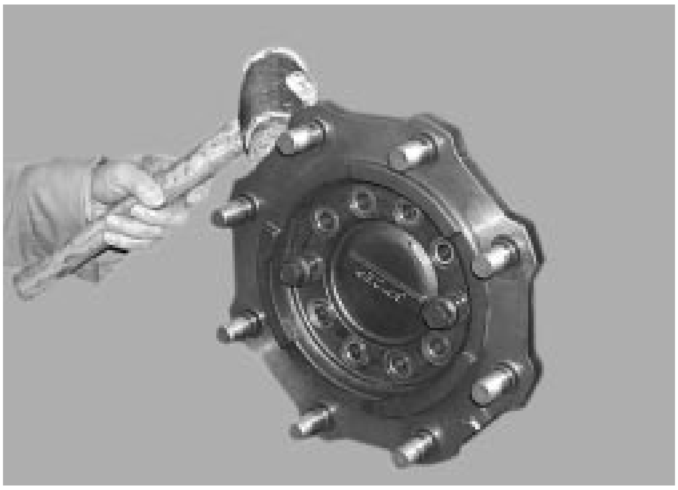


5. Loosen but do not remove hub flange bolts.

6. Remove 2 diametrically opposed hub flange bolts.

7. Replace 2 diametrically opposed hub flange bolts with 2 studs (loosely fitted).

NOTE!
REPLACEMENT STUDS SHOULD PROTRUDE BEYOND FRONT FACE OF HUB FLANGE TO AID REMOVAL

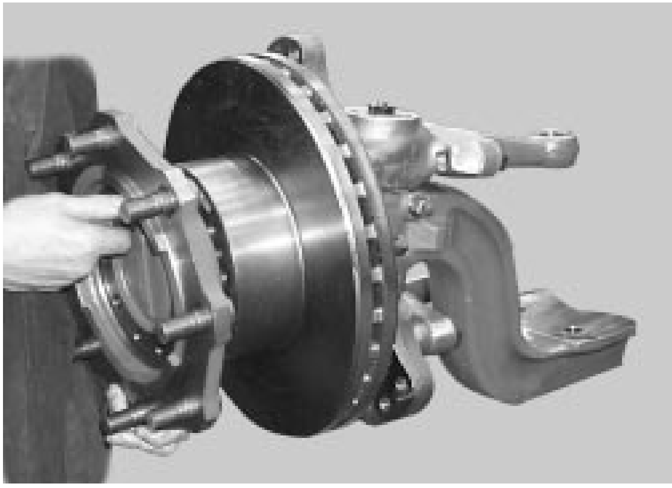


8. Gently tap hub flange outwards using a hide faced hammer.

9. Support weight of hub flange and remove hub flange retaining bolts.

10. Remove hub flange and place on a suitable workbench.

WARNING!
COMPONENT IS HEAVY
ENSURE WEIGHT IS FULLY SUPPORTED BEFORE REMOVING RETAINING BOLTS.



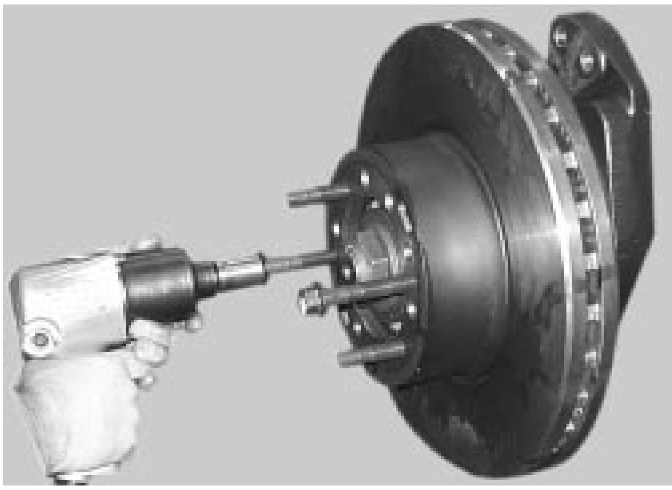
11. Inspect wheel studs and remove for replacement, any that are found to be defective.

OVERHAUL PROCEDURES

HUB END DISASSEMBLY

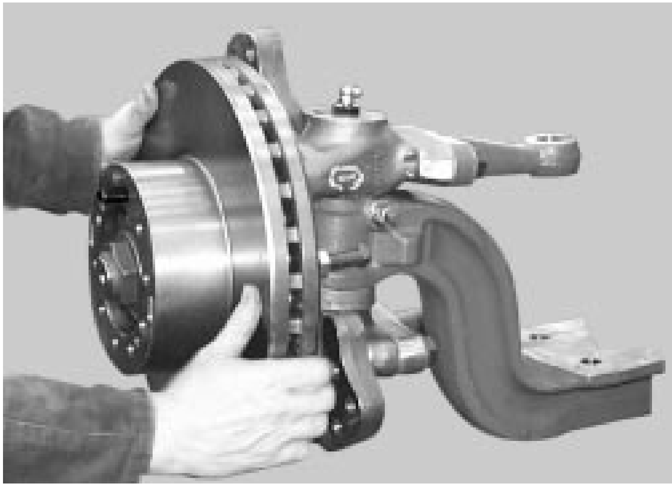
12. Once hub flange has been removed, insert two bolts into brake disc extraction holes

13. Tighten to free brake disc from hub bearing.



14. Support weight of brake disc and carefully slide along dummy studs to remove.

WARNING!
COMPONENT IS HEAVY
ENSURE WEIGHT IS FULLY SUPPORTED BEFORE REMOVING .



15. Place brake disc on a suitable work bench and inspect for cracks and defects, Replace if necessary.
(See Lubrication and maintenance section for details of typical defects and acceptability)
Check brake disc thickness is within manufacturers specifications.
Refer to table below for Acceptable dimensions:

WARNING!
DO NOT ALLOW BRAKE DISC TO WEAR BELOW MINIMUM THICKNESS!

Brake disc type	Original thickness	Minimum thickness
SB5000	34MM	28MM
SB6000	45MM	37MM
SB7000	45MM	37MM

OVERHAUL PROCEDURES

HUB END DISASSEMBLY

16. Using a small ended chisel, pry off the "staking" on the hub nut.

17. Remove hub nut and discard.

18. Remove bearing thrust washer.

19. Fit bearing guide sleeve onto swivel thread. (See chart at front of swivel assembly)

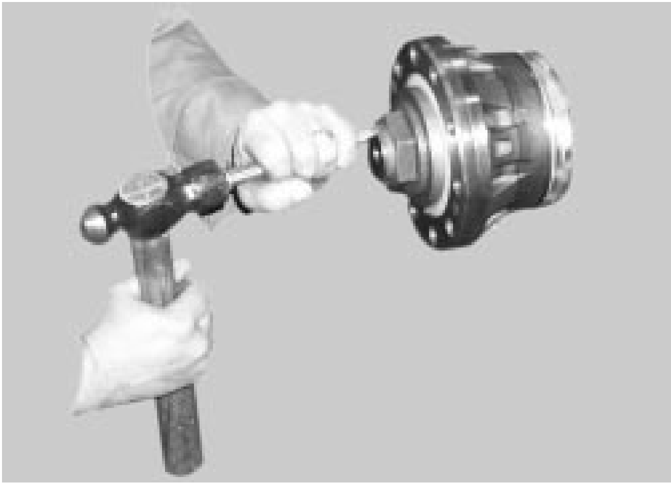
20. Carefully pull unitised hub bearing assembly towards end of swivel stub and remove.

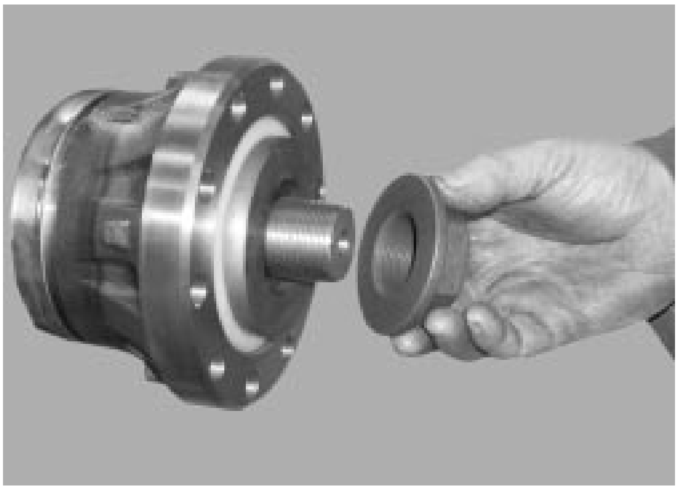
21. Place on a suitable workbench and inspect for wear / damage, taking care not to damage the ABS exciter ring in the process.

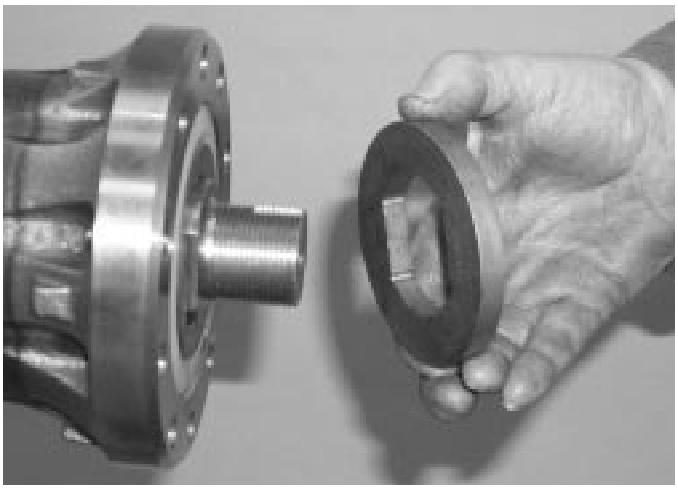
NOTE:-
THE UNITISED BEARINGS USED ON THE NDS RANGE OF AXLES, ARE NON SERVICABLE ITEMS.
BEARINGS ARE PRE ADJUSTED, LUBRICATED AND HAVE SEALS FITTED AS PART OF THE MANUFACTURING PROCESS.
THE BEARINGS ARE GREASED FOR LIFE AND THERE IS NO NEED OR FACILITY FOR RE-LUBRICATION.

22. Remove ABS sensor and sensor bush inspect for wear / damage and replace if necessary.

Stripdown remainder of axle as described in swivel assembly removal and refitting instructions.







Place bearing this way up on bench to avoid damaging pole wheel.

OVERHAUL PROCEDURES

HUB END REASSEMBLY

1. Follow instructions contained in swivel / axle bed reassembly section, before attempting to reassemble hub end.

2. Fit Unitised hub bearing guide sleeve onto swivel stub .
(see chart at front of swivel section)

3. Lightly smear the axle stub bearing journal with a thin layer of anti-fretting assembly paste, white
i.e Optimol Paste White T (Castrol) or equivalent.

4. Offer new unitised bearing onto swivel stub.

OVERHAUL PROCEDURES

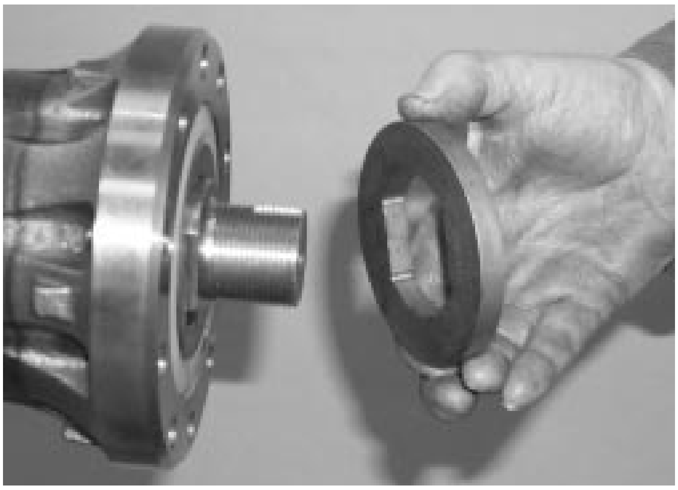
HUB END REASSEMBLY CONTINUED

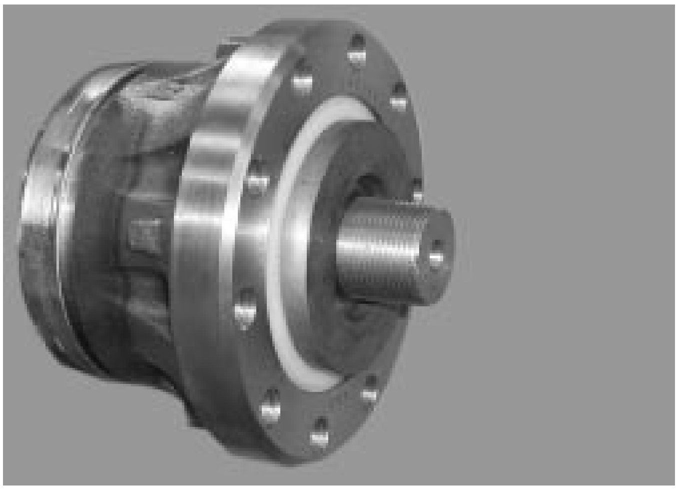
5. Place unitised hub bearing thrust washer onto axle stub.

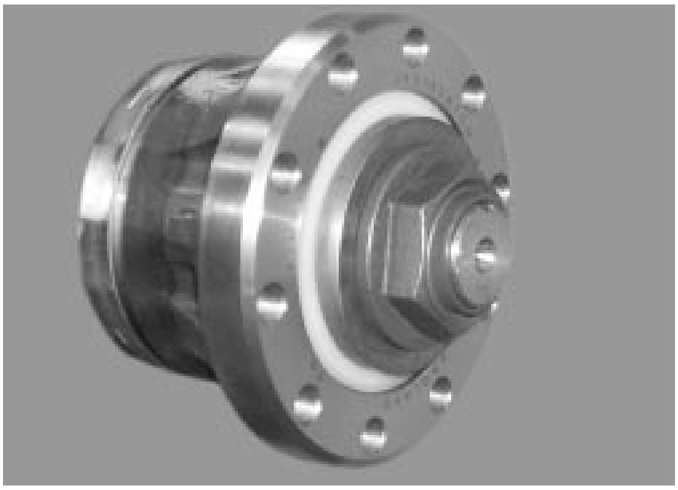
6. Fit hub nut.

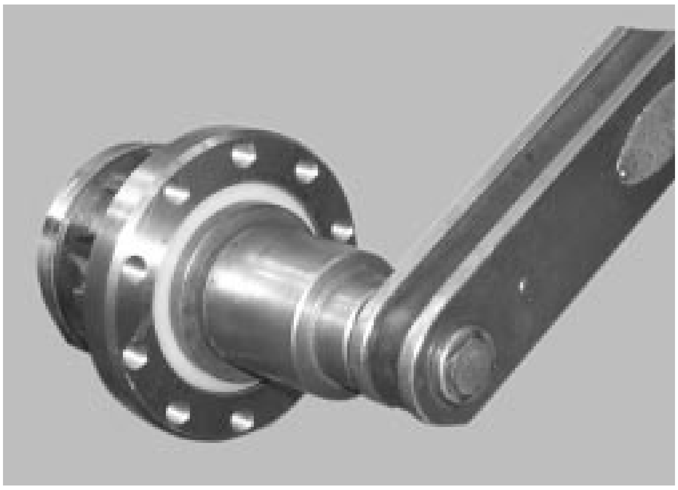
7. Tighten to specified torque.

NOTE:-
ROTATE UNITISED HUB BEARING WHILST TIGHTENING.









OVERHAUL PROCEDURES

HUB END REASSEMBLY CONTINUED

8. Stake the hub nut by deforming with a round nosed chisel.

9. Using a modified hub flange bolt as a guide. carefully position brake disc onto unitised hub bearing.

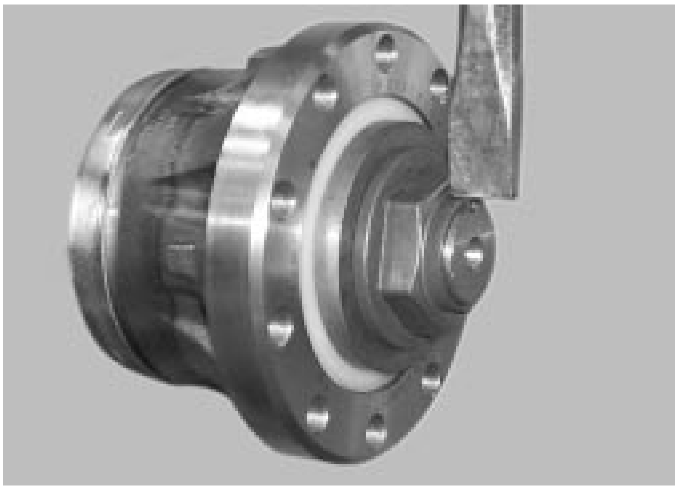
10. Tap securely home
(using a hide faced hammer to avoid damaging the brake disc itself.)

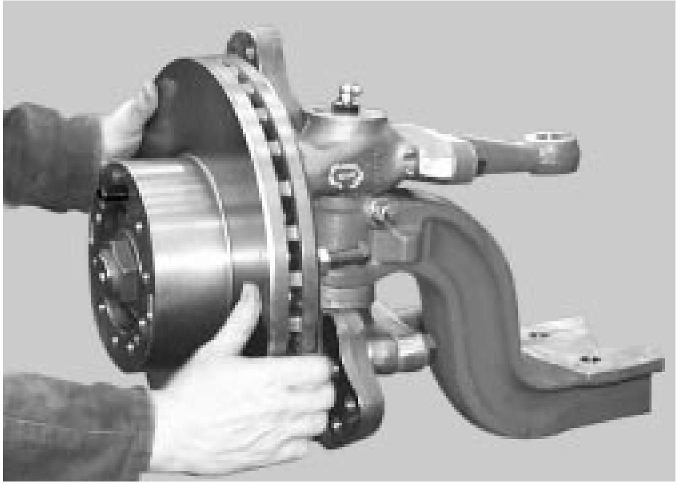
11. Remove the modified hub flange bolt at this point.

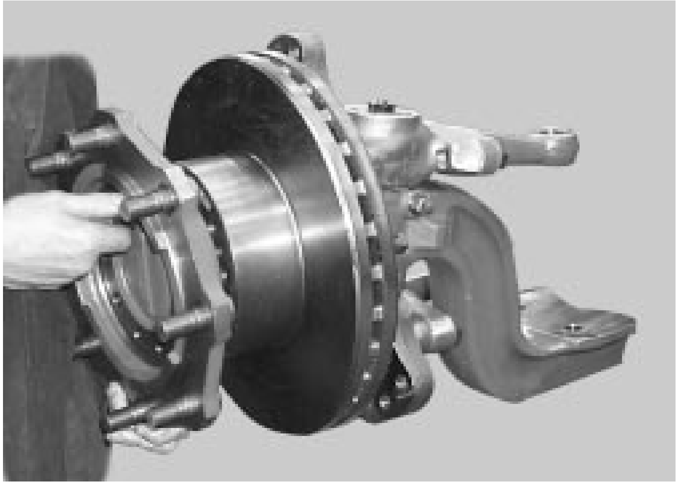
12. Carefully offer hub flange up to
brake disc / unitised hub bearing assembly and hold in position by inserting 1 - off hub flange bolt and tightening hand tight.

13. Insert remainder of hub flange bolts.

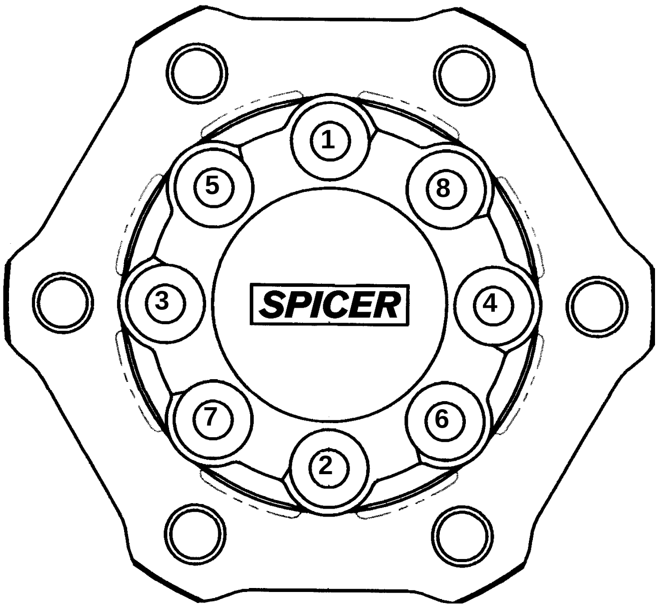
14. Tighten to correct torque using selection procedure as shown on following page.



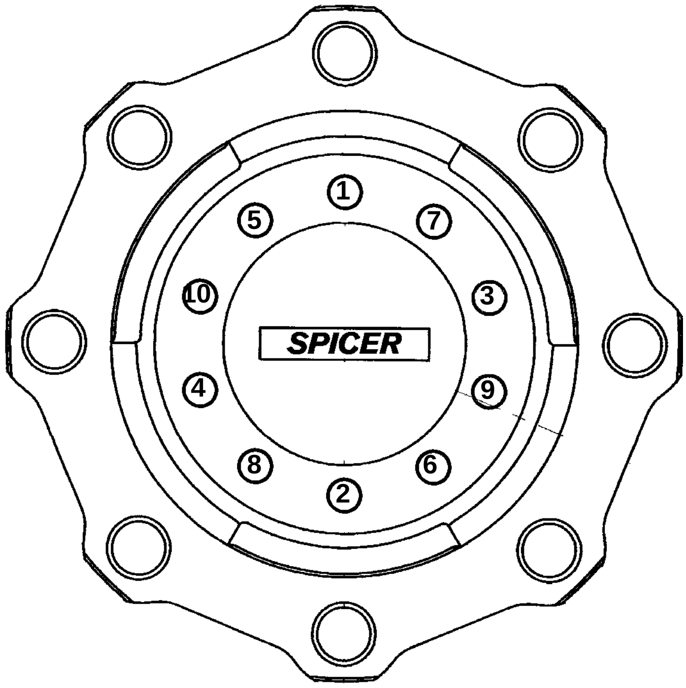




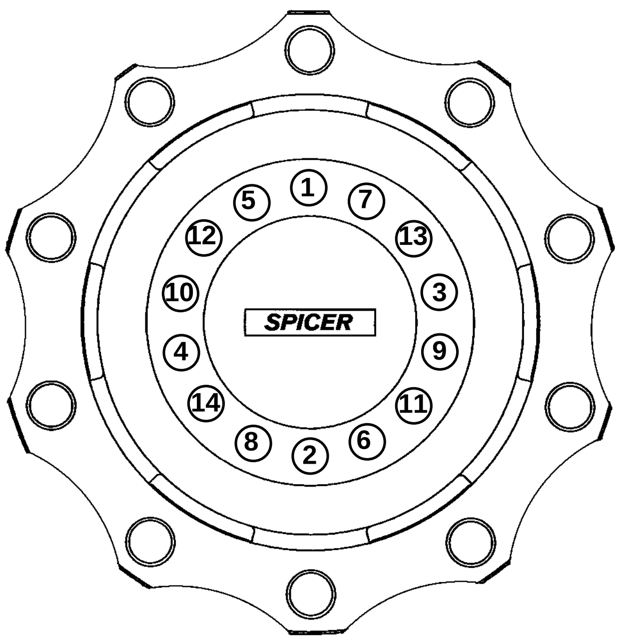
HUB FLANGE BOLT
TIGHTENING TORQUE SEQUENCE
FOR 8 BOLT FIXING



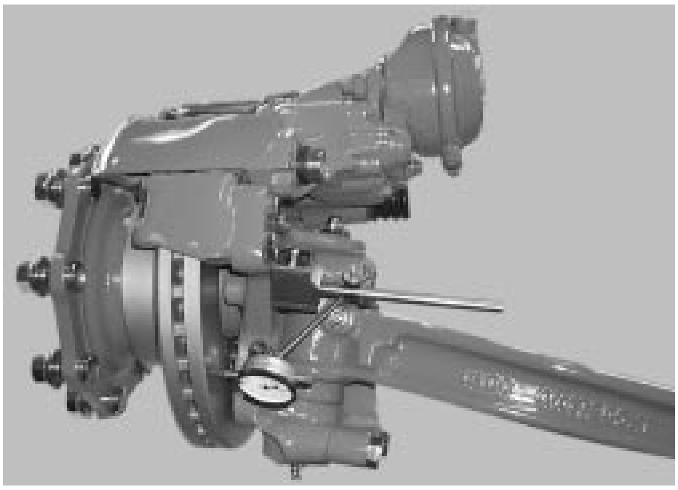
HUB FLANGE BOLT
TIGHTENING TORQUE SEQUENCE
FOR 10 BOLT FIXING



HUB FLANGE BOLT
TIGHTENING TORQUE SEQUENCE
FOR 14 BOLT FIXING



OVERHAUL PROCEDURES



HUB END REASSEMBLY CONTINUED

15. Once the hub flange has been correctly fitted; it is necessary to check the axial run out of the brake disc.

16. Position a metric dial test indicator onto axle in a suitable position as shown.

NOTE:-
POSITION MAY VARY DEPENDENT ON AXLE SPECIFICATION

17. Position stylus of dial test indicator onto brake disc as shown.

18. Rotate the hub through 360° and note any movement of the dial test indicator.

NOTE:-
MAXIMUM AXIAL RUNOUT IS 0.1mm

19. Should axial runout exceed 0.1mm. the brake disc is out of specification .

20. Remove and check out of specification disc to ensure no damage has occured to the mounting faces, or that no dirt is present.

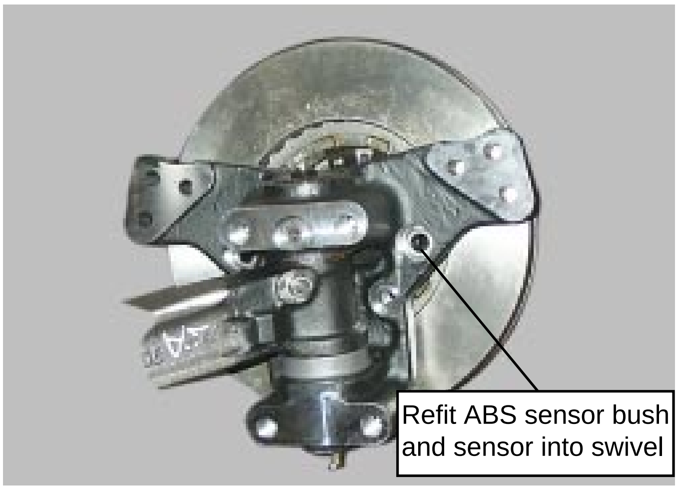
21. Remove any dirt found on the mounting faces and refit and re check disc.

NOTE:-
DAMAGED DISCS SHOULD BE REPLACED AS A MATTER OF COURSE!

22. Should it be found that a cleaned and refitted disc is still out of specification; it must be replaced.

OVERHAUL PROCEDURES

HUB END REASSEMBLY CONTINUED



23. Refit ABS sensor bush and sensor into swivel

NOTE:-
A NEW SENSOR BUSH SHOULD BE FITTED WHENEVER A NEW SENSOR IS FITTED.
IF FITTING A NEW SENSOR AND BUSH INTO AN ABS READY AXLE. SENSOR AND BUSH SHOULD BE SUPPLIED FROM THE SAME MANUFACTURER.

24. Push sensor through bush until it comes into contact with polewheel on hub assembly.

25. Rotate hub bearing assembly through at least one revolution.

THIS SERVES TO SET THE CORRECT GAP BETWEEN SENSOR AND POLEWHEEL.

OVERHAUL PROCEDURES

HUB END REASSEMBLY CONTINUED

26. Check A.B.S. sensor performance as follows :-

<u>Before commencement of this check It is important that the number of teeth be checked and found to be the correct, on both LH and RH hubs.</u>

a) Insert the probes from a volt-meter into the two plugs in the sensor connector.
b) set the voltmeter to read mili-volts AC.
c) Rotate the hub in any direction at a constant speed of 60Hz (7Kph).
To determine this speed use the following calculation ;

$$\text{RPM} = \frac{60\text{Hz}}{z} \times 60 \text{ secs}$$

where z = the number of teeth on the pole wheel.

Note :- The reading may not be steady due to the possibility of pole wheel run out and the inconsistent speed of the wheel.

d) The maximum reading (Vmax) must not be more than 80% greater than the minimum reading (Vmin). ie.

$$\frac{V\text{max}}{V\text{min}} \leq 1.8$$

If the following is true then it is likely that there is excessive pole wheel runout. The pole wheel installation will therefore need to be inspected and remounted or replaced.

$$\frac{V\text{max}}{V\text{min}} > 1.8$$

e) The minimum reading must be greater than the voltage threshold (Vt) ie.

$$V\text{min.} > Vt$$

$$Vt. = 60\text{mV}$$

If this is not the case, then the sendsor gap is too large or there may be excessive pole wheel runout. The pole wheel will therefore need to be inspected and remounted or replaced.

f) If sections d) and e) are satisfied, then the installation can be considered as satisfactory.

Note :- The above test procedure is as recommended by A.B.S. manufacturers.

OVERHAUL PROCEDURES

HUB END REASSEMBLY CONTINUED

27. Using suitable lifting equipment, support the brake caliper.

WARNING!
BRAKE CALIPER IS HEAVY.

28. Offer brake caliper up to brake bracket. (Ensure correct hand of brake caliper is selected)

29. Insert brake caliper retaining bolts and tighten hand tight.

30. Tighten brake caliper bolts to secure assembly.

31. Remove caliper lifting equipment

WARNING!
BRAKE CALIPER IS HEAVY
ENSURE WEIGHT IS FULLY SUPPORTED BY RETAINING BOLTS BEFORE REMOVING LIFTING EQUIPMENT.

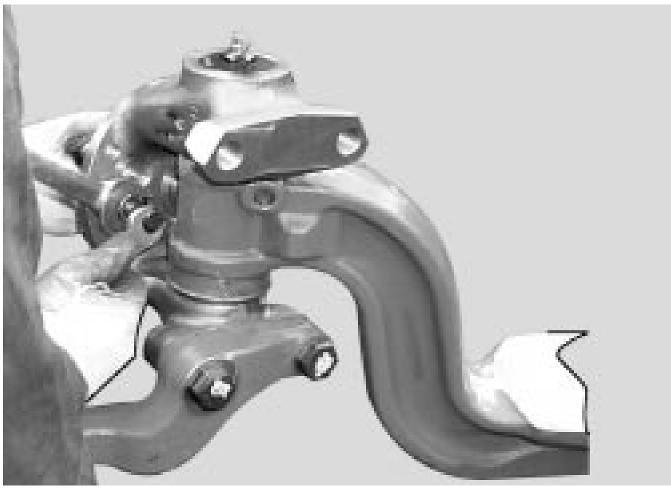
32. Tighten brake caliper bolts to correct torque.

33. If the brake caliper air chamber has been removed; Refit to caliper and tighten nuts to correct torque.

NOTE!
TAKE CARE NOT TO DAMAGE PAD WEAR SENSOR CABLE DURING REASSEMBLY OF CHAMBER TO CALIPER.

OVERHAUL PROCEDURES

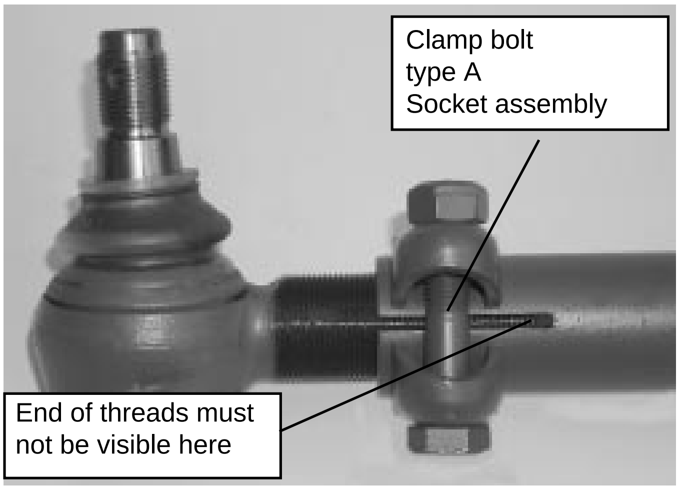
HUB END REASSEMBLY CONTINUED



34. Refit lockstop screws and adjusting nuts

35. Reset lockstop screws to achieve correct lock angles as shown on installation drawing or vehicle manufacturers specifications.

NOTE:-
DO NOT ALLOW LOCKSTOP THREADS TO PROTRUDE THROUGH FRONT FACE OF SWIVEL.

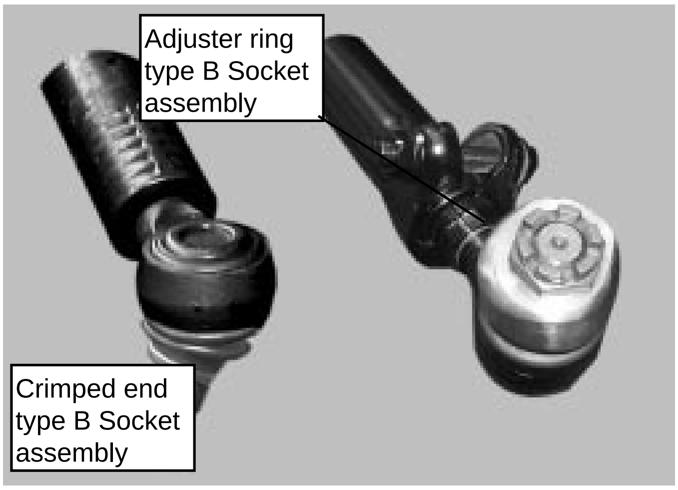


36. Check wheel alignment as follows :-

a) Set axle in straight ahead position.

b) At a point level with wheel centre, measure distance over hubs / wheel rims, both in front and behind axle centre.

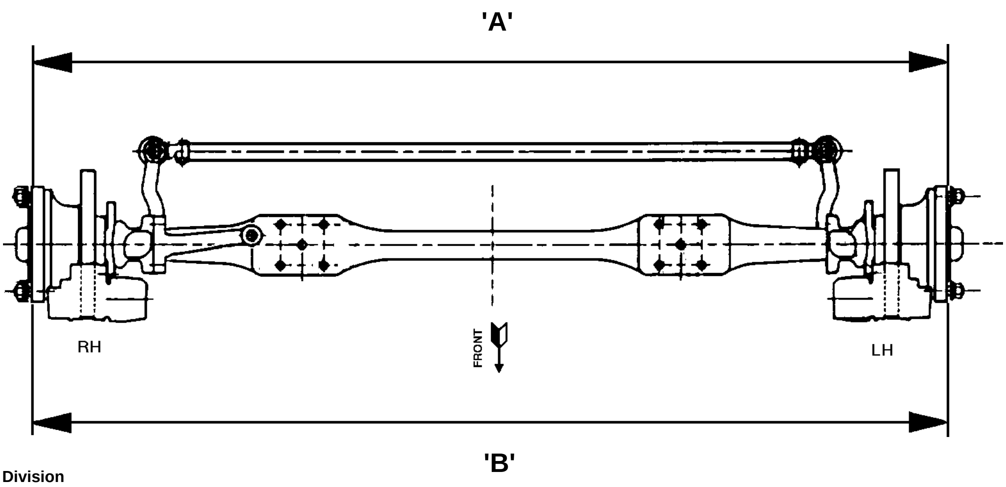
c) Front measurement ‘B’ should be 0.0" to 0.04" (0.0 to 1mm) **LESS** than rear measurement ‘A’.



d) Any adjustment on type A socket and tie rod assemblies can be effected by slackening clamp bolts in ball sockets and rotating track rod tube.
For type B socket and tie rod assemblies, slacken the clamped end of the assembly and use the adjuster ring.

e) After adjustment, tighten clamp bolts to specified torque.

NOTE:-
WHEN ADJUSTING TYPE A TIE RODS, ENSURE SOCKET THREADS ARE EQUALLY POSITIONED IN EACH END OF THE TIE ROD AND THAT THE END OF THE SOCKET THREAD IS NOT VISIBLE THROUGH THE SAWCUT



OVERHAUL PROCEDURES

HUB END REASSEMBLY CONTINUED

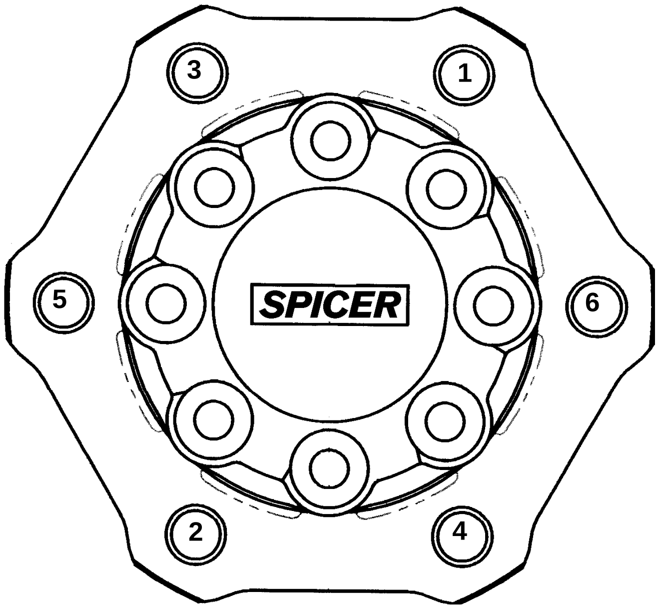
37. Re-connect brake to vehicle hydraulic system as recommended in brake manufacturer's manual.

38. Clean interfaces of wheelnuts, wheel rim & hub then re-fit road wheels securing with wheel nuts and tighten in correct sequence (as shown on following page) to specified torque.

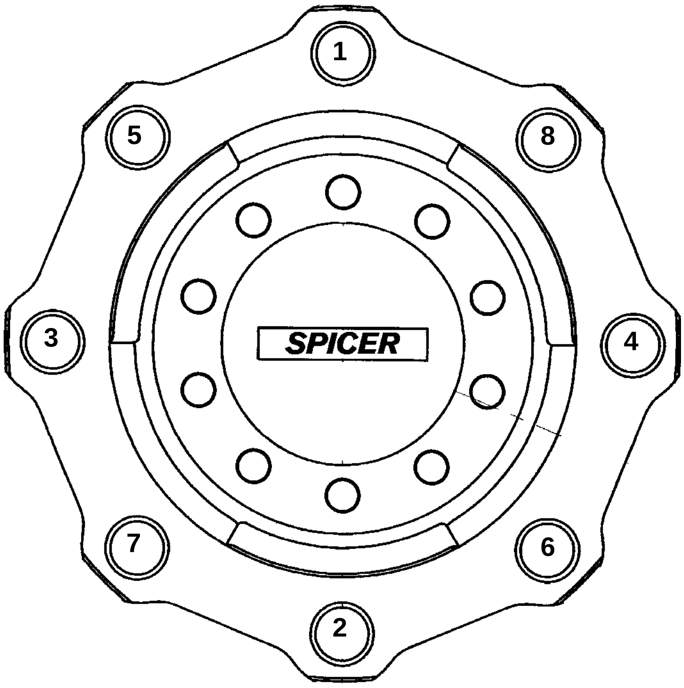
NOTE:-
INTERFACES MUST BE FREE FROM DIRT, INCLUDING BRAKE LINER MATERIAL DEBRIS, RUST AND PAINT. FAILURE TO KEEP INTERFACES CLEAN CAN AND WILL CAUSE WHEEL RIM TO DISTORT UPON TIGHTENING OF WHEEL NUTS
FOR FURTHER DETAILS SEE BS AU50 : part 2 : section 7A : 1995

39. Remove axle supports and lower vehicle to ground.

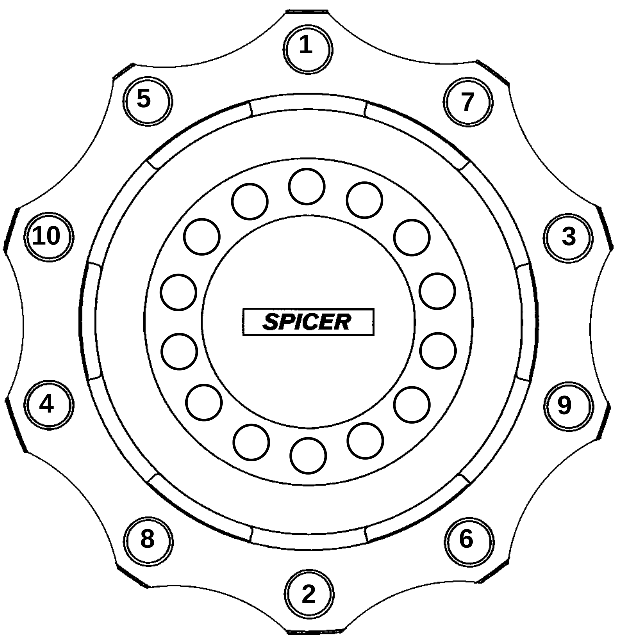
WHEELNUT TIGHTENING
TORQUE SEQUENCE
FOR 6 STUD FIXING



WHEELNUT TIGHTENING
TORQUE SEQUENCE
FOR 8 STUD FIXING



WHEELNUT TIGHTENING
TORQUE SEQUENCE
FOR 10 STUD FIXING

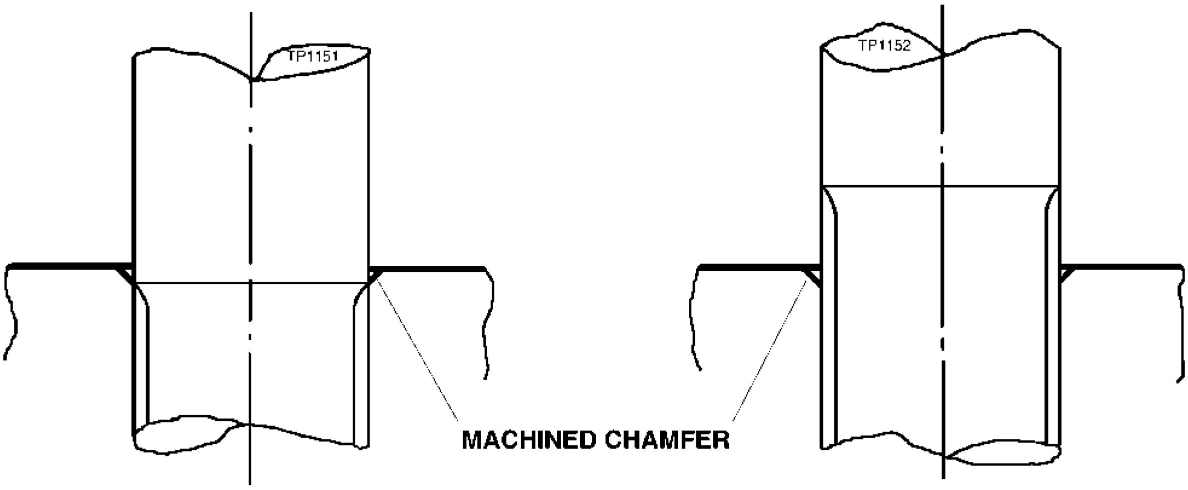


SPICER SPECIALITY AXLE DIVISION

TP1193

STANDARD STUDS - FITTED INTO MACHINED CHAMFERED HOLES

STUDS TO BE INSERTED UNTIL THREAD RUN-OUT LOCKS INTO PARENT METAL

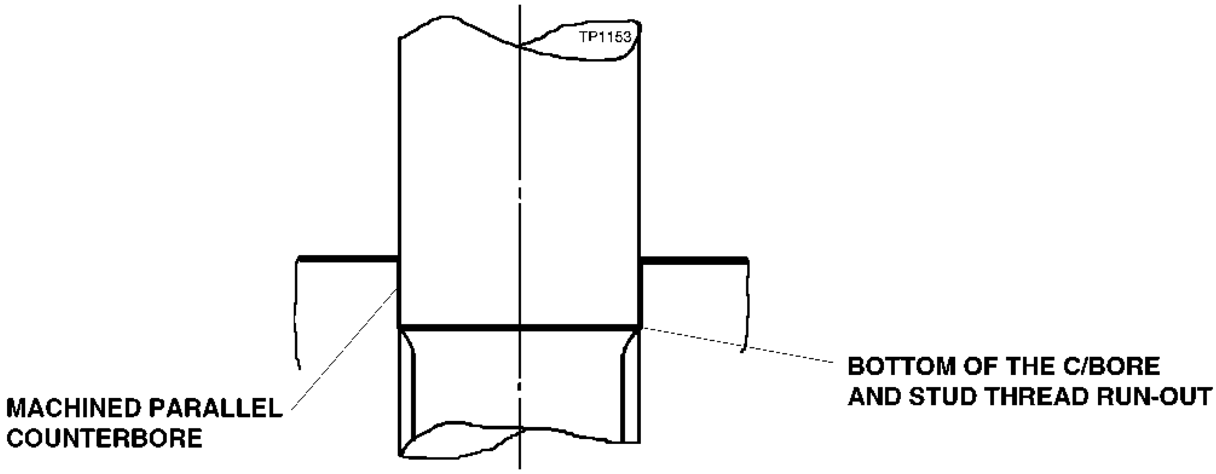


CORRECT　　　　INCORRECT

IMPORTANT :- THIS STUD FITTING PROCEDURE IS TO BE USED IN LIEU OF STATED TORQUE VALUES ON EXISTING ARRANGEMENTS.
NEW ARRANGEMENTS WILL SPECIFY TD183/1 FROM THE DATE OF ISSUE.

SPECIAL STUDS - FITTED INTO MACHINED PARALLEL COUNTERBORE

STUDS TO BE INSERTED UNTIL CORRECT TORQUE VALUE IS OBTAINED -
AS SHOWN ON RELEVANT ARRANGEMENT DRAWING



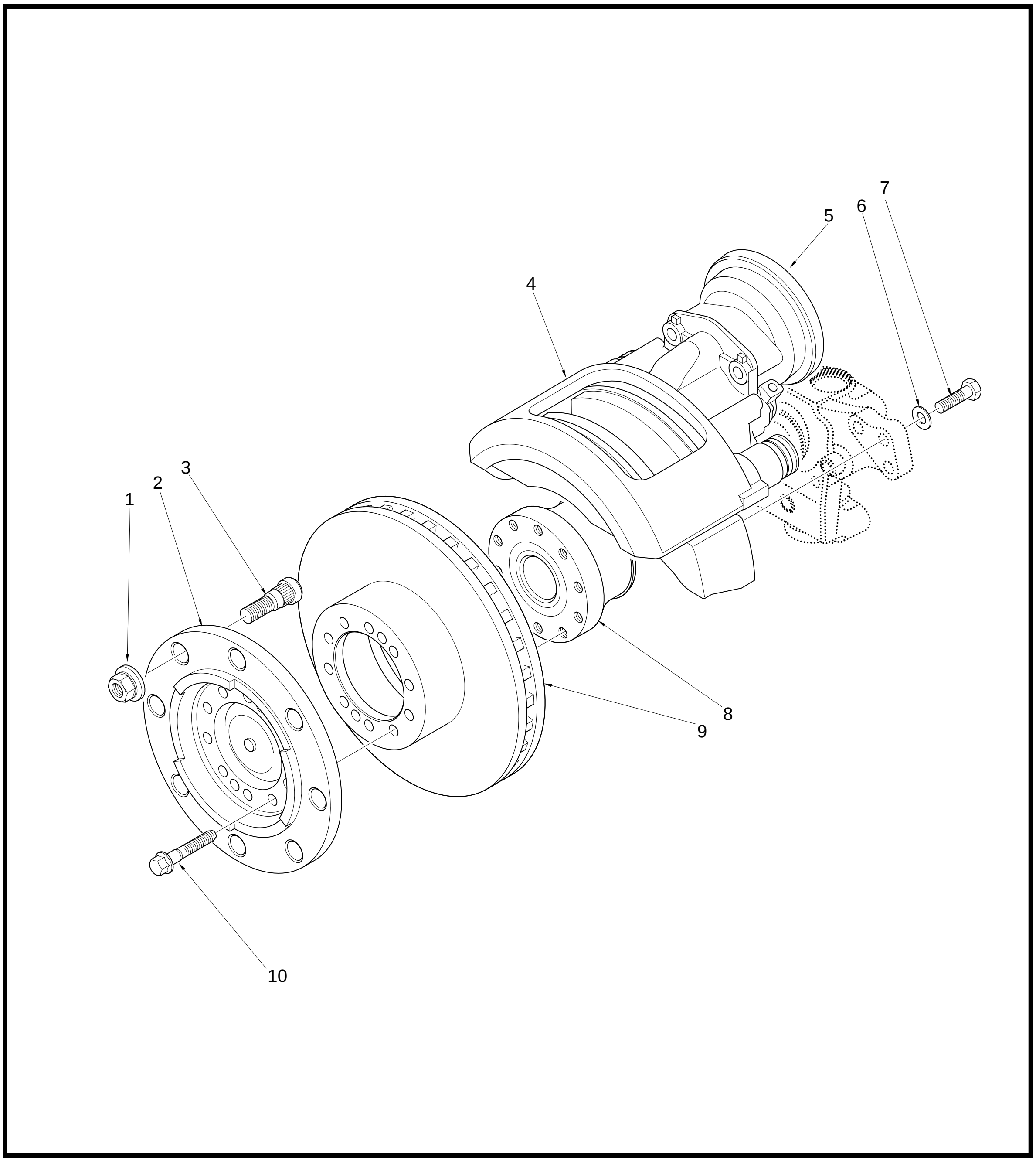
THIS SPECIFICATION IS FOR STUD FITTING ONLY ;
NUTS & SETSCREWS MUST BE TORQUED TO VALUE SPECIFIED

Alteration Numbers

ISSUE A									

DISTRIBUTION		
Front Axle B.U. Drive Axle B. U. Production	STUD FITTING PROCEDURES	TD183/1 SHT 1 OF 1

ILLUSTRATION OF NDS HUB END WITH SEPARATE BRAKE BRACKET



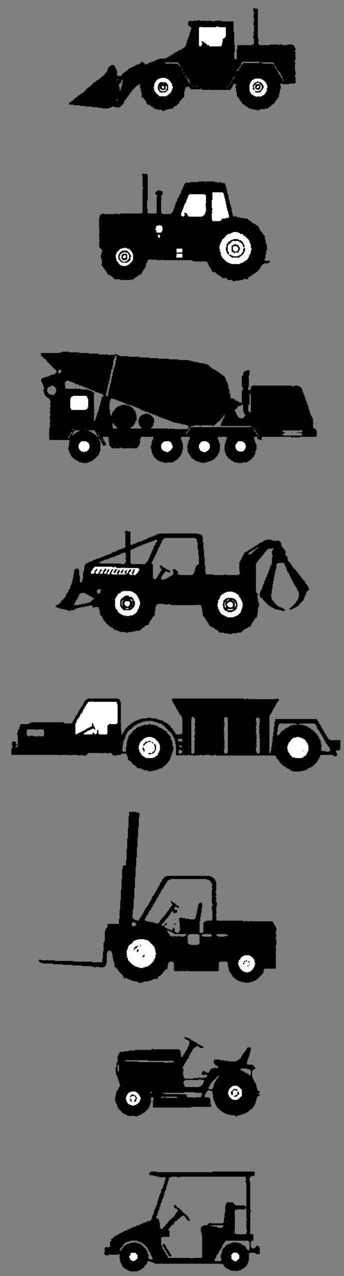
PART NUMBER	DESCRIPTION
1	Wheel nut (Not Supplied By Spicer Speciality Axles)
2	Hub flange
3	Wheel stud
4	Brake Caliper
5	Air chamber
6	Brake Caliper Mounting Washer
7	Brake Caliper Mounting Bolt
8	Unitised Hub Bearing
9	Brake Disc
10	Hub Flange Retaining Bolt

APPLICATION POLICY
Capability ratings, features and specifications vary depending upon the model type of service. Applications approvals must be obtained from Spicer Speciality axle division. We reserve the right to change or modify our product specifications, configurations, or dimensions at any time without notice.

SPICER SPECIALITY AXLE DIVISION
ABBEY ROAD
LEEDS LS5 3NF
ENGLAND
TEL (+44-113) 2584611 FAX (+44-113) 2586097

BACK / RETOUR

Maintenance Manual
NDS axles
Lubrication and Maintenance
NDS Axle range
Issue D



SPICER SPECIALITY AXLE DIVISION

DANA

MANUAL ISSUE SHEET

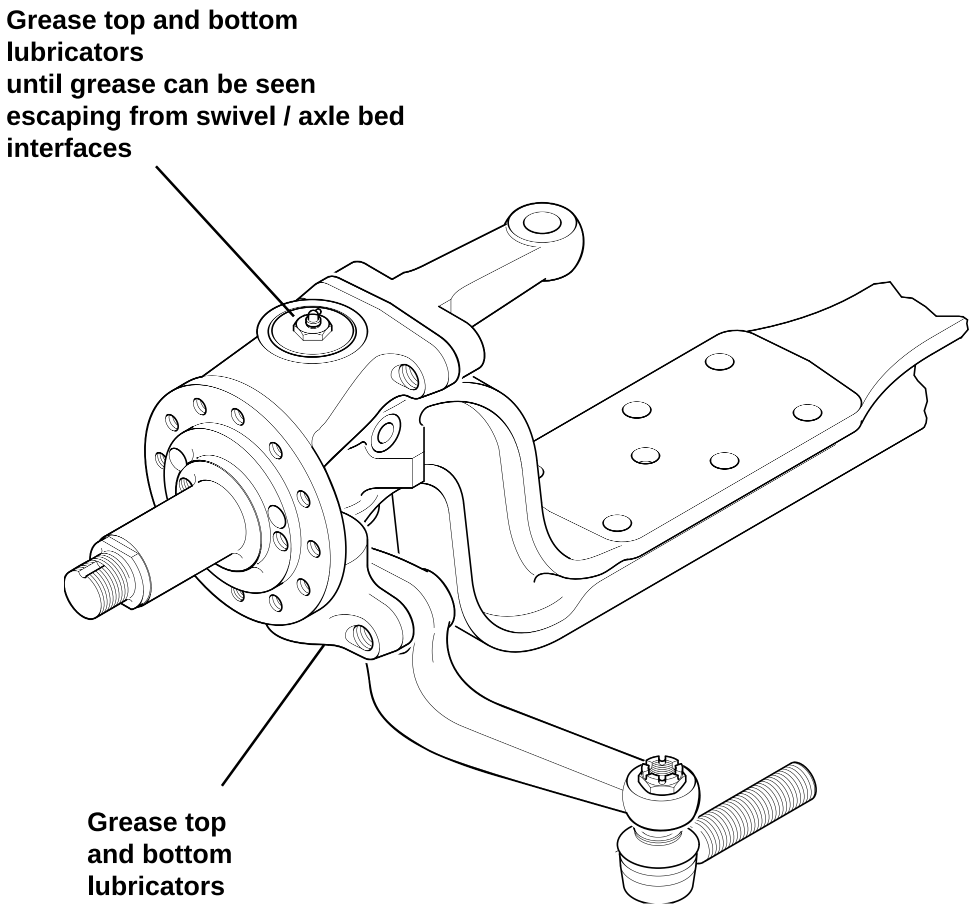
Page No.	Issue	Description / Alteration	Reason	Date
All	A	New Manual		Nov. 99
5	B	Mileage interval altered	Updated spec.	Mar.2000
9	B	Mileage interval altered	Updated spec.	Mar.2000
13	B	Tie rod torques added	New tie rod	Mar.2000
14	B	Tie rod torques added	New tie rod	Mar.2000
15	B	Air cylinder torques added	New spec	Mar.2000
18	B	Air cylinder torques added	New spec	Mar.2000
4	B	Lockstop setting info added	Clarification see SB1258	Sep.2000
3	B	Greasing period altered	Standardisation	Jan.2001
4	C	End float checking period added	Standardisation	Jan.2001

SECTION 1 LUBRICATION

1.1 GREASING PERIODS

1.1.1 ON HIGHWAY APPLICATIONS
Pressure lubricate every 6 months or 30000 miles (48000 km)
A more frequent lubrication cycle is required for axles used in on/off highway, refuse, or other severe service applications.

1.1.2 Grease points as shown in fig.no.1.



Greasing points
Fig.No.1

NOTE :- ALL OTHER COMPONENTS IN THE NDS RANGE OF AXLES ARE GREASED FOR LIFE AND REQUIRE NO FURTHER LUBRICATION DURING THE LIFE OF THE COMPONENT.

Recommended lubrication - LITHIUM BASE ROLLER BEARING GREASE NLGI NUMBER 2

1.2 Recommended Greases

Use greases to grade "F" in lubrication manual

2.1 Hub bearing check should be carried out every 30000 miles (48000 km)

a) Before commencing checks, apply parking brake, raise wheels off ground and support axle on stands. and remove brake drum (if fitted) .

WARNING!
NEVER WORK UNDER A VEHICLE SUPPORTED ONLY BY JACKS!
ALWAYS USE SUITABLE AXSLE STANDS!

b) Place magnetic base of a dial indicator on brake shoe / caliper and position dial indicator stem against a convenient marked spot on face of Hub flange
c) With dial indicator in position pull hard but steadily on Hub flange and oscillate at same time until a steady reading is achieved.
d) Without releasing the pressure, turn bearing so that dial indicator stem contacts marked spot and note reading on indicator.
e) Push bearing flange hard and oscillate as before until a steady reading is achieved.
f) Without releasing the pressure, turn bearing so that indicator stem again contacts the marked spot and note new reading on indicator.
g) The difference between readings is amount of mounted end play in bearing unit .
h) The mounted end play figure should not exceed 0.050mm for a new bearing.

NOTE:-
IF ORIGINAL BEARING UNIT IS RE-FITTED, AND END FLOAT IS MEASURED AT 1MM, WITH HUB NUT FULLY TIGHTENED TO CORRECT TORQUE, THEN THE RETAINING CLIP WITHIN THE UNIT IS DAMAGED / DISPLACED AND A NEW UNIT MUST BE FITTED.

To check front wheel ' Toe In '

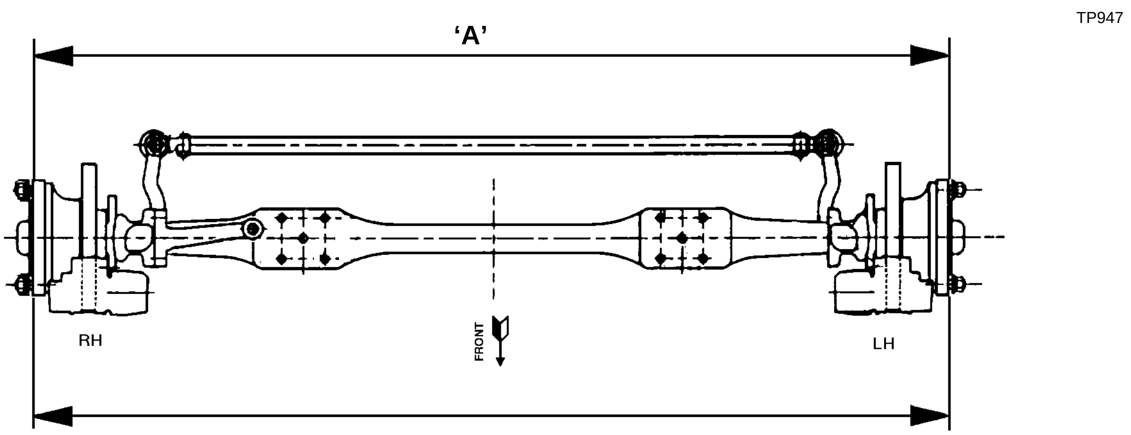
a) To preserve correct steering and avoid excessive tyre wear, tracking (or alignment) of front wheels should be checked periodically, as follows :-
Set front wheels in straight ahead position and at points level with wheel centre, measure distance over hubs / wheel rims, both in front and behind axle centre.
For correct 'Toe In' front measurement 'B' should be 0" to 0.04" (0 to1mm) smaller than rear measurement 'A' .

b) To allow for inaccuracies in wheels, same check should be made with vehicle moved an equivalent to half of a wheel revolution (180°). Any adjustment required can be effected by backing off clamp bolts in ball sockets and rotating tie (track) rod tube.
After adjustment, tighten clamp bolts to specified torque.

All steer axles supplied by Spicer Speciality Axle Division have their lockstops set to customer requirements.

It is important that when the power assisted steering is fitted, the steering gear is adjusted so that the hydraulic assistance cuts out just before the lockstops come into contact with the axle beam, to avoid excessive loads being transmitted through the steering linkages.

Incorrectly adjusted steering could lead to premature failure or shortened life of all steering components.



'B'
Measure dimensions 'A' and 'B' over hubs / wheel rims on horizontal centre line.
To give correct alignment ; dimension 'A' should be 0.0" to 0.04" (0 to1mm) greater than dimension 'B'.

Fig. No.2

2.3 Check condition of brake pads as described in relevant brake manufacturers service manual.

SECTION 2 ROUTINE MAINTENANCE Cont.

2.4 Check permissible slackness in swivel (king) pins every 30000 miles (48000 km) as follows :-

Aspects to be considered are :-

a) Lateral slackness.
b) Vertical slackness.

Before commencing checks, apply parking brake, raise wheels off ground and support axle on stands.

a) **Checking lateral slackness**
Whilst this is being carried out the brake must be applied.
Place a set -square with its stock on ground and its blade against tyre wall.
Place a mark on ground to indicate position of stock end.
Insert a lever through bottom cut-out of wheel and lever it upwards thus moving set-square outboard.
Mark changed position of stock end.
Maximum allowable stock displacement is given as follows:-

for 17.5" wheels	=	6mm.
for 19.5" wheels	=	7mm.
for 22.5" wheels	=	8mm.
for 24.0" wheels	=	9mm.

If displacement exceeds stated allowance then need for bush / bearing attention and possible renewal, is in evidence.

b) **Checking vertical slackness**
This is measured by a dial indicator anchored to axle beam and having its pointer placed vertical against swivel top.
Place a jack against underside of swivel and, whilst applying a lifting force, observe any movement on indicator dial.
If vertical movement is evident and it exceeds 0.040" (1.02mm) then re-adjustment of swivel is required by adjusting thickness of bearing adjusting washers.

2.5 Every 6 months, check for movement in ball joints as follows :-

NOTE :-
THIS TEST IS TO BE CARRIED OUT WITH VEHICLE IN LOADED CONDITION,
DO NOT JACK UP VEHICLE

a) **Axial end float (axial travel)**

End float in direction of axis of ball pin, as shown in fig. no.3 should be within limits of 0.4mm to 2.0mm max. using a test force of 850N.

b) **Radial end float (radial travel)**

Radial end float at right angles to axis of ball pin as shown in fig. no. 4 should be within limits of 0.4mm to 0.8mm max. using a test force of 6000N.

Replace ball joints if outside limits given in a) and / or b).

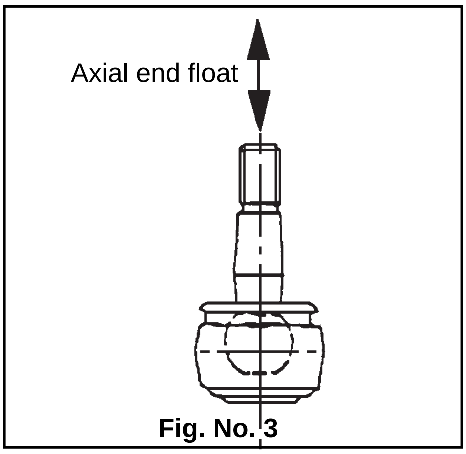


Fig. No. 3

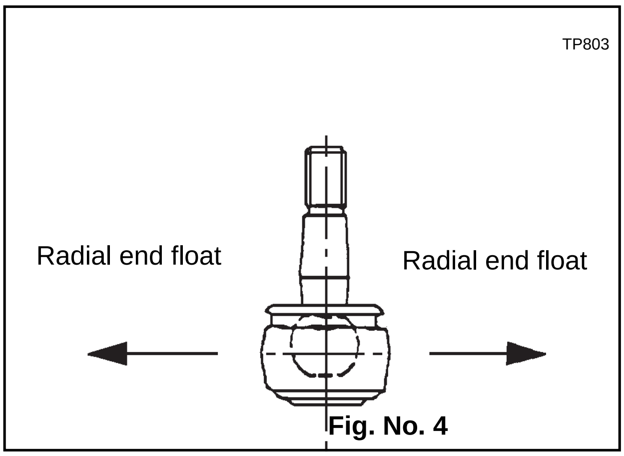


Fig. No. 4

SECTION 2 ROUTINE MAINTENANCE Cont.

2.6 Every 6 months inspect ball joints for corrosion as follows :-

NOTE:-
INSPECTION OF BALL JOINTS IS IMPORTANT, ESPECIALLY THOSE IN OLDER VEHICLES. DAMAGED SEALING BOOTS, SALT ON ROADS IN WINTER AND CLIMATIC CONDITIONS CAN CAUSE LOSS OF THE CORROSION PROTECTION COATING APPLIED DURING MANUFACTURE.

Inspection instructions:-

Ensure that ball joint is in an easy access-position.
Carefully clean the sealing boot contact area, to ensure that pollutants cannot get under the sealing boot during the following inspection procedure.
Use an appropriate inspection sheet-metal-tool, eg. spatula with cut out, (fig. no.5) to push up the sealing boot (without damaging it) until ball pin surface is visible. Degrease the ball pin surface.

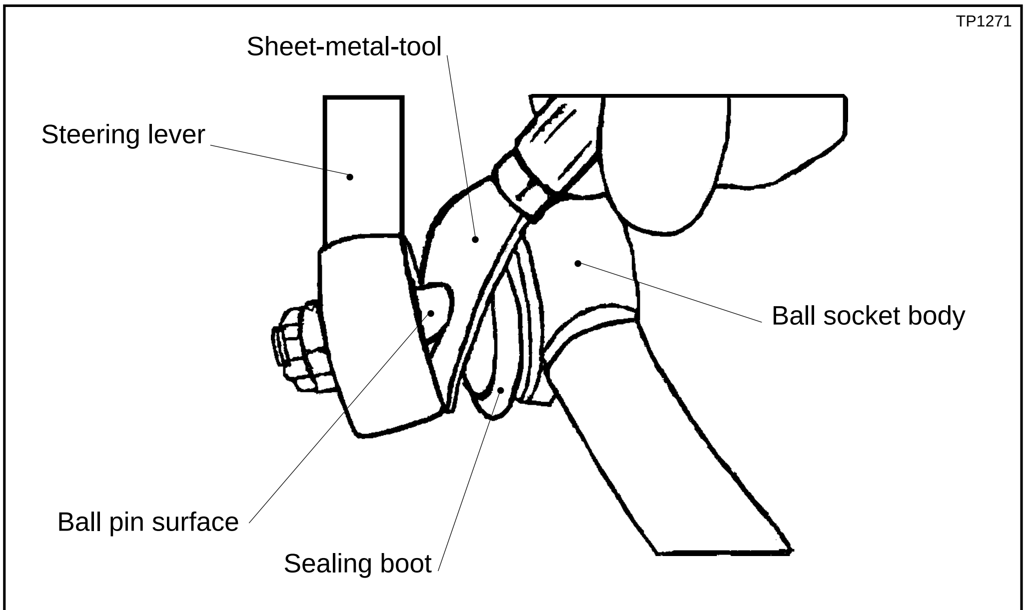


Fig. No. 5

If there is corrosion of the ball pin or the sealing boot has deteriorated through ageing or is damaged, replace the ball joint in question, or the complete tie rod or drag link as appropriate.

If there is corrosion of the steering lever area which is in contact with the sealing boot, clean and eliminate all surface irregularities.

If there is no corrosion or damage to the sealing boot, smear the steering lever surface with Lithium grease and push the sealing boot back into its properly seated position.

When dismantling tie rods, drag links or drop arms ensure that no damage is caused to the sealing boots or ball joint housings.

SECTION 3 CARE OF WHEELS AND FIXING FACES (ALL AXLES WITH SPIGOT FIXING)

At approximately 100 miles after fitting wheels, wheel nut torque should be checked with wheel ends in " cold " condition (ie not after prolonged braking.).
If any relaxation of original torque **(see specification)** has occured, re-tighten.
Relaxation of initial torque may occur because of " **Bedding Down**" of hub and wheel surfaces.

NOTE:-
TIGHTENING SHOULD NOT BE DONE IMMEDIATELY AFTER PROLONGED BRAKING I.E. WHEN WHEEL ENDS ARE HOT. A RELAXATION OF WHEEL NUT TORQUE DOES OCCUR WHEN WHEEL END IS HOT BUT SHOULD REVERT BACK TO THE ORIGINAL SETTING AS THE WHEEL END COOLS DOWN. RE- TIGHTENING WHEN HOT WILL PRODUCE A HIGHER TORQUE READING WHEN COLD!

Although this single re-tightening after first 100 miles should be sufficient to ensure wheels stay tight, extra checks are recommended within at least the first 1000 miles to check that wheel assembly is stable and that no further relaxation is occuring.

see graphic on following page for correct tightening sequence of wheel nuts

3.1 Care of wheels :-

Check for **CRACKS** in wheels, especially around the fixing holes, and in studs, nuts and washers.
If in doubt **RENEW** .
DO NOT simply re-tighten very loose wheel fixings or wheels which are continualy becoming loose.
Find out why they are loose and whether any damage has been caused.
Use **TRAINED** personnel and keep **RECORDS** of all attention to wheels and fixings, including which parts were renewed and when.

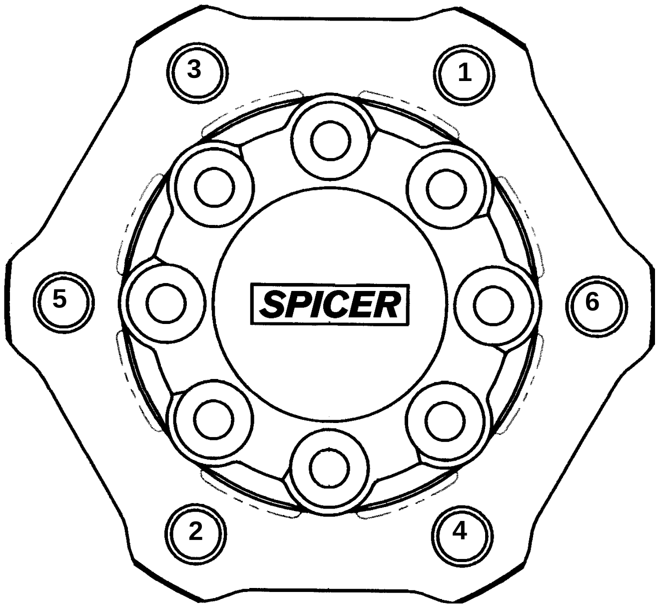
NOTE :-
FURTHER DETAILS ARE GIVEN IN BRITISH STANDARD CODE OF PRACTICE FOR THE SELECTION AND CARE OF TYRES AND WHEELS FOR COMMERCIAL VEHICLES:- BSAU50 : PART2 : SECTION 7A : 1995

3.2 PROTECTION OF SPIGOT WHEEL FIXING DIAMETERS AND PRESSURE SURFACES.

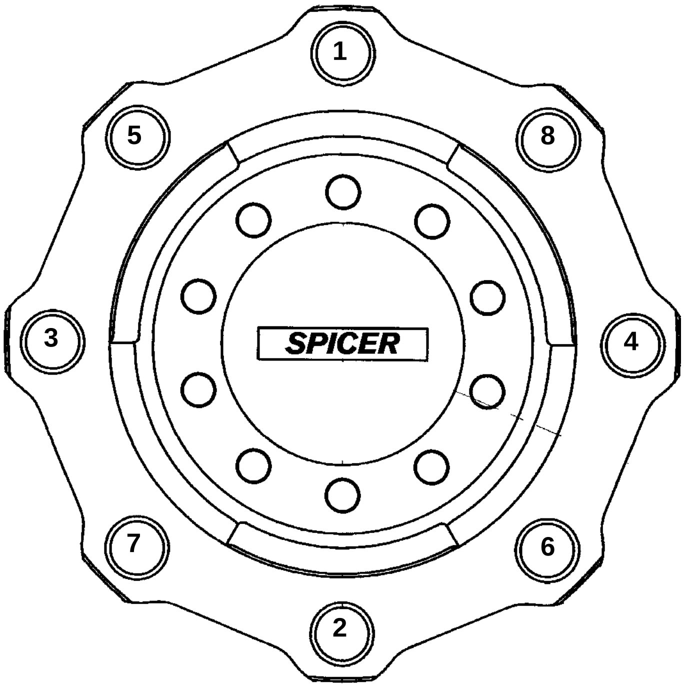
Although **Spicer Speciality Axles Division** apply an initial surface coating to wheel rim mating faces on spigot to stop rusting and facilitate easy removal of wheels. The application of P.B.C. grease such as 'Rocol Tufgear' or equivalent to wheel register is recommended.

The above P.B.C. grease is available from Rocol Ltd., Rocol House, Wakefield Road, Swillington, Leeds, UK. Phone: 44 (113) 2322600. Fax: 44 (113) 2322740.

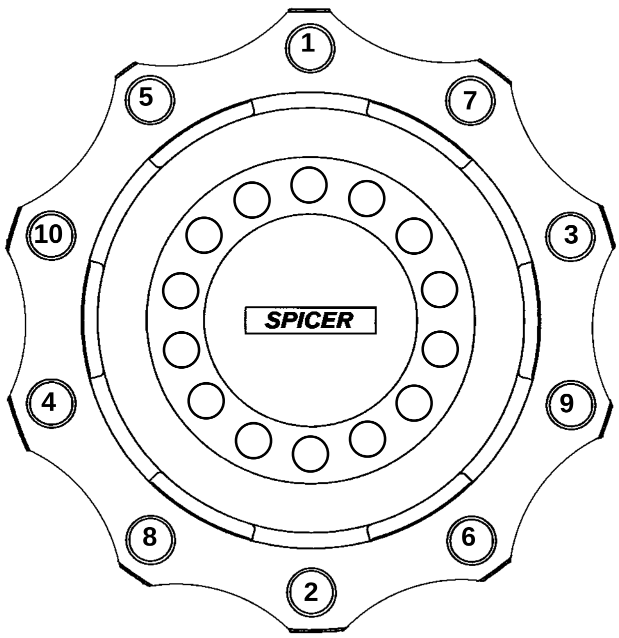
WHEELNUT TIGHTENING
TORQUE SEQUENCE
6 - STUD FIXING



WHEELNUT TIGHTENING
TORQUE SEQUENCE
8 - STUD FIXING



WHEELNUT TIGHTENING
TORQUE SEQUENCE
10 - STUD FIXING



SECTION 4 **Guidance standards for acceptable brake drum crazing (if fitted).**

Every 30000 miles (48000 km) or whenever brake drums are removed for axle maintenance purposes they should be checked for crazing.

Brake drums with crazing in excess of that shown in fig.6 below, and which are of Spicer Speciality axle division manufacture should not be re introduced into service.

Figs.7 & 8 show examples of unacceptable crazing.

fig.6

fig.7

fig.8

EVALUATION OF BRAKE DISC SURFACE

TP1627

Upon removal of brake disc Fig. 9. It's surface should be checked for defects. Inspection should cover both sides of the braking surface as well as the outer diameter of the disc.
Brake disc thickness should be checked in accordance with manufacturers dimensional recommendations.


Fig. 9

You should inspect for the following:-
- Heat checking
- Cracks
- Grooves - scoring
- Blue marks - Banding
- Polished discs

TP1628

Heat checking can be light or heavy,

If **light heat checking** type cracks (fine and light) are found as shown in Fig.10 the disc can continue to be used.

If **heavy heat checking** type cracks (deep and wide) are found the disc **must be replaced.**


Fig. 10

TP1629

Cracks can be of 2 types **Radial or Through.**

If any **radial** cracks are found in the brake disc surface as shown in fig. 11. then the disc **must be replaced.**.

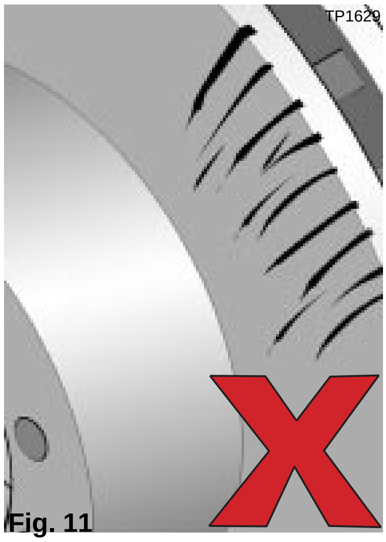


Fig. 11

TP1630

If any **Through** cracks are found in the brake disc as shown in fig. 12. then the disc **must be replaced.**.

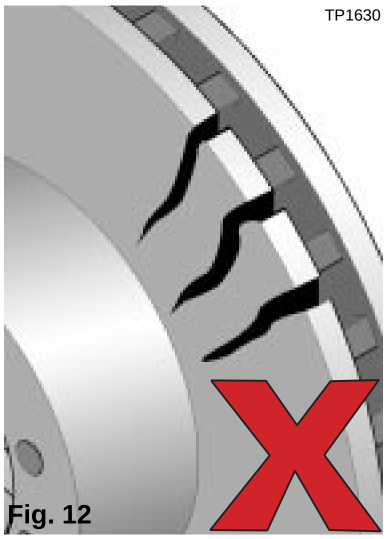


Fig. 12

EVALUATION OF BRAKE DISC SURFACE CONTINUED

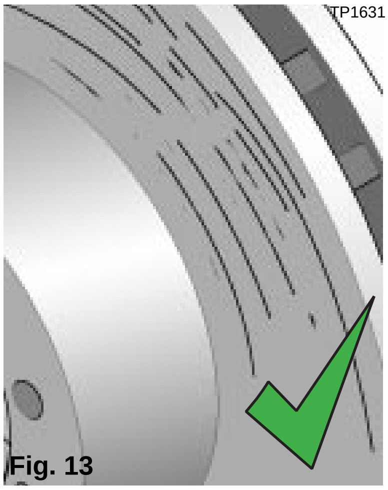


Fig. 13

Grooving - Scoring can be light or heavy,

If **light** grooving is found as shown in Fig. 13 then the disc can continue to be used.

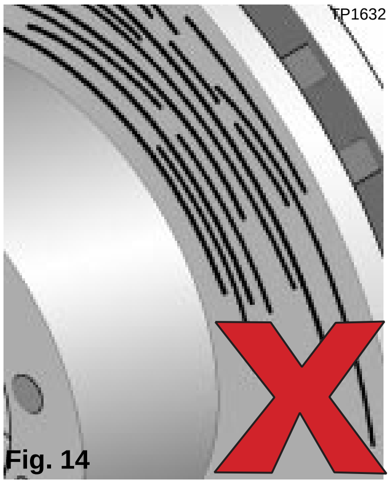


Fig. 14

If **Heavy** grooving is found as shown in Fig. 14 then the disc must be replaced.

Fig. 15

Blue marks - banding indicates that the disc has been exposed to very high temperatures.
If **Blue marks - banding** are found, the reason for the high temperatures must be investigated and corrected.
Refer to the Brake manufacturer for details.
if left uncorrected the formation of heavy heat checking / cracks will occur.

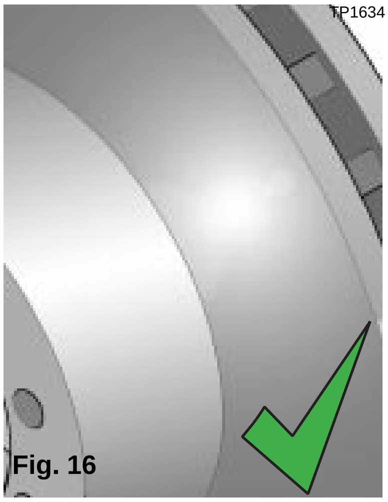


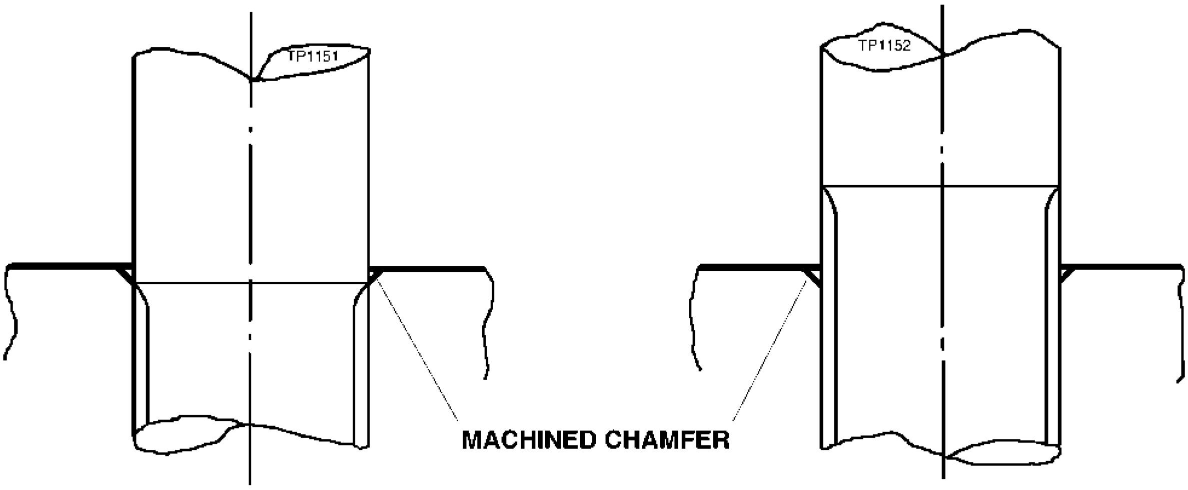
Fig. 16

Polished discs indicate the use of improper lining material or that the disc has been re- machined to too fine a surface finish.
The **Gloss / polish** should be removed using (80) grit Emery cloth and the brake manufacturer should be contacted for an alternate liner material.

SPICER SPECIALITY AXLE DIVISION

STANDARD STUDS - FITTED INTO MACHINED CHAMFERED HOLES

STUDS TO BE INSERTED UNTIL THREAD RUN-OUT LOCKS INTO PARENT METAL

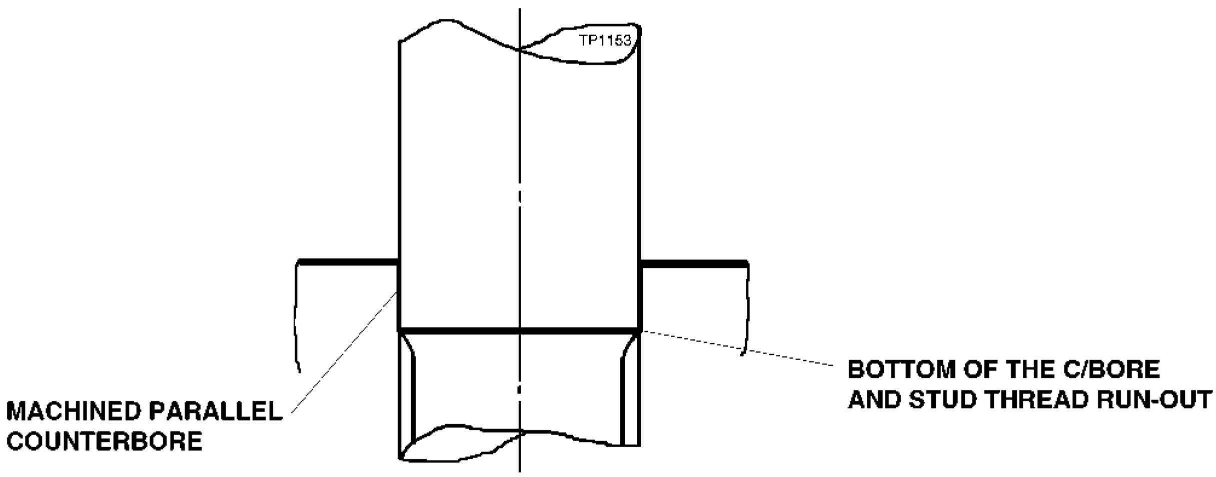


CORRECT INCORRECT

IMPORTANT :- THIS STUD FITTING PROCEDURE IS TO BE USED IN LIEU OF STATED TORQUE VALUES ON EXISTING ARRANGEMENTS.
NEW ARRANGEMENTS WILL SPECIFY TD183/1 FROM THE DATE OF ISSUE.

SPECIAL STUDS - FITTED INTO MACHINED PARALLEL COUNTERBORE

STUDS TO BE INSERTED UNTIL CORRECT TORQUE VALUE IS OBTAINED -
AS SHOWN ON RELEVANT ARRANGEMENT DRAWING



**THIS SPECIFICATION IS FOR STUD FITTING ONLY ;
NUTS & SETSCREWS MUST BE TORQUED TO VALUE SPECIFIED**

Alteration Numbers

ISSUE A									

DISTRIBUTION		
DISTRIBUTION Front Axle B.U. Drive Axle B. U. Production	STUD FITTING PROCEDURES	TD183/1 SHT 1 OF 1

SWIVEL / AXLE BED TIGHTENING TORQUES

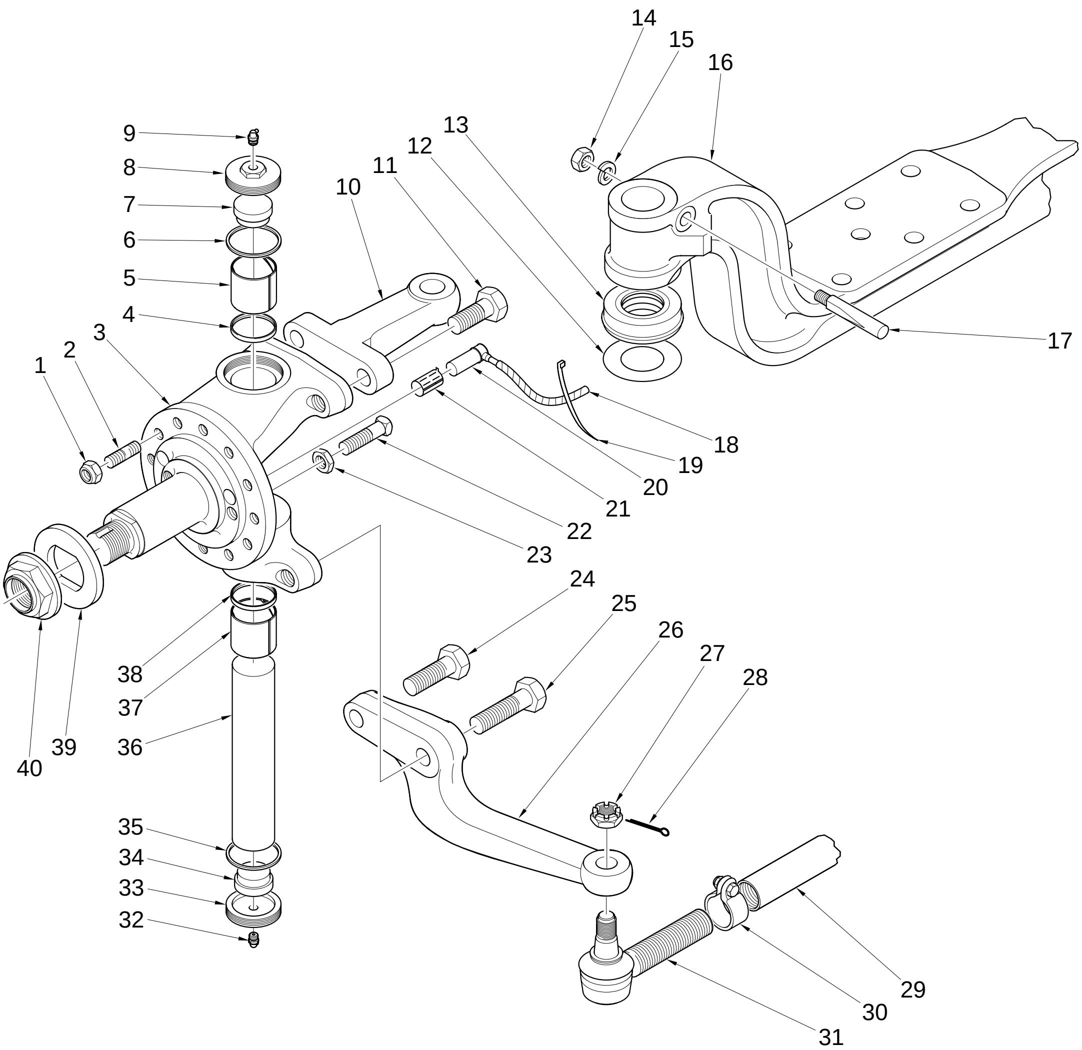


Fig.No.17

PART Nº	DESCRIPTION	TIGHTENING TORQUE		
1	Brake backplate nut 1/2" UNF	85 - 103 lbs.ft	115 - 140 NM	(All axles)
2	Brake backplate stud 1/2" UNF	See TD 183/1		(All axles)
8	Swivel top cap	25 - 75 lbs.ft	34 - 102 NM	(All axles)
9	Swivel top cap lubricator	10 - 15 lbs.ft	14 - 20 NM	(All axles)
11	Top lever bolts M20 x 2.5 grade 10.9	433 - 479 lbs.ft	587 - 649 NM	(NDS 35/41/56)
--------	Top lever bolts M20 x 2.5 grade 12.9	520 - 575 lbs.ft	705 - 780NM	(NDS 56)
--------	Top lever bolts M24 x 3 grade 10.9	751 - 830 lbs.ft	1018 - 1125 NM	(NDS 80)
14	Cotter pin nut 1/2" UNF	51 - 61 lbs.ft	69 - 82 NM	(All axles)
23	Lockstop nut	90 - 120 lbs.ft	122 - 162 NM	(All axles)
24 & 25	Bottom lever bolts M20 x 2.5 grade 10.9	433 - 479 lbs.ft	587 - 649 NM	(NDS 35/41/56)
--------	Bottom lever bolts M20 x 2.5 grade 12.9	520 - 575 lbs.ft	705 - 780NM	(NDS 80)
--------	Bottom lever bolts M24 x 3 grade 10.9	751 - 830 lbs.ft	1018 - 1125 NM	(NDS 80)
27	Ball pin nut (F4845T assembly)	155 - 170 lbs.ft	210 - 230 NM	(All axles)
--------	Ball pin nut (F4109T assembly)	184 - 206 lbs.ft	249 - 279 NM	(All axles)
--------	Ball pin nut (F4779S assembly)	100 - 170 lbs.ft	135 - 230 NM	(All axles)
--------	Ball pin nut (F4897S assembly)	190 - 220 lbs.ft	257 - 298 NM	(All axles)
30	Socket pinch bolt (F4845T assembly)	33 - 37 lbs.ft	45 - 50 NM	(All axles)
--------	Socket pinch bolt (F4109T assembly)	52 - 59 lbs.ft	70 - 80 NM	(All axles)
--------	Socket pinch bolt (F4779S assembly)	65 - 75 lbs.ft	88 - 102 NM	(All axles)
--------	Socket pinch bolt (F4897S assembly)	118 - 155 lbs.ft	160 - 210 NM	(All axles)
33	Swivel bottom cap lubricator	10 - 15 lbs.ft	14 - 20 NM	(All axles)
34	Swivel bottom cap	25 - 75 lbs.ft	34 - 102 NM	(All axles)
41	Hub nut	350 - 400 lbs.ft	475 - 542 NM	(NDS 35/41/56)
--------	Hub nut	575 - 626 lbs.ft	778 - 849 NM	(NDS 80)

SWIVEL / AXLE BED TIGHTENING TORQUES

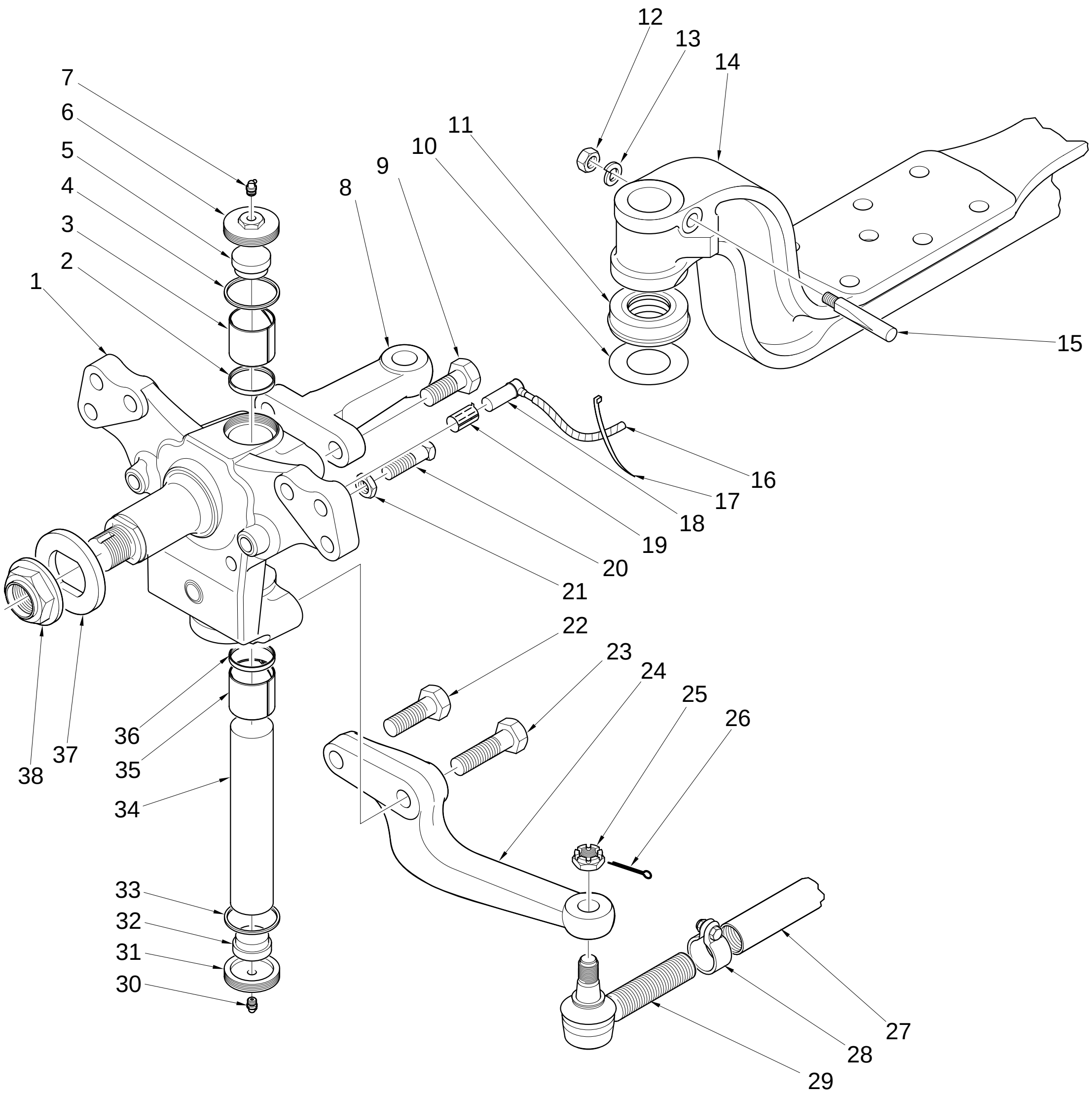


Fig.No.18

PART Nº	DESCRIPTION	TIGHTENING TORQUE		
6	Swivel top cap	25 - 75 lbs.ft	34 - 102 NM	(All axles)
7	Swivel top cap lubricator	10 - 15 lbs.ft	14 - 20 NM	(All axles)
9	Top lever bolts M20 x 2.5 grade 10.9	433 - 479 lbs.ft	587 - 649 NM	(NDS 35/41/56)
	Top lever bolts M20 x 2.5 grade 12.9	520 - 575 lbs.ft	705 - 780NM	(NDS 56)
	Top lever bolts M24 x 3 grade 10.9	751 - 830 lbs.ft	1018 - 1125 NM	(NDS 80)
12	Cotter pin nut 1/2" UNF	51 - 61 lbs.ft	69 - 82 NM	(All axles)
21	Lockstop nut	90 - 120 lbs.ft	122 - 162 NM	(All axles)
22 & 23	Bottom lever bolts M20 x 2.5 grade 10.9	433 - 479 lbs.ft	587 - 649 NM	(NDS 35/41/56)
	Bottom lever bolts M20 x 2.5 grade 12.9	520 - 575 lbs.ft	705 - 780NM	(NDS 80)
	Bottom lever bolts M24 x 3 grade 10.9	751 - 830 lbs.ft	1018 - 1125 NM	(NDS 80)
25	Ball pin nut (F4845T assembly)	155 - 170 lbs.ft	210 - 230 NM	(All axles)
	Ball pin nut (F4109T assembly)	184 - 206 lbs.ft	249 - 279 NM	(All axles)
	Ball pin nut (F4779S assembly)	100 - 170 lbs.ft	135 - 230 NM	(All axles)
	Ball pin nut (F4897S assembly)	190 - 220 lbs.ft	257 - 298 NM	(All axles)
28	Socket pinch bolt (F4845T assembly)	33 - 37 lbs.ft	45 - 50 NM	(All axles)
	Socket pinch bolt (F4109T assembly)	52 - 59 lbs.ft	70 - 80 NM	(All axles)
	Socket pinch bolt (F4779S assembly)	65 - 75 lbs.ft	88 - 102 NM	(All axles)
	Socket pinch bolt (F4897S assembly)	118 - 155 lbs.ft	160 - 210 NM	(All axles)
30	Swivel bottom cap lubricator	10 - 15 lbs.ft	14 - 20 NM	(All axles)
31	Swivel bottom cap	25 - 75 lbs.ft	34 - 102 NM	(All axles)
38	Hub nut	350 - 400 lbs.ft	475 - 542 NM	(NDS 35/41/56)
	Hub nut	575 - 626 lbs.ft	778 - 849 NM	(NDS 80)

SWIVEL / HUB END TIGHTENING TORQUES

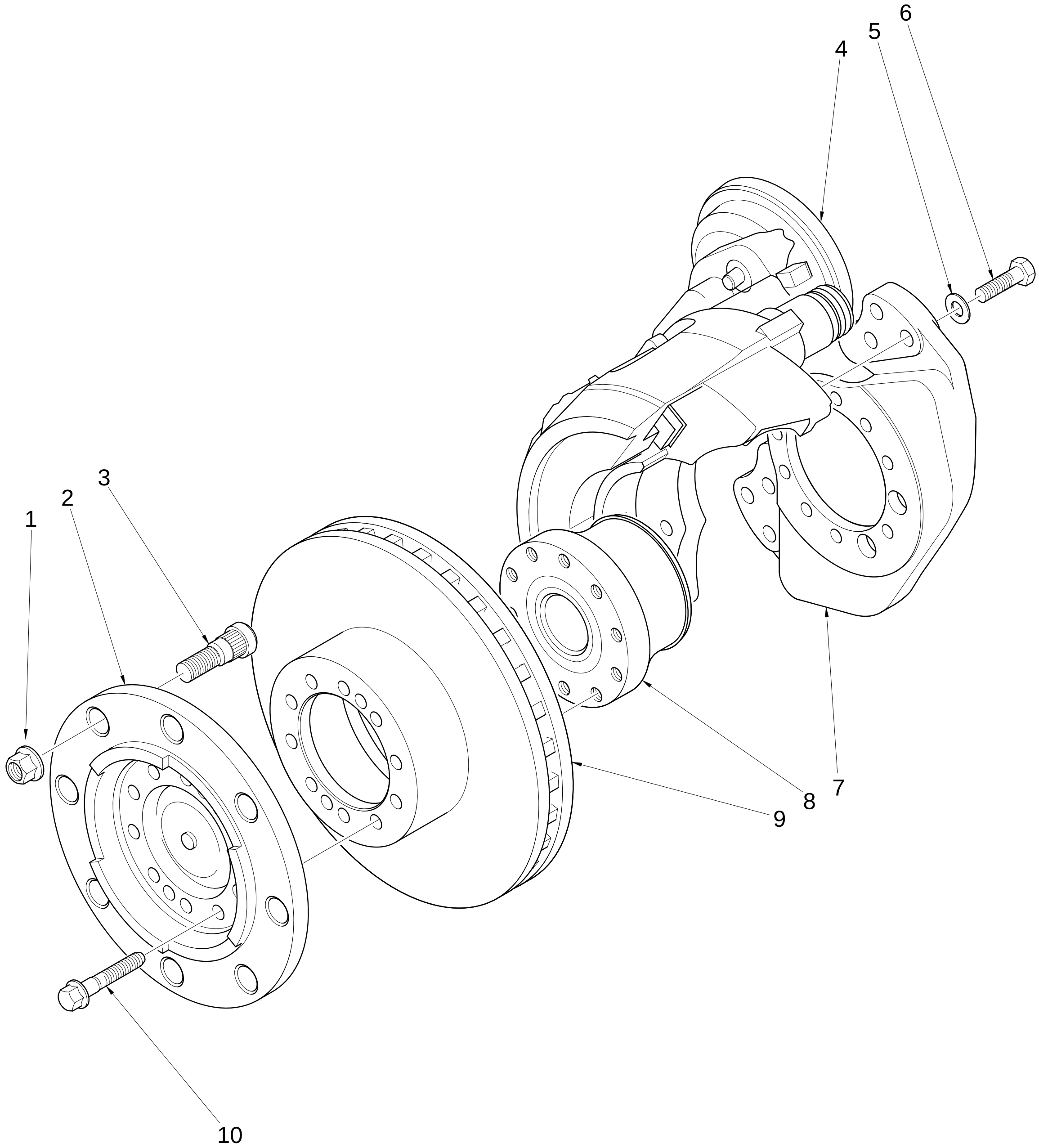


Fig.No.19

PART N°	DESCRIPTION	TIGHTENING TORQUE	
1	Wheel nut M18 x 1.5	235 - 260 lbs.ft	318 - 352NM
	Wheel nut M20 x 1.5	285 - 315 lbs.ft	386 - 427NM
	Wheel nut M22 x 1.5	475 - 525 lbs.ft	644 - 712NM
6	Brake Caliper Mounting Bolt M14 x 1.5	174 - 192 lbs.ft	236 - 260NM
	Brake Caliper Mounting Bolt M16 x 1.5	266 - 294 lbs.ft	360 - 399NM
	Brake Caliper Mounting Bolt M18 x 1.5	372 - 412 lbs.ft	504 - 559NM
	Brake Caliper Mounting Bolt M20 x 1.5	520 - 574 lbs.ft	705 - 778NM
4	Brake air cylinder retaining nuts M16 X 1.5	133 - 155 lbs.ft	180 - 210NM
10	Hub flange retaining bolt M14 x 1.5	174 - 192 lbs.ft	236 - 260NM

SWIVEL / HUB END TIGHTENING TORQUES

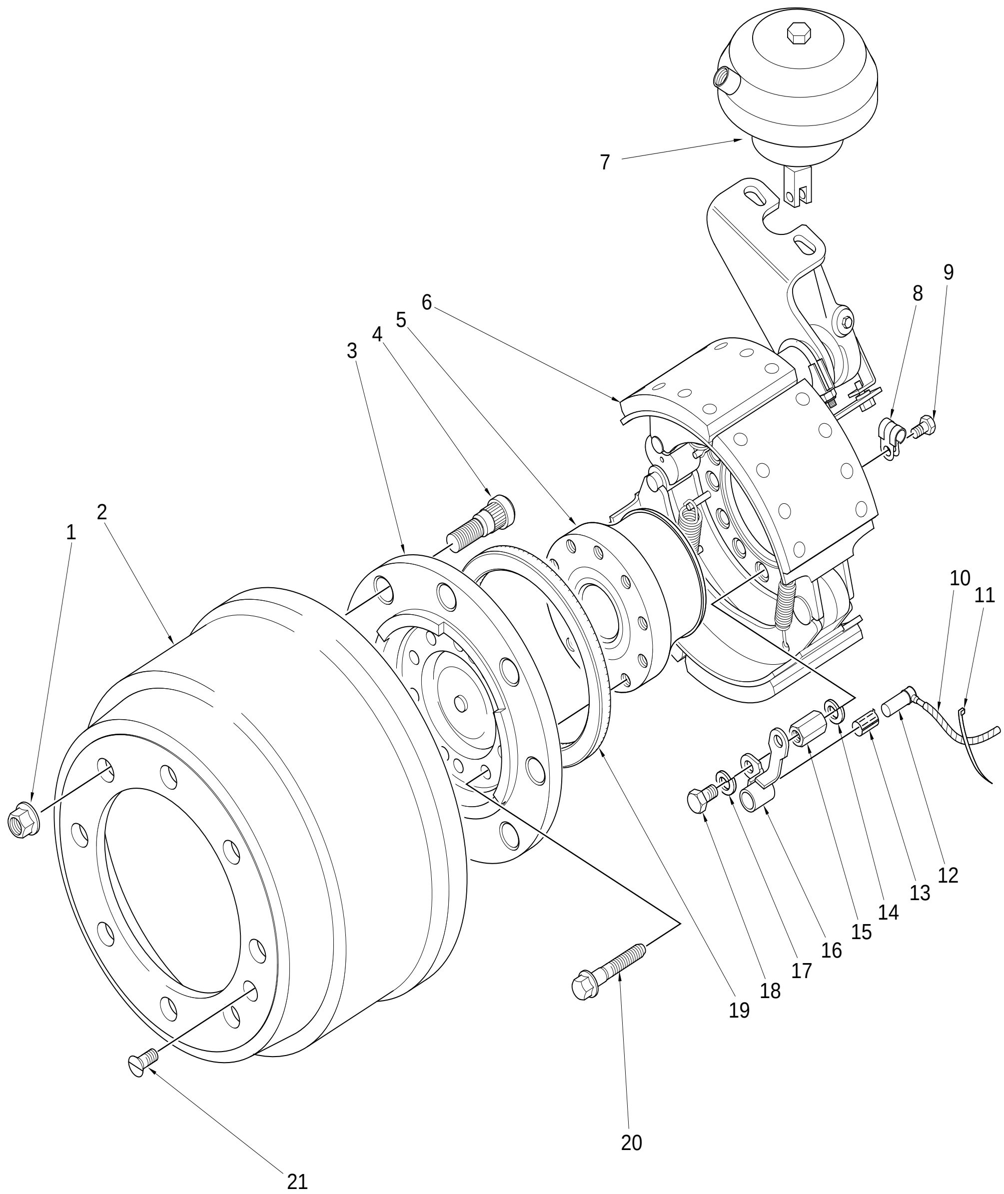


Fig.No.20

PART N°	DESCRIPTION	TIGHTENING TORQUE	
1	Wheel nut M18 x 1.5 --	235 - 260 lbs.ft	318 - 352NM
	Wheel nut M20 x 1.5 --	285 - 315 lbs.ft	386 - 427NM
	Wheel nut M22 x 1.5 --	475 - 525 lbs.ft	644 - 712NM
8	Hub flange retaining bolt M14 x 1.5 ---------------------------	174 - 192 lbs.ft	236 - 260NM
9	Brake drum retaining screw --------------------------------------	26 - 32 lbs.ft	35 - 43NM

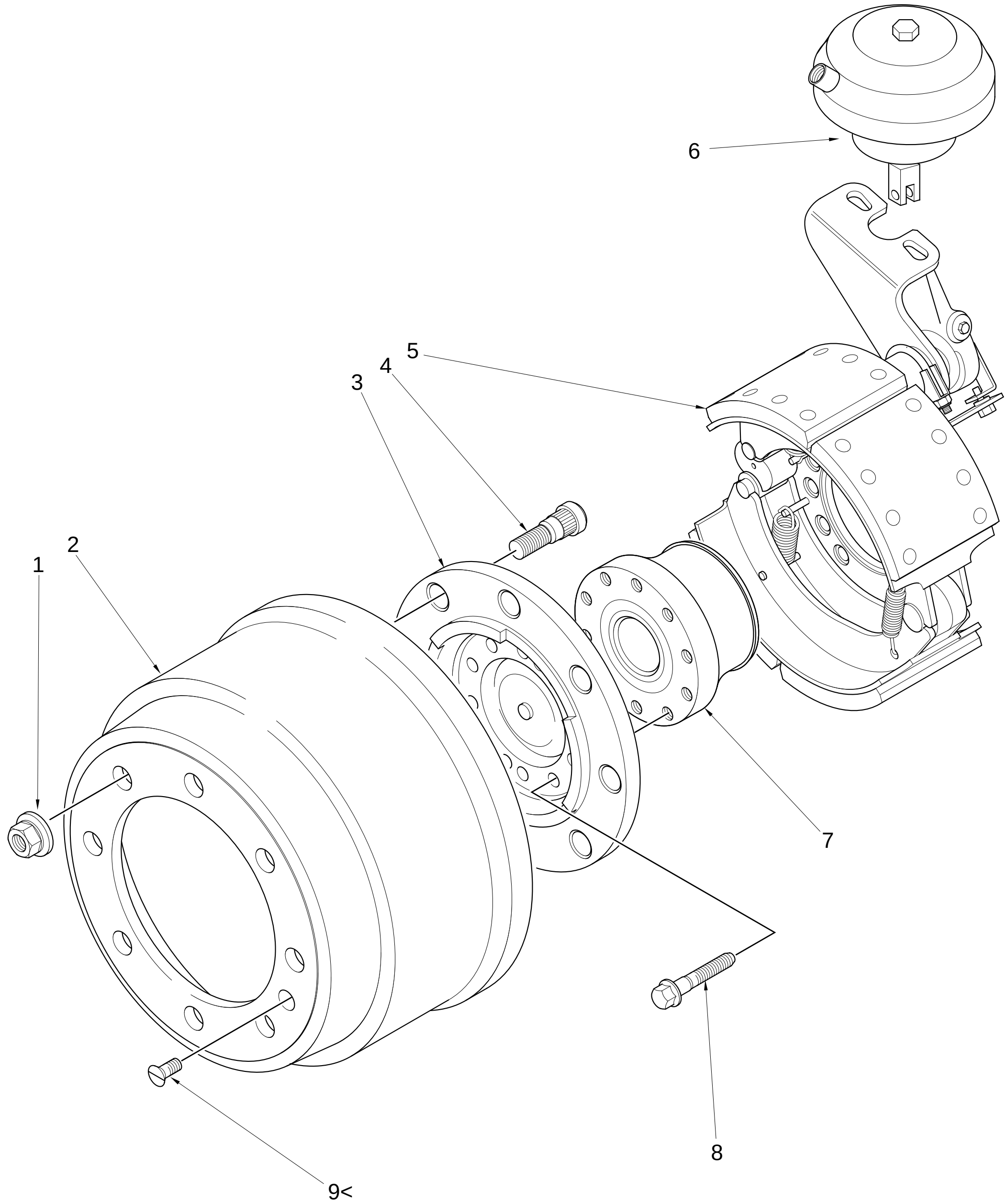


Fig.No.21

PART N°	DESCRIPTION	TIGHTENING TORQUE	
1	Wheel nut M18 x 1.5 --	235 - 260 lbs.ft	318 - 352NM
	Wheel nut M20 x 1.5 --	285 - 315 lbs.ft	386 - 427NM
	Wheel nut M22 x 1.5 --	475 - 525 lbs.ft	644 - 712NM
20	Hub flange retaining bolt M14 x 1.5 ----------------------------	174 - 192 lbs.ft	236 - 260NM
21	Brake drum retaining screw --------------------------------------	26 - 32 lbs.ft	35 - 43NM

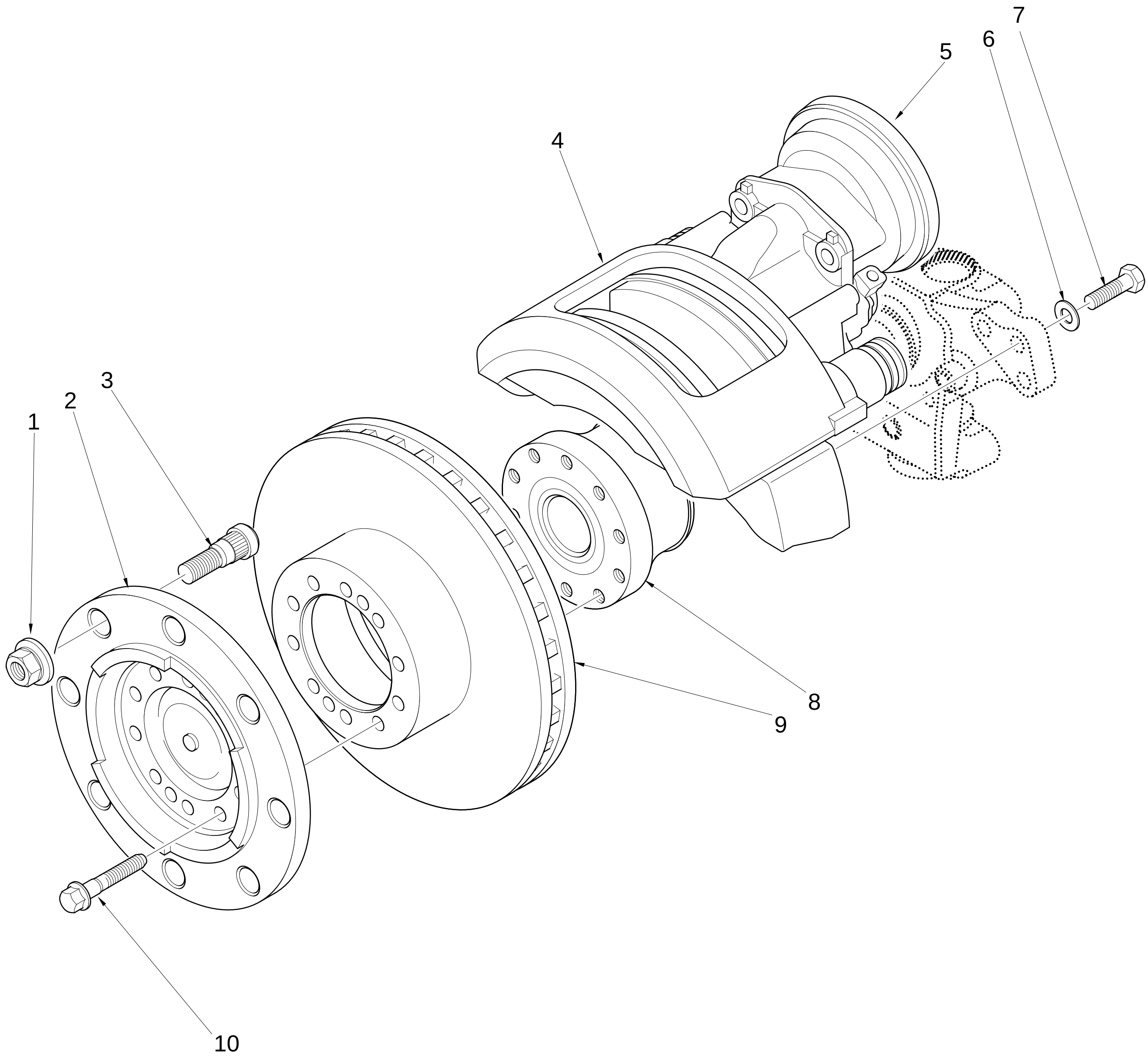


Fig.No.22

PART N^{O}	DESCRIPTION	TIGHTENING TORQUE	
1	Wheel nut M18 x 1.5 --	235 - 260 lbs.ft	318 - 352NM
	Wheel nut M20 x 1.5 --	285 - 315 lbs.ft	386 - 427NM
	Wheel nut M22 x 1.5 --	475 - 525 lbs.ft	644 - 712NM
5	Brake air cylinder retaining nuts M16 X 1.5 ------------------	133 - 155 lbs.ft	180 - 210NM
6	Brake Caliper Mounting Bolt M14 x 1.5 -----------------------	174 - 192 lbs.ft	236 - 260NM
	Brake Caliper Mounting Bolt M16 x 1.5 -----------------------	266 - 294 lbs.ft	360 - 399NM
	Brake Caliper Mounting Bolt M18 x 1.5 -----------------------	372 - 412 lbs.ft	504 - 559NM
	Brake Caliper Mounting Bolt M20 x 1.5 -----------------------	520 - 574 lbs.ft	705 - 778NM
10	Hub flange retaining bolt M14 x 1.5 ---------------------------	174 - 192 lbs.ft	236 - 260NM

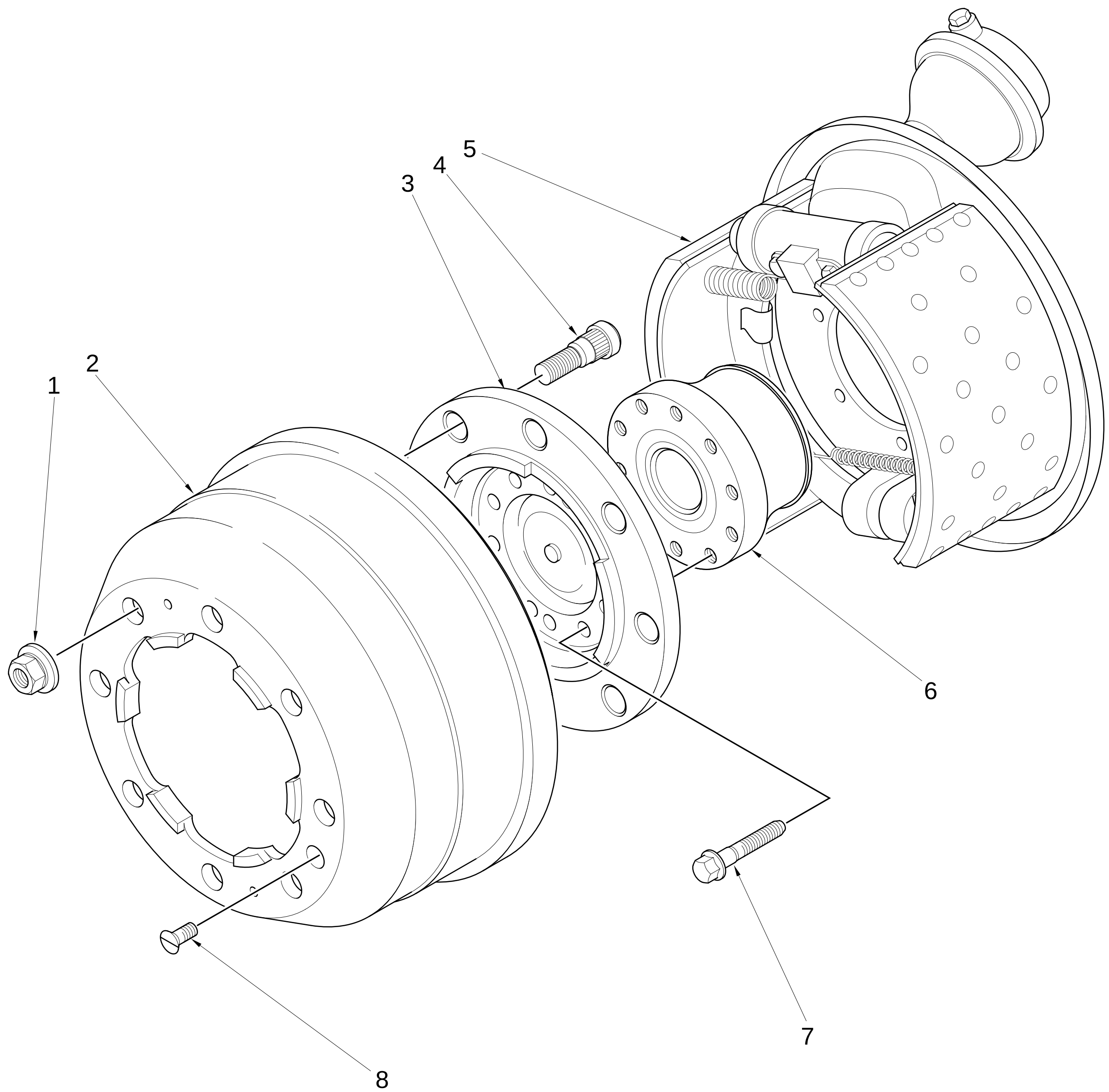


Fig.No.23

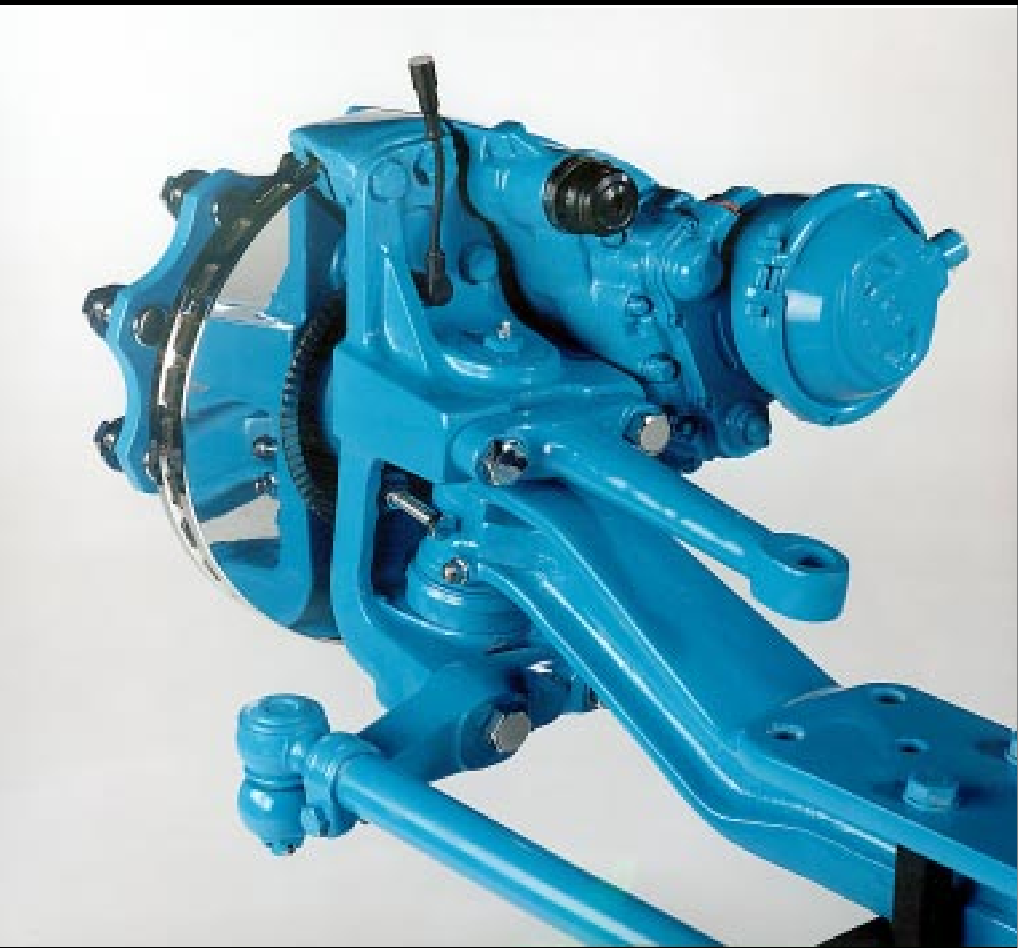
PART N°	DESCRIPTION	TIGHTENING TORQUE	
1	Wheel nut M18 x 1.5	235 - 260 lbs.ft	318 - 352NM
	Wheel nut M20 x 1.5	285 - 315 lbs.ft	386 - 427NM
	Wheel nut M22 x 1.5	475 - 525 lbs.ft	644 - 712NM
7	Hub flange retaining bolt M14 x 1.5	174 - 192 lbs.ft	236 - 260NM
8	Brake drum retaining screw	26 - 32 lbs.ft	35 - 43NM

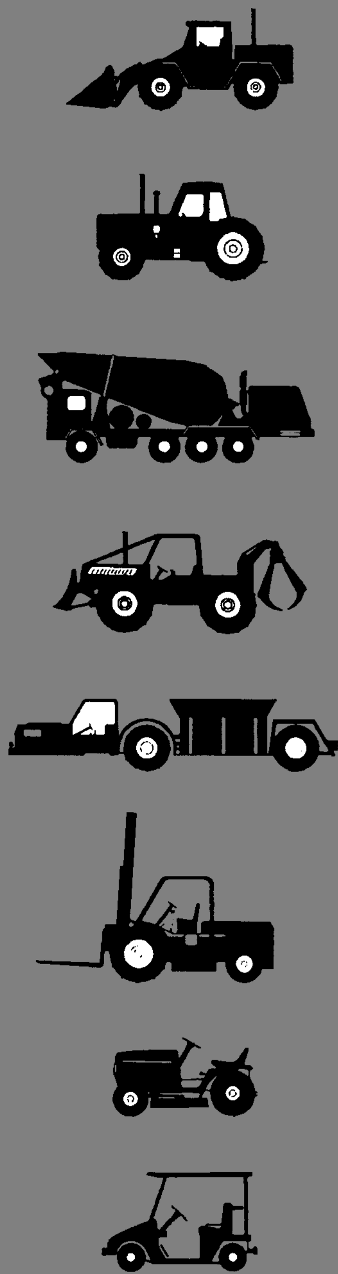
BACK / RETOUR

APPLICATION POLICY
Capability ratings, features and specifications vary depending upon the model type of service. Applications approvals must be obtained from Spicer Speciality Axle Division. We reserve the right to change or modify our product specifications, configurations, or dimensions at any time without notice.

SPICER SPECIALITY AXLE DIVISION
Abbey Road, Kirkstall
Leeds LS5 3NF
England
Tel: (113) 2584611 Fax: (113) 2586097

SERVICE MANUAL
GENERAL INFORMATION
NDS Axle range





SPICER SPECIALITY AXLE DIVISION

DANA

INFORMATION ABOUT THIS MANUAL.

THIS MANUAL IS DIVIDED INTO THE FOLLOWING GENERAL SECTIONS:-

1) GENERAL INFORMATION (this section)
2) LUBRICATION AND MAINTENANCE
3) REMOVAL AND REFITTING OF THE SWIVEL (KNUCKLE) ASSEMBLY
4) REMOVAL AND REFITTING OF THE BRAKE ASSEMBLY
5) PARTS IDENTIFICATION

The description, testing procedures, and specifications contained in this parts / service publication were current at time of printing. This manual will not be updated. If in doubt about any aspect of maintenance or servicing of the axle please contact the vehicle builder or our service department direct.

Spicer Speciality Axle Division products are subject to continual development and we reserve the right to modify procedures and to make changes in specifications at any time without prior notice and without incurring obligation.

The recommendations of the vehicle manufacturer should be considered as the primary source of service information regarding this SPICER® product. This manual is intended to be used as a supplement to such information.

Any references to brand names in this publication is made simply as an example of the types of tools and materials recommended for use and, as such, should not be considered as an endorsement.

Spicer Speciality Axle division recommends following all manufacturers recommendations for the proper handling and disposal of lubricants and solvents. For further information please contact the supplier of lubricants and solvents.

IMPORTANT NOTICE

THIS SYMBOL IS USED THROUGHOUT THIS MANUAL, TO CALL ATTENTION TO PROCEDURES WHERE CARELESSNESS OR FAILURE TO FOLLOW SPECIFIC INSTRUCTIONS MAY RESULT IN PERSONAL INJURY OR COMPONENT DAMAGE.
DEPARTURE FROM THE INSTRUCTIONS, CHOICE OF TOOLS, MATERIALS AND RECOMMENDED PARTS MENTIONED IN THIS PUBLICATION MAY JEPORDISE THE PERSONAL SAFETY OF THE SERVICE TECHNICIAN OR VEHICLE OPERATOR.

SPICER SPECIALITY AXLE DIVISION URGES CAUTION WHEN PERFORMING ANY SERVICE OR MAINTENANCE PROCEDURE

WARNING: FAILURE TO FOLLOW INDICATED PROCEDURES CREATES A HIGH RISK OF PERSONAL INJURY TO THE SERVICE TECHNICIAN.

NOTE: FAILURE TO FOLLOW INDICATED PROCEDURES MAY CAUSE COMPONENT DAMAGE OR MALFUNCTION

FOR EASE OF ASSEMBLY / DISASSEMBLY:

HELPFUL REMOVAL / INSTALLATION PROCEDURES TO AID IN THE SERVICE OF YOUR NDS AXLE

ANY ERRORS OR OMISSIONS MAY BE REPORTED TO :

THE TECHNICAL PUBLICATIONS DEPARTMENT
SPICER SPECIALITY AXLE DIVISION
ABBEY ROAD
KIRKSTALL
LEEDS
LS5 3NF
TEL: 0044-113-2584611
FAX: 0044-113-2091115

WARNINGS!

NON ASBESTOS FIBRES!
ALTHOUGH NON OF THE BRAKE LININGS USED ON THE NDS RANGE OF AXLES CONTAIN ASBESTOS.
IT SHOULD BE NOTED THAT NON ASBESTOS BRAKE LININGS CAN STILL CONTAIN INGREDIENTS WHICH CAN PRESENT HEALTH RISKS IF INHALED.
ACCORDINGLY CARE SHOULD BE TAKEN TO AVOID THE CREATION AND INHALATION OF DUST WHEN BRAKES ARE SERVICED.
FURTHER DETAILS SHOULD BE OBTAINED FROM YOUR EMPLOYER OR THE BRAKE MANUFACTURER!

PERSONAL INJURY!
TO PREVENT PERSONAL INJURY, ALWAYS WEAR APPROPRIATE PERSONAL PROTECTION EQUIPMENT (P.P.E) WHEN PERFORMING ANY MAINTENANCE WORK.

SOLVENT CLEANERS!
IF SOLVENT BASED CLEANERS ARE TO BE USED, THE MANUFACTURERS INSTRUCTIONS SHOULD BE CAREFULLY FOLLOWED AS WELL AS TAKING THE FOLLOWING BASIC PRECAUTIONS:-

1) WEAR EYE PROTECTION!
2) WEAR PROTECTIVE CLOTHING!
3) WORK IN A WELL VENTILATED AREA!
4) DO NOT USE PETROLIUM (GASOLINE) BASED PRODUCTS DUE TO THE RISK OF FIRE AND / OR EXPLOSION!

ON NO ACCOUNT SHOULD SOLVENT CLEANERS BE USED ON ANY OF THE BEARING COMPONENTS CONTAINED IN YOUR NDS RANGE AXLE

NOTE:
WELDING , MACHINING OR MODIFICATION OF ANY AXLE COMPONENT IS PROHIBITED UNLESS NOTED IN THIS MANUAL, OR OTHER SPICER SPECIALITY AXLE DIVISION SERVICE LITERATURE.

GLOSSARY OF TERMS

Due to the international nature of Spicer Speciality Axle Division products certain terms and wordsrequire clarification; hence the following list:-

ENGLISH	U.S.A
SWIVEL	KNUCKLE
COTTER PIN	DRAW KEY
AXLE BED	I BEAM
STEERING LEVER	TIE ROD ARM
HUB NUT	SPINDLE NUT
SWIVEL STOP SCREW	STOP BOLT
TOP / BOTTOM CAP	KING PIN CAP
BUSHES	BUSHINGS
LUBRICATOR	ZIRC

GENUINE SPICER SERVICE PARTS

Should an axle assembly require replacement component parts, it is recommended that Spicer Speciality Axle Division service parts be used. Spicer Speciality Axle Division service parts are manufactured under the same rigid specification as are the original equipment axle components. This assures the customer who uses genuine Spicer Speciality Axle Division service parts, maximum reliability for a Spicer Speciality Axle Division assembly.
Spicer Speciality Axle Division service parts are available through either your vehicle manufacturer or through Spicer Speciality Axle Division spares department.
The use of non Spicer service parts may cause premature component failure and void the warranty.

The items included in the spare parts section of this manual are currently available as service spare parts at the time of printing.
The part numbers and illustrations are provided specifically as a guide only.

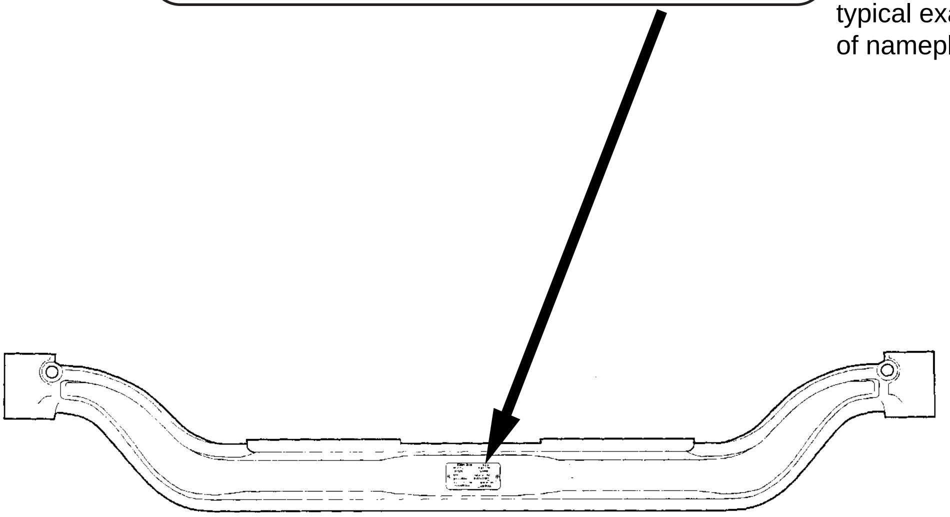
ORDERING SPARE PARTS

In order to assist our spares department when ordering spare parts for your NDS range axle, please have the following information to hand.

1. Axle type
2. Axle list number
3. serial number

These can be found on the axle nameplate situated on the front of the axle bed as shown below:-

typical example
of nameplate



ALWAYS USE GENUINE SPICER® SPARE PARTS!

BACK / RETOUR

APPLICATION POLICY
Capability ratings, features and specifications vary depending upon the model type of service. Applications approvals must be obtained from Spicer Speciality axle division. We reserve the right to change or modify our product specifications, configurations, or dimensions at any time without notice.

SPICER SPECIALITY AXLE DIVISION
ABBEY ROAD
LEEDS LS5 3NF
ENGLAND
TEL (+44-113) 2584611 FAX (+44-113) 2586097

SECTION 11: REAR AXLES

CONTENTS

ILLUSTRATIONS

1. DRIVE AXLE

1.1 DESCRIPTION

The Meritor drive axle is equipped with a single reduction standard carrier mounted in front of the axle housing. The carrier consists of a hypoid drive pinion, a ring gear set and gears in the differential assembly.

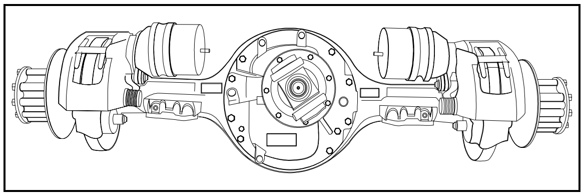


FIGURE 1: DRIVE AXLE 11019

A straight roller bearing (spigot) 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 a normal differential action between the wheels all the time.

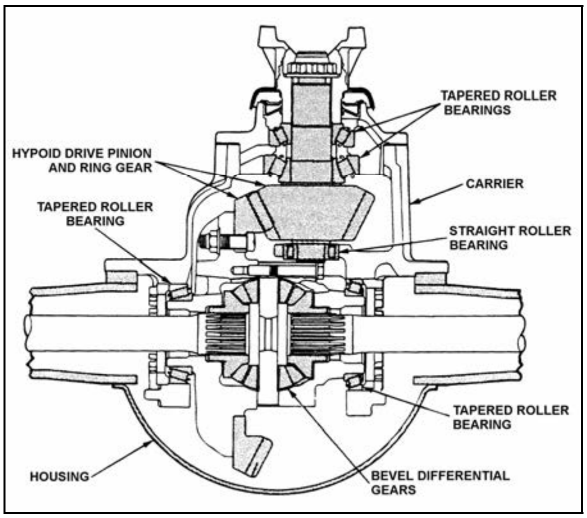


FIGURE 2: DIFFERENTIAL ASSEMBLY 11024

Several speed ratios are available for the drive axle. These ratios depend upon the motor and transmission. Also, special applications may suggest slightly different gear ratios.

1.2 DRIVE AXLE LUBRICATION

Additional lubrication information is covered in the Meritor *"Maintenance Manual No. 5"* annexed to this section. During initial stage of normal operation, tiny metal particles originating from moving parts can be found on mating surfaces. These particles are carried by the lubricant through the assembly and act as lapping compound, which accelerates wear of all parts. To ensure maximum life of the differential and prevent premature failure, the original "factory fill" lubricant should be drained. Change break-in oil before 3,000 miles (4 800 km) of initial operation (drain the unit while it is still warm from operation), in accordance with the lubrication and servicing schedule.

Change differential oil and clean the breathers, magnetic fill and drain plugs, every 100,000 miles (160 000 km) or once every two years, whichever comes first.

Use Multigrade gear oil MIL-L-2105-D. Use the 75W90-gear oil for northern climates and the 80W140 for southern climates. In extreme conditions, or for better performance, fill with synthetic gear oil. Check oil level and add (if necessary) every 6,250 miles (10 000 km) or twice a year, whichever comes first (Fig. 3).

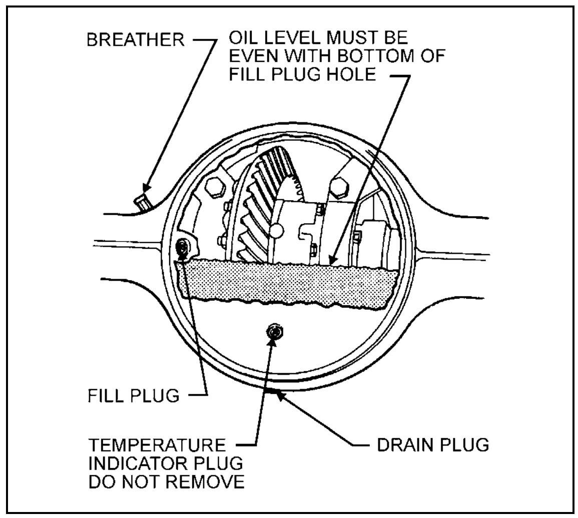


FIGURE 3: DIFFERENTIAL HOUSING BOWL 11007

1.3 MAINTENANCE

Proper vehicle operation begins with preventive maintenance, such as good differential use. The most common types of drive axle carrier failures are spinout, shock, fatigue, overheating and lubrication. Avoid neglecting these points since they would be the first steps to improper maintenance, expensive repairs, and excessive downtime.

Inspect the pinion oil seal, axle shaft flange and carrier housing gaskets for evidence of lubricant leakage. Tighten the bolts and nuts, or replace the gaskets and seals to correct leaks. Maintenance of the axle mountings consists primarily in a regular and systematic inspection of the air suspension units and radius rods, as directed in Section 16, *"Suspension".*

1.3.1 Checking and Adjusting the Oil Level

Warning: *Before servicing, park safely over a repair pit, apply parking brake, stop engine and set battery master switch to the "OFF" position.*

1. Make sure the vehicle is parked on a level surface.

Caution: *Check the oil level when the axle is at room temperature. When hot, the oil temperature may be 190ºF (88ºC) or more and can cause burns. Also, a correct reading is not obtained when the axle is warm or hot.*

2. Make sure the axle is "cold" or at room temperature.
3. Clean the area around the fill plug. Remove the fill plug from the differential axle housing bowl (Fig. 3).
4. The oil level must be even with the bottom of the hole of the fill plug.
   a. If oil flows from the hole when the plug is loosened, the oil level is high. Drain the oil to the correct level.
   b. If the oil level is below the bottom of the hole of the fill plug, add the specified oil.
5. Install and tighten the fill plug to 35-50 Ft-lbs (48-67 Nm).

1.3.2 Draining and Replacing the Oil

Warning: *Before servicing, park safely over a repair pit, apply parking brake, stop engine and set battery master switch to the "OFF" position.*

1. Make sure the vehicle is parked on a level surface. Put a large container under the axle's drain plug.

Note: *Drain the oil when the axle is warm.*

2. Remove the drain plug from the bottom of the axle. Drain and discard the oil in an environment friendly manner.
3. Install and tighten the drain plug to 35-50 Ft-lbs (48-67 Nm).
4. Clean the area around the fill plug. Remove the fill plug from the differential housing bowl.
5. Add the specified oil until the oil level is even with the bottom of the hole of the fill plug. Allow the oil to flow through the axle and check the oil level again (lube capacity 41 pints [13,3 liters]).

Caution: *The differential overheats when the oil temperature rises above 250ºF (120º*C).

6. Install and tighten the fill plug to 35-50 Ft-lbs (48-67 Nm).

1.3.3 Speed Sensors (Anti-Lock Brake system, ABS)

For removing and installing the drive axle speed sensors (for anti-lock brake systems, ABS), refer to Section 12: *''Brake and Air System''* and to Rockwell WABCO Maintenance Manual: *"Anti-Lock Brake Systems For Trucks, Tractors and Buses"*, annexed at the end of section 12.

1.4 REMOVAL AND REINSTALLATION

The following procedure deals with the removal of the drive axle assembly and its attachments as a unit. The method used to support the axle during removal and disassembly depends upon local conditions and available equipment.

1. Raise vehicle by its jacking points on the body (fig. 4 or see Section 18, *"Body"* under heading *"Vehicle Jacking Points").* Place jack stands under frame. Remove drive axle wheels (if required, refer to Section 13, *"Wheels, Hubs And Tires".*

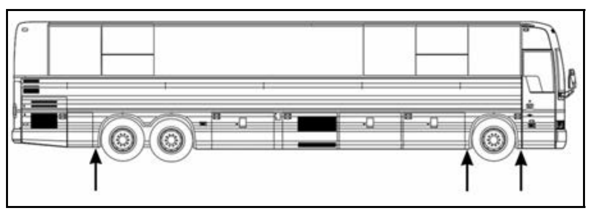


FIGURE 4: JACKING POINTS ON FRAME 11020

2. Exhaust compressed air from the air supply system by opening the drain cock on each air reservoir.
3. Disconnect the propeller shaft as directed in Section 9, *"Propeller Shaft",* in this manual.
4. On both sides of the vehicle, unscrew fasteners retaining front wheel housing plastic guards, and remove them from vehicle.

5. Disconnect both height control valve links from air spring mounting plate brackets then move the arm down to exhaust air suspension.
6. Remove cable ties securing the ABS cables (if vehicle is so equipped) to service brake chamber hoses. Disconnect the ABS cable plugs from the drive axle wheel hubs.

Note: *When removing drive axle, if unfastening cable ties is necessary for ease of operation, remember to replace them afterwards.*

7. Disconnect the brake chamber hoses.

Note: *Position the hoses so they will not be damaged when removing the axle.*

8. Install jacks under the axle jacking points to support the axle weight (refer to figure 5).

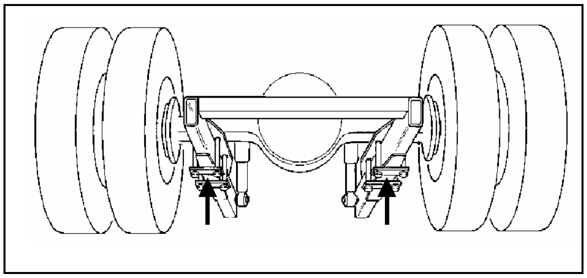


FIGURE 5: JACKING POINTS ON DRIVE AXLE H3B762

9. Remove the four shock absorbers as outlined in Section 16, *"Suspension"* under heading *"Shock Absorber Removal".*
10. Remove the sway bar.
11. Remove the lower and upper longitudinal radius rod supports from vehicle sub-frame as outlined in Section 16, *"Suspension",* under heading *"Radius Rod Removal".*
12. Remove the transversal radius rod support from the vehicle sub-frame.
13. Remove the two retaining nuts from each of the four air bellows lower mounting supports.
14. Use the jacks to lower axle. Carefully pull away the jacks axle assembly from underneath vehicle.
15. Reverse removal procedure to reinstall drive axle.

Note: *Refer to Section 16, "Suspension" for suspension components' proper tightening torques.*

Note: *Refer to section 13 "Wheels, Hubs And Tires" for correct wheel bearing adjustment procedure.*

1.5 DISASSEMBLY AND REASSEMBLY

Disassembly and re-assembly procedures are covered under applicable headings in Meritor's *"MAINTENANCE MANUAL, NO. 5",* annexed to this section.

1.6 GEAR SET IDENTIFICATION

Gear set identification is covered under applicable heading in Meritor's *"MAINTENANCE MANUAL NO. 5",* annexed to this section.

1.7 ADJUSTMENTS

Adjustments are covered under applicable headings in Meritor's *"MAINTENANCE MANUAL NO. 5",* annexed to this section.

1.8 FASTENER TORQUE CHART

A differential fastener torque chart is provided in Meritor's *"MAINTENANCE MANUAL NO. 5",* annexed to this section.

1.9 TIRE MATCHING

Drive axle tire matching is covered under the applicable heading in Section 13, *"Wheels, Hubs And Tires"* in this manual.

1.10 DRIVE AXLE ALIGNMENT

Note: For *drive axle alignment specifications, refer to paragraph 3: "Specifications" in this section.*

The drive axle alignment consists in aligning the axle according to the frame. The axle must be perpendicular to the frame. The alignment is achieved with the use of shims inserted between the lower longitudinal radius rod supports and the frame.

Drive axle alignment is factory set and is not subject to any change, except if the vehicle has been damaged by an accident or if there are requirements for replacement.

If the axle has been removed for repairs or servicing and if all the parts are reinstalled exactly in the same place, the axle alignment is not necessary. However, if the suspension supports have been replaced or altered, proceed with the following instructions to verify or adjust the drive axle alignment.

Note: *When drive axle alignment is modified, tag axle alignment must be re-verified.*

1.10.1 Procedure

1. Park vehicle on a level surface, then chock front vehicle wheels.
2. Using two jacking points (which are at least 30 inches [76 cm] apart) on drive axle, raise the vehicle sufficiently so that wheels can turn freely at about ½ inch from ground. Secure in this position with safety stands, and release parking brake.
3. Install wheel mount sensors on front and drive axles (fig. 6). Adjust front axle according to appropriate specifications chart below.

Note : *See reference numbers on wheel mount sensors (fig. 6).*

Note: *Select axle specifications in the appropriate chart.*

FRONT AXLE VEHICLES EQUIPPED WITH I-BEAM FRONT AXLE			
Alignment / value	Minimum value	Nominal value	Maximum value
Right camber (degrees)	-0.250	0.125	0.375
Left camber (degrees)	-0.250	0.125	0.375
Right caster (degrees)	2	2.75	3.5
Left caster (degrees)	2	2.75	3.5
Total toe (degrees)	0.08	0.13	0.17

DRIVE AXLE ALIGNMENT

- With the system installed as for front axle alignment (fig.6), adjust drive axle according to specifications' chart below.

DRIVE AXLE ALL VEHICLES			
Alignment / value	Minimum value	Nominal value	Maximum value
Thrust angle (deg.)	-0.04	0	0.04

TAG AXLE ALIGNMENT

- Remove and reinstall all wheel mount sensors on the drive and tag axles (fig. 7);

Note *: For an accurate alignment, the tag axle must be aligned with the drive axle.*

Note *: Reinstall wheel mount sensors as shown in figure 7. For example, the sensor from the right side of the front axle is mounted on the left side of the tag axle. For corresponding wheel mount sensor reference numbers, refer to figure 6.*

- Adjust tag axle according to specifications' chart below in reference with drive axle.

TAG AXLE ALL VEHICLES			
Alignment / value	Minimum value	Nominal value	Maximum value
Parallelism (deg.)	-0.02	0	0.02

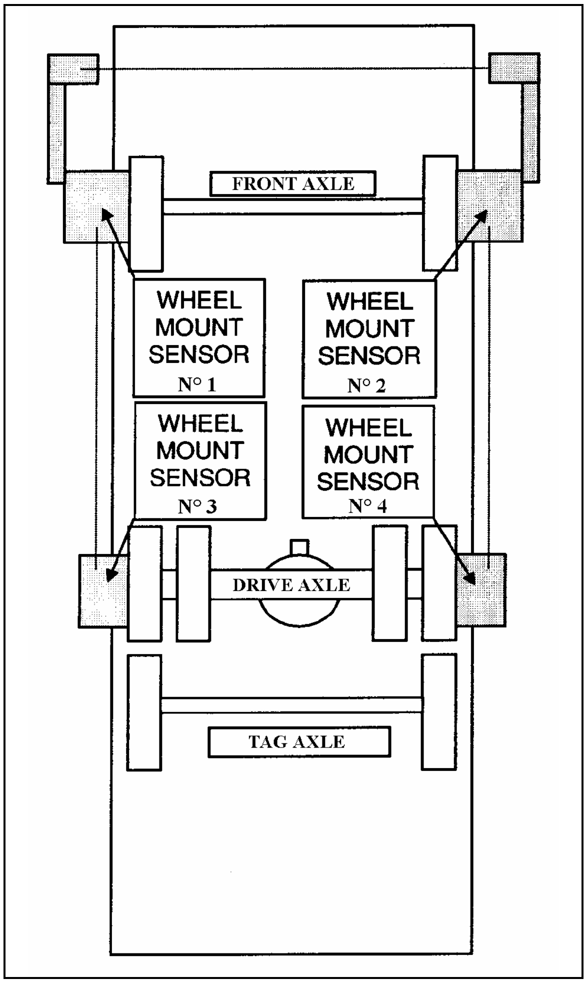


FIGURE 6: FRONT & DRIVE AXLE ALIGNMENT 11025

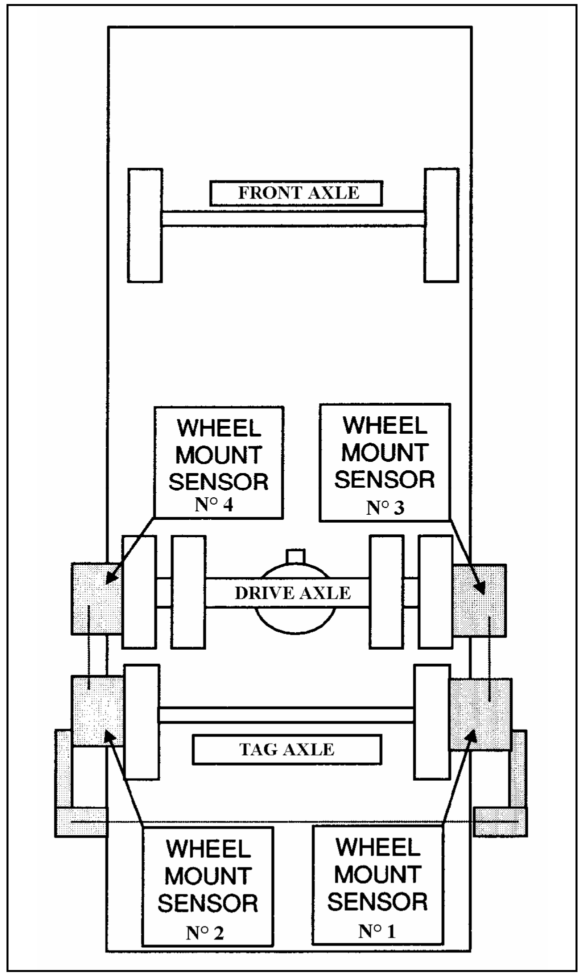


FIGURE 7: TAG AXLE ALIGNMENT 11026

Note: *Refer to Section 16,* "Suspension", *for proper torque tightening of the longitudinal radius rod support nuts.*

Note (2): *When the drive alignment is changed, the tag alignment must also be adjusted.*

1.11 AXLE SHAFT SEALING METHOD

The following method is to be used to ensure that axle shaft installation is fluid-tight:

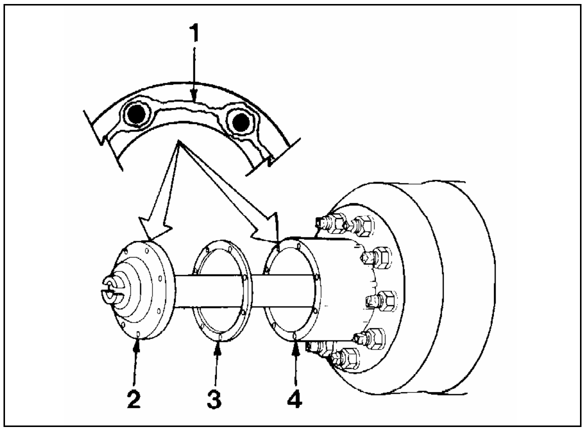


FIGURE 8: AXLE SHAFT INSTALLATION 11003

1 .... Silicone sealant*
2 .... Axle shaft
3 .... Gasket
4 .... Wheel hub

1. Clean the mounting surfaces of both the axle shaft flange and wheel hub where silicone sealant will be applied. Remove all old silicone sealant, oil, grease, dirt and moisture. Dry both surfaces.

2. Apply a continuous thin bead of silicone sealant* (Prévost P/N 680053) on the mounting surfaces and around the edge of all fastener holes of both the axle shaft flange and wheel hub.

* *GENERAL ELECTRIC Silicone Rubber Adhesive Sealant RTV 103 Black.*

Warning: *Carefully read cautions and instructions on the tube of silicone sealant and its packing.*

3. Assemble components immediately to permit the silicone sealant to compress evenly between parts.

   a. Place a new gasket, then install the axle shaft into the wheel hub and differential carrier. The gasket and flange of the axle shaft must fit flat against the wheel hub.

   b. Install the tapered dowels at each stud and into the flange of the axle shaft. Use a punch or drift and hammer if needed.

   c. Install the lock washers and nuts on the studs. Tighten nuts to the correct torque value.

Note: *Torque values are for fasteners that have a light application of oil on the threads (refer to Meritor Maintenance Manual).*

9/16-18 plain nut: 110 – 165 Ft-lbs(149 – 224 Nm)

5/8-18 plain nut: 150 - 230 Ft-lbs (203 - 312 Nm)

2. TAG AXLE

The tag axle is located behind the drive axle. It carries a single wheel and tire on each side. One optional system allows unloading of the tag axle air springs without raising the axle, while the other system enables unloading and raising of the tag axle (refer to the *"OPERATOR'S MANUAL"* for location of controls). Both these systems have been designed for the following purposes:

1. Shortening of wheelbase, thus allowing tighter turning in tight maneuvering areas such as parking lots or when making a sharp turn.

2. Transferring extra weight and additional traction to the drive wheels on slippery surfaces.

Caution: *Never exceed 30 mph (50 km/h) with tag axle up or unloaded and resume normal driving as soon as possible.*

The tag axle service brakes operate only when the axle is in normal driving (loaded) position.

2.1 GREASE LUBRICATED WHEEL BEARINGS

The unitized hub bearings used on the NDS range of axles, are non-serviceable items. Bearings are pre-adjusted, lubricated and have seals fitted as part of the manufacturing process. The bearings are greased for life and there is no need or facility for re-lubrication

Front and tag axle hub bearings need to be checked every 30,000 miles (48 000 km).

Note: *For more information on front and tag axle wheel hub, refer to "DANA SPICER Maintenance Manual Model NDS and Maintenance Manual NDS Axles" annexed at the end of Section 10.*

2.2 REMOVAL AND REINSTALLATION

The following procedure deals with the removal of the tag axle assembly along with the suspension components. The method used to support the axle and suspension components during removal and disassembly depends upon local conditions and available equipment.

1. Raise vehicle by its jacking points on the body (fig. 4 or see Section 18, *"Body"* under heading : *"Vehicle Jacking Points").* Place jack under frame. Remove drive axle wheels (if required, refer to Section 13, *"Wheels, Hubs And Tires"*).
2. Exhaust compressed air from the air supply system by opening the drain cock on each air reservoir and deplete air bags by moving leveling valve arm down.
3. Install jacks under tag axle jacking points to support the axle weight (refer to figure 10).

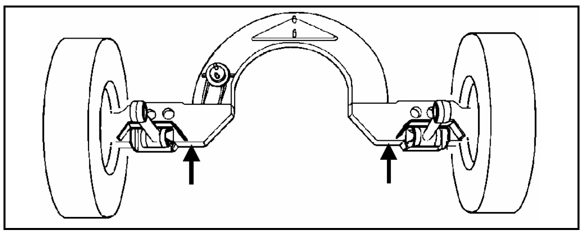


FIGURE 9: JACKING POINTS ON TAG AXLE 11023

4. Applies only to vehicles equipped with retractable tag axles: Disconnect tag axle lifting chain collars from lower longitudinal radius rods.
5. Remove the propeller shaft as directed in Section 9, *"Propeller Shaft",* in this manual.
6. Disconnect the tag axle brake chamber hoses.

Caution : *Position the hoses so they will not be damaged when removing axle.*

7. Disconnect hose from the air spring upper mounting plate.
8. Remove the two shock absorbers as outlined in Section 16, *"Suspension",* under *"Shock Absorber Removal".*
9. Disconnect the lower longitudinal radius rods as outlined in Section 16, *"Suspension",* under *"Radius Rod Removal".*
10. Disconnect the transversal radius rod.
11. Disconnect the upper longitudinal radius rod.
12. Remove the air bellows retaining nuts from each of the two upper mounting plates.
13. Use the jacks to move the axle forward to clear the axle off the transmission. Lower the axle.

Caution: *On vehicles equipped with an automatic transmission (with or without the output retarder), move tag assembly very carefully. Pay special attention to the U-shaped section, as the transmission end components may be easily damaged through a false maneuver.*

14. Reverse removal procedure to reinstall tag axle.

Note: *Refer to Section 16*, *"Suspension"*, *for proper torque tightening of suspension components.*

Note: *Refer to section* 13 *"Wheels, Hubs And Tires" for correct wheel bearing adjustment procedure.*

2.3 TAG AXLE ALIGNMENT

The tag axle alignment consists in aligning the tag axle parallel to the drive axle position. Before aligning the tag axle, proceed with the drive axle alignment (paragraph 1.10). Tag axle alignment is achieved with the use of shims inserted between the lower longitudinal radius rod supports and axle. Tag axle alignment is factory set and is not subject to any change, except if vehicle has been damaged by an accident or if there are requirements for parts replacement.

Caution: *If this setting is altered significantly, it will cause excessive tire wear.*

Note: *It may be necessary to adjust the axle TOE as well as its alignment. In this case, insert shims (7 min. - P/N 121203 or 15 min. - P/N 121240) in between mounting plate and spindle, as required.*

If axle has been removed for repair or servicing and if all parts are reinstalled exactly in their previous locations, axle alignment is not necessary. However, if the suspension supports have been replaced or have changed position, proceed with the following instructions to verify or adjust the tag axle alignment.

3. SPECIFICATIONS

Drive Axle

Make .... Meritor
Drive track .... 76.7 inches (1 949 mm)
Gear type .... Hypoid
Axle type .... Full floating
Lube capacity .... 41 pints (19,3 liters)

Drive axle ratio

World Transmission

4.88:1 Standard
4.56:1 Optional

Note: *The drive axle alignment consists in aligning the axle with reference to the frame. The axle must be perpendicular to the frame.*

Tag Axle

Make .... Prévost
Rear track .... 83.6 inches (2 124 mm)
Axle type .... Dana Spicer Europe TS8U Hub Unit

Note: *The tag axle alignment consists in aligning the tag axle parallel to the drive axle.*

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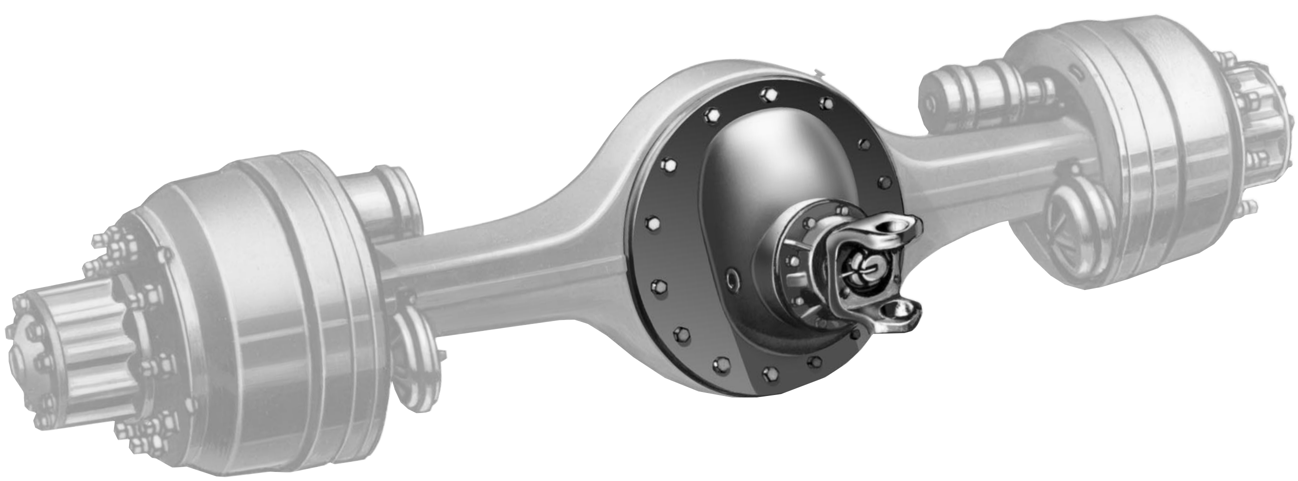
Single Reduction Differential Carriers

Maintenance Manual 5



Standard Carriers Including: Single Axles, Rear of Tandem Axles, Front Drive Steering Axles

Excluding RS and RT Series (Rear Only), Single Reduction Axles and RF Series Front Drive Axles

Before You Begin

This manual provides instructions for Meritor's early production non-RF, -RS or -RT Series axles. Before you begin procedures:

1. Read and understand all instructions an procedures before you begin to service components.
2. Read and observe all Caution and Warning safety alerts that precede instructions or procedures you will perform. These alerts help to avoid damage to components, serious personal injury, or both.
3. Follow your company's maintenance and service, installation, and diagnostics guidelines.
4. Use special tools when required to help avoid serious personal injury and damage to components.

Safety Alerts, Torque Symbol and Notes

WARNING	A Warning alerts you to an instruction or procedure that you must follow exactly to avoid serious personal injury and damage to components.
CAUTION	A Caution alerts you to an instruction or procedure that you must follow exactly to avoid damage to components and possible serious injury.
T	A torque symbol alerts you to tighten fasteners to a specified torque value.
NOTE	A Note provides information or suggestions that help you correctly service a component.

Access Information on ArvinMeritor's Web Site

Additional maintenance and service information for ArvinMeritor's commercial vehicle systems component lineup is also available at www.arvinmeritor.com.

To access information, click on Products & Services/Tech Library Icon/HVS Publications. The screen will display an index of publications by type.

Additional Information

For complete maintenance and service procedures for all single reduction differential carriers, call ArvinMeritor's Customer Service Center at 800-535-5560 to order the following publications.

- *Traction Controls* package contains two videos — *Splitting the Difference* T-87127V and *Driver-Controlled Full Locking Main Differential* T-9007V. $50. Order T-95125V for this package or each video is available individually as well.
- *Technical Electronic Library* on CD. Features product and service information on most ArvinMeritor, ZF Meritor and Meritor WABCO components. $20. Order TP-9853.

MERITOR®

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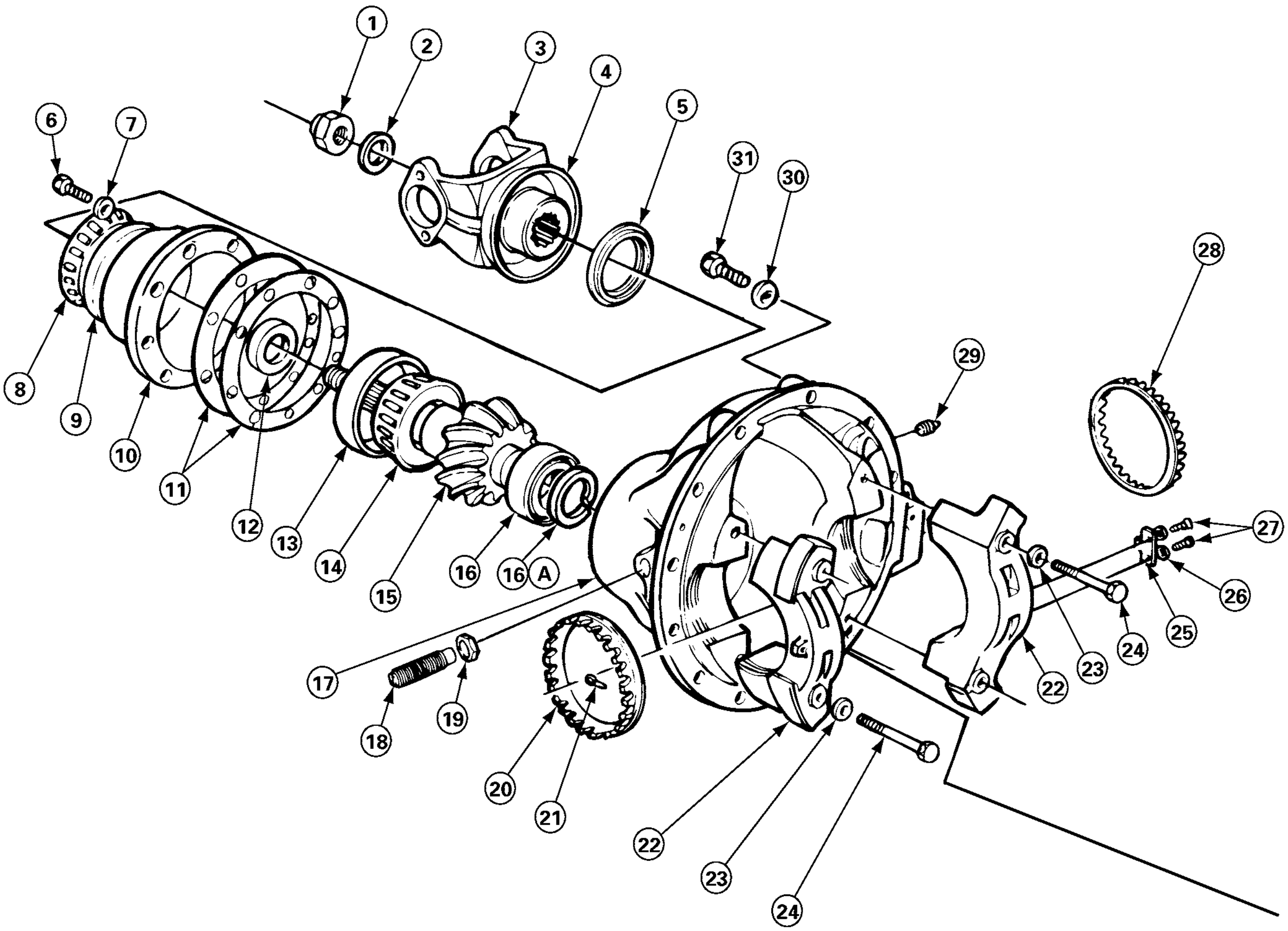
MERITOR®

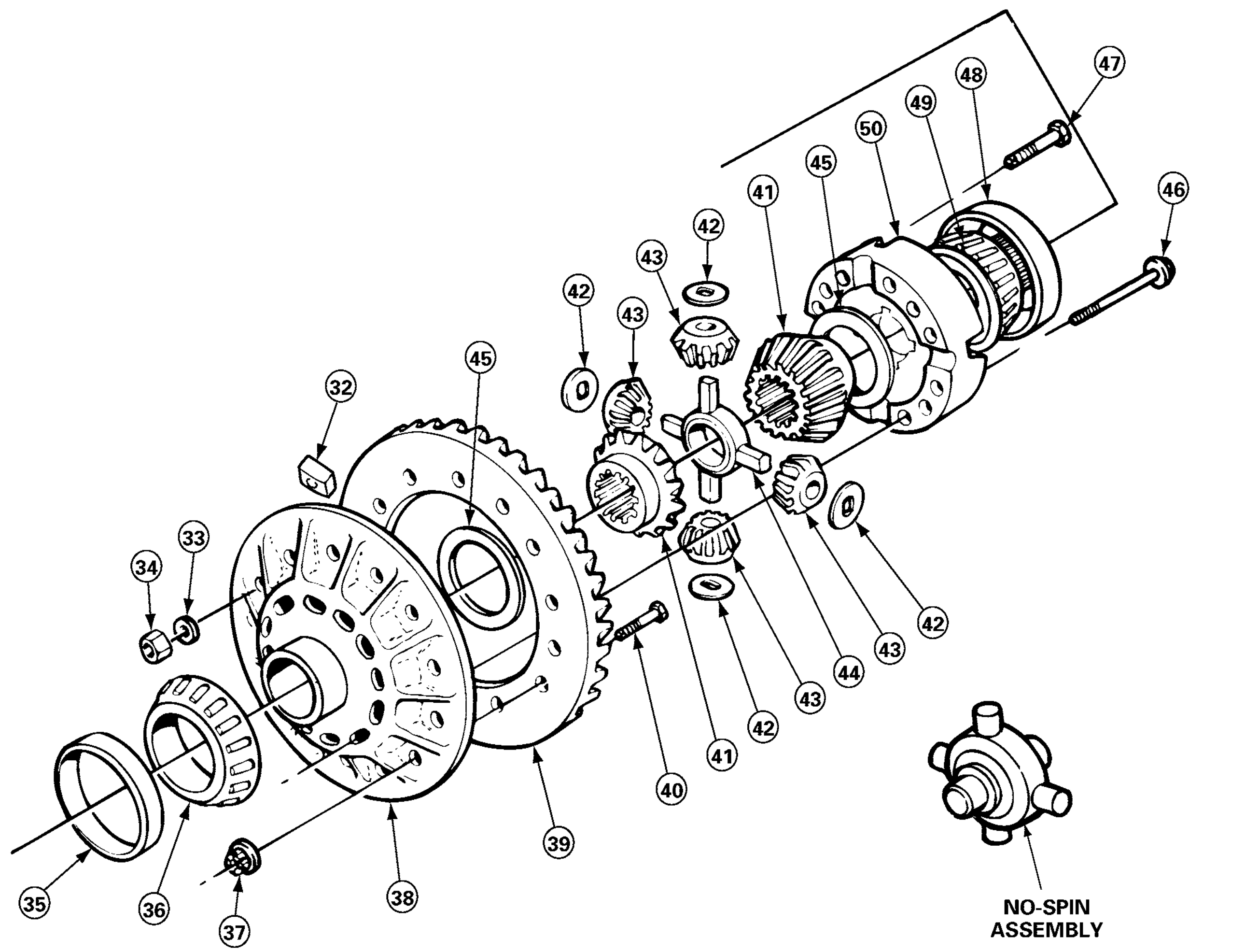
Exploded View — Legend

1	Nut — Drive Pinion	26	Washers* — Lock Plate
2	Washer — Drive Pinion*	27	Capscrews* — Lock Plate*
3	Input Yoke* or Flange*	28	Adjusting Ring — R.H.
4	Deflector	29	Plug* — Oil Fill Hole (carrier)
5	Oil Seal	30	Washer* — Capscrew/Plug*
6	Capscrew — Bearing Cage	31	Capscrew/Plug — Sensor Hole
7	Washer	32	Thrust Block*
8	Bearing Cone — Pinion Outer	33	Washers* — Differential Case
9	Bearing Cup — Pinion Outer	34	Nuts* — Differential Case
10	Bearing Cage — Drive Pinion	35	Bearing Cup — Differential L.H.
11	Shims	36	Bearing Cone — Differential L.H.
12	Spacer— Pinion Bearing	37	Nuts* — Ring Gear and Case Half
13	Bearing Cup — Pinion Inner	38	Case Half — Flange
14	Bearing Cone — Pinion Inner	39	Ring Gear
15	Drive Pinion	40	Bolts* or Rivets* — Ring Gear and Case Half
16	Spigot Bearing	41	Side Gears —Differential
16A	Snap Ring	42	Thrust Washers — Differential Pinion
17	Carrier	43	Pinions — Differential
18	Thrust Screw*	44	Spider — Differential
19	Jam Nut* — Thrust Screw*	45	Thrust Washers — Differential Side Gear
20	Adjusting Ring — L.H.	46	Capscrews — Differential Case
21	Cotter* or Pin*	47	Bolts* — Differential Case
22	Caps — Differential Bearing	48	Bearing Cup — Differential R.H.
23	Washers	49	Bearing Cone — Differential R.H.
24	Capscrews — Differential Bearing Cap	50	Case Half — Plain
25	Lock Plate* — Adjusting Ring		

* Some Meritor carriers do not have these described parts.

Single Reduction Differential Carrier

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ASSEMBLY

Standard Single Reduction Carriers

NOTE: For carriers with a differential lock, refer to Maintenance Manual 5A.

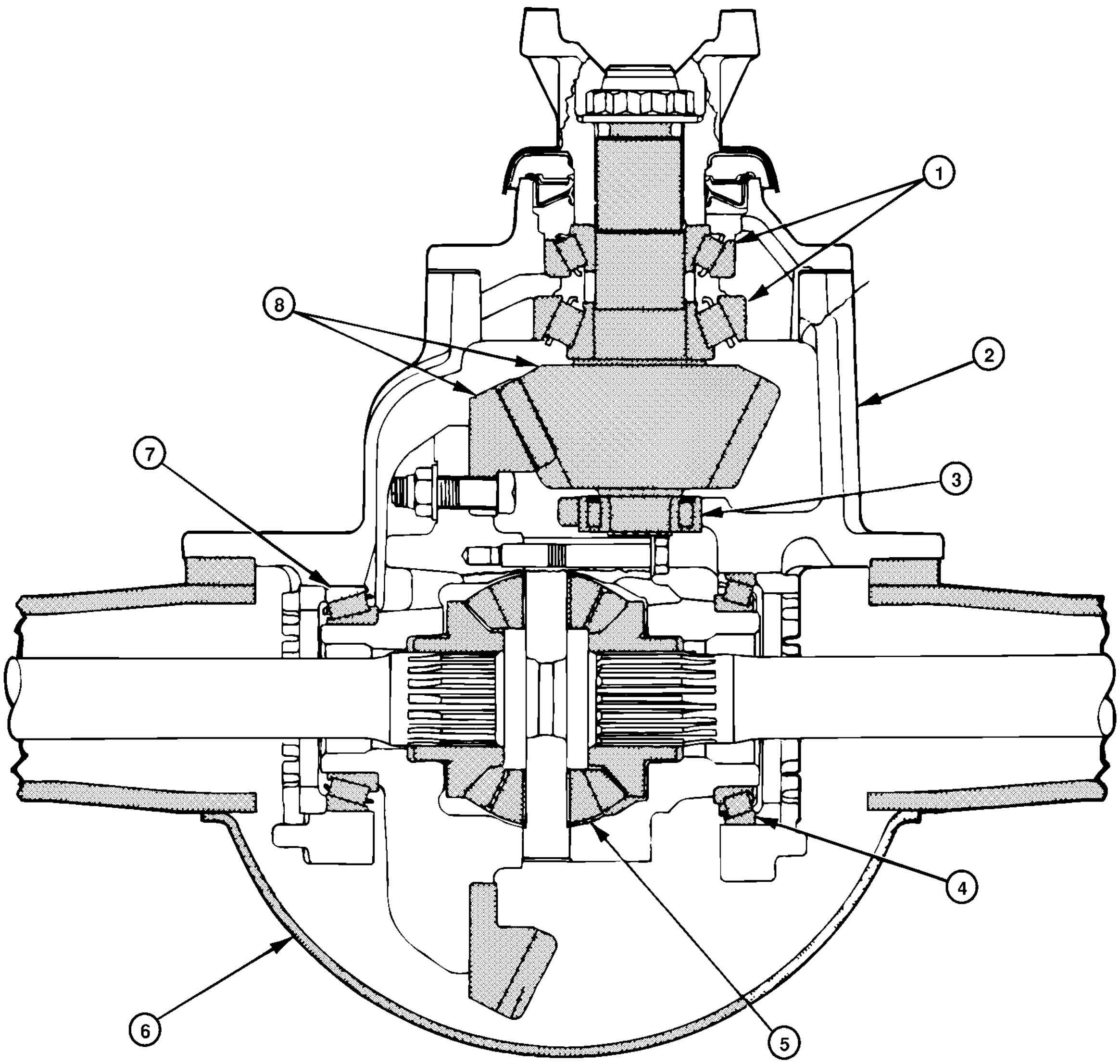
Meritor single reduction standard carriers, **Figure 1.1**, are used in most Meritor single axles, rear of tandem axles and front drive steering axles.

The single reduction carrier models are front mounted into the axle housing. These carriers have a hypoid drive pinion and ring gear set and bevel gears in the differential assembly.

A straight roller bearing (spigot) 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.

Figure 1.1



1 TAPERED ROLLER BEARINGS
2 CARRIER
3 STRAIGHT ROLLER BEARING
4 TAPERED ROLLER BEARING
5 BEVEL DIFFERENTIAL GEARS
6 HOUSING
7 TAPERED ROLLER BEARING
8 HYPOID DRIVE PINION AND RING GEAR

Axle Models Covered in This Manual

The following table lists all axle models covered in this manual.

Single Drive Axles:						**For All RS & RT Single Reduction Axle Model Series, Refer to Maintenance Manual 5A.**
A-150	E-100	F-140	H-172	Q-100	R-163	
B-100	E-105	G-161	L-100	Q-145	R-170	
B-140	E-150	H-100	L-140	RL-170	S-170	
B-150	F-100	H-140	L-155	R-100	U-140	
C-100	F-106	H-150	L-172	R-140	W-170	
D-100	F-120	H-162	M-172	R-155		
D-140	F-121	H-170	QT-140	R-160		
Rear Axle of Tandem Axles:						
SDHD	SL-100	SQHD	SSHD	SU-170		
SFHD	SLHD	SR-170	ST-170	SUHD		
SHHD	SQ-100	SRHD	STHD	SW-170		
Front Drive Steering Axles:						
FDS-75	FDS-85	FDS-93	FDS-1807	FDS-2100	FDS-2107	FDS-2111
FDS-78	FDS-90	FDS-1600	FDS-1808	FDS-2101	FDS-2110	FDS-2117

Remove Differential Carrier from Axle Housing

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

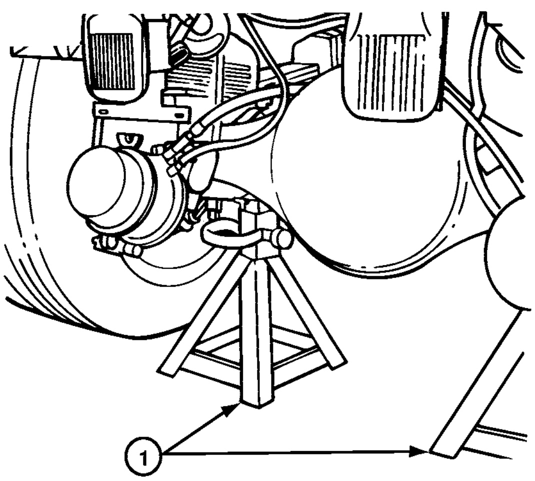
1. Raise the end of vehicle where the axle is mounted. Use a jack or other lifting tool, and place safety stands under each side of the axle. **Figure 2.1**.

WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip or fall over. Serious personal injury can result.

2. Place jack stands under each spring seat of the axle to hold vehicle in the raised position. **Figure 2.1**.

Figure 2.1



1 SAFETY STANDS

3. Remove the plug from bottom of axle housing and drain lubricant from the assembly.
4. Disconnect the driveline universal joint from the pinion input yoke or flange on the carrier. **Figure 2.2**.
5. Remove the capscrews* and washers or stud nuts* and washers from the flanges of both axle shafts.*
6. Loosen the tapered dowels* if applicable, in the axle flanges of both axle shafts using either the ***Brass Drift*** or the ***Air Hammer Vibration*** method.

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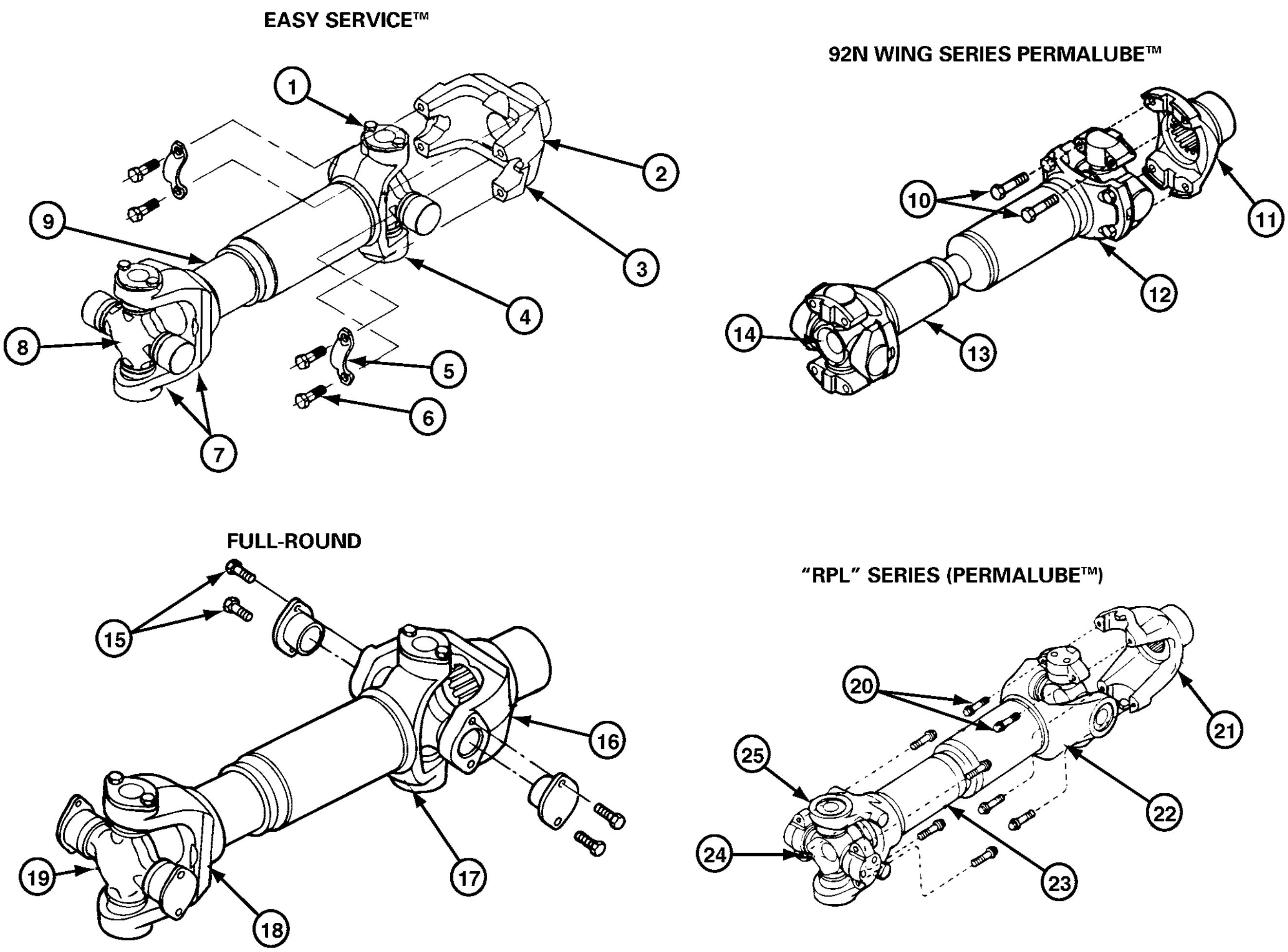
*Some Meritor carriers do not have these described parts.

Figure 2.2



1	FULL ROUND BEARING CUPS
2	END YOKE
3	YOKE SADDLE
4	WELD YOKE
5	BEARING STRAP
6	CAPSCREWS
7	EASY-SERVICE BEARING CUPS
8	U-JOINT CROSS
9	SLIP YOKE
10	CAPSCREWS
11	END YOKE
12	WELD YOKE
13	SLIP YOKE
14	U-JOINT CROSS
15	CAPSCREWS
16	END YOKE
17	WELD YOKE
18	SLIP YOKE
19	U-JOINT CROSS
20	CAPSCREWS
21	END YOKE
22	SLIP YOKE
23	TUBING
24	U-JOINT CROSS
25	WELD YOKE

Brass Drift Method

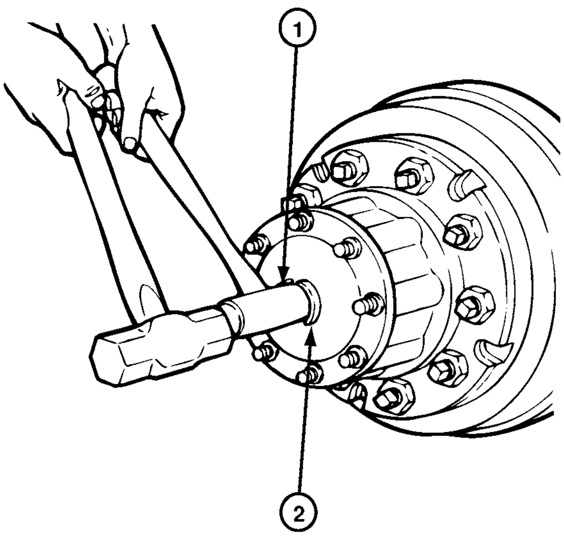
WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Do not strike the round driving lugs on the flange of an axle shaft. Pieces can break off and cause serious personal injury.

1. Hold a 1-1/2 inch diameter brass drift against the center of the axle shaft, inside the round driving lugs. **Figure 2.3**.

Figure 2.3

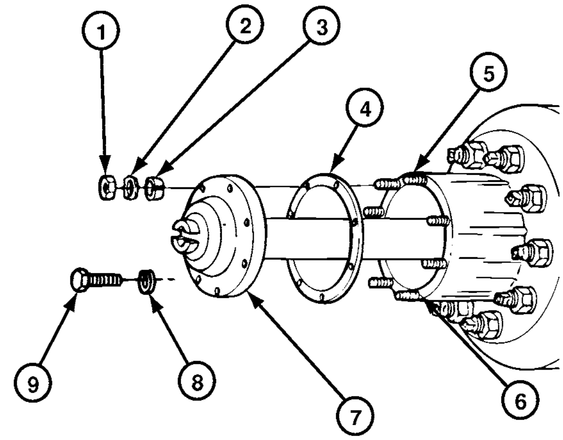


1 BRASS HAMMER
2 DRIVING LUGS

NOTE: A 1-1/2 inch diameter brass hammer can be used as a drift.

2. Strike the end of the drift with a large hammer (five to six pounds) and the axle shaft and tapered dowels will loosen.
3. Mark to identify each axle shaft before it is removed from the axle assembly.
4. Remove the tapered dowels and separate the axle shafts from the main axle hub assembly. **Figure 2.4**.

Figure 2.4



1 STUD NUT
2 WASHER
3 TAPERED DOWEL
4 GASKET
5 STUD
6 SHAFT HUB AXLE
7 AXLE SHAFT (FLANGE)
8 WASHER
9 CAPSCREW

5. Install a cover over the open end of each axle assembly hub where an axle shaft was removed.

Air Hammer Vibration Method

WARNING

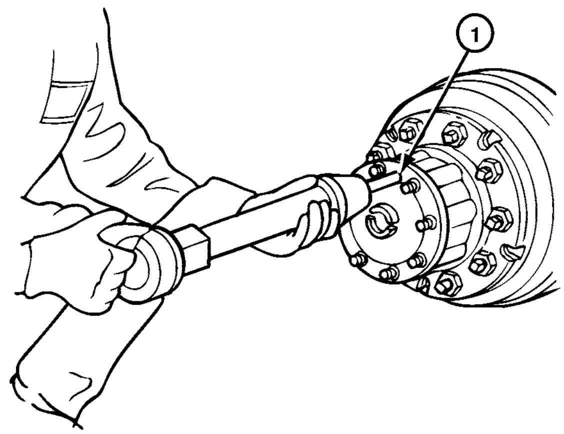
Wear safe eye protection when using an air hammer. When using power tools, axle components can loosen and break off causing serious personal injury.

CAUTION

Do not use a chisel or wedge to loosen the axle shaft and tapered dowels. Using a chisel or wedge can result in damage to the axle shaft, the gasket and seal, and/or the axle hub.

1. Use a round hammer bit and an air hammer such as Chicago Pneumatic CP-4181-PULER, or equivalent, to loosen tapered dowels and axle shaft.
2. Place the round hammer bit against the axle shaft (flange) between the hub studs. Operate the air hammer at alternate locations between the studs to loosen the tapered dowels and axle shaft from the hub. **Figure 2.5**.

Figure 2.5



1 ROUND HAMMER BIT BETWEEN HUB STUDS

3. Mark to identify each axle shaft before it is removed from the axle assembly.
4. Remove the tapered dowels and separate the axle shaft from the main axle hub assembly. **Figure 2.4**.
5. Install a cover over the open end of each axle assembly hub where an axle shaft was removed.

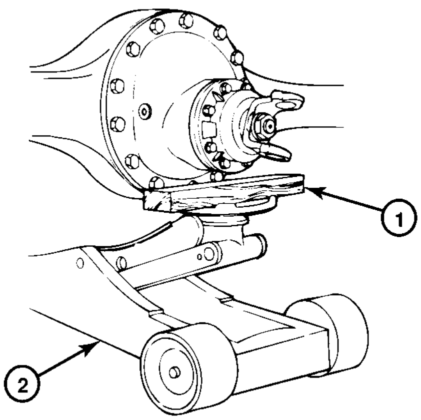
CAUTION

Do not use a chisel or wedge to loosen the axle shaft and tapered dowels. Using a chisel or wedge can result in damage to the axle shaft, the gasket and seal, and/or the axle hub.

Carrier Removal from Axle

1. Place a hydraulic roller jack under the differential carrier to support the assembly. **Figure 2.6**.
2. Remove all but the top two carrier to housing capscrews or stud nuts and washers.
3. Loosen the top two carrier-to-housing fasteners and leave attached to the assembly. The fasteners will hold the carrier in the housing.
4. Loosen the differential carrier in the axle housing. Use a leather mallet to hit the mounting flange of carrier at several points.
5. After the carrier is loosened, remove the top two fasteners.

Figure 2.6



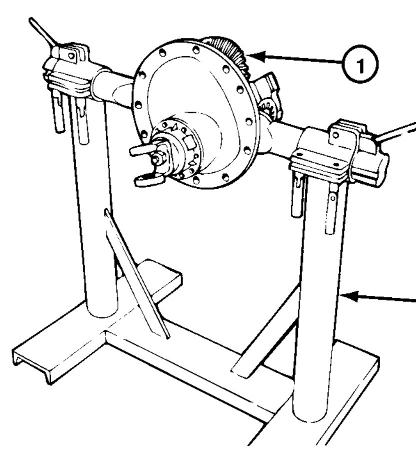
1 WOOD BLOCK
2 ROLLER JACK

CAUTION

When using a pry bar be careful not to damage the carrier or housing flange. Damage to these surfaces will cause oil leaks.

6. Carefully remove the carrier from the axle housing using the hydraulic roller jack. Use a pry bar that has a round end to help remove the carrier from the housing.
7. Lift the differential carrier by the input yoke or flange and place the assembly in a repair stand. **Figure 2.7**. Use a lifting tool for this procedure. Do not lift by hand. A carrier stand can be built by referring to **Figure 2.8**.

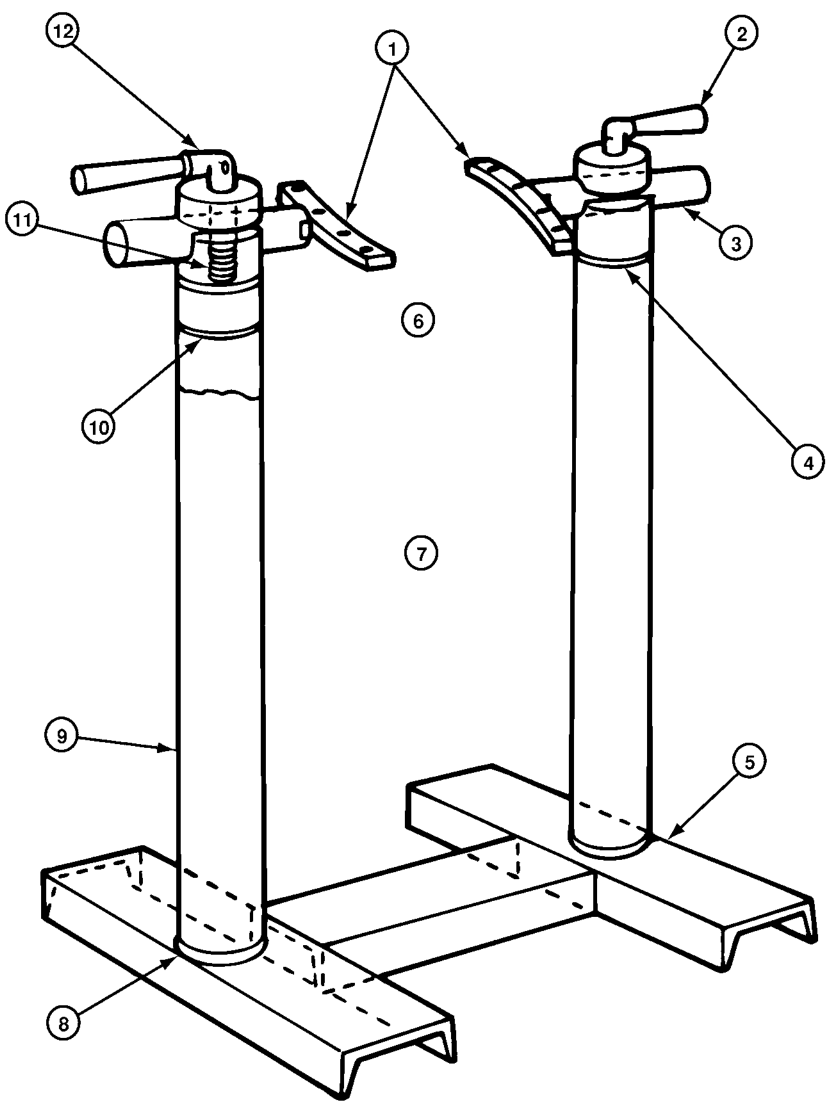
Figure 2.7



1 DIFFERENTIAL CARRIER
2 REPAIR STAND

A carrier stand, part number J 3409-D is available from Kent-Moore, Heavy-Duty Division, 28635 Mound Road, Warren, MI 48092.

Figure 2.8



1 PLATES 8' LONG x 3/4" THICK x 1-1/4" WIDE WITH A TONGUE TO FIT SLOT IN BAR WELD PLATES TO BAR
2 HANDLE 7" LONG WITH SLOT IN ONE END TO FIT CLAMP SCREW
3 BAR 2" DIAMETER x 9" LONG WITH ONE END SLOTTED TO FIT PLATE
4 WELD ALL AROUND AFTER PRESSING PLUG IN PIPE
5 WELD
6 SHAPE AND SIZE OF HOLES TO FIT CARRIER
7 23-1/2" CENTER TO CENTER OF PIPE
8 CHAMFER END OF PIPE FOR WELDING
9 4″ DIAMETER PIPE
10 PLUG 4" DIAMETER x 7" LONG WITH ONE END TURNED 3" LONG TO FIT PIPE. DRILL 2" HOLE AND MILL 3/16" WIDE SLOT 2" FROM TOP
11 SCREW 3-1/2" LONG x 5/8" DIAMETER WITH FLATS ON END TO FIT HANDLE AND 2-1/2" LENGTH OF THREAD ON OTHER END
12 DRILL 3/8" HOLE THROUGH HANDLE AND SCREW

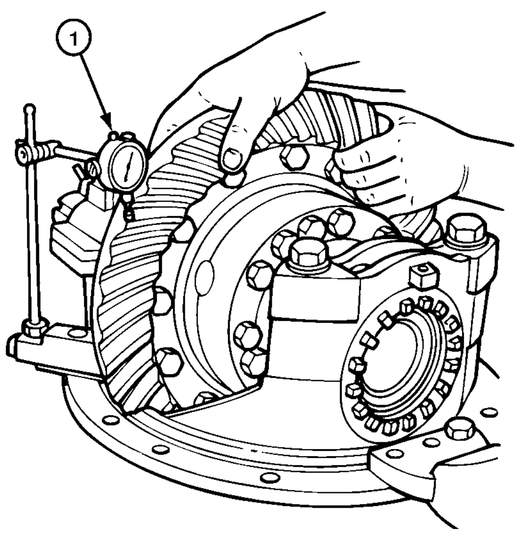
CARRIER STAND

Remove the Differential and Ring Gear from the Carrier

NOTE: Before working on the differential carrier, inspect the hypoid gear set for damage. If inspection shows no damage, the same gear set can be used again. Measure the backlash of the gear set and make a record of the dimension. **Figure 2.9**. (Refer to "Ring Gear Backlash Adjustment" in Section 5, Steps 1-5.) During differential reassembly, adjust the backlash to the original recorded dimension when the gear set is installed into the carrier.

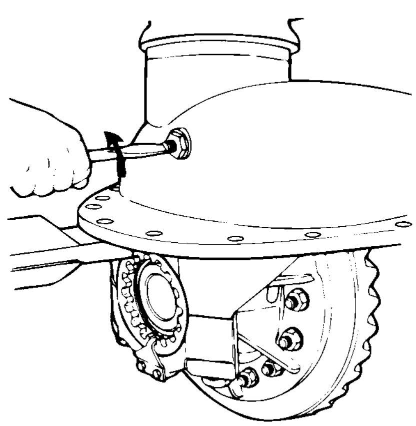
1. Loosen the jam nut* on the thrust screw*. **Figure 2.10**.

Figure 2.9



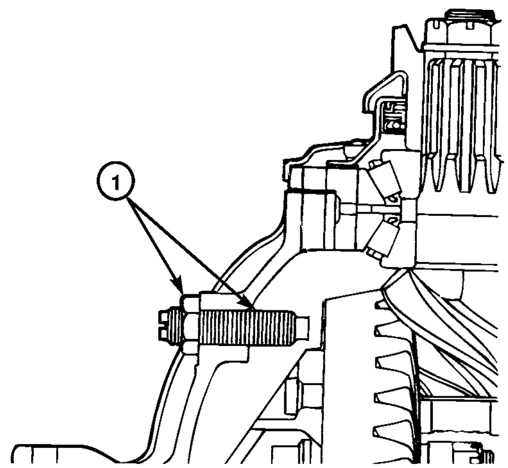
1 DIAL INDICATOR

Figure 2.10



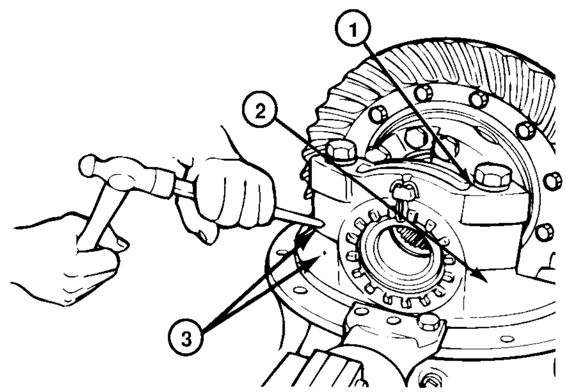
2. Remove the thrust screw* and jam nut* from the differential carrier. **Figure 2.11**.
3. Rotate the differential carrier in the repair stand until the ring gear is at the top of the assembly.
4. Mark one carrier leg and bearing cap to correctly match the parts during carrier assembly. Mark the parts using a center punch and hammer. **Figure 2.12**.

Figure 2.11



1 THRUST SCREW AND JAM NUT

Figure 2.12

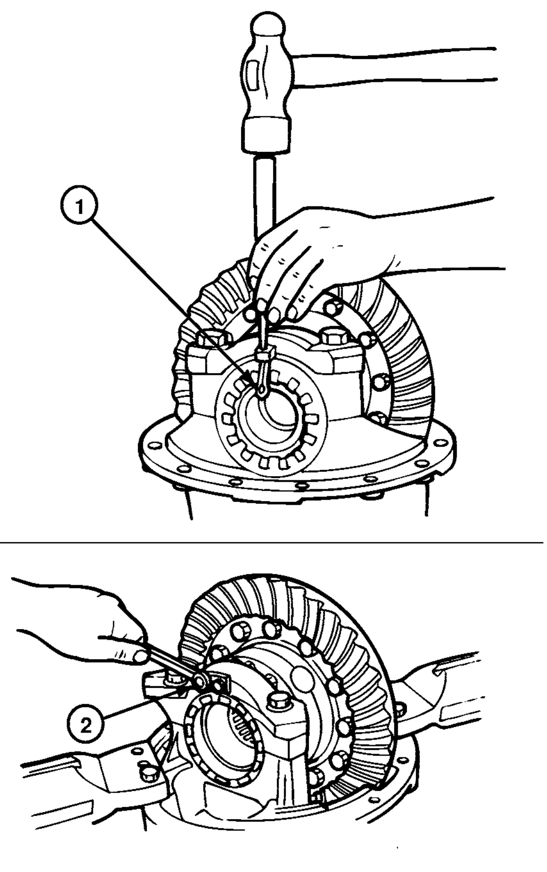


1 BEARING CAP
2 CARRIER LEG
3 MATCH MARKS

*Some Meritor carriers do not have these described parts.

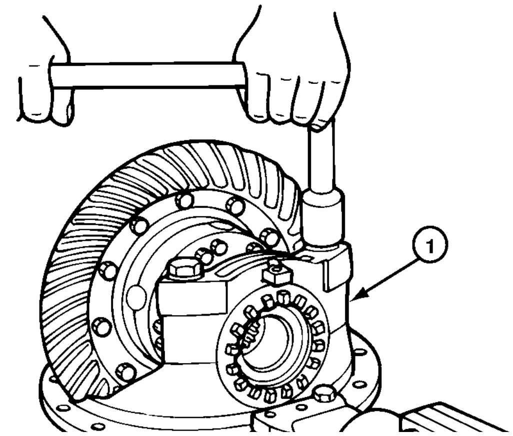
5. Remove the cotter keys*, pins* or lock plates* that hold the two bearing adjusting rings in position. Use a small drift and hammer to remove pins. Each lock plate is held in position by two capscrews. **Figure 2.13**.
6. Remove the capscrews and washers that hold the two bearing caps on the carrier. Each cap is held in position by two capscrews and washers. **Figure 2.14**.
7. Remove the bearing caps and bearing adjusting rings from the carrier. **Figure 2.15**.
8. Safely lift the main differential and ring gear assembly from the carrier. Place the assembly on a work bench. **Figure 2.16**.

Figure 2.13



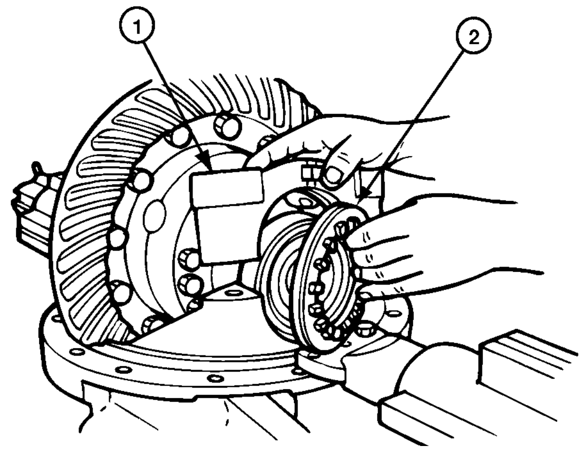
1 REMOVING COTTER KEY
2 REMOVING LOCK PLATE

Figure 2.14



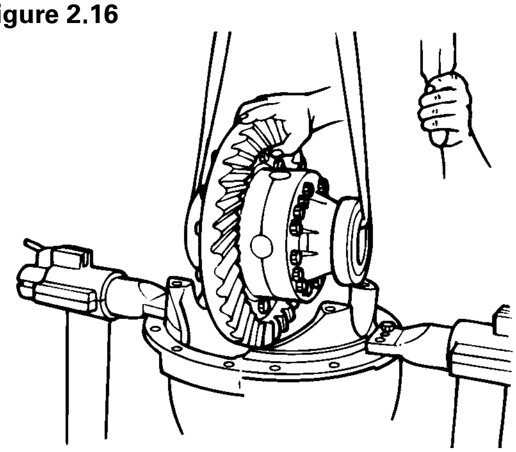
1 BEARING CAP

Figure 2.15



1 BEARING CAP
2 BEARING ADJUSTING RING

Figure 2.16

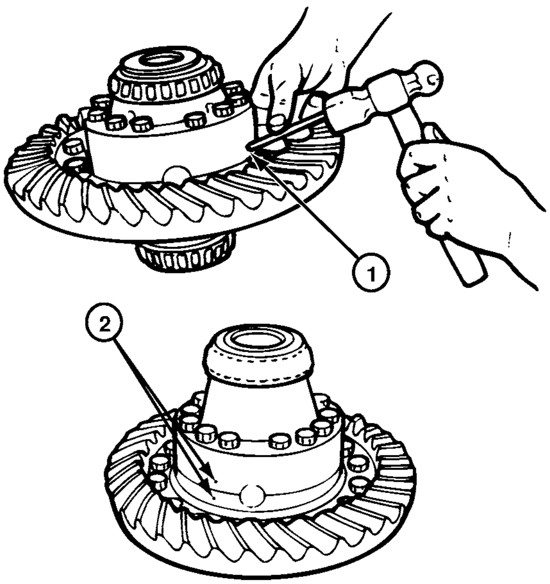


*Some Meritor carriers do not have these described parts.

Disassemble the Differential and Ring Gear Assembly

1. If the matching marks on the case halves of the differential assembly are not visible, mark each case half with a center punch and hammer. The purpose of the marks is to match the plain half and flange half correctly when you assemble the carrier. **Figure 2.17**.

Figure 2.17



1 **MATCH MARKS**
2 **MATCH MARKS**

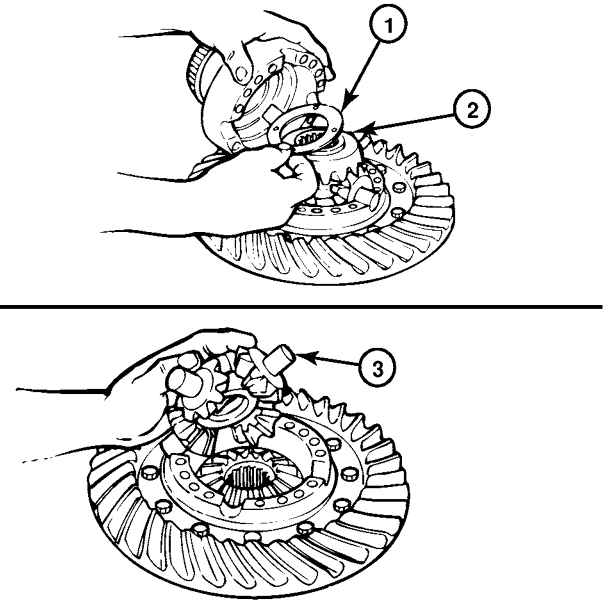
2. Remove the capscrews* and washers* or bolts*, nuts* and washers that hold the case halves together.

WARNING

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off and cause serious personal injury.

3. Separate the case halves. If necessary, use a brass, plastic or leather mallet to loosen the parts.
4. Remove the differential spider (cross), four pinion gears, two side gears and six thrust washers from inside the case halves. **Figure 2.18.**
5. If the ring gear needs to be replaced, remove the bolts*, nuts*, and washers* that hold the gear to the flange case half.

Figure 2.18



1 **THRUST WASHER**
2 **SIDE GEAR**
3 **SPIDER, PINIONS AND THRUST WASHERS**

WARNING

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

CAUTION

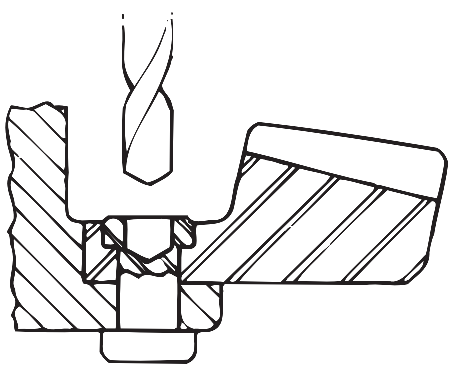
Do not remove the rivets or rivet heads with a chisel and hammer. Using a flat edge tool can cause damage to the flange case.

6. If rivets* hold the ring gear to the flange case half, remove the rivets as follows:
7. Carefully center punch each rivet head in the center, on the ring gear side of the assembly.

*Some Meritor carriers do not have these described parts.

8. Drill each rivet head on the ring gear side of the assembly to a depth equal to the thickness of one rivet head. Use a drill bit that is 1/32 of an inch smaller than the body diameter of the rivets. **Figure 2.19**.

Figure 2.19



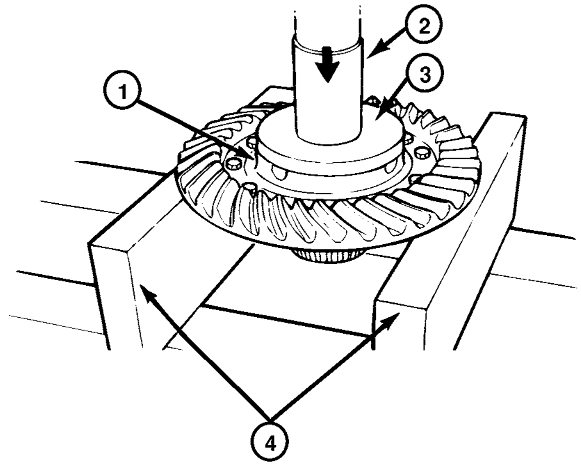
9. Press the rivets through holes in the ring gear and flange case half. Press from the drilled rivet head.

WARNING

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

10. Separate the case half and ring gear using a press. Support the assembly under the ring gear with metal or wood blocks and press the case half through the gear. **Figure 2.20**.

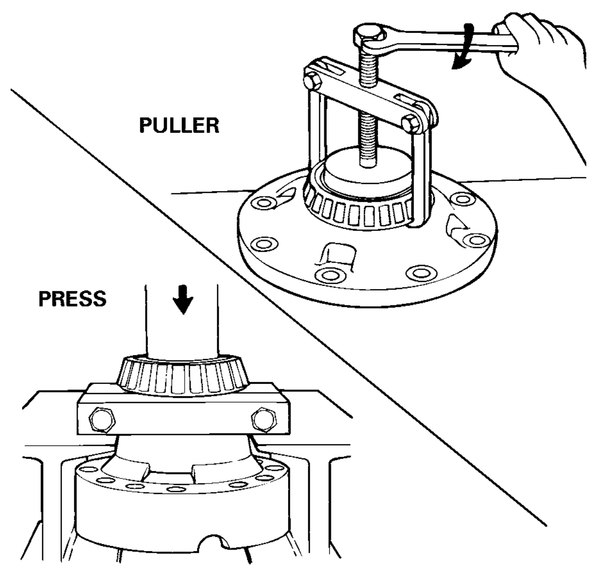
Figure 2.20



1 CASE HALF
2 PRESS
3 PLATE
4 SUPPORTS

11. If the differential bearings need to be replaced, remove the bearing cones from the case halves. Use a bearing puller or press. **Figure 2.21**.

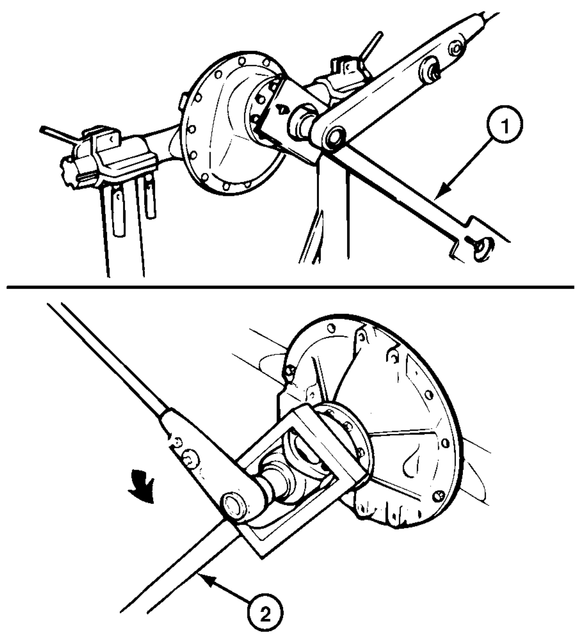
Figure 2.21



Remove the Drive Pinion and Bearing Cage from Carrier

1. Fasten a flange bar to the input yoke or flange. When the nut is removed, the bar will hold the drive pinion in position. **Figure 2.22**.

Figure 2.22



1 FLANGE BAR
2 YOKE BAR

2. Remove the nut and washer* from the drive pinion. **Figure 2.22**.
3. Remove the yoke or flange bar.

CAUTION

Do not use a hammer or mallet to loosen and remove the yoke or flange. A hammer or mallet can damage the parts and cause driveline runout, or driveline imbalance problems after carrier to driveline assembly.

4. Remove the yoke or flange from the drive pinion. If the yoke or flange is tight on the pinion, use a puller for removal. **Figure 2.23**.
5. Remove the capscrews and washers that hold the bearing cage in the carrier. **Figure 2.24**.

Figure 2.23

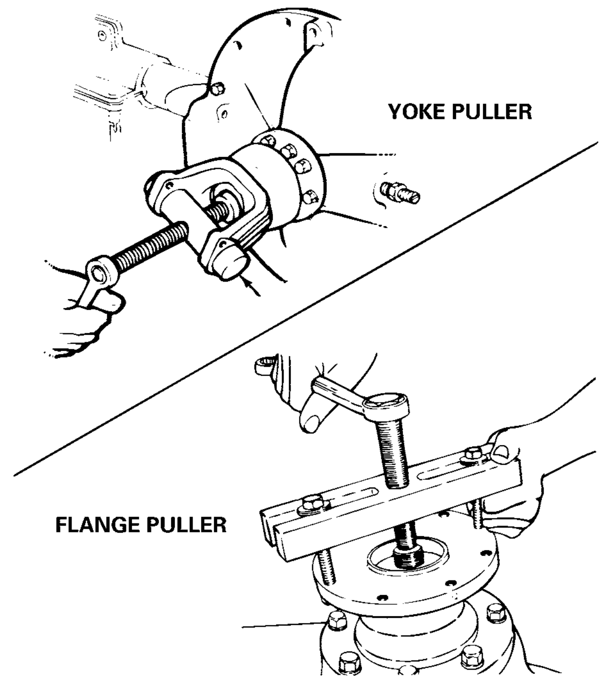
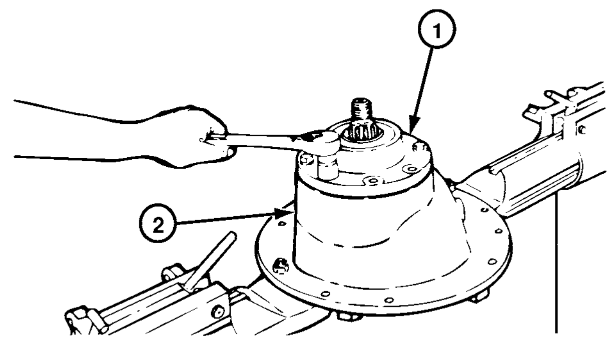


Figure 2.24



1 BEARING CAGE
2 CARRIER

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*Some Meritor carriers do not have these described parts.

WARNING

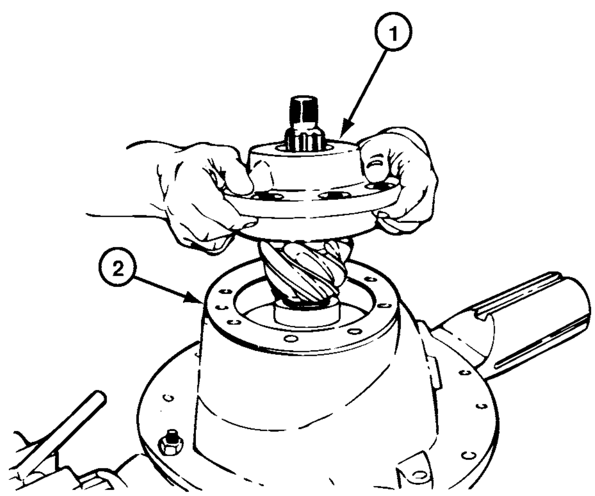
Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off and cause serious personal injury.

CAUTION

Do not use a pry bar to remove the bearing cage from the carrier. A pry bar can damage the bearing cage, shims and carrier.

6. Remove the drive pinion, bearing cage and shims from the carrier. If the bearing cage is tight in the carrier, hit the bearing cage at several points around the flange area with a leather, plastic or rubber mallet. **Figure 2.25**.

Figure 2.25

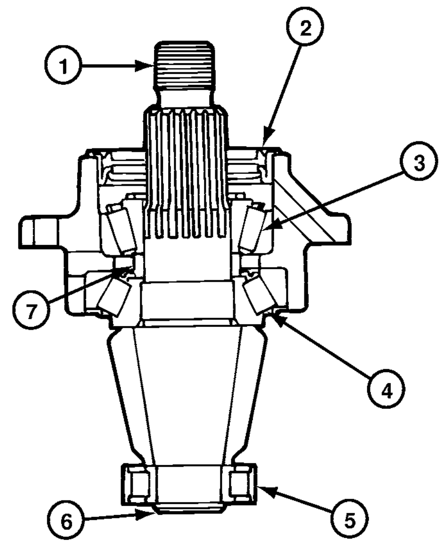


1 DRIVE PINION AND BEARING CAGE
2 SHIMS

7. If the shims are in good condition, keep the shims together for use later when the carrier is assembled.
8. If shims are to be discarded because of damage, first measure the total thickness of the pack. Make a note of the dimension. The dimension will be needed to calculate the depth of the drive pinion in the carrier when the gear set is installed.

Disassemble the Drive Pinion and Bearing Cage

Figure 2.26



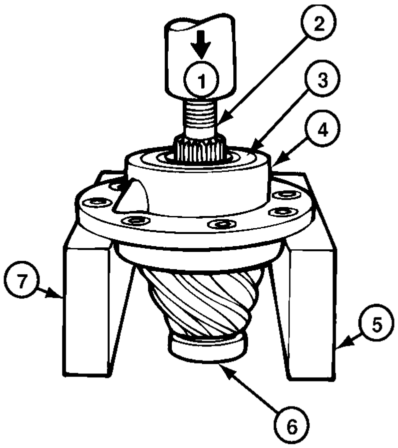
1 DRIVE PINION
2 OIL SEAL
3 OUTER BEARING (CUP AND CONE)
4 INNER BEARING (CUP AND CONE)
5 SPIGOT BEARING
6 SNAP RING
7 BEARING SPACER

WARNING

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

1. Place the drive pinion and bearing cage in a press. The pinion shaft must be toward the top of the assembly. **Figure 2.27**.

Figure 2.27



1 PRESS
2 DRIVE PINION
3 OIL SEAL
4 BEARING CAGE
5 SUPPORT
6 SPIGOT BEARING
7 SUPPORT

2. Support the bearing cage under the flange area with metal or wood blocks. **Figure 2.27**.
3. Press the drive pinion through the bearing cage. **Figure 2.27**.

WARNING

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off and cause serious personal injury.

NOTE: The inner bearing cone and bearing spacer will remain on the pinion shaft.

4. If a press is not available, use a leather, plastic or rubber mallet to drive the pinion through the bearing cage.

CAUTION

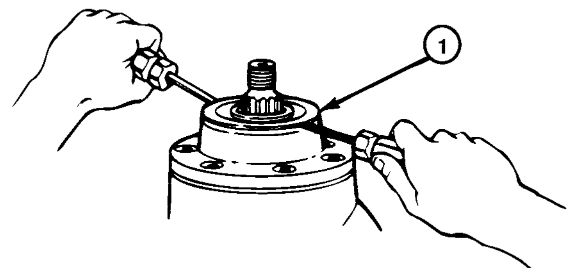
Be careful when removing the seal. Do not damage the wall of bore. Damage to the bore wall can result in oil leaks.

NOTE: When the oil seal has been removed, always replace it with a new triple-lip (main) seal during component reassembly.

5. If the pinion oil seal is mounted directly in the outer bore of the bearing cage, remove the seal at this time.

   Be careful that you do not damage the mounting surfaces of the bearing cage. **Figure 2.28**.

Figure 2.28



1 OIL SEAL

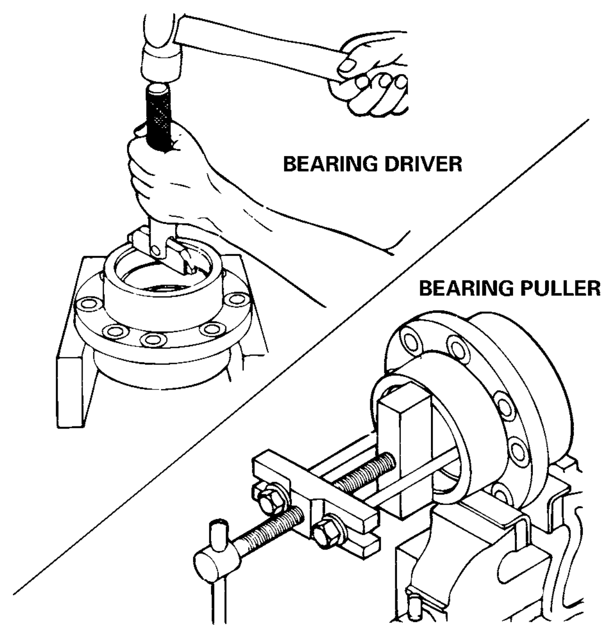
WARNING

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

6. If the pinion bearings need to be replaced, remove the inner and outer bearing cups from the inside of cage. Use a press and sleeve, bearing puller, bearing driver or a small drift hammer. The type of tool used depends on the design of the bearing cage. **Figure 2.29**.

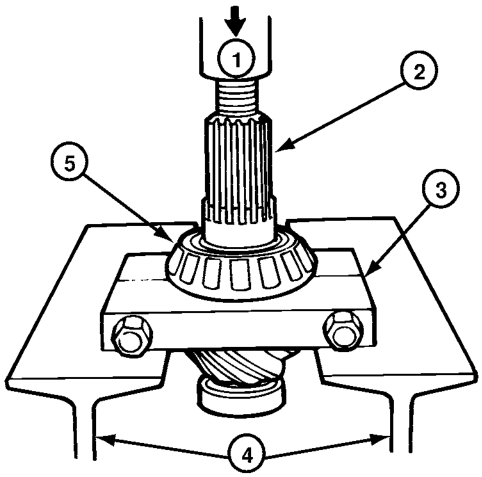
   When a press is used, support the bearing cage under the flange area with metal or wood blocks.

Figure 2.29



7. If the pinion bearings need to be replaced, remove the inner bearing cone from the drive pinion with a press or bearing puller. The puller **MUST** fit under the inner race of the cone to remove the cone correctly without damage. **Figure 2.30**.

Figure 2.30

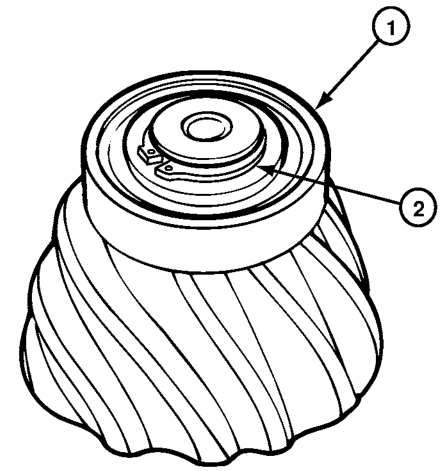


1 PRESS
2 DRIVE PINION
3 BEARING PULLER
4 SUPPORTS
5 INNER BEARING CONE

8. If the spigot bearing needs to be replaced, place the drive pinion in a vise. Install a soft metal cover over each vise jaw to protect the drive pinion.
9. Remove the snap ring* from the end of drive pinion with snap ring pliers that expand. **Figure 2.31**.

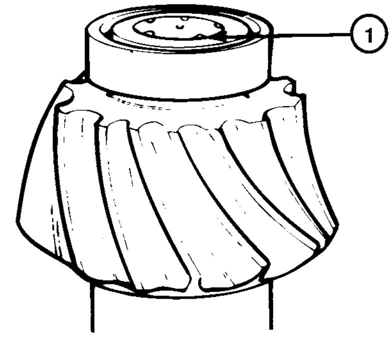
NOTE: Some spigot bearings are fastened to the drive pinion with a special peening tool. **Figure 2.32**.

Figure 2.31



1 SPIGOT BEARING
2 SNAP RING

Figure 2.32



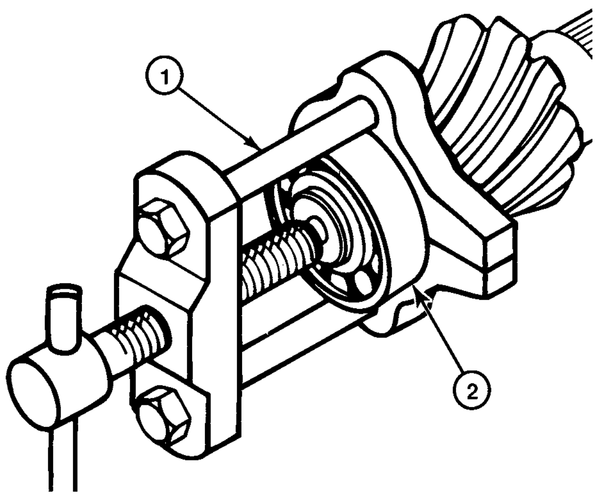
1 PEENING POINTS

*Some Meritor carriers do not have these described parts.

10. Remove the spigot bearing from the drive pinion with a bearing puller. **Figure 2.33**.

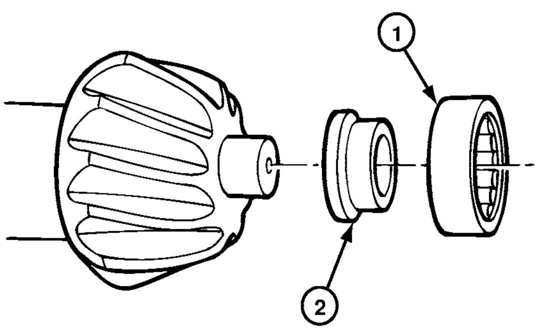
NOTE: Some spigot bearings are a two-piece assembly. Remove the inner race from the pinion with a bearing puller. Remove the outer race/roller assembly from carrier with a drift or a press. **Figure 2.34**.

Figure 2.33



1 BEARING PULLER
2 SPIGOT BEARING

Figure 2.34



1 REMOVE OUTER RACE AND ROLLER ASSEMBLY FROM CARRIER
2 REMOVE INNER RACE FROM PINION

Cleaning Ground and Polished Parts

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, emulsion-type cleaners and petroleum-based cleaners. To avoid serious personal injury when you use solvent cleaners, you must carefully follow the manufacturer's product instructions and these procedures:

- ***Wear safe eye protection.***
- ***Wear clothing that protects you skin.***
- ***Work in a well-ventilated area.***
- ***Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.***
- ***You must use hot solution tanks or alkaline solutions correctly. Follow the manufacturer's instructions carefully.***

CAUTION

Use only solvent cleaners to clean ground or polished metal parts. Hot solution tanks or water and alkaline solutions will damage parts. Isopropyl alcohol, kerosene or diesel fuel can be used for this purpose. If required, use a sharp knife to remove gasket material from parts. Be careful not to damage the ground or polished surfaces.

1. Use a cleaning solvent to clean ground or polished parts or surfaces. Kerosene or diesel fuel oil can be used for this purpose. ***Do not use gasoline.***
2. Use a tool with a flat blade, if required, to remove sealant material from parts. Be careful not to damage the polished or smooth surfaces.
3. ***Do not*** clean ground or polished parts with water or steam. Do not immerse ground or polished parts in a hot solution tank or use strong alkaline solutions for cleaning, or the smooth sealing surface may be damaged.

Cleaning Rough Parts

WARNING

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, emulsion-type cleaners and petroleum-based cleaners. To avoid serious personal injury when you use solvent cleaners, you must carefully follow the manufacturer's product instructions and these procedures:

- ***Wear safe eye protection.***
- ***Wear clothing that protects you skin.***
- ***Work in a well-ventilated area.***
- ***Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.***
- ***You must use hot solution tanks or alkaline solutions correctly. Follow the manufacturer's instructions carefully.***

1. Clean rough parts with the same method as cleaning ground and polished parts.
2. Rough parts can be cleaned in hot solution tanks with a weak or diluted alkaline solution.
3. Parts must remain in hot solution tanks until heated and completely cleaned.
4. Parts must be washed with water until all traces of the alkaline solution are removed.

Cleaning Axle Assemblies

1. A complete axle assembly can be steam cleaned on the outside to remove dirt.
2. Before the axle is steam cleaned, close or place a cover over all openings in the axle assembly. Examples of openings are breathers or vents in air chambers.

Drying Parts After Cleaning

CAUTION

Damage to bearings can result when they are rotated and dried with compressed air.

1. Parts must be dried immediately after cleaning and washing.
2. Dry the parts using soft, clean paper or cloth rags.
3. Except for bearings, parts can be dried with compressed air.

Preventing Corrosion on Cleaned Parts

1. Apply axle lubricant to cleaned and dried parts that are not damaged and are to be assembled.
2. To store parts, apply a special material that prevents corrosion to all surfaces. Wrap cleaned parts in a special paper that will protect the parts from moisture and prevent corrosion during storage.

Inspecting Parts

It is very important to inspect all parts carefully and completely before the axle or carrier is assembled. Inspect all parts for wear and replace damaged parts. Replacement of damaged or worn parts now, will prevent failure of the assembly later.

1. Inspecting Tapered Roller Bearings:

   Inspect the cup, cone, rollers and cage of all tapered roller bearings in the assembly. If any of the following conditions exist, the bearing **MUST** be replaced:

   a. The center of large-diameter end of rollers worn level with or below the outer surface. **Figure 3.1**.

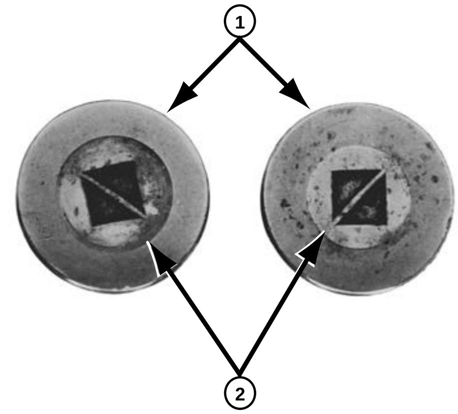
   b. The radius at large-diameter end of rollers worn to a sharp edge. **Figure 3.1**.

   c. A visible roller groove in the cup or cone inner race surfaces. The groove can be seen at the small- or large-diameter end of both parts. **Figure 3.2**.

   d. Deep cracks or breaks in the cup, cone inner race or roller surfaces. **Figure 3.2**.

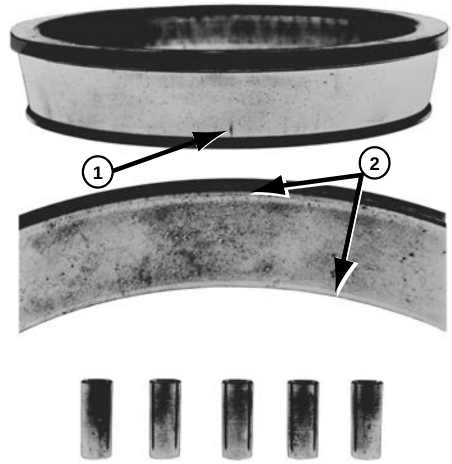
   e. Bright wear marks on the outer surface of the roller cage. **Figure 3.3**.

Figure 3.1



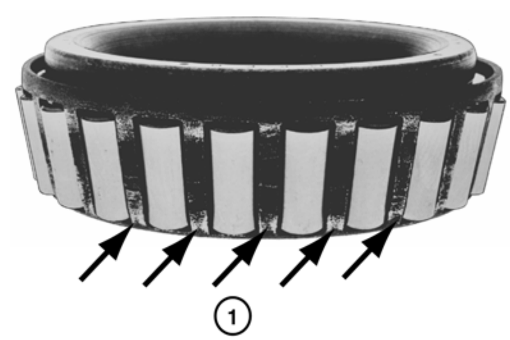
1 WORN RADIUS
2 WORN SURFACE

Figure 3.2



1 CRACK
2 WEAR GROOVE

Figure 3.3

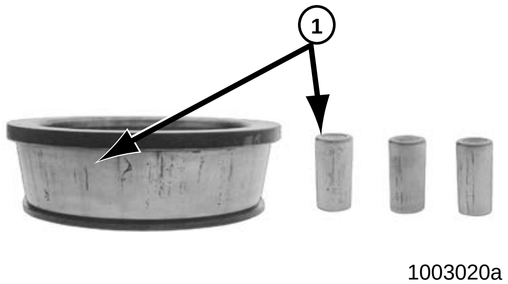


1 WEAR MARKS

f. Damage on rollers and on surfaces of the cup and cone inner race that touch the rollers. **Figure 3.4**.

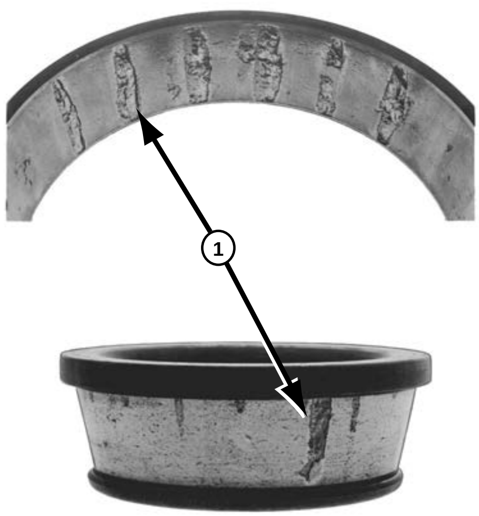
g. Damage on the cup and cone inner race surfaces that touch the rollers. **Figure 3.5**.

Figure 3.4



1 ETCHING AND PITTING

Figure 3.5



1 SPALLING AND FLAKING

CAUTION

Hypoid drive pinions and ring gears are machined in matched sets. When a drive pinion or ring gear of a hypoid set needs to be replaced, both drive gear and pinion must be replaced at the same time.

2. Inspect hypoid pinions and gears for wear or damage. Gears that are worn or damaged **MUST** be replaced.

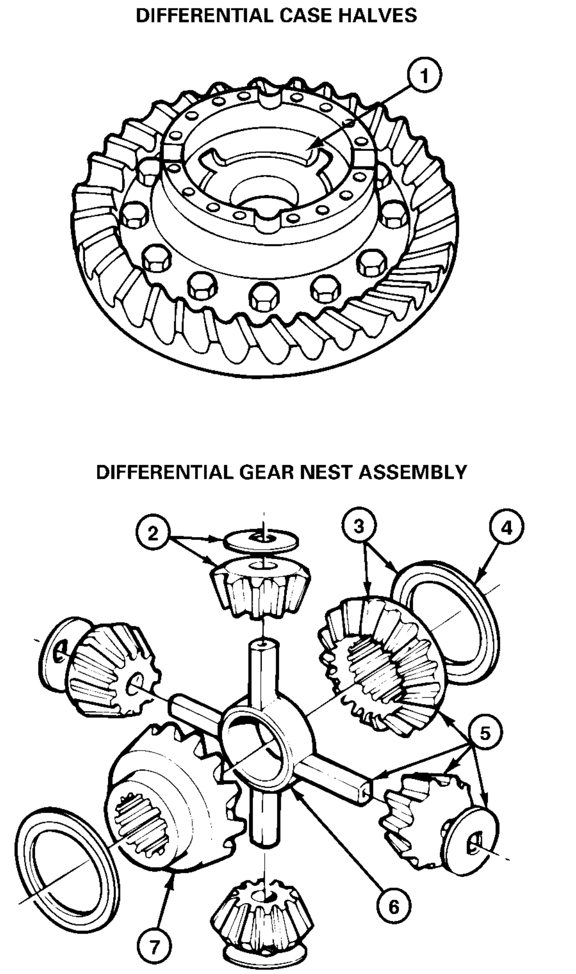
CAUTION

Always replace thrust washers, differential side gears and pinion gears in full matched sets. A higher stress on original parts and early failure of the entire assembly will result if a new part is used in combination with parts that are older or worn.

3. Inspect the Main Differential Assembly:

   Inspect the following parts for wear or stress. Parts that are damaged **MUST** be replaced. **Figure 3.6**.

Figure 3.6



1 INSPECT INSIDE SURFACES
2 PINION AND THRUST WASHER
3 SIDE GEAR AND THRUST WASHER
4 INSPECT
5 INSPECT
6 SPIDER (CROSS)
7 INSPECT

a. Inside surfaces of both case halves.
b. Both surfaces of all thrust washers.
c. The four trunnion ends of the spider (cross).
d. Teeth and splines of both differential side gears.
e. Teeth and bore of all differential pinions.

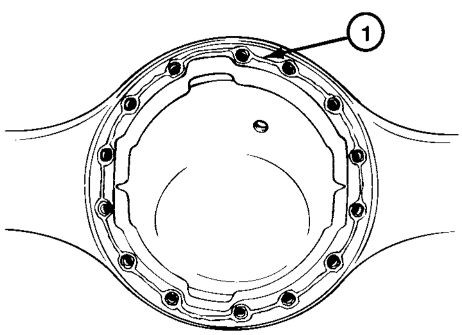
4. Inspect Axle Shafts:
   a. Inspect axle shafts for wear and cracks at the flange, shaft and splines.
   b. Replace axle shafts, if required.

Repair or Replacement of Parts, General

Replace worn or damaged parts of an axle assembly. The following are some examples in inspecting for part replacement or repair.

1. Replace any fastener if corners of the head are worn.
2. Replace washers if damaged.
3. Replace gaskets, oil seals or grease seals at the time of axle or carrier repair.
4. Clean parts and apply new silicone gasket material where required when axle or carrier is assembled. **Figure 3.7**.

Figure 3.7



1 REMOVE SILICONE GASKET FROM PARTS

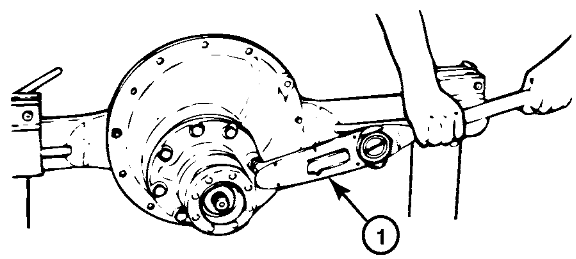
5. Remove nicks, mars and burrs from parts with machined or ground surfaces. Use a fine file, india stone, emery cloth or crocus cloth for this purpose.

CAUTION

Threads must be without damage and clean so that accurate adjustments and correct torque values can be applied to fasteners and parts.

6. Clean and repair threads of fasteners and holes. Use a die or tap of the correct size or a fine file for this purpose.
7. Tighten all fasteners to the correct torque values. Refer to **Table J** for torque values of fasteners. **Figure 3.8**.

Figure 3.8



1 ALWAYS USE TORQUE WRENCHES

8. **DO NOT** repair rear axle housings by bending or straightening.

WARNING

Repair of axle housings by bending or straightening will cause poor or unsafe vehicle operation and early failure of the axle.

Repair Axle by Welding

1. ArvinMeritor Commercial Vehicle Systems will permit repairing drive axle housing assemblies by welding **ONLY** in the following areas:
   a. Snorkel welds.
   b. Housing seam welds between the suspension attaching brackets.
   c. Bracket welding to drive axle housing. Refer to TP-9421.
   d. Refer to Meritor Maintenance Manual 8 for approved axle welding procedures.
   e. Contact your Meritor representative for further or specific recommendations.

WARNING

Using wrong welding procedures or welding at locations other than the three areas permitted by ArvinMeritor will make the heat-treated component weak. A weak component will cause poor or unsafe operation of the vehicle and early axle failure. The following procedure must be used.

CAUTION

Welding can be used when the crack or damaged area is within the old weld material. Replace the axle housing if the crack extends into the metal next to the old weld. A repaired housing must be used only in correct specified vehicle load applications.

2. Welding Procedure
   a. Drain the lubricant from the axle assembly.
   b. Remove hub, drum, wheel bearing and brake air chambers.
   c. Remove the axle shafts and differential carrier from the axle housing.

WARNING

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, emulsion-type cleaners and petroleum-based cleaners. To avoid serious personal injury when you use solvent cleaners, you must carefully follow the manufacturer's product instructions and these procedures:

- ***Wear safe eye protection.***
- ***Wear clothing that protects you skin.***
- ***Work in a well-ventilated area.***
- ***Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.***
- ***You must use hot solution tanks or alkaline solutions correctly. Follow the manufacturer's instructions carefully.***

   d. Clean the damaged area inside and outside the housing. Cleaning solvent can be used.
   e. Grind the damaged weld to the base metal.
   f. Warm the complete axle housing to a temperature of 70°F–80°F (21°C–27°C) or higher.
   g. Before you start welding, heat the damaged area to be repaired to approximately 300°F (149°C).
   h. Use a 70,000 psi tensile weld material and the correct voltage and amperage for the diameter weld rod used. Examples of weld rods that can be used are E-7018 or ER-70S-3.

CAUTION

If the E-7018 weld rod is used, the rod must be kept dry. Electrodes that are not stored in the correct sealed containers must be heated at 700°F (371°C) for one hour before welding. Wet electrodes must be dried at 180°F (82°C) for one to two hours and then heated at 700°F (371°C) for one hour before welding.

   i. Fill in the weld gap as follows:
      1. The opening in cover welds **MUST** be filled level with the old weld.
      2. The opening in seam welds **MUST** be ground out to 70% of the wall thickness. The wall thickness can be measured at the carrier opening of housing.
      3. Clean the new weld area. Carefully remove all the rough weld material.
      4. Install the differential carrier and axle shafts.
      5. Fill the axle assembly with the correct amount of lubricant. Refer to Maintenance Manual 1, *Lubrication*, for information on lubricants.

CAUTION

Do not connect the ground cable at any point on the axle assembly that will place a bearing between the ground cable and weld area. If a bearing is between the ground cable and weld, the bearing will be damaged because of electrical arcing in the bearing and bearing track areas.

A good location to connect the ground cable is the spring mounting pad of the housing.

NOTE: Before welding brackets or other components to the axle housing, contact ArvinMeritor for proper welding procedures.

Bending or Straightening Drive Axle Housings

ArvinMeritor Commercial Vehicle Systems strongly recommends against any attempt to correct or modify drive axle housings by bending or straightening. All damaged drive axle housings should be replaced.

WARNING

Do not bend or straighten damaged drive axle housings. Any bending or straightening process may result in misalignment or weakening of the axle housing and cause component damage and result in serious personal injury.

Removing Dri-Loc® Fasteners

If it is difficult to remove fasteners from components, the strength of Dri-Loc®, Meritor adhesive or Loctite® 277 can be decreased by heating. Use the following procedure:

1. Heat the fastener for three to five seconds **ONLY** and try to loosen the fastener with a wrench. **DO NOT** use an impact wrench to loosen the fastener or hit the fastener with a hammer.

CAUTION

Do not exceed 350°F (177°C) maximum. Heating must be done slowly to prevent thermal stresses in the other components.

2. Repeat Step 1 until the fastener can be removed.

Installing Fasteners with Pre-Applied Adhesive, Meritor Liquid Adhesive 2297-C-7049, Loctite® 680 Liquid Adhesive or Equivalent

Installing New Fasteners with Pre-applied Adhesive Patches

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

1. Clean the oil and dirt from threaded holes. Use a wire brush. There is no other special cleaning required.

CAUTION

Do not apply adhesives or sealants on new fasteners with pre-applied adhesive patches or inside closed threaded holes. If other adhesives or sealants are used, the new adhesive will not function correctly.

2. Assemble parts using the new pre-applied adhesive fasteners.

NOTE: There is no drying time required for fasteners with pre-applied adhesive.

3. Tighten the fasteners to the required torque value for that size fastener.

Installing Original or Used Fasteners Using Meritor Liquid Adhesive 2297-C-7049 or Loctite® 680 or Equivalent

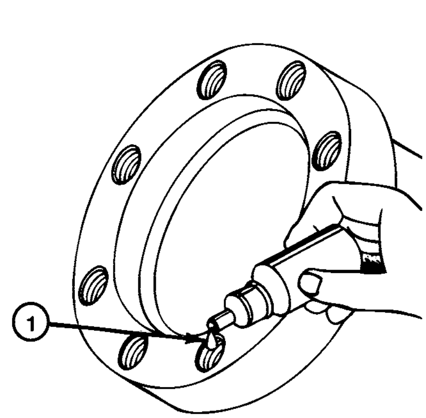
1. Clean the oil, dirt and old adhesive from all threads and threaded holes. Use a wire brush.

CAUTION

Do not apply adhesive directly to the fastener threads. Air pressure in a closed hole will push the adhesive out and away from mating surfaces as the fastener is installed.

2. Apply four or five drops of Meritor Liquid Adhesive, Loctite® 680 or equivalent inside each threaded hole or bore ONLY. Make sure the adhesive is applied inside to the bore threads. **Figure 4.1**.

Figure 4.1



1 4 TO 5 DROPS ON BORE THREADS

3. Tighten the fasteners to the required torque value for that size fastener.

NOTE: There is no drying time required for Meritor Liquid Adhesive 2297-C-7049, Loctite® 680 or equivalent.

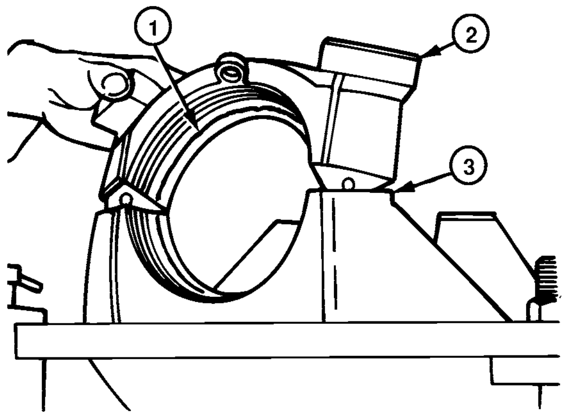
Application of Meritor Adhesive 2297-T-4180 in Bearing Bores for the Differential

Use adhesive 2297-T-4180 for all axles.

1. Clean the oil and dirt from outer diameters of bearing cups and bearing bores in the carrier and bearing caps. There is no special cleaning required.
2. Apply axle lubricant to the bearing cones and the inner diameters of the bearing cups of the main differential. **DO NOT** get oil on the outer diameter of the bearing cup and **DO NOT** permit oil to drip on the bearing bores.

3. Apply a single continuous bead of the adhesive to the bearing bores in the carrier and bearing caps. Apply the adhesive 360° around the smooth, ground surfaces only. **DO NOT** place adhesive on threaded areas. **Figure 4.2**.

Figure 4.2



1 ADHESIVE
2 BEARING CAP
3 CARRIER LEG

NOTE: Meritor adhesive 2297-T-4180 will become hard (dry) in approximately two hours. The following two steps of the procedure must be done in two hours from the time the adhesive was applied. If two hours have passed since application, clean the adhesive from the parts again and apply new adhesive.

4. Install the main differential assembly, bearing cups and bearing caps into the carrier. Use the normal procedure, refer to "Install the Differential and Ring Gear Assembly" in Section 5.
5. Adjust preload of the differential bearings, backlash and tooth contact patterns of the gear set as required using the normal procedures. Refer to "Adjust Preload of Differential Bearings" in Section 5.

Application of Three Bond 1216 or Equivalent Silicone Gasket Material

WARNING

Take care when you use silicone gasket materials to avoid serious personal injury. Follow the manufacturer's instructions to prevent irritation to the eyes and skin.

NOTE: The following silicone gasket products or equivalent are available in 3 oz (85 gram) tubes and can be used for Meritor components:

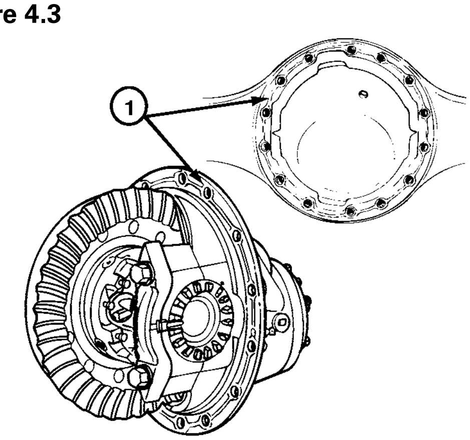
- Three Bond RTV No. TB 1216 (Grey) — Meritor Part Number 2297-Z-7098
- Loctite® Ultra Grey Adhesive/Sealant #18581 — Meritor Part Number 2297-A-7021

Also available in 120 oz (3.4 kg) cartridges:

- Three Bond RTV1216 (Grey) — Meritor Part Number 2297-A-7051

1. Remove all old gasket material from both surfaces. **Figure 4.3**.
2. Clean the surfaces where silicone gasket material will be applied. Remove all oil, grease, dirt and moisture without damaging the mating surfaces. **Figure 4.3**.

Figure 4.3



1 REMOVE OLD SEALANT MATERIAL

HOUSING AND CARRIER SHOWN

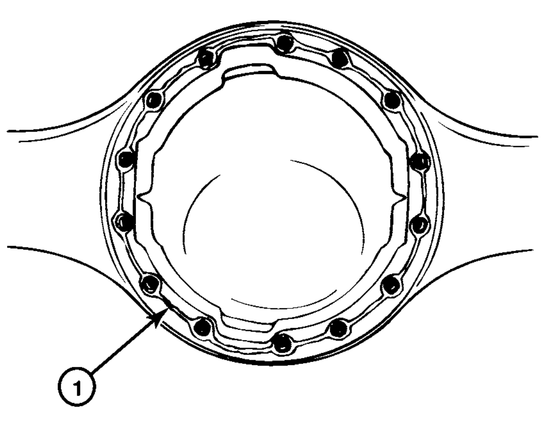
3. Dry both surfaces.

CAUTION

The amount of silicone gasket material applied must not exceed 0.125-inch (3 mm) diameter bead. Too much gasket material can block lubrication passages and result in damage to the components.

4. Apply 0.125-inch (3 mm) diameter continuous bead of the silicone gasket material around one surface. Also apply the gasket material around the edge of all fastener holes on that surface. **Figure 4.4**.
5. Assemble the components immediately to permit the silicone gasket material to compress evenly between the parts. Tighten fasteners to the required torque value for that size fastener. There is no special procedure or additional torque value required. Refer to **Table J**.
6. Wait 20 minutes before filling the assembly with lubricant.

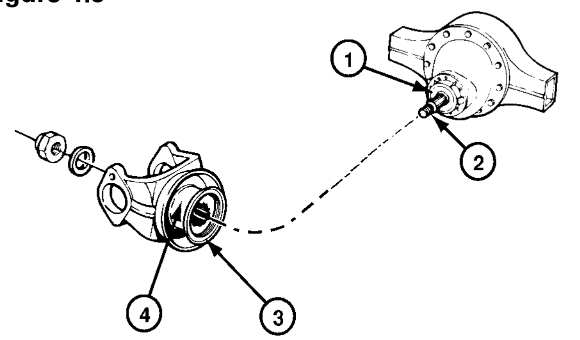
Figure 4.4



1 0.125″ (3 MM) DIAMETER SILICONE GASKET BEAD

Installing Tight Fit Yokes and POSE™ Seal

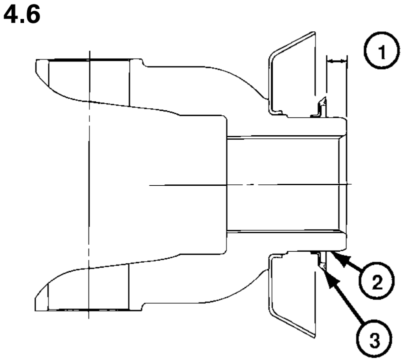
Figure 4.5



1 LUBRICATE TRIPLE-LIP (MAIN) SEAL
2 INPUT SHAFT (PINION)
3 POSE™ SEAL 0.25"–0.50" (6.4 MM–12.7 MM) ONTO HUB
4 INSPECT YOKE HUB

1. Apply the same lubricant used in the axle housing to the hub of the yoke or flange.
2. Inspect and make sure the lips of the POSE™ seal and the outer retainer of the triple-lip (main) seal are clean and free from dirt and particles that may cause lubricant leakage between the seals.
3. Install the POSE™ seal on the hub of the yoke or flange by hand. The lips of the seal must face toward the end of the hub (opposite shoulder). Slide the POSE™ seal on the hub until the lips are from 0.25-inch to 0.50-inch (6.4 mm-12.7 mm) from the end of the hub. ***Do not install the POSE™ seal against the shoulder.*** **Figure 4.6**.

Figure 4.6



1 0.25″–0.50″ (6.4 MM–12.7 MM)
2 YOKE HUB
3 FACE SEAL ASSEMBLY (POSE™ SEAL ELEMENT)

NOTE: The POSE™ seal will position itself correctly as the yoke or flange is pressed on the shaft.

4. Before you install the yoke or flange on the shaft, apply the same lubricant used in the axle housing to the hub.
5. Install the yoke or flange using the correct procedure.

NOTE: The yoke must be completely seated before tightening pinion nut to the input shaft.

General Yoke and U-Joint Reassembly

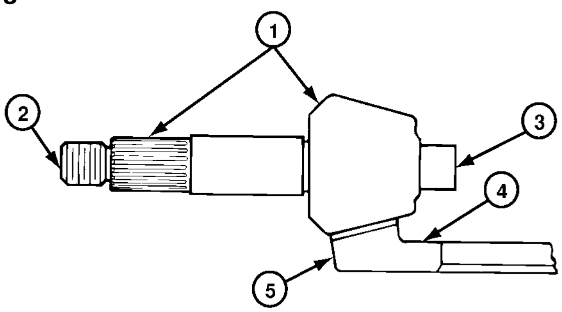
Install the end yoke hub capscrews by hand after seating the U-joint. Tighten the capscrews according to manufacturer's torque specifications.

Gear Set Information (Drive Pinion and Ring Gear Marks)

NOTE: Read the following information before installing a new gear set in the carrier. Always inspect the gear set for correct marks to make sure the gears are a matched set.

The locations of the marks are shown in **Figure 4.7**.

Figure 4.7



1 ALTERNATE LOCATIONS: PART NO., TOOTH COMBINATION NO., GEAR SET MATCH NO., PINION CONE VARIATION NO.
2 PART NO., TOOTH COMBINATION NO.
3 GEAR SET MATCH NO., PINION CONE VARIATION NO.
4 PART NO., TOOTH COMBINATION NO., GEAR SET MATCH NO.
5 PART NO., TOOTH COMBINATION NO., GEAR SET MATCH NO., PINION CONE VARIATION NO.

1. **Part Number**
   a. **Examples of gear set part numbers:**
      - Conventional ring gear, 36786.
      - Conventional drive pinion, 36787.
      - Generoid ring gear, 36786 K or 36786 K2.
      - Generoid drive pinion, 36787 K or 36787 K2.

NOTE: The last digit in part numbers for Generoid gears is a letter or letter and number.

   b. **Location on Drive Pinion:** End at threads.
   c. **Location on Ring Gear:** Front face or outer diameter.

2. **Tooth Combination Number**
   a. **Example of a tooth combination number:** 5-37.

NOTE: A 5-37 gear set has a 5-tooth drive pinion and a 37-tooth ring gear.

   b. **Location on Drive Pinion:** End at threads.
   c. **Location on Ring Gear:** Front face or outer diameter.

3. **Gear Set Match Number**

   Meritor drive pinions and ring gears are available only as matched sets. Both gears of a set have a match number.

   a. **Example of a gear set match number:** M29.

NOTE: A gear set match number has any combination of a number or letter and number.

   b. **Location on Drive Pinion:** End of gear head.
   c. **Location on Ring Gear:** Front face or outer diameter.

NOTE: The pinion cone variation number is not used when inspecting for a matched gear set. The number is used when you adjust the depth of the pinion in the carrier. Refer to the procedure for adjusting the shim pack thickness under the pinion cage heading.

4. **Pinion Cone Variation Number**

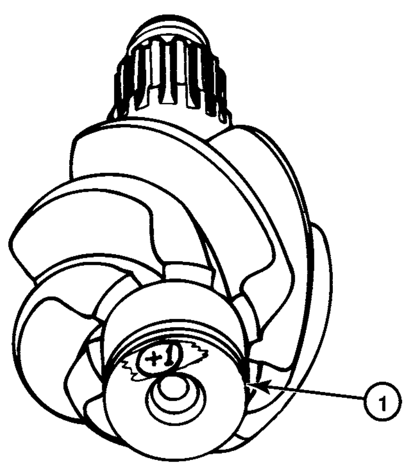
   a. Examples — refer to **Figure 4.8**.

   Pinion cone variation numbers:

   - PC+3
   - PC–5
   - +2
   - –1
   - +0.01 mm
   - –0.02 mm

   b. **Location on Gear Set:** End of pinion gear head or outer diameter of ring gear.

Figure 4.8



1 PINION CONE VARIATION NUMBER

Assemble the Drive Pinion, Bearings and Bearing Cage

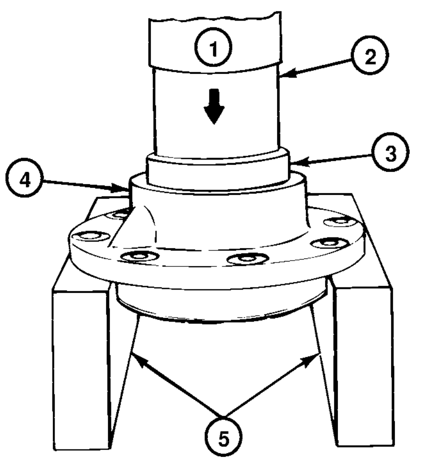
WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

1. Place the bearing cage in a press. **Figure 5.1**.

Figure 5.1



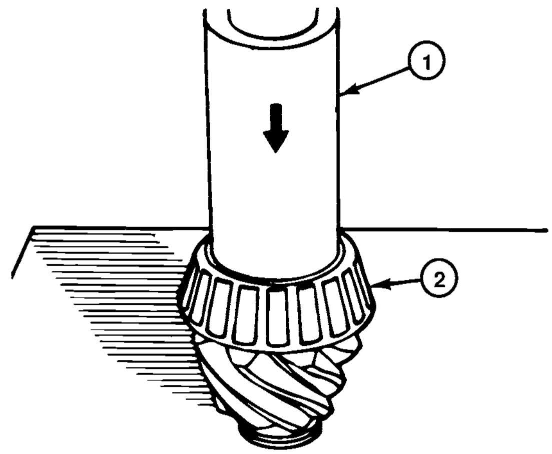
1 PRESS
2 SLEEVE
3 BEARING CUP
4 CAGE
5 SUPPORTS

2. Support the bearing cage with metal or wood blocks.
3. Press the bearing cup into the bore of bearing cage until cup is flat against bottom of bore. Use a sleeve of the correct size to install bearing cup. **Figure 5.1**.

NOTE: Use the same procedure for both bearing cups.

4. Place the drive pinion in a press, gear head (teeth) toward the bottom. **Figure 5.2**.

Figure 5.2



1 SLEEVE
2 INNER BEARING CONE

5. Press the inner bearing cone on the shaft of the drive pinion until the cone is flat against the gear head. Use a sleeve of the correct size against the bearing inner race.

NOTE: Spigot bearings are usually fastened to the drive pinion with a snap ring. Some are fastened with a peening tool, and some are a two-piece bearing assembly with the inner race pressed on the nose of the pinion and the outer race pressed into its bore in the carrier. Use the following procedure to install the spigot bearing, then continue with Steps 9-12 under "Staking the One-Piece Spigot Bearing on the Drive Pinion (Without Snap Ring)."

6. Installing the One-Piece Spigot Bearing on the Drive Pinion with Snap Ring:

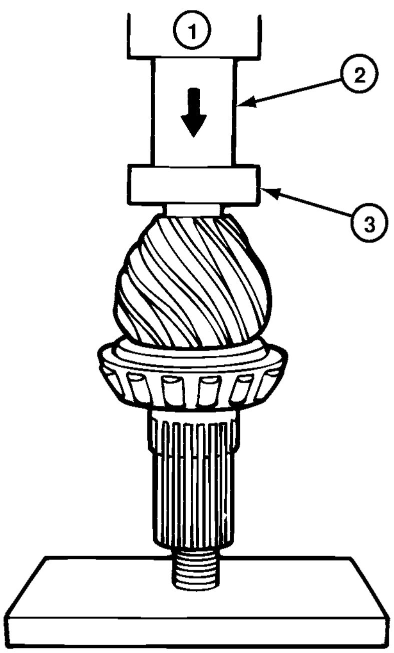
NOTE: This step applies to all axles except:

- Some 160 Series single axles may use snap rings.
- Some 160 and 180 Series rear rear tandem axles may use snap rings.

a. Place the drive pinion in a press, gear head (teeth) toward the top. **Figure 5.3**.

b. Press the spigot bearing on the end of drive pinion until the bearing is flat against the gear head. Use a sleeve of the correct size against the bearing inner race. **Figure 5.3**.

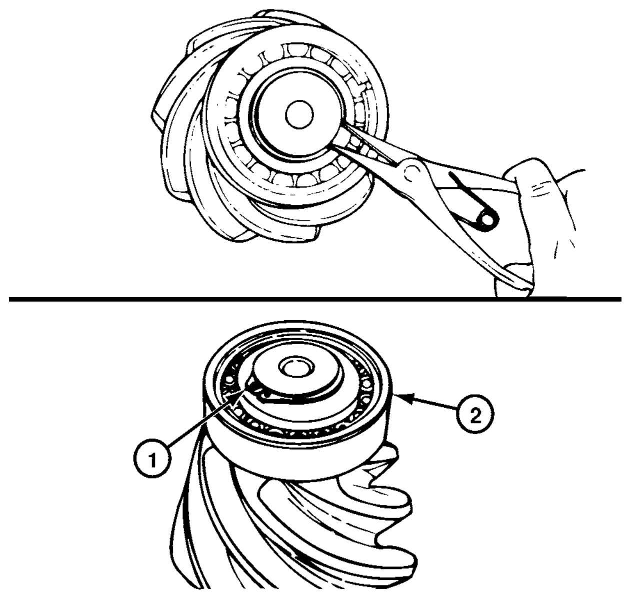
Figure 5.3



1 PRESS
2 SLEEVE
3 SPIGOT BEARING

c. Install the snap ring* into groove in end of drive pinion with snap ring pliers. **Figure 5.4**.

Figure 5.4



1 SNAP RING
2 SPIGOT BEARING

7. Staking the One-Piece Spigot Bearing on the Drive Pinion (Without Snap Ring):

NOTE: This procedure applies to some 180 Series rear rear tandem axles with existing snap ring components.

Specification

- Apply 6,614 lb. (3,000 kg) force on a 0.375-inch (10 mm) ball.
- Stake the end of drive pinion at a minimum of five points. **Figure 5.5**.

When using a staking tool and press, **Figure 5.6**, calculate the force required on the tool as follows.

6,614 lb. (3,000 kg) x amount of balls in tool = pounds or kilograms

*Some Meritor carriers do not have these described parts.

Example

6,614 lb. x 3 balls = 19,842 pounds

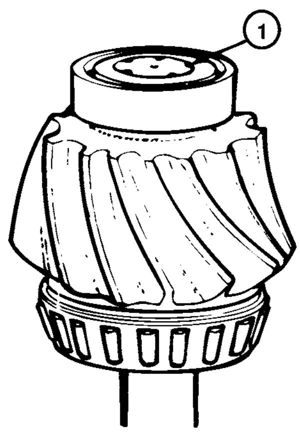
For information about the staking tool, contact your local Meritor representative. **Figure 5.6**.

a. Place the drive pinion and the tube of the staking tool in a press, spigot bearing toward the top. **Figure 5.7.**

b. Calculate the amount of force that will be required on the staking tool. Refer to specification and example calculation.

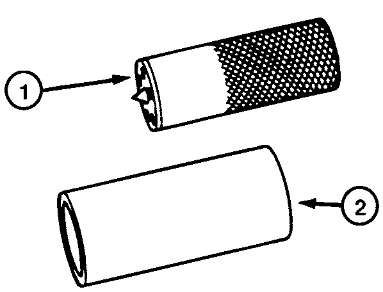
c. Place the punch of the staking tool over the end of the pinion and spigot bearing. Apply the required amount of force on the punch. **Figure 5.7**.

Figure 5.5



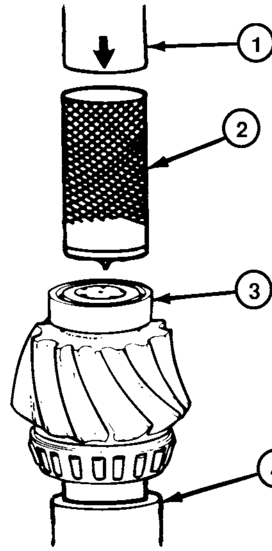
1 STAKING POINTS

Figure 5.6



1 PUNCH
2 TUBE

Figure 5.7



1 PRESS
2 INSTALL AND CENTER THE PUNCH ON THE END OF PINION.
3 SPIGOT BEARING
4 PUT THE SHAFT OF PINION INTO TUBE.

CAUTION

Do not align new points with grooves in end of drive pinion or in old points. If the new staked points are placed in the wrong areas, the spigot bearing will not be held correctly on the pinion shaft.

d. Rotate the punch as many times as required for a minimum of five points. Repeat Step **c** for each point.

NOTE: If a three-ball stake tool is used, rotate the tool 180° (degrees).

8. Installing and Staking the Two-Piece Spigot Bearing on the Drive Pinion:

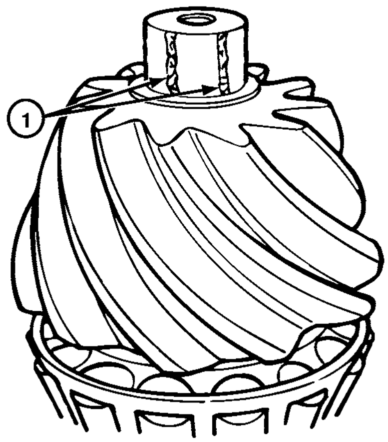
NOTE: This procedure applies to some 160 Series single rear axles and rear rear tandem axles. These axles may also use a one-piece spigot bearing with a snap ring retainer.

The inner race of two-piece spigot bearings may need to be staked in place on some R-160 series rear axles. Before you stake the pinion, you must heat the pinion stem to soften it.

Kent-Moore Kit J-39039 includes the staking tool, temperature indicating liquid, heating shield and plastigage needed for this job.

a. Apply two stripes of temperature indicating liquid on the pinion stem from the top to the bottom. **Figure 5.8**. Apply a green stripe to indicate 400°F (205°C) and a blue stripe to indicate 500°F (260°C).

Figure 5.8



1 TEMPERATURE INDICATING LIQUID APPLICATION

WARNING

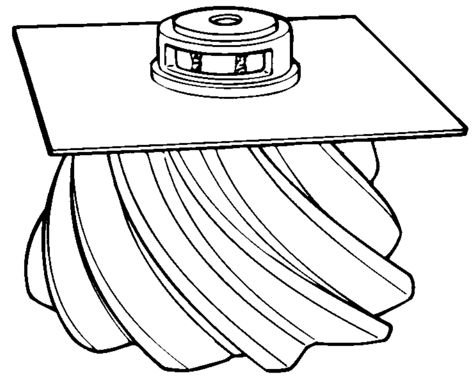
Always wear safe clothing, gloves and eye protection when working with a torch for heating parts to prevent serious personal injury during assembly.

CAUTION

Do not heat the pinion stem without the heat shield in place. Also, do not overheat the pinion stem or you will weaken the metal which can cause early failure. Correct heating will take approximately 25-35 seconds, depending on how hot the torch is.

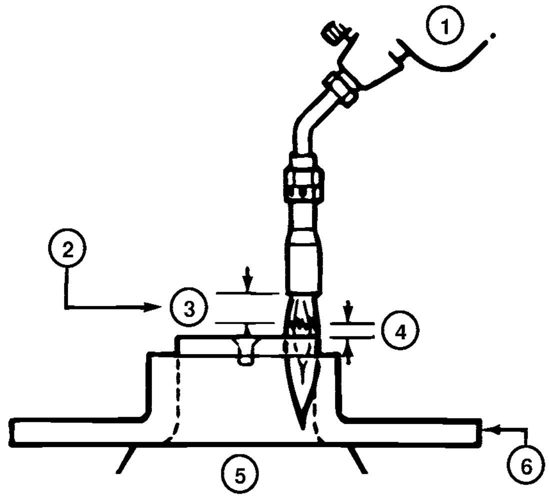
b. Place the heating shield over the pinion stem so that you can see the temperature indicating liquid through the hole in the shield. **Figure 5.9**.

Figure 5.9



c. Light and adjust the torch until the white part of the flame is approximately 1/4-inch long. Keep the white part of the flame approximately 1/8-inch from the top of the stem. **Figure 5.10**. Move the flame around the outer diameter of the top of the pinion stem. The green temperature indicating liquid will turn black before the blue liquid does. Heat the stem until the blue liquid turns black at a point in the middle of the window.

Figure 5.10



1 TORCH
2 WHITE PART OF FLAME
3 1/4"
4 1/8"
5 PINION
6 HEATING SHIELD

d. Remove the flame and the heat shield from the pinion. Let the pinion air cool for 10 minutes. Use a razor blade to remove the temperature indicating liquid.

WARNING

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

CAUTION

Do not press or directly strike the new inner race in Step e or damage to the bearing will result.

e. Use a press, if available, or a brass hammer to install the new inner race. Use the old inner race as a sleeve. The face is completely seated when you cannot fit a 0.002-inch feeler gauge between the race and the pinion shoulder.

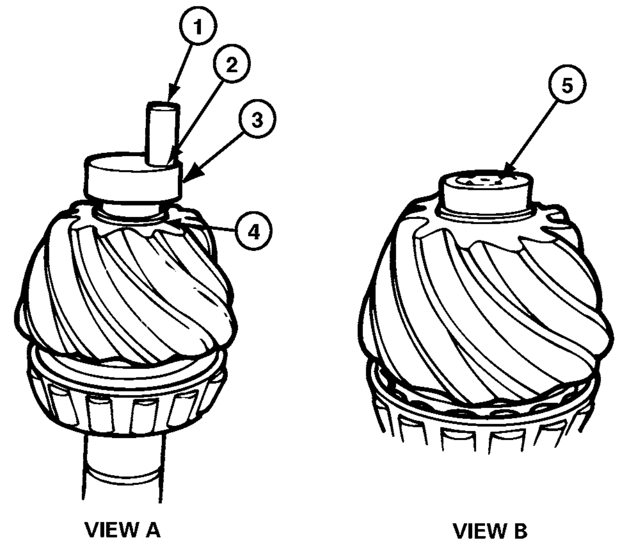
NOTE: To hold the races in place, use a staking tool, instead of the old race, to start the new race on the stem. The old race can be used to completely seat the new race.

In Step f, you do not need to use the plastigage for every stake. Use the plastigage until you are sure you are hitting the punch with the correct amount of force.

f. Place the staking tool over the bearing race. Cut a one inch piece from the green plastigage strip and place in between the punch and the staking tool. **Figure 5.11 — View A**.

g. Strike the punch with a two-three pound brass hammer to upset the end of the pinion stem. Then, remove the strip and measure its thickness against the gauge on the wrapper that the strip came in. The strip must not be less than 0.003-inch thick. This thickness indicates that you are using enough force when you hit the punch. If the strip is too thin, then you must hit the punch harder so the stake will hold the race in place. Rotate the tool and repeat this procedure until there are six evenly spaced stake marks around the stem. **Figure 5.11 — View B**.

Figure 5.11

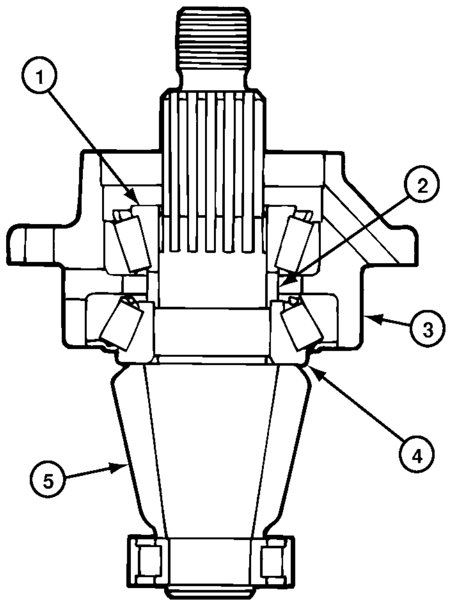


1 PUNCH
2 PLASTIGAGE
3 STAKING TOOL
4 BEARING INNER RACE
5 STAKES

h. With a press or a soft mallet and sleeve, install the outer race and roller assembly into its bore in the carrier. Use a sleeve that is the same size as the outer race and press the bearing until it is squarely against the shoulder in the bottom of its bore.

9. Apply axle lubricant to the bearing cups and to the bearing cones in the cage.
10. Install the drive pinion into the bearing cage.
11. Install the bearing spacer or spacers on pinion shaft against the inner bearing cone. **Figure 5.12**.

Figure 5.12



1 OUTER BEARING CONE
2 BEARING SPACER
3 BEARING CAGE
4 INNER BEARING CONE
5 DRIVE PINION

NOTE: The spacer or spacers control the preload adjustment of the drive pinion bearings.

12. Install the outer bearing cone on pinion shaft against the spacer. **Figure 5.12.**

NOTE: DO NOT install pinion seal in bearing cage. Continue with adjusting preload of pinion bearings.

Adjusting Preload of Pinion Bearings

Specifications

- New pinion bearings — torque
  — 5 to 45 lb-in (0.56-5.08 N•m)
- Used pinion bearing in good condition — torque
  — 10 to 30 lb-in (1.13-3.39 N•m)

Press Method

NOTE: If a press is not available, or the press does not have a pressure gauge, use the yoke or flange method to adjust pinion bearing preload. Refer to "Yoke or Flange Method" in this section.

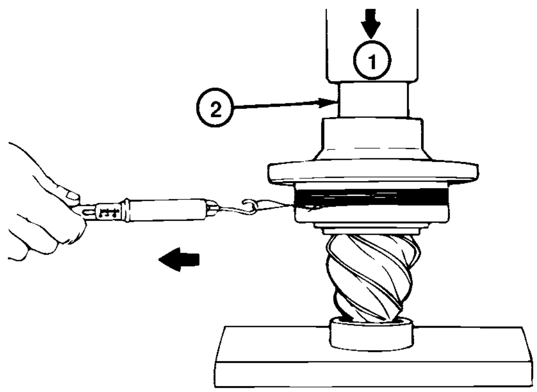
1. Place the drive pinion and cage assembly in a press, gear head (teeth) toward the bottom.
2. Install a sleeve of the correct size against the inner race of the outer bearing. **Figure 5.13.**
3. Apply and hold the correct amount pressure to the pinion bearings. Refer to **Table A**. As pressure is applied rotate the bearing cage several times so that bearings make normal contact.

Table A: Pinion Bearing Preload Adjustment Values

Thread Size of Pinion Shaft	Press Pressure Needed on Bearings for Correct Preload.		Torque Value Needed on Pinion Nut for Correct Bearing Preload.	
	pounds/tons	(kg/metric tons)	lb-ft	(N•m)
7/8"-20	22,000/1	(9979/10)	200-275	(271-373)
1"-20	30,000/15	(13608/13.6)	300-400	(407-542)
1 1/4"-12	54,000/27	(24494/24.5)	700-900	(949-1220)
1 1/4"-18	54,000/27	(24494/24.5)	700-900	(949-1220)
1 1/2"-12	54,000/27	(24494/24.5)	800-1100	(1085-1491)
1 1/2"-18	54,000/27	(24494/24.5)	800-1100	(1085-1491)
1 3/4"-12	50,000/25	(22680/22.7)	900-1200	(1220-1627)
2"-12	50,000/25	(22680/22.7)	1200-1500	(1627-2034)

4. While pressure is held against the assembly, wind a cord around the bearing cage several times.

Figure 5.13

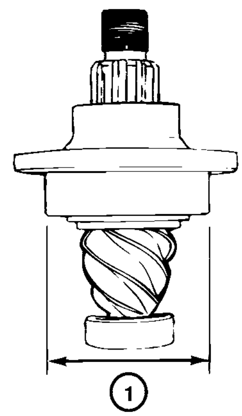


1 PRESS
2 SLEEVE

5. Attach a spring scale to the end of the cord.
6. Pull the cord with scale on a horizontal line. As the bearing cage rotates, read the value indicated on scale. Write down and record the reading. **Figure 5.13**.

   NOTE: Do not read starting torque. Read only the torque value after the cage starts to rotate. Starting torque will give a false reading.
7. Measure the diameter of bearing cage where the cord was wound. Measure in inches or centimeters. **Figure 5.14**.
8. Divide the dimension in half to get the radius. Write down and record the radius dimension.

Figure 5.14



1 MEASURE DIAMETER OF CAGE.

9. Use the following procedure to calculate the bearing preload (torque).
   - Pounds Pulled x Radius (inches) = lb-in Preload

     — Preload x 0.113 = N•m Preload
   - Kilograms Pulled x Radius (cm) = kg-cm Preload

     — Preload x 0.098 = N•m Preload

or

Examples

- Reading from spring scale = 7.5 pounds (3.4 kg)
- Diameter of bearing cage = 6.62 inches (16.80 cm)
- Radius of bearing cage = 3.31 inches (8.40 cm)

  7.50 lb. x 3.31 in. = 24.80 in-lb Preload

  Preload x 0.113 = 2.800 N•m Preload

or

  3.4 kg x 8.4 cm = 28.6 kg-cm Preload

  Preload x 0.098 = 2.800 N•m Preload

10. If the preload (torque) of pinion bearings is not within specifications, do the following procedure then repeat Steps **a** through **i**.

    To increase preload, install a thinner bearing spacer. To decrease preload, install a thicker bearing spacer.

11. Inspect the bearing preload with the drive pinion and cage assembly installed in the carrier. Follow the procedures to adjust preload of pinion bearings, yoke or flange method.

Yoke or Flange Method

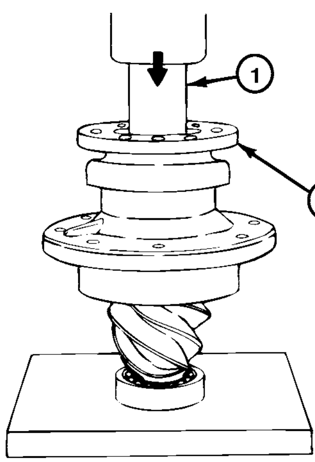
WARNING

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

1. Install the input yoke or flange, nut and washer* on the drive pinion. The yoke or flange **MUST** be seated against the outer bearing.

NOTE: Use a press to install the yoke or flange. **Figure 5.15**.

Figure 5.15



1 PRESS
2 INPUT FLANGE SHOWN

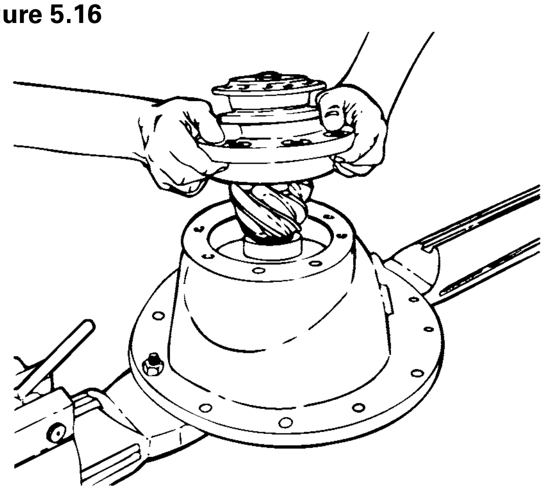
*Some Meritor carriers do not have these described parts.

CAUTION

Do not install tight fit yokes or flanges on shafts using a hammer or mallet. A hammer or mallet will damage the yoke or flange.

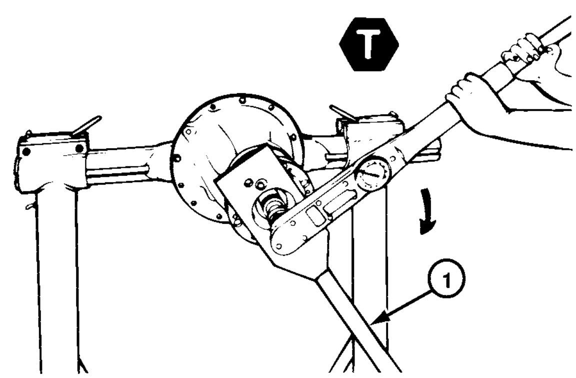
2. Temporarily install the drive pinion and cage assembly in the carrier. Do not install shims under the bearing cage. **Figure 5.16**.

Figure 5.16



3. Install the bearing cage to carrier capscrews. Washers are not required at this time. Tighten the capscrews by hand until snug.
4. Fasten a yoke or flange bar to the input yoke or flange. The bar will hold the drive pinion in position when the nut is tightened. **Figure 5.17**.

Figure 5.17

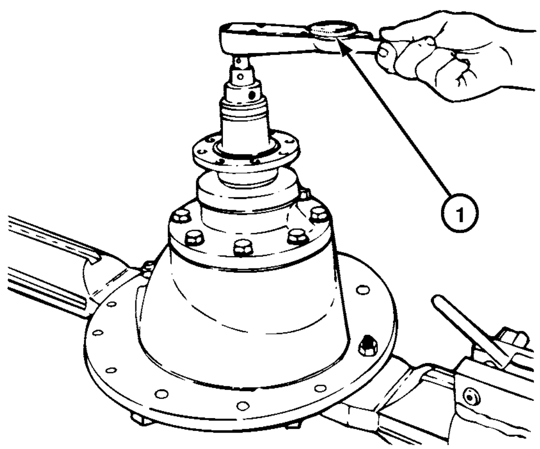


1 USE FLANGE OR YOKE BAR.

5. Tighten the nut on drive pinion to the correct torque value. **Figure 5.17**. Refer to **Table A**.

6. Remove the yoke or flange bar.
7. Attach a torque wrench on the drive pinion nut. Rotate the drive pinion and read the value indicated on torque wrench. **Figure 5.18**.

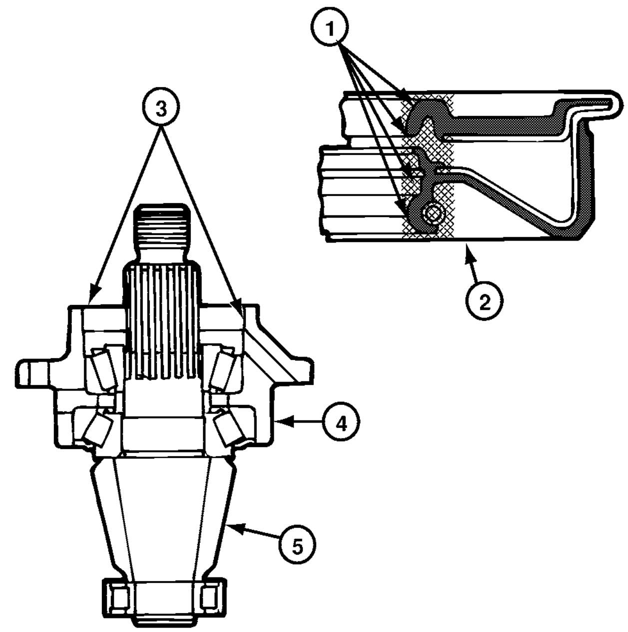
Figure 5.18



1 READ TORQUE VALUE.

8. If the preload (torque) of pinion bearings is not within specifications, remove the pinion and cage assembly from carrier. Do the following procedure, then repeat Steps **a** through **g**.
   - To **INCREASE** preload, install a thinner bearing spacer.
   - To **DECREASE** preload, install a thicker bearing spacer.
9. After adjusting preload of pinion bearings, remove the drive pinion and bearing cage from carrier. Follow Steps 1-5 under "Remove the Drive Pinion and Bearing Cage from Carrier."
10. Install a new triple-lip seal as follows.
    a. Apply the same lubricant used in the axle housing to the outer surface of the seal and the seal bore in the bearing cage. **Figure 5.19**.

Figure 5.19



1 APPLY GREASE.
2 TRIPLE-LIP (MAIN) SEAL
3 APPLY LUBRICANT TO SEAL BORE.
4 BEARING CAGE
5 DRIVE PINION

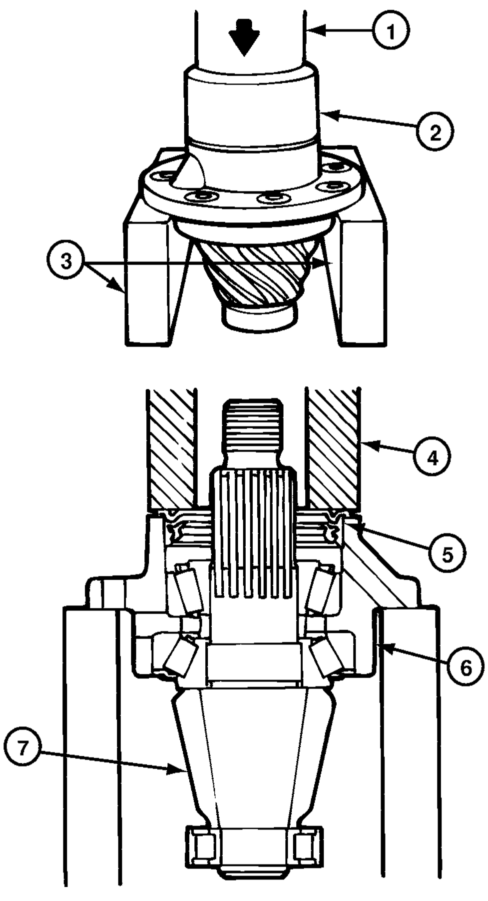
CAUTION

Make sure that the seal lips are clean and free from dirt and particles that will cause a leak between the yoke and the seal.

b. Place the drive pinion and cage assembly in a press, seal bore toward the top.

c. Press the seal into bearing cage until flange of seal is flat against the top of bearing cage. Use a sleeve or seal driver of the correct size that fits against the metal flange of seal. The diameter of the sleeve or drive **MUST** be larger than the diameter of the flange. **Figure 5.20**.

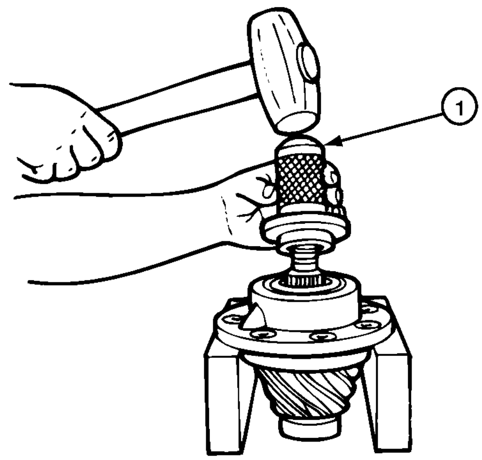
Figure 5.20



1 PRESS
2 SLEEVE
3 SUPPORTS
4 SLEEVE
5 SEAL
6 BEARING CAGE
7 DRIVE PINION

NOTE: If a press is not available, use a mallet and the sleeve or driver to install the seal. **Figure 5.21**.

Figure 5.21

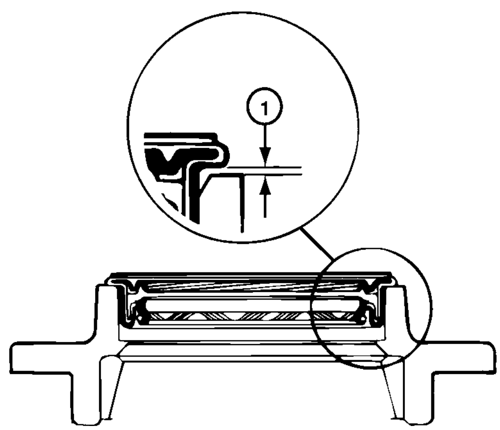


1 SEAL DRIVER

d. After the triple-lip seal is installed, a gap of approximately 0.015- to 0.030-inch (0.38-0.76 mm) between the flange and bearing cage is normal. **Figure 5.22**.

Inspect the gap with a feeler gauge at several points around the seal. The gap must be within 0.015- to 0.030-inch (0.38-0.76 mm). The difference between the largest and smallest gap measurement **MUST NOT** exceed 0.010-inch (0.254 mm).

Figure 5.22



1 0.015-0.030" (0.38-0.76 MM)

SHOWN WITHOUT BEARINGS AND PINION

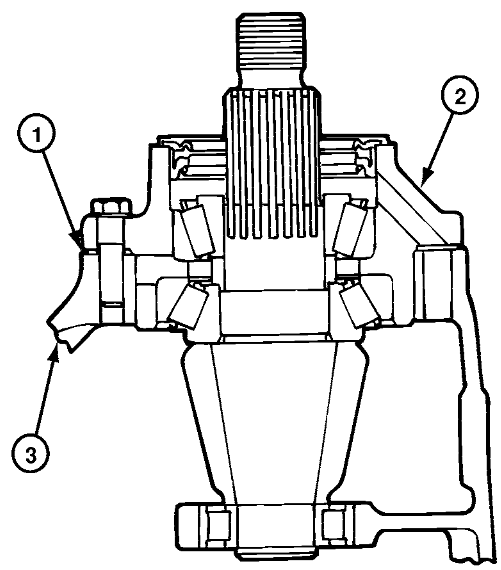
⚠ WARNING

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off and cause serious personal injury.

Adjusting Shim Pack Thickness for the Pinion Cage (Depth of Pinion)

NOTE: Use this procedure if a new drive pinion and ring gear set is installed, or if the depth of the drive pinion has to be adjusted. **Figure 5.23**.

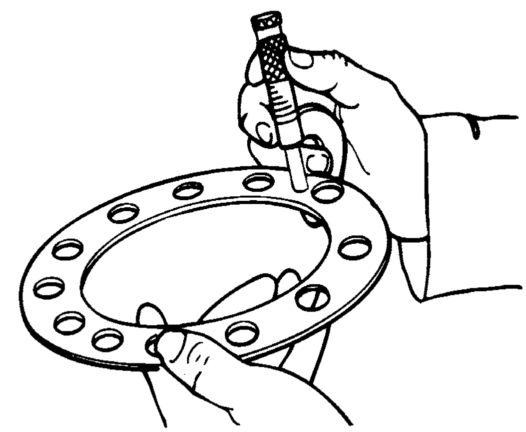
Figure 5.23



1 SHIM PACK CONTROLS DEPTH OF PINION.
2 BEARING CAGE
3 CARRIER

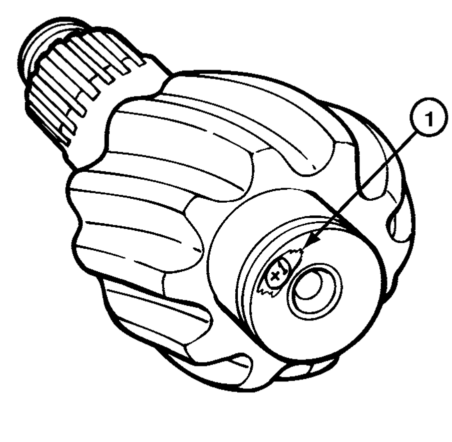
1. Measure the thickness of the old shim pack that was removed from under the pinion cage with a micrometer. Record the measurement for use later. **Figure 5.24**.

Figure 5.24



2. Look at the pinion cone (PC) variation number on the old drive pinion that is being replaced. Refer to "Gear Set Information," Step 4, in Section 4 for examples and location of the number. Record the number for later use. If (PC) variation number cannot be located, assemble gear set with shim pack thickness found in Step 1 under "Adjusting Shim Pack Thickness for the Pinion Cage (Depth of Pinion)." **Figure 5.25**.

Figure 5.25



1 PINION CONE VARIATION NUMBER

NOTE: The pinion cone number can be either 100ths of a millimeter or 1,000ths of an inch. Refer to the following examples.

PC +3, PC–3, +3 or –3 = 0.003 inch

PC +.03, PC–0.03 mm, +0.03 mm or –0.03 = 0.03 mm

To change millimeters to inches — millimeters x 0.039

To change inches to millimeters — inches x 25.40

3. If the old pinion cone number is a plus (+) number, subtract the number from the old shim pack thickness that was measured in Step 2.
4. If the old pinion cone number is a minus (–) number, add the number to the old shim pack thickness that was measured in Step 2.

NOTE: The value calculated in Step 3 or 4 is the thickness of the standard shim pack, without a variation.

5. Look at the pinion cone (PC) variation number on the new drive pinion that will be installed. Record the number for later use.
6. If the new pinion cone number is a plus (+) number, add the number to the standard shim pack thickness that was calculated in Step 3 or 4.
7. If the new pinion cone number is a minus (–) number, subtract the number from the standard shim pack thickness that was calculated in Step 3 or 4.

NOTE: The value calculated in Step 6 or 7 is the thickness of the new shim pack that will be installed. Refer to the following examples, **Table B**.

8. Install the drive pinion, bearing cage and new shim pack into the carrier.

Table B: Shim Pack Thickness Calculations

Examples:	**Inches**	**mm**
1. Old Shim Pack Thickness Old PC Number, PC +2 inches (+0.05 mm) Standard Shim Pack Thickness New PC Number, PC +5 inches (+0.13 mm) New Shim Pack Thickness	0.030 – 0.002 = 0.028 + 0.005 = 0.033	0.760 – 0.050 = 0.710 + 0.130 = 0.840
2. Old Shim Pack Thickness Old PC Number, PC –2 inches (–0.05 mm) Standard Shim Pack Thickness New PC Number, PC +5 inches (+0.13 mm) New Shim Pack Thickness	0.030 + 0.002 = 0.032 + 0.005 = 0.037	0.760 + 0.050 = 0.810 + 0.130 = 0.940
3. Old Shim Pack Thickness Old PC Number, PC +2 inches (+0.05 mm) Standard Shim Pack Thickness New PC Number, PC –5 inches (–0.13 mm) New Shim Pack Thickness	0.030 – 0.002 = 0.028 – 0.005 = 0.023	0.760 – 0.050 = 0.710 – 0.130 = 0.580
4. Old Shim Pack Thickness Old PC Number, PC –2 inches (–0.05 mm) Standard Shim Pack Thickness New PC Number, PC –5 inches (–0.13 mm) New Shim Pack Thickness	0.030 + 0.002 = 0.032 – 0.005 = 0.027	0.760 + 0.050 = 0.810 – 0.130 = 0.608

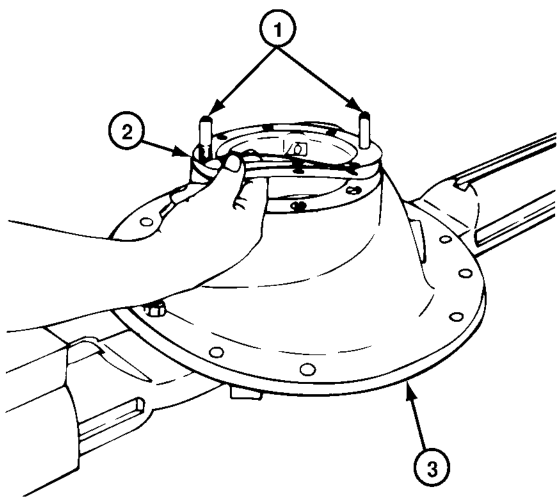
NOTE: Drive pinions and ring gears **MUST** be replaced as fully matched sets.

Installing the Drive Pinion, Bearing Cage and Shim Pack into the Carrier

NOTE: If a new drive pinion and ring gear set is installed, or if the depth of the drive pinion has to be adjusted, calculate the thickness of the shim pack. Refer to "Adjusting Shim Pack Thickness for the Pinion Cage (Depth of Pinion)" in this section.

1. Select the correct shim pack between the bearing cage and carrier. **Figure 5.26**.
2. Apply Loctite® 518 Gasket Eliminator to face of carrier.
3. Align the oil slots in the shims with oil slots in the bearing cage and carrier. The use of guide studs will help align the shims. **Figure 5.26**.

Figure 5.26



1 GUIDE STUDS
2 THREE SHIMS MINIMUM
3 CARRIER

NOTE: If the pack is made from different thickness shims, install the thinnest shims on both sides of the pack for maximum sealing.

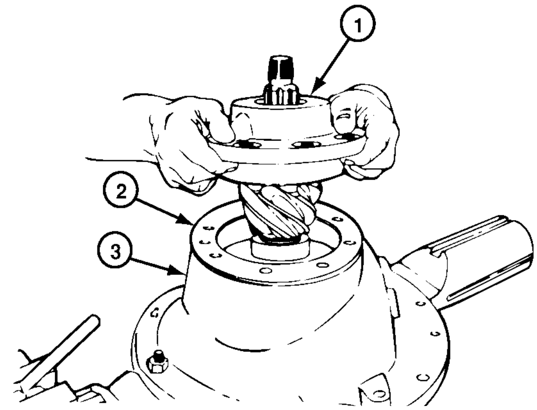
4. Apply Loctite® 518 Gasket Eliminator to top of shim pack.

WARNING

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off and cause serious personal injury.

5. Install the drive pinion and bearing cage into the carrier. If necessary, use a rubber, plastic or leather mallet to hit the assembly into position. **Figure 5.27**.

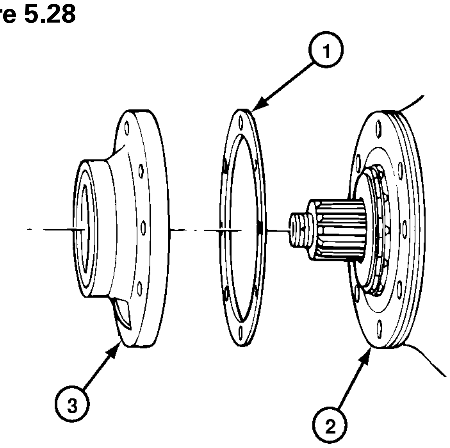
Figure 5.27



1 DRIVE PINION AND BEARING CAGE
2 SHIMS
3 CARRIER

6. If used, install the cover* and seal assembly and gasket* over the bearing cage. **Figure 5.28**.

Figure 5.28

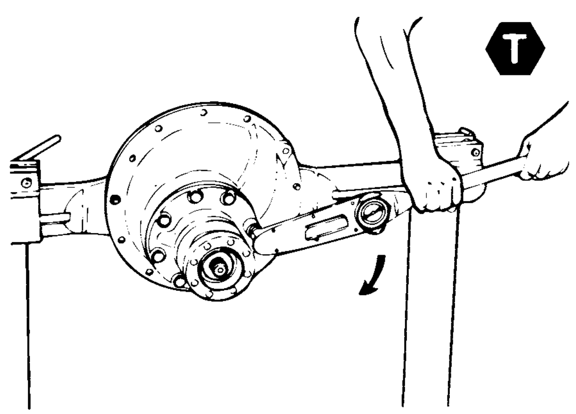


1 GASKET
2 BEARING CAGE
3 COVER AND SEAL ASSEMBLY

*Some Meritor carriers do not have these described parts.

7. Align the oil slots in the cover* and gasket* with oil slot in the bearing cage.
8. Install the bearing cage to carrier capscrews and washers. Tighten capscrews to correct torque value. Refer to **Table J. Figure 5.29**.

Figure 5.29



Installing Tight Fit Yokes and POSE™ Seal

CAUTION

Make sure that the seal lips are clean and free from dirt and particles that will cause a leak between the yoke and the seal.

Do not install tight fit yokes on shafts using a hammer or mallet. Using a hammer or mallet can damage the yoke.

1. Apply axle lubricant on the yoke seal.
2. Inspect all surfaces of the yoke hub for damage.

   If carrier uses a POSE™ seal element, install a new POSE™ seal as follows:

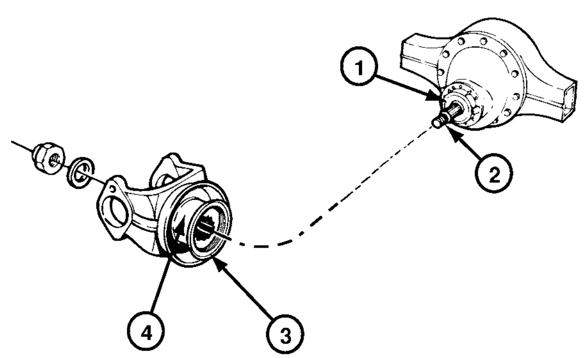
   a. Lightly lubricate yoke journal with same lubricant used in the axle housing.

CAUTION

Make sure that the seal lips are clean and free from dirt and particles that can cause a leak between the yoke and the POSE™ seal.

   b. Partially install the POSE™ seal onto the yoke to 1/4-inch – 1/2-inch as shown in **Figure 5.30**.

Figure 5.30



1 LUBRICATE TRIPLE-LIP (MAIN) SEAL.
2 INPUT SHAFT (PINION)
3 POSE™ SEAL 0.25"–0.50" (6.4 MM–12.7 MM) ONTO HUB
4 INSPECT YOKE HUB.

NOTE: DO NOT install POSE™ seal all the way against the yoke shoulder. This seal is designed to position itself as yoke is installed.

   c. Before installing the yoke onto the drive pinion, lubricate the yoke again with the same lubricant used in the axle housing.

3. Slide the yoke over the input shaft pinion. Align the yoke splines with the shaft splines.

CAUTION

Do not use a hammer or mallet to install the yoke to the input pinion shaft. Using a hammer or mallet can damage the yoke or flange.

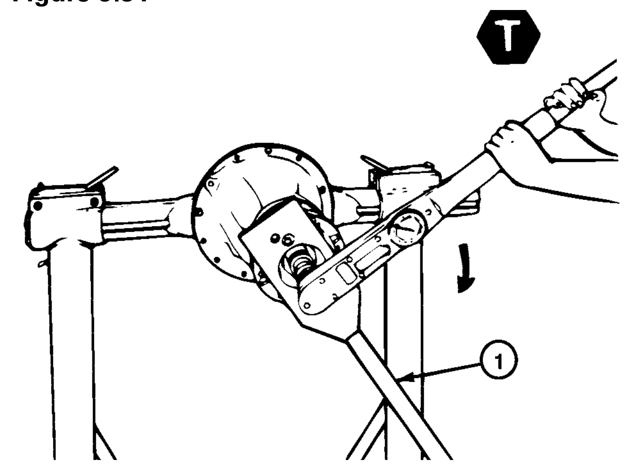
4. Install the input yoke flange onto the drive pinion shaft. The yoke or flange must be fully seated against the outer differential bearing **BEFORE** the nut is torqued to specifications.

---

*Some Meritor carriers do not have these described parts.

5. Install the drive pinion nut on the input pinion shaft and against the yoke collar. Tighten the nut against yoke collar to torque specifications. **Figure 5.31**. Refer to **Table J**. T

Figure 5.31



1 USE FLANGE OR YOKE BAR.

Assemble the Main Differential and Ring Gear Assembly

CAUTION

Do not press a cold ring gear on the flange case half. A cold ring gear will damage the case half because of the tight fit. Metal particles between the parts will cause gear runout that exceeds the Meritor specification of 0.008-inch (0.200 mm).

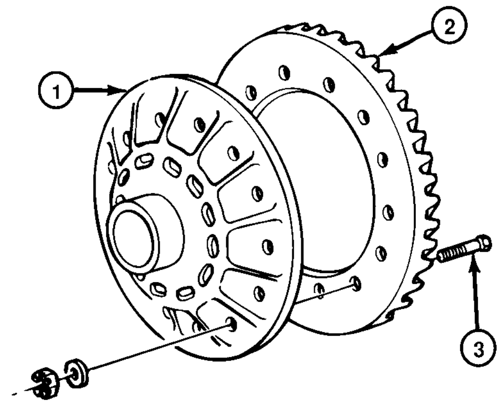
1. Expand the ring gear by heating the gear in a tank of water to a temperature of 160°F to 180°F (71°C-82°C) for 10 to 15 minutes.

WARNING

Wear safe clothing and gloves for protection from injury when working with the hot ring gear.

2. Safely lift the ring gear from the tank of water using a lifting tool.
3. Install the ring gear on the flange case half immediately after the gear is heated. If the ring gear does not fit easily on the case half, heat the gear again. Repeat Step 1.
4. Align fastener holes of the ring gear and flange case half. Rotate the ring gear as needed.
5. If rivets* were used to hold the ring gear to the flange case half, replace them with bolts, nuts and washers.
6. Install the bolts*, nuts* and washers* that hold the ring gear to the flange case half. Install the bolts from the gear side of the assembly. The bolt heads **MUST** be against the ring gear. **Figure 5.32**.

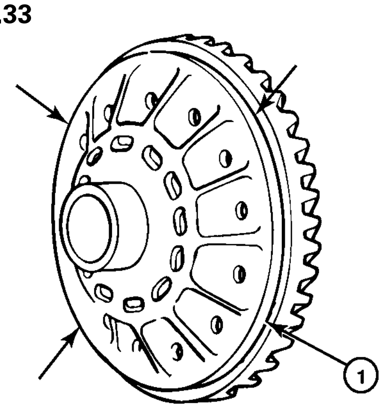
Figure 5.32



1 FLANGE CASE HALF
2 RING GEAR
3 BOLT HEAD AGAINST GEAR

7. Tighten the bolts* and nuts* to the correct torque value. Refer to **Table J**. T
8. Inspect for gaps between the back surface of the ring gear and the case flange after the bolts are installed. Use an 0.003-inch (0.080 mm) feeler gauge and inspect at four points around the assembly. **Figure 5.33**.

Figure 5.33

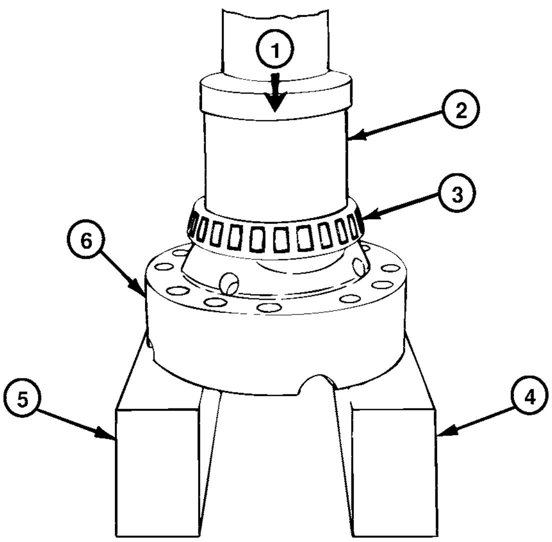


1 CHECK FOR 0.003" GAP AT FOUR LOCATIONS.

*Some Meritor carriers do not have these described parts.

9. Inspect the flange case half and ring gear for the problem that causes the gap. Repair or replace parts that do not meet specifications.
10. Assemble the repaired or replaced ring gear on the flange case half. Repeat the Main Differential and Ring Gear Assembly procedure.
11. Install the bearing cones on both of the case halves. Use a press and sleeve of the correct size. **Figure 5.34**.

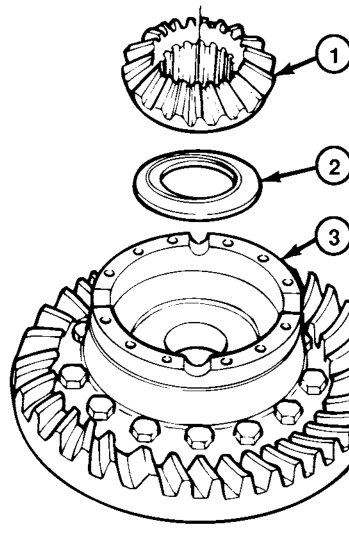
Figure 5.34



1 PRESS
2 SLEEVE
3 BEARING CONE
4 SUPPORT
5 SUPPORT
6 CASE HALF

12. Apply axle lubricant on the inside surfaces of both case halves, spider (cross), thrust washers, side gears and differential pinions.
13. Place the flange case half on a bench, ring gear teeth toward top.
14. Install one thrust washer and side gear into the flange case half. **Figure 5.35**.

Figure 5.35



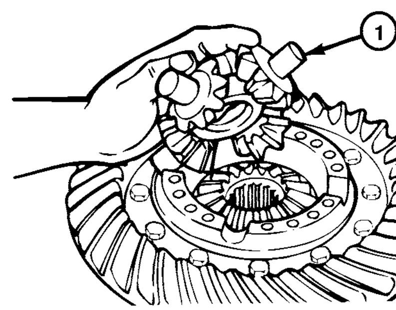
1 SIDE GEAR
2 THRUST WASHER
3 FLANGE CASE HALF

CAUTION

The side gears in some carrier models have hubs of different lengths. Install the correct length side gear into the flange case half.

15. Install the spider (cross), differential pinions and thrust washers into the flange case half. **Figure 5.36**.

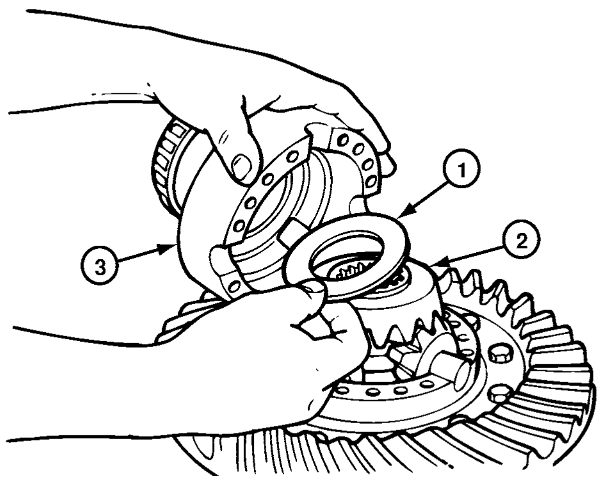
Figure 5.36



1 SPIDER, PINION AND THRUST WASHERS

16. Install the second side gear and thrust washer over spider and differential pinions. **Figure 5.37**.

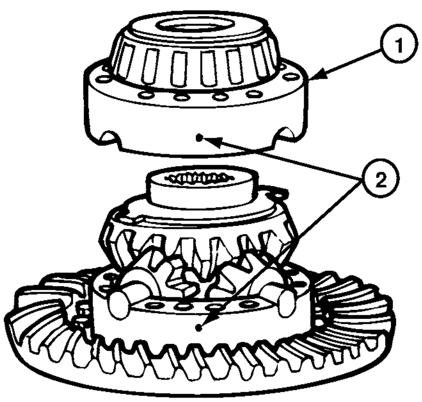
Figure 5.37



1 THRUST WASHER
2 SIDE GEAR
3 PLAIN CASE HALF

17. Place the plain half of the differential case over the flange half and gears. Rotate the plain half as needed to align the match marks. **Figure 5.37** and **Figure 5.38**.

Figure 5.38

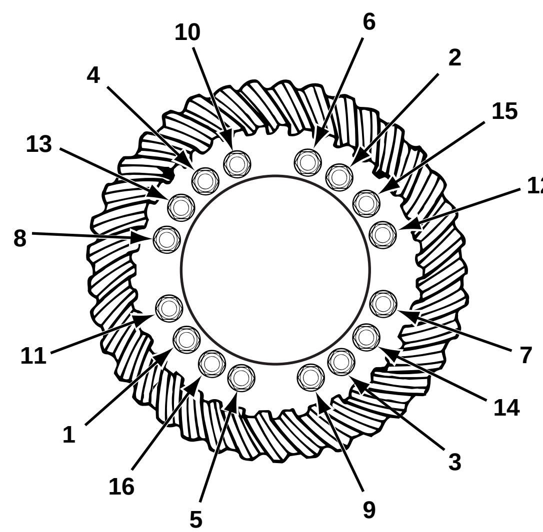


1 PLAIN CASE HALF
2 MATCH MARKS

18. Install Dri-Loc fasteners into the case halves. Refer to "Application of Three Bond 1216 or Equivalent Silicone Gasket Material" in Section 4 and the following Steps **a** and **b**.

   a. Install four capscrews* and washers* or bolts*, nuts* and washers* into the case halves. The distance between the fasteners **MUST** be equal. Tighten the fasteners to the correct torque value in a progressive criss-cross pattern opposite each other. Refer to **Figure 5.39** and to **Table J**. T

Figure 5.39



   b. Install the other fasteners into the case halves. Tighten the fasteners to the correct torque value. Refer to **Table J**. T

19. Inspect the rotating resistance of the differential gears. Use the following procedure.

*Some Meritor carriers do not have these described parts.

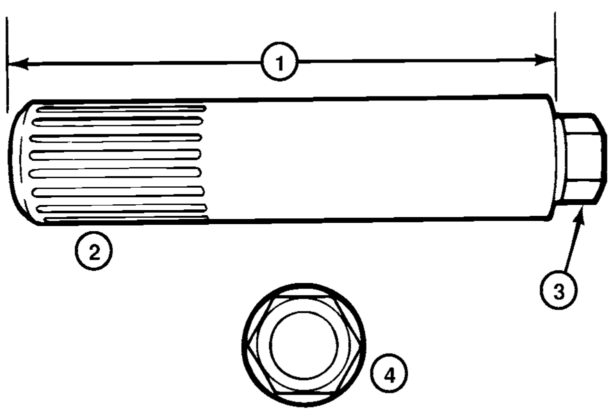
Inspecting the Rotating Resistance of the Differential Gears

Specification

- 50 lb-ft (67.8 N•m) maximum torque applied to one side gear. T

NOTE: Make a tool for inspecting the rotating resistance of the differential gears. The tool can be made from an axle shaft that matches the spline size of the differential side gear. Refer to **Figure 5.40** and **Figure 5.41**.

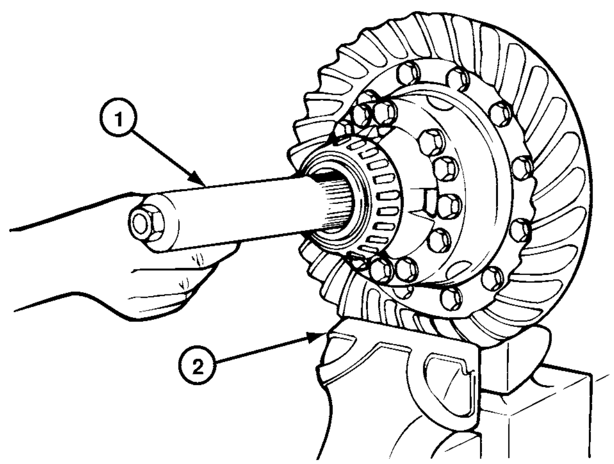
Figure 5.40



1 APPROXIMATELY 12-INCHES (304.8 MM)
2 SIDE VIEW
3 WELD NUT TO END OF SHAFT.
4 END VIEW

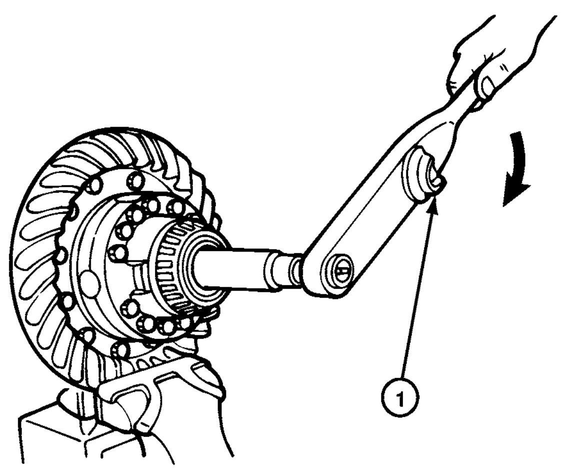
1. Install soft metal covers over vise jaws to protect the ring gear. **Figure 5.41**.
2. Place the differential and ring gear assembly in the vise and close the vise jaws.
3. Install the tool into the differential until the splines of the tool and one side gear are engaged. **Figure 5.41**.
4. Engage a torque wrench to the nut of the tool and rotate the differential gears. As the differential gears rotate, read the value indicated on the torque wrench. **Figure 5.42**.

Figure 5.41



1 TOOL FOR CHECKING RESISTANCE
2 SOFT METAL COVER

Figure 5.42



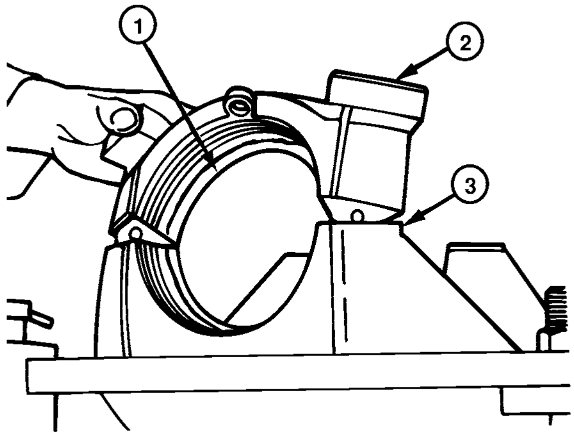
1 READ TORQUE VALUE.

5. If the torque value exceeds the specification, disassemble the differential gears from the case halves.
6. Inspect the case halves, spider, gears and thrust washers for the problem that causes the torque value to exceed the specification. Repair or replace parts.
7. After all the differential assembly parts are repaired or replaced, assemble the parts and repeat Steps 1 through 7.

Install the Differential and Ring Gear Assembly

1. Clean and dry the bearing cups and bores of the carrier legs and bearing caps.
2. Apply axle lubricant on the inner diameter of the bearing cups and on both bearing cones that are assembled on the case halves.
3. Apply Meritor Adhesive into the bearing bores of the carrier legs and bearing caps. Make certain not to allow adhesive to contact adjusting ring threads. Refer to "Application of Three Bond 1216 or Equivalent Silicone Gasket Material" in Section 4. **Figure 5.43**.

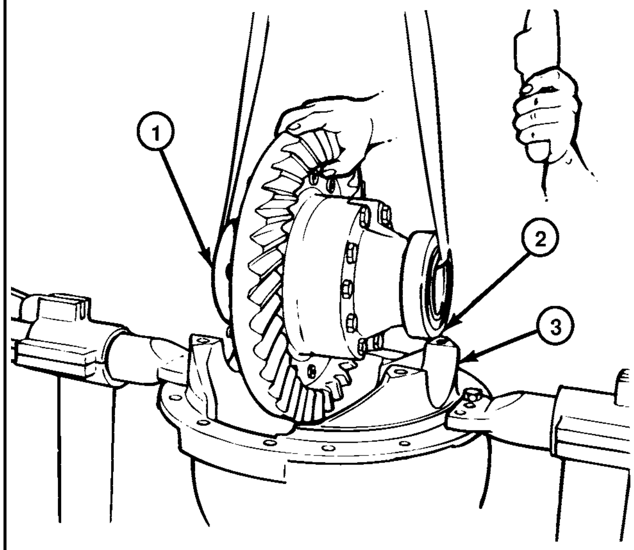
Figure 5.43



1 ADHESIVE
2 BEARING CAP
3 CARRIER LEG

4. Install the bearing cups over the bearing cones that are assembled on the case halves. **Figure 5.44**.
5. Safely lift the differential and ring gear assembly and install into the carrier. The bearing cups **MUST** be flat against the bores between the carrier legs. **Figure 5.44**.

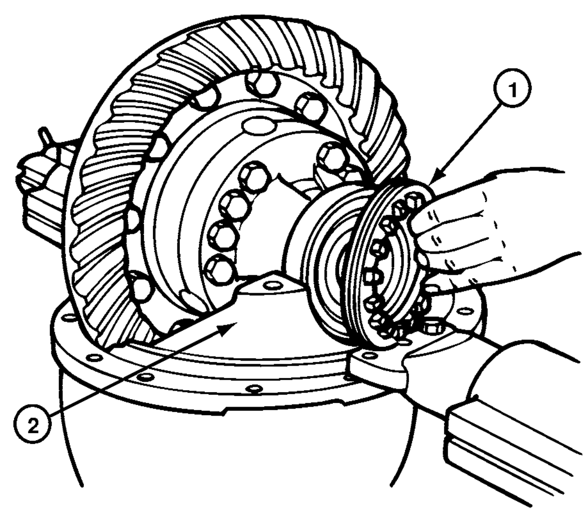
Figure 5.44



1 BEARING CUP
2 BEARING CUP
3 LEG BORE

6. Install both of the bearing adjusting rings into position between the carrier legs. Turn each adjusting ring hand-tight against the bearing cup. **Figure 5.45**.

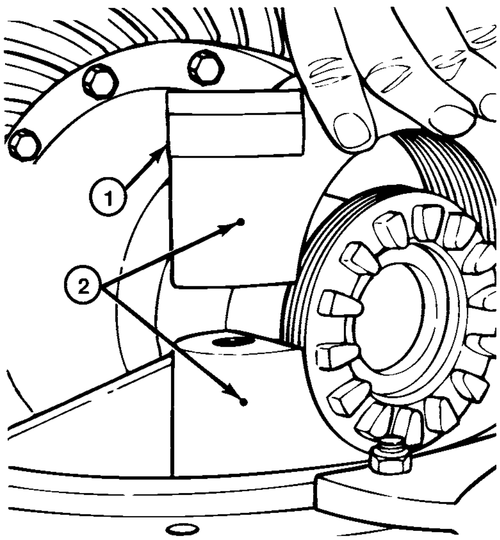
Figure 5.45



1 ADJUSTING RING
2 LEG

7. Install the bearing caps over the bearings and adjusting rings in the correct location as marked before removal. **Figure 5.46**.

Figure 5.46



1 BEARING CAP
2 MATCH MARKS

WARNING

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off and cause serious personal injury.

8. Seat each bearing cap with a light leather, plastic or rubber mallet. The caps **MUST** fit easily against the bearings, adjusting rings and carrier. ***Do not force the bearing caps into position.***

CAUTION

If bearing caps are not installed in the correct original locations, the bores and threads in caps will not match the carrier. Assembling mismatched caps into the carrier can result in carrier damage after reassembly to axle and during vehicle operation. Do not force the bearing caps into unmatched bore locations in the carrier.

9. If bearing caps do not correctly fit into position, inspect the alignment of match marks between caps and carrier. Remove the caps and repeat Steps 6-8.

10. Install the capscrews and washers that hold bearing caps to the carrier. Tighten the capscrews by hand four to six turns, then tighten the capscrews to the correct torque value. Refer to **Table J**. T

NOTE: Do not install the cotter keys*, pins* or lock plates* that hold the bearing adjusting rings in position. Continue by adjusting the preload of differential bearings, adjust backlash of the hypoid gear and inspect tooth contact patterns.

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* Some Meritor carriers do not have these described parts.

Adjust Preload of Differential Bearings

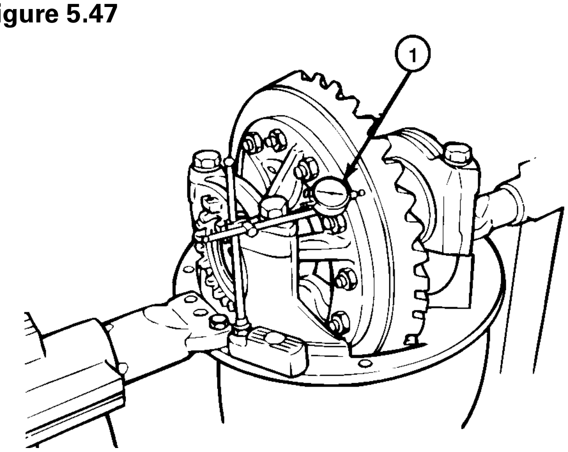
Specifications

- Preload of differential bearings (all carrier models)
  - — 15 to 35 lb-in (1.7-3.9 N•m) torque. T
- Expansion between bearing caps (leg spread)
  - — R-140, R-155 and R-160 carrier models: 0.002- to 0.009-inch (0.050-0.229 mm)
  - — R, S, U and W 120 series and most (check latest specifications) other carrier models: 0.00- to 0.013-inch (0.150-0.330 mm)

Method 1

1. Attach a dial indicator on the mounting flange of the carrier.
2. Adjust the dial indicator so that the plunger or pointer is against the back surface of the ring gear. **Figure 5.47**.

Figure 5.47



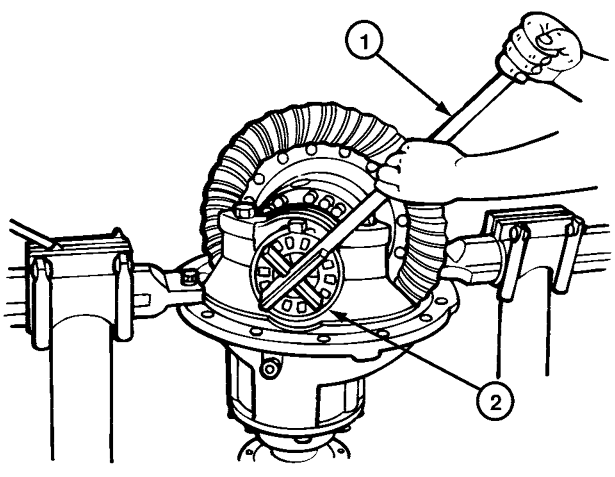
1 DIAL INDICATOR

CAUTION

When you turn the adjusting rings, always use a tool that engages two or more opposite notches in the ring. A "T" bar wrench can be used for this purpose. If the tool does not correctly fit into the notches, damage to the lugs will occur. **Figure 5.48**.

3. Loosen the bearing adjusting ring that is opposite the ring gear so that a small amount of end play shows on the dial indicator. **Figure 5.48.** Move the differential and ring gear to the left and right with pry bars while you read the dial indicator. Use the following Step **a** or **b**.

Figure 5.48

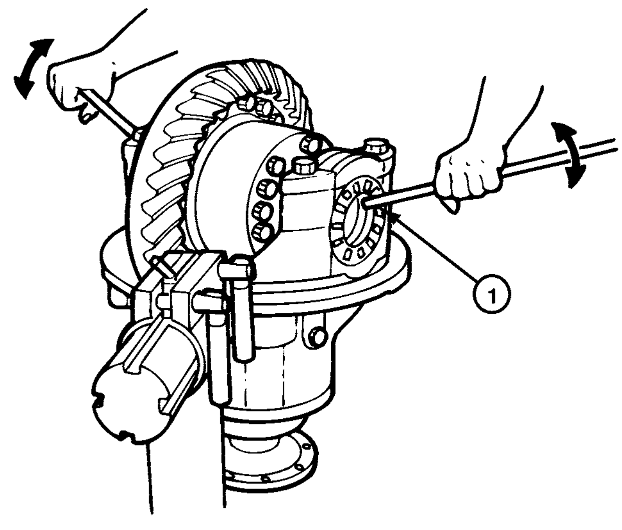


1 "T" BAR WRENCH
2 ADJUSTING RING OPPOSITE RING GEAR

a. Use two pry bars that fit between the bearing adjusting rings and ends of the differential case. The pry bars **MUST NOT** touch the differential bearings. **Figure 5.49**.

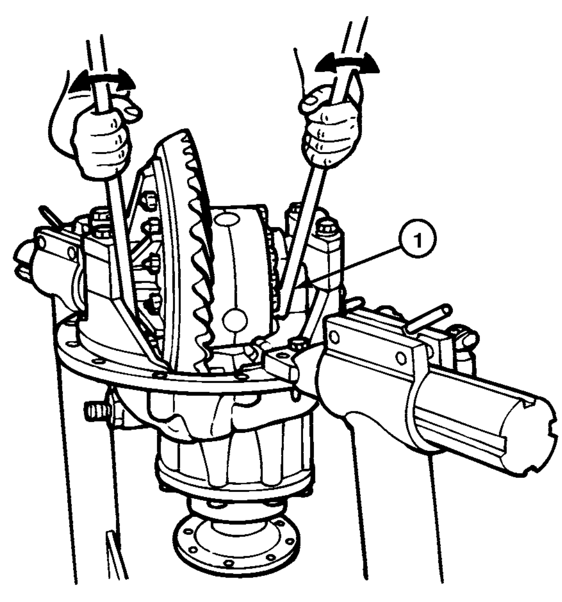
b. Use two pry bars between the differential case or ring gear and the carrier at locations other than described in Step **a**. The pry bars **MUST NOT** touch the differential bearings. **Figure 5.50**.

Figure 5.49



1 BARS MUST NOT TOUCH BEARINGS.

Figure 5.50



1 BARS MUST NOT TOUCH BEARINGS.

4. Tighten the same bearing adjusting ring so that no end play shows on the dial indicator. Move the differential and ring gear to the left and right as needed. Repeat Step **a** or **b**.
5. Tighten each bearing adjusting ring one notch from the zero end play measured in Step 4.
6. Continue by checking runout of the ring gear.

Method 2

A second method of inspecting preload is to measure the expansion between the bearing caps (leg spread) after the adjusting rings are tightened. Use the following procedure.

1. Turn both adjusting rings hand tight against the differential bearings.
2. Measure the distance X or Y between opposite surfaces of the bearing caps. Use a large micrometer of the correct size. **Figure 5.51** and **Figure 5.52**. Record the measurement.

Figure 5.51

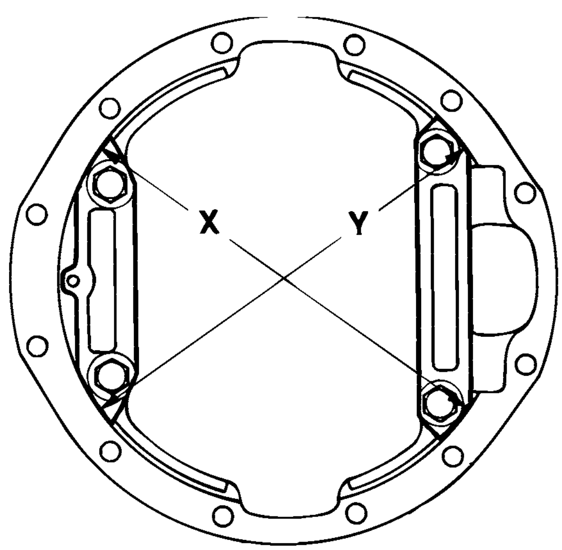
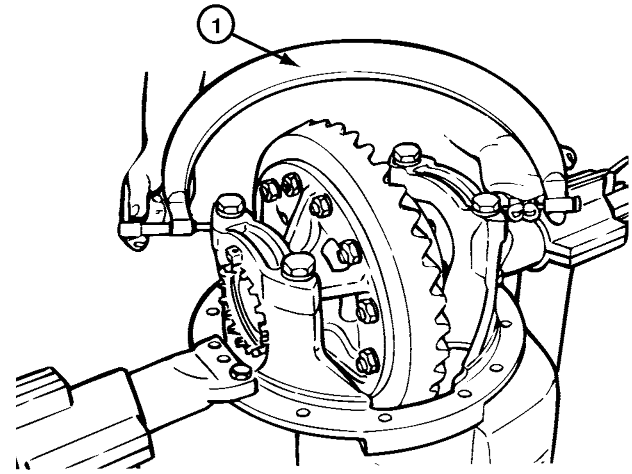


Figure 5.52



1 MICROMETER

3. Tighten each bearing adjusting ring one notch.
4. Measure the distance X or Y again. Compare the dimension with the distance X or Y measured in Step 2. The difference between the two dimensions is the amount the bearing caps have expanded.

Example

- Measurements of R-155 carrier
- Distance X or Y
  — before tightening adjusting rings = 13.927-inch (353.740 mm)
- Distance X or Y
  — after tightening adjusting rings = 13.936-inch (353.970 mm)
- 13.936-inch – 13.927-inch = 0.009-inch (0.230 mm) difference

If the dimension is within specifications, continue by checking runout of the ring gear. If the dimension is less than specifications, repeat Steps 3 and 4 as needed.

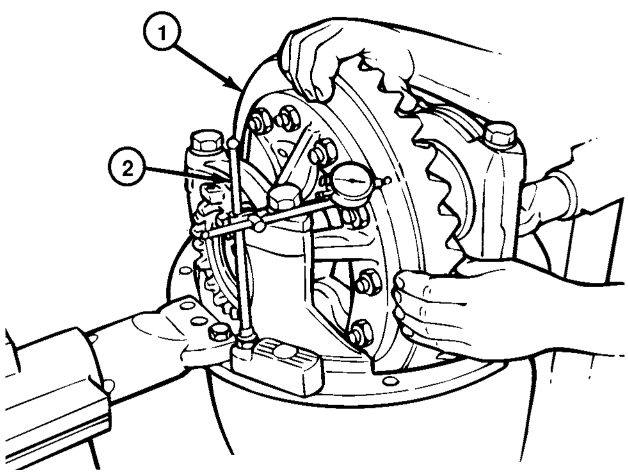
Inspect Runout of Ring Gear

Runout Specification

- 0.008-inch (0.200 mm)

1. Attach a dial indicator on the mounting flange of the carrier. **Figure 5.53**.

Figure 5.53



1 ROTATE RING GEAR.
2 DIAL INDICATOR

2. Adjust the dial indicator so that the plunger or pointer is against the back surface of the ring gear.
3. Set the dial indicator to zero (0).
4. Rotate the differential and ring gear and read the dial indicator. The runout of the ring gear **must not exceed** 0.008-inch (0.200 mm). **Figure 5.53**.

   If runout of the ring gear exceeds specifications, remove the differential and ring gear assembly from the carrier. Refer to "Remove the Differential and Ring Gear from the Carrier" in Section 2 and the following Steps 5 and 6.
5. Inspect the differential parts including the carrier for the problem that causes the runout of gear to exceed specifications. Repair or replace parts.
6. After the parts are repaired or replaced, install the differential and ring gear into the carrier. Refer to "Install the Differential and Ring Gear Assembly" in this section.
7. Repeat preload adjustment of differential bearings.

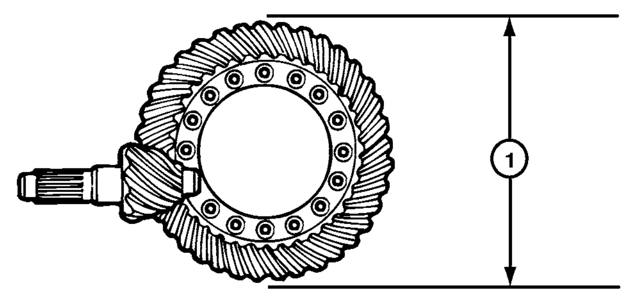
Ring Gear Backlash Adjustment

Specifications

- Ring gears that have a pitch diameter of less than 17-inches (431.8 mm)
  - — Range of backlash setting: 0.008- to 0.018-inch (0.200-0.460 mm).
  - — Backlash setting for new gear sets: 0.012-inch (0.300 mm)
- Ring gears that have a pitch diameter greater than 17-inches (431.8 mm)
  - — Range of backlash setting: 0.010- to 0.020-inch (0.250-0.510 mm)
  - — Backlash setting for new gear sets: 0.015-inch (0.380 mm)

NOTE: Measure the outer diameter of ring gear for approximate pitch diameter. **Figure 5.54.**

Figure 5.54



1 MEASURE OUTER DIAMETER FOR APPROXIMATE. PITCH DIAMETER

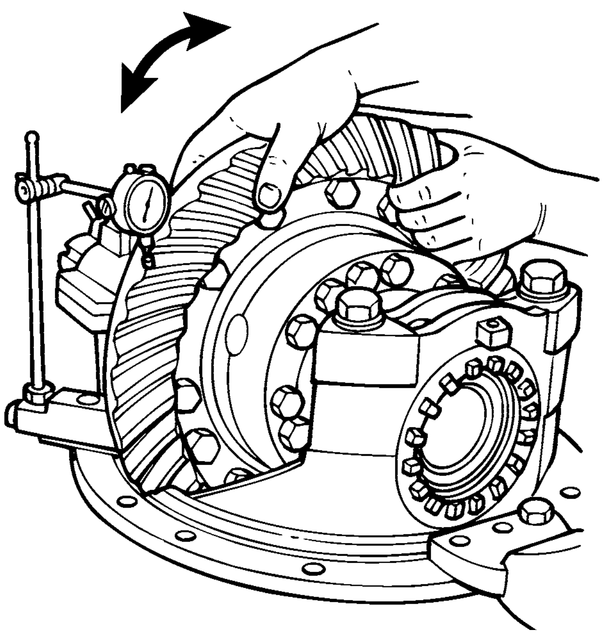
If the old gear set is installed, adjust the backlash to the setting that was measured before the carrier was disassembled.

If a new gear set is installed, adjust the backlash to the correct specification for new gear sets.

After inspection of the tooth contact patterns, the backlash can be adjusted within specification limits, if needed. To change the location of the pattern use the following procedures.

1. Attach a dial indicator on the mounting flange of the carrier. **Figure 5.55**.

Figure 5.55



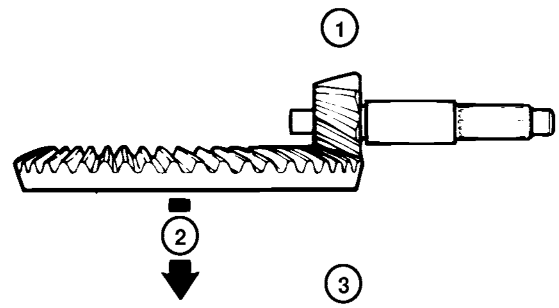
2. Adjust the dial indicator so that the plunger or pointer is against the tooth surface. **Figure 5.55**.
3. Adjust the indicator dial to zero (0).
4. Hold the drive pinion in position.
5. After reading the dial indicator, rotate the differential and ring gear a small amount in both directions, against the drive pinion teeth. If the backlash reading is within specification, continue inspecting tooth contact patterns. If the backlash reading is not within specifications, adjust backlash as needed. Continue following Steps 6 and 7.

NOTE: Backlash is increased by moving the ring gear away from the drive pinion. **Figure 5.56**.

Backlash is decreased by moving the ring gear toward the drive pinion. **Figure 5.57**.

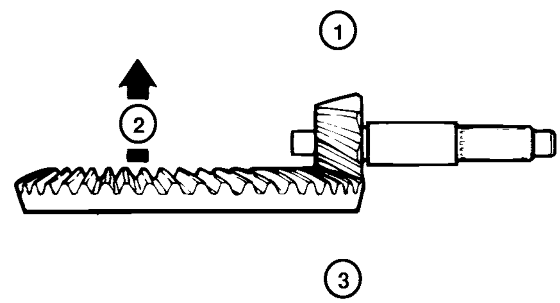
6. Loosen one bearing adjusting ring one notch then tighten the opposite ring the same amount. Refer to **Figure 5.56** and **Figure 5.57**.

Figure 5.56



1 TIGHTEN ADJUSTING RING THIS SIDE.
2 INCREASE BACKLASH.
3 LOOSEN ADJUSTING RING THIS SIDE.

Figure 5.57



1 LOOSEN ADJUSTING RING THIS SIDE.
2 DECREASE BACKLASH.
3 TIGHTEN ADJUSTING RING THIS SIDE.

NOTE: When you adjust backlash, move the ring gear **ONLY. DO NOT** move the drive pinion.

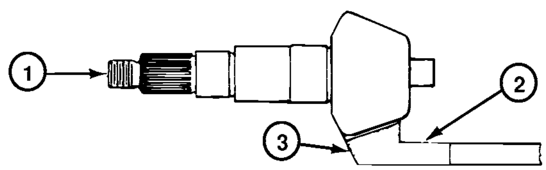
7. Repeat Steps 2-6 until the backlash is within specifications.

Inspect Tooth Contact Patterns of the Gear Set

General Information

Meritor carriers can have a conventional **HYPOID** gear set or a **GENEROID** hypoid gear set. The tooth contact patterns for each type of gear set are different. Look at the part numbers to see what type of gear set is in the carrier. Refer to **Figure 5.58** for the location of part numbers.

Figure 5.58



1 PART NO.
2 PART NO.
3 PART NO. OPTION

Examples of part numbers for conventional **HYPOID** gear sets.

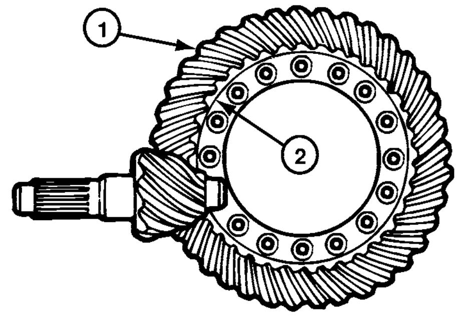
- 36786 for the ring gear.
- 36787 for the drive pinion.

Examples of part numbers for **GENEROID** gear sets.

- 36786-K or 36786-K2 for the ring gear.
- 36787-K or 36787-K2 for the drive pinion.

In the following procedures, movement of the contact pattern in the length of the tooth is indicated as, toward the "heel" or "toe" of the ring gear. **Figure 5.59**.

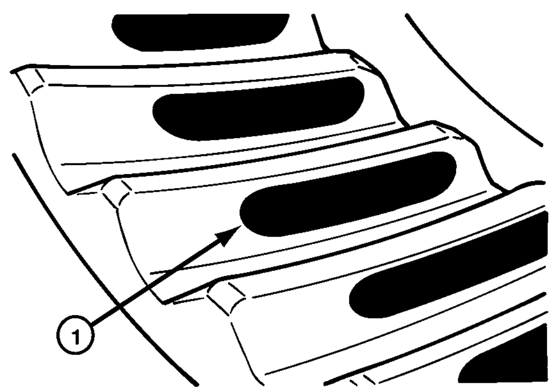
Figure 5.59



1 HEEL
2 TOE

Always inspect tooth contact patterns on the drive side of the gear teeth. **Figure 5.60**.

Figure 5.60

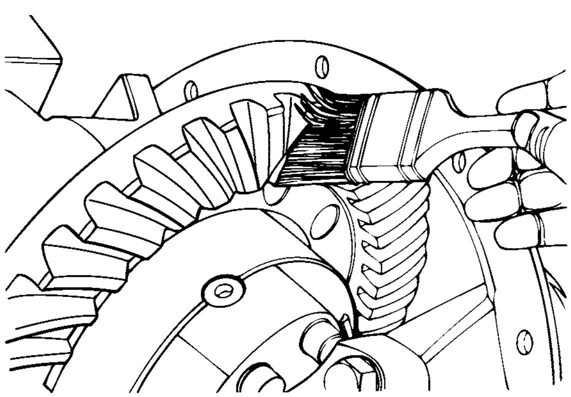


1 DRIVE SIDE (CONVEX)

Tooth Contact Patterns of Conventional Hypoid and Generoid Hypoid Gear Sets

1. Adjust the backlash of a new gear set to either 0.012-inch (0.305 mm) or 0.015-inch (0.380 mm) depending on the size of the ring gear. Adjust the backlash of an old gear set to the setting that was measured before the carrier was disassembled. Refer to "Ring Gear Backlash Adjustment" in this section.
2. Apply a marking compound to approximately 12 gear teeth of the ring gear. Rotate the ring gear so that the 12 gear teeth are next to the drive pinion. **Figure 5.61**.

Figure 5.61



3. Rotate ring gear forward and backward so that the 12 gear teeth go past the drive pinion six times to get the contact patterns. Repeat if needed to get a more clear pattern.
4. Look at the contact patterns on the ring gear teeth. Compare the patterns to **Figure 5.62** or **Figure 5.65**, **Figure 5.63** or **Figure 5.66**, and **Figure 5.64** or **Figure 5.67**.

   The Location of Good Hand-Rolled Contact Patterns.

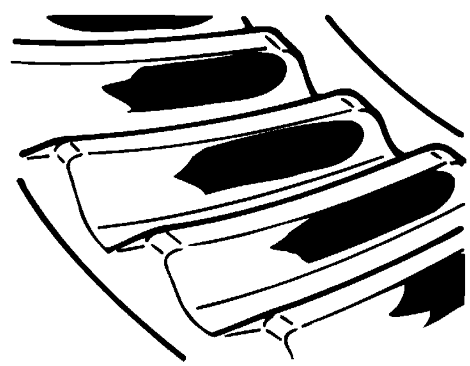
   New Conventional and Generoid Gear Sets — toward the toe of the gear tooth and in the center between the top and bottom of the tooth. Refer to **Figure 5.62** and **Figure 5.65**.

   When the carrier is being operated, a good pattern will extend approximately the full length of the gear tooth. The top of the pattern will be near the top of the gear tooth. Refer to **Figure 5.68** or **Figure 5.69**.

   The location of a good hand-rolled contact pattern for an old gear set **MUST** match the wear pattern in the ring gear. The contact pattern will be smaller in area than the wear pattern.

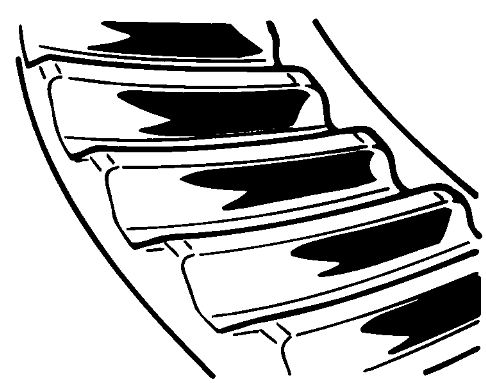
   If the contact patterns require adjustment, continue by following Step 5 to move the contact patterns between the top and bottom of the gear teeth. If the contact patterns are in the center of the gear teeth, continue by following Step 6.

Figure 5.62



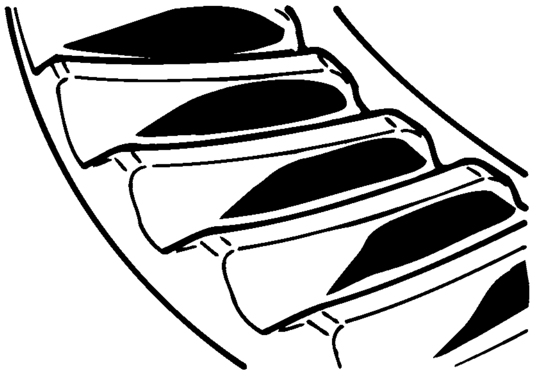
Good Hand-Rolled Pattern/Conventional Gears

Figure 5.63



High Pattern/Conventional Gears

Figure 5.64

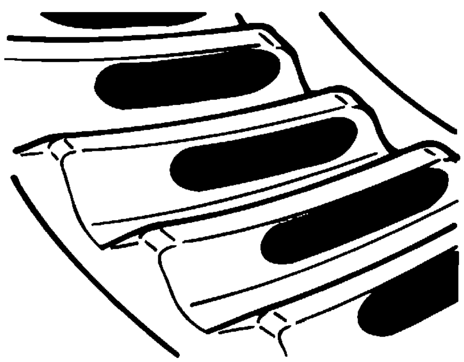


Low Pattern/Conventional Gears

Figure 5.67

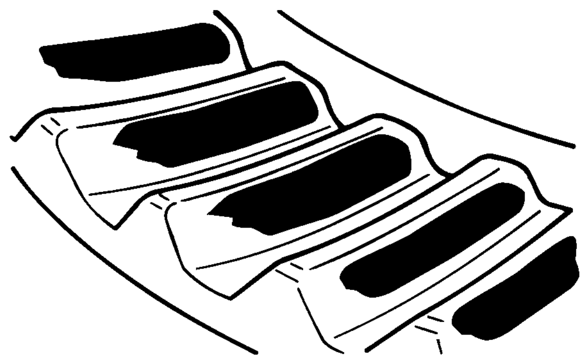
Low Pattern/Generoid Gears

Figure 5.65



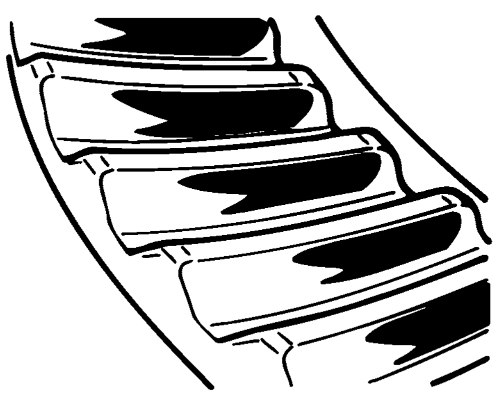
Good Hand-Rolled Pattern/Generoid Gears

Figure 5.68



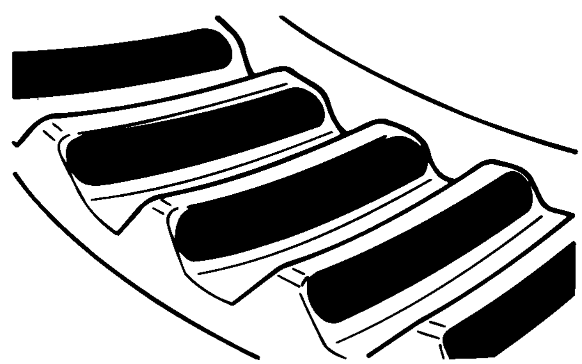
Good Pattern in Operation Conventional Gears

Figure 5.66



High Pattern/Generoid Gears

Figure 5.69



Good Pattern in Operation Generoid Gears

5. Change the thickness of the shim pack under bearing cage to move the contact patterns between the top and bottom of the gear teeth. Use the following procedure.

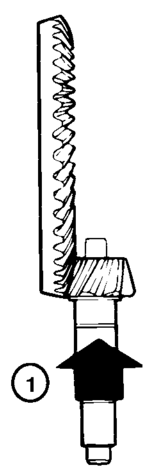
   a. Remove the drive pinion and bearing cage from the carrier. Refer to "Remove the Drive Pinion and Bearing Cage from Carrier" in Section 2.

NOTE: A high contact pattern indicates that the drive pinion was not installed deep enough into the carrier. A low contact pattern indicates that the drive pinion was installed too deep in the carrier.

   b. To correct a high contact pattern, **Figure 5.63**, decrease the thickness of the shim pack under the bearing cage. When decreasing the thickness of the shim pack, the drive pinion will move toward the ring gear. **Figure 5.70**.

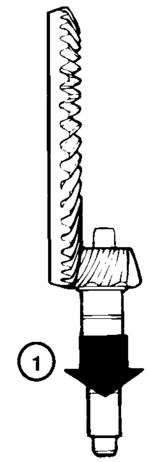
   To correct a low contact pattern, **Figure 5.71**, increase the thickness of shim pack under the bearing cage. When increasing the thickness of the shim pack, the drive pinion will move away from the ring gear. **Figure 5.71**.

Figure 5.70



1 DECREASE SHIM PACK.

Figure 5.71



1 INCREASE SHIM PACK.

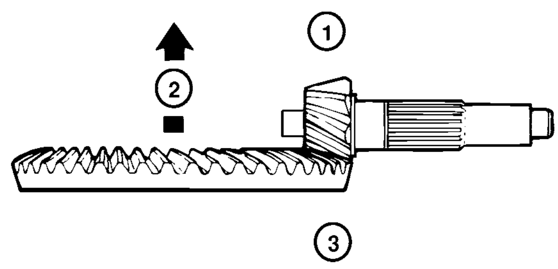
   c. Install the drive pinion, bearing cage and shims into the carrier. Refer to "Adjusting Shim Pack Thickness for the Pinion Cage (Depth of Pinion)" in this section.

   d. Repeat Steps 2-5 until the contact patterns are in the center between the top and bottom of the gear teeth.

6. Adjust backlash of the ring gear within specification range to move the contact patterns to the correct location in the length of the gear teeth. Refer to "Ring Gear Backlash Adjustment" in this section.

   a. Decrease backlash to move the contact patterns toward the toe of the ring gear teeth. **Figure 5.72**.

Figure 5.72

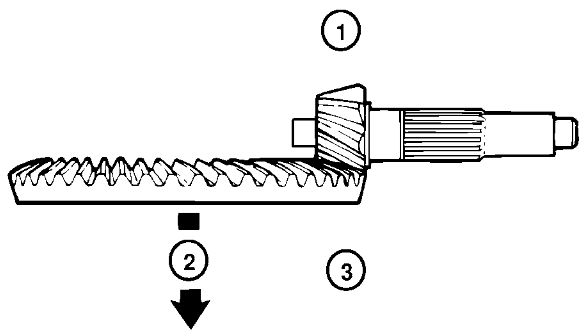


1 MOVE PATTERN TOWARD TOE, LOOSEN ADJUSTING RING THIS SIDE.
2 DECREASE BACKLASH.
3 TIGHTEN ADJUSTING RING.

b. Increase backlash to move the contact patterns toward the heel of the ring gear teeth. **Figure 5.73**.

c. Repeat Steps 2-4 and 6 until the contact patterns are at the correct location in the length of the gear teeth.

Figure 5.73



1 MOVE PATTERN TOWARD TOE, LOOSEN ADJUSTING RING THIS SIDE.
2 DECREASE BACKLASH.
3 LOOSEN ADJUSTING RING.

CAUTION

If the carrier has cotter keys, lock the adjusting rings only with cotter keys. If your carrier has roll pins, reuse the roll pins or lock the adjusting rings with cotter keys. Do not force a roll pin into a cotter key hole.

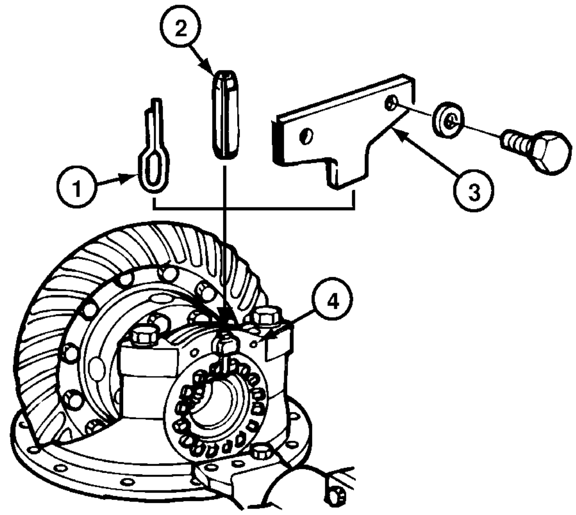
7. Install cotter keys*, pins*, or lock plates* that hold the two bearing adjusting rings in position. Use the following procedures.

   a. **Cotter Keys*** — Install cotter keys between lugs of the adjusting ring and through the boss of the bearing cap. Bend the two ends of the cotter key around the boss. **Figure 5.74**.

   b. **Pins*** — Install pin through boss of the bearing cap until the pin is between lugs of the adjusting ring. Use a drift and hammer to install the pin. **Figure 5.74**.

   c. **Lock Plates*** — Install lock plate on bearing cap so that the tab is between lugs of the adjusting ring. Install the two capscrews that hold the lock plate to the bearing cap. Tighten the capscrews to correct torque value. Refer to **Table J**. **Figure 5.74**. T

Figure 5.74



1 COTTER KEY
2 PIN
3 LOCK PLATE
4 THREADED HOLES IN CAP WHEN LOCK PLATE IS USED

SHOWN WITH COTTER KEY INSTALLED

*Some Meritor carriers do not have these described parts.

Install and Adjust the Thrust Screw*

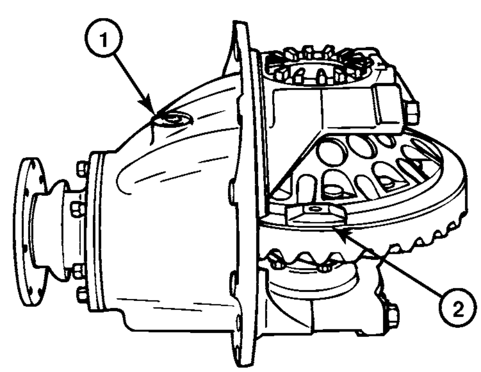
Specification

- Clearance between thrust screw and ring gear — 0.025- to 0.045-inch (0.650-1.140 mm).
- Loosen the thrust screw 1/2 turn or 180°.

If the carrier does not have a thrust block*, start at Step 4.

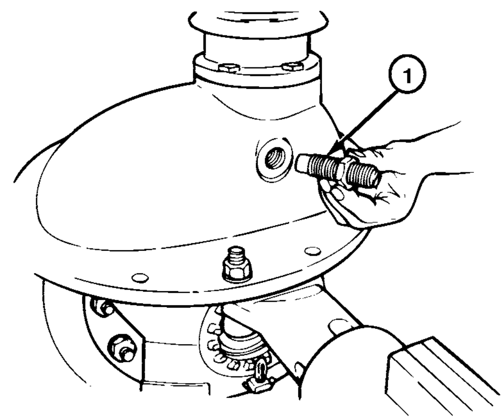
1. Rotate the carrier in the repair stand until the back surface of ring gear is toward the top. **Figure 5.75**.
2. Place the thrust block* on the back surface of the ring gear. The thrust block* **MUST** be in the center between the outer diameter of gear and differential case.
3. Rotate the ring gear until the thrust block* and hole for thrust screw, in carrier, are aligned. **Figure 5.75**.
4. Install the jam nut* on the thrust screw*, one half the distance between both ends.
5. Install the thrust screw* into the carrier until the screw stops against the ring gear or thrust block*. **Figure 5.76**.
6. Loosen the thrust screw* 1/2 turn, 180°. **Figure 5.77**.

Figure 5.75



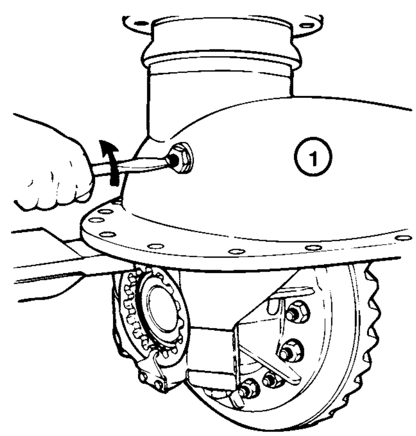
1 HOLE FOR THRUST SCREW
2 THRUST BLOCK

Figure 5.76



1 THRUST SCREW AND JAM NUT

Figure 5.77

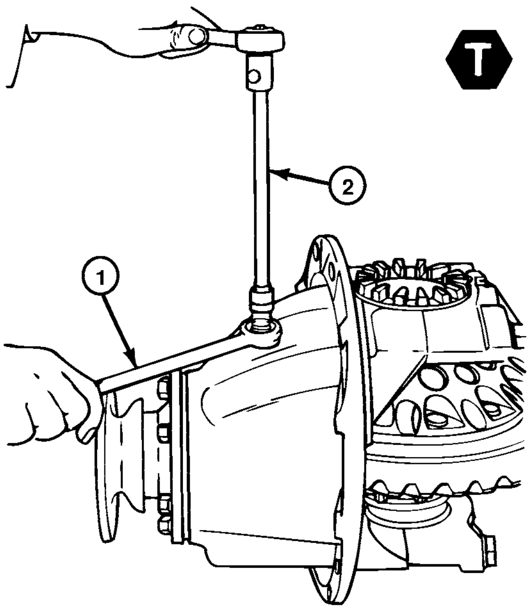


1 LOOSEN THRUST SCREW 1/2 TURN.

*Some Meritor carriers do not have these described parts.

7. Tighten the jam nut* to the correct torque value against the carrier. Refer to **Table J**. **Figure 5.78**.

Figure 5.78



1 TIGHTEN JAM NUT TO CORRECT TORQUE VALUE.
2 HOLD THRUST SCREW IN POSITION.

Install Differential Carrier into Axle Housing

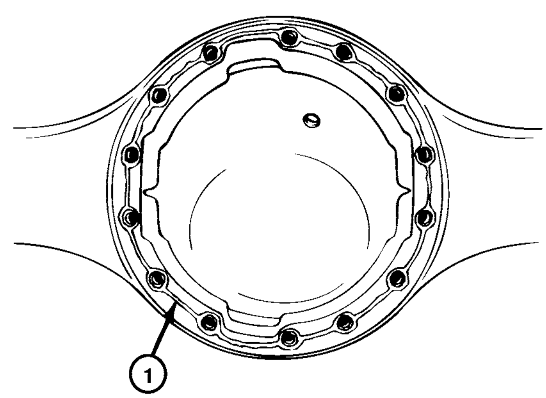
WARNING

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, emulsion-type cleaners and petroleum-based cleaners. To avoid serious personal injury when you use solvent cleaners, you must carefully follow the manufacturer's product instructions and these procedures:

- ***Wear safe eye protection.***
- ***Wear clothing that protects you skin.***
- ***Work in a well-ventilated area.***
- ***Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.***
- ***You must use hot solution tanks or alkaline solutions correctly. Follow the manufacturer's instructions carefully.***

1. Clean the inside of axle housing and the mounting surface where the carrier fastens. Use a cleaning solvent and rags to remove dirt. Blow dry the cleaned areas with air. Also refer to "Cleaning Axle Assemblies" in Section 3.
2. Inspect the axle housing for damage. Repair or replace the axle housing. Refer to "Repair or Replacement of Parts, General" in Section 3.
3. Inspect for loose studs* in the mounting surface of the housing where the carrier fastens. Remove and clean the studs* that are loose.
4. Apply liquid adhesive to the threaded holes and install the studs* into axle housing. Refer to "Application of Meritor Adhesive 2297-T-4180 in Bearing Bores for the Differential" in Section 4. Tighten studs* to correct torque value. Refer to **Table J**.
5. Apply silicone gasket material to the mounting surface of the housing where the carrier fastens. Refer to "Application of Three Bond 1216 or Equivalent Silicone Gasket Material" in Section 4. **Figure 5.79**.

Figure 5.79



1 1/8" (3.2 MM) DIAMETER SILICONE GASKET BEAD

*Some Meritor carriers do not have these described parts.

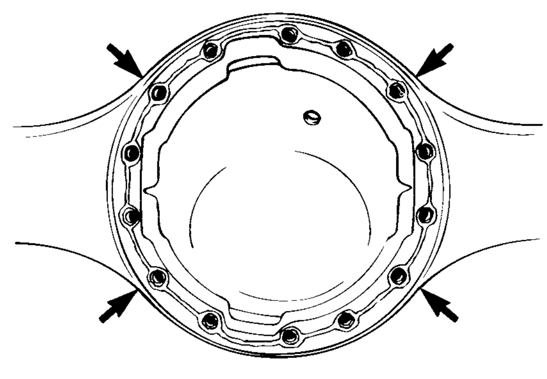
6. Install the carrier into the axle housing. Use a hydraulic roller jack or a lifting tool.

CAUTION

Do not use a hammer or a mallet to install the carrier. A hammer or a mallet will damage the mounting flange of the carrier and cause oil leaks.

7. Install the nuts* and the washers or the capscrews and washers in the four corner locations around the carrier and the axle housing. Tighten the fasteners by hand. Do not tighten to the specified torque. **Figure 5.80**.
8. Carefully push the carrier into position. Tighten the four fasteners two or three turns each in a pattern opposite each other. Refer to **Figure 5.80**.

Figure 5.80

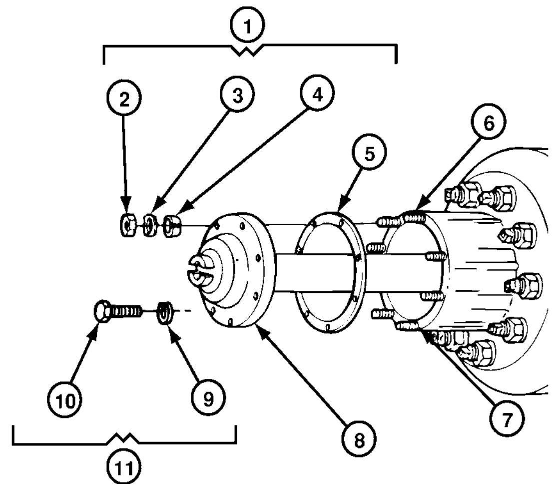


9. Repeat Step 9 until the four fasteners are tightened to the correct torque value.
   - **Fasteners with standard flat washers**: Tighten fasteners to 150-230 lb-ft (203-312 N•m).
10. Install the remaining fasteners and washers that hold the carrier in the axle housing. Tighten fasteners to the correct torque value. Refer to **Table J**.
11. Connect the driveline universal joint to the pinion input yoke or flange on the carrier.

*Some Meritor carriers do not have these described parts.

12. Install the gaskets and axle shafts into the axle housing and carrier. The gasket and flange of the axle shafts **MUST** fit flat against the wheel hub. **Figure 5.81**.

Figure 5.81



1	TAPERED DOWEL RETENTION	7	SHAFT HUB AXLE
2	STUD NUT	8	AXLE SHAFT (FLANGE)
3	WASHER	9	WASHER
4	TAPERED DOWEL	10	CAPSCREW
5	GASKET	11	NON-TAPERED DOWEL RETENTION
6	STUD		

Straight Holes, Nuts and Hardened Washers

1. Clean the mating surfaces of the axle shaft and the wheel hub.
2. If silicone gasket material is used, apply a 1/8-inch diameter bead of the gasket material around the mating surface of the hub and around the edge of each fastener hole in that surface.
3. Install the gasket and the axle shaft into the housing. The gasket and the flange of the axle shaft **MUST** fit flat against the wheel hub. Refer to **Figure 5.81**.
4. Install the Grade 8 nuts and hardened washers on the stud. (Lock washers are an acceptable alternative.) Tighten the stud nuts to the torque specified in **Table C**.

Tapered Dowel, Hardened Washer and Hardened Nut

1. Clean the mating surfaces of the axle shaft and the wheel hub.
2. If silicone gasket material is used, apply a 1/8-inch diameter bead of the gasket material around the mating surface of the hub and around the edge of each fastener hole in that surface.
3. Install the gasket and the axle shaft into the housing. The gasket and the flange of the axle shaft **MUST** fit flat against the wheel hub. Refer to **Figure 5.81**.
4. Install solid tapered dowels over each stud and into the flange of the axle shaft. Use a punch or a drift and hammer, if necessary.
5. Install the Grade 8 nuts and hardened washers on the stud. (Lock washers are an acceptable alternative.) Tighten the stud nuts to the torque specified in **Table D**.

Table C: Shaft-to-Hub Torque Fastener — Non-tapered Dowel Applications

Fastener	Thread Size	Torque Value — Grade 8 Nuts lb-ft (N•m) T	
		Plain Nut	Lock Nut
Stud Nut (Axle Shaft)	.62-18 .75-16	150-230 (203-312) 310-400 (420-542)	130-190 (176-258) 270-350 (366-475)
Studs	All	Install the course thread end of stud into hub and tighten to last thread.	

Table D: Shaft-to-Hub Torque Fastener — Tapered Dowel Applications

Fastener	Thread Size	Torque Value — Grade 8 Nuts lb-ft (N•m) T	
		Plain Nut	Lock Nut
Stud Nut (Axle Shaft)	.44-20 .50-20 .56-18 .62-18	50-75 (81-102) 75-115 (115-156) 110-165 (176-224) 150-230 (203-312)	40-65 (67-88) 65-100 (102-136) 100-145 (149-197) 130-190 (176-258)
Studs	All	Install the course thread end of stud into hub and tighten to last thread.	

Section 6
Lubrication

MERITOR®

NOTE: For complete information on lubricating drive axles and carriers, refer to Maintenance Manual 1, *Lubrication*.

Refer to **Table E**, **Table F** and **Table I** for standard information on lubricants, schedules and capacities.

Table E: Lubricant Cross Reference (Viscosity) and Temperature

Meritor Lubricant Specification	Description	Cross Reference	Minimum Outside Temperature	Maximum Outside Temperature
O-76-A	Hypoid Gear Oil	GL-5, S.A.E. 85W/140	+10°F (–12.2°C)	- - -**
O-76-B	Hypoid Gear Oil	GL-5, S.A.E. 80W/140	–15°F (–26.1°C)	- - -**
O-76-D	Hypoid Gear Oil	GL-5, S.A.E. 80W/90	–15°F (–26.1°C)	- - -**
O-76-E	Hypoid Gear Oil	GL-5, S.A.E. 75W/90	–40°F (–40°C)	- - -**
O-76-J	Hypoid Gear Oil	GL-5, S.A.E. 75W	–40°F (–40°C)	+ 35°F (+ 1.6°C)
O-76-L	Hypoid Gear Oil	GL-5, S.A.E. 75W/140	–40°F (–40°C)	- - -**
There is no upper limit on these outside temperatures, but the axle sump temperature ***must never exceed* **250°F (+ 121°C).**				

Table F: Rear Drive Axle Oil Change Intervals and Specifications ①

APPLIES TO ALL REAR AXLES EXCEPT THE "ADVANCED LUBE" REAR AXLES.

<table>
<tr><th colspan="4">On-Highway Operation Intervals</th><th colspan="4">Off-Highway Operation Intervals②</th><th rowspan="3">Meritor Specifications (Military)</th><th rowspan="3">Oil Description</th><th colspan="4">Outside Temperature</th></tr>
<tr><th rowspan="2">Initial Oil Change</th><th rowspan="2">Inspect Oil Level</th><th rowspan="2">Petroleum Oil Change</th><th rowspan="2">Synthetic Oil Change</th><th rowspan="2">Initial Oil Change</th><th rowspan="2">Inspect Oil Level</th><th rowspan="2">Petroleum Oil Change③</th><th rowspan="2">Synthetic Oil Change</th><th colspan="2">F°</th><th colspan="2">C°</th></tr>
<tr><th>Min.</th><th>Max.</th><th>Min.</th><th>Max.</th></tr>
<tr><td rowspan="7">3,000 miles (4,800 km)</td><td rowspan="7">3,000 miles (4,800 km), once a month or the fleet maint-enance interval (whichever comes first)</td><td rowspan="6">If annual mileage is less than 100,000 miles (160,000 km) change oil once a year.</td><td rowspan="7">250,000 miles (400,000 km)</td><td rowspan="7">1,000 miles (1,600 km)</td><td rowspan="7">1,000 miles (1,600 km)</td><td rowspan="6">If annual mileage is less than 60,000 miles (96,000 km) change oil twice a year.</td><td rowspan="7">50,000 miles (80,000 km)</td><td>O-76A, Gear Oil (MIL-L-2105D or MIL-PRF-2105E)</td><td>GL-5, SAE 85W/140</td><td>10</td><td>None</td><td>–12</td><td>None</td></tr>
<tr><td>O-76D, Gear Oil (MIL-L-2105D or MIL-PRF-2105E)</td><td>GL-5, SAE 80W/90</td><td>–15</td><td>None</td><td>–26</td><td>None</td></tr>
<tr><td>O-76E, Gear Oil (MIL-L-2105D or MIL-PRF-2105E)</td><td>GL-5, SAE 75W/90</td><td>–40</td><td>None</td><td>–40</td><td>None</td></tr>
<tr><td>O-76J, Gear Oil (MIL-L-2105D or MIL-PRF-2105E)</td><td>GL-5, SAE 75W</td><td>–40</td><td>35</td><td>–40</td><td>2</td></tr>
<tr><td>O-76L, Gear Oil (MIL-L-2105D or MIL-PRF-2105E)</td><td>GL-5, SAE 75W/140</td><td>–40</td><td>None</td><td>–40</td><td>None</td></tr>
<tr><td>O-76M, Full Synthetic Gear Oil (MIL-L-2105D or MIL-PRF-2105E)</td><td>GL-5, SAE 75W/140</td><td>–40</td><td>None</td><td>–40</td><td>None</td></tr>
<tr><td>If annual mileage is more than 100,000 miles (160,000 km), change oil every 100,000 miles (160,000 km).</td><td>If annual mileage is more than 60,000 miles (96,000 km), change oil every 30,000 miles (48,000 km).</td><td>O-76N, Full Synthetic Gear Oil (MIL-L-2105D or MIL-PRF-2105E)</td><td>GL-5, SAE 75W/90</td><td>–40</td><td>None</td><td>–40</td><td>None</td></tr>
</table>

NOTES

① If oil pump and filter is used, change filter every 100,000 miles (160,000 km). Inspect oil level. Add correct oil as required.

② Includes heavy-duty on-highway and on/off-highway applications.

③ For continuous heavy-duty operation, inspect oil level every 1,000 miles (1,600 kilometers).

Table G: "Advanced Lube" Rear Drive Axle without Oil Pump and Filter Oil Change Intervals and Specifications①

APPLIES TO TANDEM REAR AXLES MANUFACTURED AFTER JANUARY 1, 1993 EQUIPPED WITH "MEMBRANE" TYPE BREATHERS AND ADVANCED MATERIAL TRIPLE-LIP SEALS.

On-Highway Operation Intervals			On-/Off-Highway Operation Intervals②			Meritor Specifications (Military)	Oil Description	Outside Temperature			
								F°		C°	
Inspect Oil Level	Petroleum Oil Change③	Synthetic Oil Change④	Inspect Oil Level⑤	Petroleum Oil Change③	Synthetic Oil Change④			Min.	Max.	Min.	Max.
3,000 miles (4,800 km), once a month or the fleet maintenance interval (whichever comes first)	100,000 miles (160,000 km)	250,000 miles (400,000 km)	3,000 miles (4,800 km) or 200 hours of operation	40,000 miles (64,000 km)	80,000 miles (128,000 km)	O-76A, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 85W/140	10	None	–12	None
						O-76D, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 80W/90	–15	None	–26	None
						O-76E, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/90	–40	None	–40	None
						O-76J, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W	–40	35	–40	2
						O-76L, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/140	–40	None	–40	None
						O-76M, Full Synthetic Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/140	–40	None	–40	None
						O-76N, Full Synthetic Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/90	–40	None	–40	None

NOTES

① If a No-Spin differential is installed, oil (petroleum or synthetic) must be changed at minimum interval of 64,000 km (40,000 miles) or a maximum interval of 50,000 miles (80,000 km).
② Also applies to heavy-duty on-highway applications. Does not apply to off-highway applications.
③ For petroleum oil with extended drain additives, use the "Synthetic Oil Change" interval.
④ Applies to semi-synthetic oils and full-synthetic oils. For a list of approved synthetic oils, refer to Maintenance Manual 1, *Lubrication*.
⑤ For continuous heavy-duty operation, inspect the oil level every 1,000 miles (1,600 km). Add the correct oil as required.

Table H: Tandem "Advanced Lube" Rear Drive Axle with Oil Pump and Filter Oil Change Intervals and Specifications①②

APPLIES TO TANDEM REAR AXLES MANUFACTURED AFTER JANUARY 1, 1993 EQUIPPED WITH "MEMBRANE" TYPE BREATHERS AND ADVANCED MATERIAL TRIPLE-LIP SEALS.

On-Highway Operation Intervals			On-/Off-Highway Operation Intervals③			Meritor Specifications (Military)	Oil Description	Outside Temperature			
								F°		C°	
Inspect Oil Level	Petroleum Oil Change④	Synthetic Oil Change⑤	Inspect Oil Level⑥	Petroleum Oil Change④	Synthetic Oil Change⑤			Min.	Max.	Min.	Max.
3,000 miles (4,800 km), once a month or the fleet maintenance interval (whichever comes first)	100,000 miles (160,000 km)	500,000 miles (800,000 km)	3,000 miles (4,800 km) or 200 hours of operation	50,000 miles (80,000 km)	100,000 miles (160,000 km)	O-76A, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 85W/140	10	None	–12	None
						O-76D, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 80W/90	–15	None	–26	None
						O-76E, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/90	–40	None	–40	None
						O-76J, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W	–40	35	–40	2
						O-76L, Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/140	–40	None	–40	None
						O-76M, Full Synthetic Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/140	–40	None	–40	None
						O-76N, Full Synthetic Gear Oil (MIL-PRF-2105E)	GL-5, SAE 75W/90	–40	None	–40	None

NOTES

① Replace oil filter every 100,000 miles (160,000 km). Inspect oil level. Add specified oil as required.
② If No-Spin differential is installed, oil (petroleum or synthetic) must be changed at minimum interval of 40,000 miles (64,000 km) or a maximum interval of 50,000 miles (80,000 km).
③ Applies to heavy-duty on-highway applications and to on/off highway applications. Does not apply to off-highway applications.
④ For petroleum oil with extended drain additives, use the "Synthetic Oil Change" interval.
⑤ Applies to semi-synthetic oils. For a list of approved synthetic oils, refer to Maintenance Manual 1, *Lubrication*.
⑥ For continuous heavy-duty operation, inspect the oil level every 1,000 miles (1,600 km). Add the correct oil as required.

Axle Lubricant Capacities

Use the following lubricant capacities as a guide only. The capacities are measured with the drive pinion in the horizontal position. When the angle of the drive pinion changes, the lubricant capacity of the axle will change.

Table I: Axle Lubricant Capacities

Axle Model	Capacity U.S. Pints	Capacity Liters
Single Drive Axles		
A-150	5.5	2.6
B-100	10	4.7
B-140	12	5.7
B-150	3.5	1.7
C-100	12.5	5.9
D-100	12.5	5.9
D-140	12.5	5.9
E-100	15	7.1
E-105	12.5	5.9
E-150	9	4.3
F-100	13	6.2
F-106	13	6.2
F-120	15	7.1
F-121	15	7.1
F-140	14	6.6
FDS-75	14	6.6
FDS-78	14	6.6
FDS-85	15	7.1
FDS-90	14	6.6
FDS-93	14	6.6
FDS-750	7	3.3
FDS-1600	23	10.9
FDS-1800	35	16.6
FDS-1805	35	16.6
FDS-1807	27	13.2
FDS-1808	27.9	13.2
FDS-2100	27.9	13.2
FDS-2101	27.9	13.2
FDS-2107	43	20.3
FDS-2110	43	20.3
FDS-2111	43	20.3
FDS-2117	43	20.3
G-161	21	9.9
H-100	20	9.5
H-140	21	9.9
H-150	11	5.2
H-162	20	9.5
H-170	27*	12.8
H-172	27	12.8
L-100	23	10.9
L-140	24	11.4
L-155	24	11.4

Axle Model	Capacity U.S. Pints	Capacity Liters
Single Drive Axles (Continued)		
L-172	27	12.8
M-172	27	12.8
QT-140	24	11.4
Q-100	31	14.7
Q-145	24	11.4
RL-170	48	22.7
R-100	30	14.2
R-140	28	13.2
R-155	28	13.2
R-160	28	13.2
R-163	34	16.1
R-170	43	20.3
S-170	43	20.3
U-140	24	11.4
U-170	43	20.3
W-170	43	20.3
* Includes 1 pint (0.97 liter) for each wheel end and with drive pinion angle at 3°.		

Axle Model	Capacity U.S. Pints	Capacity Liters
Rear Axle of Tandems		
SDHD (DHR rear)	16	7.6
SFHD (FHR rear)	16.5	7.8
SHHD (HHR rear)	26	12.3
SL-100 (LR-100 rear)	37	17.5
SLHD (LHR rear)	32	15.1
SQ-100 (QR-100 rear)	33	15.7
SQHD (QHR rear)	31	14.7
SQHP (QAR rear)	36	17
SR-170 (RR-170 rear)	43	20.3
SRHD (RHR rear)	36	17
SSHD (SHR rear)	28	13.2
ST-170 (TR-170 rear)	43	20.3
STHD (THR rear)	28	13.2
SU-170 (UR-170 rear)	43	20.3
SUHD (UHR rear)	28	13.2
SW-170 (WR-170 rear)	43	20.3

Torque Values for Fasteners

General Information

1. The torque values in **Table J** are for fasteners that have a light application of oil on the threads.
2. If the fasteners are dry, increase the torque values by ten percent (10%).
3. If the fasteners have a heavy application of oil on the threads, decrease the torque values by ten percent (10%).
4. If you do not know the size of the fastener that is being installed, measure the fastener. Use the following procedure.

American Standard Fasteners

a. Measure the diameter of the threads in inches, dimension X. **Figure 7.1**.

b. Count the amount of threads there are in one inch (1.0 inch). **Figure 7.1**.

Example

- American Standard size fastener is .50-13.
  - — 0.50 is the diameter of the fastener in inches or dimension X.
  - — 13 is the amount of threads in one inch (1.0 inch).

Metric Fasteners

a. Measure the diameter of the threads in millimeters (mm), dimension X. **Figure 7.2**.

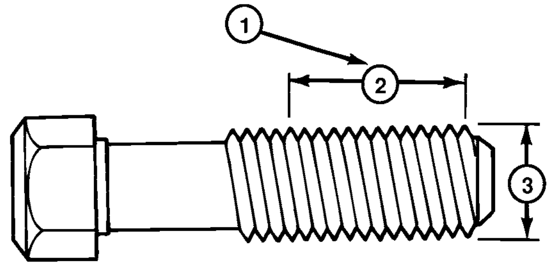
b. Measure the distance of ten (10) threads, point to point in millimeters (mm), dimension Y. Make a note of dimension Y. **Figure 7.2**.

c. Divide dimension Y by ten (10). The result will be the distance between two threads or pitch.

Example

- Metric size fastener is M8 x 1.25.
  - — M8 is the diameter of the fastener in millimeters (mm) or dimension X.
  - — 1.25 is the distance between two threads or pitch.
  - — Compare the size of fastener measured in Step 4 to the list of fasteners in **Table J** to find the correct torque value.

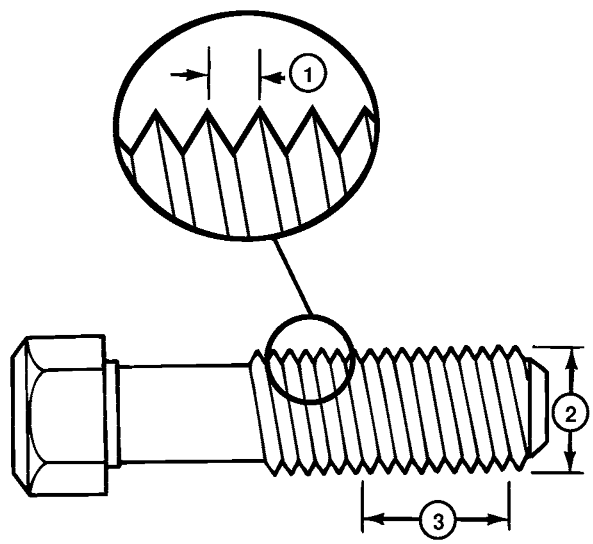
Figure 7.1



1 AMOUNT OF THREADS IN ONE INCH
2 1″
3 X

X DIMENSION = (EXAMPLE 1/2")

Figure 7.2



1 PITCH
2 X
3 Y

X DIMENSION = (EXAMPLE M8 OR 8 MM)
Y DIMENSION = DISTANCE OF 10 THREADS

Figure 7.3

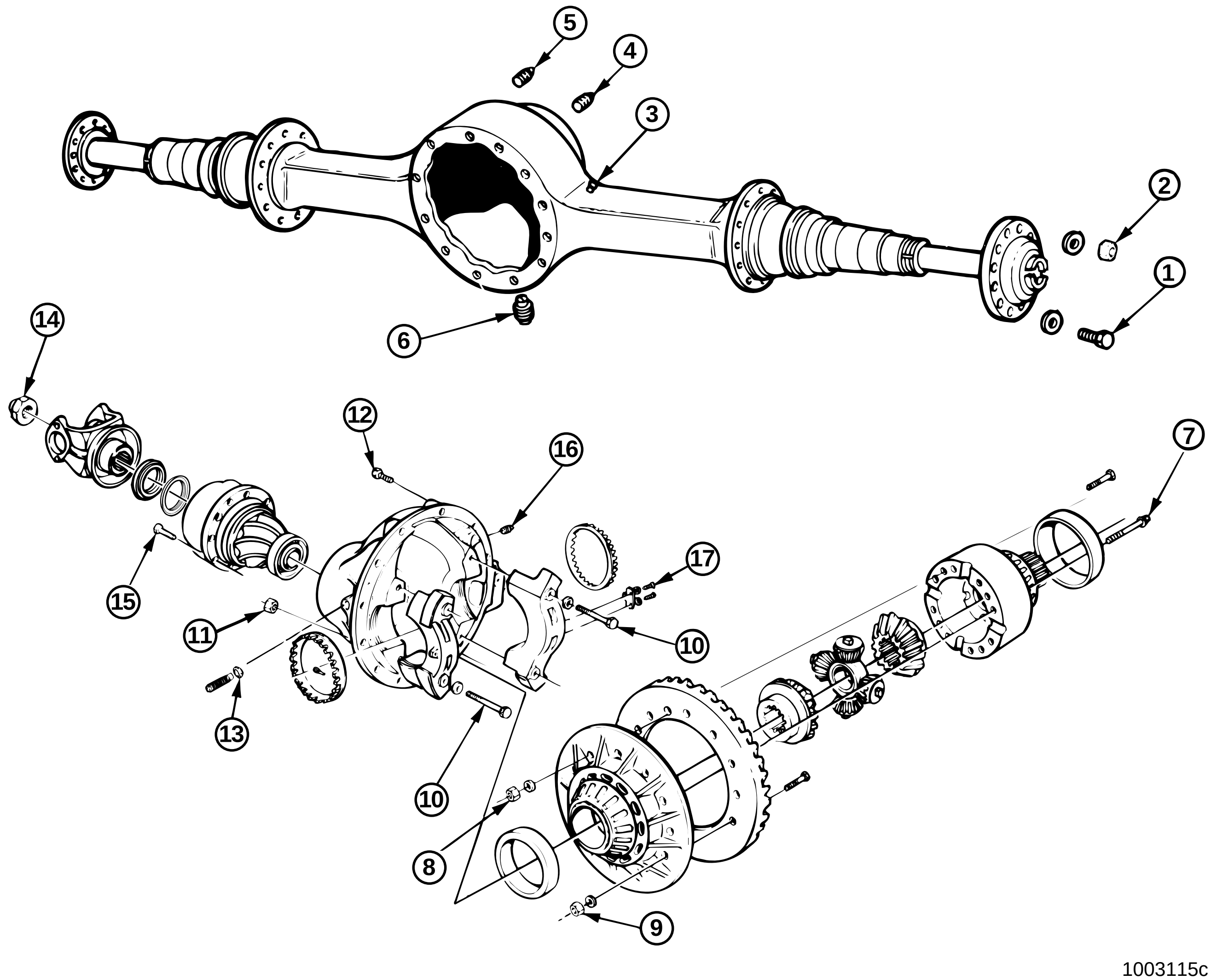


Table J: Fastener Torque Information

Fastener		Thread Size	Torque Value lb-ft (N•m)	
1.	*Capscrew, Axle Shaft	.31-24 .50-13	18-24 85-115	(24-33) (115-156)
2.	*Nut, Axle Shaft Stud	Plain Nut .44-20 .50-20 .56-18 .62-18 Lock Nut .44-20 .50-20 .56-18 .62-18	 50-75 75-115 110-165 150-230 40-65 65-100 100-145 130-190	 (68-102) (102-156) (149-224) (203-312) (54-88)3 (88-136) (136-197) (176-258)

* Some Meritor carriers do not have these described parts.

Table J: Fastener Torque Information

Fastener		Thread Size	Torque Value lb-ft (N•m)	
3.	Breather	.38-18	20 minimum (27 minimum)	
4.	*Plug, Oil Fill (Housing)	.75-14	35 minimum (47.5 minimum)	
5.	*Plug, Heat Indicator	.50-14	25 minimum (34 minimum)	
6.	Plug, Oil Drain	.50-14	25 minimum (34 minimum)	
7.	Capscrew, Differential Case Grade 10.9 Flange Head Grade 10.9 Standard Hex Head Grade 12.9 Standard Hex Head Grade 12.9 Flange Head Grade 12.9 Standard Head	.38-16 .44-14 .50-13 .56-12 .62-11 M12 x 1.75 M12 x 1.75 M12 x 1.75 M16 x 2 M16 x 2	35-50 60-75 85-115 130-165 180-230 85-103 74-96 105-125 203-251 220-310	(48-68) (81-102) (115-156) (176-224) (244-312) (115-140) (100-130) (143-169) (275-340) (300-420)
8.	*Nut, Differential Case Bolt	.50-13 .50-20 .62-11 .62-18 M12 x 1.75 M16 x 2	75-100 85-115 150-190 180-230 74-96 220-310	(102-136) (115-156) (203-258) (244-312) (100-130) (300-420)
9.	*Nut, Ring Gear Bolt Flange Head Standard Hex Head	.50-13 .50-20 .62-11 .62-18 M12 x 1.25 M12 x 1.75 M16 x 1.5 M16 x 1.5	75-100 85-115 150-190 180-230 66-81 77-85 192-214 196-262	(102-136) (115-156) (203-258) (244-312) (90-110) (104-115) (260-190) (265-355)
10.	Capscrew, Bearing Cap	.56-12 .62-11 .75-10 .88-14 .88-9 M16 x 2 M20 x 2.5 M22 x 2.5	110-145 150-190 270-350 360-470 425-550 181-221 347-431 479-597	(149-197) (203-258) (366-475) (488-637) (576-746) (245-300) (470-585) (650-810)
11.	Nut, Housing to Carrier Stud	.44-20 .50-20 .56-18 .62-18	50-75 75-115 110-165 150-230	(68-102) (102-156) (149-224) (203-312)
12.	Capscrew, Carrier to Housing	.44-14 .50-13 .56-12 .62-11 .75-10 M12 x 1.75 M16 x 2	50-75 75-115 110-165 150-230 270-400 74-89 181-221	(68-102) (102-156) (149-224) (203-312) (366-542) (100-120) (245-300)

* Some Meritor carriers do not have these described parts.

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Table J: Fastener Torque Information

Fastener		Thread Size	Torque Value lb-ft (N•m)	
13.	*Jam Nut, Thrust Screw	.75-16 .88-14 1.12-16 M22 x 1.5 M30 x 1.5	150-190 150-300 150-190 148-210 236-295	(203-258) (203-407) (203-258) (200-285) (320-400)
14.	Nut, Drive Pinion	.88-20 1.00-20 1.25-12 1.25-18 1.50-12 1.50-18 1.75-12 M32 x 1.5 M39 x 1.5 M45 x 1.5	200-275 300-400 700-900 700-900 800-1100 800-1100 900-1200 738-918 922-1132 996-1232	(271-373) (407-542) (949-1220) (949-1220) (1085-1491) (1085-1491) (1220-1627) (1000-1245) (1250-1535) (1350-1670)
15.	Capscrew, Bearing Cage	.38-16 .44-14 .50-13 .56-12 .62-11 M12 x 1.75	30-50 50-75 75-115 110-165 150-230 70-110	(41-68) (68-102) (102-156) (149-224) (203-312) (90-150)
16.	*Plug, Oil Fill (Carrier)	.75-14 1.5-11.5 M24 x 1.5	25 minimum (34 minimum) 120 minimum (163 minimum) 35 minimum (47 minimum)	
17.	*Capscrew, Lock Plate	.31-18 M8 x 1.25	20-30 21-26	(27-41) (28-35)

* Some Meritor carriers do not have these described parts.

Drive Pinion Bearings — Preload (Refer to Section 5)

Specification	New bearings — 5 to 45 lb-in (0.56-5.08 N•m) torque Used bearings — 10 to 30 lb-in (1.13-3.39 N•m) torque
Adjustment	Preload is controlled by the thickness of the spacer between bearings. — To increase preload install a thinner spacer — To decrease preload install a thicker spacer

Drive Pinion — Depth in Carrier (Refer to Section 5)

Specification	Install the correct amount of shims between the bearing cage and carrier. To calculate, use old shim pack thickness and new and old pinion cone numbers.
Adjustment	Change the thickness of the shim pack to get a good gear tooth contact pattern.

Hypoid Gear Set — Tooth Contact Patterns (Hand Rolled) (Refer to Section 5)

Specification	Conventional gear set — Toward the toe of the gear tooth and in the center between the top and bottom of the tooth Generoid gear set — Between the center and toe of the tooth and in the center between the top and bottom of the tooth
Adjustment	Tooth contact patterns are controlled by the thickness of the shim pack between the pinion bearing cage and carrier and by ring gear backlash — To move the contact pattern lower, decrease the thickness of the shim pack under the pinion bearing cage — To move the contact pattern higher, increase the thickness of the shim pack under the pinion bearing cage — To move the contact pattern toward the toe of the tooth, decrease backlash of the ring gear — To move the contact pattern toward the heel of the tooth, increase backlash of the ring gear.

Main Differential Bearings — Preload (Refer to Section 5)

Specification	15 to 35 lb-in (1.7-3.9 N•m) torque ***or*** Expansion between bearing caps — R-140, R-155 and R-160 carrier models — 0.002 to 0.009 inch (0.050-0.229 mm) — All other carrier models — 0.006 to 0.013 inch (0.150-0.330 mm)
Adjustment	Preload is controlled by tightening both adjusting rings after zero end play is reached

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Main Differential Gears — Rotating Resistance (Refer to Section 5)

Specification	50 lb-ft (68 N•m) torque applied to one side gear

Ring Gear — Backlash (Refer to Section 5)

Specification	Ring gears that have a pitch diameter of less than 17 inches (431.8 mm) — Range: 0.008 to 0.018 inch (0.200-0.460 mm) 0.012 inch (0.300 mm) for a new gear set Ring gears that have a pitch diameter of 17 inches (431.8 mm) or greater — Range: 0.010 to 0.020 inch (0.250-0.510 mm) 0.015 inch (0.380 mm) for a new gear set
Adjustment	Backlash is controlled by the position of the ring gear. Change backlash within specifications to get a good tooth contact pattern. — To increase backlash, move the ring gear away from the drive pinion — To decrease backlash, move the ring gear toward the drive pinion

Ring Gear — Runout (Refer to Section 5)

Specification	0.008 inch (0.200 mm) maximum

Spigot Bearing — Peening on the Drive Pinion (Refer to Section 5)

Specification	Apply 6,614 lb (3,000 kg) load on a 0.375 inch or 10 mm ball. Peen the end of the drive pinion at a minimum of five points. Softening of the pinion stem end by heating may be required.

SINGLE AXLE without Driver Controlled Main Differential Lock (DCDL)

TANDEM AXLE without Driver Controlled Main Differential Lock (DCDL), with Inter-Axle Differential (IAD)

These instructions are for vehicles equipped with Meritor single or tandem rear drive axles.

The instructions supersede all other instructions for the purpose of transporting vehicles for service or new vehicle drive-away dated before April 1995, including those contained in Meritor Maintenance Manuals.

When transporting a vehicle with the wheels of one or both drive axles on the road, it is possible to damage the axles if the wrong procedure is used before transporting begins. Meritor recommends that you use the following procedure.

Before Towing or Drive-Away

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Engage the parking brake to prevent the vehicle from moving before you begin maintenance or service procedures that require you to be under the vehicle. Serious personal injury can result.

1. Apply the vehicle parking brakes using the switch inside the cab of the vehicle.

NOTE: Single Axle continue with Step 5. Tandem Axle continue with Step 2.

2. Shift the transmission into neutral and start the vehicle's engine.
3. Shift the IAD to the unlocked (disengaged) position using the switch inside the cab of the vehicle. The indicator light in the cab will go off.
4. Stop the engine.

NOTE: Remove both axle shafts from the axle(s) that will remain on the road when the vehicle is transported. Continue with Step 5 for both axle shafts.

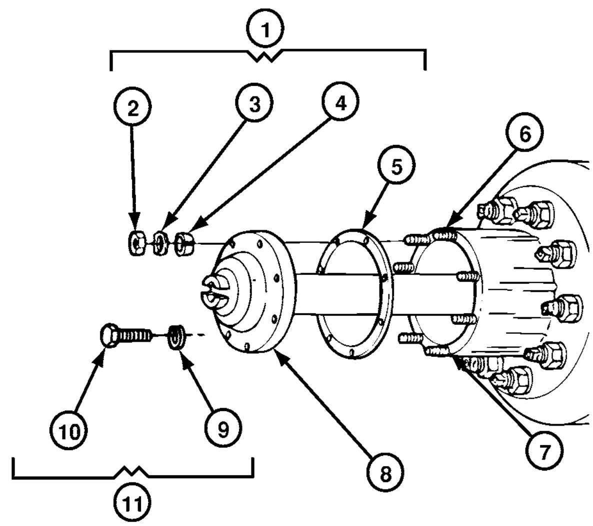
5. Remove the stud nuts or capscrews and the washers from the flange of the axle shaft. **Figure 9.1**.

CAUTION

Do not use a chisel or wedge to loosen the axle shaft and tapered dowels. Using a chisel or wedge can result in damage to the axle shaft, the gasket and seal, and/or the axle hub.

6. Loosen the tapered dowels, if used, in the flange of the axle shaft using one of the two following methods. **Figure 9.1**.

Figure 9.1



1 TAPERED DOWEL RETENTION
2 STUD NUT
3 WASHER
4 TAPERED DOWEL
5 GASKET
6 STUD
7 SHAFT HUB AXLE
8 AXLE SHAFT (FLANGE)
9 WASHER
10 CAPSCREW
11 NON-TAPERED DOWEL RETENTION

7. Brass Drift Method:

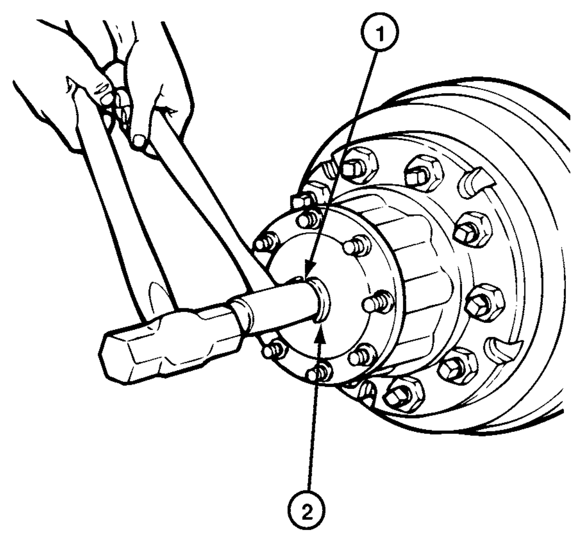
⚠ WARNING

Do not strike the round driving lugs on the flange of an axle shaft. Pieces can break off and cause serious personal injury.

NOTE: A 1.5-inch (38.1 mm) diameter brass hammer can be used as a drift.

a. Hold a 1.5-inch (38.1 mm) diameter brass drift against the center of the axle shaft flange, **inside the round driving lugs. Figure 9.2**.

Figure 9.2



1 BRASS HAMMER INSIDE LUGS
2 ROUND DRIVING LUG

b. Hit the end of the drift with a large hammer (5 to 6 lbs, 2 to 3 kg) to loosen the axle shaft and tapered dowels from the hub. **Figure 9.2**.

⚠ WARNING

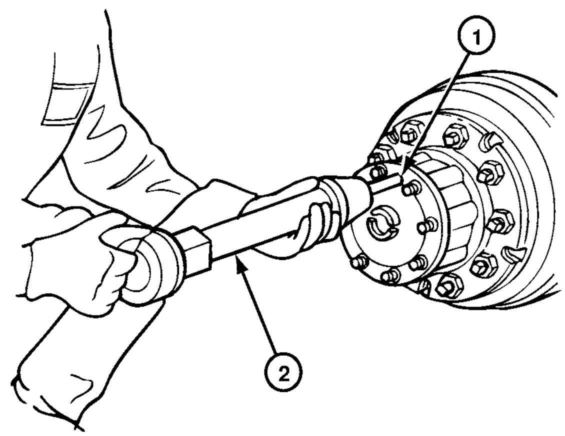
Wear safe eye protection when using an air hammer. Power tools and components can loosen and break and cause serious personal injury.

8. Air Hammer Vibration Method:

a. Use an air hammer, such as Chicago Pneumatic CP-4181-PULER, or equivalent, with a round hammer bit to loosen the axle shaft and dowels.

b. Place the round hammer bit against the axle shaft flange between the studs, at different points around the flange. Operate the air hammer at each location and loosen the axle shaft and tapered dowels from the hub. **Figure 9.3**.

Figure 9.3



1 BIT PLACED BETWEEN STUDS
2 AIR HAMMER AND BIT

9. Identify each axle shaft that is removed from the axle assembly so they can be installed in the same location after transporting or repair is completed. (Example: Match mark a mating axle shaft and hub.)

10. Remove the tapered dowels, gasket (if used) and the axle shaft from the axle assembly. **Figure 9.1**.

11. Install a cover over the open end of each hub where an axle shaft was removed. This will prevent dirt from entering the bearing cavity and loss of lubricant.

NOTE: If an air supply will be used for the brake system of the transported vehicle, continue with Steps 12 and 13, otherwise continue with Step 14.

12. Connect an auxiliary air supply to the brake system of the vehicle that is being transported. Before moving the vehicle, charge the brake system with the correct amount of air pressure to operate the brakes. Refer to the instructions supplied by the manufacturer of the vehicle for procedures and specifications. If an auxiliary air supply is not used, continue with Step 14.
13. When the correct amount of air pressure is in the brake system, release the parking brakes of the vehicle that is being transported. Step 14 is not required.

WARNING

When you work on a spring chamber, carefully follow the service instructions of the chamber manufacturer. Sudden release of a compressed spring can cause serious personal injury.

14. If there are spring (parking) brakes on the axle(s) that will remain on the road when the vehicle is transported, and they cannot be released by air pressure, manually compress and lock each spring so that the brakes are released. Refer to the manufacturer's instructions.

After Towing or Drive-Away

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Engage the parking brake to prevent the vehicle from moving before you begin maintenance or service procedures that require you to be under the vehicle. Serious personal injury can result.

1. If an auxiliary air supply was used, apply the vehicle parking brakes using the switch inside the cab of the vehicle. If an auxiliary air supply was not used, begin with Step 2.

WARNING

When you work on a spring chamber, carefully follow the service instructions of the chamber manufacturer. Sudden release of a compressed spring can cause serious personal injury.

2. Apply the vehicle spring (parking) brakes by manually releasing each spring that was compressed before transporting started. Refer to manufacturer's instructions.
3. Disconnect the auxiliary air supply, if used, from the brake system of the vehicle that was transported. Connect the vehicle's air supply to the brake system.
4. Remove the covers from the hubs.

NOTE: Continue with Steps 5 through 7 to install all axle shafts.

5. Install the gasket, if used, and axle shaft into the axle housing and carrier in the same location it was removed from. The gasket and flange of the axle shaft must be flat against the hub. Rotate the axle shaft and/or the driveline as necessary to align the splines and the holes in the flange with the studs in the hub. **Figure 9.1**.
6. Install the dowels, if used, over each stud and into the tapered holes of the flange.
7. Install the washers and capscrews or stud nuts. Determine the size of the fasteners and tighten the capscrews or nuts to the corresponding torque value shown in **Table K**.

Table K

Fasteners	Thread Size	Torque Value lb-ft (N•m)
Capscrews:	0.31"-24 0.50"-13	18-24 (24-33) 85-115 (115-156)
Stud Nuts: (plain nuts)	0.44"-20 0.50"-20 0.56"-18 0.62"-18 0.75"-16	50-75 (68-102) 75-115 (102-156) 110-165 (149-224) 150-230 (203-312) 310-400 (420-542)
(lock nut)	0.44"-20 0.50"-20 0.56"-18 0.62"-18 0.75"-16	40-65 (54-88) 65-100 (88-136) 100-145 (136-197) 130-190 (176-258) 270-350 (366-475)

8. Inspect the lubricant level in the axles and hubs where the axle shafts were removed. Add the correct type and amount of lubricant if necessary. For information about lubrication, refer to Maintenance Manual MM 1, *Lubrication*, or refer to the Lubrication Section of the Maintenance Manual for the axle model you are working with.

Notes

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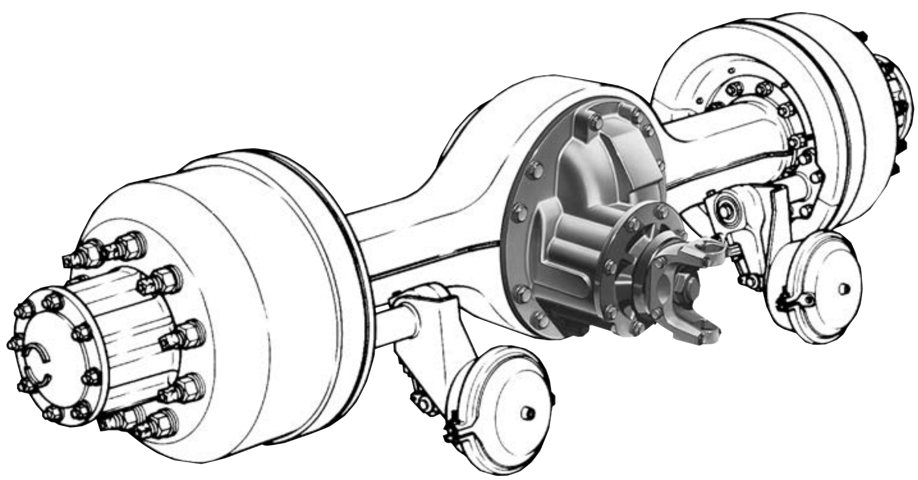
Single-Reduction Differential Carriers

Single Rear Drive Axles, Rear-Rear Tandem Drive Axles and Front Drive Steer Axles

Maintenance Manual 5A



RS and RT Series Single-Reduction Axles (Single, Rear of Tandem)

MX and RF Series Front Drive Axles

Before You Begin

This manual provides instructions for the Meritor MX-, RS-, RT- and RF-Series axles. Before you begin procedures:

1. Read and understand all instructions and procedures before you begin to service components.
2. Read and observe all Caution and Warning safety alerts that precede instructions or procedures you will perform. These alerts help to avoid damage to components, serious personal injury, or both.
3. Follow your company's maintenance and service, installation, and diagnostics guidelines.
4. Use special tools when required to help avoid serious personal injury and damage to components.

Safety Alerts, Torque Symbol and Notes

WARNING	A Warning alerts you to an instruction or procedure that you must follow exactly to avoid serious personal injury.
CAUTION	A Caution alerts you to an instruction or procedure that you must follow exactly to avoid damage to components.
T	A torque symbol alerts you to tighten fasteners to a specified torque value.
NOTE	A Note provides information or suggestions that help you correctly service a component.

Access Product and Service Information on Our Website

Visit the DriveTrain Plus™ by ArvinMeritor Tech Library at arvinmeritor.com to access and order product and service information.

To Order Information by Phone

Call ArvinMeritor's Customer Service Center at 800-535-5560 to order the following publications.

- Lubrication (Maintenance Manual 1)
- Single-Reduction Differential Carriers (Maintenance Manual 5)
- Single-Reduction Forward Differential Carriers on Tandem and Tridem Axles (Maintenance Manual 5L)
- Drive Axle Housings (Maintenance Manual 8)
- Approved Rear Drive Axle Lubricants (TP-9539)
- Driver Instruction Kit (TP-9579)
- Failure Analysis for Drive Axle Components (TP-9955)
- Traction Controls package that contains two videos: Splitting the Difference (T-87127V) and Driver-Controlled, Full-Locking Main Differential (T-9007V). Order T-95125V for this package. Each video is also available separately.
- Drivetrain Plus™ by ArvinMeritor Technical Electronic Library on CD. Features product and service information on most Meritor, ZF Meritor and Meritor WABCO products. $20. Order TP-9853.

How to Order Tools and Supplies Specified in This Manual

Call ArvinMeritor's Commercial Vehicle Aftermarket at 888-725-9355 to order Meritor tools and supplies.

SPX Kent-Moore, 28635 Mound Road, Warren, Michigan, 48092. Call the company's customer service center at 800-345-2233, or visit their website at spxkentmoore.com.

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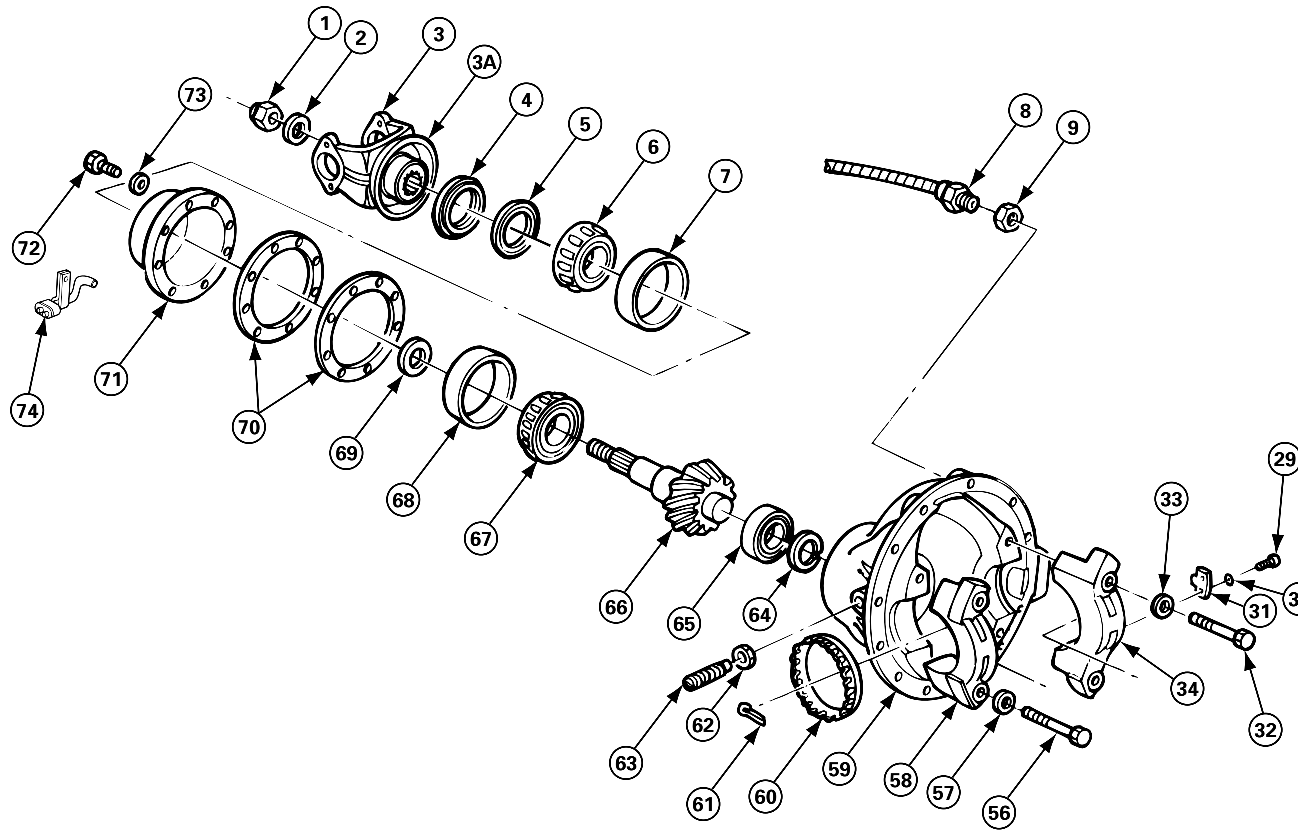
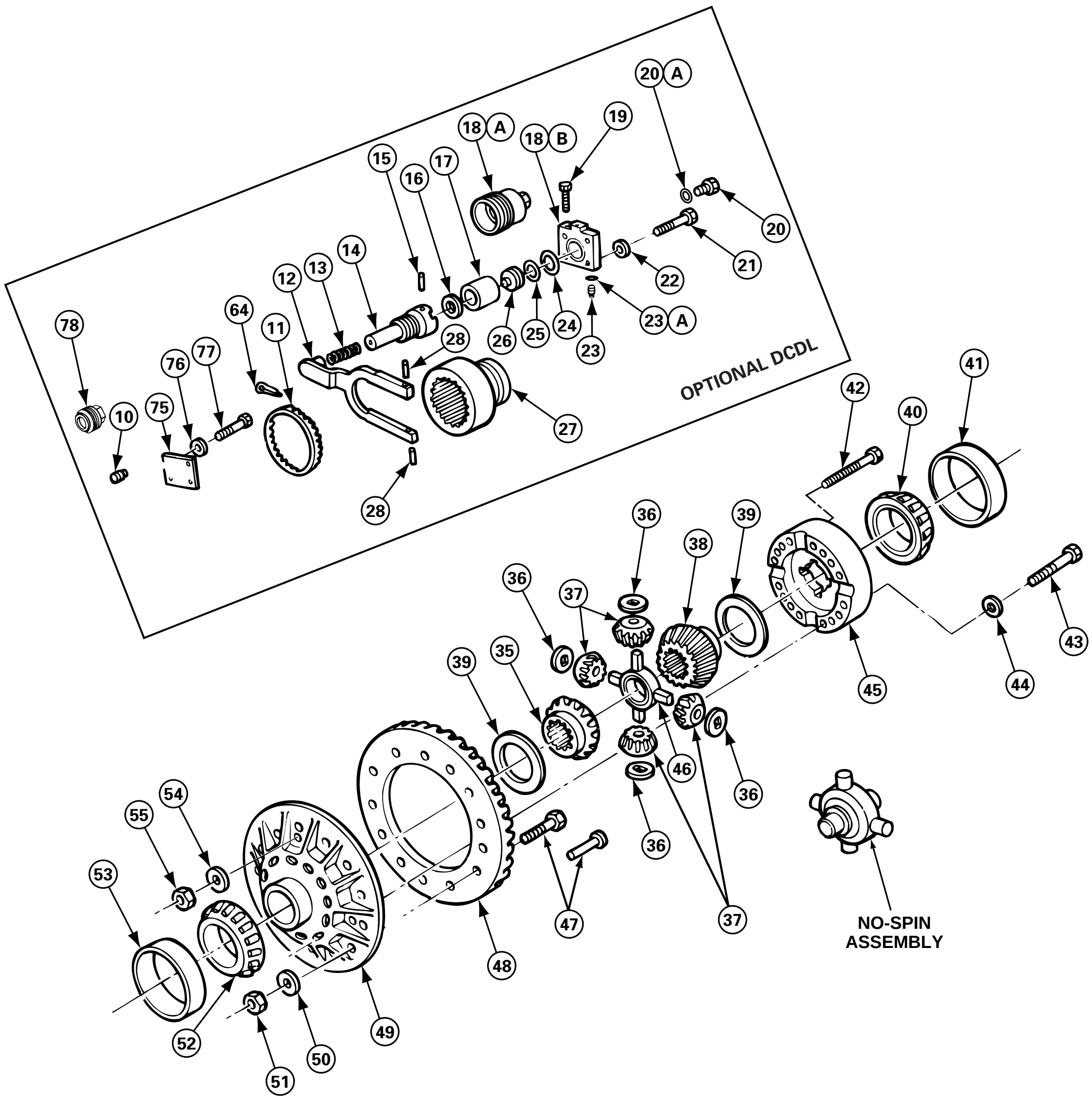
Single-Reduction Differential Carrier



1	Nut — Drive Pinion*	32	Capscrews — Differential Bearing Cap	65	Spigot Bearing
2	Washer — Drive Pinion*	33	Washers	66	Drive Pinion
3	Input Yoke* or Flange*	34	Caps — Differential Bearing	67	Bearing Cone — Pinion Inner
3A	Deflector	56	Capscrews — Differential Bearing Cup	68	Bearing Cup — Pinion Inner
4	POSE™ seal	57	Washers	69	Spacer — Pinion Bearing
5	Triple Lip (Main) Seal	58	Caps — Differential Bearing	70	Shims
6	Bearing Cone — Outer	59	Carrier	71	Bearing Cage — Drive Pinion
7	Bearing Cup — Inner	60	Adjusting Ring	72	Capscrew — Bearing Cage
8	Sensor Switch	61	Cotter Pin — Adjusting Ring	73	Washer
9	Lock Nut — Sensor Switch	62	Jam Nut* — Thrust Screw*	74	Clip and Cable Holder
29	Capscrews* — Lock Plate*	63	Thrust Screw*	75	Cover — Bolt-On
30	Washers* — Lock Plate*	64	Snap Ring	76	Washer
31	Lock Plate — Adjusting Ring			77	Bolt
				78	Cover — Screw-In

* Some Meritor carriers do not have these described parts.



10	Plug
11	Adjusting Ring — R.H.
12	Shift Fork
13	Spring — Shift Shaft
14	Shift Shaft
15	Pin — Spring Retaining
16	Washer* or Silastic* — Air Cylinder
17	Tube — Air Cylinder
18A	Screw-In Differential Lock Cylinder
18B	Cylinder Cover
19	Capscrew — Manual Actuation
20	Plug — Cylinder Cover
20A	Gasket — Cover Plug
21	Capscrews — Cylinder Cover
22	Washers — Cylinder Cover
23	Plug — Cylinder Cover
23A	Gasket — Cover Plug
24	Copper Gasket — Cylinder Cover
25	O-Ring — Piston
26	Piston
27	Shift Collar
28	Pins — Shift Fork
35	Side Gears — Differential
36	Thrust Washers — Differential Pinion
37	Pinions — Differential
38	Differential — Side Gears
39	Thrust Washers — Differential Side Gear
40	Cone — Differential Bearing
41	Cup — Differential Bearing
42	“Thru” Bolt
43	Bolts* — Differential Case
44	Washers — Differential Case
45	Case Assembly — Main Differential
46	Spider — Differential
47	Bolts* or Rivets* — Ring Gear and Case Half
48	Ring Gear (Pinion Drive Gear)
49	Case Half — Flange
50	Washers — Case Half
51	Nuts* — Case Half
52	Bearing Cone — Differential L.H.
53	Bearing Cup — Differential L.H.
54	Washer for “Thru” Bolt
55	Nut for “Thru” Bolt
64	Snap Ring
75	Cover — Bolt-On
76	Washer
77	Bolt
78	Cover — Screw-In

* Some Meritor carriers do not have these described parts.

Standard Single-Reduction Carriers Without Differential Lock

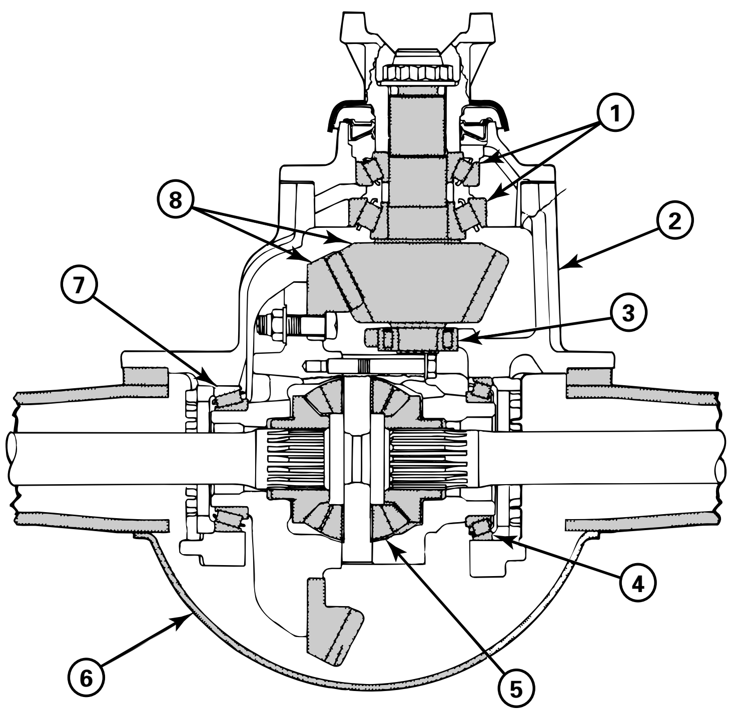
Meritor single-reduction standard carriers are used in most Meritor single axles, rear of tandem axles and front drive steer axles. **Figure 1.1**.

The single-reduction carriers are front mounted into the axle housing. These carriers have a hypoid drive pinion and ring gear set and bevel gears in the differential assembly.

A straight roller bearing or spigot 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 at all times.

Figure 1.1



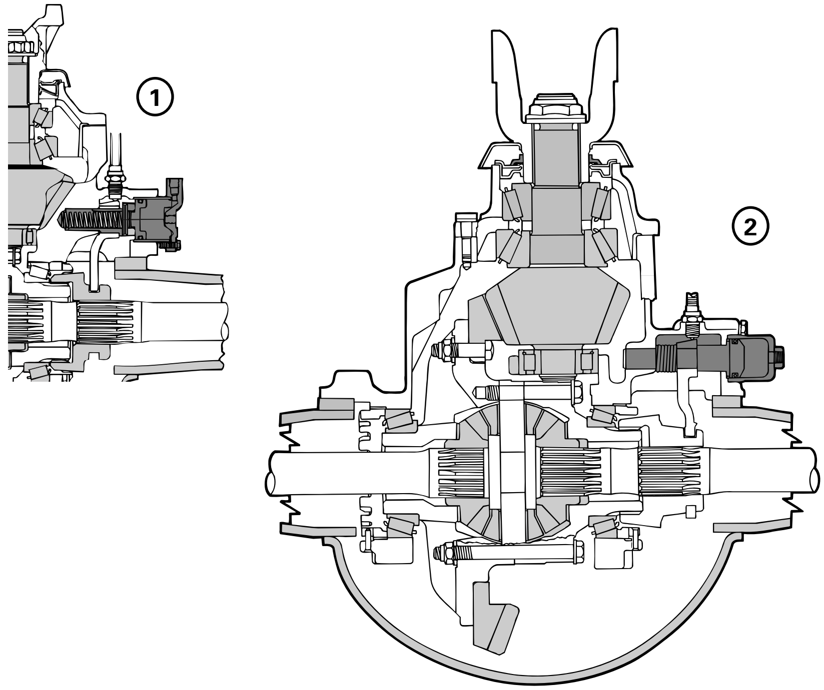
1 TAPERED ROLLER BEARINGS
2 CARRIER
3 STRAIGHT ROLLER BEARING
4 TAPERED ROLLER BEARING
5 BEVEL DIFFERENTIAL GEARS
6 HOUSING
7 TAPERED ROLLER BEARING
8 HYPOID DRIVE PINION AND RING GEAR

Single-Reduction Carriers with DCDL (Driver-Controlled Main Differential Lock)

Meritor single-reduction carriers with driver-controlled main differential lock (DCDL) have the same type of gears and bearings as the standard-type carriers. **Figure 1.2.** The differential lock is operated by an air-actuated shift assembly that is mounted on the carrier.

- When the differential lock is activated, the shift collar moves along the splines of the axle shaft toward the differential case.
- When the splines on the collar are engaged with splines on the differential case, the axle shafts and differential assembly are locked together.
- When the carrier operates with the DCDL in the locked position, there is no differential action between the wheels.
- When the carrier is operated in the unlocked position, there is normal differential action between the wheels at all times.

Figure 1.2



1 BOLT-IN STYLE
2 SCREW-IN STYLE OR THREADED

STANDARD CARRIER WITH DIFFERENTIAL LOCK (DCDL)

MERITOR®

Axle Models Covered in this Manual

Single Drive Axles				For other models (non-MX-, RS-, RT- and RF-Series), refer to Maintenance Manual 5, Single-Reduction Differential Carriers. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.
RS-13-120	RS-17-145	RS-21-160	RS-23-186	
RS-15-120	RS-17-145A	RS-21-160A	RS-25-160	
RS-16-140	RS-19-144	RS-23-160	RS-25-160A	
RS-16-141	RS-19-144A	RS-23-160A	RS-26-160	
RS-16-145	RS-19-145	RS-23-161	RS-26-180	
RS-17-140	RS-19-145A	RS-23-161A	RS-26-185	
RS-17-141	RS-21-145	RS-23-180	RS-30-180	
RS-17-144	RS-21-145A	RS-23-185	RS-30-185	
RS-17-144A				
Rear Axle of Tandem Axles				
RT-34-140	RT-40-146	RT-44-145P	RT-46-169A	
RT-34-144	RT-40-149	RT-44-149	RT-46-169P	
RT-34-144A	RT-40-149A	RT-46-16HEH	RT-48-180	
RT-34-144P	RT-40-149P	RT-46-16HP	RT-48-185	
RT-34-145	RT-40-160	RT-46-160	RT-50-160	
RT-34-145P	RT-40-160A	RT-46-160A	RT-50-160P	
RT-34-146	RT-40-160P	RT-46-160P	RT-52-180	
RT-40-140	RT-40-169	RT-46-164	RT-52-185	
RT-40-145	RT-40-169A	RT-46-164EH	RT-58-180	
RT-40-145A	RT-40-169P	RT-46-164P	RT-58-185	
RT-40-145P	RT-44-145	RT-46-169		
Front Drive Steer Axles				
MX-10-120	RF-7-120	RF-21-160		
MX-12-120	RF-9-120	RF-21-185		
MX-14-120	RF-12-120	RF-21-355		
MX-16-120	RF-12-125	RF-22-166		
MX-21-160	RF-16-145	RF-23-180		
MX-21-160R	RF-21-155	RF-23-185		
MX-23-160	RF-21-156			
MX-23-160R				

Stall Testing with Automatic Transmissions

Stall testing is an experimental test procedure sometimes used for automatic transmission diagnostics, vehicle performance evaluation or to test service and park brake hold. During stall testing or a similar procedure, the drive axle input receives multiplied torque that can greatly exceed the axle torque rating. This can cause drive axle damage and result in immediate axle failure or shortened axle life.

Meritor regards stall testing to be outside the scope of normal vehicle operation. Axle damage or failure caused by stall testing or a similar procedure voids Meritor's warranty.

For questions related to stall testing, contact ArvinMeritor's Customer Service Center at 800-535-5560.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury can result.

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off and cause serious personal injury.

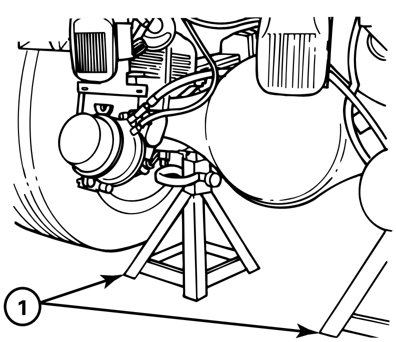
Removal

Differential Carrier from the Axle Housing

NOTE: If the vehicle is equipped with a driver-controlled main differential lock, the DCDL collar must be engaged before removing axle shafts. Refer to complete instructions under Driver-Controlled Main Differential Lock Assembly and **Figure 5.1.**

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. **Figure 2.1.**
2. Use a jack or other lifting tool to raise the vehicle so that the wheels to be serviced are off the ground. Support the vehicle with safety stands. **Figure 2.1.**
3. Place a drain pan under the rear axle.

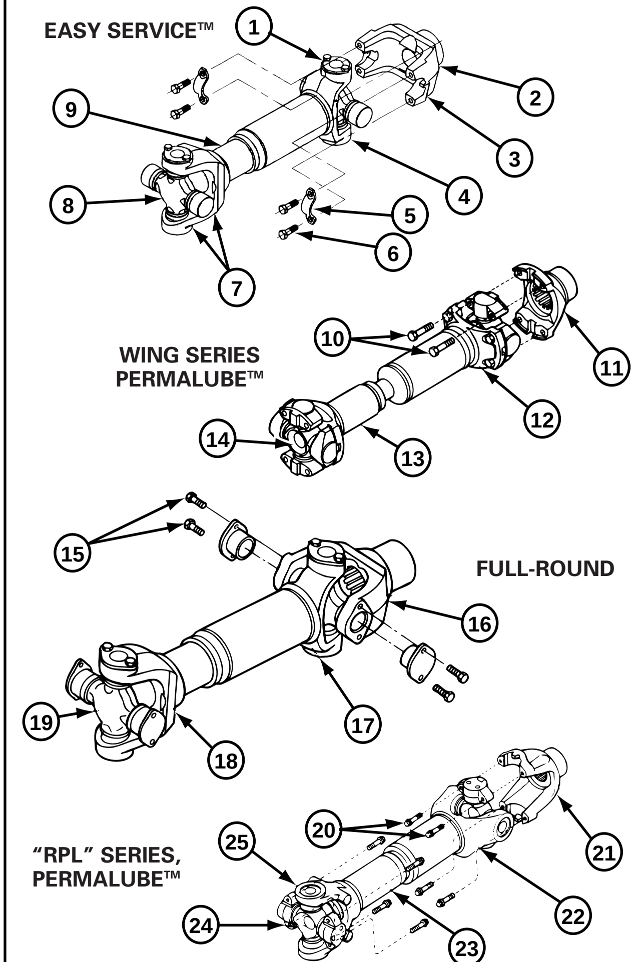
Figure 2.1



1 SAFETY STANDS

4. Remove the plug from bottom of axle housing. Drain lubricant from the assembly.
5. Disconnect the driveline universal joint from the pinion input yoke or flange on the carrier. **Figure 2.2.**

Figure 2.2



1	FULL ROUND BEARING CUPS	13	SLIP YOKE
2	END YOKE	14	U-JOINT CROSS
3	YOKE SADDLE	15	CAPSCREWS
4	WELD YOKE	16	END YOKE
5	BEARING STRAP	17	WELD YOKE
6	CAPSCREWS	18	SLIP YOKE
7	EASY-SERVICE BEARING CUPS	19	U-JOINT CROSS
8	U-JOINT CROSS	20	CAPSCREWS
9	SLIP YOKE	21	END YOKE
10	CAPSCREWS	22	SLIP YOKE
11	END YOKE	23	TUBING
12	WELD YOKE	24	U-JOINT CROSS
		25	WELD YOKE

6. Remove the capscrews and washers or stud nuts and washers, if equipped, from the flanges of both axle shafts.
7. Loosen the tapered dowels, if equipped, in the axle flanges of both axle shafts using one of the following methods.

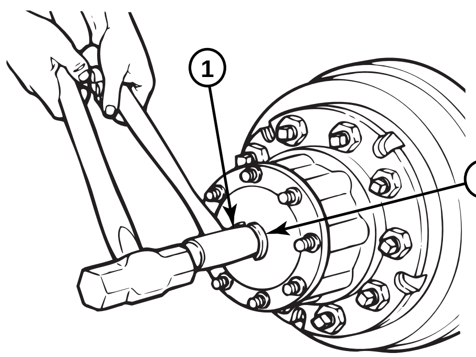
Brass Drift Method

WARNING

Do not strike the round driving lugs on the flange of an axle shaft. Pieces can break off and cause serious personal injury.

1. Hold a 1-1/2-inch diameter brass drift or brass hammer against the center of the axle shaft, inside the round driving lugs. **Figure 2.3.**

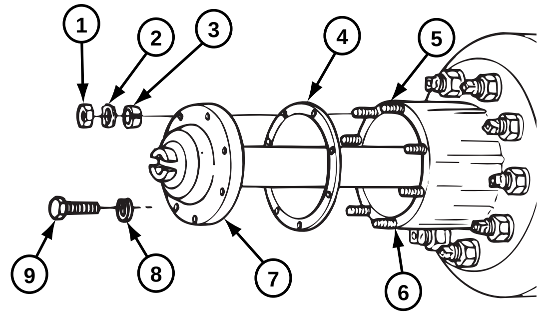
Figure 2.3



1 BRASS HAMMER
2 DRIVING LUGS

2. Strike the end of the drift with a large hammer, five to six pounds, and the axle shaft and tapered dowels will loosen.
3. Mark each axle shaft before it is removed from the axle assembly.
4. Remove the tapered dowels and separate the axle shafts from the main axle hub assembly. **Figure 2.4.**
5. Install a cover over the open end of each axle assembly hub where an axle shaft was removed.

Figure 2.4



1 STUD NUT
2 WASHER
3 TAPERED DOWEL
4 GASKET
5 STUD
6 SHAFT HUB AXLE
7 AXLE SHAFT OR FLANGE
8 WASHER
9 CAPSCREW

Air Hammer Vibration Method

WARNING

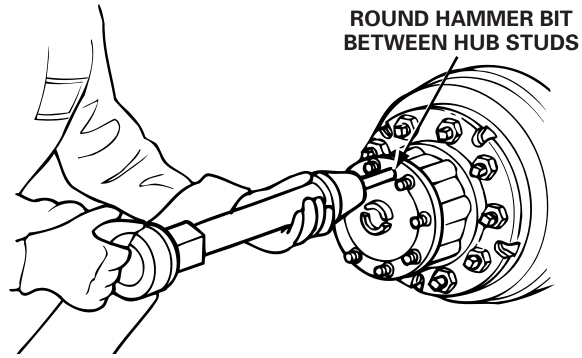
Wear safe eye protection when using an air hammer. When using power tools, axle components can loosen and break off causing serious personal injury.

CAUTION

Do not use a chisel or wedge to loosen the axle shaft and tapered dowels. Using a chisel or wedge can result in damage to the axle shaft, the gasket and seal, and the axle hub.

1. Use a round hammer bit and an air hammer to loosen tapered dowels and axle shaft.
2. Place the round hammer bit against the axle shaft or flange between the hub studs. Operate the air hammer at alternate locations between the studs to loosen the tapered dowels and axle shaft from the hub. **Figure 2.5.**

Figure 2.5



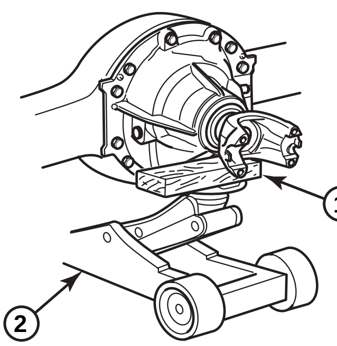
1 ROUND HAMMER BIT BETWEEN HUB STUDS

3. Mark each axle shaft before it is removed from the axle assembly.
4. Remove the tapered dowels and separate the axle shaft from the main axle hub assembly. **Figure 2.4**.

Carrier from the Axle

1. Place a hydraulic roller jack under the differential carrier to support the assembly. **Figure 2.6**.

Figure 2.6



1 WOOD BLOCK
2 ROLLER JACK

2. Remove all but the top two carrier to housing capscrews or stud nuts and washers.
3. Loosen the top two carrier-to-housing fasteners and leave attached to the assembly. The fasteners will hold the carrier in the housing.
4. Loosen the differential carrier in the axle housing. Use a leather mallet to hit the mounting flange of carrier at several points.
5. After the carrier is loosened, remove the top two fasteners.

CAUTION

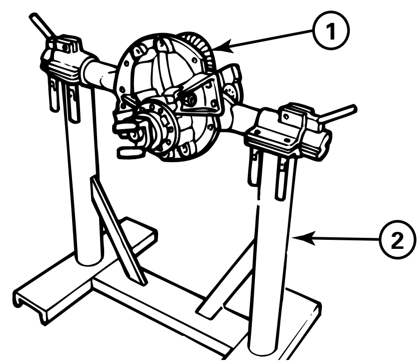
When using a pry bar, be careful not to damage the carrier or housing flange. Damage to these surfaces will cause oil leaks.

6. Use the hydraulic roller jack to remove the carrier from the axle housing. Use a pry bar that has a round end to help remove the carrier from the housing.

NOTE: A carrier stand is available from SPX Kent-Moore. Refer to the Service Notes page on the front inside cover of this manual to obtain the stand.

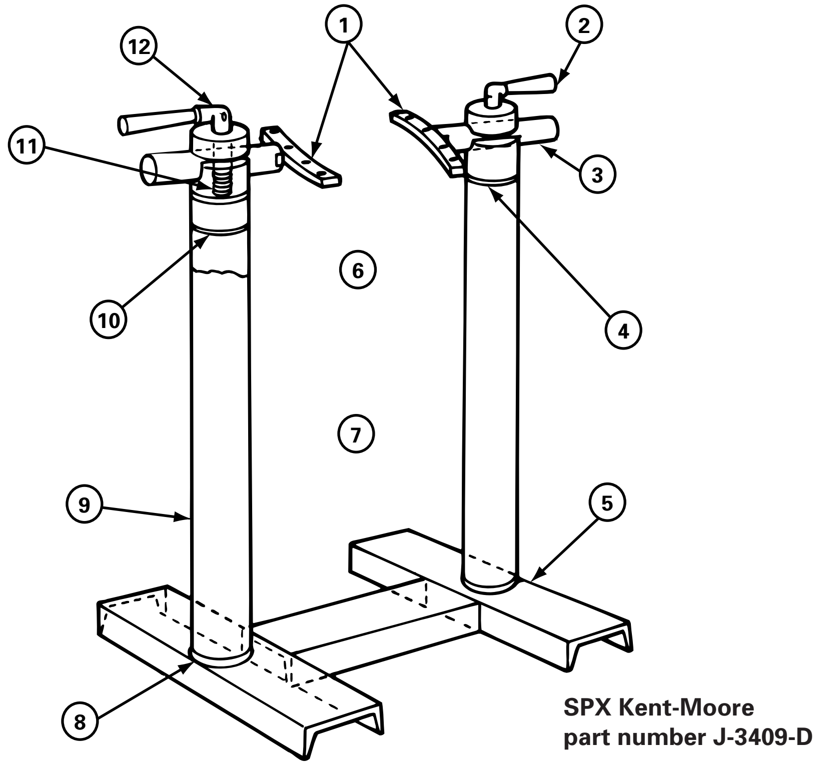
7. Use a lifting tool to lift the differential carrier by the input yoke or flange and place the assembly in a repair stand. **Figure 2.7.** Do not lift by hand. A carrier stand can be built by referring to **Figure 2.8.**

Figure 2.7



1 DIFFERENTIAL CARRIER 2 REPAIR STAND

Figure 2.8



1 PLATES 8′ LONG x 3/4″ THICK x 1-1/4″ WIDE WITH A TONGUE TO FIT SLOT IN BAR WELD PLATES TO BAR
2 HANDLE 7″ LONG WITH SLOT IN ONE END TO FIT CLAMP SCREW
3 BAR 2″ DIAMETER X 9″ LONG WITH ONE END SLOTTED TO FIT PLATE
4 WELD ALL AROUND AFTER PRESSING PLUG IN PIPE
5 WELD
6 SHAPE AND SIZE OF HOLES TO FIT CARRIER
7 23-1/2″ CENTER TO CENTER OF PIPE
8 CHAMFER END OF PIPE FOR WELDING
9 4″ DIAMETER PIPE
10 PLUG 4″ DIAMETER x 7″ LONG WITH ONE END TURNED 3″ LONG TO FIT PIPE DRILL 2″ HOLE AND MILL 3/16″ WIDE SLOT 2″ FROM TOP
11 SCREW 3-1/2″ LONG x 5/8″ DIAMETER WITH FLATS ON END TO FIT HANDLE AND 2-1/2″ LENGTH OF THREAD ON OTHER END
12 DRILL 3/8″ HOLE THROUGH HANDLE AND SCREW

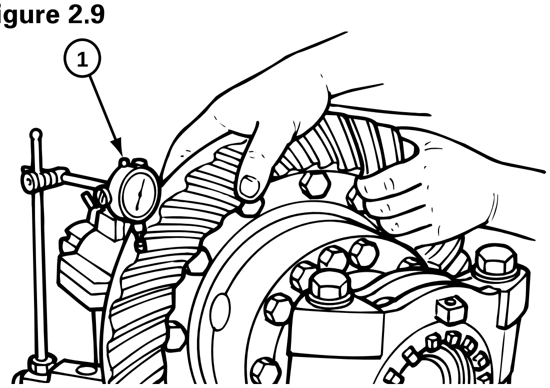
CARRIER STAND

Differential and Ring Gear from the Carrier

NOTE: Before working on the differential carrier, inspect the hypoid gear set for damage. If inspection shows no damage, the same gear set can be used again. Measure the backlash of the gear set and make a record of the dimension. **Figure 2.9**. Refer to Section 4.

1. Loosen the jam nut on the thrust screw, if equipped.
2. Remove the thrust screw and jam nut, if equipped, from the differential carrier. **Figures 2.10 and 2.11**.

Figure 2.9



1 DIAL INDICATOR

Figure 2.10

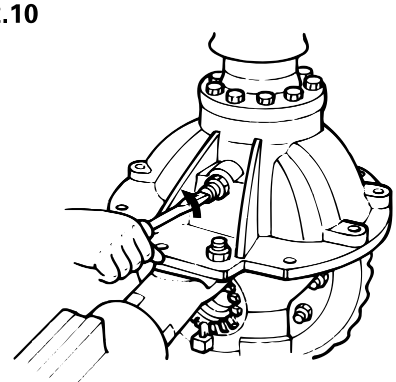
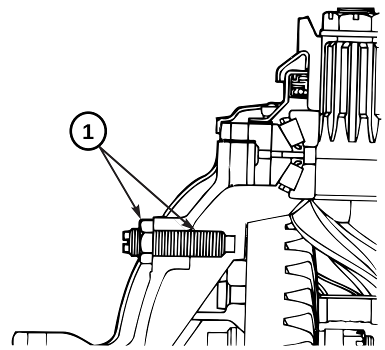


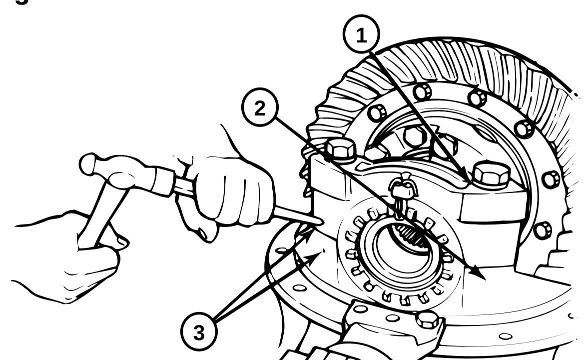
Figure 2.11



1 THRUST SCREW AND JAM NUT

3. Rotate the differential carrier in the repair stand until the ring gear is at the top of the assembly.
4. Mark one carrier leg and bearing cap to correctly match the parts during carrier assembly. Mark the parts using a center punch and hammer. **Figure 2.12.**

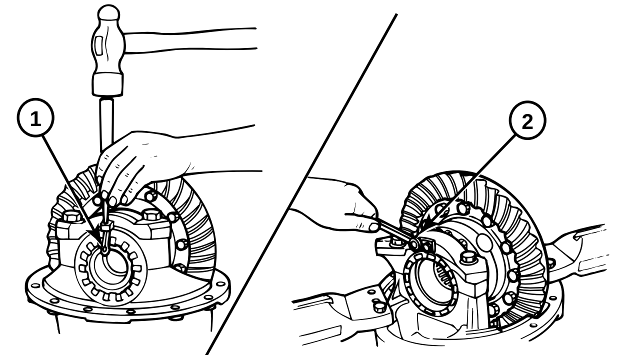
Figure 2.12



1 BEARING CAP
2 CARRIER LEG
3 MATCH MARKS

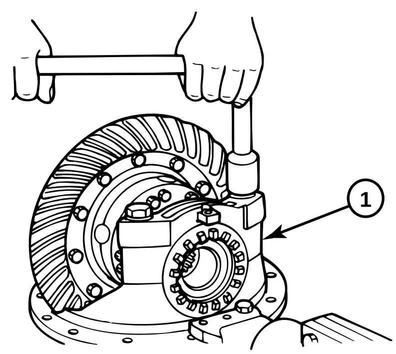
5. Remove the cotter keys, pins or lock plates, if equipped, that hold the bearing adjusting rings in position. Use a small drift and hammer to remove pins. Each lock plate is held in position by two capscrews. **Figure 2.13**.
6. Remove the capscrews and washers that hold the two bearing caps on the carrier. Each cap is held in position by two capscrews and washers. **Figure 2.14**.
7. Remove the bearing caps and bearing adjusting rings from the carrier. **Figure 2.15**.
8. Safely lift the main differential and ring gear assembly from the carrier. Place the assembly on a work bench. **Figure 2.16.**

Figure 2.13



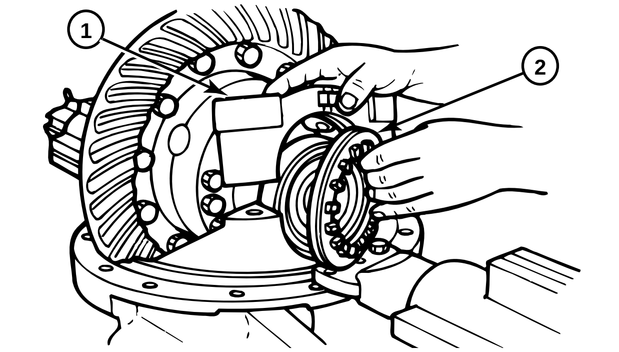
1 REMOVING COTTER KEY
2 REMOVING LOCK PLATE

Figure 2.14



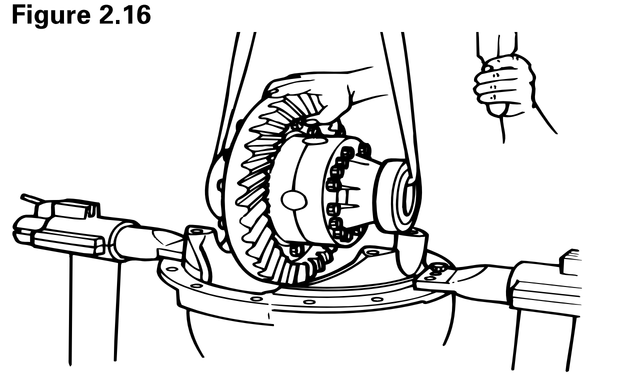
1 BEARING CAP

Figure 2.15



1 BEARING CAP
2 BEARING ADJUSTING RING

Figure 2.16



Disassembly

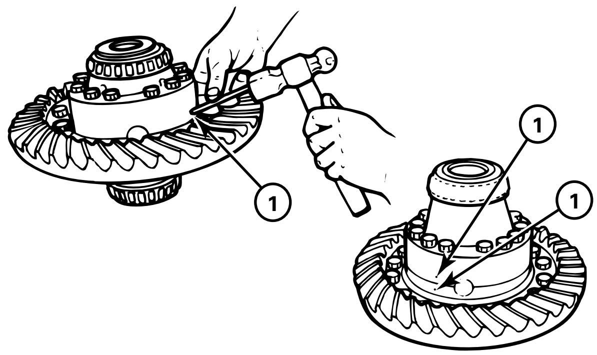
Differential and Ring Gear Assembly

WARNING

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

1. If the match marks on the case halves of the differential assembly are not visible, mark each case half with a center punch and hammer. **Figure 2.17**.
2. Remove the capscrews and washers or bolts, nuts and washers, if equipped, that hold the case halves together.

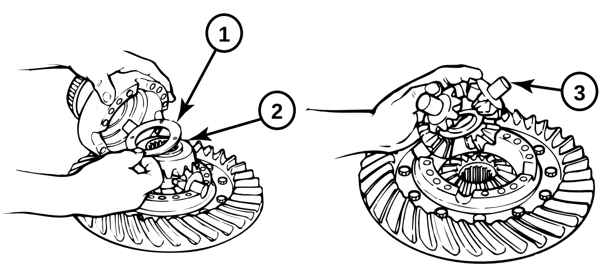
Figure 2.17



1 MATCH MARKS

3. Separate the case halves. If necessary, use a brass, plastic or leather mallet to loosen the parts.
4. Remove the differential spider or cross, four pinion gears, two side gears and six thrust washers from inside the case halves. **Figure 2.18.**
5. If the ring gear needs to be replaced, remove the bolts, nuts, and washers, if equipped, that hold the gear to the flange case half.

Figure 2.18



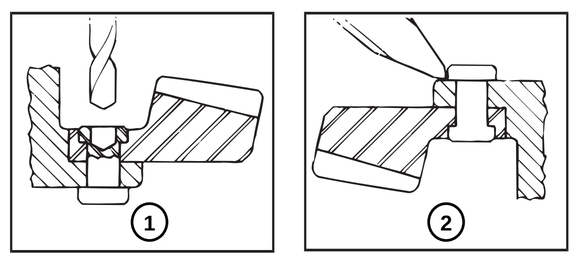
1 THRUST WASHER
2 SIDE GEAR
3 SPIDER, PINIONS AND THRUST WASHERS

⚠ CAUTION

Do not remove the rivets or rivet heads with a chisel and hammer. Using a flat edge tool can cause damage to the flange case.

6. If rivets hold the ring gear to the flange case half, remove the rivets as follows.
   A. Carefully center punch each rivet head in the center, on the ring gear side of the assembly. Do not use a chisel and hammer. **Figure 2.19.**
   B. Drill each rivet head on the ring gear side of the assembly to a depth equal to the thickness of one rivet head. Use a drill bit that is 0.03125-inch (0.79375 mm) smaller than the body diameter of the rivets. **Figure 2.19.**
   C. Press the rivets through holes in the ring gear and flange case half. Press from the drilled rivet head.

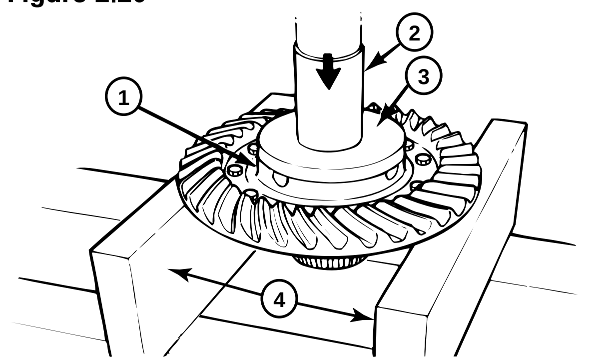
Figure 2.19



1 CORRECT DRILLING RIVETS FROM HEAD
2 WRONG CHISELING RIVETS FROM HEAD

7. Use a press to separate the case half and ring gear. Support the assembly under the ring gear with metal or wood blocks. Press the case half through the gear. **Figure 2.20.**

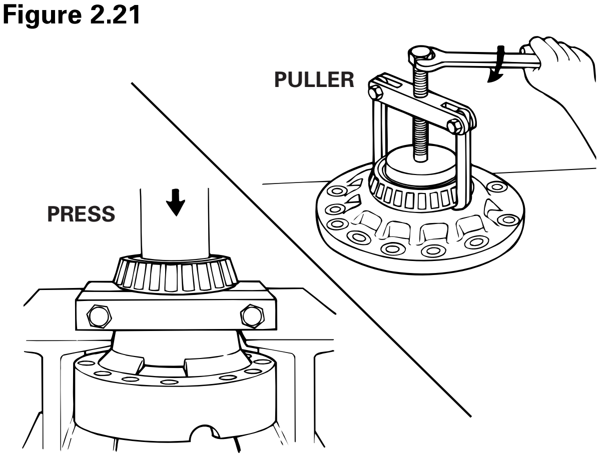
Figure 2.20



1 CASE HALF
2 PRESS
3 PLATE
4 SUPPORTS

8. If the differential bearings need to be replaced, use a bearing puller or press to remove the bearing cones from the case halves. **Figure 2.21.**

Figure 2.21

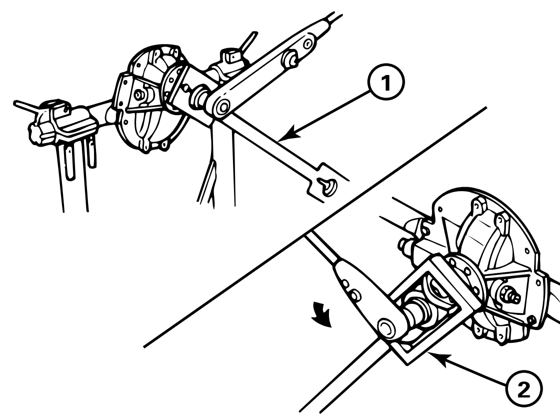


Removal

Drive Pinion and Bearing Cage from the Carrier

1. Fasten a flange bar to the input yoke or flange. When the nut is removed, the bar will hold the drive pinion in position. **Figure 2.22.**
2. Remove the nut and washer, if equipped, from the drive pinion. **Figure 2.22.**
3. Remove the yoke or flange bar.

Figure 2.22



1 FLANGE BAR
2 YOKE BAR

CAUTION

Do not use a hammer or mallet to loosen and remove the yoke or flange. A hammer or mallet can damage the parts and cause driveline runout, or driveline imbalance problems after carrier to driveline assembly.

4. Remove the yoke or flange from the drive pinion. Do not use a hammer or mallet.
   - **If the yoke or flange is tight on the pinion**: Use a puller for removal. **Figure 2.23.**
5. Remove the capscrews and washers that hold the bearing cage in the carrier. **Figure 2.24.**

Figure 2.23

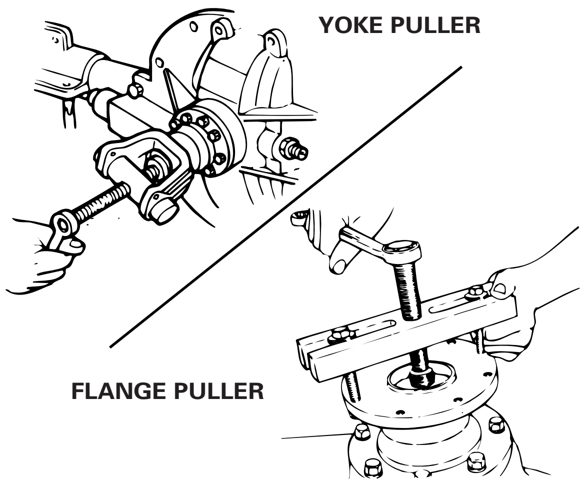
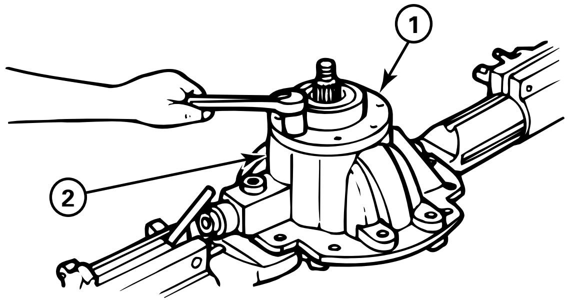


Figure 2.24



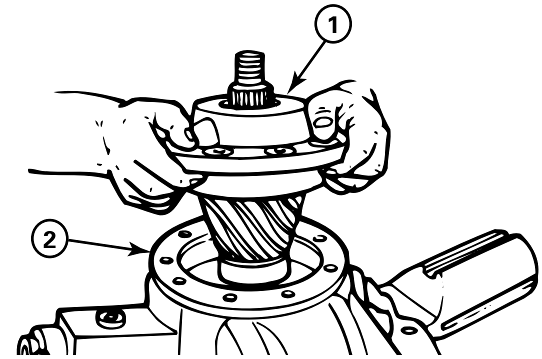
1 BEARING CAGE
2 CARRIER

CAUTION

Do not use a pry bar to remove the bearing cage from the carrier. A pry bar can damage the bearing case, shims and carrier.

6. Remove the drive pinion, bearing cage and shims from the carrier. Do not use a pry bar.
   - **If the bearing cage is tight in the carrier**: Hit the bearing cage at several points around the flange area with a leather, plastic or rubber mallet. **Figure 2.25.**

Figure 2.25



1 DRIVE PINION AND BEARING CAGE
2 SHIMS

7. If the shims are in good condition, keep the shims together to use when the carrier is assembled.
8. If shims are to be discarded because of damage, first measure the total thickness of the pack. Make a note of the dimension. The dimension will be needed to calculate the depth of the drive pinion in the carrier when the gear set is installed.

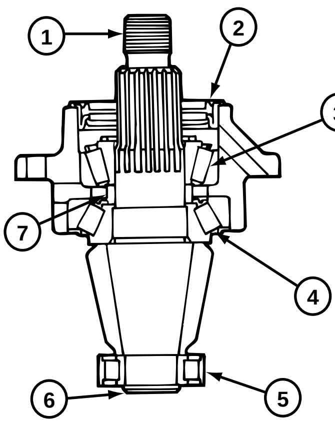
Disassembly

Drive Pinion and Bearing Cage

WARNING

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

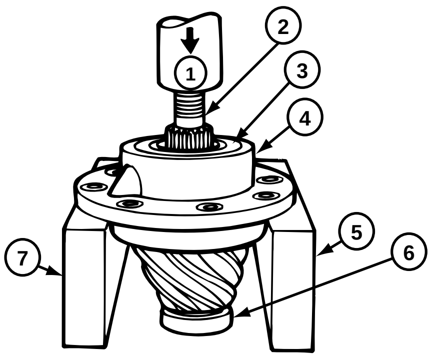
Figure 2.26



1	DRIVE PINION	5	SPIGOT BEARING
2	OIL SEAL	6	SNAP RING
3	OUTER BEARING, CUP AND CONE	7	BEARING SPACER
4	INNER BEARING, CUP AND CONE		

1. Place the drive pinion and bearing cage in a press. The pinion shaft must be toward the top of the assembly. **Figure 2.27.**

Figure 2.27



1	PRESS	5	SUPPORT
2	DRIVE PINION	6	SPIGOT BEARING
3	OIL SEAL	7	SUPPORT
4	BEARING CAGE		

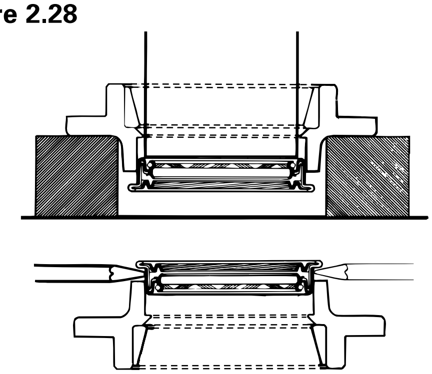
2. Support the bearing cage under the flange area with metal or wood blocks. **Figure 2.27.**
3. Press the drive pinion through the bearing cage. The inner bearing cone and bearing spacer will remain on the pinion shaft. **Figure 2.27.**
   - **If a press is not available:** Use a leather, plastic or rubber mallet to drive the pinion through the bearing cage.

CAUTION

Be careful when removing the seal. Do not damage the wall of bore. Damage to the bore wall can result in oil leaks.

4. Use a press and a sleeve to remove the triple-lip or unitized oil seal from the bearing cage.
   - **If a press is not available:** Place a tool with a flat blade under the flange to remove the oil seal from the cage. **Figure 2.28.**

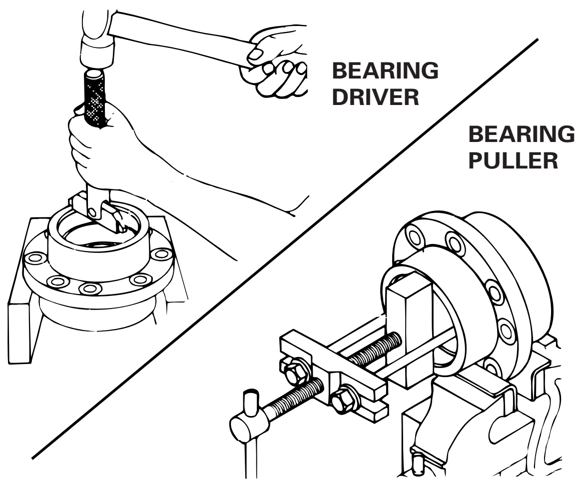
Figure 2.28



5. If the pinion bearings need to be replaced, remove the inner and outer bearing cups from the inside of cage. Use a press and sleeve, bearing puller or a small drift hammer. The type of tool used depends on the design of the bearing cage. **Figure 2.29.**

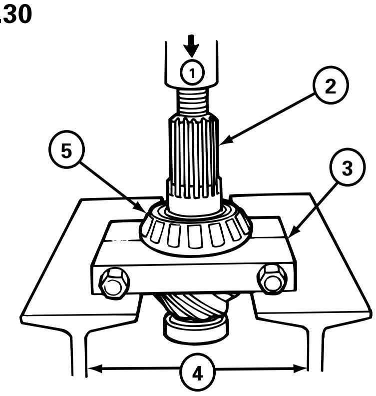
   When a press is used, support the bearing cage under the flange area with metal or wood blocks.

Figure 2.29



6. If the pinion bearings need to be replaced, remove the inner bearing cone from the drive pinion with a press or bearing puller. The puller MUST fit under the inner race of the cone to remove the cone correctly without damage. **Figure 2.30.**

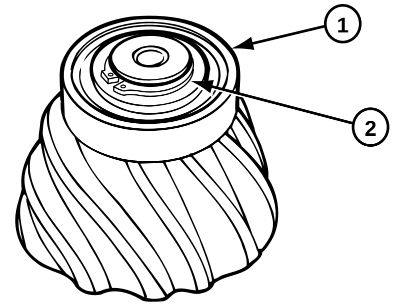
Figure 2.30



1 PRESS
2 DRIVE PINION
3 BEARING PULLER
4 SUPPORTS
5 INNER BEARING CONE

7. If the spigot bearing needs to be replaced, place the drive pinion in a vise. Install a soft metal cover over each vise jaw to protect the drive pinion.
8. Remove the snap ring, if equipped, from the end of drive pinion with snap ring pliers that expand. **Figure 2.31.**

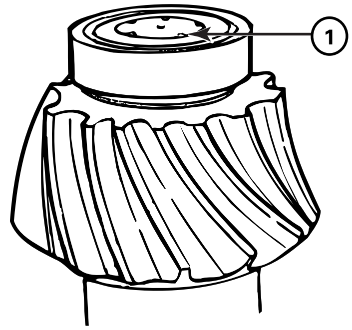
Figure 2.31



1 SPIGOT BEARING 2 SNAP RING

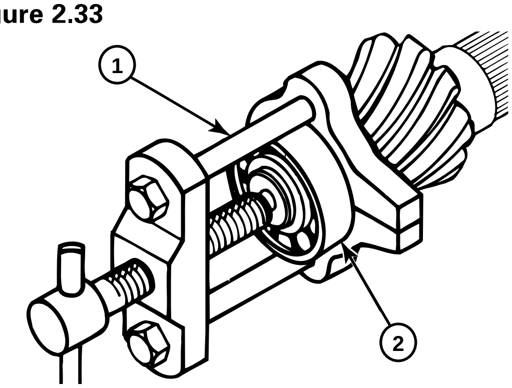
9. Remove the spigot bearing from the drive pinion with a bearing puller. **Figure 2.33.** Some spigot bearings are fastened to the drive pinion with a special peening tool. **Figure 2.32.**

Figure 2.32



1 PEENING POINTS

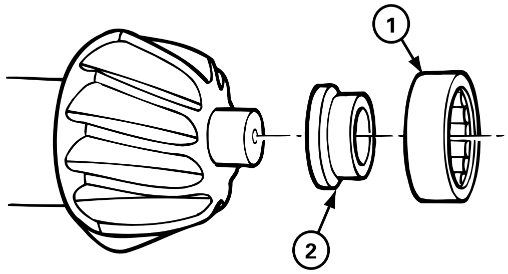
Figure 2.33



1 BEARING PULLER 2 SPIGOT BEARING

10. If the spigot bearings are a two-piece assembly, remove the inner race from the pinion with a bearing puller. Remove the outer race and roller assembly from the carrier with a drift or a press. **Figure 2.34.**

Figure 2.34



1 Remove outer race and roller assembly from carrier.
2 Remove inner race from pinion.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

Take care when you use Loctite® adhesive to avoid serious personal injury. Read the manufacturer's instructions before using this product. Follow the instructions carefully to prevent irritation to the eyes and skin.

Clean and Inspect Yokes

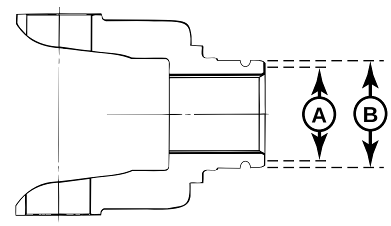
CAUTION

Do not install a press on shaft excluder or POSE™ seal after installation of a unitized pinion seal. The use of a POSE™ seal will prevent correct seating of the unitized pinion seal on the yoke and will result in lubricant leakage at the seal. POSE™ seal installation is recommended only for triple lip and other previous design seals.

Do not use thin metal wear sleeves to refresh the yoke surface. Wear sleeves pressed onto the yoke will prevent correct seating of the pinion seal and damage the pinion seal assembly. Wear sleeve usage will cause the seal to leak.

1. Clean the ground and polished surface of the yoke journal using a clean shop towel and a safe cleaning solvent. Do not use abrasive cleaners, towels, or scrubbers to clean yoke or flange surface. Do not use gasoline.
2. Inspect the yoke seal surface for any grooves.
   A. If grooves are present on yoke hubs used with single or triple lip seals, the yokes must be replaced.
   B. If grooves are present, use calipers to measure the groove diameters. If any of the yoke grooves measure less than the dimensions in **Figure 3.1**, replace the yoke.

Figure 3.1



Yoke Seal Diameter	Minimum Yoke Diameter at Groove (Inches)
3.000/3.005"	2.990"
3.250/3.255"	3.240"

A MINIMUM GROOVE DEPTH — DIAMETER
B YOKE SEAL DIAMETER

UNITIZED PINION SEAL (UPS)

Clean Ground and Polished Parts

1. Use a cleaning solvent to clean ground or polished parts or surfaces. Kerosene or diesel fuel oil can be used for this purpose. Do not use gasoline.
2. Use a tool with a flat blade if required, to remove sealant material from parts. Be careful not to damage the polished or smooth surfaces.

CAUTION

Do not use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts can result.

3. Do not clean ground or polished parts with water or steam. Do not immerse ground or polished parts in a hot solution tank or use strong alkaline solutions for cleaning, or the smooth sealing surface may be damaged.

Clean Rough Parts

1. Clean rough parts with the same method as cleaning ground and polished parts.
2. Rough parts can be cleaned in hot solution tanks with a weak or diluted alkaline solution.
3. Parts must remain in hot solution tanks until heated and completely cleaned.
4. Parts must be washed with water until all traces of the alkaline solution are removed.

Clean Axle Assemblies

1. A complete axle assembly can be steam cleaned on the outside to remove dirt.
2. Before the axle is steam cleaned, close or place a cover over all openings in the axle assembly. Examples of openings are breathers or vents in air chambers.

Dry Parts After Cleaning

1. Parts must be dried immediately after cleaning and washing.
2. Dry the parts using soft, clean paper or cloth rags.

CAUTION

Damage to bearings can result when they are rotated and dried with compressed air.

3. Except for bearings, parts can be dried with compressed air.

Prevent Corrosion on Cleaned Parts

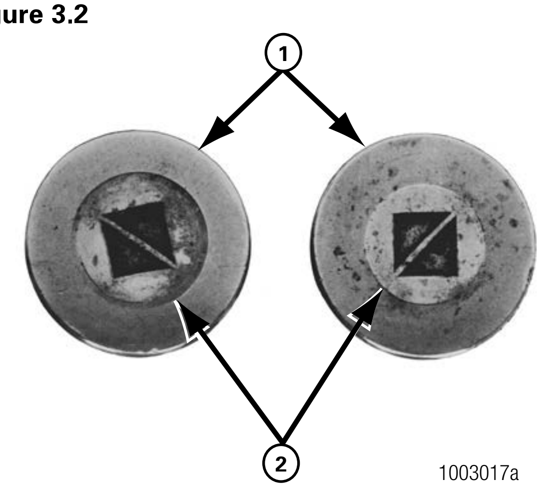
1. Apply axle lubricant to cleaned and dried parts that are not damaged and are to be assembled.
2. To store parts, apply a special material that prevents corrosion to all surfaces. Wrap cleaned parts in a special paper that will protect the parts from moisture and prevent corrosion.

Inspect Parts

It is very important to inspect all parts carefully and completely before the axle or carrier is assembled. Check all parts for wear and replace damaged parts.

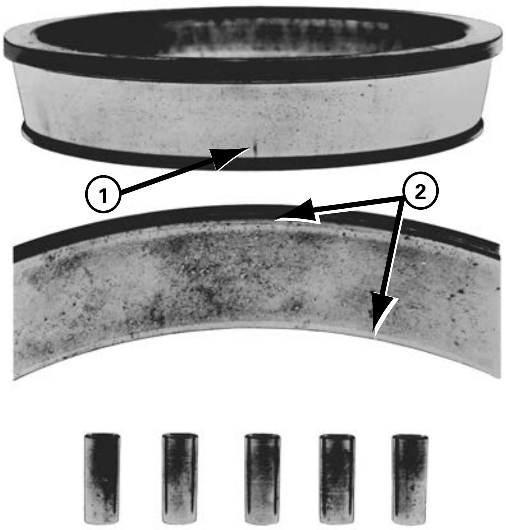
1. Inspect the cup, cone, rollers and cage of all tapered roller bearings in the assembly. If any of the following conditions exist, replace the bearing.
   - The center of the large-diameter end of the rollers is worn level with or below the outer surface. **Figure 3.2**.
   - The radius at the large-diameter end of the rollers is worn to a sharp edge. **Figure 3.2.**
   - There is a visible roller groove in the cup or cone inner race surfaces. The groove can be seen at the small- or large-diameter end of both parts. **Figure 3.3**.
   - There are deep cracks or breaks in the cup, cone inner race or roller surfaces. **Figure 3.3**.
   - There are bright wear marks on the outer surface of the roller cage. **Figure 3.4**.
   - There is damage on the rollers and on the surfaces of the cup and cone inner race that touch the rollers. **Figure 3.5**.
   - There is damage on the cup and cone inner race surfaces that touch the rollers. **Figure 3.6**.

Figure 3.2



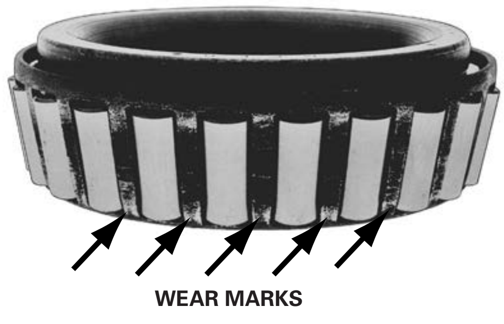
1 WORN RADIUS
2 WORN SURFACE

Figure 3.3



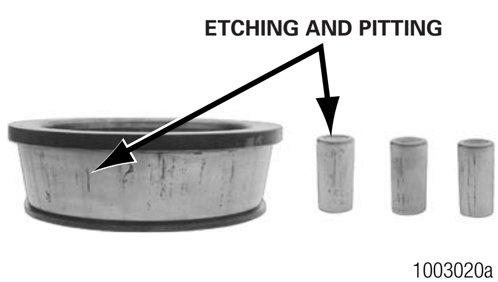
1 CRACK
2 WEAR GROOVE

Figure 3.4



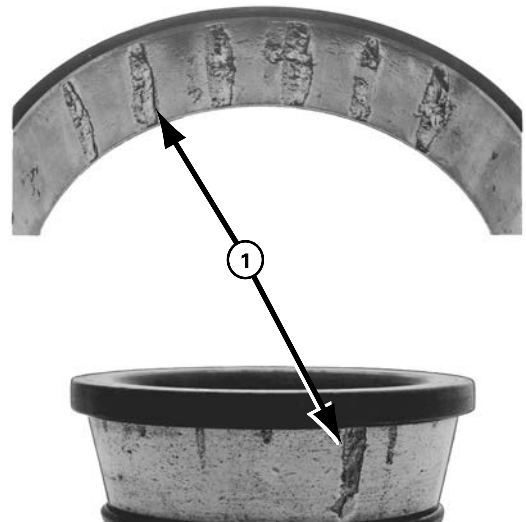
1 WEAR MARKS

Figure 3.5



1 ETCHING AND PITTING

Figure 3.6



1 SPALLING AND FLAKING

CAUTION

A drive pinion and ring gear are machined as a matched set. When you replace either a drive pinion or a ring gear, you must replace both parts as a matched set. Do not mix old and new parts. Damage to components can result.

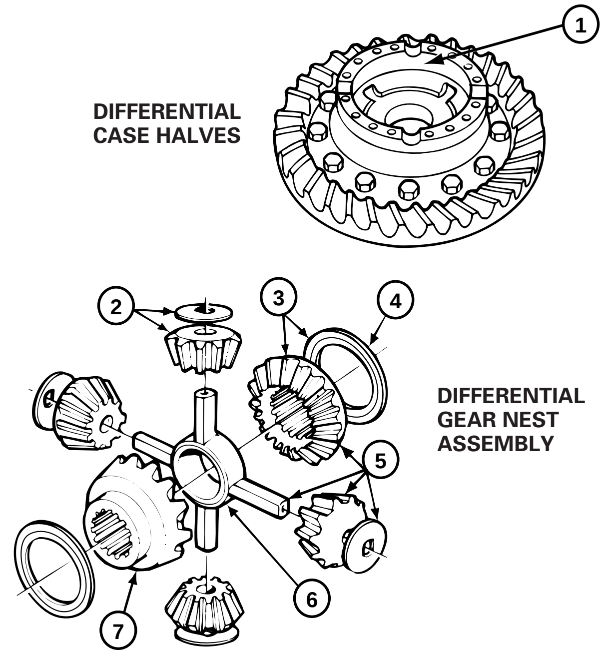
2. Inspect hypoid pinions and gears for wear and damage. Replace gears that are worn or damaged.

CAUTION

A thrust washer, differential side gear and pinion gear are machined as a matched set. When you replace any of these parts, you must install a new matched set. Do not mix old and new parts. Damage to components can result.

3. Inspect the following main differential assembly parts for wear or stress. Replace parts that are damaged. **Figure 3.7**.
   - Inside surfaces of both case halves
   - Both surfaces of all thrust washers
   - The four trunnion ends of the spider or cross
   - Teeth and splines of both differential side gears
   - Teeth and bore of all differential pinions

Figure 3.7



1 **Inspect inside surfaces.**
2 **PINION AND THRUST WASHER**
3 **SIDE GEAR AND THRUST WASHER**
4 **Inspect.**
5 **Inspect.**
6 **SPIDER OR CROSS**
7 **Inspect.**

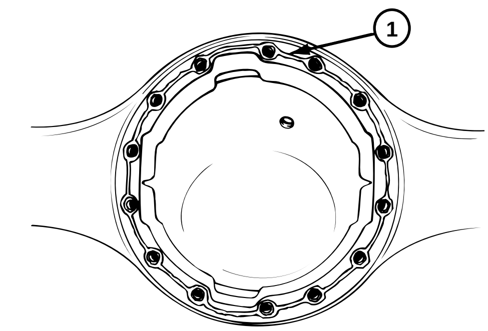
4. Inspect axle shafts for wear and cracks at the flange, shaft and splines. Replace the axle shafts, if required.
5. Inspect the breather.
   A. Remove the breather from the axle housing.
   B. Clean the breather. If the breather remains dirty after cleaning, replace the breather.
   C. Apply compressed air to the breather. If compressed air does not pass through the breather, replace the breather.
   D. Install the breather in the axle housing.

Repair or Replace Parts

NOTE: Threads must be without damage and clean so that accurate adjustments and correct torque values can be applied to fasteners and parts.

1. Replace any fastener if corners of the head are worn.
2. Replace washers if damaged.
3. Replace gaskets, oil seals or grease seals at the time of axle or carrier repair.
4. Clean parts and apply new silicone gasket material where required when axle or carrier is assembled. **Figure 3.8.**
5. Remove nicks, mars and burrs from parts with machined or ground surfaces. Use a fine file, india stone, emery cloth or crocus cloth.
6. Clean and repair threads of fasteners and holes. Use a die or tap of the correct size or a fine file.

Figure 3.8



1 **Remove silicone gasket from parts.**

Repair Welding on Axle Housings

For Complete Welding Instructions on Meritor Drive Axle Housings

WARNING

Wear safe clothing and eye protection when you use welding equipment. Welding equipment can burn you and cause serious personal injury. Follow the operating instructions and safety procedures recommended by the welding equipment manufacturers.

Axle weld locations and welding procedures must adhere to Meritor's standards. Welding at locations other than those authorized by Meritor will void the warranty and can reduce axle beam fatigue life. Serious personal injury and damage to components can result.

Refer to Maintenance Manual 8, Drive Axle Housings. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Meritor permits drive axle housing assembly repair welding in the following locations only.

- Housing-to-cover weld joints
- Snorkel welds
- Housing seam welds between the suspension attaching brackets
- Bracket welding to the drive axle housing

Prepare the Axle

WARNING

The high temperature caused by the open flame from the cutting torch can ignite the oil in the axle housing and can cause serious personal injury.

1. Remove the oil drain plug from the bottom of the axle housing and drain the lubricant from the assembly.

CAUTION

Remove the differential carrier from the axle housing before you weld onto an axle. Do not weld onto an axle with the differential carrier installed. Electrical arching and damage to components can result.

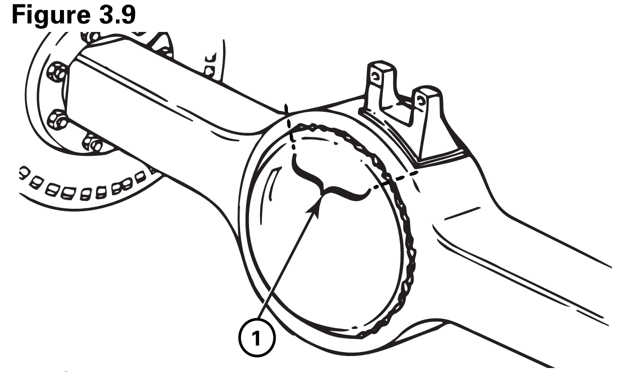
2. Remove the differential carrier from the axle housing. Refer to the correct Meritor carrier maintenance manual or the vehicle manufacturer's instructions.

CAUTION

Remove the brake air chambers before you weld onto an axle. Do not expose a brake air chamber to more than 250°F (121°C). Damage to the air chamber can result.

3. Remove the wheel-end components and brake air chambers from the axle. Refer to the correct Meritor brake maintenance manual or the vehicle manufacturer's instructions.
4. For housing-to-cover welds, clean the outside housing-to-cover weld area 2.00-3.00-inches (50.8-76.2 mm) past each end or side of the crack. Clean the inside area where the cover mates with the housing. Clean the area completely around the cover. Use a wire brush and a cleaning solvent that will remove dirt and grease from these areas. **Figure 3.9.**

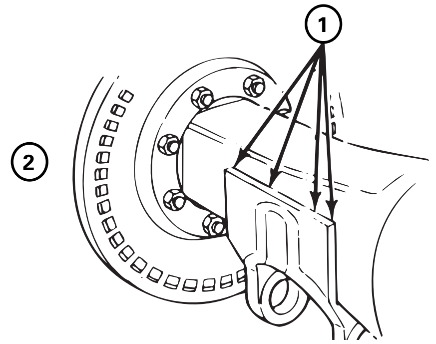
Figure 3.9



1 Clean this area.

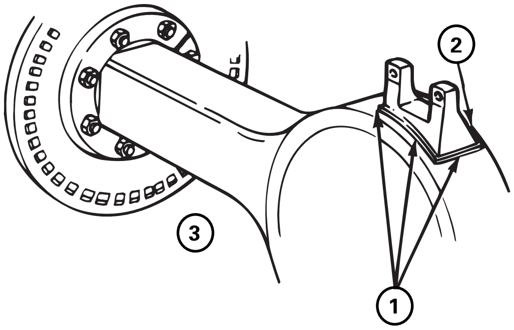
5. For suspension bracket welds, clean both lower and upper suspension brackets and the areas of the axle housing around each bracket. Use a wire brush and a cleaning solvent that will remove dirt and grease from these areas. **Figures 3.10 and 3.11.**

Figure 3.10



1 Clean these areas.
2 LOWER BRACKET

Figure 3.11



1 Clean these areas.
2 Clean this area.
3 UPPER BRACKET

WARNING

The axle housing must be 70°F (21°C) or warmer before you weld onto the axle. Do not weld onto a cold axle or weld cold parts onto an axle. Cracks in the weld area, damage to components and serious personal injury can result.

6. Ensure that the axle housing temperature measures 70°F (21°C) or warmer.
   - **If the axle housing temperature measures less than 70°F (21°C):** Store the axle in a heated room until the housing reaches the correct temperature.
7. Heat the damaged area to approximately 300°F (149°C) before you begin welding.
8. Use suitable weld wire electrodes when you weld. Suitable weld wire electrodes include either BS EN 499 – E 42 2 B 32 H5 or BS EN 440 – G 42 2 M GSi (American Welding Society equivalents E7018 and ER70S3, respectively).
9. For complete welding instructions, refer to Maintenance Manual 8. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Do Not Bend or Straighten a Damaged Drive Axle Housing

WARNING

Replace damaged or out-of-specification axle components. Do not bend, repair or recondition axle components by welding or heat-treating. A bent axle beam reduces axle strength, affects vehicle operation and voids Meritor's warranty. Serious personal injury and damage to components can result.

Always replace a damaged drive axle housing. Do not bend or straighten a damaged housing, which can misalign or weaken it, and void Meritor's warranty.

Fasteners

Removing Fasteners Secured with Adhesive

If it is difficult to remove fasteners secured with Dri-Loc®, Meritor adhesive or Loctite® 277 adhesive, use the following procedure.

When you remove fasteners secured with adhesive, slowly heat the fastener to 350°F (177°C). Do not exceed this temperature, or heat fasteners quickly. Damage to components can result.

1. Heat the fastener for three to five seconds. Try to loosen the fastener with a wrench. Do not use an impact wrench or hit the fastener with a hammer.
2. Repeat Step 1 until you can remove the fastener.

New Fasteners with Pre-Applied Adhesive

NOTE: No drying time is required for fasteners with pre-applied adhesive.

1. Use a wire brush to clean the oil and dirt from threaded holes.
2. Install new fasteners with pre-applied adhesive to assemble parts. Do not apply adhesives or sealants to fasteners with pre-applied adhesive, or to fastener holes.
3. Tighten the fasteners to the required torque value for that size fastener.

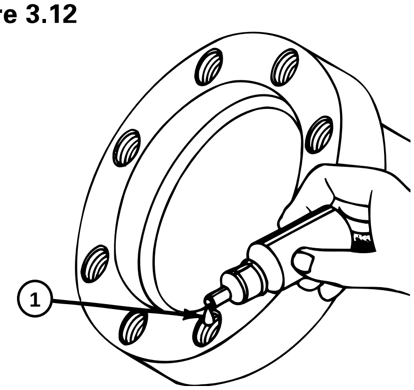
Original or Used Fasteners

1. Use a wire brush to clean the oil, dirt and old adhesive from all threads and threaded holes.

NOTE: There is no drying time required for Meritor liquid adhesive 2297-C-7049, Loctite® 638 or 680 liquid adhesive or equivalent.

2. Apply four or five drops of Meritor liquid adhesive, Loctite® 638 or 680 liquid adhesive or equivalent inside each threaded hole or bore. Do not apply adhesive directly to the fastener threads. **Figure 3.12**.
3. Tighten the fasteners to the required torque value for that size fastener.

Figure 3.12



1 4 TO 5 DROPS ON BORE THREADS

Applying Adhesive and Silicone Gasket Material

Meritor Specification 2297-T-4180 Adhesive in Differential Bearing Bores

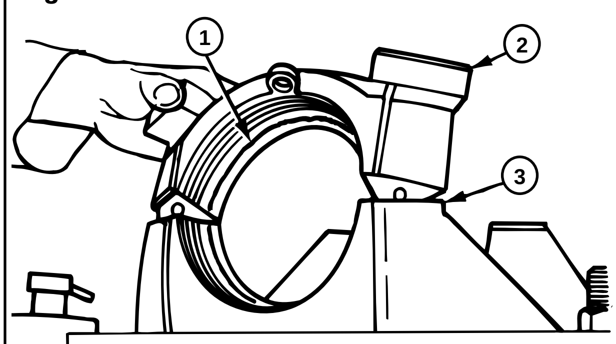
NOTE: Use Meritor specification 2297-T-4180 adhesive for all axles.

1. Clean the oil and dirt from outer diameters of bearing cups and bearing bores in the carrier and bearing caps. There is no special cleaning required.
2. Apply axle lubricant to the bearing cones and the inner diameters of the bearing cups of the main differential. Do not get oil on the outer diameter of the bearing cup and do not permit oil to drip onto the bearing bores.

NOTE: Meritor specification 2297-T-4180 adhesive will dry in approximately two hours. You must complete the procedure within two hours from the time you apply the adhesive. If two hours have passed since application, clean the adhesive from the parts and apply new adhesive.

3. Apply a single continuous bead of the adhesive to the bearing bores in the carrier and bearing caps. Apply the adhesive around the circumference of the smooth, ground surfaces only. Do not place adhesive on threaded areas. **Figure 3.13.**
4. Install the main differential assembly, bearing cups and bearing caps into the carrier. Refer to Section 4.

Figure 3.13



1 ADHESIVE
2 BEARING CAP
3 CARRIER LEG

5. Adjust preload of the differential bearings, backlash and tooth contact patterns of the gear set as required. Refer to Section 4.

Three Bond 1216, or Equivalent, Silicone Gasket Material

WARNING

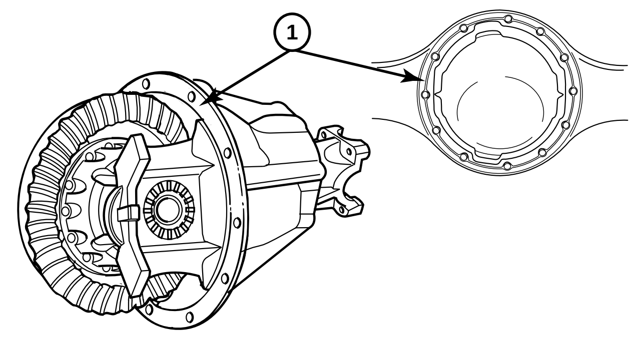
When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

NOTE: The following silicone gasket products or equivalent can be used for Meritor components:

- Three Bond Liquid Gasket TB 1216 (Grey)
- Loctite® Grey RTV 5699
- From Meritor: Ten-ounce tubes, part number 2297-F-7052

1. Use a tool with a flat blade, if required, to remove all old gasket material from surfaces. **Figure 3.14.**

Figure 3.14



1 Remove old sealant material.

HOUSING AND CARRIER SHOWN

2. Use a cleaning solvent to clean the surfaces where you will apply silicone gasket material. Remove all oil, grease, dirt and moisture without damaging the mating surfaces. **Figure 3.14.**

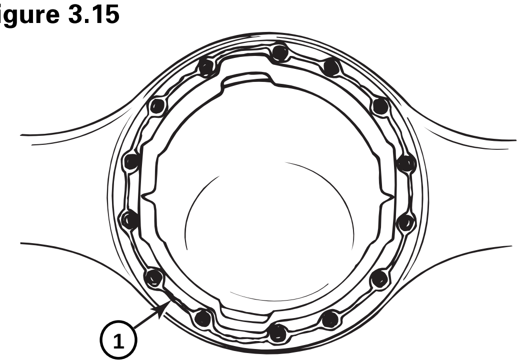
3. Dry surfaces.

CAUTION

Apply silicone gasket material in a continuous 0.125-inch (3 mm) bead. If you use more than this amount, gasket material can break off and plug lubrication passages. Damage to components can result.

4. Apply 0.125-inch (3 mm) diameter continuous bead of the silicone gasket material around one surface. Also apply the gasket material around the edge of all fastener holes on that surface. **Figure 3.15.**

Figure 3.15



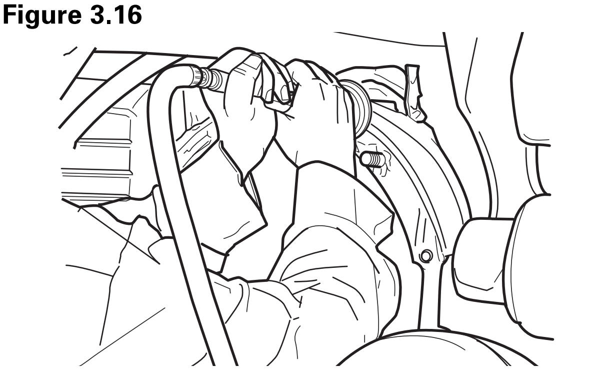
1 0.125″ (3 MM) DIAMETER SILICONE GASKET BEAD

5. Assemble the components immediately to permit the silicone gasket material to compress evenly between the parts. Tighten fasteners to the required torque value for that size fastener. Refer to Section 7.
6. Wait 20 minutes before filling the assembly with lubricant. Refer to Section 6.

Carrier-to-Housing Joint Repair

1. Remove the carrier from the housing. Refer to Section 2.
2. Remove all debris from inside the housing.
3. Use a rotary tool with a ScotchBrite™ pad to clean all silicone residue from the housing and carrier faces. **Figure 3.16.** Surfaces must be clean, dry and free of foreign matter. The surfaces must not be oily to the touch.

Figure 3.16



CLEANING HOUSING FACE WITH ROTARY TOOL AND SCOTCHBRITE™ PAD

4. Remove metal filings from the magnets inside the housing.
5. Use solvent to clean the inside of the housing.
6. Use Loctite® ODC Free cleaner or brake cleaner to clean the housing and carrier faces.
7. Dry the housing and carrier faces.
8. Use a rotary wire brush to remove any nylon patch material and clean the carrier-to-housing capscrew threads. Use a clean cloth to wipe the threads.
9. Use a tap to clean the internal threads in the housing.

WARNING

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

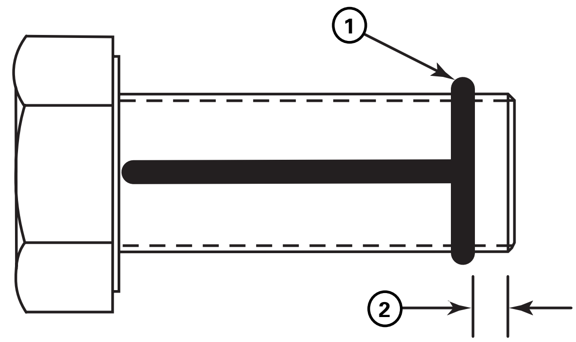
10. Apply a 0.25-inch (6 mm) bead of Loctite® 5699 silicone gasket material to the housing face. Do not use Three Bond 1216E silicone products.
11. Install two long studs in the carrier to guide the carrier into the housing.
12. Immediately install the carrier into the housing to permit the silicone gasket material to compress evenly between the faces.

CAUTION

Apply silicone gasket material in a continuous 0.125-inch (3 mm) bead. If you use more than this amount, gasket material can break off and plug lubrication passages. Damage to components can result.

13. Apply a 0.125-inch (3 mm) bead of Loctite® 242 threadlocker around the capscrew threads approximately 0.25-inch (6 mm) from the end. Apply a 0.125-inch (3 mm) bead of Loctite® 242 threadlocker across the length of the threads. **Figure 3.17.**

Figure 3.17



1 360° LOCTITE® BEAD
2 0.25" (6 MM)

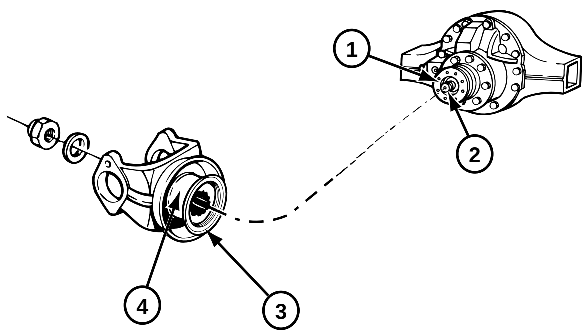
LOCTITE® 242 THREADLOCKER APPLICATION

14. Install the capscrews. Use a crossing pattern to tighten the capscrews evenly. The capscrews must be tightened within 10 minutes of initial application of Loctite® 242 threadlocker.
    - Tighten 1/2-inch capscrews to 140 lb-ft (190 N•m). T
    - Tighten 5/8-inch capscrews to 225 lb-ft (306 N•m). T
15. Wait a minimum of 60 minutes before filling the assembly with lubricant. Refer to Section 6.

Installing Tight Fit Yokes and POSE™ Seal

Refer to Figure 3.18

Figure 3.18



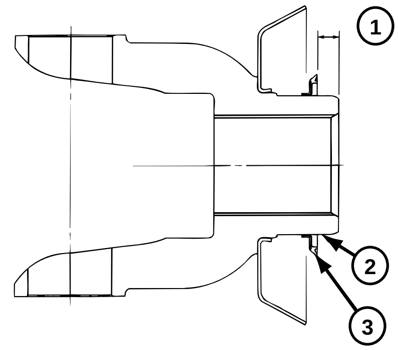
1 Lubricate triple-lip or main seal.
2 INPUT SHAFT OR PINION
3 POSE™ SEAL, 0.25-0.50″ (6.4-12.7 MM) ONTO HUB
4 Inspect yoke hub.

1. Apply the same lubricant used in the axle housing to the hub of the yoke or flange.
2. Inspect and verify that the lips of the POSE™ seal and the outer retainer of the triple-lip seal or main seal are clean and free from dirt and particles that may cause lubricant leakage between the seals.
3. Install the POSE™ seal on the hub of the yoke or flange by hand. The lips of the seal must face toward the end of the hub or the opposite shoulder. Slide the POSE™ seal on the hub until the lips are from 0.25-0.50-inch (6.4-12.7 mm) from the end of the hub. Do not install the POSE™ seal against the shoulder. **Figure 3.19.**

NOTE: The POSE™ seal will position itself correctly as the yoke or flange is pressed on the shaft.

4. Before you install the yoke or flange on the shaft, apply the same lubricant used in the axle housing to the hub.
5. Install the yoke or flange using the correct procedure. The yoke must be completely seated before tightening the pinion nut to the input shaft.

Figure 3.19



1 0.25-0.50″ (6.4-12.7 MM)
2 YOKE HUB
3 FACE SEAL ASSEMBLY, POSE™ SEAL ELEMENT

Installing Any Type Yoke with a Unitized Pinion Seal (UPS)

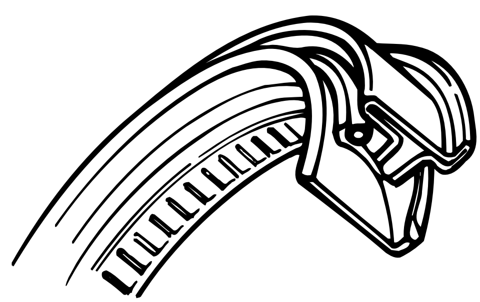
CAUTION

Once the yoke is partially or fully installed and then removed for any reason, the unitized pinion seal will be damaged and unusable. If the yoke and unitized pinion seal are removed after partial or full installation, remove and discard the original unitized pinion seal and replace it with another new unitized pinion seal.

If the inner sleeve of the seal is removed, the seal is not usable. A new seal is required. This will occur if a yoke is installed into the seal and then removed.

1. Remove the replacement unitized seal from the package. **Figure 3.20.**

Figure 3.20



UNITIZED SEAL

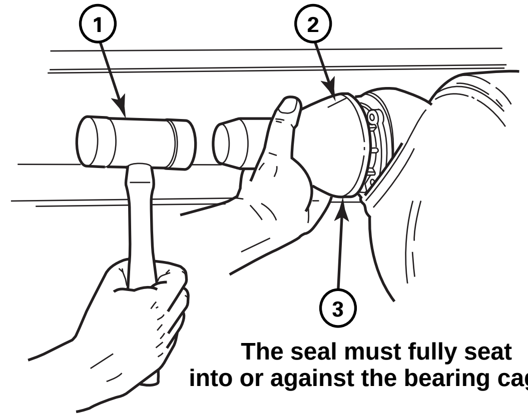
2. Select the correct seal driver from **Table A**. Each seal driver is designed to correctly install a specific diameter seal. To determine the yoke seal diameter, measure the yoke journal. Refer to **Table A** on the following page.
3. Position the seal on the driver.

CAUTION

Use a rubber mallet to install the seal. Do not use a steel, brass or plastic hammer. Damage to the seal and driver tool can result.

4. Use a rubber mallet to drive the seal into or against the bearing cage. The seal must fully seat into or against the bearing cage. **Figure 3.21**.
5. Use a 0.010-inch shim to check for clearance between the entire seal flange circumference and the bearing cage.
   - **If the 0.010-inch shim slides between the seal flange and bearing cage:** Correctly position the seal driver and drive the seal into the bore until the 0.010-inch shim cannot slide between the seal flange and bearing cage at any point around the seal flange. **Figure 3.22**.

Figure 3.21



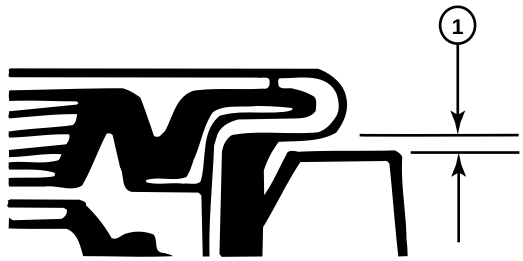
1 RUBBER MALLET
2 REFERENCE MARK
3 SEAL DRIVER R4422401

Table A: Unitized Pinion Seals and Seal Drivers

Single Models	Tandem Models	Meritor Unitized Pinion Seal	Seal Installation Location	Meritor Seal Driver	Yoke Seal Diameter Inches
MX-21-160 MX-23-160R RF-16-145 RF-21-160 RF-22-166 RF-23-185 RS-17-145 RS-19-145 RS-21-145 RS-21-160 RS-23-160 /A RS-23-161 /A RS-25-160 /A RS-23-186 RS-26-185 RS-30-185	RT-34-144 /P RT-34-145 /P RT-40-145 /A /P RT-40-149 /A /P RT-44-145 /P RT-40-160 /A /P RT-40-169 /A /P RT-46-160 /A /P RT-46-169 /A /P RT-46-164EH /P RT-46-16HEH /P RT-50-160 /P RT-52-185* RT-58-185*	A-1205-R-2592	Tandem Forward Input — 145 models from 11/93 to present	R4422402	3.250 3.255
		A-1205-P-2590	Tandem Forward Output — Tandem Forward Input 145 models before 11/93 with seal A-1205-F-2424	R4422401	3.000 3.005
		A-1205-N-2588	Tandem and Single Rear Input — 145 models	R4422401	3.000 3.005
		A-1205-Q-2591	Tandem and Single Rear Input — 160/164/185 models	R4422402	3.250 3.255
To obtain Meritor seal driver KIT 4454, refer to the Service Notes page on the front inside cover of this manual.					

* Forward and rear input only.

Figure 3.22



MEASURING SEAL GAP

1 0.010" (0.254 MM)

Clean, Inspect and Install the Yoke After Installing a Unitized Pinion Seal

WARNING

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

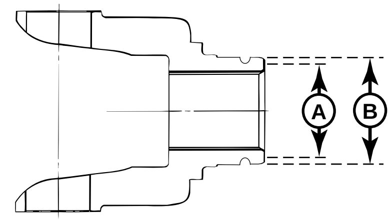
- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

1. Use a clean shop towel and a safe cleaning solvent to clean the ground and polished surface of the yoke journal. Do not use gasoline, abrasive cleaners, towels, or scrubbers to clean the yoke. Do not attempt to polish the yoke.

NOTE: The unitized seal features a rubber inner sleeve that is designed to seal and rotate with the yoke. This feature allows you to reuse a yoke with minor grooves.

2. Inspect the yoke seal surface for grooves.
   - **If you find grooves on the yoke:** Use calipers to measure the groove diameters.
     If any groove diameter measures less than the dimensions shown in **Figure 3.23**, replace the yoke.

Figure 3.23



Yoke Seal Diameter	Minimum Yoke Diameter at Groove (Inches)
3.000/3.005"	2.990"
3.250/3.255"	3.240"

A MINIMUM GROOVE DEPTH — DIAMETER
B YOKE SEAL DIAMETER

CAUTION

Do not install a POSE™ seal after you install a unitized pinion seal. The use of a POSE™ seal will prevent correct seating of the unitized pinion seal on the yoke and can result in lubricant leakage at the seal. POSE™ seal installation is recommended only for triple lip and other previous design seals.

Do not use thin metal wear sleeves to refresh the yoke surface. Wear sleeves pressed onto the yoke can prevent correct seating of the pinion seal, damage the pinion seal assembly and can cause the seal to leak.

3. Before you install the yoke, lightly lubricate or coat the yoke seal journal with axle oil.
4. Align the yoke splines with the shaft splines. Slide the yoke over the shaft spline.

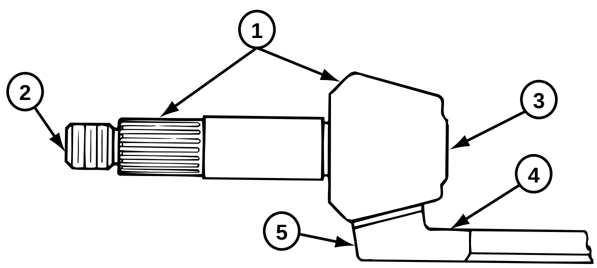
General Yoke and U-Joint Reassembly

Install the end yoke hub capscrews by hand after seating the U-joint. Tighten the capscrews according to manufacturer's torque specifications.

Gear Sets

Refer to the following examples for information on identifying gear sets with matched parts. Always check match numbers to verify that the gear set you will install has matched parts. **Figure 3.24.**

Figure 3.24



ALTERNATE LOCATIONS:

1 PART NUMBER, TOOTH COMBINATION NUMBER, GEAR SET MATCH NUMBER, PINION CONE VARIATION NUMBER
2 PART NUMBER, TOOTH COMBINATION NUMBER
3 GEAR SET MATCH NUMBER, PINION CONE VARIATION NUMBER
4 PART NUMBER, TOOTH COMBINATION NUMBER, GEAR SET MATCH NUMBER
5 PART NUMBER, TOOTH COMBINATION NUMBER GEAR SET MATCH NUMBER

Examples

Gear Set

Part	Number	Location
Conventional ring gear	36786	On the front face or outer diameter
Conventional drive pinion	36787	At the end at threads
Generoid ring gear	36786 K or 36786 K2	On the front face or outer diameter
Generoid drive pinion	36787 K or 36787 K2	At the end at threads

Gear Set Tooth Combination Number

Gear Set Teeth	Drive Pinion Location	Ring Gear Location
5-37 = gear set has a five-tooth drive pinion and a 37-tooth ring gear	At the end at threads	On the front face or outer diameter

Gear Set Match Number

NOTE: Meritor's drive pinions and ring gears are only available as matched sets. Each gear in a set has an alpha-numeric match number.

Match Number	Drive Pinion Location	Ring Gear Location
M29	At the end of the gear head	On the front face or outer diameter

Pinion Cone Variation Number

NOTE: Don't use the pinion cone variation number when you check for a matched gear set. Use this number when you adjust the pinion depth in the carrier. Refer to Section 4.

Pinion Cone (PC) Variation Number	Drive Pinion Location	Ring Gear Location
PC+3 +2 +0.01 mm PC-5 –1 –0.02 mm	At the end of the pinon gear head	On the outer diameter

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off and cause serious personal injury.

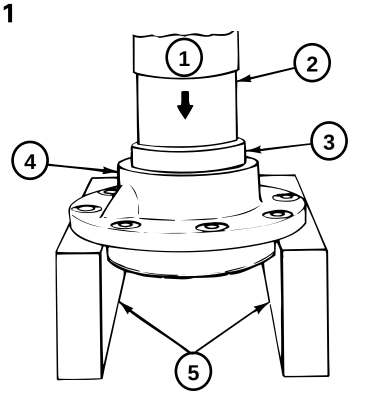
Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

Assembly

Drive Pinion, Bearings and Bearing Cage

1. Place the bearing cage in a press. **Figure 4.1.**

Figure 4.1



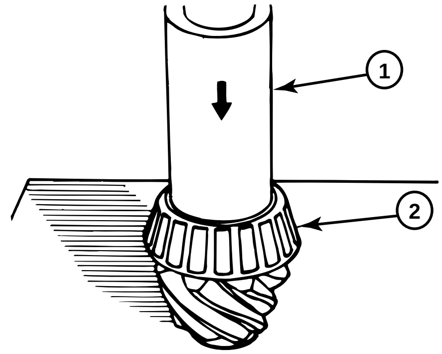
1 PRESS
2 SLEEVE
3 BEARING CUP
4 CAGE
5 SUPPORTS

2. Support the bearing cage with metal or wood blocks.
3. Press the bearing cup into the bore of bearing cage until cup is flat against bottom of bore. Use a sleeve of the correct size to install bearing cup. **Figure 4.1.**

NOTE: Use the same procedure for both bearing cups.

4. Place the drive pinion in a press with the gear head or teeth toward the bottom. **Figure 4.2**.

Figure 4.2



1 SLEEVE
2 INNER BEARING CONE

5. Press the inner bearing cone on the shaft of the drive pinion until the cone is flat against the gear head. Use a sleeve of the correct size against the bearing inner race.

NOTE: Spigot bearings are usually fastened to the drive pinion with a snap ring. Some are fastened with a peening tool, and some are a two-piece bearing assembly with the inner race pressed on the nose of the pinion and the outer race pressed into its bore in the carrier.

6. Install the spigot bearing using one of the following three procedures.

Installation

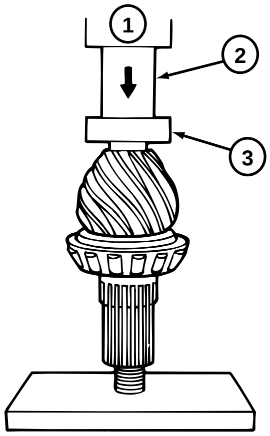
One-Piece Spigot Bearing on the Drive Pinion with Snap Ring

NOTE: The following procedure applies to all axles except:

- Some 160 Series single axles may use snap rings.
- Some 160 and 180 Series rear-rear tandem axles may use snap rings.

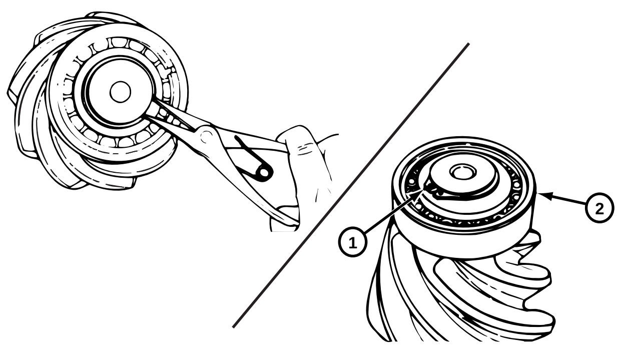
1. Place the drive pinion in a press with the gear head or the teeth toward the top. **Figure 4.3**.
2. Press the spigot bearing on the end of drive pinion. The bearing must be flat against the gear head. Use a sleeve of the correct size against the bearing inner race. **Figure 4.3.**
3. Use snap ring pliers to install the snap ring, if equipped, into the groove in the end of the drive pinion. **Figure 4.4.**

Figure 4.3



1 PRESS
2 SLEEVE
3 SPIGOT BEARING

Figure 4.4



1 SNAP RING
2 SPIGOT BEARING

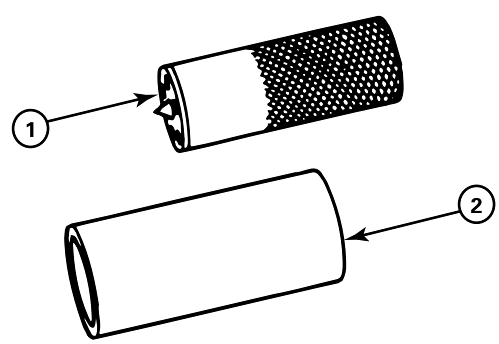
One-Piece Spigot Bearing on the Drive Pinion Without Snap Ring

NOTE: The following procedure applies to some 180 Series rear-rear tandem axles with existing snap ring components.

For ordering information about the staking tool, refer to the Service Notes page on the front inside cover of this manual. **Figure 4.5.**

1. Place the drive pinion and the tube of the staking tool in a press with the spigot bearing toward the top. **Figure 4.6.**

Figure 4.5



1 PUNCH
2 TUBE

2. When using a staking tool and press, apply 6,614 lb (3 000 kg) force on a 0.375-inch (10 mm) ball. Calculate the force required on the tool as follows.

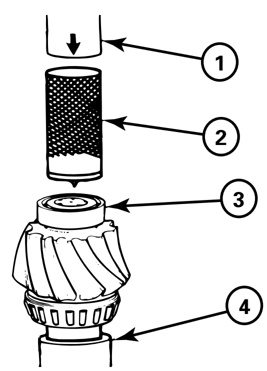
   6,614 lb (3 000 kg) x amount of balls in tool = pounds or kilograms

   Example

   6,614 lb (3 000 kg) x 3 balls = 19,842 pounds (9 000 kg)

3. Place the punch of the staking tool over the end of the pinion and spigot bearing. Apply the required amount of force on the punch. **Figure 4.6.**

Figure 4.6



1 PRESS
2 Install and center the punch on the end of pinion.
3 SPIGOT BEARING
4 Place the shaft of pinion into tube.

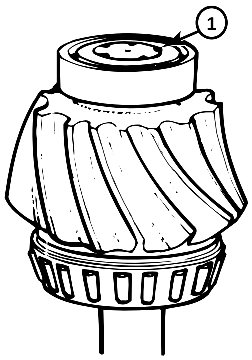
CAUTION

Do not align new points with the grooves in the end of the drive pinion or in old points. If the new staked points are placed in the wrong areas, the spigot bearing will not be held correctly on the pinion shaft.

NOTE: If a three-ball stake tool is used, rotate the tool 180 degrees.

4. Stake the end of the drive pinion at a minimum of five points. **Figure 4.7.** Rotate the punch as many times as required for a minimum of five points. Repeat Step 3 for each point.

Figure 4.7



1 STAKING POINTS

Two-Piece Spigot Bearing on the Drive Pinion

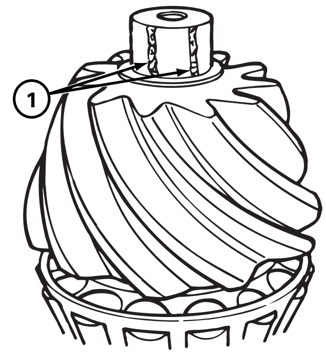
NOTE: This procedure applies to some 160 Series single rear axles and rear-rear tandem axles. These axles may also use a one-piece spigot bearing with a snap ring retainer.

NOTE: The inner race of two-piece spigot bearings must be staked in place on RS and RR-160 series rear axles. Before you stake the pinion, you must heat the pinion stem to soften it.

NOTE: SPX Kent-Moore kit number J-39039 includes the staking tool, temperature indicating liquid, heat shield and plastigage needed for this procedure. To obtain this kit, refer to the Service Notes page on the front inside cover of this manual.

1. Apply two stripes of temperature indicating liquid on the pinion stem from the top to the bottom. **Figure 4.8.** Apply a green stripe to indicate 400°F (205°C) and a blue stripe to indicate 500°F (260°C).

Figure 4.8



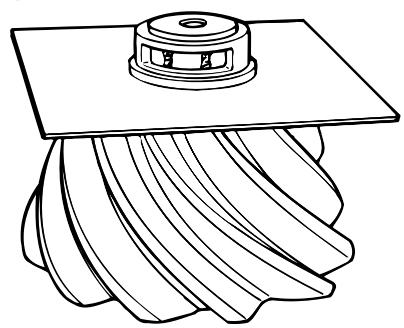
1 TEMPERATURE INDICATING LIQUID APPLICATION

CAUTION

You must use the heat shield when you heat the pinion stem. Do not heat the pinion stem without the heat shield in place. Damage to components can result.

2. Place the heat shield over the pinion stem so that you can see the temperature indicating liquid through the hole in the shield. **Figure 4.9.**

Figure 4.9



WARNING

Read the manufacturer's instructions before using a torch. Always wear safe clothing, gloves and eye protection when working with a torch for heating parts to prevent serious personal injury during assembly.

3. Put on safe clothing, gloves and eye protection.

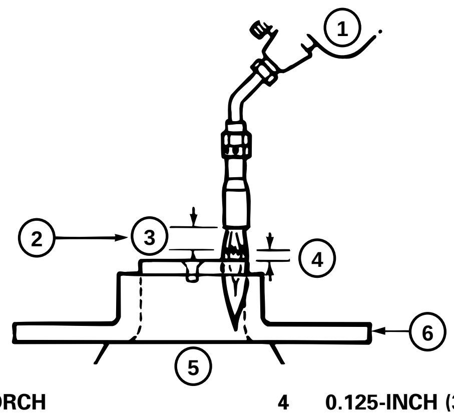
CAUTION

Do not overheat the pinion stem or you will weaken the metal. Damage to components can result.

NOTE: Correct heating will take approximately 25-35 seconds, depending on how hot the torch is.

4. Light and adjust the torch until the white part of the flame is approximately 0.25-inch (6 mm) long. Keep the white part of the flame approximately 0.125-inch (3 mm) from the top of the stem. **Figure 4.10.** Move the flame around the outer diameter of the top of the pinion stem. The green temperature indicating liquid will turn black before the blue liquid does. Heat the stem until the blue liquid turns black at a point in the middle of the window.
5. Remove the flame and the heat shield from the pinion. Let the pinion air cool for 10 minutes. Use a razor blade to remove the temperature indicating liquid.

Figure 4.10



1	TORCH	4	0.125-INCH (3 MM)
2	WHITE PART OF FLAME	5	PINION
3	0.25-INCH (6 MM)	6	HEAT SHIELD

CAUTION

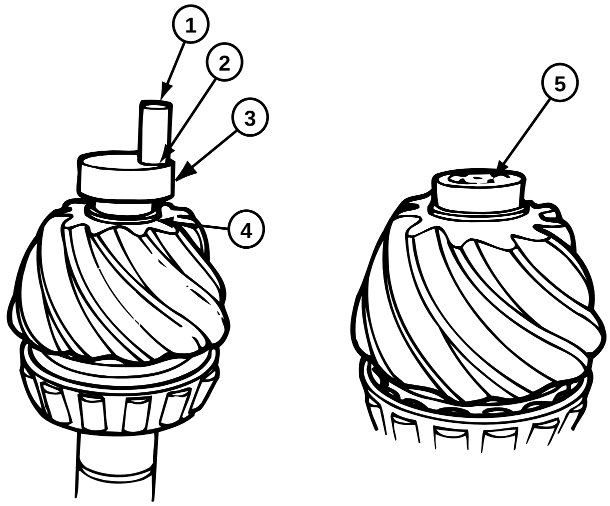
Do not press or directly strike the new inner race. Damage to the bearing will result.

6. Use a press, if available, or a brass hammer to install the new inner race. Use the old inner race as a sleeve. The face is completely seated when you cannot fit a 0.002-inch (0.0508 mm) feeler gauge between the race and the pinion shoulder.

NOTE: To hold the races in place, use a staking tool, not the old race, to start the new race on the stem. The old race can be used to completely seat the new race.

7. Place the staking tool over the bearing race. Cut a 1-inch (25 mm) piece from the green plastigage strip and place in between the punch and the staking tool. You do not need to use the plastigage for every stake. Use the plastigage until you are sure you are hitting the punch with the correct amount of force. **Figure 4.11.**
8. Strike the punch with a 2-3 pound (0.9-1.4 kg) brass hammer to upset the end of the pinion stem. Remove the strip and measure its thickness against the gauge on the strip's wrapper. The strip must not be less than 0.003-inch (0.0762 mm) thick. This thickness indicates that you are using enough force when you hit the punch. If the strip is too thin, then you must hit the punch harder so the stake will hold the race in place. Rotate the tool and repeat this procedure until there are six evenly spaced stake marks around the stem. **Figure 4.11.**
9. With a press or a soft mallet and sleeve, install the outer race and roller assembly into its bore in the carrier. Use a sleeve that is the same size as the outer race. Press the bearing until it is squarely against the shoulder in the bottom of its bore.

Figure 4.11

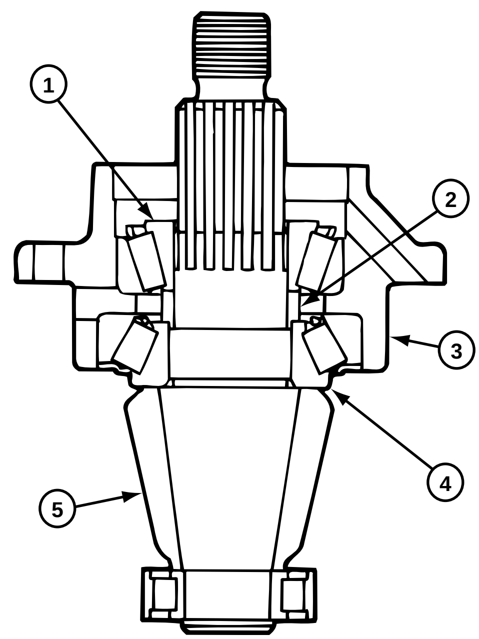


1 PUNCH
2 PLASTIGAGE
3 STAKING TOOL
4 BEARING INNER RACE
5 STAKES

Drive Pinion

1. Apply axle lubricant to the bearing cups and to the bearing cones in the cage.
2. Install the drive pinion into the bearing cage.
3. Install the bearing spacer or spacers onto the pinion shaft against the inner bearing cone. **Figure 4.12.** The spacer or spacers control the preload adjustment of the drive pinion bearings.
4. Install the outer bearing cone onto the pinion shaft against the spacer. Do not install the pinion seal in the bearing cage. **Figure 4.12.**

Figure 4.12



1 OUTER BEARING CONE
2 BEARING SPACER
3 BEARING CAGE
4 INNER BEARING CONE
5 DRIVE PINION

Adjustment

Pinion Bearing Preload

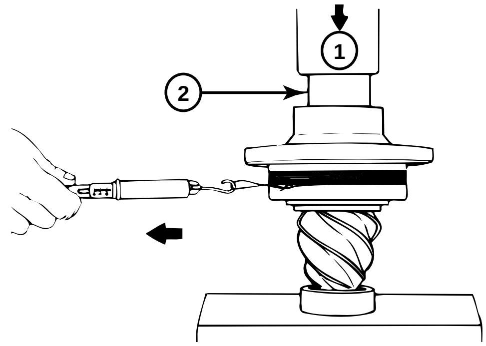
Press Method

If a press is not available, or the press does not have a pressure gauge, use the yoke or flange method to adjust pinion bearing preload. Refer to Yoke or Flange Method.

NOTE: Do not read starting torque. Read only the torque value after the cage starts to rotate. Starting torque will give an incorrect reading.

1. Place the drive pinion and cage assembly in a press, gear head or teeth toward the bottom.
2. Install a sleeve of the correct size against the inner race of the outer bearing. **Figure 4.13.**

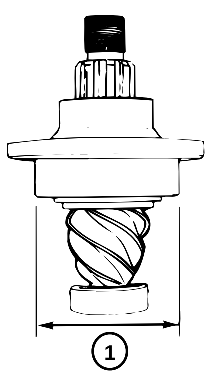
Figure 4.13



1 PRESS
2 SLEEVE

3. Apply and hold the correct amount of pressure to the pinion bearings. Refer to **Table B**. As pressure is applied, rotate the bearing cage several times so that the bearings make normal contact.
4. While pressure is held against the assembly, wind a cord around the bearing cage several times.
5. Attach a spring scale to the end of the cord.
6. Pull the cord on a horizontal line. As the bearing cage rotates, read the value indicated on the scale. Record the reading. **Figure 4.13.**
7. Measure the diameter of the bearing cage where the cord was wound. Measure in inches or centimeters. **Figure 4.14.**

Figure 4.14



1 Measure diameter of cage.

8. Divide the dimension in half to get the radius. Record the radius dimension.

Table B

Thread Size of Pinion Shaft	Press Pressure Needed on Bearings for Correct Preload		Torque Value Needed on Pinion Nut for Correct Bearing Preload	
	pounds/ tons	(kg/metric tons)	lb-ft	(N•m)
7/8"-20	22,000/1	(9979/10)	200-275	(271-373)
1"-20	30,000/15	(13 608/13.6)	300-400	(407-542)
1-1/4"-12	54,000/27	(24 494/24.5)	700-900	(949-1220)
1-1/4"-18	54,000/27	(24 494/24.5)	700-900	(949-1220)
1-1/2"-12	54,000/27	(24 494/24.5)	800-1100	(1085-1491)
1-1/2"-18	54,000/27	(24 494/24.5)	800-1100	(1085-1491)
1-3/4"-12	50,000/25	(22 680/22.7)	900-1200	(1220-1627)
2"-12	50,000/25	(22 680/22.7)	1200-1500	(1627-2034)

9. Use the following procedure to calculate the bearing preload or torque.
   - Pounds Pulled x Radius (inches) = lb-in Preload

     — Preload x 0.113 = N•m Preload
   - Kilograms Pulled x Radius (cm) = kg-cm lb-in Preload

     — Preload x 0.098 = N•m Preload

or

Examples

- Reading from spring scale = 7.5 pounds (3.4 kg)
- Diameter of bearing cage = 6.62-inches (16.8 cm)
- Radius of bearing cage = 3.31-inches (8.4 cm)

  7.5 lb x 3.31 in = 24.8 in-lb Preload

  Preload x 0.113 = 2.8 N•m Preload

  or

  3.4 kg x 8.4 cm = 28.6 kg-cm Preload

  Preload x 0.098 = 2.8 N•m Preload

10. If the preload or torque of pinion bearings is not within 5-45 lb-in (0.56-5.08 N•m) for new pinion bearings or 10-30 lb-in (1.13-3.39 N•m) for used pinion bearings in good condition, adjust the spacer and repeat Steps 1 through 9. T
    - **To increase preload:** Install a thinner bearing spacer.
    - **To decrease preload:** Install a thicker bearing spacer.
11. Check the bearing preload with the drive pinion and cage assembly installed in the carrier. Follow the procedures to adjust pinion bearing preload, yoke or flange method.

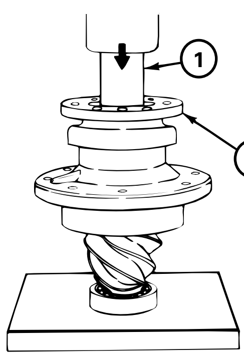
Yoke or Flange Method

CAUTION

Do not install tight-fitting yokes or flanges on shafts using a hammer or mallet. A hammer or mallet will damage the yoke or flange.

1. Use a press to install the input yoke or flange, nut and washer, if equipped, onto the drive pinion. The yoke or flange must be seated against the outer bearing. **Figure 4.15.**

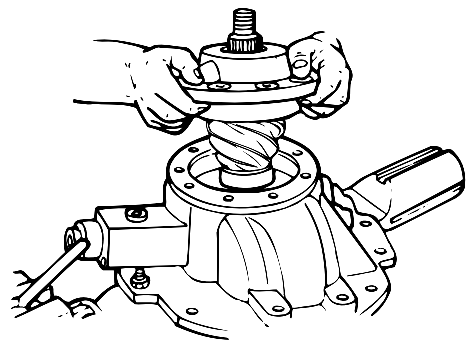
Figure 4.15



1 PRESS
2 INPUT FLANGE SHOWN

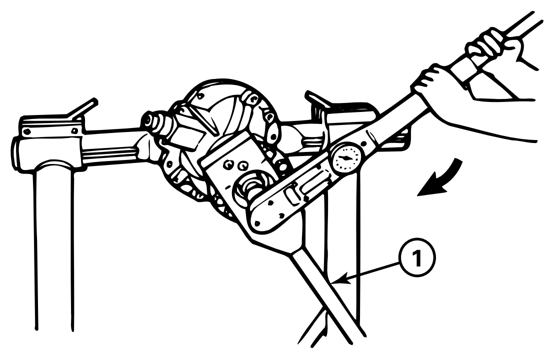
2. Install the drive pinion and cage assembly into the carrier. Do not install shims under the bearing cage. **Figure 4.16.**
3. Install the bearing cage-to-carrier capscrews. Washers are not required at this time. Hand-tighten the capscrews.

Figure 4.16



4. Fasten a yoke or flange bar to the input yoke or flange. The bar will hold the drive pinion in position when the nut is tightened. **Figure 4.17.**

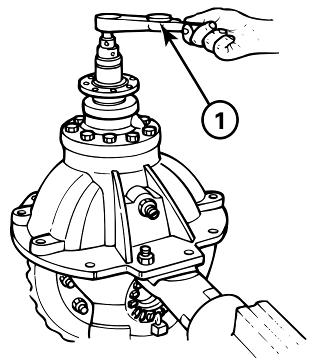
Figure 4.17



1 FLANGE BAR SHOWN

5. Tighten the drive pinion nut to the correct torque value. **Figure 4.17.** Refer to **Table B.**
6. Remove the yoke or flange bar.
7. Attach a torque wrench on the drive pinion nut. Rotate the drive pinion and read the value indicated on torque wrench. **Figure 4.18.**

Figure 4.18



1 Read torque value.

8. If the pinion bearing preload or torque is not within 5-45 lb-in (0.56-5.08 N•m) for new pinion bearings or 10-30 lb-in (1.13-3.39 N•m) for used pinion bearings in good condition, remove the pinion and cage assembly from the carrier. Adjust the spacer and repeat Steps 1 through 7. T
   - **To increase preload:** Install a thinner bearing spacer.
   - **To decrease preload:** Install a thicker bearing spacer.
9. After adjusting pinion bearing preload, remove the drive pinion and bearing cage from the carrier. Refer to Section 2.
10. Install a new triple-lip seal.

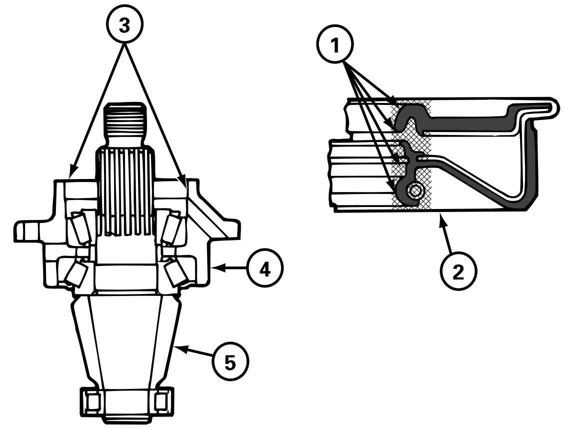
CAUTION

The seal lips must be clean. Dirt and particles may cause a leak between the yoke and the seal.

A. Apply the same lubricant used in the axle housing to the outer surface of the seal and the seal bore in the bearing cage. **Figure 4.19.**

B. Place the drive pinion and cage assembly in a press with the seal bore toward the top.

Figure 4.19



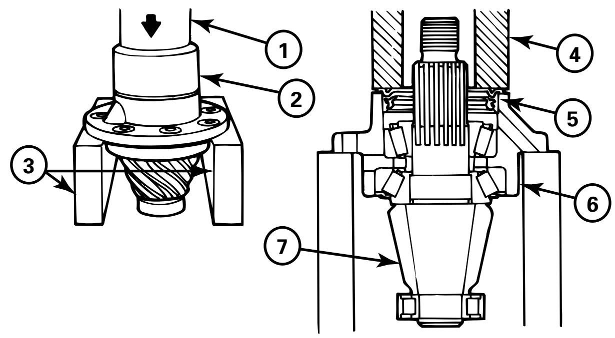
1 Apply grease.
2 TRIPLE-LIP, MAIN SEAL
3 Apply lubricant to seal bore.
4 BEARING CAGE
5 DRIVE PINION

C. Press the seal into the bearing cage. The seal flange must be flat against the top of the bearing cage. Use a sleeve or seal driver of the correct size that fits against the metal seal flange. The diameter of the sleeve or driver must be larger than the flange diameter. **Figure 4.20.**
   - **If a press is not available:** Use a mallet and the sleeve or driver to install the seal. **Figure 4.21.**

D. After the triple-lip seal is installed, a gap of approximately 0.015-0.030-inch (0.38-0.76 mm) between the flange and bearing cage is normal. **Figure 4.22.**

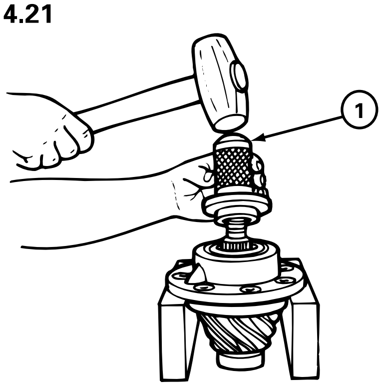
E. Check the gap with a feeler gauge at several points around the seal. The gap must be within 0.015-0.030-inch (0.38-0.76 mm). The difference between the largest and smallest gap measurement must not exceed 0.010-inch (0.0254 mm).

Figure 4.20



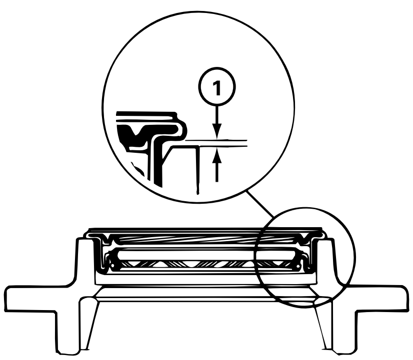
1	PRESS	5	SEAL
2	SLEEVE	6	BEARING CAGE
3	SUPPORTS	7	DRIVE PINION
4	SLEEVE		

Figure 4.21



1 SEAL DRIVER

Figure 4.22



1 0.015-0.030″ (0.38-0.76 MM)

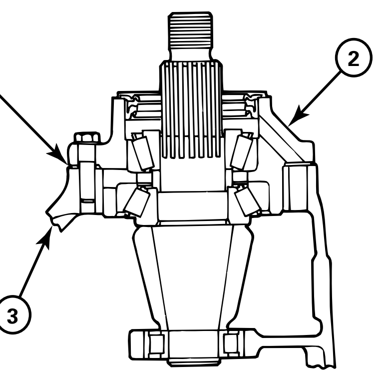
SHOWN WITHOUT BEARINGS AND PINION

Shim Pack Thickness for a New Drive Pinion

NOTE: Use this procedure if you'll install a new drive pinion and ring gear set, or if you have to adjust the depth of the drive pinion. **Figure 4.23**.

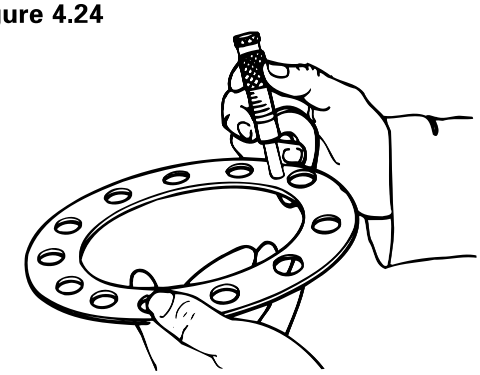
1. Use a micrometer to measure the thickness of the shim pack that was removed from under the pinion cage. Record the measurement. **Figure 4.24**.

Figure 4.23



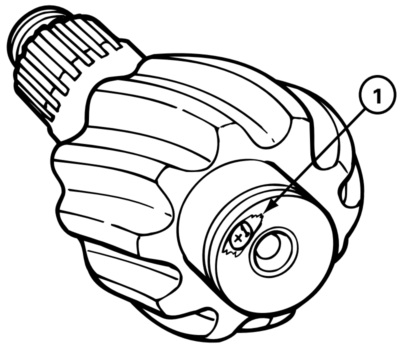
1	SHIM PACK CONTROLS DEPTH OF PINION	2	BEARING CAGE
		3	CARRIER

Figure 4.24



2. Find the pinion cone (PC) variation number on the drive pinion you'll replace. **Figure 4.25**. Record the number. The pinion cone number can be one of the following values.
   - PC +3, PC –3, +3 or –3 = 0.003-inch
   - PC +.03, PC 0.03 mm, +0.03 mm or –0.03 = 0.03 mm

Figure 4.25



1 PINION CONE VARIATION NUMBER

3. If you can't find the PC number or it's unreadable, install a new shim pack of the same thickness that you measured in Step 1.
4. If the old pinion cone number is a plus (+) number, subtract the number from the old shim pack thickness that was measured in Step 2.
5. If the old pinion cone number is a minus (–) number, add the number to the old shim pack thickness that was measured in Step 2.
6. Find the pinion cone (PC) variation number on the new drive pinion that will be installed. Record the number.
7. If the new pinion cone number is a plus (+) number, add the number to the standard shim pack thickness that was calculated in Step 4 or Step 5. Use new shims to make a shim pack to the correct thickness. Refer to **Table C.**
8. If the new pinion cone number is a minus (–) number, subtract the number from the standard shim pack thickness that was calculated in Step 4 or Step 5. Use new shims to make a shim pack to the correct thickness. Refer to **Table C**.

Table C

Examples	Inches	mm
1. Old Shim Pack Thickness. Old PC Number, PC +2 inches (+0.05 mm) Standard Shim Pack Thickness. New PC Number, PC +5 inches (+0.13 mm) New Shim Pack Thickness	0.030 – 0.002 = 0.028 + 0.005 = 0.033	0.760 – 0.050 = 0.710 + 0.130 = 0.840
2. Old Shim Pack Thickness Old PC Number, PC –2 inches (–0.05 mm) Standard Shim Pack Thickness. New PC Number, PC +5 inches (+0.13 mm) New Shim Pack Thickness	0.030 + 0.002 = 0.032 + 0.005 = 0.037	0.760 + 0.050 = 0.810 + 0.130 = 0.940
3. Old Shim Pack Thickness Old PC Number, PC +2 inches (+0.05 mm) Standard Shim Pack Thickness. New PC Number, PC –5 inches (–0.13 mm) New Shim Pack Thickness	0.030 – 0.002 = 0.028 – 0.005 = 0.023	0.760 – 0.050 = 0.710 – 0.130 = 0.580
4. Old Shim Pack Thickness Old PC Number, PC –2 inches (–0.05 mm) Standard Shim Pack Thickness. New PC Number, PC –5 inches (–0.13 mm) New Shim Pack Thickness	0.030 + 0.002 = 0.032– 0.005 = 0.027	0.760 + 0.050 = 0.810 – 0.130 = 0.680

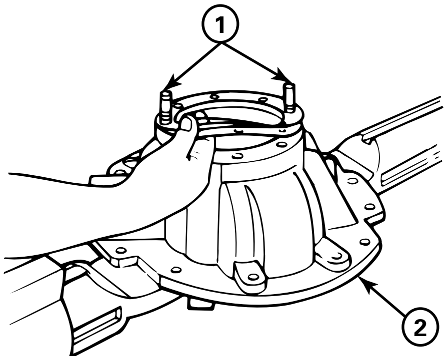
Installation

Drive Pinion, Bearing Cage and Shim Pack into the Carrier

NOTE: If a new drive pinion and ring gear set is installed, or if the depth of the drive pinion has to be adjusted, calculate the thickness of the shim pack. Refer to the procedure Shim Pack Thickness for a New Drive Pinion.

1. Select the correct shim pack and install it between the bearing cage and carrier. **Figure 4.26.**

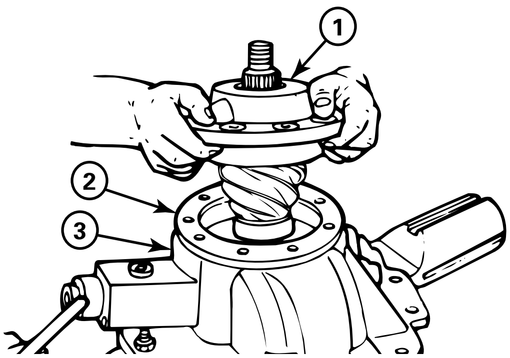
Figure 4.26



1 GUIDE STUDS
2 CARRIER

2. Apply Loctite® 518 Gasket Eliminator to the carrier face.
3. Align the oil slots in the shims with oil slots in the bearing cage and carrier. Use guide studs to help align the shims. **Figure 4.26**.
4. Apply Loctite® 518 Gasket Eliminator to the top of the shim pack.
5. Install the drive pinion and bearing cage into the carrier. If necessary, use a rubber, plastic or leather mallet to hit the assembly into position. **Figure 4.27**.

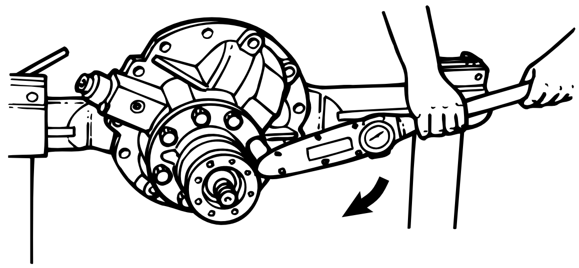
Figure 4.27



1 DRIVE PINION AND BEARING CAGE
2 SHIMS
3 CARRIER

6. Install the bearing cage-to-carrier capscrews and washers. Tighten the capscrews to the correct torque value. **Figure 4.28.** Refer to Section 7.

Figure 4.28



Tight Fit Yokes and POSE™ Seal

CAUTION

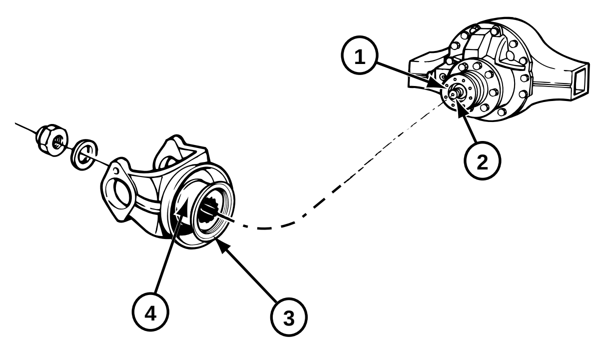
Do not install tight fit yokes on shafts using a hammer or mallet. Using a hammer or mallet can damage the yoke.

The seal lips must be clean. Dirt and particles may cause a leak between the yoke and the POSE™ seal.

NOTE: Do not install POSE™ seal all the way against the yoke shoulder. This seal is designed to position itself as yoke is installed.

1. Apply axle lubricant on the yoke seal.
2. Check all surfaces of the yoke hub for damage.
3. If the carrier uses a POSE™ seal element, install a new POSE™ seal.
   A. Lightly lubricate the yoke journal with the same lubricant used in the axle housing.
   B. Partially install the POSE™ seal onto the yoke 0.25-0.5-inch (6-13 mm). **Figure 4.29.**
   C. Before installing the yoke onto the drive pinion, lubricate the yoke with the same lubricant used in the axle housing.

Figure 4.29



1 Lubricate triple-lip or main seal.
2 INPUT SHAFT, PINION
3 POSE™ SEAL, 0.25-0.50″ (6-13 MM) ONTO HUB
4 Check yoke hub.

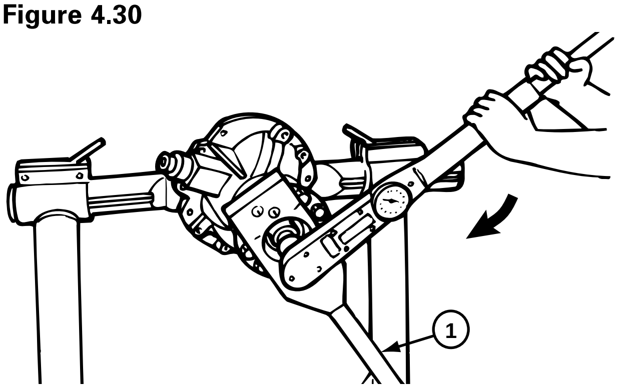
4. Slide the yoke over the input shaft pinion. Align the yoke splines with the shaft splines.

CAUTION

Do not use a hammer or mallet to install the yoke to the input pinion shaft. Using a hammer or mallet can damage the yoke or flange.

5. Install the input yoke flange onto the drive pinion shaft. The yoke or flange must be fully seated against the outer differential bearing before the nut is tightened to specifications.
6. Install the drive pinion nut and washer on the input pinion shaft and against the yoke collar. Tighten the nut against yoke collar to torque specifications. **Figure 4.30.** Refer to Section 7.

Figure 4.30



1 Use flange or yoke bar.

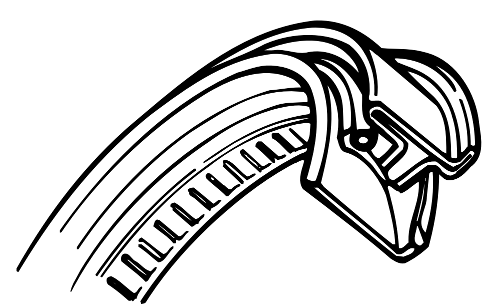
Any Type Yoke with a Unitized Pinion Seal (UPS)

NOTE: Once the yoke is partially or fully installed and then removed for any reason, the unitized pinion seal will be damaged and unusable. If the yoke and unitized pinion seal are removed after partial or full installation, remove and discard the original unitized pinion seal and replace it with another new unitized pinion seal.

If the inner sleeve of the seal is removed, the seal is not usable. A new seal is required. This will occur if a yoke is installed into the seal and then removed.

1. Remove the replacement unitized seal from the package**. Figure 4.31.**
2. Select the correct seal driver from **Table D.** Each seal driver is designed to correctly install a specific diameter seal. To determine the yoke seal diameter, measure the yoke journal. Refer to **Table D**.
3. Position the seal on the driver.

Figure 4.31



UNITIZED SEAL

Table D: Unitized Pinion Seals and Seal Drivers

Single Models	Tandem Models	Meritor Unitized Pinion Seal	Seal Installation Location	Meritor Seal Driver	Yoke Seal Diameter Inches
MX-21-160 MX-23-160R RF-16-145 RF-21-160 RF-22-166 RF-23-185 RS-17-145 RS-19-145 RS-21-145 RS-21-160 RS-23-160 /A RS-23-161 /A RS-25-160 /A RS-23-186 RS-26-185 RS-30-185	RT-34-144 /P RT-34-145 /P RT-40-145 /A /P RT-40-149 /A /P RT-44-145 /P RT-40-160 /A /P RT-40-169 /A /P RT-46-160 /A /P RT-46-169 /A /P RT-46-164EH /P RT-46-16HEH /P RT-50-160 /P RT-52-185* RT-58-185*	A-1205-R-2592	Tandem Forward Input — 145 models from 11/93 to present	R4422402	3.250 3.255
		A-1205-P-2590	Tandem Forward Output — Tandem Forward Input 145 models before 11/93 with seal A-1205-F-2424	R4422401	3.000 3.005
		A-1205-N-2588	Tandem and Single Rear Input — 145 models	R4422401	3.000 3.005
		A-1205-Q-2591	Tandem and Single Rear Input — 160/164/185 models	R4422402	3.250 3.255
To obtain Meritor seal driver KIT 4454, refer to the Service Notes page on the front inside cover of this manual.					

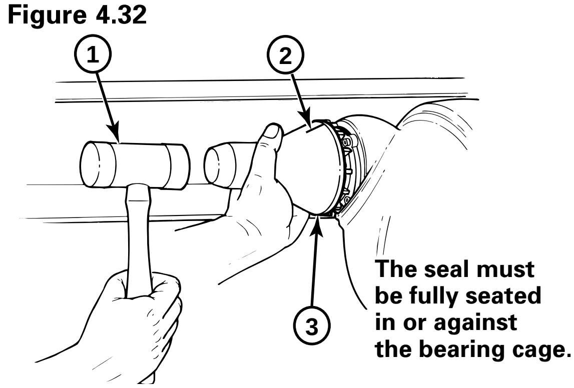
* Forward and rear input only.

CAUTION

Use a rubber mallet to install the seal. Do not use a steel, brass or plastic hammer. Damage to the seal and driver tool can result.

4. Use a rubber mallet to drive the seal into or against the bearing cage. The seal must fully seat into or against the bearing cage. **Figure 4.32.**

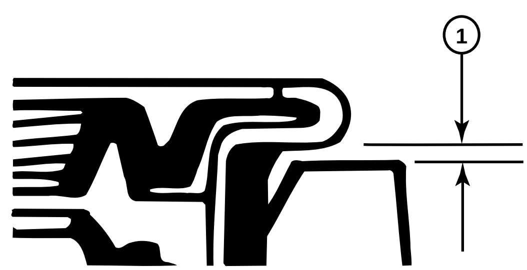
Figure 4.32



1 RUBBER MALLET
2 REFERENCE MARK
3 SEAL DRIVER R4422401

5. Use a 0.010-inch (0.25 mm) shim to check for clearance between the entire seal flange circumference and the bearing cage.
   - **If the 0.010-inch (0.25 mm) shim slides between the seal flange and bearing cage**: Correctly position the seal driver and drive the seal into the bore until the 0.010-inch (0.25 mm) shim cannot slide between the seal flange and bearing cage at any point around the seal flange. **Figure 4.33.**

Figure 4.33



MEASURING SEAL GAP
1 0.010" (0.25 MM)

Clean, Inspect and Install the Yoke After Installing a Unitized Pinion Seal

WARNING

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

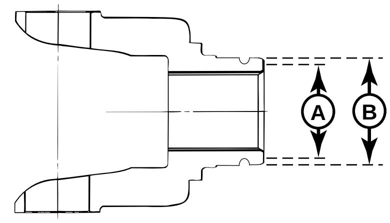
- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

1. Use a clean shop towel and a safe cleaning solvent to clean the ground and polished surface of the yoke journal. Do not use gasoline, abrasive cleaners, towels, or scrubbers to clean the yoke. Do not attempt to polish the yoke.

NOTE: The unitized seal features a rubber inner sleeve that is designed to seal and rotate with the yoke. This feature allows you to reuse a yoke with minor grooves.

2. Inspect the yoke seal surface for grooves.
   - **If you find grooves on the yoke**: Use calipers to measure the groove diameters. If any groove diameter measures less than the dimensions shown in **Figure 4.34**, replace the yoke.

Figure 4.34



Yoke Seal Diameter	Minimum Yoke Diameter at Groove (Inches)
3.000/3.005"	2.990"
3.250/3.255"	3.240"

1 MINIMUM GROOVE DEPTH — DIAMETER
2 YOKE SEAL DIAMETER

CAUTION

Do not install a POSE™ seal after you install a unitized pinion seal. The use of a POSE™ seal will prevent correct seating of the unitized pinion seal on the yoke and can result in lubricant leakage at the seal. POSE™ seal installation is recommended only for triple lip and other previous design seals. Damage to components can result.

Do not use thin metal wear sleeves to refresh the yoke surface. Wear sleeves pressed onto the yoke can prevent correct seating of the pinion seal, damage the pinion seal assembly and can cause the seal to leak. Damage to components can result.

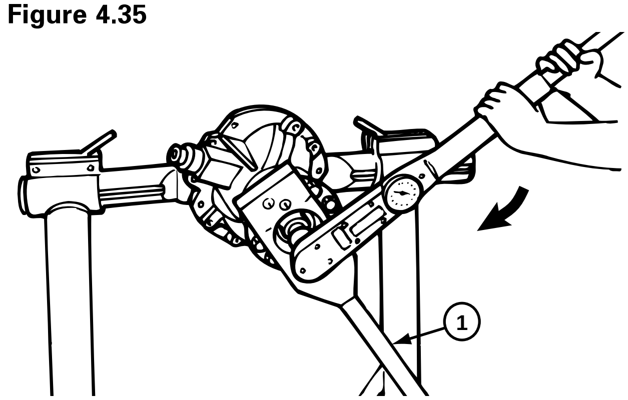
3. Before you install the yoke, lightly lubricate or coat the yoke seal journal with axle oil.
4. Align the yoke splines with the shaft splines. Slide the yoke over the shaft spline.

CAUTION

Do not use a hammer or mallet to install the yoke to the input pinion shaft. Using a hammer or mallet can damage the yoke or flange.

5. Install the input yoke flange onto the drive pinion shaft. The yoke or flange must be fully seated against the outer differential bearing before the nut is torqued to specifications.
6. Install the drive pinion nut, and washer if required, on the input pinion shaft and against the yoke collar. Tighten the nut against yoke collar to torque specifications. **Figure 4.35.** Refer to Section 7.

Figure 4.35



1 Use flange or yoke bar.

Assembly

Main Differential and Ring Gear Assembly

CAUTION

Heat the ring gear before seating it onto the differential case. Do not press a cold ring gear on the flange case half. A cold ring gear will damage the case half because of the tight fit.

1. Heat the ring gear in a tank of water to a temperature of 160°F-180°F (71°C-82°C) for 10 to 15 minutes.

WARNING

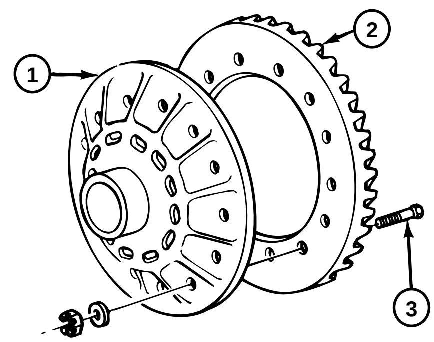
Wear safe clothing and gloves when working with the hot ring gear to prevent serious personal injury.

2. Use a lifting tool to safely lift the ring gear from the tank of water.
3. Install the ring gear on the flange case half immediately after the gear is heated.
   - **If the ring gear does not fit easily on the case half**: Heat the gear again.
4. Align the ring gear and the flange case half fastener holes. Rotate the ring gear as necessary.

NOTE: If rivets were used to hold the ring gear to the flange case half, replace them with bolts, nuts and washers.

5. Install the bolts, nuts and washers that hold the ring gear to the flange case half. Install the bolts from the gear side of the assembly. The bolt heads must be against the ring gear. **Figure 4.36**.

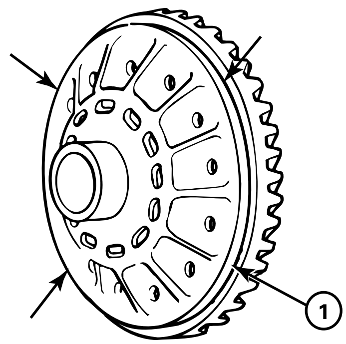
Figure 4.36



1 FLANGE CASE HALF
2 RING GEAR
3 BOLT HEAD AGAINST GEAR

6. Tighten the bolts and nuts to the correct torque value. Refer to Section 7.
7. Use a 0.003-inch (0.08 mm) feeler gauge to check for gaps between the back surface of the ring gear and the case flange. Check for gaps at four points around the assembly. **Figure 4.37**.
   - **If the gaps exceed specifications**: Check the flange case half and ring gear for the problem that causes the gap. Repair or replace parts. Assemble the ring gear on the flange case half. Repeat the procedure in Tight Fit Yokes and POSE™ Seal.

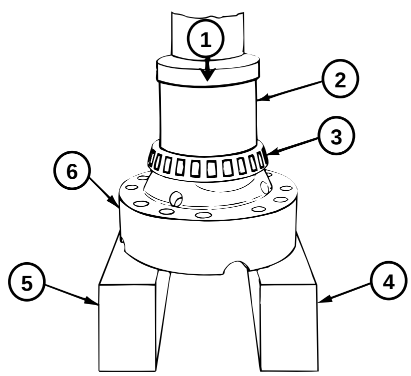
Figure 4.37



1 Check for 0.003" (0.08 mm) gap at four locations.

8. Use a press and the correct size sleeve to install the bearing cones on both of the case halves. **Figure 4.38.**

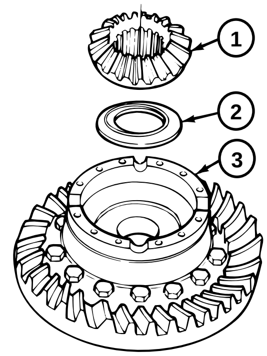
Figure 4.38



1	PRESS	4	SUPPORT
2	SLEEVE	5	SUPPORT
3	BEARING CONE	6	CASE HALF

9. Apply axle lubricant on the inside surfaces of both case halves, spider or cross, thrust washers, side gears and differential pinions.
10. Place the flange case half on a bench with the ring gear teeth toward the top.
11. Install one thrust washer and side gear into the flange case half. **Figure 4.39.**

Figure 4.39



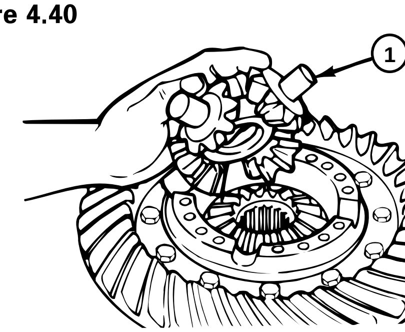
1 SIDE GEAR
2 THRUST WASHER
3 FLANGE CASE HALF

CAUTION

The side gears in some carrier models have hubs of different lengths. Install the correct length side gear into the flange case half. Damage to components can result.

12. Install the spider or cross, differential pinions and thrust washers into the flange case half. **Figure 4.40.**

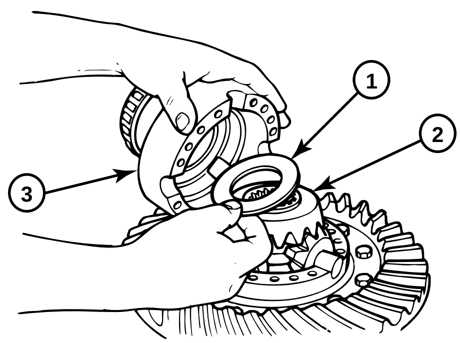
Figure 4.40



1 SPIDER, PINION AND THRUST WASHERS

13. Install the second side gear and thrust washer over the spider and differential pinions. **Figure 4.41**.

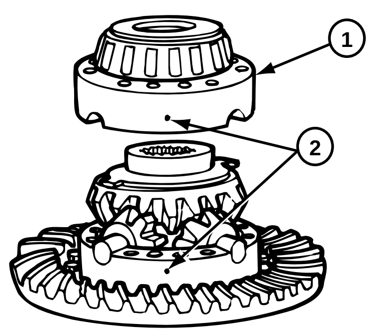
Figure 4.41



1 THRUST WASHER
2 SIDE GEAR
3 PLAIN CASE HALF

14. Place the plain half of the differential case over the flange half and gears. Rotate the plain half to align the match marks. **Figures 4.41 and 4.42**.

Figure 4.42



1 PLAIN CASE HALF
2 MATCH MARKS

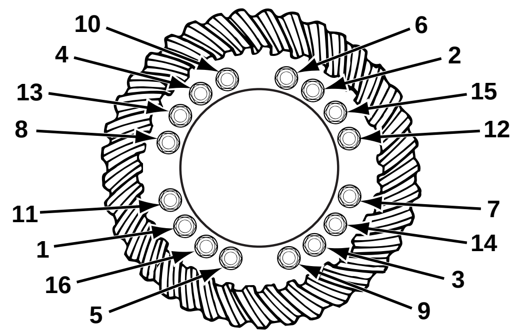
15. Install Dri-Loc fasteners into the case halves. Refer to Section 3.

    A. Install four capscrews and washers or bolts, nuts and washers, if equipped, into the case halves. The distance between the fasteners must be equal. Tighten the fasteners to the correct torque value in a progressive criss-cross pattern opposite each other. Refer to Section 7. **Figure 4.43**

    B. Install the other fasteners into the case halves. Tighten the fasteners to the correct torque value. Refer to Section 7.

16. Check the differential gears rotating resistance.

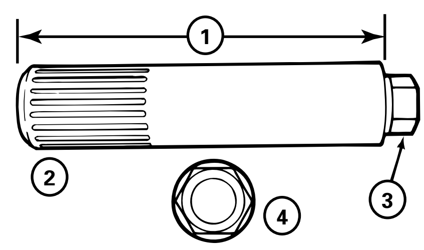
Figure 4.43



Differential Gears Rotating Resistance Check

1. Make an inspection tool using an axle shaft that matches the spline size of the differential side gear. Cut the shaft to approximately 12-inches (304.8 mm). Weld a nut onto the end of the shaft. **Figure 4.44.**

Figure 4.44

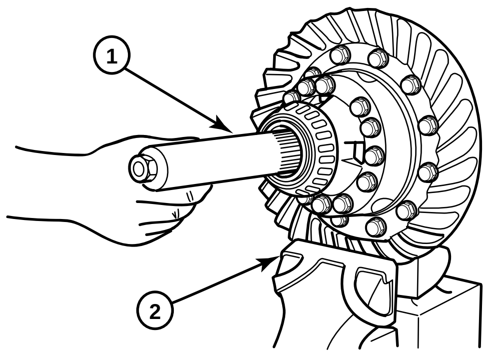


1 APPROXIMATELY 12" (304.8 MM)
2 SIDE VIEW
3 Weld nut to end of shaft.
4 END VIEW

2. Place the differential and ring gear assembly in a vise. Install soft metal covers over vise jaws to protect the ring gear. **Figure 4.45.**
3. Install the tool into the differential until the splines of the tool are engaged with one side gear. **Figure 4.45.**

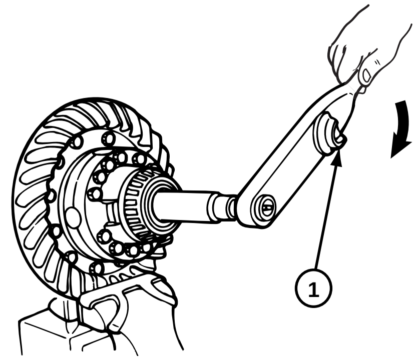
4. Place a torque wrench onto the nut of the tool and rotate the differential gears. As the differential gears rotate, read the value indicated on the torque wrench. **Figure 4.46**.
   - **If the torque value exceeds 50 lb-ft (67.8 N•m)**: Disassemble the differential gears from the case halves. Inspect the case halves, spider, gears and thrust washers. Repair or replace parts. Assemble the parts and repeat Steps 2-4.

Figure 4.45



1 TOOL FOR CHECKING RESISTANCE
2 SOFT METAL COVER

Figure 4.46



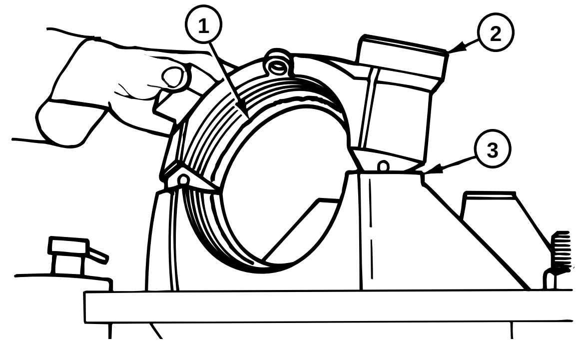
1 Read torque value.

Installation

Differential and Ring Gear Assembly

1. Clean and dry the bearing cups and bores of the carrier legs and bearing caps.
2. Apply axle lubricant on the inner diameter of the bearing cups and on both bearing cones that are assembled on the case halves.
3. Apply adhesive into the bearing bores of the carrier legs and bearing caps. Adhesive must not contact the adjusting ring threads. Refer to Section 3. **Figure 4.47**.

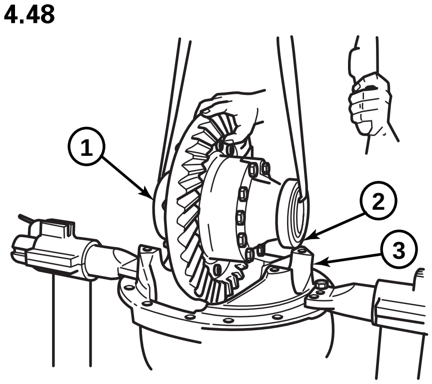
Figure 4.47



1 ADHESIVE
2 BEARING CAP
3 CARRIER LEG

4. Install the bearing cups over the bearing cones that are assembled on the case halves. **Figure 4.48**.

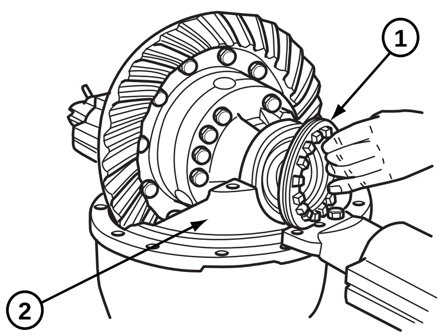
Figure 4.48



1 BEARING CUP
2 BEARING CUP
3 LEG BORE

5. Safely lift the differential and ring gear assembly and install it into the carrier. The bearing cups must be flat against the bores between the carrier legs. **Figure 4.48.**
6. Install both of the bearing adjusting rings into position between the carrier legs. Turn each adjusting ring hand-tight against the bearing cup. **Figure 4.49**.

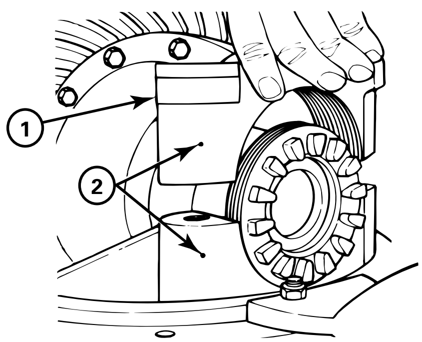
Figure 4.49



1 ADJUSTING RING
2 LEG

7. Install the bearing caps over the bearings and adjusting rings. Align the match marks you made when you removed the caps. **Figure 4.50.**

Figure 4.50



1 BEARING CAP
2 MATCH MARKS

CAUTION

If bearing caps are not installed in correct locations, the bores and threads in caps will not match the carrier. You will have problems assembling the caps on the carrier and damage to parts can occur. Do not force the bearing caps into position.

8. Seat each bearing cap with a light leather, plastic or rubber mallet. The caps must fit easily against the bearings, adjusting rings and carrier. Do not force the bearing caps into position.
   - **If bearing caps do not correctly fit into position:** Check the alignment of match marks between caps and carrier. Remove the caps and repeat Steps 6-8.

9. Install the capscrews and washers that hold bearing caps to the carrier. Hand-tighten the capscrews four to six turns. Tighten the capscrews to the correct torque value. Refer to Section 7.

NOTE: Do not install the cotter keys, pins or lock plates, if equipped, that hold the bearing adjusting rings in position.

10. Adjust differential bearing preload and hypoid gear backlash. Check the tooth contact patterns.

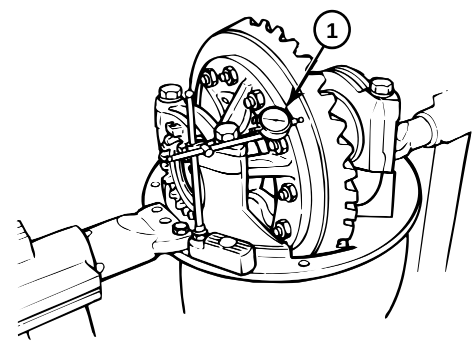
Adjust Differential Bearing Preload

Differential Bearing Preload	All Carrier Models	15-35 lb-in (1.7-3.9 N•m)
Expansion between bearing caps	RS-140, RS-145 and RS-160 carrier models	0.002-0.009-inch (0.05-0.229 mm)
	RS-120 and all other carrier models	0.006-0.013-inch (0.15-0.33 mm)

Method 1

1. Attach a dial indicator onto the carrier mounting flange so that the plunger or pointer is against the ring gear back surface. **Figure 4.51.**

Figure 4.51



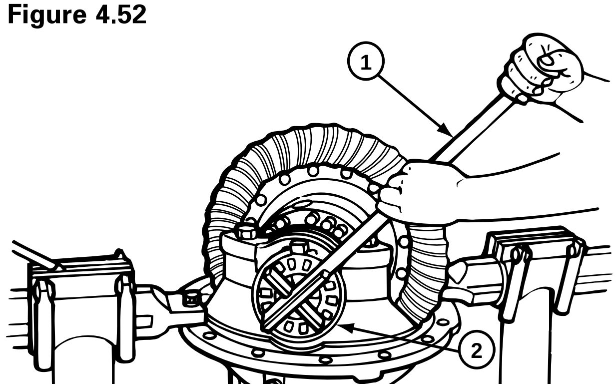
1 DIAL INDICATOR

CAUTION

**When you turn the adjusting rings, always use a tool that engages two or more opposite notches in the ring. A T-bar wrench can be used for this purpose. If the tool does not correctly fit into
the notches, damage to the lugs will occur.**

2. Use a T-bar wrench to loosen the bearing adjusting ring that is opposite the ring gear. A small amount of end play will show on the dial indicator. **Figure 4.52.**

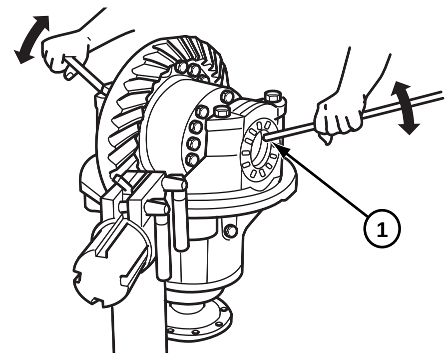
Figure 4.52



1 T-BAR WRENCH
2 ADJUSTING RING OPPOSITE RING GEAR

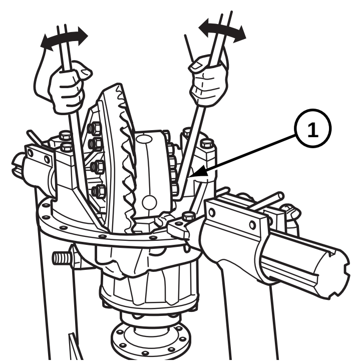
3. Use one of the following methods to move the differential and ring gear to the left and right while you read the dial indicator.
   A. Insert two pry bars between the bearing adjusting rings and ends of the differential case. The pry bars must not touch the differential bearings. **Figure 4.53.**
   B. Insert two pry bars between the differential case or ring gear and the carrier at locations other than described in Step A. The pry bars must not touch the differential bearings. **Figure 4.54.**

Figure 4.53



1 **Bars must not touch bearings.**

Figure 4.54



1 **Bars must not touch bearings.**

4. Tighten the bearing adjusting ring until the dial indicator reads ZERO end play. Move the differential and ring gear to the left and right as needed. If necessary, repeat Step A or B.
5. Tighten each bearing adjusting ring one notch from ZERO.
6. Proceed to check ring gear runout.

Method 2

1. Hand-tighten both adjusting rings against the differential bearings.
2. Use a micrometer to measure distance X or Y between the opposite surfaces of the bearing caps. **Figures 4.55 and 4.56.** Record the measurement.

Figure 4.55

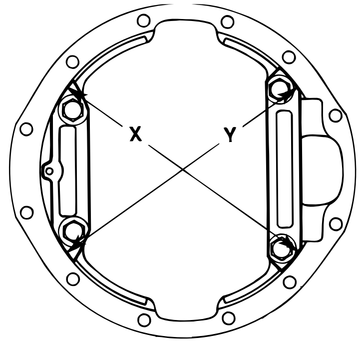
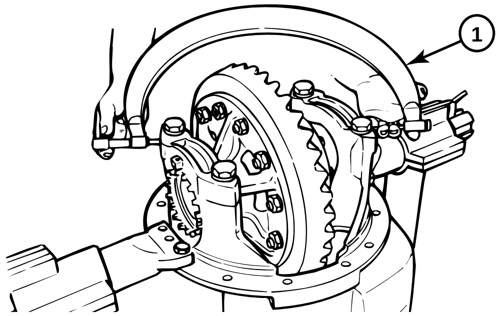


Figure 4.56



1 MICROMETER

3. Tighten each bearing adjusting ring one notch.
4. Measure distance X or Y again. Compare the measurement with the one you obtained in Step 2. The difference between the two dimensions is the amount the bearing caps have expanded.

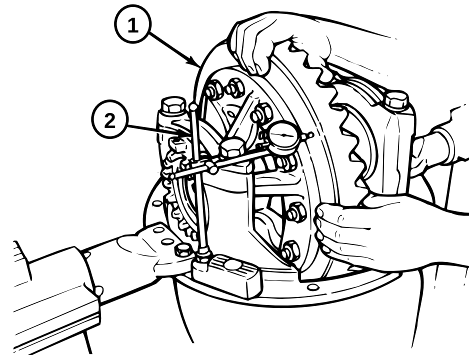
Example

- Measurements of RS-145 carrier
- Distance X or Y
  — before tightening adjusting rings = 13.927-inch (353.74 mm).
- Distance X or Y
  — after tightening adjusting rings = 13.936-inch (353.97 mm)
- 13.936-inch – 13.927-inch = 0.009-inch (0.23 mm) difference.
- **If the dimension is within specifications**: Continue by checking ring gear runout.
- **If the dimension is less than specifications**: Repeat Steps 3 and 4 as needed.

Check Ring Gear Runout

1. Attach a dial indicator onto the carrier mounting flange. **Figure 4.57.**

Figure 4.57



1 Rotate ring gear.
2 DIAL INDICATOR

2. Adjust the dial indicator so that the plunger or pointer is against the back surface of the ring gear. Set the dial indicator to ZERO.
3. Rotate the differential and ring gear. Read the dial indicator. Runout must not exceed 0.008-inch (0.20 mm). **Figure 4.57.**
   - **If runout exceeds specifications**: Remove the differential and ring gear assembly from the carrier. Refer to Differential and Ring Gear from the Carrier in Section 2 and Steps 4 and 5 below.
   - **If runout is within specifications**: Proceed to Ring Gear Backlash Adjustment.
4. Check the differential parts including the carrier for wear and damage. Repair or replace parts.
5. Install the differential and ring gear into the carrier. Refer to Differential and Ring Gear Assembly in this section. Repeat preload adjustment of differential bearings.

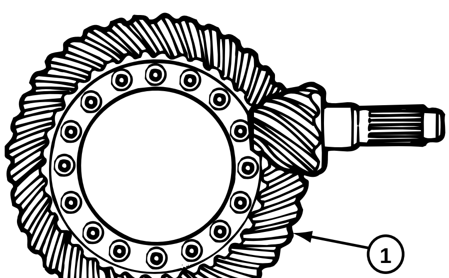
Ring Gear Backlash Adjustment

Ring Gear Pitch Diameter	Range of Backlash Setting	Backlash Setting for New Gear Sets
Less than 17-inches (431.8 mm)	0.008-0.018-inch (0.20-0.46 mm)	0.012-inch (0.30 mm)
Greater than 17-inches (431.8 mm)	0.010-0.020-inch (0.25-0.51 mm)	0.015-inch (0.38 mm)

Measure the outer diameter of ring gear for approximate pitch diameter. **Figure 4.58.**

- **If the old gear set is installed:** Adjust the backlash to the setting that was measured before the carrier was disassembled.
- **If a new gear set is installed:** Adjust the backlash to the correct specification for new gear sets.

Figure 4.58

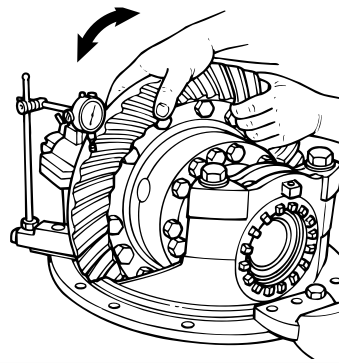


1 Measure outer diameter for approximate pitch diameter.

After checking the tooth contact patterns, the backlash can be adjusted within specification limits, if needed. To change the location of the pattern use the following procedures.

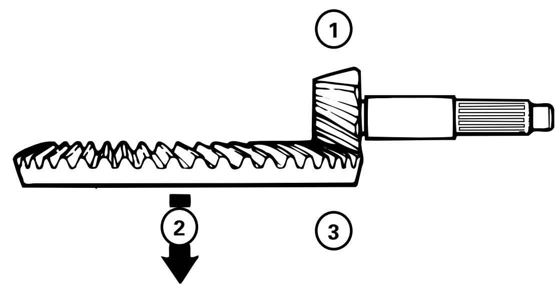
1. Attach a dial indicator onto the mounting flange of the carrier. **Figure 4.59.**

Figure 4.59



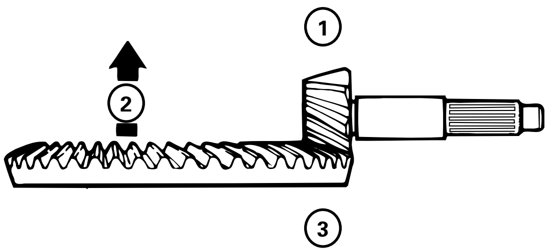
2. Adjust the dial indicator so that the plunger or pointer is against the tooth surface. **Figure 4.59.**
3. Adjust the indicator dial to ZERO. Hold the drive pinion in position.
4. After reading the dial indicator, rotate the differential and ring gear a small amount in both directions against the drive pinion teeth.
   - **If the backlash reading is within specifications:** Check the tooth contact patterns.
   - **If the backlash reading is not within specifications:** Adjust backlash as needed.
5. Loosen one bearing adjusting ring one notch then tighten the opposite ring the same amount.
   - **To increase backlash:** Move the ring gear away from the drive pinion. **Figure 4.60.**
   - **To decrease backlash:** Move the ring gear toward the drive pinion. **Figure 4.61.**

Figure 4.60



1 Tighten adjusting ring this side.
2 Increase backlash.
3 Loosen adjusting ring this side.

Figure 4.61



1 Loosen adjusting ring this side.
2 Decrease backlash.
3 Tighten adjusting ring this side.

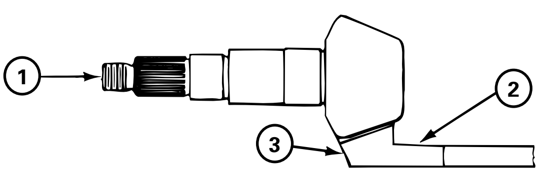
NOTE: When you adjust backlash, move the ring gear only. Do not move the drive pinion.

6. Repeat Steps 2-5 until the backlash is within specifications.

Check Gear Set Tooth Contact Patterns (Backlash)

Some Meritor carriers have a generoid hypoid gear set. The tooth contact patterns for each type of gear set are different. Check the part numbers to determine what type of gear set is in the carrier. Refer to **Figure 4.62** for the location of part numbers.

Figure 4.62



1 PART NUMBER
2 PART NUMBER
3 PART NUMBER OPTION

Examples

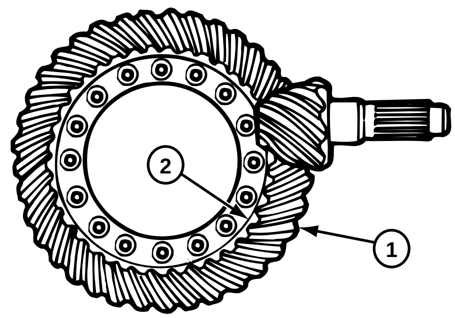
Part numbers for generoid gear sets

- 36786-K or 36786-K2 for the ring gear
- 36787-K or 36787-K2 for the drive pinion

In the following procedures, movement of the contact pattern in the length of the tooth is indicated as toward the heel or toe of the ring gear. **Figure 4.63.**

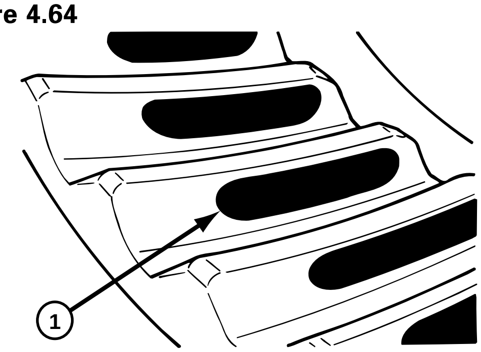
Always check tooth contact patterns on the drive side of the gear teeth. **Figure 4.64.**

Figure 4.63



1 HEEL
2 TOE

Figure 4.64

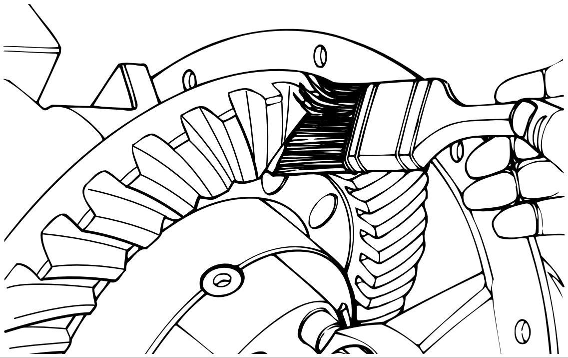


1 DRIVE SIDE, CONVEX

1. Adjust the backlash of a new gear set to either 0.012-inch (0.305 mm) or 0.015-inch (0.380 mm) depending on the size of the ring gear. Adjust the backlash of an old gear set to the setting that you measured before the carrier was disassembled. Refer to Ring Gear Backlash Adjustment.

2. Apply a marking compound onto approximately 12 gear teeth of the ring gear. Rotate the ring gear so that the 12 gear teeth are next to the drive pinion. **Figure 4.65.**

Figure 4.65



3. Rotate the ring gear forward and backward so that the 12 gear teeth go past the drive pinion six times to get the contact patterns. Repeat if needed to get a clearer pattern.
4. Look at the contact patterns on the ring gear teeth. Compare the patterns to **Figures 4.66, 4.67 and 4.68.**

   The location of good hand-rolled contact patterns for new conventional and generoid gear sets is toward the toe of the gear tooth and in the center between the top and bottom of the tooth. **Figure 4.66.**

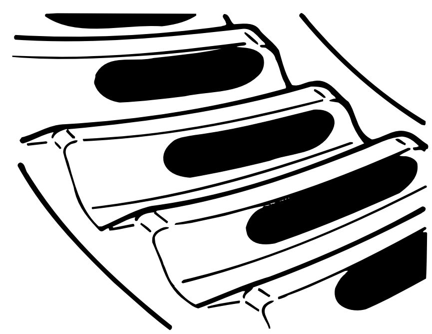
   When the carrier is operated, a good pattern will extend approximately the full length of the gear tooth. The top of the pattern will be near the top of the gear tooth. **Figure 4.69.**

   The location of a good hand-rolled contact pattern for an old gear set must match the wear pattern in the ring gear. The new contact pattern will be smaller in area than the old wear pattern.

   A high contact pattern indicates that the drive pinion was not installed deep enough into the carrier. A low contact pattern indicates that the drive pinion was installed too deep in the carrier.

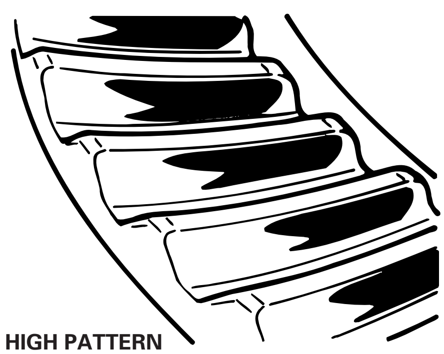
   - **If the contact patterns require adjustment:** Continue by following Step 5 to move the contact patterns between the top and bottom of the gear teeth.
   - **If the contact patterns are in the center of the gear teeth:** Continue by following Step 6.

Figure 4.66



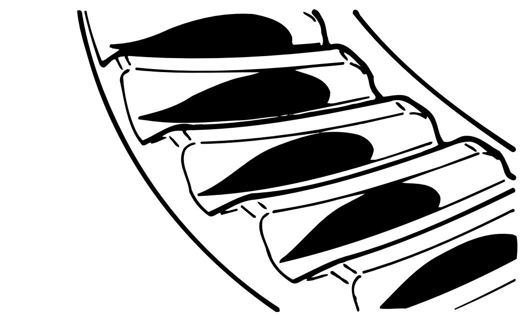
GOOD HAND-ROLLED PATTERN, HYPOID GENEROID GEARS

Figure 4.67



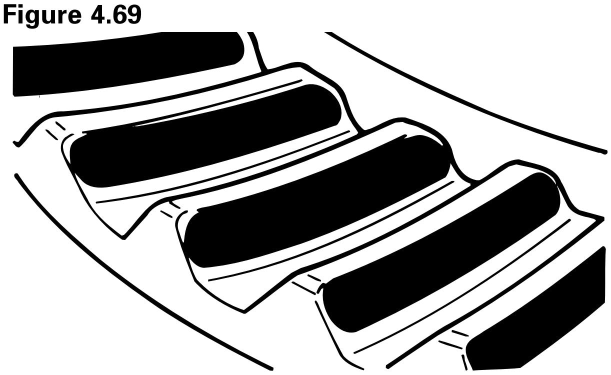
HIGH PATTERN, HYPOID GENEROID GEARS

Figure 4.68



LOW PATTERN, HYPOID GENEROID GEARS

Figure 4.69



GOOD PATTERN IN OPERATION, GENEROID GEARS

5. Change the thickness of the shim pack under the bearing cage to move the contact patterns between the top and bottom of the gear teeth. Use the following procedure.

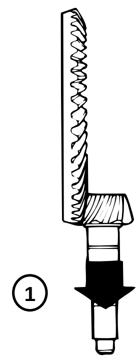
   A. Remove the drive pinion and bearing cage from the carrier. Refer to Drive Pinion and Bearing Cage from the Carrier in Section 2.

      - **To correct a high contact pattern**: Decrease the thickness of the shim pack under the bearing cage. When decreasing the thickness of the shim pack, the drive pinion will move toward the ring gear. **Figure 4.70.**
      - **To correct a low contact pattern**: Increase the thickness of shim pack under the bearing cage. When increasing the thickness of the shim pack, the drive pinion will move away from the ring gear. **Figure 4.71.**

   B. Install the drive pinion, bearing cage and shims into the carrier. Refer to Shim Pack Thickness for a New Drive Pinion in this section.

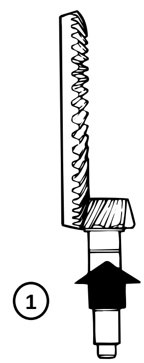
   C. Repeat Steps 2-5 until the contact patterns are in the center between the top and bottom of the gear teeth.

Figure 4.70



1 Decrease shim pack.

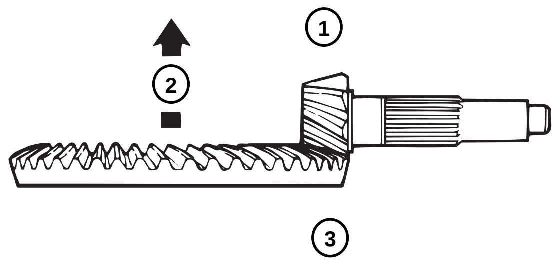
Figure 4.71



1 Increase shim pack.

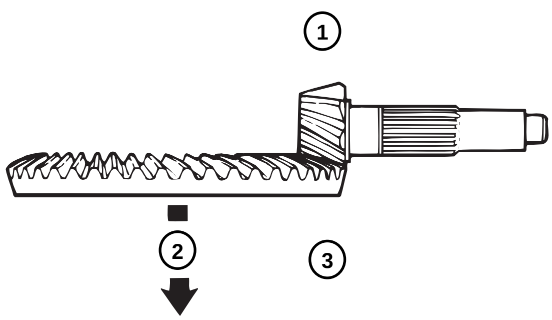
6. Adjust backlash of the ring gear within the specification range to move the contact patterns to the correct location in the length of the gear teeth. Refer to Ring Gear Backlash Adjustment.
   A. Decrease backlash to move the contact patterns toward the toe of the ring gear teeth. **Figure 4.72.**
   B. Increase backlash to move the contact patterns toward the heel of the ring gear teeth. **Figure 4.73.**
   C. Repeat Steps 2-4 and Step 6 until the contact patterns are at the correct location in the length of the gear teeth.

Figure 4.72



1 **Move pattern toward toe, loosen adjusting ring this side.**
2 **Decrease backlash.**
3 **Tighten adjusting ring.**

Figure 4.73



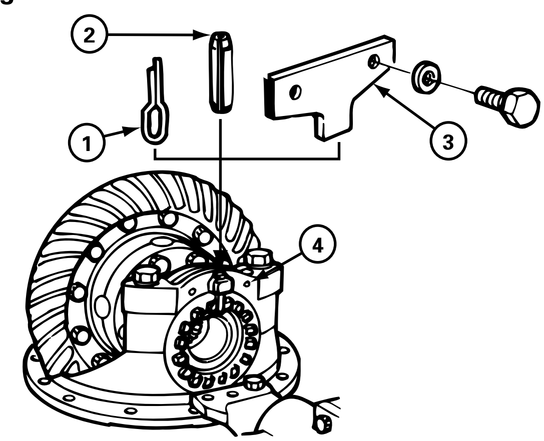
1 **Move pattern toward toe, loosen adjusting ring this side.**
2 **Decrease backlash.**
3 **Loosen adjusting ring.**

CAUTION

If the carrier has cotter keys, lock the adjusting rings only with cotter keys. If the carrier has roll pins, reuse the roll pins or lock the adjusting rings with cotter keys. Do not force a roll pin into a cotter key hole. Damage to components can result.

7. Install the cotter keys, pins, or lock plates, if equipped, that hold the two bearing adjusting rings in position. Use the following procedures.
   A. Install cotter keys between the lugs of the adjusting ring and through the boss of the bearing cap. Bend the two ends of the cotter key around the boss. **Figure 4.74.**
   B. Use a drift and hammer to install the pin through the boss of the bearing cap until the pin is between the lugs of the adjusting ring. **Figure 4.74.**
   C. Install the lock plate on the bearing cap so that the tab is between the lugs of the adjusting ring. Install the two capscrews that hold the lock plate to the bearing cap. Tighten the capscrews to correct torque value. Refer to Section 7. **Figure 4.74.**

Figure 4.74



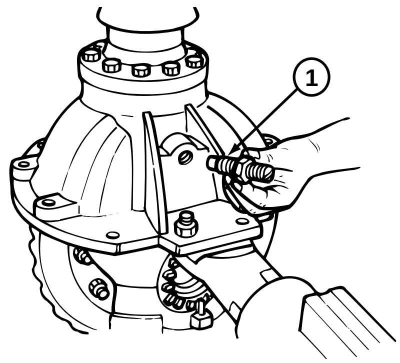
1 **COTTER KEY**
2 **PIN**
3 **LOCK PLATE**
4 **THREADED HOLES IN CAP WHEN LOCK PLATE IS USED**

Installation

Adjust the Thrust Screw

1. Rotate the carrier in the repair stand until the back surface of ring gear is toward the top.
2. Install the jam nut on the thrust screw, if equipped, one half the distance between both ends. **Figure 4.75.**

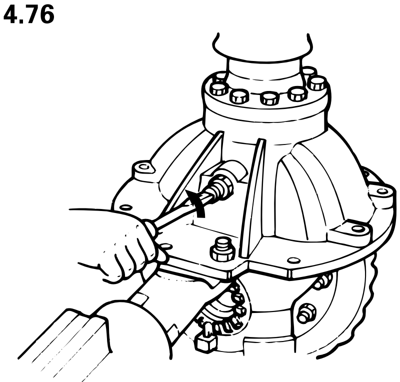
Figure 4.75



1 THRUST SCREW AND JAM NUT

3. Install the thrust screw. Clearance between the thrust screw and the ring gear must be 0.025-0.045-inch (0.65-1.14 mm).
4. Loosen the thrust screw 1/2 turn, 180 degrees. **Figure 4.76.**

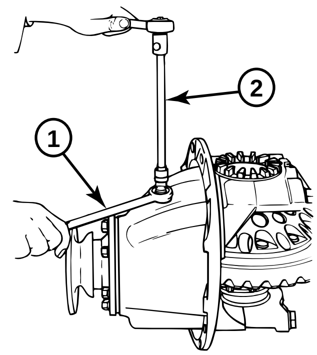
Figure 4.76



1 Loosen thrust screw 1/2 turn.

5. Tighten the jam nut, if equipped, to the correct torque value against the carrier. Refer to Section 7. **Figure 4.77.**

Figure 4.77



1 Hold thrust screw in position.
2 Tighten jam nut to correct torque value.

Differential Carrier into Axle Housing

WARNING

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

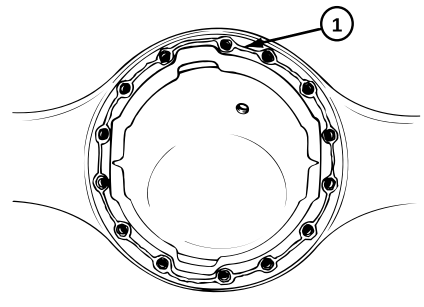
Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

NOTE: To complete the assembly of axles equipped with driver-controlled main differential locks, refer to DCDL Assembly into Carrier in Section 5.

1. Use a cleaning solvent and rags to clean the inside of the axle housing and the carrier mounting surface. Refer to Section 3.
2. Inspect the axle housing for damage. Repair or replace the axle housing. Refer to Section 3.
3. Check for loose studs, if equipped, in the mounting surface of the housing where the carrier fastens. Remove and clean the studs that are loose.
4. Apply liquid adhesive to the threaded holes. Install the studs into axle housing. Refer to Section 3. Tighten the studs to correct torque value. Refer to Section 7. T
5. Apply silicone gasket material to the mounting surface of the housing where the carrier fastens. Refer to Section 3. **Figure 4.78.**

Figure 4.78



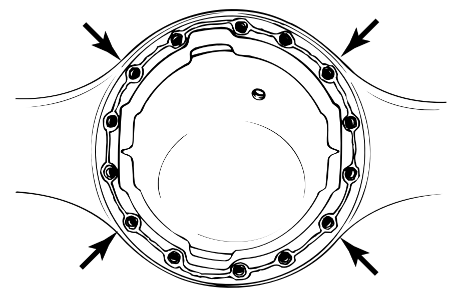
1 0.125" (3 MM) DIA. SILICONE GASKET BEAD

CAUTION

Do not install the carriers using a hammer or mallet. A hammer or mallet will damage the mounting flange of carrier and cause oil leaks.

6. Use a hydraulic roller jack or a lifting tool to install the carrier into the axle housing.
7. Install nuts and washers or capscrews and washers, if equipped, in the four corner locations around the carrier and axle housing. Hand-tighten the fasteners. **Figure 4.79.**
8. Carefully push the carrier into position. Tighten the four fasteners two or three turns each in a pattern opposite each other. **Figure 4.79.**

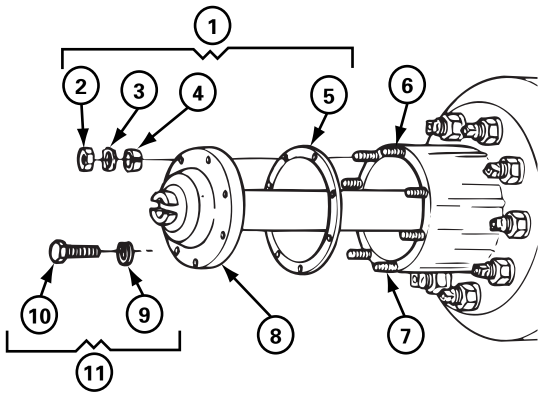
Figure 4.79



9. Repeat Step 8 until the four fasteners are tightened to the correct torque value. Refer to Section 7.

10. Install the other fasteners and washers that hold the carrier in the axle housing. Tighten fasteners to the correct torque value. Refer to Section 7.
11. Connect the driveline universal joint to the pinion input yoke or flange on the carrier.
12. Install the gaskets and axle shafts into the axle housing and carrier. The gasket and flange of the axle shafts must fit flat against the wheel hub. **Figure 4.80.**

Figure 4.80



1	TAPERED DOWEL RETENTION	8	AXLE SHAFT OR FLANGE
2	STUD NUT	9	WASHER
3	WASHER	10	CAPSCREW
4	TAPERED DOWEL	11	NON-TAPERED DOWEL RETENTION
5	GASKET		
6	STUD		
7	SHAFT HUB AXLE		

Straight Holes, Nuts and Hardened Washers

1. Clean the mating surfaces of the axle shaft and the wheel hub.
2. If silicone gasket material is used, apply a 0.125-inch (3 mm) diameter bead of the gasket material around the mating surface of the hub and around the edge of each fastener hole.
3. Install the gasket and the axle shaft into the housing. The gasket and the flange of the axle shaft must fit flat against the wheel hub. **Figure 4.80.**
4. Install the Grade 8 nuts and hardened washers on the stud. Lock washers are an acceptable alternative. Tighten the stud nuts to the torque specified in **Table E.**

Table E: Shaft-to-Hub Torque Fastener Chart — Non-Tapered Dowel Applications

Fastener	Thread Size	Torque Value — Grade 8 Nuts lb-ft (N•m)	
		Plain Nut	Lock Nut
Stud Nut, Axle Shaft	0.62-18	150-230 (244-312)	130-190 (203-258)
	0.75-16	310-400 (420-542)	270-350 (366-475)
Studs	All	Install the course thread end of stud into hub and tighten to last thread.	

Tapered Dowel, Hardened Washer and Hardened Nut

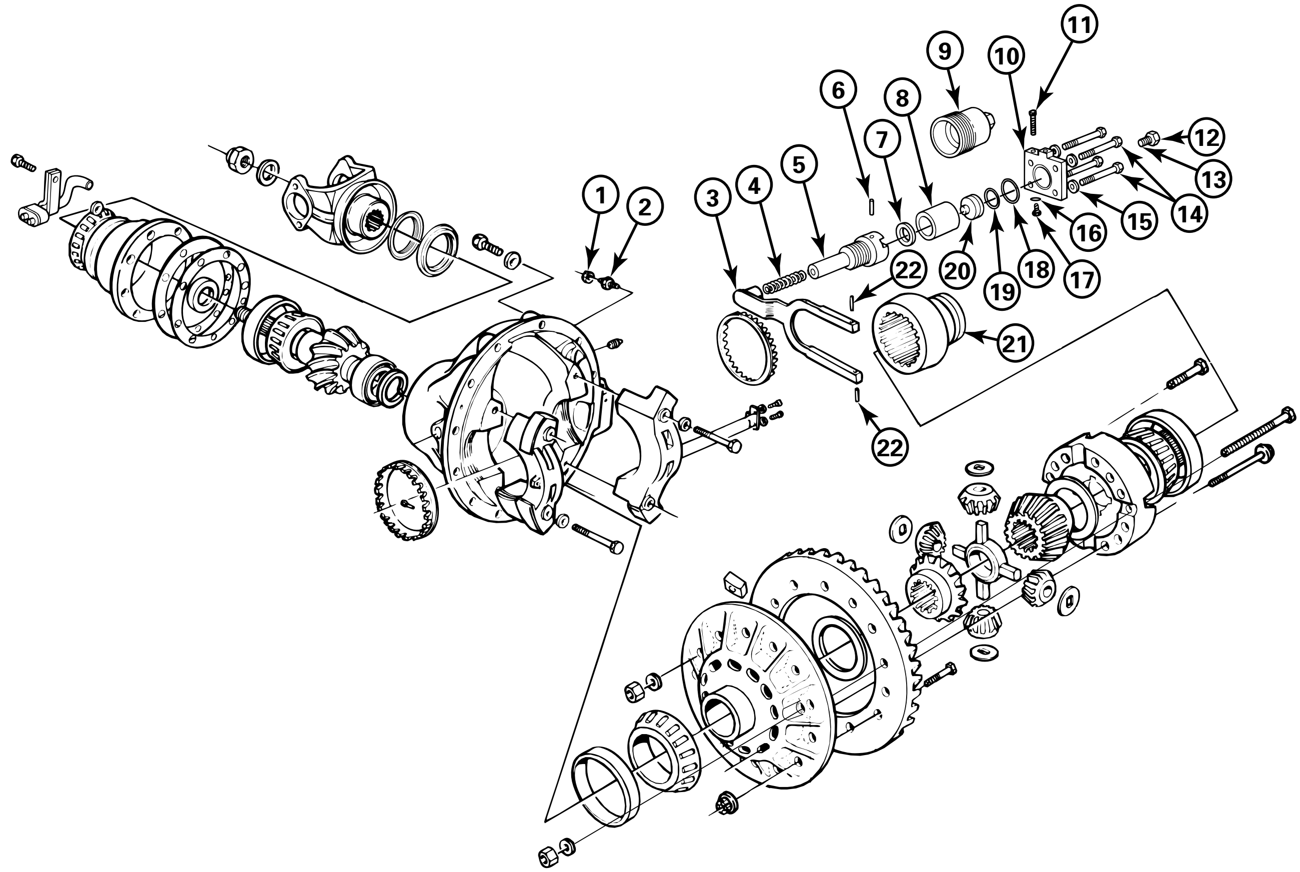
1. Clean the mating surfaces of the axle shaft and the wheel hub.
2. If silicone gasket material is used, apply a 0.125-inch (3 mm) diameter bead of the gasket material around the mating surface of the hub and around the edge of each fastener hole.
3. Install the gasket and the axle shaft into the housing. The gasket and the flange of the axle shaft must fit flat against the wheel hub. **Figure 4.80.**
4. Install solid tapered dowels over each stud and into the flange of the axle shaft. Use a punch or a drift and hammer, if necessary.
5. Install the Grade 8 nuts and hardened washers on the stud. Lock washers are an acceptable alternative. Tighten the stud nuts to the torque specified in **Table F.**

Table F: Shaft-to-Hub Torque Fastener Chart — Tapered Dowel Applications

Fastener	Thread Size	Torque Value — Grade 8 Nuts lb-ft (N•m)	
		Plain Nut	Lock Nut
Stud Nut, Axle Shaft	0.44-20	50-75 (81-102)	40-65 (67-88)
	0.50-20	75-115 (115-156)	65-100 (102-136)
	0.56-18	110-165 (176-224)	100-145 (149-197)
	0.62-18	150-230 (244-312)	130-190 (203-258)
Studs	All	Install the course thread end of stud into hub and tighten to last thread.	

Driver-Controlled Main Differential Lock Assembly

Figure 5.1



1 LOCK NUT — SENSOR SWITCH
2 SENSOR SWITCH
3 SHIFT FORK
4 SHIFT SHAFT SPRING
5 SHIFT SHAFT
6 SPRING RETAINING PIN
7 FLAT WASHER, OR SILASTIC AS REQUIRED
8 AIR CYLINDER TUBE
9 SCREW-IN DIFFERENTIAL LOCK
10 CYLINDER COVER
11 CAPSCREW — MANUAL ACTUATION, STORAGE POSITION
12 WASHER, OPERATING POSITION
13 PLUG GASKET, OPERATING POSITION
14 COVER CAPSCREWS
15 WASHERS
16 PLUG GASKET, STORAGE POSITION
17 COVER PLUG, STORAGE POSITION
18 COVER COPPER GASKET
19 PISTON O-RING
20 PISTON
21 SHIFT COLLAR
22 SHIFT FORK ROLL PINS

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Some Meritor drive axle models have a DCDL or a driver-controlled main differential lock. This differential lock is operated by a carrier-mounted, air-actuated shift unit. When activated, the shift unit moves a sliding collar which is installed on the splines of the axle shaft. When engaged, the collar locks the axle shafts together with a second set of splines on the differential case. When the DCDL is engaged, there is no differential action. **Figure 5.1.**

NOTE: The Meritor carrier models with driver-controlled differential lock equipment are manufactured in metric dimensions and sizes. When these carriers are serviced, it is important to use the correct metric size tools on the fasteners. Refer to Section 7.

CAUTION

If the vehicle must be towed to a service facility with the drive axle wheels on the ground, remove the axle shafts before the vehicle is towed. Damage to components can result.

1. Remove the axle shafts before the vehicle is towed. Refer to Section 10.
2. Install the axle shafts after the vehicle is towed. Refer to Section 10.
3. If the differential carrier must be removed from the axle housing, use the following procedures.

Removal

Differential Carrier from Axle Housing

WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

Before the differential carrier can be removed or installed, the differential lock must be shifted into and held in the locked or 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: If the axle shafts were removed for towing with the differential in the unlocked or disengaged position, install the right-hand axle shaft into the housing before removing the differential carrier. Refer to Section 10.

To shift into the locked position, refer to Manual Engaging Method in this section.

Axle Setup for DCDL Disassembly

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Remove the drain plug from the bottom of the housing and drain the lubricant.

WARNING

During DCDL disassembly, when the DCDL is in the locked or engaged position and the vehicle's wheels are raised from the floor, do not start the engine and engage the transmission. The vehicle can move and cause serious personal injury. Damage to components can result.

3. Use a jack to raise the vehicle so that the wheels to be serviced are off the ground. Place a safety stand under the spring seats to hold the vehicle in the raised position.
4. Disconnect the driveline from the pinion input yoke.
5. Disconnect the vehicle air line from the differential lock actuator assembly.

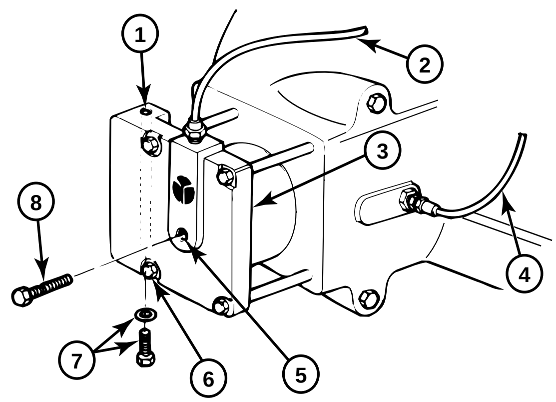
DCDL Assembly Manual Engaging Methods

Bolt-On Style Differential Lock Cylinder

Use the following manual engaging method to lock out the bolt-on DCDL assembly. **Figure 5.2.**

1. Follow Steps 2-5 of Axle Setup for DCDL Disassembly in this section.
2. Remove the plug and gasket from the hole in the center of the cylinder cover.

Figure 5.2



1 TOP SIDE STORAGE HOLE FOR MANUAL ENGAGING CAPSCREW
2 AIR LINE
3 CYLINDER COVER
4 WIRE
5 SERVICE POSITION CAPSCREW HOLE
6 BOTTOM SIDE STORAGE HOLE FOR PLUG AND GASKET
7 PLUG AND GASKET
8 MANUAL ENGAGING CAPSCREW

BOLT-ON DCDL ASSEMBLY

NOTE: The storage hole for the plug and gasket is located on the opposite side of the cylinder cover where the storage hole for the manual engaging capscrew is located.

3. Remove the manual engaging cap screw from the top storage hole in the cylinder cover.
4. Install the plug and gasket into the bottom storage hole in the cylinder cover.
5. Install the manual engaging capscrew into the threaded hole in the center of the cylinder cover.

CAUTION

There will be a small amount of spring resistance felt when you turn in the manual engaging capscrew. If a high resistance is felt before reaching the locked or engaged position, stop turning the capscrew, or the cover and capscrew threads will be damaged.

6. Turn the manual adjusting capscrew to the right until the head is approximately 0.25-0.5-inch (6-13 mm) from the cylinder cover. Do not turn the capscrew beyond its normal stop. If the 0.25-10.5-inch (6-13 mm) service position of the capscrew is achieved, the main differential lock is completely engaged.

   A high resistance on the capscrew indicates that the splines of the shift collar and the differential case half are not aligned or engaged. To align the splines, use the following procedure.

   A. Rotate the drive pinion or right-hand wheel to align the splines of the shift collar and case half while you turn in the manual engaging capscrew.

   B. When a normal amount of spring resistance is felt on the capscrew, the splines are engaged. Continue to turn in the manual engaging capscrew until the head is approximately 0.25-inch (6 mm) from the cylinder cover.

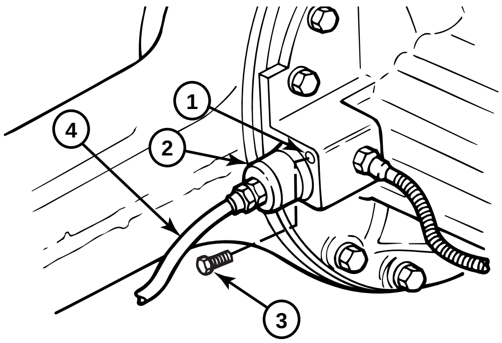
7. Remove the carrier from the axle housing. Refer to Section 2.

Screw-In Style Differential Lock Cylinder

Use the following manual engaging method to lockout the screw-in DCDL assembly.

1. Follow Steps 2-5 of Axle Setup for DCDL Disassembly in this section.
2. Remove the manual engaging capscrew from the storage hole in the carrier casting, next to the cylinder. **Figure 5.3**.

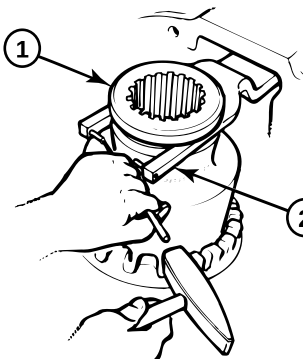
Figure 5.3



1 STORAGE HOLE
2 CYLINDER
3 MANUAL ENGAGING CAPSCREW
4 AIR HOSE

THREADED SHIFT ASSEMBLY

Figure 5.4



1 SHIFT COLLAR
2 SHIFT FORK

3. Remove air line and fitting. Install the manual engaging capscrew into the threaded hole in the center of the cylinder cover.
4. Turn the manual adjusting capscrew to the right until the head is approximately 0.25-inch (6 mm) from the cylinder cover. Do not turn the capscrew beyond its normal stop. The capscrew is now in the service position and the main differential lock is completely engaged.
5. Remove the carrier from the axle housing. Refer to Section 2.

Differential and Gear Assembly

Differential Lock Sliding Collar

1. For carriers with roll pins, tap out the two retainer roll pins, if equipped, until they are level with the inner face of the shift fork. Release the differential lock if it is manually engaged. **Figure 5.4.**
2. For carriers without roll pins, snap out collar from fork.
3. If required, remove the DCDL assembly at this time.

Bolt-On Style Differential Lock Cylinder

NOTE: On some bolt-on assemblies, a roll pin is installed in the shift shaft and is used as a stop for the shift shaft spring. It is not necessary to remove this roll pin during a normal disassembly.

A. Remove the sensor switch and lock nut.

B. Remove the four capscrews and washers that hold the cylinder cover to carrier. Remove the cylinder cover and copper gasket. **Figure 5.5**.

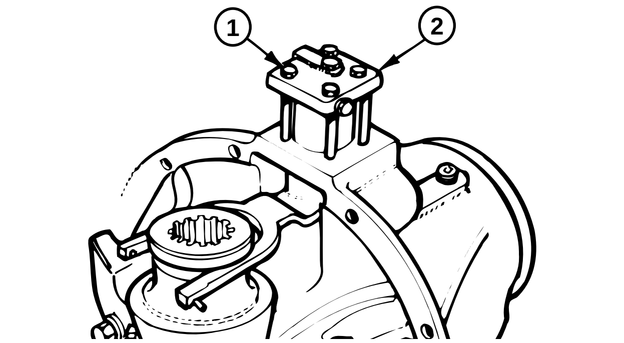
C. Remove the shift unit-cylinder and piston. Remove the O-ring from the piston.

D. Remove the shift shaft from the shift fork. The shaft may be secured with liquid adhesive or pre-applied adhesive material. Refer to Section 3.

E. Remove the shift shaft spring and flat washer. Some models use silastic seal instead of the flat washer.

F. Remove the shift fork.

Figure 5.5



1 CAPSCREW AND WASHER
2 COVER, COPPER GASKET UNDER COVER

BOLT-ON SHIFT ASSEMBLY

Screw-In Style Differential Lock Cylinder

A. Remove the sensor switch.

B. Remove the cylinder by turning hex nut at the top of the cylinder with a wrench. The cylinder may be secured to the carrier casting with Loctite® adhesive or equivalent pre-applied liquid adhesive. Refer to Section 3.

C. Remove the shift shaft, spring and shift fork.

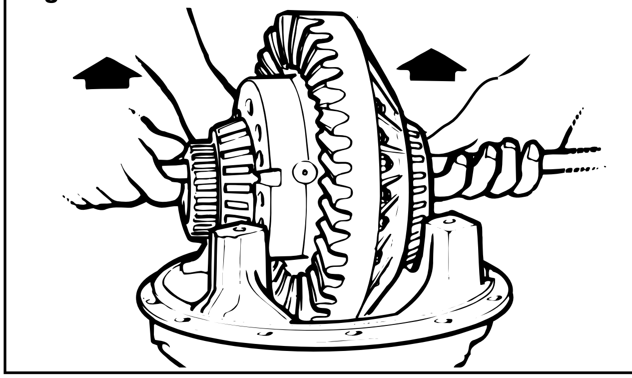
4. Remove the cotter keys, pins or lock plates, if equipped, that hold the two bearing adjusting rings in position. Use a small drift and hammer to remove pins. Each lock plate is held in position by two capscrews.

5. Mark one bearing cap and one carrier leg so that these parts will be assembled in the correct positions. Remove the bearing cap capscrews and washers, the bearing caps and the adjusting rings.

6. Lift the differential and gear assembly from the carrier. Tilt the assembly as required to permit the ring gear to clear the support for the pinion spigot bearing. **Figure 5.6.**

   Further disassembly of these carriers is the same as axles without the driver-controlled main differential lock. To continue disassembly, follow the procedures in Section 2.

Figure 5.6



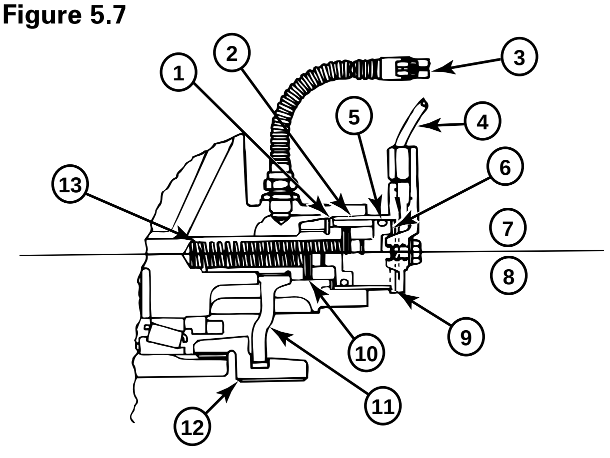
Installation

DCDL Assembly into Carrier

Bolt-On Style Differential Lock Assembly

Install the differential shift assembly after the differential carrier is assembled and the gear and bearing adjustments are completed. **Figure 5.7.**

Figure 5.7

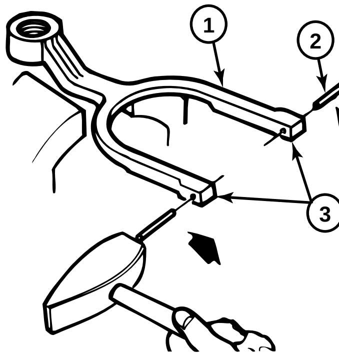


1 FLAT WASHER OR SILASTIC AS REQUIRED
2 CYLINDER
3 ELECTRIC CONNECTION FOR SENSOR
4 AIR LINE
5 O-RING
6 PISTON
7 DISENGAGED
8 ENGAGED
9 COPPER GASKET
10 PIN
11 SHIFT FORK
12 COLLAR
13 SHIFT SHAFT AND SPRING

BOLT-ON STYLE

1. On carrier models with shift fork roll pins, 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 face. **Figure 5.8.** Do not install the pins completely at this time.

Figure 5.8



1 SHIFT FORK
2 ROLL PIN
3 INNER YOKE FACES

2. On models without roll pins, snap the fork into position.

WARNING

Take care when you use Loctite® adhesive to avoid serious personal injury. Read the manufacturer's instructions before using this product. Follow the instructions carefully to prevent irritation to the eyes and skin.

3. Apply Loctite® 222 threadlocker, Meritor part number 2297-B-6112, to the threads of the shift shaft.
4. Install the shift fork into its correct position in the carrier case. **Figure 5.9.**
5. Hold the shift fork in position. Install the shift shaft spring into the shift shaft opening in the carrier, through the shift fork bore and into the bore for the shift shaft spring. **Figure 5.10.**
6. Slide the shift shaft over the spring. Install the shaft into the shift fork. Tighten to 20-25 lb-ft (27-34 N•m). T

Figure 5.9

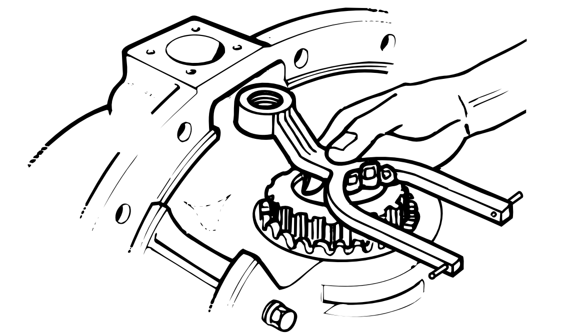
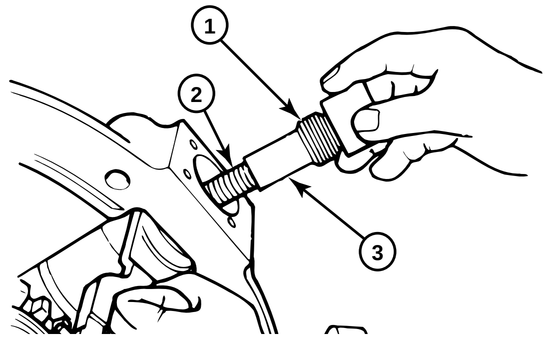


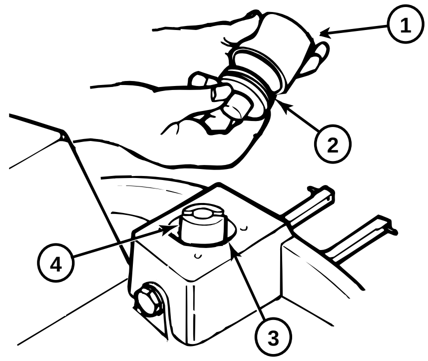
Figure 5.10



1 Apply Loctite® 222 threadlocker.
2 SPRING
3 SHIFT SHAFT

7. Install the flat washer, when used, or apply silastic sealant, Meritor part number 1199-Q-2981, to the bottom of the cylinder bore. **Figure 5.11.**
8. Install the O-ring into its groove on the piston. Lubricate the O-ring with axle lubricant. Install the piston into the air cylinder. **Figure 5.11.**

Figure 5.11

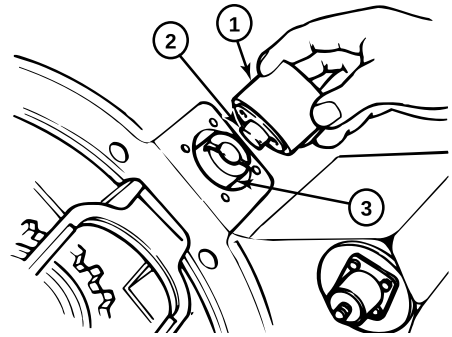


1 AIR CYLINDER
2 PISTON AND O-RING
3 Install flat washer or apply silastic sealant.
4 SHIFT SHAFT

BOLT-ON STYLE

9. Install the cylinder into the housing bore. Verify that the pilot journal on the piston is against its bore on the shift shaft. **Figure 5.12.**
10. Install the copper gasket into its bore on the inside of the cylinder cover. Place the cover in position over the cylinder so that the air intake port will point up when the carrier is installed into the housing. Install the cover with the four attaching capscrews and washers. Tighten the capscrews to 7.4-8.9 lb-ft (10-12 N•m). **Figures 5.7 and 5.13.** T
11. Slide the shift collar into the fork. Engage the shift collar splines with the splines of the differential case. Use the manual actuation capscrew to move the shift collar splines into the differential case splines. Refer to Manual Engaging Method in this section.
12. Hold the shift collar in the locked or engaged position. If employed, tap the two roll pins into the shift fork ends until they are level with the outer yoke faces. **Figure 5.14**.
13. While the shift collar is still in the locked position, place the sensor switch, with the jam nut loosely attached into its hole.
14. Connect a battery or bulb tester to the sensor switch. Rotate the switch into its hole until contact with the shift fork causes the testing light to go on. Turn the switch one additional revolution. Tighten the jam nut to 26-33 lb-ft (34-45 N•m). T

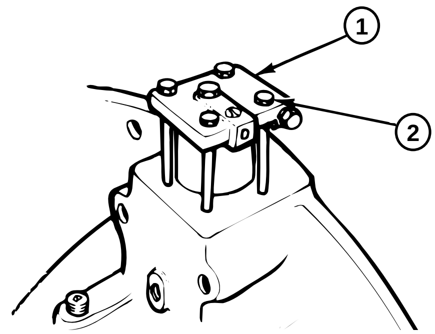
Figure 5.12



1 CYLINDER AND PISTON
2 PILOT JOURNAL
3 SHIFT SHAFT

BOLT-ON STYLE

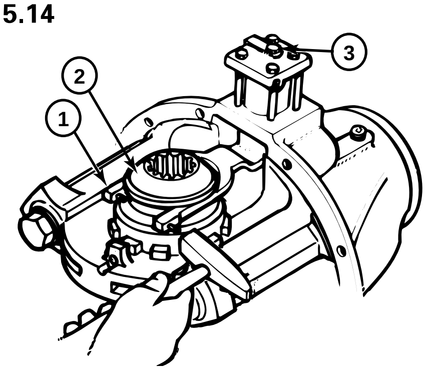
Figure 5.13



1 CYLINDER COVER
2 CAPSCREW 7.4-8.9 LB-FT (10-12 N•m)

BOLT-ON STYLE

Figure 5.14



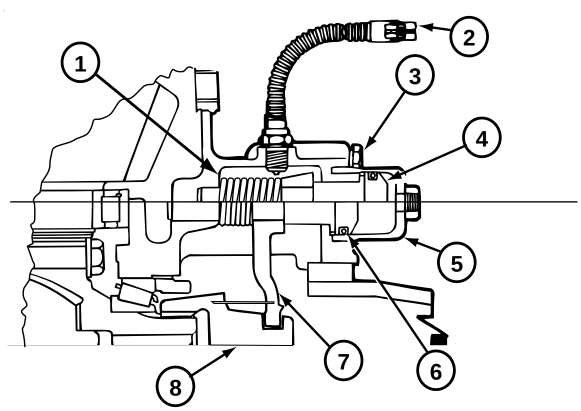
1 SHIFT FORK
2 SHIFT COLLAR
3 MANUAL ACTUATION CAPSCREW

BOLT-ON STYLE

Screw-In Style Differential Lock Assembly

Install the differential shift assembly after the differential carrier is assembled and the gear and bearing adjustments are completed. **Figure 5.15.**

Figure 5.15

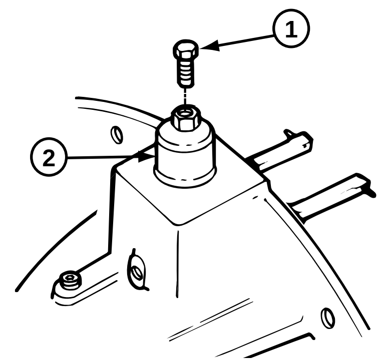


1 SHIFT SHAFT AND SPRING
2 ELECTRIC CONNECTION FOR SENSOR
3 PISTON
4 DISENGAGED
5 ENGAGED
6 CYLINDER
7 O-RING
8 SHIFT FORK
9 COLLAR

SCREW-IN STYLE

1. Install the shift spring and fork into the correct position in the carrier case. Compress the spring slightly while installing the fork.
2. Install the shift shaft into the shaft bore of the carrier. Slide the shaft through the shift fork bore and shift spring inside diameter.
3. Inspect the piston O-ring. Replace the O-ring if there is any evidence of cuts, cracks, abrasion or wear.
4. Lightly lubricate the O-ring and DCDL cylinder bore with the same lubricant used in the axle housing.
5. Install the piston and O-ring assembly into the DCDL cylinder. Slide the piston to the port end of the cylinder.
6. Coat the DCDL cylinder threads with Loctite® 518 Gasket Eliminator.
7. Screw the DCDL cylinder in place. Tighten the cylinder to 80-100 lb-ft (109-136 N•m). **Figure 5.16.** T

Figure 5.16



1 MANUAL ACTUATION CAPSCREW
2 SCREW-IN CYLINDER 80-100 LB-FT (109-136 N•m)

SCREW-IN STYLE

8. Snap the shift collar into the fork. Engage the shift collar splines with the splines of the differential case. Use the manual actuation capscrew to move the shift collar splines into the differential case splines. Refer to Manual Engaging Method in this section.
9. Install the sensor switch into its hole. Tighten the switch to 25-35 lb-ft (35-45 N•m). T
10. Connect a battery or bulb tester to the sensor switch. With the DCDL engaged, the tester light should go on.
    - **If the light does not go on:** Check the following.
        A. Verify that the fork is aligned with the sensor switch when it is in the engaged position.
        B. Check for a loose wiring connection. The connector must be tightly seated.
        C. Verify that the sensor switch is fully seated against the carrier spotface.
    - **If light fails to go on after these checks:** The sensor switch should be replaced.

Differential Lock Assembly Cover Plates

WARNING

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions.
If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

Take care when you use Loctite® adhesive to avoid serious personal injury. Read the manufacturer's instructions before using this product. Follow the instructions carefully to prevent irritation to the eyes and skin.

NOTE: For carriers without the differential lock or air shift, assemble the sensor switch plug and cover plate as follows.

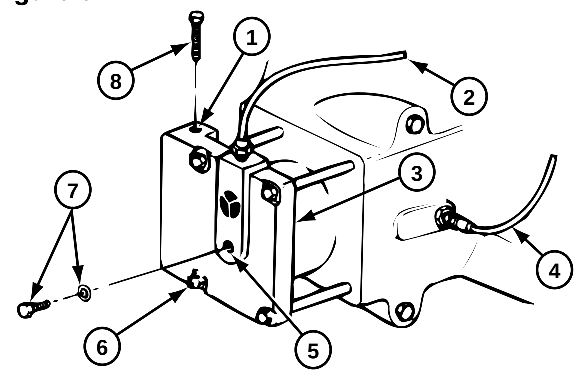
Bolt-On Cover Plate Assemblies

1. Install the washer and plug into the hole for the sensor switch. Tighten the plug to 45-55 lb-ft (60-74 N•m). **Figure 5.17.** T
2. Apply silicone gasket material to the cover plate mounting surface on the carrier. Refer to Section 3.
3. Install the four washers and capscrews. Tighten the capscrews to 7.4-8.9 lb-ft (10-12 N•m). **Figure 5.18.** T

Screw-In Cover Plate Assemblies

1. Apply Loctite® 518 liquid adhesive to the plate threads.
2. Install the bolts and washers. Tighten the plate into the carrier opening to 7.5-9.0 lb-ft (10-12 N•m). T

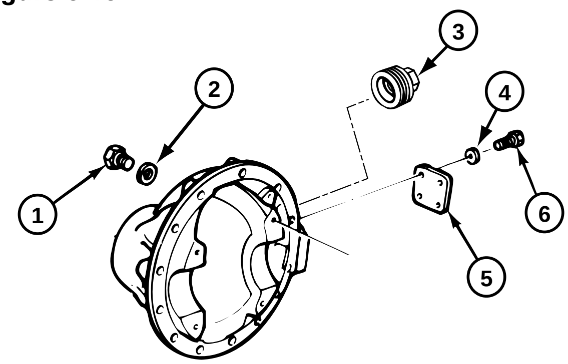
Figure 5.17



1 TOP STORAGE HOLE FOR MANUAL ENGAGING CAPSCREW
2 AIR LINE
3 CYLINDER COVER
4 WIRE
5 SERVICE POSITION CAPSCREW HOLE
6 BOTTOM STORAGE HOLE FOR PLUG AND GASKET
7 PLUG AND GASKET
8 MANUAL ENGAGING CAPSCREW

BOLT-ON DCDL SHIFT ASSEMBLY

Figure 5.18



1 SENSOR SWITCH PLUG
2 WASHER
3 SCREW-IN COVER PLATE (APPLY LOCTITE® 518 LIQUID ADHESIVE TO COVER PLATE THREADS)
4 WASHER
5 BOLT-ON COVER PLATE (APPLY SILICONE GASKET MATERIAL)
6 CAPSCREW

Install the Carrier into Axle Housing

WARNING

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

1. Use a cleaning solvent and rags to clean the inside of the axle housing and the mounting surface. Blow dry the cleaned areas with compressed air. Refer to Section 3.
2. Inspect the axle housing for damage. If necessary, repair or replace the housing. Refer to Section 3.
3. Check for loose studs in the mounting surface of the housing where the carrier fastens. Remove and replace any studs where required.
4. Install the differential carrier into the housing, using the Manual Engaging Method.

Manual Engaging Method

1. Align the splines of the shift collar and the differential case half by hand or by installing the right-hand axle shaft through the shift collar and into the side gear.
2. Install the manual engaging capscrew into the threaded hole in the center of the cylinder cover.

CAUTION

There will be a small amount of spring resistance when you turn in the manual engaging capscrew. If a high resistance is felt before reaching the locked or engaged position, stop turning the capscrew. Damage to components can result.

3. Turn the manual adjusting capscrew to the right until the distance from the head of the capscrew is approximately 0.25-0.50-inch (6-13 mm) from the cylinder cover. Do not turn the capscrew beyond its normal stop. When the capscrew head is in the service position 0.25-0.50-inch (6-13 mm) from top of DCDL, the main differential lock is manually engaged.

   A high resistance on the capscrew indicates that the splines of the shift collar and the differential case half are not aligned or engaged.

   Lift the shift collar as required and rotate to align the splines of collar and case half while turning the manual engaging capscrew inward. When the normal amount of spring resistance is again felt on the capscrew, the splines are engaged. Continue to turn in the manual engaging capscrew until the 0.25-0.50-inch (6-13 mm) service position is achieved.
4. Clean both the DCDL actuator and the housing mounting surfaces.

WARNING

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

5. Apply silicone gasket material to the cleaned housing surface for the DCDL actuator. Refer to Section 3.
6. Remove the short plug and gasket from the storage hole of the DCDL.

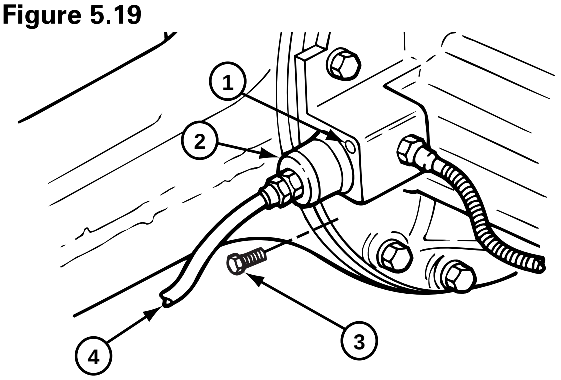
7. Remove the long manual engaging capscrew from the center of the DCDL.

NOTE: When the manual engaging capscrew is removed from the service position in the center of the DCDL actuator, the main differential lock is disengaged.

8. Clean the plug, gasket, cylinder cover, and threaded service position hole in the center of the DCDL cylinder cover.
9. Install the manual engaging capscrew into the DCDL storage hole in the bolt-on or the screw-in DCDL assembly. **Figures 5.17 and 5.19.** The sealing gasket must be under the head of the capscrew.
   A. On a bolt-on DCDL shift assembly, remove the short plug and gasket from the storage hole of the DCDL.

      Install the short plug and gasket into the service position hole in the center of the DCDL. **Figure 5.17.**
   B. On a screw-in DCDL shift assembly, install the short screw or plug into the storage hole located in the top of the screw-in DCDL shift assembly. **Figure 5.19.**

Figure 5.19



1 STORAGE HOLE
2 CYLINDER
3 MANUAL ENGAGING CAPSCREW
4 AIR HOSE

SCREW-IN DCDL SHIFT ASSEMBLY

10. Tighten the plug, if equipped, to 44-55 lb-ft (60-75 N•m). Tighten the manual engaging capscrew to 22-28 lb-ft (30-38 N•m) for bolt-on style cylinders and to 7-11 lb-ft (10-15 N•m) for screw-in type reverse shifters.
11. Connect the vehicle air line to the differential lock actuator assembly.
12. Install the electrical connection on the sensor switch located in the carrier, below the actuator assembly.
13. Install the right and left-hand axle shafts. Follow the procedures from Before Towing or Drive-Away in Section 10.
14. Remove the safety stand from under the drive axle. Lower the vehicle to the floor.
15. Proceed to Check the Differential Lock.

Check the Differential Lock

1. Shift the vehicle transmission to neutral. Start the engine to get the system air pressure to the normal level.

WARNING

During DCDL disassembly, when the DCDL is in the locked or engaged position and one of the vehicle's wheels is raised from the floor, do not start the engine and engage the transmission. The vehicle can move and cause serious personal injury.

2. Place the differential lock switch, in the cab of the vehicle, in the unlocked or disengaged position.
3. Drive the vehicle at 5-10 mph (8-16 km/h) and check the differential lock indicator light. The light must be off when the switch is in the unlocked or disengaged position.
4. Continue to drive the vehicle and place the differential lock switch in the locked or engaged position. Let up on the accelerator to remove the driveline torque and permit the shift. The light must be on when the switch is in the locked position.
   - **If the indicator light remains ON with the switch in the unlocked position:** The differential is still in the locked position. Verify that the manual engaging capscrew was removed from the cylinder cover of the actuator assembly. Refer to Steps 6-12 of Manual Engaging Method.

MERITOR®

Driver Caution Label

Verify that the driver caution label is installed in the vehicle cab. The caution label must be placed in a location that is easily visible to the driver. The recommended location is on the instrument panel, next to the differential lock switch and lock indicator light. **Figure 5.20.**

Driver caution labels, TP-86101, are available from ArvinMeritor's Commercial Vehicle Aftermarket. To obtain labels, refer to the Service Notes page on the front inside cover of this manual.

Figure 5.20

CAUTION

This vehicle is equipped with the
MERITOR DRIVER CONTROLLED FULL LOCKING DIFFERENTIAL.

ENGAGE FULL LOCKING DIFFERENTIAL ONLY
UNDER POOR TRACTION CONDITIONS.
DO NOT USE DURING DOWNHILL OPERATION.
DO NOT USE AT SPEEDS ABOVE 25 M.P.H.

WHEN ENGAGED, YOUR VEHICLE'S STEERING CHARACTERISTICS WILL BE AFFECTED. THIS "UNDERSTEER" CONDITION REQUIRES CAREFUL DRIVING PROCEDURES.

WHEN DISENGAGED, NORMAL VEHICLE HANDLING WILL RESUME.

For further information on this system, see your vehicle
operator's manual or Meritor Driver Instruction Kit TP-9646.

TP-86101

Traction Control Videos

Traction Controls contains two videos — the all-new Splitting the Difference and Driver-Controlled, Full-Locking Main Differential. The videos are also available in CD format.

Driver-Controlled, Full-Locking Main Differential is one of the industry's best videos on the operation of the main differential. The video explains in full detail how this system works and further discusses the advantages of Meritor's unique traction control device — DCDL. Testimonials from a large North American fleet support the ease of use of the DCDL.

Also included are several technical pieces to supplement the videos by providing detailed instructions on operating the DCDL and IAD, driver instructions and the difference between the two systems.

To obtain these videos, refer to the Service Notes page on the front inside cover of this manual.

NOTE: For complete information on lubricating drive axles and carriers, refer to Maintenance Manual 1, Lubrication. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Refer to **Table G**, **Table H** and **Table I** for standard information on lubricants, schedules and capacities.

Table G: Lubricant Cross Reference (Viscosity) and Temperature Chart

Meritor Lubricant Specification	Description	Cross Reference	Minimum Outside Temperature	Maximum Outside Temperature
O-76-A	Hypoid Gear Oil	GL-5, S.A.E. 85W/140	+10°F (–12.2°C)	- - -*
O-76-B	Hypoid Gear Oil	GL-5, S.A.E. 80W/140	–15°F (–26.1°C)	- - -*
O-76-D	Hypoid Gear Oil	GL-5, S.A.E. 80W/90	–15°F (–26.1°C)	- - -*
O-76-E	Hypoid Gear Oil	GL-5, S.A.E. 75W/90	–40°F (–40°C)	- - -*
O-76-J	Hypoid Gear Oil	GL-5, S.A.E. 75W	–40°F (–40°C)	+35°F (+1.6°C)
O-76-L	Hypoid Gear Oil	GL-5, S.A.E. 75W/140	–40°F (–40°C)	- - -*
*There is no upper limit on these outside temperatures, but the axle sump temperature must never exceed 250°F (+121°C).				

Table H: Oil Change Intervals and Specifications for All Front Drive and Rear Drive Axles ①

Vocation or Vehicle Operation	Linehaul Motorhome Intercity Coach	City Delivery School Bus Fire Truck	Construction Transit Bus Refuse Yard Tractor Logging Heavy Haul Mining Oil Field Rescue
Initial Oil Change	No longer required as of January 1, 1993		
Check Oil Level and Breather	Every 25,000 miles (40 000 km) or the fleet maintenance interval, whichever comes first	Every 10,000 miles (16 000 km), once a month or the fleet maintenance interval, whichever comes first	Every 5,000 miles (8000 km), once a month or the fleet maintenance interval, whichever comes first ②
Petroleum based oil change on axle WITH or WITHOUT pump and filter system	Every 100,000 miles (160 000 km) or annually, whichever comes first	Every 50,000 miles (80 000 km) or annually, whichever comes first	Every 25,000 miles (40 000 km) or annually, whichever comes first
Synthetic oil change on axle WITHOUT pump and filter system ③	Every 250,000 miles (400 000 km) or 3 years, whichever comes first	Every 100,000 miles (160 000 km) or annually, whichever comes first	Every 50,000 miles (80 000 km) or annually, whichever comes first
Synthetic oil change on axle WITH pump and filter system ③	Every 500,000 miles (800 000 km)	Every 250,000 miles (400 000 km)	Every 100,000 miles (160 000 km)
Filter change on axle with pump and filter system	Every 100,000 miles (160 000 km)	Every 100,000 miles (160 000 km)	Every 100,000 miles (160 000 km)

① If a No-Spin differential is installed, change the oil, petroleum or synthetic, at a minimum interval of 40,000 miles (64 000 km) or a maximum interval of 50,000 miles (80 000 km).

② For continuous heavy-duty operation, check the oil level every 1,000 miles (1600 km). Add the correct type and amount of oil as required.

③ This interval applies to approved semi-synthetic and full synthetic oils only. For a list of approved extended-drain axle oils, refer to TP-9539, Approved Rear Drive Axle Lubricants. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Lubricant Capacities

Use the following lubricant capacities as a guide only. The capacities are measured with the drive pinion in the horizontal position. When the angle of the drive pinion changes, the lubricant capacity of the axle will change.

Table I

Axle Model	Capacity U.S. Pints	Capacity Liters*
Single Drive Axles		
MX-10-120	16.0	7.6
MX-12-120	16.0	7.6
MX-14-120	16.0	7.6
MX-16-120	16.0	7.6
MX-21-160/160R	43.0	20.0
MX-23-160/160R	43.0	20.0
RF-7-120	15.3	7.2
RF-9-120	15.3	7.2
RF-12-120	15.3	7.2
RF-12-125	15.3	7.2
RF-16-145	36.4	17.2
RF-21-155	27.9	13.2
RF-21-156	27.9	13.2
RF-21-160	43.7	20.7
RF-21-185	39.3	18.6
RF-21-355	28.0	13.2
RF-22-166	43.7	20.7
RF-23-180	39.3	18.6
RF-23-185	39.3	18.6
RS-13-120	15.0	7.2
RS-15-120	15.0	7.2
RS-16-140	33.6	15.9
RS-16-141	33.6	15.9
RS-16-145	33.6	15.9
RS-17-140	32.0	15.4
RS-17-141	33.6	15.9
RS-17-144	32.3	15.3
RS-17-145	33.6	15.9
RS-19-144	32.3	15.3
RS-19-145	36.0	17.3
RS-21-145	35.0	16.9
RS-21-160	39.5	18.7
RS-23-160	43/41	20.7/19.5
RS-23-160A	39.5	18.7
RS-23-161/161A	37.2	17.6
RS-23-180	39.0	18.6
RS-23-185	39.0	18.6
RS-23-186	39.0	18.6
RS-25-160	39.0	18.6

Axle Model	Capacity U.S. Pints	Capacity Liters*
Single Drive Axles		
RS-25-160A	37.2	17.6
RS-26-160	51.0	24.2
RS-26-180	38.0	18.3
RS-26-185	38.0	18.3
RS-30-180	38.0	18.3
RS-30-185	38.0	18.3

* Includes 1 pint (0.97 liter) for each wheel end and with drive pinion angle at 3°.

Axle Model	Capacity U.S. Pints	Capacity Liters
Rear Axle of Tandems		
RT-34-140 (RR-17-140)	35.0	16.9
RT-34-144	25.8	12.2
RT-34-145 (RR-17-145 rear)	36.0	17.1
RT-34-145P	25.4	12.0
RT-34-146	25.4	12.0
RT-40-140 (RR-20-140)	35.0	16.9
RT-40-145/149 (RR-20-145 rear)	36.0	17.3
RT-40-145P	25.8	12.2
RT-40-146	25.8	12.2
RT-40-160	34.4	16.3
RT-40-169	34.4	16.3
RT-44-145 (RR-22-145 rear)	35.0	16.9
RT-44-145P	25.1	11.9
RT-46-160/169 (RR-23-160 rear)	43/41	20.7/19.5
RT-46-160A/160P	34.4	16.3
RT-46-164	33.2	15.7
RT-46-164EH/16HEH	33.2	15.7
RT-48-180 (RR-24-180 rear)	39.0	18.6
RT-50-160/160P	33.2	15.7
RT-52-160 (RR-26-160 rear)	51.0	24.2
RT-52-180/185 (RR-26-180 rear)	39.0	18.3
RT-58-180/185 (RR-29-180 rear)	39.0	18.3

Torque Values for Fasteners

General Information

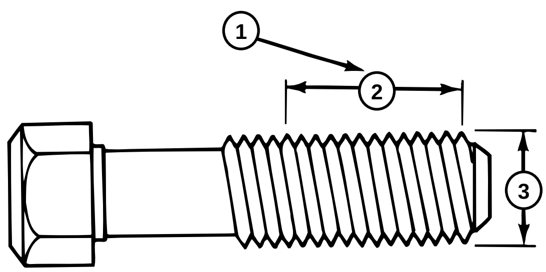
1. The torque values in **Table J** are for fasteners that have a light application of oil on the threads.
   - **If the fasteners are dry:** Increase the torque values by 10%.
   - **If the fasteners have a heavy application of oil on the threads:** Decrease the torque values by 10%.
2. If you do not know the size of the fastener that is being installed, measure the fastener. Use the following procedure.

American Standard Fasteners

A. Measure the diameter of the threads in inches, dimension X. **Figure 7.1.**

B. Count the amount of threads in 1-inch. **Figure 7.1.**

Figure 7.1



1 AMOUNT OF THREADS IN 1"
2 1"
3 X
X DIMENSION = EXAMPLE 1/2"

Example

- American Standard size fastener is 0.50-13.
  - — 0.50 is the diameter of the fastener in inches or dimension X.
  - — 13 is the amount of threads in 1-inch.

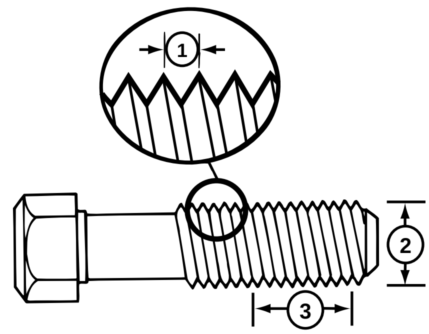
Metric Fasteners

A. Measure the diameter of the threads in millimeters (mm), dimension X. **Figure 7.2.**

B. Measure the distance of 10 threads, point to point in millimeters (mm), dimension Y. Make a note of dimension Y. **Figure 7.2.**

C. Divide dimension Y by 10. The result will be the distance between two threads or pitch.

Figure 7.2



1 PITCH
2 X
3 Y
X DIMENSION = EXAMPLE M8 OR 8 MM
Y DIMENSION = DISTANCE OF 10 THREADS

Example

- Metric size fastener is M8 x 1.25.
  - — M8 is the diameter of the fastener in millimeters (mm) or dimension X.
  - — 1.25 is the distance between two threads or pitch.

3. Compare the size of fastener measured in Step 2 to the list of fasteners in **Table J** to find the correct torque value.

Figure 7.3

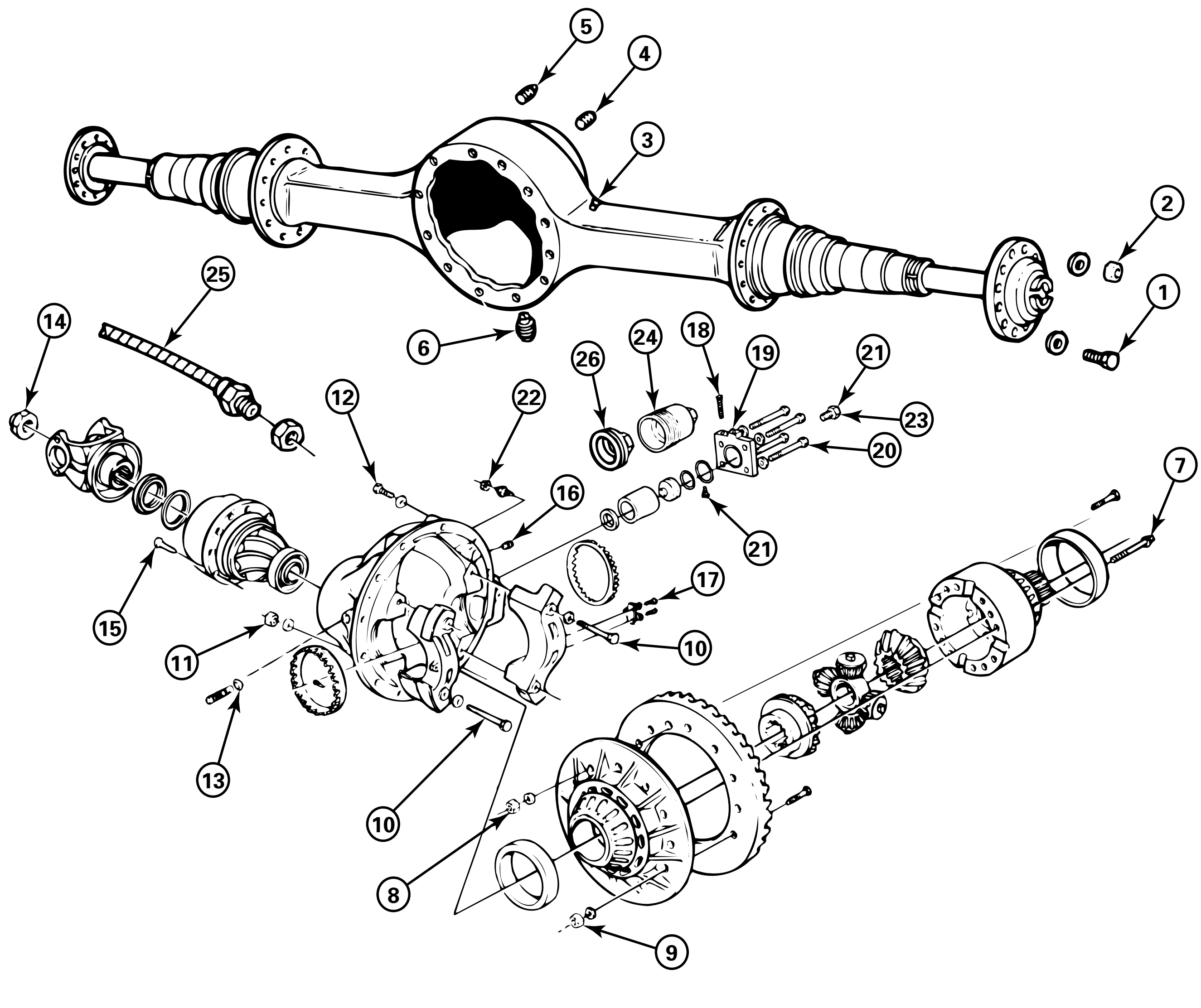


Table J: Torque Chart

Fastener		Thread Size	Torque Value lb-ft (N•m)	
1.	Capscrew, Axle Shaft	.31-24 .50-13	18-24 85-115	(24-33) (115-156)
2.	Nut, Axle Shaft Stud	Plain Nut .44-20 .50-20 .56-18 .62-18 Lock Nut .44-20 .50-20 .56-18 .62-18	50-75 75-115 110-165 150-230 40-65 65-100 100-145 130-190	(68-102) (102-156) (149-224) (203-312) (54-88) (88-136) (136-197) (176-258)
3.	Breather	.38-18	20 minimum (27 minimum)	
4.	Plug, Oil Fill, Housing	.75-14	35 minimum (47.5 minimum)	
5.	Plug, Heat Indicator	.50-14	25 minimum (34 minimum)	
6.	Plug, Oil Drain	.50-14	25 minimum (34 minimum)	
7.	Capscrew, Differential Case Grade 10.9 Flange Head Grade 10.9 Standard Hex Head Grade 12.9 Standard Hex Head Grade 12.9 Flange Head Grade 12.9 Standard Head	.38-16 .44-14 .50-13 .56-12 .62-11 M12 x 1.75 M12 x 1.75 M12 x 1.75 M16 x 2 M16 x 2	35-50 60-75 85-115 130-165 180-230 85-103 74-96 105-125 203-251 220-310	(48-68) (81-102) (115-156) (176-224) (244-312) (115-140) (100-130) (143-169) (275-340) (300-420)
8.	Nut, Differential Case Bolt	.50-13 .50-20 .62-11 .62-18 M12 x 1.75 M16 x 2	75-100 85-115 150-190 180-230 74-96 220-310	(102-136) (115-156) (203-258) (244-312) (100-130) (300-420)
9.	Nut, Ring Gear Bolt Flange Head Standard Hex Head	.50-13 .50-20 .62-11 .62-18 M12 x 1.25 M12 x 1.75 M16 x 1.5 M16 x 1.5	75-100 85-115 150-190 180-230 66-81 77-85 192-214 196-262	(102-136) (115-156) (203-258) (244-312) (90-110) (104-115) (260-190) (265-355)
10.	Capscrew, Bearing Cap	.56-12 .62-11 .75-10 .88-14 .88-9 M16 x 2 M20 x 2.5 M22 x 2.5	110-145 150-190 270-350 360-470 425-550 181-221 347-431 479-597	(149-197) (203-258) (366-475) (488-637) (576-746) (245-300) (470-585) (650-810)
11.	Nut, Housing to Carrier Stud	.44-20 .50-20 .56-18 .62-18	50-75 75-115 110-165 150-230	(68-102) (102-156) (149-224) (203-312)
12.	Capscrew, Carrier to Housing	.44-14 .50-13 .56-12 .62-11 .75-10 M12 x 1.75 M16 x 2	50-75 75-115 110-165 150-230 270-400 74-89 181-221	(68-102) (102-156) (149-224) (203-312) (366-542) (100-120) (245-300)

Table J: Torque Chart, Continued

Fastener		Thread Size	Torque Value lb-ft (N•m)	
13.	Jam Nut, Thrust Screw	.75-16 .88-14 1.12-16 M22 x 1.5 M30 x 1.5	150-190 150-300 150-190 148-210 236-295	(203-258) (203-407) (203-258) (200-285) (320-400)
14.	Input Yoke-to-Input Shaft Nut	Refer to **Table K**.		
15.	Capscrew, Bearing Cage	.38-16 .44-14 .50-13 .56-12 .62-11 M12 x 1.75	30-50 50-75 75-115 110-165 150-230 70-110	(41-68) (68-102) (102-156) (149-224) (203-312) (90-150)
16.	Plug, Oil Fill, Carrier	.75-14 1.5-11.5 M24 x 1.5	25 minimum (34 minimum) 120 minimum (163 minimum) 35 minimum (47 minimum)	
17.	Capscrew, Lock Plate	.31-18 M8 x 1.25	20-30 21-26	(27-41) (28-35)

Torque Values are for Carriers with Bolt-On Style Differential Lock Cylinders

Fastener		Thread Size	Torque Value lb-ft (N•m)	
18.	Capscrew, Manual Actuation, Storage Position	M10 x 1.5	15-25	(20-35)
19.	Adapter, Air Cylinder	M12 x 1.5	22-30	(30-40)
20.	Capscrew, Air Cylinder Cover	M6 x 1	7-12	(10-16)
21.	Capscrew/Plug, Air Cylinder Cover Operating Position Storage Position	M10 x 1.5	 15-25 15-25	 (20-35) (20-35)
22.	Lock Nut, Sensor Switch	M16 x 1	25-35	(35-45)

Torque Values are for Carriers with Screw-In Style Differential Lock Cylinders

Fastener		Thread Size	Torque Value lb-ft (N•m)	
23.	Capscrew, Manual Actuation, Storage Position	M10 x 1.25	7-11	(10-15)
24.	Air Cylinder	M60 x 2.0	80-100	(109-136)
25.	Sensor Switch	M16 x 1.0	25-35	(35-45)
26.	Screw-In DCDL Cylinder Plug or Cap	M60 x 2.0	80-100	(109-136)

Table K: Input and Output Yoke Pinion Nut Fastener Torque Specifications

Single and Rear of Tandem Axles

Axle Model / Pinion Nut Location	RS-120, RS-125, RS-140	RS-144/145	RF-166, RS-160, RS-161, RS-185, RS-186	RS-210, RS-220, RS-230	RS-240	RS-380
Carrier Input Yoke	740-920 lb-ft (1000-1245 N•m)	920-1130 lb-ft (1250-1535 N•m)	1000-1230 lb-ft (1350-1670 N•m)	740-920 lb-ft (1000-1245 N•m)	740-920 lb-ft (1000-1245 N•m)	800-1100 lb-ft (1085-1496 N•m)
Fastener Size	M32 x 1.5	M39 x 1.5	M45 x 1.5	M32 x 1.5	M39 x 1.5	1-1/2 - 12 UNF

Drive Pinion Bearings — Preload (Refer to Section 4)

Specification	New bearings 15-25 lb-in (1.7-2.8 N•m) Used bearings 5-25 lb-in (1.7-2.8 N•m)
Adjustment	Preload is controlled by the thickness of the spacer between bearings. To increase preload, install a thinner spacer To decrease preload, install a thicker spacer

Drive Pinion — Depth in Carrier (Refer to Section 4)

Specification	Install the correct amount of shims between the bearing cage and carrier. To calculate, use old shim pack thickness and new and old pinion cone numbers.
Adjustment	Change the thickness of the shim pack to get a good gear tooth contact pattern.

Hypoid Gear Set — Tooth Contact Patterns (Hand Rolled) (Refer to Section 4)

Specification	Conventional gear set Toward the toe of the gear tooth and in the center between the top and bottom of the tooth Generoid gear set Between the center and toe of the tooth and in the center between the top and bottom of the tooth
Adjustment	Tooth contact patterns are controlled by the thickness of the shim pack between the pinion bearing cage and carrier and by ring gear backlash To move the contact pattern lower, decrease the thickness of the shim pack under the pinion bearing cage To move the contact pattern higher, increase the thickness of the shim pack under the pinion bearing cage To move the contact pattern toward the toe of the tooth, decrease backlash of the ring gear To move the contact pattern toward the heel of the tooth, increase backlash of the ring gear

Main Differential Bearings — Preload (Refer to Section 4)

Specification	15-35 lb-in (1.7-3.9 N•m) or Expansion between bearing caps RS-140, RS-145 and RS-160 carrier models — 0.002-0.009-inch (0.05-0.229 mm) All other carrier models — 0.006-0.013-inch (0.15-0.33 mm)
Adjustment	Preload is controlled by tightening both adjusting rings after zero end play is reached

Main Differential Gears — Rotating Resistance (Refer to Section 4)

Specification	50 lb-ft (68 N•m) torque applied to one side gear

Ring Gear — Backlash (Refer to Section 4)

Specification	Ring gears that have a pitch diameter of less than 17-inches (431.8 mm) Range: 0.008-0.018-inch (0.20-0.46 mm) 0.012-inch (0.30 mm) for a new gear set Ring gears that have a pitch diameter of 17-inches (431.8 mm) or greater Range: 0.010-0.020-inch (0.25-0.51 mm) 0.015-inch (0.38 mm) for a new gear set
Adjustment	Backlash is controlled by the position of the ring gear. Change backlash within specifications to get a good tooth contact pattern. To increase backlash, move the ring gear away from the drive pinion To decrease backlash, move the ring gear toward the drive pinion

Ring Gear — Runout (Refer to Section 4)

Specification	0.008-inch (0.20 mm) maximum

DCDL Sensor Switch — Installation (Refer to Section 4)

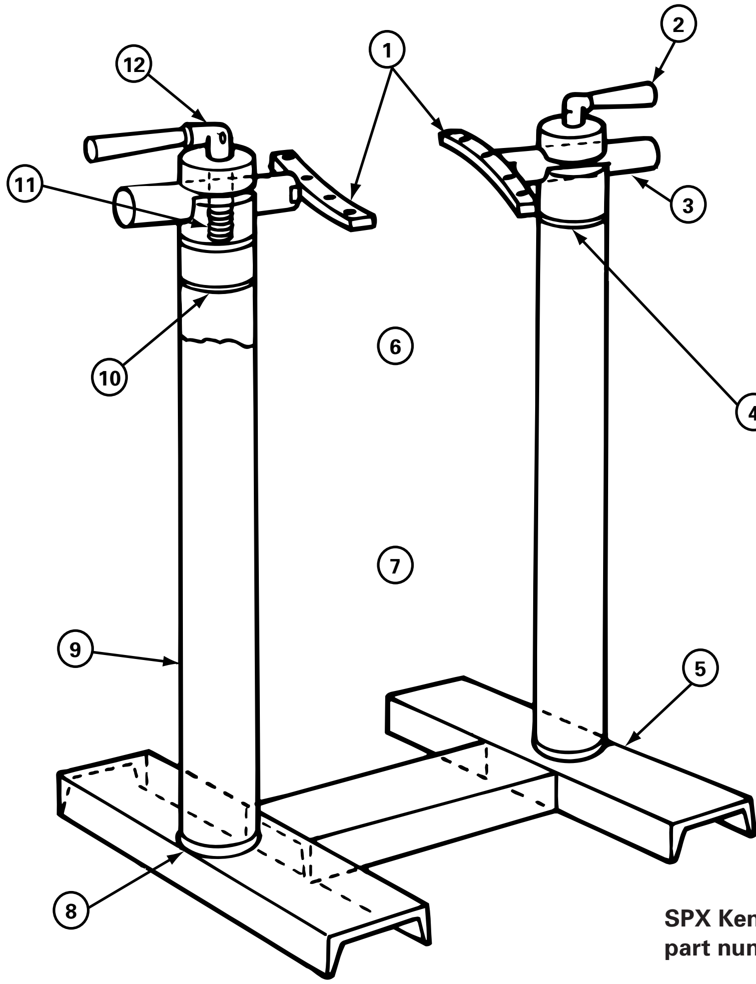
Specification	Shift the differential to the locked position. Tighten the sensor switch into the carrier until the test light comes on. Tighten the sensor switch one additional turn and tighten lock nut to correct torque value.

Spigot Bearing — Peening on the Drive Pinion (Refer to Section 5)

Specification	Apply 6,614 lb (3000 kg) load on a 0.375-inch (10 mm) ball. Peen the end of the drive pinion at a minimum of five points. Softening of the pinion stem end by heating may be required.

Carrier Repair Stand Specifications

Figure 9.1



SPX Kent-Moore
part number J-3409-D

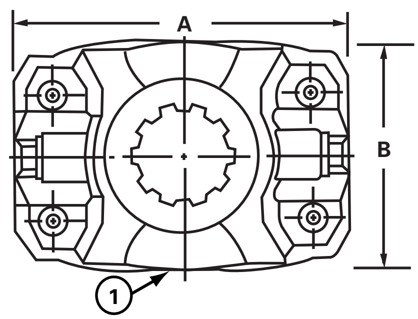
1 PLATES 8′ LONG X 3/4″ THICK X 1-1/4″ WIDE WITH A TONGUE TO FIT SLOT IN BAR WELD PLATES TO BAR
2 HANDLE 7″ LONG WITH SLOT IN ONE END TO FIT CLAMP SCREW
3 BAR 2″ DIAMETER X 9″ LONG WITH ONE END SLOTTED TO FIT PLATE
4 WELD ALL AROUND AFTER PRESSING PLUG IN PIPE
5 WELD
6 SHAPE AND SIZE OF HOLES TO FIT CARRIER
7 23-1/2″ CENTER TO CENTER OF PIPE
8 CHAMFER END OF PIPE FOR WELDING
9 4″ DIAMETER PIPE
10 PLUG 4″ DIAMETER X 7″ LONG WITH ONE END TURNED 3″ LONG TO FIT PIPE. DRILL 2″ HOLE AND MILL 3/16″ WIDE SLOT 2″ FROM TOP
11 SCREW 3-1/2″ LONG X 5/8″ DIAMETER WITH FLATS ON END TO FIT HANDLE AND 2-1/2″ LENGTH OF THREAD ON OTHER END
12 DRILL 3/8″ HOLE THROUGH HANDLE AND SCREW

To obtain a repair stand, refer to the Service Notes page on the front inside cover of this manual.

How to Make a Yoke Bar

1. Measure dimensions A and B of the yoke you are servicing. **Figure 9.2.**

Figure 9.2



1 YOKE

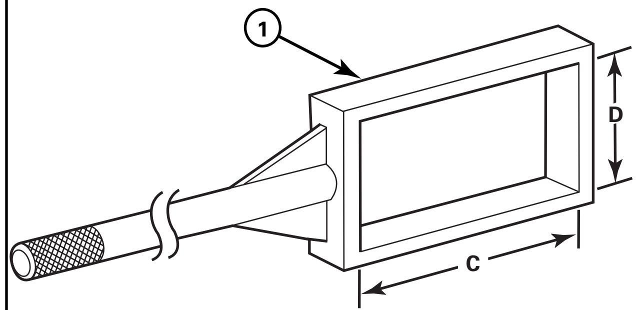
2. Calculate dimensions C and D of the yoke bar by adding 0.125-0.250-inch to dimensions A and B of the yoke. **Figure 9.3.**

WARNING

Wear safe clothing and eye protection when you use welding equipment. Welding equipment can burn you and cause serious personal injury. Follow the operating instructions and safety procedures recommended by the welding equipment manufacturer.

3. To make the box section, cut and weld 1.0-inch x 2.0-inch mild steel square stock according to dimensions C and D. **Figure 9.3.**
4. Cut a 4.0-foot x 1.25-inch piece of mild steel round stock to make the yoke bar handle. Center weld this piece to the box section. **Figure 9.3.**
   - **To increase yoke bar rigidity**: Weld two angle pieces onto the handle. **Figure 9.3.**

Figure 9.3

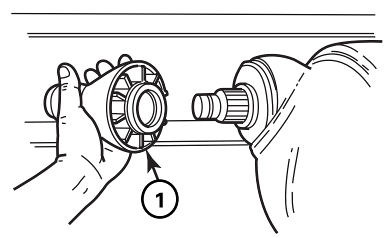


1 YOKE BAR

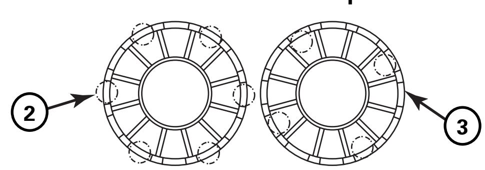
Unitized Pinion Seals and Seal Drivers

Refer to **Table L** and **Figure 9.4** for information on unitized pinion seals and seal drivers.

Figure 9.4



Position the seal driver to prevent the driver spokes from hitting the fastener heads on the forward tandem output seals.



1 SEAL DRIVER
2 FASTENER HEADS
3 SEAL DRIVER R4422401

Table L: Unitized Pinion Seals and Seal Drivers

<table>
<tr><th>Single Models</th><th>Tandem Models</th><th>Meritor Unitized Pinion Seal</th><th>Seal Installation Location</th><th>Meritor Seal Driver</th><th>Yoke Seal Diameter Inches</th></tr>
<tr><td rowspan="4">MX-21-160
MX-23-160R
RF-16-145
RF-21-160
RF-22-166
RF-23-185
RS-17-145
RS-19-145
RS-21-145
RS-21-160
RS-23-160 /A
RS-23-161 /A
RS-25-160 /A
RS-23-186
RS-26-185
RS-30-185</td><td rowspan="4">RT-34-144 /P
RT-34-145 /P
RT-40-145 /A /P
RT-40-149 /A /P
RT-44-145 /P
RT-40-160 /A /P
RT-40-169 /A /P
RT-46-160 /A /P
RT-46-169 /A /P
RT-46-164EH /P
RT-46-16HEH /P
RT-50-160 /P
RT-52-185*
RT-58-185*</td><td>A-1205-R-2592</td><td>Tandem Forward Input — 145 models from 11-93 to present</td><td>R4422402</td><td>3.250
3.255</td></tr>
<tr><td>A-1205-P-2590</td><td>Tandem Forward Output — Tandem Forward Input 145 models before 11/93 with seal A-1205-F-2424</td><td>R4422401</td><td>3.000
3.005</td></tr>
<tr><td>A-1205-N-2588</td><td>Tandem and Single Rear Input — 145 models</td><td>R4422401</td><td>3.000
3.005</td></tr>
<tr><td>A-1205-Q-2591</td><td>Tandem and Single Rear Input — 160/164/185 models</td><td>R4422402</td><td>3.250
3.255</td></tr>
<tr><td colspan="6">To obtain Meritor seal driver KIT 4454, refer to the Service Notes page on the front inside cover of this manual.</td></tr>
</table>

* Forward and rear input only.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

Before you service a spring chamber, carefully follow the manufacturer's instructions to compress and lock the spring to completely release the brake. Verify that no air pressure remains in the service chamber before you proceed. Sudden release of compressed air can cause serious personal injury and damage to components.

Engage the parking brake to prevent the vehicle from moving before you begin maintenance or service procedures that require you to be under the vehicle. Serious personal injury can result.

CAUTION

If the vehicle is equipped with a front drive axle, tow the vehicle from the front, with the front wheels off the ground. If this is not possible, you must remove the front drive shaft before towing. Damage to components can result.

Do not use a chisel or wedge to loosen the axle shaft and tapered dowels. Using a chisel or wedge can result in damage to the axle shaft, the gasket and seal, and the axle hub.

NOTE: For complete towing information, refer to Technical Bulletin TP-9579, Driver Instruction Kit. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

These instructions supersede all other instructions for the purpose of transporting vehicles for service or new vehicle drive-away dated before April 1995, including those contained in Meritor Maintenance Manuals.

When transporting a vehicle with the wheels of one or both drive axles on the road, it is possible to damage the axles if the wrong procedure is used before transporting begins. Meritor recommends that you use the following procedure.

Type of Axle

These instructions are for vehicles equipped with the following Meritor single or tandem rear drive axles.

- Single Axle, with Driver-Controlled Main Differential Lock (DCDL — Screw-In [threaded] shift assembly)
- Tandem Axle, with Driver-Controlled Main Differential Lock (DCDL — Screw-In [threaded] shift assembly) and with Inter-Axle Differential (IAD)

Before Towing or Drive-Away

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Apply the vehicle parking brakes using the switch inside the cab of the vehicle.
3. Shift the transmission into neutral and start the vehicle's engine.
4. Shift the DCDL and the IAD to the unlocked or disengaged positions using the switches inside the cab of the vehicle. The indicator lights in the cab will go off.
5. Stop the engine.

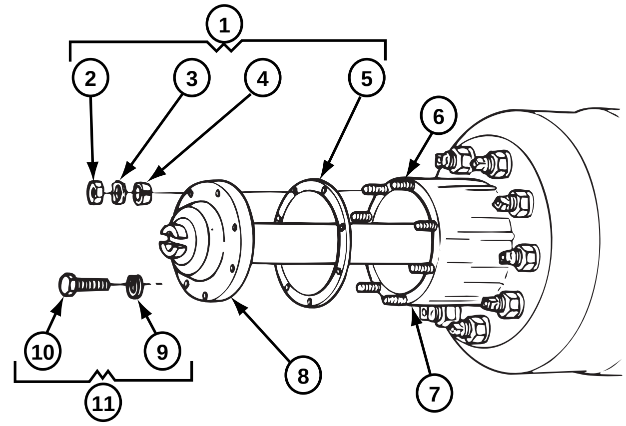
NOTE: Remove only the axle shaft(s), shown in **Table M** at this time, from the axle(s) that will remain on the road when the vehicle is transported.

Table M

Single Axles Remove the left-hand (road side) axle shaft
Tandem Axles **Forward Axle:** Remove the right-hand (curb side) axle shaft **Rear Axle:** Remove the left-hand (road side) axle shaft

6. Remove the stud nuts or capscrews and the washers from the flange of the axle shaft. **Figure 10.1.**

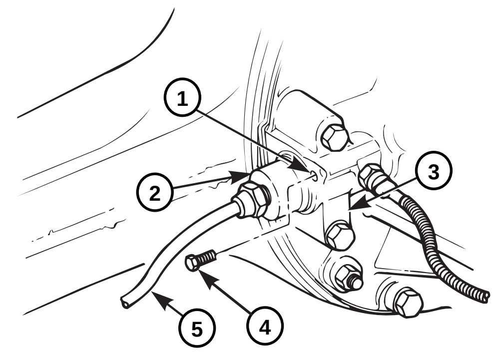
Figure 10.1



1 TAPERED DOWEL RETENTION
2 STUD NUT
3 WASHER
4 TAPERED DOWEL
5 GASKET
6 STUD
7 SHAFT HUB AXLE
8 AXLE SHAFT OR FLANGE
9 WASHER
10 CAPSCREW
11 NON-TAPERED DOWEL RETENTION

7. Loosen the tapered dowels, if used, in the flange of the axle shaft. **Figure 10.1**. Refer to Section 2.
8. Identify each axle shaft that is removed from the axle assembly so they can be installed in the same location after transporting or repair is completed.
9. Remove the tapered dowels, gasket, if used, and the axle shaft from the axle assembly. **Figure 10.1**.
10. Disconnect the air hose from the shift cylinder. **Figure 10.2**.
11. Remove the manual engaging capscrew from the storage hole. The storage hole of threaded shift assemblies is located in the shift tower of the carrier, next to the cylinder. **Figure 10.2**.
12. Lock or engage the main differential using the Manual Engaging Method. Refer to Section 5.
13. Remove the remaining axle shaft(s) from the axle(s) that will remain on the road when the vehicle is transported.
14. Install a cover over the open end of each hub where an axle shaft was removed. This will prevent dirt from entering the bearing cavity and loss of lubricant.

Figure 10.2



1 STORAGE HOLE
2 CYLINDER
3 SHIFT TOWER
4 MANUAL ENGAGING CAPSCREW
5 AIR HOSE

THREADED SHIFT ASSEMBLY

NOTE: If an air supply will be used for the brake system of the transported vehicle, continue with Steps 15 and 16, otherwise continue with Step 17.

15. Connect an auxiliary air supply to the brake system of the vehicle that is being transported. Before moving the vehicle, charge the brake system with the correct amount of air pressure to operate the brakes. Refer to the instructions, supplied by the manufacturer of the vehicle for procedures and specifications. If an auxiliary air supply is not used, continue with Step 17.
16. When the correct amount of air pressure is in the brake system, release the parking brakes of the vehicle that is being transported. Step 17 is not required.
17. If there are spring or parking brakes on the axle(s) that will remain on the road when the vehicle is transported, and they cannot be released by air pressure, manually compress and lock each spring so that the brakes are released. Refer to the manufacturer's instructions.

After Towing or Drive-Away

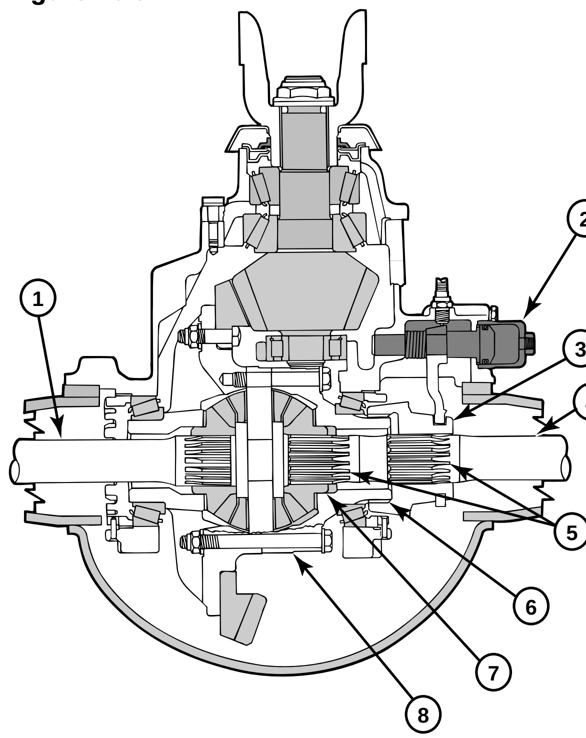
1. If an auxiliary air supply was used, apply the vehicle parking brakes using the switch inside the cab of the vehicle. If an auxiliary air supply was not used, begin with Step 2.
2. Apply the vehicle spring or parking brakes by manually releasing each spring that was compressed before transporting started. Refer to the manufacturer's instructions.
3. Disconnect the auxiliary air supply, if used, from the brake system of the vehicle that was transported. Connect the vehicle's air supply to the brake system.
4. Remove the covers from the hubs.

NOTE: Install only the axle s haft(s) shown in **Table N** at this time. These axle shafts have a double row of splines that engage with splines of the side gear and shift collar in the main differential. **Figure 10.3**.

Table N

Single Axles	Install the right-hand (curb side) axle shaft
Tandem Axles — **Forward Axle:**	Install the left-hand (road side) axle shaft
Tandem Axles — **Rear Axle:**	Install the right-hand (curb side) axle shaft

Figure 10.3



1 LEFT-HAND, ROAD SIDE, AXLE SHAFT
2 SHIFT ASSEMBLY
3 SHIFT COLLAR
4 RIGHT-HAND, CURB SIDE, AXLE SHAFT
5 DOUBLE ROW OF SPLINES
6 SHIFT COLLAR AND DIFFERENTIAL CASE SPLINES ENGAGED OR LOCKED
7 SIDE GEAR
8 DIFFERENTIAL CASE

SINGLE AXLE OR REAR AXLE OF TANDEM SHOWN WITH SCREW-IN SHIFT ASSEMBLY AND IN THE LOCKED OR ENGAGED POSITION

5. Install the gasket, if used, and axle shaft into the axle housing and carrier in the same location. The gasket and flange of the axle shaft must be flat against the hub. Rotate the axle shaft or the driveline as necessary to align the splines and the holes in the flange with the studs in the hub. **Figure 10.1**.
6. Install the dowels, if used, over each stud and into the tapered holes of the flange.
7. Install the washers and capscrews or stud nuts. Determine the size of the fasteners and tighten the capscrews or nuts to the torque value shown in the following table.

Fastener	Thread Size	Torque Value lb-ft (N•m)
Capscrews	0.31″-24 0.50″-13	18-24 (24-33) 85-115 (115-156)
Stud Nuts plain nut	0.44″-20 0.50″-20 0.56″-18 0.62″-18 0.75″-16	50-75 (68-102) 75-115 (102-156) 110-165 (149-224) 150-230 (203-312) 310-400 (420-542)
lock nut	0.44″-20 0.50″-20 0.56″-18 0.62″-18 0.75″-16	40-65 (54-88) 65-100 (88-136) 100-145 (136-197) 130-190 (176-258) 270-350 (366-475)

8. Unlock or disengage the DCDL by removing the manual engaging capscrew from the shift assembly.
9. Install the manual engaging capscrew into the storage hole. The storage hole of threaded shift assemblies is located in the shift tower of the carrier next to the cylinder. Tighten the capscrew to 15-25 lb-ft (20-35 N•m). **Figure 10.2.** T
10. Connect the air hose to the shift cylinder. Tighten the air hose to 22-30 lb-ft (30-40 N•m). T
11. Install the remaining axle shaft into the axle housing and carrier.
12. Check the lubricant level in the axles and hubs where the axle shafts were removed. Add the correct type and amount of lubricant if necessary. Refer to Section 6.

Type of Axle

These instructions are for vehicles equipped with the following Meritor single or tandem rear drive axles.

- Single Axle, with Driver-Controlled Main Differential Lock (DCDL — Bolt-On shift assembly)
- Tandem Axle, with Driver-Controlled Main Differential Lock (DCDL — Bolt-On shift assembly) and with Inter-Axle Differential (IAD)

Before Towing or Drive-Away

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Apply the vehicle parking brakes using the switch inside the cab of the vehicle.
3. Shift the transmission into neutral and start the vehicle's engine.
4. Shift the DCDL and the IAD to the unlocked or disengaged positions using the switches inside the cab of the vehicle. The indicator lights in the cab will go off.
5. Stop the engine.

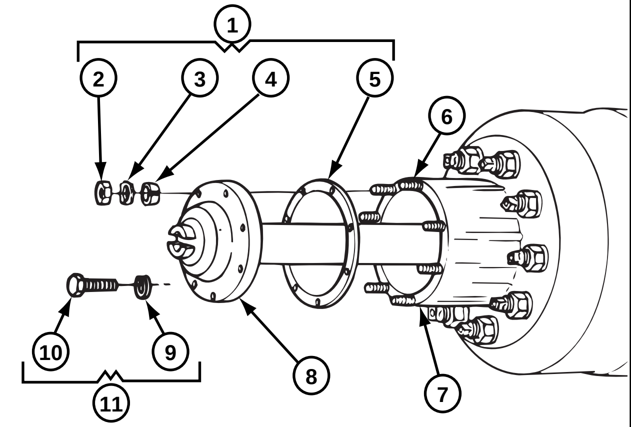
NOTE: Remove only the axle shaft(s), shown in **Table O** at this time, from the axle(s) that will remain on the road when the vehicle is transported.

Table O

Single Axles Remove the left-hand (road side) axle shaft
Tandem Axles **Forward Axle:** Remove the right-hand (curb side) axle shaft **Rear Axle:** Remove the left-hand (road side) axle shaft

6. Remove the stud nuts or capscrews and the washers from the flange of the axle shaft. **Figure 10.4.**

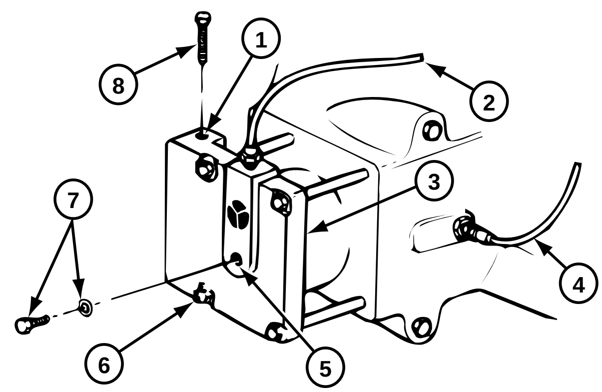
Figure 10.4



1	TAPERED DOWEL RETENTION	6	STUD
2	STUD NUT	7	SHAFT HUB AXLE
3	WASHER	8	AXLE SHAFT OR FLANGE
4	TAPERED DOWEL	9	WASHER
5	GASKET	10	CAPSCREW
		11	NON-TAPERED DOWEL RETENTION

7. Loosen the tapered dowels, if used, in the flange of the axle shaft. **Figure 10.4**. Refer to Section 2.
8. Identify each axle shaft that is removed from the axle assembly so they can be installed in the same location after transporting or repair is completed.
9. Remove the tapered dowels, gasket, if used, and the axle shaft from the axle assembly. **Figure 10.5**.
10. Remove the manual engaging capscrew from the storage hole. The storage hole of bolted-on shift assemblies is located in the top side of the shift cylinder cover. **Figure 10.5**.

Figure 10.5



1 TOP STORAGE HOLE FOR MANUAL ENGAGING CAPSCREW
2 AIR LINE
3 CYLINDER COVER
4 WIRE
5 SERVICE POSITION CAPSCREW HOLE
6 BOTTOM STORAGE HOLE FOR PLUG AND GASKET
7 PLUG AND GASKET
8 MANUAL ENGAGING CAPSCREW

BOLT-ON SHIFT ASSEMBLY

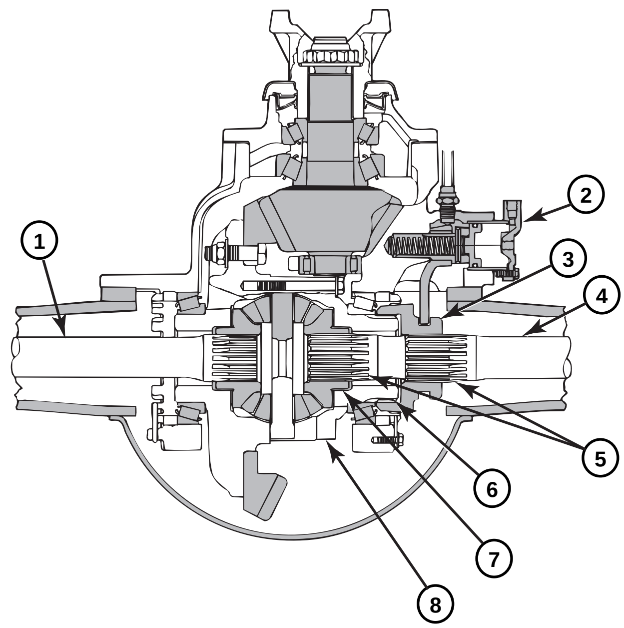
11. Remove the plug and gasket from the center of the shift cylinder cover. Install the plug and gasket into the bottom side storage hole of the shift cylinder cover on the opposite end of the storage hole for the manual engaging capscrew. Tighten the plug to 15-25 lb-ft (20-35 N•m). **Figure 10.5.** T
12. Lock or engage the main differential using one of the two following methods: Air Pressure Method or Manual Engaging Method.

13. Lock or engage the main differential using the air pressure method.
    A. Install the manual engaging capscrew into the threaded hole in the center of the cylinder cover. Turn the capscrew to the right three to five turns. **Figure 10.7**.
    B. Shift the transmission into neutral and start the vehicle's engine. Let the engine idle to increase the pressure in the air system. Do not release the parking brakes.
    C. Shift the main differential to the locked or engaged position using the switch inside the cab of the vehicle. When the differential is locked, the indicator light in the cab will go on. If the light does not go on it will be necessary to rotate the main driveline or the IAD by hand until the main differential is locked and the indicator light goes on.

NOTE: When the shift collar is completely engaged with the splines of the main differential case, the differential is locked and the driveline cannot be rotated. **Figure 10.6**.

    D. While the differential is held in the locked position by air pressure, turn the manual engaging capscrew to the right until you feel resistance against the piston. Stop turning the capscrew.
    E. Place the main differential lock switch in the unlocked or disengaged position.
    F. Stop the engine. Proceed to Step 15.

Figure 10.6



1 LEFT-HAND, ROAD SIDE, AXLE SHAFT
2 SHIFT ASSEMBLY
3 SHIFT COLLAR
4 RIGHT-HAND, CURB SIDE, AXLE SHAFT
5 DOUBLE ROW OF SPLINES
6 SHIFT COLLAR AND DIFFERENTIAL CASE SPLINES ENGAGED OR LOCKED
7 SIDE GEAR
8 DIFFERENTIAL CASE

SINGLE AXLE OR REAR AXLE OF TANDEM SHOWN WITH BOLTED-ON SHIFT ASSEMBLY AND SHOWN IN THE LOCKED OR ENGAGED POSITION

14. Lock or engage the main differential using the manual engaging method.

CAUTION

When you turn the manual engaging capscrew and you feel a high resistance, stop turning the capscrew. A high resistance against the capscrew indicates that the splines of the shift collar and differential case are not aligned. Damage to the threads of the cylinder cover and capscrew will result.

A. Install the manual engaging capscrew into the threaded hole in the center of the cylinder cover. **Figure 10.7**.

B. Turn the capscrew to the right until the head is approximately 0.25-0.50-inch (6.4-12.7 mm) from the cylinder cover. The capscrew is now in the service position and the main differential is locked or engaged. **Figure 10.8**. When you turn the capscrew you will feel a small amount of resistance. This is normal.

- **If you feel a high resistance before achieving the 0.25-0.50-inch (6.4-12.7 mm) distance between the capscrew head and cylinder**: Stop turning the capscrew and continue with Steps C, D and E.

C. Rotate the main driveline or the IAD a small amount by hand.

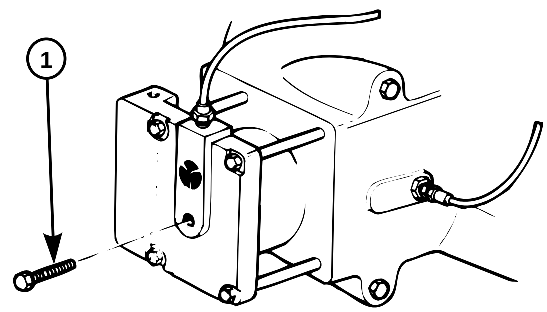
D. Turn the manual engaging capscrew again to the right. If you still feel a high resistance, stop turning the capscrew.

E. Repeat Steps C and D until you feel a low resistance on the capscrew. Continue with Step B.

15. Remove the remaining axle shaft(s) from the axle(s) that will remain on the road when the vehicle is transported.

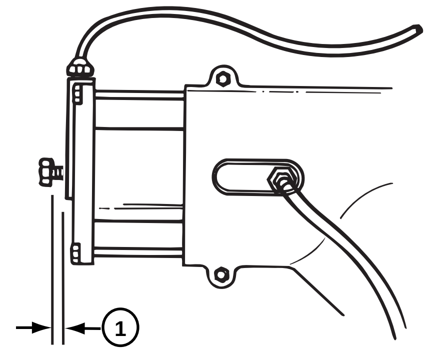
16. Install a cover over the open end of each hub where an axle shaft was removed. This will prevent dirt from entering the bearing cavity and loss of lubricant.

Figure 10.7



1 MANUAL ENGAGING CAPSCREW
BOLT-ON SHIFT ASSEMBLY

Figure 10.8



1 0.25-0.50" (6.4-12.7 MM)

NOTE: If an air supply will be used for the brake system of the transported vehicle, continue with Steps 17 and 18. Otherwise continue with Step 19.

17. Connect an auxiliary air supply to the brake system of the vehicle that is being transported. Before moving the vehicle, charge the brake system with the correct amount of air pressure to operate the brakes. Refer to the instructions supplied by the manufacturer of the vehicle for procedures and specifications. If an auxiliary air supply is not used, continue with Step 19.

18. When the correct amount of air pressure is in the brake system, release the parking brakes of the vehicle that is being transported. Step 19 is not required.

19. If there are spring or parking brakes on the axle(s) that will remain on the road when the vehicle is transported, and they cannot be released by air pressure, manually compress and lock each spring so that the brakes are released. Refer to the manufacturer's instructions.

After Towing or Drive-Away

1. If an auxiliary air supply was used, apply the vehicle parking brakes using the switch inside the cab of the vehicle. If an auxiliary air supply was not used, begin with Step 2.
2. Apply the vehicle spring or parking brakes by manually releasing each spring that was compressed before transporting started. Refer to the manufacturer's instructions.
3. Disconnect the auxiliary air supply, if used, from the brake system of the vehicle that was transported. Connect the vehicle's air supply to the brake system.
4. Remove the covers from the hubs.

NOTE: Install only the axle shaft(s) shown in **Table P** at this time. These axle shafts have a double row of splines that engage with splines of the side gear and shift collar in the main differential. **Figure 10.6**.

Table P

Single Axles Install the right-hand (curb side) axle shaft
Tandem Axles **Forward Axle**: Install the left-hand (road side) axle shaft **Rear Axle**: Install the right-hand (curb side) axle shaft

5. Install the gasket, if used, and axle shaft into the axle housing and carrier in the same location. The gasket and flange of the axle shaft must be flat against the hub. Rotate the axle shaft or the driveline as necessary to align the splines and the holes in the flange with the studs in the hub. **Figure 10.4**.
6. Install the dowels, if used, over each stud and into the tapered holes of the flange.
7. Install the washers and capscrews or stud nuts. Determine the size of the fasteners and tighten the capscrews or nuts to the torque value shown in the table below.

Fastener	Thread Size	Torque Value lb-ft (N•m)
Capscrews	0.31″-24 0.50″-13	18-24 (24-33) 85-115 (115-156)
Stud Nuts plain nut	0.44″-20 0.50″-20 0.56″-18 0.62″-18 0.75″-16	50-75 (68-102) 75-115 (102-156) 110-165 (149-224) 150-230 (203-312) 310-400 (420-542)
lock nut	0.44″-20 0.50″-20 0.56″-18 0.62″-18 0.75″-16	40-65 (54-88) 65-100 (88-136) 100-145 (136-197) 130-190 (176-258) 270-350 (366-475)

8. Unlock or disengage the DCDL by removing the manual engaging capscrew from the shift assembly.
9. Install the manual engaging capscrew into the storage hole. The storage hole of bolted-on shift assemblies is located in the top side of the shift cylinder cover. Tighten the capscrew to 15-25 lb-ft (20-35 N•m). **Figure 10.5**. T
10. Remove the plug and gasket from the storage hole. Install the plug and gasket into the threaded hole in the center of the shift cylinder cover. Tighten the plug to 15-25 lb-ft (25-30 N•m). T
11. Install the remaining axle shaft into the axle housing and carrier.
12. Check the lubricant level in the axles and hubs where the axle shafts were removed. Add the correct type and amount of lubricant if necessary. Refer to Section 6.

Type of Axle

These instructions are for vehicles equipped with the following Meritor single or tandem rear drive axles.

- Single Axle, without Driver-Controlled Main Differential Lock (DCDL)
- Tandem Axle, without Driver-Controlled Main Differential Lock (DCDL), with Inter-Axle Differential (IAD)

Before Towing or Drive-Away

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Apply the vehicle parking brakes using the switch inside the cab of the vehicle.

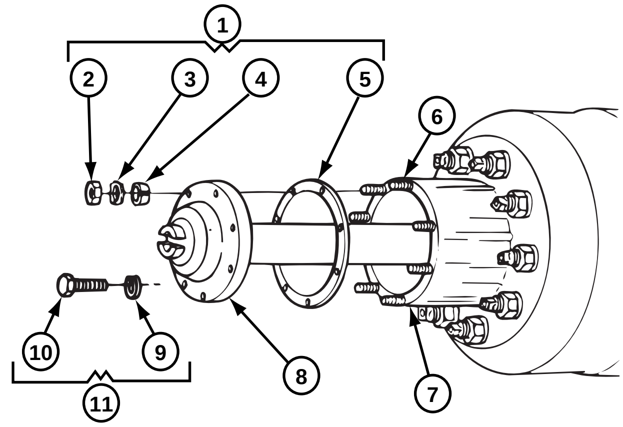
NOTE: For a single axle, continue with Step 6. For a tandem axle, continue with Step 3.

3. Shift the transmission into neutral and start the vehicle's engine.
4. Shift the IAD to the unlocked or disengaged position using the switch inside the cab of the vehicle. The indicator light in the cab will go off.
5. Stop the engine.

NOTE: Remove both axle shafts from the axle(s) that will remain on the road when the vehicle is transported.

6. Remove the stud nuts or capscrews and the washers from the flange of the axle shaft. **Figure 10.9.**
7. Loosen the tapered dowels, if used, in the flange of the axle shaft. Refer to Section 2. **Figure 10.9.**
8. Identify each axle shaft that is removed from the axle assembly so they can be installed in the same location after transporting or repair is completed.
9. Remove the tapered dowels, gasket, if used, and the axle shaft from the axle assembly. **Figure 10.9.**

Figure 10.9



1 TAPERED DOWEL RETENTION
2 STUD NUT
3 WASHER
4 TAPERED DOWEL
5 GASKET
6 STUD
7 SHAFT HUB AXLE
8 AXLE SHAFT OR FLANGE
9 WASHER
10 CAPSCREW
11 NON-TAPERED DOWEL RETENTION

10. Install a cover over the open end of each hub where an axle shaft was removed. This will prevent dirt from entering the bearing cavity and loss of lubricant.

NOTE: If an air supply will be used for the brake system of the transported vehicle, continue with Steps 11 and 12, otherwise continue with Step 13.

11. Connect an auxiliary air supply to the brake system of the vehicle that is being transported. Before moving the vehicle, charge the brake system with the correct amount of air pressure to operate the brakes. Refer to the instructions supplied by the manufacturer of the vehicle for procedures and specifications. If an auxiliary air supply is not used, continue with Step 13.
12. When the correct amount of air pressure is in the brake system, release the parking brakes of the vehicle that is being transported. Step 13 is not required.

13. If there are spring or parking brakes on the axle(s) that will remain on the road when the vehicle is transported, and they cannot be released by air pressure, manually compress and lock each spring so that the brakes are released. Refer to the manufacturer's instructions.

After Towing or Drive-Away

1. If an auxiliary air supply was used, apply the vehicle parking brakes using the switch inside the cab of the vehicle. If an auxiliary air supply was not used, begin with Step 2.
2. Apply the vehicle spring or parking brakes by manually releasing each spring that was compressed before transporting started. Refer to the manufacturer's instructions.
3. Disconnect the auxiliary air supply, if used, from the brake system of the vehicle that was transported. Connect the vehicle's air supply to the brake system.
4. Remove the covers from the hubs.
5. Install the gasket, if used, and axle shaft into the axle housing and carrier in the same location. The gasket and flange of the axle shaft must be flat against the hub. Rotate the axle shaft or the driveline as necessary to align the splines and the holes in the flange with the studs in the hub. **Figure 10.9**.
6. Install the dowels, if used, over each stud and into the tapered holes of the flange.
7. Install the washers and capscrews or stud nuts. Determine the size of the fasteners and tighten the capscrews or nuts to the torque value shown in the table below.

Fastener	Thread Size	Torque Value lb-ft (N•m)
Capscrews	0.31″-24	18-24 (24-33)
	0.50″-13	85-115 (115-156)
Stud Nuts		
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)
	0.75″-16	310-400 (420-542)
lock nut	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)
	0.75″-16	270-350 (366-475)

8. Check the lubricant level in the axles and hubs where the axle shafts were removed. Add the correct type and amount of lubricant if necessary. Refer to Section 6.

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SECTION 12: BRAKE AND AIR SYSTEM

CONTENTS

ILLUSTRATIONS

1. AIR SYSTEM

The basic air system consists of an air compressor, reservoirs, valves, filters and interconnecting lines and hoses. It provides a means for braking, operating controls and accessories, and suspension (refer to Section 16, *"Suspension"*, for complete information on suspension description and maintenance). An air system schematic diagram is annexed in the technical publications box provided with the vehicle for better understanding of the system.

2. BRAKES

This vehicle uses both the service brake and emergency/parking brake. The service brake air system is divided into two independent circuits to isolate front brakes from rear brakes, thus providing safe breaking in the event that one circuit fails. Front axle brakes operate from the secondary air system, while brakes on both the drive axle and tag axle operate from the primary air system.

***Note**: The tag axle service brake operates only when the axle is in normal ride position (loaded and down).*

Furthermore, the brake application or release, which is speed up by a pneumatic relay valve (R-12), will start with the rear axles and will be followed by the front axle, thus providing uniform braking on a slippery road. The vehicle is also equipped with an Anti-Lock Braking System (ABS), which is detailed later in this section.

The drive and tag axles are provided with spring-loaded emergency/parking brakes, which are applied automatically whenever the control valve supply pressure drops below 40 psi (275 kPa). The optional emergency/parking brake overrule system allows the driver to release spring brakes, and to move the vehicle to a safe parking place, such as in the case of a self-application of these brakes due to a drop in air pressure.

3. AIR RESERVOIRS

The air coming from the air dryer is first forwarded to the wet air tank, then to the primary (for the primary brake system), secondary (for the secondary brake system), and accessory (for the pneumatic accessories) air tanks (Fig. 1).

Two additional air reservoirs may be installed on the vehicle: the kneeling air tank and emergency/ parking brake overrule air tank.

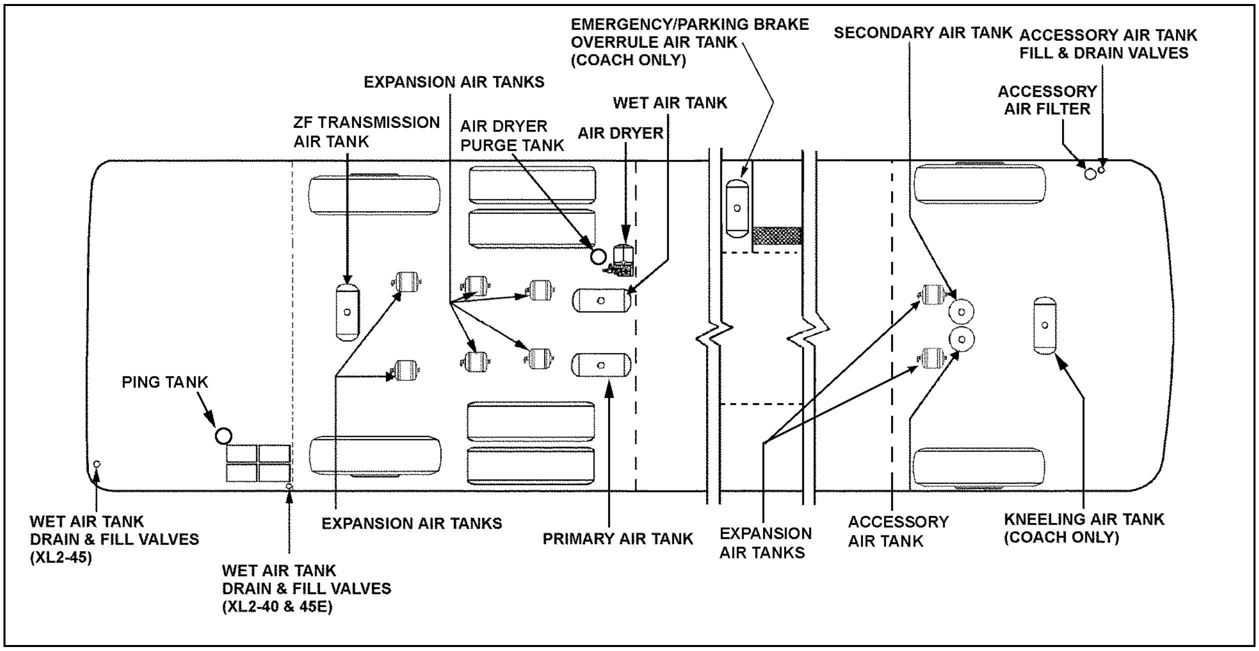


FIGURE 1: AIR RESERVOIRS LOCATION 24006

3.1 MAINTENANCE

Ensure that the wet (main) air tank is purged during pre-starting inspection. In addition, it is good practice to purge this reservoir at the end of every working day. The remaining reservoirs must be purged at every 12,500 miles (or 20 000 km) or once every year, whichever comes first.

3.1.1 Wet (Main) Air Tank

This reservoir, located above the L.H. wheel of drive axle in the rear wheelhousing, is provided with a bottom drain valve. A recommended purge using the bottom drain valve should be done every 12,500 miles (20 000 km), or once a year, whichever comes first.

3.1.2 Primary Air Tank

This reservoir is located above the R.H. wheel of the drive axle and is provided with a bottom drain valve (Fig. 1). It is recommended to purge the primary air tank every 12,500 miles (20 000 km) or once a year, whichever comes first.

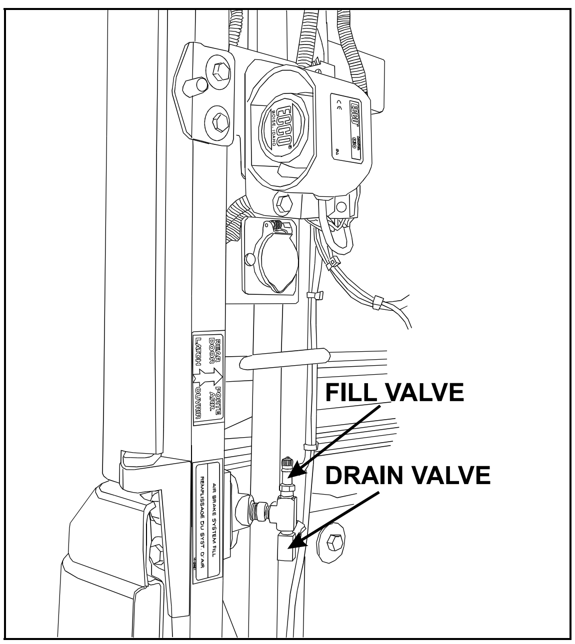


FIGURE 2: REAR VALVE LOCATION (TYPICAL) 12202

3.1.3 Accessory Air Tank

The accessory air tank is installed close to the front axle and is provided with a bottom drain valve (Fig. 1).

Purge the reservoir by it's drain valve every 12,500 miles (20 000 km) or once a year, whichever comes first.

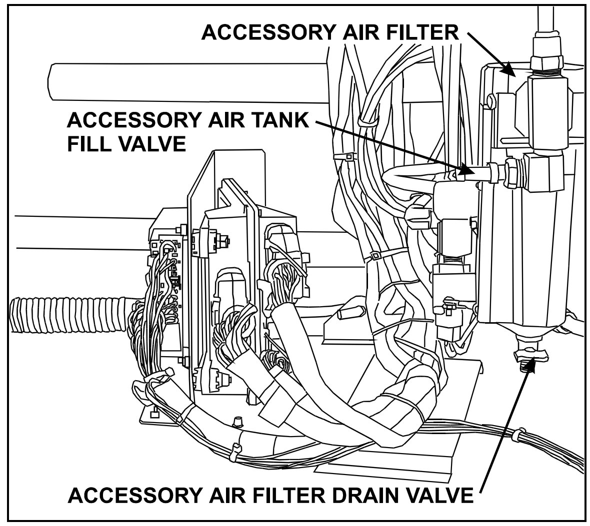


FIGURE 3: FRONT SERVICE COMPARTMENT 12201

3.1.4 Emergency/Parking Brake Overrule Air Tank

Installed on vehicles equipped with this option, this reservoir is located aft of the evaporator compartment (Fig. 1). It is provided with a bottom drain valve.

Purge this reservoir every 12,500 miles (20 000 km) or once a year, whichever comes first.

3.1.5 Secondary Air Tank

This tank is located in the front wheelhousing, behind the steering axle (Fig. 1). It is provided with a bottom drain valve

Purge this reservoir every 12,500 miles (20 000 km) or once a year, whichever comes first.

3.1.6 Kneeling Air Tank

The kneeling air tank is installed on vehicles equipped with the Kneeling or Hi/Low-Buoy options. It is located in the front wheelhousing (Fig. 1), and is provided with a bottom drain valve.

3.2 PING TANK

The ping tank may be located behind the tag axle or in the engine compartment; in this case, it is accessible through the engine compartment R.H. side door. It is used to dissipate heat and to reduce noise produced by the air compressor cycling on and off.

4. AIR SYSTEM EMERGENCY FILL VALVES

All vehicles come equipped with two emergency fill valves that enable system pressurization by an external source such as an air compressor. The rear valve is located in the engine compartment and is accessible from engine R.H. side door (Fig 2.). It can be positioned close to the door hinge or the door opening.

***Caution**: Maximum allowable air pressure is 125 psi (860 kPa). Air filled through these two points will pass through the standard air filtering system provided by Prevost. Do not fill system by any point on the system.*

The front valve is located in the front service compartment close to R.H. side of door frame (Fig. 3).

These two air system emergency fill valves are fitted with the same valve stems as standard tires, and can be filled by any standard external air supply line.

The rear air system emergency fill valve will supply air for all systems (brakes, suspension and accessories) while the front fill valve will supply air for accessories only.

5. ACCESSORY AIR FILTER

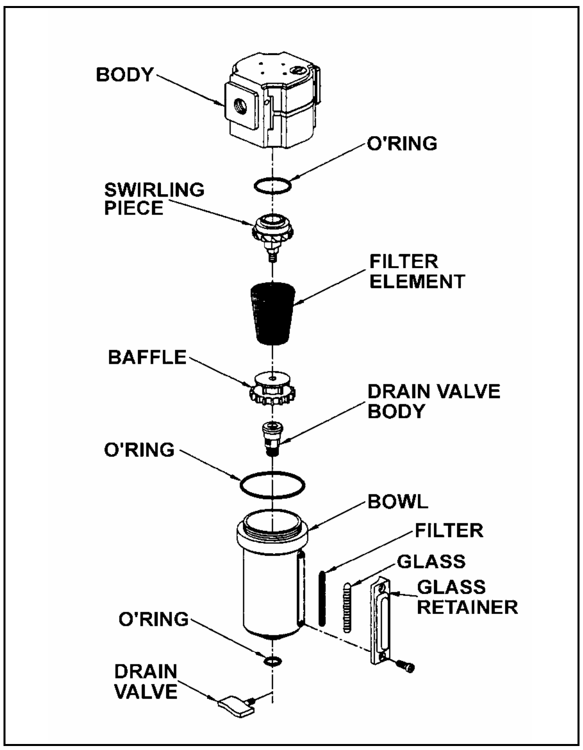


FIGURE 4: ACCESSORY AIR FILTER 12088

This filter is located inside the front service compartment (Fig. 3). Its main function consists in filtering the air supplied to the accessory air system, when connected to an external supply line. Ensure filter is purged whenever supplying the system with an external air line and at least every 12,500 miles (20 000 km).

To purge, open drain valve (Fig. 4), let the moisture come out, then close the drain valve.

5.1 FILTER ELEMENT REPLACEMENT

Replace filter element whichever of the following occurs first: every 100,000 miles (160 000 km), every two years, or whenever differential pressure exceeds 15 psi (105 kPa) between filter inlet and outlet ports. Check condition of all three O'rings for damage. Replace when necessary (Fig. 4).

5.2 CLEANING

Clean filter body and bowl with a warm water and soap solution. Rinse thoroughly with clean water. Blow dry with compressed air making sure the air stream is moisture free and clean. Pay particular attention to the internal passages.

Inspect all parts for damage and replace if necessary.

6. AIR GAUGES (PRIMARY, SECONDARY AND ACCESSORY)

The air pressure gauges, located on the dashboard (see *"Operator's Manual" or "Owner's Manual"*), are connected to the DC-4 double check valve, located on the pneumatic accessory panel in the front service compartment.

The latter is connected to the air lines running from the primary and secondary air tanks, as shown on the pneumatic system diagram provided in the technical publications box. The accessory air gauge is connected to the accessory air tank using the drain valve connector. The vehicle should never be set in motion until the buzzer alarm and warning lights turn off, i.e. when air pressure registers at least 66 psi (455 kPa). Moreover, if pressure drops below 66 psi (455 kPa), the *"Low air pressure"* warning lights will turn on, and the *"Low air pressure"* buzzer will sound. Stop the vehicle immediately, determine and correct the cause(s) of pressure loss. Check the gauges regularly with an accurate test gauge. Replace the gauge with a new unit if there is a difference of 4 psi (27 kPa) or more in the reading.

7. AIR FILTER/DRYER

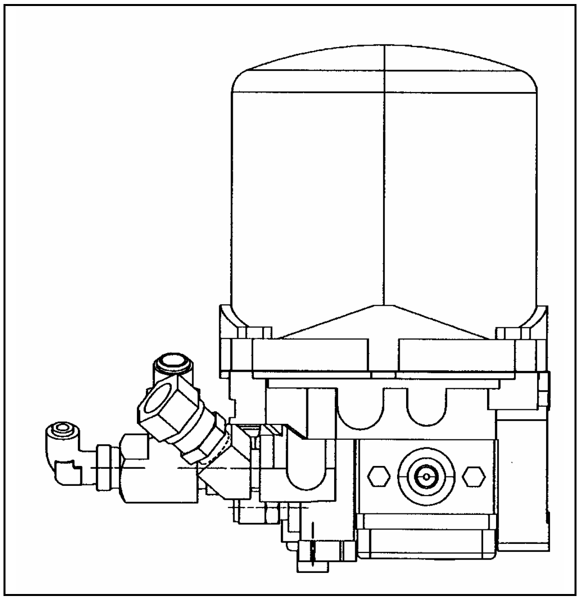


FIGURE 5: HALDEX AIR FILTER DRYER 12194

The air filter/dryer is located in front of rear wheelhousing above drive axle (Fig. 1 & 5). Its purpose is to remove moisture that could damage the air system before the air enters the system reservoir. The air filter/dryer also filters the air to remove dirt, compressor oil, and other contaminants that can damage the system. Change cartridge every 100,000 miles (160 000 km) or once every two years, whichever comes first. The air dryer may be purged for maintenance purposes using the remote drain valve located in the engine compartment and accessible through the engine compartment R.H. side door. The valve is positioned over the battery assembly, close to the door hinge or close to the L.H. side of door opening depending on type of vehicle (Fig. 2). The air filter/dryer has a built-in governor to maintain the system between 108 psig and 123 psig.

Maintenance and repair information is supplied in the maintenance information annexed to this section.

7.1 AIR FILTER/DRYER PURGE TANK

A tank is supplied to purge the air filter/dryer to remove moisture and contaminants.

8. AIR LINES

Copper piping, nylon-reinforced tubing, and flexible hoses are used to connect the units in the pneumatic system, including air brake system, suspension system and accessory systems such as the entrance door, fresh air damper cylinder, air horns, etc. Furthermore, the nylon tubing is color coded to ease identification. Refer to the following table for the complete color identification code. Service instructions for each type of air line are also provided under the applicable headings.

Color	Circuit
Red	Secondary
Green	Primary and Delivery
Yellow	Parking Brake
Blue	Suspension
Black	Accessory
Brown	Trailer Brake

8.1 COPPER PIPING

A heat dissipation copper piping assembly is used to dissipate the heat coming from the compressor before it enters the air filter/dryer. Connections should be checked for leakage at least every 6,250 miles (10 000 km) or twice a year, whichever comes first. Tighten or replace when necessary. When replacing copper piping, the parts must be free of burrs, copper cuttings, and dirt. Blow out piping with compressed air. Any such particles will destroy sealing seats in air control units. Also, new piping must be the same size as the old one.

8.2 FLEXIBLE HOSES

A flexible hose is used normally where it is impractical to use copper or nylon tubing due to constant flexing during operation, such as brake chamber hoses. Hose connections should be tested for leakage at least every 6,250 miles (10 000 km) or twice a year, whichever comes first and tightened or replaced if necessary. Any hose which is chafed, worn or kinked should be replaced.

Teflon-braided stainless steel hoses used in the engine compartment must be replaced only with similar hoses.

8.3 NYLON TUBING

Nylon tubing is used for air lines in areas where usage of this material is suitable. Nylon tubing is flexible, durable, and weather resistant. When replacing an air line, use nylon tubing only where it has been used previously.

Nylon air lines must never be routed in areas where temperature could exceed 200°F (93°C).

Caution*: Nylon air lines should be used to replace existing nylon lines only, and must comply with the color identification code to ease pneumatic system troubleshooting.*

8.4 AIR LINE OPERATING TEST

If any trouble symptom such as slow brake application or slow brake release indicates a restricted or clogged air line, disconnect the suspected tube or hose at both ends and blow through it to clear the passage.

Inspect tubing and hose for partial restriction that may be caused by dents or kinks. If such a condition is found, the tubing or hose should be replaced.

8.5 AIR LINE LEAKAGE TEST

With air system fully charged and the brakes applied, coat all tubing and hose connections with a soapy solution to check for air leakage. No leakage is permitted. Leakage can sometimes be corrected by tightening the connection. If this fails to correct the leakage, new fittings, nylon tubing, copper tubing, teflon-braided stainless steel and flexible hoses must be installed as applicable.

8.6 MAINTENANCE

Inspect all lines for cuts, swelling, kinks or other damage or deterioration. Check for lines being pinched by other components. Retaining clips and ties must be in place.

Any support or bracket should be in good condition and mounted firmly in position. Hose spring guards should be in usable condition and not distorted. Particular attention should be given to long lines. Any supporting component (clips, ties, grommets, etc.) must be secured to prevent against unnecessary vibration and eventual loosening of connection. Any detected leak should be repaired. Be sure nylon lines are not near areas of intense heat. Check for any missing grommets or loose material where chafing or cutting may occur. Replace with new material as required. In general, lines should be securely located in position and free from any binding condition which would hinder air flow.

9. PRESSURE REGULATING VALVES

There is one pressure regulator for the belt tensioners, and an optional one installed on vehicles equipped with the world transmission output retarder.

The belt tensioner pressure regulating valve is located in the engine compartment above the doors and is used to limit the air pressure in belt tensioners to 50 ± 2 psi (345 ± 15 kPa) for coaches, WE and W0 MTH and to 45 ± 2 psi (310 ± 15 kPa) for W5 MTH (Fig. 7).

The optional regulator is located in the engine compartment (accessible through the engine R.H. side door). It is used for transmission retarder and should be adjusted to 80 ± 3 psi (550 ± 20 kPa).

	Air Pressure (psi)	**Air Pressure (kPa)**
Belt Tensioner	**series 60** 50 (coach, WE & W0) 45 (W5)	**series 60** 345 310
Retarder	80 ± 3	550 ± 20

9.1 MAINTENANCE

Every 100,000 miles (160 000 km) or once every two years, whichever comes first, disassemble the regulating valve and wash all metal parts in a cleaning solvent (Fig. 6). Examine the diaphragm; if cracked, worn or damaged, replace with a new one. If the valve is excessively grooved or pitted, it should be replaced. Replace any other part that appears worn or damaged. After reassembly, adjust to the specified pressure setting and check for air leakage.

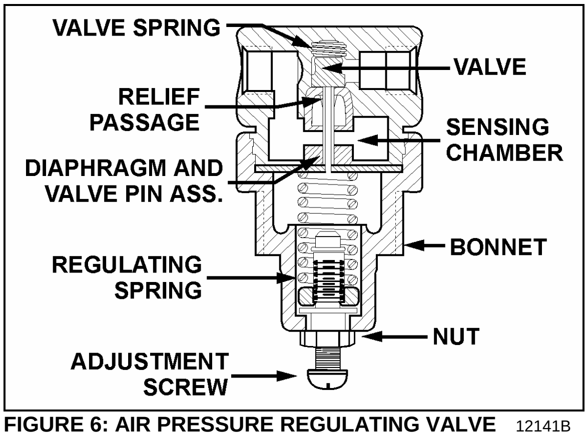


FIGURE 6: AIR PRESSURE REGULATING VALVE 12141B

9.2 PRESSURE SETTING PROCEDURE

Remove the dust cap from the pressure check valve (Fig. 7). Attach a pressure gauge at this port and check the pressure reading. If the pressure reading is incorrect, adjust as follows:

1. Loosen the locking nut, turn the adjustment screw counterclockwise to decrease pressure by approximately 10 psi (70 kPa) below the required pressure.
2. Turn the adjustment screw clockwise to increase the pressure slowly until the required pressure setting is reached. Tighten the locking nut.
3. Remove pressure gauge and replace dust cap on the air pressure check valve.

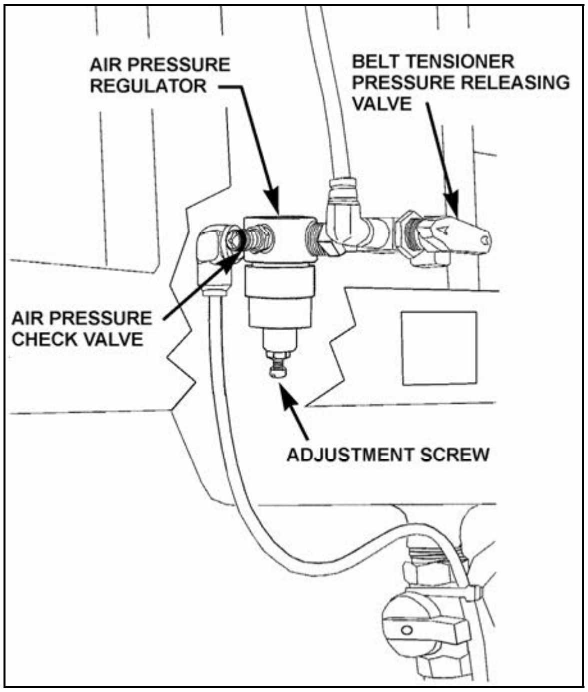


FIGURE 7: AIR PRESSURE REGULATOR 12200

10. AIR COMPRESSOR (BA-921)

The air compressor is located on starter side of the engine, on the rear of the engine gear case (Fig. 8). Its function is to provide and maintain air under pressure to operate devices in brake and air systems.

This air compressor also drives the engine fuel pump which is bolted to the rear end of the compressor. The compressor crankshaft is designed to accept a drive coupling which is placed between the compressor and fuel pump.

The compressor is driven by the bull gear, and is water cooled. Engine coolant is fed to the compressor through a flexible hose tapped into the block water jacket and connected to the rear of the compressor. Coolant returns from the top of the compressor (governor side) through a flexible hose to the engine pump.

The air is taken from the air intake manifold and entered in the top of the compressor. The compressed air is pushed into the discharge line located on side of the compressor, which sends air to the air dryer. Lubricating oil is supplied to the compressor by a line from the cylinder block oil gallery connected to the air compressor. Lubricating oil returns to the engine crankcase through the air compressor drive assembly.

Maintenance and repair information on the Bendix BA-921 air compressor is supplied in the applicable booklet annexed to this section under reference number SD-01-676.

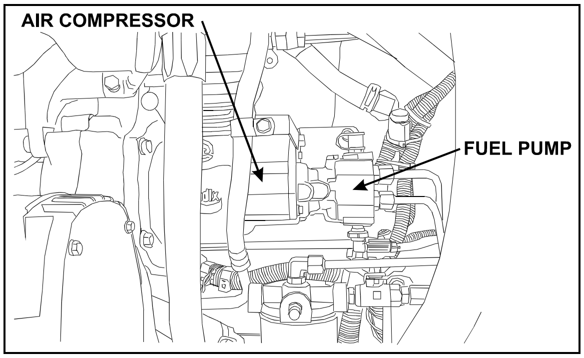


FIGURE 8: AIR COMPRESSOR 03053

10.1 COMPRESSOR REMOVAL AND INSTALLATION

1. Exhaust compressed air from air system by opening the drain valve of each air tank.
2. Drain the engine cooling system. See Section 5: "*Cooling System*".
3. Identify and disconnect all air, coolant and oil lines from the compressor assembly.
4. Access the compressor by the engine R.H. side compartment. Remove the four compressor mounting bolts and the two fuel pump support bracket bolts.
5. Slide air compressor rearward to disengage the hub from coupling. Remove the air compressor.

Reverse removal procedure for installation.

11. EMERGENCY/PARKING BRAKE CONTROL VALVE (PP-1)

A push-pull control valve mounted on the L.H. lateral console is provided for parking brake application or release. The spring brakes are self-actuated whenever the control valve supply pressure drops below 40 psi (275 kPa). In the UP position, brakes are ON. In the DOWN position, brakes are RELEASED. A protective case around the knob prevents accidentally releasing the brakes.

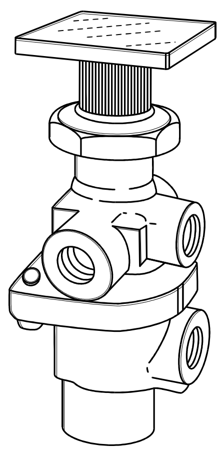


FIGURE 9: PP-1 12142

Maintenance and repair information on this valve is supplied in the applicable booklet annexed to this section under reference number SD-03-3611.

Remove the valve the following way:

1. Drain the air system.
2. Access this valve by tearing out the finishing panel, which holds the controls in place (Fig. 11).
3. Disconnect the air tubes.
4. Remove the retaining screws.
5. Service or replace the valve.
6. Installation is the reverse of removal.

12. EMERGENCY / PARKING BRAKE OVERRULE CONTROL VALVE (RD-3)

A RD-3 control valve is used with the optional parking brake overrule system. In the case of self-application of spring brakes due to a pressure drop, the brakes can be released by holding down this control valve. Maintenance and repair information on this valve is supplied in the applicable booklet annexed to this section under reference number SD-03-3611.

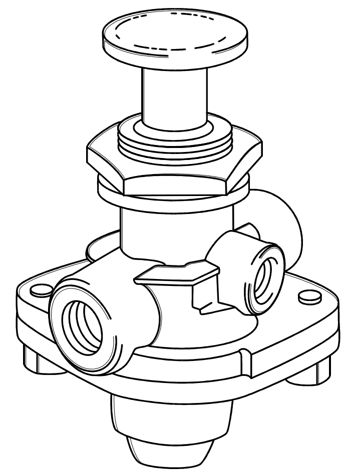


FIGURE 10: RD-3 12136

13. FLIP-FLOP CONTROL VALVE (TW-1)

A flip-flop control valve mounted on the L.H. lateral console is provided to unload tag axle air springs (and to lift tag axle if vehicle is so equipped). Another one controls the low-buoy system (coaches only). It is a manually operated "on-off" valve. Maintenance and repair information on this valve is supplied in the applicable booklet annexed to this section under reference number SD-03-3602.

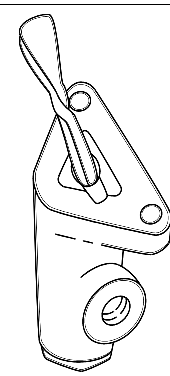


FIGURE 11: TW-1 12138

14. DUAL BRAKE APPLICATION VALVE (E-10P)

The E-10P dual brake valve is a floor mounted, foot-operated type brake valve with two separate supply and delivery circuits. This valve is located in the front service compartment (Fig. 14).

14.1 BRAKE PEDAL ADJUSTMENT

After brake pedal replacement or repair, adjust the pedal to its proper position according to the following procedure:

1. Replace the linkage, loosen threaded rod lock nuts and screw or unscrew the threaded adjustment rod in order to obtain a 45° brake pedal inclination (Fig. 14).
2. Tighten threaded rod lock nuts.

14.1.1 Maintenance

Maintenance and repair information on the E-10P dual brake application valve is supplied in the applicable booklet annexed to this section under reference number SD-03-830.

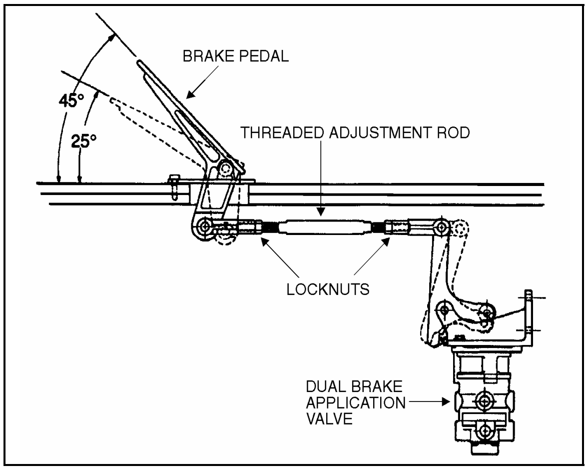


FIGURE 12: BRAKE PEDAL ADJUSTMENT 12040

15. STOPLIGHT SWITCHES

Two electro-pneumatic stoplight switches are mounted on the dual brake application valve (E-12). The upper one is used for the primary air circuit while the lower one is used for the secondary air circuit. Both switches are connected in parallel and have the same purpose, i.e. completing the electrical circuit and lighting the stoplights when a brake application is made. The upper switch (AC Delco) is designed to close its contact between 2 psi and 4 psi (14 kPa to 28 kPa) (Fig. 15), while the lower one (Bendix, SL-5) closes its contact at 4 psi (28 kPa) (Fig. 16). The switches are not a serviceable items; if found defective, the complete unit must be replaced.

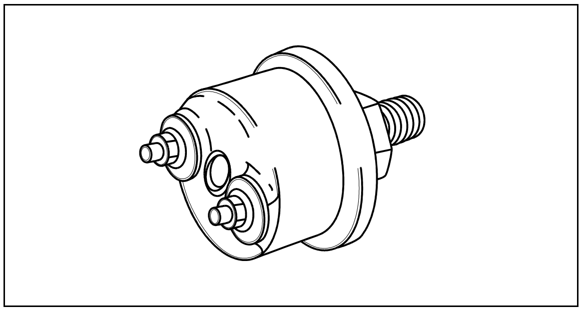


FIGURE 13: **DELCO SWITCH** 12139

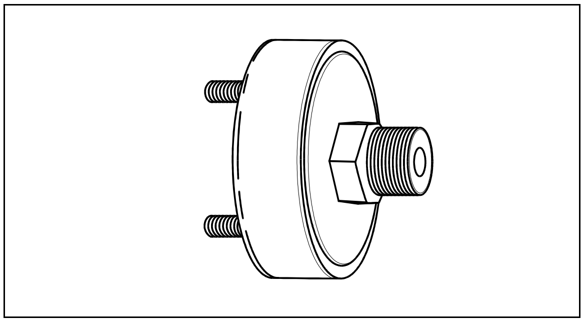


FIGURE 14: BENDIX SWITCH 12140

16. PARKING BRAKE ALARM SWITCH

Refer to the appropriate annexed booklet (Bendix, SL-5 Stop Light Switch; reference no. SD-06-2501).

The parking brake alarm uses the same switch as the stoplights. It is mounted on the spring brake valve and operates in conjunction with a NC relay to sound a warning alarm by completing the electrical circuit when the ignition key is turned OFF with parking brake released.

17. BRAKE RELAY VALVE (R-12 & R-12DC)

The primary air system includes three brake relay valves being supplied by the dual brake valve, and which function is to speed up the application and release of the service brakes.

One R-12DC valve supplies the drive axle service brake air line, while the other two valves supply independently both the tag axle right and left service brake air line and act as interlock valves. These valves are accessible from under the vehicle at the level of the tag axle. Maintenance and repair information on these valves is supplied in the applicable booklets annexed to this section under reference number SD-03-1064 and SD-03-1068.

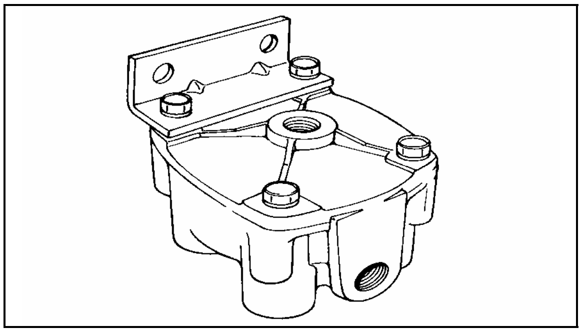


FIGURE 15: R-12 12074

18. QUICK RELEASE VALVES (QR-1)

The quick release valve is located on the front axle service brakes air line and permit rapid exhaust of air pressure from brakes, thus decreasing the brake release time.

Maintenance and repair information on this valve is supplied in the applicable booklet annexed to this section under reference number SD-03-901.

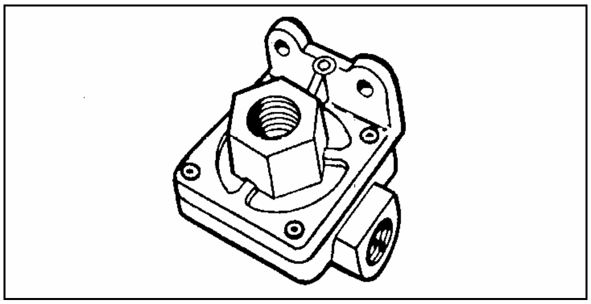


FIGURE 16: QR-1 12075

19. SPRING BRAKE VALVE (SR-1)

The spring brake valve is located on the pneumatic accessory panel in the front service compartment. The function of the SR-1 is to modulate the spring brakes during the application of the foot brake valve in the event of loss of service brake pressure. Maintenance and repair information on the spring brake valve is supplied in the applicable booklet annexed to this section under reference number SD-03-4508.

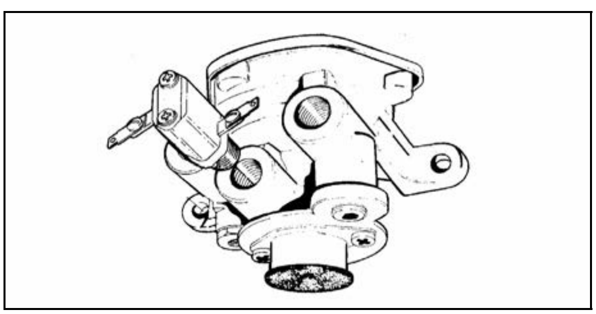


FIGURE 17: SR-1 12076

20. PRESSURE PROTECTION VALVE (PR-4)

Maintenance and repair information on the pressure protection valve is supplied in the applicable booklet annexed to this section under reference number SD-03-2010.

The air system includes two pressure protection valves (Fig. 20). One valve is installed on the manifold block, and insures at all times a minimum pressure of 70 psi (482 kPa) in the suspension air system in the event that a pressure drop occurs in either the suspension air system or accessory air system. This valve is located in the front service compartment besides the air filter.

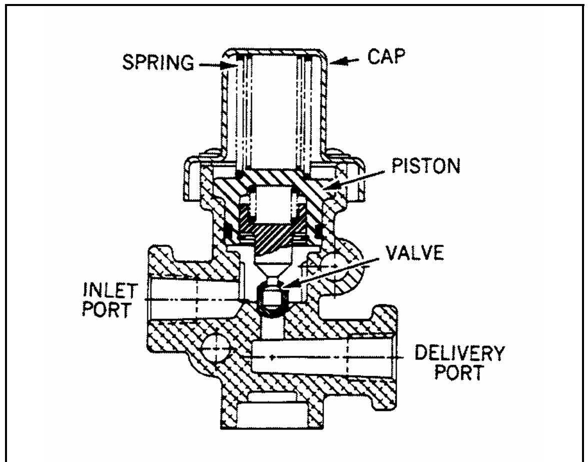


FIGURE 18: PR-4 12174

The other valve is installed on the accessory air tank, and insures a minimum pressure of 70 psi (482 kPa) in the accessory air system in the event that a pressure drop occurs in either the suspension air system or braking air system (refer to Fig. 1 for accessory air tank location).

21. LOW PRESSURE INDICATOR (LP-3)

Maintenance and repair information on the low pressure indicators is supplied in the applicable booklet annexed to this section under reference number SD-06-1600.

The air system includes two low pressure switches (Fig. 19), both located on the pneumatic accessory panel in the front service compartment. One serves for the parking brake signal, its pressure setting is 66 ± 6 psi (455 ± 40 kPa). The remaining pressure switch monitors the parking brake telltale panel indicator, its pressure setting is 30 psi (205 kPa).

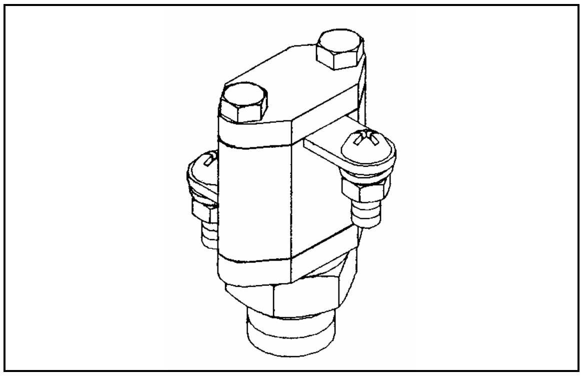


FIGURE 19: LP-3 12078

22. SHUTTLE-TYPE DOUBLE CHECK VALVE (DC-4)

Maintenance and repair information on the shuttle-type double check valve is supplied in the applicable booklet annexed to this section under reference number SD-03-2202.

The double check valve is located on the pneumatic accessory panel in the front service compartment. In the event of a pressure drop in either the primary or secondary system, this unit will protect the emergency /parking brake control valve and the intact portion of the air system from pressure loss.

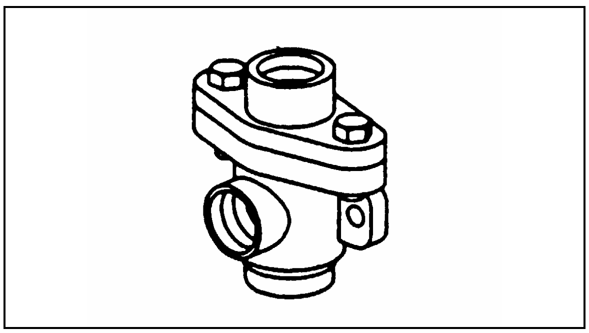


FIGURE 20: DC-4 12134

23. EMERGENCY DOOR OPENING VALVES

Two emergency door opening three-way valves are installed on coaches. One is in the front service compartment, readily accessible. The other one is on the R.H. side lateral console, close to the entrance door. When used, the valve releases pressure in the door locking cylinder, thus allowing the door to be manually opened.

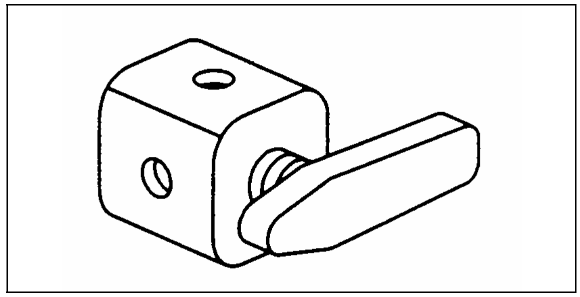


FIGURE 21: THREE-WAY VALVE 12186

24. AIR HORN VALVE

The air horn valve is located in the L.H. front service compartment. The air horn button is on the center of the steering wheel. Refer to section 23 "ACCESSORIES" for more information.

25. AIR SYSTEM TROUBLESHOOTING

The following list has been designed to help in troubleshooting some of the most common problems in the air system and main causes. For air brakes troubleshooting, refer to "*Air Brakes Troubleshooting"* in this section. For more troubleshooting information, refer to the manufacturer's brochures annexed to this section.

Air pressure doesn't rise to, or doesn't maintain, a normal setting:

- Defective air gauge (registering incorrectly).
- Excessive leaking in air system.
- Reservoir drain cock open.
- Governor poorly adjusted or defective.
- Defective compressor.
- Worn compressor or excessive wear on piston and/or ring.
- Air pressure rises to normal setting too slowly.

Excessive leaking in air system:

- Clogged engine air cleaner.
- Worn compressor or excessive wear on piston and/or ring.
- Engine speed too low.

Air pressure rises above a normal setting:

- Defective air gauge (registering incorrectly).

- Governor poorly adjusted or defective.
- Restriction in line between governor and compressor unloading mechanism.

Air pressure drops quickly when engine is stopped:

- Leaks in compressor discharge valve.
- Leaks in governor.
- Leaks in air lines.
- Leaks in air system valves.

26. BRAKE OPERATION

The vehicle braking system uses both service and parking air-operated brakes. The air system is divided into two independent circuits to isolate the front axle brakes and the rear axle brakes (drive and tag), thus providing safe brake operation in the event that one circuit of the system fails. The primary circuit is connected to the drive and tag axle brakes, while the secondary circuit is connected to the front axle brakes. The tag axle service brakes operate only when the axle is in the normal driving (loaded) position. The spring-type emergency brakes are mounted on the drive and tag axles, and will apply automatically if primary system pressure falls below 40 psi (276 kPa). The optional parking brake override system can cancel the parking brakes, enabling the driver to move the vehicle to a safe parking place. To operate this system, push down and hold the control knob located on the R.H. side of the driver's seat (see *"Operator's Manual"* for more details).

Furthermore, brake application or release, which is speed up by a pneumatic relay valve (R-12), will start with the rear axles and be followed by the front axle, thus providing uniform braking on a slippery surface. The vehicle may also be equipped with an Anti-lock Brake System (ABS), detailed later in this section.

Brake and air system maintenance consists of periodic inspections. Check all parts for damage and brake adjustment (refer to subsequent headings in this section for more details). Ensure all fasteners are tight (refer to "*Specifications"* for recommended tightening torques).

27. AIR BRAKES

27.1 DISC BRAKES

Knorr-Bremse SB7000 disc brakes are used on all axles. The front and drive axle discs are actuated by 24 square inch effective area air brake chambers, while on tag axle, the brake chambers have a 16 square inch effective area for service brake and a 16 square inch effective area for emergency/parking brakes. The *Knorr-Bremse SB7000* brakes are supplied with automatic clearance (slack) adjusters as standard equipment for easier adjustment. For more information on disc brake components and maintenance, refer to the manufacturer's brochure at the end of this section.

27.1.1 Disc Brake Pads

Brake pads have to be checked on a regular basis depending on the vehicle operation. The remaining thickness of the pads should never be less than 3/32 in (2 mm). To check pad condition without removing the wheel, verify the position of guide bushing (6) relatively to guide sleeve (4) (see Fig. 23). When guide sleeve is in alignment with guide bushing, brake pad thickness has to be checked more precisely with the wheel removed. When replacing brake pads, all four pads on an axle have to be changed at the same time. There is no inner or outer pad, since all pads are the same. Once removed, worn pads should be replaced in their original position.

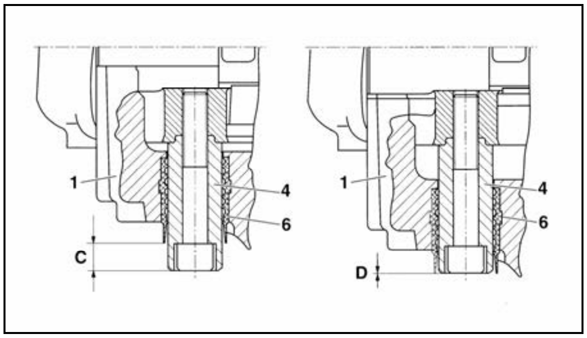


FIGURE 22: BRAKE PAD CHECK 12117

27.1.2 Caliper Maintenance

Use the following procedure for brake calipers servicing. The procedure must be followed in proper sequence to ensure that only needed repairs or replacements are performed on calipers. Problems such as hot brakes or cracked rotors may be effects of sticking calipers, too-small clearance between rotor and pad or possible trapped air pressure in the brake chamber. If any of these symptoms occur, perform this procedure before replacing the rotor to ensure the cause of the problem is properly solved.

1. Check for presence of residual pressure:

To check if there is any residual air pressure in the brake chamber, make four or five brake applications, then try to turn the wheel manually, if the wheel does not turn, use a wrench to crack the air line and listen for trapped air in the brake chamber then try to turn the wheel manually again. If you find trapped air in the brake booster, ensure that all pneumatic components in the braking system are functioning properly.

Note: *A residual pressure of 2-3 PSI in the system is sufficient to prevent the brakes from releasing. Also the stop light switch can operate with as little as 1 PSI, therefore an illuminated brake light does not mean brakes are dragging.*

2. Pad to rotor clearance inspection:

Remove clip and washer (26 & 45, Fig. 24), push down retainer bar (11), pull out pin (44) and remove retainer bar. Push caliper toward actuator (center of vehicle) for maximum clearance.

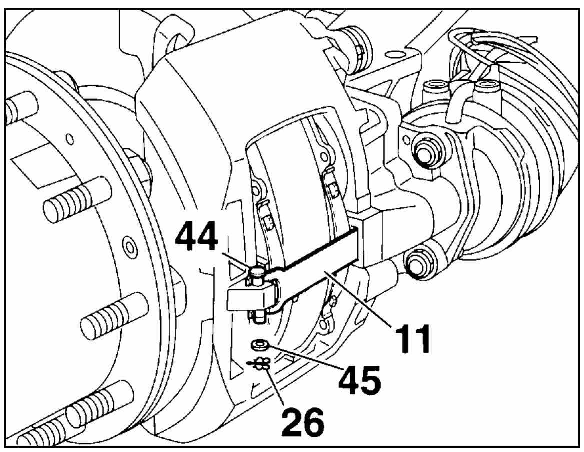


FIGURE 23: CLEARANCE INSPECTION 12119

3. Measure pad to rotor clearance:

Place a long feeler gauge (long enough to measure across entire tappet surface) between the tappet and the backing plate of the pad, measure clearance at both tappets. Clearance should range between 0.020 and 0.035 inch (0.5 mm and 0.9 mm), with a maximum difference between tappet measurements on same brake of 0.008 inch (0.2 mm).

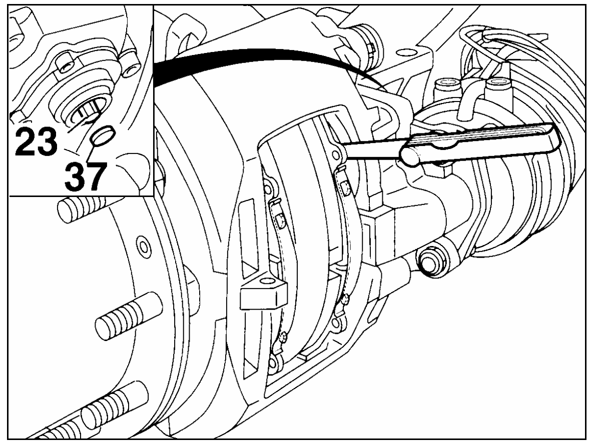


FIGURE 24: RUNNING CLEARANCE 12116

4. Checking the adjuster

Warning: *Use only a standard box wrench on the adjuster hexagonal pinion. Do not overtorque the pinion as overtorquing will damage the pinion.*

a) Remove cap (37, Fig. 26).

b) Using a box wrench (8 mm), turn the adjuster pinion (23, Fig. 26) counterclockwise about 2 - 3 clicks to increase running clearance. By operating the braking system about 5 - 10 times (30 PSI or 2 bar), the wrench should turn clockwise in small increments if the adjuster is functioning correctly (Figs. 26 and 27).

Note: With increasing number of applications, the incremental adjustment will decrease.

c) In case of malfunction, i. e. the pinion or box wrench:

   i) Does not turn.

   ii) Turns only with the first application.

   iii) Turns forwards then backwards with every application.

In any of the above cases, the automatic adjuster has failed and the caliper must be replaced. In such cases the brakes can be adjusted manually to run a short distance.

d) Take the box wrench off. Replace the cap and check for proper sealing.

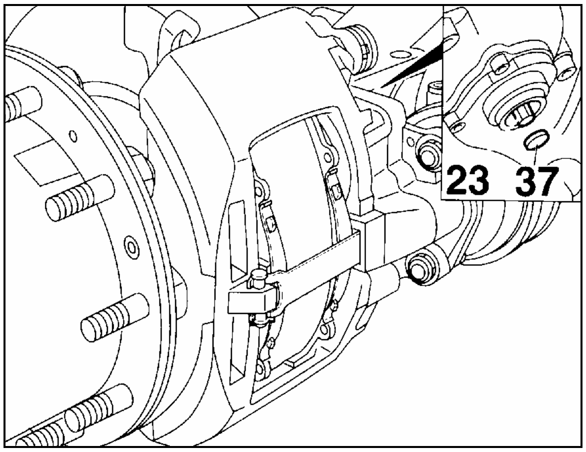


FIGURE 25: ADJUSTER PINION 12120

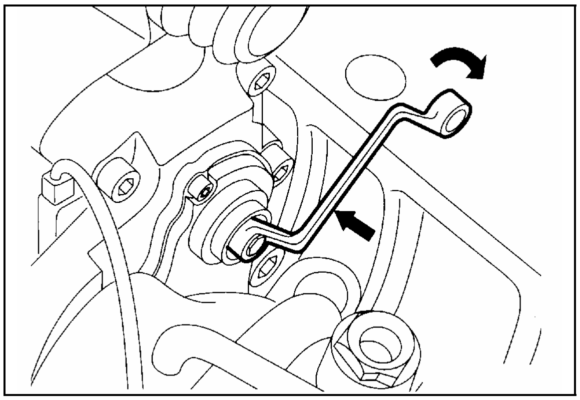


FIGURE 26: BOX WRENCH ON ADJUSTER PINION 12118

27.1.3 Roadside Inspection for Knorr/Bendix Air Disc Brakes

The coach is equipped with air disc brakes and therefore, cannot be inspected using the requirements for chamber stroke or visible lining clearance or lining thickness as specified for drum brakes. The roadside inspector should use the following instructions to determine that the air disc brakes are within proper adjustment and have sufficient pad wear thickness.

The Knorr/Bendix air disc brake is designed to move freely, with minimal force, in the axial direction on the two sliding pins as identified in figure 28. The movement in the axial direction should not exceed 2 mm (5/64").

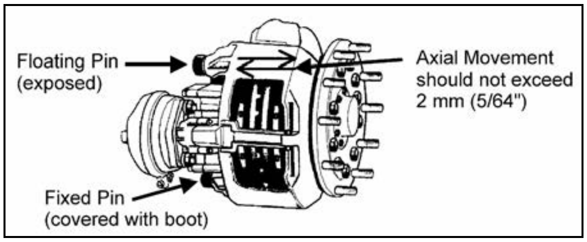


FIGURE 27: CALIPER AXIAL MOVEMENT 12132

The pad thickness can be seen but would require removal of the tire and rim. An indicator of the pad wear condition is available by inspecting the floating pin location in relation to the rubber bushing as shown in figure 29. When pads are in new thickness condition, the pin will be exposed (C) 19 mm (¾"). When the pads are worn to replacement conditions, the pin will be nearly flush to the bushing (D) or within 1 mm (3/64") of the edge of the rubber bushing.

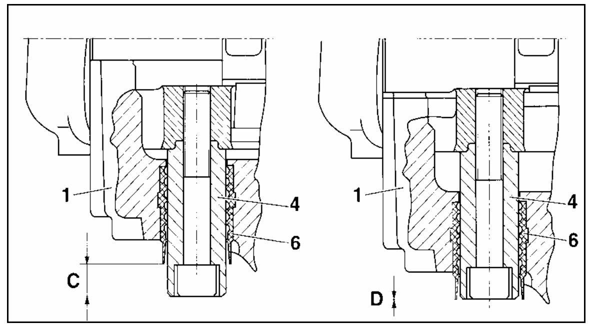


FIGURE 28: BRAKE PAD CHECK 12117

27.1.4 Pad Removal

Turn adjuster pinion (23) counterclockwise to increase pad to rotor clearance (a clicking noise will be heard). Push caliper toward actuator and remove pads (12).

Caution: *Do not apply brakes while pads are removed as this could cause over stroke damage to the adjusting mechanism.*

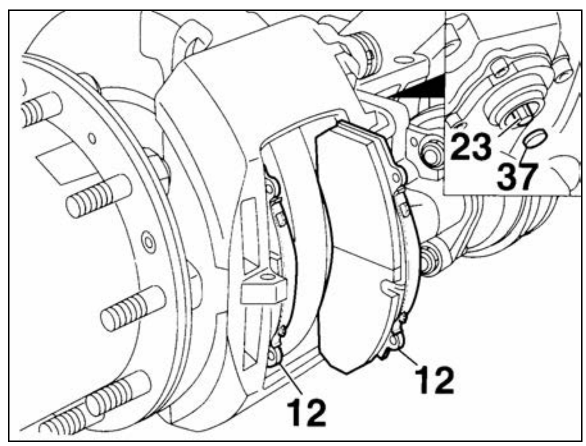


FIGURE 29: PAD REMOVAL 12111

27.1.5 Checking Pad Wear

Minimum friction material thickness is 2 mm (A, Fig. 31)

New friction material has a thickness of 21 mm (B, Fig. 31)

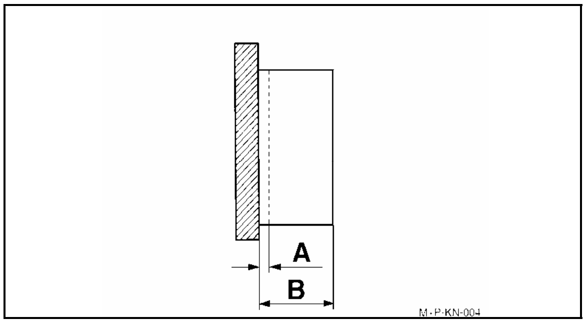


FIGURE 30: PAD WEAR 12112

27.1.6 Important Pad and Rotor Measurements

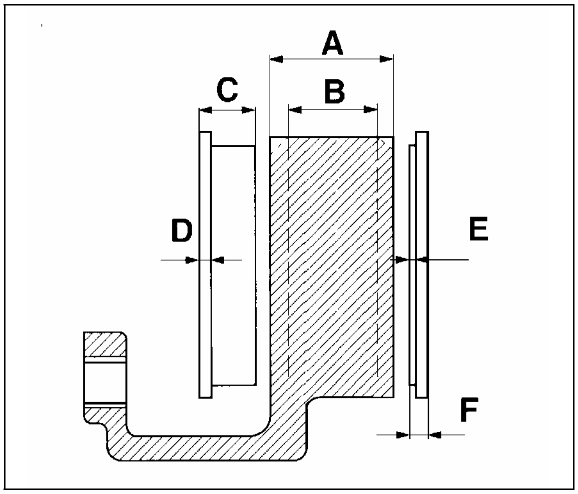


FIGURE 31: ROTOR AND PAD WEAR LIMITS 12113

A = Rotor thickness (new): 45 mm;

B = Rotor thickness (worn): 37 mm Requires replacement;

C = Overall thickness of pad (new): 30 mm;

D = Backplate: 9 mm;

E = Minimum thickness of pad material: 2 mm;

F = Minimum allowed thickness of overall backplate and friction material: 11 mm. **Replacement necessary**.

27.1.7 Checking Caliper Guidance and Seal Condition

Perform sliding test. You must be able to slide the caliper easily at any time. Sliding test should be performed at least every three months or more often depending on the type of operation.

Sliding Test (Refer to Fig. 33):

a) Using hand pressure only, the caliper (1) must slide freely with its guide pin arrangements (4-7) across a distance of 1 3/16 inch (30 mm) when the pads are removed. The sleeve (5) is sealed using the boot (9) and the cap (10).

b) The rubber components (9 and 10) should show no damage. The positioning must be checked. If necessary the caliper has to be repaired using the guide kit (part #611168) or with the seal and guide kit (part #611199). When repairing a caliper with the above kits, make sure all parts in the kit are used. Use special green grease (Prévost #683344) to reassemble the slide pin into the bushing, white or yellow grease (Prévost #683345) may be used for all other lubrication needs.

c) Depending on caliper manufacturing date, black paint may be present on the unsealed pin (short pin). Paint on the slide pin can prevent the caliper from sliding properly especially when the pad starts to wear. If paint is present on the pin, separate the pin from the bushing, clean and reinstall the pin according to procedure.

Note: *Do not attempt to use thinner or alcohol to clean the pin without removing it as it may damage the rubber bushing.*

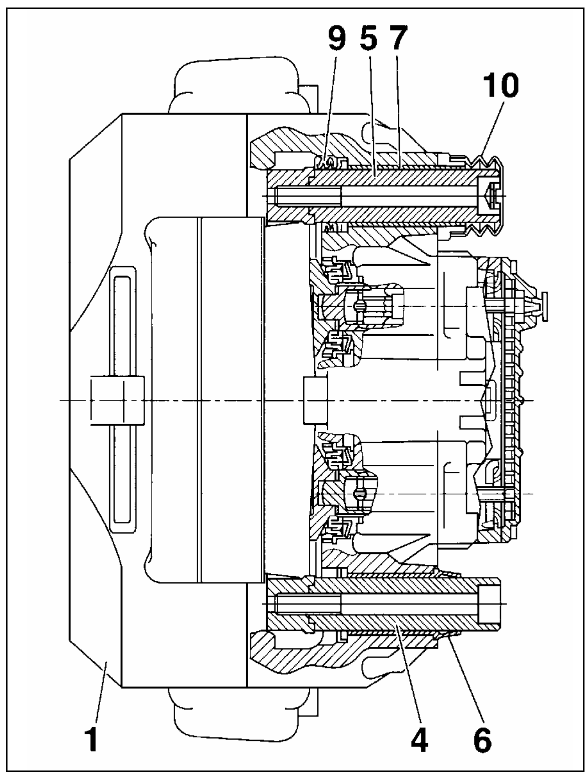


FIGURE 32: CALIPER GUIDANCE 12114

27.1.8 Checking the Tappet Boots

a) The rubber boots (13, Fig. 34) should show no damage, check the attachment.

***Caution:** Any ingress of water and dirt will lead to corrosion and may affect the function of the actuation mechanism and adjuster unit.*

b) If boots are damaged but show no corrosion, the boots and tappets should be replaced (Prévost #611177).

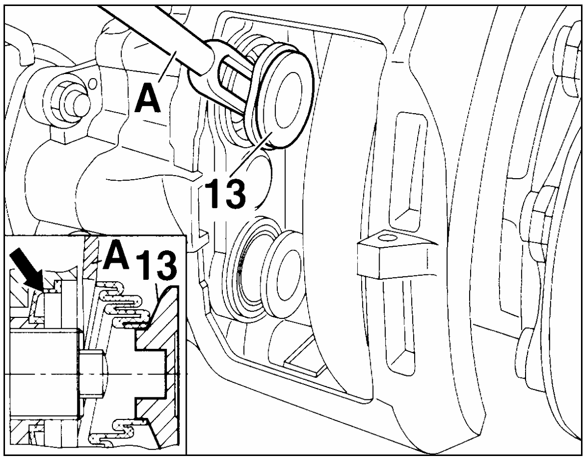


FIGURE 33: RUBBER BOOTS 12115

27.1.9 Pad Installation

Turn adjuster pinion (23, Fig. 35) counterclockwise until tappets are fully retracted and clean pad seat area. Slide caliper to full outboard position and install outside pad. Slide caliper to full inboard position and install inside pad.

***Warning:** It is recommended to change all pads on an axle at the same time.*

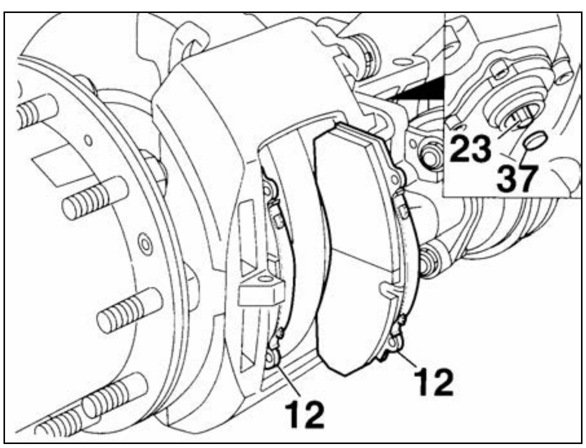


FIGURE 34: PAD INSTALLATION 12111

27.1.10 Adjusting the Running Clearance

a) Insert a feeler gauge 0.028 inch (0.7 mm thickness) between tappet and pad backplate (Fig. 36). Turn adjuster pinion clockwise until 0.028 inch (0.7 mm) clearance is achieved. Replace cap (37) (Prévost # 641313).

b) To ensure a constant running clearance between the rotor and pads, the brake is equipped with an automatic adjuster unit. When the pads and rotor wear, the running clearance between the pads and rotor increases. The adjuster (23, Fig. 36) and turning device turn the threaded tubes by the amount necessary to compensate the wear.

Total running clearance should be between 0.020 and 0.035 inch (0.5 and 0.9 mm). Smaller clearances may lead to overheating problems.

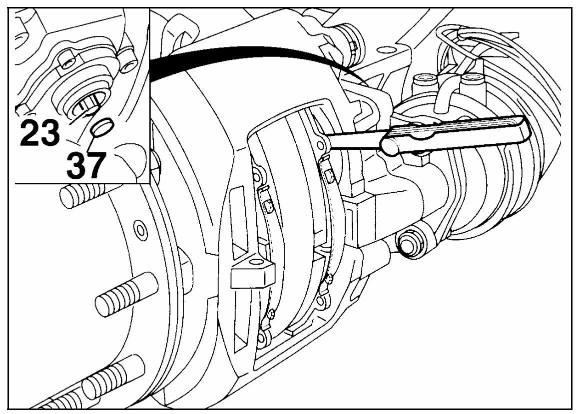


FIGURE 35: RUNNING CLEARANCE 12116

27.1.11 Brake Tools

Four brake tools are available from Prévost to facilitate disc brake maintenance:

a) #641321, Tappet with boot (item 13).
b) #641322, Caliper inner boot (item 9).
c) #641323, Caliper bushing (item 7).
d) #641435, Fork for boot tappet (item 13).

Maintenance tip

Using the following procedure, pad wear can be determined without removing the wheel.

27.1.12 Checking Brake Pads

Brake pads have to be checked on a regular basis depending on the vehicle operation. The remaining thickness of the pads should never be less than 3/32 inch (2 mm). To check pad condition without removing the wheel, verify the position of guide bushing (6) relatively to guide sleeve (4) (Fig. 37). When guide sleeve is in alignment with guide bushing, brake pad thickness must be checked more precisely with wheel removed. When replacing the brake pads, all four pads on an axle have to be changed at the same time. There is no inner or outer pad, since all pads are the same. Worn pads should be replaced in the same position.

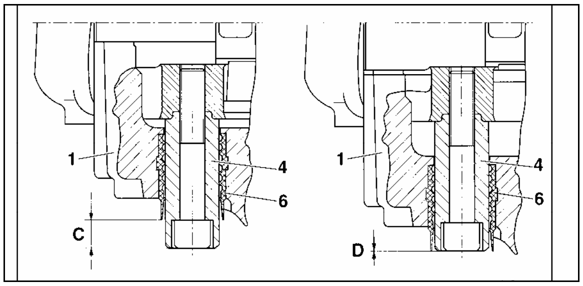


FIGURE 36: BRAKE PAD CHECK 12117

27.1.13 Torque specifications

For proper caliper maintenance, refer to the following figures.

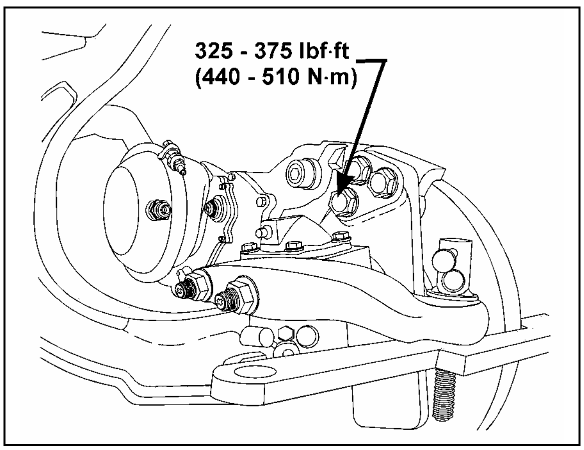


FIGURE 37: TORQUE SPECIFICATION 12145

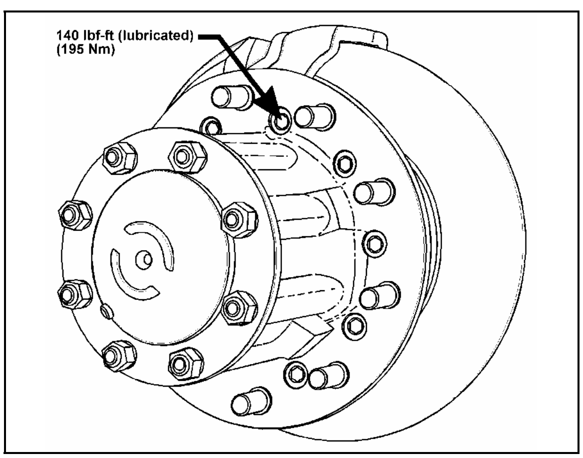


FIGURE 38: TORQUE SPECIFICATION 12149

28. SAFE SERVICE PROCEDURES

Most recently manufactured brake linings no longer contain asbestos fibers. Instead of asbestos, these linings contain a variety of ingredients, including glass fibers, mineral wool, aramid fibers, ceramic fibers, and carbon fibers. At present, OSHA (Occupational Safety and Health Administration) does not specifically regulate these non-asbestos fibers, except as nuisance dust. Medical experts do not agree about the potential long-term risks from working with and inhaling non-asbestos fibers. Nonetheless some experts think that long-term exposure to some non-asbestos fibers could cause diseases of the lung, including pneumoconiosis, fibrosis, and cancer. Therefore, lining suppliers recommend that workers use caution to avoid creating and breathing dust when working on brakes that contain non-asbestos fibers.

***Warning**:*

Whenever possible, work on brakes in a separate area away from other operations.

Always wear a respirator approved by NIOSH (National Institute of Occupational Safety and Health) or MSHA (Mine Safety and Health Administration) during all brake service procedures. Wear the respirator from removal of the wheels through assembly.

NEVER use compressed air or dry brushing to clean brake parts or assemblies. OSHA recommends that you use cylinders that enclose the brake. These cylinders have vacuums with high efficiency (HEPA (Health and Environment Protection Agency)) filters and workmans' arm sleeves. But, if such equipment is not available, carefully clean parts and assemblies in the open air.

Clean brake parts and assemblies in the open air. During disassembly, carefully place all parts on the floor to avoid getting dust into the air. Use an industrial vacuum cleaner with a HEPA filter system to clean dust from the brake drums, backing plates and other brake parts. After using the vacuum, remove any remaining dust with a rag soaked in water and wrung until nearly dry.

If you must grind or machine brake linings, take additional precautions because contact with fiber dust is higher during these operations. In addition to wearing an approved respirator, do such work in an area with exhaust ventilation.

When cleaning the work area, NEVER use compressed air or dry sweeping to clean the work area. Use an industrial vacuum with a HEPA filter and rags soaked in water and wrung until nearly dry. Dispose of used rags with care to avoid getting dust into the air. Use an approved respirator when emptying vacuum cleaners and handling used rags.

Wash your hands before eating, drinking or smoking. Do not wear your work clothes home. Vacuum your work clothes after use and then launder them separately, without shaking, to prevent fiber dust from getting into the air.

Material safety data sheets on this product, as required by OSHA, are available from Rockwell and Knorr-Bremse.

29. AIR BRAKE TROUBLESHOOTING

The following tests and check lists have been designed to identify the cause(s) of a sluggish performance and/or leaks in the system. These tests require very little time to perform, and give you a general idea of the system condition. Each test is provided with a corresponding check list which will guide you to the most common causes of problems.

Before performing any test, check all air lines for kinks or dents, and hoses for signs of wear, drying out or overheating.

Warning*: When working on or around brake system and its related components, the following precautions should be observed:*

Always block vehicle wheels. Stop engine when working under a vehicle. Keep hands away from chamber push rods and slack adjusters as they may apply when system pressure drops.

Never connect or disconnect a hose or line containing air pressure. It may whip as air escapes. Never remove a component or pipe plug unless you are sure all system pressure has been depleted.

Never exceed recommended air pressure and always wear safety glasses when working with air pressure. Never look into air jets or direct them at anyone.

Never attempt to disassemble a component until you have read and understood the recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to the use of those tools.

Always clean connecting piping and/or fittings, and coat pipe threads with Teflon pipe sealant before installing any air brake system component.

Pressure Build-Up / Low Pressure Warning / Cutoff Point / Air Filter/Dryer Built-in Governor Cutout

CONDITION: Vehicle leveled, parking brake applied.

1. Completely drain wet, primary and secondary air reservoirs only.
2. Start engine and run at fast idle. Low pressure warning lights should be *"On"*.
3. Start checking pressure at 50 psi (344 kPa).
4. Low pressure warning lights and buzzer should go off at or above 60 psi (415 kPa).
5. At 85 psi (586 kPa), run engine at full rpm, then check that build up time to 100 psi (690 kPa) is 30 seconds or less.
6. Air filter/dryer built-in governor cut-out. Cuts out at the correct pressure of 123 psi ±3 (847±21 kPa).
7. Air filter/dryer built-in governor cut-in. Cuts in around 110 psi (758 kPa).

For common corrections, refer to the following check list:

High or Low Warning Cutoff Point

✓ Perform a telltale light and gauge test. Replace entire cluster if found defective.

High or Low Air Filter/Dryer Built-in Governor Cutout Point

✓ Perform a telltale light and gauge test. Replace entire cluster if found defective.

OR

✓ Repair or replace air filter/dryer as necessary after checking that compressor unloader mechanism operates correctly.

More than 30 seconds to build-up pressure from 85 to 100 psi (585 - 690 kPa) at full engine RPM

- ✓ Perform a telltale light and gauge test. Replace entire cluster if found defective.
- ✓ Check compressor strainer or inlet line. If restricted, clean or replace element or faulty line.
- ✓ Check compressor head or discharge line for carbonization or restriction. Clean or replace as necessary.
- ✓ If discharge valves leak, pull head and correct or replace cylinder head.
- ✓ If drive is slipping, replace gear.
- ✓ If inlet valves are stuck, open or leaking severely, replace unloader kit, inlet valves and/or seats as necessary.
- ✓ If drain cock is found open, close it.
- ✓ Listen for air leaks and repair.
- ✓ Redo list to check all items repaired or replaced.

Air Supply Reservoir Leakage

CONDITION**:** Full pressure, engine stopped, parking brake applied

1. Allow at least 1 minute for pressure to stabilize.
2. Stop engine, then check air pressure gauge for 2 minutes. Note any pressure drop.
3. Pressure should not drop by more than 3 psi (20 kPa) per minute.

For common corrections, refer to the following check list:

Excessive air loss:

- ✓ With the primary air system at normal operating pressure (95 - 125 psi (655 - 860 kPa)), coat all air line connections and pneumatic components with a water and soap solution. Bubbles will indicate an air leak, and none should be permissible. Repair or replace defective parts.
- ✓ Listen for leaks and correct as required.
- ✓ Redo test to check all items repaired or replaced.

Brake System Air Leakage

CONDITION**:** Full pressure, engine stopped, parking brake released.

1. Apply service (foot) brakes, allow at least 1 minute for pressure to stabilize.
2. Hold down foot valve for 2 minutes while observing air pressure gauge on the dashboard.
3. Pressure drop should not be more than 4 psi (27 kPa) per minute.

For common corrections, refer to the following check list.

Excessive leakage on brake service side:

- ✓ With the primary air system at normal operating pressure (95 - 125 psi (655 - 860 kPa)) and foot brake applied, coat all air line connections and brake pneumatic components with a water and soap solution. Bubbles will indicate an air leak, and none should be permissible. Repair or replace defective parts.
- ✓ Listen for leaks and correct as required.
- ✓ Redo test to check all items repaired or replaced.

30. BRAKE AIR CHAMBER

If this vehicle is equipped with *Knorr-Bremse SB7000* disc brakes on all axles, it also uses “Knorr-Bremse” brake chambers. The tag and drive axle chambers consist of two separate air chambers, each having its own diaphragm and push rod. They are used as a service brake chamber, an emergency brake in case of air pressure loss and a spring-applied parking brake. Refer to figures 41 and 42.

The front axle brake air chambers are used only for service brake duty (Fig. 41).

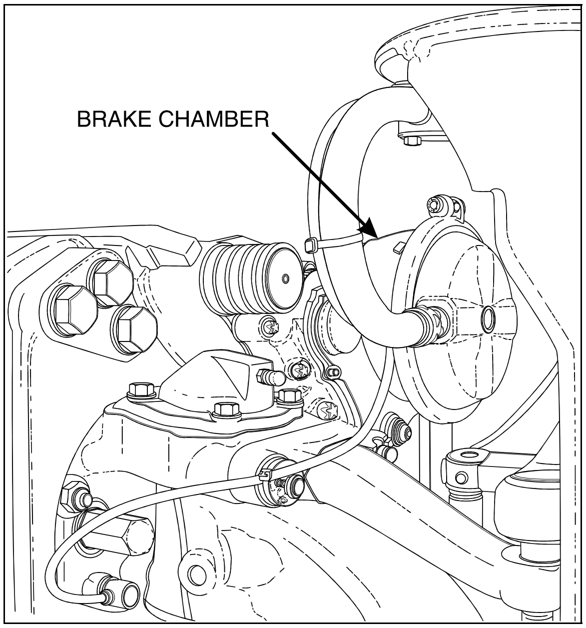


FIGURE 39: FRONT AXLE BRAKE AIR CHAMBER 12158

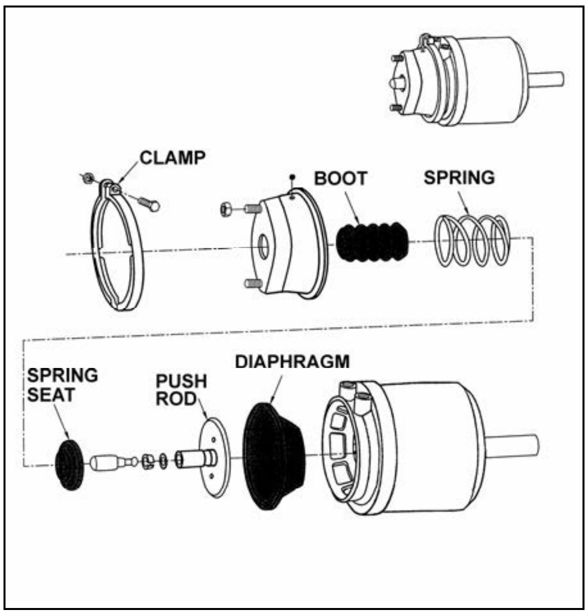


FIGURE 40: TAG AXLE BRAKE AIR CHAMBER 12126

30.1 MAINTENANCE

Every 6,250 Miles (10 000 km) or twice a year, whichever comes first depending on type of operation:

Check all hoses and lines. They should be secure and in good condition.

Every 100,000 Miles (160 000 km) or once a year, whichever comes first depending on type of operation:

1. Disassemble and clean all parts.
2. Install new diaphragm or any other part if worn or deteriorated.

***Note**: When the diaphragm, spring, or both are replaced, they should be replaced in the corresponding chamber on the same axle.*

3. Perform an airtighteness test:

a) Make and hold a full brake application.

b) Coat clamping ring(s) with a soapy solution. If leakage is detected, tighten clamping ring only enough to stop leakage. ***Do not overtighten*** as this can distort sealing surface or clamping ring. Coat area around push rod hole (loosen boot if necessary). No leakage is permitted. If leakage is detected, the diaphragm must be replaced.

30.2 EMERGENCY/PARKING BRAKE MANUAL RELEASE

***Warning**: Never stand in the axis line of the spring brake chambers, especially when caging the spring.*

Drive Axle

1. Block the wheels to prevent the vehicle from moving.
2. Remove the release stud tool from its storage place on drive axle brake air chamber.
3. Remove the access plug from the end of the spring chamber, then insert the release stud through the opening. Turn the release stud ¼ turn (clockwise) to anchor it into the spring plate. Install the flat washer and nut, then turn the nut clockwise to cage the spring. Repeat on the opposite side.

***Warning:** Make sure the release stud is properly anchored in spring plate receptacle prior to caging the spring.*

4. To manually reset the emergency/parking brake, turn the nut counterclockwise. Reinstall access plugs on the spring chambers, and release stud tools in their storage places.

Tag Axle

1. Block the wheels to prevent the vehicle from moving.
2. Turn the release bolt counterclockwise to cage the power spring (approx. 2.5 inches (6 cm)). Repeat on the opposite side.

3. To manually reset the emergency/parking brake, turn the bolt clockwise.

30.3 BRAKE CHAMBER REMOVAL

Warning: *To prevent personal injuries, brakes should be inoperative prior to working on any of their components.*

Warning*: To prevent personal injuries, brake chambers should be made inoperative by releasing spring tension prior to disposal.*

1. Block the wheels to prevent the vehicle from moving.
2. Safely support vehicle at the recommended body jacking points.
3. To gain access to a given brake air chamber, the corresponding wheel can be removed (refer to Section 13: *"Wheels, Hubs and Tires"*).
4. Exhaust compressed air from system by opening the drain valve of each reservoir.
5. For the drive and tag axles brake chambers, manually release spring brakes (refer to "*Emergency/Parking Brake, Manual Release"* procedure in this section).
6. Disconnect air line(s) from brake chamber.
7. Remove the cotter pin connecting brake chamber and slack adjuster (drive axle).
8. Unbolt and remove the brake chamber from vehicle.

30.4 BRAKE CHAMBER INSTALLATION

Reverse removal procedure, then check brake adjustment.

Caution*: Always clean air lines and fittings, and coat pipe threads with teflon pipe sealant before reconnecting air lines.*

30.5 BRAKE CHAMBER DISASSEMBLY

Warning: *Spring brake chambers, on drive and tag axles contain an extremely high compressive force spring, which can possibly cause serious injury if special precautions are not taken when working around this area.*

To avoid such injury, the following recommendations must be applied:

1. Prévost recommends the installation of a new spring brake chamber if it is found to be defective.

2. Spring brake chamber maintenance and/or repair must be performed by trained and qualified personnel only.

3. Before manually releasing spring brakes, visually check spring brake for cracks and/or corrosion.

4. On "MGM" brake chambers (drive axle), make sure the release stud is properly anchored in spring plate receptacle prior to caging the spring.

5. Never stand in the axis line of the spring brake chambers, especially when caging the spring.

Warning: *To prevent personal injury, brakes should be inoperative before working on any components.*

1. Block the wheels to prevent the vehicle from moving.
2. Safely support vehicle at the recommended body jacking points.

Note*: To gain access to a given brake air chamber, the corresponding wheel can be removed (refer to Section 13: "Wheels, Hubs and Tires").*

3. Exhaust compressed air from air system by opening the drain valve of each reservoir.
4. For the drive and tag axles brake chambers, manually release spring brakes (refer to "*Emergency/Parking Brake Manual Release"* procedure in this section).
5. Remove clamp ring, remove and discard the existing diaphragm. Install the new diaphragm squarely on body.
6. Reverse the procedure for assembly. Tap clamp ring to ensure proper seating. Check for proper operation before placing vehicle in service.

31. ANTI-LOCK BRAKING SYSTEM (ABS)

This device has been designed to ensure stability and permit steering control of vehicle during hard braking, and to minimize its stopping distance whatever the road conditions are. On slippery roads and generally in emergency situations, over-braking frequently induces wheel lock. The anti-lock braking system provides maximum braking performance while maintaining adequate steering control on slippery roads.

The ABS continuously monitors wheel behavior during braking. Sensors on each wheel of front and drive axles (tag axle is slave to drive axle) transmit data to a four channel electronic processor which senses when any wheel is about to lock. Modulator valves quickly adjust the brake pressure (up to 5 times per second) to prevent wheel locking. Each wheel is therefore controlled according to the grip available between its tire and the road.

With this device, the vehicle is brought to a halt in the shortest possible time, while remaining stable and under the driver's control.

Since the braking system has dual circuits, the ABS is also provided with a secondary system should a fault develop in the ABS. Anti-lock systems are a parallel system which does not hinder brake functioning in case of failure. Braking system functions in normal, non anti-lock controlled operation during ABS system failure.

The ABS system consists of two diagonally related circuits, only the half of the system which has sustained damage or other fault is switched off (i.e. wheels return to normal non-ABS braking). The other diagonal half remains under full ABS control.

Note*: ABS is active on service brake, transmission retarder, Jake brake, but is inactive on emergency/parking brake.*

Note*: The ABS system is inoperative at speeds under 4 mph (6 Km/h). Illumination of ABS telltale indicator at these speeds is normal.*

Caution*: Disconnect the ECU or pull the ABS fuse before towing vehicle.*

31.1 TROUBLESHOOTING AND TESTING

For troubleshooting and testing of the vehicle's anti-lock braking system, refer to Meritor Wabco Maintenance Manual MM-0112: *"Anti-Lock Braking System (ABS) for Trucks, Tractors and Buses"*, at the end of this section. Use dashboard Message Center Display (MCD) Diagnostic Mode for troubleshooting and repair.

31.2 ABS COMPONENTS

The main components of the ABS system are listed hereafter. Refer to each component for its specific function in the system and for proper maintenance.

31.2.1 Electronic Control Unit (ECU)

This control unit is located in the front service compartment, (refer to figure 43 for location). According to the data transmitted by the sensors (number of pulses/sec is proportional to the speed of each wheel), the electronic control unit determines which wheel is accelerating or decelerating. It then establishes a reference speed (average speed) from each wheel data, and compares the speed of each wheel with this reference speed to determine which wheel is accelerating or decelerating.

As soon as wheel deceleration or wheel slip threshold values are exceeded, the electronic control unit signals a solenoid control valve to limit the excessive brake pressure produced by the driver in the appropriate brake chamber.

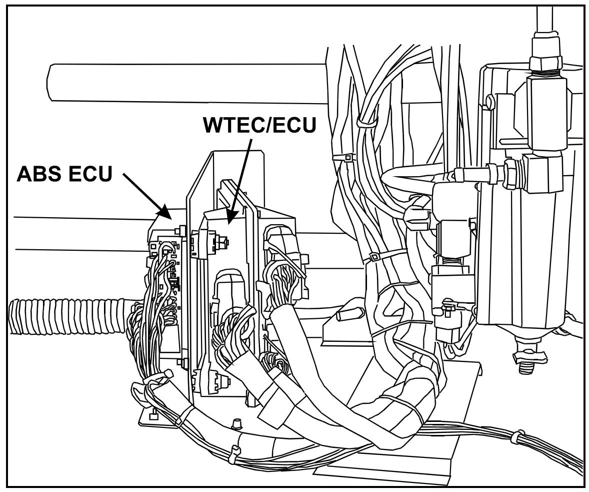


FIGURE 41: ABS ECU LOCATION 12147

Maintenance

No specific maintenance is required. The ECU is not serviceable. When found to be defective, replace.

Caution*: In order to protect the ABS electronic control unit from voltage surges, always disconnect before performing any welding procedure on vehicle.*

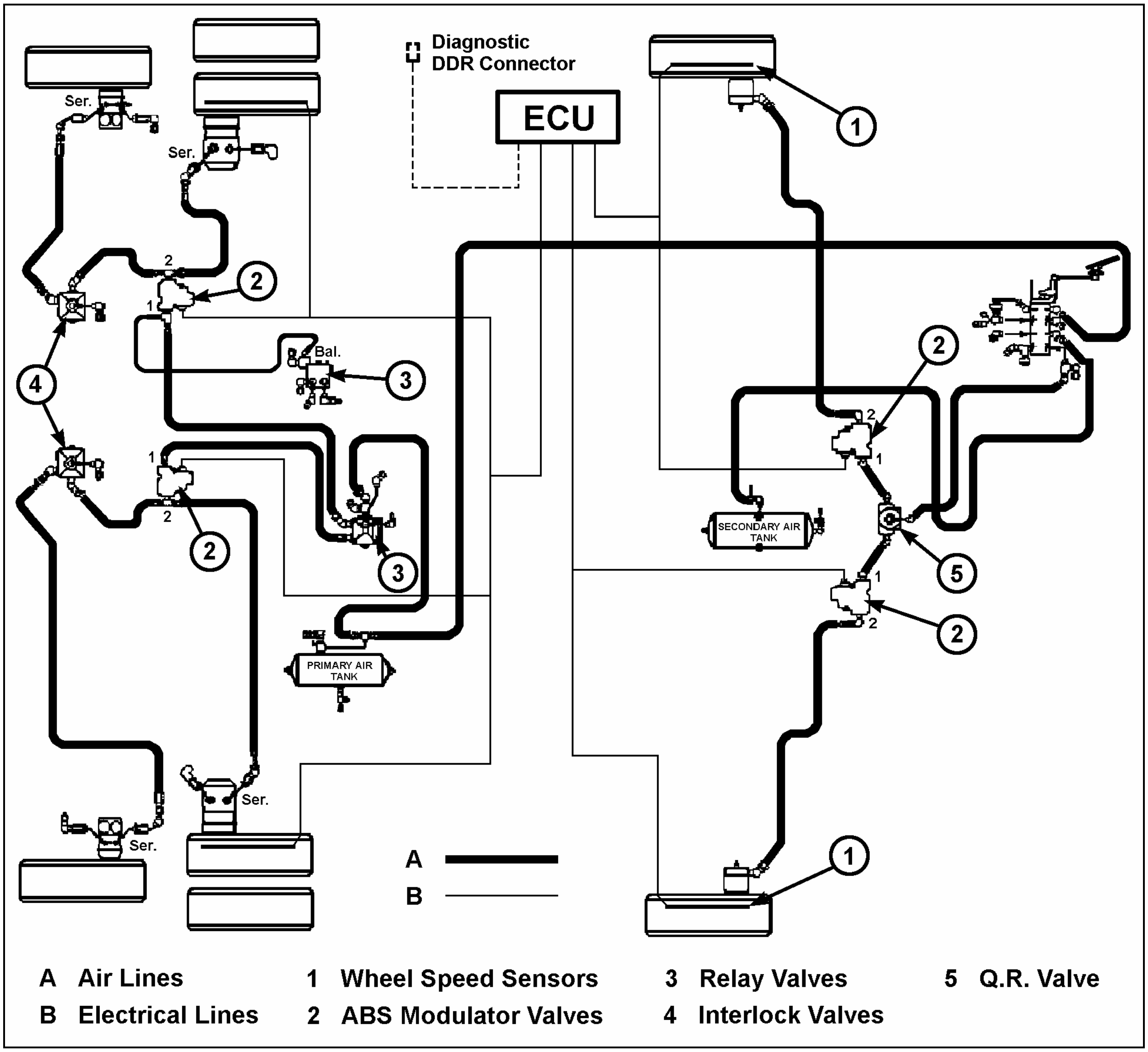


FIGURE 42: ABS 4S/4M CONFIGURATION

31.2.2 ABS Modulator Valve

This ABS system is equipped with four modulator valves, located between the brake chamber and the relay valve or quick release valve (Fig. 45). Note that there is only one solenoid valve controlling the drive and tag axle wheels on the same side (tag axle is slave to drive axle).

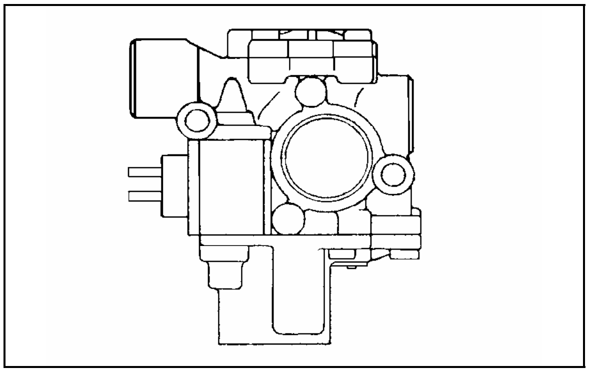


FIGURE 43: ABS MODULATOR VALVE 12084

This is an *"On/Off"* type valve, i.e., at brake application, the valve exhausts air from the brake chamber when the electronic unit senses that the corresponding wheel speed is decreasing in relation to the other wheels.

Maintenance

No specific maintenance is required for the solenoid control valve.

31.2.3 Sensors

The sensors are mounted on the front and drive axle wheel hubs (Fig. 45). The inductive sensors consist essentially of a permanent magnet with a round pole pin and a coil. The rotation of the toothed wheel alters the magnetic flux picked up by the coil, producing an alternating voltage, the frequency of which is proportional to wheel speed. When wheel speed decreases, magnetic flux decreases proportionately. Consequently, the electronic control unit will command the solenoid control valve to decrease the pressure at the corresponding brake chamber.

Maintenance

No specific maintenance is required for sensors, except if the sensors have to be removed for axle servicing. In such a case, sensors should be lubricated with a special grease (Prévost #680460) before reinstallation. Refer to paragraph *"Sensor Installation"* for details.

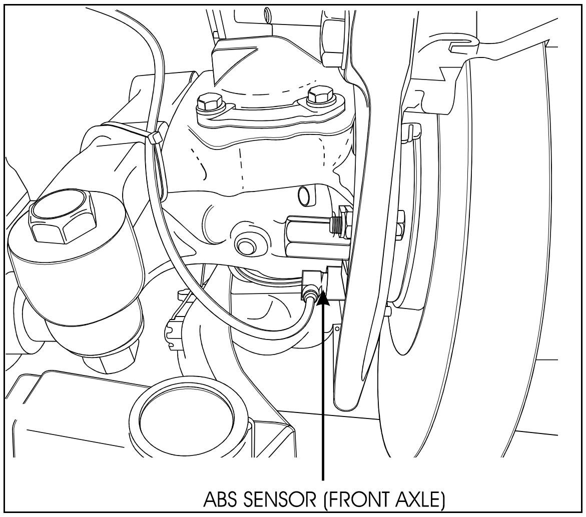


FIGURE 44: ABS SENSOR LOCATION 12153

Note: *The resistance value, when sensors are checked as a unit, must be equal to 1,75 k ohms. To check the sensors for proper output voltage after the sensors and toothed wheels have been assembled to the axle, connect a suitable AC voltmeter across the output terminals. With the hubs rotating at 30 rpm, the output voltages should read from 50 to 1999 mV to be acceptable.*

31.2.4 Sensor Installation

The following procedure deals with sensor installation on the axle wheel hubs. Read procedure carefully before reinstalling a sensor, as its installation must comply with operational tolerances and specifications.

1. Apply recommended lubricant (Prévost #680460) to spring clip and sensor.

Caution*: Use only this type of grease on the sensors.*

2. Insert spring clip in the holder on hub. Make sure the spring clip tabs are on the inboard side of the vehicle. Push in until the clip stops.
3. Push the sensor completely inside the spring clip until it is in contact with the tooth wheel. Ensure mounting is rigid, as it is an important criterion for adequate sensor operation.

Note*: This installation should be of the "press fit" type.*

31.2.5 Spring clip

The spring clip retains the sensor in its mounting bracket close to the toothed pulse wheel. The gap between the sensor end and teeth is set automatically by pushing the sensor in the clip hard up against the tooth wheel, and the latter knocks back the sensor to its adjusted position (Fig. 47).

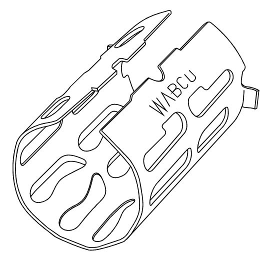


FIGURE 45: SPRING CLIP 12161

Maintenance

The spring clip requires no specific maintenance.

32. FITTING TIGHTENING TORQUES

45° Flare and Inverted Flare: Tighten assembly with a wrench until a solid feeling is encountered. From that point, tighten 1/6 turn (Fig. 48).

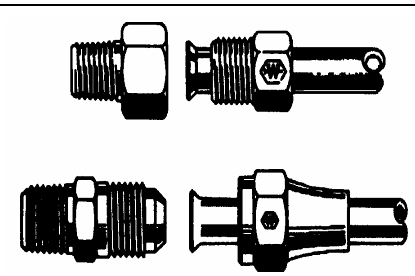


FIGURE 46: HOSE FITTINGS 12053

Compression: Tighten nut by hand (Fig. 49). From that point, tighten using a wrench the number of turns indicated in the chart hereafter.

Fitting size	Pipe diameter (inches)	Number of additional turns required following hand tightening
2	1/8	1 ¼
3	3/16	1 ¼
4	1/4	1 ¼
5	5/16	1 ¾
6	3/8	2 ¼
8	1/2	2 ¼
10	5/8	2 ¼
12	3/4	2 ¼
16	1	2 ¼

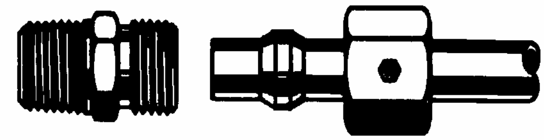


FIGURE 47: HOSE FITTING 12054

NTA-Type Plastic Tubing: Hand tighten nut (Fig. 50). From that point, tighten using a wrench the number of turns indicated in the following chart.

Tubing diameter (inches)	Number of additional turns required following hand tightening
1/4	3
3/8 to 1/2	4
5/8 to 3/4	3 ½

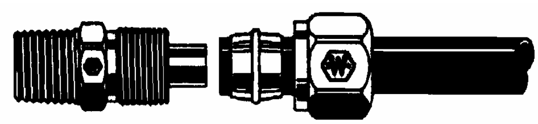


FIGURE 48: HOSE FITTING 12055

AB-Type Copper Piping: Hand tighten nut (Fig. 51). From that point, tighten with a wrench the number of turns indicated in the following chart.

Piping diameter (inches)	Number of additional turns required following hand tightening
1/4, 3/8, 1/2	2
5/8, 3/4	3

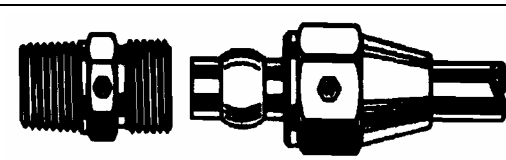


FIGURE 49: HOSE FITTING 12056

Pipe Tightening: All connections must be hand tightened. From that point, tighten a minimum of 2 ½ additional turns.

Note: *Use Locktite (Prévost number 680098) pipe sealant to seal pipe thread.*

33. SPECIFICATIONS

Air Compressor

Make....................Bendix Westinghouse
Model....................BA-921
Capacity (at 1250 rpm)....................15.7 cfm (0,445 m^3/min.)
Supplier number....................801287
Prévost number....................641990

BA-921 Service Kits

ST-4 Safety Valve

Supplier number....................800534
Prévost number....................641989

Series 60 Seal Kit

Supplier number....................5012371
Prévost number....................641988

Compressor Seal Kit

Supplier number....................5008559
Prévost number....................641987

Cylinder Head Gasket Kit

Supplier number....................5008558
Prévost number....................641986

Air Dryer

Make....................Haldex
Model....................AT-87192
Supplier number....................108229
Prévost number....................70303498
Desiccant cartridge Prévost number....................3097369

Flip-Flop Control Valve

Make....................Bendix Westinghouse
Model....................TW-1
Type....................On-Off
Supplier number....................229635
Prévost number....................640136

Emergency/Parking Brake Control Valve

Make....................Bendix Westinghouse
Model....................PP-1
Automatic release pressure....................40 psi (275 kPa) nominal
Supplier number....................287325
Prévost number....................641128

Emergency/Parking Brake Overrule Control Valve

Make....................Bendix Westinghouse
Model....................RD-3
Supplier number....................281481
Prévost number....................640472

Dual Brake Application Valve

Make....................Bendix Westinghouse
Model....................E-10P
Supplier number....................5006280
Prévost number....................641856

Stoplight Switches

Make........ Bendix Westinghouse
Model........ SL-5
Contact close (ascending pressure) .... 4 psi and more (28 kPa)
Supplier number........ 286404
Prévost number........ 641462

Brake Relay Valves

Make........ Bendix Westinghouse
Model........ R-12 & R-12C
Supplier number........ 102852
Prévost number........ 641088

Quick Release Valve

Make........ Bendix Westinghouse
Model........ QR-1
Supplier number........ 5001496
Prévost number........ 641429

Spring Brake Valve

Make........ Bendix Westinghouse
Model........ SR-1
Supplier number........ 286364
Prévost number........ 640870

Pressure Protection Valve

Make........ Bendix Westinghouse
Model........ PR-4
Nominal closing pressure........ 70 psi (482 kPa)
Supplier number........ 277226
Prévost number........ 641137

Shuttle-Type Double Check Valve

Make........ Bendix Westinghouse
Model........ DC-4
Supplier number........ 277988
Prévost number........ 641015

Low Pressure Indicators

Make........ Bendix Westinghouse
Model........ LP-3
Contact close .... 66 psi (455 kPa)
Supplier number........ 277227
Prévost number........ 640975

Air Pressure Regulator

Make........ Norgren
Adjustable output range .... 0-80/85 psi (0-552/586 kPa)
Recommended pressure setting........ 75 psi (517 kPa)
Supplier number........ R06-2G7 RNKA
Prévost number........ 641472

Air Filter Element

Make.. Norgren
Type .... With manual drain
Supplier number.. F74G-345-004
Prévost number.. 641338

Front Axle Brake Chambers

Make.. Knorr-Bremse
Type 24
Supplier number (R.H.) .... BS-3457 II 34671
Prévost number (R.H.) 641414
Supplier number (L.H.)... BS-3457 II 34670
Prévost number (L.H.).. 641413

Drive Axle Brake Chambers

Make.. Knorr-Bremse
Type .... 24 as service -24 as emergency
Supplier number.. II/35699/BS-9524
Prévost number.. 641432

Piggy Back (On Drive Brakes)

Make.. Knorr-Bremse
Type .... 24 as emergency
Supplier number.. II/17567/0061
Prévost number.. 641433

Tag Axle Brake Chambers

Make.. Knorr-Bremse
Type .... 16 as service – 16 as emergency
Supplier number.. II/18224/V1-BS9396
Prévost number.. 641308

Piggy Back (On Tag Brakes)

Make.. Knorr-Bremse
Type .... 16 as emergency
Supplier number.. II/18224/0061
Prévost number.. 641431

Brake Lining (All Axles)

Make.. Knorr-Bremse
Supplier number.. II 33976
Prévost number.. 611049
Prévost number.. 641226

ABS ANTILOCK BRAKING SYSTEM (if applicable)

ABS MODULATOR VALVE

Make.. Rockwell Wabco
Voltage .... 24 V
Supplier number.. 472 195 006 0
Prévost number.. 641097

Sensor, Front Axle

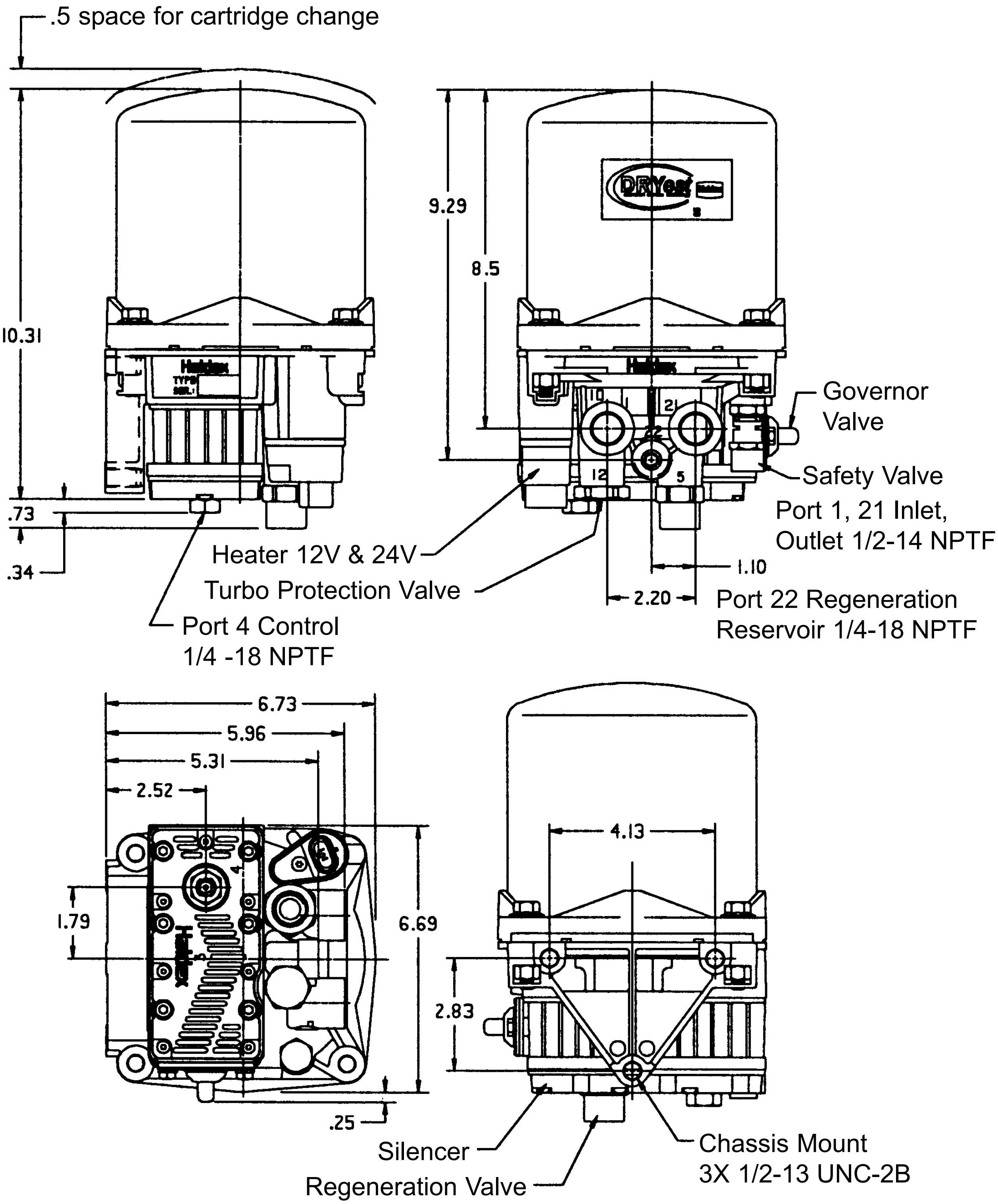
Supplier number.. 441 032-572-0
Prévost number.. 641288

Sensor, Drive Axle (In Wheel End)

Supplier number.. 441 032-576-0
Prévost number.. 641095

DRY*est* Air Dryer
Installation and Maintenance

L31166
9/02



The Haldex DRY*est* is a desiccant type dryer that effectively removes moisture, oil and contaminants from the compressed air system. This reduces the risk of freezing or corrosion of the components in the air system. When compressor cut-out is reached, dry air is allowed to flow back to regenerate the desiccant bed. The SIX (6) different applications available for the DRY*est* are illustrated on the next page.

Application Schematics

FIG. 2.A. Standard System Regeneration with Integrated Governor

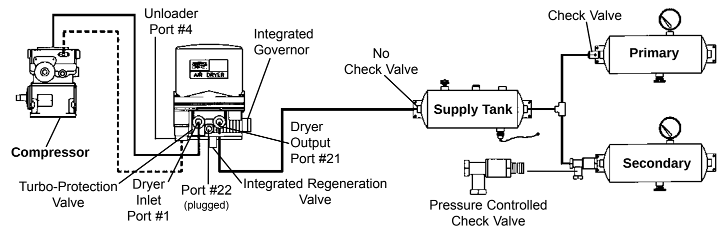


FIG. 2.B System Regeneration with External Governor

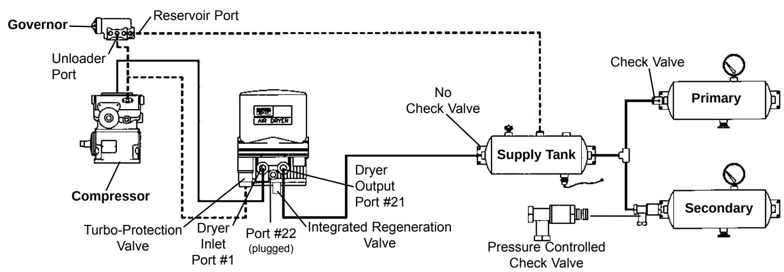


FIG. 2.C External Purge Tank Regeneration with Integrated Governor

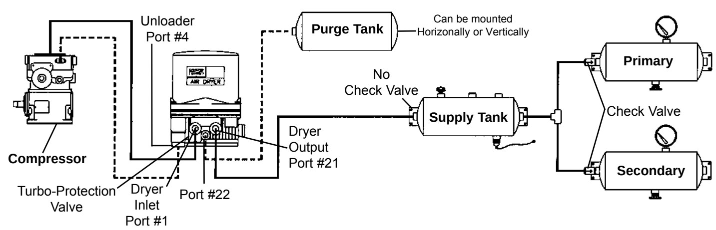


FIG. 2.D External Purge Tank Regeneration with External Governor

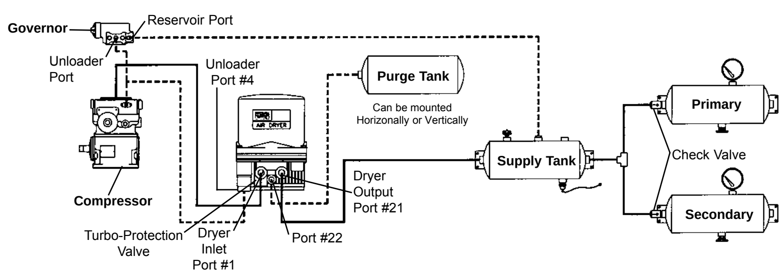


FIG. 2.E. Blow Thru: External Purge Tank with Integrated Governor

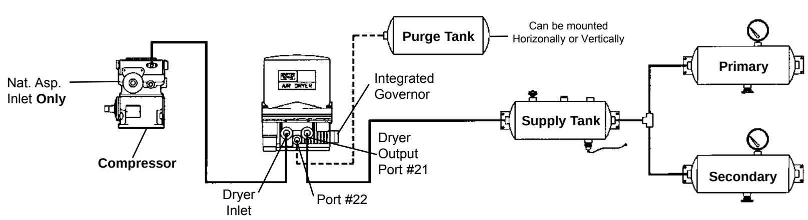
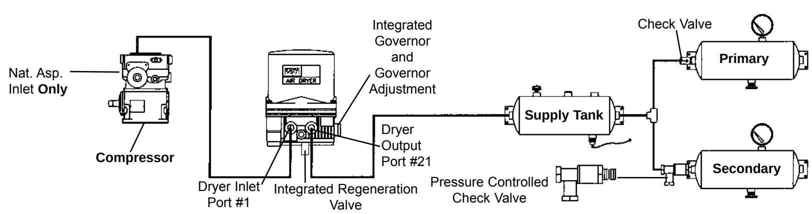


FIG. 2.F. Blow Thru: System Regeneration with Integrated Governor



Installing the DRY*est*

IMPORTANT CAUTION

1. Park the vehicle on a level surface, apply the parking brakes and always block the wheels.
2. Stop the engine when working around the vehicle.
3. Make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle.
4. Following the vehicle manufacturer's recommended procedures; deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment, the engine should be shut off. Where circumstances require that the engine be in operation, extreme caution should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated or electrically charged components.
6. Never connect or disconnect a hose or line containing pressure. Never remove a component plug unless you are certain all system pressure has been depleted.
7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to the use of those tools.
9. Use only genuine Haldex replacement parts, components and kits. Replacement hardware, tubing, fitting, etc should be of equivalent size, type and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

General

The vehicle installation guidelines presented in the Application Schematic apply to all DRY*est* Air Dryer installations. Determine your system configuration and plumb accordingly. Vehicles with the Holset Type-E or QE compressor require the following additional instructions.

Haldex "isolation valve" must be mounted before the DRYest. Consult Cummins for additional plumbing requirements.

Mounting on Vehicle

1. Locate with sufficient space to facilitate service & visual access.
2. Mount away from direct tire splash.
3. Brackets, Fittings and Lines to be mounted in a protected area.
4. Exhaust port downward.
5. Mount in area to avoid excessive heat.
6. Rigid mount to avoid excess vibration.
7. Line from compressor to DRY*est* should have continuous downward slope and no dips.
8. 90° Fittings should be avoided.
9. Not to exceed 15° inclination.
10. Maintain a minimum of ½" above the dryer for access to the desiccant cartridge.
11. The dryer is equipped with an integrated mounting bracket. The enclosed template is to be used to drill three (3) 9/16" holes. If the dryer is to be bolted directly to the frame or support member, check vehicle manufacturer's recommendations.
12. A mounting bracket can be used if necessary.
13. Install the dryer using the enclosed ½" bolts. Tighten to 45-55 ft-lb.

Heater Connection

1. Locate a circuit with the correct voltage that is "hot" when the ignition is "ON". The current draw is 8 amp@12V; 4amp@24V. A 10-15amp fuse is recommended in this line. Connect one heater lead to this wire.
2. Connect other lead to a good ground on vehicle chassis or electrical junction box.
3. For upgrade heater and connector information see " Service Information".

Installing the DRY*est* (con'd)

Compressor Discharge Line
General
While minimum diameters are specified, larger line diameters generally improve performance and life and reduce temperatures, particularly in severe applications.

1. The compressor discharge line material should be wire braided "Teflon" hose, copper tubing or a combination of both.
2. Compressor discharge line lengths and inside diameter requirements are dependent on the vehicle application.
3. The dryer inlet temperature must be less than 170°F. This can normally be accomplished with 12' to 15' of air compressor discharge line length.
4. Excessive line length should also be avoided to prevent freeze-up. The dryer inlet temperature must be greater than 40°F. If the discharge line exceeds 15', the line can be insulated as needed to prevent freeze-up.

Air Connections

1. Connect a suitable line from the compressor to the ½" NPT Inlet Port #1.
2. From the ½" NPT dryer outlet, Port #21, use a suitable line and connect to the supply tank.
3. Connect a ¼" nylon line or equivalent for control line(s).

Exhaust Line

1. If it is necessary to direct DRY*est* Air Dryer discharge contaminates away from vehicle components, it will be necessary to purchase an air dryer with special hose fitting option.

Testing the DRY*est*

Before placing the vehicle in service, perform the following tests.

1. Close all reservoir drain cocks.
2. Build up system air pressure to governor cut-out and note that the air dryer purges with an audible exhaust of air. If system 2.E or 2.F is used, the purge will be followed by a steady pulsating flow of air indicating that the system is "unloaded" and is venting to atmosphere.
3. Actuate the service brakes to reduce system air pressure to governor cut-in. Note that the system once again builds to full pressure and is followed by a purge.
4. It is recommended that the vehicle be tested for leakage using the following procedure to assure that the air dryer will not cycle excessively:
   A. Apply the parking brakes, build system pressure to governor cut-out and allow pressure to stabilize for at least 1 min.
   B. Observe the dash gauge pressures for 2 min. and note any pressure drop. Pressure drop should not exceed 4 psi with brake released and 6 psi with brakes applied. Any noticeable leakage must be repaired to avoid excessive cycling.
   C. On vehicles using "system regeneration": At cut-out pressure, system air is allowed to backflow from the secondary reservoir for desiccant regeneration. The vehicle secondary air gauge pressure will drop approximately 6 psi after the dryer purges.
5. Charge Cycle Time: During normal, daily operation the compressor should recover from governor cut-in to governor cut-out in 90 seconds or less at engine RPM's depending on vehicle vocation.
6. Purge Cycle Time: During normal vehicle operation, the air compressor must remain unloaded for a minimum of 30 seconds between charge cycles. This minimum purge time is required to insure complete regeneration of the desiccant.

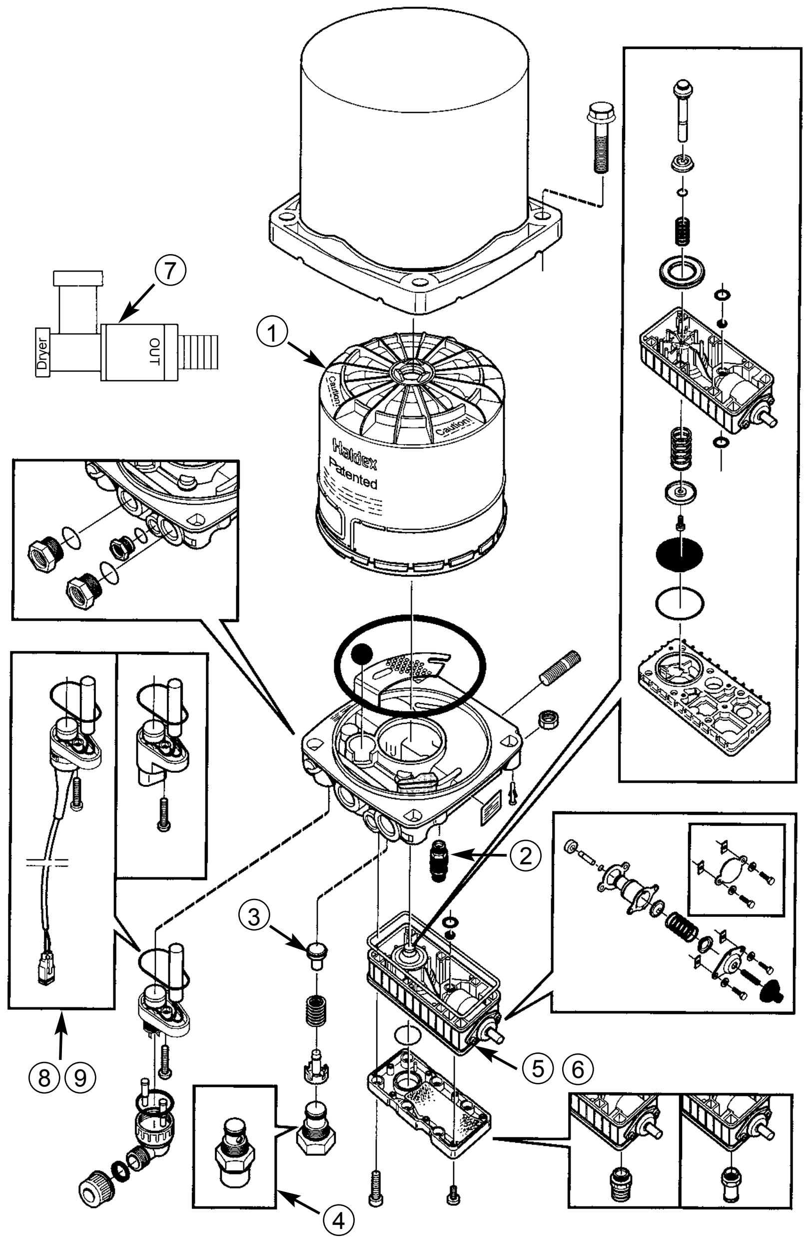
Troubleshooting

Problem	Cause	Repair
Water in air system	1. Contaminants in desiccant. 2. Leaks in air system.	1. Change desiccant cartridge. Check compressor for excessive oil passage. 2. Tighten air connections, soap connection and recheck for leaks per Testing the DRY*est* section.
Constant exhaust of air at air dryer and not Blow-Thru Type	1. Defective dryer outlet check valve. 2. Dryer unloading valve not closing.	1. Clean valve seat and replace check valve. 2. At compressor cut-out there **must** be a slight blow of regenerated air from the purge tank for approximately 30 seconds. If air flow continues, replace valve pack.
Excessive compressor cycling	1. Excessive leaks in air system. 2. Defective dryer outlet check valve. 3. Undersize compressor, duty cycle of compressor should not exceed 25%.	1. Tighten air connections, soap connection and recheck for leaks. 2. Clean valve seat and replace check valve. 3. Reduce air demand or use greater output compressor.
Safety valve is open	1. Desiccant cartridge is plugged. 2. Ice block in dryer. 3. Excessive system pressure.	1. Excessive oil passage from compressor. Check for worn compressor. Replace desiccant cartridge. 2. Check heater function. 3. Repair or replace governor.
Short life of dryer or desiccant cartridge	1. Air at inlet of dryer exceeds 170°F. 2. Duty cycle of compressor does not allow for sufficient time for desiccant regeneration.	1. Extend length of compressor discharge line; see Installing the DRY*est* section. The 170°F dryer inlet temperature can usually be accomplished with 12’ to 15’ of compressor discharge line. 2. During normal operation the compressor must remain unloaded for a minimum of 30 seconds to allow for sufficient purge. Lengthy loading times must be avoided. Air dryer must be “by-passed” in applications with high air use such as bulk unloading.
Poor drying efficiency	1. Air at inlet of dryer exceeds 170°F.	1. Extend length of compressor discharge line; see Installing the DRY*est* section. The 170°F dryer inlet temperature can usually be accomplished with 12’ to 15’ of compressor discharge line.

Service Parts

General Instructions
The following parts are available for maintenance and repair. Each service kit comes with specific repair instructions.

1. Desiccant Cartridge: 47178964
2. Safety Valve: 47178275
3. Check Valve: 47177433
4. Regeneration Valve: 47177434
5. Valve Pack with Integrated Governor: 47177343
6. Valve Pack w/o Integrated Governor: 47177442
7. Pressure Controlled Check Valve: 47110007
8. 12 V Heater: 47110020
9. 24 V Heater: 47110021
10. Integrated Turbo Protection Valve: 47189189 (Not Shown)



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Bendix

Service Data

SD-01-676

BA-921BENDIX AIR POWER COMPRESSOR

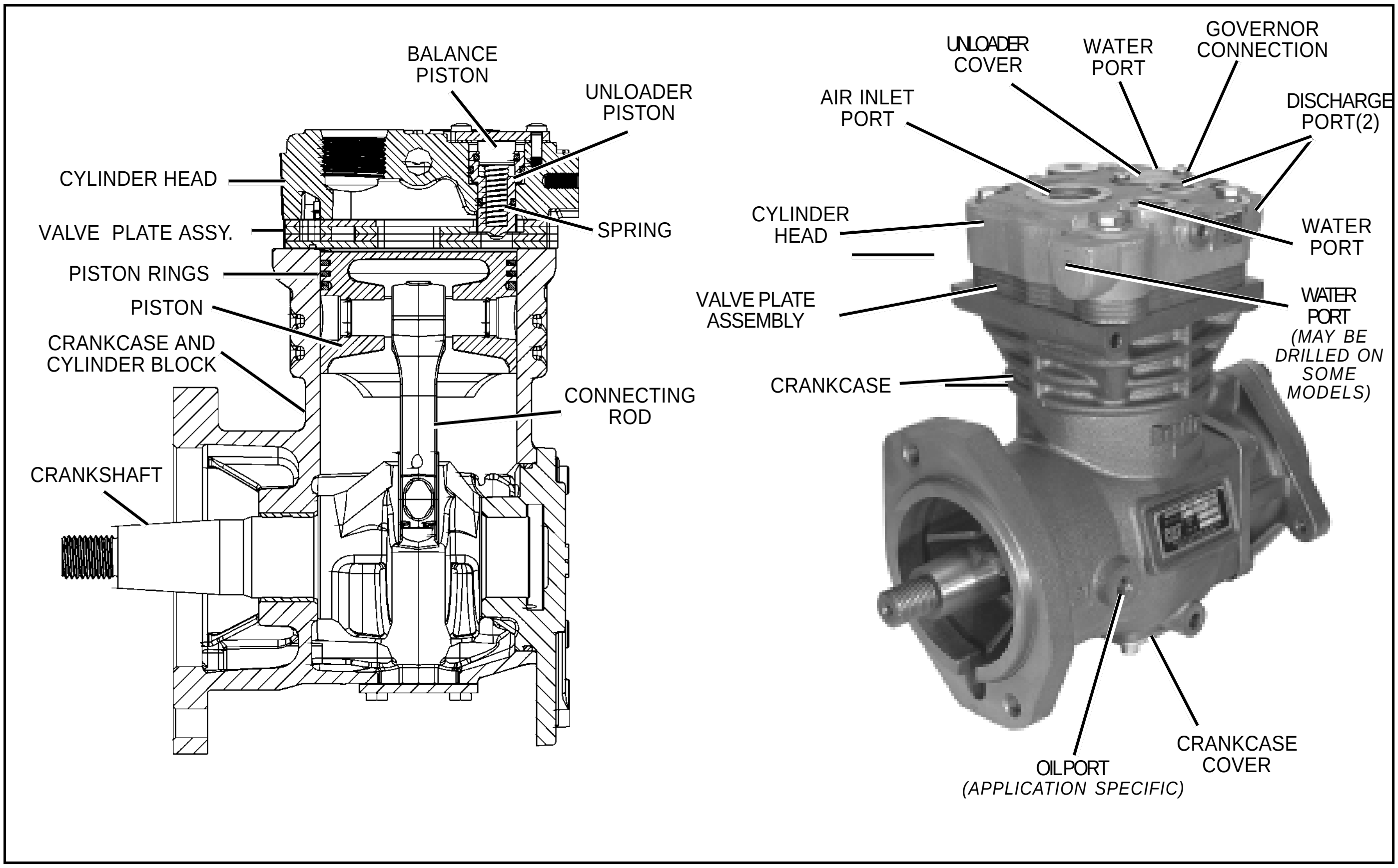


FIGURE 1 - BA-921 COMPRESSOR

DESCRIPTION

The function of the air compressor is to provide and maintain air under pressure to operate devices in the air brake and/or auxiliary air systems. The BA-921 compressor is a single cylinder reciprocating compressor with a rated displacement of 15.8 cubic feet per minute at 1250 RPM.

The compressor consists of a water cooled cylinder head and valve plate assembly and an air cooled integral crankcase and cylinder block. The cylinder head is an aluminum casting which contains the required air and water ports as well as an unloader piston. The valve plate assembly consists of laminated and brazed steel plates which incorporate various valve openings and channels for conducting air and engine coolant into and out of the cylinder head.

The discharge valves are part of the valve plate assembly. The cylinder head, with the valve plate comprise a complete cylinder head assembly.

The cast iron crankcase and cylinder block assembly, houses the piston, connecting rod, crankshaft and related bearings.

The BA-921 crankcase cover is stamped with information identifying the compressor model, customer piece number, Bendix piece number and serial number. See figure 2.

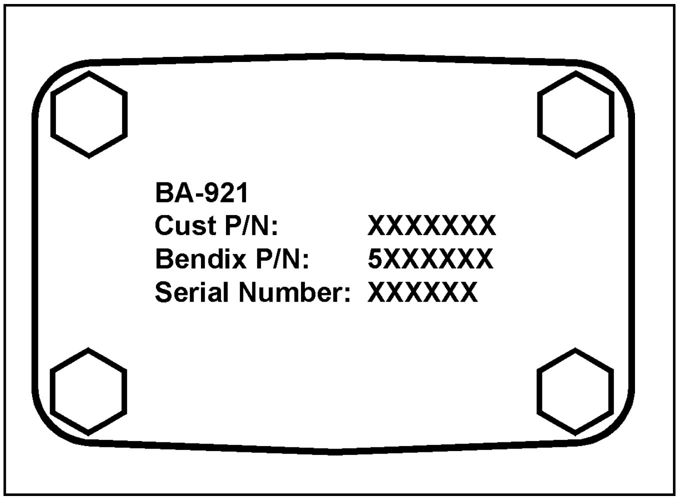


FIGURE 2 - BA-921 CRANKCASE COVER

OPERATION

The compressor is driven by the vehicle engine and functions continuously while the engine is in operation. Actual compression of air is controlled by the compressor unloading mechanism operating in conjunction with a governor.

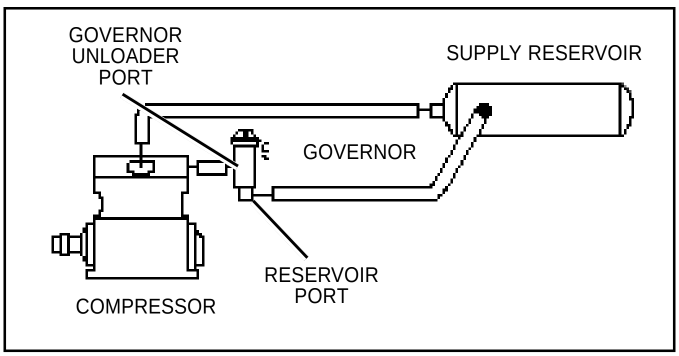


FIGURE 3 - BA-921 COMPRESSOR UNLOADER SYSTEM

AIR INTAKE (LOADED)

During the piston down stroke, a vacuum is created in the cylinder bore above the piston. The vacuum causes the inlet reed valve to flex open. Atmospheric air flows through the open inlet valve and fills the cylinder bore above the piston. See figures 4 & 7.

AIR COMPRESSION (LOADED)

When the piston reaches approximately bottom dead center (BDC), the inlet reed valve closes. Air above the piston is trapped by the closed inlet reed valve and is compressed as the piston begins to move toward top dead center (TDC). When air in the cylinder bore reaches a pressure greater than that of the system pressure the discharge reed valves open and air flows into the discharge line and air brake system.

Air, during the compression stroke, flows into the hollow center of the unloader piston through an opening in the end of the piston. Compressed air acts on the interior surfaces

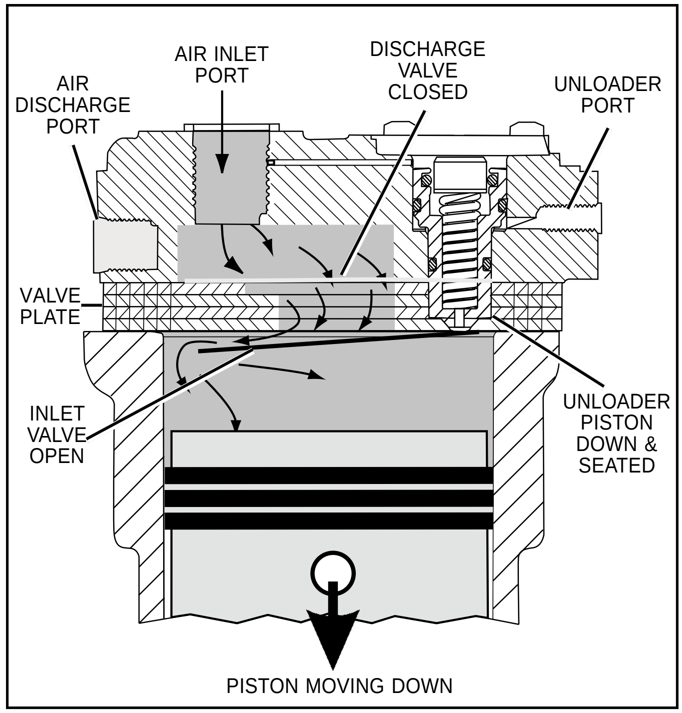


FIGURE 4 - OPERATIONAL-LOADED (INTAKE)

of the unloader piston and, along with the unloader piston spring, holds the unloader piston against its seat on the valve plate. See figures 5 & 7.

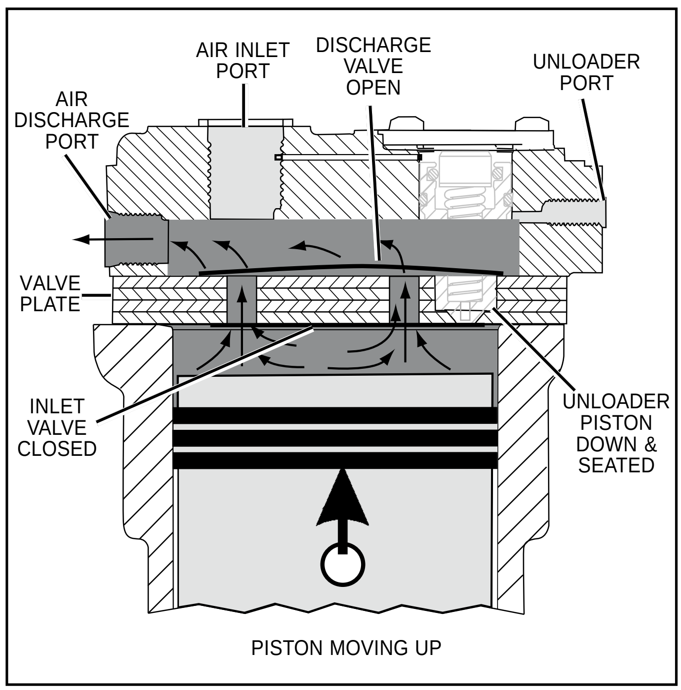


FIGURE 5 - OPERATIONAL-LOADED (COMPRESSION)

NON-COMPRESSION OF AIR (UNLOADED)

When air pressure in the supply reservoir reaches the cut-out setting of the governor, the governor delivers system air to the compressor unloader port. Air entering the unloader port acts on the unloader piston causing it to move away from its seat on the valve plate assembly. When the

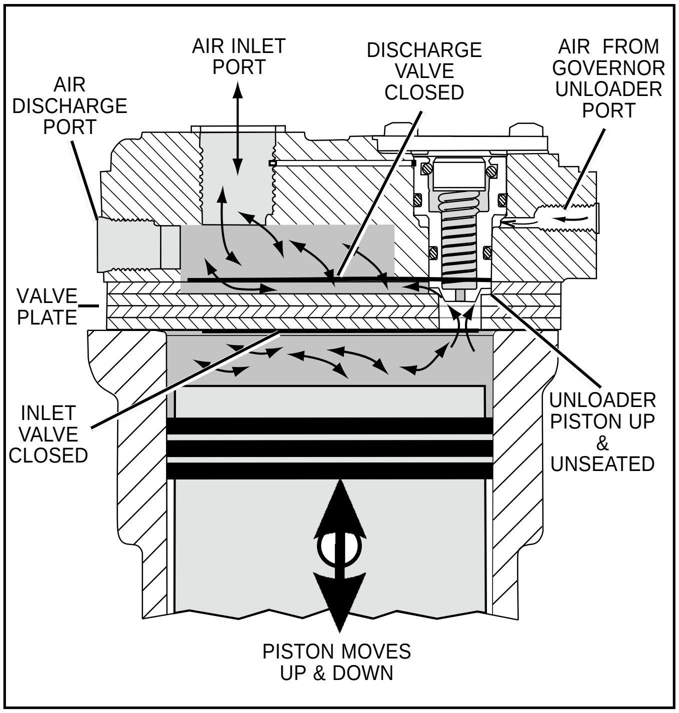


FIGURE 6 - OPERATIONAL-UNLOADED

unloader piston is unseated a passage is opened between the cylinder bore and the air inlet cavity in the cylinder head. Air compression ceases. See figures 6 & 7.

As the piston moves from bottom dead center (BDC) to top dead center (TDC) air in the cylinder bore flows past the unseated unloader piston, into the cylinder head inlet cavity and out the inlet port. On the piston down stroke (TDC to BDC) air flows in the reverse direction, from the inlet cavity past the unseated unloader piston and into the cylinder bore.

LUBRICATION

The vehicle's engine provides a continuous supply of oil to the compressor. Oil is routed from the engine to the compressor oil inlet. An oil passage in the crankshaft conducts pressurized oil to precision sleeve main bearings and to the connecting rod bearings. Spray lubrication of the cylinder bores, connecting rod wrist pin bushings, and ball type main bearings is obtained as oil is forced out around the crankshaft journals by engine oil pressure. Oil then falls to the bottom of the compressor crankcase and is returned to the engine through drain holes in the compressor mounting flange.

COOLING

Cooling fins are part of the crankcase/cylinder block casting. Coolant flowing from the engine cooling system through connecting lines enters the head and passes through internal passages in the cylinder head and valve plate assembly and is returned to the engine. Proper cooling is important in maintaining discharge air temperatures below the maximum recommended 400 degrees Fahrenheit. Figure 8 illustrates

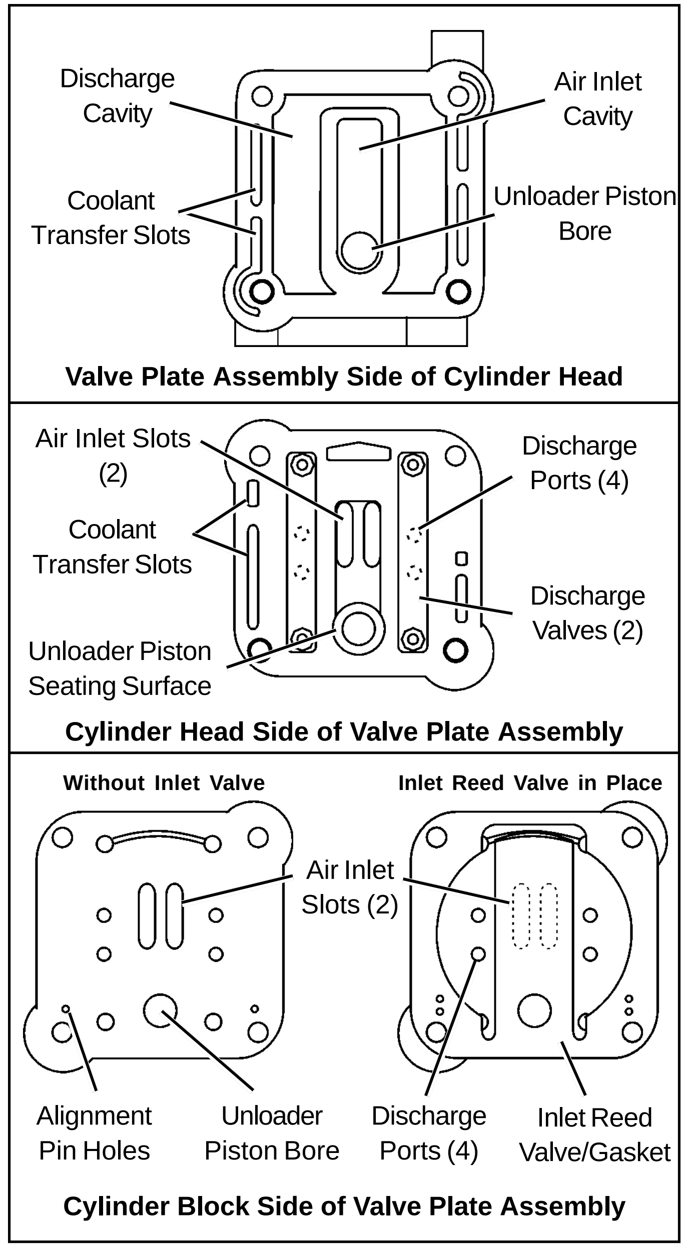


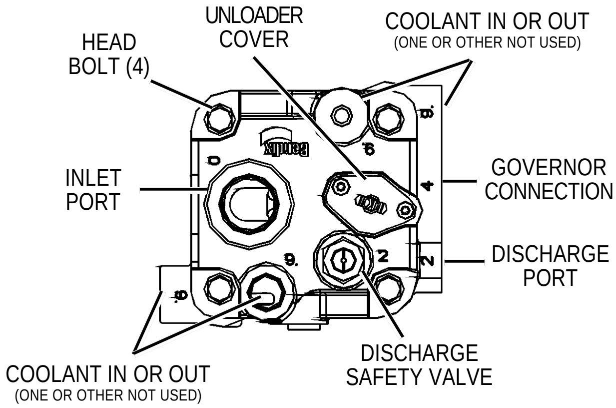
FIGURE 7 - CYLINDER HEAD AND VALVE PLATE ASSY.

the various approved coolant flow connections. See the tabulated technical data in the back of this manual for specific requirements.

PREVENTATIVE MAINTENANCE

Important Note: Review the warranty policy before performing any intrusive maintenance procedures. An extended warranty may be voided if intrusive maintenance is performed during this period.

EVERY 6 MONTHS, 1800 OPERATING HOURS OR AFTER EACH 50,000 MILES WHICHEVER OCCURS FIRST PERFORM THE FOLLOWING INSPECTIONS AND TESTS.



CYLINDER HEAD PORT IDENTIFICATION

The cylinder head connection ports are identified with cast in numerals as follows:

Atmospheric AIR IN	0
Compressed AIR OUT	2
Coolant IN or OUT	9
Governor Control	4

FIGURE 8- TYPICAL BA-921 CYLINDER HEAD

AIR INDUCTION

The BA-921 compressor is designed for either natural aspiration (connection to the vacuum side of the engine's air induction system) or turbocharging. When attached to the pressure side of the turbocharger, pressure at the BA-921 inlet port must not exceed 45 psig. See the tabulated technical data in the back of this manual.

One of the single most important aspects of compressor preventive maintenance is the induction of clean air. Since the BA-921 is connected to the engine air cleaner, proper periodic maintenance of the engine air filter eliminates the need for separate filter maintenance.

Inspect the compressor intake fittings, and the connecting hoses each time engine air cleaner maintenance is performed.

1. Inspect the intake hose adapters for physical damage. Make certain to check the adapters at both ends of the intake hose or tubing.
2. The intake hose clamps and tighten them if needed.
3. Inspect the intake hose or line for signs of drying, cracking, chafing and ruptures and replace it if necessary.

COMPRESSOR COOLING

Inspect the compressor discharge port, inlet cavity and discharge line for evidence of restrictions and carboning. If excessive buildup is noted, thoroughly clean or replace the affected parts. Since carbon buildup generally indicates inadequate cooling, closely inspect the compressor cooling system. Check all compressor coolant lines for kinks and restrictions to flow. **Minimum** coolant line size is 3/8" I.D. Check coolant lines for internal clogging from rust scale. If coolant lines appear suspicious, check the coolant flow and compare to the tabulated technical data present in the back of this manual. Carefully inspect the air induction system for restrictions.

LUBRICATION

Check the external oil supply line for kinks, bends, or restrictions to flow. Supply lines must be a minimum of 3/16" I.D. Refer to the tabulated technical data in the back of this manual for oil pressure minimum values.

COMPRESSOR DRIVE

Check for noisy compressor operation, which could indicate excessive drive component wear. Adjust and/or replace as necessary. Check all compressor mounting bolts and retighten evenly if necessary. Check for leakage and proper unloader mechanism operation. Repair or replace parts as necessary.

COMPRESSOR UNLOADER & GOVERNOR

Test and inspect the compressor and governor unloader system for proper operation and pressure setting.

1. Make certain the unloader system lines are connected as illustrated in figure 3.
2. Cycle the compressor through the loaded and unloaded cycle several times. Make certain that the governor cuts out at its specified pressure (cut in should be approximately 15-20 psi less than cutout pressure). Adjust or replace the governor as required.
3. Note that the compressor cycles to the loaded and unloaded conditions promptly. If prompt action is not noted, repair or replace the governor and/or repair the compressor unloader.

SERVICE TESTS

GENERAL

The following compressor operating and leakage tests need not be performed on a regular basis. These tests should be performed when; it is suspected that leakage is substantially affecting compressor buildup performance, or when it is suspected that the compressor is “cycling” between the load and unloaded modes due to unloader plunger leakage.

OPERATING TESTS

Compressor Performance

Vehicles manufactured after the effective date of FMVSS 121 must have a compressor capable of raising air system pressure from 85-100 psi in 25 seconds or less, with the minimum required reservoir volume for the vehicle. This test is performed with the engine operating at maximum recommended governed speed. The vehicle manufacturer must certify this performance on new vehicles with appropriate allowances for air systems with greater than the minimum required reservoir volume. As a less severe alternative to running a high RPM test, a new compressor's buildup time can be measured and recorded at high idle. Subsequent testing throughout the compressor's service life can be compared to the base line new compressor performance. Compressor buildup times should be recorded and kept with the vehicle maintenance files for reference. When testing compressor buildup times it is essential that air system leakage be kept below the allowed maximum for the vehicle type being tested. Before running buildup tests check the service and supply systems for excessive leakage and repair as necessary.

Note: Supply system leakage is not displayed on the vehicle dash gauges and must be tested separately. Supply system components such as the governor, air dyer, reservoir drain cocks, safety valve and check valves can leak without indication on the dash gauges. These components must be checked for leakage separately and individually. Refer to the various maintenance manuals for individual component leakage tests and the Bendix "Test and Checklist" published in the Air Brake System Handbook (BW5057) for air system leakage testing.

LEAKAGE TESTS

Cylinder Head

Check for cylinder head gasket air leakage.

1. With the engine running, lower air system pressure to 60 psi and apply a soap solution around the cylinder head. Check the gasket between the cylinder head and valve plate assembly and the reed valve/gasket between the valve plate assembly and cylinder block for air leakage.
2. No leakage is permitted. If leakage is detected replace the compressor or repair the cylinder head using a genuine Bendix maintenance kit available from an authorized Bendix parts outlets.

Unloader

In order to test the inlet and discharge valves and the unloader piston, it is necessary to have shop air pressure and an assortment of fittings. A soap solution is also required.

Build-Up tests

1. With the engine running, lower air system pressure to 90 psi and raise engine RPM to 1800. Measure and record the time required to raise system pressure from 100 psi to 130 psi Run this test three times and use the average time.

   Note: This test should be run with the engine and air system at normal operating temperature (i.e. not cold).
2. Compare the average time recorded in step 2 with previously recorded build up times to evaluate compressor performance.

Unloader leakage is exhibited by excessive compressor cycling between the loaded and unloaded condition.

1. With service and supply system leakage below the maximum allowable limits and the vehicle parked, bring system pressure to governor cutout and allow the engine to idle.
2. The compressor should remain unloaded for a minimum of 5-10 minutes. If compressor cycling occurs more frequently and service and supply system leakage is within tolerance replace the compressor or repair the compressor unloader system using a genuine Bendix maintenance kit available from authorized Bendix parts outlets.

COMPRESSOR REMOVAL & DISASSEMBLY

GENERAL

The following disassembly and assembly procedure is presented for reference purposes and presupposes that a rebuild or repair of the compressor is being undertaken. Several maintenance kits are available and the instructions provided with these parts and kits should be followed in lieu of the instructions presented here.

MAINTENANCE KITS & SERVICE PARTS

Cylinder Head Gasket Kit.

Unloader Kit.

Governor Adapter Kit.

Safety Valve.

Seal Kits.

All components shown in figure 9 with a key number are available in kits and/or as individual service parts.

IMPORTANT! PLEASE READ:

When working on or around a vehicle, the following general precautions should be observed:

1. **Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.**
2. **Stop the engine when working around the vehicle.**

3. **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.**
4. **Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.**
5. **When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, extreme caution should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.**
6. **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 depleted.**
7. **Never exceed recommended pressures and always wear safety glasses.**
8. **Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.**
9. **Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.**
10. **Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.**
11. **Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.**

REMOVAL

In many instances it may not be necessary to remove the compressor from the vehicle when installing the various maintenance kits and service parts. The maintenance technician must assess the installation and determine the correct course of action.

These instructions are general and are intended to be a guide. In some cases additional preparations and precautions are necessary. In all cases follow the instructions contained in the vehicle maintenance manual in lieu of the instructions, precautions and procedures presented in this manual.

1. Block the wheels of the vehicle and drain the air pressure from all the reservoirs in the system.
2. Drain the engine cooling system and the cylinder head of the compressor. Identify and disconnect all air, water and oil lines leading to the compressor.
3. Remove as much road dirt and grease from the exterior of the compressor as possible.
4. Remove the discharge and inlet fittings, if applicable, and note their position on the compressor to aid in reassembly.

   Note: If a cylinder head maintenance kit is being installed, stop here and proceed to PREPARATION FOR DISASSEMBLY. If replacing the compressor continue.
3. Remove any supporting bracketing attached to the compressor and note their positions on the compressor to aid in reassembly.
5. Remove the flange mounting bolts and remove the compressor from the vehicle.
6. Inspect gear and associated drive parts for visible wear or damage. Since these parts are precision fitted, they must be replaced if they are worn or damaged. If replacing the compressor or replacing the drive gear, remove the drive gear from the compressor crankshaft using a gear puller.
7. If the compressor is being replaced stop here and proceed to "Installing The Compressor" at the end of the assembly procedure.

PREPARATION FOR DISASSEMBLY

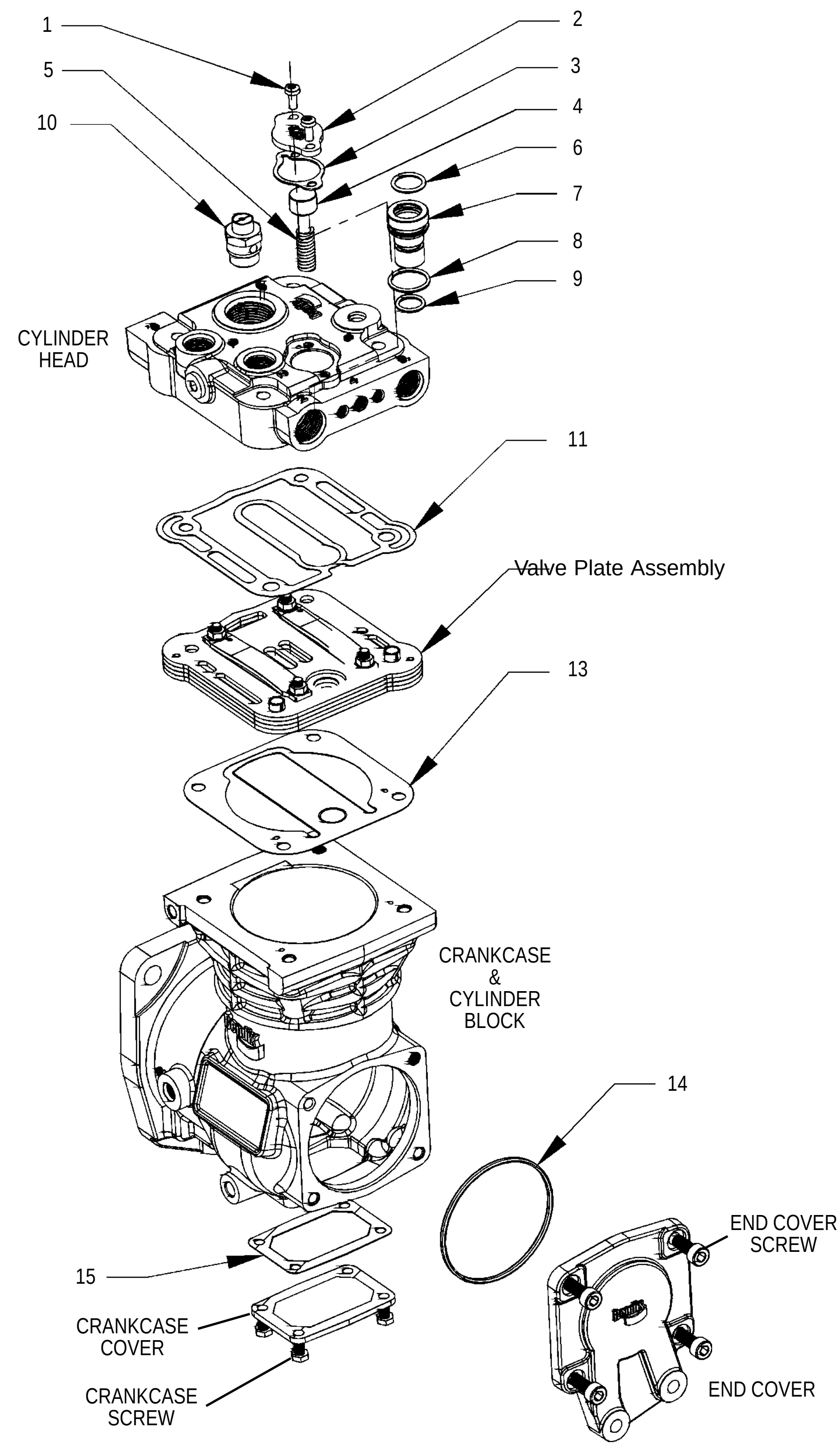
Remove the balance of road dirt and grease from the exterior of the compressor with a cleaning solvent. Mark the rear end cover or end cover adapter in relation to the crankcase. It is recommended but not specifically necessary to mark the relationship of the cylinder head to the valve plate assembly and crankcase and cylinder block assembly.

A convenient method to indicate the above relationships is to use a metal scribe to mark the parts with numbers or lines. Do not use marking methods such as chalk that can be wiped off or obliterated during rebuilding.

Prior to disassembly make certain that the appropriate kits and or replacement parts are available. Refer to figure 9 during the entire disassembly and assembly procedure.

CYLINDER HEAD

1. Remove the discharge safety valve (10) from the cylinder head.
2. To restrain the spring force exerted by balance piston spring (5), hold the unloader cover (2) in place while removing the two unloader cover cap screws (1). Carefully release the hold on the unloader cover until the spring force is relaxed, then remove the unloader cover (2).
3. Remove the unloader cover gasket (3).



Item	Qty.	Description	Item	Qty.	Description	Item	Qty	Description
1	2	Unloader Cover Cap Screw	6	1	O-Ring	11	1	Head Gasket
2	1	Unloader Cover	7	1	O-Ring	12	--	Intentionally Left Blank
3	1	Unloader Cap Gasket	8	1	Unloader Piston	13	1	Inlet Reed Valve/Gasket
4	1	Unloader Balance Piston	9	1	O-Ring	14	1	O-Ring
5	1	Spring	10	1	Safety Valve	15	1	Bottom Cover Gasket

FIGURE 9- BA-921 EXPLODED VIEW OF SERVICEABLE PARTS

4. Remove the balance piston (4) and its spring (5) from the cylinder head.
5. Remove the four hex head bolts and washers from the cylinder head.
6. Gently tap the head and valve plate assembly with a soft mallet to break the gasket seal. Lift the cylinder head and valve plate assembly (12) off the cylinder block.
7. Remove the metal reed valve/gasket (13).
8. Gently tap the head and valve plate assembly (12) with a soft mallet to break the gasket seal. Then separate the cylinder head from the valve plate assembly (12) and remove the gasket (11).
9. Turn the aluminum cylinder head over to expose the interior portion of the head. Push the unloader piston (8) along with its o-rings (6, 7 & 9) out of the cylinder head.

CRANKCASE COVER

1. Remove the four crankcase cover cap screws securing the crankcase cover to the crankcase. Using a soft mallet, gently tap the crankcase cover to break the gasket seal. Remove the crankcase cover gasket (15).

REAR END COVER OR END COVER ADAPTER

1. Remove the four end cover cap screws that secure the rear end cover or end cover adapter to the crankcase.
2. Remove the rear end cover or end cover adapter from the crankcase. Remove the o-ring seal (14) from the end cover.

CLEANING OF PARTS

GENERAL

All parts should be cleaned in a good commercial grade of solvent and dried prior to inspection.

CYLINDER HEAD

1. Carefully remove all gasket material adhering to the aluminum cylinder head, steel valve plate assembly and cast iron cylinder block. Make certain not to deeply scratch or mar the gasket surfaces. Pay particular attention to the gasket surfaces of the aluminum head.
2. Remove carbon deposits from the discharge and inlet cavities of the cylinder head and valve plate assembly. They must be open and clear in both assemblies. Make certain not to damage the aluminum head.
3. Remove rust and scale from the cooling cavities and passages in the head and valve plate assembly (12) and use shop air to clear debris from the passages.
4. Check the threads in all cylinder head ports for galling. Minor chasing is permitted.
5. Make certain the unloader vent passage under the unloader cover (2) in the head is open and free of debris.

INSPECTION OF PARTS

CYLINDER HEAD & VALVE PLATE

1. Carefully inspect the cylinder head gasket surfaces for deep gouges and nicks. If detected, the compressor must be replaced.
2. Carefully inspect the valve plate assembly gasket surfaces for deep gouges and nicks. Pay particular attention to the metal gasket surface. A metal gasket (18) is used between the valve plate assembly and cylinder block. This surface must be smooth and free of all but the most minor scratching. If excessive marring or gouging is detected, the compressor must be replaced.
3. Inspect the cylinder head for cracks or damage. With the cylinder head and head gasket secured to the valve plate assembly, apply shop air pressure to one of the coolant ports with all others plugged, and check for leakage by applying a soap solution to the exterior of the head. If leakage is detected in the cylinder head casting, replace the compressor.

END COVER OR END COVER ADAPTER

Check for cracks and external damage. Check the crankshaft main bearing surface in the end cover or end cover adapter, check for excessive wear and flat spots and replace the end cover if necessary. Check for galling of the oil port threads and replace the end cover or end cover adapter if necessary. Minor thread chasing is permitted but do not “recut” the threads if they are badly damaged.

CYLINDER BLOCK

1. Check the cylinder head gasket surface on the cylinder block for nicks, gouges, and marring. A metal gasket is used to seal the cylinder head to the cylinder block. This surface must be smooth and free of all but the most minor scratching. If excessive marring or gouging is detected, the compressor must be replaced.

ASSEMBLY

General Note: All torques specified in this manual are assembly torques and typically can be expected to fall off after assembly is accomplished. **Do not re-torque** after initial assembly torques fall unless instructed otherwise. A compiled listing of torque specifications is presented at the end of this manual.

INCH POUNDS TO FOOT POUNDS

To convert inch pounds to foot pounds of torque, divide inch pounds by 12.

Example: $\frac{\text{12 Inch Pounds}}{12} = \text{1 Foot Pound}$

FOOT POUNDS TO INCH POUNDS

To convert foot pounds to inch pounds of torque, multiply foot pounds by 12.

Example: 1 Foot Pound x 12 = 12 Inch Pounds

CRANKCASE COVER

1. Position the crankcase cover gasket (15) on either the crankcase or crankcase cover and install the crankcase cover on the crankcase using the four cap screws. "Snug" the four cap screws then torque to 62-71 inch pounds using a crossing pattern.

CRANKCASE END COVER OR ADAPTER

1. Install the end cover o-ring (14) on the crankcase end cover.
2. Orient the crankcase end cover or end cover adapter to the crankcase using the reference marks made during disassembly. Carefully install the end cover or end cover adapter in the crankcase making certain not to damage the crankshaft bearing surface in it.
3. Install the four end cover screws or studs. "Snug" the screws then tighten to 195 to 213 inch pounds using a crossing pattern.

CYLINDER HEAD

1. Note the position of the protruding alignment pins on the cylinder block. Install the metal inlet reed valve/gasket (13) over the alignment pins on the cylinder block.
2. Position the valve plate assembly (12) on the cylinder block so that the alignment pins in the cylinder block fit into the corresponding holes in the valve plate assembly (12).
3. Position and install the metal gasket (11) over the alignment bushings protruding from the valve plate assembly (12). When properly installed, the outline of the gasket matches the outline of the valve plate.
4. Position and install the cylinder head over the alignment bushings protruding from the valve plate assembly (12).

   Note: The alignment bushings will only fit into two of the four cylinder head bolt holes.
5. Install the four hex head cylinder head bolts and washers and snug them, then tighten evenly to a torque of 265 to 292 inch pounds using a crossing pattern.
6. Install the unloader piston (8) with its pre-installed o-rings in the cylinder head making certain not to damage them in the process.
7. Install the balance piston spring (5) in the unloader piston (8), then install the small diameter of the balance piston (4) through the center of the spring.
8. Install the unloader cover gasket (3) on the cylinder head making certain the unloader vent passage and both screw holes align.
9. Position the unloader cover (2) on top of the balance piston (4) making certain the stamped logo is visible.
10. Press and hold the unloader cover (2) in place on the cylinder head and install both unloader cover cap screws (1). Torque the cover cap screws (1) to 62 to 71 inch pounds.

INSTALLING THE COMPRESSOR

1. If the compressor was removed for replacement, install the drive components. **Torque the crankshaft nut to 250 foot pounds.**
2. Install any supporting bracketing on the compressor in the same position noted and marked during removal.
3. Install the gasket on the drive flange of the compressor. Make certain oil supply or return holes in the gasket are properly aligned with the compressor and engine. Gasket sealants are not recommended. Secure the compressor on the engine and tighten the mounting bolts.
4. Install the discharge, inlet and governor adapter fittings, if applicable, in the same position on the compressor noted and marked during disassembly. Make certain the threads are clean and the fittings are free of corrosion. Replace as necessary. See the Torque Specifications for various fitting sizes and types of thread at the rear of this manual.
5. Inspect all air, oil, and coolant lines and fittings before reconnecting them to the compressor. Make certain o-ring seals are in good or new condition. Tighten all hose clamps.
6. Clean oil supply line. Before connecting this line to the compressor. Run the engine briefly to be sure oil is flowing freely through the supply line.
7. Before returning the vehicle to service, perform the Operation and Leakage Tests specified in this manual. Pay particular attention to all lines reconnected during installation and check for air, oil, and coolant leaks at compressor connections. Also check for noisy operation.

TESTING REBUILT COMPRESSOR

In order to properly test a compressor under operating conditions, a test rack for correct mounting, cooling, lubricating, and driving the compressor is necessary. Such tests are not compulsory if the unit has been carefully rebuilt by an experienced person. A compressor efficiency or build up test can be run which is not too difficult. An engine lubricated compressor must be connected to an oil supply line of at least 15 psi. pressure during the test and an oil return line must be installed to keep the crankcase drained. Connect to the compressor discharge port, a reservoir with a volume of 1500 cubic inches, including the volume of the connecting line. With the compressor operating at 2100

RPM., the time required to raise the reservoir(s) pressure from 85 psi to 100 psi should not exceed 5 seconds. During this test, the compressor should be checked for gasket leakage and noisy operation, as well as unloader operation and leakage. If the compressor functions as indicated reinstall on the vehicle connecting all lines as marked in the disassembly procedure.

BA-921 SPECIFICATIONS

Typical weight .... 28 lbs.
Number of cylinders 1
Bore Diameter .... 92mm (3.622 in.)
Stroke .... 54 mm (2.125 in.)
Calculated displacement at 1250 RPM .... 15.8 CFM
Flow Capacity @ 1800 RPM & 120 PSI .... 11.8 CFM
Flow Capacity @ 3000 RPM & 120 PSI .... 18.0 CFM
Maximum recommended RPM .... 3000 RPM
Minimum coolant flow maximum RPM ...... 1.3 Gals./Min.
Approximate horsepower required:
Loaded 1800 RPM at 120 PSIG .... 4.5 HP
Unloaded 1800 RPM .... 1.3 HP
Maximum inlet air temperature .... 250 F°
Maximum discharge air temperature .... 400 F°
Minimum oil pressure required at
engine idling speed .... 15 PSI
Minimum oil pressure required at
maximum governed engine speed .... 15 PSI
Minimum oil-supply line size .... 3/16" I.D.
Minimum unloader-line size .... 3/16" I.D.
Minimum Governor Cutout Pressure .... 90 PSI

TORQUE SPECIFICATIONS

Assembly Torques in inch pounds (in. lbs.)
M8x1.25-6g Cylinder Head .... 265 - 292
M5x0.75-6g Unloader Cap .... 62 - 71
M8x1.25-6g Governor Adapter .... 133 - 142
M8x1.25-6g Rear End Cover .... 195 - 213
M6x1.00-6g Crankcase Cover .... 62 - 71
M20x2.50-6g Crankshaft Nut .... 1858 - 2567
Inlet Port Fittings
7/8"-12 UNF .... 221 - 248
3/4"-14 NPT .... 2 - 3 TFFT[1]
Discharge Port Fittings
7/8"-12 UNF .... 221 - 248
3/4"-14 NPT .... 2 - 3 TFFT[1]
Water Port Fittings
3/4"-16 UNF .... 221 - 248
3/8"-18 NPT .... 2 - 3 TFFT[1]
Unloader Port Fittings
1/8"-27 NPT .... 2 - 3 TFFT[1]
Safety Valve Port
3/4"-16 UNF .... 221 - 248
1/2"-14 NPT .... 2 - 3 TFFT[1]
Oil Port 7/16"-16 UNF .... 177 - 204

[1]Note: TFFT = Turns From Finger Tight

COMPRESSOR TROUBLESHOOTING CHART

SYMPTOMS	CAUSE	REMEDY
1. Compressor passes excessive oil as evidenced by presence of oil at the exhaust ports of valving.	A. Restricted air intake.	A. Check engine air cleaner and replace if necessary. Check compressor air inlet for kinks, excessive bends and be certain inlet lines have minimum specified inside diameter. Recommended maximum air inlet restriction is 25" of water.
	B. Restricted oil return to engine.	B. Oil return to the engine should not be in any way restricted. Make certain oil drain passages in the compressor and mating engine surfaces are unobstructed and aligned. Correct gaskets must be used. Special care must be taken when seal ants are used with, or instead of, gaskets.
	C. Poorly filtered inlet air.	C. Check for damaged, defective or dirty air filter on engine or compressor. Check for leaking, damaged or defective compressor air intake components (e.g. induction line, fittings, gaskets, filter bodies, etc.). The compressor intake should not be connected to any part of the exhaust gas recirculation (E.G.R.) system on the engine.
	D. Insufficient compressor cooling (compressor runs hot).	D. For water-cooled portions of the compressor: 1. Check for proper coolant line sizes. Minimum recommended size is 3/8" I.D. tubing. 2. Check the coolant flow through the compressor. Minimum allowable flow is 2.5 gallons per minute at engine governed speed. If low cool ant flow is detected, inspect the coolant lines and fittings for accumulated rust scale, kinks and restrictions. 3. Water temperature should not exceed 200 degrees Fahrenheit. 4. Optimum cooling is achieved when engine coolant flows, as shown in Figure 8 of this manual.
	E. Contaminants not being regularly drained from system reservoirs.	E. Check reservoir drain valves to insure that they are functioning properly. It is recommended that the vehicle should be equipped with functioning automatic drain valves, or have all reservoirs drained to zero (0) psi daily, or optimally to be equipped with a desiccant-type air dryer prior to the reservoir system.

COMPRESSOR TROUBLESHOOTING CHART (Continued)

SYMPTOMS	CAUSE	REMEDY
1. (Continued.)	F. Compressor runs loaded an excessive amount of time.	F. Vehicle system leakage should not exceed industry standards of 1 psi pressure drop per minute without brakes applied and 3 psi pressure drop per minute with brakes applied. If leakage is excessive, check for system leaks and repair.
	G. Excessive engine crankcase pressure.	G. Test for excessive engine crankcase pressure & replace or repair ventilation components as necessary. (An indication of crankcase pressure is a loose or partially lifted dipstick.)
	H. Excessive engine oil pressure.	H. Check the engine oil pressure with a test gauge and compare the reading to the engine specifications. Bendix does not recommend restricting the compressor oil supply line because of the possibility of plugging the restriction with oil contaminants. Minimum oil supply line size is 3/16" I.D. tubing.
	I. Faulty compressor.	I. Replace or repair the compressor only after making certain none of the preceding installation defects exist.
2. Noisy compressor operation.	A. Loose drive gear or components.	A.. Inspect the fit of the drive gear on the compressor crankshaft. The gear or coupling must be completely seated and the crankshaft nut must be tight. If the compressor crankshaft surface is damaged, it is an indication of loose drive components. If damage to the compressor crankshaft is detected, replace the compressor. When installing the drive gear or pulley, torque the crankshaft nut to the appropriate torque specifications and use care when pressing drive components onto the crankshaft. Do not back off the crankshaft nut once it is tightened to the proper torque. Do not use impact wrenches to install the crankshaft nut.
	B. Excessively worn drive couplings or gears.	B. Inspect drive gear and couplings and engine for excessive wear. Replace as necessary. (Nonmetallic gears should be replaced when the compressor is changed.)
	C. Compressor cylinder head or discharge line restrictions.	C. Inspect the compressor discharge port and discharge line for carbon build-up. If carbon is detected, check for proper cooling to the compressor. (See Cause and Remedy (D) under Symptom #1.) Inspect the discharge line for kinks and restrictions. Replace discharge line as necessary.

COMPRESSOR TROUBLESHOOTING CHART (Continued)

SYMPTOMS	CAUSE	REMEDY
2. (Continued.)	D. Worn or burned out bearings.	D. Check for proper oil pressure in the compressor. Minimum required oil pressure; 15 psi engine idling, 15 psi maximum governed engine rpm. Check for excessive oil temperature—should not exceed 240 degrees Fahrenheit.
	E. Faulty compressor.	E. Replace or repair the compressor after determining none of the preceding installation defects exist.
3. Excessive build-up and recover time. Compressor should be capable of building air system from 85-100 psi in 40 seconds with engine at full governed rpm. Minimum compressor performance is certified to meet Federal requirements by the vehicle manufacturer. Do not downsize the original equipment compressor.	A. Dirty induction air filter.	A. Inspect engine or compressor air filter and replace if necessary.
	B. Restricted induction line.	B. Inspect the compressor air induction line for kinks and restrictions and replace as necessary.
	C. Restricted discharge line or compressor discharge cavity.	C. Inspect the compressor discharge port and line for restrictions and carbon build-up. If a carbon build-up is found, check for proper compressor cooling. Replace faulty sections of the discharge line.
	D. Slipping drive components.	D. Check for faulty drive gears and couplings and replace as necessary. Check the condition of drive belts and replace or tighten, whichever is appropriate.
	E. Excessive air system leakage.	E. Test for excessive system leakage and repair as necessary. Use the following as a guide: Build system pressure to governor cutout and allow the pressure to stabilize for one minute. Using the dash gauge, note the system pressure and the pressure drop after two minutes. The pressure drops should not exceed: 1. 2 psi in each reservoir for a single vehicle. 2. 6 psi in each reservoir for a tractor and trailer. 3. 8 psi in each reservoir for a tractor and 2 trailers.
	F. Sticking unloader pistons.	F. Check the operation of the unloading mechanism. Check for proper operation of the compressor air governor. Make certain the air connections between the governor and compressor are correct. Refer to figure 3. If the governor is operating properly, replace the unloader mechanism. Inspect for bent, linked or blocked tubing leading to or from the governor.
	G. Faulty compressor.	G. Replace or repair the compressor after determining none of the preceding installation defects exist.

COMPRESSOR TROUBLESHOOTING CHART (Continued)

SYMPTOMS	CAUSE	REMEDY
4. Compressor fails to unload.	A. Faulty governor or installation.	A. Test the governor for proper operation and inspect air lines to and from it for kinks or restrictions. Replace or repair the governor or connecting air lines
	B. Faulty or worn unloader pistons or bores.	B. Inspect for worn, dirty or corroded unloader piston and bore. Replace as necessary.
5. Compressor leaks oil.	A. Damaged mounting gasket.	A. Check the compressor mounting bolt torque. If the mounting bolt torque is low, replace the compressor mounting gasket before re-torquing the mounting bolts.
	B. Cracked crankcase or end cover.	B. Visually inspect the compressor exterior for cracked or broken components. Cracked or broken crankcases or mounting flanges can be caused by loose mounting bolts. The end cover can be cracked by over-torquing fitting or plugs installed in the end cover. Replace or repair the compressor as necessary.
	C. Loose crankcase end cover or bottom cover.	C. Check the cap screw torques and tighten as necessary. Replace gaskets or o-ring.
	D. Loose oil supply or return line fittings.	D. Check the torque of external oil line fittings and tighten as necessary.
	E. Porous compressor casting.	E. Replace the compressor if porosity is found.
	F. Mounting flange or end cover, o-ring or gasket missing, cut or damaged.	F. Replace as necessary.
6. Compressor constantly cycles (compressor remains unloaded for a very short time).	A. Leaking compressor unloader piston.	A. Repair or replace as necessary. Remove the compressor inlet air strainer or fitting. With the compressor unloaded (not compressing air), listen for air escaping.
	B. Faulty Governor installation.	B. Test the governor for proper operation and inspect air lines for kinks or restrictions. Replace or repair the governor or connecting air lines as required.
	C. Excessive system leakage.	C. Test for excessive system leakage as instructed in Symptom #3 Remedy E. Reduce leakage wherever possible.
	D. Excessive reservoir contaminants.	D. Drain reservoirs.

COMPRESSOR TROUBLESHOOTING CHART (Continued)

SYMPTOMS	CAUSE	REMEDY
7. Compressor leaks coolant.	A. Improperly installed plugs and coolant line fittings.	A. Check torque of fittings and plugs and tighten as necessary. Over torqued fittings and plugs can crack the head or block casting.
	B. Freeze cracks due to improper antifreeze strength.	B. Test antifreeze and strengthen as necessary. Check coolant flow through compressor to as sure the proper antifreeze mixture reaches the compressor.
	C. Faulty compressor (porous castings).	C. If casting porosity is detected, replace the com-pressor.
8. Compressor head gasket failure.	A. Restricted discharge line.	A. Clear restriction or replace line.
	B. Loose head bolts	B. Tighten evenly to a torque of 265-292 inch pounds.
	C. Faulty compressor or head gasket.	C. Check for rough or poorly machined head or block surfaces. Replace compressor as necessary.

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Service Data

E-8P & E-10P DUAL BRAKE VALVES

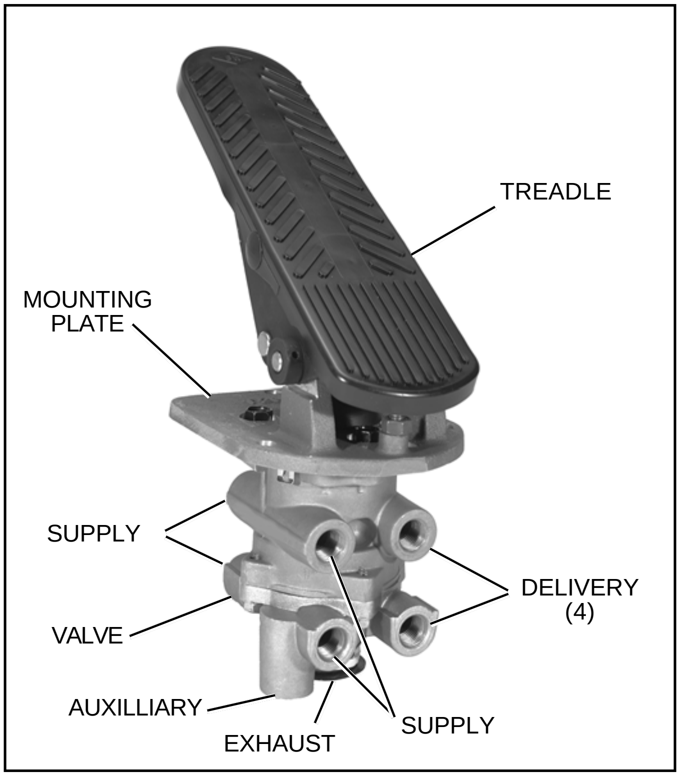

*FIGURE 1 - **E-8P***

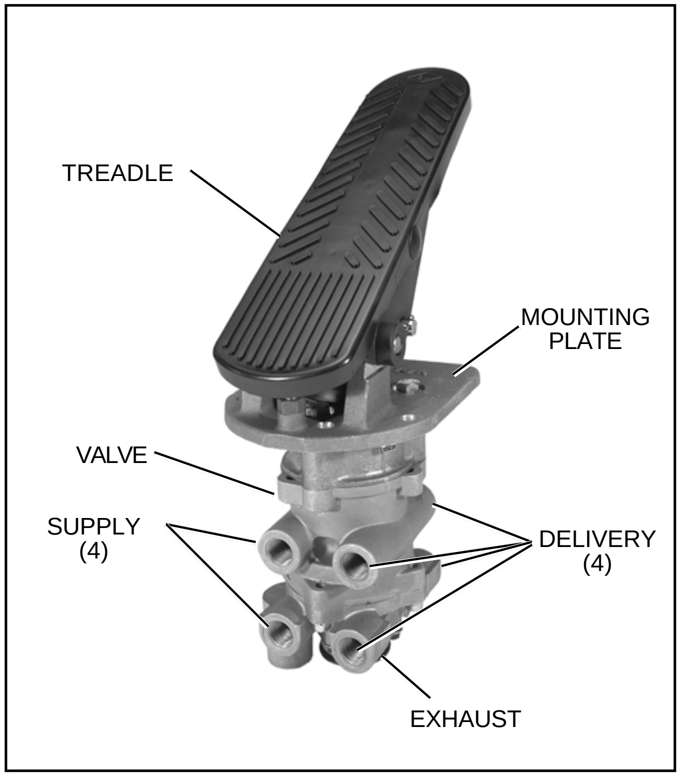

*FIGURE 2 - **E-10P***

DESCRIPTION

Refer to Figures 4, 5 and 6 for item numbers referenced in parenthesis.

The E-8P (Figure 1) and E-10P (Figure 2) Dual Brake Valves are floor mounted, treadle operated type brake valves with two separate supply and delivery circuits for service (primary and secondary) braking, which provides the driver with a graduated control for applying and releasing the vehicle brakes.

The E-10P Dual Brake Valve (Figure 2) is similar to the E-8P Dual Brake Valve except that a metal coil spring (5) housed in an upper body assembly replaces the rubber spring (27) used in the E-8P valve. The use of a metal coil spring (and the upper body assembly) provides greater treadle travel and, therefore, provides the driver with a less sensitive "feel" when making a brake application. The E-10P Dual Brake Valve is generally used on busses, where smooth brake applications contribute to passenger comfort.

The circuits in the E-8P/E-10P Dual Brake Valves are identified as follows: The No. 1 or primary circuit is that portion of the valve between the spring seat which contacts the plunger and the relay piston; the No. 2 or secondary circuit is that portion between the relay piston and the exhaust cavity.

The primary circuit of the valve is similar in operation to a standard single circuit air brake valve and under normal operating conditions the secondary circuit is similar in operation to a relay valve.

Both primary and secondary circuits of the brake valve use a common exhaust protected by an exhaust diaphragm.

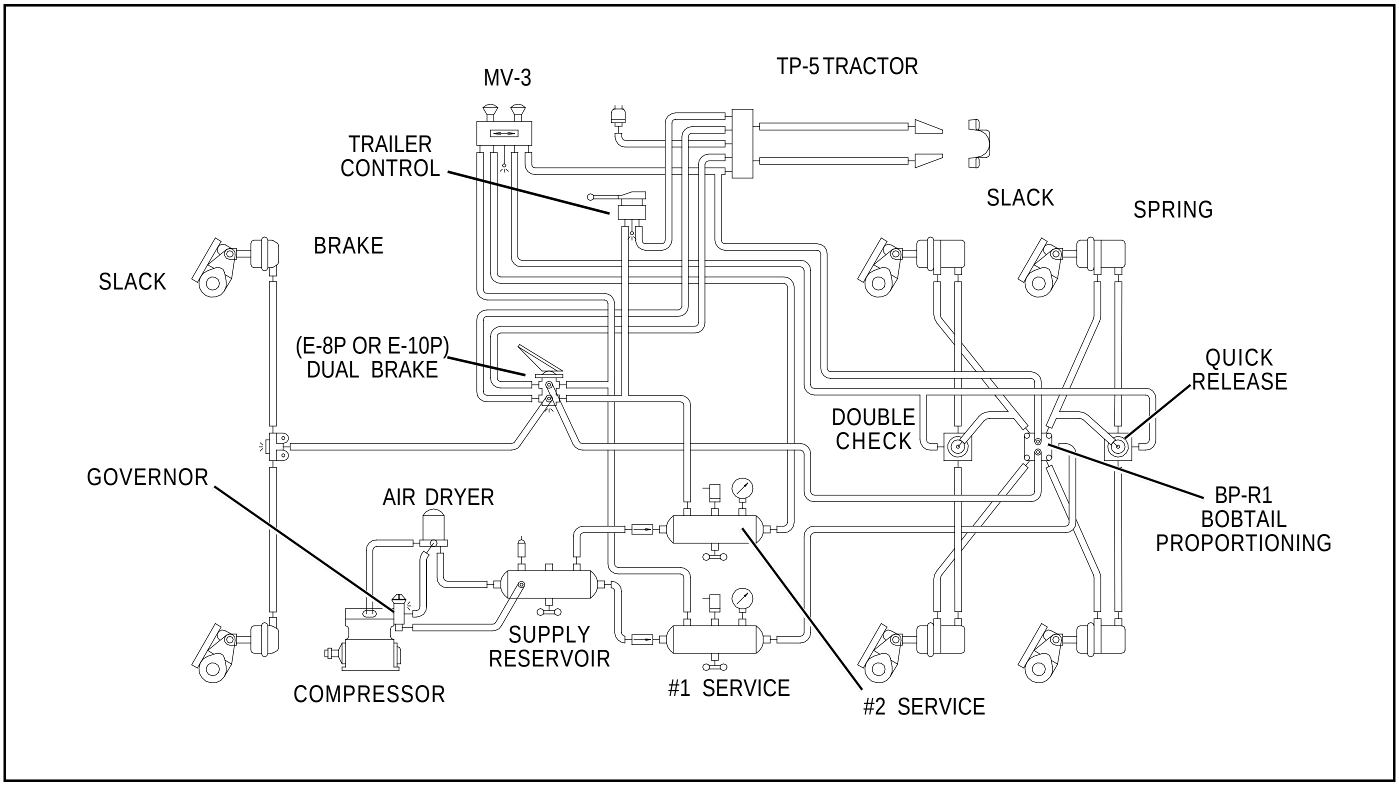

*FIGURE 3 - **TYPICAL PIPING SCHEMATIC***

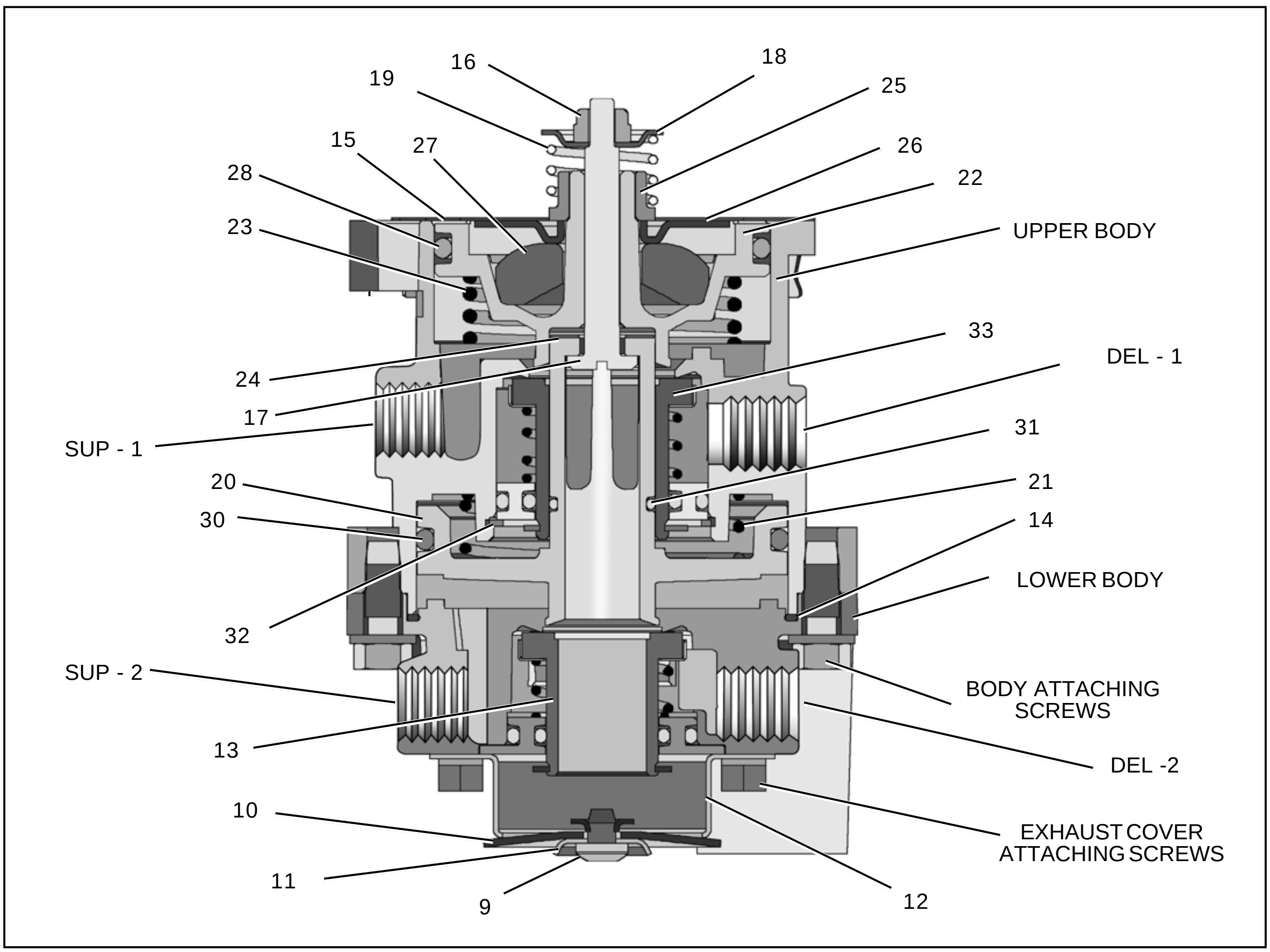

*FIGURE 4 - **E-8P SECTIONAL VIEW***

OPERATION - Refer to Figure 3

APPLYING: NORMAL OPERATION - NO. 1 OR PRIMARY CIRCUIT PORTION

When the brake treadle is depressed, the plunger exerts force on the spring seat (26), graduating spring (23), and primary piston (22). The primary piston, which contains the exhaust valve seat, closes the primary exhaust valve. As the exhaust valve closes, the primary inlet valve is moved off its seat allowing primary air to flow out the No. 1 or primary delivery port.

APPLYING: NORMAL OPERATION - NO. 2 OR SECONDARY CIRCUIT

When the primary inlet valve (33) is moved off its seat, air is permitted to pass through the bleed passage and enters the relay piston cavity. The air pressure moves the relay piston (20), which contains the exhaust seat, and closes the secondary exhaust valve. As the secondary exhaust valve closes, the inlet valve (13) is moved off its seat allowing the secondary air to flow out the delivery of the same circuit. Because of the small volume of air required to move the relay piston (20), action of the secondary circuit of the valve is almost simultaneous with the primary circuit portion.

APPLYING: LOSS OF AIR IN THE NO. 2 OR SECONDARY CIRCUIT

Should air be lost in the No. 2 or secondary circuit, the No. 1 or primary circuit will continue to function as described above under *Normal Operation: No.1 or Primary Circuit Portion*.

APPLYING: LOSS OF AIR IN THE NO. 1 OR PRIMARY CIRCUIT

Should air be lost in the primary circuit, the function will be as follows: As the brake treadle is depressed and no air pressure is present in the primary circuit supply and delivery ports, the primary piston (22) will mechanically move the relay piston (20) , allowing the piston to close the secondary exhaust valve and open the secondary inlet valve and allow air to flow out the secondary delivery port.

BALANCED: NO. 1 OR PRIMARY CIRCUIT

When the primary delivery pressure acting on the primary piston (22) equals the mechanical force of the brake pedal application, the primary piston (22) will move and the primary inlet valve (33) will close, stopping further flow of air from the primary supply line through the valve. The exhaust valve remains closed preventing any escape of air through the exhaust port.

BALANCED: NO. 2 OR SECONDARY CIRCUIT

When the air pressure on the delivery side of the relay piston (20) approaches that being delivered on the primary side of the relay piston, the relay piston moves closing the secondary inlet valve and stopping further flow of air from the supply line through the valve. The exhaust remains closed as the secondary delivery pressure balances the primary delivery pressure.

When applications in the graduating range are made, a balanced position in the primary circuit is reached as the air pressure on the delivery side of the primary piston (22) equals the effort exerted by the driver's foot on the treadle. A balanced position in the secondary portion is reached when air pressure on the secondary side of the relay piston (20) closely approaches the air pressure on the primary side of the relay piston.

When the brake treadle is fully depressed, both the primary and secondary inlet valves remain open and full reservoir pressure is delivered to the actuators.

RELEASING: NO. 1 OR PRIMARY CIRCUIT

With the brake treadle released, mechanical force is removed from the spring seat (26), graduating spring (23), and primary piston (22). Air pressure and spring load moves the primary piston, opening the primary exhaust valve, allowing air pressure in the primary delivery line to exhaust out the exhaust port.

RELEASING: NO. 2 OR SECONDARY CIRCUIT

With the brake treadle released, air is exhausted from the primary circuit side of the relay piston (20). Air pressure and spring load move the relay piston, opening the secondary exhaust valve, allowing air pressure in the secondary delivery line to exhaust out the exhaust port.

PREVENTIVE MAINTENANCE

Important: Review the warranty policy before performing any intrusive maintenance procedures. An extended warranty may be voided if intrusive maintenance is performed during this period.

Because no two vehicles operate under identical conditions, maintenance and maintenance intervals will vary. Experience is a valuable guide in determining the best maintenance interval for any one particular operation.

Visually check for physical damage to the brake valve such as broken air lines and broken or missing parts.

Every 3 months, or 25,000 miles or 900 operating hours:

Clean any accumulated dirt, gravel, or foreign material away from the heel of the treadle, plunger boot, and mounting plate.

Using light oil, lubricate the treadle roller, roller pin, and hinge pin.

Check the rubber plunger boot for cracks, holes or deterioration and replace if necessary. Also, check mounting plate and treadle for integrity.

Apply 2 to 4 drops of oil between plunger and mounting plate - **do not over oil!**

Every year, or 100,000 miles, or 3,600 operating hours:

Disassemble, clean parts with mineral spirits, replace all rubber parts, or any part worn or damaged. Check for proper operation before placing vehicle in service.

SERVICE CHECKS

OPERATING CHECK

Check the delivery pressure of both primary and secondary circuits using accurate test gauges. Depress the treadle to several positions between the fully released and fully applied positions, and check the delivered pressure on the test gauges to see that it varies equally and proportionately with the movement of the brake pedal.

After a full application is released, the reading on the test gauges should fall off to zero promptly. It should be noted that the primary circuit delivery pressure will be about 2 PSI greater than the secondary circuit delivery pressure with both supply reservoirs at the same pressure. This is normal for this valve.

Important: A change in vehicle braking characteristics or a low pressure warning may indicate a malfunction in one or the other brake circuit, and although the vehicle air brake system may continue to function, the vehicle should not be operated until the necessary repairs have been made and both braking circuits, including the pneumatic and mechanical devices, are operating normally. Always check the vehicle brake system for proper operation after performing brake work and before returning the vehicle to service.

LEAKAGE CHECK

1. Make and hold a high pressure (80 psi) application.
2. Coat the exhaust port and body of the brake valve with a soap solution.
3. Leakage permitted is a one inch bubble in 3 seconds. If the brake valve does not function as described above or leakage is excessive, it is recommended that it be replaced with a new or remanufactured unit, or repaired with genuine Bendix parts available at authorized Bendix parts outlets.

Refer to figures 4, 5 and 6 for item numbers referenced in parenthesis.

REMOVAL

1. Chock the vehicle wheels or park the vehicle by mechanical means. (Block and hold vehicle by means other than air brakes.) Drain all air system reservoirs.
2. Identify and disconnect all supply and delivery lines at the brake valve.
3. Remove the brake valve and treadle assembly from the vehicle by removing the three cap screws on the outer bolt circle of the mounting plate. The basic brake valve alone can be removed by removing the three cap screws on the inner bolt circle.

DISASSEMBLY (Figures 4, 5 and 6)

1. If the entire brake valve and treadle assembly was removed from the vehicle, remove the three cap screws securing the treadle assembly to the basic brake valve.
2. Remove the screw (9) securing the exhaust diaphragm (10) and washer (11) to the exhaust cover (12).
3. Remove the four screws that secure the exhaust cover (12) to the lower body.
4. Remove the secondary inlet and exhaust valve assembly (13) from the lower body.
5. Remove the four hex head cap screws securing the lower body to the upper body and separate the body halves.
6. Remove the rubber seal ring (14) from the lower body.
7. **For E-8P only:** While applying thumb pressure to the primary piston (22), lift out and up on the three lock tabs of the primary piston retainer (15).
8. **For E-10P only:** While depressing spring seat (7), remove retaining ring (8). Remove spring seat (7) and coil spring (5).

   Caution: Before proceeding with the disassembly, refer to Figures 3 and 4 and note that the lock nut (16) and stem (17) are used to contain the primary piston return spring (**for E-8P:** 23, **for E-10P:** 6), stem spring (19), and the relay piston spring (21). The combined force of these springs is approximately 50 pounds and care must be taken when removing the lock nut as the spring forces will be released. It is recommended that the primary piston and relay piston be manually or mechanically contained while the nut and stem are being removed.
9. Using a 3/8" wrench, hold the lock nut (16) on the threaded end of the stem (17). Insert a screwdriver to restrain the stem, remove the lock nut (16), spring seat, (18) and stem spring (19).
10. **For E-10P only:** Remove adapter (1) and o-ring (4). Remove the primary piston (2) from adapter (1) and o-ring (34) from the primary piston (2).

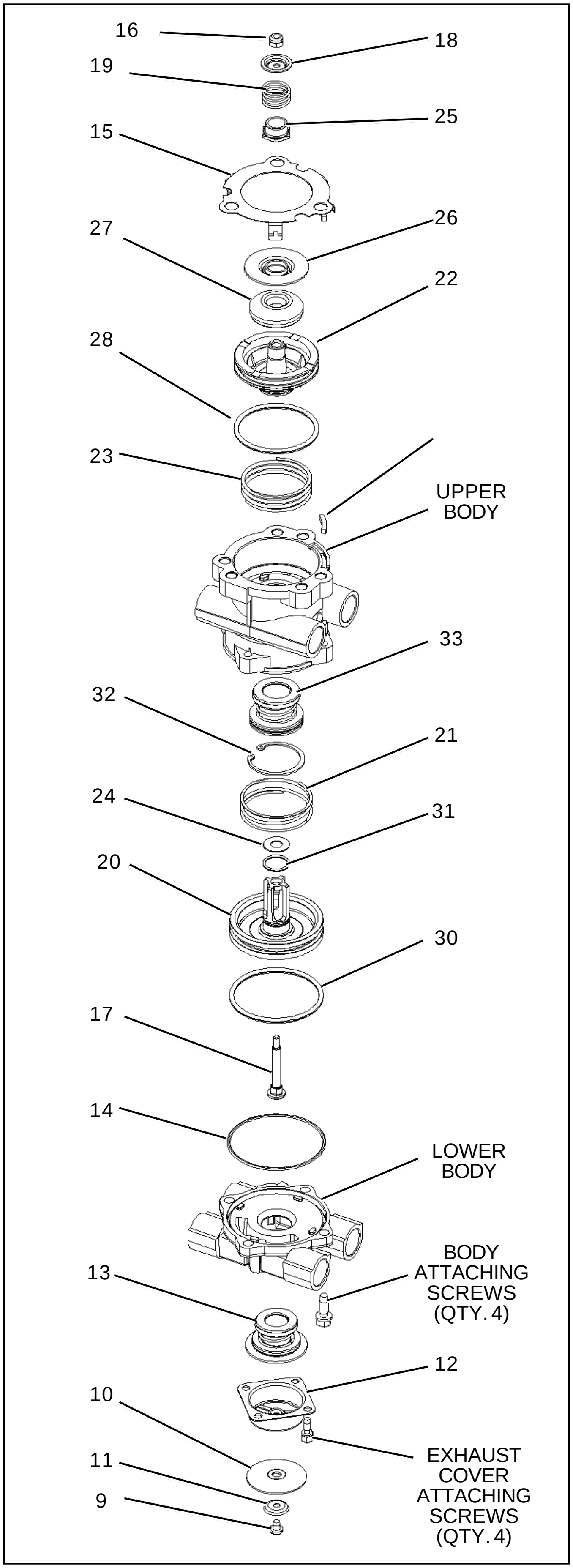

FIGURE 5 - ***E-8P BRAKE VALVE - EXPLODED VIEW***

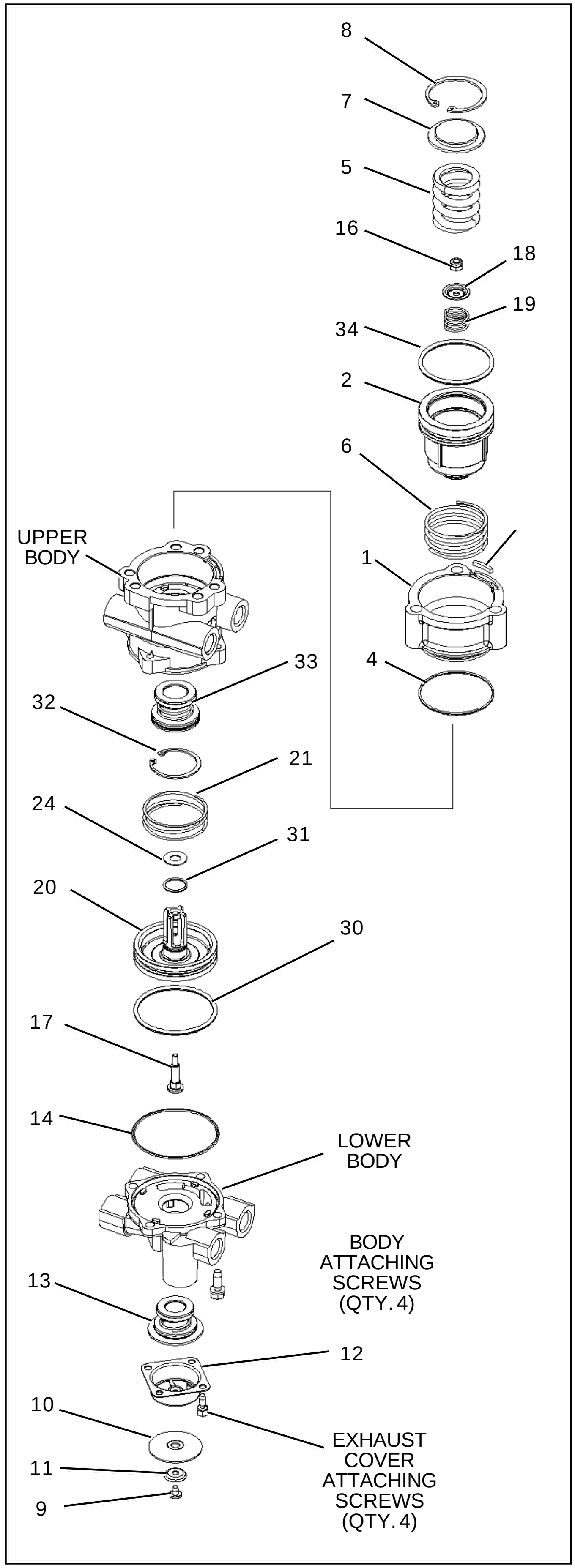

FIGURE 6 - ***E-10P BRAKE VALVE - EXPLODED VIEW***

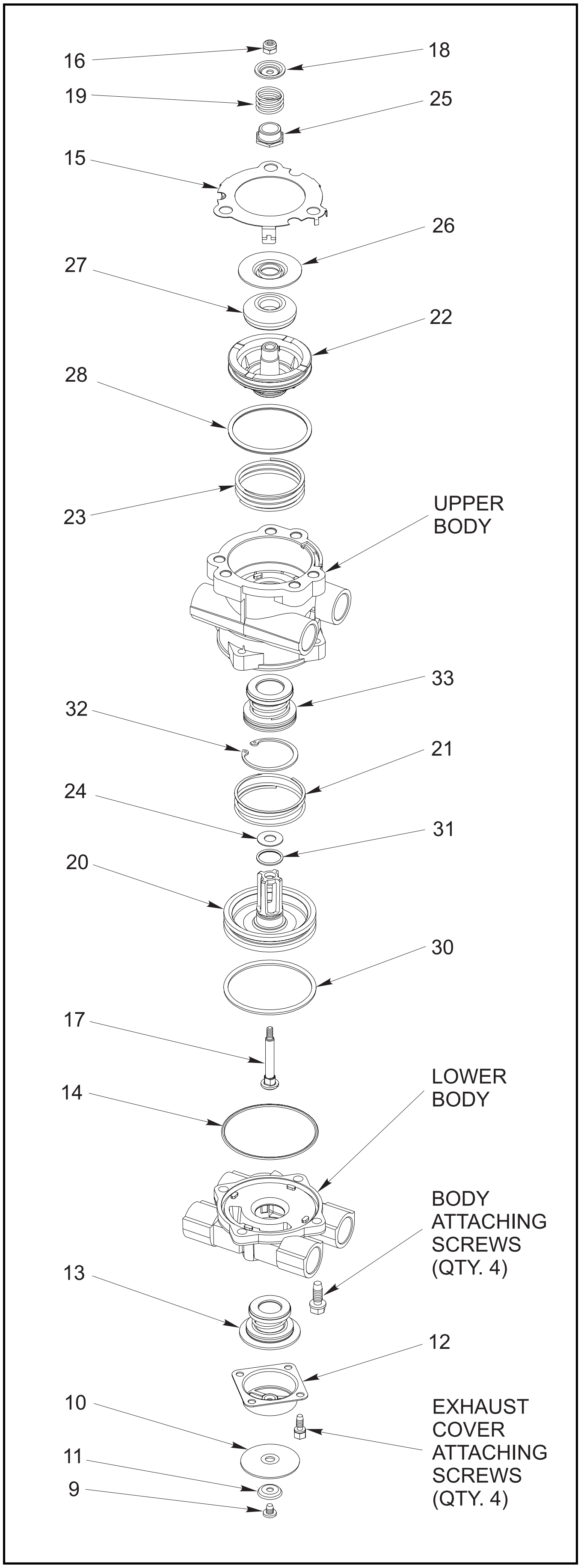

FIGURE 5 - ***E-8P BRAKE VALVE - EXPLODED VIEW***
FIGURE 5 - ***E-8P BRAKE VALVE - EXPLODED VIEW***

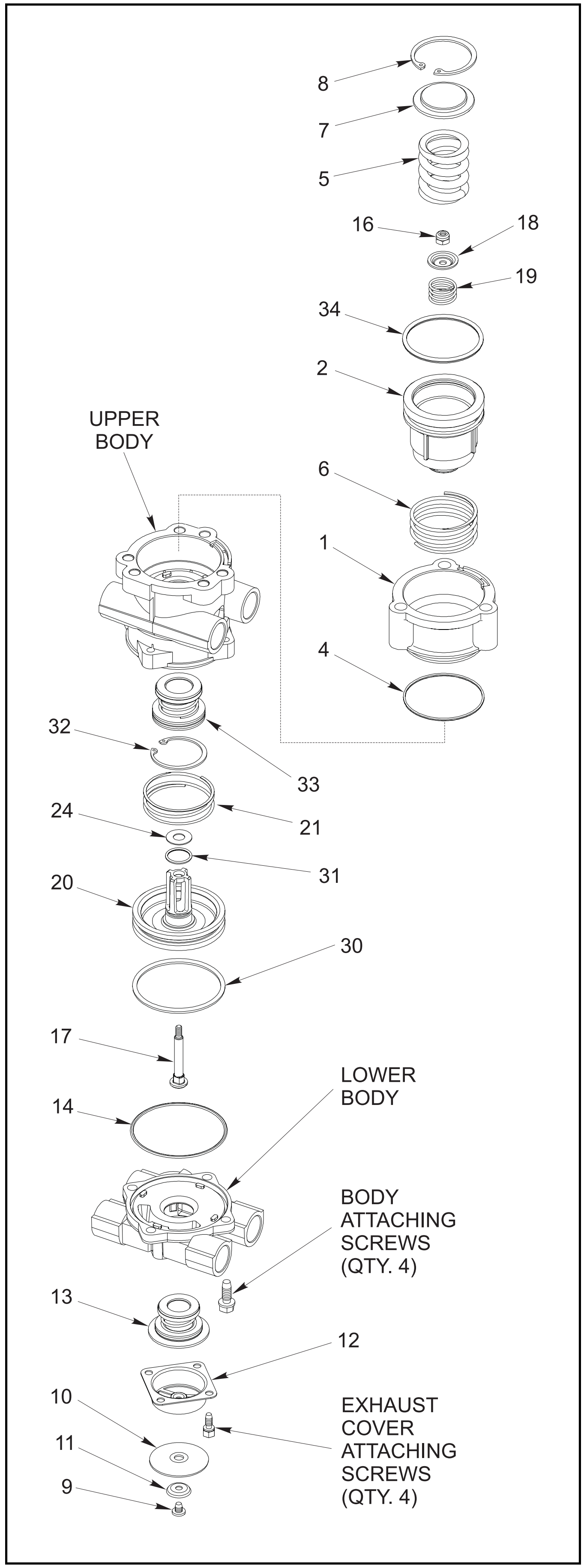

FIGURE 6 - ***E-10P BRAKE VALVE - EXPLODED VIEW***
FIGURE 6 - ***E-10P BRAKE VALVE - EXPLODED VIEW***

11. Remove the relay piston (20), relay piston spring (21), primary piston (**E-8P:** 22, **E-10P:** 2) and primary piston return spring (**E-8P:** 23, **E-10P:** 6) from the upper body. Use care so as not to nick seats.
12. A small washer (24) will be found in the cavity of the lower side of the primary piston (**for E-8P**: 22, **for E-10P**: 2).
13. For **E-8P only:** Disassemble the primary piston by rotating the spring seat nut (25) counterclockwise. Separate the spring seat nut, spring seat (26), and rubber spring (27) and remove the piston o-ring (28).
14. Remove the large and small o-rings (30 & 31) from the relay piston (20).
15. Remove the retaining ring (32) securing the primary inlet and exhaust valve assembly (33) in the upper body and remove the valve assembly.

CLEANING AND INSPECTION

1. Wash all metal parts in mineral spirits and dry.
2. Inspect all parts for excessive wear or deterioration.
3. Inspect the valve seats for nicks or burrs.
4. Check the springs for cracks or corrosion.
5. Replace all rubber parts and any part not found to be serviceable during inspection, use only genuine Bendix replacement parts.

ASSEMBLY

Prior to reassembling, lubricate all o-rings, o-ring grooves, piston bores, and metal to metal moving surfaces with Dow Corning 55 o-ring lubricant (Bendix piece number 291126).

Note: All torques specified in this manual are **assembly** torques and can be expected to fall off, after assembly is accomplished. **Do not retorque** after initial assembly torques fall.

1. Install the primary inlet and exhaust assembly (33) in the upper body and replace the retaining ring (32) to secure it. Be sure the retaining ring is seated completely in its groove.
2. Install the large and small o-rings (30 & 31) on the relay piston (20).
3. **For E-8P only:** Install o-ring (28) in the primary piston (22) o-ring groove.
4. **For E-8P only:** Install the rubber spring (do not lubricate) (27), concave side down in the primary piston (22) and place the spring seat (26), flat side up, over the rubber spring.
5. **For E-8P only:** Install the primary piston spring seat nut (25), with its hex closest to the spring seat, and rotate clockwise until the top surface of the spring seat is even with the top surface of the piston. Set aside.
6. Place relay piston spring (21) in concave portion of relay piston (20) and install relay piston through primary inlet/exhaust assembly (33) into under side of upper body.
7. **For E-10P only:** Install o-ring (4) on adapter (1) and install adapter on upper body. Install o-ring (34) on primary piston (2).
8. Place screwdriver, blade up, in vise. Insert stem (17) through the relay piston upper body sub assembly, slide this assembly over the blade of the secured screwdriver, engage the screwdriver blade in the slot in the head of the stem.
9. Place the washer (24) over the stem (17) and on top of the relay piston (20).
10. Install primary return spring (**E-8P**: 23, **E-10P**: 6) in upper body piston bore.
11. **For E-8P only:** Install the primary piston rubber spring sub assembly (steps 4 & 5) over the stem, into the upper body piston bore. **For E-10P:** Install primary piston sub-assembly (reference step 7).
12. Compress piston(s) (**For E-8P:** the relay piston (20), **for E-10P:** the primary and relay pistons (2 & 20)) and retaining ring into the upper body from either side and hold compressed, either manually or mechanically. **See the cautionary note under step 8 in the Disassembly section of this manual.**
13. Place the stem spring (19) (**E-8P:** place over the spring seat nut (25)), the spring seat (18) (concave side up) and lock nut (16) on the stem (17). Torque to 20 - 30 inch pounds.
14. **For E-8P only:** Install the primary piston retainer (15) over the piston, making certain all three lock tabs have engaged the outer lip of the body.
15. **For E-10P only:** Install coil spring (5), spring seat (7), and retaining ring (8) .
16. Replace the rubber seal ring (14) on the lower body.
17. Install the 4 hex head cap screws securing the lower body to the upper body. Torque to 30 - 60 inch pounds.
18. Install the secondary inlet and exhaust valve assembly (13) on the lower body.
19. Install the screws that secure the exhaust cover (12) to the lower body. Torque to 20 - 40 inch pounds.
20. Secure the screw (9) holding the exhaust diaphragm (10) and the diaphragm washer (11) to the exhaust cover (12). Torque to 5 - 10 inch pounds.
21. Install all air line fittings and plugs making certain thread sealant material does not enter valve.

VALVE INSTALLATION

1. Install the assembled brake valve on the vehicle.

2. Reconnect all air lines to the valve using the identification made during VALVE REMOVAL step 1.
3. After installing the brake valve assembly, perform the "OPERATION AND LEAKAGE CHECKS" before placing the vehicle in service.

IMPORTANT: MAINTENANCE PRECAUTIONS

When working on or around a vehicle, the following general precautions should be observed:

1. **Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.**
2. **Stop the engine when working around the vehicle.**
3. **Drain the air pressure from all reservoirs before beginning ANY work on the vehicle.**
4. **Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.**
5. **When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.**
6. **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 depleted.**
7. **Never exceed recommended pressures and always wear safety glasses.**
8. **Do not attempt to install, remove, disassemble, or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.**
9. **Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.**
10. **Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.**
11. **Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.**

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Service Data

SD-03-901*

QR AND QR-1 QUICK RELEASE VALVES

*Formerly SD-03-69

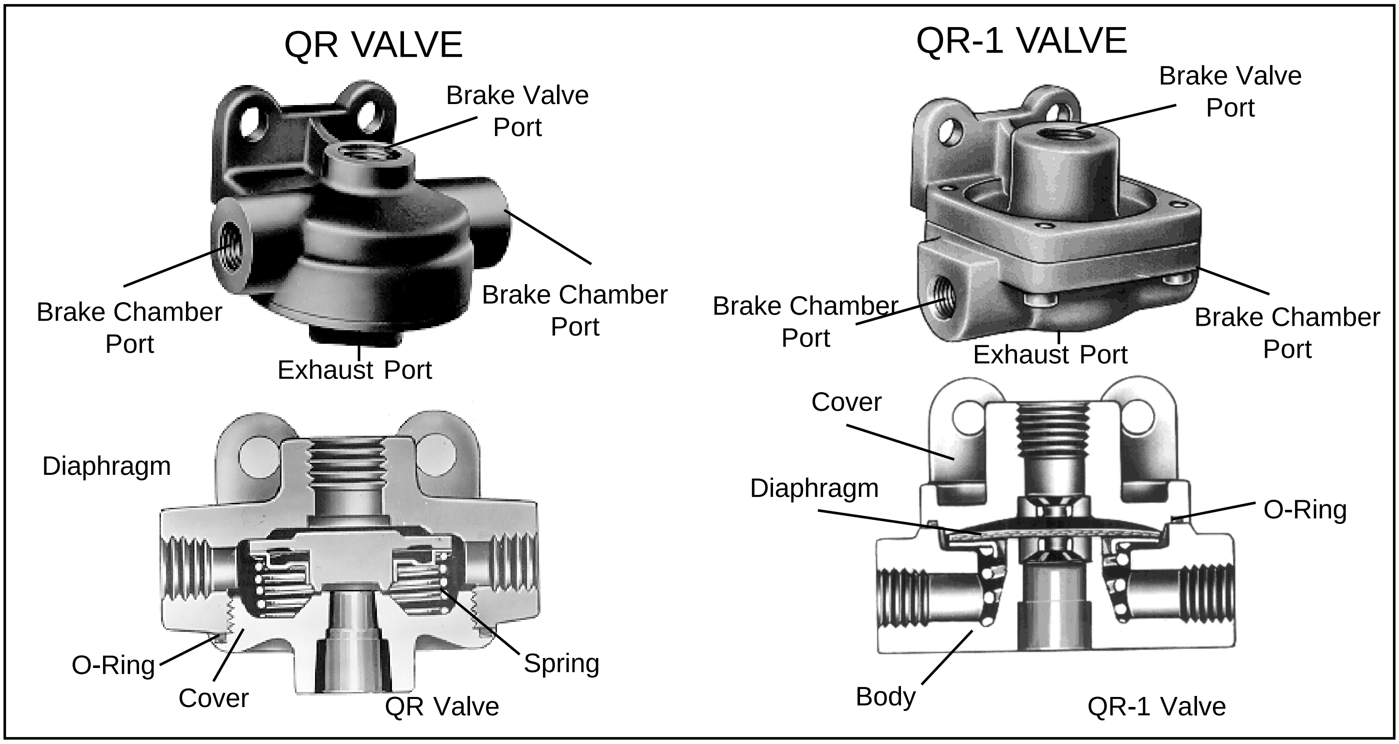

FIGURE 1

DESCRIPTION

The function of the Quick Release Valve is to speed up the exhaust of air from the air chambers. It is mounted close to the chambers it serves. In its standard configuration the valve is designed to deliver within one (1) psi of control pressure to the controlled device; however, for special applications the valve is available with greater differential pressure designed into the valve.

Reference Figure 1, two styles of Quick Release Valves are available and are functionally the same; the QR valve, which is of older design and utilizes a spring and spring seat, and the QR-1 valve, which in its standard configuration does not employ a spring or spring seat.

(Note: AR-1 Valves with a pressure differential employ a spring and spring seat.)

Porting consists of one (1) brake valve port, two (2) delivery ports and one (1) exhaust port.

OPERATION

When a brake application is made, air pressure enters the brake valve port; the diaphragm moves down, sealing the exhaust. At the same time, air pressure forces the edges of the diaphragm down and air flows out the delivery port.

When air pressure being delivered (beneath the diaphragm) equals the pressure being delivered by the brake valve (above the diaphragm), the outer edge of the diaphragm will seal against the body seat. The exhaust port is still sealed by the center portion of the diaphragm when the brake valve application is released; the air pressure above the diaphragm is released back through the brake valve exhaust; air pressure beneath the diaphragm forces the diaphragm to rise, opening the exhaust, allowing air in the chambers to exhaust.

PREVENTIVE MAINTENANCE

Every 12 months, 100,000 miles or 3600 operating hours; disassemble valve, wash metal parts in mineral spirits, wipe rubber parts dry. It is recommended that all rubber parts be replaced. Inspect all parts and replace any part showing signs of wear or deterioration.

OPERATING AND LEAKAGE TESTS

While holding a foot brake valve application:

1. Coat exhaust port with soap solution; leakage of a one (1) inch bubble in three (3) seconds is permitted.
2. Coat body and cover with soap solution. No leakage permitted between body and cover.

If the valve does not function as described, or if leakage is excessive, it is recommended that it be replaced with a new or remanufactured unit, or repaired with genuine Bendix parts.

REMOVING AND INSTALLING

REMOVING

Block vehicle wheels and/or hold vehicle by means other than air brakes.

Drain all air brake system reservoirs.

Disconnect air lines from valve.

Remove mounting bolts, then valve.

INSTALLING

Mount valve with exhaust port pointing down; securely tighten mounting bolts.

Connect air lines to valve (brake valve application line to top port; brake chamber line to side ports.)

DISASSEMBLY

QR VALVE

1. Using wrench on square portion of exhaust port, remove cover.
2. Remove spring, spring seat and diaphragm. Remove cover O-Ring.

QR-1 VALVE

1. Remove four screws.
2. Remove spring and spring seat {if so equipped).
3. Remove diaphragm.
4. Remove cover O-Ring.

CLEANING AND INSPECTION

Clean all metal parts in mineral spirits. Wipe all rubber parts clean.

It is recommended that all rubber parts and any other part showing signs of wear or deterioration be replaced with genuine Bendix parts.

ASSEMBLY

QR VALVE

1. Position spring seat over the diaphragm and then install into body.
2. Install spring and cover O-Ring.
3. Install cover; tighten securely. (Torque to 150-400 inch pounds.)

QR-1 VALVE

1. If valve is equipped within spring and spring seat:
a. Position spring in body.
b. Position diaphragm over spring seat.
c. Install O-Ring in cover groove; install cover and tighten screws evenly and securely. (Torque to 30-60 inch pounds.)
2. If valve is not equipped with spring and spring seat:
a. Install diaphragm.
b. Install O-Ring in cover groove; install cover and tighten screws evenly and securely. (Torque to 30-60 inch pounds.)
3. Perform tests as outlined in “Operating and Leakage Tests” section.

IMPORTANT! PLEASE READ

When working on or around a vehicle, the following general precautions should be observed:

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.
2. Stop the engine when working around the vehicle.
3. 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.
4. Following the vehicle manufacturer’s recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.
6. 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 depleted.
7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

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Service Data

SD-03-1064*

R-12 & R-14 RELAY VALVES

* FORMERLY SD-03-31

*FIGURE 1 - **EXTERIOR VIEWS***

DESCRIPTION

The Relay Valve in an air brake system functions as a relay station to speed up the application and release of the brakes. The valve is normally mounted at the rear of the vehicle in proximity to the chambers it serves. The valve operates as a remote controlled brake valve that delivers or releases air to the chambers in response to the control air delivered to it from the foot brake valve or other source.

The R-12 and R-14 Relay Valves are designed for either reservoir or frame mounting. A universal mounting bracket is furnished that permits easy interchange with other Bendix relay valves. Both valves are available in the two body styles illustrated in Figure 1. The R-14 differs from the R-12 in that it incorporates a quick release and anti-compounding feature located above its horizontal service port. The R-14's anti-compound feature allows it

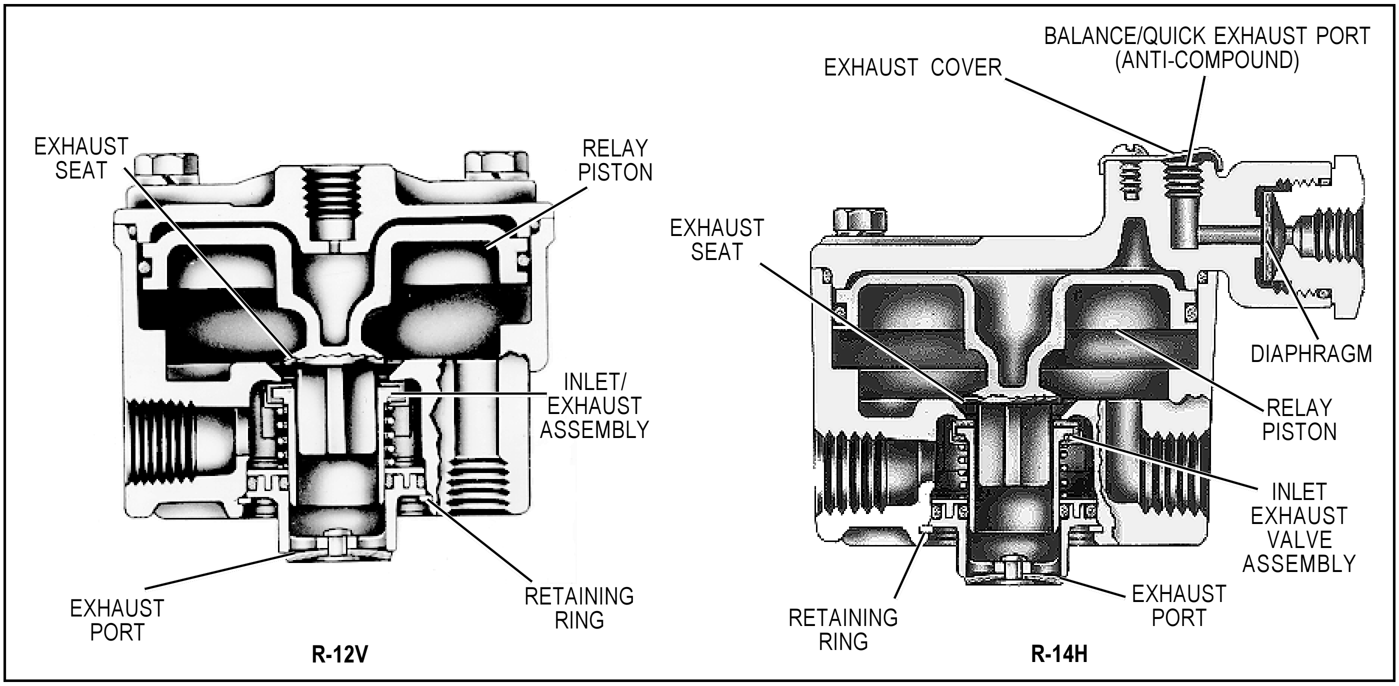

*FIGURE 2 - **SECTIONAL VIEWS***

to be conveniently used as either a service or spring brake relay valve. An exhaust cover is installed that protects the 1/8" balance port when the R-14 anti-compound feature is not in use.

All parts are interchangeable between the R-12 and R-14 with the exception of the detail components of the R-14 cover. Both valves make extensive use of non-metallic internal components. For ease of servicing, the inlet/exhaust valve can be replaced without the need for line removal.

OPERATION

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.

BALANCE

The air pressure being delivered by the open inlet valve also is effective on the bottom area of the relay piston. When air pressure beneath the piston equals the service air pressure above, the piston lifts slightly and the inlet spring returns the inlet valve to its seat. The exhaust remains closed as the service line pressure balances the delivery pressure. As delivered air pressure is changed, the valve reacts instantly to the change, holding the brake application at that level.

EXHAUST OR RELEASE

When air pressure is released from the service port and air pressure in the cavity above the relay piston is exhausted, air pressure beneath the piston lifts the 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.

ANTI COMPOUNDING (SIMULTANEOUS SERVICE AND PARK APPLICATION)

In those applications where the R-14 Relay Valve is used to control spring brake chambers, the anti-compound feature may be utilized. With the anti-compound feature of the R-14 connected, a service application made while the vehicle is parked is countered by a release of the parking brakes. To utilize this feature, the exhaust cover of the quick release portion of the R-14 is removed and a line is installed which is connected to the delivery of the service brake valve or relay valve. With no air pressure at the service port of the R-14, the parking brakes are applied. If a service brake application is made, air from the service brake valve enters the exhaust port of the quick release of the R-14 and moves the diaphragm, blocking the service port. Air then proceeds into the cavity above the relay piston, forces the piston down, closing the exhaust and opening the inlet to deliver air to the spring brake cavity as described under the section of this manual entitled *Application*.

PREVENTIVE MAINTENANCE

Important: Review the warranty policy before performing any intrusive maintenance procedures. An extended warranty may be voided if intrusive maintenance is performed during this period.

Because no two vehicles operate under identical conditions, maintenance and maintenance intervals will vary. Experience is a valuable guide in determining the best maintenance interval for any one particular operation.

1. Every three months or 25,000 miles or 900 operating hours check for proper operation.
2. Every twelve months or 100,000 miles or 3600 operating hours: disassemble valve, clean parts with mineral spirits. Replace all rubber parts and any part worn or damaged. Check for proper operation before placing vehicle in service.

OPERATIONAL AND LEAKAGE TEST

1. Chock the wheels, fully charge air brake system and adjust the brakes.
2. Make several brake applications and check for prompt application and release at each wheel.
3. Check for inlet valve and o-ring leakage.
   A. Make this check with the service brakes released when the R-12 or R-14 is used to control the service brakes.
   B. Make the check with the spring brakes applied (PARK) when the R-14 is used to control the spring brakes. Coat the exhaust port and the area around the retaining ring with a soap solution; a 1 inch bubble in 3 seconds leakage is permitted.
4. Check for exhaust valve leakage.
   A. Make this check with the service brakes fully applied if the R-12 or R-14 control the service brakes.
   B. Make this check with the spring brakes fully released if the R-14 is used to control the spring brakes. Coat the exhaust port with a soap solution; a 1 inch bubble in 3 seconds leakage is permitted. Coat the outside of the valve where the cover joins the body to check for seal ring leakage; no leakage is permitted.
5. If the R-14 is used to control the spring brakes, place the park control in the released position and coat the balance port with a soap solution to check the diaphragm and its seat. Leakage equivalent to a 1 inch bubble in 3 seconds is permitted.

Note: If the anti-compound feature is in use, the line attached to the balance port must be disconnected to perform this test.

If the valves do not function as described above, or if leakage is excessive, it is recommended that the valves be replaced with new or remanufactured units or repaired with genuine Bendix parts, available at any authorized Bendix parts outlet.

REMOVAL AND INSTALLATION

REMOVAL

1. Block and hold vehicle by means other than air brakes.
2. Drain air brake system reservoirs.
3. If entire valve is to be removed, identify air lines to facilitate installation.
4. Disconnect air lines from valve.*
5. Remove valve from reservoir or if remotely mounted, remove mounting bolts and then valve.

*It is generally not necessary to remove entire valve to service the inlet/exhaust valve. The inlet/exhaust valve insert can be removed by removing the snap ring, exhaust cover assembly and then inlet/exhaust valve.

Caution: Drain all reservoirs before attempting to remove the inlet exhaust valve.

DISASSEMBLY

Note: Prior to disassembly, mark the location of the mounting bracket to the cover and the cover to the body.

1. Remove the four (4) cap screws and lockwashers securing the cover to the body.
2. Remove the cover, sealing ring, and mounting bracket.
3. Remove the piston and o-ring from the body.
4. While depressing the exhaust cover, remove the retaining ring and slowly relax the spring beneath the exhaust cover.
5. Remove the exhaust cover assembly and o-rings.
6. Remove the inlet/exhaust valve return spring from the body.
7. Remove the inlet/exhaust valve from the body.
8. Remove the valve retainer from the inlet/exhaust valve.
9. Remove the Phillips head screw and exhaust cover from the R-14 cover.
10. Remove the service port cap nut and o-ring from the R-14.
11. Remove the diaphragm from the R-14 cover.

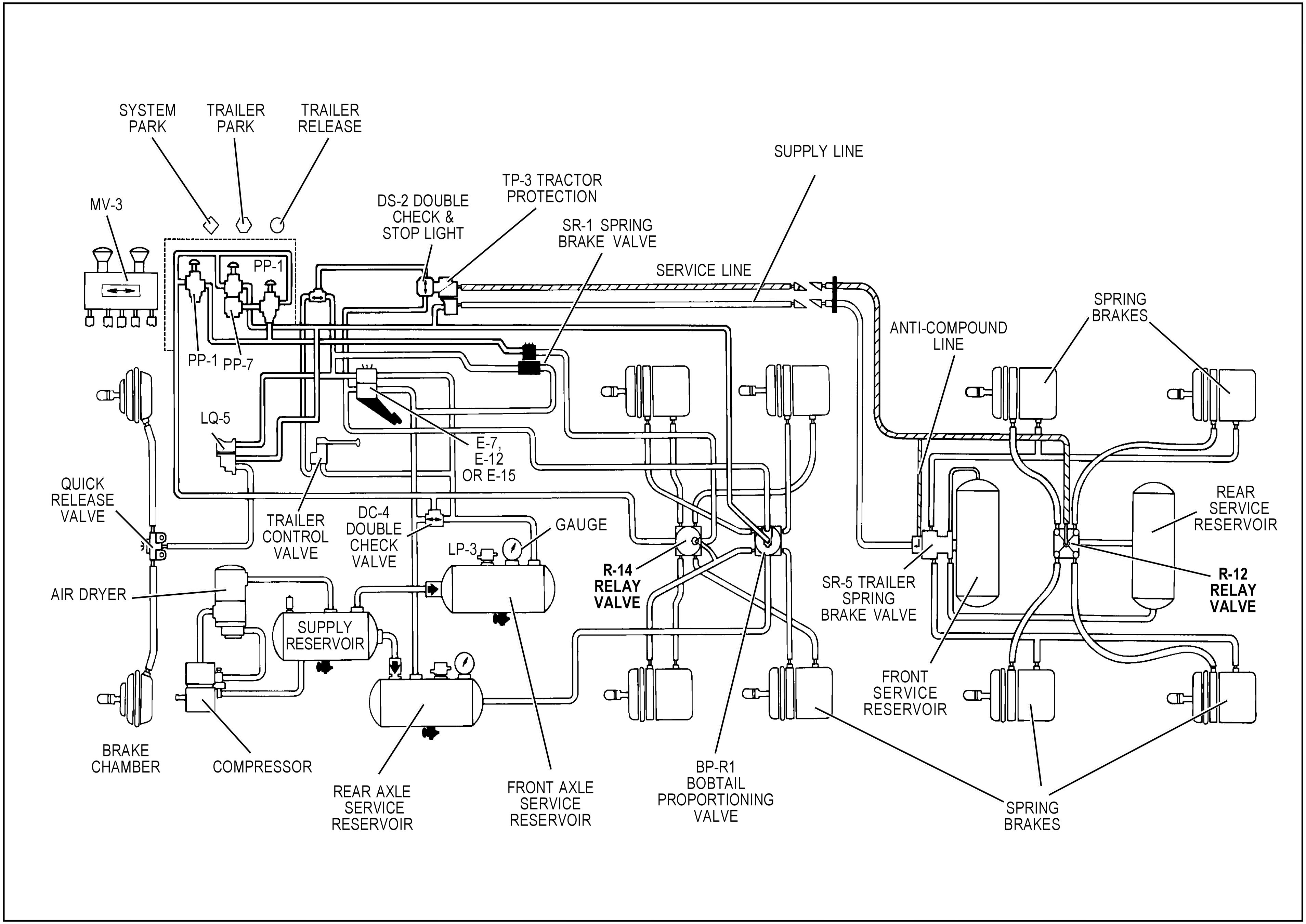

FIGURE 3 - **TYPICAL PIPING SCHEMATIC**

CLEANING AND INSPECTION

1. Wash all metal parts in mineral spirits and dry them thoroughly.

   (**Note:** When rebuilding, all springs and all rubber parts should be replaced.)
2. Inspect all metal parts for deterioration and wear, as evidenced by scratches, scoring and corrosion.
3. Inspect the exhaust valve seat on the relay piston for nicks and scratches which could cause excessive leakage.
4. Inspect the inlet valve seat in the body for scratches and nicks, which could cause excessive leakage.
5. Inspect the exhaust seat of the quick release diaphragm in the R-14 cover and make sure all internal air passages in this area are open and clean and free of nicks and scratches.
6. Replace all parts not considered serviceable during these inspections and all springs and rubber parts. Use only genuine Bendix replacement parts, available from any authorized Bendix parts outlet.

ASSEMBLY

Note: All torque specified in this manual are assembly torque and can be expected to fall off slightly after assembly. **Do not re-torque** after initial assembly torque fall. For assembly, hand wrenches are recommended.

Prior to assembly, lubricate all o-rings, o-ring bores and any sliding surface with a silicone lubricant equivalent to Dow Corning #10.

1. Install large piston o-ring on piston.
2. Install inner and outer o-rings in the exhaust cover assembly.
3. Install the sealing ring on the cover.
4. Install piston in body, taking care not to damage the piston o-ring.
5. Noting the reference marks made during disassembly, install the cover on the valve body and the mounting bracket on the cover.
6. Secure the mounting bracket and cover to the body using the four (4) cap screws and lock washers. Torque to 80-120 inch pounds.
7. Install the valve retainer on the inlet/exhaust valve and install in the body.
8. Install the inlet/exhaust valve return spring in the body.
9. Install the exhaust cover assembly in the body, taking care not to damage the o-ring.
10. While depressing the exhaust cover, install the retaining ring. Make certain the retainer is completely seated in its groove in the body.
11. Install the R-14 service port cap nut o-ring on the cap nut. Install the diaphragm in the R-14 cover making certain it is positioned between the guide ribs in the cover.
13. Install the service port cap nut and torque to 150 inch pounds.
14. If the quick release exhaust port was protected with an exhaust cover, install the cover using the #10-24 Phillips head screw. Torque to approx. 15-25 inch pounds.
15. Test the valves as outlined in the *Operational and Leakage Test* section before returning the valve to service.

INSTALLATION

1. Clean air lines.
2. Inspect all lines and/or hoses for damage and replace as necessary.
3. Install valve and tighten mounting bolts.
4. Connect air lines to valve (plug any unused ports).
5. Test valve as outlined in *Operational and Leakage Tests*.

IMPORTANT! PLEASE READ

When working on or around a vehicle, the following general precautions should be observed:

1. **Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.**
2. **Stop the engine when working around the vehicle.**
3. **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.**
4. **Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.**
5. **When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.**
6. **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 depleted.**
7. **Never exceed recommended pressures and always wear safety glasses.**

8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be at tempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

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Service Data

SD-03-1068

R-12DC RELAY VALVE WITH BIASED DOUBLE CHECK

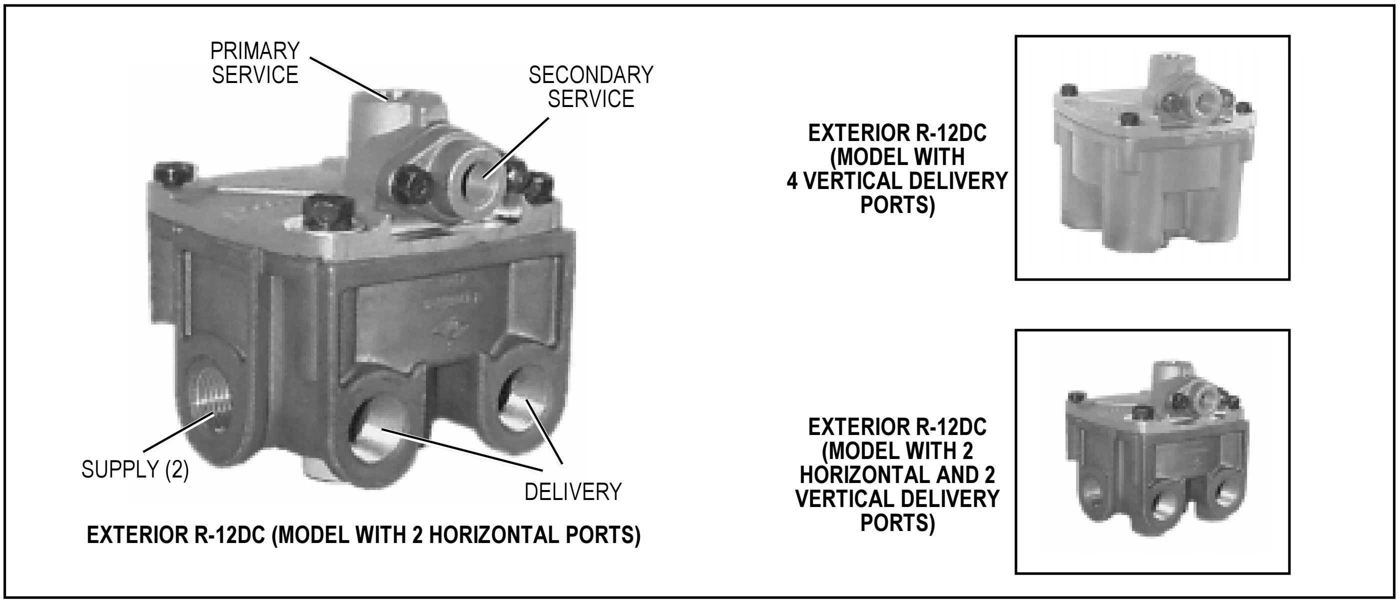


*FIGURE 1 - **EXTERIOR VIEWS.***

DESCRIPTION

The Relay Valve in an air brake system functions as a relay station to speed up the application and release of the brakes. The valve is normally mounted at the rear of the vehicle in proximity to the chambers it serves. The valve operates as a remote controlled brake valve that delivers or releases air to the chambers in response to the control air delivered to it from the foot brake valve.

The R-12DC Relay Valves are designed for either reservoir or frame mounting. (See Figure 1). For ease of servicing, the inlet/exhaust valve can be replaced without the need for line removal.

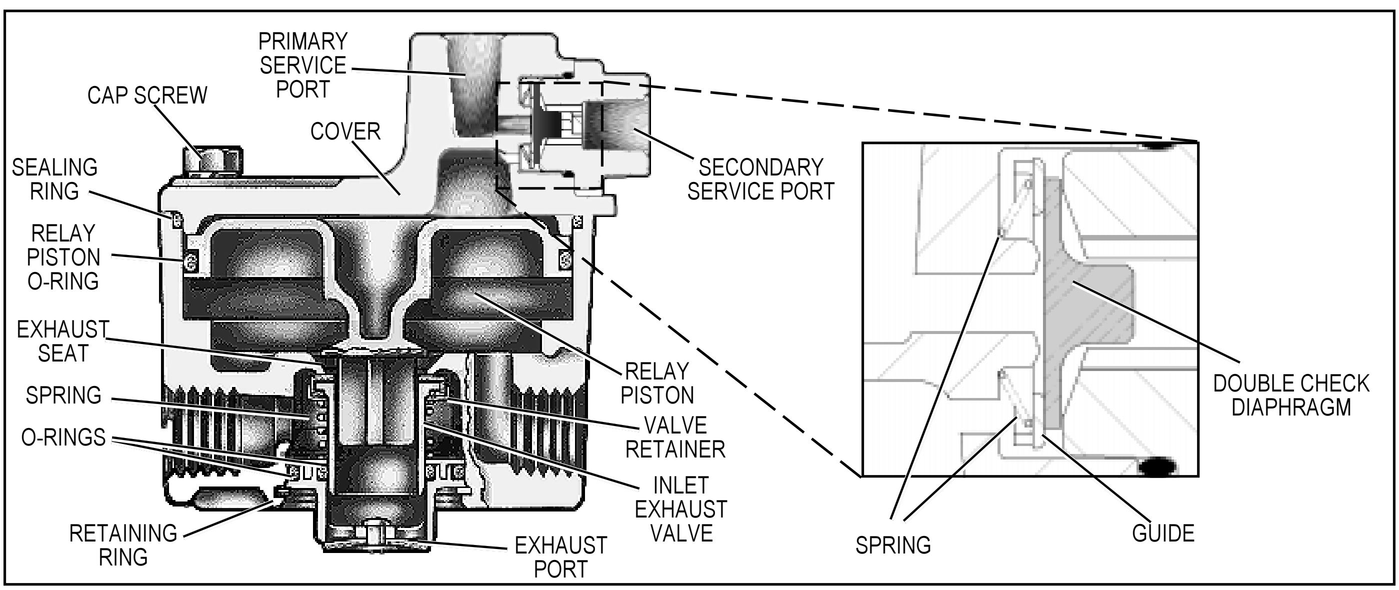


*FIGURE 2 - **R-12DC SECTIONAL VIEW***

OPERATION

APPLICATION

Under normal conditions, the internal biased double check valve assures that the primary service signal controls the valve. Air pressure delivered to the primary 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 service brake chambers. In the event of a loss of the primary service line, (see Figure 4) the double check valve mechanism in the cover of the R-12DC will move, shutting off the primary service line, and instead allow the secondary service line to apply the air pressure needed to operate the valve.

Note: Secondary service line may leak out of the primary service at control pressures up to 20 psi when the primary signal is not present.

BALANCE

The air pressure being delivered by the open inlet valve also is effective on the bottom area of the relay piston.

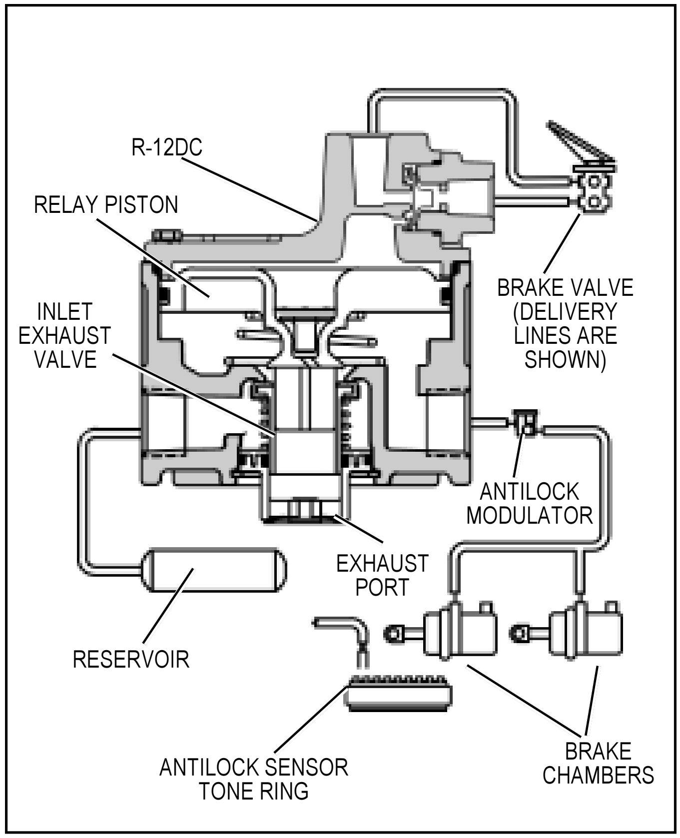


*FIGURE 3 - **R-12DC SECTIONAL VIEW WITH TYPICAL SYSTEM COMPONENTS***

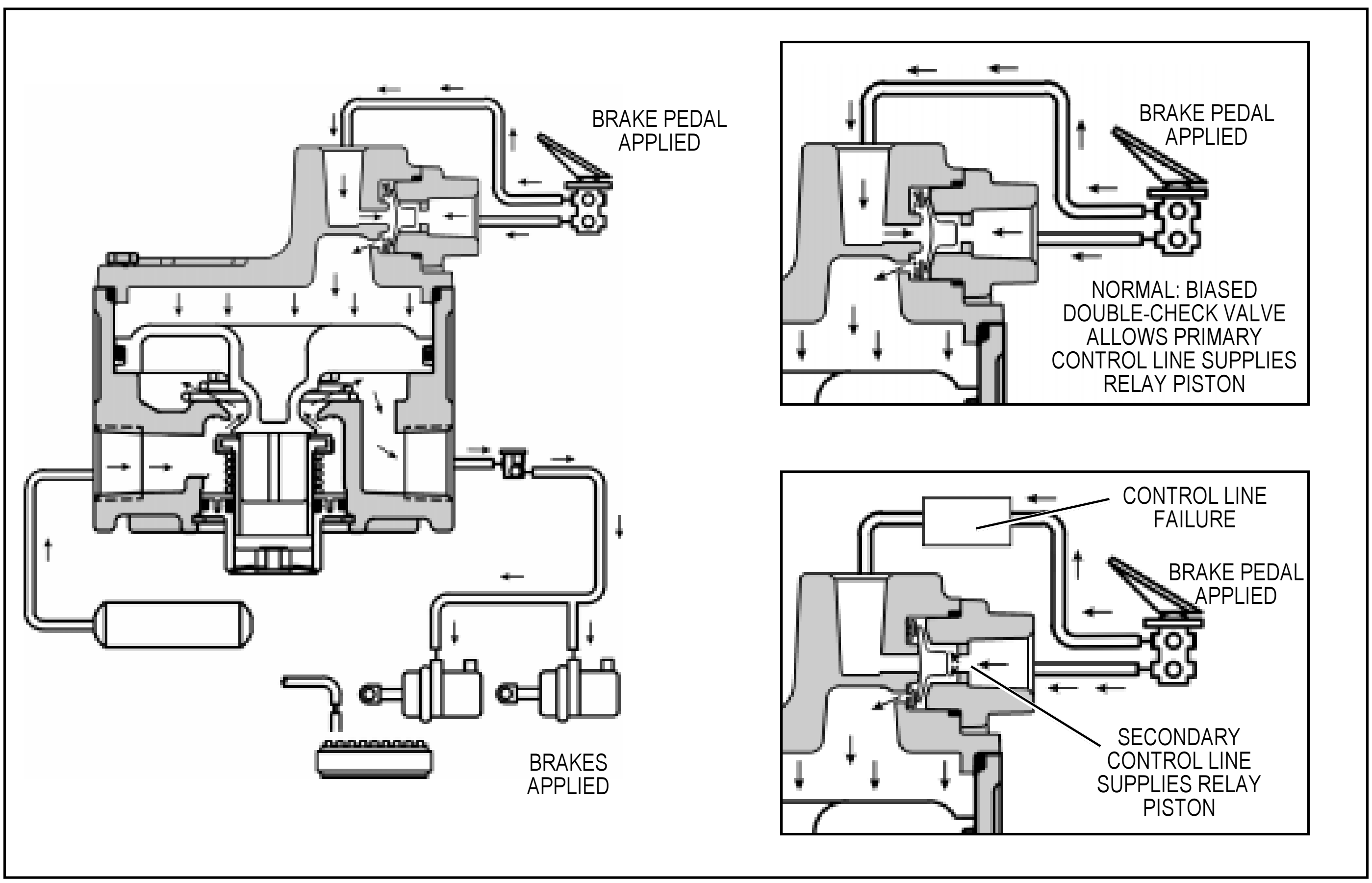


*FIGURE 4 - **R-12DC APPLIED POSITION (SHOWING BIASED DOUBLE CHECK OPERATIONAL VIEWS)***

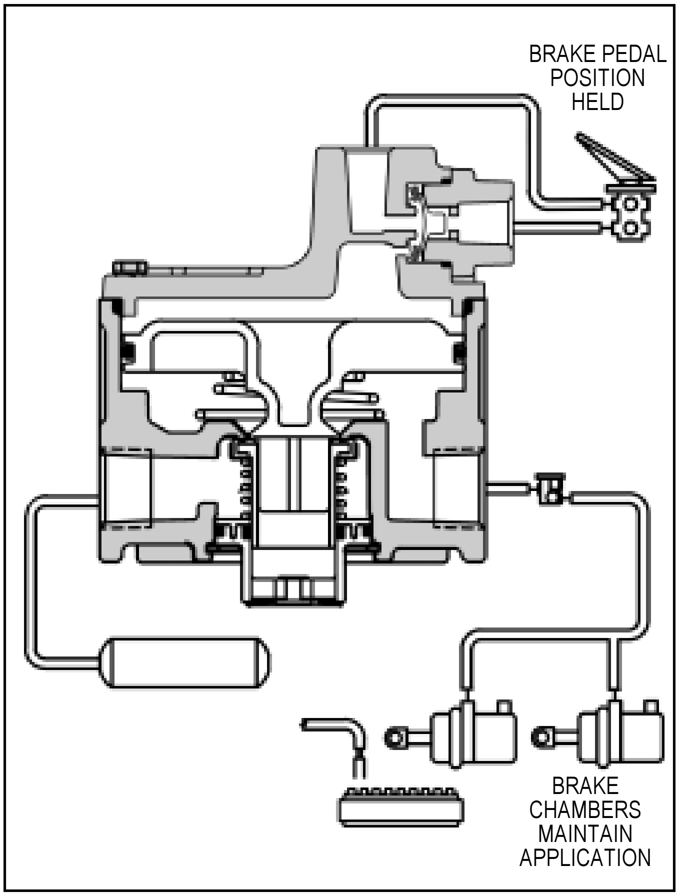


*FIGURE 5 - **R-12DC BALANCE POSITION***

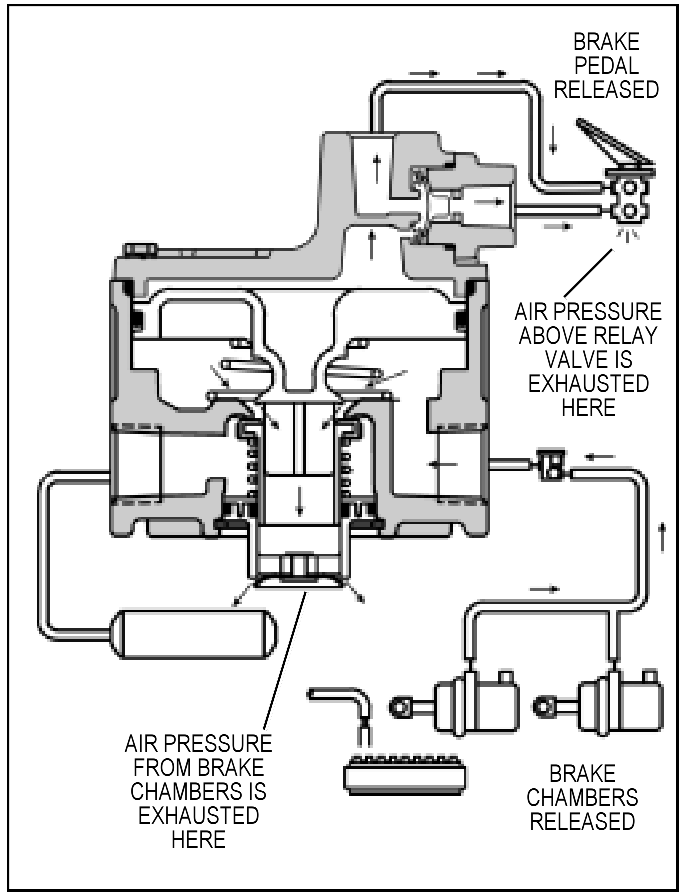


*FIGURE 6 - **R-12DC EXHAUST POSITION***

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 seat. The exhaust remains closed as the service line pressure balances the delivery pressure. As delivered air pressure is changed, the valve reacts instantly to the change, holding the brake application at that level.

EXHAUST OR RELEASE

When air pressure is released from the service port and air pressure in the cavity above the relay piston is exhausted through the brake valve. At the same time, 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.

PREVENTIVE MAINTENANCE

Important: Review the warranty policy before performing any intrusive maintenance procedures. An extended warranty may be voided if intrusive maintenance is performed during this period.

Because no two vehicles operate under identical conditions, maintenance and maintenance intervals will vary. Experience is a valuable guide in determining the best maintenance interval for any one particular operation.

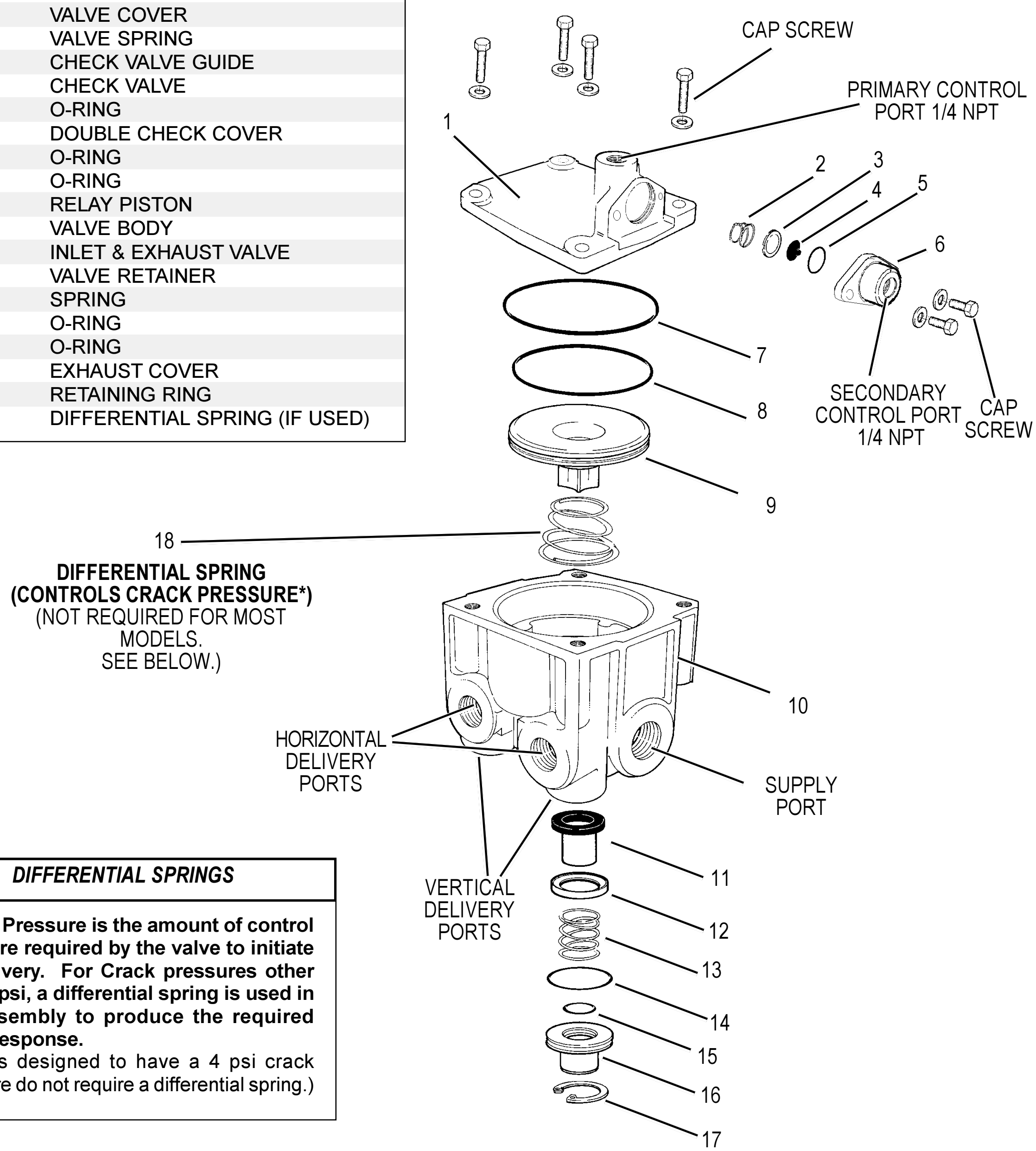
1. Every three months or 25,000 miles or 900 operating hours check for proper operation.
2. Every twelve months or 100,000 miles or 3600 operating hours: disassemble valve, clean parts with mineral spirits. Replace all rubber parts and any worn or damaged part. Check for proper operation before placing vehicle in service.

REMOVAL AND INSTALLATION

REMOVAL

1. Block and hold vehicle by means other than air brakes.
2. Drain air brake system reservoirs.
3. If entire valve is to be removed, identify air lines to facilitate installation. Prior to disassembly, remove as much contamination as possible from the exterior of the device taking care to keep all contamination from entering the open ports.
4. Disconnect air lines from valve.*
5. Remove valve from reservoir or if remotely mounted, remove mounting bolts and then valve.

Key No.	DESCRIPTION
1	VALVE COVER
2	VALVE SPRING
3	CHECK VALVE GUIDE
4	CHECK VALVE
5	O-RING
6	DOUBLE CHECK COVER
7	O-RING
8	O-RING
9	RELAY PISTON
10	VALVE BODY
11	INLET & EXHAUST VALVE
12	VALVE RETAINER
13	SPRING
14	O-RING
15	O-RING
16	EXHAUST COVER
17	RETAINING RING
18	DIFFERENTIAL SPRING (IF USED)



DIFFERENTIAL SPRINGS
***Crack Pressure is the amount of control pressure required by the valve to initiate air delivery. For Crack pressures other than 4 psi, a differential spring is used in the assembly to produce the required valve response.** (Models designed to have a 4 psi crack pressure do not require a differential spring.)

*FIGURE 7 - **R-12DC EXPLODED VIEW***

*It is generally not necessary to remove entire valve to service the inlet/exhaust valve. The inlet/exhaust valve insert can be removed by removing the snap ring, exhaust cover assembly and then inlet/exhaust valve.

Caution: Drain all reservoirs before attempting to remove the inlet exhaust valve.

DISASSEMBLY

Note: Prior to disassembly, mark the location of the mounting bracket to the cover and the cover to the body.

CAUTION: The valve body may be lightly clamped in a bench vise during disassembly, however, over-clamping will result in damage to the valve and result in leakage and/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 the four cap screws securing the mounting bracket and cover to the body. Retain the cap screws for reuse.
2. Discard the mounting bracket.
3. Remove and discard sealing ring (7) from the cover (1).

a. Remove the 2 torx screws securing the double check cover (6) to the cover (1).

b. Remove the double check cover (6) from cover (1) and remove and discard spring (2), guide (3), double check diaphragm (4), and o-ring (5).

4. Remove and discard sealing ring (7) from the cover (1), and mounting bracket.
5. Remove piston (9) from the body (10) and retain for reuse.
6. Remove and discard o-ring (8) from piston (9).
7. Depress and hold the exhaust cover assembly (16) and remove and discard retaining ring (17) from the valve body (10).
8. Slowly release the holding force on the exhaust cover assembly (16) to relax the spring.
9. Remove and discard the following parts:
   a. Exhaust cover assembly (16)
   b. O-rings (14 & 15)
   c. Spring (13)
   d. Inlet exhaust valve (11)
   e. Retainer (12)

CLEANING AND INSPECTION

1. Wash all metal parts in mineral spirits and dry them thoroughly.

   (**Note:** When servicing the R-12DC, all springs and all rubber parts should be replaced.)
2. Inspect all metal parts for deterioration and wear, as evidenced by scratches, scoring and corrosion.
3. Inspect the exhaust valve seat on the relay piston for nicks and scratches which could cause excessive leakage.
4. Inspect the inlet valve seat in the body for scratches and nicks, which could cause excessive leakage.
5. Inspect the check valve seat in the R-12DC cover and make sure all internal air passages in this area are open and clean and free of nicks and scratches.
6. Replace all parts not considered serviceable during these inspections and all springs and rubber parts. Use only genuine Bendix replacement parts, available from any authorized Bendix parts outlet.

ASSEMBLY

Note: All torque specified in this manual are assembly torque and can be expected to fall off slightly after assembly. **Do not re-torque** after initial assembly torque fall. For assembly, hand wrenches are recommended.

Prior to assembly, lubricate all o-rings, o-ring bores and any sliding surface with a silicone lubricant equivalent to Dow Corning #10.

Wash all remaining parts in mineral spirits and dry thoroughly. Using the lubricant provided in this kit, lightly lubricate all o-rings, o-ring grooves, body bores any sliding surfaces.

1. Install o-rings (14 & 15) in the exhaust cover assembly (16).
2. Install o-ring (8) on piston (9).
3. Install sealing ring (7) on cover (1)
4. Install retainer (12) on inlet exhaust valve (11) and insert both in the body (10).
5. Install spring (13) in the body (10).
6. Install exhaust cover assembly (16) in the body (10). Depress and hold the exhaust cover assembly in the body.
7. Install retaining ring (17) in the body (10). Make certain the retaining ring is completely seated in the groove in the body.
8. Install piston (9) in body (10).
9. Install o-ring (5) on double check cover (6), install spring (2), guide (3) and double check diaphragm (4) in cover (1). Install cover (1) and torque torx head screws to 80-100 in. lbs.
10. Referring to the marks made during disassembly, install cover (1)
11. Install the mounting bracket (not shown) on the cover (1).
12. Install the four cap screws in the cover (1) and torque to 80-100 inch pounds
13. Test the valve as outlined in the *Operational and Leakage Test* section before returning the valve to service.

INSTALLATION

1. Clean air lines.
2. Inspect all lines and/or hoses for damage and replace as necessary.
3. Install valve and tighten mounting bolts.
4. Connect air lines to valve (plug any unused ports).
5. Test valve as outlined in *Operational and Leakage Tests*.

OPERATIONAL AND LEAKAGE TEST

1. Chock the wheels, fully charge air brake system and adjust the brakes.
2. Make several brake applications and check for prompt application and release at each wheel.

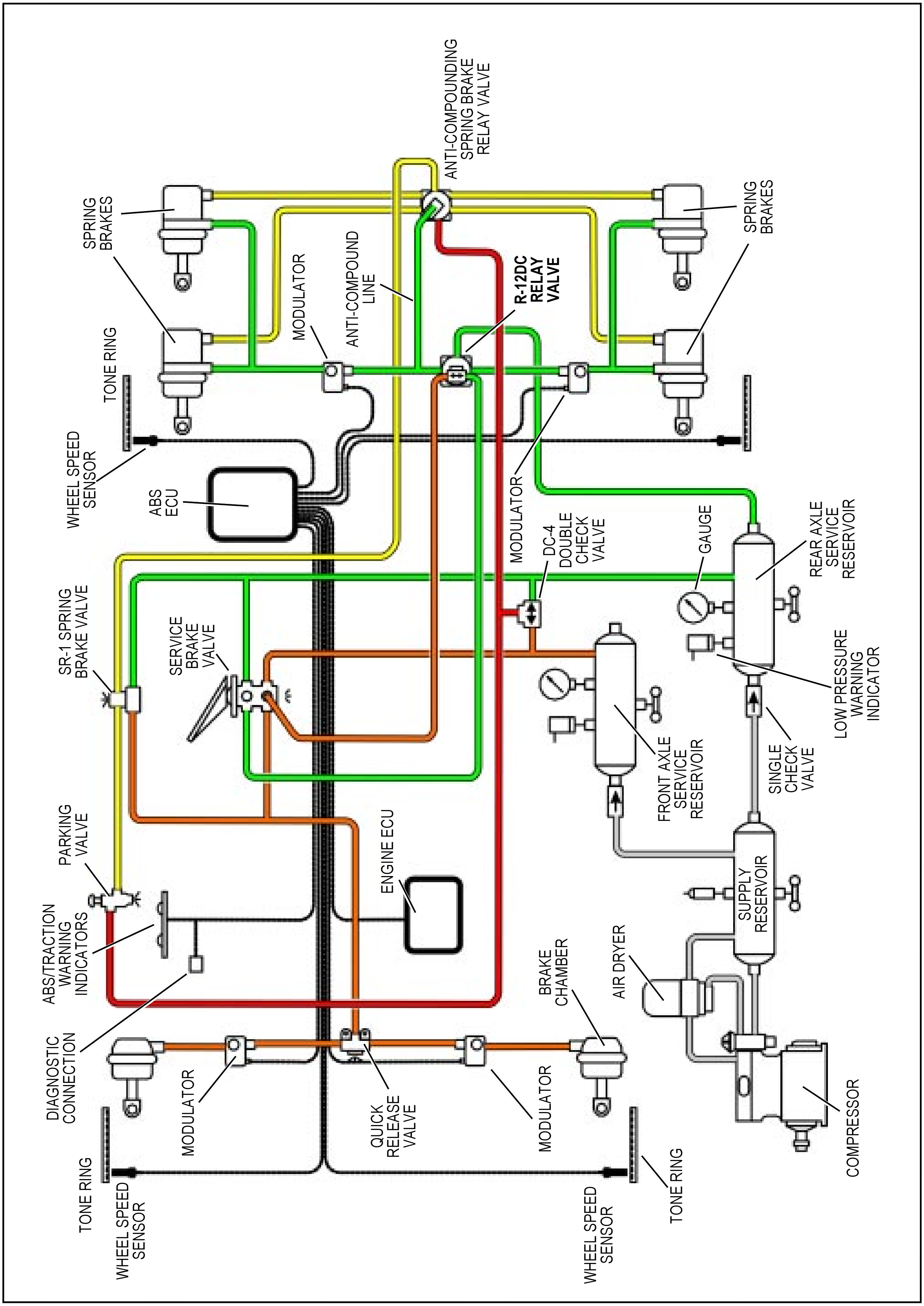


FIGURE 8 - TYPICAL PIPING SCHEMATIC

3. Check for inlet valve and o-ring leakage. Make this check with the service brakes released. Coat the exhaust port and the area around the retaining ring with a soap solution; a 1 inch bubble in 3 seconds leakage is permitted.
4. Check for exhaust valve leakage. Make this check with the service brakes fully applied. Coat the outside of the valve where the cover joins the body to check for seal ring leakage; no leakage is permitted.

If the valves do not function as described above, or if leakage is excessive, it is recommended that the valves be replaced with new or remanufactured units or repaired with genuine Bendix parts, available at any authorized Bendix parts outlet.

IMPORTANT! PLEASE READ

When working on or around a vehicle, the following general precautions should be observed:

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.
2. Stop the engine when working around the vehicle.
3. 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.
4. Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.
6. 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 depleted.
7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be at tempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

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Service Data

SD-03-2010*

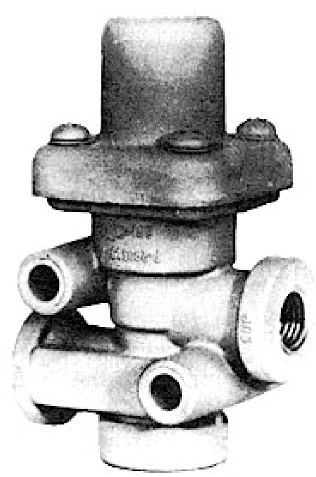
PRESSURE PROTECTION VALVES

*Formerly SD-03-55

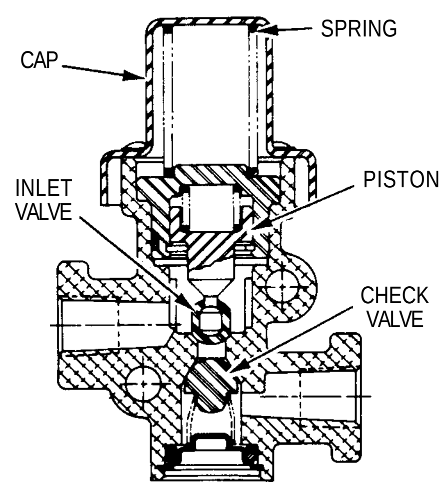
DESCRIPTION

The pressure protection valve is a normally closed, pressure control valve which can be referred to as a non-exhausting sequence valve. These valves are used in many different applications. An example would be in an air brake system to protect one reservoir, or reservoir system from another, by closing automatically at a preset pressure should a reservoir system failure occur. The valves can also be used to delay filling of auxiliary reservoirs to insure a quick build-up of brake system pressure.

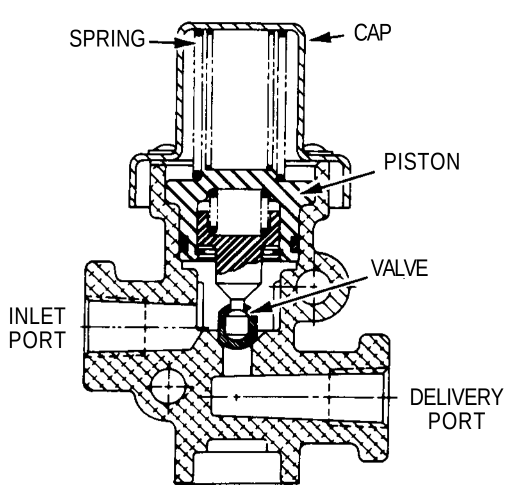
The PR-2 and PR-4 pressure protection valves have one 1/4" N.P.T.F. supply port and one 1/4" N.P.T.F. delivery port which are identified. Both valves are provided with two 9/32" mounting holes through the body. The closing pressure of the PR-2 is externally adjustable while the PR-4 has a fixed setting.



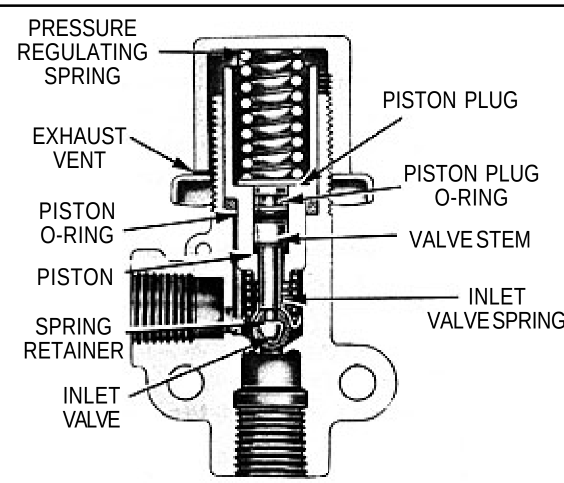
PR-3 OR PR-4



PR-3



PR-4



PR-2

OPERATION

Air entering the supply port is initially prevented from flowing out the delivery port by the inlet valve which is held closed by the pressure regulating spring above the piston. When sufficient air pressure builds beneath the piston to overcome the setting of the regulating spring, the piston will move, causing the inlet valve to unseat (open), and allow air to flow out the delivery port. As long as air pressure at the supply port and beneath the piston remains above the specified closing pressure, the inlet valve will remain open.

NOTE: The PR-2 and PR-4 closing pressure is noted on the label affixed to the valve. Opening pressures of the valves are higher than closing pressures. The pressure ranges are noted below:

PR-2-Opening pressure 15-20 psi higher than closing pressure.

PR-3 & PR-4-Opening pressure approx. 10 psi higher than closing pressure.

PR-3-Check valve will retain maximum pressure in downstream reservoir.

If for any reason system air pressure is decreased below the specified closing pressure, the regulating spring will move the piston closing the inlet valve. The remaining air pressure at either the supply or delivery side, (depending upon where the pressure drop has occurred) will be retained.

PREVENTIVE MAINTENANCE

Every three months, 900 operating hours or 25,000 miles, whichever if first, it is recommended that the operation and leakage checks described in this manual be performed.

OPERATING AND LEAKAGE CHECKS

OPERATING CHECKS

1. Provide a pressure gauge and drain valve at the supply side and delivery side of the pressure protection valve being checked.
2. Build up the air system to full pressure and shut off the engine.
3. While watching the gauges on the supply and delivery sides of the valve, slowly begin to exhaust pressure from the delivery side. Note that both gauges will show pressure loss until the closing pressure of the pressure protection valve is reached.

   The pressure protection valve should close at approximately (± 5 psi) the pressure indicated on the valve's label or in the vehicle handbook. The gauge on the delivery side of the valve should continue to show loss of pressure while the gauge on the supply side should stop at the same pressure as the setting of the valve.
4. (PR-3 only) Build pressure up again and shut off engine. Slowly exhaust air from the supply side of the PR-3. The gauge on the delivery side of the valve should remain at the highest pressure previously attained.

LEAKAGE CHECKS

1. Build up the air system to full pressure and shut off the engine.
2. Apply a soap solution around the cap of the pressure protection valve. A one-inch bubble in three seconds or longer is acceptable. PR-3 - No leakage permissable at bottom of valve.
3. Drain the air pressure from the delivery side of the pressure protection valve and disconnect the air line to it.
4. Apply a soap solution to the delivery port. A one inch bubble in five seconds or more is acceptable.

GENERAL

If the pressure protection valve does not operate as described or leakage is excessive, it is recommended that a replacement be obtained at the nearest authorized AlliedSignal Truck Brake Systems Co. distributor.

REMOVING AND INSTALLING

REMOVING

1. Block or hold the vehicle by means other than air brakes.
2. Drain all system reservoirs individually, to 0 psi.
3. Disconnect and identify (supply and delivery) the air lines leading to and from the pressure protection valve.
4. Remove the mounting bolts, if any, that secure the valve.

INSTALLING

1. Re-install the mounting bolts and secure the replacement valve to the vehicle.
2. Reconnect the supply delivery air lines to the proper ports of the replacement valve.

GENERAL

After installing a replacement valve, it is recommended that the operating and leakage checks be performed as outlined in this manual. If the closing pressure does not conform to that shown on the valve label or in the vehicle or a different setting is desired, the PR-2 may be adjusted by loosening the locknut and tightening or loosening the adjusting cap as required; however, if the proper setting cannot be attained by moderate adjustment of the cap, the valve may have the wrong spring and will have to be exchanged for the correct valve. The PR-3 and PR-4 are not adjustable.

IMPORTANT! PLEASE READ

When working on or around a vehicle, the following general precautions should be observed:

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.
2. Stop the engine when working around the vehicle.
3. 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.
4. Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.
6. 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 depleted.
7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

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Service Data

SD-03-2202*

DOUBLE CHECK VALVES

*FORMERLY SD-03-67

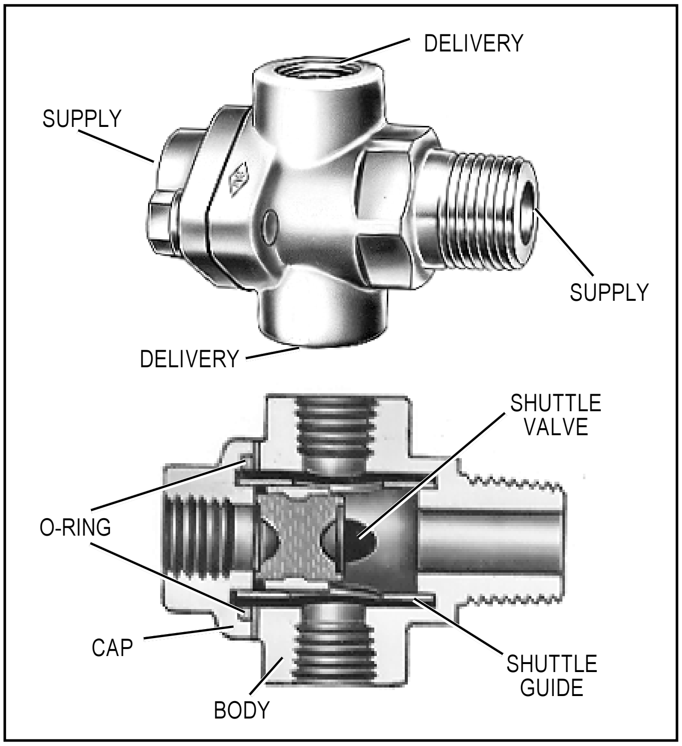

*FIGURE 1 - **DOUBLE CHECK VALVE (SHUTTLE TYPE)***

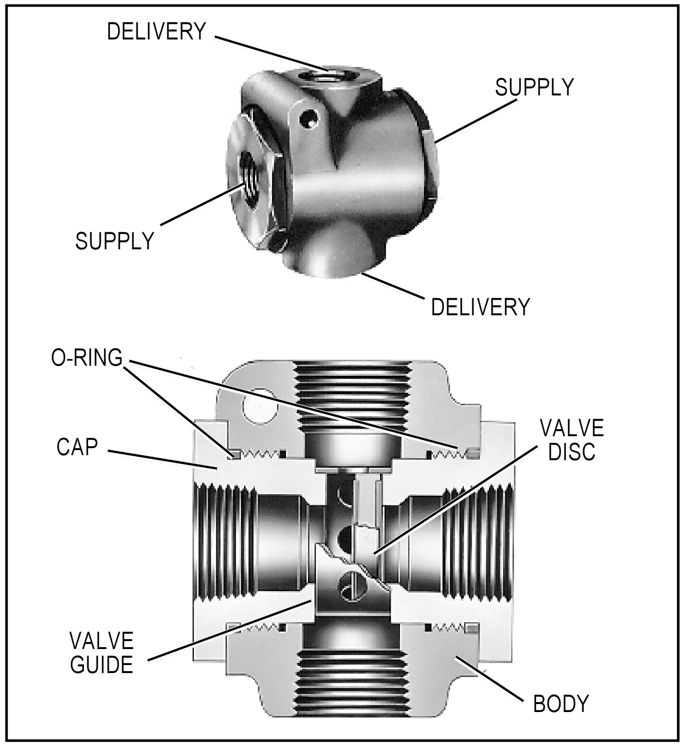

*FIGURE 2 - **DOUBLE CHECK VALVE (DISC TYPE)***

DESCRIPTION

Double Check Valves are used in an air brake system to direct a flow of air into a common line from either of two sources, whichever is at the higher pressure. They may be used for directing air flow for specific functions or to select the higher pressure of either of two sources of air as a supply source.

AlliedSignal manufactures two types of Bendix Double Check Valves: shuttle and disc. Although the valves are somewhat different physically, the same function is performed by both types. The difference in the design of the two valves is that the shuttle type has a movable shuttle to seal off the lower pressure source, whereas the disc type has a movable disc.

OPERATION

As air under pressure enters either end of the Double Check Valve (inlet port) the moving shuttle or disc responds to the pressure and seals the opposite port, assuming it is at a lower pressure level than the other. The air flow continues out the delivery port of the Double Check Valve. The position of the shuttle or disc will reverse if the pressure levels are reversed. Double Check Valves are designed so that the shuttle or disc can never impede the backflow of air in the exhaust mode.

Figure 3 (see page 2) illustrates a typical use of a Double Check Valve to control a given device, such as trailer brakes, from either of two control sources.

Figure 4 (see page 2) illustrates a typical use of a Double Check Valve to supply air to a system or systems from either of two separate sources, whichever is at the greater pressure level. In this type of installation the pressure differential to which the valve is subjected may under certain conditions be minimal. It is therefore suggested that performance of the Double Check Valve will be optimized if it is mounted in the horizontal position.

PREVENTIVE MAINTENANCE

Every 3600 operating hours, 100,000 miles, or yearly, disassemble, clean and inspect all parts. Install new parts if they show signs of wear or deterioration.

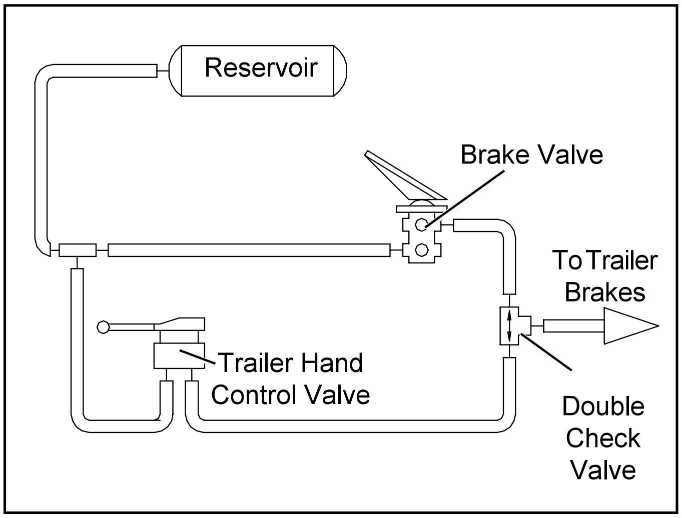

*FIGURE 3 - **DOUBLE CHECK VALVE: CONTROL OF SYSTEM FROM EITHER OF TWO CONTROL SOURCES***

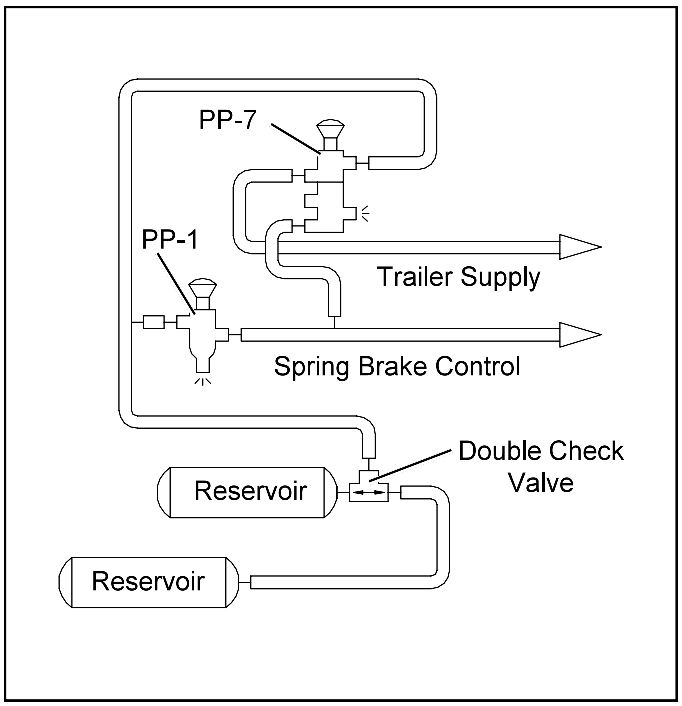

*FIGURE 4 - **DOUBLE CHECK VALVE: SYSTEM WITH TWO SUPPLY SOURCES***

SERVICE CHECKS

OPERATING AND LEAKAGE TEST

A. When the Double Check Valve is used in conjunction with a Trailer Control Valve, the following operating and leakage test can be made:

1. Apply and release foot brake valve and note that the brakes apply and release on both tractor and trailer.
2. Apply and release the Trailer Control Valve and note that only the trailer brakes apply and release. With trailer control valve applied check exhaust port of foot brake valve for leakage with soap solution. Permissible leakage is a one inch bubble in five seconds (100 sccm).
3. Apply and hold a full foot brake valve application. Check exhaust port of Trailer Control Valve for leakage with soap solution. Permissible leakage is a one inch bubble in five seconds (100 sccm). (**Note**: On some vehicles, an exhaust line is connected to the exhaust port and piped outside the cab in which case it may be necessary to disconnect this line to make leakage check.)

B. If Double Check Valve is to be bench tested or tested on the vehicle, two separately controlled air supplies must be connected to the inlet ports.

1. Install an accurate test gauge in the outlet port or in a line from outlet port.
2. Apply and release air to one inlet port and note that gauge registers application and release.
3. Repeat by applying and releasing air to other inlet port.
4. Leakage check should be performed at inlet ports of valve in the following manner:
   a. Disconnect line from one inlet port.
   b. Apply air to other inlet port and coat opposite inlet port with soap solution. Permissible leakage is a one inch bubble in five seconds (100 sccm).
   c. Repeat Step "b" applying air to other inlet port while checking opposite inlet port for leakage.

If the Double Check Valve does not function as described or if leakage is excessive, it is recommended that the valve be repaired or replaced with genuine Bendix parts. The following instructions should prove helpful:

DISASSEMBLY

1. Remove end cap(s) from valve.
2. Remove grommets (if applicable).
3. Remove shuttle and/or shuttle guide, disc and/or disc guide (depending upon type of valve).

CLEANING AND INSPECTION

1. Clean all metal parts in a cleaning solvent.
2. Inspect all metal parts for signs of cracks, wear or deterioration. Replace all parts not considered serviceable.
3. Replace all rubber parts.

ASSEMBLY

1. Install disc guide, disc and/or shuttle and shuttle guide.
2. Coat all static seals such as o-rings, grommets, etc. with BW 650M Silicone lubricant (BW 291126). It is not necessary to lubricate shuttles or discs.
3. Install grommets.
4. Install end cap(s).

TESTING OF REBUILT DOUBLE CHECK VALVE

Perform operating and leakage tests as described in "Service Checks" section.

IMPORTANT! PLEASE READ:

When working on or around a vehicle, the following general precautions should be observed:

1. **Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.**
2. **Stop the engine when working around the vehicle.**
3. **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.**
4. **Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.**
5. **When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.**
6. **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 depleted.**
7. **Never exceed recommended pressures and always wear safety glasses.**
8. **Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.**
9. **Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.**
10. **Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.**
11. **Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.**

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Service Data

SD-03-3602*

TW-1, TW-3, TW-4, TW-5 & TW-6 CONTROL VALVES

*Formerly SD-03-64

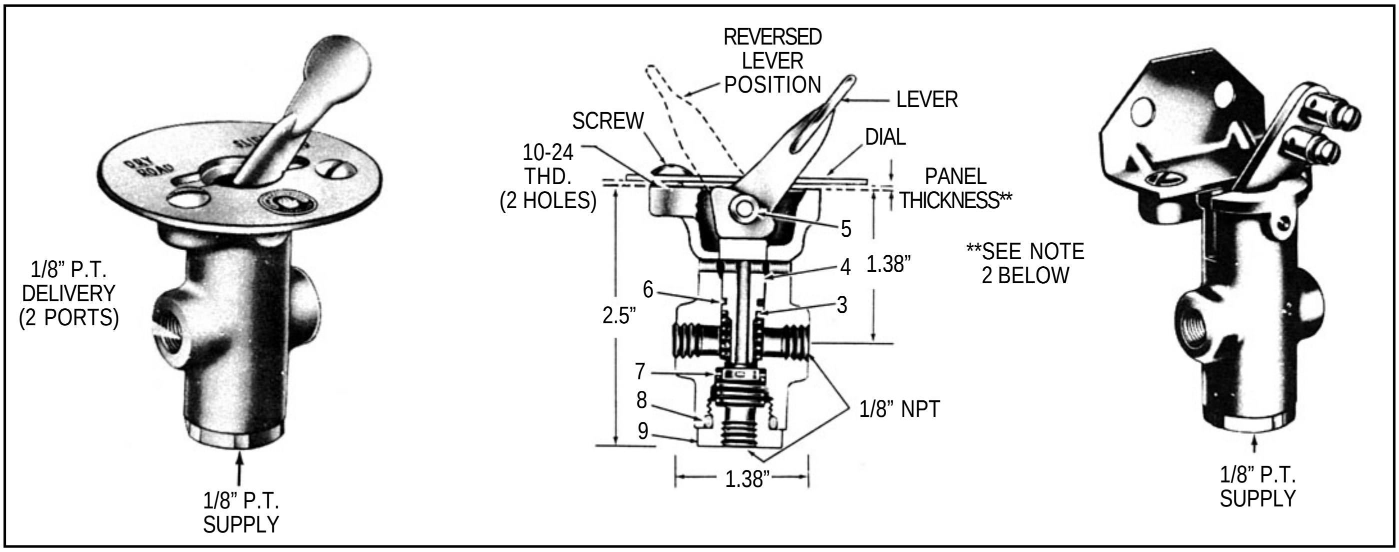

FIGURE 1 - TW-1

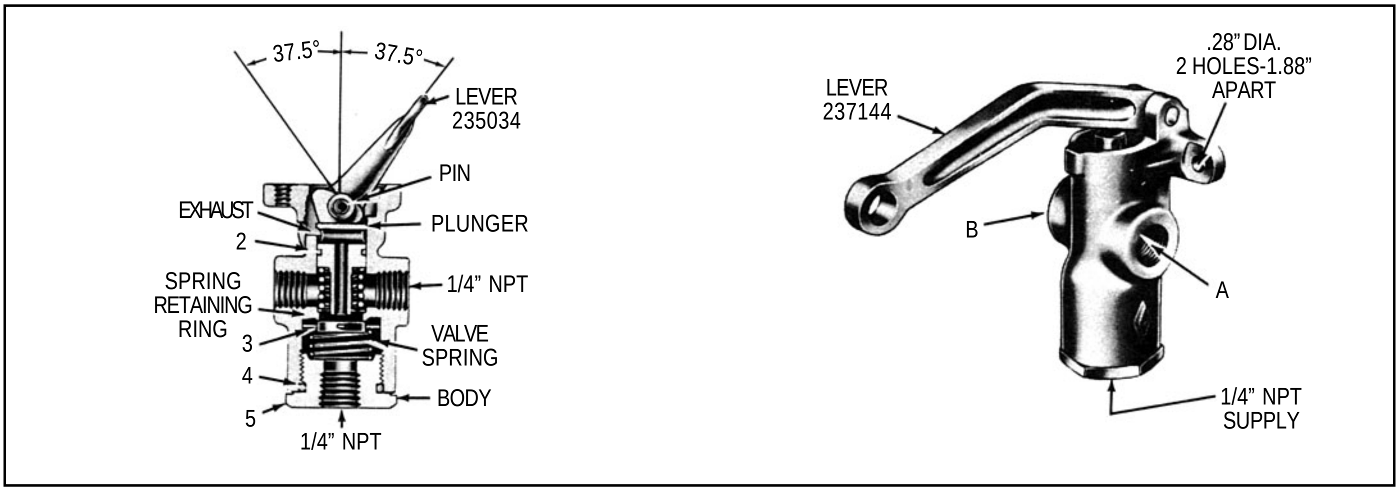

FIGURE 2 - TW-3

DESCRIPTION

The TW series valves are manually operated on-off valves. They are extensively used in air systems to control nonmodulating air controlled devices. They may be lever or button operated, direct or remote control.

The TW-1 (Figure 1) is normally panel mounted with a steel, zinc or nylon manually operated lever. Some are equipped with a steel lever with connectors for Bowden cable control. All TW-1's have 1/8" NPT ports.

The TW-3 (Figure 2) is lever operated, either direct or remote and differs from the TW-1 in having 1/4" NPT ports and larger capacity. Some versions have a heavy inlet valve spring making them suitable for vacuum control.

TW-4's and TW-5's (Figure 3) are similar to the TW-1 except the plunger is designed for a push button, giving momentary application whenever the button is depressed.

The TW-6 (Figure 4) is a TW-1 with a grounding switch included. In the exhaust position the switch is open. When the valve is applied the switch is closed.

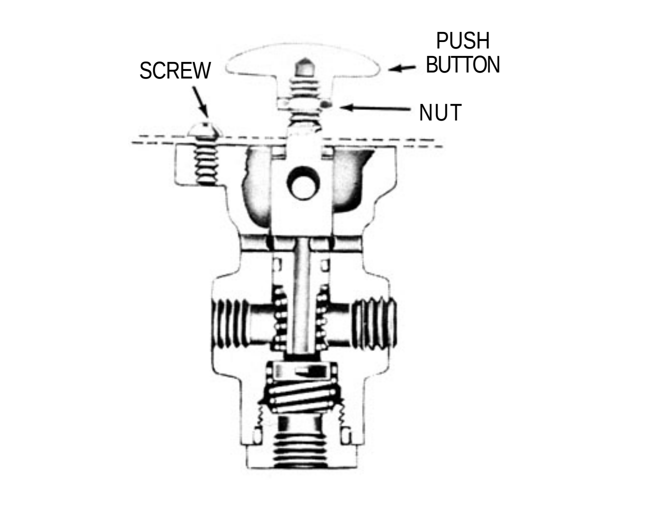

FIGURE 3 - TW-4

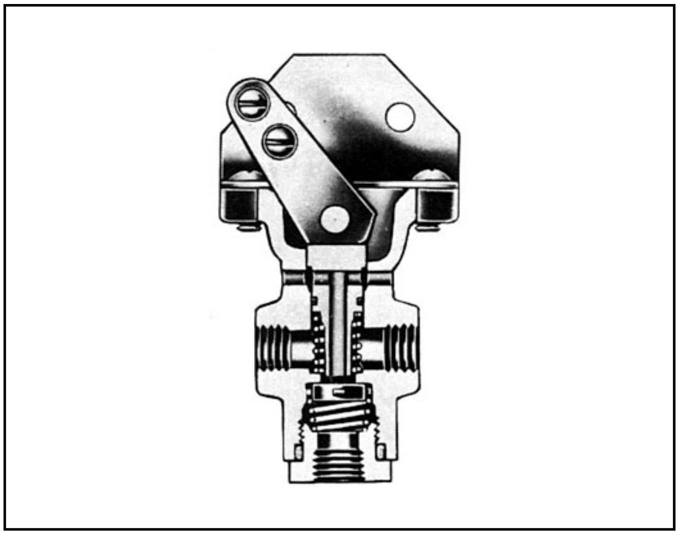

FIGURE 4 - TW-6

OPERATION

With air pressure a the supply port (Figure 1) and the plunger in the upward position the valve is in the exhaust position. The delivery ports are open to atmosphere through the exhaust passage in the center of the plunger.

When the plunger is depressed by the cam action of the lever (Figure 1) or by a direct force on a push button (Figure 3) the plunger contacts the inlet valve, closing the exhaust passage and pushes the inlet valve off the inlet seat in the body, allowing supply air to flow through the delivery ports to the controlled device.

PREVENTIVE MAINTENANCE

Every year, 100,000 miles or 1800 operating hours disassemble, clean and check all parts and replace if necessary.

SERVICE CHECKS

OPERATING AND LEAKAGE TESTS

Connect a 100 psi air pressure source to the supply port and connect delivery to an air gauge. (if there are two delivery ports, plug one.) With the valve in the released position, check for leakage at the exhaust holes with a soap solution. No leakage permitted. Place the valve in the applied position. Supply air pressure should show on the gauge. Check for leakage at the exhaust holes. No leakage permitted.

If the TW valve does not function as described or if leakage occurs, it is recommended that it be replaced with a new unit or repaired with genuine Bendix parts.

REMOVING

Secure the vehicle with other means than brakes and drain the reservoirs.

Disconnect all air lines and remove the valve.

INSTALLING

Place valve handle through appropriate hole in panel, place dial (if used) over handle and install mtg. screws. Connect air lines.

DISASSEMBLY

Remove operating handle or lever by driving the pin out of the body (Figure 1) and remove the lever, plunger and plunger spring. Remove the O-Ring from the plunger.

Remove the supply cap nut, inlet valve and spring. Remove the 0-Ring from the supply cap nut.

CLEANING AND INSPECTION OF PARTS

Wipe rubber parts clean. Clean plastic and metal parts in mineral spirits and dry thoroughly. Inspect all rubber parts for wear or deterioration and replace where necessary. Polish the inlet seat in the body if nicked or corroded. Inspect all springs for cracks, distortion or corrosion and replace if necessary.

ASSEMBLY

Prior to assembly lubricate body bore, plunger, O-Rings, and cap nut threads with Bendix silicone lubricant BW 650M Pc. No. 291126.

Place inlet valve in body.

Place inlet valve spring on inlet valve.

Place O-Ring on cap nut and install cap nut.

Install plunger spring from top of body.

Install O-Ring on plunger and install plunger.

TW-1 TW-3 & TW-6

Depress plunger, place lever cam in slot in body, line up holes in body with hole in lever and insert pin.

TW-4 & TW-5

Depress plunger with button until hole in plunger lines up with holes in body. Insert pin.

LEAKAGE TEST

Test valve per instructions in paragraph on "Service Checks."

IMPORTANT! PLEASE READ

When working on or around a vehicle, the following general precautions should be observed:

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.
2. Stop the engine when working around the vehicle.
3. 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.
4. Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.
6. 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 depleted.
7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

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Service Data

SD-03-3611*

PUSH-PULL TYPE CONTROL VALVES: PP-1, PP-2, PP-5, PP-8, & RD-3

*FORMERLY SD-03-61

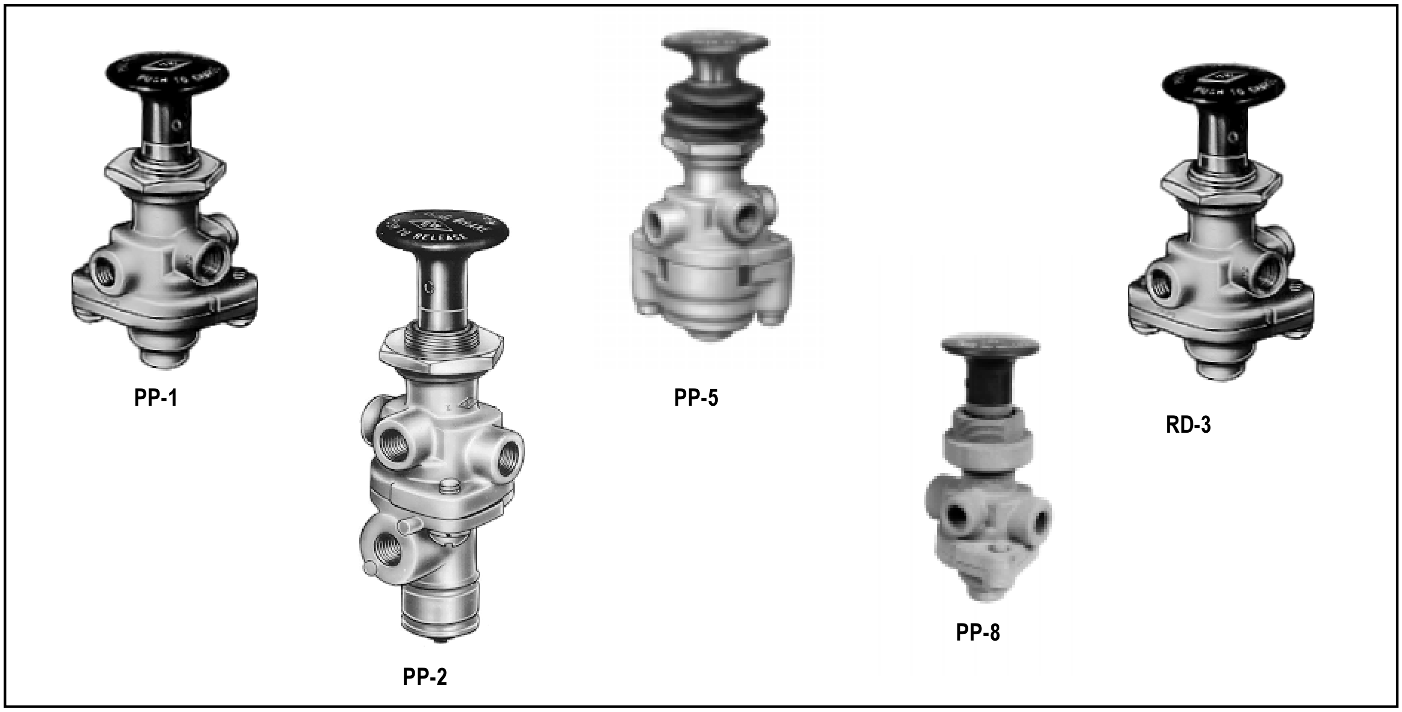


*FIGURE 1 - **PUSH-PULL TYPE CONTROL VALVES***

DESCRIPTION

The PP valves are push-pull manually operable on-off air control valves with an exhaust function. Most are pressure sensitive, so that they will automatically move from the applied to the exhaust position as supply pressure is reduced to a certain minimum, depending on the spring installed. The exception to this is the PP-8 valve and some PP-1 valves which have no spring. The PP-8 valve also has a larger diameter shaft for button mounting so that when installed on the same panel with other PP valves the buttons cannot be inadvertently mixed. The PP-8 is normally used to operate tractor spring brakes independently from the trailer.

The PP-5 is unique in having an auxiliary piston in the lower cover which, upon receiving a pneumatic signal of 18 psi or more, will cause the valve to move from the applied to the exhaust position from a 100 psi application.

The RD-3 differs slightly in that it normally remains in the exhaust position and requires a constant manual force to hold it in the applied position.

The PP-2 has an auxiliary port which may be plumbed into a service brake line to release the spring brakes if a service application is made, preventing compounding of forces on the foundation brakes.

PREVENTIVE MAINTENANCE

Every six months, 50,000 miles or 1800 operating hours, disassemble, clean and replace parts if necessary.

REMOVAL

Block and/or hold the vehicle by a means other than air brakes and drain all reservoirs.

1. Drive the Button Roll-Pin out with a punch and remove the button.
2. Mark each air supply line and its port for easy reinstallation, then disconnect them. Remove the valve from the panel by removing the Panel Mounting Nut.

	AUTOMATIC EXHAUST	MOMENTARY APPLY	PILOT TRIP FEATURE	NON-AUTOMATIC
PP-1	20,30,40 or 60 psi			
PP-2	40 psi			
PP-5	40 psi		18 psi	
RD-3		Must be held manually		
PP-8				Will remain in either position

INSTALLING

1. Install valve in panel, securing with the Panel Mounting Nut.
2. Reconnect the air lines using marks made during removal as a guide.
3. Install the operating button. Secure the operating button by installing the Button Roll Pin.

DISASSEMBLY: PP-1, PP-8 AND RD-3

1. Remove the two cap screws (3) which retain the lower cover and remove cover. Remove the sealing ring (4).
2. Insert a small punch through the roll pin hole in the stem and remove the lock nut (5).
3. Remove inlet-exhaust valve (6) and plunger (7) and spring (8) (if any).
4. Remove o-ring (9) from plunger.

DISASSEMBLY: PP-5

1. Perform same operations as for PP-1.
2. Remove inlet seal (10) in Figure 4 from lower cover. Remove the ring diaphragm (4) from the inlet seat.
3. Remove piston (11) Figure 4 and o-ring (2).

DISASSEMBLY: PP-2

1. Insert a small punch through the roll pin hole in the plunger and remove the lock nut (1) from the plunger.
2. Withdraw the plunger and remove the spring (9) and o-ring (8).
3. Remove the two machine screws (2) and remove the lower cover (3).
4. Remove the inlet-exhaust valve (4), and piston (5).
5. Remove o-rings (6 & 7) from piston.

OPERATING AND LEAKAGE TESTS

PP-1, PP-8, RD-3

1. An accurate test gauge should be tee'd into the supply line and a means of controlling the supply pressure provided. Apply a 120 psi air source to the supply port. A small volume reservoir (e.g. 90 cu. in.) with a gauge should be connected to the delivery port.
2. With 120 psi supply pressure, and the button pulled out (exhaust position), leakage at the exhaust port should not exceed a 1" bubble in five seconds; at the plunger stem a 1" bubble in five seconds. There should be no leakage between upper and lower body.
3. Push the button in (applied position). Leakage at the exhaust port should not exceed a 1" bubble in 3 seconds; at the plunger a 1" bubble in three seconds. (The RD-3 will have to be manually held in this position.)
4. Reduce the supply pressure. At a pressure from 60 to 20 psi depending on the spring installed the button should pop out automatically, exhausting the delivery volume. (This does not apply to the RD-3, PP-8 or some PP-1's).

PP-5

1. Proceed as for PP-1 through Step 3.
2. Connect a modulated source of air pressure to the pilot air inlet. With the button pushed in (applied position) with 125 psi supply pressure and a gradually increasing pressure applied at the pilot air port the valve should move to the release position with a pilot pressure of not more than 18 psi. Leakage in this mode should not exceed a 1" bubble in three seconds at the exhaust port and a 1" bubble in five seconds at the plunger stem.

PP-2

1. Proceed as for PP-1 through Step 1.
2. With the button pulled out (exhaust position), leakage at the brake valve port or at the plunger stem should not exceed a 1" bubble in five seconds.
3. Push the button in. Supply pressure should be present in the delivery volume. Leakage at the exhaust port or around the plunger stem should not exceed a 1" bubble in five seconds.
4. Pull the button out and apply supply pressure at the brake valve port. Supply pressure should be present in the delivery volume and leakage at the exhaust port should not exceed a 1" bubble in five seconds.

Note: If any of the above push-pull valves do not function as described or if leakage is excessive, it is recommended they be returned to our nearest authorized distributor for a factory rebuilt or new valve.

IMPORTANT! PLEASE READ:

When working on or around a vehicle, the following general precautions should be observed:

1. **Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.**
2. **Stop the engine when working around the vehicle.**

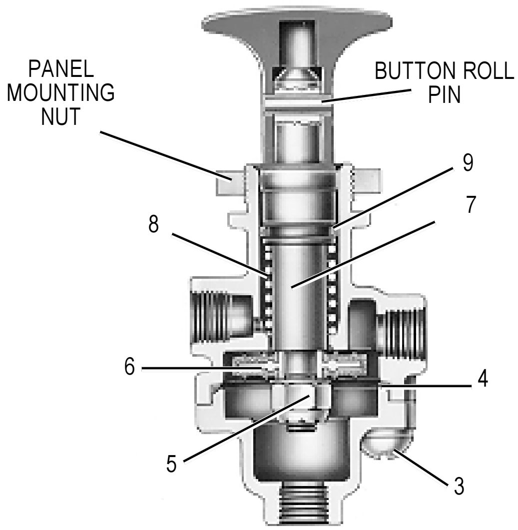


FIGURE 2 **PP-1**

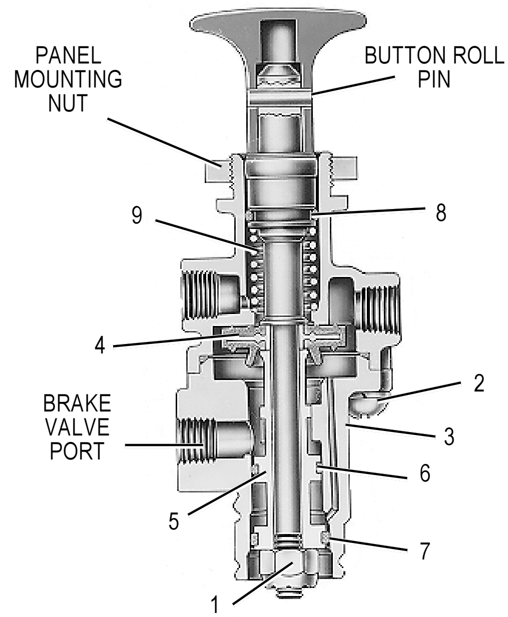
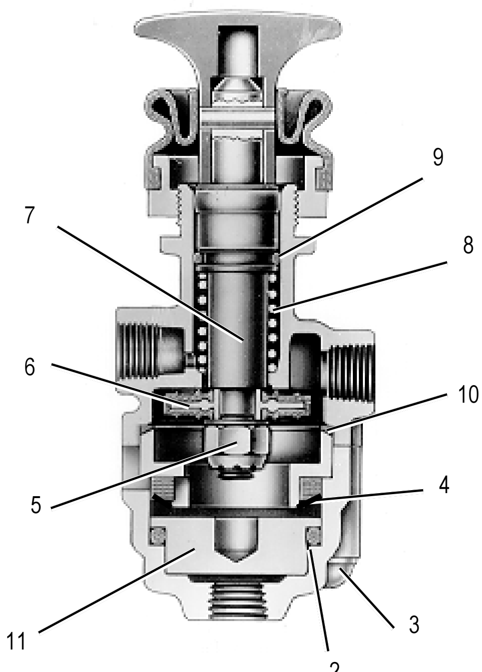


FIGURE 3 **PP-2**



PP-5

FIGURE 4

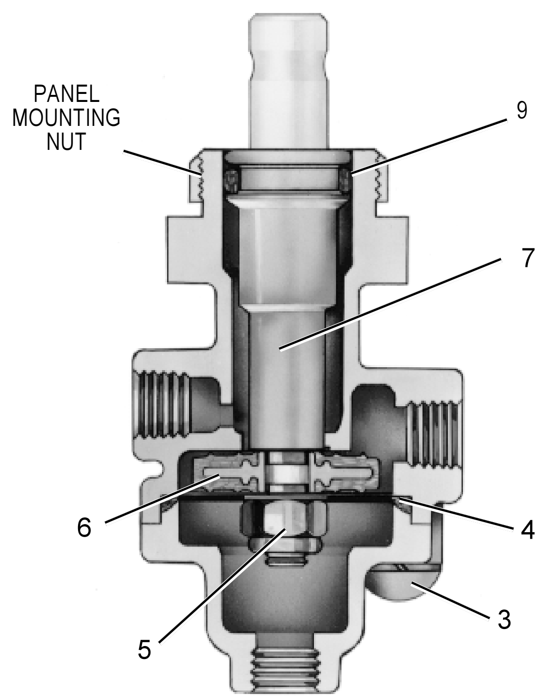
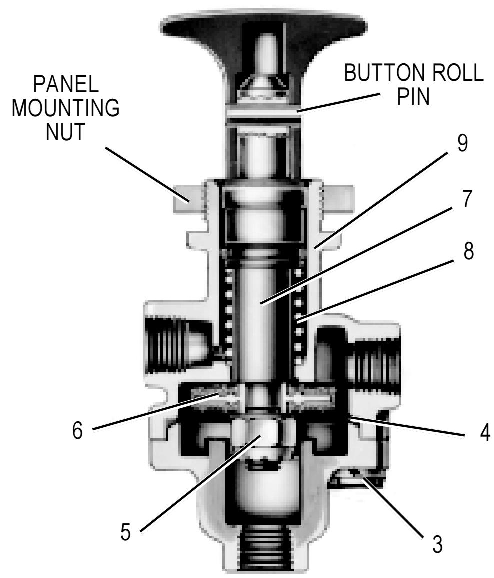


FIGURE 5 **PP-8**

3. **If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning <u>any</u> work on the vehicle.**
4. **Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.**
5. **When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, <u>extreme caution</u> should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.**

6. **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 depleted.**
7. **Never exceed recommended pressures and always wear safety glasses.**
8. **Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.**
9. **Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.**
10. **Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.**
11. **Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.**



RD-3

FIGURE 6

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Service Data

SD-03-4508*

SR-1 SPRING BRAKE VALVE

*Formerly SD-03-87

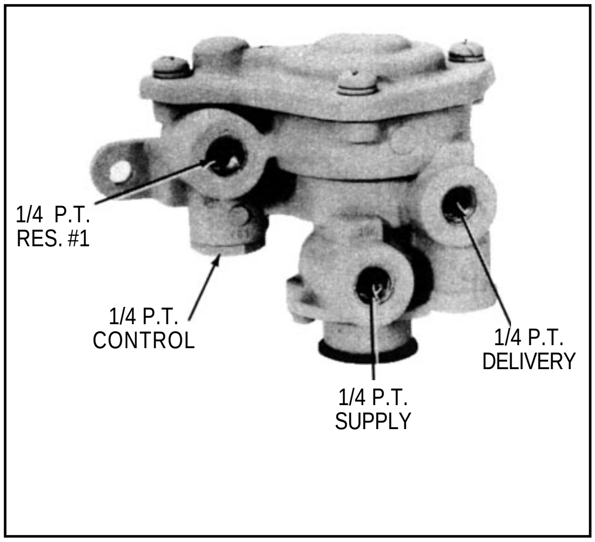

FIGURE 1 - EXTERIOR VIEW

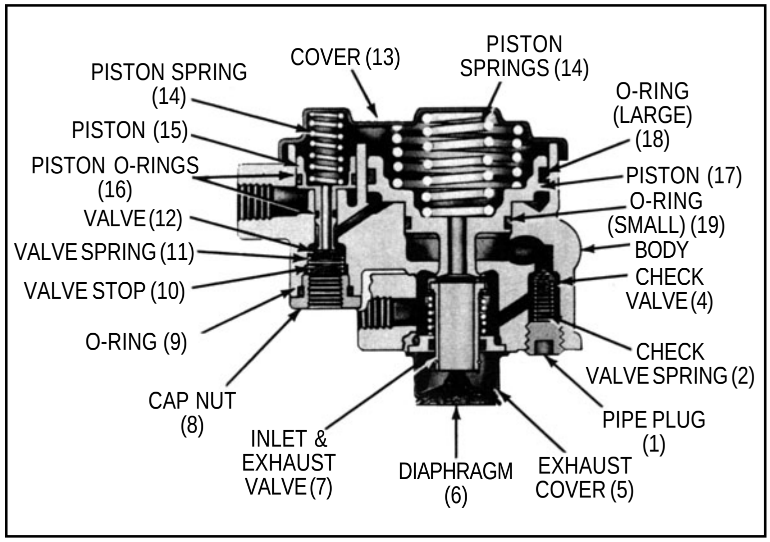

FIGURE 2 - SECTIONAL VIEW

DESCRIPTION:

The SR-1 Spring Brake Valve is used in dual or “split” air brake systems equipped with spring brake actuators. The function of the SR-1 is to supply a specific, limited hold-off pressure to the spring brakes, and in the event of loss of No. 1 service air pressure, to modulate the spring brakes through the use of the service brake valve.

The valve has four identified 1/4" N.P.T.F. ports and a diaphragm protected exhaust port. Two 5/16" diameter holes are provided in the integral mounting bracket of the valve body. The SR-1 must be mounted with the exhaust port down toward the road surface.

OPERATION - INITIAL AIR SYSTEM CHARGE

Upon initial charge, air from #1 & #2 service reservoirs flows through the park control valve and enters the SR-1 supply port. Air entering the supply port flows past inlet and exhaust valve B to the underside of piston B and out the delivery port of the SR-1 to the emergency air connection at the spring brake actuator. Note that the springs above piston B force it into contact with inlet and exhaust valve B. In the position shown the exhaust is closed and the inlet is open.

Air flowing from the No. 1 reservoir only enters the reservoir port of the SR-1. This air remains under piston A as system pressure builds. With No. 1 reservoir pressure below approximately 55 P.S.I. the spring above piston A forces it into contact with inlet and exhaust valve A causing the exhaust to seal and the inlet to open.

With air system pressure above approximately 55 P.S.I. in No. 1 & 2 service reservoirs, piston A has moved against the force of the spring above it, allowing the inlet of valve A to close and opening the hollow exhaust passage through piston A.

OPERATION - AIR BRAKE SYSTEM FULLY CHARGED

When air pressure beneath piston B is approximately 95** P.S.I., piston B rises slightly, against the force of the springs above it, allowing the inlet of valve B to close. The exhaust through valve B remains closed. The closing of the inlet portion of valve B retains approximately 95* P.S.I. in the hold- off cavity of the spring brake actuators while allowing full air system pressure to build elsewhere.

**Note: Other spring brake hold-off pressures are supplied according to the vehicle manufacturer’s specifications. 95 P.S.I. was chosen only for the purpose of explanation.

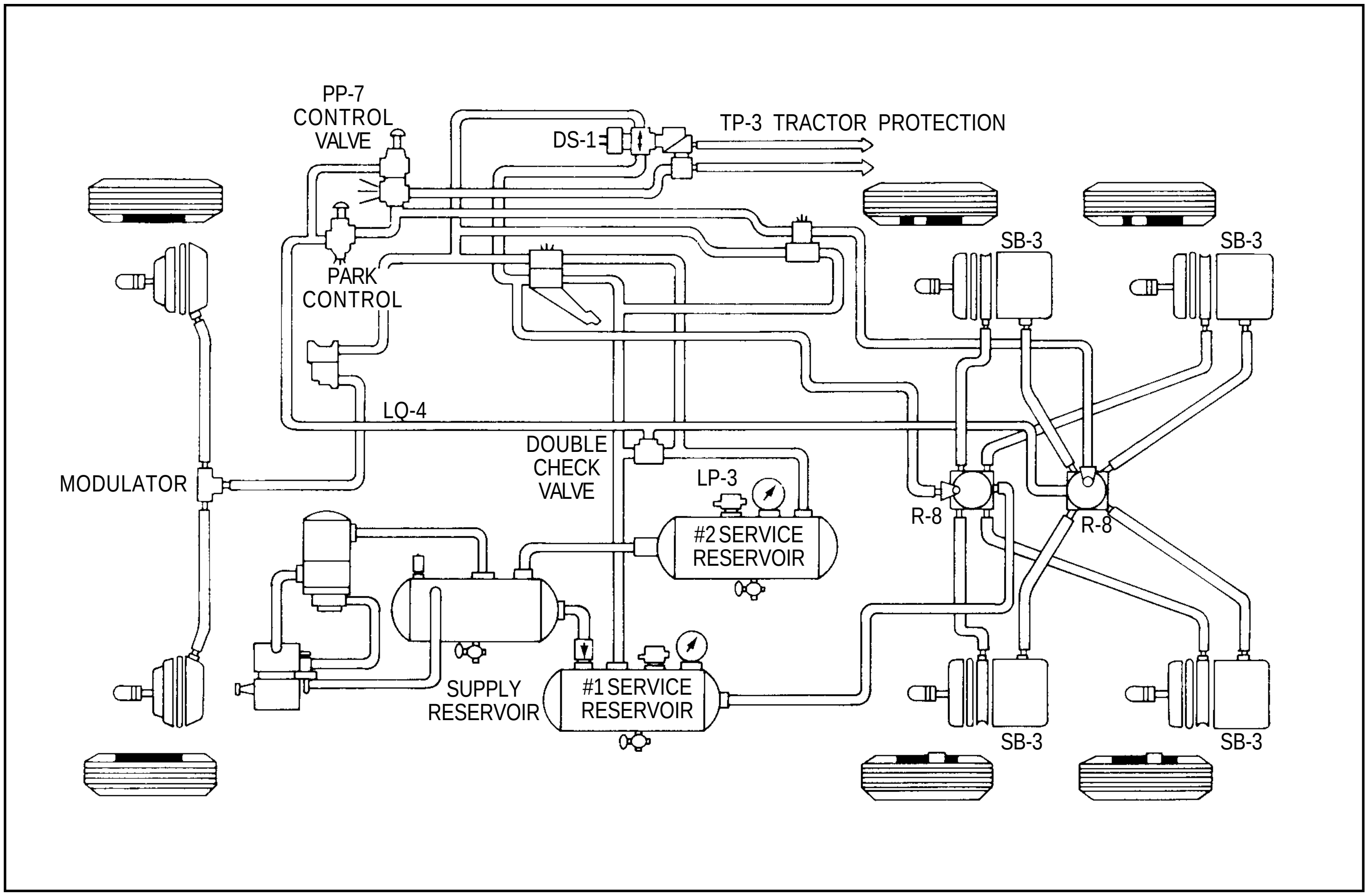

FIGURE 3 - PIPING DIAGRAM

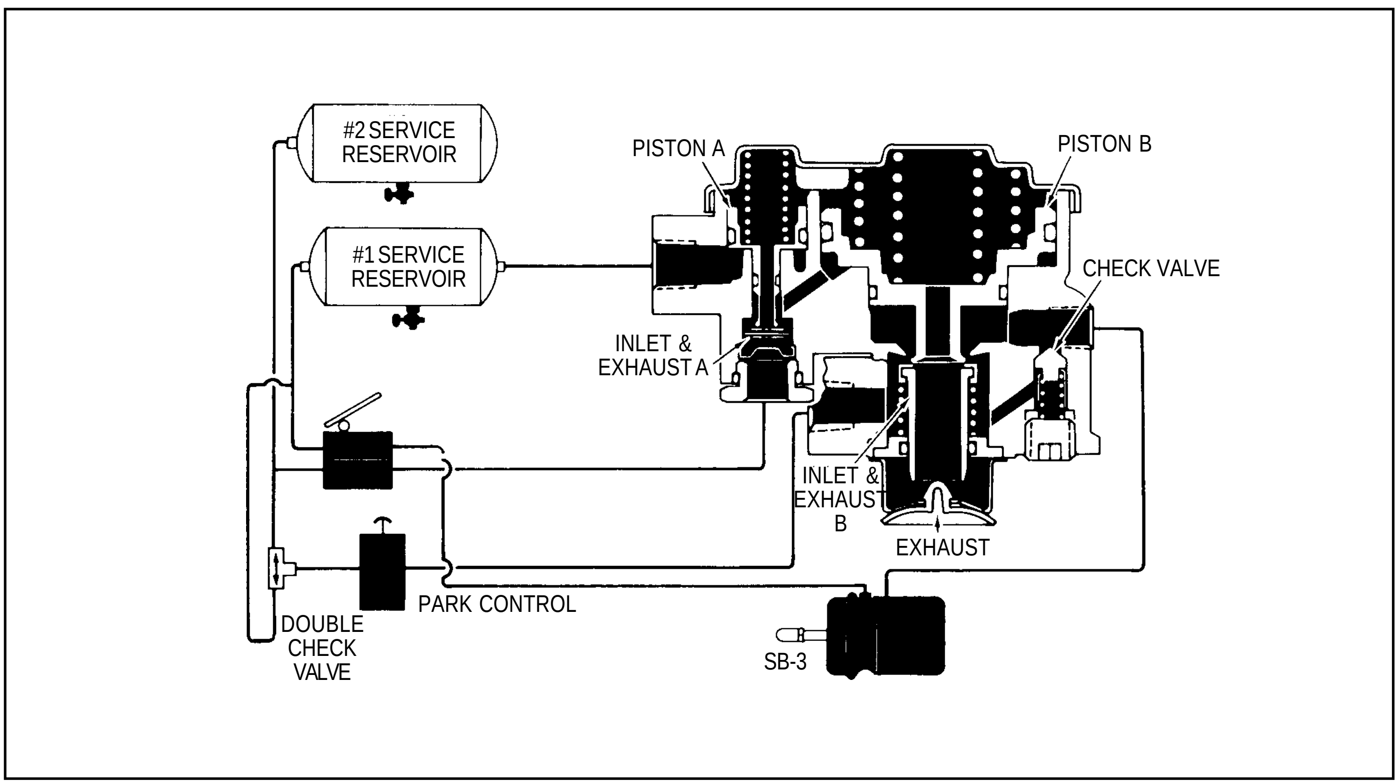

FIGURE 4 - CHARGING - BELOW 55 P.S.I.

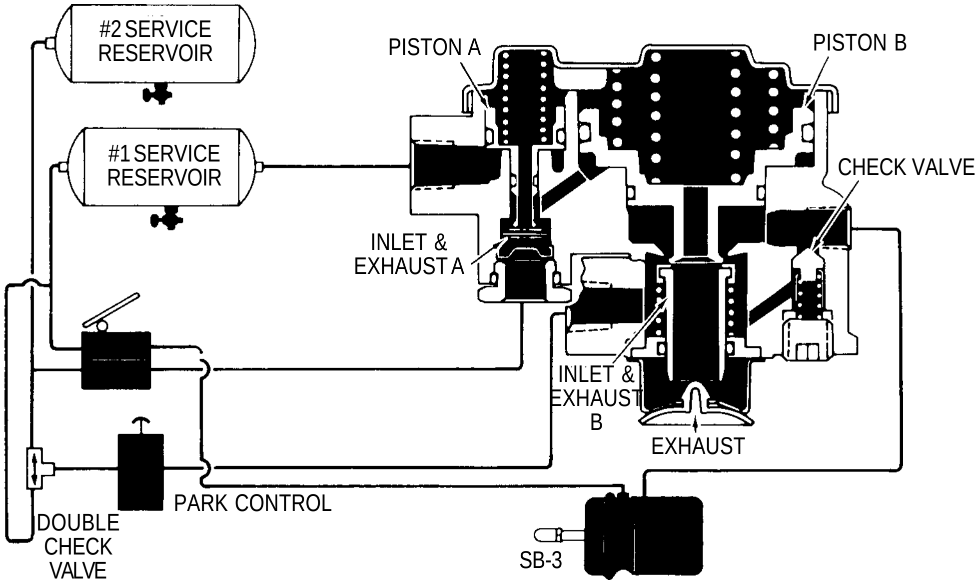

FIGURE 5 - SYSTEM FULLY CHARGED

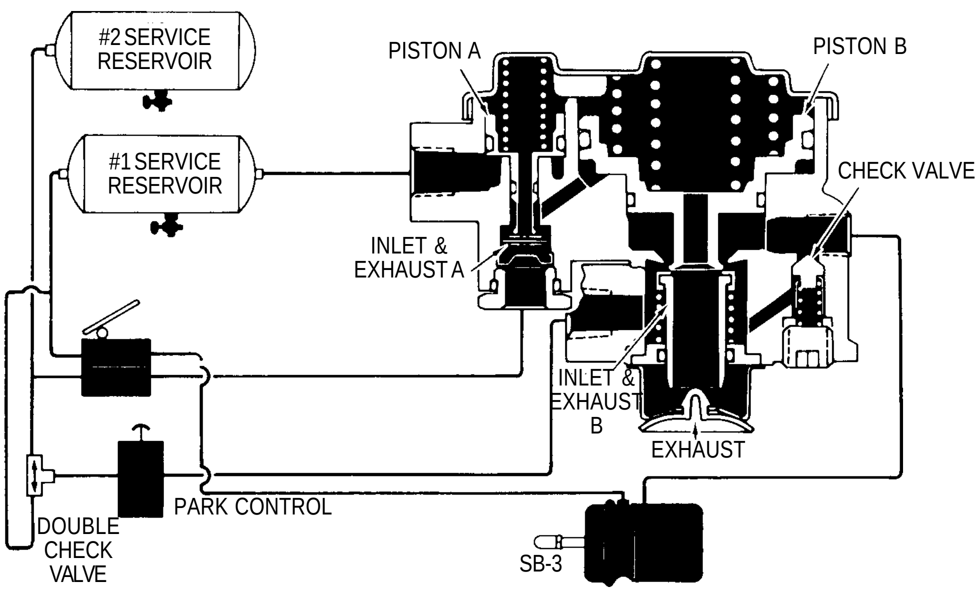

FIGURE 6 - NORMAL SERVICE APPLICATION

OPERATION - NORMAL SERVICE RESERVOIRS 1& 2 CHARGED

When a service application is made by actuating the dual brake valve; air, from the No. 2 delivery circuit is delivered from the brake valve to the control port, and is stopped at the closed inlet of valve A. No movement of the internal components of the SR-1 takes place. Air from the No. 1 delivery circuit of the dual brake valve actuates the service section of the spring brake actuators.

OPERATION - SERVICE APPLICATION WITH LOSS OF NO. 2 RESERVOIR PRESSURE

In the event air pressure is lost in No. 2 reservoir, the No. 1 reservoir as well as the parking control valve will be protected through the action of the double and single check valves in the air system. A service application of the dual air brake valve in this situation results in little or no air being delivered from the No. 2 delivery circuit to the control port of the SR-1. No movement of the SR-1 internal components takes place. Braking is assured because the No. 1 service reservoir is protected by a check valve and the No. 1 delivery

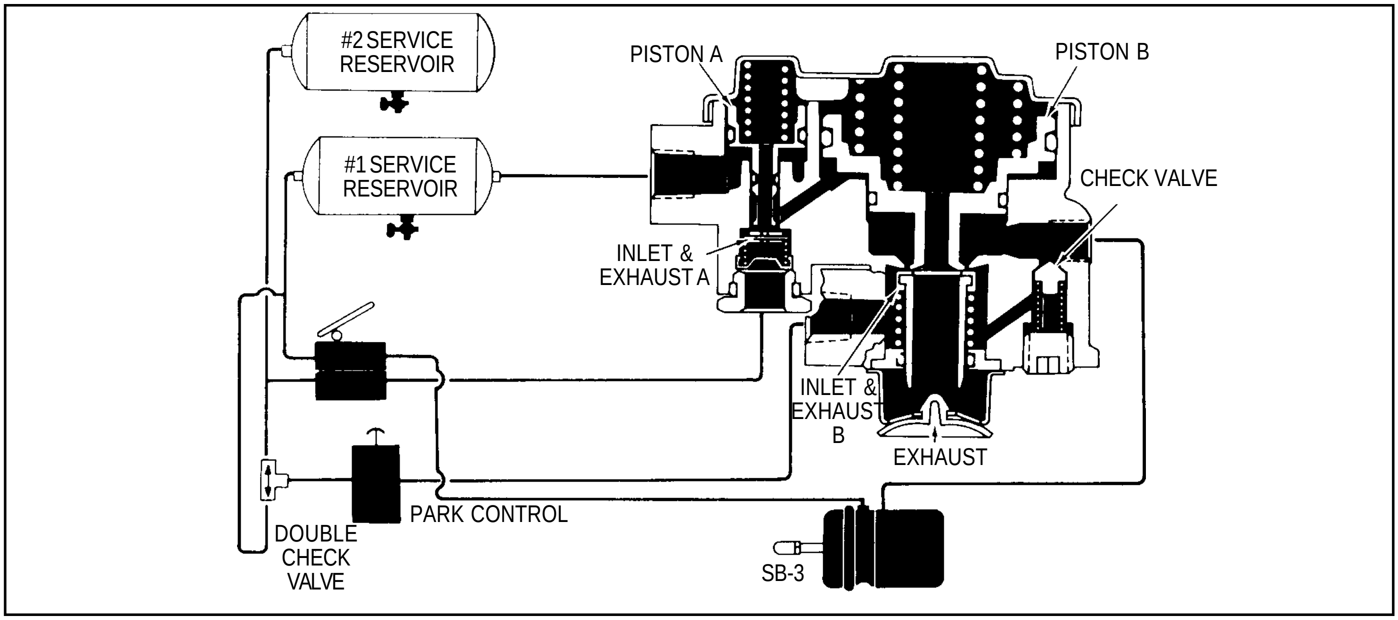

FIGURE 7 - SERVICE APPLICATION - LOSS OF #2 RESERVOIR

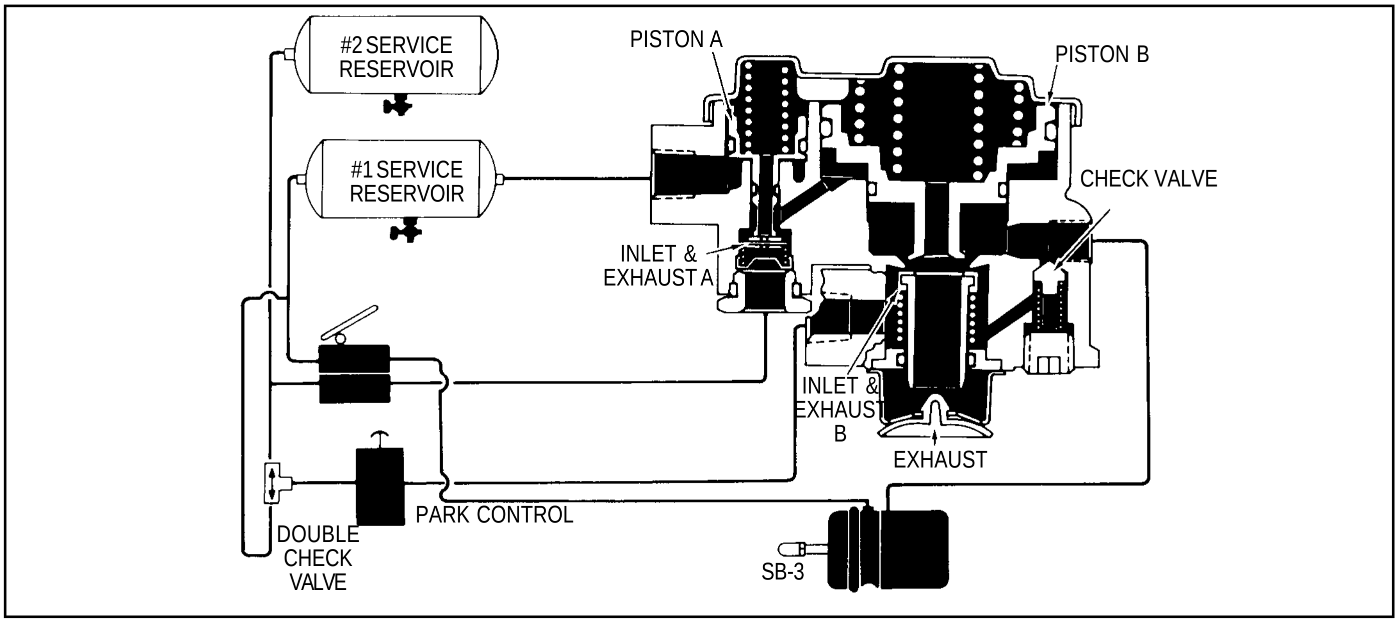

FIGURE 8 - SERVICE APPLICATION - LOSS OF #1 RESERVOIR

circuit of the dual brake valve will apply the service section of the spring brake actuators.

OPERATION - SERVICE APPLICATION WITH LOSS OF NO. 1 RESERVOIR PRESSURE

If air pressure in the No. 1 service reservoir falls below approximately 55 P.S.I., the pressure beneath piston A is insufficient to resist the spring force above and piston A moves into contact with valve A. Initial contact between piston A and valve A closes the hollow exhaust passage of piston A. Continued movement of the piston opens the inlet of valve A.

The No. 2 service reservoir and the park control valve are protected from pressure loss by the action of the Double Check Valve.

When a service application of the dual brake valve is made, air delivered from the No. 2 delivery circuit of the dual brake valve enters the SR-1 control port. Air entering the control port, now moves past the inlet of valve A and is conducted through a passage in the body to the underside of piston B. The added force of air pressure beneath piston B, moves up, opening the exhaust of valve B. When the exhaust of valve B opens, air pressure trapped in the emergency section of the spring brake actuator is allowed to escape resulting in a brake application by the emergency section. The amount of air pressure released from the spring brake is in proportion to the amount of air pressure delivered to the control port of the SR-1 by the No. 2 delivery of the dual brake valve.

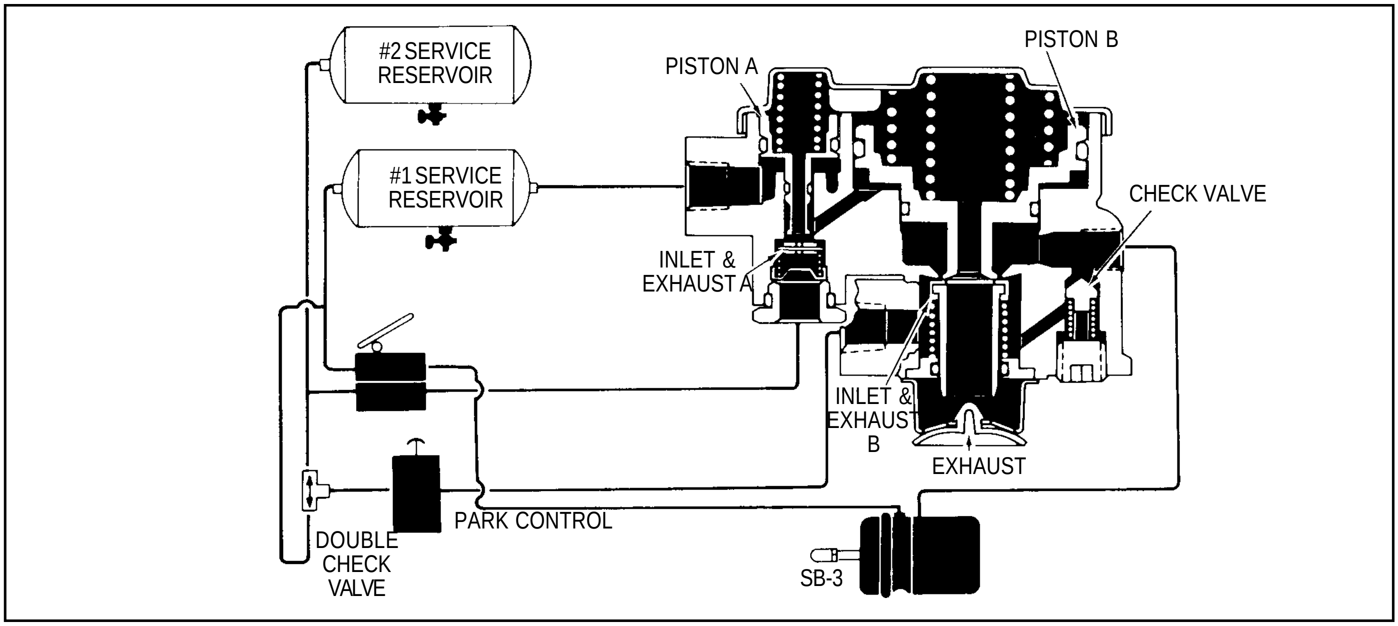

FIGURE 9 - PARK APPLICATION

OPERATION - PARKING

If both systems #1 and #2 are intact and the park control valve is placed in the "park" or exhaust position, the SR-1 supply of air pressure and the air pressure in the spring brake actuator cavities is exhausted. The single check valve in the SR-1 assists this exhaust of air pressure from the spring brake by allowing the air below piston B to flow back out the open exhaust of the park control valve. When air pressure below piston B has dropped sufficiently, piston B moves down opening the inlet of valve B thus providing an additional exhaust passage for air exhausting through the SR-1 from the spring brakes.

PREVENTIVE MAINTENANCE

Every 3600 operating hours, 100,000 miles or yearly, disassemble valve, clean all parts in mineral spirits. Replace all rubber parts, and any part worn or damaged with genuine Bendix parts.

SERVICE CHECKS

OPERATING CHECKS

Block vehicle and hold by means other than vehicle brakes. Charge air brake system to governor cut-out pressure.

1. Place parking control valve in the "park" position. Observe that the spring brake actuators apply promptly. In the delivery port of the valve install a test gauge known to be accurate. Place the parking control valve in the "release" position. Observe that the spring brake actuators release fully.
2. With the parking control valve in the "release" position, note the gauge pressure reading. (Check the vehicle manual for the correct spring brake actuator hold-off pressure.) If the pressure reading is incorrect, the valve must be repaired or replaced.
3. Place the parking control valve in the "park" position, the gauge reading should drop to zero promptly. A slow release of pressure may indicate faulty operation of the single check valve (within the Modulating Valve.)
4. Place the parking control valve in the "release" position. Locate the number one service reservoir and drain it completely.

   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. After several applications, pressure on the gauge will drop to the point where release of the spring brake actuators will no longer occur.

LEAKAGE CHECK

With the air system fully charged and the parking control valve in the "release" position, coat the exhaust port and around the valve corner with a soap solution. Slight leakage is permitted.

If the SR-1 Spring Brake Valve does not function as described above, or leakage is excessive, it is recommended that it be returned to the nearest Bendix authorized distributor for a new or remanufactured valve. If this is not possible, the valve can be repaired with genuine Bendix parts in which case the following should prove helpful.

Note: A maintenance kit for the SR-1 Spring Brake Valve is available from any authorized Bendix outlet. All parts necessary for minor repair are included.

REMOVAL

1. Prior to removing the SR-1 apply the parking brakes and drain all the vehicle reservoirs.
2. Identify all air lines before disconnecting.
3. Remove the two mounting bolts from the SR-1 and remove the valve.

DISASSEMBLY (REFER TO FIGURE 2)

1. Remove the socket head pipe plug (1).
2. Remove the check valve spring (2) and the check valve (4).
3. Remove the two phillips head screws and remove the exhaust cover (5).
4. Separate the exhaust diaphragm (6) from the cover.
5. Remove the inlet and exhaust valve assembly (7).
6. Remove the inlet and exhaust valve cap nut (8) and separate the cap nut o-ring (9).
7. Remove the valve stop (10) valve spring (11) and inlet and exhaust valve (12).
8. Remove the four phillips head screws and lockwashers that secure the cover to the body. Caution: the cover is under a spring load, and should be held while removing the screws.
9. Remove the cover (13) and the three piston springs (14). Note: Some SR-1 piece numbers have one large piston spring.
10. Remove the small piston (15) and the small and large o-rings (16).
11. Remove the large piston (17). Remove piston o-rings (18) & (19).

CLEANING & INSPECTION

Wash all metal parts in mineral spirts and dry.

Inspect all parts for excessive wear or deterioration.

Inspect the valve seats for nicks or burrs.

Check the springs for cracks or corrosion.

Replace all rubber parts and any part not found to be serviceable during inspection. Use only genuine Bendix replacement parts.

ASSEMBLY (REFER TO FIGURE 2)

Prior to assembly of the SR-1 Spring Brake Valve, lubricate all o-rings, o-ring grooves, and piston bores with Dow Corning 55-M Pneumatic Grease (Bendix No. 291126).

Note: All torques specified in this manual are assembly torques and can be expected to fall off, after assembly is accomplished. Do not retorque after initial assembly torques fall.

1. Assemble the check valve (4), and valve spring (2) and install in body.
2. Apply pipe sealant to the socket head pipe plug (1) and install in the body. Tighten to 130-170 inch pounds torque.
3. Install inlet and exhaust valve assembly (7) in valve body.
4. Secure the exhaust cover (5) with two 10-24 phillips screws and lockwashers. Tighten to 20-30 inch pounds torque.
5. Install exhaust diaphragm (6) into the exhaust cover.
6. Place inlet exhaust valve (12) in the body. Install the valve spring (11) and valve stop (10).
7. Install o-ring (9) on cap nut and install cap nut (8) in body. Tighten to 100- 125 inch pounds torque.
8. Install the small and large o-rings (16) on the small diameter piston (15) and install piston in the body.
9. Install large o-ring (18) and small o-ring (19) on the large diameter piston and install piston in the body.
10. Install the piston springs (14) in their respective pistons.
11. Secure the cover to body using four 1/4"-20 phillips head screws and lockwashers. Tighten to 50-80 inch pounds torque.

TESTING THE REBUILT SR-1 SPRING BRAKE VALVE

Test the rebuilt SR-1 Spring Brake Valve by performing the operation and leakage test outlined in the “Service Checks” section of this manual.

IMPORTANT! PLEASE READ

When working on or around a vehicle, the following general precautions should be observed:

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.
2. Stop the engine when working around the vehicle.
3. 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.
4. Following the vehicle manufacturer’s recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.
6. 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 depleted.
7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures.

Use only the proper tools and observe all precautions pertaining to use of those tools.

9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

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Service Data

SD-06-1600*

LOW PRESSURE INDICATORS

*Formerly SD-06-2

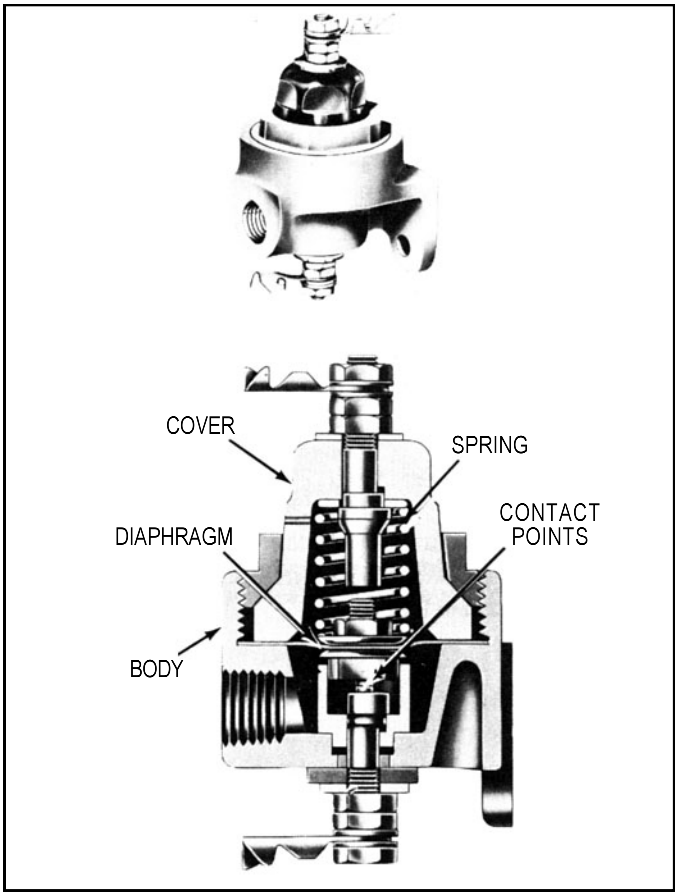

FIGURE 1 - LP-2

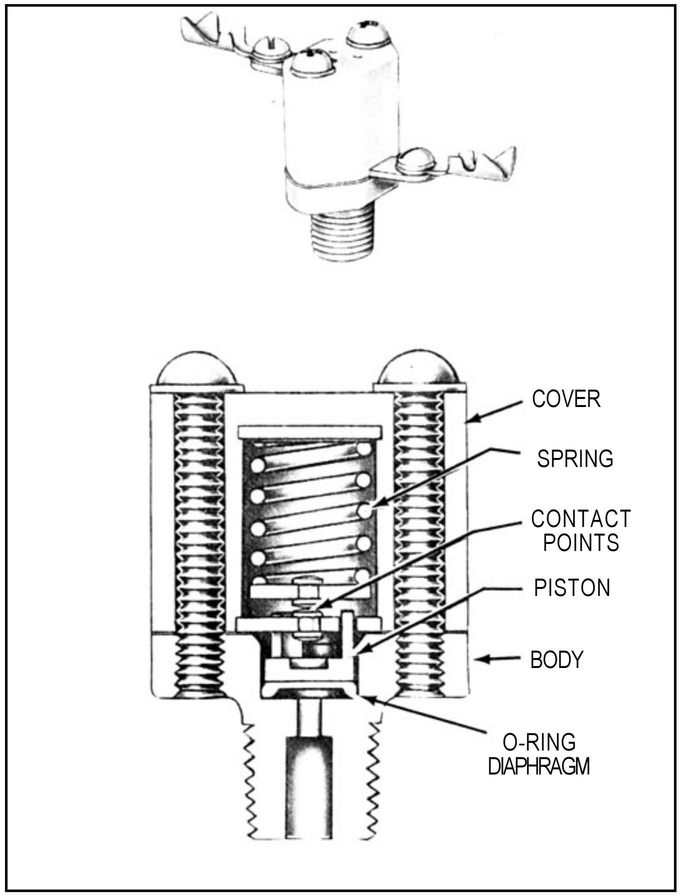

FIGURE 2 - LP-3

DESCRIPTION

The Low Pressure Indicator is a safety device designed to give an automatic warning to the driver whenever air pressure in the air brake system is below the safe minimum for normal vehicle operation. It is usually used to operate an electrical buzzer or warning light, or both, which are audible or visible to the driver.

Two styles of Low Pressure Indicators are currently manufactured.

The LP-2 Low Pressure Indicator, which is the older style and consists of a die cast body with a spring loaded diaphragm clamped between the body and the Bakelite cover.

The LP-3 Low Pressure Indicator is the newer style, consisting of a die cast body, nylon cover and employs a spring loaded O-Ring diaphragm and piston. The LP-3 is available with either one terminal or two. The single terminal unit utilizes a metallic gasket between body and case to ground the lower contract strip. The two terminal unit utilizes a phenolic insulating gasket to isolate both terminals from the vehicle frame.

The electrical contacts provided in both the LP-2 and LP-3 indicators remain closed by spring force until the air brake system pressure below the diaphragm is above the setting (force) of the Low Pressure Indicator spring. The setting of the indicator and piece number is marked on a label on the valve body. If a label is not present, then the vehicle manual should be consulted for the proper setting. The nominal setting of the indicator is 60 psi; however, pressure settings may vary depending upon the vehicle.

OPERATION

To describe the operation, we shall assume that the Low

Pressure Indicator is set for 60 psi. When air pressure at the supply port and under the diaphragm is above 60 psi, the electrical contacts remain open because the force exerted by air pressure underneath the diaphragm overcomes the force exerted by the spring above the diaphragm.

When air pressure below the diaphragm drops below 60 psi, the spring exerts a force which is greater than the force exerted by the air pressure below the diaphragm. This causes the diaphragm (and the piston in the LP-3) to move and allow the electrical contacts to close. This completes or closes the electrical circuit to the warning device, warning the driver of low air pressure in the system.

PREVENTIVE MAINTENANCE

Every six months, 1800 operating hours or 50,000 miles, check electrical connections. Low Pressure Indicator should be checked for proper operation by performing "Operating Test" as described elsewhere in this sheet.

TESTING FOR SERVICEABILITY

OPERATING TEST

1. If possible, determine the setting of the Low Pressure Indicator by referring to the label on the valve or the vehicle manual.
2. Operation of the Low Pressure Indicator may be checked with ignition switch "on" by reducing the system pressure and observing that low pressure warning occurs when system pressure drops below the setting of the Low Pressure Indicator. The contacts will be closed when the warning device operates. If the setting of the indicator is unknown, the contacts should close between approximately 70 psi and 50 psi.

LEAKAGE TEST

1. With air pressure present at the supply port, coat the indicator with soap solution. No leakage permitted.

REMOVING

1. Block the wheels. Otherwise, secure the vehicle with other than service brakes.
2. The ignition switch should be in the "off" position.
3. Drain the air from the system.
4. Disconnect the electrical connections at the Low Pressure Indicator.
5. Disconnect the air line and mounting bolts or unscrew the Indicator from the fitting and remove.

INSTALLING

1. Install in a convenient location for servicing.
2. Connect to a reservoir pressure line at a high point in the system for adequate drainage.
3. If installing an LP-2G Indicator, use a supply line of 1/4 O.D. minimum.
4. Connect the Indicator terminals in series with the ignition switch and the warning device.

DISASSEMBLY

NOTE: It is generally recommended that the Low Pressure Indicator, if faulty, be replaced with a new unit; however, service parts are available; and if repairs are necessary, the following will apply:

LP-2 Unscrew the cover retainer from the body. Remove cover and remove spring and diaphragm assembly.

LP-3. Remove cover screws, lockwashers. Remove cover, contact disc, spring, and shim(s). (Note: Shims may or may not be present.) Remove contact plate, gasket, piston, and O-Ring diaphragm.

CLEANING AND INSPECTION

Clean all metal parts in mineral spirits.

Inspect all parts for wear, cracks, or deterioration and replace all parts not considered serviceable with genuine Bendix parts.

If contact points are not pitted severely, they can be dressed with a fine file.

ASSEMBLY

LP-2

1. Place and position the diaphragm assembly in the body. Position the spring so that it rests on the upper diaphragm follower.
2. Place cover over the diaphragm and screw cover retainer to the body and tighten securely. (Torque to 110-130 inch pounds.)

LP-3

1. Lubricate bore of body and both sides of the O-Ring diaphragm with silicone lubricant BW-650-M (Bendix piece no. 291126).
2. Install O-Ring diaphragm in body. (Note: O-Ring portion of diaphragm should face supply port.)
3. Install piston in body. Flat side of piston should face O-Ring diaphragm.
4. Install gasket. (Always use a phenolic gasket in a two terminal switch and a metallic gasket in the single terminal.)
5. Position contact plate over fingers of piston. Contact plate should rest on face of gasket.
6. If shim(s) are used, place shim(s) in cover.
7. Place spring in cover.
8. Place contact point so that it rests on spring.

9. Install cover on body, using machine screws, making certain that the contact plate is in position over fingers of piston, and arm of contact plate is positioned so that it will fit in groove of cover.
10. Tighten screws securely. (Torque to 20-30 inch pounds).

TEST OF REBUILT LOW PRESSURE INDICATOR

After rebuilding, perform the leakage and operating tests as outlined in section “Testing for Serviceability.”

IMPORTANT! PLEASE READ

When working on or around a vehicle, the following general precautions should be observed:

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.
2. Stop the engine when working around the vehicle.
3. 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.
4. Following the vehicle manufacturer’s recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.
6. 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 depleted.
7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

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Service Data

SD-06-2501*

SL-5 STOP LIGHT SWITCH & DS-2 COMBINED STOP LIGHT SWITCH & DOUBLE CHECK VALVE

*Formerly SD-06-7

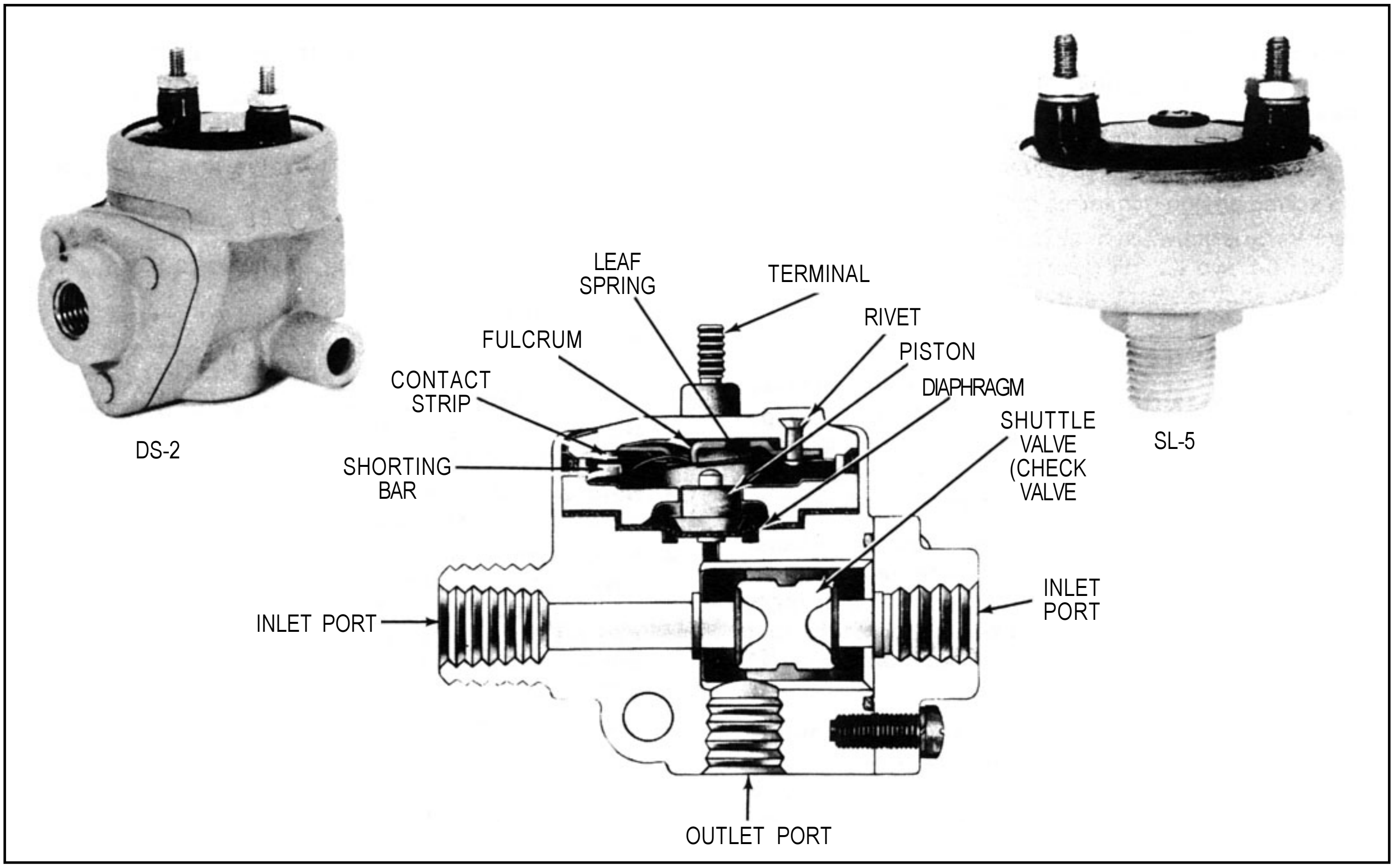


FIGURE 1 - DS-2 SECTIONAL

DESCRIPTION

The stop light switch (SL-5) is an electro-pneumatic 5 psi non- grounded switch that operates in conjunction with the brake valve and stop lights by completing the electrical circuit and lighting the stop lights when a brake application is made.

The combined stop light switch and double check valve (DS-2), as the name implies, combines a stop light switch (SL-5) with a double check valve to perform the function of both. It operates in conjunction with the brake valve and hand control valve by directing the flow of air from whichever delivers the higher pressure into a common delivery line and to the stop light switch, closing the electrical circuit to the stop lamps.

The stop light switch can be used with either 12 or 24 volt systems.

The stoplight switch is not a serviceable item; and if found defective in either device, the complete unit must be replaced.

The shuttle valve in the DS-2 is serviceable and may be replaced.

Both the SL-5 and DS-2 have been tested and meet the requirements of FMVSS-121.

OPERATION

The stop switch mechanism is identical in the SL-5 and DS-2.

When a brake application is made, air pressure from the brake valve enters the cavity below the diaphragm. The air pressure below the diaphragm moves the piston until it contacts the leaf spring. The leaf spring travels past a fulcrum at which point the leaf springs snaps a shorting bar which mates with the contact strips. The stop light electrical circuit is completed, lighting the stop lights before the brake application pressures reach 6 psi.

The snap action spring design minimizes arcing.

The Double Check Valve is activated by air being introduced through either of the two (2) inlet ports. The greater pressure pushes the shuttle along its guides and closes the opposite inlet port. The air is then directed out the common delivery line and to the stop light switch.

PREVENTIVE MAINTENANCE

Every six months, 1800 operating hours or 50,000 miles check the electrical connections and determine that stop lamps operate properly.

OPERATING AND LEAKAGE TEST

1. Install an accurate air gauge in the service line (or brake chamber). Apply brake valve gradually. Stop lamps should light at 6 psi or less and go out after the brake application is released. This checks the electrical function of the stop light switch in either the SL-5 or DS-2.
2. (DS-2 only) Apply the foot valve and coat the exhaust port of the hand valve (or other alternate source). Reverse the above, applying the hand valve or other alternate source and coat the exhaust port of the foot valve. In either mode a leakage of not more than a 1" bubble in 5 seconds is permissible.
3. (SL-5 or DS-2) When pressurized, no leakage is permitted from the body of the valve or switch.

If the SL-5 or DS-2 does not function as described above or if leakage is excessive, the valve or switch should be replaced with a new unit or in the case of the double check portion of the DS-2 repaired with genuine Bendix parts.

REMOVING AND INSTALLING

REMOVING

1. Block vehicle wheels or hold by means other than vehicle service brakes.
2. Disconnect electrical connections from terminal screws.
3. (SL-5) Remove the switch using a wrench on the hex portion of the body.
4. (DS-2) Disconnect air lines and remove the DS-2.

INSTALLING

1. Replace the SL-5 or DS-2 in the port from which it was removed. Do not install with the terminals pointing down.
2. Secure electrical connections.
3. Reinstall air line connections to DS-2 valve.

DISASSEMBLY (Double Check Valve)

1. Remove three cap screws and cap.
2. Remove O-Ring seal from cap.
3. Remove shuttle valve.

CLEANING AND INSPECTION

1. Blow dust or other foreign material out of body. Do not immerse in cleaning fluid.
2. Inspect shuttle valve and O-Ring and replace if deteriorated.

TEST

Repeat "Operating and Leakage Test."

IMPORTANT! PLEASE READ

When working on or around a vehicle, the following general precautions should be observed:

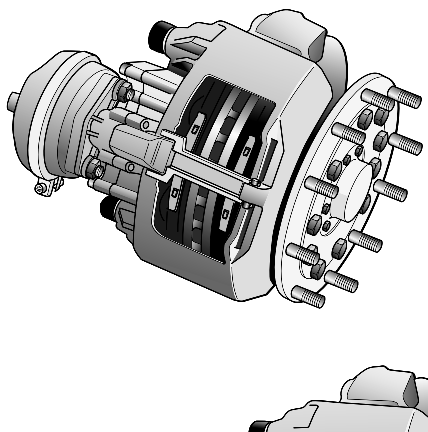
1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels.
2. Stop the engine when working around the vehicle.
3. If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle.
4. Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that removes all electrical power from the vehicle.
5. When working in the engine compartment the engine should be shut off. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.
6. 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 depleted.
7. Never exceed recommended pressures and always wear safety glasses.
8. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
9. Use only genuine Bendix replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, etc. should be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
10. Components with stripped threads or damaged parts should be replaced rather than repaired. Repairs requiring machining or welding should not be attempted unless specifically approved and stated by the vehicle or component manufacturer.
11. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

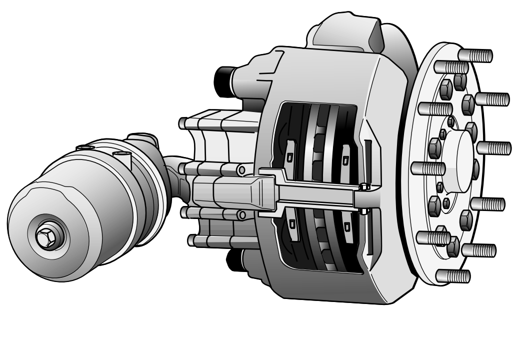
Service Manual

RA-SB0002-EN

Pneumatic Disc Brake

SB 6... / SB 7...
Axial- and Radial Disc Brake





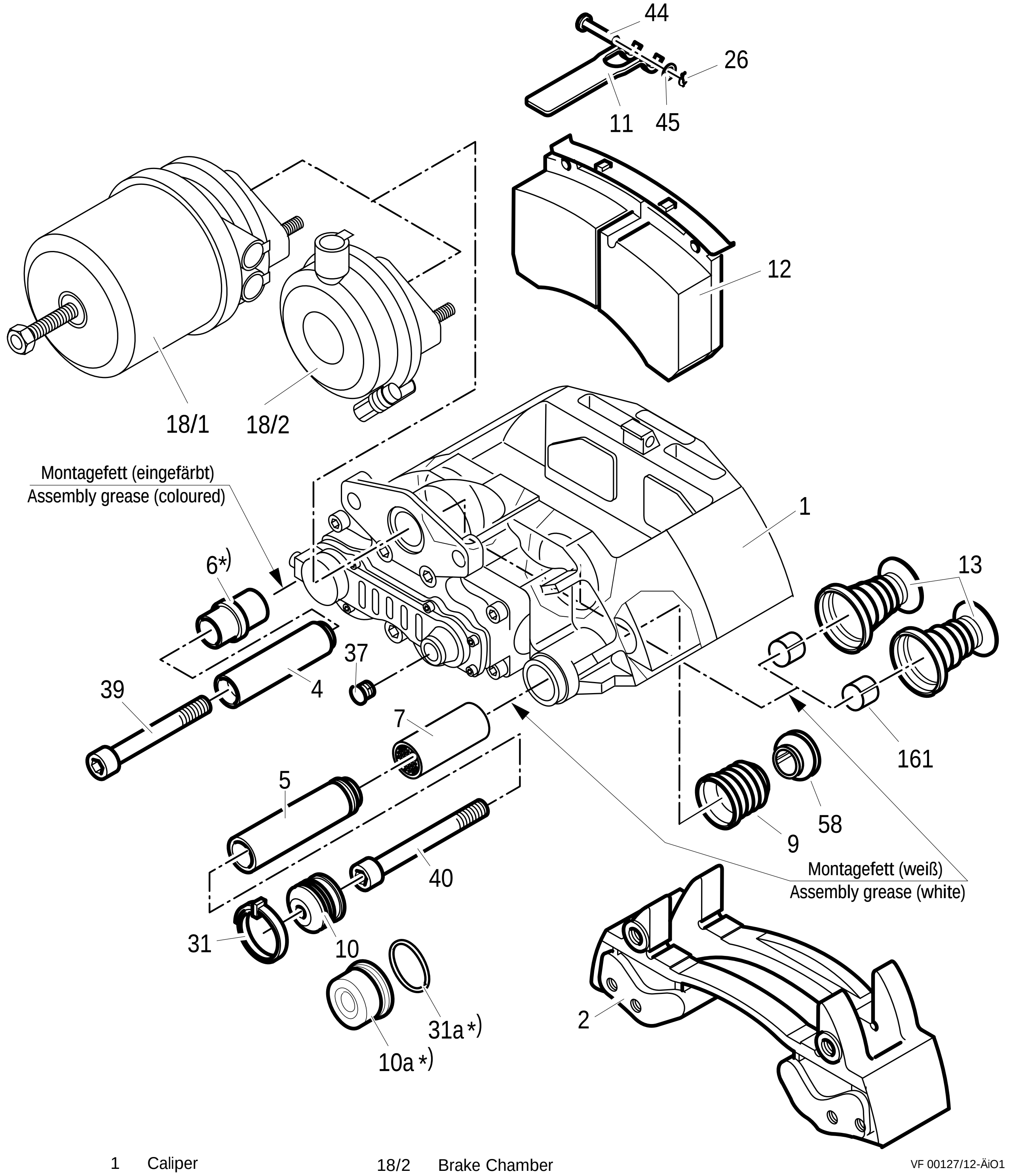
KNORR-BREMSE
Systems for Commercial Vehicles

Index

1 Overall view

1.1 Axial Disc Brake Components

(for Wear Indicatators Kits see 1.2.1)



1	Caliper	18/2	Brake Chamber
2	Carrier	26	Spring Clip
4	Sleeve	31	Outer Boot Clip
5	Sleeve	31a	O-Ring
6	Rubber Bush	37	Adjuster Cap
7	Brass Bush	39	Caliper Bolt
9	Inner Boot	40	Caliper Bolt
10	Outer Boot	44	Pad Retainer Pin
10a	Steel Cap	45	Washer
11	Pad Retainer	58	Ring
12	Pad	161	Tappet Bush
13	Tappet with Boot		
18/1	Spring Brake		

*) possible variants by items 10a & 31a

If short rubber bush (6) (sleeve ring is placed centrally), Caliper bolts (39) & (40) are identically

1.2 Axial Disc Brake Repair Kits

ATENTION!

Use only KNORR-BREMSE parts

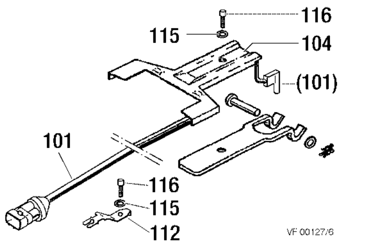
The following Repair Kits are available

Description	Contents	Association of Repair Kits to the Disc Brakes and Repair Kit's Order no.
Carrier Guide Kit	2, 4, 5, 31, 39, 40	
Carrier Guide Kit (Steel Cap)	2, 4, 5, 10a, 31a, 39, 40	
Wear Indicator Kit (per axle)	for variants see 1.2.1 with or without 104	
Guide Pins Kit	4-7, 9, 10, 31, 39, 40, 58	
Guide Pins Kit (Steel Cap)	4, 5, 6, 7, 9, 10a, 31a, 39, 40, 58	
Seal Kit for Guide Pins	9, 10, 31, 37, 58	
Tappet and Boot Kit (2 pcs)	13, 161	
Pad Set (per axle)	12, 26, 37, 44, 45	see Disc Brake Product Catalogue (Part Number Y000875), also available as an electronic form (CD-ROM, http://www.Knorr-BremseSfN.com)
Adjuster Cap (4 pcs)	37	
Pad Retainer Kit (per axle)	11, 26, 44, 45	
Pad Retainer Kit (per axle)	11, 26, 44, 45, 104, 115, 116	
Kit for Rubber Sleeve	4, 6, 39	
Outer Guide Seal Kit (10 pcs)	10, 31	
Repair Kit	5, 7, 9, 10a, 31a, 40, 58	
Kit for Steel Cap	10a, 31a	
Screw Kit for Steel Cap	10a, 31a, 39, 40	
Screw Kit for Outer Boot	10, 31, 39, 40	
Exchange Caliper r.h.	only in assembled condition	see Type plate on the Caliper
Exchange Caliper l.h.		

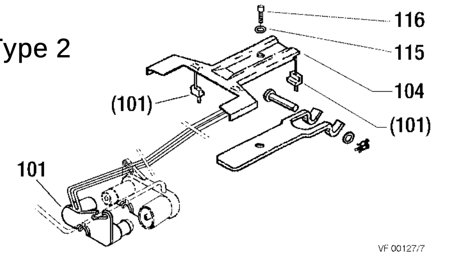
1.2.1 Axial Disc Brake Wear Indicator Kits

(Typical kits are shown below)

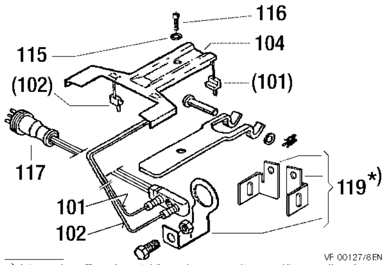
Type 1



Type 2

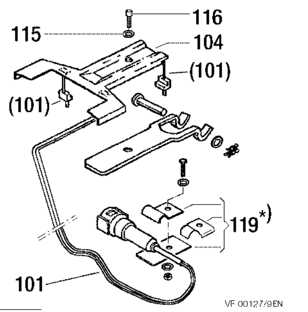


Type 3



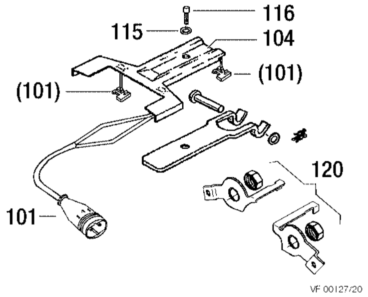
*) Mounting Bracket 119 varies to suit specific applications

Type 4



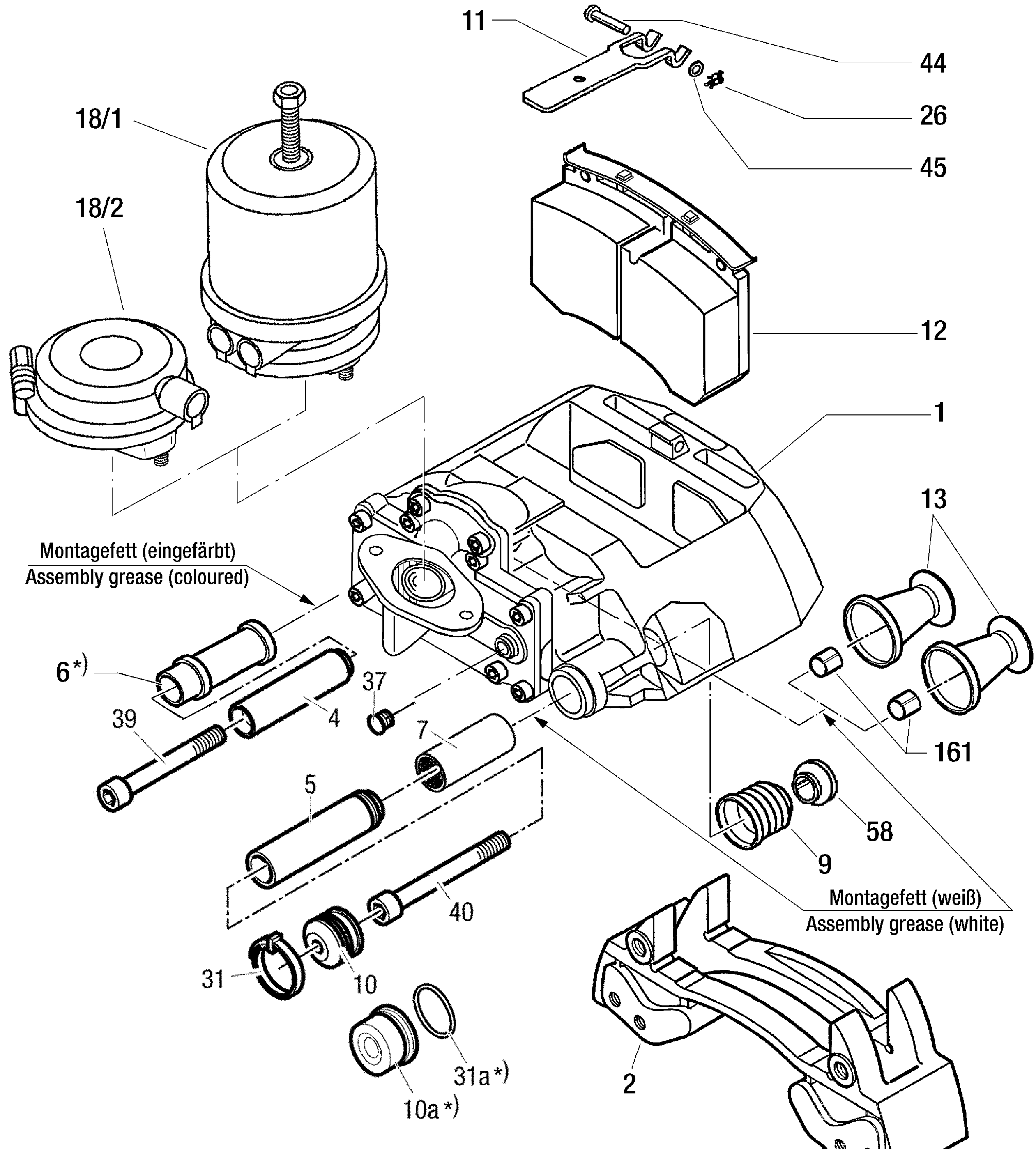
*) Mounting Bracket 119 varies to suit specific applications

Type 5



101	Sensor	115	Spring Washer
102	Sensor	116	Screw
104	Cable Protection Plate	117	Wear Indicator Cable
112	Clip	119	Bracket
		120	Bracket

1.3 Radial Disc Brake Components
(for Wear Indicator Kits see 1.4.1)



1	Caliper	26	Spring Clip
2	Carrier	31	Outer Boot Clip
4	Sleeve	31a	O-Ring
5	Sleeve	37	Adjuster Cap
6	Rubber Bush	39	Caliper Bolt
7	Brass Bush	40	Caliper Bolt
9	Inner Boot	44	Pad Retainer Pin
10	Outer Boot	45	Washer
10a	Steel Cap	58	Ring
11	Pad Retainer	161	Tappet Bush
12	Pad		
13	Tappet with Boot		
18/1	Spring Brake		
18/2	Brake Chamber		

*) possible variants by items 10a & 31a

If short rubber bush (6) (sleeve ring is placed centrally), Caliper bolts (39) & (40) are identically

1.4 Radial Disc Brake Repair Kits

ATENTION!

Use only KNORR-BREMSE parts

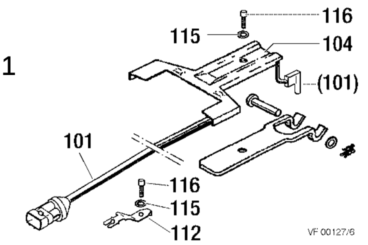
The following Repair Kits are available

<table>
<tr><th>Description</th><th>Contents</th><th>Association of Repair Kits to the Disc Brakes and Repair Kit’s Order no.</th></tr>
<tr><td>Carrier Guide Kit</td><td>2, 4, 5, 31, 39, 40</td><td rowspan="17">see Disc Brake Product Catalogue (Part Number Y000875), also available as an electronic form (CD-ROM, http://www.Knorr-BremseSfN.com)</td></tr>
<tr><td>Carrier Guide Kit (Steel Cap)</td><td>2, 4, 5, 10a, 31a, 39, 40</td></tr>
<tr><td>Wear Indicator Kit
(per axle)</td><td>for variants see 1.2.1
with or without 104</td></tr>
<tr><td>Guide Pins Kit</td><td>4-7, 9, 10, 31, 39, 40, 58</td></tr>
<tr><td>Guide Pins Kit (Steel Cap)</td><td>4, 5, 6, 7, 9, 10a, 31a, 39, 40, 58</td></tr>
<tr><td>Seal Kit for Guide Pins</td><td>9, 10, 31, 37, 58</td></tr>
<tr><td>Tappet and Boot Kit (2 pcs)</td><td>13, 161</td></tr>
<tr><td>Pad Set (per axle)</td><td>12, 26, 37, 44, 45</td></tr>
<tr><td>Adjuster Cap (4 pcs)</td><td>37</td></tr>
<tr><td>Pad Retainer Kit (per axle)</td><td>11, 26, 44, 45</td></tr>
<tr><td>Pad Retainer Kit (per axle)</td><td>11, 26, 44, 45, 104, 115, 116</td></tr>
<tr><td>Kit for Rubber Sleeve</td><td>4, 6, 39</td></tr>
<tr><td>Outer Guide Seal Kit (10 pcs)</td><td>10, 31</td></tr>
<tr><td>Repair Kit</td><td>5, 7, 9, 10a, 31a, 40, 58</td></tr>
<tr><td>Kit for Steel Cap</td><td>10a, 31a</td></tr>
<tr><td>Screw Kit for Steel Cap</td><td>10a, 31a, 39, 40</td></tr>
<tr><td>Screw Kit for Outer Boot</td><td>10, 31, 39, 40</td></tr>
<tr><td>Exchange Caliper r.h.</td><td rowspan="2">only in assembled condition</td><td rowspan="2">see Type plate on the Caliper</td></tr>
<tr><td>Exchange Caliper l.h.</td></tr>
</table>

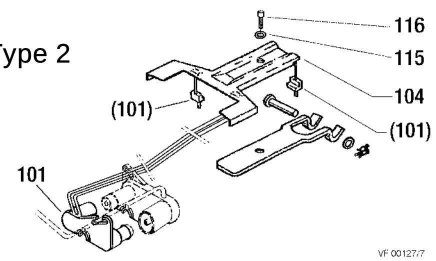
1.4.1 Radial Disc Brake Wear Indicator Kits

(Typical kits are shown below)

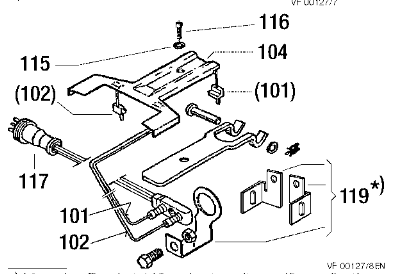
Type 1



Type 2

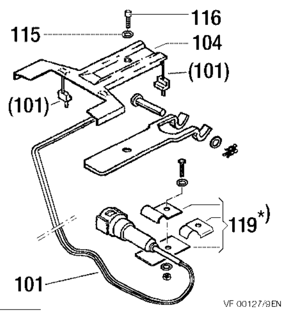


Type 3



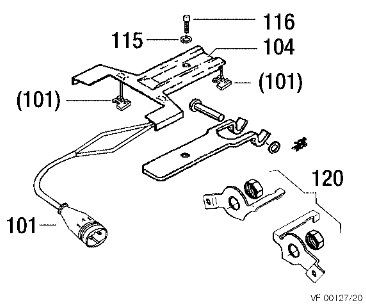
*) Mounting Bracket 119 varies to suit specific applications

Type 4



*) Mounting Bracket 119 varies to suit specific applications

Type 5



101	Sensor	115	Spring Washer
102	Sensor	116	Screw
104	Cable Protection Plate	117	Wear Indicator Cable
112	Clip	119	Bracket
		120	Bracket

1.5 Brake Discs
(for “Axial- and Radial Disc Brake”)

When replacing the Discs, please also refer to the instructions of the Vehicle Manufacturer.

This should also be done when fitting KNORR-Brake Discs.

When replacing Discs, please adhere to the recommended bolt tightening torques.

The use of non-approved Brake Discs will reduce levels of safety and invalidate warranty.

Brake Discs can be ordered through the Knorr-Aftermarket Organisation.

Detailed informations can be taken out from our Product Catalogue “Disc Brake“ (Part Number Y000875).
This is also available as an electronic form (CD-ROM, http://www.Knorr-BremseSfN.com).

2 General Information
(for “Axial- and Radial Disc Brake”)

2.1 Service Tools

Part Number	Description
II 19252	Press-In Tool for Tappet and Boot (13)
II 19253	Pull-In Tool for Inner Boot (9)
II 19254	Pull-In/Out Tool for Brass Bush (7)
II 32202	Wedged Fork for removal of Tappet and Boot (13)
II 36797	Grooving Tool for Brass Bush (7)
Z001105	Press in Tool for Steel Cap (10a)

Service tool kit ZB 9032 II 37951/004EX contains the above listed tools as well as this Service manual. The service video in English is available separately in the UK as Part No. KBP2060/1 and in other territories as RA-SB0002 EN.

2.2 Diagnostic Equipment

Part Number	Description
II 36695	**ZB 9031** Hand held device for checking Potentiometer function. (Also Pad + Disc wear when 13 pin chassis plug installed).
II 38691F	**ZB 9033** Chassis mounted device for measuring Pad + Disc wear

2.3 Lubrication

Part Number	Description	Colour	Application
II 14525	Renolit HLT2	White [2)]	Brass Bush (7)
II 32793	Syntheso GL EP1	Green [2)]	Rubber Bush (6)

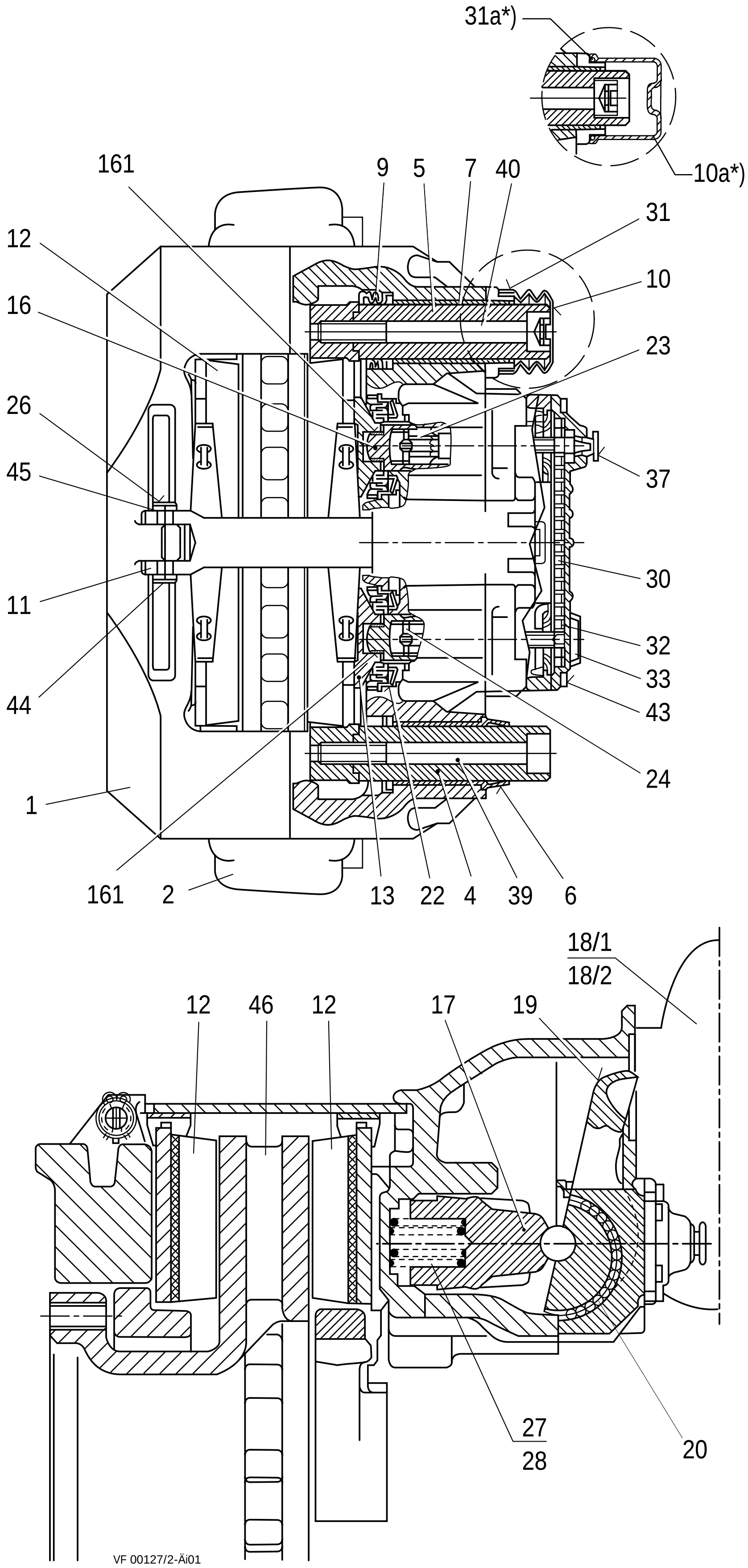
[2)] **Important Note:** The correct Grease MUST be used for each Bush!

2.4 Torque requirements

Item Number		Torque [Nm]	spanner size (mm)
39 + 40	Caliper Bolts M16x1,5 - 10.9	$285^{\pm 25}$	14
	Actuator Mounting Nuts M16x1,5	180^{+30}	24

3 Description and function

3.1 Axial Disc Brake Sectioned View



1	Caliper
2	Carrier
4	Sleeve
5	Sleeve
6	Rubber Bush
7	Brass Bush
9	Inner Boot
10	Outer Boot
10a	Steelcap
11	Pad Retainer
12	Pad
13	Tappet with Boot
16	Threaded Tube
17	Bridge
18/1	Spring Brake
18/2	Brake Chamber
19	Lever
20	Eccentric Bearing
22	Inner Seal Cap
23	Adjuster Unit
24	Turning Device
26	Spring Clip
27	Spring
28	Spring
30	Chain
31	Outer Boot Clip
31a	O-Ring
32	Chain Wheel
33	Wear Sensor
37	Adjuster Cap
39	Caliper Bolt
40	Caliper Bolt
44	Pad Retainer Pin
45	Washer
46	Disc
161	Tappet Bush

*) possible variants by items 10a & 31a

3.2 Description of operation
(Floating Caliper principle)

3.2.1 Brake actuation

During actuation, the Push Rod of the Actuator (18/1 or 18/2) moves the Lever (19). The input forces are transferred via the Eccentric Bearing (20) to the Bridge (17). The force is then distributed by the Bridge (17) and the two Threaded Tubes (16) to the Tappets (13) and finally to the inboard Pad (12).

After overcoming the running clearance between the Pads and the Disc, the reaction forces are transmitted to the outboard Pad (12). The clamping forces on the Pads (12) and the Disc (46) generate the braking force for the wheel.

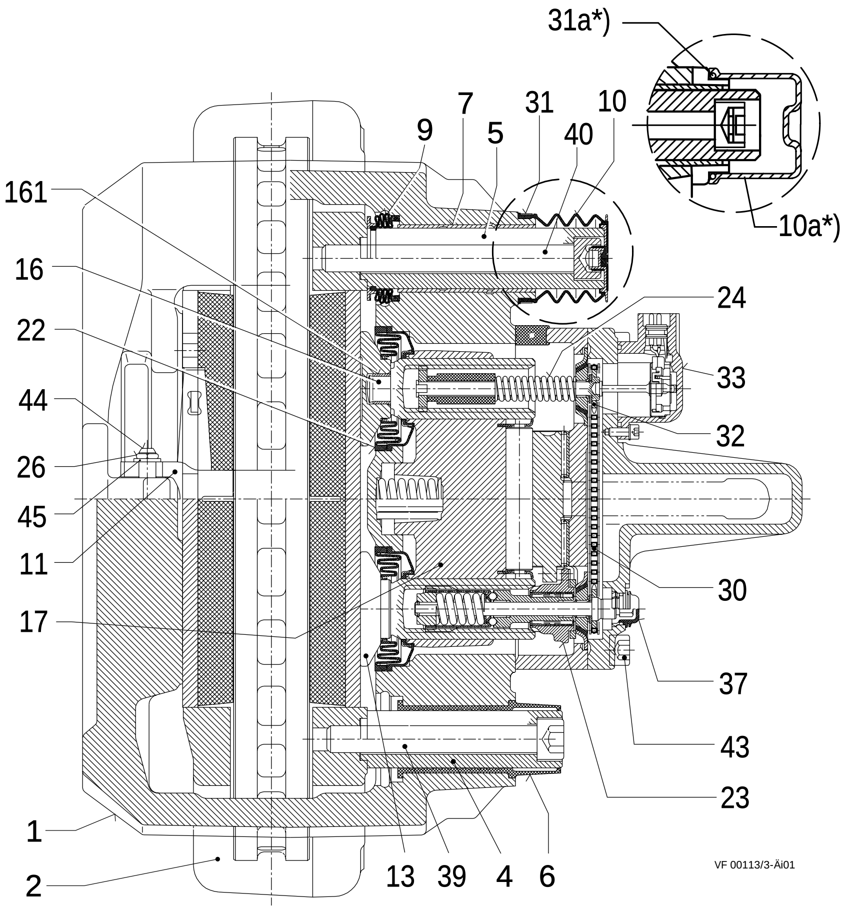
3.2.2. Brake release

After releasing the air pressure, the two Return Springs (27/28) push the Bridge (17) and Lever (19) back to the start position; this ensures a running clearance between Pads and Disc is maintained.

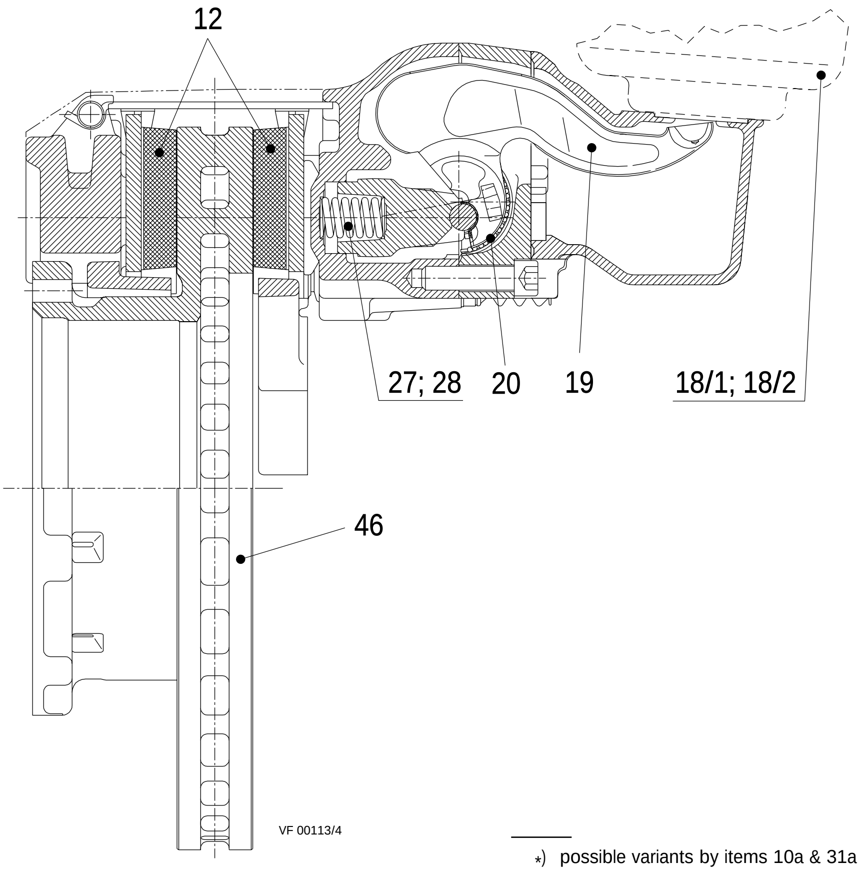
3.2.3 Brake adjustment (automatic)

To ensure a constant running clearance between Disc and Pads, the brake is equipped with a low wearing, automatic adjuster mechanism.
The Adjuster (23) operates with every cycle of actuation due to the mechanical connection with Lever (19). As the Pads and Disc wear, the running clearance increases. The Adjuster (23) and Turning Device (24) turn the Threaded Tubes (16) by an amount necessary to compensate for this wear. The total running clearance (sum of clearance both sides of Disc) should be between 0.6 and 0.9 mm.; smaller clearances may lead to overheating problems.

3.3 Radial Disc Brake Sectioned View



1	Caliper
2	Carrier
4	Sleeve
5	Sleeve
6	Rubber Bush
7	Brass Bush
9	Inner Boot
10	Outer Boot
10a	Steelcap
11	Pad Retainer
12	Pad
13	Tappet with Boot
16	Threaded Tube
17	Bridge
18/1	Spring Brake
18/2	Brake Chamber
19	Lever
20	Eccentric Bearing
22	Inner Seal Cap
23	Adjuster Unit
24	Turning Device
26	Spring Clip
27	Spring
28	Spring
30	Chain
31	Outer Boot Clip
31a	O-Ring
32	Chain Wheel
33	Wear Sensor
37	Adjuster Cap
39	Caliper Bolt
40	Caliper Bolt
44	Pad Retainer Pin
45	Washer
46	Disc
161	Tappet Bush



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3.4.1. Brake Actuation

During actuation, the Push Rod of the Actuator (18/1 or 18/2) moves the Lever (19). The input forces are transferred via the Eccentric Bearing (20) to the Bridge (17). The force is then distributed by the Bridge (17) and the two Threaded Tubes (16) to the Tappets (13) and finally to the inboard Pad (12).

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3.4.2. Brake release

After releasing the air pressure, the two Return Springs (27/28) push the Bridge (17) and Lever (19) back to the start position; this ensures a running clearance between Pads and Disc is maintained.

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4 Safety Instructions for service work
(for “Axial- and Radial Disc Brake”)

Please also refer to the relevant safety instructions for repair work on commercial vehicles, especially for jacking up and securing the vehicle.

Use only original KNORR-BREMSE parts.

WARNING!

Before starting repair work, ensure the service brake and parking brake are not applied and that the vehicle cannot roll away.

Please follow repair manual instructions and adhere to the wear limits of the Pads and the Discs - see Section 5.3.

Use only recommended tools - see Section 2.1.

Tighten bolts and nuts to the recommended torque values - see Section 2.4.

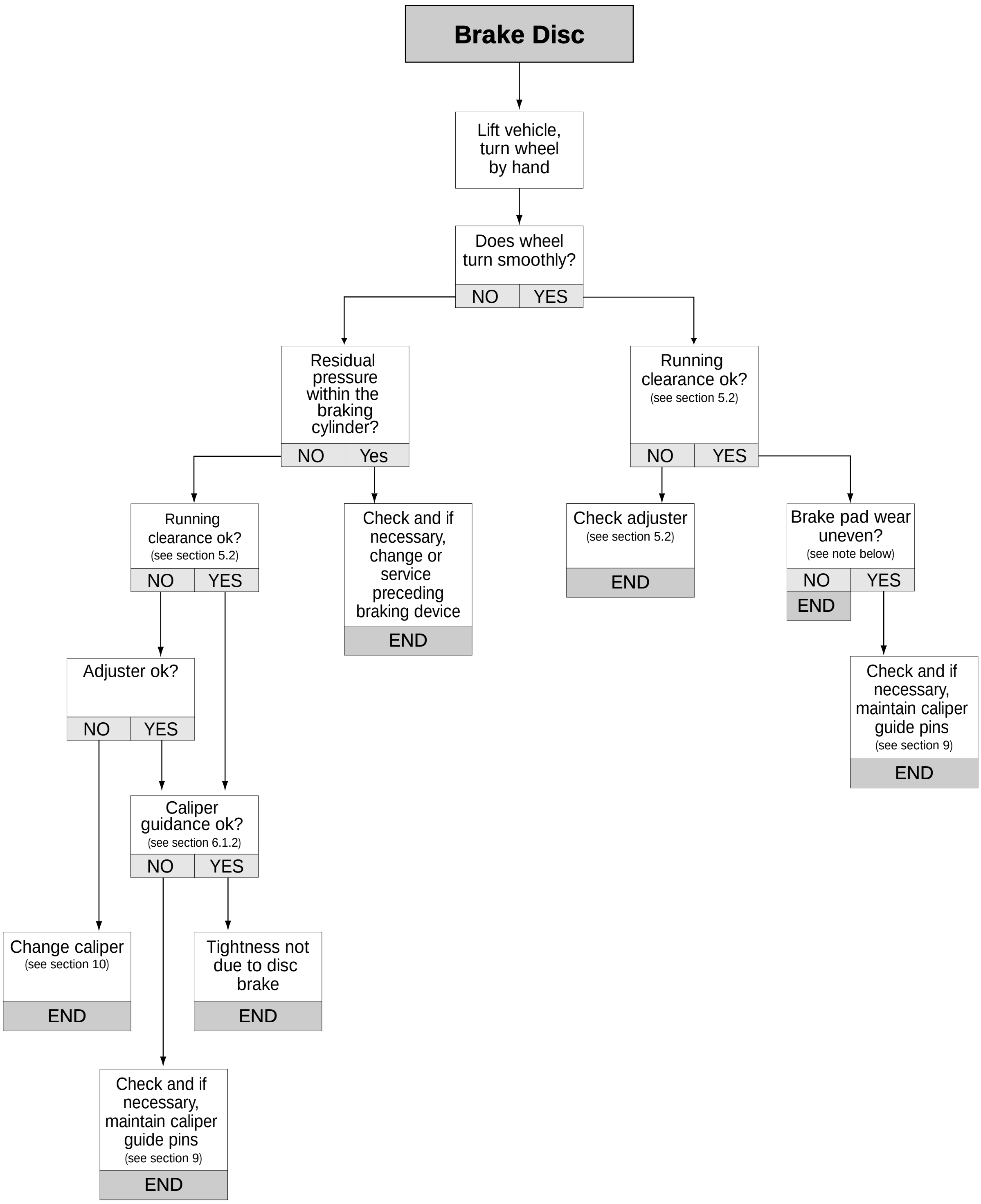
After re-fitting the wheel according to the Vehicle Manufacturer’s recommendations, please ensure that there is sufficient clearance between the Tyre Inflation Valve, the Caliper and the wheel rim, to avoid damage to the Valve.

After service work:
Check the brake performance and the system behaviour on a rolling road or by actual road test.

5 Brake Testing

(for Axial- and Radial Disc Brake)

5.1 Fault finding procedure



Note: Difference between inboard and outboard pad < 5, and diagonal wear ≤ 2 mm

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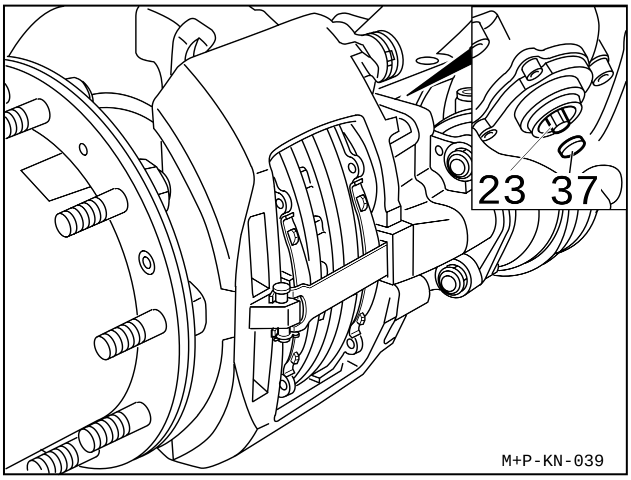
5.2 Adjuster check

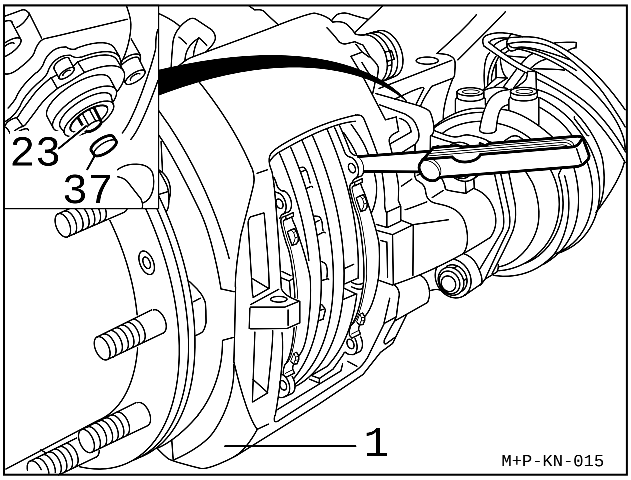
WARNING!

Before starting repair work, ensure the service brake and parking brake are not applied and that the vehicle cannot roll away.



Remove wheel.

The caliper assemply should be pushed inboard on its guide pins. Using a suitable tool, press the inboard pad (12) away from the Tappets and check Tappet and inboard pad backplate - it should be between 0.5mm & 1.0mm. If the running clearance is too small or large, the adjuster may not be functioning correctly and should be checked as follows.

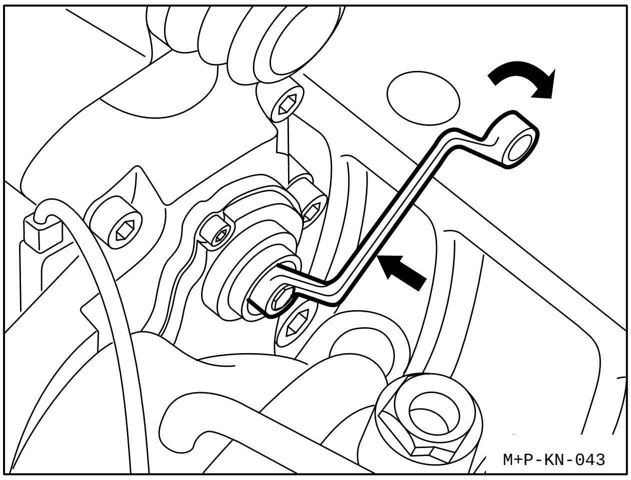


Remove Cap (37).

WARNING!

Do not overload or damage the Adjuster (23). Use only 8mm Ring Spanner or 1/4" drive Socket with a lever length no greater than 100mm.
***DO NOT** use an Open Ended Spanner since this may damage the Adjuster shaft.*

The Adjuster should be turned counter-clockwise for 2 or 3 clicks (increasing running clearance).



Attention!

Make sure that the Ring Spanner or Socket can turn freely during following procedure.

By applying the brake 5 - 10 times (about 2 Bar) the Spanner or Socket should turn clockwise in small increments if the Adjuster is functioning correctly (see notes below).

If Pads are not being changed, Cap (37) should be replaced having lightly greased it with Renolit HLT2 (available as part number II14525).

NOTE:
As the number of applications increases, incremental adjustment will decrease.

NOTE:
If the Spanner or Socket does not turn, turns only with the first application or turns forward and backward with every application, the automatic Adjuster has failed and the Caliper must be replaced.

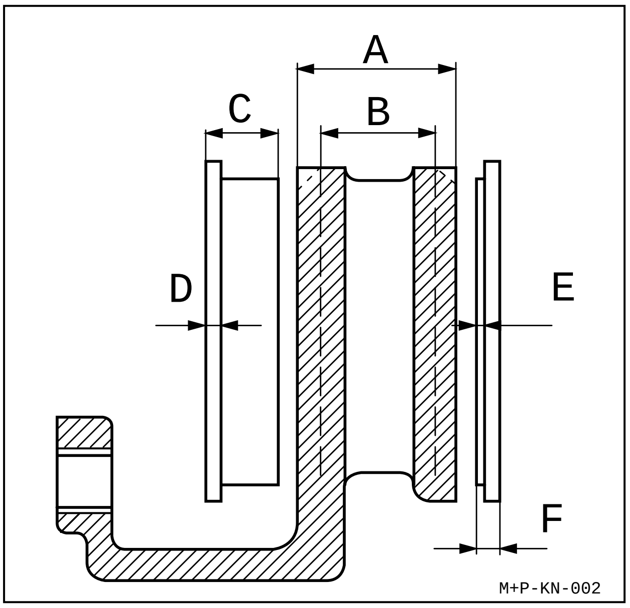
5.3 Wear Limits of Pads and Discs

WARNING!

For optimum safety, stay within the Disc and Pad Wear Limits

Pads

The thickness of the Pads must be checked regularly dependent on the usage of the vehicle.
The Pads should be checked corresponding to any legal requirements that may apply.
If no Wear Indicator has been connected this should be at least every 3 month.
If friction material is less than 2mm (see E), the Pads must be replaced.



Discs

Measure thickness at thinnest point. Avoid measuring near the edge of the disc as a burr may be present.

- A = Disc thickness (new condition) 45mm
- B = Disc thickness (worn) 37 mm, Disc must be replaced
- C = Overall thickness of Pad (new condition) 30mm
- D = Backplate 9mm
- E = Minimum thickness of friction material 2mm
- F = Minimum allowed thickness in worn condition for backplate and friction material 11mm (replacement of Pads necessary).

If wear dimension B ≤ 39 mm Disc should be renewed together with Pads.

Wear dimension B = 37mm must not decrease.

WARNING!

If these recommendation are ignored, there is a danger of brake failure

Check Disc at each change of Pads for grooves and cracks.
The diagram shows possible conditions of the surface.

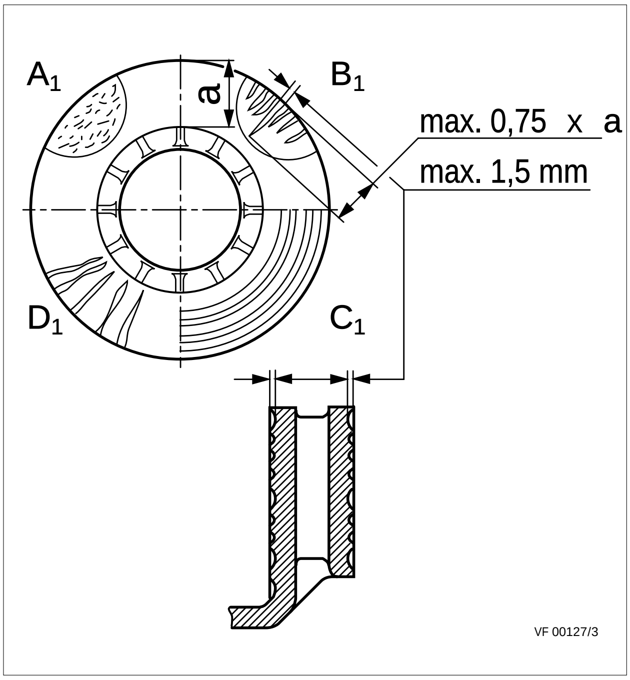
A_1 = Small cracks spread over the surface are allowed

B_1 = Cracks less than 1.5mm deep or wide, running in a Radial direction, are allowed

C_1 = Grooves (circumferencial) less than 1.5mm wide are allowed

D_1 = Cracks in the vanes are not allowed and the Disc MUST BE REPLACED.

a = Pad contact area



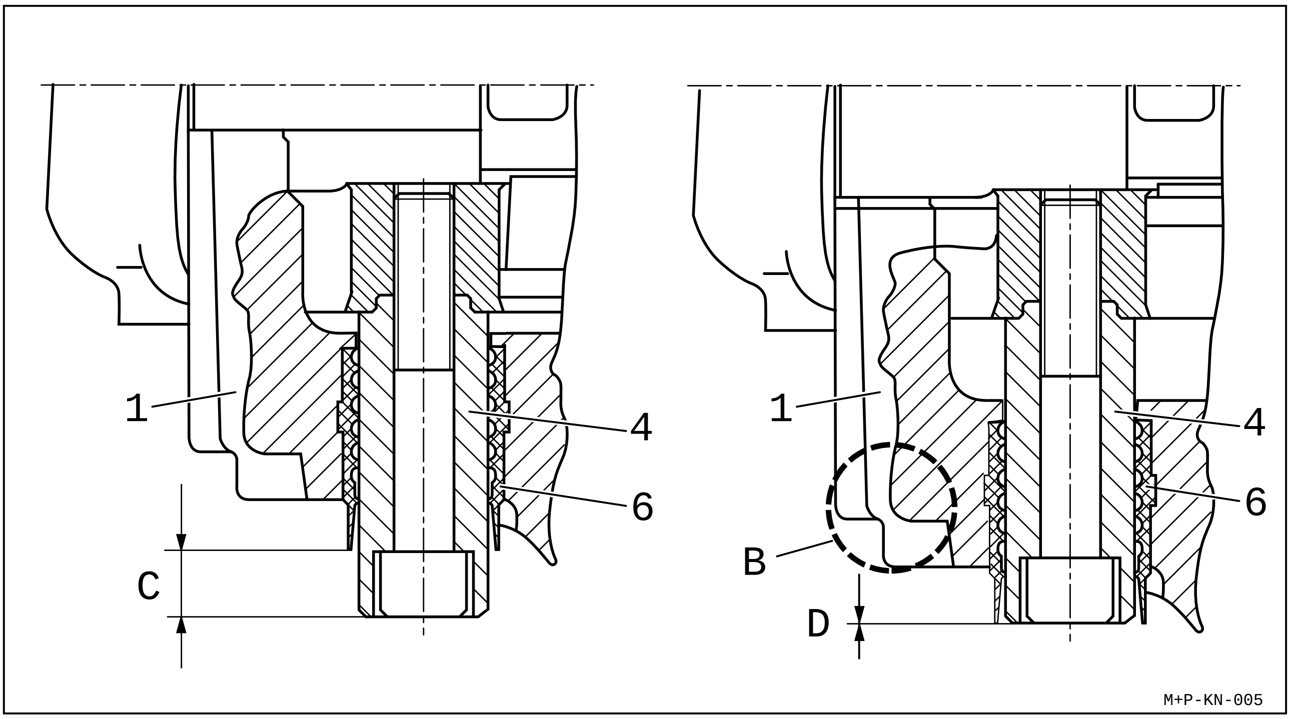
Note
In case of surface conditions A_1,-C_1, the Disc can continue to be used until the minimum thickness of 37mm is reached.

Knorr-Bremse Discs are normally service-free and grinding when changing Pads is not necessary. However, grinding could be useful, e.g. to increase the load-bearing surface of the Pads after severe grooving on the entire friction surface has occurred. To meet safety requirements, the minimum thickness after regrinding is > 39 mm.
In addition, the recommendation of the Vehicle Manufacturer MUST be followed.

WARNING!

If these recommendations are ignored, there is a danger of brake failure. If the Pads are worn down to the backplate or if Disc wear is excessive, brake performance will be severely affected and may be lost completely.

5.3.1 Brake Wear Check using Guide Pin (For all Axial and Radial Disc Brakes except those listed in Section 5.3.2 - These Callipers do not have the rib in position B (see also Section 5.3.2)



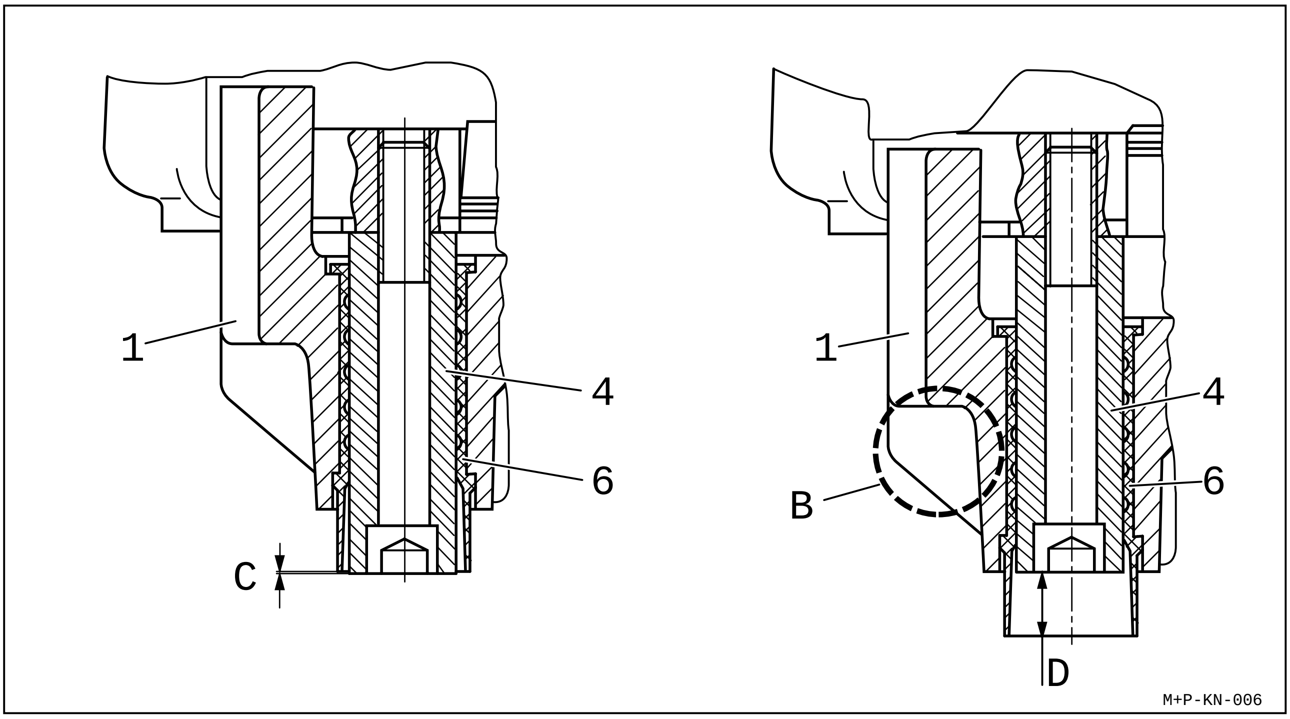
The condition of the Pads can be visually determined without removing the road wheel by noting the position of the Fixed Sleeve (4) in the Floating Caliper (1).

If dimension ‘C’ is less than 1mm, a more accurate check of the Pads and Disc must be made.

If necessary change the Pads - see Section 6

B = without rib (see also Section 5.3.2)
C = pin protrusion - shown in new condition
D = minimal pin protrusion - Pads and Disc must be checked with road wheel removed

5.3.2 Brake Wear Check using Guide Pin (Only for Axial Disc Brakes SB 7541, SB 7551 to SB 7629, SB 7639 and Radial Disc Brakes SB 7102, SB 7112, SB 7103, SB 7113, SB 7104, SB 7114, SB 7105, SB 7115, SB 7108, SB7118, SB 7109, SB 7119, SB 7120, SB 7130 - These Callipers do have the rib in position B (see also Section 5.3.1)



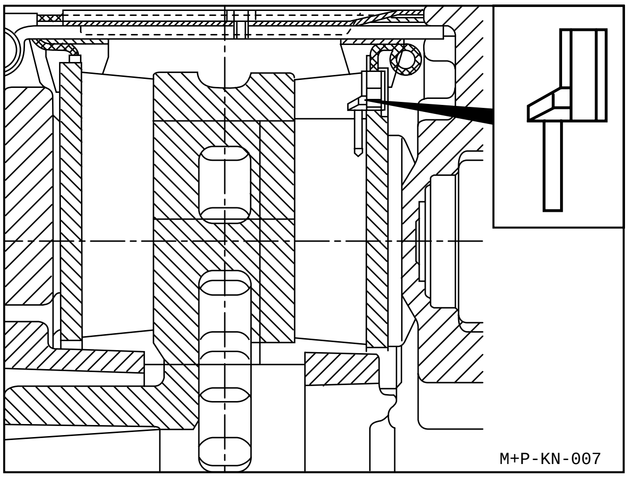
The condition of the Pads can be visually determined without removing the road wheel by noting the position of the Fixed Sleeve (4) in the Floating Caliper (1).

If the head of the Fixed Sleeve (4) is inside the Rubber Bush (6) by a dimension D greater than 18mm, then a more accurate check of the Pads and Disc must be made.

If necessary change the Pads - see Section 6.

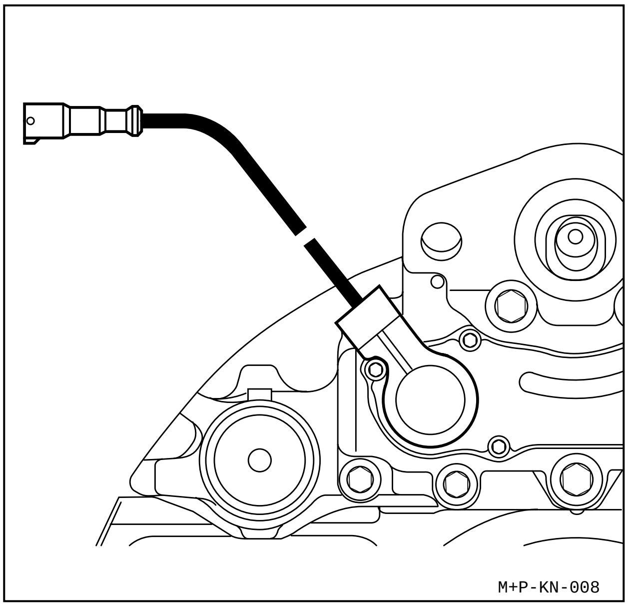
B = with rib (see also Section 5.3.1)
C = new condition
D = 18 mm or more, Pads and Disc must be checked with road wheel removed

5.3.3 Wear Indicators



Due to different Vehicle Manufacturer and vehicle types there are several types of Pad Wear Indicator used.

a) In - Pad Normally Closed Indicator - Circuit is broken when Pad Wear reaches limit.
b) In - Pad Normally Open Indicator - Circuit is made when Pad Wear reaches limit.



c) Wear Indicator using built in Potentiometer. This is available either as an on/off version or as a continuous signal version which can be linked to the vehicle's electronic monitoring systems.

An optical or acoustic device may be linked to any of the above.

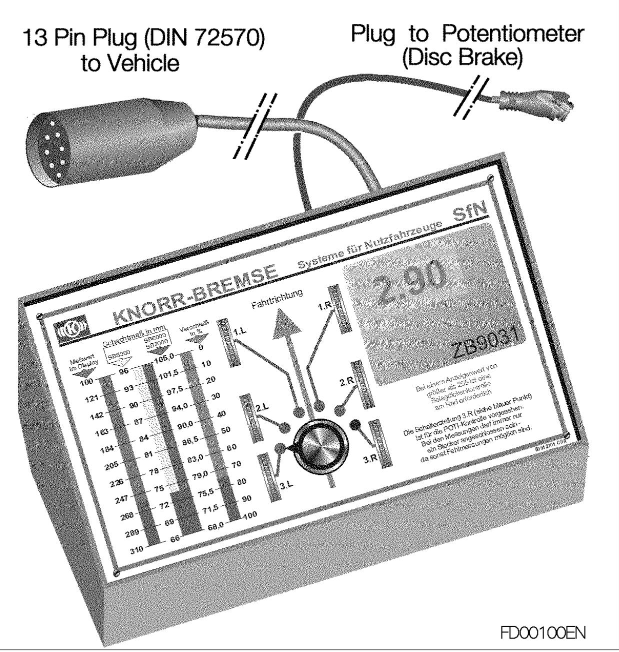
Important
Please also refer to specifications provided by the Vehicle Manufacturer

5.4 Knorr-Bremse Diagnostic Equipment

The Knorr-Bremse Diagnostic Unit **ZB 9031** is a hand held device suitable for vehicles that are fitted with Knorr-Bremse Disc Brakes using a continuous signal type of Wear Potentiometer.
The wear condition of each brake can be measured by connecting the device to a suitable 13 pin socket (DIN 72570) where fitted. This socket will have been connected to each sensor by the vehicle manufacturer.
The Diagnostic unit allows:

- Quick and simple wear check.
- A check of the potentiometer function.

A detailed instruction manual is included with each unit.



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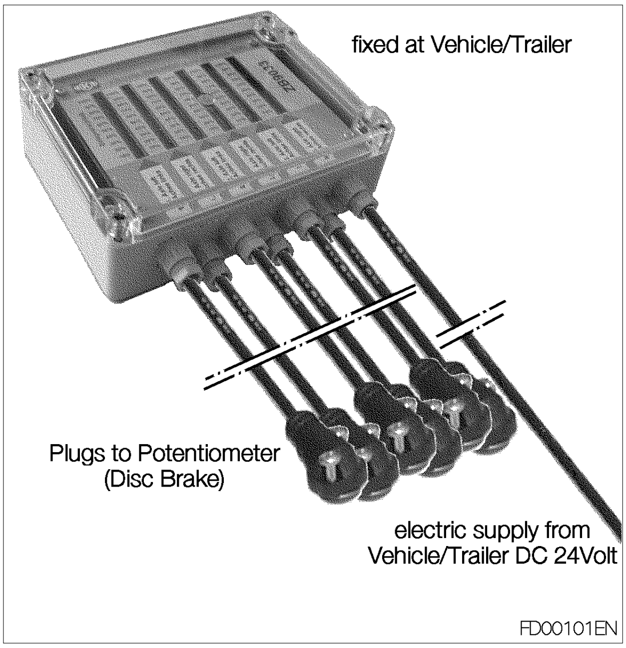
5.5 Knorr-Bremse Diagnostic Equipment

The Knorr-Bremse Wear Check Module **ZB 9033** is a chassis mounted device suitable for vehicles that are fitted with Knorr-Bremse Disc Brakes using a continuous signal type of Wear Potentiometer.
The module continuously monitors and displays the wear at each brake.
For vehicles without an automatic brake control system, particularly Trailer applications, the module allows for a quick and simple wear check.
The Wear Check Module allows:

- Up to 6 Brakes to be checked together.
- LED monitoring of each Brake condition.

A detailed instruction manual is included with each unit.



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6 Pad replacement
(for “Axial- and Radial Disc Brake”)

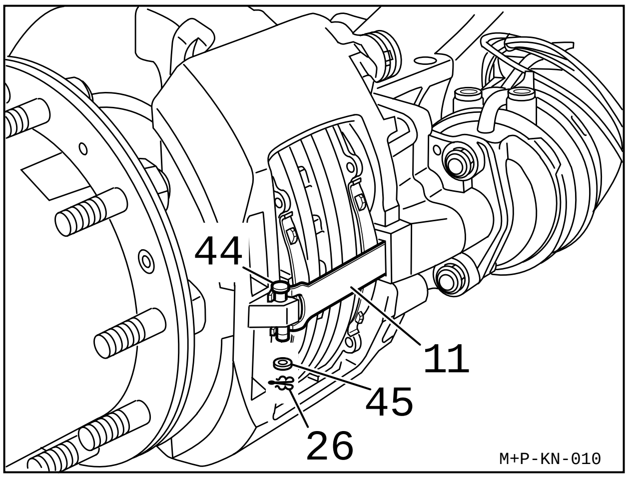
> ***WARNING!***
>
> *Before starting repair work, ensure the service brake and parking brake are not applied and that the vehicle cannot roll away.*

6.1 Pad removal

Take the wheel off (refer to Vehicle Manufacturer’s recommendations).

Remove Clip (26) and Washer (45), push down the Pad Retainer (11) and remove Pin (44).

If the Pad Retainer (11) is corroded, it should be replaced.



Important
Before removing Pads it is strongly recommended that the Adjuster mechanism is checked for correct operation. See Section (5.2)

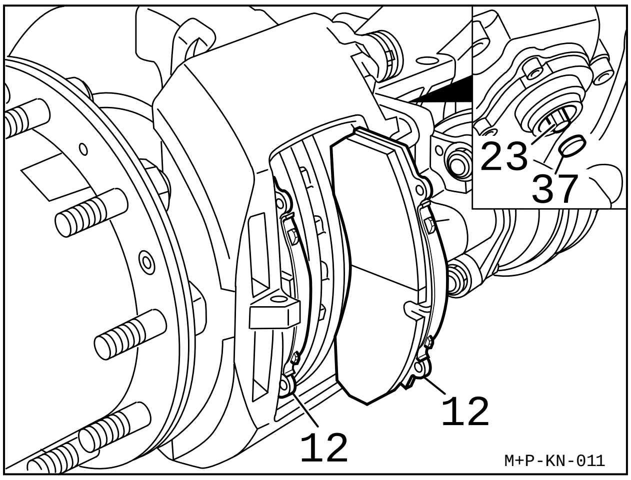
> ***WARNING!***
>
> *Do not overload or damage the Adjuster (23). Use only 8mm Ring Spanner or 1/4” drive Socket with a lever length no greater than 100mm.*
> ***DO NOT*** *use an Open Ended Spanner since this may damage the Adjuster shaft.*

Remove Cap (37).

Turn the Adjuster counter-clockwise until Pads can be removed. A clicking noise will be heard during this procedure.

Push inboard Pad (12) toward Actuator.

Pull out both Pads (12).

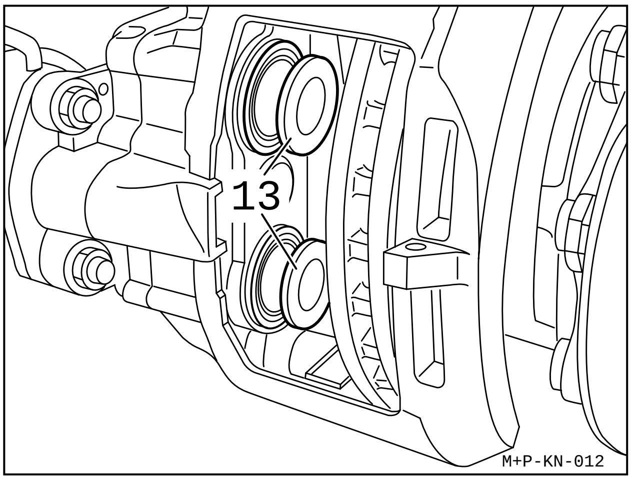


6.1.1 Tappet Boot Check

The Adjuster (23) should be screwed clockwise until the boots are clearly visible.
The Boots should not show any damage.
Check the attachment of the Boots into the Caliper housing.

Important
Any ingress of water or dirt past the Tappet Boot will lead to corrosion and affect the function of the Actuation Mechanism and Adjuster Unit.

If damaged, the Boot and Tappet must be replaced (see Section 7).

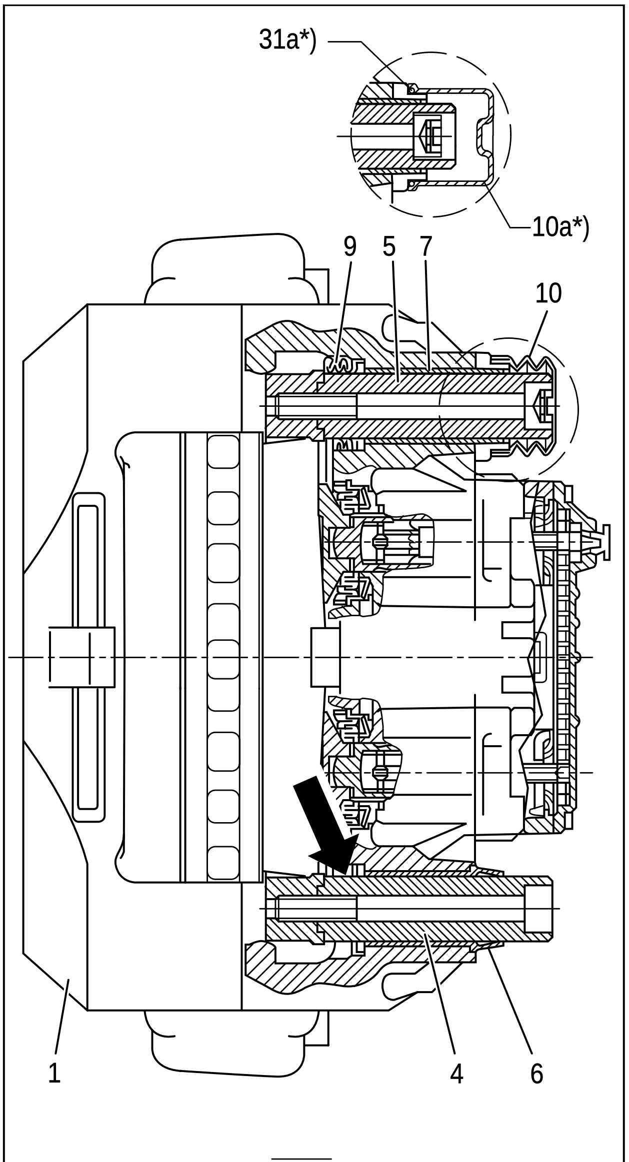


6.1.2 Caliper guidance check

Following Pad removal (Section 6.1)

Using hand pressure only (no tools), the Caliper (1) must slide freely over the whole length of the Guide Pin arrangement >30mm.
During this operation the Sleeve (5) is sealed by the Boot (9) and Cap (10) or Steel Cap (10a) and O-Ring (31a). These must show no signs of damage. Check that these are correctly seated.

The Caliper may have to be re-sealed by using a suitable Kit (see page 5 or page 7).



6.2 Pad fitting

WARNING!

Pads must be changed as an axle set and NOT individually.
Use only Pads which are permitted by the vehicle manufacturer,axle manufacturer and brake manufacturer.
Failure to comply with this may invalidate the vehicle manufacturer's warranty

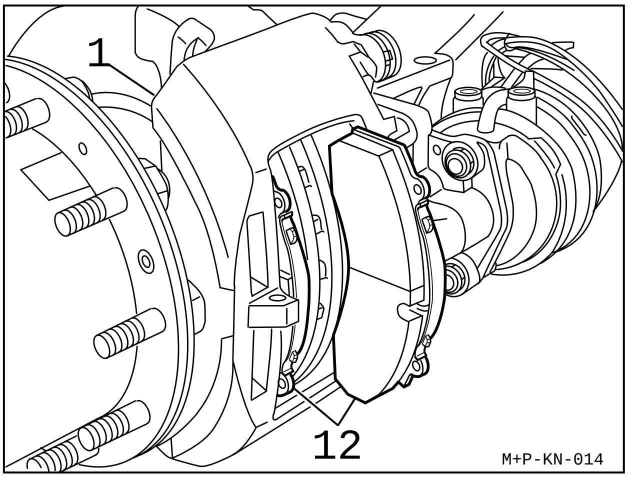
Note:
Before placing the Pads into the Carrier, the Adjuster (23) must be further de-adjusted by rotating it counter clockwise.

Clean the Pad abutments.

Push Caliper (1) outboard and fit the outboard Pad (12).

For fitting the inboard Pad (12) push Caliper (1) in the opposite direction.

If fitted, replace Wear Indicators and fittings / brackets etc. See page 5 or 7.



WARNING!

Do not overload or damage the Adjuster (23). Use only 8mm Ring Spanner or 1/4" drive Socket with a lever length no greater than 100mm.
***DO NOT** use an Open Ended Spanner since this may damage the Adjuster shaft.*

Rotate the Adjuster clockwise until the Pads come into contact with the Disc. Then turn back the Adjuster 2 clicks.

The hub should turn easily by hand after having applied and released the brake.

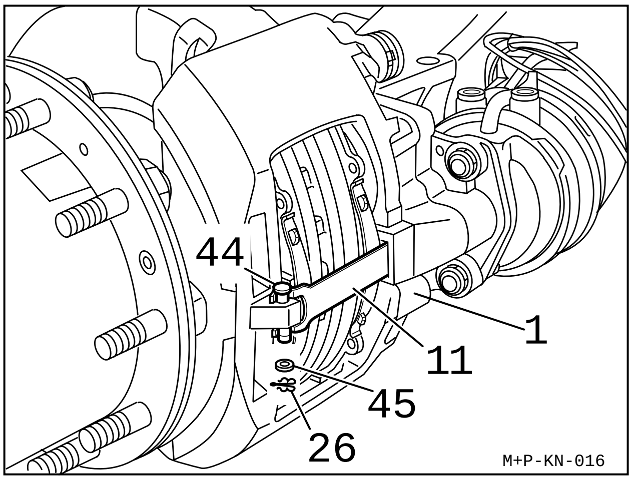
The Cap (37) must then be replaced having lightly greased it with Renolit HLT2 (available as part number II14525).

After setting the Pad Retainer (11) into the groove of the Caliper (1), it must be pushed in to enable the positioning of Pad Retainer Pin (44).

Fit washer (45) and Spring Clip (26) to the Pad Retainer Pin (44) (use only new parts).

Our recommendation is fitting Washer (45) and Spring Clip (26) pointing downwards (see diagram).

Wheel mounting (refer to Vehicle Manufacturer's recommentations).



IMPORTANT!

New Pads need bedding in. Heavy or long duration braking should initially be avoided.

7 Tappet with Boot replacement
(for "Axial- and Radial Disc Brake")

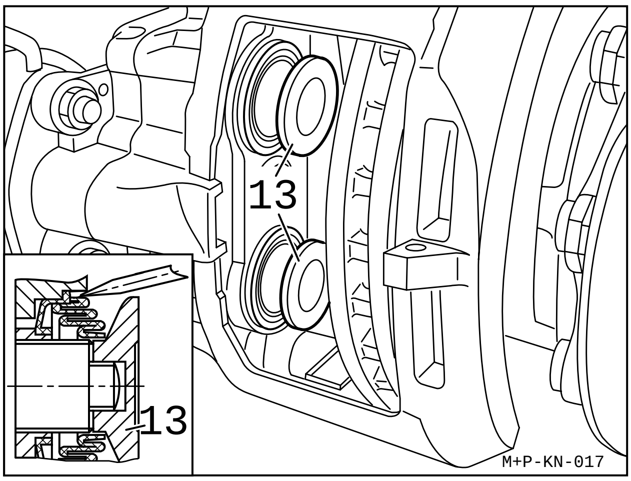
7.1 Tappet with Boot removal

Note:
It may be easier to remove the Caliper from the axle to replace the Tappets of the Caliper (see Section 10.1).

The Adjuster (23) must be screwed clockwise until the Boots can be reached.

If the Caliper has been removed from the vehicle care must be taken not to overrun the threads (see section 7.1.1).

To remove the Tappet Boot from the Caliper bore, a Screwdriver should be used to deform the Boot location ring - see diagram.



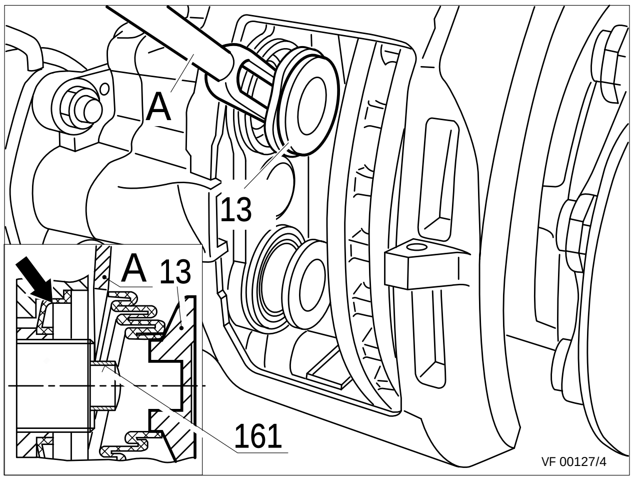
Warning!

Great care must be taken not to damage the Inner Seal since it is not a replacement item.

The Tappets (13) can be removed from the Threaded Tubes by using Wedge Fork A. (Order No. II32202).

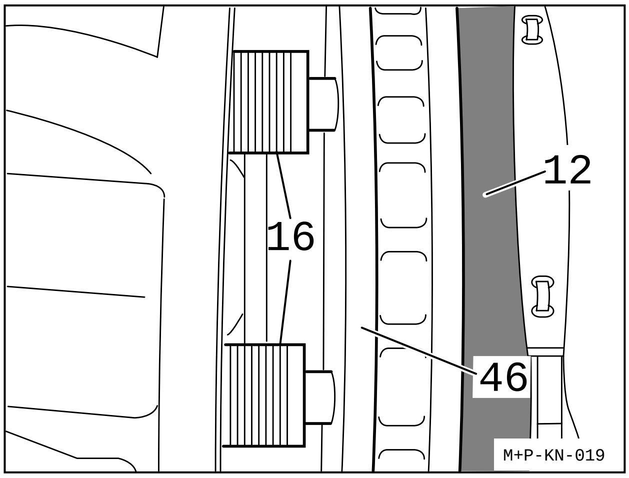
Remove the old Tappet Bush (116).

Check Inner Seal (arrow) and if damaged, the Caliper must be replaced .



7.1.1 Adjuster thread inspection

Place an unworn Pad (12) **into the outboard gap** to avoid overrunning of the Threaded Tubes.

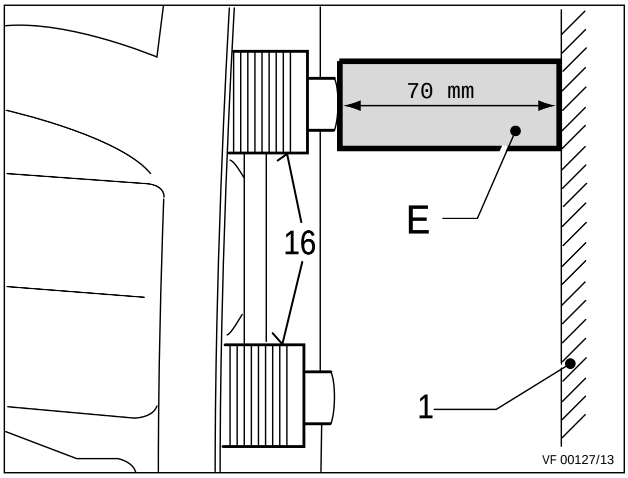


IMPORTANT!

Threaded Tubes should not overrun the inner thread of the Bridge.
The Caliper must be changed if synchronisation is lost.

For the inspection of the threads, the tubes must be screwed out (max. 30mm) by turning the Adjuster (23) clockwise.

If Caliper is not installed on axle, put a spacer E (length = 70mm) into the Caliper (1) to avoid overrunning of the Threaded Tubes (16) when screwing them out (see illustration opposite). During screwing, the threads can be checked for corrision damage.
In case of water ingress or corrosion, the Caliper must be replaced.



7.2 Tappet with Boot fitting

With Caliper fixed to axle:
Grease threads with RENOLIT HLT2 (Order No. II14525).

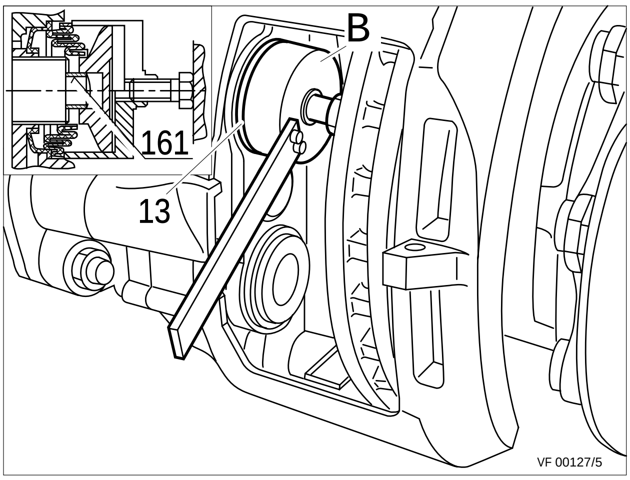
Screw back Threaded Tubes (16), by turning the Adjuster (23) counter-clockwise.

Place new Tappet Bush (161) onto the head of the Tube (16).

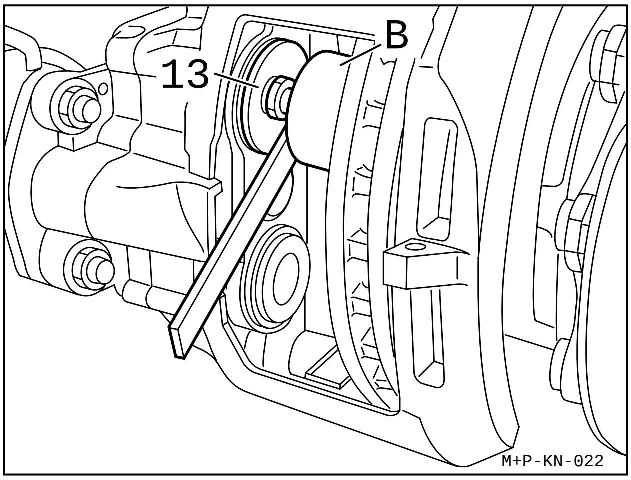
Sealing seat in the caliper for Tappet with Boot (13) must be clean and free of grease.

Place Tappet with Boot (13) onto the head of the Tube.

Use Push-In Tool with the short strut (B)
(Order No II19252) for positioning and pressing-in the Boot (13).



Using Tool B in reverse, the Tappet can be pressed on.



With Caliper not installed on axle
Grease threads with RENOLIT HLT2 (Order No. II14525).

Screw back Threaded Tubes (16), by turning the Adjuster (23) counter-clockwise.

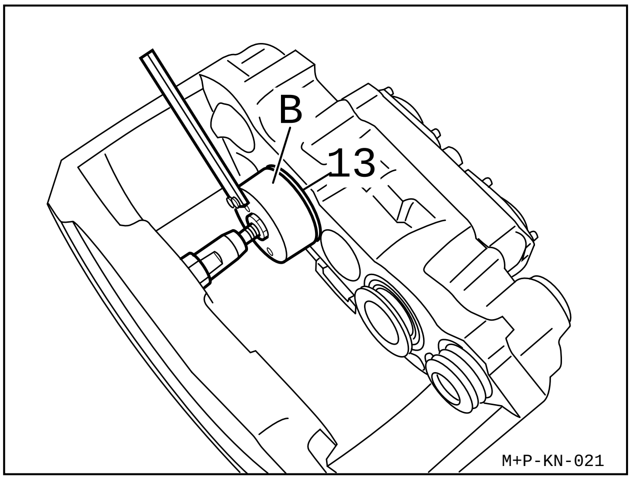
Sealing seat in the caliper for Tappet with Boot (13) must be clean and free of grease.

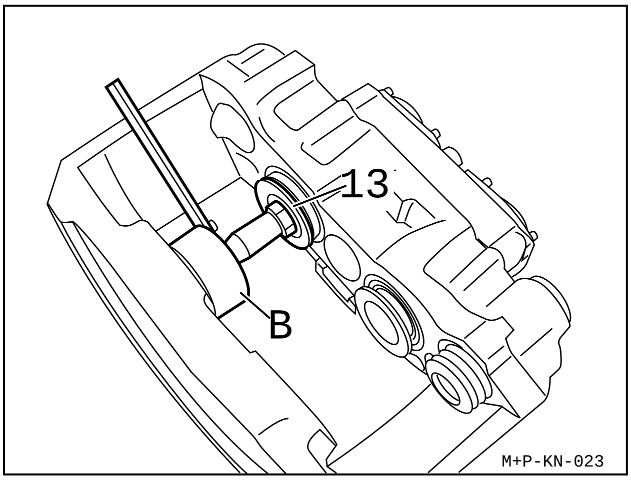
Place new Tappet Bush (161) onto the head of the Tube (16).

Place Tappet with Boot (13) onto the head of the Tube.

Use Push-In Tool with the long strut (B) (Order No II19252) for positioning and pressing-in the Boot (13).

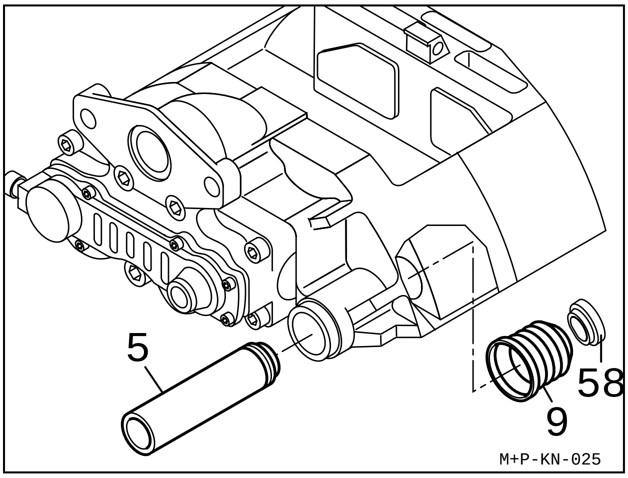
Using the Tool (B) in reverse, the Tappet can be pressed on.





8 Caliper Suspension sealing

(Replacement of inner Boot (9))
(for the Axial and Radial Disc Brake)



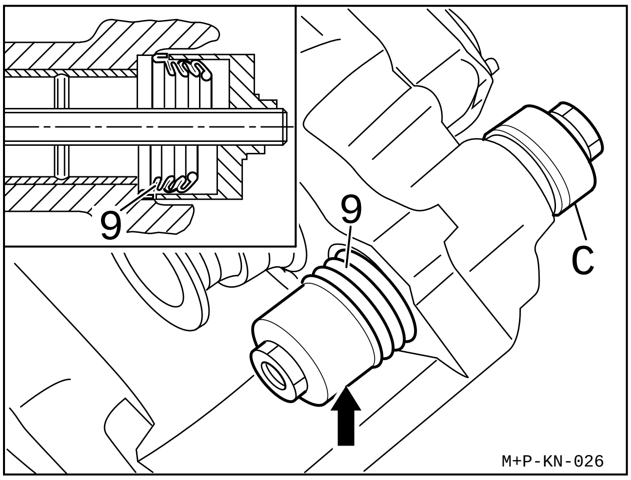
Remove Caliper (see Section 10.1)

Remove Ring (58)

Pull out Sleeve (5)

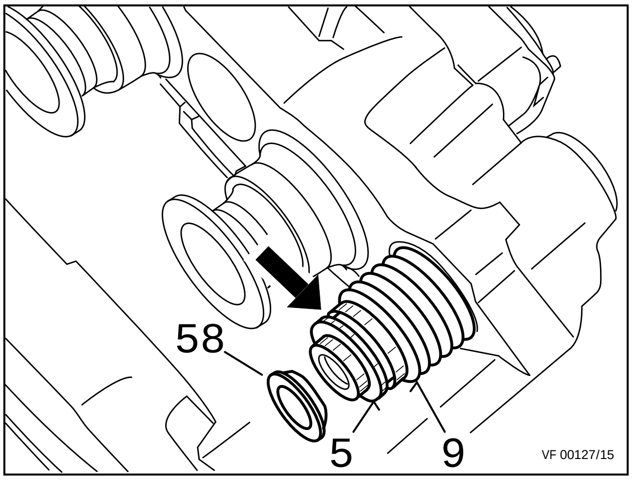
Push out Boot (9) with screw driver.

Inspect and clean contact area of Boot (9)



Put new Boot (9) into the Sleeve (arrow) of the Tool C (Order No II19253).

Position Sleeve with Boot (9) into the Caliper bore and pull in.



Fit the Sleeve (5)
The Boot end must engage in the groove of the Sleeve (5) (arrow). Lock with Ring (58) by pushing until it engages.

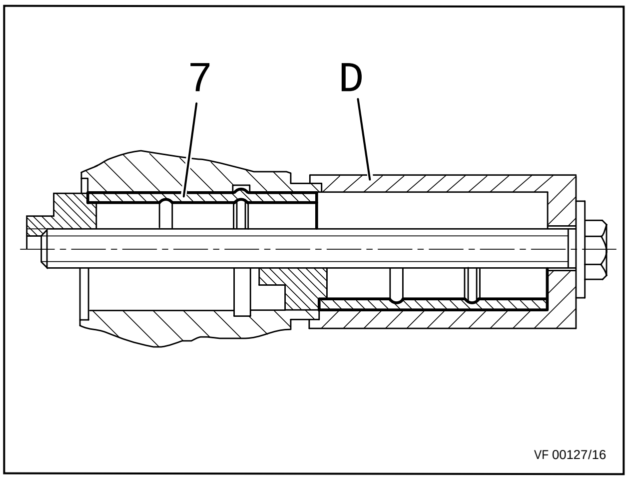
Important:
Before fitting the Caliper the unsealed Sleeve with the Rubber Bush should be checked for its ability to slide.

Fit Caliper (see Section 10.2).

9 Guide Pin Bush replacement
(for “Axial- and Radial Disc Brake”)

Remove Caliper (see Section 10.1)

Remove Sleeve (5) and inner Boot (9) (see Section 8).



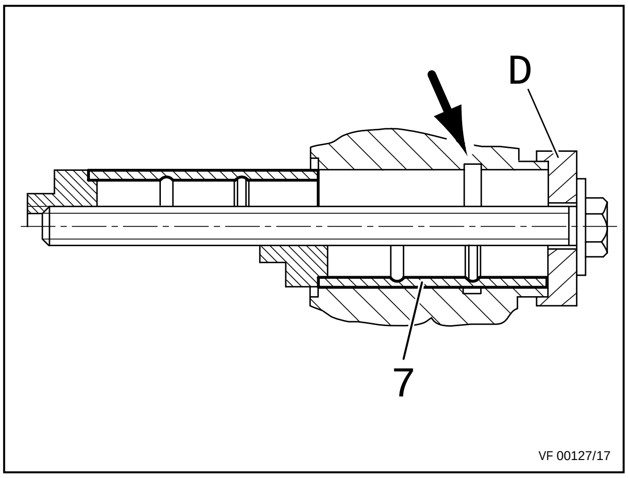
9.1 Brass Bush (7) replacement

Remove old Sleeve (5).

Pull out Bush (7) with Tool (D) (Order No. II19254).

If Caliper has no groove (see arrow)
(Note: Groove is always located on the inboard side)

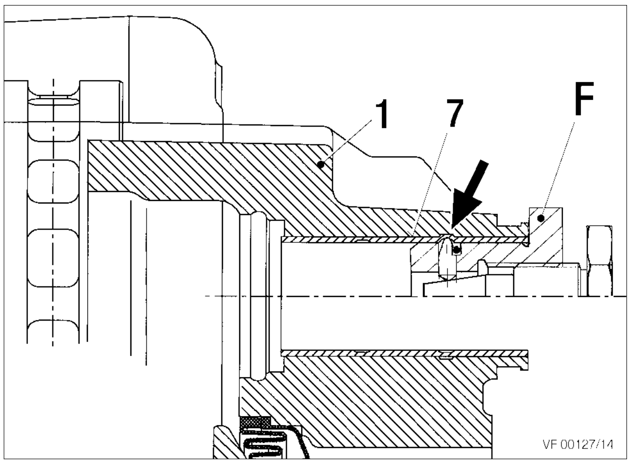
Pull in new Brass Bush (7) with Tool (D).



If Caliper has a groove:
Pull in new Brass Bush (7) with Tool (D).
To prevent longitudinal displacement use Tool (F) (Order No II36797) to create new groove.

Check contact area of Brass Bush (7) for burrs.
Remove burrs.
Grease Bush with white Grease RENOLIT HLT2 (Order No II14525).

Insert new Sleeve (5).

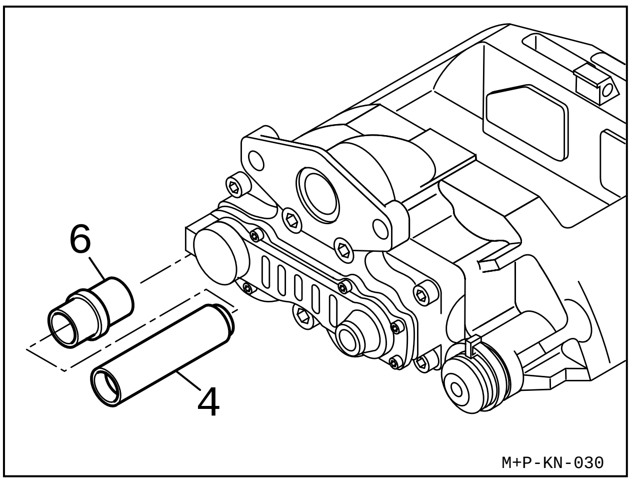


Note:
The Guide Pins Kit contains new Sleeves (4) & (5) and new Caliper Bolts (39) & (40) (see Section 1.2 and 1.4).

9.2 Rubber Bush (6) replacement

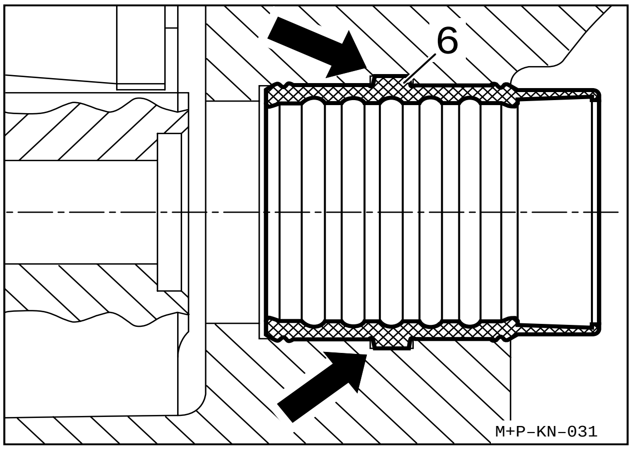
Remove old Sleeve (4)

Pull Rubber Bush (6) out of bore.
Check bore for corrosion, clean if necessary with Corrosion protection paint (e.g. Zinc spray).



Note:
Grease new Rubber Bush (6) inside and outside with green Grease SYNTHESO GL EP 1 (Order No II32793).

Deform new Rubber Bush (6) and push from the inner side of the Caliper into the bore.
Push Rubber Bush (6) so that the outer positioning ring locates in the groove (see arrows).



IMPORTANT!

Under no circumstances must the white Grease (containing mineral oil) be used for lubricating the Bush or Sleeve. Use only synthetic based green Grease (Part Number II32793).

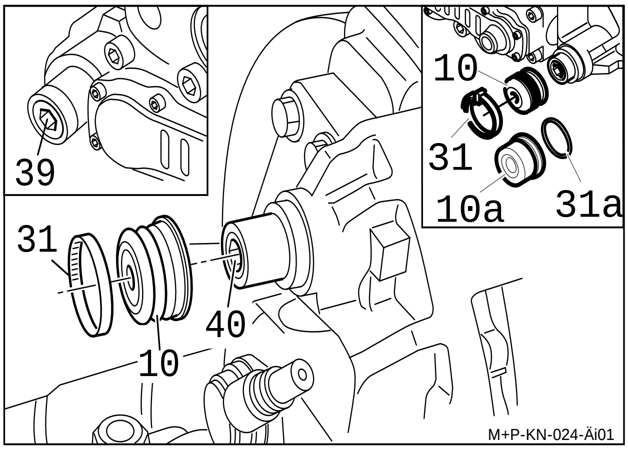
Note:
The Guide Pins Kit contains new Sleeves (4) & (5) and new Caliper Bolts (39) & (40).

Assemble Sleeve (4)

Re-fit Caliper (see Section 10.2)

Important:
Torque Caliper Bolts to 285^{+25} Nm and check that the Caliper slides easily.

10 Caliper replacement
(for Axial- and Radial Disc Brake)



10.1 Caliper removal

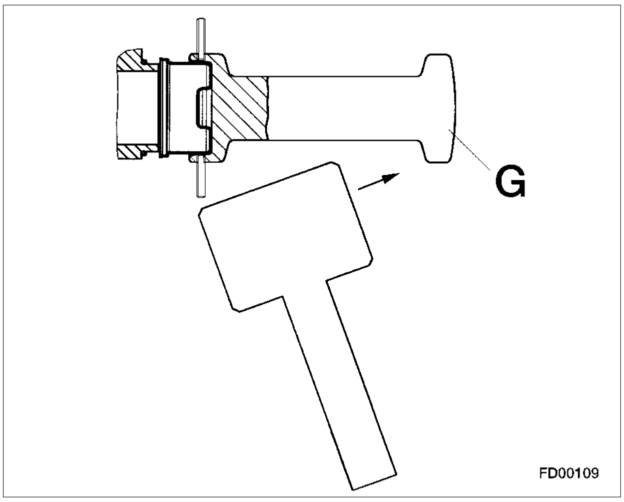
Remove Pads (see Section 6.1)

Remove Actuator (see Section 12.1 and 12.3).

Remove Outer Boot Clip (31) and take off Outer Boot (10)

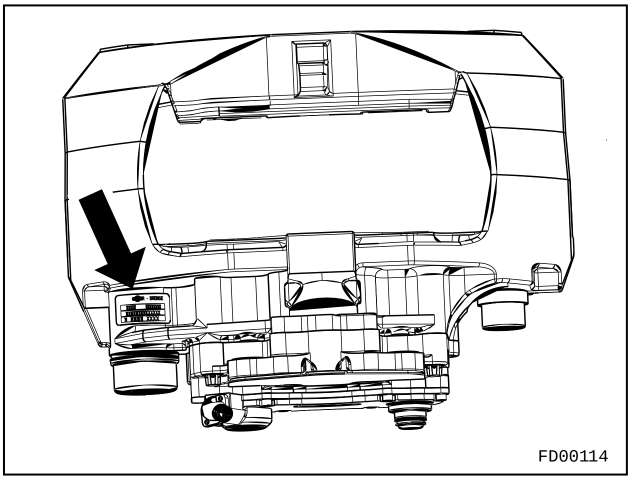
Note:
As well as Calipers with Outer Boot (10) and Outer Boot Clip (31) there are versions with Steel Cap (10a) and O-Ring (31a) available.

On models with Steel Caps (10a) and O-Rings (31a), place tool (G) (Part Number Z001105) onto the Steel Cap and tighten the threated pin by a hexagon socket spanner. Then use hammer as shown.



Remove Cylinder Bolts (39 and 40).

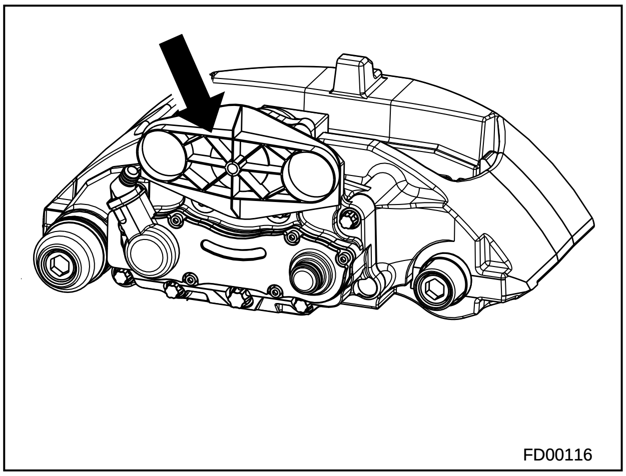
> ### *WARNING!*
>
> *Hold Caliper only at its outer side. Never get your fingers between Caliper and Carrier!*



Remove Caliper from Carrier.

> ### *IMPORTANT!*
>
> *The opening or dismantling of the Caliper has not been authorized. Use only Genuine Knorr-Bremse Service Exchange Calipers.*

10.2 Caliper fitting

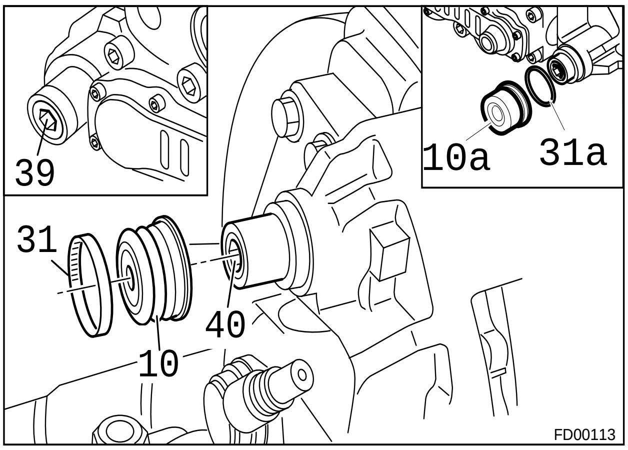


The correct choice of Caliper must be ensured by checking the Part No. on the label (arrow, picture above)

Note:
Service Exchange Calipers have a blue label.

The Service Exchange Caliper has a plastic cap or an adhesive tape in the area of the Actuator attachment. Remove the cap tape after installing the Caliper (see arrow).

Note:
The service exchange Caliper includes sealing and guiding elements. The Pads are not included.

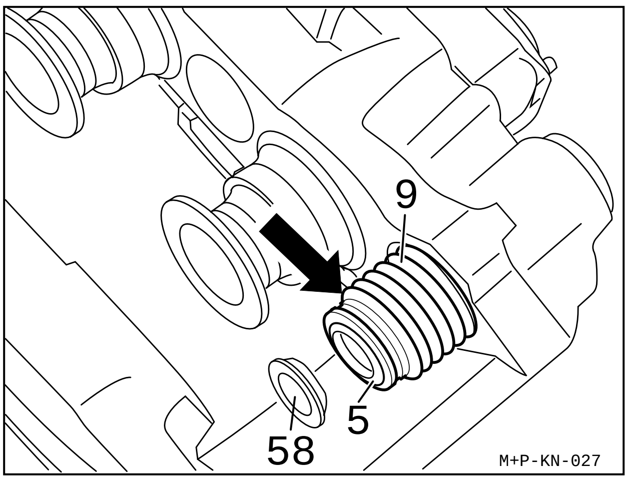


> ### *WARNING!*
>
> *Hold Caliper only at its outer side. Never get your fingers between Caliper and Carrier!*

10.2.1 Caliper with Outer Boot (10)

Locate the Caliper to the Carrier.

Screw-in Caliper Bolts (39 and 40) and tighten to 285^{+25} Nm (use only new parts).



Check that the Caliper slides easily.

Check the position of the Inner Boot (9) on the Sleeve (5).

Check Adjuster function (see Section 5.2)

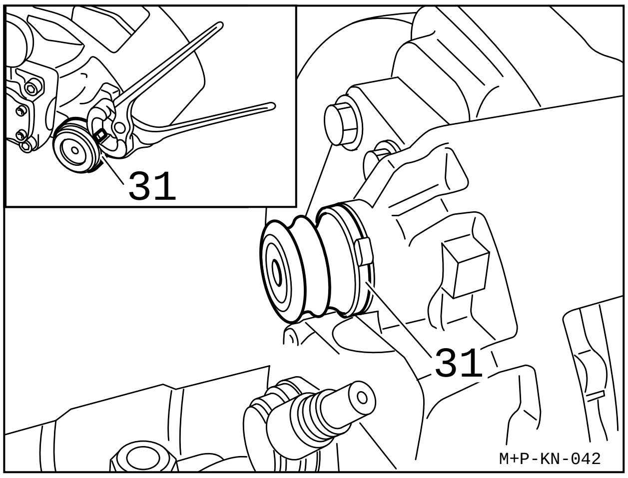
If necessary use new Outer Boot (10).

Check grease-free seating of the Outer Boot (10) on the Caliper (1)

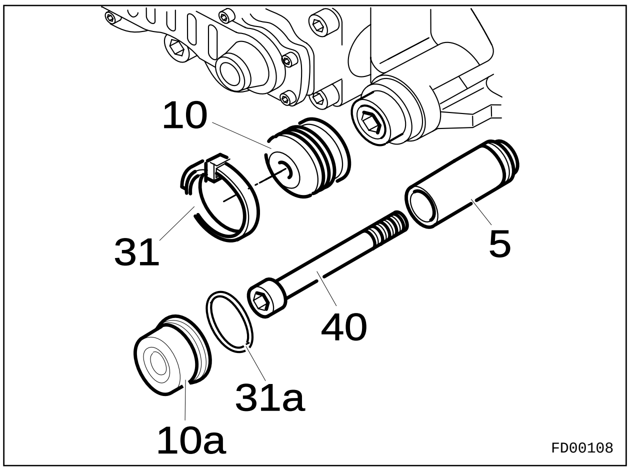
Tighten Outer Boot Clip (31)

Fit the Pads (see Section 6.2)

Attach Brake Chamber or Spring Brake (see Section 12.2 or 12.4)



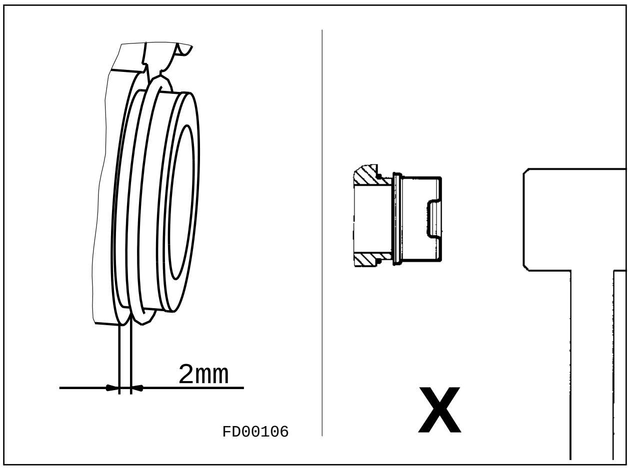
10.2.2 Caliper with Steelcap (10a)



IMPORTANT!

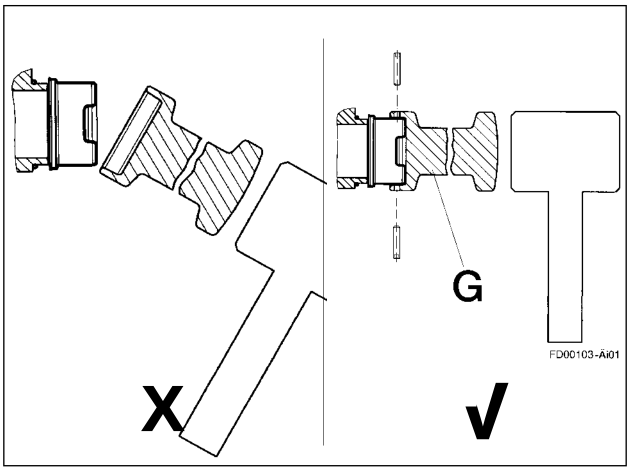
It is ***only*** *allowed to replace the Outer Boot (10) by the Steel Cap (10a) when replacing the Sleeve (5), the O-Ring (31a) and the Screw (40) at the same time. Replace only after permission by Axle- or Vehicle-manufacturer. On SB 6... (19,5“) only permissible after manufacturing date A0026. (see type plate).*

It may be easier to remove the Caliper and the Carrier from the axle to replace the Steel Cap.



Assemply at the Vehicle :

The fitting must be carried out with Pads still installed.
- Clean area.
- Using the Grease supplied (II14525), lightly lubricate the O-Ring and place it over the cast spigot (see Sketch).
- Remove Threated Pins from assembly tool (G) to avoid demage of the Steel Cap.
- Hold the new Steel Cap on the end of the Spigot. By using a suitable press or special assembly tool (Part Number Z001105) and a hammer, press the Steel Cap fully on the spigot making sure not to deform the Cap.
  After removal the Steel Cap and the O-Ring must not be refitted.



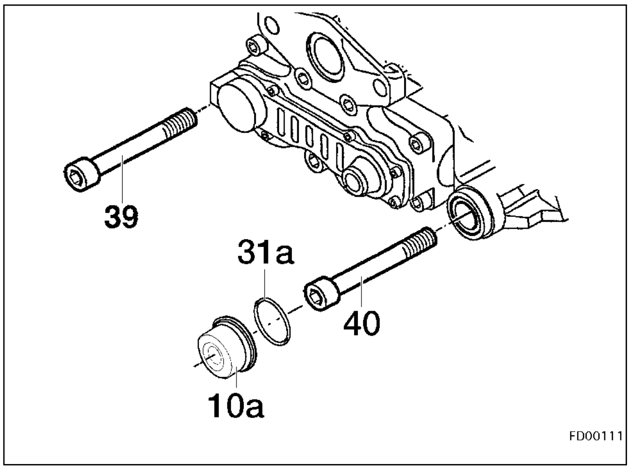
IMPORTANT!

The Steel Cap (10a) and the O-Ring must only be used once.

Assemply on the Caliper and Carrier removed from the axle:

IMPORTANT!

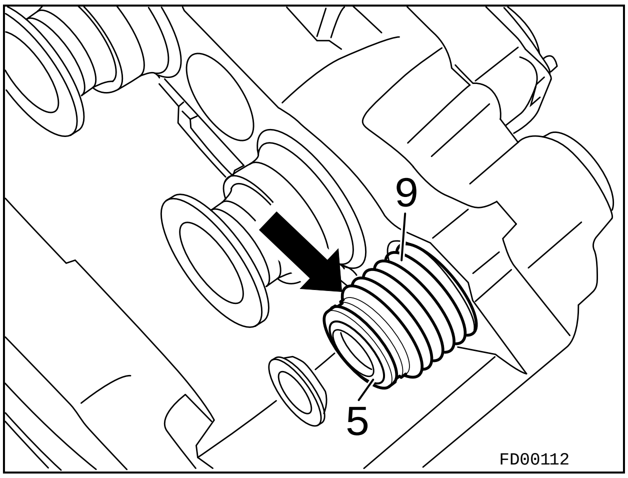
It is only allowed to replace the Outer Boot (10) by the Steel Cap (10a) when replacing the Sleeve (5), the O-Ring (31a) and the Screw (40) at the same time. Replace only after permission by Axle- or Vehicle-manufacturer. On SB 6... (19,5") only permissible after manufacturing date A0026. (see type plate).



Put the Caliper on the Carrier.

IMPORTANT!

Special threated Screw (40) and Steel Cap (10a) as well as the O-Ring (31a) must be renewed whenever Screw (40) has been removed.



Screw-in Caliper Bolts (39 and 40) and tighten to 285^{+25} Nm.

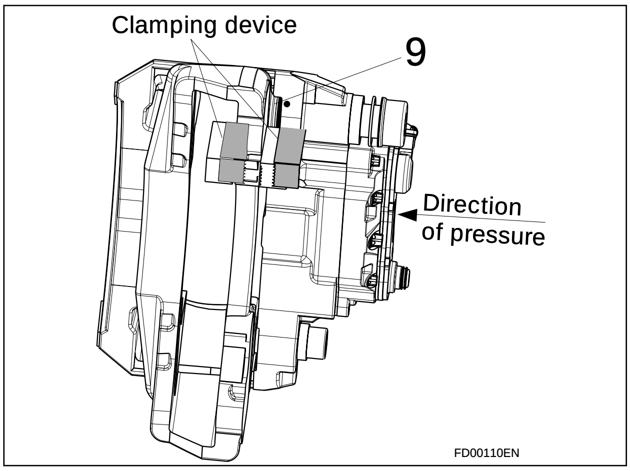
Check the position of the Inner Boot (9) on the Sleeve (5).

Check that the Caliper slides easily.

In the shown clamping (e.g. vice) press the Caliper against the Carrier as far as possible. The inner Boot (9) must be in compressed condition, this to prevent air being trapped inside of the Cap.

The assembly of the Steel Cap (10a) can now be carried out as in Section " Assembly at the Vehicle".

Check Adjuster (Section 5.2).



11 Carrier replacement
(for Axial- and Radial Disc Brake)

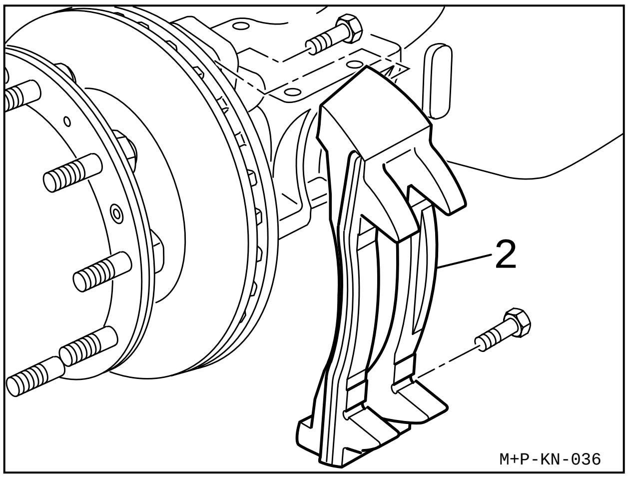
Remove Caliper (see Section 10.1).

Remove Carrier (2) from axle.

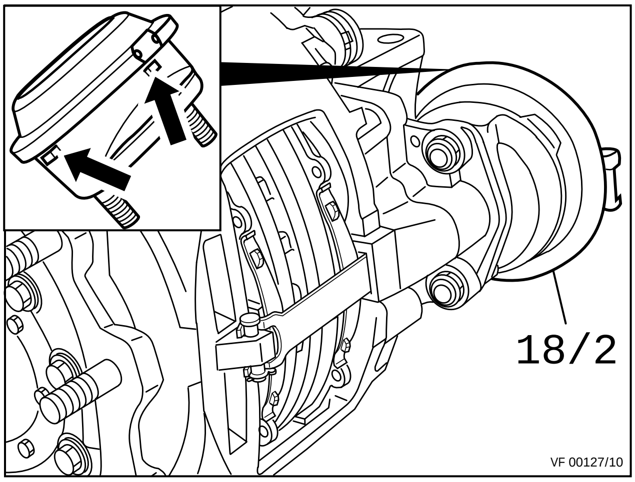
Clean axle contact area.

Attach new Carrier with new bolts from the relevant truck manufacturer. Bolts are not supplied by Knorr-Bremse.

Attach Caliper (see Section 10.2)



12 Actuation cylinder replacement
(for “Axial- and Radial Disc Brake”)



12.1 Brake Chamber removal

Disconnect air line from Brake Chamber (18/2)

Unscrew Brake Chamber Mounting Nuts (do not re-use them).

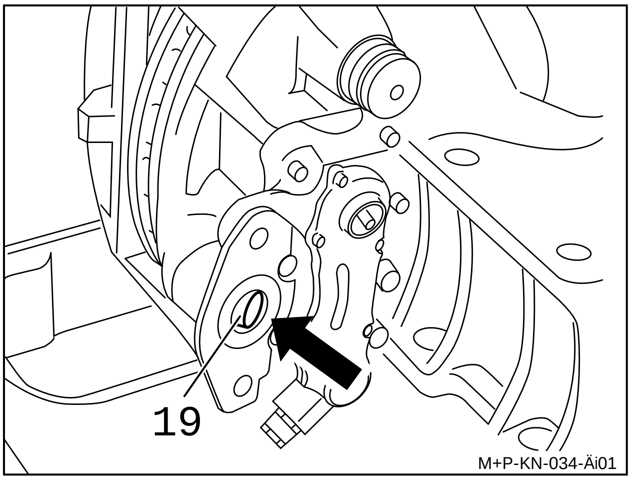
Remove Brake Chamber

12.2 Brake Chamber fitting

IMPORTANT:
New Brake Chambers (18/2) have drain plugs installed. Remove bottom plug (see arrows). All other drain holes should be plugged.

Before fitting the new Brake Actuator, the sealing surface (see arrow) must be cleaned, and the Spherical Cup (19) in the Lever must be greased with white Grease RENOLIT HLT2 (Order no II14525).

Surface area of the flange must be plain and clean.



IMPORTANT!

Do not use Grease containing molybdenum disulphate. Use only KORR-Actuators which are recommended by the Vehicle Manufacturer.

Attach Actuator with new Nuts
(self-locking EN ISO 7042) and torque tighten
to 180 $^{+30}$ Nm.

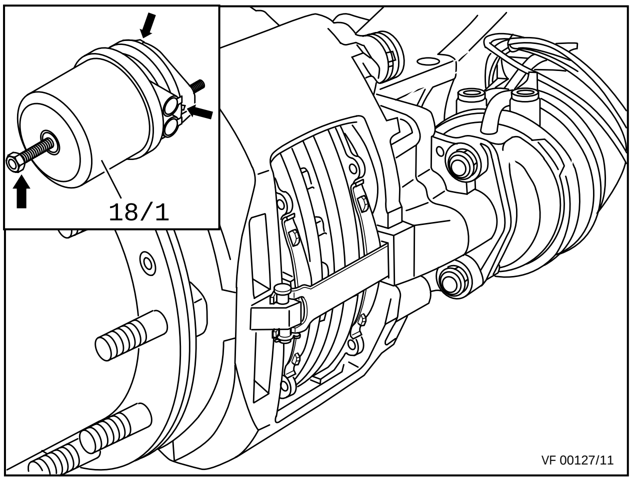
Connect air hose and check for leakage.

Make sure that hose is not twisted and that chafing is not possible.

IMPORTANT!

Check function and effectiveness of the brake.

12.3 Spring Brake removal



CAUTION!

Chock wheels before releasing Spring Brake

Release parking brake, move Hand Control Valve to ‘run’ position.

Screw-out Release Bolt (arrow) with a maximum torque of 35Nm.

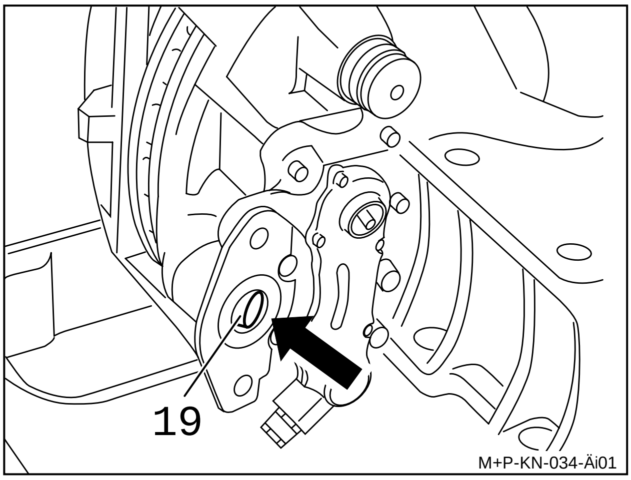
Release air from brake, move Hand Control Valve to ‘park’ position.

Disconnect air hoses from Spring Brake Actuator (18/1)

Unscrew Spring Brake Actuator Mounting Nuts (do not re-use).

Remove Spring Brake Actuator.

12.4 Spring Brake fitting



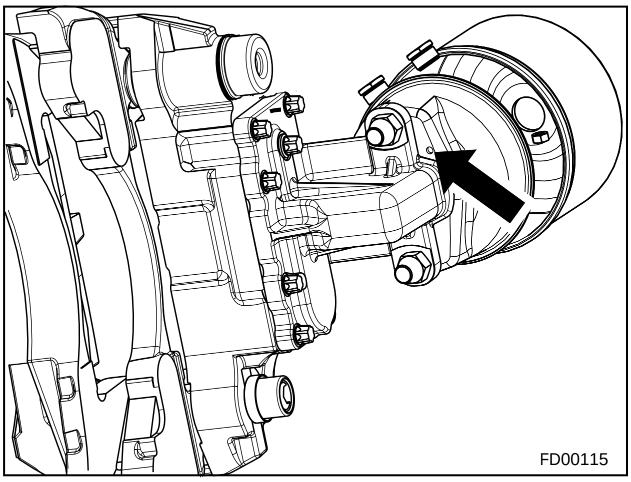
IMPORTANT!
New Spring Brake Actuators (18/1) have drain plugs installed. Remove bottom plug (see arrows).
All other drain holes should be plugged.

Before fitting the new Brake Actuator, the sealing surfaces have to be cleaned, and the Spherical Cup (19) in the Lever must be greased with white Grease RENOLIT HLT2 (Order no II14525)

Surface area of the flange must be plain and clean.

IMPORTANT!

Do not use grease containing molybdenum disulphate.
Use only KNORR-BREMSE Actuators which are recommended by the Vehicle Manufacturer.



IMPORTANT!

On Radial Disc Brake the Train Plugs in the bottom of the Cylinderflange must be open.

Attach Actuator with new Nuts
(self-locking EN ISO 7042) and torque tighten to
180^{+30} Nm.

Connect air hose, ensuring that hoses are not mixed up.

Make sure that hoses are not twisted and that chafing is not possible.

Release parking brake, move Hand Control Valve to 'run' position, and check for leakage.

Screw in Spring Brake Release bolt to maximum 70 Nm.

IMPORTANT!

Check function and effectiveness of the brake.

13 Additional information

13.1 Service Video

A Video is available for additional information.

Order number: RA-SB0002.DE Video (German)
RA-SB0002.EN Video (English)
(in UK. order KBP2060/1)
RA-SB0002.IT Video (Italian)
RA-SB0002.SP Video (Spannish)
RA-SB0002.PO Video (Portugese)
RA-SB0002.DA Video (Danish)
RA-SB0002.HU Video (Hungarian)
RA-SB0002.FR Video (French)

13.2 Service Tool Kit ZB 9032

For service and repair work we recommend our Tool Kit ZB 9032 II 37951/004EX, which contains all necessary special tools.

13.3 Diagnostic Equipment

For vehicles fitted with continuous potentiometer type wear sensors, Knorr-Bremse Diagnostic Equipment may be used to ensure quick and simple measurement of wear at each caliper.
See sections 5.4 and 5.5.

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► Bendix Commercial Vehicle Systems
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Sistemas para Veículos Comerciais
Brasil Ltda.
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$2.50

TRACTOR ABS

MERITOR WABCO

Anti-Lock Braking System (ABS) for Trucks, Tractors and Buses

Maintenance Manual MM-0112
Revised 04-01

- For E Version ECUs
- 12-Volt Systems

Before You Begin

This manual provides instructions for Meritor WABCO's anti-lock braking system for trucks, tractors and buses. Before you begin procedures:

1. Read and understand all instructions and procedures before you begin to service components.
2. Read and observe all Caution and Warning safety alerts that precede instructions or procedures you will perform. These alerts help to avoid damage to components, serious personal injury, or both.
3. Follow your company's maintenance and service, installation, and diagnostics guidelines.
4. Use special tools when required to help avoid serious personal injury and damage to components.

Safety Alerts, Torque Symbol and Notes

⚠ ***WARNING***	A Warning alerts you to an instruction or procedure that you must follow exactly to avoid serious personal injury and damage to components.
⚠ ***CAUTION***	A Caution alerts you to an instruction or procedure that you must follow exactly to avoid damage to components and possible serious injury.
T	A torque symbol alerts you to tighten fasteners to a specified torque value.
NOTE	A Note provides information or suggestions that help you correctly service a component.

Access Information on ArvinMeritor's Web Site

Additional maintenance and service information for ArvinMeritor's commercial vehicle systems component lineup is also available at www.arvinmeritor.com.

To access information, click on Products & Services/Tech Library Icon/HVS Publications. The screen will display an index of publications by type.

Additional Information

Call ArvinMeritor's Customer Service Center at 800-535-5560 to order the following item.

- *Drivetrain Plus™ by ArvinMeritor Technical Electronic Library* on CD. Features product and service information on most Meritor, ZF Meritor and Meritor WABCO products. $20. Order TP-9853.

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Asbestos and Non-Asbestos Fibers

ASBESTOS FIBERS WARNING

The following procedures for servicing brakes are recommended to reduce exposure to asbestos fiber dust, a cancer and lung disease hazard. Material Safety Data Sheets are available from ArvinMeritor.

Hazard Summary

Because some brake linings contain asbestos, workers who service brakes must understand the potential hazards of asbestos and precautions for reducing risks. Exposure to airborne asbestos dust can cause serious and possibly fatal diseases, including asbestosis (a chronic lung disease) and cancer, principally lung cancer and mesothelioma (a cancer of the lining of the chest or abdominal cavities). Some studies show that the risk of lung cancer among persons who smoke and who are exposed to asbestos is much greater than the risk for non-smokers. Symptoms of these diseases may not become apparent for 15, 20 or more years after the first exposure to asbestos.

Accordingly, workers must use caution to avoid creating and breathing dust when servicing brakes. Specific recommended work practices for reducing exposure to asbestos dust follow. Consult your employer for more details.

Recommended Work Practices

1. Separate Work Areas. Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons. OSHA has set a maximum allowable level of exposure for asbestos of 0.1 f/cc as an 8-hour time-weighted average and 1.0 f/cc averaged over a 30-minute period. Scientists disagree, however, to what extent adherence to the maximum allowable exposure levels will eliminate the risk of disease that can result from inhaling asbestos dust. OSHA requires that the following sign be posted at the entrance to areas where exposures exceed either of the maximum allowable levels:

DANGER: ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE CLOTHING
ARE REQUIRED IN THIS AREA.

2. Respiratory Protection. Wear a respirator equipped with a high-efficiency (HEPA) filter approved by NIOSH or MSHA for use with asbestos at all times when servicing brakes, beginning with the removal of the wheels.

3. Procedures for Servicing Brakes.

a. Enclose the brake assembly within a negative pressure enclosure. The enclosure should be equipped with a HEPA vacuum and worker arm sleeves. With the enclosure in place, use the HEPA vacuum to loosen and vacuum residue from the brake parts.

b. As an alternative procedure, use a catch basin with water and a biodegradable, non-phosphate, water-based detergent to wash the brake drum or rotor and other brake parts. The solution should be applied with low pressure to prevent dust from becoming airborne. Allow the solution to flow between the brake drum and the brake support or the brake rotor and caliper. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.

c. If an enclosed vacuum system or brake washing equipment is not available, employers may adopt their own written procedures for servicing brakes, provided that the exposure levels associated with the employer's procedures do not exceed the levels associated with the enclosed vacuum system or brake washing equipment. Consult OSHA regulations for more details.

d. Wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA for use with asbestos when grinding or machining brake linings. In addition, do such work in an area with a local exhaust ventilation system equipped with a HEPA filter.

e. **NEVER** use compressed air by itself, dry brushing, or a vacuum not equipped with a HEPA filter when cleaning brake parts or assemblies. **NEVER** use carcinogenic solvents, flammable solvents, or solvents that can damage brake components as wetting agents.

4. Cleaning Work Areas. Clean work areas with a vacuum equipped with a HEPA filter or by wet wiping. **NEVER** use compressed air or dry sweeping to clean work areas. When you empty vacuum cleaners and handle used rags, wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA for use with asbestos. When you replace a HEPA filter, wet the filter with a fine mist of water and dispose of the used filter with care.

5. Worker Clean-Up**.** After servicing brakes, wash your hands before you eat, drink or smoke. Shower after work. Do not wear work clothes home. Use a vacuum equipped with a HEPA filter to vacuum work clothes after they are worn. Launder them separately. Do not shake or use compressed air to remove dust from work clothes.

6. Waste Disposal. Dispose of discarded linings, used rags, cloths and HEPA filters with care, such as in sealed plastic bags. Consult applicable EPA, state and local regulations on waste disposal.

Regulatory Guidance

References to OSHA, NIOSH, MSHA, and EPA, which are regulatory agencies in the United States, are made to provide further guidance to employers and workers employed within the United States. Employers and workers employed outside of the United States should consult the regulations that apply to them for further guidance.

NON-ASBESTOS FIBERS WARNING

The following procedures for servicing brakes are recommended to reduce exposure to non-asbestos fiber dust, a cancer and lung disease hazard. Material Safety Data Sheets are available from ArvinMeritor.

Hazard Summary

Most recently manufactured brake linings do not contain asbestos fibers. These brake linings may contain one or more of a variety of ingredients, including glass fibers, mineral wool, aramid fibers, ceramic fibers and silica that can present health risks if inhaled. Scientists disagree on the extent of the risks from exposure to these substances. Nonetheless, exposure to silica dust can cause silicosis, a non-cancerous lung disease. Silicosis gradually reduces lung capacity and efficiency and can result in serious breathing difficulty. Some scientists believe other types of non-asbestos fibers, when inhaled, can cause similar diseases of the lung. In addition, silica dust and ceramic fiber dust are known to the State of California to cause lung cancer. U.S. and international agencies have also determined that dust from mineral wool, ceramic fibers and silica are potential causes of cancer.

Accordingly, workers must use caution to avoid creating and breathing dust when servicing brakes. Specific recommended work practices for reducing exposure to non-asbestos dust follow. Consult your employer for more details.

Recommended Work Practices

1. Separate Work Areas. Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons.

2. Respiratory Protection. OSHA has set a maximum allowable level of exposure for silica of 0.1 mg/m^3 as an 8-hour time-weighted average. Some manufacturers of non-asbestos brake linings recommend that exposures to other ingredients found in non-asbestos brake linings be kept below 1.0 f/cc as an 8-hour time-weighted average. Scientists disagree, however, to what extent adherence to these maximum allowable exposure levels will eliminate the risk of disease that can result from inhaling non-asbestos dust.

Therefore, wear respiratory protection at all times during brake servicing, beginning with the removal of the wheels. Wear a respirator equipped with a high-efficiency (HEPA) filter approved by NIOSH or MSHA, if the exposure levels may exceed OSHA or manufacturers' recommended maximum levels. Even when exposures are expected to be within the maximum allowable levels, wearing such a respirator at all times during brake servicing will help minimize exposure.

3. Procedures for Servicing Brakes.

a. Enclose the brake assembly within a negative pressure enclosure. The enclosure should be equipped with a HEPA vacuum and worker arm sleeves. With the enclosure in place, use the HEPA vacuum to loosen and vacuum residue from the brake parts.

b. As an alternative procedure, use a catch basin with water and a biodegradable, non-phosphate, water-based detergent to wash the brake drum or rotor and other brake parts. The solution should be applied with low pressure to prevent dust from becoming airborne. Allow the solution to flow between the brake drum and the brake support or the brake rotor and caliper. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.

c. If an enclosed vacuum system or brake washing equipment is not available, carefully clean the brake parts in the open air. Wet the parts with a solution applied with a pump-spray bottle that creates a fine mist. Use a solution containing water, and, if available, a biodegradable, non-phosphate, water-based detergent. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.

d. Wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA when grinding or machining brake linings. In addition, do such work in an area with a local exhaust ventilation system equipped with a HEPA filter.

e. **NEVER** use compressed air by itself, dry brushing, or a vacuum not equipped with a HEPA filter when cleaning brake parts or assemblies. **NEVER** use carcinogenic solvents, flammable solvents, or solvents that can damage brake components as wetting agents.

4. Cleaning Work Areas. Clean work areas with a vacuum equipped with a HEPA filter or by wet wiping. **NEVER** use compressed air or dry sweeping to clean work areas. When you empty vacuum cleaners and handle used rags, wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA, to minimize exposure. When you replace a HEPA filter, wet the filter with a fine mist of water and dispose of the used filter with care.

5. Worker Clean-Up. After servicing brakes, wash your hands before you eat, drink or smoke. Shower after work. Do not wear work clothes home. Use a vacuum equipped with a HEPA filter to vacuum work clothes after they are worn. Launder them separately. Do not shake or use compressed air to remove dust from work clothes.

6. Waste Disposal**.** Dispose of discarded linings, used rags, cloths and HEPA filters with care, such as in sealed plastic bags. Consult applicable EPA, state and local regulations on waste disposal.

Regulatory Guidance

References to OSHA, NIOSH, MSHA, and EPA, which are regulatory agencies in the United States, are made to provide further guidance to employers and workers employed within the United States. Employers and workers employed outside of the United States should consult the regulations that apply to them for further guidance.

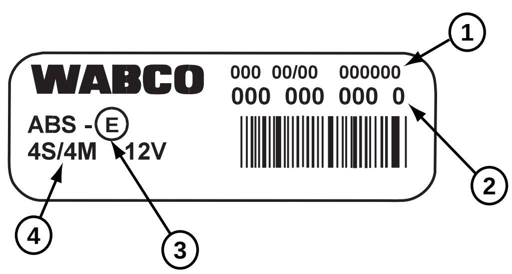
Notes

Contents

This manual contains service information for E version Meritor WABCO Anti-Lock Braking System (ABS) and ABS with Automatic Traction Control (ATC) for trucks, tractors and buses. E version ABS incorporates Power Line Carrier Communication (PLC), an optional feature that allows tractor/trailer communication. For the driver, this means that a trailer ABS indicator lamp located on the vehicle dash will come on if a fault occurs in the trailer ABS — if the trailer is equipped with PLC.

NOTE: For diagnostic and testing procedures for systems with C version ECUs, use Maintenance Manual 28. For D version ECUs, use Maintenance Manual 30. The ABS version is marked on the ECU. **Figure 1.1**. If you cannot identify the ECU version installed on your vehicle, contact ArvinMeritor's Customer Service Center at 800-535-5560.

Figure 1.1



1. **Manufacturing Information**
2. **Part Number**
3. **ECU Version**
4. **ABS Configuration**

How ABS Works

Meritor WABCO ABS is an electronic system that monitors and controls wheel speed during braking. The system works with standard air brake systems.

ABS monitors wheel speeds at all times and controls braking during wheel lock situations. The system improves vehicle stability and control by reducing wheel lock during braking.

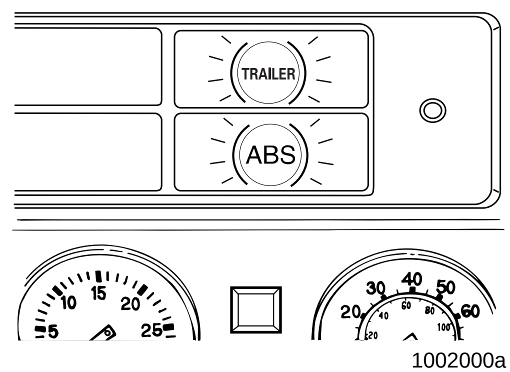
The ECU receives and processes signals from the wheel speed sensors. When the ECU detects a wheel lockup, the unit activates the appropriate modulator valve, and air pressure is controlled.

In the event of a malfunction in the system, the ABS in the affected wheel(s) is disabled; that wheel still has normal brakes. The other wheels keep the ABS function.

Two ABS indicator lamps, one for tractor and one for trailer, let drivers know the status of the system. The tractor ABS lamp is also used to display tractor blink code diagnostics. **Figure 1.2**. The location of the ABS indicator lamps vary, depending on the make and model of the vehicle.

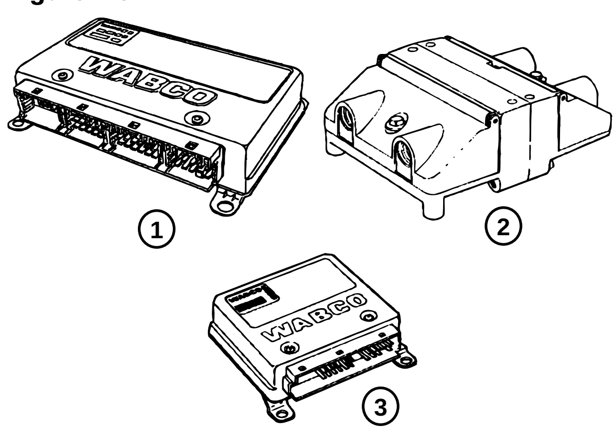
Blink code diagnostics information for trailer ABS is not included in this manual. Use Maintenance Manual 33 for Meritor WABCO Easy-Stop™ Trailer ABS for trailer diagnostics.

Figure 1.2



NOTE: Do not open the ECU. Opening the ECU to gain access to the internal components will void the warranty.

Figure 1.3



1. **Universal ECU**
2. **Frame-mounted ECU**
3. **Basic ECU**

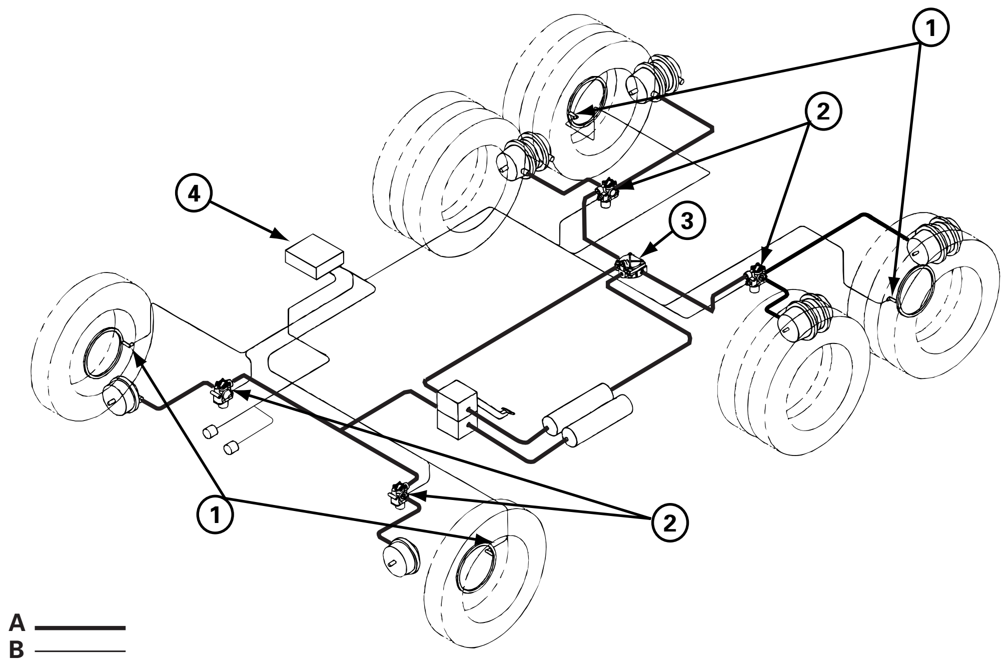
ABS Configuration

NOTE: With E Basic, 4S/4M is the only configuration used.

The ABS configuration is defined by the number of wheel end sensors and modulator valves. There are three common ABS configurations used with E version ECUs:

- 4S/4M (4 wheel speed sensors, 4 modulator valves) **Figure 1.4.**
- 6S/4M (6 wheel speed sensors, 4 modulator valves)
- 6S/6M (6 wheel speed sensors, 6 modulator valves)

Figure 1.4



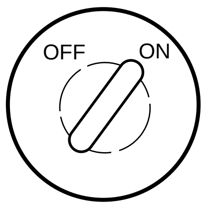
A. Air Lines	**1. Wheel Speed Sensors**	**3. Relay Valve**
B. Electrical Lines	**2. ABS Modulator Valves**	**4. ECU**

4S/4M Configuration

NOTE: Typical illustrations in this manual use the 4S/4M configuration as a sample. Layouts for 4S/4M, 6S/4M, and 6S/6M configurations are included in Appendix I.

ABS Indicator Lamp

The ABS indicator lamp works as follows:

Ignition ON 	Normal Operation	ABS lamp comes on at ignition momentarily for a bulb check, then goes out.	System is O.K.
	After servicing ABS	ABS lamp does not go out at ignition.	When vehicle is driven at speeds above 4 mph (6 km/h), lamp goes out. System is O.K.
	Off-road ABS operation. Refer to "Off-Road ABS" in this section.	ABS lamp flashes during vehicle operation.	The vehicle's normal ABS function is being modified due to road conditions.
	Existing Fault	ABS lamp does not go out at ignition.	Lamp does not go out at speeds above 4 mph (6 km/h) — a fault exists in the ABS system.

NOTE: If the ECU senses a tractor ABS fault during normal vehicle operation, the ABS indicator lamp will come on and stay on.

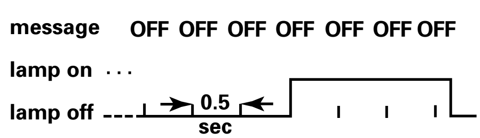
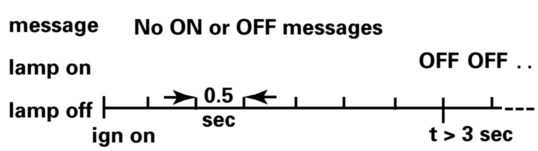
Trailer ABS Indicator Lamp

The trailer ABS indicator lamp on vehicle dash applies to Trailer ABS only. The lamp is controlled by a signal to the tractor ECU, sent over the power line (PLC function). When a trailer ABS fault is detected, an ON message is sent, when no fault is detected, the ECU receives an OFF message. **Table A** illustrates trailer ABS lamp operation at power-up, or ignition on. **Table B** depicts lamp responses that occur during operation.

Lamp turn ON and OFF messages do not turn the lamp ON or OFF instantly. The delay between the receipt of the message and the lamp response time is intentional. It prevents erratic lamp activity.

NOTE: For doubles or triples, the lamp does not distinguish between trailers. A system fault in any of the trailers will activate the trailer ABS indicator lamp.

Table A: Dash-mounted Trailer ABS Indicator Lamp Operation — Bulb Check (Information for Drivers)

Signal from trailer to tractor ECU	Status of Trailer ABS Lamp on vehicle dash	Explanation
Single or Multiple Trailers 	Trailer ABS lamp comes on at ignition, OFF message is detected within three seconds of ignition, Trailer ABS lamp goes out.	Bulb Check performed AND Trailer ABS system is OK. In this case, the lamp is ON for a Bulb Check only.
Single or Multiple Trailers 	Trailer ABS lamp does not come on within three seconds of ignition.	No Bulb Check, trailer added after initial power-up, system OK. There was no trailer PLC message for at least three seconds following ignition ON.

ON = Turn ON message to "trailer ABS" lamp

OFF = Turn OFF message to "trailer ABS" lamp

Removing a trailer with a Fault will cause ABS lamp to turn off. Remember to have trailer with fault repaired as soon as possible before returning to service.

Table B: Dash-mounted Trailer ABS Indicator Lamp Operation (Information for Service Technicians)

Signal from trailer to tractor ECU	Status of Trailer ABS Lamp on vehicle dash	Explanation	Action
Single or Multiple Trailers **message** **No ON or OFF messages** **lamp on** **lamp off** **0.5 sec**	Trailer ABS lamp does not come on within three seconds of ignition.	Not using the PLC system (no trailer connected) or trailer not equipped with PLC or fault in PLC system.	Use lamp on side of trailer to identify fault. Make necessary repairs.
Single Trailer **message** **OFF OFF OFF ON ON ON ON ON** **lamp on** **lamp off** **0.5 sec**	Trailer ABS lamp comes on.	Trailer ABS fault(s) occurred during operation and still exists.	
Multiple Trailers/Dollies **message** **OFF OFF OFF OFF OFF OFF OFF** **OFF OFF OFF ON ON ON ON** **lamp on** **lamp off** **0.5 sec**			
Single Trailer **message** **ON ON OFF OFF OFF OFF OFF OFF** **lamp on** **lamp off** **0.5 sec** **t + 2.5**	Trailer ABS lamp comes on but goes out after 2.5 seconds after fault is detected.	Trailer ABS fault occurred during operation and the fault was corrected.	None
Multiple Trailers/Dollies **message** **OFF OFF OFF OFF OFF OFF OFF** **ON ON OFF OFF OFF OFF OFF OFF** **lamp on** **lamp off** **0.5 sec** **t + 2.5**			
Single Trailer **message** **ON ON ON No ON or OFF messages** **lamp on** **lamp off** **0.5 sec** **t** **t + 10 sec**	ABS lamp is off, comes on, then goes off, 10 seconds after loss of messages.	ABS fault existed, then signal was lost because trailer disconnected or PLC fault.	Use lamp on side of trailer to identify fault. Make necessary repairs.
Multiple Trailers/Dollies **message** **OFF OFF OFF OFF OFF OFF OFF** **ON ON** **lamp on** **lamp off** **0.5 sec** **t + 2.5**		ABS fault existed, then trailer with fault lost signal because trailer was disconnected or PLC fault.	
Single Trailer to Multiples **message** **OFF OFF OFF** **lamp on** **ON ON ON ON ON ON** **lamp off** **0.5 sec**	ABS lamp is on and stays on when a new trailer with no new fault is added.	There was a fault in existence before the new trailer was added AND the ignition was not turned off before the trailer was added.	
Single Trailer to Multiples **ON ON ON** **message** **ON ON ON ON ON ON** **lamp on** **lamp off** **0.5 sec**	ABS lamp is on and stays on when a new trailer with a new fault is added.	ABS fault was in existence before the new trailer was added AND the ignition was not turned off before the trailer was added AND the new trailer has an ABS fault.	

ON = Turn ON message to "trailer ABS" lamp

OFF = Turn OFF message to "trailer ABS" lamp

Removing a trailer with a Fault will cause ABS lamp to turn off. Remember to have trailer with fault repaired as soon as possible before returning to service.

ABS Modulator Valves

Modulator valves control the air pressure to each affected brake during an ABS function.

Valve Arrangement Option

In **Figure 1.4** on page 4, the modulator valves on the rear axle are mounted separately and a relay valve is used to deliver air pressure to the modulator valves. There is also an optional valve package available from Meritor WABCO, the ABS Valve Package, which may be found on certain vehicle models. The **ABS valve package** may be used on all D and E version units, including D and E Basic, and is available for front or rear axle installation.

Easy Listening Tip!

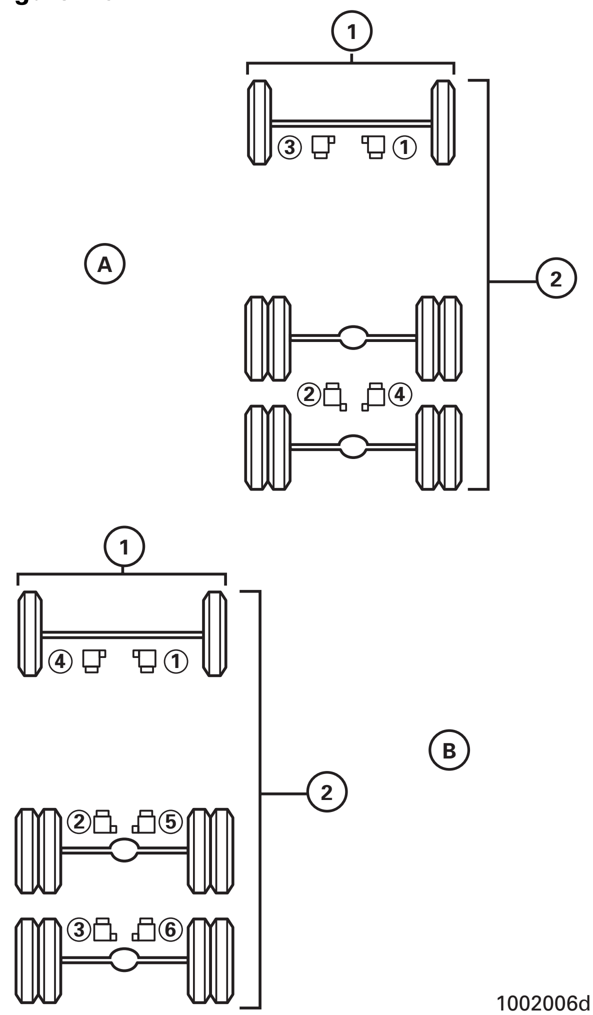
To make sure the ABS valves are working — just listen! Refer to **Figure 1.5**.

1. Apply the brakes.
2. Turn on the ignition.
3. Wait for the ABS indicator lamp to come on.
4. Listen to the valves cycle one by one, as follows:

   NOTE: In previous versions of ABS, the valves are cycled diagonally. Diagonal cycling does not occur with E version ABS.

   - 4M (channel) valve cycle order: 1 – 2 – 3 – 4
   - 6M (channel) valve cycle order: 1 – 2 – 3 – 4 – 5 – 6

Figure 1.5

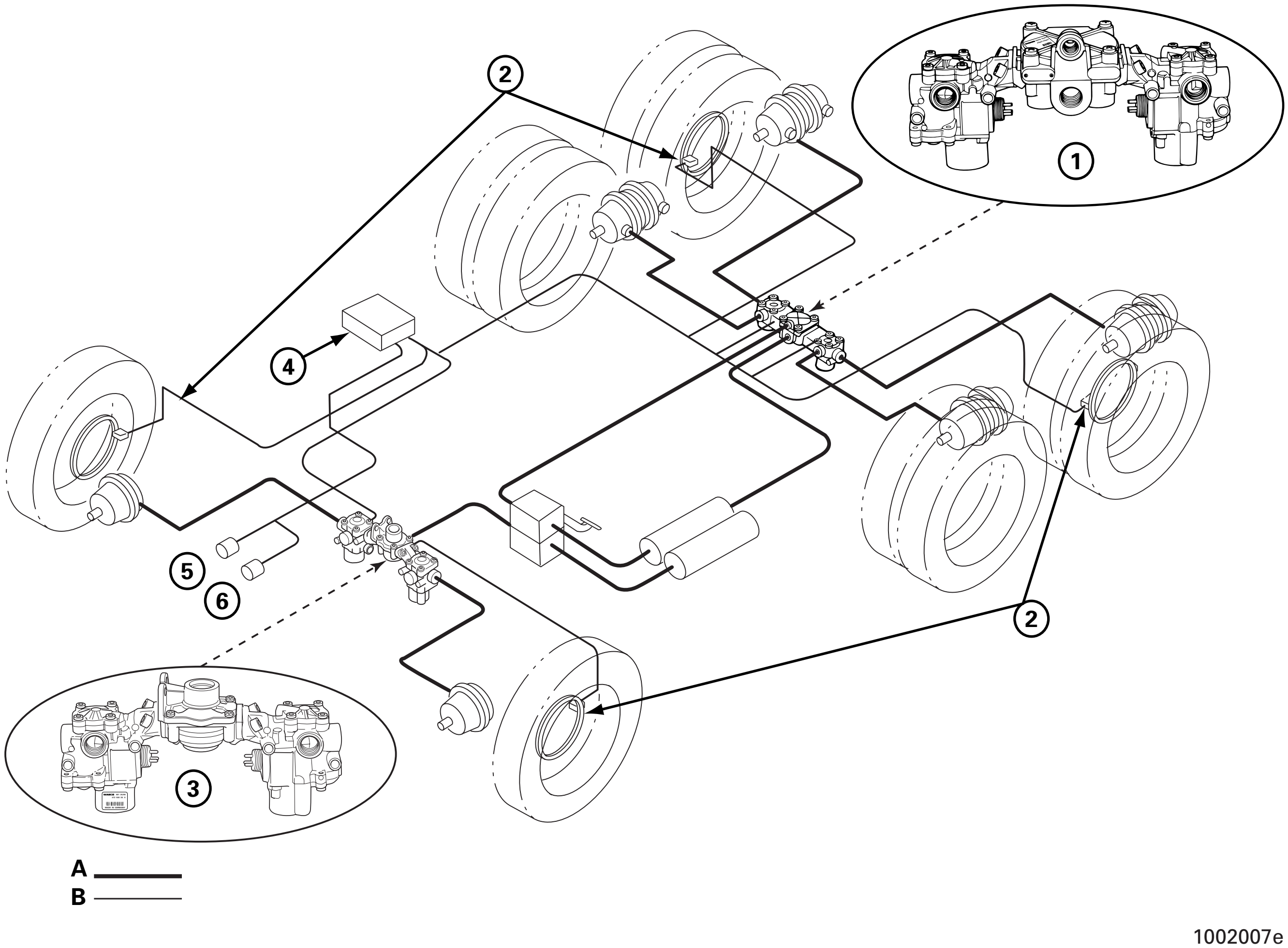


A. **4M Channel**
B. **6M Channel**
1. **Cab**
2. **Curbside**

ABS Valve Packages

The front ABS valve package combines a quick release valve with two ABS modulator valves and is mounted in the front of the vehicle. The rear ABS valve package combines a service brake relay valve with two ABS modulator valves and is mounted in the rear of the vehicle. The valve package — front or rear — must be mounted near the brake chambers it serves. **Figure 1.6.**

Figure 1.6



A. Air Lines
B. Electrical Lines
1. Rear ABS Valve Package
2. Wheel Speed Sensors
3. Front ABS Valve Package
4. ECU
5. Tractor ABS Indicator Lamp
6. Trailer ABS Indicator Lamp

4S/4M Configuration

ABS Sensors

ABS sensor systems consist of a tooth wheel mounted on the hub of each monitored wheel and a sensor installed so that its end is against the tooth wheel. The sensor continuously sends wheel speed information to the ECU. A sensor clip holds the sensor in place at the tooth wheel.

The type of axle determines sensor mounting location:

- Steering axle sensors are installed in the steering knuckle or in a bolted-on bracket.
- Drive axle sensors are mounted in a block attached to the axle housing or in a bolted-on bracket.

Off-Road ABS

On some vehicles, an off-road ABS function may be selected. Off-road ABS improves vehicle control and helps reduce stopping distances in off-road conditions or on poor traction surfaces such as loose gravel, sand and dirt. **This option is not available on 4S/4M Frame-mounted ECUs.**

NOTE: On vehicles equipped with an off-road switch, the off-road ABS mode is manually selected by the driver. On some vehicles, the off-road mode may be fully automatic. Refer to the vehicle specifications for information about the off-road ABS feature.

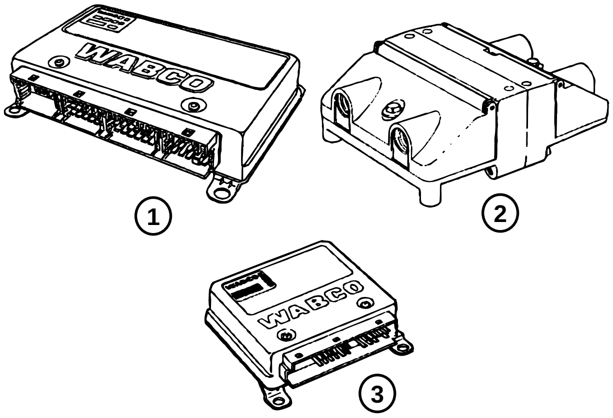
The ABS indicator lamp on the dash will flash while the vehicle is in the off-road mode. This alerts the driver that the vehicle's normal ABS function is being modified.

Automatic Traction Control (ATC)

ATC is an option with Basic and Frame-mounted E version ECUs. It is available with all Universal ECUs. ATC can be used with individual valves, or with an integrated ABS/ATC valve package. Section 2 describes ATC in detail.

System Components

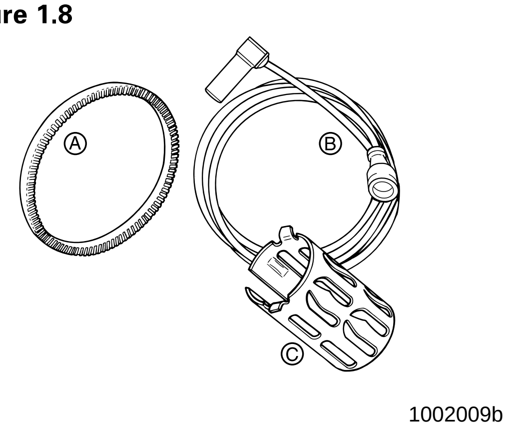
Figure 1.7



1. **Universal ECU**
2. **Frame-mounted ECU**
3. **Basic ECU**

The ECU is the brain of the ABS system. It receives information from the sensors and sends signals to the ABS valves. ECUs are available for cab- or Frame-mounted applications. Basic and Universal ECUs are cab-mounted. **Figure 1.7.**

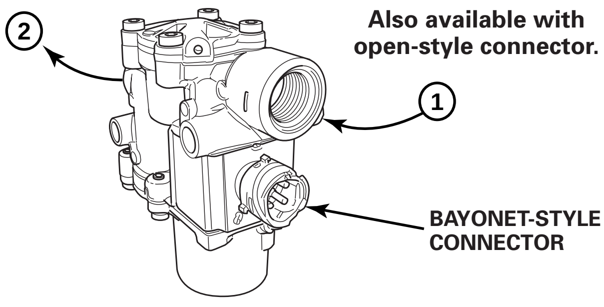
Figure 1.8



A tooth wheel (A) is mounted at, or cast in, the hub of each sensed wheel, with a sensor (B) installed so that its end is against the tooth wheel. A sensor clip (C) holds the sensor in place at the tooth wheel. **Figure 1.8.**

NOTE: The sensor and clip must be greased with Meritor WABCO-recommended lubricant. Refer to "Sensor Lube Specification" in Section 4 for lube specification.

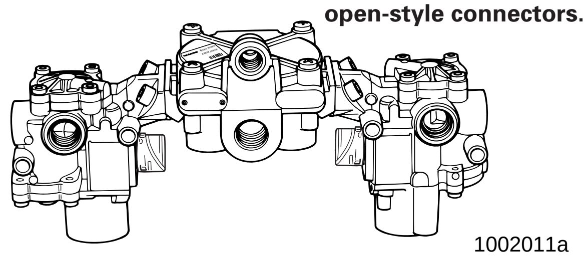
Figure 1.9



1. **Air In (Port 1)**
2. **Air Out (Port 2)**

An **ABS modulator valve** controls air pressure to each affected brake during an ABS event. The modulator valve is usually located on a frame rail or cross member near the brake chamber. The modulator valve is available in bayonet-style (**Figure 1.9**) or open-style connector.

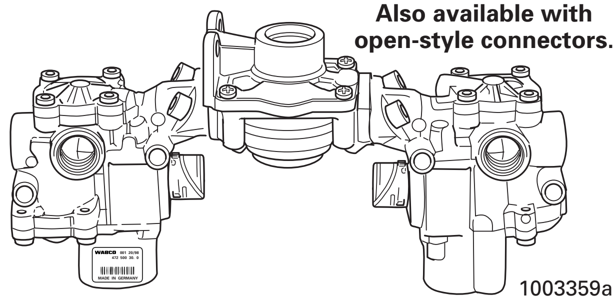
Figure 1.10



The **ABS valve package** is an alternative to individual valves.

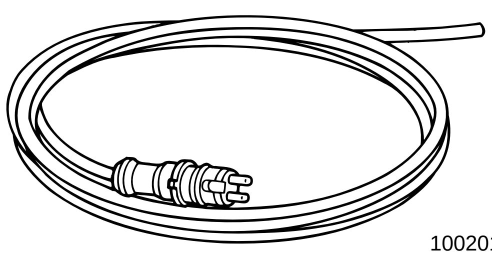
The **rear ABS valve package** combines two modulator valves and one service relay valve. **Figure 1.10.**

Figure 1.11



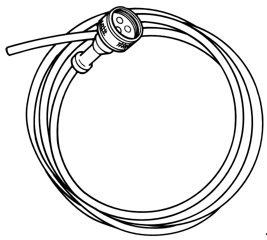
The **front ABS valve package** combines two modulator valves and a quick release valve. **Figure 1.11.**

Figure 1.12



Sensor cables connect the sensor to the ECU. **Figure 1.12.**

Figure 1.13



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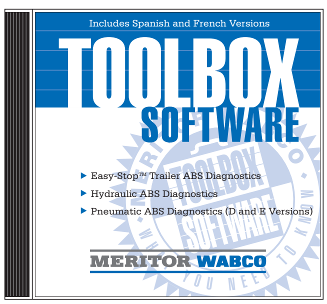
ABS modulator valve cables connect the modulator valve to the ECU. **Figure 1.13.**

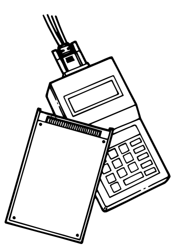
Figure 1.14



Available from SPX (Kent-Moore), 800-328-6657

TOOLBOX Software is a PC-based diagnostics program that can display wheel speed data, test individual components, verify installation wiring and more. Runs in Windows® 95, 98 and NT. An RS232 to J1708 convertor box is required. Versions 3.2 and higher support E version ABS.

Figure 1.15



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Available from SPX (Kent-Moore), 800-328-6657

The **MPSI Pro-Link® 9000** with a multiple protocol cartridge (MPC) and Meritor WABCO applications card, version 2.0 or higher, provides diagnostic and testing capabilities for the E version ABS. **Figure 1.15.**

NOTE: The PLC functions of E version ABS cannot be tested with the Pro-Link.

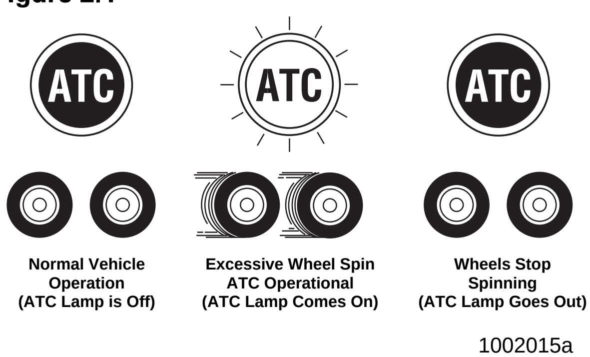
ATC

Automatic Traction Control (ATC) is available as an option on all E version ABS ECUs and is standard on most. ATC can be used with individual valves, or with an integrated ABS/ATC valve package. ATC helps improve traction when vehicles are on slippery surfaces by reducing drive wheel overspin. ATC works automatically in two different ways:

1. If a drive wheel starts to spin, ATC applies air pressure to brake the wheel. This transfers engine torque to the wheels with better traction.
2. If all drive wheels spin, ATC reduces engine torque to provide improved traction.

ATC turns itself on and off, drivers do not have to select this feature. If drive wheels spin during acceleration, the ATC indicator lamp comes on, indicating ATC is active. It goes out when the drive wheels stop spinning. **Figure 2.1**.

Figure 2.1



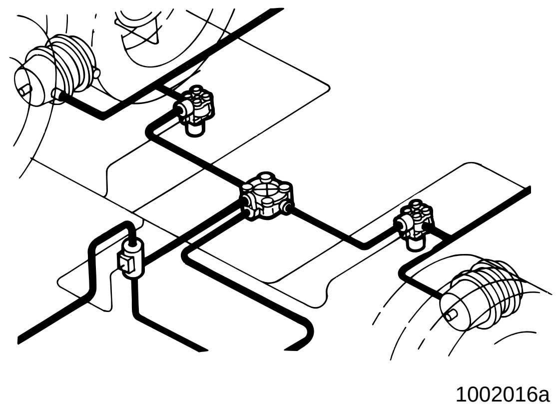
NOTE: Some vehicle manufacturers may refer to ATC as Anti-Spin Regulation (ASR).

If ATC is installed, there will be an indicator lamp on the vehicle dash or instrument panel marked ATC or ASR.

If the ATC lamp goes out before the ABS lamp, there is no ATC.

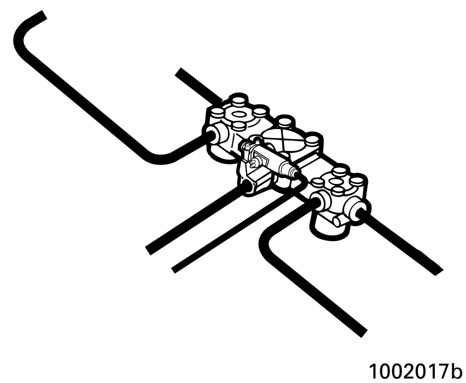
An ATC installation may use an individually mounted valve, or the valve may be part of the ABS valve package. **Figures 2.2 and 2.3.**

Figure 2.2



Individual ATC Valve

Figure 2.3



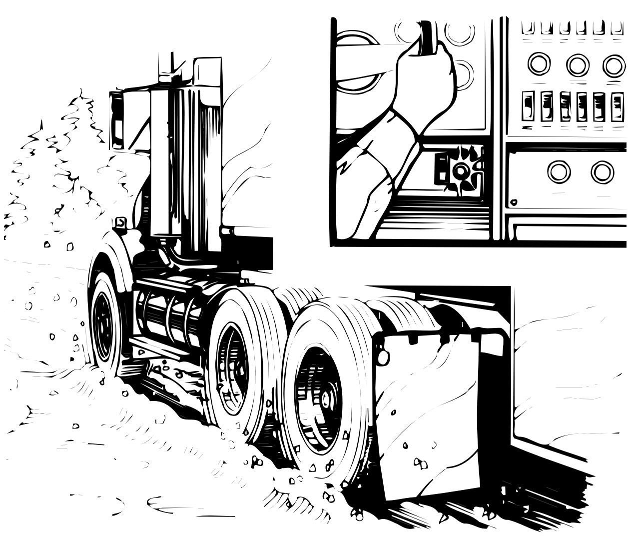
ABS/ATC Valve Package

Deep Snow and Mud Switch

A deep snow and mud option switch is included with ATC. This function increases available traction on extra soft surfaces like snow, mud or gravel, by slightly increasing the permissible wheel spin.

Drivers use a deep snow and mud switch to select this feature. When this function is in use, the ATC indicator lamp blinks continuously. **Figure 2.4.**

Figure 2.4



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Switch and lamp locations will vary, depending on the vehicle make and model.

Here's how the Deep Snow and Mud feature works:

Driver Action	System Response	Function: Active	Function: Not Active
Press deep snow and mud switch	ATC lamp blinks continuously	X	
Press switch again	ATC lamp stops blinking		X

NOTE: Turning off the ignition will also deactivate the deep snow and mud feature.

ATC Components

ATC may be used with individual ABS modulator valves, or installed with the ABS Valve Package.

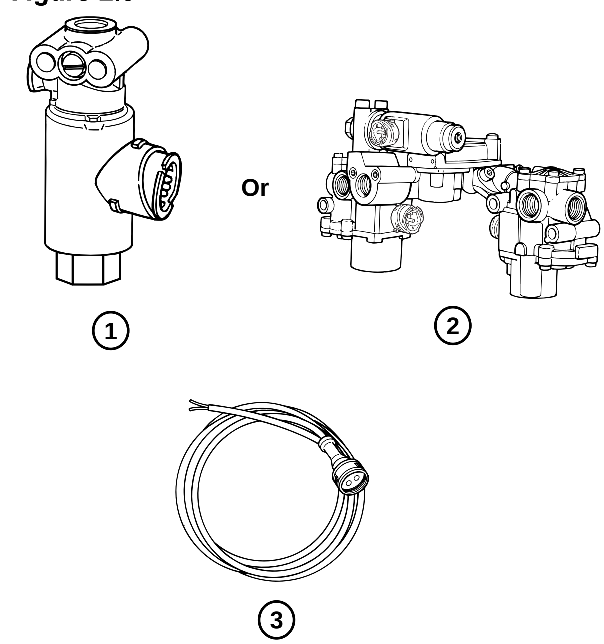
When installed with individual ABS modulator valves, an ATC solenoid valve is mounted on the frame or cross member, near the rear of the vehicle.

When it is part of the ABS valve package, an ATC valve is attached to the relay valve.

A cable connects the ECU to the ATC valve.

ATC components are illustrated in **Figure 2.5.**

Figure 2.5



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1. **ATC Valve (also available with open-style connector)**
2. **ABS/ATC Valve Package**
3. **Cable**

General Maintenance Information

There is no regularly scheduled maintenance required for the Meritor WABCO ABS or ABS/ATC. However, ABS does not change current vehicle maintenance requirements.

LAMP CHECK

To make sure the ABS tractor lamp is operating, drivers should check the lamp every time the vehicle is started. When the vehicle is started, the ABS lamp should come on momentarily. If it does not come on, it could mean a burned-out bulb.

System Diagnostics

Use any of the following methods to diagnose E version ABS:

- TOOLBOX Software, version 3.2 or higher, a PC-based ABS diagnostic and testing program that runs in Windows 95, 98 or NT
- Blink Codes — Tractor ABS only
- MPSI Pro-Link with MPC and Meritor WABCO applications card, version 2.0 or higher
- OEM Diagnostic Displays (Refer to the Vehicle Operator's Manual)

Information about TOOLBOX Software, MPSI Pro-Link and Blink Codes follows. If you have any questions about system diagnostics, please contact ArvinMeritor's Customer Service Center at 800-535-5560.

TOOLBOX Software

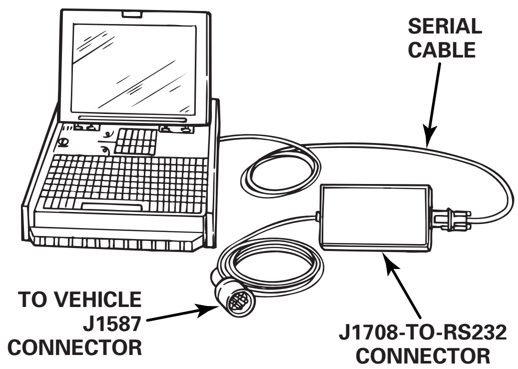
NOTE: For complete instructions for using TOOLBOX Software, refer to the User's Manual.

If you have TOOLBOX Software installed on your computer, use it to identify system faults. Then, follow the on-screen repair information to make the necessary repairs or replacements.

To display E version ABS faults:

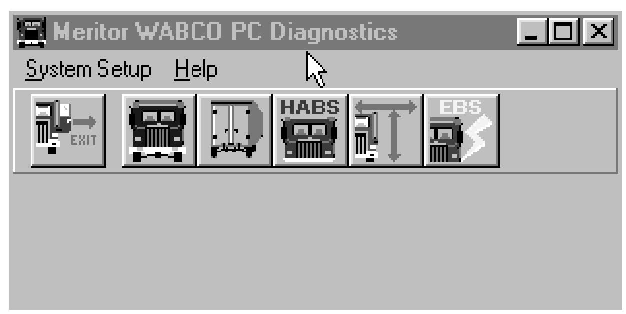
1. Connect the computer to the vehicle:
   - Attach the cable from your computer to the J1708 to RS232 converter box.
   - Attach the diagnostic cable (Deutsch) to the vehicle. **Figure 3.1.**

Figure 3.1



2. Select TOOLBOX Software from Desktop or from the Windows Start Menu to display the TOOLBOX Main Menu. **Figure 3.2.**

Figure 3.2



3. From the **Main Menu**, select **Tractor ABS Diagnostics**, or use the pull down menu to make your selection. **Figure 3.3**. The **ABS Main Screen** will appear. **Figure 3.4**.

Figure 3.3

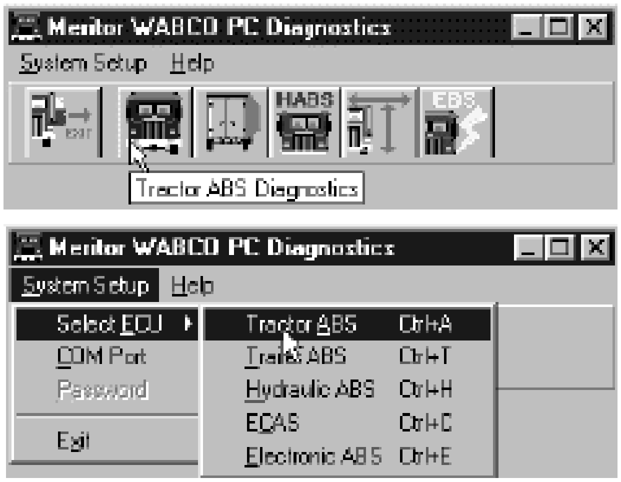
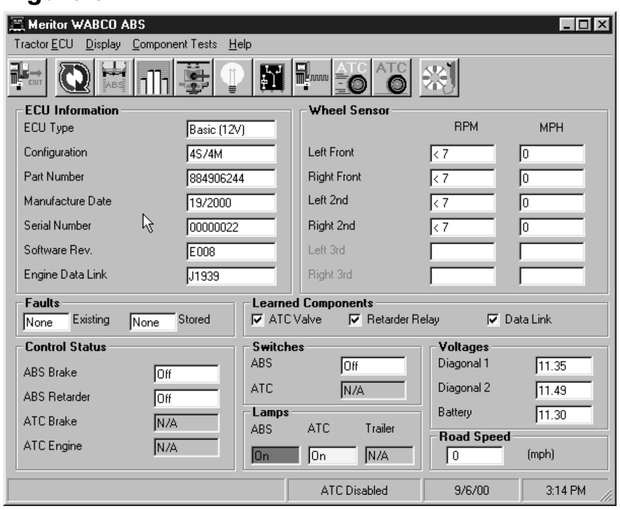


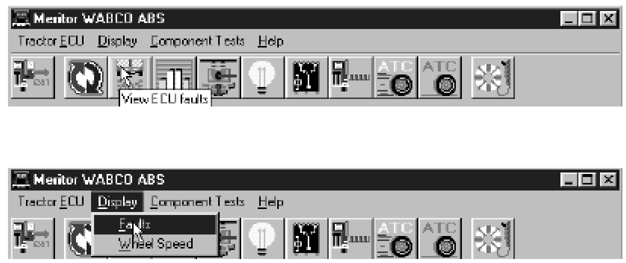
Figure 3.4



4. From the **ABS Main Screen**, select the **Faults** icon, or use the pull down menu to display the faults from the ECU. **Figure 3.5**.

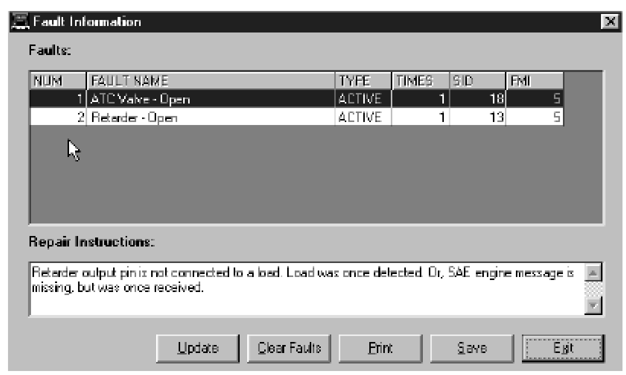
NOTE: If there are **Faults** in the system (**YES** in existing or stores fields) double-click on the **YES** to display **Fault Information.**

Figure 3.5



5. The **Fault Information Screen** contains a description of the fault. Repair instructions for each fault appear at the bottom of the screen. **Figure 3.6**.

Figure 3.6



NOTE: Faults that occur after the screen is displayed will not appear until a screen update is requested. Use the **Update** button at the bottom of the screen to refresh the fault information table.

6. After making the necessary repairs, use the **Clear Faults** button at the bottom of the screen to clear the fault. Use the **Update** button to refresh the fault information table and display the new list of faults.

Blink Code Diagnostics (Tractor ABS only)

Definitions

Before using blink code diagnostics, you should be familiar with a few basic terms. If you used previous versions of Meritor WABCO's blink code diagnostics, review these definitions to identify major changes.

ABS Indicator Lamp: This lamp serves two purposes: it alerts drivers to an ABS tractor fault and it is used during diagnostics to display the blink code.

Blink Code: A series of blinks or flashes that describe a particular ABS system fault or condition.

Blink Code Cycle: Two sets of flashes with each set separated by a one-and-one-half second pause. Blink codes are defined in Blink Code Identification in this section.

Blink Code Switch: A momentary switch that activates blink code diagnostic capabilities. Switch types and locations vary, depending on the make and model of the vehicle.

Clear: The process of erasing faults from the ECU.

Diagnostics: The process of using blink codes to determine ABS system faults.

Fault: An ABS malfunction detected and stored in memory by the Meritor WABCO ECU. System faults may be **Active** or **Stored.**

Active Fault: A condition that **currently exists** in the ABS system; for example, a sensor circuit malfunction on the left front steering axle. An active fault must be repaired before it can be cleared from memory — and before you can display additional blink code faults.

Stored Fault: There are two types of stored faults:

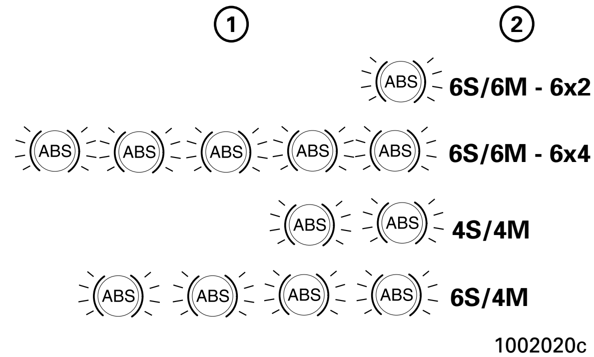
A. A repaired active fault that **has not been cleared** from the ECU.

B. A fault that occurred but **no longer exists**. For example, a loose wire that makes intermittent contact. Because stored faults are not currently active they do not have to be repaired before they can be cleared from memory.

Meritor WABCO recommends you keep a record of these faults for future reference.

System Configuration Code: One digit code displayed during the clear mode. Blink codes for common ABS system configurations are shown in **Figure 3.7.**

Figure 3.7



1. **Number of Flashes**
2. **ABS Configuration**

Diagnostic Mode

To enter the diagnostic mode, press and hold the blink code switch for one second, then release.

Clear Mode

To erase faults from the ECU, you must be in the clear mode. To enter the clear mode, press and hold the blink code switch for at least three seconds, then release.

If the system displays eight quick flashes followed by a system configuration code, the clear was successful. Stored ABS faults have been cleared from memory.

If you do not receive eight flashes, there are still active faults that must be repaired before they can be cleared.

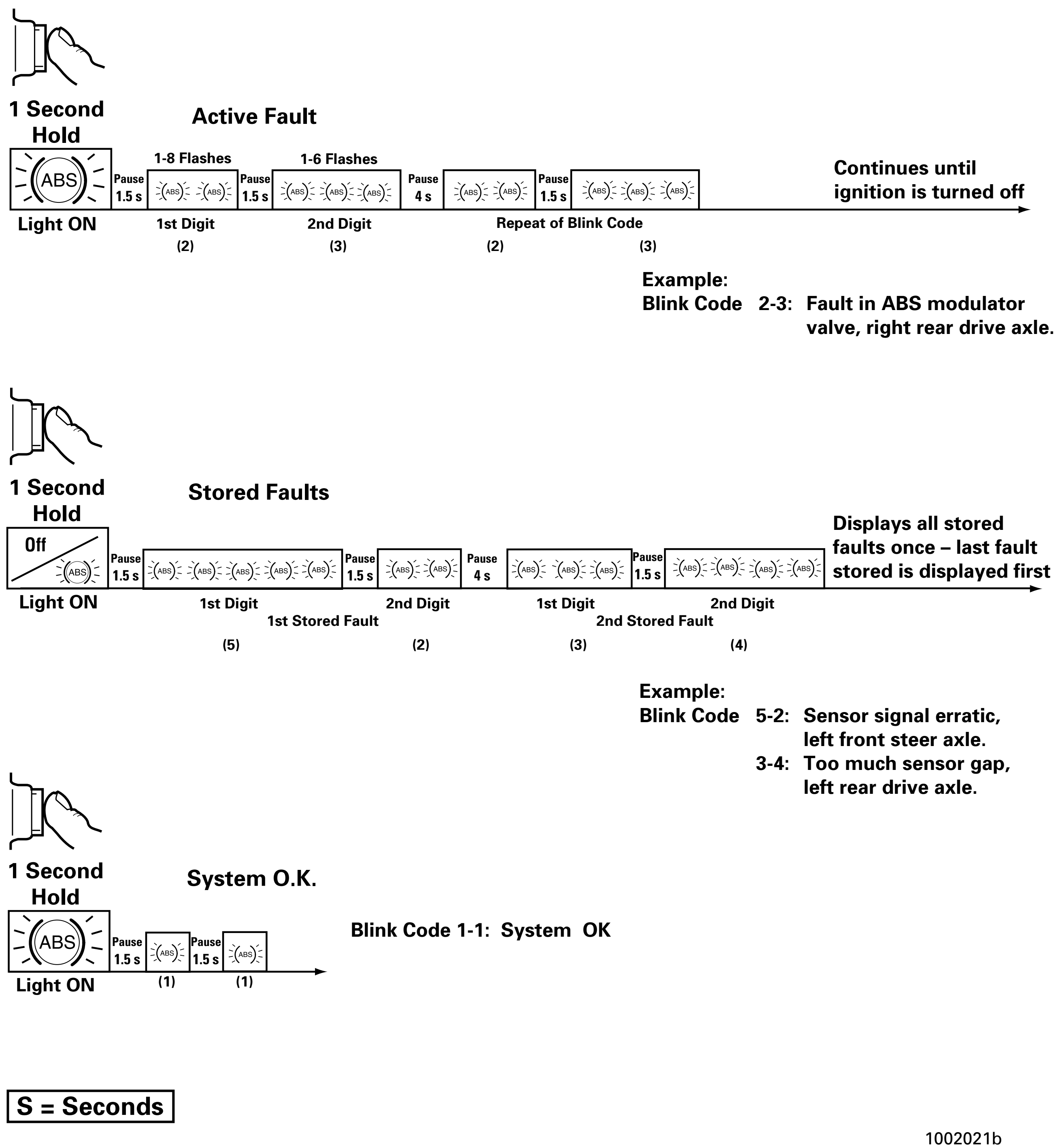
NOTE: The clear mode is also used to disable the ATC function.

Blink Code Diagnostics

Troubleshooting with Blink Code Diagnostics			
Mode	**Procedure**	**System Response**	**Action**
DIAGNOSTICS	**Step I.** Turn Ignition ON	Possible responses: A. ABS indicator lamp comes on momentarily then goes out, indicating System O.K. B. ABS indicator lamp does not light, indicating possible wiring fault or burned-out bulb. C. ABS indicator lamp stays on, indicating: • Fault, or faults, in the system. • Sensor fault during last operation. • Faults cleared from ECU, but vehicle not driven. • ECU disconnected.	 No recognizable active faults in the ABS. No action required. Inspect wiring. Inspect bulb. Make necessary repairs. Continue with blink code diagnostics. **(Go to Step II.)** Continue with blink code diagnostics. **(Go to Step II.)** Drive vehicle — lamp will go out when vehicle reaches 4 mph (6 km/h). Connect ECU.
	Step II. Press and hold Blink Code Switch for one second, then release.	ABS indicator lamp begins flashing two-digit blink code(s).	Determine if fault is active or stored: **Active Fault:** Lamp will repeatedly display one code. **Stored Fault:** Lamp will display code for each stored fault then stop blinking. Faults will be displayed **one time only**.
	Step III. Count the flashes to determine the blink code.	First Digit: 1 - 8 flashes, Pause (1-1/2 seconds). Second Digit: 1 - 6 flashes, Pause (4 seconds).	Find definition for blink code on blink code chart.
	Step IV. Turn Ignition OFF. Repair and Record faults.	Active Fault. Stored Faults.	Make the necessary repairs. Repeat Steps I, II, and III until System O.K. code (1-1) received. Record for future reference. **NOTE:** Last fault stored is first fault displayed.
CLEAR	**Step V.** Turn Ignition ON. Clear Faults from memory: **Press and hold** blink code switch for at least three seconds, then release.	ABS Indicator Lamp flashes eight times. Eight flashes not received.	All stored faults successfully cleared. Turn ignition OFF. Active faults still exist, repeat Steps I through V.

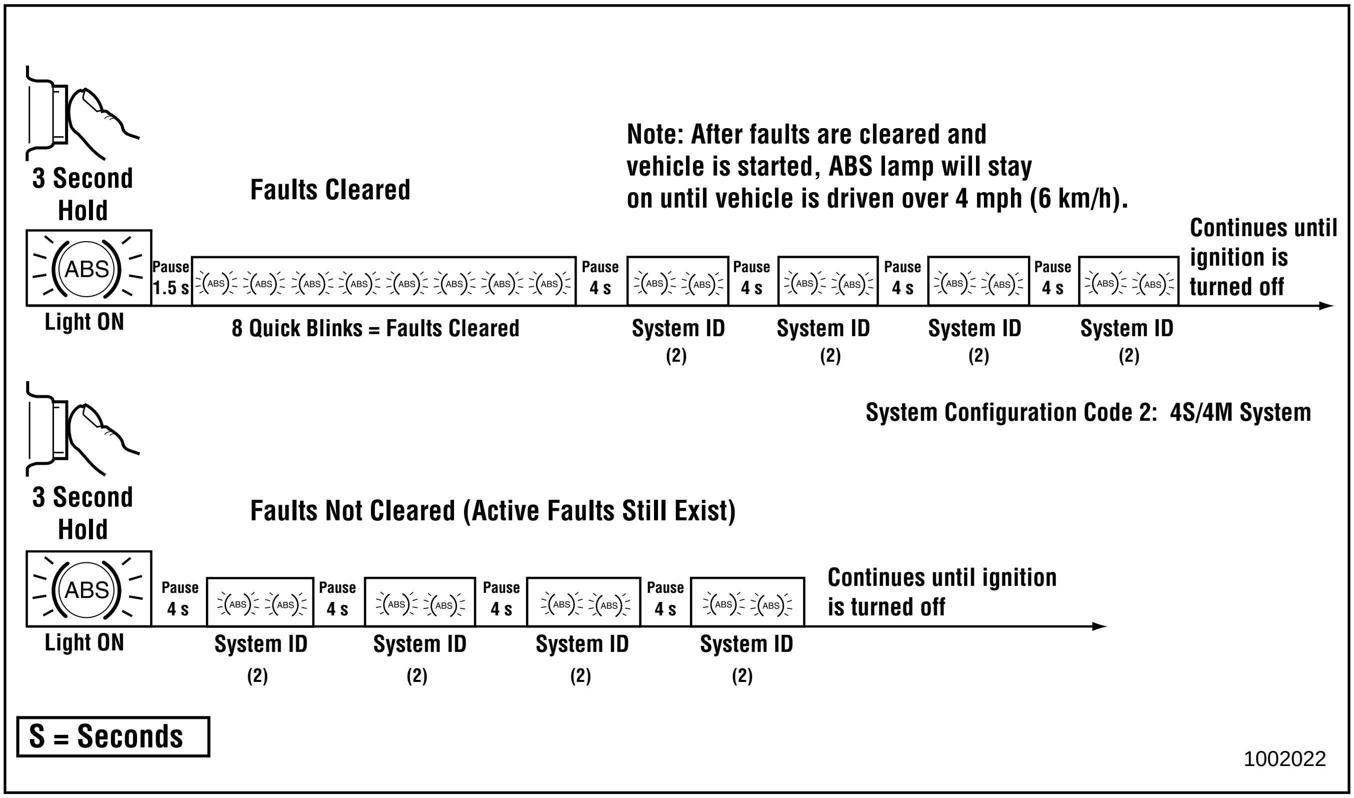
Blink Codes Illustrated

Figure 3.8



Continued on next page.

Blink Codes Illustrated (Continued)



Working with Blink Codes

Blink Code Conditions

When using blink code diagnostics, the following conditions could occur:

Blink Code Conditions		
Condition	**Reason**	**Action**
ABS indicator lamp does not come on at ignition.	Loose or burned-out bulb.	Check bulb. Check connections. Make necessary repairs.
	Voltage not within acceptable range (9.5-14.0 volts).	Check connections. Measure voltage. Make necessary repairs.
Can't use blink code diagnostics; ABS indicator lamp will not go off when blink code is activated.	Switch not held for proper length of time: 1 Second — Diagnostics Mode 3 Seconds — Clear All Mode	Repeat procedure, hold switch for proper length of time.
	Improper or faulty wiring.	Inspect and repair wiring.
Eight Flashes not received after blink code switch pressed for **at least** three seconds, then released.	Active Faults still exist.	Identify active faults, then make necessary repairs. Turn ignition OFF, then repeat Blink Code Diagnostics.

Blink Code Identification

Use the following information to identify the blink code:

Blink Code Identification	
First Digit (Type of Fault)	**Second Digit — Specific Location of Fault**
1 No faults	1 No faults
2 ABS modulator valve 3 Too much sensor gap 4 Sensor short or open 5 Sensor signal erratic/tire size 6 Tooth wheel	1 Right front steer axle (curb side) 2 Left front steer axle (driver's side) 3 Right rear drive axle (curb side) 4 Left rear drive axle (driver's side) 5 Right rear/additional axle (curb side)* 6 Left rear/additional axle (driver's side)*
7 System function**	1 J1939 datalink 2 ATC valve 3 Retarder relay (third brake) 4 ABS indicator lamp 5 ATC configuration 6 ATC prop./dif lock/stop valve
8 ECU	1 Low power supply 2 High power supply 3 Internal fault 4 System configuration error 5 Ground

* Tandem, lift, tag or pusher axle depending upon the type of suspension.

** If this code continues after all repairs have been made — or if you receive a code for a component that is not installed on the vehicle — it may be necessary to reconfigure the ECU. Refer to the Reconfiguration Procedure described in Appendix III. TOOLBOX Software may also be used to reconfigure the ECU (refer to Appendix III). Contact ArvinMeritor's Customer Service Center at 800-535-5560 for reconfiguration information.

Blink Code Troubleshooting and Repair

Blink Code	Action Required	Reference
2-1 2-4 2-2 2-5 2-3 2-6	Check ABS modulator valve, valve cable, and connectors. Verify 4.0-9.0 ohms resistance (ABS modulator valve).	Refer to "Valve Tests," page 34.
3-1 3-4 3-2 3-5 3-3 3-6	Adjust wheel sensor to touch tooth wheel. Check sensor gap. Check for loose wheel bearings or excessive hub runout. Verify minimum 0.2 volts AC output @ 30 rpm.	Refer to "Sensor Adjustment," page 32, "Sensor Output Voltage Test," page 32, and "Component Tests and Functions," page 27.
4-1 4-4 4-2 4-5 4-3 4-6	Check sensor, sensor cable, and connectors. Verify 900-2000 ohms resistance.	Repair or replace as needed.
5-1 5-4 5-2 5-5 5-3 5-6	Check for tire size mismatch or tooth wheel difference. Check sensor, sensor cable, and connector for intermittent contact.	Refer to "Tire Size Range," page 31.
6-1 6-4 6-2 6-5 6-3 6-6	Check for damaged tooth wheel.	Repair or replace as needed.
7-1*	Check for proper J1939 data link connection. Verify wheel spin on each axle.	Refer to wiring diagram in Appendix II.
7-2*	Check ATC Valve, valve cables, and connectors. Verify 7.0-14.0 ohms resistance.	Refer to "Valve Tests," page 34.
7-3*	Check retarder (third brake) connections.	Refer to wiring diagram in Appendix II.
7-4*	Check ABS indicator light connections. Verify blink code switch was activated longer than 16 seconds.	
7-5*	Verify proper ATC set-up.	
7-6*	Verify accuracy of blink code and clear from ECU memory.	Refer to "Blink Code Diagnostics (Tractor ABS only)," page 17.
8-1	Check for low voltage. Check vehicle voltage, fuse, and supply to ECU (9.5-14.0 volts).	Refer to wiring diagram in Appendix II and "Voltage Check," page 31.
8-2	Check for high voltage. Check vehicle voltage (9.5-14.0 volts). Verify accuracy of blink code and clear from ECU memory.	Refer to "Voltage Check," page 31, and "Blink Code Diagnostics (Tractor ABS only)," page 17.
8-3	Verify accuracy of blink code and clear from ECU memory.	Refer to "Blink Code Diagnostics (Tractor ABS only)" and "Clear Mode," page 17.
8-4	Verify all ECU connectors are in place. Verify accuracy of blink code and clear from ECU memory. *If code does not clear, it may be necessary to replace the ECU.*	Contact ArvinMeritor's Customer Service Center at 800-535-5560.
8-5	Check all ABS, ECU and ATC valve grounds.	Refer to wiring diagram in Appendix II.

* If this code continues after all repairs have been made — or if you receive a code for a component that is not installed on the vehicle — it may be necessary to reconfigure the ECU. Refer to the Reconfiguration Procedure described in Appendix III. TOOLBOX Software may also be used to reconfigure the ECU (refer to Appendix III). Contact ArvinMeritor's Customer Service Center at 800-535-5560 for reconfiguration information.

Pro-Link® Diagnostics

NOTE: You must use Multiple Protocol Cartridge (MPC) and Meritor WABCO application card, version 2.0 or higher, with E version ECUs. The PLC functions of E version ABS cannot be tested with the Pro-Link.

The Pro-Link® 9000 may be used in place of blink code diagnostic procedures.

The following Pro-Link information applies to E version ECUs. Refer to Maintenance Manual 28 if you are using the Pro-Link with C version ECUs or Maintenance Manual 30 if you are using the Pro-Link with D version ABS.

Diagnostic Procedure

1. Slide the MPC into the Pro-Link keypad until the connection is tight. Then, insert the Meritor WABCO applications card into the cartridge.
2. Chock the wheels, apply the parking brake, and make sure ignition power is off.
3. Locate the 6-pin diagnostic receptacle in the vehicle cab. Insert the 6-pin connector from the Pro-Link into the receptacle.
4. Turn the ignition to the ON/RUN position. The Pro-Link screen should power up.

   If the Pro-Link does not power up, or if the screen indicates NO DATA RECEIVED:

   - Check connections.
   - Make sure the cartridge is properly connected to the Pro-Link keypad.
   - Verify 9.5-14.0 volts DC power and ground at the connector and ABS ECU.
   - Check the fuse panel for a blown fuse.
   - Check for proper wiring in the diagnostic connector.
5. Refer to the Pro-Link manual for complete diagnostic instructions.

The Pro-Link® 9000 is available from Kent-Moore, 800-328-6657.

Pro-Link Screens

This information provides basic screen explanations for the Pro-Link® 9000 with an MPC and Meritor WABCO application card. For complete operating instructions and test information, refer to the Pro-Link manual.

Fault Information Screens:

Existing Faults: Use these screens to identify existing faults. The Pro-Link screen displays a written description of the fault, including the location on the vehicle where each exists. As long as there is an active (existing) fault in the system, the Pro-Link will not let you clear faults.

Stored Faults: Use these screens to identify faults stored in the ECU memory. Stored faults may be existing faults that have been repaired, or faults that existed for a short time, then corrected themselves. After displaying the stored faults, the Pro-Link lets you erase them from memory. All stored faults are cleared at one time.

Pro-Link Display

Depending upon the ECU being tested, the Pro-Link screen will display certain options or components only when recognized by the ECU. These include:

- ATC, ATC Indicator Lamps, Trailer ABS Indicator Lamp, ATC Valve
- Engine Datalink
- Retarder Relay
- Retarder Datalink

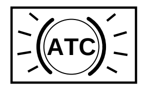
J1939 Datalink Verification — Pro-Link 9000

The Pro-Link diagnostic tool may be used to verify J1939 datalink connection. If you do not have a Pro-Link, you can use the blink code switch to verify this connection.

1. Turn ignition ON. Press blink code switch — hold for 3 seconds.

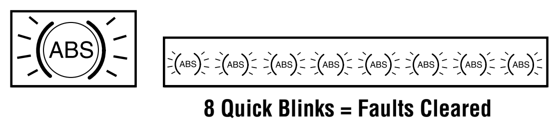
   A. ATC indicator lamp will come on and stay on for the entire test.

   If vehicle is not equipped with ATC, the ATC indicator lamp will not come on.



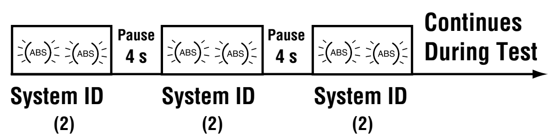
   B. ABS indicator lamp will come on and blink 8 times.

   If the lamp does not blink 8 times, there are faults that must be cleared before you continue with this test.



   C. The eight quick flashes will be followed by the system configuration code. A 4S/4M (2 blinks) system is identified here.

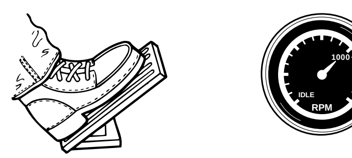
   The system configuration code will continue during the entire test.



2. Activate the J1939 engine torque reduction code, as follows:

   A. Step on the accelerator. Bring the engine to 1000 rpm.

   Leave your foot on the accelerator during the entire test.



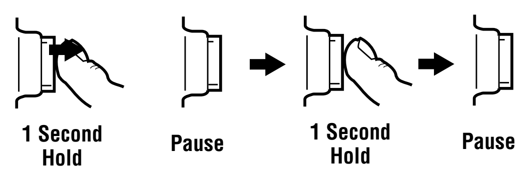
   B. While engine is at 1000 rpm, press the blink code switch twice, as follows:

   Press for one second

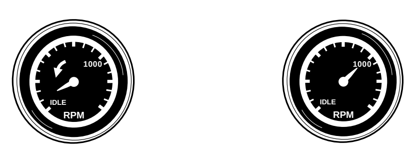
   Release for one second

   Press for one second

   Release for one second

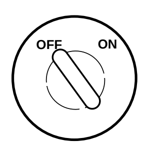


   C. The engine will go to idle for approximately 10 seconds and then return to 1000 rpm.



3. Turn ignition OFF.

   Test complete, engine torque reduction command verified.



Component Test Screens

These screens help you test ABS components. Select this function from the Tractor ABS/ATC menu.

ABS VALVES

ATC

ABS INDICATOR LAMP

ABS TRAILER INDICATOR LAMP

ATC INDICATOR LAMP

ABS/ATC SWITCHES

SENSORS

ENGINE DATALINK

RETARDER RELAY

RETARDER DATALINK

VEHICLE VOLTAGES

Select the appropriate function. Each screen has instructions to guide you through the test. Refer to the Pro-Link Manual for complete instructions.

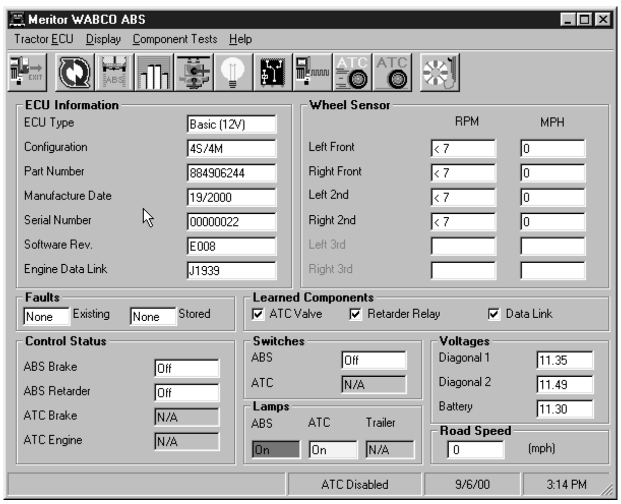
System Information

TOOLBOX Software Display

NOTE: Refer to page 15 of this manual for instructions for running TOOLBOX Software, or refer to the Software Owner's Manual, TP-99102, for complete instructions.

The quickest method of verifying system information is the TOOLBOX Software **ABS Main Screen. Figure 3.9.**

Figure 3.9



This screen provides information about the current state of Meritor WABCO ABS. ECU information is read once from the ECU and does not change. All other information (e.g., wheel sensors, control status, voltages, faults and road speed) is read and updated continuously.

The status of ABS switches and lamps, as well as other data, may also be observed from this screen.

Pro-Link 9000 Display

With some ECUs, the Pro-Link will display system information — components or options supported by the ECU. Access these screens through System Setup (main ABS menu).

The following screens illustrate:

- A 4S/4M ABS/ATC system
- Where the ECU has not recognized a retarder relay
- Where the ECU has recognized a J1939 datalink
- The ECU is capable of supporting ABS and ATC switches.

NOTE: Yes indicates the ECU is capable of supporting these options. These may or may not be installed on the vehicle.

TRACTOR ABS/ATC	
SYSTEM INFORMATION	
SENSORS	**4**
MODULATORS	**4**

ATC VALVE	YES
RETARDER RELAY	NO
J1939	YES
DIFF LOCK	NO
ABS SWITCH	YES
ATC SWITCH	YES

Component Tests and Functions

TOOLBOX Software

NOTE: Refer to page 15 of this manual for instructions for running TOOLBOX Software, or refer to the Software Owner's Manual, TP-99102, for complete instructions.

Use TOOLBOX Software to display wheel speeds, cycle ABS valves, activate ABS and ATC lamps, including the trailer ABS lamp, and turn the retarder relay on or off. In addition, the J1939 engine datalink connection may be quickly verified by using TOOLBOX Software.

Wheel Speed

Select the wheel speed icon or use the pull down menu from the ABS Main Screen to display wheel speed data in both numeric and graphical form. This data may be shown in RPM or MPH format (**Figure 3.10**) and in vertical or horizontal graphs (**Figures 3.11 and 3.12**). Select the appearance and style from the options menu.

Figure 3.10

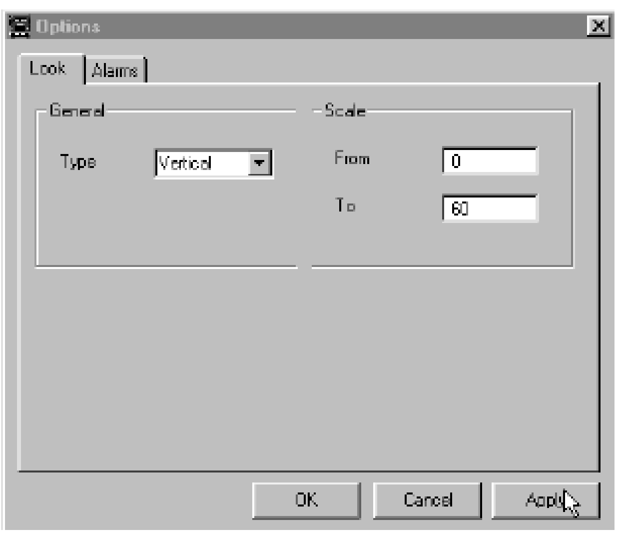
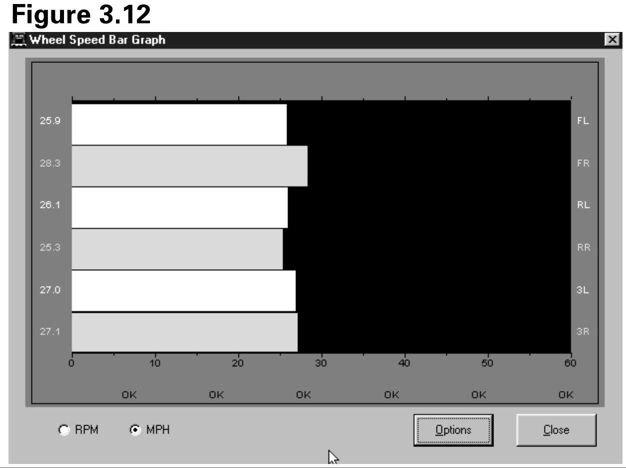


Figure 3.11

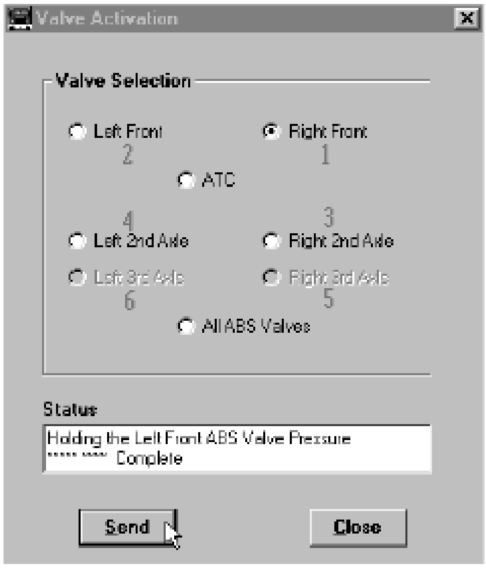
Figure 3.12



Valve Activation

Select the valve icon or use the pull down menu to select and cycle individual ABS valves. Then listen to ensure the correct valve is cycling. This is helpful when verifying proper operation, installation and wiring. **Figure 3.13.**

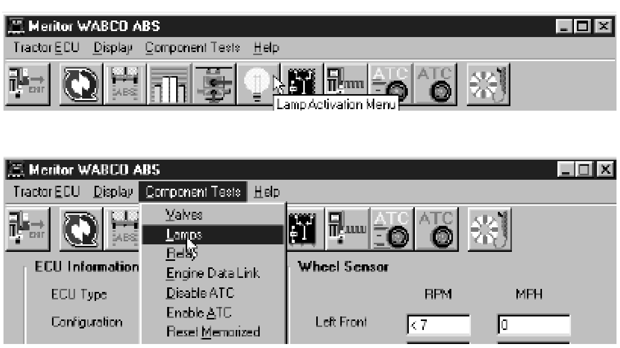
Figure 3.13



Lamp Activation

Select the lamp icon or use the pull down menu to turn the tractor and trailer ABS and/or the ATC (wheel spin) lamps on or off. This is helpful when verifying proper operation, installation and wiring of the lamps to the ECU. **Figure 3.14.**

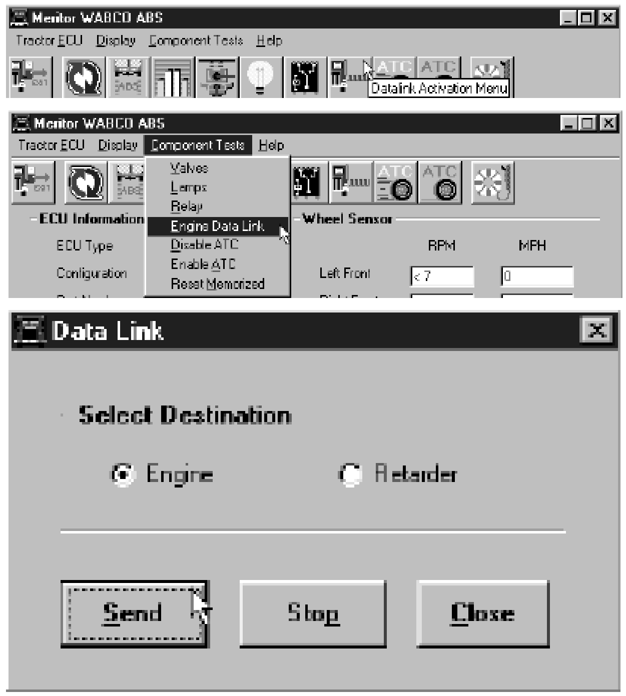
Figure 3.14



Data Link Activation

Select the **Engine Data Link** icon from the Main ABS Screen or use the pull down menu to send a "limit engine torque" command to the engine or a "disable retarder" command to the retarder. **Figure 3.15.**

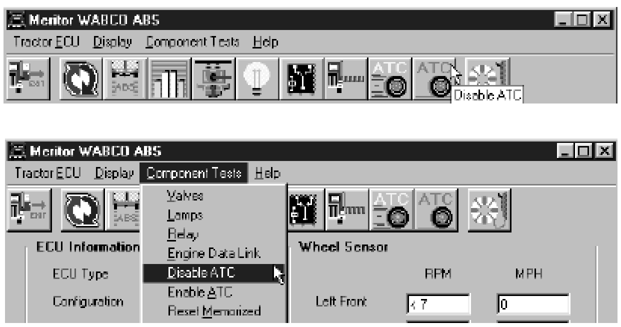
Figure 3.15



Disable or Enable ATC

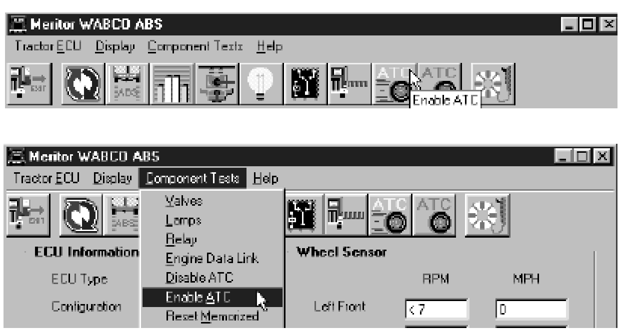
Select the **Disable ATC** icon or use the pull down menu on the **ABS Main Screen** to send the command to the ECU to disable automatic traction control. ATC will remain disabled until the enable command is sent — or until the vehicle ignition is cycled. **Always disable ATC for dynamometer testing. Figure 3.16.**

Figure 3.16



Select the **Enable ATC** icon or use the pull down menu on the ABS Main Screens to send a command to the ECU to enable ATC. This is the normal state of the ECU. **Figure 3.17.**

Figure 3.17



NOTE: The status bar on the **ABS Main Screen** reflects the current status of the ATC function; enabled, disabled or N/A (not available).

Component Tests and Functions (Pro-Link)

These screens help you test ABS components. Select this function from the Tractor ABS/ATC menu.

TRACTOR COMP TESTS
— SELECTIONS —
↑ VEHICLE VOLTAGES ↓

Select the appropriate function. Each screen has instructions to guide you through the test. Refer to the Pro-Link Manual for complete instructions.

The following definitions explain the function of each test.

Component Test	Function
Vehicle Voltages	Monitors the voltage signals powering the ECU.
ABS Valves	Cycles the valves, one at a time. With brake pedal applied, you should hear four short air exhausts, then one long air pressure hold. A menu selection lets you choose from four or six valves. This test is used to verify valve locations and proper wiring. **NOTE:** The treadle must be applied to pressurize the brake chambers.
ATC	Checks the ATC valve. You will hear a click as the valve cycles. **NOTE:** TOOLBOX Software or the Pro-Link may be used to shut off ATC for dynamometer testing.
ABS Tractor Lamp	Monitors the commanded (on/off) states of the ABS tractor lamp. Follow the screen prompts (1 On, 2 Off) to change the status of the lamp on the instrument panel.
ABS Trailer Lamp	Monitors the commanded (on/off) states of the ABS trailer lamp. Follow the screen prompts (1 On, 2 Off) to change the status of the lamp on the instrument panel.
ATC Tractor Lamp	Monitors the commanded (on/off) states of the ATC tractor lamp. Follow the screen prompts (1 On, 2 Off) to change the status of the lamp on the instrument panel.
ABS/ATC Switches	Checks the status of ABS and ATC/Deep Snow and Mud switches on the instrument panel.
Sensors	Monitors the input to the ECU from the wheel. Vehicle must be stationary and wheels must be rotated during this test.
Engine Datalink	Checks wiring connections and response between the engine and the ECU.
Retarder Relay	Activates the relay to verify function (a click will be heard). This test also checks wiring connections.
Retarder Datalink	Checks wiring connections and retarder response between the retarder and the ECU.

Tire Size Range

For proper ABS/ATC operation with the standard ECU, front and rear tire sizes must be within ± 14% of each other. When this tire size range is exceeded without electronically modifying the ECU, the system performance can be affected and the indicator lamp can illuminate.

Call Meritor WABCO at 800-535-5560 if you plan a tire size difference greater than 14%.

Calculate the tire size with the following equation:

$$\%\ \text{Difference} = \left\{ \frac{\text{RPM Steer}}{\text{RPM Drive}} - 1 \right\} \times 100$$

RPM — tire revolutions per mile

Testing Components

CAUTION

When troubleshooting and testing the ABS system, do not damage the connector terminals.

Voltage Check

Measure voltage at the pins indicated in **Table C**.

- Voltage must be between 9.5 and 14.0 volts.
- The ignition must be turned ON for this test.

Table C: Voltage Check Pins

ECU	Connector	Pins
Universal	14-Pin	4 and 9 9 and 4
Basic	14-Pin	7 and 4 8 and 9
Frame-mounted	X1-Grey	1 and 12 2 and 11

NOTE: Pin locations are illustrated in **Figure 3.18** (Frame) and **Figure 3.19** (Basic and Universal).

Figure 3.18

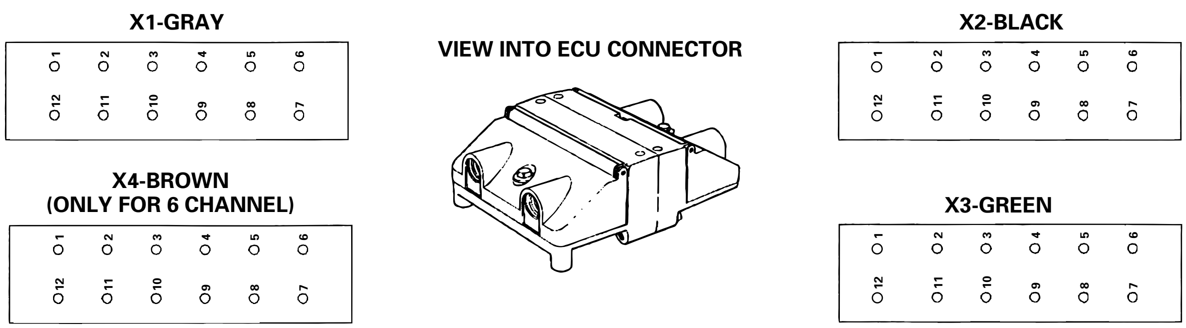
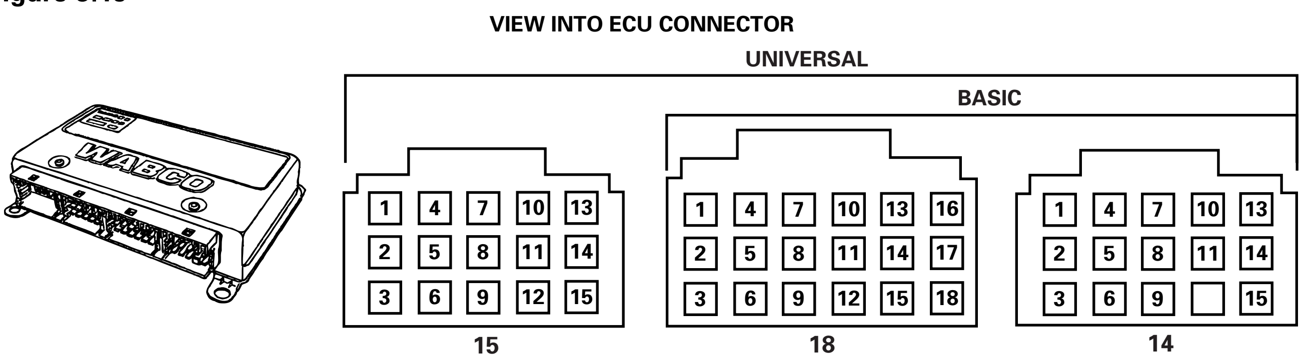


Figure 3.19



Location of Sensors

On steering axles, the sensor is accessible on the in-board side of the steering knuckle.

On drive axles, the drum assembly may have to be pulled to gain access to the sensor.

Sensor Adjustment

- Push the sensor in until it contacts the tooth wheel.
- Do not pry or push sensors with sharp objects.
- Sensors will self-adjust during wheel rotation.

Sensor Output Voltage Test

Voltage must be at least 0.2 volts AC at 30 rpm.

1. Turn ignition OFF.
2. Disconnect the appropriate connector from the ECU (refer to wiring diagram).
3. Rotate wheel by hand at 30 rpm (1/2 revolution per second).
4. Measure voltage at the pins indicated in **Table D**.
   - If the minimum output voltage is less than 0.2, push the corresponding sensor toward the tooth wheel, then repeat the measurement.

Table D: Sensor Check Pins

ECU	Sensor	Connector	Pins
Universal	LF	18-Pin	12 and 15
	RF	18-Pin	10 and 13
	LR	18-Pin	11 and 14
	RR	18-Pin	17 and 18
	LR (3rd Axle)	15-Pin	2 and 5
	RR (3rd Axle)	15-Pin	11 and 14
Basic	LF	18-Pin	12 and 15
	RF	18-Pin	10 and 13
	LR	18-Pin	11 and 14
	RR	18-Pin	17 and 18
Frame-mounted	LF	X2 — Black	7 and 8
	RF	X2 — Black	5 and 6
	LR	X3 — Green	1 and 2
	RR	X3 — Green	3 and 4
	LR (3rd Axle)	X4 — Brown	3 and 4
	RR (3rd Axle)	X4 — Brown	5 and 6

Sensor Resistance

The sensor circuit resistance must be between 900 and 2000 ohms. Resistance can be measured at the sensor connector, or at the pins on the ECU connector. To measure resistance:

1. Turn ignition OFF.
2. To measure resistance at the sensor connector, disconnect the ECU connector from the ECU. To measure resistance at the sensor connector, disconnect the sensor from the sensor extension cable.
3. Measure output at the pins indicated in **Table D**.

Dynamometer Testing Vehicles with ATC

WARNING

The automatic traction control (ATC) function must be disabled before any type of dynamometer testing is conducted on the vehicle. If the ATC is not disabled, the vehicle ATC may actuate and cause the vehicle to move forward without warning to the operator. If the vehicle moves forward unexpectedly, the vehicle may cause damage or injuries to individuals who are in the path of the vehicle.

CAUTION

Do not cycle the vehicle ignition while the vehicle is on a dynamometer. Cycling the vehicle ignition will enable the ATC.

Vehicles with ATC must have the ATC disabled to test the vehicle on a dynamometer. To disable the ATC use one of the following methods:

1. **Blink Code Switch**

   Press and hold the blink code switch for at least three seconds. (Refer to Blink Code Diagnostics (Tractor ABS only) and Clear Mode in this section for a description of how the blink code display will appear.)

   - Once the system configuration code begins, ATC has been disabled.
   - The ATC lamp comes on and stays on while ATC is disabled.
   - ATC will remain disabled until the vehicle ignition is cycled.
   - After testing, ATC will automatically reactivate the first time the vehicle ignition is cycled.

2. **Remove Power**

   Remove the ABS circuit breaker/fuse or remove the ECU power connector to disable the ABS and ATC.

   - After testing, re-install the circuit breaker/ fuse and the ATC will automatically reactivate the first time the vehicle power is applied to the ECU.

3. **TOOLBOX Software**

   At the ABS Main Menu, select the ***Disable ATC*** icon or use the pull down menu to send the command to the ECU to disable the ATC. Refer to the TOOLBOX Software Owner's Manual for complete instructions for using TOOLBOX.

   - ATC will remain disabled until the enable command is sent or the vehicle ignition is cycled.
   - After testing, ATC will automatically reactivate the first time the vehicle ignition is cycled.

4. **MPSI Pro-Link**

   Refer to the MPSI Pro-Link Owner's Manual for instructions.

   - ATC will remain disabled until the enable command is sent or the vehicle ignition is cycled.
   - After testing, ATC will automatically reactivate the first time the vehicle ignition is cycled.

Valve Tests

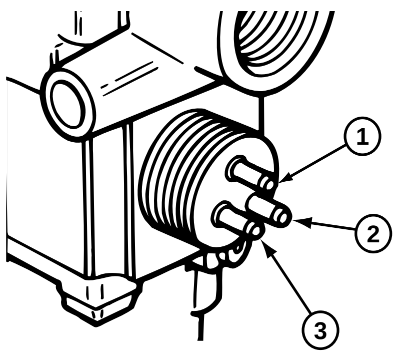
ABS Modulator Valve

Measure resistance across each valve solenoid coil terminal and ground on the ABS valve to ensure 4.0 to 9.0 ohms. **Figure 3.20.**

- If the resistance is greater than 9.0 ohms, clean the electrical contacts in the solenoid. Check the resistance again.
- To check the cable and the ABS valve as one unit, measure resistance across the pins on the ECU connector of the harness. Check the diagram of the system you are testing for pin numbers. (Refer to Appendix II.)

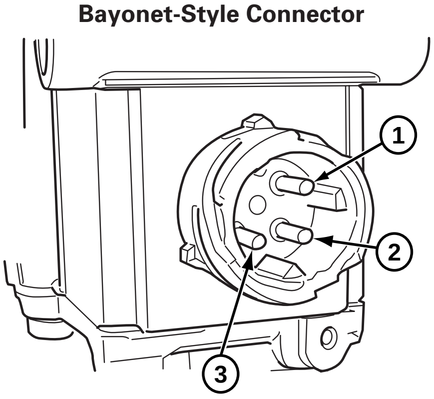
Figure 3.20

Open-Style Connector



1. **Ground Terminal**
2. **Exhaust Solenoid (blue wire)**
3. **Inlet Solenoid (brown wire)**

Bayonet-Style Connector



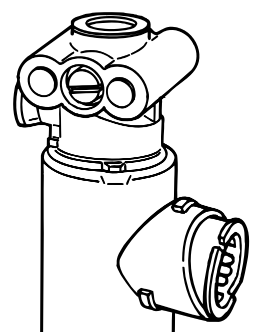
1. **Exhaust Solenoid (blue wire)**
2. **Inlet Solenoid (brown wire)**
3. **Ground Terminal**

ATC Valve

Measure resistance across the two electrical terminals on the ATC valve to ensure 7.0 to 14.0 ohms. **Figure 3.21.**

- If the resistance is greater than 14.0 ohms, clean the electrical contacts on the solenoid. Check the resistance again.
- To check the cable and ATC valve as one unit, measure resistance across the pins on the ECU connector of the harness. Check the diagram of the system you are testing for pin numbers. (Refer to Appendix II.)

Figure 3.21



NOTE: Refer to Appendix III for ABS Valve Package Troubleshooting Guide.

Component Removal and Installation

Valves

- ABS Modulator Valves
- ATC Valve
- ABS Valve Package (Front or Rear)
  - — Modulator Valves
  - — Relay Valve or Quick Disconnect Valve
  - — ATC Valve

Sensor Lube Specification

Meritor WABCO specifications call for a sensor lubricant with the following characteristics:

Lube must be mineral oil-based and contain molydisulfide. It should have excellent anti-corrosion and adhesion characteristics, and be capable of continuous function in a temperature range of –40° to 300°F (–40° to 150°C).

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Release all air from the air systems before you remove any components. Pressurized air can cause serious personal injury.

CAUTION

Use the following procedures to avoid damage to the electrical system and ABS/ATC components.

When welding on an ABS- or ABS/ATC-equipped vehicle is necessary, disconnect the power connector from the ECU.

Sensors

Wheel Speed Sensor Removal — Front Axle

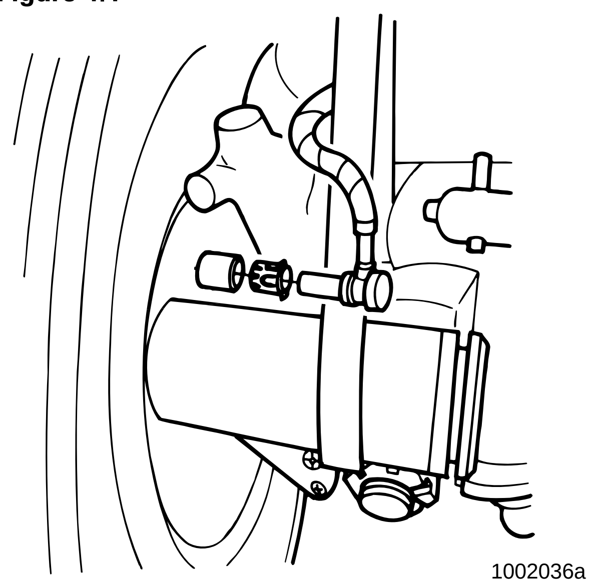
To remove the sensor from the front axle:

WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury can result.

1. Put blocks under the rear tires to stop the vehicle from moving. Apply the parking brake.
2. If necessary, raise the front tires off the ground. Put safety stands under the axle.
3. Disconnect the fasteners that hold the sensor cable to other components.
4. Disconnect the sensor cable from the chassis harness.
5. Remove the sensor from the sensor holder. Use a twisting motion if necessary. **Do not pull on the cable. Figure 4.1.**

Figure 4.1



Knuckle-Mounted Sensor

Wheel Speed Sensor Installation — Front Axle

To replace the sensor in the front axle:

1. Connect the sensor cable to the chassis harness.
2. Install the fasteners used to hold the sensor cable in place.
3. Apply a Meritor WABCO recommended lubricant to the sensor spring clip and sensor.
4. Install the sensor spring clip. Make sure the spring clip tabs are on the inboard side of the vehicle.
5. Push the sensor spring clip into the bushing in the steering knuckle until the clip stops.
6. Push the sensor completely into the sensor spring clip until it contacts the tooth wheel.

NOTE: After installation, there should be no gap between the sensor and the tooth wheel. During normal operation, a gap of up to 0.04-inch is allowable.

7. Remove the blocks and safety stands.

Wheel Speed Sensor Removal — Rear Axle

To remove the sensor from the rear axle:

WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury can result.

1. Put blocks under the front tires to stop the vehicle from moving.
2. Raise the rear tire off the ground. Put safety stands under the axle.
3. Release the parking brake and back off the slack adjuster to release the brake shoes.
4. Remove the wheel and tire assembly from the axle.
5. Remove the brake drum.
6. Remove the sensor from the mounting block in the axle housing. Use a twisting motion if necessary. **Do not pull on the cable.**
7. Remove the sensor spring clip from the mounting block.
8. Disconnect the fasteners that hold the sensor cable and the hose clamp to other components.
9. Disconnect the sensor cable from the chassis harness.

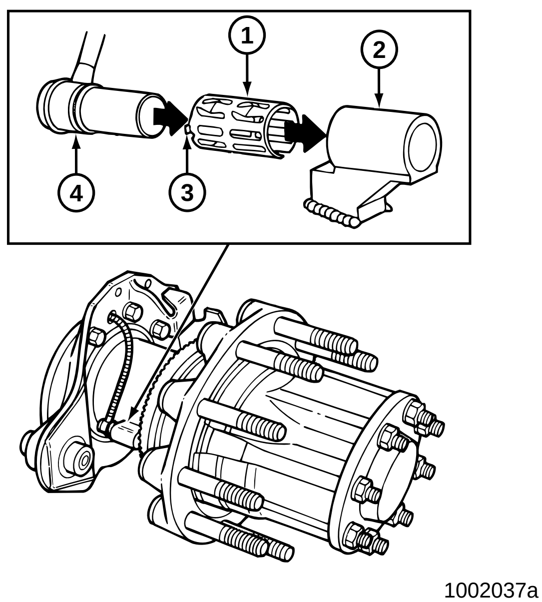
Wheel Speed Sensor Installation — Rear Axle

1. Apply a Meritor WABCO recommended lubricant to the sensor spring clip and sensor.
2. Install the sensor spring clip. Make sure the spring clip tabs are on the inboard side of the vehicle.
3. Push the sensor spring clip into the mounting block until it stops.

NOTE: After installation, there should be no gap between the sensor and the tooth wheel. During normal operation, a gap of up to 0.04-inch is allowable.

4. Push the sensor completely into the sensor spring clip until it contacts the tooth wheel. **Figure 4.2.**

Figure 4.2



1. **Spring Clip**
2. **Sensor Holder**
3. **Spring Clip Tab**
4. **Sensor**

5. Insert the sensor cable through the hole in the spider and axle housing flange. Route the cable to the frame rail. Be sure to route the cable in a way that will prevent pinching or chafing and will allow sufficient movement for suspension travel.
6. Connect the sensor cable to the chassis harness.
7. Install the fasteners that hold the sensor cable in place.
8. Install the brake drum on the wheel hub.
9. Complete the installation per vehicle manufacturer's manual.

Valves

ABS Modulator Valve

Removal

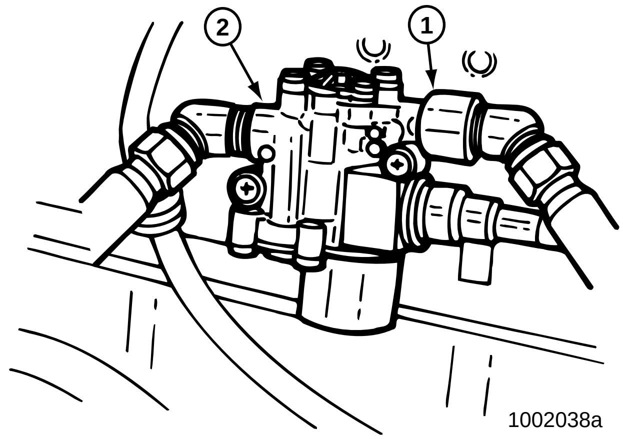
1. Turn ignition switch to the OFF position, apply parking brake.

WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury can result.

2. Put blocks under the front and rear tires to stop the vehicle from moving.
3. If necessary, raise the vehicle off the ground and put safety stands under the axle.
4. Disconnect the wiring connector from the ABS valve.
5. Disconnect the air lines from Ports 1 (air supply) and 2 (air discharge) of the ABS valve. **Figure 4.3**.
6. Remove the two mounting capscrews and nuts.
7. Remove the ABS valve.

Figure 4.3



1. **Port 1 (Air In)**
2. **Port 2 (Air Out)**

Installation

CAUTION

Moisture can affect the performance of all ABS/ATC systems, as well as the standard braking system. Moisture in air lines can cause air lines to freeze in cold weather.

To install the ABS modulator valve:

1. Install the ABS valve with two mounting capscrews and nuts. Tighten the capscrews per the manufacturer's recommendation.
2. Connect the line to the brake chambers to Port 2 of the ABS valve. Connect the air supply line to Port 1 of the ABS valve.
3. Connect the wiring connector to the ABS valve. Hand tighten only.
4. Remove the blocks and stands.
5. Test the installation. (Refer to below.)

Checking the Installation

To test the modulator valve:

1. Apply the brakes. Listen for leaks at the modulator valve.
2. Turn the ignition on and listen to the modulator valve cycle. If the valve fails to cycle, check the electrical cable connection. Make repairs as needed.
3. Drive the vehicle. Verify that the ABS indicator lamp operates properly.

ATC Valve

Removal

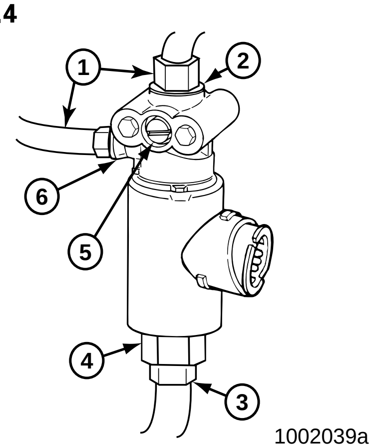
1. Turn ignition switch to the OFF position. Apply parking brake.

WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury can result.

2. Put blocks under the front and rear tires to stop the vehicle from moving.
3. If necessary, raise the vehicle off the ground. Put safety stands under the axle.
4. **Relieve line pressure by bleeding the air from the appropriate supply tank.**
5. Disconnect the wiring from the ATC valve.
6. Disconnect the air lines from Port 1 (air supply), Port 2 (air discharge), and Port 3 (treadle) of the ATC valve. **Figure 4.4.**

Figure 4.4



1. **Air Lines**
2. **Port 1 (Air Supply)**
3. **Air Line**
4. **Port 3 (Treadle)**
5. **Valve Control Do Not Open**
6. **Port 2 (Air Discharge)**

7. Remove the two mounting capscrews and nuts. Remove the ATC valve.

Installation

1. Install the ATC valve with two mounting capscrews and nuts.

   Tighten the capscrews per the manufacturer's recommendation.
2. Connect the air supply, discharge, and treadle lines to Ports 1, 2, and 3 of the ATC valve.
3. Connect the harness connector to the ATC valve. Hand tighten only.
4. Remove blocks and stands.
5. Test the installation. (Refer to below.)

Checking the Installation

To test the ATC valve:

1. Start vehicle.
2. Fully charge reservoirs with air. Shut off vehicle.
3. Apply brakes.
4. Listen for air leaks at ATC valve.
5. Release brakes.
6. Activate ATC valve using the MPSI tool.
7. Disconnect MPSI tool.
8. Drive the vehicle. Verify that the ATC indicator lamp operates properly.

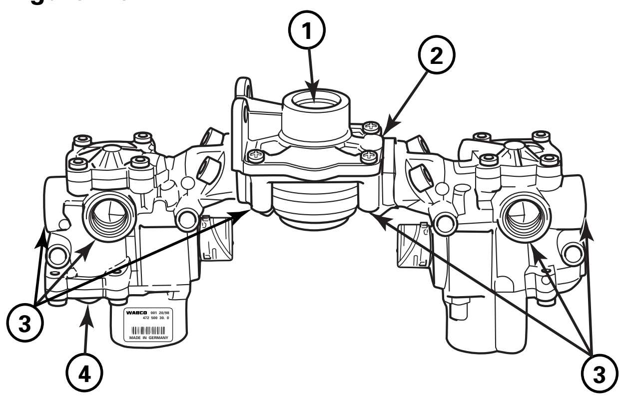
Front or Rear ABS Valve Package

Removal and Replacement — Complete Package

Figure 4.5: Front ABS Valve Package

Figure 4.6: Rear ABS Valve Package

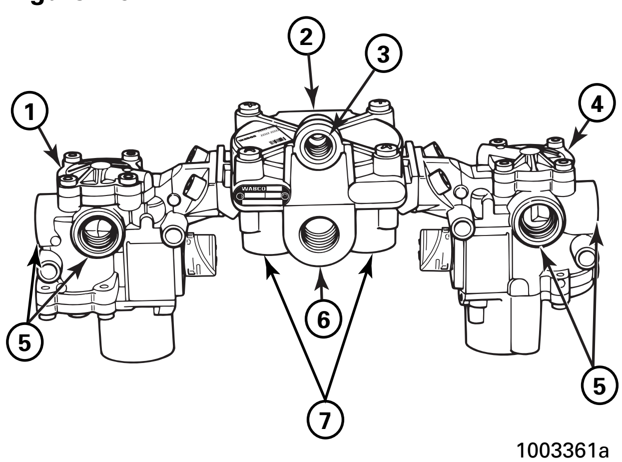
Figure 4.5



1003362a

1. **Supply Port 1/2” NPT**
2. **Quick Release Valve**
3. **1/2” NPT Delivery Ports**
4. **Modulator Valve**

Figure 4.6



1003361a

1. **ABS Modulator Valve**
2. **Relay Valve**
3. **Control Port 1/4” NPT**
4. **ABS Modulator Valve**
5. **Delivery Ports 1/2” NPT**
6. **Supply Port 1/2” NPT**
7. **Delivery Ports 3/8” NPT**

⚠ *WARNING*

Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury can result.

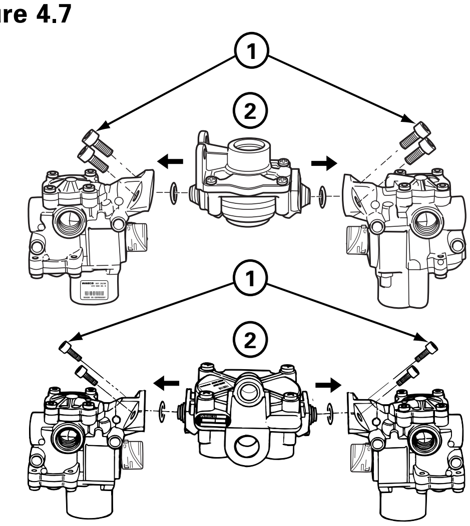
1. Put blocks under tires to stop the vehicle from moving.
2. If necessary, raise the tires off the ground.
3. Drain air from all system air tanks.
4. Remove all air lines and connections from ABS valve package.
5. Remove mounting bolts from the valve package — remove the valve package from vehicle.
6. **Replace the ABS valve package:** Tighten bolts to OE recommendation. Remove blocks and safety stands as necessary.
7. Test the installation. (Refer to page 37.)

Removal and Replacement — Component Valves

(Refer to Figure 4.7)

1. Remove ABS valve package from vehicle.
2. Use a **6 mm** Allen wrench to loosen and remove the Allen head bolts.

Figure 4.7



1002041c

1. **Allen Head Bolts**
2. **13-15 lb-ft (18-20 N•m)**

3. Carefully separate ABS modulator valve(s) from the relay or quick release valve.
4. Remove and discard old O-rings. Lubricate replacement O-rings with grease provided.
5. Plug any unused ports on the replacement valve(s).
6. Attach ABS modulator valve(s) to the relay valve. Torque the Allen head bolts to 13-15 lb-ft (18-20 N•m). T
7. **Replace the ABS valve package**: Tighten bolts to OE recommendation. Remove blocks and safety stands as necessary.
8. Check the valves for leaks:
   - Modulator valve(s) (Refer to page 37.)
   - Relay or quick release valve (Refer to page 42.)

ATC Valve on the Rear ABS Valve Package

Removal

NOTE: If there is enough room to work, it is not necessary to remove the valve package from the vehicle before replacing the ATC valve. If the valve package must be removed, follow the instructions for removing and replacing the ABS Valve Package that appear in this section of the manual.

When installing the new ATC valve on the valve package, you must use the new O-rings, seals, mounting bolts, and lubricant included with the replacement kit.

1. Turn ignition switch to the OFF position, apply parking brake.

WARNING

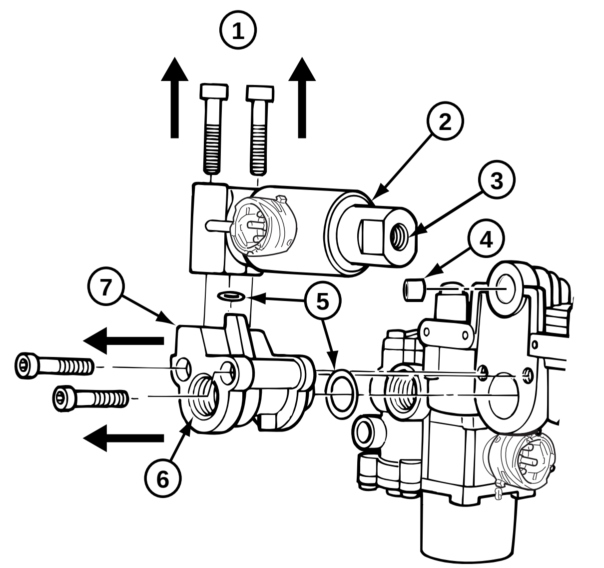
Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury can result.

2. Put blocks under the front and rear tires to stop the vehicle from moving.
3. If necessary, raise the vehicle off the ground. Put safety stands under the axle.
4. **Relieve line pressure by bleeding the air from the appropriate supply tank.**
5. Disconnect the wiring from the ATC valve.
6. Disconnect supply air line from the adapter and the treadle air line from the ATC valve.
7. Use a 5 mm Allen wrench to remove the two screws that hold the adapter piece to the relay valve portion of the valve package.

   Use a 6 mm Allen wrench to remove the two mounting bolts that hold the ATC valve to the adapter piece. Remove the ATC valve from the adapter piece. Remove the ATC valve.

   Remove the adapter piece, seal, and O-rings from the valve package. **Figure 4.8**.

Figure 4.8



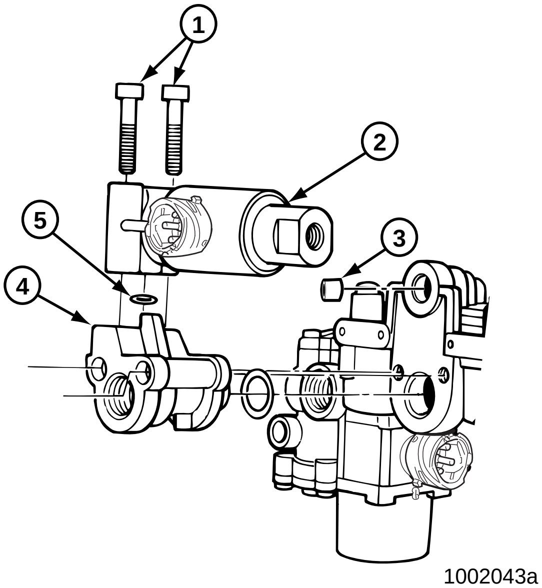
1. **Mounting Bolts**
2. **ATC Valve**
3. **Treadle Air Line**
4. **Seal**
5. **O-rings**
6. **Supply Air Line**
7. **Adapter**

Installation

1. Clean and lubricate the small adapter piece O-ring. Install O-ring on adapter piece.

   Use the two new M8 Allen head bolts to attach the ATC valve to the adapter piece. Use a 6 mm Allen head tool to tighten to 12-13 lb-ft (18-20 N•m). **Figure 4.9.** T

Figure 4.9

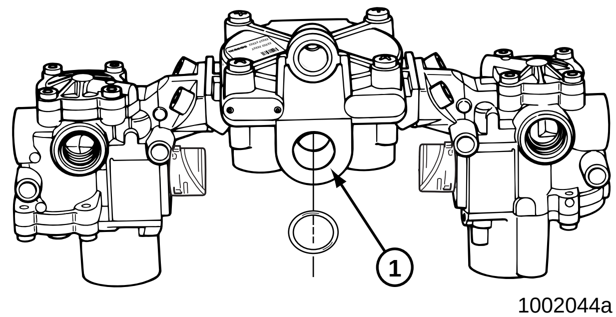


1. **Mounting Bolts 12-13 lb-ft (18-20 N•m)**
2. **ATC Valve**
3. **Seal**
4. **Adapter**
5. **O-ring**

2. Lubricate the replacement seal and install it in Port 2 of the ATC valve.

   Lubricate the large replacement O-ring and install it in the groove of the relay valve supply port. **Figure 4.10.**

Figure 4.10

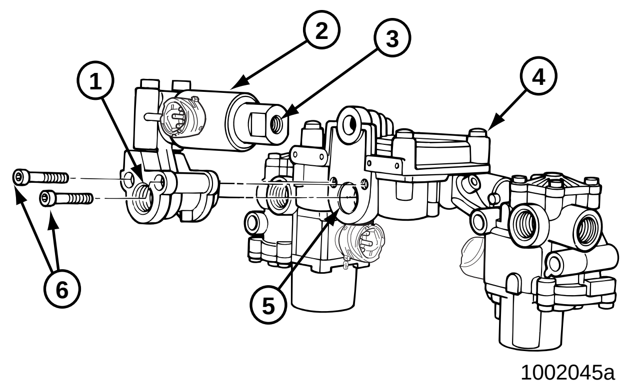


1. **Relay Valve Supply Port**

NOTE: Use Meritor WABCO-recommended lubricant.

3. Use the two M6 Allen head bolts to attach the adapter to the relay valve. Use a 5 mm Allen head tool to tighten to 4-5 lb-ft (6-8 N•m). **Figure 4.11.** T

Figure 4.11



1. **Supply Port**
2. **ATC Valve and Adapter**
3. **Control Port**
4. **ABS Valve Package**
5. **O-ring (Installed)**
6. **Mounting Bolts 4-5 lb-ft (6-8 N•m)**

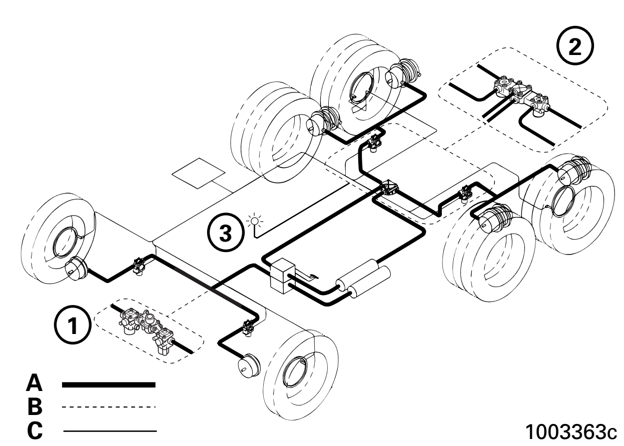
4. Connect the supply air line to the supply port on the adapter. Connect the treadle air line to the control port on the ATC valve.
5. Attach the wiring connector to the ATC valve. Hand tighten only.
6. Remove blocks and stands.
7. Test the installation. (See below.)

Checking the Installation

To test the valves:

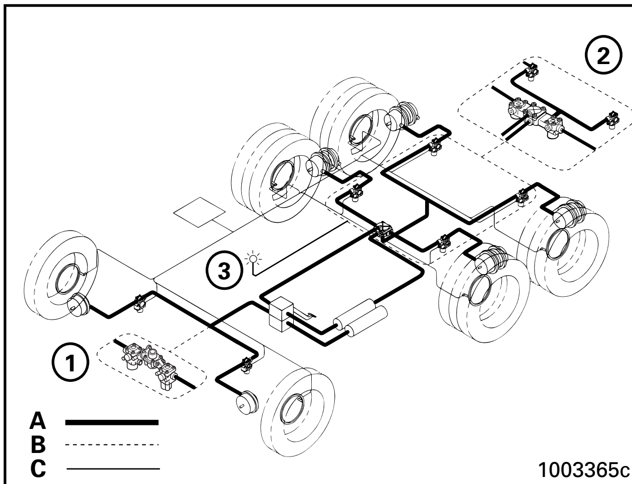
1. Start vehicle.
2. Fully charge reservoirs with air. Shut off vehicle.
3. Apply brakes.
4. Listen for air leaks at all valves.
5. Drive the vehicle. Verify that the ABS indicator lamp operates properly.

E Version Standard or Basic 4S/4M ABS



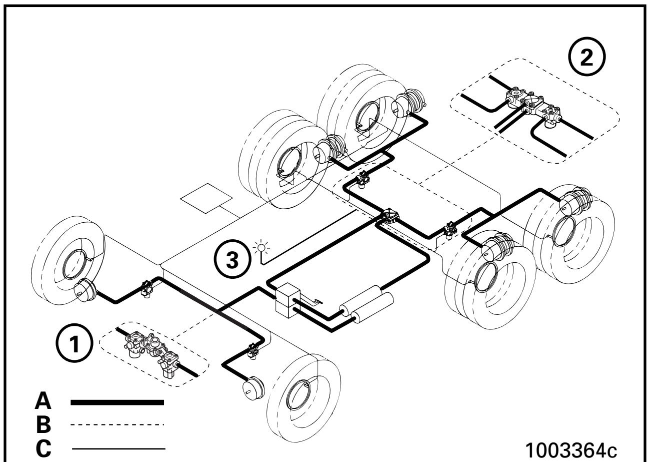
A. Air Lines
B. Elec. Lines
C. Lamps (Up to three: ABS, Trailer ABS, ATC)
1. Valve Package Installation (Front)
2. Valve Package Installation (Rear)
3. Lamps

E Version 6S/6M ABS



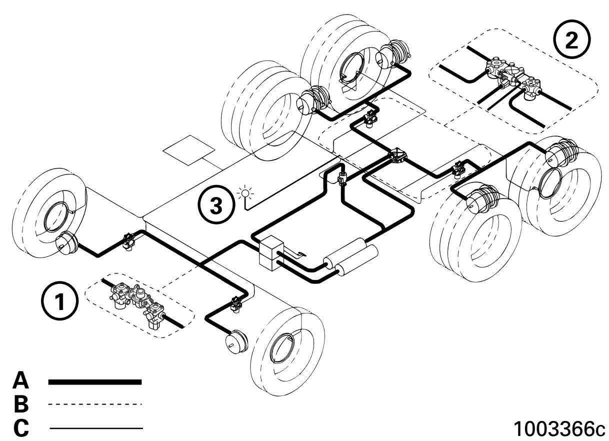
A. Air Lines
B. Elec. Lines
C. Lamps (Up to three: ABS, Trailer ABS, ATC)
1. Valve Package Installation (Front)
2. Valve Package Installation (Rear)
3. Lamps

E Version 6S/4M ABS



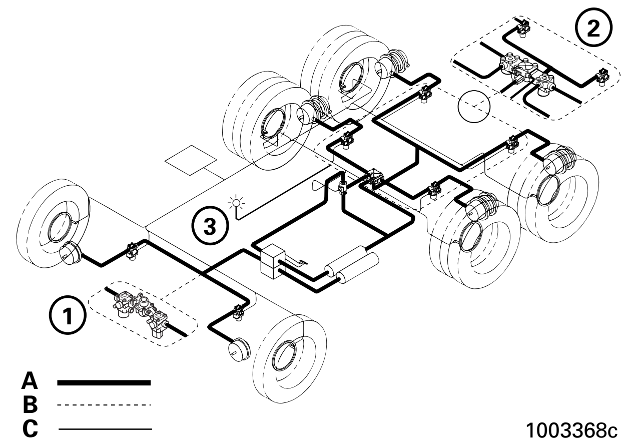
A. Air Lines
B. Elec. Lines
C. Lamps (Up to three: ABS, Trailer ABS, ATC)
1. Valve Package Installation (Front)
2. Valve Package Installation (Rear)
3. Lamps

E Version 4S/4M ABS/ATC



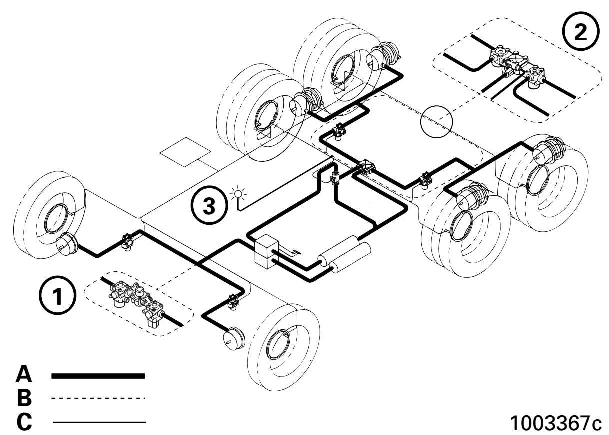
A. Air Lines
B. Elec. Lines
C. Lamps (Up to three: ABS, Trailer ABS, ATC)
1. Valve Package Installation (Front)
2. Valve Package Installation (Rear)
3. Lamps

E Version 6S/6M ABS/ATC



A. Air Lines
B. Elec. Lines
C. Lamps (Up to three: ABS, Trailer ABS, ATC)
1. Valve Package Installation (Front)
2. Valve Package Installation (Rear)
3. Lamps

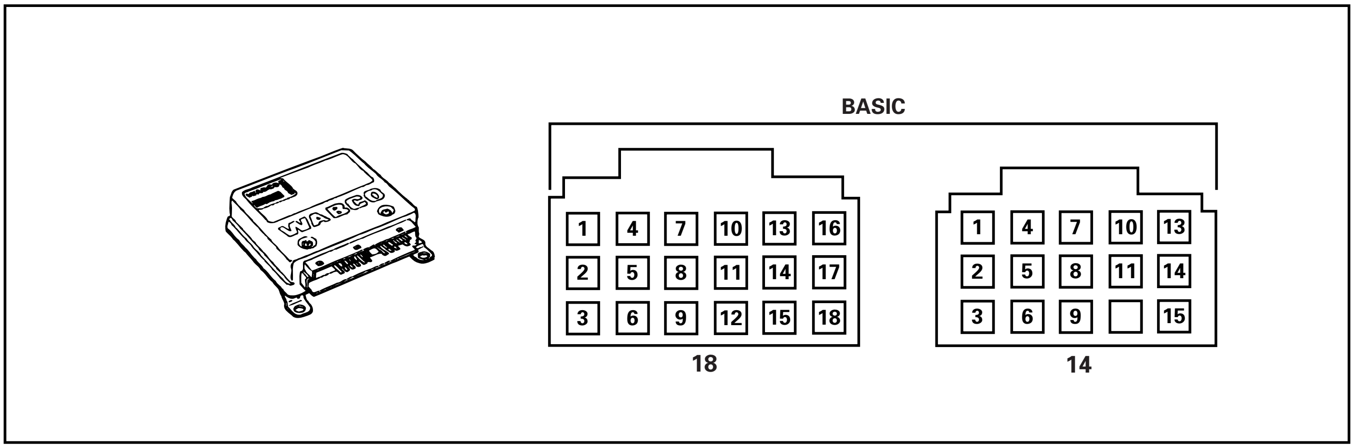
E Version 6S/4M ABS/ATC



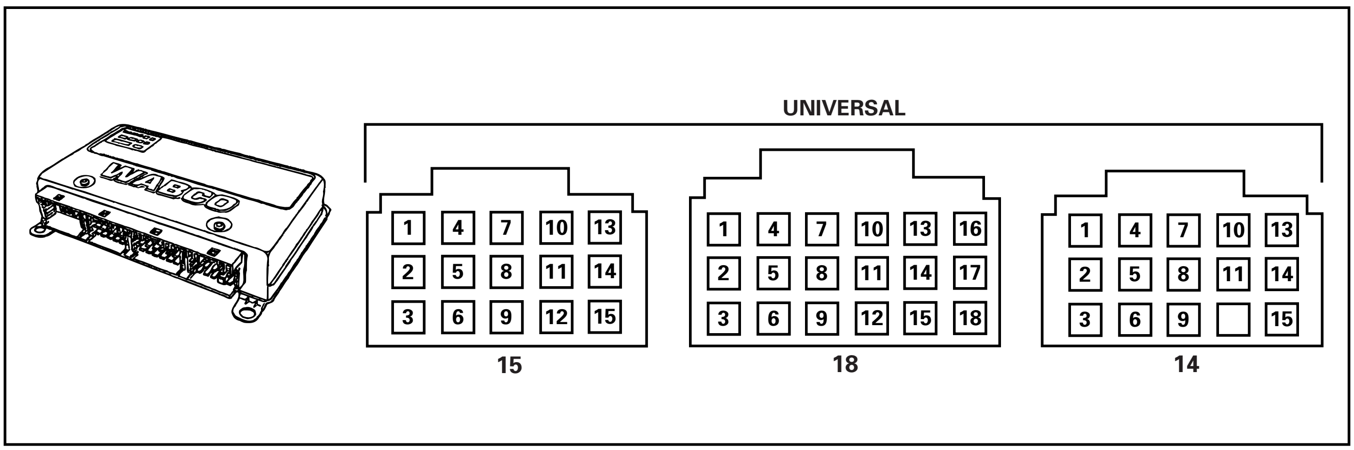
A. Air Lines
B. Elec. Lines
C. Lamps (Up to three: ABS, Trailer ABS, ATC)
1. Valve Package Installation (Front)
2. Valve Package Installation (Rear)
3. Lamps

ECU Connector Pin Assignments

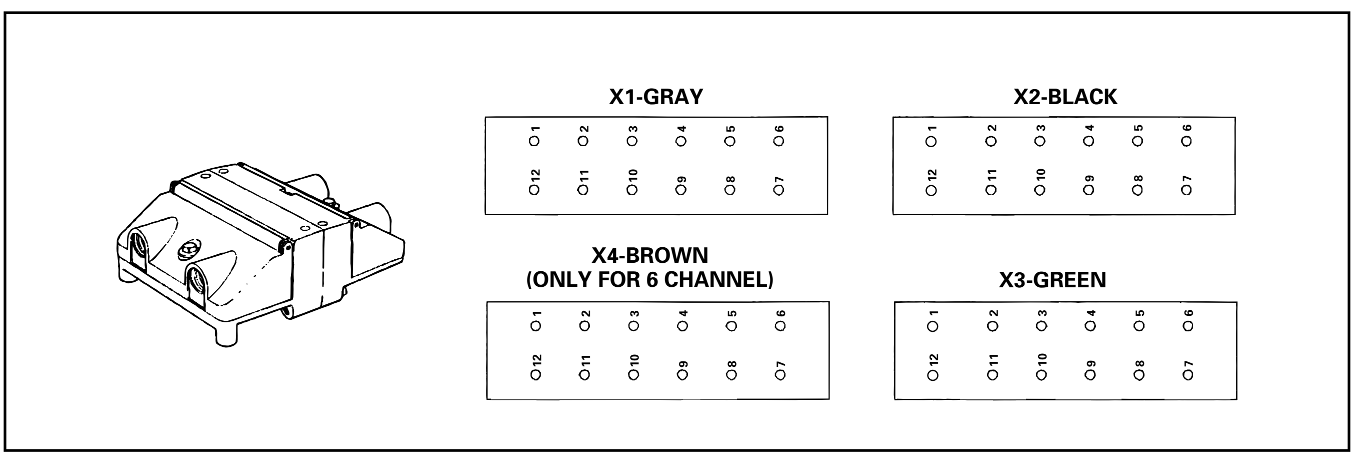
• Basic ECU (Cab-mounted)



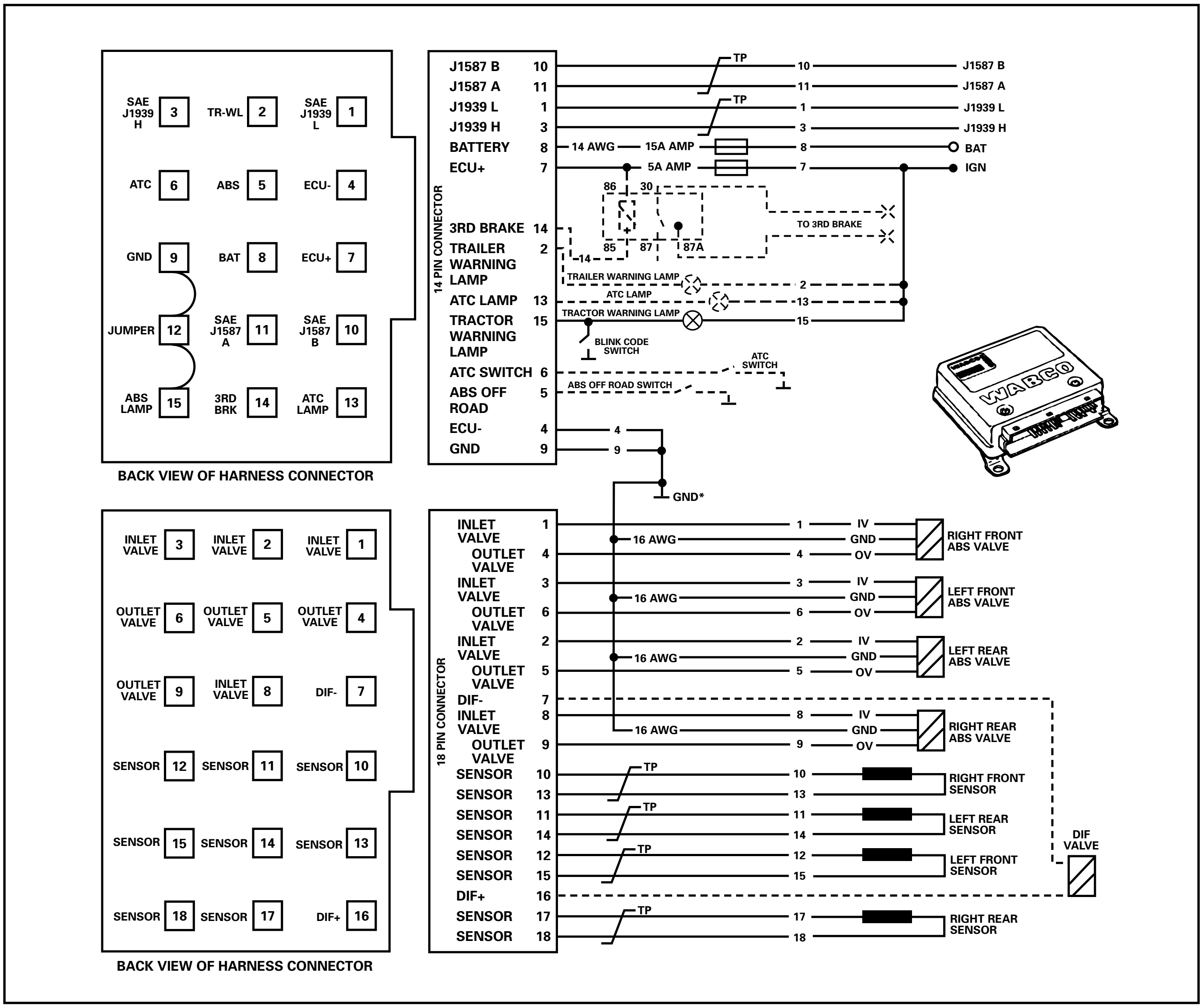
• Universal ECU (Cab-mounted)



• Frame-mounted ECU



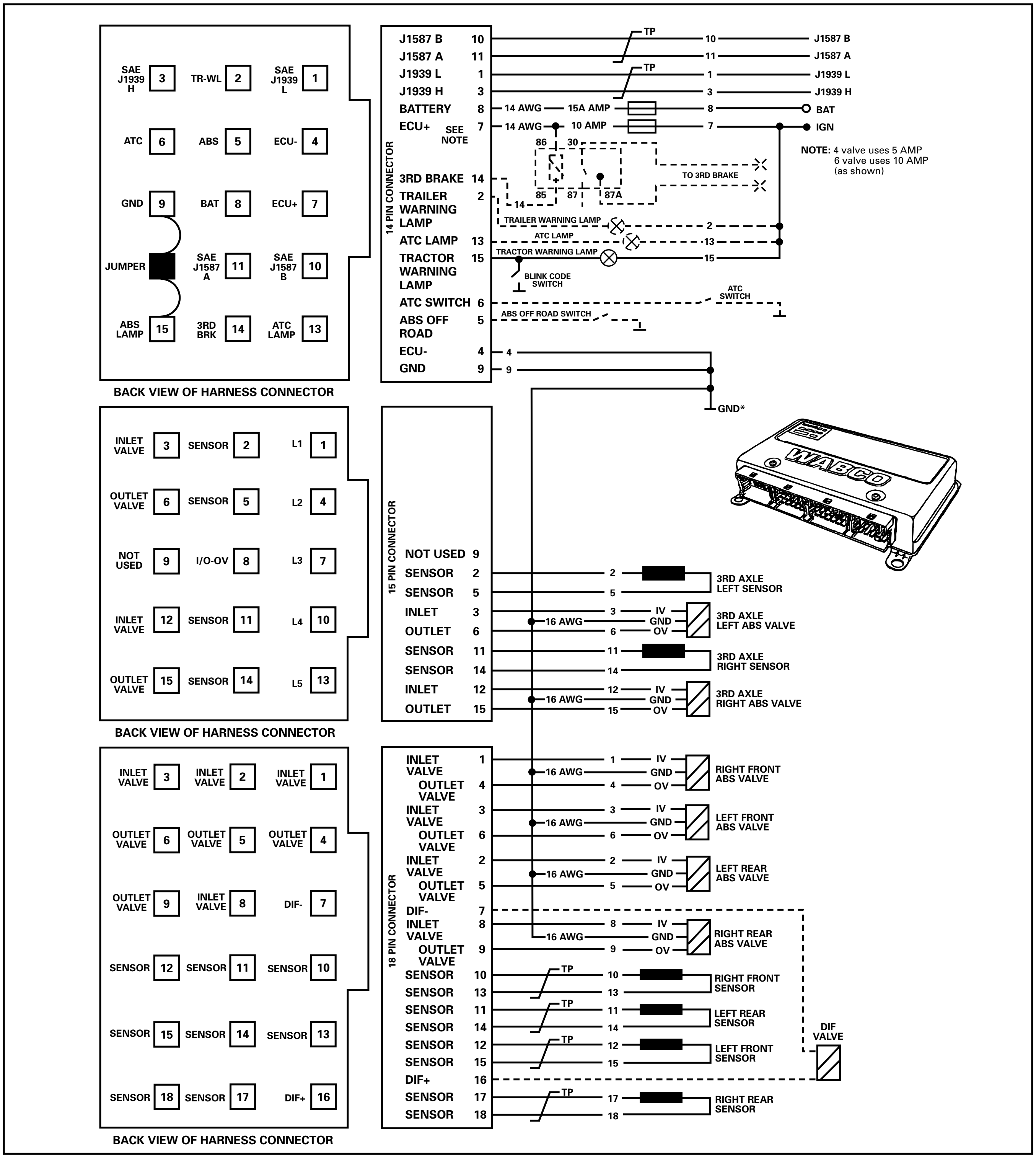
• Basic ECU (Cab-mounted)



1. Momentary Switch
2. – – – – – – – Optional Equipment
3. Twisted Pair = TP
4. All unmarked wires should be 16 or 18 AWG.
5. All fuses should be blade type.

*All connected to a common star ground.

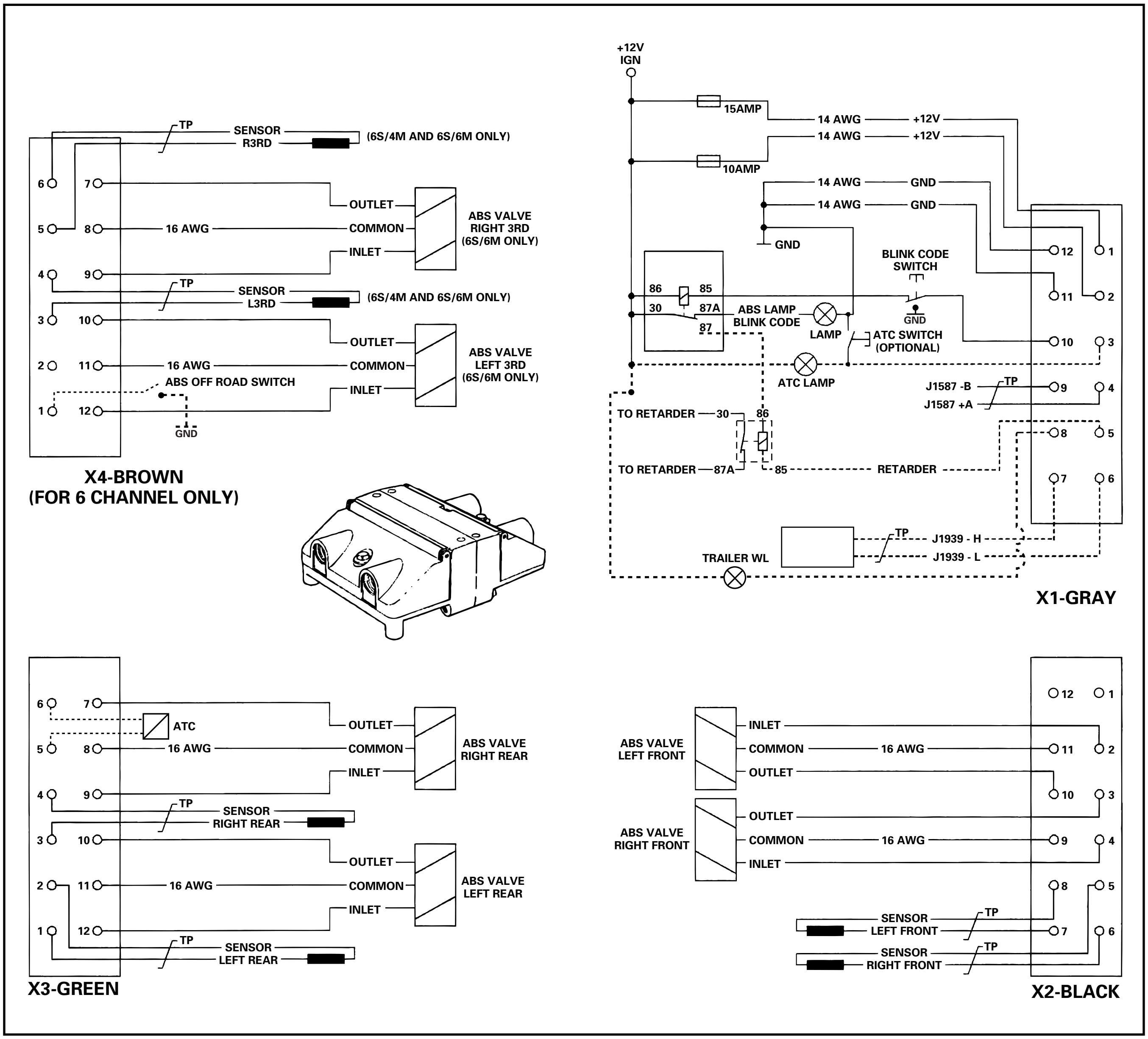
• Universal ECU (Cab-mounted)



1. Momentary Switch
2. ------- Optional Equipment
3. Twisted Pair = TP
4. All unmarked wires should be 16 or 18 AWG.
5. All fuses should be blade type.

*All connected to a common star ground.

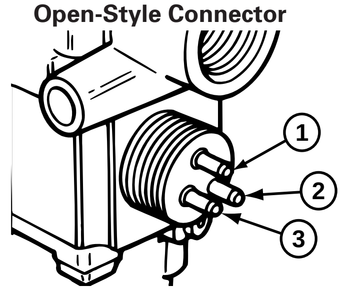
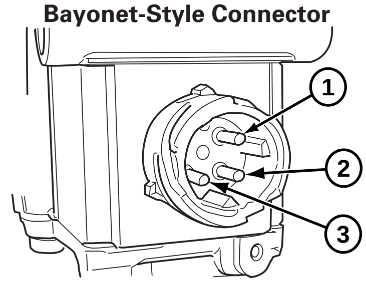
• Frame-mounted ECU



1. ------- Optional Equipment
2. TP = Twisted Pair
3. All unmarked wires should be 16 or 18 AWG.
4. All fuses should be blade type.

Troubleshooting Guide — Meritor WABCO ABS Valve Package

This Troubleshooting Guide is a reference tool to help identify possible malfunctions of the ABS modulator or relay valves. It does not take the place of diagnostic tests or other service instructions.

ABS Valve Package Troubleshooting Guide		
Condition	**Possible Cause**	**Recommended Action**
Air constantly leaks from exhaust port of relay valve.	Internal relay valve problem.	• Replace the relay valve.
Air leaks from exhaust port of ABS modulator valve or relay valve when parking brake is released.	Parking brake problem. OR Anti-compound 2-way check valve problem.	• Service appropriate component. — Refer to manufacturer's service manual for instructions.
Rear service brakes releasing slowly (brakes dragging).	Kinked air line. Dirt buildup inside relay valve.	• Inspect/repair lines, brakes. ***If condition is not corrected:*** • Replace relay valve.
Valves don't cycle at power-up. OR Indicator lamp comes on (blink code or diagnostic tool indicates electrical problem with ABS valve).	Broken wire. OR Loose or broken terminal connection. Corroded connector pins. OR Problem with solenoid. **Open-Style Connector**  **1. Ground Terminal** **2. Exhaust Solenoid (blue wire)** **3. Inlet Solenoid (brown wire)** **Bayonet-Style Connector**  **1. Exhaust Solenoid (blue wire)** **2. Inlet Solenoid (brown wire)** **3. Ground Terminal**	• Check wires and connections. — Make repairs as needed. ***If condition is not corrected:*** • Measure resistance across each valve solenoid coil terminal and ground on the ABS modulator valve to ensure **4.0** to **8.0** ohms. — If **greater than 8.0 ohms,** clean valve and repeat measurement. — If cleaning does not solve problem, replace the ABS modulator valve. — If **less than 4.0 ohms,** replace ABS modulator valve.
ABS valve package damaged.	• Road Hazards. OR • Vehicle Damage.	• Replace complete ABS valve package or individual component as required.

Reconfiguration Procedure

How to Reconfigure an ECU (E Version)

Before reconfiguring the ECU, contact ArvinMeritor's Customer Service Center at 800-535-5560 for additional information.

E version ECUs memorize the following components if they are connected at power-up:

- ATC valve
- Retarder relay
- Datalink SAE J1939

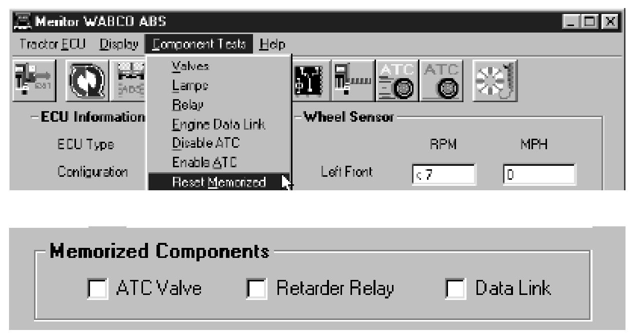
Once these components have been memorized, the ECU will look for them at each power-up. If a memorized component is not present, the ECU will record a fault. For example, if an ATC valve is memorized, but is not present at the next power-up, the ECU records a fault. This can occur if an ECU is moved from one truck to another and one or more of the memorized components are not available on the new truck. If this occurs, use TOOLBOX Software to reconfigure the ECU. If you do not have TOOLBOX Software, follow the Manual Reconfiguration instructions listed on page 51.

TOOLBOX Software

NOTE: For complete instructions for using TOOLBOX Software, refer to the *TOOLBOX User's Manual*, TP-99102.

To reconfigure the ECU with TOOLBOX Software, use the ***Reset Memorized*** command.

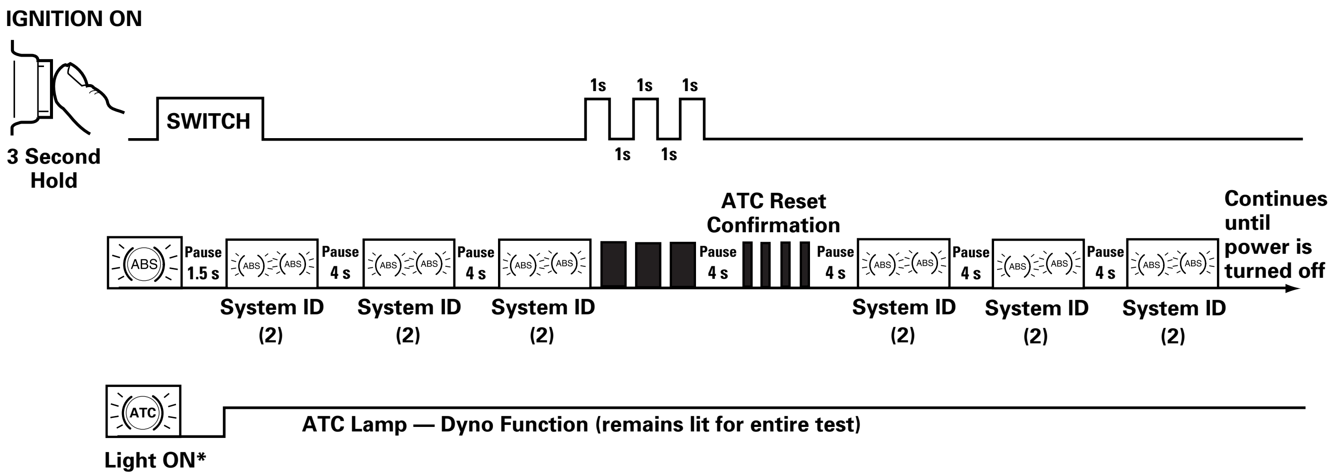
Select ***Reset Memorized*** from the pull down menu to tell the ECU to reset the memorized or "learned" components.



Manual Reconfiguration

Action	Result	Reason
1. Turn ignition ON. 2. Press and hold blink switch for at least three seconds. **NOTE:** Do not hold this switch longer than seven seconds.	ABS lamp displays the ABS system configuration code*: • One blink: 6S/6M • Two blinks: 4S/4M • Four blinks: 6S/4M * The ABS lamp may display eight quick flashes before the system configuration code begins.	Stored faults cleared, no active faults present. Continue with reconfiguration. **NOTE:** The reconfiguration procedure can not be conducted if there are active faults present. These must be repaired before proceeding with the reconfiguration.
Observe the ABS and ATC lamps.	ATC lamp comes on and stays on.	A complete ATC system — including an ATC lamp — is installed. If not, the ATC lamp will not come on.
	ABS lamp will continuously blink the system configuration code.	ECU reconfiguring the system. The ECU checks the following components and reprograms itself based on the new system: • ATC valve AND/OR • Retarder relay AND/OR • Datalink J1939
While the configuration code is flashing, press the blink code switch three times (one second each, with a one second pause between each). Turn ignition OFF.	ABS lamp displays **four quick flashes**, followed by a continuous display of the system configuration code. **NOTE:** System configuration code continues until ignition is turned OFF.	Successfully reconfigured.

A system reconfiguration is illustrated below:



***ATC Lamp will light only if ATC is connected.**

1003371a

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SECTION 13: WHEELS, HUBS & TIRES

CONTENTS

ILLUSTRATIONS

1. WHEELS

When the vehicle is provided with stud-mounted wheels, wheel studs and nuts on the left side of the vehicle have left-hand threads whereas those on the right side have right-hand threads. If equipped with hub-mounted wheels, all studs and nuts have right-hand threads. Either steel wheels or optional aluminum-polished wheels may be installed on the vehicle. Both are mounted with radial tubeless tires.

All wheel dimensions are 22.50 X 9.0 inches (571.5 X 228.6 mm) for 315/80 R 22.5 tires except for inner drive wheels ,which are always steel wheels and 22.50 X 8.25 inches (571.5 X 209.6 mm) for 315/80 R 22.5 tires. All other wheels can either be steel or aluminum wheels.

Note: *MTH vehicles come equipped with 22.50 X 10.5 wheel dimensions (571.5 X 266.7 mm) for 365/70 R 22.5 tires on front and tag axle.*

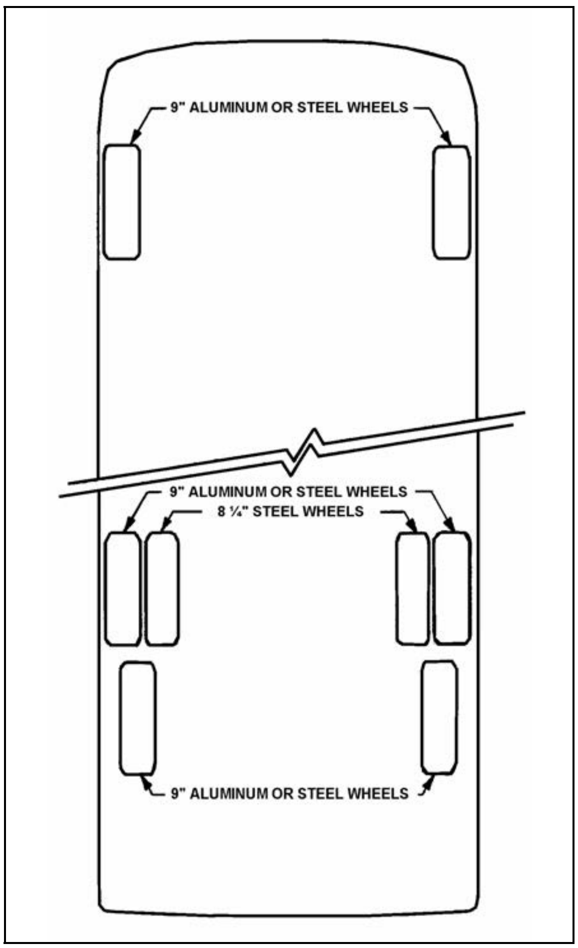

FIGURE 1: ALUM/STEEL WHEEL ARRANGEMENT 13001

2. WHEEL MAINTENANCE

Wheel maintenance consists of periodic inspections. Check all parts for damage and make sure that wheel nuts are tightened to the proper torque. In the case of a new vehicle, or after a wheel installation, stud nuts should be tightened every 100 miles (160-km) for the first 500 miles (800-km) to allow setting in of clamping surfaces.

Wheel studs and nuts must be kept free from grease and oil. No lubricant whatsoever should be used. Cleanliness of the wheel and its rotor mating surfaces is important for proper wheel mounting.

However, for hub mounted wheels, it is recommended to add some rust protection lubricant on the pilot diameter of the hub (to facilitate future removal).

It is also important that wheel stud nuts be tightened alternately on opposite sides of the wheel. Refer to Figure 2 for the suggested tightening sequence.

2.1 INSPECTION

Tighten stud nuts progressively as shown in Figure 2. The final tightening should be done with a torque wrench. Tighten stud nuts to 450 - 500 Ft-lbs (610 - 680 Nm) for aluminum as well as steel wheels.

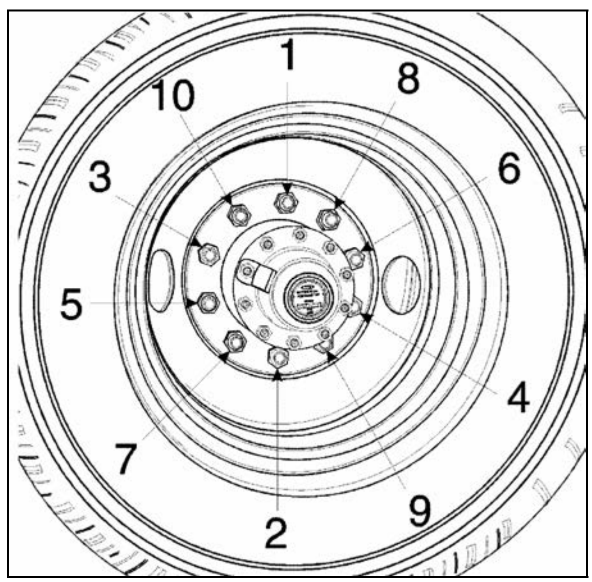

FIGURE 2: TIGHTENING SEQUENCE 13018

2.2 SINGLE WHEEL REMOVAL

1. Stop engine and apply parking brake.
2. Loosen wheel nuts about one turn (do not remove the nuts). This is not necessary if equipped with hydraulic powered gun.

Note: *For stud-mounted wheels, turn nuts counterclockwise for R.H. side and clockwise for the L.H. side of vehicle. For hub-mounted wheels, turn nuts counterclockwise on both sides of the vehicle.*

3. Raise the vehicle by its jacking points on the body. See Section 18, *"Body",* under heading *"Vehicle Jacking Points";*
4. Unscrew wheel hex stud nuts and remove the wheel;

Caution: *Always mark position of the wheel on the axle prior to removal in order to replace wheel at the same location, thus avoiding a new wheel balancing.*

2.3 SINGLE WHEEL INSTALLATION

1. Mount the wheel over studs, being careful not to damage stud threads;
2. Screw in the hex stud nuts (refer to Figure 2 for sequence) so that wheel will position itself concentrically with hub. This is important, otherwise wheel may be eccentric with hub and will not run straight. In this initial step, slightly tighten the nuts to correctly position the wheel;
3. Tighten stud nuts progressively as shown in Figure 2. The final tightening should be done with a torque wrench. Tighten stud nuts to 450 - 500 Ft-lbs (610 - 680 Nm) for aluminum as well as steel wheel.

Caution: *Insufficient mounting-torque can result in damage to parts. Excessive mounting torque can cause studs to break and the wheel to crack in stud hole area.*

3. DUAL WHEELS

3.1 OUTER WHEEL REMOVAL

Same as described in *"Single Wheel Removal"* procedure described previously.

3.2 INNER WHEEL

1. Remove outer wheel;
2. Unscrew inner cap nuts
3. Remove inner wheel.

3.3 INNER WHEEL INSTALLATION

1. Mount the wheel over studs, being careful not to damage stud threads;
2. Screw in the inner cap nuts (Fig. 3), so that wheel will position itself concentrically with hub. Refer to Figure 2 for sequence;
3. Tighten inner cap nuts progressively according to sequence shown in Figure 2. Final tightening should be done with a torque wrench. Tighten inner cap nuts to 450 - 500 Ft-lbs (610 - 680 Nm) for aluminum as well as steel wheel.

Caution: *Insufficient mounting-torque can result in damage to parts. Excessive mounting torque can cause studs to break and the wheel to crack in stud hole area.*

3.4 OUTER WHEEL INSTALLATION

With inner wheel installed, tighten the hex stud nuts (Fig. 4) using the single wheel installation procedure described previously.

Note: *On dual wheel assemblies, position the wheels with the tire valves 180º apart in order to have access to both the inner and outer valves.*

3.5 INSPECTION

1. Loosen a hex stud nut three turns (Fig. 4);
2. Tighten the inner cap nut to 450 - 500 Ft-lbs (610 - 680 Nm);
3. Tighten the hex stud nut to 450 - 500 Ft-lbs (610 - 680 Nm).

Repeat for each of the 10 *"hex stud nut - inner cap nut assemblies"* according to the tightening sequence in Figure 2.

Caution: *Do not attempt to tighten an inner cap nut without having previously loosened the hex stud nut.*

Caution: *The actual length of thread engagement present in an assembled wheel can not always be determined by visual inspection of measurement of a tightened assembly. The* *relationship of the wheel cap nut seat to the end of the stud may vary. If there is any doubt that enough thread engagement is present, the number of engaged threads may be counted. Tighten all nuts in the regular manner, then loosen one to hand-tightness. The number of turns to disengage a 1-1/8-inch nut should be at least five full turns. At least seven full turns should be required to disengage a ¾-inch nut or a M22 nut. Ideally, when torqued to the proper load, the stud should be flush with the face of the nut.* ***The face of the nut may be recessed in nuts that are taller for improved wrench-ing. With most of the nuts in present use, a few unengaged threads at the outer end will cause no problem provided at least 5-7 full turns are required to disengage the nut depending on thread size.***

4. ALUMINUM WHEEL ANTI-CORROSION PROTECTION

Clean wheels often by means of a high pressure water jet. Cleaning may be accelerated with mild soap. Do not use concentrated alkaline cleaning products.

When tire is removed, clean and inspect wheel thoroughly. Remove dirt and corrosion on rim by means of a wire brush. Do not use a wire brush on the outer surface of the wheel.

The following measures should be taken to maintain original appearance of the aluminum wheels:

1. Remove any tar from wheel surface with a good quality tar remover.
2. Spray Alcoa Cleaner (Prévost #683529) evenly on cool outer surface of wheel. Let work 15-20 minutes (keep wet by spraying more Cleaner if necessary).
3. Rinse thoroughly with clean water and let air dry. Heavy oxidation may require a repeat application of cleaner.
4. Apply Alcoa Polish (Prévost #683528) sparingly to a small area using a clean, soft cloth. Work polish into surface as you would a rubbing compound.
5. Buff, turning cloth frequently, until surface is clean and shiny. Let air dry. Use power buffer to improve ease of use and gloss uniformity.
6. On completely dry, clean and polished surface, generously apply Alcoa sealant (Prévost #683527). Rinse thoroughly with water while surface is still wet in appearance (have water source ready as the dry time is very short, usually less than 2 minutes).
7. For best results, finish by wiping the surface with a clean rag to remove excess water, then allow surface to dry.

Clean aluminum wheels as required to maintain original look.

Warning: *Wheel surfaces may have sharp or cutting edges that may cause injury to the hands. To prevent contact with sharp edges, it is strongly recommended to wear rubber gloves when washing or polishing wheels.*

5. WHEEL STRAIGHTNESS TEST

1. Slightly raise axle to be checked and place a safety support underneath;
2. Check wheel lateral runout. Install a dial gauge as shown in Figure 3, then rotate the wheel by hand one full turn. As the wheel turns, note any variation on the dial gauge;

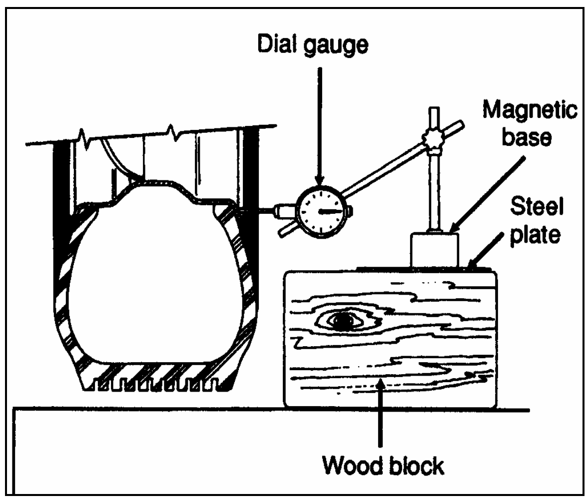

FIGURE 3: DIAL GAUGE INSTALLATION 13008

Caution: *Damage to the dial gauge could occur if it strikes a wheel balancing weight.*

3. If the variation in lateral runout exceeds 0.0625 inch (1,6 mm), the wheel must be replaced.

If doubt exists whether wheel or hub is distorted, hub may be checked as follows:

- Replace the existing wheel with a wheel known to be correct;
- Check wheel lateral runout as outlined in step 2;
- If, within specifications, the hub is correct but the suspected wheel must be replaced.

Warning: *NEVER STRAIGHTEN ALUMINUM WHEELS. Never heat aluminum wheels to repair damages incurred after hitting a curb or resulting from other causes. The special alloy in wheels has been heat treated, and any uncontrolled heating could alter wheel structure. Furthermore, never weld aluminum-forged wheels for any reason whatsoever.*

6. WHEEL STUDS

Stripped threads may be the result of excessive torquing or may have been damaged during wheel installation when placing the wheel over the studs. A stud having damaged threads must be replaced. Broken studs are a direct result of operating with loose stud nuts or improperly seated wheels. When a broken stud is replaced, the adjacent studs, on each side of the broken one must also be replaced since they could have been subjected to excessive strain and may be fatigued.

When installing wheel studs to hubs, check nuts retaining the wheel stud to wheel hub and replace if they are deformed, damaged or severely corroded. Install nut (and washer where applicable) to new stud. Torque to 450 - 500 Ft-lbs (610 - 680 Nm).

Note: *For stud-mounted wheels, turn nuts counterclockwise on R.H. side of vehicle and clockwise on L.H. side. For hub-mounted wheels, turn nuts counterclockwise on both sides of vehicle.*

6.1 DRIVE AXLE STUDS

Stud-mounted wheels are mounted on the drive axle with ¾"-16 studs with an inner cap nut, and a 1-1/8"-16 nut. Hub-mounted wheels are mounted with M22 x 1.5 studs and an M22 flange nut.

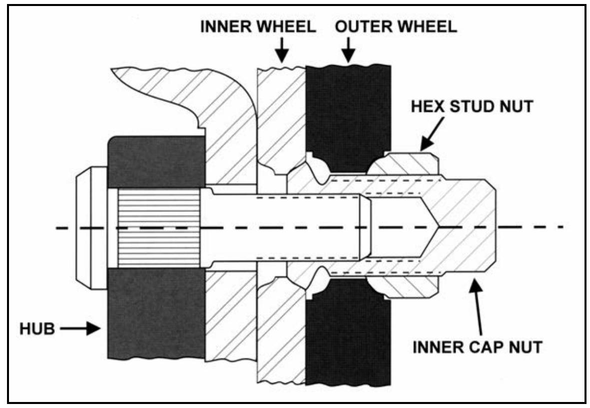

FIGURE 4: STUD-MOUNTED WHEELS 13007

6.2 FRONT AND TAG AXLE STUDS

Wheel can be mounted on tag axle with studs (1-1/8"-16 thread) or hub mounted (M22 x 1.5 thread).

Note: *Wheel studs and nuts must be kept free from grease and oil. No lubricant whatsoever should be used.*

7. HUB MOUNTED WHEELS

Wheel surfaces in contact with hubs, nuts or other wheels should be kept free of all rust, grease and paint (except for initial "E" coat protection, applied to stop rusting and to facilitate wheel removal). The reason for this is to assure that all faces are clamped together without buildup of any coating. The threads of the wheel studs and the wheel nuts should be clean and undamaged.

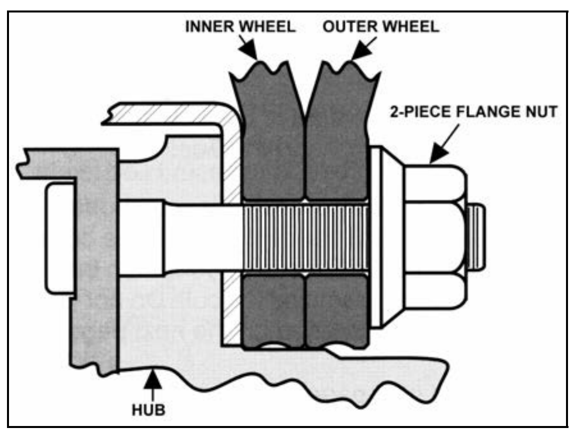

FIGURE 5: HUB-MOUNTED WHEELS 13025

Note*: When painting wheels, make sure to mask all surfaces identified above.*

Using a calibrated torque wrench, tighten wheel nuts to 450 - 500 Ft-lbs (610 - 680 Nm) of torque. Do not use power tools or long bars for tightening. Tighten wheel nuts alternately as shown in figure 2.

Note: *Tightening should not be done immediately after prolonged braking or when wheel ends are hot.*

Check wheel nut torque at every 100 miles (160 km) for 500 miles (800 km) after fitting wheels. Let cool before checking. If any relaxation of the initial 450 - 500 Ft-lbs (610 - 680 Nm) of torque has occurred, retighten. Relaxation of initial torque may occur because of the "bedding down" of the hub and wheel surfaces.

Note: *Torque relaxation occurs when wheel ends are hot but should revert to original setting when cool. Retightening when hot will produce a higher torque reading than recommended.*

7.1 CARE OF WHEELS

Check for cracks in wheels, especially around the fixing holes, studs, nuts and washers. If in doubt, renew.

Do not simply retighten very loose wheel fixings or wheels that are continually becoming loose. Find out why they are loose and whether any damage has been caused.

Use trained personnel and keep records of all attention to wheels and fixings, including which parts were renewed and when.

8. FRONT AND TAG AXLE WHEEL HUBS

The unitized hub bearings used on the NDS range of axles, are non-serviceable items. Bearings are pre-adjusted, lubricated and have seals fitted as part of the manufacturing process. The bearings are greased for life and there is no need or facility for re-lubrication

8.1 HUB BEARING INSPECTION

An inspection should be made at intervals of 30,000 miles (48 000 km).

- Apply parking brake, raise wheels off the ground and support axle on stands. When the wheels are raised, they should revolve quite freely without roughness.
- Place magnetic base of a dial indicator on brake caliper and position dial indicator stem against a convenient marked spot on face of hub flange.
- With dial indicator in position pull hard but steadily on hub flange and oscillate at same time until a steady reading is achieved.
- Without releasing the pressure, turn bearing so that dial indicator stem contacts marked spot and note reading on indicator.
- Push bearing flange hard and oscillate as before until a steady reading is achieved.
- Without releasing the pressure, turn bearing so that indicator stem again contacts the marked spot and note new reading on indicator.
- The difference between readings is the amount of mounted end play in bearing unit.
- The mounted end play figure should not exceed 0.050 mm for a new bearing.

Note: *If original bearing unit is re-fitted, and end-float is measured at 1 mm, with hub not fully tightened to correct torque, then the retaining clip within the unit is damaged and a new unit must be fitted.*

Note: *For more information on front and tag axle wheel hub, refer to "DANA SPICER Maintenance Manual Model NDS and Maintenance Manual NDS Axles" annexed at the end of Section 10.*

Note: *For vehicles equipped with Independent Front Suspension, refer to Section 16 "Suspension".*

9. DRIVE AXLE WHEEL HUBS

Drive wheels use a single oil-seal assembly. They are lubricated from the oil supply in the differential housing. Bearings are tapered rollers, adjustable to compensate wear. Maintain differential oil level with general-purpose gear lubricant (refer to Section 24 *"Lubrication"* for proper oil grade selection) to ensure adequate oil supply to wheel bearings at all times.

9.1 BEARING ADJUSTMENT

To adjust drive wheel bearings:

1. Raise vehicle until both dual wheels can be turned freely (approximately 6 inches from the ground). Position jack stands under drive

axle, then lower vehicle approximately 2 inches in order to avoid entire weight of the axle being supported by the suspension air bellows and the shock absorber pins.

2. Remove axle shaft as indicated in *"Meritor - Maintenance Manual No. 5"* under heading *"Single Reduction Differential Carriers"* annexed to *"Section 11"* of this manual. Remove gaskets. Unscrew lock nut and remove adjusting nut lock ring.

3. To adjust, tighten adjusting nut until the wheel binds. Rotate the wheel while tightening so that all surfaces are in proper contact. Back off adjusting nut approximately, ¼ to 1/3 turn to assure 0.001/0.007" (0.0254/0.1778 mm) endplay and to ensure that wheel turns freely. Replace the lock ring, and adjust nut dowel pin in one of the holes. The ring may be turned over if necessary to allow more accurate bearing adjustment.

4. Tighten lock nut and check bearing adjustment. Replace the axle shaft using a new gasket.

9.2 DISASSEMBLY AND REPAIR

1. Jack vehicle as per “Bearing Adjustment" and remove axle shaft as indicated in *"Meritor - Maintenance Manual No. 5"* entitled *"Single Reduction Differential Carriers"* annexed to Section 11 of this manual.

2. Remove wheels and tires.

Caution: *Always mark position of the wheel on the axle before removal, to replace wheel at the same location, thus avoiding a new wheel balancing.*

3. Remove lock nut, lock ring and adjusting nut from axle housing to prevent the outer bearing from falling out. Remove outer bearing cone and roller assembly.

4. Remove screws attaching inner oil seal retainer to hub, and remove inner oil seal assembly. Remove inner bearing cone and roller assembly. Bearing cups can be separated from the hub using a hammer and a long brass drift.

5. Thoroughly clean all parts. Bearing cone and roller assemblies can be cleaned in a suitable cleaning solvent using a stiff brush to remove old lubricant.

6. In case that excessive wear, deterioration, cracking or pitting is present on the bearing cups, rollers or cones, the bearings should be replaced. Seals should be replaced each time they are removed from the hub. To install new oil seal, use a suitable adapter and drive the seal into the retainer bore until it bottoms.

7. When installing wheel on spindle, center the wheel hub with spindle to avoid damaging the seal with the end of the spindle. Push wheel straight over the spindle until inside diameter of seal press fits on wiper ring. Fill hub cavity with general-purpose gear lubricant (refer to Section 24 *"Lubrication"* for proper oil grade selection). Lubricate, then install outer bearing cone. Adjust bearing and lock. Assemble axle flange to axle using a new gasket. Apply sealant in stud area. After both wheels have been assembled according to above procedure, fill the differential with the recommended lubricant to the proper factory recommended level.

Note: *During regular inspection, do not forget to check lubricant level in differential. Clean thoroughly or replace vent as required.*

10. SPARE WHEEL (IF APPLICABLE)

Tire failure is a rare event if tires are properly cared for. In case of a flat tire, move vehicle a safe distance away from traffic and apply parking brake. Remember to use the hazard flashers and according to the Highway Code regulations, set up the triangular reflectors (see *"Emergency Warning Reflectors"* in the Operator's Manual) at an adequate distance, to warn incoming motorists.

The spare wheel is stored in a dedicated compartment behind the front bumper. To access, pull the release handle located in the front service compartment. Although the bumper is heavy, sprung hinges permit one person operation.

When closing bumper compartment, make sure bumper is securely installed.

Note: *Converted vehicles contain no spare wheel. Access to compartment is also obtained by pulling the release handle located in the front service compartment.*

Warning: *This compartment has not been designed for storage. Never leave loose objects in this area since they may interfere with steering linkage mechanism. Make sure bumper is safely locked in place after closing the compartment.*

10.1 PULLING OUT SPARE WHEEL

To remove the spare, untighten the pressure screw holding the tire in place, then press down on the spring loaded locking pin located at the top of the retaining bracket and remove the bracket. Using the strap, pull the spare out of the compartment (refer to the following illustrations). Rollers ease manipulation. Remove the protective cover. Install the flat in place of the spare by reversing the procedure. Do not forget to have the flat repaired as soon as possible.

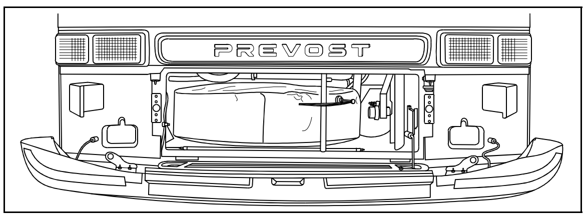

FIGURE 6: SPARE WHEEL COMPARTMENT

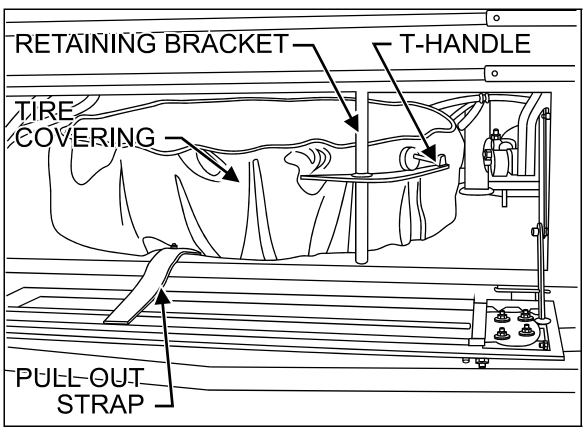

FIGURE 7: SPARE WHEEL AND TIRE 18415

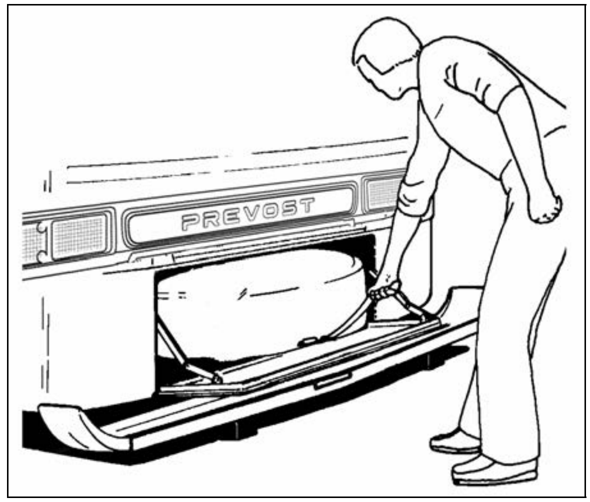

FIGURE 8: REMOVING SPARE WHEEL AND TIRE 13022

Note*: The jack and wheelnut wrench are either stored at right in forward baggage compartment or at left in rear baggage compartment.*

The jack/tools kit stowed in the forward R.H. baggage compartment contains a:

1. Hydraulic jack;
2. Jack bar;
3. Wheel nut wrench and extension;
4. Triangular reflectors box.

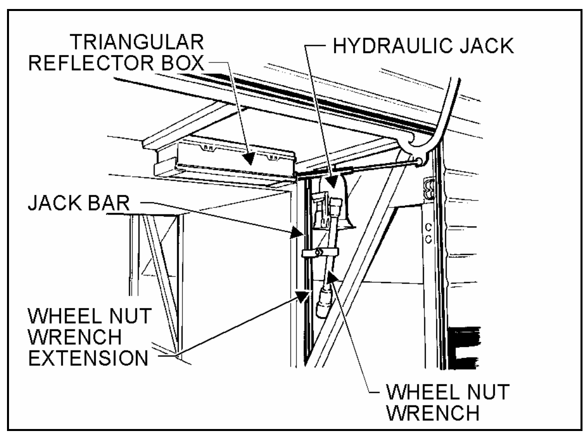

FIGURE 9: FORWARD R.H. SIDE COMPARTMENT 23012

Note*: Check the inflation pressure of the spare tire periodically to keep it ready for use. Inflate spare tire to the pressure of the tire, which has the highest pressure on the vehicle. When installing, deflate to correct pressure if necessary.*

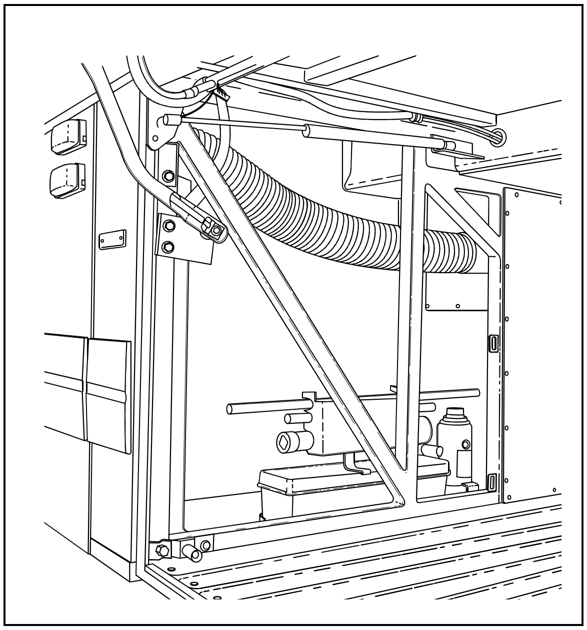

FIGURE 10: REAR BAGGAGE COMP. L.H. SIDE

10.2 CHANGING A FLAT

In case of flat tire, refer to appropriate procedure under “Wheel Maintenance" heading in this section.

Note: *For hydraulic jack placement, refer to Section 18 "Body", under heading "Vehicle Jacking Points".*

Warning: *Place jack on stable and level ground; if necessary, place a board under the jack. Do not raise the vehicle until you are sure the jack is securely engaged.*

Warning: *To prevent personal injury and/or equipment damage, use only the recommended jacking points. Passengers must not remain inside vehicle while wheel is being replaced.*

Caution*: Adjust tire pressure according to the appropriate cold tire inflation-pressure.*

Note: *Store damaged wheel in spare tire compartment. Repair and balance the flat tire as soon as possible.*

10.3 SPARE WHEEL MAINTENANCE

Maintenance of the spare wheel and tire consists in ensuring that tire inflation pressure is the same as the tire on the coach that has the highest inflation pressure (refer to “Specifications” in this section for the recommended tire inflation pressure). Inspect rim to ensure that there is no important corrosion. In addition, check if spare wheel covering is in good condition and check that spare tire is securely fastened in compartment.

11. TIRE MAINTENANCE

The most critical factor in tire maintenance is proper inflation (Fig. 11). No tire is impervious to loss of air pressure. To avoid the hazards of under inflation, always maintain tires at their recommended inflation pressure. Improper inflation decreases tire life.

An under inflated tire builds up heat that can cause sudden tire destruction, resulting in improper vehicle handling and possible loss of vehicle control. At least once a week, before driving (when tires are cold), check inflation pressure on all the tires, including the spare tire. This is especially important in cases when different drivers operate the vehicle.

Warning: *Failure to maintain correct tire inflation pressure may result in sudden tire destruction, improper vehicle handling, and will cause rapid and irregular tire wear. Inflation pressure should be checked weekly and always before long distance trips.*

11.1 INFLATION PRESSURE

The condition and pressure of the tires can greatly affect both useful tire life and road safety.

At regular intervals, verify the tire pressures. Use an accurate tire pressure gauge when checking inflation pressures. Never exceed the maximum inflation pressure specified on each tire.

Note: *Inflation pressure should be checked when tires are cold. Cold tire inflation pressure can be measured when a vehicle has not been driven for at least 3 hours or less than 1 mile (1.6 km). Driving, even for a short distance, causes tires to heat up and air pressure to increase. Check inflation pressure on all tires (including the spare tire) using an accurate tire gauge.*

Note: *The recommended tire inflation pressures are given in the applicable documents supplied with the vehicle. In addition, cold tire inflation pressures are listed on the Department of Transport's certification plate, affixed on the panel behind the driver's seat. For special tire selection, a "*PRÉVOST COACH SPECIAL SPECIFICATION*" chart is supplied with the vehicle and is affixed on the left wall near the driver's seat. Remember, tire inflation pressure must be adjusted according to vehicle loading - see table in "Coach Final Record"*

Caution: *Never bleed air from hot tires as tires will then be under inflated. Use an accurate tire gauge to check pressures (Do not kick tires as an inflation check. This is an unreliable method).*

Caution: *These tire pressures are established in accordance with the maximum allowable load on each axle. A lower pressure is recommended if the axle load is less than the above specifications. Weigh vehicle fully loaded and pressurize according to tire manufacturer's recommendations. For other tire and wheel specifications, see Prévost tire pressure tabulation in "Coach Final Record".*

Warning: *Incorrect tire pressures cause increased tire wear and adversely affect road holding of the vehicle, which may lead to loss of vehicle control.*

Warning*: Recommended tire inflation pressures and maximum allowable loads apply to speeds up to 65 mph (105 km/hr). Do not drive vehicle at a higher speed than 65 mph (105 km/h) or above the posted speed limit.*

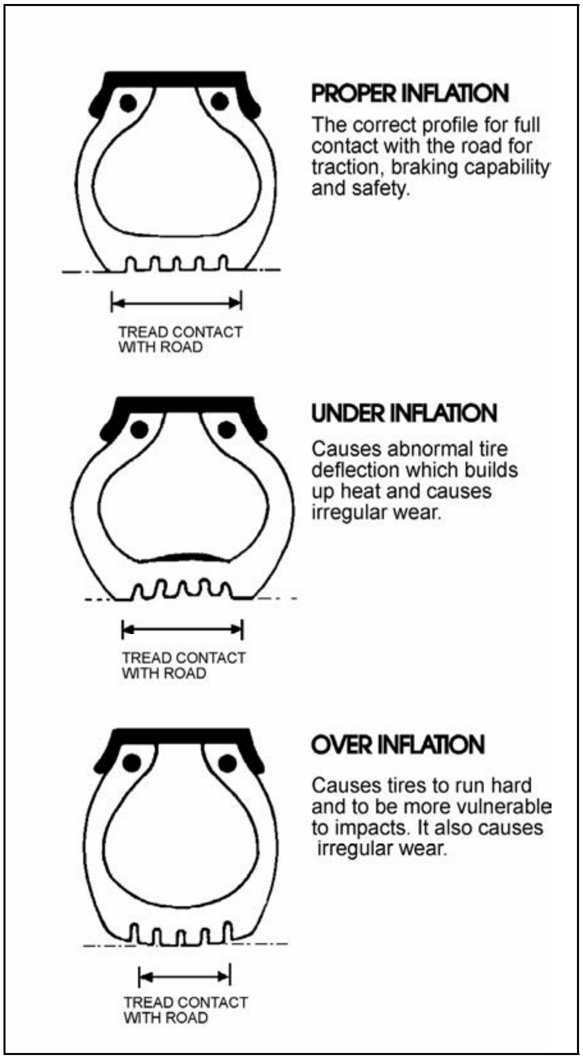

FIGURE 11: TIRE INFLATION 13009

Warning: *All tires on the same axle should always be inflated to the same pressure. There should not be a difference in pressure between right and left tires on the same axle. A 5-psi (35-kPa) underinflation in one front tire can not only reduce vehicle maneuverability, but will create steering hazards which can lead to an accident.*

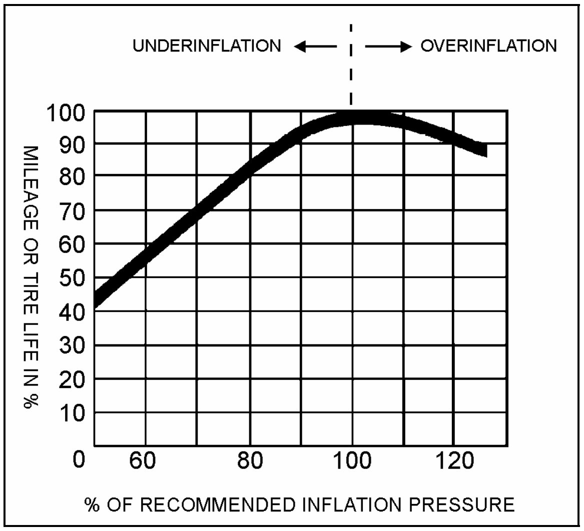

FIGURE 12: TIRE LIFE / INFLATION PRESSURE 13010

11.2 TIRE MATCHING

Unmatched tires on drive axle will cause tire wear and scuffing, as well as possible damage to the drive unit. Consequently, we recommend that tires be matched within 1/8" (3 mm) of the same rolling radius.

Note: *It is recommended that all tires on coach be of the same type.*

11.3 WHEEL BALANCING

Before balancing, wheels must be clean and free from all foreign matter. The tires should be in good condition and properly mounted. An unbalanced wheel can be due to a bent wheel or improper mounting. Before removing the wheel from the vehicle, check for swaying movement and if necessary, check the wheel lateral runout as outlined under heading *"Wheel Straightness Check".*

Warning: *When balancing wheel and tire assemblies, it is strongly recommended to closely follow instructions covering the operation of wheel balancer.*

Caution: *A maximum of 16-oz (450 g) of balancing weight is recommended. If more weight is necessary, check and correct the cause.*

11.4 TIRE ROTATION

Radial tires should be rotated only when necessary. If the tires are wearing evenly, there is no need to rotate. If irregular wear becomes apparent or if the wear rate on the tires is perceptively different (from axle to axle), then tires should be rotated in such a manner as to alleviate the condition.

Note: *There is no restriction on criss-cross rotation.*

12. SPECIFICATIONS

STEEL WHEELS (except inner drive axle)

Wheel size.. 9.0" X 22.5"

Wheel nut torque.. 450 - 500 Ft-lbs (610 - 680 Nm)

Tire size.. 315/80 R 22.5

STEEL WHEELS (inner drive axle)

Wheel size.. 8.25" X 22.5"

Wheel nut torque.. 450 - 500 Ft-lbs (610 - 680 Nm)

Tire size.. 315/80 R 22.5

ALUMINUM WHEELS (except inner drive axle)

Wheel size.. 9" X 22.5"

Wheel nut torque.. 450 - 500 Ft-lbs (610 - 680 Nm)

Tire size.. 315/80 R 22.5

SPECIAL WHEELS FOR VEHICLES EQUIPPED WITH IFS (Front & Tag axle)

Wheel size.. 10.5" X 22.5"

Wheel nut torque.. 450 - 500 Ft-lbs (610 - 680 Nm)

Tire size.. 365/70 R 22.5

RECOMMENDED TIRE INFLATION PRESSURE AT MAXIMUM LOAD (cold)

Note*: Vehicle is delivered with the specific inflation pressure certification plate according to the tire selection.*

Warning*: Special tire selection may lower maximum allowable speed limit, even below posted speed limit. For maximum safety, check with tire manufacturer.*

Caution: *In the case of a converted vehicle, weigh fully loaded and pressurize according to tire manufacturer's recommendations.*

Warning*: Recommended tire inflation pressures and maximum allowable loads apply to speeds up to 65 mph (105 km/hr). Do not drive vehicle at a higher speed than 65 mph (105 km/h) or above the posted speed limit.*

ALUMINUM WHEEL CLEANING AND MAINTENANCE PRODUCTS

Aluminum Wheel Cleaner (22 Oz bottle) ....Prévost #683529
Aluminum Wheel Polish (16 Oz bottle)..Prévost #683528
Aluminum Wheel Sealer (13 Oz bottle) ....Prévost #683527

TRUCK AND TRAILER

Alcoa Dura-Bright® Wheels

More shine. Less maintenance.

You said you wanted aluminum wheels that kept their brilliant good looks with as little effort as possible. And, we listened.

Introducing the first aluminum wheels you don't polish or scrub – just spray with soap and water. And, of course, they're from the aluminum wheel experts, Alcoa.

It's not a coating. It's not a finish. It's a patented treatment that penetrates the aluminum. Alcoa Dura-Bright® wheels need no painting, no polishing, no special chemicals. We think you'll agree. Alcoa Dura-Bright® wheels are the closest to a maintenance-free shine you'll ever see.

Available exclusively from Alcoa, Dura-Bright® wheel treatment:

- protects wheels against oxidation and corrosion.
- cleans easily, so brake dust, road salt, dirt and oil residue quickly wash away.
- brightens the wheel.

Now your wheels can look their best with less effort than with any previous steel or aluminum wheel. That lets you save money and time – and still hit the road with clean, bright, good-looking wheels on your trucks and trailers.

Along with faster, easier cleaning and maintenance, you get all the advantages you've come to expect from Alcoa aluminum wheels, including:

- less weight for increased payload and greater fuel efficiency.
- better heat dissipation for extended tire and brake life.
- higher resale value (historically up to $1,500 on trucks with regular Alcoa aluminum wheels. Alcoa Dura-Bright® wheels may result in even more).
- one-piece, forged-in strength.
- the widest selection of wheels and wheel accessories in the industry.

Leave it to the company that invented the first practical aluminum truck wheel in 1948 to come up with Dura-Bright® wheels – the next revolution in wheel maintenance.

Alcoa Wheels – Look Smart

ALCOA

Dura-Bright® Wheel Specifications

Alcoa aluminum disc wheel mounting dimensions are consistent with SAE Recommended Practice J694 August '98. Part numbers listed for all sizes are Dura-Bright® brushed finish. Buffed finishes are indicated by changing the last digit of the part number listed to one of the following: For buffed outside only, part number should end in "1". For buffed inside only, part number should end in "2". For buffed both sides, part number should end in "3". Valve hole is on the inside. To protect the surface of Dura-Bright® wheels used in dual applications, Alcoa recommends the use of Alcoa DiscMate™ wheel spacers.

Dura-Bright® finished wheels currently available are listed below. Other wheel part numbers may be available upon request. Contact your Alcoa sales representative for availability.

CLASSIC TUBELESS WHEELS (round hand holes) – ENGLISH UNITS

Wheel description	Maximum wheel load[1] in pounds	Wheel wt. lbs.	Outset inches[3]	Inset inches	Maximum inflation PSI – cold	Valve stem	Part number[2]	DiscMate™	Stabilizer	Front outer cap nuts	Rear inner cap nuts Al/Al	Rear inner cap nuts Al/Stl	Rear outer cap nuts	Lug nut covers	Hub cover system kits front/rear
10-hole, stud located ball seat mounting – 11.25 in. bolt circle, 8.73 in. hub bore, 1.219 in. bolt hole diameter															
22.5x8.25-15°DC	7200	53	6.66	5.68	120	TR545D	883110DB	3/4" - 016000 1-1/8" - 017000	2225	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	5996 L&R	150	Front - 076015 Rear - 077015
22.5x9.00-15°DC	9000	60	6.94	5.94	130	TR543C	893000DB	3/4" - 016000 1-1/8" - 017000	2127	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	5996 L&R	150	Front - 076015 Rear - 077015
24.5x8.25-15°DC**	7200	59	6.6	5.59	120	TR545D	983120DB	3/4" - 016000 1-1/8" - 017000	—	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	3/4" Stud 5995 L&R 1-1/8" Stud 5996 L&R	150	Front - 076015 Rear - 077015
10-hole, hub piloted mounting – 285.75mm bolt circle, 220.1mm hub bore, 26.75mm bolt hole diameter (use two-piece flange nuts)															
22.5x8.25-15°DC**	7300	47	6.66	5.81	120	TR545D	883620DB	011000	2227	39874	—	—	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
22.5x9.00-15°DC**	9000	60	6.94	6.04	130	TR543C	893600DB	011000	2127	39874	—	—	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
24.5x8.25-15°DC**	7300	55	6.6	5.73	120	TR545D	983620DB	011000	2247	39874	—	—	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
10-hole, hub piloted bus mounting – 11.25 in. bolt circle, 8.670 in. hub bore, 1.219 in. bolt hole diameter (use two-piece flange nuts)															
22.5x8.25-15°DC	7300	53	6.66	5.82	120	TR545D	883610DB	015000	2225	—	—	—	—	1821	—
24.5x8.25-15°DC	7300	62	6.6	5.77	120	TR545D	983610DB	015000	2245	—	—	—	—	1821	—

CLASSIC TUBELESS WHEELS (round hand holes) – ENGLISH UNITS (METRIC UNITS)

Wheel description	Maximum wheel load[1] in lbs. (kgs)	Wheel wt. lbs. (kgs)	Outset inches[3] (mm)	Inset inches (mm)	Maximum inflation PSI–cold (Kpa)	Valve stem	Part number[2]	DiscMate™	Stabilizer	Front outer cap nuts	Rear inner cap nuts Al/Al	Rear inner cap nuts Al/Stl	Rear outer cap nuts	Lug nut covers	Hub cover system kits front/rear
10-hole, hub piloted mounting – 335mm bolt circle, 281.2mm hub bore, 26.75mm bolt hole diameter (use two-piece flange nuts)															
22.5x8.25-15°DC (26mm)	7830* (3550)	55.1 (25.0)	6.60 (168)	5.70 (145)	138 (952)	60MS27	885530DB†	013000	—	39874	—	—	39874	181	—
22.5x9.00-15°DC (26mm)	8820* (4000)	58.0 (26.3)	6.93 (176)	6.02 (153)	142 (978)	60MS27	894530DB†	013000	—	39874	—	—	39874	181	—
10-hole, hub piloted mounting – 335mm bolt circle, 281.2mm hub bore, 32.87mm bolt hole diameter (use two-piece flange nuts)															
22.5x8.25-15°DC (32mm)	7830* (3550)	55.1 (25.0)	6.60 (168)	5.70 (145)	138 (952)	60MS27	885550DB†	018000	—	430632	—	—	430732	—	—
22.5x9.00-15°DC (32mm)	8820* (4000)	57.1 (25.9)	6.93 (176)	6.02 (153)	142 (978)	60MS27	894550DB†	018000	—	430632	—	—	430732	—	—

Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating. Do not overinflate. Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire, perform a wheel fitment check to ensure proper clearance from any obstructions. Valve hole is on the inside unless noted otherwise.

1 Capacity ratings as dual or single in highway service – bias-ply or radial. Load ratings in lbs. for items 6 and 7 are rounded to nearest multiple of 5.

2 Some wheels may bear part numbers not shown in this manual. Before servicing these wheels, contact your Alcoa wheel representative for proper load, inflation and part compatibility information.

3 Outset (positive)/inset (negative) – The distance from the rim centerline to the mounting face of wheel. Inset (negative) places the rim centerline inboard of the wheel mounting face, and outset (positive) places the rim centerline outboard of the wheel mounting face (1/2 dual spacing = offset).

** The lighter-weight Alcoa New Generation wheels.

† Indicates European Mount New Generation wheel for North American market.

‡ Hub cover system kits P/N 076085 (front) and P/N 077085 (rear) contain screw-on Hug-a-Lug® nut covers and require a minimum of four threads of the stud to extend above the tightened cap nut for use.

Dura-Bright® wheels should be cleaned with soap and water only. No abrasives or brushing. Detailed care and maintenance instructions for Dura-Bright® finished wheels are available in the Alcoa Dura-Bright® Wheel Finish Care and Maintenance publication by Alcoa. For your free copy, contact Alcoa Wheel Products, 1600 Harvard Avenue, Cleveland, OH 44105, (800) 242-9898.

Alcoa Wheel Products
1600 Harvard Avenue
Cleveland, Ohio 44105
800.242.9898

ALCOA

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800.668.1150

www.alcoawheels.com

Alcoa Dura-Bright®
Wheel Finish
Care and Maintenance

New Dura-Bright® wheels shed dirt, brake dust and grease.
Wash them off - no scrubbing, no special chemical solutions - and watch them shine.

ALCOA

Alcoa Dura-Bright® Wheel Care and Maintenance

Maintenance against corrosion

1. Clean frequently with high-pressure water from a hose. The use of a mild detergent will speed the cleaning process. Do not clean with abrasives, abrasive brushes, steel wool, scouring pads or strong chemicals, such as acids or lye-based products. Never spray cold water on extremely hot wheels. Always allow time to cool before cleaning.

2. When tires are removed, the entire rim must be cleaned and inspected (see section 2, page 3 of the Alcoa Wheel Service Manual, July 2002). With a brush, remove any foreign products **from the tire side of the rim** (portion of the wheel that supports the tire). Do not use an abrasive brush to remove dirt, corrosion or other foreign products from the Dura-Bright® wheel surfaces. Generously coat the entire air chamber surface with an approved surface protectant and lubricate each time the tire is removed (see 3-1, page 11 of the Alcoa Wheel Service Manual, July 2002).

3. To maintain the original appearance of your Alcoa Dura-Bright® wheels, the following procedures are recommended:

a. After installing new wheels and prior to operating your vehicle, use a sponge or cloth to wash exposed wheels surfaces with a mild detergent and warm water. Do not use abrasives, abrasive brushes, steel wool, scouring pads or strong chemicals (such as acids or lye-based products). Standard off-the-shelf car wash and wheel detergents are sufficient.

b. Rinse thoroughly with clean water. Warm water and a mild detergent will speed the cleaning process.

c. Wipe dry to avoid water spots.

d. Clean your Alcoa Dura-Bright® wheels using the above procedures as frequently as required to maintain their appearance. Typical road soils, grime and brake dust trap moisture, which can cause corrosion over a period of time. These must be removed regularly. To assist in the removal of excessive dust, dirt and road grime, the use of warm, high-pressure water with a mild detergent is recommended. The surface of Alcoa Dura-Bright® wheels will be damaged, discolored or removed if abrasives, abrasive brushes, steel wool, scouring pads or strong chemicals (such as acids or lye-based products) are used to clean the wheel. **DO NOT USE** the Alcoa Aluminum Care System on Dura-Bright® wheels at any time during their service life.

4. Once in service, Dura-Bright® wheels can become nicked or scratched by road debris and/or mechanical damage. If this occurs, continue to follow the normal washing and cleaning instructions provided above. The surface of Alcoa Dura-Bright® wheels is designed to limit cracking and peeling if nicked or scratched while in service.

5. Even as durable as Dura-Bright® wheels are, the mounting area can become scratched, marred or discolored when mounted against another wheel, hub or drum. Keeping this surface consistently located. The use of a wheel mounting surface guard, such as Alcoa DiscMates™, is highly recommended. The use of the Alcoa Hub Cover System on Alcoa Dura-Bright® wheels will also assist in limiting such damage and help maintain the appearance of your Alcoa Dura-Bright® wheels.

Do not exceed maximum wheel load. Customer must compare OEM vehicle load raiting to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire, perform a wheel fitment check to ensure proper clearance from any obstructions.

Avoid abuse

Abuse can shorten the life of a wheel. Lack of care in changing a tire, heavy pounding on the wheel rim, overloading or hitting curbs at high speed or a sharp angle can damage wheels.

Rim flange wear

Irregular wear on the sruface of the rim flange is caused by the chafer and side wall area of the tire working on the surface of the rim flange. Remove the wheel from service when rim flange wear is excessive. Excessive wear can be determined using an Alcoa approved wear gauge and procedures. For availability, contact Alcoa Wheel Products at 800-242-9898 or 1600 Harvard Avenue, Cleveland, Ohio 44105. If rim flange wear becomes sharp and/or cuts the tire, contact Alcoa Wheel Products for recommended maintenance procedures.

Valves

Alcoa drop center wheels for tubeless tires come from the factory with air valves installed. If it becomes necessary to replace an air valve, install it using the following torque values.

10 to 14 foot-pounds for part numbers	**7 to 11 foot-pounds for part numbers**
TR 509	TR 542 Series
TR 510	TR 543 Series
TR 511	TR 544 Series
	TR 545 Series

Replacement valves may be obtained from your authorized Alcoa wheel distributor. Always use silicone O-rings - not rubber - when reinstalling valve stems. Metal valve stem caps are recommended over plastic.

Identification

Alcoa wheel identification

Since 1977, all Alcoa aluminum disc wheels have been identified with a stamp that shows the wheel load rating, maximum inflation pressure, date of manufacture, part number, wheel description and DOT marking designation (shown below).

Wheel Load Rating (Pounds) — Maximum Inflation Pressure — FMVSS 120 Designation

ALCOA® FORGED **MAX LOAD 7300** **MAX PSI 120** **T-DOT**

060602 **PART NO 883620DB** **22.5X8.25 15^{o} DC**

Date of Manufacture (Day/Month/Year) — Wheel Description

Prior to June 1996, all Alcoa heavy duty truck wheels has the Alcoa identification symbol on the outside of the disc near the hand hole and in line with the valve location. This marking was phased out on heavy duty truck wheels manufactured after June 1996.

Note: Prior to June 1999, all heavy duty truck wheels manufactured by Alcoa Wheel Products were date stamped with the month and year only.

Keep wheel nuts tight

Wheel cap nuts must be kept tight (see section 4 of the Alcoa Wheel Service Manual, July 2002). When checking the cap nuts on dual disc wheels using the stud located ball seat mounting system, loosen every other outer cap nut and then check the torque of the inner cap nuts. Re-torque the loosened outer cap nuts. Repeat these steps on the remaining studs. Check all cap nuts for proper torque after the first use or any removal. Inspect wheels and check wheel nuts during service stops (see section 2 of the Alcoa Wheel Service Manual, July 2002). Dirt streaks from cap nuts may indicate looseness.

Flange nuts must be kept tight, and studs and nuts should be checked frequently. At tire changes, nuts and studs should be inspected to be sure they are in good condition. If nuts require frequent tightening or studs break frequently, hardware and mounting practices should be reviewed.

The proper torque for ball seat cap nuts is between 350 and 400 foot-pounds for stud threads lubricated with SAE 30W oil and between 450 and 500 foot-pounds for threads that are not lubricated. The proper torque for M22-1.5 two-piece flange nuts (33 mm hex head) is between 450 and 500 foot-pounds.

Lead balance weights (clip-on)

Lead balance weights for Alcoa wheels are available from your Alcoa wheel distributor. With radial tires, it may be necessary to temporarily reduce the tire pressure to allow clearance of the weight clamp over the rim flange.

Do not straighten wheels

Do not heat wheels in an attempt to soften them for straightening to repair damage from striking curbs or other causes. The special alloy used in these wheels is heat-treated, and uncontrolled heating will weaken the wheel.

Do not rework, weld, heat or braze Alcoa aluminum wheels for any reason. This does not include normal wheel maintenance as described and approved by Alcoa.

Owner/in-service identification

Some fleets wish to specially identify wheels with OWNERSHIP and IN-SERVICE DATE information. If this practice is adopted:

1. Use “Lo-Stress” stamps or equivalent.
2. Location of stamped areas on outside disc should be in space outward from a line between hand hole centers and a minimum of one inch from the periphery of any hand hole.
3. Location of stamped identification on inside of wheel should be as close to the factory identification stamping as possible.

Note: Use of an impression stamp on Dura-Bright® wheels can affect the appearance and performance of the Dura-Bright® surface treatment local to the stamp.

Limited Warranty

FOR HEAVY DUTY TRUCKS, TRUCK TRAILERS AND BUSES

Dura-Bright wheels denoted by Alcoa part numbers ending with a “4” and “7” with bead seat diameters measured in 0.5-inch increments

Alcoa Inc. warrants to the original purchaser from Alcoa or its authorized distributor that a new Alcoa Dura-Bright® aluminum disc heavy duty truck, truck trailer or bus wheel is free from defects in material and workmanship. Alcoa agrees, without charge, to repair or replace a Dura-Bright® wheel that fails in normal use and service because of defects in material or workmanship. Wheels are structurally warranted for 60 months from the date of manufacture, and the Dura-Bright® surface treatment is also warranted for 60 months from the date of manufacture. Alcoa bus mount wheels (10-hole, 11.25-inch bolt circle, 8.670-inch hub bore with 1.22-inch diameter bolt holes) and other wheels used in transit bus service are structurally warranted for 120 months from the date of manufacture, and the Dura-Bright® surface treatment is warranted for 60 months from the date of manufacture. In all cases, the date of manufacture is shown on the wheel. Alcoa does not warrant and will not repair, replace or make adjustments with respect to normal wear or for any wheel that has been damaged or subjected to misuse or abuse including, without limitation, the following:

(a) Using a tire that is improperly sized according to standards recommended by Alcoa or the Tire and Rim Association, Inc.;
(b) Loading beyond the applicable maximum wheel load as specified by Alcoa;
(c) Inflating the tire beyond the applicable maximum as specified by Alcoa;
(d) Changing the original condition of the wheel by alteration or by subjecting it to processing, such as heating, welding, straightening or machining;
(e) Accidents, road conditions, abnormal or severe operating conditions;
(f) Failure to follow instructions and recommended maintenance on the wheel as set forth in the Alcoa Wheel Service Manual, Alcoa Technical Bulletins and other Alcoa literature. Recommended maintenance includes, without limitation, periodic cleaning with standard non-abrasive wheel and/or car wash cleaners/ detergents, valve replacement and rim flange wear inspections and procedures.

This limited warranty in regards to the Dura-Bright® wheel finish (denoted by Alcoa part numbers ending in “4” and “7”) does not cover corrosion or other damage associated with the conditions addressed above or associated with the following: damage in areas of the mounting surfaces (such as lug holes, hubs, drums and against other wheels in dual position), damage due to cleaning with abrasives, abrasive brushes, steel wool, scouring pads or strong chemicals (such as acids or lye-based products), and removal/damage of the Dura-Bright® wheel finish, including chipping, by contact with road obstacles such as stones, gravel, concrete curbs, metallic barriers, signs, etc. Alcoa recommends cleaning the wheels with mild soap and water. For detailed recommended use and maintenance instructions, see the Alcoa Wheel Service Manual and the Alcoa Dura-Bright® Wheel Finish Care and Maintenance instructions.

THERE IS NO WARRANTY THAT THE WHEEL IS MERCHANTABLE OR SATISFACTORY FOR ANY PARTICULAR PURPOSE. NOR IS THERE ANY OTHER WARRANTY, EXPRESSED OR IMPLIED, ON THE WHEEL.

ALCOA WILL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES FOR ANY BREACH OF WARRANTY, ITS LIABILITY AND THE PURCHASER’S EXCLUSIVE REMEDY BEING EXPRESSLY LIMITED TO REPAIR OR REPLACEMENT OF THE WHEEL.

Repair or replacement will be handled by any authorized Alcoa wheel distributor or by any Alcoa wheel representative under Alcoa’s return policy. This warranty gives you specific legal rights. You may also have other rights under other applicable laws.

To obtain a copy of the Alcoa Wheel Service Manual, the Alcoa Dura-Bright® Wheel Finish Care and Maintenance instructions, or other product and specification literature, contact Alcoa Wheel Products at 800-242-9898 or at 1600 Harvard Avenue, Cleveland, Ohio 44105. For additional information on our warranty or to submit a warranty claim, contact the Alcoa Wheel Service Center at 800-242-9898 (option 2) or 888-279-3055.

Do not exceed maximum wheel load. Customer must compare OEM vehicle load raiting to maximum wheel load rating.

Refer to tire manufacturer’s recommedation for proper tire pressure. Before mounting the tire, perform a wheel fitment check to ensure proper clearance from any obstructions.

ALCOA

WHEEL SERVICE MANUAL

SAFETY AND MAINTENANCE INSTRUCTIONS FOR ALCOA TRUCK, TRAILER, BUS AND MOTOR HOME WHEELS

February 2004

Supersedes July 2003

LIMITED WARRANTY

FOR HEAVY DUTY TRUCKS, TRUCK TRAILERS,
BUSES, RV and MOTORHOME WHEELS

(Wheels with bead seat diameters measured in .5 inch increments and Alcoa tube type wheels)

Alcoa warrants to the original purchaser, from Alcoa or its authorized distributor, that a new Alcoa aluminum disc heavy duty truck, truck trailer, bus, 19.5-inch and 22.5-inch RV or motorhome wheel is free from defects in material and workmanship. Alcoa agrees, without charge, to repair or replace a wheel that fails in normal use and service because of defects in material and workmanship. Truck, truck trailer, Dura-Flange® and the Dura-Bright® Surface Treatment wheels not used in transit service are warranted for 60 months from the date of manufacture as shown on the wheel except the Dura-Flange® rim flange treatment is warranted for a period of 24 months. Alcoa bus mount wheels (10-hole, 11.25 inch bolt circle, 8.670 inch hub bore with 1.22 inch diameter bolt holes) and other wheels used in transit service are warranted for 120 months from date of manufacture, except the Dura-Bright® Surface Treatment on bus and transit service wheels is warranted for a period of 60 months from the date of manufacture and the Dura-Flange® rim flange treatment is warranted for 24 months. Satin finish, polished and Dura-Bright® surface treatment 19.5-inch and 22.5-inch RV and motorhome wheels are warranted for 120 months from the date of manufacture as shown on the wheel. Alcoa does not warrant and will not repair or replace or make adjustment with respect to any wheel that has been subjected to misuse or abuse including the following:

(a) Using a tire that is oversized according to standards recommended by the Tire and Rim Association, Inc. or other recognized tire and rim agencies such as ETRTO (Europe) or others;

(b) Loading the wheel beyond the applicable maximum wheel load as specified by Alcoa;

(c) Inflating beyond the applicable maximum as specified by Alcoa;

(d) Changing the original condition of the wheel by alteration or by subjecting it to any processing such as welding or straightening.

(e) Accidents, abnormal or severe operating conditions including without limitation tire fires, brake fires, severe brake system drags or seizures or running with a flat tire; or

(f) Failure to follow maintenance and other instructions and warnings set forth in the Alcoa Heavy Duty Wheel Service Manual, Alcoa Technical Bulletins and other Alcoa literature. Recommended maintenance includes, without limitation, using proper torque, periodic cleaning, polishing, valve replacement, periodic inspection for damage, loose lug nuts and rim flange wear inspections and procedures.

(g) Nicks, scratches and other surface blemishes resulting from improper maintenance, cleaning, road debris, curbing, accident or operation are not warrantable.

(h) Damage due to cleaning with abrasives, abrasive brushes, steel wool, scouring pads, or strong chemicals (acids or alkaline).

Dura-Bright® Surface Treated Wheels are warranted against:

(a) Filiform corrosion (worm or hair like lines, generally milky in appearance, underneath surface protective treatment and emanating from damage to the surface treatment such as nicks, scratches or damage from mounting hardware or wheel weights)

(b) Blistering due to loss of adhesion of the surface treatment,

(c) Lift off of the surface treatment due to physical damage (nicks, scratches, gouges)

If nicks, dings, scratches or other damage does occur to the Dura-Bright® treatment that exposes the aluminum underneath, the metal exposed may naturally oxidize, but any corrosion will be confined to the metal exposed and will not extend into or underneath the Dura-Bright® treatment.

Normally, any washing materials or chemicals (including mild acid washes) that can safely be used on a vehicle, its painted surfaces and components, can safely be used on the Dura-Bright® surface treatment. The Dura-Bright® treatment prevents corrosion of aluminum wheels and protects their shine. So long as the treatment remains in place (see comments (g) and (h) above) and is maintained in accordance with the Alcoa Dura-Bright® Care and Maintenance manual, it is warranted against corrosion. If corrosion does occur within the treatment warranty period, subject to the limitations stated above, Alcoa will replace any wheel exhibiting such corrosion.

THERE IS NO WARRANTY THAT THE WHEEL SHALL BE MERCHANTABLE OR FIT FOR ANY PARTICULAR PURPOSE, NOR IS THERE ANY OTHER WARRANTY, EXPRESS OR IMPLIED, EXCEPT SUCH AS IS EXPRESSLY SET FORTH HEREIN.

ALCOA SHALL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES FOR ANY BREACH OF WARRANTY, ITS LIABILITY AND THE PURCHASER'S EXCLUSIVE REMEDY BEING LIMITED TO REPAIR OR REPLACEMENT OF THE WHEEL AS STATED IN THIS LIMITED WARRANTY.

Alcoa Wheel Service Manual. This limited warranty should be used in conjunction with the Alcoa Wheel Service Manual and the Alcoa Dura-Bright® Wheel Finish Care and Maintenance Manual. The Wheel Service Manual contains important safety information and warnings, and failure to read and understand this information may result in serious injury or death. The limited warranty is included with the Wheel Service Manual, but may appear elsewhere. If you do not have copies of the Wheel Service Manual you may obtain copies free of charge from Alcoa Wheel and Forged Products, 1600 Harvard Avenue, Cleveland, Ohio 44105, (800) 242-9898 and on the web at www.alcoawheels.com.

How to use this manual

This manual is written in a style called structured text.

Throughout the manual you will find numbers which look like this (See 3-1, page 18). These numbers are cross references to other sections of the manual. The numbers (3-1) refer to section 3, subtopic 1. When you turn to page 18 you will find the section number and subtopic number under the heading in each section as shown below:

Recommendations for mounting tubeless tires

3-1

The cross references will help you find related information in the manual. For example in section 4-1 you will read the following sentence...

"Make sure all wheel cap nuts are properly torqued–check them often (see 4-9, page 29)."

By turning to section 4, subtopic 9, on page 29 you will find information on proper torquing.

Note: The **Alcoa Heavy Duty Wheel Service Manual** contains information for proper service and operation of Alcoa heavy duty wheels. Alcoa heavy duty wheels for heavy duty trucks, truck trailers and buses are Alcoa tubeless wheels with bead seat diameters measured in .5 inch increments and Alcoa tube type wheels.

Note: Dura-Bright® wheels produced after November 2002 have Alcoa wheel part numbers ending with "DB" (earlier wheels have part numbers ending in a 4 or 7) with bead seat diameters measured in 0.5-inch increments. Not all Alcoa wheels are available with the Dura-Bright® surface treatment.

WARNING

WARNING Wheels that are not properly installed or maintained may not work properly.

Failure to follow proper wheel installation or maintenance practices may result in injury or death.

Follow the proper wheel installation and maintenance practices as contained in this Alcoa Service Manual. For additional copies of the manual, available free of charge from Alcoa, or for the most recent updates, contact Alcoa Wheel and Forged Products at 1-800-242-9898 option 1 or on the web at www.alcoawheels.com.

To obtain Alcoa rim flange wear gauge(s) at no charge and information on free training on proper installation and maintenance procedures, contact Alcoa Wheel and Forged Products at (800) 242-9898 option 1 or on the web at www.alcoawheels.com.

Table of Contents

1 Specifications

Alcoa aluminum disc wheel mounting dimensions are consistent with SAE Recommended Practice J694 Feburary 2001. Part numbers listed for all sizes are satin finish. Polished finishes are indicated by changing the last digit of the part number listed to one of the following: For polished outside only, part number should end in "1." For polished inside only, part number should end in "2." For polished both sides, part number should end in "3." Valve hole is on the inside.

Dura-Bright® surface treatment wheels are identified by using the regular numerical part number and the addition of "DB" at the end. Finishes are indicated by changing the last numerical digit of the part number to one of the following. For brushed both sides, the number is "0." For buffed outside only, the number is "1." For buffed inside only, the number is "2." For buffed both sides, the number is "3." Currently, only the wheel item numbers marked with DB are available with the Dura-Bright® surface treatment.

Dura-Flange® wheels are identified by using the regular numerical part number and the addition of "DF" at the end. Only the wheel item numbers marked with DF are available with the Dura-Flange® option and are only available as satin finish (last part number ends in "0").

CLASSIC TUBELESS WHEELS (round hand holes) (ENGLISH UNITS)

Item no.	Wheel description	Maximum wheel load[1] in lbs.	Wheel wt. lbs.	Outset inches[3]	Inset inches	Maximum inflation PSI—cold	Valve stem	Part number[2]	DiscMate	Stabilizer	Front Outer Cap Nuts	Rear Inner Cap Nuts Al/Al	Rear Inner Cap Nuts Al/Stl	Rear Outer Cap Nuts	Lug Nut Covers	Hub Cover System Kits Front/Rear
Six-hole, stud located mounting, ball seat — 8.750 in. bolt circle, 6.495 in. hub bore, 1.219 in. bolt hole dia.																
1.	17.5x6.75-15°DC	5070	32	5.55	4.72	125	TR543C	663170	—	2125	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	5996 L&R	150	–
10-hole, stud located mounting, ball seat — 8.750 in. bolt circle, 6.495 in. hub bore, 1.219 in. bolt hole dia.																
2.	17.5x6.75-15°DC	5070	31	5.55	4.72	125	TR543C	663070	—	2125	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	5996 L&R	150	–
10-hole, stud located mounting, ball seat — 11.25 in. bolt circle, 8.73 in. hub bore, 1.219 in. bolt hole dia.																
[DB]3.	22.5x7.50-15°DC	7200	53	6.28	5.32	120	TR545D	873100	3/4" - 016000, 1-1/8" - 017000	2225	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	5996 L&R	150	Front - 076015 Rear - 077015
[DB]4.	22.5x8.25-15°DC	7200	53	6.66	5.68	120	TR545D	883110	3/4" - 016000, 1-1/8" - 017000	2225	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	5996 L&R	150	Front - 076015 Rear - 077015
[DB]5.	22.5x9.00-15°DC	9000	60	6.94	5.94	130	TR543E	893000	3/4" - 016000, 1-1/8" - 017000	2127	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	5996 L&R	150	Front - 076015 Rear - 077015
6.	22.5x12.25-15°DC	11,400	62	.56 Reversible	—	125	005435	823000	3/4" - 016000, 1-1/8" - 017000	–	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	–	–	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	150	Front - 076015 Rear - 077015
7.	22.5x12.25-15°DC	11,400	66	3.88	2.76	125	TR543E outset TR545E inset	823050	3/4" - 016000, 1-1/8" - 017000	–	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	–	–	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	150	Front - 076015 Rear - 077015
8.	22.5x12.25-15°DC	11,000	70	5.84	4.68	120	TR545E	823060A	3/4" - 016000, 1-1/8" - 017000	–	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	–	–	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	150	Front - 076015 Rear - 077015
9.	22.5x13.00-15°DC	12,300	72	3.5	2.38	125	TR543E	833050	3/4" - 016000, 1-1/8" - 017000	–	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	–	–	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	150	Front - 076015 Rear - 077015
10.	22.5x13.00-15°DC	11,000	73	—*	5.3	120	TR545E	833060A	3/4" - 016000, 1-1/8" - 017000	–	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	–	–	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	150	Front - 076015 Rear - 077015
††11.	22.5x14.00-15°DC	12,800	71	2	0.87	125	TR543E outset TR545E inset	841100	3/4" - 016000, 1-1/8" - 017000	–	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	–	–	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	150	Front - 076015 Rear - 077015
[DB]**12.	24.5x8.25-15°DC	7200	59	6.6	5.59	120	TR545D	983120	3/4" - 016000, 1-1/8" - 017000	–	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	5988 L&R	7896 L&R	3/4" Stud 5995 L&R, 1-1/8" Stud 5996 L&R	150	Front - 076015 Rear - 077015
10-hole, stud located mounting, ball seat — 13.19 in. bolt circle, 10.65 in. hub bore, 1.360 in. bolt hole dia. (valve hole is on outside)																
13.	22.5x13.00-15°DC	11,000	76	—*	6.12	120	TR543	833070A	–	–	–	–	–	–	–	–
Eight-hole, hub piloted mounting — 6.50 in. bolt circle, 4.770 in. hub bore, .68 in. bolt hole dia. (use two-piece flange nuts)																
14.	17.5x6.75-15°DC	6050	30	–	0	130	TR542	661400	–	–	39946	–	–	–	190	–
Eight-hole, hub piloted mounting — 6.50 in. bolt circle, 4.880 in. hub bore, .68 in. bolt hole dia. (use two-piece flange nuts)																
15.	17.5x6.75-15°DC	6050	29.7	–	0	130	TR542	662400	–	–	39946	–	–	–	190	–
Eight-hole, hub piloted mounting — 275mm bolt circle, 221.1mm hub bore, 26.75mm bolt hole dia. (use two-piece flange nuts)																
[DB]16.	22.5x7.50-15°DC	7300	53	6.28	5.44	120	TR545D	873400	014000	2225	39874	–	–	39874	181	–
**17.	22.5x8.25-15°DC	7300	50	6.66	5.82	120	TR545D	883420	014000	2227	39874	–	–	39874	181	–
††18.	22.5x14.00-15°DC	12,800	71	2.0	0.87	125	TR543E outset TR545E inset	841400	014000	–	39874	–	–	39874	181	or 076_085‡
[DB]19.	24.5x8.25-15°DC	7300	62	6.6	5.77	120	TR509	983400	014000	2245	39874	–	–	39874	181	–

Continued on next page

1 Specifications cont'd.

10-hole, hub piloted mounting — 285.75mm bolt circle, 220.1mm hub bore, 26.75mm bolt hole dia. (use two-piece flange nuts)															
DB 20. 22.5x7.50-15°DC	7300	53	6.28	5.44	120	TR545D	873600	011000	2225	39874	–	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB DF **21. 22.5x8.25-15°DC	7300	47	6.66	5.81	120	TR545D	883620	011000	2227	39874	–	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB DF §22. 22.5x8.25-15°DC	8000	55	6.66	5.69	120	TR543C	885600	011000	2225	39874	–	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB 23. 22.5x9.00-15°DC	9000	60	6.94	6.04	130	TR543C	893600	011000	2127	39874	–	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
24. 22.5x9.00-15°DC	10,000	53	—	3.12	130	TR545E	893630	011000	–	39874	–	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB 25. 22.5x10.50-15°DC	10,500	68	66.1	5.5	130	TR544	803600	011000	–	39874	–	–	–	181	Front - 076018 or 076085‡
26. 22.5x12.25-15°DC	11,400	63	.56 Reversible	—	125	TR543E	823600	011000	–	39874	–	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB 27. 22.5x12.25-15°DC	11,400	66	3.88	2.75	125	TR543E outset TR545E inset	823650	011000	–	39874	–	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
28. 22.5x12.25-15°DC	11,000	71	5.8	4.68	120	TR545E	823660A	011000	—	39874	–	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
29. 22.5x12.25-15°DC	10,000	74	6.24	5.12	120	TR545E	823670A	011000	–	39874	–	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
30. 22.5x13.00-15°DC	12,300	73	3.5	2.38	125	TR543E outset TR545E inset	833650	011000	–	39874	–	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
31. 22.5x13.00-15°DC	11,000	74	6.42	5.3	120	TR545E	833660A	011000	–	39874	–	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
††32. 22.5x14.00-15°DC	12,800	71	2.0	0.87	125	TR543E outset TR545E inset	841600	011000	–	39874	–	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
††33. 22.5x14.00-15°DC	12,800	71	1.13	0	125	TR543E outset TR545E inset	841610	011000	–	39874	–	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB DF **34. 24.5x8.25-15°DC	7300	55	6.6	5.73	120	TR545D	983620	011000	2247	39874	– –	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
DB DF §35. 24.5x8.25-15°DC	8000	65	6.6	5.63	120	TR545D	985600	011000	2245	39874	–	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
10-hole, hub piloted bus mounting — 11.25 in. bolt circle, 8.670 in. hub bore, 1.219 in. bolt hole dia. (use two-piece flange nuts)															
DB 36. 22.5x8.25-15°DC	7300	53	6.66	5.82	120	TR545D	883610	015000	2225	–	–	–	–	1821	–
DB 37. 24.5x8.25-15°DC	7300	62	6.6	5.77	120	TR545D	983610	015000	2245	–	–	–	–	1821	–

Continued on next page

1 Specifications cont'd.

Item no.	Wheel description	CLASSIC TUBELESS WHEELS — ENGLISH UNITS (METRIC UNITS) Maximum wheel load[1] in lbs. (kilograms)	Wheel wt. lbs. (kilograms)	Outset inches[3] (mm)	Inset inches (mm)	Maximum inflation PSI—cold (KPa)	Valve stem	Part number[2]	DiscMate	Stabilizer	Front Outer Cap Nuts	Rear Inner Cap Nuts Al/Al	Rear Inner Cap Nuts Al/Stl	Rear Outer Cap Nuts	Lug Nut Covers	Hub Cover System Kits Front/Rear
Eight-hole, hub piloted mounting — 275mm bolt circle, 221.1mm hub bore, 24.75mm bolt hole dia. (use two-piece flange nuts)																
38.	17.5x6.75-15°DC	5515 (2500)	29.5 (13.4)	5.55 (141)	4.72 (120)	142 (978)	TR543C	663470	014000	2126	39874	–	–	39874	181	–
DB 39.	19.5x6.75RW-15°DC	5515 (2500)	37.0 (16.8)	5.55 (141)	4.72 (120)	142 (978)	TR543C	764480	014000	2126	39874	–	–	39874	181	–
40.	19.5x7.50RW-15°DC	6615 (3000)	37.7 (17.1)	6.10 (155)	5.28 (134)	142 (978)	TR543C	773400	014000	2126	39874	–	–	39874	181	–
10-hole, hub piloted mounting — 225mm bolt circle, 176.1mm hub bore, 26.5mm bolt hole dia. (use two-piece flange nuts)																
41.	17.5x6.00-15°DC	5515 (2500)	28.0 (12.7)	5.24 (133)	4.49 (114)	142 (976)	TR543D	663200		2125	–	–	–	–	–	–
10-hole, hub piloted mounting — 285.75mm bolt circle, 220.1mm hub bore, 26.75mm bolt hole dia. (use two-piece flange nuts)																
42.	19.5x7.50RW-15°DC	6615 (3000)	37.7 (17.1)	6.10 (155)	5.28 (134)	142 (978)	TR543C	773600	011000	2126	39874	–	–	39874	181	Front - 076018 or 076085‡ Rear - 077018 or 077085‡
10-hole, hub piloted mounting — 335mm bolt circle, 281.2mm hub bore, 26.75mm bolt hole dia. (use two-piece flange nuts)																
DB †43.	22.5x8.25-15°DC	7830 (3550)	55.1 (25.0)	6.60 (168)	5.70 (145)	138 (952)	60MS27	885530	013000	–	39874	–	–	39874	181	–
DB †44.	22.5x9.00-15°DC	8820 (4000)	58.0 (26.3)	6.93 (176)	6.02 (153)	142 (978)	60MS27	894530	013000	–	39874	–	–	39874	181	–
‡‡45.	22.5x13.00-15°DC	11,000 (4988)	75.0 (34.0)	—	6.12 (155)	120 (827)	TR543	833570A	013000	–	39874	–	–	39874	181	–
‡‡46.	22.5x13.00-15°DC	12,800 (5806)	76.0 (34.5)	—	6.12 (155)	120 (827)	TR543	833570B	013000	–	39874	–	–	39874	181	–
47.	24.5x8.25-15°DC	8500 (3855)	62.6 (28.4)	6.79 (172.5)	5.81 (147.5)	120 (827)	TR545D	983500	013000	–	39874	–	–	–	181	–
10-hole, hub piloted mounting — 335mm bolt circle, 281.2mm hub bore, 32.87mm bolt hole dia. (use two-piece sleeved cap nuts)																
DB †48.	22.5x8.25-15°DC (32mm bolt hole)	7830 (3550)	55.1 (25.0)	6.60 (168)	5.70 (145)	138 (952)	60MS27	885550	018000	–	430632	–	–	430732	–	–
DB †49.	22.5x9.00-15°DC (32mm bolt hole)	8820 (4000)	57.1 (25.9)	6.93 (176)	6.02 (153)	142 (978)	60MS27	894550	018000	–	430632	–	–	430732	–	–

Read carefully all sections of this Service Manual regarding proper inspection, installation and maintenance. Mishandled tires and wheels can explode, causing serious or fatal injury to you and others. Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating. Do not overinflate. Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire, perform a wheel fitment check to insure proper clearance from any obstructions. Never use any flammable material on tires or rims, to seat beads or for any other purposes. Always use safety cages or other approved restraining devices during inflation. Avoid wheel separation — tighten nuts in the order and to the torque value specified in this manual.

[1] Capacity ratings as dual or single in highway service – bias-ply or radial. Load ratings in lbs. for items 38 through 49 rounded to nearest multiple of 5.

[2] Some wheels may bear part numbers not shown in this manual. Before servicing these wheels contact your Alcoa Wheel Representative for proper load, inflation and part compatibility information.

[3] Outset (Positive)/Inset (Negative)—The distance from the rim centerline to the mounting face of wheel. Inset (negative) places the rim centerline inboard of the wheel mounting face and outset (positive) places the rim centerline outboard of the wheel mounting face (1/2 dual spacing = offset).

* These wheels must be installed only in the inset position because spherical ball seats are on only one side of the disc. **Indicates lighter weight Alcoa New Generation wheels.

† Indicates European New Generation Wheels. ‡Hub cover system kits P/N 076085 (front) and P/N 077085 (rear) contain screw-on Hug-a-lug® nut covers and require a minimum of four threads of the stud to extend above the tightened cap nut for use.

†† P/Ns 841100, 841400, 841600 and 841610 are recommended for use on drive axle and trailer axle positions.

‡‡ The minumum stud standout required for P/N 833570 is 2.375 inches (60.3mm) when using nut P/N39874. Taller nuts will require more stud standout.

§ P/Ns 885600 and 985600 are Alcoa Severe Service Wheels and are available with either the Dura-Flange® treatment option or the Dura-Bright® surface teatment option.

DB Wheels with the Dura-Bright® surface treatment option shine without polishing. Just wash with soap and water, do not polish or clean with abrasives. For more information call 800-242-9898 option 6 or visit www.dontpolish.com.

Specifications subject to change without notice. To request a copy of the current Alcoa Specifications Data brochure for aluminum wheels for trucks, trailers and buses, call toll-free 800-242-9898, option 1. To view online, go to www.alcoawheels.com. The Spec Data brochure contains current part number availability and complete specifications such as wheel dimensions, load rating, wheel weight, outset and inset, inflation pressure and accessory part numbers.

Alcoa provides training, live or on video, on proper wheel installation and maintenance practices free of charge. Contact Alcoa Wheel and Forged Products at 1-800-242-9898, option 4.

Note: Dura-Bright® wheels produced after November 2002 have Alcoa wheel part numbers ending with "DB" (earlier wheels have part numbers ending in a 4 or 7) with bead seat diameters measured in 0.5-inch increments. Not all Alcoa wheels are available with the Dura-Bright® surface treatment.

Note: The Dura-Bright® surface treatment and the Dura-Flange® options are not currently available together on the same wheel. Dura-Bright® is available in all polishing finishes, Dura-Flange® is only available in satin finish.

2 Inspection

2

Inspect thoroughly and frequently

2-1

Safe operation requires thorough examination of wheels and attaching hardware, at frequent intervals, both on and off the vehicle.

Wheels that have been in service need to be inspected at regular intervals to assure proper and safe performance.

Like tires and other vehicle components that work hard, wheels will eventually wear out. It isn't always possible to predict exactly when the useful life of a wheel will end. But generally, older wheels and wheels operating in extreme conditions should be examined more frequently for obvious signs that they should be removed from service.

As an aid to the owner in determining the period of time a wheel has been in service, it is recommended the owner stamp an "in service" date onto the wheel at the time of receipt. See 5-5, page 36 for recommended stamping locations.

Pay particular attention to front-end assemblies. Examine all exposed areas frequently. Clean wheels and look for cracks or other damage. Also check the inner dualed wheel when the outer wheel is removed.

During tire changes, thoroughly examine the entire wheel. Pay particular attention to the rim contour and the surfaces of the rim. On tube-type wheels, carefully inspect the gutter area normally concealed by the side rings.

Be sure that the best wheels are on the front of the vehicle.

Hidden damage

Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Do not overinflate. Use the tire manufacturer's recommended pressure, but under no circumstances exceed cold tire pressures listed in *Section 1 Specifications* of this manual. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

Some forms of wheel damage can be hidden beneath the tire, so whenever a tire is removed, thoroughly examine the complete wheel. Remove all grease and road dirt. Use a wire brush or steel wool to remove rubber from the bead seats.

Check mounting holes for the enlargement and elongation which can occur if the cap nuts are not kept tight (see 2-5, page 9). Dirt streaks radiating from stud holes may indicate loose cap nuts (see 4-9, page 29).

Excessive heat damage

2-2

WARNING

WARNING **Excessive heat from fire, brake malfunction, wheel bearing failure or other sources may weaken the metal and cause the wheel/tire assembly to separate explosively.**

Exploding wheel/tire assembly can cause death or serious injury.

Immediately and permanently remove from service any wheel that has been exposed to excessive heat.

Inspect for exposure to excessive heat. A wheel that has been subjected to excessive heat may appear charred or burned. A wheel that has been exposed to excessive heat may appear to be in good condition if it has been cleaned. Even if a wheel does not appear to be obviously burned, check the valve hole and labels for evidence of charring, melting, blistering or burning.

A wheel may discolor from excessive heat. It can appear a dull grayish color and will not polish to a bright finish as a typical wheel would.

Any wheel run with a flat tire longer than the time necessary to immediately pull off the road should be checked for excessive heat damage.

A blistered, charred, blackened or cracked-looking logo decal on an Alcoa wheel may indicate that the wheel has been exposed to excessive heat.

Dimension checks

2-3

Open side circumference check

WARNING

WARNING **Wheels that have been subjected to high pressure tire and rim separation, run flat, excessive heat or other physical damage may no longer have sufficient dimension and contour to retain tire bead while under pressure.**

Rims that lack proper dimension and contour can lead to explosive separation of tire and rim, causing injury or death.

Follow dimension check procedures described in this section during each wheel inspection.

2

The circumference of the bead seat on the open side of the wheel should be checked with each tire change. The open side is the side opposite the disc face. In the case of center flange wide base wheels, or wheels with insets less than 3 inches, both rim flanges should be checked. Measure the circumference of the bead seat on the open side (see illustration below) with a ball tape. Ball tapes used for measuring wheel circumference can be purchased from the Tire and Rim Association, Inc., 175 Montrose West Avenue, Copley, Ohio 44321.

If the circumference of the bead seat does not match the required dimension as indicated by the ball tape, remove the wheel from service. Be sure to clearly mark the wheel as out-of-service or otherwise render the wheel unusable.

Any wheel known to have been run with a flat tire or operated under abnormal conditions should be checked before continued service. If a ball tape is unavailable, roll the unmounted wheel without a tire several revolutions over a smooth, flat, level, clean surface. Any deviation from rolling in a straight line is an indication of a potential lack of proper dimension and contour. Remove the wheel from service until it can be properly checked with a ball tape.

Continued on the next page

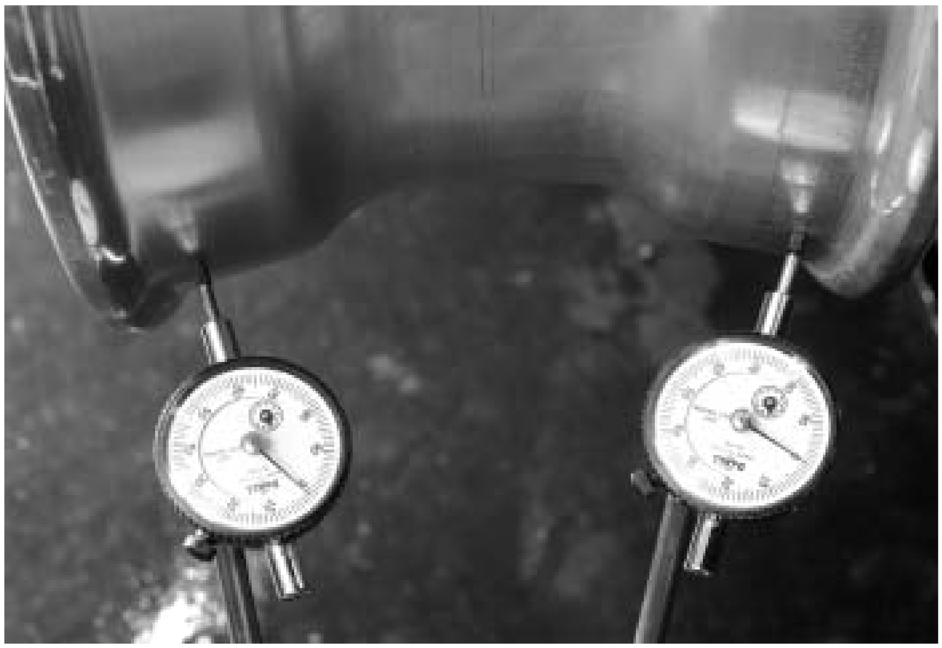
2

Dimension checks (continued)

Tire wear or ride problems

If you experience tire wear or ride problems it may be helpful to check radial run out. Remove the wheel from the vehicle, deflate and remove the tire (see 3-5, page 22 for recommendations and instructions for demounting tubeless tires and 6-5, page 43 for recommendations and instructions for demounting tube-type tires).

Remount the wheel on the vehicle without the tire. Be sure to follow proper mounting procedures to assure the wheel is well centered on the hub. Place a dial indicator as illustrated below to trace the bead seats of the wheel. Rotate the wheel noting the amount of variation shown on the dial indicator. *Note:* Alcoa aluminum wheels should be tested for radial run out only at the bead seat surface. A total indicator reading of .045 inches is acceptable.



Tire wear can also be caused by improperly seated tires. Inspect the tire for proper seating on the wheel. The tire beads may not be seated properly. If so, remove the wheel from the vehicle, deflate and break the bead seats (see 3-5, page 22 for recommendations and instructions for demounting tubeless tires and 6-5, page 43 for recommendations and instructions for demounting tube-type tires). Adequately lubricate the bead seats and properly reseat the tire beads. Reinflate the wheel in a safety cage or other suitable restraint (refer to OSHA rule 1910.177, paragraph b, see Section 7, page 44).

Cracked or damaged wheel checks

2-4

WARNING

WARNING **Cracked or damaged wheels may cause wheels to fail or come off the vehicle while the vehicle is moving.**

Wheels that fail or come off the vehicle while it is moving can cause serious injury or death.

Immediately remove cracked or damaged wheels from service.

Inspect wheels for cracks or damage according to the following sections of Chapter 2. Remove wheels from service with known or suspected damage.

Mounting area

2-5

Stud hole cracks are usually caused by improper torquing (see 4-9, page 29 and 5-2, page 35), excessive loading or insufficient mounting flange support by the hub or brake drum. Remove wheel from service.

Shown below are stud hole cracks emanating from stud hole to stud hole. Causes are: undersized diameter of wheel support surface (see specifications below), support surface not flat, incorrect attachment parts (see 4-12, page 34) and insufficient torque (see 4-9, page 29 and 5-2, page 35). Remove wheel from service.

Support surface should be flat to the diameter recommended on the chart on the following page.

Inspect the hub/drum contact area thoroughly for cracks or other damage.

2

Mounting area (continued)

Support surface diameters

Support surface (backup diameter) should be flat to the diameter recommended on the chart below:

Number of Bolts	Bolt Circle	Mounting Type	Backup Diameter	Thread Size
10	11.25 inch	U.S. Stud pilot	13.2-13.5 in.	.750/1.125 in.
10	285.75mm	Hub pilot	13.2-13.4 in.	22mm
10	335mm	Hub pilot	15.0-15.2 in.	22mm
8	275mm	U.S. Stud pilot	13.2-13.5 in.	22mm
8	275mm	ISO Hub pilot	12.4-12.6 in.	20mm

Corrosion

2-6

Due to aluminum's natural resistance to corrosion, Alcoa aluminum disc wheels do not need to be painted for most operating conditions. However, certain environments can lead to corrosion. Some of these are: salt, chloride compounds used for snow removal and highly alkaline materials. If the air used to fill tubeless tires, or the tire itself, is not dry, the areas of the wheel under the tire can corrode severely.

Bead seat and valve stem corrosion often are caused by entrapped moisture which contains corrosive elements. Mild corrosion should be removed thoroughly by wire brush and the rim protected with a coating of non-water-based lubricant (see 3-1, page 18). Remove any severely corroded wheel from service.

CAUTION

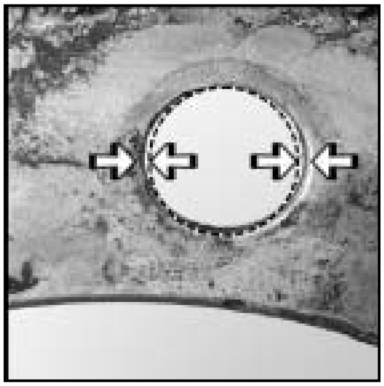
CAUTION The use of liquid tire balancers or sealants in Alcoa wheels may cause extremely rapid corrosion of the wheel rim surface.

Severely corroded wheels are unsuitable for service. Alcoa wheels corroded by the use of liquid tire balancers or sealants will not be replaced under the Alcoa limited warranty.

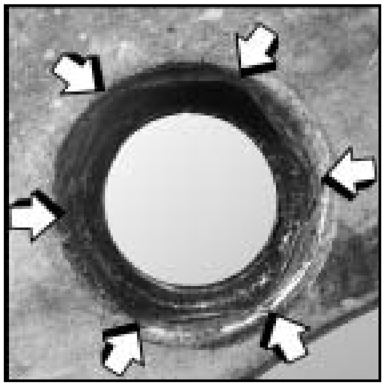
Stud holes

2-7

If wheels are run loose, both stud located wheels and hub piloted wheels can be damaged. Look for wallowed out or elongated ball seats on stud located wheels. On hub piloted wheels look for elongated stud holes. Over torquing can lead to damaged ball seats on stud located wheels and can damage the disc surface of hub piloted wheels. Remove damaged wheels from service.



Damaged hub piloted bolt hole. Elongation from true round (dashed circle) indicated by arrows.



Damaged ball seat contact area. Pounding of nut on ball seat contact area identified by arrows.

2

Disc area

2-8

Inspect both sides of disc area for hand hole cracks. If cracks are found, remove the wheel from service.

Rim area

Check the entire rim area for nicks, gouges and cracks. Loss of air may be caused by cracks in areas around the valve stem hole. Remove the wheel from service.

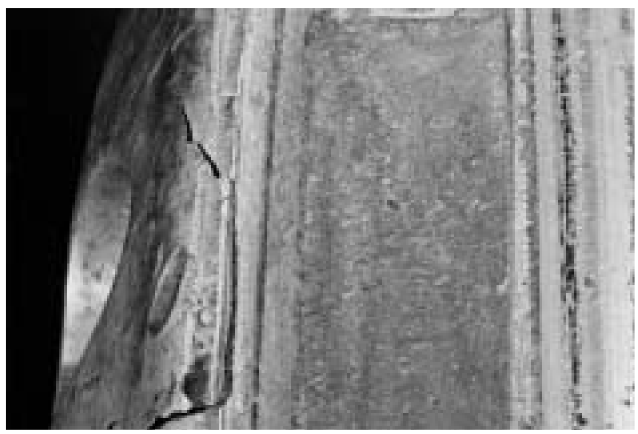
2-9

2

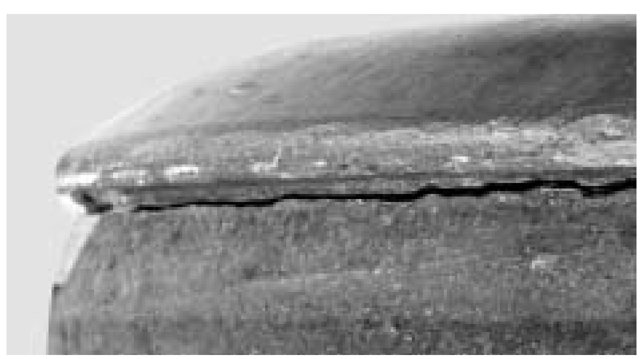
Gutter area

Projections on the side of the wheel gutter area on tube type wheels can cause uneven seating of the side and lock ring and chipping of the gutter. Such projections must be removed. Remove the wheel from service if damaged.

2-10



Cracking in bottom of gutter flange. Occasionally, circumferential cracks may appear in the bottom of the gutter area. This area should be thoroughly cleaned and carefully inspected after a tire is removed from the wheel. Also check the side underneath gutter flange for circumferential cracks. Gutter flange cracks can ultimately lead to the separation of the rim area from the disc. Immediately remove from service a wheel that exhibits any cracks.

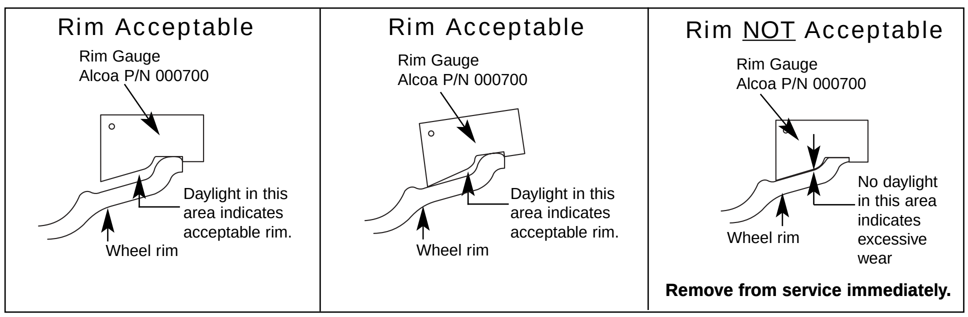


Rim flange wear

2-11

Irregular wear on the surface of the rim flange is caused by abrasion from the tire chafer and sidewall. Rim flange wear happens most often in applications with heavy or shifting loads. If you are experiencing excessive rim flange wear in your operation, consider using Alcoa Dura-Flange® aluminum wheels. These wheels have been specially treated to significantly reduce rim flange wear. Remove wheels from service when rim flange wear is excessive. Excessive wear can be determined using an Alcoa approved wear gauge and procedures detailed below. If rim flange wear becomes sharp and/or cuts the tire, contact Alcoa for recommended maintenance procedures.

Alcoa Rim Flange Wear Gauge Instructions



To obtain a gauge(s) at no charge and information on free training on proper installation and maintenance procedures, contact **Alcoa Wheel and Forged Products** at (800) 242-9898 option 1 or on the web at **www.alcoawheels.com.**

Determining Rim Flange Wear

STEP 1. Remove the wheel/tire assembly from the vehicle. Remove the valve core to deflate the tire completely. Remove the tire from the wheel according to OSHA regulations, TMC recommended practices for tire and rim safety procedures and/or the Alcoa Wheel Service Manual.

Photo 1. Acceptable Rim Flange Wear Condition

2

Rim flange wear (continued)

STEP 2. After the wheel is separated from the tire, use a ball tape to verify the circumference of the bead seat on the open side is acceptable (see 2-3, page 7). Check the wheel flange with the Alcoa Rim Flange Wear Gauge to determine if the wheels must be removed from service for excessive rim flange wear (photo 1 on page 13).

See **Rim Flange Wear Gauge Instructions** illustrations above to make this determination. If you do not have an Alcoa Rim Flange Wear Gauge, contact Alcoa Wheel and Forged Products to obtain a gauge(s) at no charge.

STEP 3. If the wheel is deemed to be serviceable by the rim flange gauge, examine the wheel flange edge for sharpness by using a rubber sharpness gauge. These gauges are constructed by having a section of tire side wall or a suitable piece of rubber attached to a block of wood (photo 2). By running the sharpness indicator gauge along the wheel in the area of the wear, determine if the wear is sharp enough to cut or damage the rubber on the sharpness indicator (photo 3). If the rubber is cut, then follow the edge removal instructions below.

Photo 2. A rubber sharpness gauge constructed from a section of tire side wall or a suitable piece of rubber attached to a block of wood.

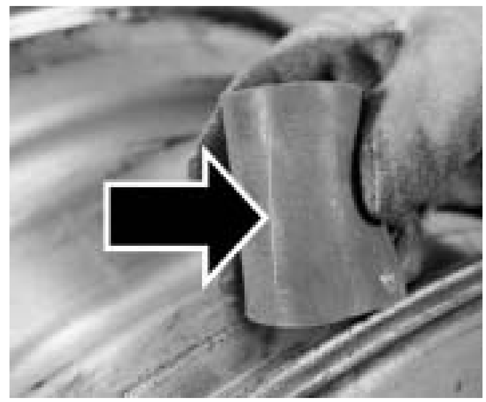


Photo 3. Run the sharpness indicator gauge along the wheel in the area of the wear to determine if the wear is sharp enough to cut or damage the rubber on the sharpness indicator.

NOTICE: Examine the tire for cuts in the bead area and side wall. If no damage occurred to these areas, return the tire to service. Cut tires should be removed from service. The tire should be inspected at this time for any other damage and be treated per normal tire procedures recommended by the tire manufacturer.

If the flange cuts or appears close to being sharp enough to cut the rubber on the sharpness indicator gauge, the edge can be removed per the edge removal procedures below. If the rubber is not cut, then the wheel can be returned to service without further work for rim flange wear.

NOTICE: Check the wheel at every tire change or ONCE PER YEAR for rim flange wear and any sharp edges. If you follow this practice, you will significantly reduce the possibility of a rim flange cutting into the tire.

CAUTION

CAUTION Do not run unprotected hands or fingers across worn rim flange areas of used wheels.

Worn rim flange areas are sharp and can cut hands or fingers. Cuts can lead to infection.

Always wear gloves when handling used wheels or when testing for edge sharpness.

Rim flange wear (continued)

Edge Removal Procedures

There are many tools available to remove the sharp edge on the wheel caused by rim flange wear. Here are some examples of commonly used tools:

File. A file can be used very effectively to remove the edge (photo 4).

Photo 4. Removing sharp edge by hand with a metal file.

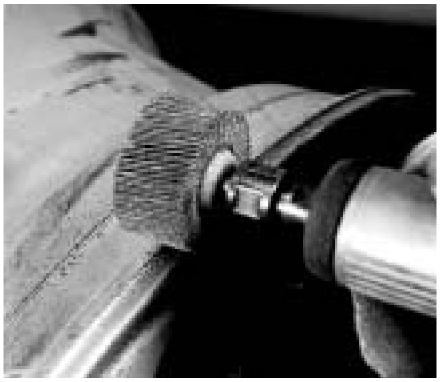


Photo 5. Air or electric power sander.

Air or Electric Powered Sander. This provides a very quick and effective method of removing the edge. Operators should use all care to keep a uniform edge when using these tools (photo 5).

Air or Electric Grinder. Another quick and effective method of removing the sharp edge caused by rim flange wear. Be careful as grinding pads may “gum up” from the aluminum that is removed (photo 6). Care must be used to avoid gouging the wheel.

Photo 6. Air or electric grinder

Photo 7. Die grinder.

2

Rim flange wear (continued)

Die Grinder. Used with a sanding wheel, cutting stone or grinding tool, this is a version of an electric grinder. This tool is very quick and effective as well, and care must be taken to remove metal as uniformly as possible and not to gouge the wheel (photo 7 on page 15).

CAUTION

CAUTION Removing sharp edges with hand or power tools produces metal filings and sparks. Many power tools have edges that are sharp or may become hot during use. Some power tools produce excessive noise when used.

Metal filings can be sharp and, when projected by the action of power tools, can cause serious skin or eye damage. Excessive noise from power tools can harm hearing. Sharp edges can produce cuts and hot surfaces can cause burns. Cuts and burns can lead to infection.

Always wear appropriate safety gear such as protective eye wear, gloves, protective clothing and hearing protection when using hand or power tools (photo 8).

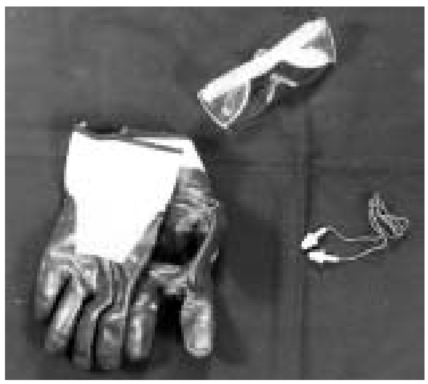


Photo 8. Always use proper safety gear.

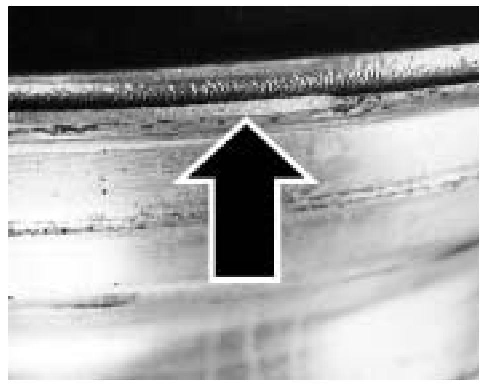


Photo 9. Adequate repair for sharp edge resulting from rim flange wear removes just enough metal to smooth the edge.

STEP 4. The photographs show the process of removing the edge. With whatever tool is selected, work the tool around the wheel's circumference removing only enough material to eliminate the sharp edge. This should only be a small amount of metal. Perform this work on both flanges if the there is evidence of sharpness.

Regardless of the method which you choose, the objective is to remove the sharp edge (photo 9). Remove just enough metal to smooth the edge. Take care to make sure the edge removal is as uniform as possible. Avoid gouging the wheel.

Rim flange wear (continued)

STEP 5. After the edge is removed, run the sharpness indicator gauge along the area of edge removal to check for any remaining sharpness. If the rubber is still cut, perform the steps again to remove the sharp edge. Always remove the minimum amount of material necessary to eliminate the sharp edge.

STEP 6. Check the rim flange height with the Alcoa Rim Flange Wear gauge to make sure there is adequate height remaining to safely support the tire. The photograph again shows how this gauge is used (photo 1). Be sure to move the gauge all around the wheel's circumference and make sure that no area of the flange is below what the gauge indicates is acceptable. If the entire wheel flange is within the limits of the rim flange wear gauge, the wheel may be returned to service.

STEP 7. Always inspect the wheel for any other conditions that would warrant removal from service. Consult the Alcoa Wheel Service Manual or the TMC User's Guide to Wheels and Rims.

WARNING

WARNING Welding or brazing the rim flange or any area of an Alcoa aluminum wheel will weaken the wheel. Weakened or damaged wheels can lead to an explosive separation of tires and wheels or wheel failure on the vehicle.

Explosive separations of tires and wheels or wheel failure on the vehicle could cause injuries or death.

Never attempt to weld or braze any surface of an Alcoa aluminum wheel.

WARNING

WARNING Returning wheels to service with inadequate flange height as determined by the Alcoa Rim Flange Wear Gauge can lead to an explosive separation of tires and wheels.

Explosive separation can result in serious injury or death.

Wheels with flange height that falls below the Alcoa gauge have inadequate rim flange height to support the tire on the rim. Permanently remove any wheel from service that has inadequate rim flange height.

Always follow safe mounting procedures as recommended using OSHA approved tire inflation cages. See the Alcoa Wheel Service Manual or OSHA safety wall charts and procedures.

3 Alcoa 15° Drop Center Wheel for Tubeless Tires

3

Recommendations for mounting tubeless tires

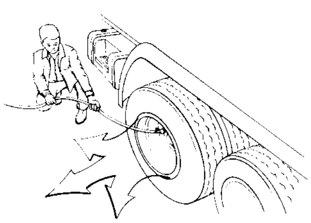
3-1

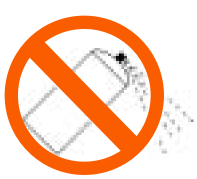
NOTICE: For complete information on tube type wheels, contact Alcoa.

> **WARNING**
>
> **WARNING Damaged tires or wheels can lead to an explosive separation of tires and wheels.**
>
> **Explosive separation can result in serious injury or death.**
>
> **Inspect tires and wheels for damage before removing from vehicle. If damage is found, the tire must be completely deflated before loosening cap nuts. Remove damaged tires or wheels from service.**

> **WARNING**
>
> **WARNING Use of inner tubes in tubeless wheels will hide slow leaks. Slow leaks may indicate cracked (see section 2-9, page 12) or damaged wheels which lead to wheel failures.**
>
> **Wheel failures can cause accidents which may result in serious injury or death.**
>
> **Never use an inner tube on an Alcoa tubeless wheel, and always remove cracked or damaged wheels from service.**

NOTICE: Alcoa aluminum 19.5"RW and non-symetrical well wide base wheels require special tire mounting techniques, See Section 3-2.





1. Do not gouge or nick the wheel. Place aluminum wheels on clean wooden floor or rubber mat when hand mounting tires. Additional care should be used when mounting Alcoa Dura-Bright® surface treated wheels since minor nicks and scratches cannot be polished out (see section 5-8, pages 37 & 38 for specific cautions, care and maintenance procedures). DiscMate wheel spacers are recommended for use with Alcoa Dura-Bright® surface treated wheels to protect the wheel contact surfaces from marring.

2. Always use a rubber, leather-faced or plastic mallet.

3. Inspect the wheel for damage. Do not use a damaged or severely corroded wheel. (See Section 2, page 5).

4. Clean the wheel face with mild detergent and the tire bead seat areas with a wire brush. Be sure the wheel is dry before applying tire lubricant.

5. Inspect the tire for damage. Be sure the inside of the tire is dry before it is mounted.

6. Use of a non-water-based lubricant is recommended as a rim surface protectant and tire mounting lubricant. Coat the entire rim surface. (See 3-2, page 19).

7. Lubricate the rim and tire bead immediately before mounting the tire. Do not use any lubricant which contains water. Water-based lubricants can promote corrosion attack on the rim surface. The use of non-water-based lubricants is especially important when mounting tubeless tires as the air in the tire is contained by the seal between the bead and tire rim.

8. Never lubricate the rim or tire bead with a flammable solution. This can lead to an explosion during airing of the tire or in subsequent operation of the vehicle **(see Warning below).**

9. If using a tire mounting/demounting machine on aluminum wheels, care should be taken to prevent gouging the wheel.

10. Use only dry air for tire inflation. The use of moisture traps in the air compressor feed line is recommended.

11. Do not overinflate. Use the tire manufacturer's recommended pressure, but under no circumstances exceed cold tire pressures listed in **Section 1 Specifications** of this manual (see page 2).

12. When inflating a tire in an inflation cage or while mounted on a vehicle, always use a clip-on air chuck or threaded straight chuck and a remote valve with pressure gauge. Securely anchor the inflation cage and during inflation or handling of an inflated wheel and tire assembly, stay out of the path of potential exploding parts or air blasts.

Recommendations for mounting tubeless tires (continued)

WARNING **Use of a volatile or flammable material, such as ether or gasoline, as an aid to seating the tire beads on the wheel can lead to an uncontrolled pressure build-up in the tire and may result in an explosion.**

Explosive separation of the tire and wheel can occur while seating beads in this manner, while adding air to the tire on or off the vehicle, or later on the road. Loss of vehicle control can result, which can cause serious injury or death.

Use only approved mechanical or pneumatic bead seating devices.

WARNING **A pressurized tire/wheel assembly can explode and separate violently.**

This violent separation can cause serious injury or death.

Always contain the tire/wheel assembly in an inflation cage during inflation.

Mounting tubeless tires

3-2

NOTICE: Not all tire mounting/demounting machines work alike. Be sure to read the operating or instruction manual for your particular machine before attempting to mount or demount tires.

NOTICE: Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

NOTICE: When match mounting tires on Alcoa wheels locate valve stem adjacent to low point mark on the tire.

NOTICE: Alcoa aluminum 19.5" RW and non-symmetrical wide base wheels require tires to be mounted and demounted over the disc side of the wheel only.

NOTICE: Refer to tire manufacturer's recommendation for proper tire pressure.

1

Position wheel on machine. Lubricate wheel (entire air chamber surface) and tire bead using approved lubricant. Tire beads should be mounted over the rim flange closest to the wheel well. Push bead over flange as far as possible.

2

Insert curved end of tool between bead and wheel flange with tool stop against flange. In circular motion, use short successive bites to work the bead over the flange. Push down on tool as bead is worked over flange.

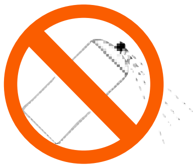
3

Lubricate the second tire bead. Start second bead into the well, holding it in position with the clamp to the rim flange. Lubricate bead half way around. With curved end of tool between tire bead and flange, and the stop towards the wheel, push tool outward to work tire over flange. Continue to pry bead over flange using the tool until remaining bead is over flange. Seat the tire bead using an air ring or other mechanical bead seating aid.

4

Place tire/wheel assembly inside safety cage or other suitable restraint (refer to OSHA rule 1910.177, paragraph **b**, see Section 7, page 44). **Refer to tire manufacturer's recommendation for proper tire pressure.** Using a clip-on air chuck or a self-locking straight chuck with remote valve and pressure gauge, inflate the tire/wheel assembly to proper pressure. If air escapes, roll tire or use bead expander to force tire beads against rim. Be sure to stay out of the path of potential exploding parts or air blasts.

Mounting tubeless tires continued



NOTICE: Not all tire mounting/demounting machines work alike. Be sure to read the operating or instruction manual for your particular machine before attempting to mount or demount tires.

NOTICE: Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

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NOTICE: When match mounting tires on Alcoa wheels locate valve stem adjacent to low point mark on the tire.

NOTICE: Alcoa aluminum 19.5" RW and non-symmetrical wide base wheels require tires to be mounted and demounted over the disc side of the wheel only.

NOTICE: Refer to tire manufacturer's recommendation for proper tire pressure.

NOTICE: Alcoa aluminum 19.5"RW and non-symetrical well wide base wheels require tires be mounted and demounted **over the disc side of the wheel only.** For a free instruction wall chart, contact: Alcoa Inquiry Fulfillment, Markinetics Inc., P.O. Box 809, Marietta, OH 45750.

WARNING

WARNING Use of a volatile or flammable material, such as ether or gasoline, as an aid to seating the tire beads on the wheel can lead to an uncontrolled pressure build-up in the tire and may result in an explosion.

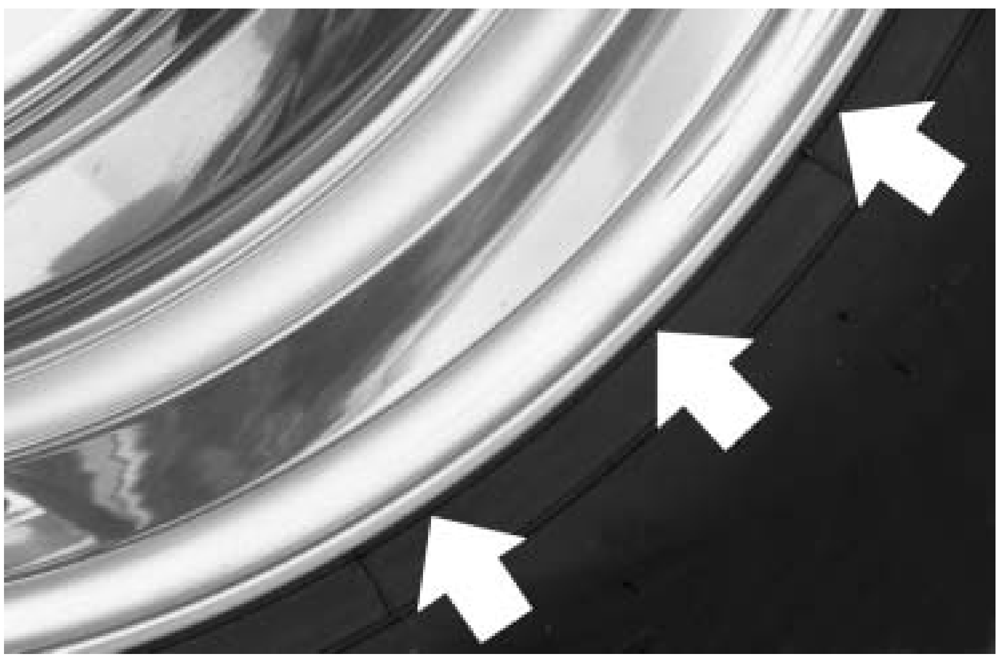
Explosive separation of the tire and wheel can occur while seating beads in this manner, while adding air to the tire or later on the road. Loss of vehicle control can result, which can cause serious injury or death.

Use only approved mechanical or pneumatic bead seating devices.

CAUTION

CAUTION The use of liquid tire balancers or sealants in Alcoa wheels may cause extremely rapid corrosion of the wheel rim surface.

Severely corroded wheels are unsuitable for service. Alcoa wheels corroded by the use of liquid tire balancers or sealants will not be replaced under the Alcoa limited warranty.



Heavy duty truck tires have a "guide rib" molded into the sidewall next to the tire bead. When the tire is inflated this ring should be evenly spaced from the wheel rim all the way around the wheel. Check the position of the ring before removing the assembly from the inflation cage. If the ring and wheel are not concentric, deflate the assembly in the cage and remount the tire.

Rim width to tire matching

3-3

Rim to tire matching chart for medium and heavy trucks.

Tire Size (for both radial and bias tires)		Approved Rim Widths	Tire Size (for both radial and bias tires)		Approved Rim Widths
8R	17.5HC	6.00HC	8	22.5	5.25, 6.00, 6.75
215/75R	17.5	6.00, 6.75	9	22.5	6.00, 6.75, 7.50
9R	17.5HC	6.75HC	10	22.5	6.75, 7.50, 8.25
10R	17.5HC	6.75HC, 7.50HC	245/75R	22.5	6.75, 7.50
245/75R	17.5	6.75, 7.50	11	22.5	7.50, 8.25
11R	17.5HC	8.25HC	255/70R	22.5	7.50, 8.25
			265/75R	22.5	7.50, 8.25
			12	22.5	8.25, 9.00
			295/75R	22.5	8.25, 9.00
			305/85R	22.5	8.25, 9.00
			315/80R	22.5	9.00, 9.75
			15	22.5	11.75, 12.25
			385/65R	22.5	11.75, 12.25
			425/65R	22.5	11.75, 12.25, 13.00
			16.5	22.5	12.25, 13.00
			18	22.5	13.00, 14.00
			445/50R	22.5	14.00
			445/55R	22.5	14.00
			445/65R	22.5	12.25, 13.00, 14.00
8	19.5	5.25, 6.00, 6.75	11	24.5	7.50, 8.25
225/70R	19.5	6.00, 6.00RW, 6.75, 6.75RW	275/80R	24.5	7.50, 8.25
245/70R	19.5	6.75, 6.75RW, 7.50, 7.50RW	285/75R	24.5	8.25
265/70R	19.5	7.50, 7.50RW, 8.25, 8.25RW	12	24.5	8.25, 9.00
285/70R	19.5	8.25, 8.25RW, 9.00	305/75R	24.5	8.25, 9.00
305/70R	19.5	8.25, 8.25RW, 9.00			
445/65R	19.5	13.00, 14.00			

There may be additional rim to tire matches not shown above. Contact the tire manufacturer or your Alcoa wheel representative for additional information.

Recommendations for demounting tubeless tires

3-4

WARNING

WARNING An aluminum wheel can be structurally weakened by uncontrolled excessive heat.

Tire/wheel assemblies using wheels that have been exposed to excessive heat may experience a sudden and unpredictable tire/wheel separation causing serious injury or death.

Immediately and permanently remove any wheel from service that has been subjected to uncontrolled excessive heat (such as a tire fire, wheel bearing failure or braking system drag/seize) or a high pressure tire/wheel separation.

WARNING

WARNING Damaged tires or wheels can lead to an explosive separation of tires and wheels.

Explosive separation can result in serious injury or death.

Inspect tires and wheels for damage before removing from vehicle. If damage is found, tire must be completely deflated before loosening cap nuts. Remove damaged tires or wheels from service.

Recommendations for demounting tubeless tires (continued)

1. When hand demounting tires from wheels, placing aluminum wheels on a clean wooden floor, or rubber mat is recommended. Additional care should be used when demounting Alcoa Dura-Bright® surface treated wheels since minor nicks and scratches can not be polished out (see section 5-8, pages 37-38 for specific cautions, care and maintenance procedures).

2. Always use a rubber, leather-faced or plastic mallet.

3. Keep tire tools smooth. Use them with care. Rim gouges or nicks may cause cracks.

4. If using a tire mounting/demounting machine on aluminum wheels, care should be taken to prevent gouging the wheel.

3

Demounting of tubeless tires

3-5

NOTICE: Not all tire mounting/demounting machines work alike. Be sure to read the operating or instruction manual for your particular machine before attempting to mount or demount tires.

Remove the valve core from the valve stem to ensure complete deflation. Place wheel on machine and position tool so flat end can be driven between tire bead and rim flange. Straighten tool to a vertical position until bead is separated from wheel.

Repeat procedure at intervals until bead is totally separated from wheel. Repeat procedure on other side of tire. Tire is now ready for demounting. Lubricate the tire bead.

Insert curved end of tire tools between tire and wheel, approximately 10 inches apart. Pull one tool toward center of wheel, then pull second tool in the same manner. To free bead, leave one tool in position, take out and reinsert the other tool, curved end between bead and flange, a short distance from the spanned area. Pry bead free of rim, repeating process until entire bead is free from wheel.

Insert straight end of tire tool between beads and both rim flanges, hooking stop on the tool over second flange. Position inserted tool at 90° angle to tire assembly at top of wheel and lubricate bead areas on both sided of tool. Lean tire assembly toward tool and rock or bounce to pry off the tire.

4 Wheel Installation

Recommendations for proper installation of wheels

4-1

NOTICE: Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

1. For the same reason the best tires are run on the front axle, the best wheels also should be used on the front axle.

2. Make sure all wheel cap nuts are properly torqued — check them often (see section 4-9, page 29). If the wheel is loose, the holes will pound out (deform). If some cap nuts are tight and others are loose, the wheel may develop cracks or studs may break. Dirt streaks radiating from stud holes can indicate loose nuts (see Section 2, pages 5-17).

3. Be sure the end of the wheel wrench is smooth or cover the wheel mounting surface with a protective shield prior to tightening the cap nuts. The wrench end will mar the wheel around the cap nuts if it is not smooth.

4. Keep all component contact surfaces smooth and clean. Dirt or projections on mounting surfaces may lead to loose wheels. Remove all projections resulting from burrs, nicks, etc. Be sure that loose dirt does not fall onto mounting surface during assembly.

5. Check for and replace bent, broken, cracked or damaged studs. When replacing broken studs, always replace the studs on each side of the broken stud. If two or more studs are broken, replace all the studs for that wheel position. Check with the stud manufacturer for regular maintenance and stud replacement practices. All wheel fastener hardware should be grade 8 or metric conversion 10.9. Follow the hardware manufacturer's recommendations when replacing studs.

6. Do not introduce any foreign objects such as spacers or high hats into the contact surface areas of the mounting system unless approved by Alcoa. Do not paint Alcoa forged aluminum wheels.

7. Additional care should be used when mounting Alcoa Dura-Bright® surface treated wheels since minor nicks and scratches cannot be polished out (see section 5-8, page 37-38 for specific cautions, care and maintenance procedures).

8. DiscMates are a protection gasket designed to be placed between the wheels and also the brake drum/wheel contact surfaces (see sections 4-5, page 24; 4-6, page 25; 4-7, page 26 and 4-10, page 31). DiscMates are recommended to be replaced when the tire/wheel assemblies are removed and reinstalled.

WARNING

WARNING Wheels that are not properly installed or maintained may not work properly.

Failure to follow proper wheel installation or maintenance practices may result in injury or death.

Follow the proper wheel installation and maintenance practices as contained in this Alcoa Wheel Service Manual. For training on proper installation and maintenance, available free of charge from Alcoa, or for the most recent updates, contact Alcoa Wheel and Forged Products at 1-800-242-9898 option 1 or on the web at www.alcoawheels.com.

Wheel cap nuts

4-2

4

WARNING **Use of chrome-plated cap nuts which have chrome plating on the surfaces which contact the wheel can cause reduced and inconsistent wheel clamping.**

This condition can cause wheels to loosen and disengage from the vehicle, causing injury or death.

Never use cap nuts with chrome-plated contact surfaces. Use only recommended hardware on Alcoa aluminum wheels.

There are many types of nuts and studs in use, and their design and specifications are not standardized. The “R” and “L” on cap nut part numbers indicate right and left-hand threads respectively. Alcoa recommends the following cap nuts for use with Alcoa aluminum truck wheels:

Cap Nuts

2-piece 33mm hex head flange nut. Mounts single and dualed wheels to wheel centering hubs. Right hand threads used on both sides of vehicle. Single wheels require 2” (50.8 mm) stud standout. Dualed wheels require 2-13/16 (71.44 mm) stud standout. P/N 39874 (supersedes P/Ns 39701 and 39691); M22-1.5 RH threads.

2-piece 30mm hex head flange nut. Mounts single and dualed wheels to wheel centering hubs. Right hand threads used on both sides of vehicle. P/N 39708; M20x1.5 RH threads.

2-piece 33mm hex head flange nut. Mounts dualed wheels with **32mm bolt holes** to wheel centering hubs. Right hand threads used on both sides of vehicle. P/N 4307.32; M22x1.5 RH threads.

1-1/8" cap nut. Mounts standard single wheels and wide base wheels to 1-1/8" studs. Also mounts outer dualed wheel to 1-1/8" inner cap nut. P/N 5996R, 5996L (replaces P/N 5552R, 5552L).

3/4"x16 cap nut. Mounts Alcoa wide base wheels to 3/4" studs. Do not use on steel wheels. P/N 5995R, 5995L (replaces P/N 5554R, 5554L).

2 piece 1-1/16” hex head flange nut. Mounts single and dualed wheels to wheel centering hubs. Right hand threads used in both sides of vehicle. P/N 39946; 5/8”x18 RH threads

2-piece 33mm hex head flange nut. Mounts single wheels to wheel centering hubs with 32mm bolt holes. Right hand threads used on both sides of vehicle. P/N 4306.32; M22x1.5 RH threads.

Inner cap nut, inner thread 3/4"x16, outer thread 1-1/8"x16. For use with steel inner dual wheel an aluminum outer dual wheel with 1.31" (1-5/16) to 1.44" (1-7/16) stud standout. P/N 7896R, 7896L (Grade 8).

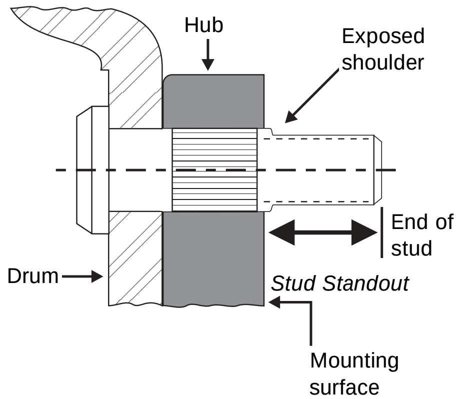
Inner cap nut, inner thread 3/4"x16, outer thread 1-1/8"x16. For use with standard length studs (1.31" [1-5/16] to 1.44" [1-7/16]) stud stand-out) or longer studs not to exceed 1.88" [1-7/8] stud standout. Full internal and external threads. P/N 5978R, 5978L (Grade 8). For studs without exposed shoulders. Do not use with steel inner dualed wheel.

Inner cap nut for use with standard length studs (1.31" [1-5/16] to 1.44" [1-7/16]) stud standout) or longer studs not to exceed 1.88" (1-7/8) stud standout. Full internal and external threads, counter bore 5/16" deep at open end. Prevents stud from bottoming out in cap nut. P/N 5988R, 5988L (Grade 8). For use with studs with exposed shoulders. Do not use with steel inner dualed wheel.

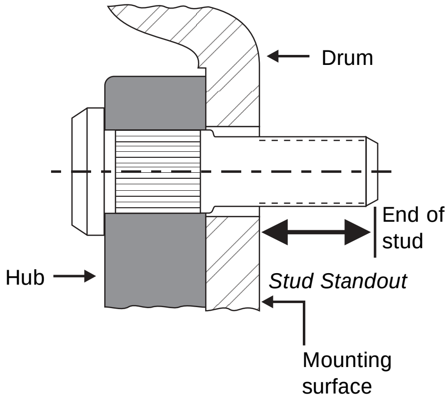
How to measure stud standout

4-3

Stud standout is measured from the axle end mounting surface to the end of the stud.



Inboard mounted drum



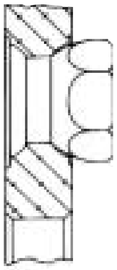
Outboard mounted drum

4

Stud located ball seats are spherical

4-4

The nut seat for the stud located ball seat mounting system is a precision-machined spherical surface. Cap nuts must be properly manufactured to assure correct seating. Never use one or two-piece flange nuts on a wheel designed with ball seats (see 4-12, page 34). Ball seat cap nuts may be obtained from your Alcoa Wheel Distributor.



Single wheel, stud located, ball seat mounting

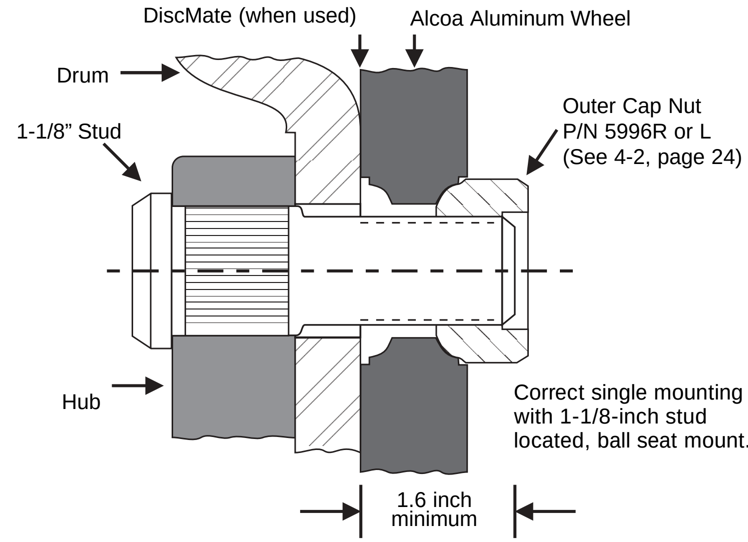
4-5

NOTICE: Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

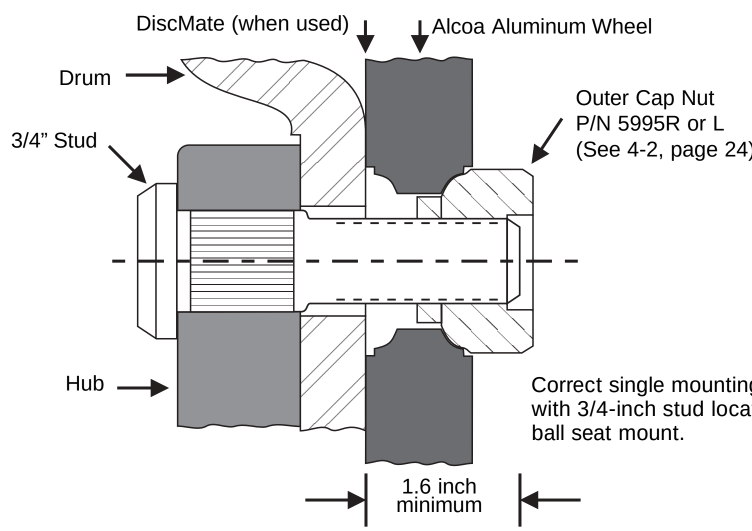
Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

Front wheels are mounted as singles and require 1.6" (1-39/64") minimum stud standout. Most vehicles have 1-1/8-inch studs on the front hubs. Alcoa single cap nuts, Part Nos. 5996R and 5996L, or equivalents, should be used. Some front hubs have 3/4-inch studs. On these hubs, use Alcoa single cap nuts, Part Nos. 5995R and 5995L or equivalents.

DiscMate wheel spacers are recommended for use with Alcoa Dura-Bright® surface treated wheels to protect the wheel contact surfaces from marring. DiscMate wheel spacers are placed between the contact surfaces of the Dura-Bright® wheel and the brake drum as shown below.



Correct single mounting with 1-1/8-inch stud located, ball seat mount.



Correct single mounting with 3/4-inch stud located, ball seat mount.

Dualed wheels, stud located, ball seat mounting

4-6

Rear wheels are most frequently mounted as duals. Each inner aluminum wheel is attached by 10 inner cap nuts. Alcoa recommends use of inner cap nuts 5978R, 5978L, or 5988R, 5988L (see 4-2, page 24).

Cap nuts recommended by Alcoa are compatible with Alcoa wheels. Hardware of equal dimensions and strength may be used.

Continued on next page.

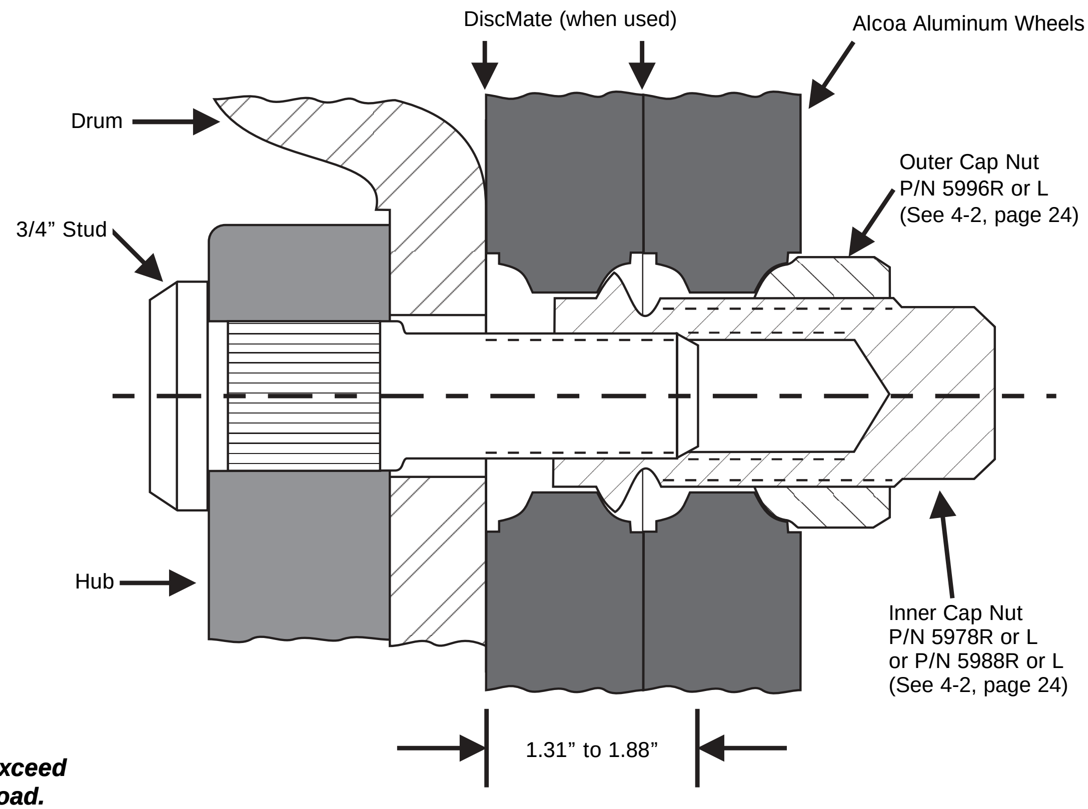
Dualed wheels, stud located, ball seat mounting (continued)

Most vehicles have standard length studs (1.31" [1-5/16"] to 1.44" [1-7/16"] stud standout). Some vehicles use studs longer than standard (up to 1.88" [1-7/8"] standout).

When changing types of brake drums be sure to check for excessive stud standout (greater than 1.88" [1-7/8"]). Excessive stud standout may cause the inner cap nut to bottom out on the longer stud preventing proper seating of the wheel.

Each outer dual wheel is attached by 10 single cap nuts which thread on the inner cap nuts. Use Alcoa outer cap nuts, Part Nos. 5996R, 5996L or equivalents. Match mounted dual wheels should be put on the vehicles with the valve stems180° apart.

DiscMate wheel spacers are recommended for use with Alcoa Dura-Bright® surface treated wheels to protect the wheel contact surfaces from marring. DiscMate wheel spacers are placed between the contact surfaces of the Dura-Bright® wheel and the brake drum and between the dual aluminum wheels as shown below.



Correct mounting for dual aluminum, stud located, ball seat mount, wheels.

NOTICE: Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

WARNING

WARNING Incorrect inner cap nuts used with dualed aluminum wheels can bottom out on the unthreaded portion of the stud before the wheels are properly seated.

Improperly seated wheels can run loose, cause stud breakage and disengage from the vehicle which can cause serious injury or death. Loose running wheels can lead to stud breakage.

Use only cap nut 5978R or L, 5988R or L, or their equivalent when mounting dual aluminum wheels.

On occasion Alcoa aluminum truck wheels are operated dualed with a steel inner wheel. In the event a steel inner wheel is used, extreme care must be exercised to properly seat it to the hub or drum prior to mounting the outer aluminum wheel. Selection of an inner cap nut capable of fixing the steel inner wheel and providing adequate external thread length to secure the outer aluminum dualed wheel is critical to a safe assembly. Alcoa recommends the use of inner cap nuts 7896R and L (Grade 8), or equivalent, for this purpose.

Dualed wheels, steel inner/ aluminum outer stud located ball seat mounting

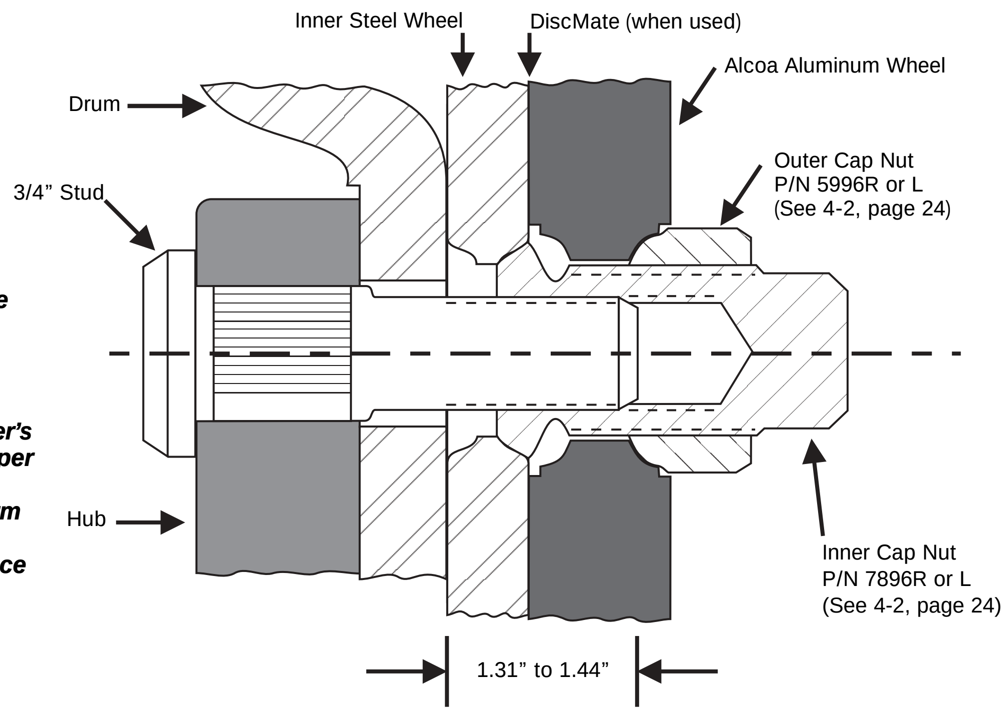
DiscMate wheel spacers are recommended for use with Alcoa Dura-Bright® surface treated wheels to protect the wheel contact surfaces from marring. DiscMate wheel spacers are placed between the contact surfaces of the Dura-Bright® wheel and the brake drum and between the steel and aluminum wheels as shown below.

4-7

NOTICE: Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

4



Correct dual mounting for steel inner/aluminum outer stud located ball seat mount.

WARNING **Incorrect inner cap nuts used with steel wheels can bottom out on the unthreaded portion of the stud before the wheels are properly seated.**

Improperly seated wheels can run loose, cause stud breakage and disengage from the vehicle which can cause serious injury or death. Loose running wheels can lead to stud breakage.

Use only cap nut 7896R or L or its equivalent when mounting steel inner duals.

WARNING **Inadequate wheel support surface can lead to stud hole-to-stud hole fracture resulting in separation of the outer disc and rim from the vehicle.**

Separation of the wheel from the vehicle can cause injury or death.

Alcoa aluminum wheels with 11-1/4" diameter bolt circle require a support surface at least 13-3/16" in diameter. Check the outer support surface of the inner steel wheel for flatness and adequate diameter before installing the outer wheel. When the wheels are serviced, check the mounting surfaces of both wheels for stud hole to stud hole cracks. If cracks are found, remove the wheel from service. For the support surface diameter required by other bolt circle sizes, ask your Alcoa representative.

WARNING **Use of two-piece flange nuts on ball seat wheels or ball seat cap nuts on hub piloted wheels is dangerous.**

Using the wrong cap nuts can cause loss of torque, broken studs and cracked wheels, conditions which can lead to injury or death.

Use only hardware designed specifically for each wheel type. See 4-2, page 24 for proper hardware assemblies.

Cap nut thread engagement, stud located wheels, ball seat mounting

4-8

The actual length of thread engagement present in an assembled wheel can not always be determined by visual inspection or measurement of a tightened assembly. The relationship of the wheel cap nut seat to the end of the stud may vary. If there is any doubt that enough thread engagement is present, the number of engaged threads may be counted. Tighten all nuts in the regular manner, then loosen one to hand-tightness. The number of turns to disengage a 1-1/8-inch nut should be at least five full turns. At least seven full turns should be required to disengage a 3/4-inch nut. Ideally, when torqued to the proper load, the stud should be flush with the face of the nut. The face of the nut may be recessed in nuts that are taller for improved wrenching. With most of the nuts in present use, a few unengaged threads at the outer end will cause no problem provided at least 5-7 full turns are required to disengage the nut depending on thread size.

Cap nuts made to Alcoa specification usually give more than the necessary thread engagement on a given stud.

Some states have laws which dictate full thread engagement or thread engagement past the nut body. Make sure you know the laws for the states in which you operate and comply.

Tightening stud located, ball seat cap nuts

4-9

4

The number of turns to disengage a 1-1/8-inch nut should be at least five full turns. At least seven full turns should be required to disengage a 3/4-inch nut.

WARNING

WARNING Lubricants should not be applied to the cap nut seat or to the cap nut-to-wheel contact surface.

Oiled seats can lead to over-torquing which can stretch studs causing failure of studs. Failed studs can cause the wheel to disengage from the vehicle, causing injury or death.

Lubricants must be completely removed from the cap nut seats and contact surfaces if applied accidentally.

Cap nuts must be kept tight, and studs and nuts should be checked frequently. Nuts should be retorqued if necessary. At tire changes, nuts and studs should be inspected for cracks and stripped or damaged threads. After each wheel mounting, cap nut torque should be checked with a torque wrench.

Impact wrenches, if used, should be carefully adjusted to apply torques within the limits recommended. Torquing of cap nuts should be done in recommended sequences.

WARNING

WARNING Undertorqued cap nuts allow wheels to run loose, pounding out (deforming) the ball seats, fatiguing studs or losing nuts. Overtorquing can stretch studs causing them to fail.

Both under and overtorquing can lead to wheels coming off, causing injury or death.

Check all parts, including wheels, studs and cap nuts. Check mounting faces of wheels, hubs and drums. Check for dirt, corrosion or damage. Remove dirt and rust; replace damaged parts. Follow correct tightening sequences and torque levels.

Continued on next page

Tightening stud located, ball seat cap nuts (continued)

Stud located, ball seat mounting system.

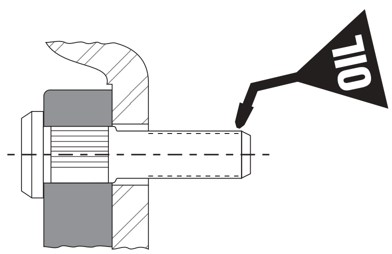
It is recommended that stud threads on stud located mounting systems be lubricated with SAE 30W oil and torqued between 350 and 400 foot-pounds. If threads are not lubricated, torque to between 450 and 500 foot-pounds. Note: when dualing steel wheels with Alcoa aluminum wheels, follow the steel wheel manufacturer's recommendations regarding the proper torque and use of thread lubricants to mount the wheel.

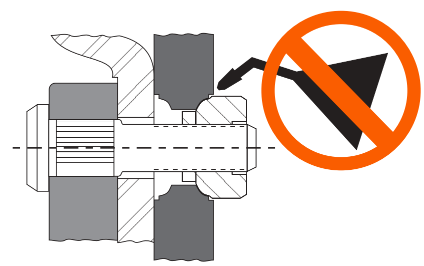
WARNING

WARNING Application of lubricant to the ball seats can cause excessive torque. Over torque can stretch studs causing them to fail.

Overtorquing can lead to wheel disengagement causing injury or death.

Do not allow oil to contact ball seats or mounting surfaces of the wheel, hub or drum. Do not use aerosol cans for lubrication of stud threads.

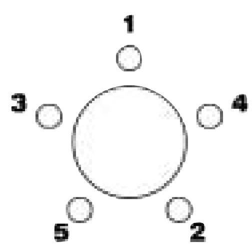




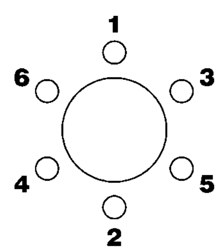
On vehicles equipped to accept wheels manufactured for use with the stud located ball seat mounting system, wheel studs on the right side of the vehicle have right-hand threads and those on the left have left-hand threads. The "R" and "L" on the studs and nuts indicate right and left-hand threads respectively (see 4-2, page 24).

After mounting a wheel over the studs, snug up the cap nuts in the order shown in the illustrations that follow. After all the cap nuts have been snugged, tighten the cap nuts to the recommended torques, following the same tightening sequence.

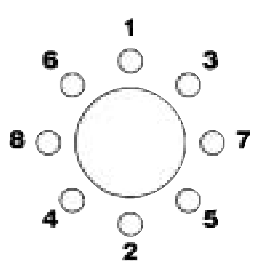
NOTICE: In service, stud dimensions and condition may change over time due to environmental conditions, multiple re-installations, improper torquing and other factors. Consult with your hub and stud manufacturer for maintenance and replacement recommendations.



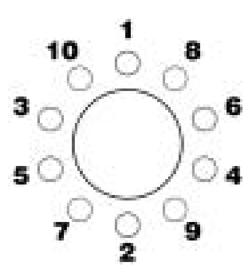
Five Stud



Six Stud



Eight Stud



Ten Stud

Continued on the next page

Tightening stud located, ball seat cap nuts (continued)

After 50-100 miles of operation, torque should be rechecked. Loosen outer cap nuts on every other stud to check the torque on inner cap nuts, then retorque outer cap nuts. Repeat steps on remaining studs. **Check torque frequently from then on.** If nuts require frequent tightening, studs break frequently, or wheel nut seats are pounding out, hardware and mounting practices should be reviewed. Note: whenever the outer cap nut is loosened **ALWAYS** retorque the inner cap nut before retorquing the outer cap nut.

Single, dualed and wide base wheels, hub piloted mounting, two-piece flange nuts

4-10

NOTICE: Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

Most U.S. manufacturers of highway trucks, tractors and trailers which incorporate the hub piloted wheel mounting system require wheel studs and cap nuts with metric threads. Most frequently these are M22x1.5.

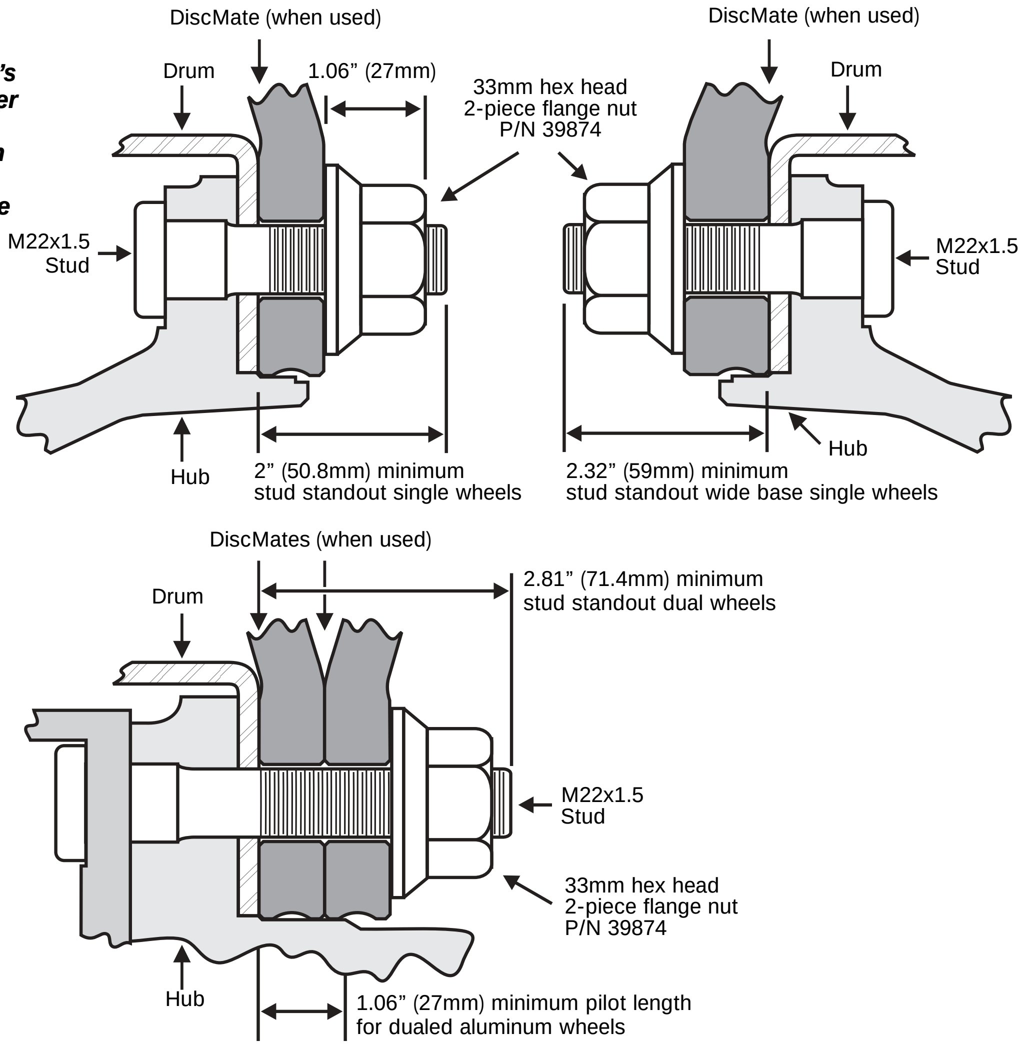
Generally the same diameter stud is used to mount either single or dualed wheels.

Studs on both sides of the vehicle are right-hand threads thereby eliminating the need for flange nuts peculiar to either the right or left side of the vehicle. The same flange nut is used to mount dualed or single wheels. Proper stud standout for single wheels is 2-inch (50.8mm) minimum, dualed wheels require 2.81-inch (71.4mm) minimum and single wide base wheels require 2.32-inch (59mm).

Some states have laws which dictate full thread engagement or thread engagement past the nut body. Make sure you know the laws for the states in which you operate and comply.

DiscMate wheel spacers are recommended for use with Alcoa Dura-Bright® surface treated wheels to protect the wheel contact surfaces from marring. DiscMate wheel spacers are placed between the contact surfaces of the Dura-Bright® wheel and the brake drum and between the dual wheels as shown below.

Note: Some stud located ball seat wheels have the same number of holes and bolt circle diameter as hub piloted wheels. They should not be mixed.



Typical assembly of single and dual wheels of hub piloted type with 33mm hex head two-piece flange nut, Part No. 39874. If hex nuts with greater overall height are used, more stud length is required.

Continued on the next page.

Single, dualed and wide base wheels, hub piloted mounting, two-piece flange nuts (continued)

Hubs designed for steel hub piloted wheels may not have enough pilot length to locate dualed aluminum wheels. Pay close attention to pilot length, particularly when converting from steel to aluminum duals. Measure the hub pilot to make sure the hub has a minimum pilot length of 1.06-inch or 27mm for dualed wheels.

When mounting painted steel inner dual wheels with outer aluminum wheels, be cautious of excessive paint build-up on the inner steel wheel. Excessive paint can reduce the clamping force and allow the wheels to become loose.

Match mounted dual wheels should be put on the vehicle with the valve stems 180° apart.

Tightening hub piloted mounting, two-piece flange nuts

4-11

Flange nuts must be kept tight, and studs and nuts should be checked frequently. At tire changes, nuts and studs should be inspected to be sure they are in good condition. If nuts require frequent tightening or studs break frequently, hardware and mounting practices should be reviewed.

Impact wrenches, if used, should be carefully adjusted to apply torques within the limits recommended. Torquing of flange nuts should be done in recommended sequences.

WARNING

WARNING Undertorqued flange nuts allow wheels to run loose and fatigue studs or lose nuts. Overtorquing can stretch studs causing them to fail.

Both under and overtorquing can lead to wheel disengagement causing injury or death.

Check all parts including wheels, studs and flange nuts. Check mounting faces of wheels, hubs and drums. Check for dirt, corrosion or damage. Remove dirt and rust; replace damaged parts. Follow correct tightening sequences and torque levels.

Two-piece flange nuts with a 33mm hex head design (see 4-2, page 24), used with hub piloted wheels should be tightened to a torque of 450 to 500 foot-pounds. Two-piece flange nuts with 1-1/2-inch hex head design and other designs have different torque requirements. Inquire of the manufacturer for the proper torque values.

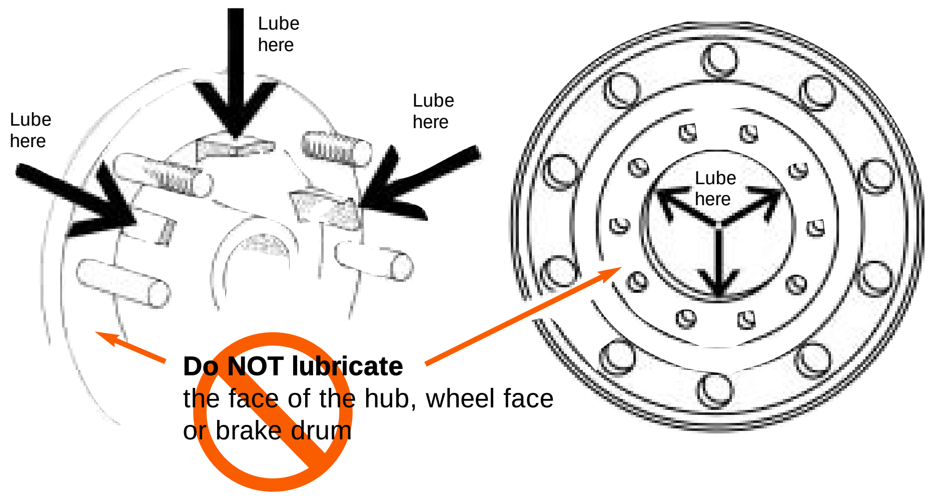
Wheel studs on both the right and left side hubs of vehicles utilizing the hub piloted wheel system have right-hand threads.

Prior to mounting hub piloted wheels, generously coat the wheel pilot or hub pads with a non-water-based lubricant to minimize corrosion product build-up between the wheel and hub pilot. Excessive corrosion build-up between the wheel and hub pilots can make wheel removal difficult. Do not lubricate the face of the wheel, hub or brake drum (see illustration on the next page).

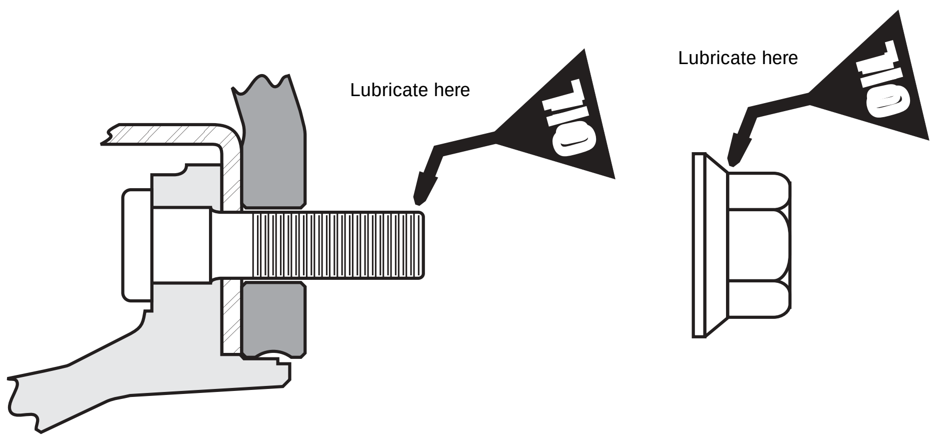
Continued on the next page.

Tightening hub piloted mounting, two-piece flange nuts (continued)

Lubricate the hub pads or the wheel hub bore generously with a non-water-based lubricant.

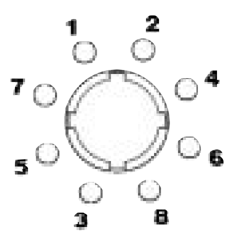


Before installing two-piece flange nuts, lightly lubricate the stud threads and the contact surfaces between the cap nut and the washer as illustrated below with an SAE 30W oil. This will minimize corrosion between the mating surfaces. Lubrication is not necessary with new hardware.

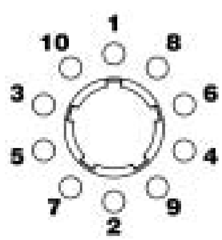


Position one of the hub's pilot pads at the twelve o'clock position. After positioning wheels on the pilot pads, hand tighten all two-piece flange nuts, then tighten to the recommended torque following the proper sequence shown below for your type wheel. After 50-100 miles of operation, torque should be rechecked. **Check torque frequently from then on.** If nuts require frequent tightening, studs break frequently, or wheel bolt holes are pounding out, hardware and mounting practices should be reviewed.

NOTICE: In service, stud dimensions and condition may change over time due to environmental conditions, multiple re-installations, improper torquing and other factors. Consult with your hub and stud manufacturer for maintenance and replacement recommendations.



Eight Stud



Ten Stud

Incorrect assemblies

4-12

4

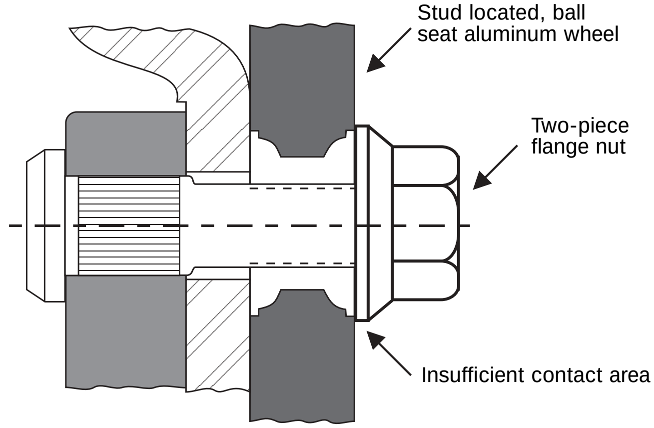
WARNING

WARNING Use of two-piece flange nuts on ball seat wheels, ball seat cap nuts on hub piloted wheels or single-piece flange nuts in place of 2-piece flange nuts is dangerous.

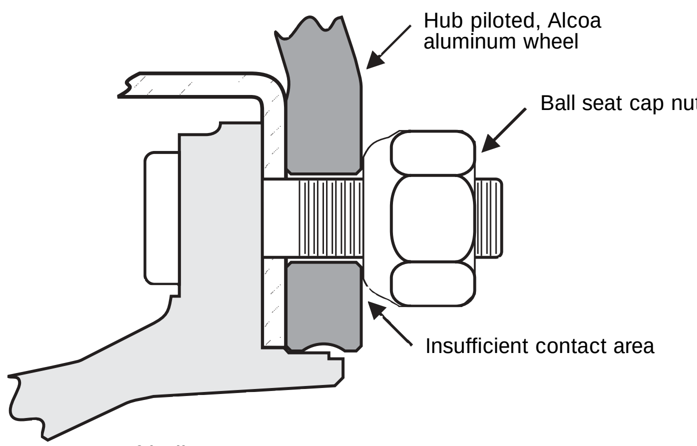
Using the wrong wheel nuts can cause loss of torque, broken studs and cracked wheels, conditions which can lead to injury or death.

Use only hardware designed specifically for each wheel type. See 4-2, page 24 for proper hardware assemblies.

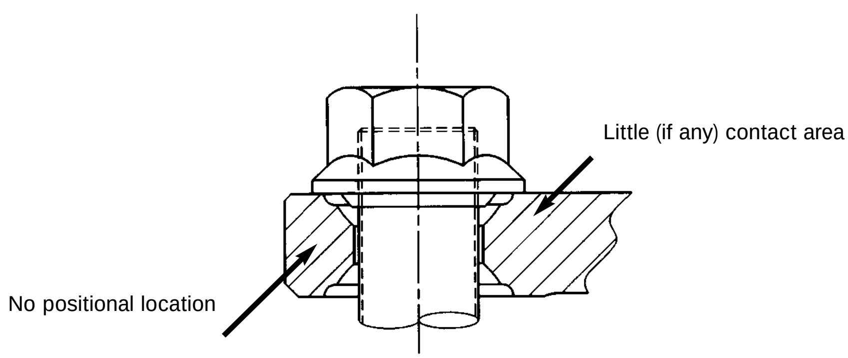
The following are examples of **incorrect** wheel assemblies.



Incorrect use of two-piece flange nut.
Do not use two-piece flange nuts with ball seat wheels.



Incorrect use of ball seat cap nut.
Do not use ball seat cap nuts with hub piloted wheels.



Incorrect use of one-piece flange nut positioned on Alcoa ball seat wheel.
Do not use one-piece flange nut on ball seat wheels.

5 Proper Torque, Wheel Identification, Valves and Surface Maintenance

Avoid abuse

5-1

Abuse can shorten the life of a wheel. Lack of care in changing a tire, heavy pounding of the wheel rim, overloading, exposure to excessive heat or hitting curbs at high speed or a sharp angle can damage wheels.

Do not overinflate. Use the tire manufacturer's recommended pressure, but under no circumstances exceed cold tire pressures listed in Section 1 Specifications of this manual. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire perform a wheel fitment check to insure proper clearance from any obstructions.

Keep wheel nuts tight

5-2

Wheel cap nuts must be kept tight (see 4-9, page 29). When checking the cap nuts on dual disc wheels utilizing the stud located ball seat mounting system, loosen every other outer cap nut and then check the torque of the inner cap nuts. Retorque the loosened outer cap nuts. Repeat procedure with the rest of the nuts. Check all cap nuts for proper torque after the first use or any removal. Inspect wheels and check wheel nuts during service stops. (See Section 2, page 5). Dirt streaks from cap nuts may indicate looseness.

Flange nuts must be kept tight, and studs and nuts should be checked frequently. At tire changes nuts and studs should be inspected to be sure they are in good condition. If nuts require frequent tightening or studs break frequently, hardware and mounting practices should be reviewed.

For proper nut torque, refer to the chart below:

Mount Type	Nut Thread	Torque Level Ft-Lb Lubricated*	Torque Level Ft-Lb Dry*
Hub piloted using two-piece flange nut	11/16" - 16 M20 x 1.5 M22 x 1.5	300-400 280-330 450-500	
Stud piloted, double cap nut standard type (7/8" radius)	3/4" - 16 1-1/8" - 16	350-400 350-400	450-500 450-500
Stud piloted, double cap nut heavy duty type (1-3/16" radius)	15/16" - 12 1-1/8" - 16 1-5/16" - 12	650-800	750-900 750-900 750-900

For nuts used on **hub piloted wheels, apply two drops of oil to the point between the nut and flange and two drops to the first two or three threads at the tip of each stud (see 4-11, page 32).*

*For nuts used on **stud piloted wheels,** apply two drops of oil to the first two or three threads at the tip of each stud only (see 4-9, page 29).*

NOTE:

1. If using specialty fasteners (cap nuts), consult the manufacturer for recommended torque values.

2. Tightening wheel nuts to their specified torque is extremely important. Undertightening which results in loose wheels can damage wheels, studs and hubs, and can result in wheel loss. Overtightening can damage studs, nuts and wheels and results in loose wheels as well.

3. Regardless of the torque method used, all torque wrenches, air wrenches and any other tools should be calibrated periodically to ensure the proper torque is applied.

Lead balance weights (clip on)

5-3

Lead balance weights for Alcoa wheels are available from your Alcoa Wheel Distributor. With radial tires it may be necessary to temporarily reduce the tire pressure when installing clip-on weights to allow clearance of the weight clamp over the rim flange. Use of coated balance weights is recommended to avoid staining and corrosion of the aluminum wheel surface.

Excessive rim flange wear (see section 2-11, pages 13-17) could dictate the use of “stick-on” or adhesive wheel weights if there is inadequate rim to properly hold a clip-on style weight.

Improperly installed weights could “fly off” during use and damage the vehicle or cause personal injury. Always follow the recommended procedures in this manual or the wheel weight manufacturer. Adhesive weights should be applied only to a clean surface on the brake side of the wheel rim. These weights should be installed only in a location where they will not contact the brake components during vehicle operation.

Do not straighten wheels

5-4

Do not heat wheels in an attempt to soften them for straightening to repair damage from striking curbs or other causes. The special alloy used in these wheels is heat treated, and uncontrolled heating will weaken the wheel.

Do not rework, weld, heat or braze Alcoa aluminum wheels for any reason. This does not include normal wheel maintenance as described and approved by Alcoa.

WARNING An aluminum wheel can be structurally weakened by uncontrolled excessive heat.

Tire/wheel assemblies using wheels that have been exposed to excessive heat may experience a sudden and unpredictable tire/wheel separation causing serious injury or death.

Immediately and permanently remove any wheel from service that has been subjected to uncontrolled excessive heat (such as a tire fire, wheel bearing failure or braking system drag/seize) or a high pressure tire/wheel separation.

5

Owner/in-service identification

5-5

Some fleets wish to specially identify wheels as to OWNERSHIP and IN-SERVICE dates. Alcoa recommends that fleets and owner-operators adopt the practice of permanently stamping wheels with the date they are first placed into service.

1. Use "Lo-Stress" stamps or equivalent.

2. Location of stamped areas on outside disc should be in space outward from a line between hand hole centers and a minimum of one inch from the periphery of any hand hole.

3. Location of stamped identification on inside of wheel should be as close to the factory identification stamping as possible.

Note: Use of an impression stamp on Dura-Bright® surface treated wheels can affect the appearance and performance of the Dura-Bright® surface treatment local to the stamp.

Valves

5-6

Alcoa drop center wheels for tubeless tires come from the factory with air valves installed. If it becomes necessary to replace an air valve, install it using the following torque values.

10-14 foot-pounds for Part Nos.	7-11 foot-pounds for Part Nos.
TR 509 TR 510 TR 511	TR 542 Series TR 543 Series TR 544 Series TR 545 Series 60MS27N

Replacement valves may be obtained from your authorized Alcoa Wheel Distributor. Always use silicone o-rings – not rubber – when reinstalling valve stems. Metal valve stem caps are recommended instead of plastic.

When replacing valve stems, it is recommended to lubricate the threads and o-ring with a non-waterbased lubricant.

Maintenance against corrosion (non-Dura-Bright® surface treated wheels)

5-7

Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire, perform a wheel fitment check to ensure proper clearance from any obstructions.

The following information is for standard Alcoa forged aluminum wheels **without** the Dura-Bright® surface treatment. See section 5-8, page 37 for specific instructions on the care and clearing of Alcoa Dura-Bright® surface treated wheels.

1. Clean frequently with high pressure water from a hose. The use of a mild detergent will speed the cleaning process. Use no harsh alkaline cleaners.

2. When tires are removed the entire wheel must be cleaned and inspected. (See Section 2, page 5). With a wire brush, remove any foreign products from the tire side of the rim. Do not use a wire brush to remove dirt and corrosion products from the appearance surface of the wheel. Generously coat the entire air chamber surface with an approved surface protectant and lubricant each time the tire is removed (See 3-1, page 18).

3. To maintain the original appearance of your Alcoa wheels, the following procedures are recommended:

a. After installing new wheels and prior to operating your vehicle, use a sponge, cloth or soft fiber brush to wash exposed wheel surfaces with a mild detergent and warm water solution.

b. Rinse thoroughly with clean water.

c. Wipe dry to avoid water spots.

d. Wax the cleaned surface with **Alcoa Advanced Aluminum Care System Polish** or Simonize, Mothers, California Gold paste wax, No. 7 Car Wax or equivalent.

e. Clean your Alcoa truck wheels as frequently as required to maintain their appearance.

Dura-Bright® surface treated wheels cleaning and maintenance

5-8

Do not exceed maximum wheel load. Customer must compare OEM vehicle load rating to maximum wheel load rating.

Refer to tire manufacturer's recommendation for proper tire pressure. Before mounting the tire, perform a wheel fitment check to ensure proper clearance from any obstructions.

1. Clean frequently with high-pressure water from a hose. The use of a mild detergent will speed the cleaning process. Do not clean with abrasives, abrasive brushes, steel wool, scouring pads or strong chemicals, such as acids or lye-based products. Never spray cold water on extremely hot wheels. Always allow time to cool before cleaning.

2. When tires are removed, the entire rim must be cleaned and inspected (see section 2, page 5). With a brush, remove any foreign products from the tire side of the rim (portion of the wheel that supports the tire). Do not use an abrasive brush to remove dirt, corrosion or other foreign products from the Dura-Bright® wheel surfaces. Generously coat the entire air chamber surface with an approved surface protectant and lubricate each time the tire is removed (see 3-1, page 18 of the Alcoa Wheel Service Manual, July 2002).

3. To maintain the original appearance of your Alcoa Dura-Bright® wheels, the following procedures are recommended:

a. After installing new wheels and prior to operating your vehicle, use a sponge or cloth to wash exposed wheels surfaces with a mild detergent and warm water. Do not use abrasives, abrasive brushes, steel wool, scouring pads or strong chemicals (such as acids or lye-based products). Standard off-the-shelf car wash and wheel detergents are sufficient. Warm water and a mild detergent will speed the cleaning process.

b. Rinse thoroughly with clean water.

c. Wipe dry to avoid water spots.

Dura-Bright® surface treated wheels cleaning and maintenance (continued)

d. Clean your Alcoa Dura-Bright® wheels using the above procedures as frequently as required to maintain their appearance. Typical road soils, grime and brake dust trap moisture, which can cause corrosion over a period of time. These must be removed regularly. To assist in the removal of excessive dust, dirt and road grime, the use of warm, high-pressure water with a mild detergent is recommended. The surface of Alcoa Dura-Bright® wheels will be damaged, discolored or removed if abrasives, abrasive brushes, steel wool, scouring pads or strong chemicals (such as acids or lye-based products) are used to clean the wheel. DO NOT USE the Alcoa Aluminum Care System on Dura-Bright® wheels at any time during their service life.

4. Once in service, Dura-Bright® wheels can become nicked or scratched by road debris and/or mechanical damage. If this occurs, continue to follow the normal washing and cleaning instructions provided above. The surface of an Alcoa Dura-Bright® wheel is designed to limit cracking and peeling if nicked or scratched while in service.

5. Even as durable as Dura-Bright® wheels are, the mounting area can become scratched, marred or discolored when mounted against another wheel, hub or drum. The use of a wheel mounting surface guard, such as Alcoa DiscMates™, is highly recommended. The use of the Alcoa Hub Cover System on Alcoa Dura-Bright® wheels will also assist in limiting such damage and help maintain the appearance of your Alcoa Dura-Bright® wheels.

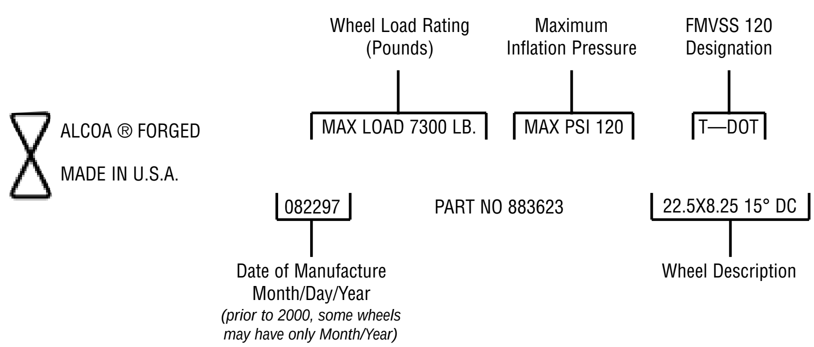
Identification

5-9

Alcoa wheel identification

Since 1977, all Alcoa aluminum disc wheels have been identified with a stamp that shows the wheel load rating, maximum inflation pressure, date of manufacture, part number, wheel description and DOT marking designation.

Prior to June 1996, all Alcoa heavy duty truck wheels had the Alcoa identification symbol on the outside of the disc neat the hand hole in line with the valve location. This marking was phased out on heavy duty truck wheels manufactured after June 1996.



All Dura-Bright® surface treated wheels are designated by the letters "DB" following the part number such as 883620DB.

Note: Dura-Bright® wheels produced after November 2002 have Alcoa wheel part numbers ending with “DB” (earlier wheels have part numbers ending in a 4 or 7) with bead seat diameters measured in 0.5-inch increments. Not all Alcoa wheels are available with the Dura-Bright® surface treatment.

6 Flat Base Wheel for Tube-type Tires

Tube-type wheel part interchangeability

WARNING

WARNING Mismatched rim/wheel components can lead to explosive separation of wheel components.

Explosive separation of wheel parts can cause serious injury or death.

See chart below for matching components.

6-1

Multipiece Rim Matching Chart

The following is the Alcoa Aluminum Wheel interchangeability information from the OSHA Multipiece Rim Matching Chart. For a complete matching chart, write to: **U.S. Department of Labor, Occupational Health and Safety Administration, Publications Department, Room N4101, Washington, DC 20210**

Read across the chart to find interchangeable components for specific size and type of Alcoa wheel. The information which is found in the shaded areas of the OSHA Multipiece Rim Matching Chart is represented in the table below.

RIM SIZE	RIM BASE IDENTIFICATION STAMPING	2 PIECE ASSEMBLIES	3 PIECE ASSEMBLIES	
		SIDE RING IDENTIFICATION STAMPING	LOCK RING IDENTIFICATION STAMPING	FLANGE IDENTIFICATION STAMPING
20 x 7.5	20x7.5FL; B7520FL	20x7.5FL; R20X7.5FL; R7520FL	20X7.5FL; LR20X7.5FL; LR7520FL	20X7.5-5° -FL; 20X7.5-8.05° -7.5FL; F20X7.5FL; F7520FL
	1020 20-7.5; T/M 20-7.5 8-A3-190	1020 RC20-7.5; T/M 20-7.5 8-A3-190	NONE	NONE
	1120 10-7.5; D-13520 20-7.5; A-AA2951 20-7.5; K-H 20X7.5	1120 RC 20-7.5; D 20-7.5 D 13520SR; F20-7.5 A-AA2951-1	NONE	NONE
	20X7.5-5°; 20X7.50-5°; F20750B (2)	NONE	20X7.0-7.5-8.0-5°	20X7.5-5° -FL; 20X7.5-8.05° -7.5FL; F7520FL
	20X7.5LA; 20X7.5MS; B7520LA	R20X7.5LA; 20X7.5MS; R7520LA	NONE	NONE
	20X7.5LB; 20X7.5DT-LB (3); B7520LB; G20750B (2)	R20X7.5-8.0-9.0LB-LW; 20X7.5-8.0DT-LB-LW (3); R8020LW	NONE	NONE
	20X7.5LW; 20X7.50LW; B7520LW; G20750B (2)	20X7.5-8.0-9.0LW; 20X7.5-8.0-DT-LB-LW (3); R8020LW	NONE	NONE
	20X7.5M	R20X7.5-8.0-9.0LB-LW; 20X7.5-8.0DT-LB-LW (3); R8020LW	LR20X7.5-8.5-10.0M; LR20M	F20X7.5-8.5M; F7520M
	20X7.5DA5°	20X7.5DA5°; 20X7.5FLN; 20X7.5N5°	NONE	NONE
	20X7.5FLN	20X7.5FLN; 20X7.5DA5°; 20X7.5N5°	NONE	NONE
	20X7.5N5°	20X7.5N5°; 20X7.5FLN; 20X7.5DA5°	NONE	NONE
	B7520KB	R8020KW	NONE	NONE
	B7520KW	R8020KW	NONE	NONE
	B7520KWX	R8020KW	NONE	NONE
	BW-5 20X7.5	BW-5 20X7.5	BW-5 20X7.5-8.0V-8.5V	B-5° 20X7.5
20 x 8.0	20X8.0-5°; 20X8.00-5°; F20800B (2)	NONE	20X7.0-7.5-8.0-5.0°	20X8.0-5°; 20X7.5-8.05° -7.5FL
	20X8.0LW; 20X8.00LW; B8020LW; G20800B (2)	R20X7.5-8.0-9.0LB-LW; 20X7.5-8.0DT-LB-LW (3); R8020LW	LR20X7.5-8.5-10.0M; LR20M	F20X7.5-8.5M; F7520M
	B8020KW	R7520K	NONE	NONE
	BW-5 20X8.0	NONE	BW-5 20X7.5-8.0V-8.5V	BW-5 20X8.0V-8.5V
22 x 7.5	1022 22-7.5; T/M 22-7.5 8-A3-191	1022 RC22-75; T/M 22-7.5 8-A3-191	NONE	NONE
	1122 22-7.5; D-13522 22-7.5; A-AA2952 22-7.5	1122 RC22-7.5; D 22-7.5 D 13522-SR; F 22-7.5 A-AA2952-1	NONE	NONE
	22X7.5-5°; 22X7.50-5°; F22750B (2)	NONE	22X7.0-7.5-8.0-5°	22X7.5-5° -FL; 22X7.5-8.05° -7.5FL; F7522FL
	22X7.5FL; B7522FL	22X7.5FL; R22X7.5FL; R7522FL	22X7.5FL; LR22X7.5FL; LR7522FL	22X7.5-5° -FL; 22X7.5-8.05° -FL; F22X7.5FL; F7522FL
	22X7.5LB; 22X7.5DT-LB (3); B7522LB; G22750B (2)	R22X7.5-8.0-9.0LB-LW, 22X7.5-8.0DT-LB-LW (3); R8022LW	NONE	NONE
	22X7.5LW; 22X7.50LW; B7522LW; G22750B (2)	R22X7.5-8.0-9.0LB-LW, 22X7.5-8.0DT-LB-LW (3); R8022LW	NONE	NONE
	22X7.5M	R22X7.5-8.0LB-LW; R8022LW	LR22M; LR22X7.5-8.5-10.0M	F7522M
	22X7.5DA5°	22X7.5DA5°; 22X7.5FLN; 22X7.5N5°	NONE	NONE
	22X7.5FLN	22X7.5FLN; 22X7.5DA5°; 22X7.5N5°	NONE	NONE
	22X7.5N5°	22X7.5N5°; 22X7.5FLN; 22X7.5DA5°	NONE	NONE
	B7522KB	R8022KW	NONE	NONE
	B7522KW	R8022KW	NONE	NONE
	B7522KWX	R8022KW	NONE	NONE
	BW-5 22X7.5	BW-5 22X7.5	BW-5 22X7.5-8.0V-8.5V	B-5° 22X7.5
22 x 8.0	22X8.0-5°; 22X8.00-5°; F22800B (2)	NONE	22X7.0-7.5-8.0-5°	22X8.0-5°
	22X8.0LW; 22X8.00LW; B8022LW; G22800B (2)	R22X7.5-8.0-9.0-LB-LW; 22X7.5-8.0DT-LB-LW (3); R8022LW	LR22M	F7522M
	B8022KW	R7522KW	NONE	NONE
	BW-5 22X8.0	NONE	BW-5 22X7.5-8.0V-8.5V	BW-5 22X8.0V-8.5V

Part numbers listed by Alcoa are followed by one of the characters X-T-N-B, or current Alcoa part numbers (i.e., 371010) end in 0-1-2 or 3, indicating a finish condition which does not affect the interchangeability of parts as shown on the chart.

Mounting recommendations for tubed tires

6-2

1. Inspect the wheel for damage. Do not use a bent, cracked, damaged or severely corroded wheel. (See Section 2, page 5).

2. Inspect ring(s) for corrosion, bending or other damage and discard if any is apparent.

3. Thoroughly clean the wheel and rings. Clean the wheel face with a mild detergent. Clean the tire bead seat areas and gutter flange with a wire brush.

4. Do not gouge or nick the wheel. Place wheels on a wooden floor or rubber mat. Always use a rubber, leather-faced or plastic mallet.

5. Inspect and clean the tire, tube, and flap before mounting — replace if damaged, badly worn or defective.

6. Insert lubricated tube and flap in tire.

7. Lubricate the tire beads and rim, then mount tire, tube and flap assembly onto rim. Do not use any lubricant which contains water or a solvent which can injure rubber.

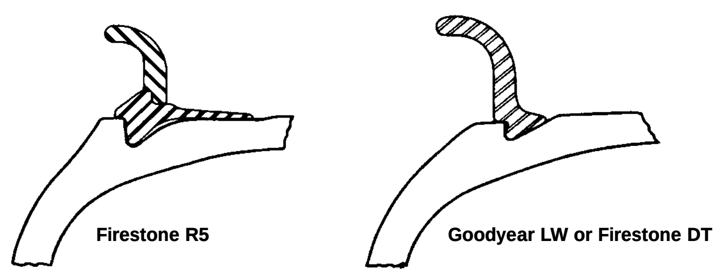
8. Select the proper rim components and assemble to rim (see 6-3, page 41). Discard bent, damaged or corroded side and lock rings. Do not use any side or lock ring which is not clearly identifiable.

WARNING

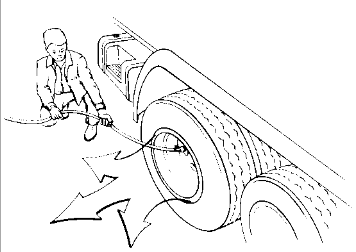
WARNING Use of a Firestone 5° side and lock ring assembly with a wheel machined for Firestone DT or Goodyear LW split side ring and vice versa can lead to explosive separation of wheel and tire.

An explosive separation of miss-matched wheel components can lead to injury or death.

Alcoa Aluminum Disc Wheels are available to accept (1) Firestone 5° side and lock rings or (2) Goodyear LW and Firestone DT split side rings. Select the proper side and lock rings by referring to the Multipiece Rim/Wheel Matching Chart on page of this manual.



Always use the proper side and lock ring assembly or split side rings required for each particular wheel.



9. Do not overinflate. Use the tire manufacturer's recommended pressure, but under no circumstances exceed cold tire pressures listed in **Section 1 Specifications** of this manual (see page 2).

10. When inflating a tire in an inflation cage or while mounted on a vehicle, always use a clip-on air chuck and a remote valve with pressure gauge. During inflation or handling an inflated wheel and tire assembly, stay out of the path of potential exploding parts or air blasts.

6

Mounting of tubed tires

6-3

When mounting Alcoa flat base wheels for tube-type tires you must use the proper side ring or side and lock ring required for each wheel. The table below lists the Alcoa tube-type wheels currently in production and the proper side ring or side and lock ring identification recommended for each wheel. See the Multipiece Rim Matching Chart on page 39 for information on older wheels with part numbers not shown here.

Alcoa Flat Base Wheels for Tube-type Tires That Use Goodyear LW or Firestone DT Split Side Rings Only (2 Piece Assemblies)		
Wheel Size	Alcoa Part Number Identification Stamping	Side Ring Identification Stamping
22x8.00 LW	481010	R8022LW recommended or: R22X7.5-8.0-9.0LB-LW 22X7.5-8.0DT-LB-LW (3)
22x7.50 LW	471010	R8022LW recommended or: R22X7.5-8.0-9.0LB-LW 22X7.5-8.0DT-LB-LW (3)
Current Alcoa part numbers (i.e., 481010) end in 0-1-2 or 3, indicating a finish condition which does not affect the compatibility of parts as shown in the table.		

Lubricate tube, flap and wheel. Insert tube and flap into tire. Place them on the wheel so that the valve is aligned with the valve slot.

Place side ring on wheel and tire and stand on the ring to position it below the lock ring groove. If a split side ring is required, start the leading edge and walk the side ring onto the wheel

If the wheel requires a lock ring, start the leading edge of the lock ring being sure that it is seating in the machined groove. Then walk the lock ring onto the wheel, as illustrated

Seat the second end of the split side ring or lock ring with a rubber, plastic or leather-facet mallet as shown. Check carefully to see that the split side ring or side ring and lock ring assembly is in the proper position. If not, completely remove the components and start over.

Inflate to 10 psi. Check to see that all components are properly in place. If not, deflate the tire by removing the valve core and reposition components properly. Place in a safety cage or other suitable restraining device (refer to OSHA rule 1910.177, paragraph B, see Section 7, page 44). Use clip-on chuck and stand behind barrier during inflation. Do not lean on cage. Inflate to recommended pressure. Deflate completely to avoid localized over-stretching of the tube. Reinflate to the tire manufacturer's recommended pressure.

Demounting recommendations for tubed tires

6-4

WARNING

WARNING An inflated tire contains air under pressure which can be a dangerous explosive force.

Explosive separation of a tire and wheel can cause serious injury or death.

Follow proper service procedures to avoid injury or death.

WARNING An aluminum wheel can be structurally weakened by uncontrolled excessive heat.

Tire/wheel assemblies using wheels that have been exposed to excessive heat may experience a sudden and unpredictable tire/wheel separation causing serious injury or death.

Immediately and permanently remove any wheel from service that has been subjected to uncontrolled excessive heat (such as a tire fire, wheel bearing failure or braking system drag/seize) or a high pressure tire/wheel separation.

1. Before removing wheel from vehicle, remove the valve core from the valve stem to ensure complete deflation of tire.

2. Do not gouge or nick the wheel. Place aluminum wheels on a clean wooden floor or rubber mat.

3. Always use a rubber, leather-faced or plastic mallet.

4. Keep tire tools smooth. Use them with care. Rim gouges or nicks near the fixed flange can cause cracks.

5. Remove steel side rings carefully. If bead is well-loosened, rings can be removed without gouging the wheel.

6. Discard bent, damaged or corroded side and lock rings. Using bent, damaged or corroded rings can shorten service life of wheel and introduce the danger of an explosive separation.

Demounting of tubed tires

6-5

NOTICE: Tire must be completely deflated and valve core removed before demounting.

If manually breaking the tire beads from the wheel, it is important to use the proper tools. Tire tools may be inserted next to the tire side wall and the side ring or locking ring. Tools must be smooth and used with care if gouging the rim is to be avoided. A stop, welded to the tool, is recommended.

Once the tool is inserted, pry down and out as illustrated. Leaving one tool in position, work the other around the tire until the bead is completely free.

Insert the tapered end of the tire tool into the notch on the locking ring. Pry up carefully to avoid bending the ring and gouging the wheel.

Using the same procedures as outlined in Step 1, loosen the bead on the opposite side of the wheel. Do not drive tools into rim area. Lift wheel from tire.

6

7 OSHA Regulations

OSHA Regulations

7-1

Sec. 1910.177 Servicing multi-piece and single piece rim wheels.

(a) Scope

(1) This section applies to the servicing of multi-piece and single piece rim wheels used on large vehicles such as trucks, tractors, trailers, buses and off-road machines. It does not apply to the servicing of rim wheels used on automobiles, or on pickup trucks and vans utilizing automobile tires or truck tires designated ``LT''.

(2) This section does not apply to employers and places of employment regulated under the Construction Safety Standards, 29 CFR part 1926; the Agriculture Standards, 29 CFR part 1928; the Shipyard Standards, 29 CFR part 1915; or the Longshoring Standards, 29 CFR part 1918.

(3) All provisions of this section apply to the servicing of both single piece rim wheels and multi-piece rim wheels unless designated otherwise.

(b) Definitions

Barrier means a fence, wall or other structure or object placed between a single piece rim wheel and an employee during tire inflation, to contain the rim wheel components in the event of the sudden release of the contained air of the single piece rim wheel.

Charts means the U.S. Department of Labor, Occupational Safety and Health Administration publications entitled ``Demounting and Mounting Procedures for Truck/Bus Tires'' and ``Multi-piece Rim Matching Chart,'' the National Highway Traffic Safety Administration (NHTSA) publications entitled ``Demounting and Mounting Procedures Truck/Bus Tires'' and ``Multi-piece Rim Matching Chart,'' or any other poster which contains at least the same instructions, safety precautions and other information contained in the charts that is applicable to the types of wheels being serviced.

Installing a rim wheel means the transfer and attachment of an assembled rim wheel onto a vehicle axle hub. Removing means the opposite of installing.

Mounting a tire means the assembly or putting together of the wheel and tire components to form a rim wheel, including inflation. **Demounting means the opposite of mounting.**

Multi-piece rim wheel means the assemblage of a multi-piece wheel with the tire tube and other components.

Multi-piece wheel means a vehicle wheel consisting of two or more parts, one of which is a side or locking ring designed to hold the tire on the wheel by interlocking components when the tire is inflated.

Restraining device means an apparatus such as a cage, rack, assemblage of bars and other components that will constrain all rim wheel components during an explosive separation of a multi-piece rim wheel, or during the sudden release of the contained air of a single piece rim wheel.

Rim manual means a publication containing instructions from the manufacturer or other qualified organization for correct mounting, demounting, maintenance, and safety precautions peculiar to the type of wheel being serviced.

Rim wheel means an assemblage of tire, tube and liner (where appropriate), and wheel components.

Service or servicing means the mounting and demounting of rim wheels, and related activities such as inflating, deflating, installing, removing, and handling.

Service area means that part of an employer's premises used for the servicing of rim wheels, or any other place where an employee services rim wheels.

Single piece rim wheel means the assemblage of single piece rim wheel with the tire and other components.

Single piece wheel means a vehicle wheel consisting of one part, designed to hold the tire on the wheel when the tire is inflated.

Trajectory means any potential path or route that a rim wheel component may travel during an explosive separation, or the sudden release of the pressurized air, or an area at which an airblast from a single piece rim wheel may be released. The trajectory may deviate from paths which are perpendicular to the assembled position of the rim wheel at the time of separation or explosion. (See appendix A for examples of trajectories.)

Wheel means that portion of a rim wheel which provides the method of attachment of the assembly to the axle of a vehicle and also provides the means to contain the inflated portion of the assembly (i.e., the tire and/or tube).

(c) Employee Training

(1) The employer shall provide a program to train all employees who service rim wheels in the hazards involved in servicing those rim wheels and the safety procedures to be followed.

- (i) The employer shall assure that no employee services any rim wheel unless the employee has been trained and instructed in correct procedures of servicing the type of wheel being serviced, and in the safe operating procedures described in paragraphs (f) and (g) of this section.
- (ii) Information to be used in the training program shall include, at a minimum, the applicable data contained in the charts (rim manuals) and the contents of this standard.
- (iii) Where an employer knows or has reason to believe that any of his employees is unable to read and understand the charts or rim manual, the employer shall assure that the employee is instructed concerning the contents of the charts and rim manual in a manner which the employee is able to understand.

(2) The employer shall assure that each employee demonstrates and maintains the ability to service rim wheels safely, including performance of the following tasks:

- (i) Demounting of tires (including deflation);
- (ii) Inspection and identification of the rim wheel components;
- (iii) Mounting of tires (including inflation with a restraining device or other safeguard required by this section);
- (iv) Use of the restraining device or barrier, and other equipment required by this section;
- (v) Handling of rim wheels;
- (vi) Inflation of the tire when a single piece rim wheel is mounted on a vehicle;
- (vii) An understanding of the necessity of standing outside the trajectory both during inflation of the tire and during inspection of the rim wheel following inflation; and
- (viii) Installation and removal of rim wheels.

(3) The employer shall evaluate each employee's ability to perform these tasks and to service rim wheels safely, and shall provide additional training as necessary to assure that each employee maintains his or her proficiency.

(d) Tire servicing equipment.

(1) The employer shall furnish a restraining device for inflating tires on multi-piece wheels.

(2) The employer shall provide a restraining device or barrier for inflating tires on single piece wheels unless the rim wheel will be bolted onto a vehicle during inflation.

(3) Restraining devices and barriers shall comply with the following requirements:

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(i) Each restraining device or barrier shall have the capacity to withstand the maximum force that would be transferred to it during a rim wheel separation occurring at 150 percent of the maximum tire specification pressure for the type of rim wheel being serviced.

(ii) Restraining devices and barriers shall be capable of preventing the rim wheel components from being thrown outside or beyond the device or barrier for any rim wheel positioned within or behind the device;

(iii) Restraining devices and barriers shall be visually inspected prior to each day's use and after any separation of the rim wheel components or sudden release of contained air. Any restraining device or barrier exhibiting damage such as the following defects shall be immediately removed from service:

(A) Cracks at welds;

(B) Cracked or broken components;

(C) Bent or sprung components caused by mishandling, abuse, tire explosion or rim wheel separation;

(D) Pitting of components due to corrosion; or

(E) Other structural damage which would decrease its effectiveness.

(iv) Restraining devices or barriers removed from service shall not be returned to service until they are repaired and reinspected. Restraining devices or barriers requiring structural repair such as component replacement or rewelding shall not be returned to service until they are certified by either the manufacturer or a Registered Professional Engineer as meeting the strength requirements of paragraph (d)(3)(i) of this section.

(4) The employer shall furnish and assure that an air line assembly consisting of the following components be used for inflating tires:

(i) A clip-on chuck;

(ii) An in-line valve with a pressure gauge or a presettable regulator; and

(iii) A sufficient length of hose between the clip-on chuck and the in-line valve (if one is used) to allow the employee to stand outside the trajectory.

(5) Current charts or rim manuals containing instructions for the type of wheels being serviced shall be available in the service area.

(6) The employer shall furnish and assure that only tools recommended in the rim manual for the type of wheel being serviced are used to service rim wheels.

(e) Wheel component acceptability.

(1) Multi-piece wheel components shall not be interchanged except as provided in the charts or in the applicable rim manual.

(2) Multi-piece wheel components and single piece wheels shall be inspected prior to assembly. Any wheel or wheel component which is bent out of shape, pitted from corrosion, broken, or cracked shall not be used and shall be marked or tagged unserviceable and removed from the service area. Damaged or leaky valves shall be replaced.

(3) Rim flanges, rim gutters, rings, bead seating surfaces and the bead areas of tires shall be free of any dirt, surface rust, scale or loose or flaked rubber build-up prior to mounting and inflation.

(4) The size (bead diameter and tire/wheel widths) and type of both the tire and the wheel shall be checked for compatibility prior to assembly of the rim wheel.

(f) Safe operating procedure - multi-piece rim wheels.

The employer shall establish a safe operating procedure for servicing multi-piece rim wheels and shall assure that employees are instructed in and follow that procedure. The procedure shall include at least the following elements:

(1) Tires shall be completely deflated before demounting by removal of the valve core.

(2) Tires shall be completely deflated by removing the valve core before a rim wheel is removed from the axle in either of the following situations:

(i) When the tire has been driven underinflated at 80% or less of its recommended pressure, or

(ii) When there is obvious or suspected damage to the tire or wheel components.

(3) Rubber lubricant shall be applied to bead and rim mating surfaces during assembly of the wheel and inflation of the tire, unless the tire or wheel manufacturer recommends against it.

(4) If a tire on a vehicle is underinflated but has more than 80% of the recommended pressure, the tire may be inflated while the rim wheel is on the vehicle provided remote control inflation equipment is used, and no employees remain in the trajectory during inflation.

(5) Tires shall be inflated outside a restraining device only to a pressure sufficient to force the tire bead onto the rim ledge and create an airtight seal with the tire and bead.

(6) Whenever a rim wheel is in a restraining device the employee shall not rest or lean any part of his body or equipment on or against the restraining device.

(7) After tire inflation, the tire and wheel components shall be inspected while still within the restraining device to make sure that they are properly seated and locked. If further adjustment to the tire or wheel components is necessary, the tire shall be deflated by removal of the valve core before the adjustment is made.

(8) No attempt shall be made to correct the seating of side and lock rings by hammering, striking or forcing the components while the tire is pressurized.

(9) Cracked, broken, bent or otherwise damaged rim components shall not be reworked, welded, brazed, or otherwise heated.

(10) Whenever multi-piece rim wheels are being handled, employees shall stay out of the trajectory unless the employer can demonstrate that performance of the servicing makes the employee's presence in the trajectory necessary.

(11) No heat shall be applied to a multi-piece wheel or wheel component.

(f) Safe operating procedure - single piece rim wheels.

The employer shall establish a safe operating procedure for servicing single piece rim wheels and shall assure that employees are instructed in and follow that procedure. The procedure shall include at least the following elements:

(1) Tires shall be completely deflated by removal of the valve core before demounting.

(2) Mounting and demounting of the tire shall be done only from the narrow ledge side of the wheel. Care shall be taken to avoid damaging the tire beads while mounting tires on wheels. Tires shall be mounted only on compatible wheels of matching bead diameter and width.

(3) Nonflammable rubber lubricant shall be applied to bead and wheel mating surfaces before assembly of the rim wheel, unless the tire or wheel manufacturer recommends against the use of any rubber lubricant.

(4) If a tire changing machine is used, the tire shall be inflated only to the minimum pressure necessary to force the tire bead onto the rim ledge while on the tire changing machine.

(5) If a bead expander is used, it shall be removed before the valve core is installed and as soon as the rim wheel becomes airtight (the tire bead slips onto the bead seat).

(6) Tires may be inflated only when contained within a restraining device, positioned behind a barrier or bolted on the vehicle with the lug nuts fully tightened.

(7) Tires shall not be inflated when any flat, solid surface is in the trajectory and within one foot of the sidewall.

(8) Employees shall stay out of the trajectory when inflating a tire.

(9) Tires shall not be inflated to more than the inflation pressure stamped in the sidewall unless a higher pressure is recommended by the manufacturer.

(10) Tires shall not be inflated above the maximum pressure recommended by the manufacturer to seat the tire bead firmly against the rim flange.

(11) No heat shall be applied to a single piece wheel.

(12) Cracked, broken, bent, or otherwise damaged wheels shall not be reworked, welded, brazed, or otherwise heated.

[GRAPHIC] [TIFF OMITTED] TC27OC91.036

Appendix B - Ordering Information for NHTSA Charts

OSHA has printed two charts entitled ``Demounting and Mounting Procedures for Truck/Bus Tires'' and ``Multi-piece Rim Matching Chart,'' as part of a continuing campaign to reduce accidents among employees who service large vehicle rim wheels.

Reprints of the charts are available through the Occupational Safety and Health Administration (OSHA) Area and Regional Offices. The address and telephone number of the nearest OSHA office can be obtained by looking in the local telephone directory under U.S. Government, U.S. Department of Labor, Occupational Safety and Health Administration.

Single copies are available without charge.

Individuals, establishments and other organizations desiring single or multiple copies of these charts may order them from the OSHA Publications Office, U.S. Department of Labor, Room N-3101, Washington, DC 20210, Telephone (202) 219-4667.

[49 FR 4350, Feb. 3, 1984, as amended at 52 FR 36026, Sept. 25, 1987; 53 FR 34737, Sept. 8, 1988; 61 FR 9239, Mar. 7, 1996]

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8 Glossary of Common Terms

Glossary of Common Terms

8-1

1/2 DUAL SPACING - One half the distance between the two center lines of dualed wheels. The dimension is the same as the OUTSET dimension.

2-PIECE FLANGE NUT - A two-piece washer and nut combination used to secure hub piloted wheels.

AIR CHAMBER - The space enclosed by a tire and wheel rim or inner tube.

BEAD SEAT - The area along the outer edges of the rim where the mounted tire and rim are in contact.

BOLT CIRCLE - The circle defined by the centers of the bolt holes (stud holes) of a wheel, dimensions stated in diameter inches or millimeters.

BOLT HOLE - Hole found in the disc of the wheel through which the bolt (stud) passes.

BORE - See "HUB BORE."

CENTER BORE - See "HUB BORE."

CONE LOCK CAP NUT - See "2-PIECE FLANGE NUT."

DC - Abbreviation for drop center.

DISC AREA - The vertical wheel face which supports the rim.

DISC WHEEL - A one-piece (forged) or two-piece (welded) assembly of a disc and a rim.

DROP CENTER - The well or center portion of the wheel rim.

FLAT BASE WHEEL - A multi-piece wheel with a removable side ring.

FOOT-POUNDS - The measure of the amount of torque applied to a cap nut or other part. May be measured with a torque wrench.

GUTTER FLANGE - A groove which supports the removable portion of a multi-piece wheel.

HUB BORE - The center hole of a disc wheel, dimensions stated in diameter inches or millimeters.

HUB PILOTED MOUNTING - A wheel mounting system which uses the hub to center the wheel and two-piece flange nuts to secure it.

in. - Abbreviation for inches.

INNER CAP NUT - Cap nut used to mount the inner wheel in a dualed stud located wheel system.

INSET - The distance from the wheel mounting surface to the rim centerline when the centerline is placed inboard of the mounting surface.

kg - Abbreviation for kilogram (weight measurement), equal to 1000 grams.

kPa - Abbreviation for kilo Pascals (pressure measurement).

Glossary of Common Terms (continued)

LOCK RING - The third piece of a three rim assembly which positions and supports the side ring to the rim base.

MAXIMUM INFLATION - The highest amount of air pressure allowed, measured at normal ambient temperatures.

mm - Abbreviation for millimeters.

MULTI-PIECE WHEEL - A wheel assembly in which the rim portion of the wheel consists of two or more separate parts.

OFFSET - See "OUTSET."

OPEN SIDE - The side of the wheel opposite the disc face.

OSHA - Abbreviation for the U.S. Department of Labor, Occupational Health and Safety Administration.

OUTER CAP NUT - A cap nut used to secure the outer stud located wheel in a dualed wheel pair and thread onto the inner cap nut.

OUTSET - The distance from the mounting surface of the wheel to the rim centerline when the rim centerline is mounted outboard of the hub face. This dimension is the same as the 1/2 DUAL SPACING dimension.

PILOT PAD - The raised surfaces on a hub used to center a hub piloted wheel.

PSI - Abbreviation for pounds per square inch.

REVERSIBLE - Term applied to a disc wheel which can be reversed on the hub without changing the position of the tire centerline.

RIM CENTERLINE - A line to the radial axis of the wheel running through the mid point between the rim flanges.

RIM FLANGE - That portion of the rim which extends above the rim surface which retains the tire bead.

RIM - That portion of the wheel which supports the tire.

SIDE RING - A removable piece of a multi-piece wheel assembly which provides lateral support for one tire bead.

SINGLE CAP NUT - A cap nut used to secure single wheels or outer dual wheels.

STUD - A threaded bolt extending from the hub surface to which the wheels are secured by the cap nuts.

STUD LOCATED, BALL SEAT MOUNTING - A wheel mounting system which uses the studs and spherical ball seat cap nuts to center and secure the wheel.

TIRE BEAD - That surface of the tire which contacts the angled surface of the wheel rim.

TORQUE - The amount of force used to tighten cap nuts. Usually stated in foot-pounds or kilograms and measured with a torque wrench.

WHEEL MOUNTING FACE - That portion of the wheel face which contacts the hub or brake drum.

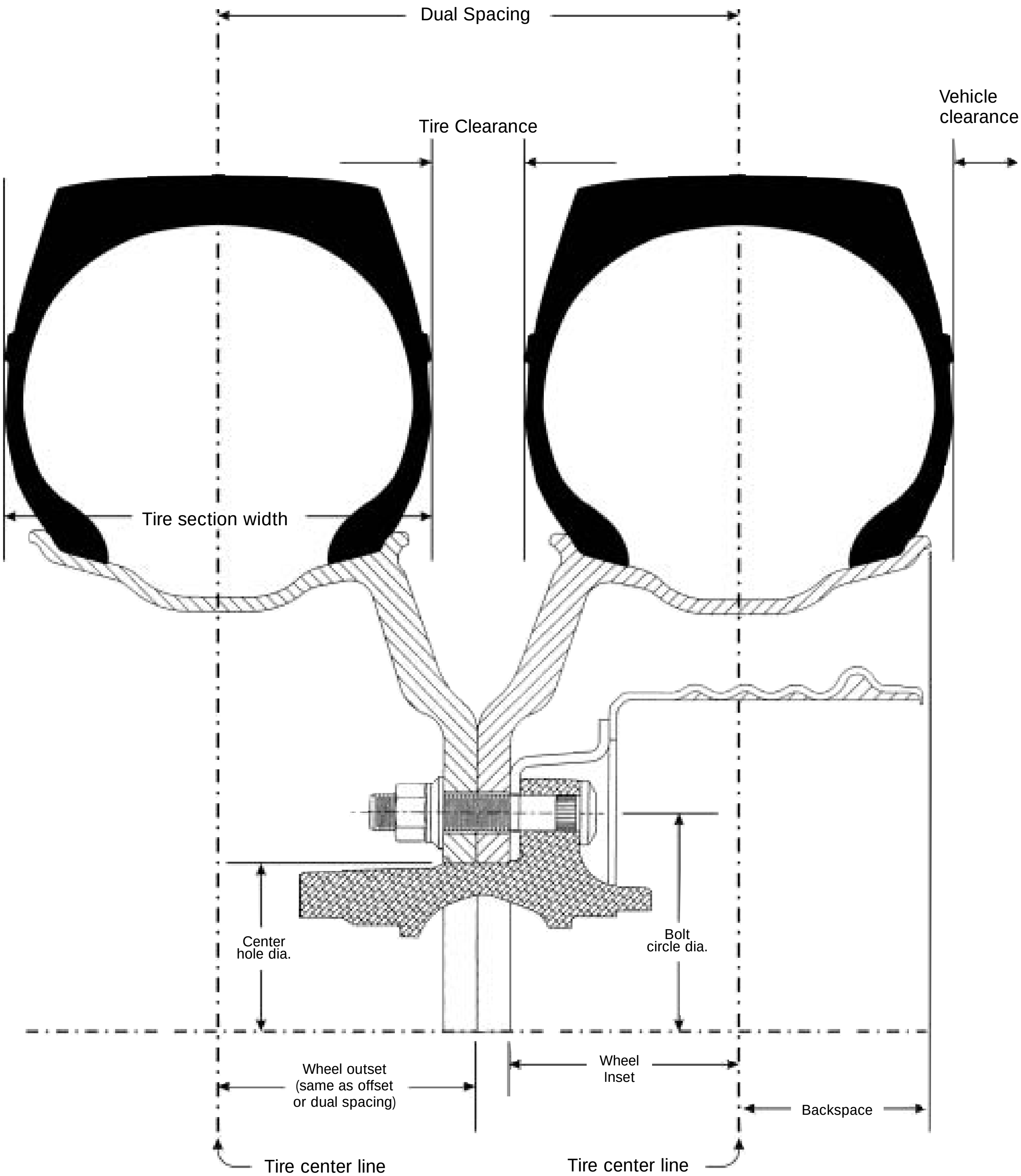
wt. - Abbreviation for weight.

Wheel measurement

8-2

How to measure minimum dual spacing

Minimum dual spacing measurement is determined by the tire manufacturer and may be obtained from the tire manufacturer's handbook. To determine if the Alcoa aluminum dual wheel assembly has adequate minimum dual spacing for the selected tires, double the wheel outset measurement of the Alcoa wheel used. If the doubled outset measurement is equal to or greater than the tire manufacturer's recommendation, there will be sufficient minimum dual spacing. Wheel inset and outset is given for each Alcoa wheel on pages 2 and 3. Both inset and outset wheels are measured from the mounting surface of the wheel to the center line of the rim. Maintaining proper tire inflation and load ratings are essential to maintaining proper minimum dual spacing.



8

9 Conversion Tables

Inch Fraction, Decimal and Millimeter Equivalents Chart (Up to 1 inch)

9-1

Inches	Decimals	Millimeters
1/64	0.0156	0.3969
1/32	0.0313	0.7938
3/64	0.0469	01.1906
1/16	0.0625	1.5875
5/64	0.0781	1.9844
3/32	0.0938	2.3813
7/64	0.1094	2.7781
1/8	**0.1250**	**3.1750**
9/64	0.1406	3.5719
5/32	0.1563	3.9688
11/64	0.1719	4.3656
3/16	0.1875	4.7625
13/64	0.2031	5.1594
7/32	0.2188	5.5563
15/64	0.2344	5.9531
1/4	**0.2500**	**6.3500**
17/64	0.2656	6.7469
9/32	0.2813	7.1438
19/64	0.2969	7.5406
5/16	0.3125	7.9375
21/64	0.3281	8.3344
11/32	0.3438	8.7313
23/64	0.3594	9.1281
3/8	**0.3750**	**9.5250**
25/64	0.3906	9.9219
13/32	0.4063	10.3188
27/64	0.4219	10.7156
7/16	0.4375	11.1125
29/64	0.4531	11.5094
15/32	0.4688	11.9063
31/64	0.4844	12.3031
1/2	**0.5000**	**12.7000**

Inches	Decimals	Millimeters
33/64	0.5156	13.0969
17/32	0.5313	13.4938
35/64	0.5469	13.8906
9/16	0.5625	14.2875
37/64	0.5781	14.6844
19/32	0.5938	15.0813
39/64	0.6094	15.4781
5/8	**0.6250**	**15.8750**
41/64	0.6406	16.2719
21/32	0.6563	16.6688
43/64	0.6719	17.0656
11/16	0.6875	17.4625
45/64	0.7031	17.8594
23/32	0.7188	18.2563
47/64	0.7344	18.6531
3/4	**0.7500**	**19.0500**
49/64	0.7656	19.4469
25/32	0.7813	19.8438
51/64	0.7969	20.2406
13/16	0.8125	20.6375
53/64	0.8281	21.0344
27/32	0.8438	21.4313
55/64	0.8594	21.8281
7/8	**0.8750**	**22.2250**
57/64	0.8906	22.6219
29/32	0.9063	23.0188
59/64	0.9219	23.4156
15/16	0.9375	23.8125
61/64	0.9531	24.2094
31/32	0.9688	24.6063
63/64	0.9844	25.0031
1	**1.000**	**25.4000**

Conversion Factors

9-2

Inches to Millimeters

Inches	x	25.4	=	Millimeters

Millimeters to Inches

Millimeters	x	0.03937	=	Inches

PSI to kPa

PSI	x	6.8948	=	kPa

kPa to PSI

kPa	x	0.145	=	PSI

Pounds to Kilograms

Pounds	x	0.4536	=	kg

Kilograms to Pounds

kg	x	2.2050	=	Pounds

Foot-pounds to Kilogram Meters

Ft-lbs	x	0.13826	=	kgm

Kilogram Meters to Foot-pounds

kgm	x	7.23	=	Ft-lbs

Alcoa Wheel and Forged Products
1600 Harvard Avenue
Cleveland, Ohio 44105
(800) 242-9898

www.alcoawheels.com

Form E37-13584
Printed in USA 02/04/30M

SECTION 14: STEERING

CONTENTS

ILLUSTRATIONS

1. STEERING SYSTEM

1.1 DESCRIPTION

The steering system consists of the steering wheel and column assembly, a vane-type hydraulic pump, reservoir, filter, interconnecting system lines and hoses, integral power steering gear, linkage and steering damper (Fig. 1). The steering linkage includes the pitman arm, drag link, steering arm, tie rod arms and tie rod.

Hydraulic components are added to transmit, increase and regulate steering control forces.

These elements are:

1. Steering stabilizer (damper);
2. A vane type hydraulic pump; and
3. Hydraulic reservoir and hoses.

The steering stabilizer reduces road shocks and vibrations in the system. The steering gearbox is self powered and provides movement with power assistance to the left wheel.

Steering stability and tire wear are influenced by wheels, hubs, tires, air suspension, brakes, front suspension and front end alignment which are all covered in their respective sections in this manual.

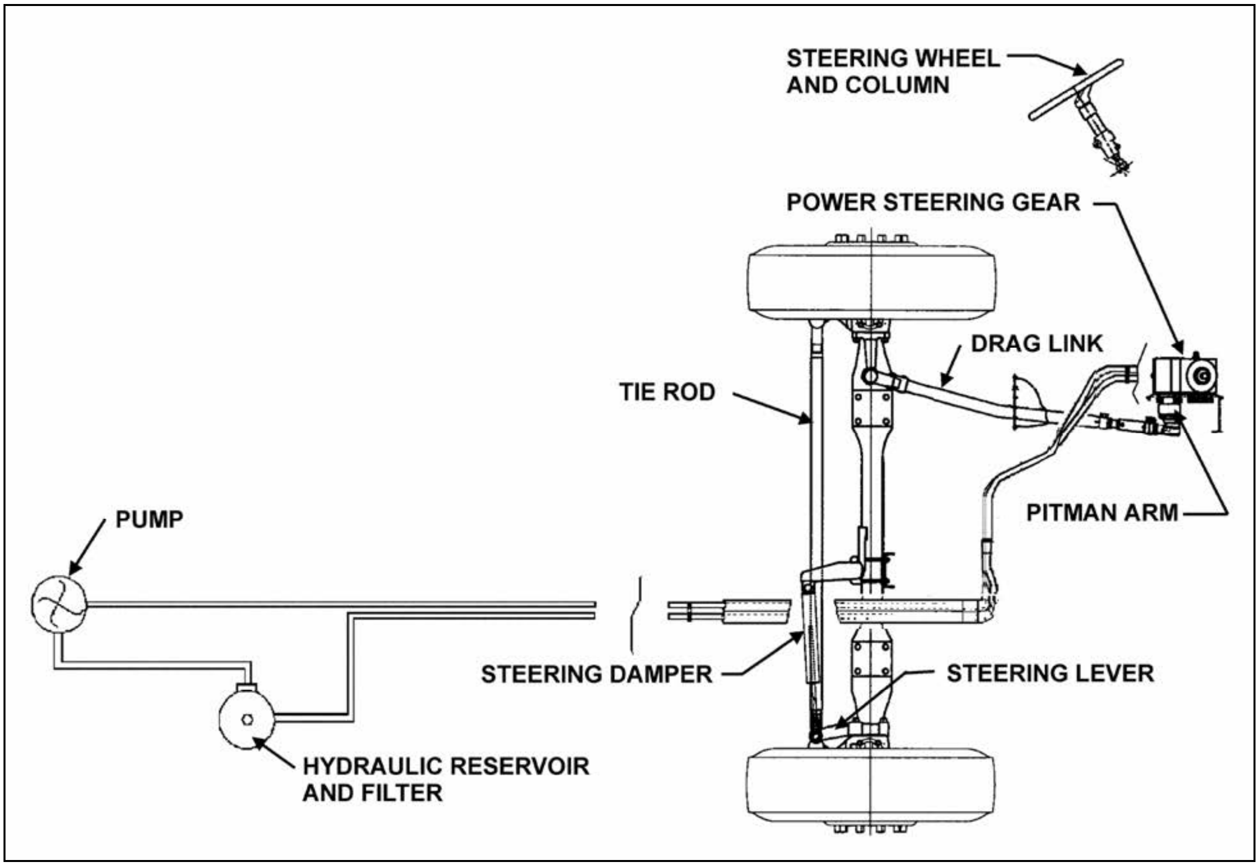


FIGURE 1: STEERING SYSTEM AXLE SETUP 14041

2. POWER STEERING GEAR

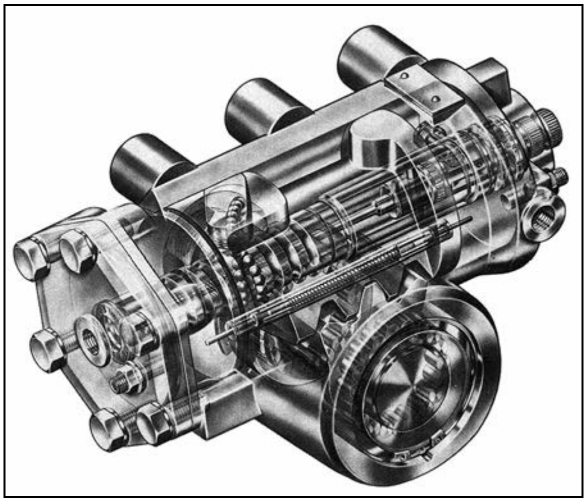


FIGURE 2: POWER STEERING GEAR 14035

2.1 DESCRIPTION

The power steering gear is located in the lower part of front service compartment (Figs. 2 & 3). The housing of the ZF-Servocom contains a control valve, working cylinder and a complete mechanical steering gear. The pressure oil for the steering is delivered by a motor-driven oil pump which is supplied with oil from an oil tank.

The housing is designed as a cylinder for the piston, which converts the rotation of the steering shaft and the worm into an axial movement and transfers this to the steering worm sector shaft. The serration of the sector shaft is straight-cut with a high surface quality in such a way that it is only possible to set a unique setting without play on installation in the straight-ahead driving area by means of the two eccentrically designed lateral housing covers.

The piston and worm are connected via a ball chain. When the worm is turned, the balls are collected by a circulating pipe at one end of the chain and fed in again at the other end, thus producing an endless ball chain.

The control valve consists of the valve slide in a needle bearing in the worm, with six control grooves on the circumference and the control sleeve on the worm, which also has six control grooves. The valve slide, designed with steering shaft connection, turns together with the worm as the steering wheel is turned.

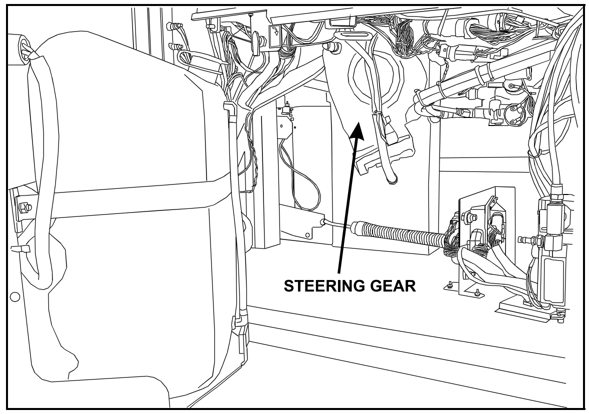


FIGURE 3: FRONT SERVICE COMPARTMENT 14039

A torsion bar, which is pinned with the valve slide and the worm, keeps the control valve in the neutral position as long as no opposing force is applied to the steering wheel. The steering housing contains a pressure relief valve, which limits the discharge pressure of the oil pump to the maximum value required. A replenishing valve can also be used, through which oil is sucked from the return if steering is not hydraulically boosted.

Compared with constant ratio, steering versions with variable ratio are more directly designed in the center area than outside the center area. The resulting smaller steering corrections benefit steering behavior in straight-ahead driving. At the same time, the indirect transmission means that there is a higher hydraulic torque available at the steering arm in parking movement. If the hydraulic assistance fails, the operating forces on the steering wheel are correspondingly lower in this area. This is achieved through a piston/steering worm sector shaft serration with differing modulus and angle of pressure.

Upon transfer of a torque from the steering shaft to the worm, or vice versa, the torsion bar is deformed in the elastic area so that there is torsion between the valve slide and the control sleeve. When the steering wheel is released, the torsion bar ensures that the valve is returned to the neutral position.

Refer to the *"ZF-SERVOCOM Repair Manual"* and "*ZF-SERVOCOM Operating, Servicing /Maintenance and Inspection Instructions"* annexed to this section for the functional aspects and maintenance procedure of the steering gear.

Note: *Also available is the ZF-Servocomtronic, which provides variable assistance in function of speed.*

2.2 POWER STEERING GEAR REMOVAL

Warning: *The steering gearbox weighs approximately 100 lbs (45 kg) dry. Exercise caution when handling.*

1. Put a container into place, then disconnect both the inlet and outlet hoses from the power steering gear. Cover fittings to prevent fluid contamination.
2. Mark both the pitman arm and sector shaft with a line, then remove pitman arm. Refer to *"11.1 Pitman Arm Removal"* procedure.
3. Mark both the steering shaft universal joint yoke and steering gear input shaft with a line, then disconnect universal joint.
4. Unscrew and remove the power steering gear.

2.3 POWER STEERING GEAR INSTALLATION

Reverse *"Power Steering Gear Removal"* procedure paying particular attention to the following:

1. Tighten fasteners as recommended under paragraph 14: *''Torque Specifications".*
2. Bleed air from the system as per step 3, next.

3. BLEEDING POWER STEERING HYDRAULIC SYSTEM

To bleed the power steering hydraulic system, refer to the *"ZF-SERVOCOM Repair Manual"* annexed to this section, under heading *"Setting And Functional Test"*.

4. HYDRAULIC PRESSURE TEST

Perform a pressure test as outlined in the *"ZF-SERVOCOM Repair Manual"* annexed to this section under heading *"Setting And Functional Test"*.

5. TROUBLESHOOTING

Perform troubleshooting of the steering gear as outlined in the *"ZF-SERVOCOM Repair Manual"*, the *"ZF-SERVOCOM Operating, Servicing /Maintenance and Inspection Instructions* and the *"TRW - Power Steering Pump Service Manual"* and the "TRW - Chart Your Way To Easy Steering" guide annexed to this section.

Note: *For vehicles equipped with ZF-SERVOCOMTRONIC unit, refer to the supplement to the repair manual ZF-SERVOCOM.*

6. POWER STEERING HYDRAULIC PUMP

6.1 DESCRIPTION

The power steering pump is a vane type, gear driven, hydraulic unit which supplies hydraulic pressure for the operation of the steering gear. The pump is mounted on the engine, on the crankshaft pulley’s R.H. side.

6.2 REMOVAL AND INSTALLATION

The pump is accessible through the engine compartment rear door.

To remove the pump, proceed as follows:

1. Put an empty container directly below pump, then disconnect both the inlet and outlet hoses from the pump. Block fitting cavities to prevent fluid contamination.
2. Remove the two (2) mounting screws, then slowly pry out the pump.
3. Remove and discard gasket.

Caution: *Inspect the drive coupling thoroughly, and replace if necessary (the drive coupling is a fiber component located between the engine and the pump).*

For pump installation, reverse the removal procedure paying particular attention to the following:

Caution: *Ensure that drive coupling is correctly positioned before reinstalling the pump.*

1. Install a new gasket (Prévost P/N 510488).

2. Bleed air from the system as per step 3, *"Bleeding Power Steering Hydraulic System"*.

6.3 MAINTENANCE

Refer to the *"ZF-SERVOCOM Repair Manual"* and the *"TRW - Power Steering Pump Service Manual"* annexed to this section.

7. STEERING WHEEL

7.1 REMOVAL

1. Set the battery master switch located in the R.H. side rear service compartment, or the engine compartment to the *"OFF"* position.

2. Using a tool, such as a small flat head screwdriver, pry off the air horn cap.

3. Loosen the small screw in center of cap and the other retaining the black wire, then disconnect the white terminal. Remove horn cap.

4. Loosen and remove the steering wheel nut.

5. Using a suitable puller, remove the steering wheel.

7.2 INSTALLATION

To install, reverse the removal procedure. Torque steering wheel nut to 35-45 Ft-lbs (47-60 Nm).

8. STEERING COLUMN

8.1 REMOVAL

To disassemble the steering column from system, refer to Figure 4. The steering column has no lubrication points. The lower steering column U-joint is easily accessible through the front service compartment. The upper steering column U-joint and the steering slip joint are accessible from the front driver's area. To access these joints, proceed as follows:

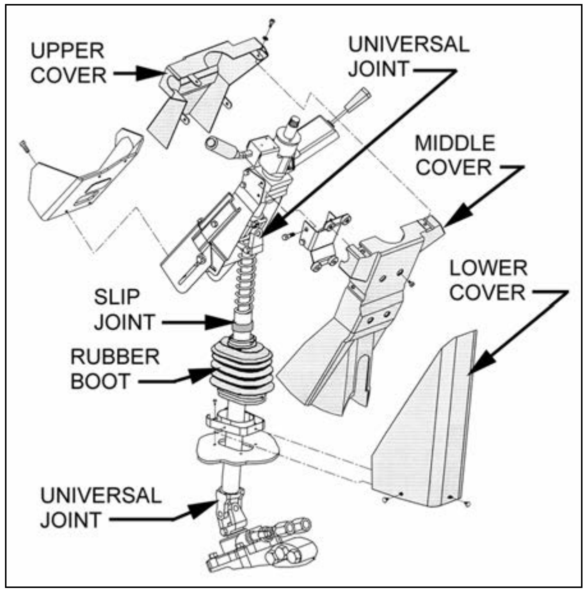


FIGURE 4: STEERING COLUMN 14040

1. From the front driver's compartment area, remove the three plastic fasteners on steering column lower cover. Remove the lower cover (Fig. 4).

2. Unscrew the four retaining screws on steering column middle cover.

3. Unscrew the four retaining screws fixing steering column upper cover to middle cover. Remove the steering column middle and upper covers.

4. Position the steering wheel in order to gain access to the joints.

9. TURNING ANGLE ADJUSTMENT

The maximum turning angle is set through two (2) steering stop screws installed on the axle center. Steering stop screws are factory adjusted to accommodate the chassis design, and therefore, do not require adjustment on new vehicles. However, these should be checked and adjusted if necessary, any time a steering system component is repaired, disassembled or adjusted. Refer to section 10 *"Front Axle"* under heading *''6.4 ''Turning Angle Adjusment".*

Caution: *To prevent the steering damper from interfering with the adjustment of turning angles, make sure its fixing bracket is at correct location on the axle (refer to* "12.2 Steering Stabilizer Cylinder (Damper)).

Hydraulic Stop

Caution: *Reduce or shut off the power steering hydraulic pressure before the boss on the axle touches the stop screw. If not, the components of the front axle will be damaged (refer to* "ZF-SERVOCOM Repair Manual" *and "ZF-SERVOCOM Operating, Servicing/Maintenance and Inspection Instructions" annexed to this section, under heading* "Setting The Steering Limiter").

Caution: *Never maintain the relief pressure for more than 5 seconds, since damage to the power steering pump may occur.*

10. STEERING LINKAGE ADJUSTMENT

The steering linkage includes the pitman arm, drag link, steering arm, tie rod arms and tie rod.

Perform lubrication according to *"DANA SPICER NDS Axles Lubrication and Maintenance"* annexed to section 10 *"Front Axle".*

Drag link ends are provided with grease fittings. Under normal conditions, these should be serviced every 6,250 miles (10 000 km). Refer to section 24 *"Lubrication".*

Steering linkage pivot points should be checked each time they are lubricated. Looseness can be visually detected while rotating the steering wheel in both directions. Replace defective parts.

Caution: *Front wheel alignment should be checked and adjusted if necessary, any time a component of the steering system is repaired, disassembled or adjusted. Refer to section 10* "Front Axle" *under heading* 6. "Front Wheel Alignment".

11. PITMAN ARM

11.1 REMOVAL

1. Remove cotter pin, nut and washers from drag link ball stud at pitman arm.
2. Disconnect drag link from pitman arm, using jaw style pullers (pressure screw type).

Warning: *Always wear approved eye protection when operating pullers.*

Caution: *Do not drive (hammer in) pitman arm on or off pitman shaft as this can damage the steering gear.*

Caution: *Heating of components to aid in disassembly is not allowed because it has a detrimental effect on axle components and steering linkages.*

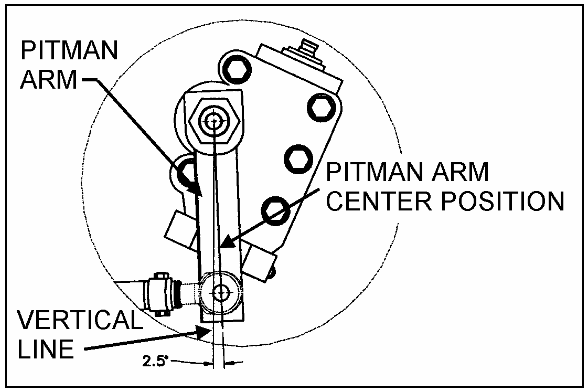


FIGURE 5: PITMAN ARM ADJUSTMENT 14037

3. Using a cold chisel, undo punch mark that locks fixing nut to the pitman arm.
4. Remove pitman arm fixing nut.
5. Check the radial position of the pitman arm in relation to the sector shaft prior to removal of pitman arm.
6. Add reference marks to the arm and shaft if necessary to ensure correct alignment at reassembly.
7. You must use a puller to remove pitman arm.

11.2 INSTALLATION

1. Position pitman arm on sector gear shaft with reference marks aligned.
2. Install fixing nut (Prévost #661050). Tighten nut to 400-450 Ft-lbs (545-610 Nm).

Note: *Use a new nut if the previously removed nut was punched.*

3. Lock nut with sector shaft using a punch mark into the groove (Refer to figure 6).

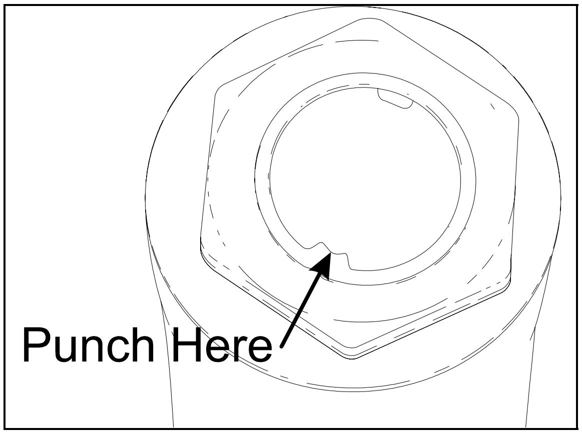


FIGURE 6: FIXING NUT PUNCH MARK 16098

4. Connect drag link to pitman arm while ensuring that rubber stabilizer is in place on the rod end. Install washers. Tighten nut to 160-215 Ft-lbs (220-290 Nm). Afterwards, install a new cotter pin.

Caution: *Input shaft marks must be aligned before adjusting pitman arm.*

11.3 ADJUSTMENT

1. Disconnect the drag link from pitman arm. Center steering wheel by dividing the total number of steering wheel turns in two. Scribe a reference mark on steering gearbox at the center previously determined.
2. Using a protractor, check the angle of the pitman arm (refer to Fig. 5 for details).
3. The pitman arm should be adjusted to an angle of 2.5º in relation with the vertical axis (towards front of vehicle). If not, unscrew and remove fixing nut. Remove the pitman arm according to the procedure outlined under previous heading *"Pitman arm removal"*. Adjust to the proper angle.
4. When adjustment is achieved, replace fixing nut and torque to 400-450 Ft-lbs (545-610 Nm).

12. MAINTENANCE

The power steering system requires little maintenance. However, the system should be kept clean to ensure maximum operating performance and troublefree service. Periodic inspections should also be made to check for leakage and all parts for damage or distortion. Insure all fasteners are tight (see *"14. Specifications"* for recommended tightening torques.

When the slightest evidence of dirt, sludge or water is discovered in the system, disconnect fluid lines at the power steering gear to drain the system. Drain and refill the system with *"Dexron-IIE or Dexron-III"* automatic transmission oil.

Air in the hydraulic system will cause spongy action and noisy operation. When a hose has been disconnected or when fluid has been lost for any reason, the system must be bled. Bleed system as outlined under heading 3*: "Bleeding Power Steering Hydraulic System".*

Warning: *Do not operate the pump without fluid in the power steering fluid reservoir.*

If the steering linkage between the steering gear and the two front wheels is not properly adjusted, or if it is bent, twisted or worn, the steering of the vehicle will be seriously impaired. Whenever a steering linkage part is repaired, replaced or adjusted, steering geometry and front wheel alignment must be checked and necessary corrections made. Refer to section 10 *"Front Axle"* under heading 6: *"Front Wheel Alignment"*.

At regular lubrication intervals, the steering linkage should be thoroughly inspected for worn or loose components.

After the vehicle has been operated continually and high mileage figures have been reached, overhaul of the various steering units will be required. General overhaul procedure normally requires removal of the entire assembly, cleaning and inspection of all parts and final assembly. Careful inspection of all parts during overhaul is very important and must not be neglected.
Lubrication fittings must all be cleaned before applying lubricant. Moreover, always be sure the equipment used in applying lubricant is clean.

Every precaution should be taken to prevent entry of dirt, grit, lint or other foreign matter into lubricant containers. Replace fittings that have become broken or damaged. Lubrication intervals, as well as the recommended lubricants for the steering components, are given in the *"Lubrication And Servicing Schedule"* in Section 24 of this manual. The intervals given in the schedule are recommended for normal service. More frequent intervals may be required under severe operating conditions.

12.1 POWER STEERING RESERVOIR AND FILTER

The power steering reservoir is located on R.H. side of engine compartment and accessible through the engine compartment doors. (Fig. 7).

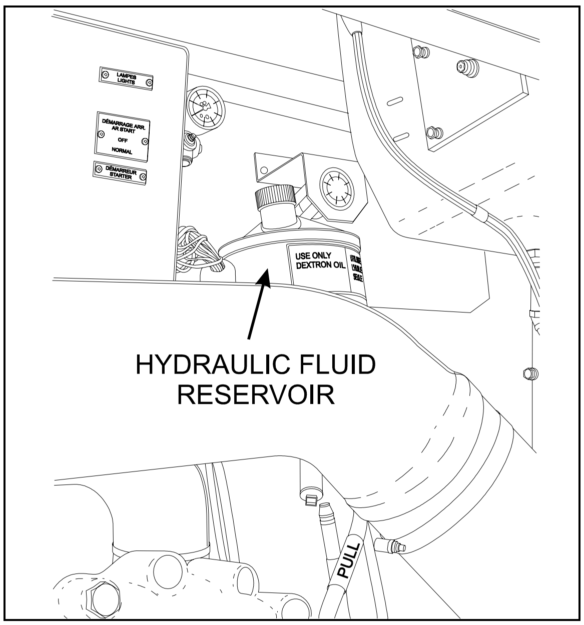


FIGURE 7: HYDRAULIC FLUID RESERVOIR LOCATION 14044

At regular intervals, fluid level should be checked in the reservoir and filter assembly. Furthermore, the oil filter cartridge element in the power steering reservoir should be replaced every 50,000 miles (80 000 km) or once a year, whichever comes first.

12.1.1 Oil Level Check Procedure

1. Stop engine. Open engine compartment R.H. side door.
2. Unscrew and remove the dipstick located on top of reservoir and wipe with a clean rag.
3. Insert dipstick in reservoir. Remove it again to check fluid level (Fig. 8).
4. Adjust level to *"FULL"* mark using proper dipstick side depending on fluid temperature, use *"Dexron-IIE or Dexron-III"* automatic transmission oil.
5. Reinsert and tighten the dipstick.

12.1.2 Filter Replacement

1. Unscrew and remove the cover nut located on top of the power steering reservoir.
2. Remove the reservoir cover and the gasket.
3. Remove the retaining spring and finally the filter cartridge element.

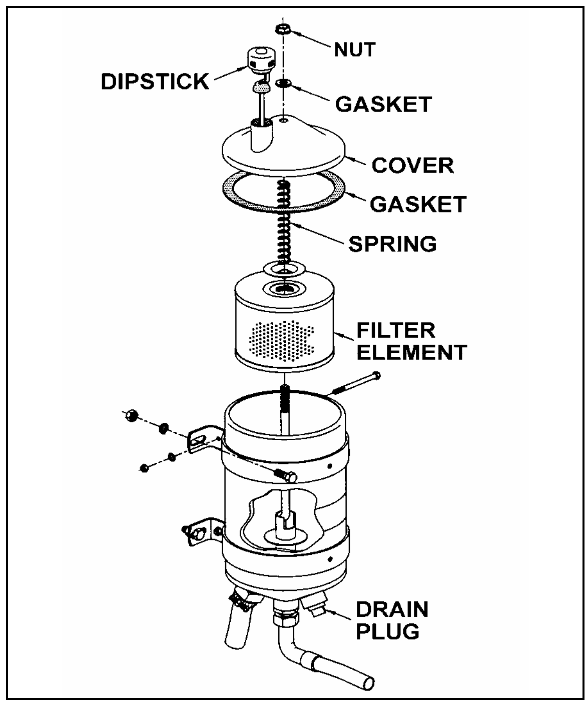


FIGURE 8: POWER STEERING FLUID RESERVOIR 14018A

12.2 STEERING STABILIZER CYLINDER (DAMPER)

The steering damper is located on R.H. side, at back of front axle (Fig.9).

The cylinder is nonadjustable and non-repairable. Check for oil leaks or lack of resistance.

Disconnect the cylinder from axle, then carefully attempt to extend and collapse it manually.

The rod end (ball joint) is provided with a grease fitting. Under normal conditions, it should be serviced every 6,250 miles (10 000 km) or twice a year, whichever comes first. Good quality lithium-base grease NLGI No. 1 and 2 are recommended (refer to section 24 *"Lubrication")*. Check the ball joint for wear, and replace if necessary.

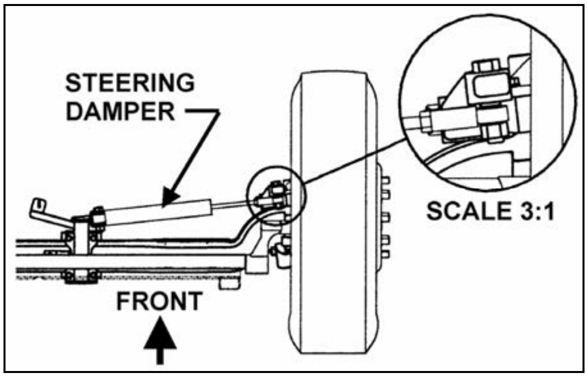


FIGURE 9: STEERING STABILIZER (DAMPER) 14042

12.3 DRAG LINK

Lubricate the fittings every 6,250 miles (10 000 km) or twice a year, whichever comes first. Good quality lithium-base grease NLGI No. 1 and 2 are recommended (refer to section 24 *"Lubrication")*.

12.4 POWER STEERING HYDRAULIC PUMP

For maintenance of the power steering hydraulic pump, refer to the *"TRW - Power Steering Pump Service Manual"* annexed to this section.

13. DRIVING TIPS

In order to maximize power steering pump service life, do not attempt to turn the steering wheel when the vehicle is stationary, and especially when service brakes are applied (wheel locking will oppose the effect of steering geometry which tends to make the front wheels rotate in opposite directions).
Persisting in turning, or maintaining the steering wheel with an extra effort, could make the hydraulic system work at the relief pressure, and consequently, cause the hydraulic fluid to become overheated.

Caution: *Never maintain the hydraulic system at the relief pressure for longer than 5/10 seconds to avoid damaging the power steering pump.*

Note: *Unequal or low tire pressure, oversize tires, and vehicle overloading are some of the causes that may increase steering effort.*

14. TORQUE SPECIFICATIONS

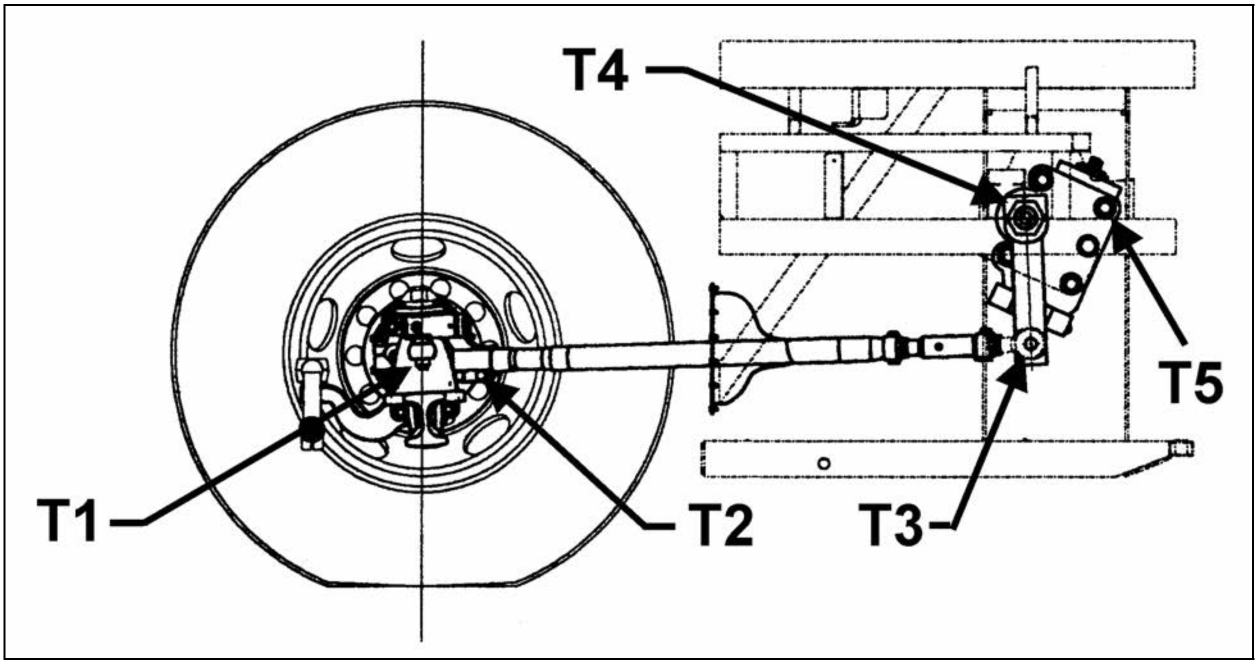


FIGURE 10: DRAG LINK COMPONENTS 14038

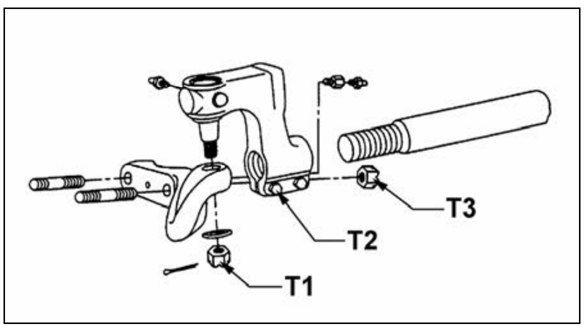


FIGURE 11: TIE ROD END 14036

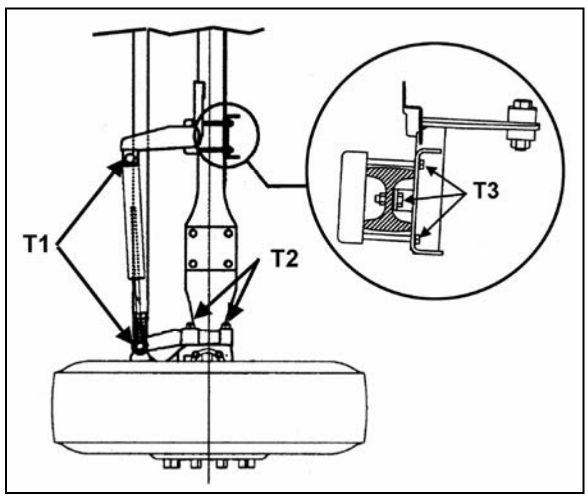


FIGURE 12: FRONT AXLE COMPONENTS 14045

DRY TORQUES			
Description	**Reference**	**Ft-lbs**	**Nm**
Drag Link End Stud Nut (on steering arm)	Fig. 10, T1	160-300	220-410
Drag Link End Pinch Bolt Nuts	Fig. 10, T2	50-65	70-90
Drag Link End Stud Nut (on pitman arm)	Fig. 10, T3	160-215	220-290
Pitman Arm Fixing Nut	Fig. 10, T4	400-450	545-610
Tie Rod End Screw Pin Nut	Fig. 11, T1	100-175	135-240
Tie Rod End Pinch bolt Nuts	Fig. 11, T2	65-75	90-100
Lower Lever Stud Nuts	Fig.11, T3	190-275	260-375
Steering Stabilizer (damper) Fixing Nuts	Fig. 12, T1	100-120	135-165
Steering Top Lever Nuts	Fig. 12, T2	150-200	205-275
Steering Damper Mounting Support Nuts	Fig. 12, T3	65-70	90-95

TORQUE (LUBRICATED WITH LOCTITE #242 BLUE)			
Description	**Reference**	**Ft-lbs**	**Nm**
Steering Gear Fixing Bolts (5)	Fig. 10, T5	265-310	360-420

15. SPECIFICATIONS

Power Steering Gear

Make .... ZF-SERVOCOMTRONIC
Model 8098
Supplier number 8098-988-571
Prevost number 661044
F.E.W. .... 16,600 lbs (7 545 kg)
Pressure rating .... 2,175 psi (150 Bar)
Gear ratio (center) .... 22.2 : 1
Gear ratio (extremities) .... 26.2 : 1
Minimum pump flow for 1.5 hwt/sec .... 4.22 gpm (16 lpm)

Power Steering Gear

Make .... ZF-SERVOCOM
Model 8098
Supplier number 8098-988-570
Prevost number 661045
F.E.W. .... 16,600 lbs (7 545 kg)
Pressure rating .... 2,175 psi (150 Bar)
Gear ratio (center) .... 22.2 : 1
Gear ratio (extremities) .... 26.2 : 1
Minimum pump flow for 1.5 hwt/sec .... 4.22 gpm (16 lpm)

Power Steering Pump

Make .... TRW
Type .... PS Series
Relief valve setting .... 2,175 psi (14 990 kPa)
Controlled flow rate .... 4.23 gpm (16 lpm)
Inlet port .... 1 1/4 NPT
Outlet port .... 3/4-16 straight thread SAE O' ring boss conn.
Supplier number PS251615L10200
Prevost number 661009
Gasket - Supplier number 23516100
Gasket - Prevost number 510488

Power Steering Reservoir

Make .... Nelson Muffler
Oil capacity .... 4 US qts (3.7 liters)
Supplier number 91410A
Prevost number 660982
Make .... Nelson Muffler
Element filter - Supplier number .... 83804 E
Element filter - Prevost number 660987

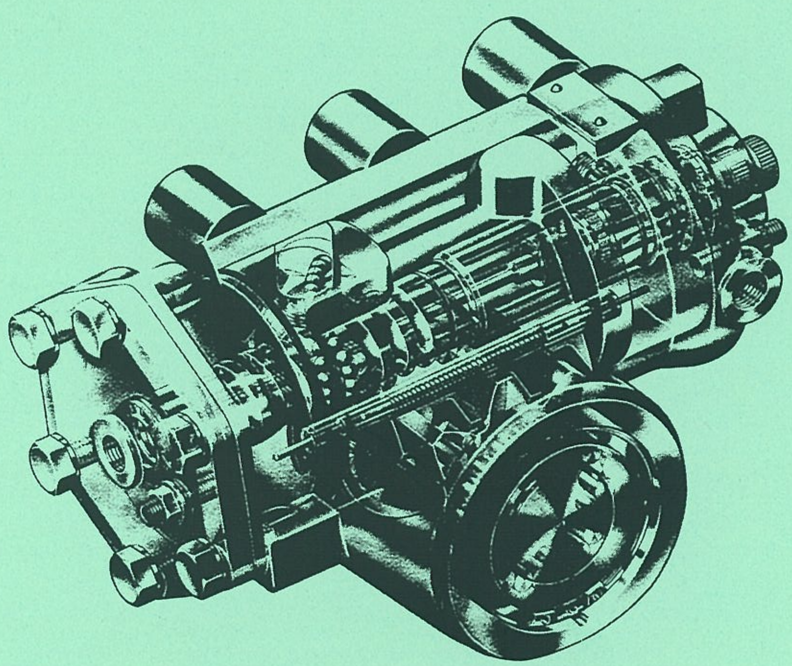
Steering Stabilizer Cylinder (Damper)

Make .... Arvin
Extended length .... 32.73±0.12"
Collapsed length .... 20.26±0.12"
Stroke .... 12.47±0.12"
Supplier number 651535
Prevost number 660979
Dust cap - Prevost number 660980

ZF-Servocom®

and ZF Recirculating ball power steering (CV)

Operating, servicing/maintenance and inspection instructions



ZF-FRIEDRICHSHAFEN AG
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Important general information

→ The present Manual aims to help the user properly to execute the necessary maintenance and repair work on the ZF product.

→ Read the Manual before starting any inspection and repair work.

→ On completion of the maintenance and repair work, the specialist personnel must make certain that the product is once more operating flawlessly.

→ ***Please note that the ZF product must be repaired only in workshops that***

- ☞ ***employ trained personnel***
- ☞ ***have the prescribed equipment, including a test rig, crack detector and special tools***
- ☞ ***use ZF genuine spare parts.***

→ This Manual is only for foremen and fitters who have undergone practical and theoretical training in our Customer Service School. Together with service information bulletins, it is intended to supplement their knowledge.

→ All work carried out on ZF products must be executed with extreme care and diligence. This applies in particular to products and transmission components from vehicles damaged in accidents.

→ The manufacturer does not, of course, accept any liability for damage and its consequences arising from incorrectly or inexpertly executed repairs.

→ This Manual draws attention to notes on safety as follows:

Note: Where incorrect and careless work can cause damage to the product.

⚠ **Attention:** Where incorrect and careless work can lead to personal injury and endanger life.

→ This Manual is not part of the updating service.

→ The contents of the additional service information bulletins must also be observed.

Table of contents:

I. Operation

Attention: important safety information for the driver and workshop personnel

If correctly installed, properly maintained and free of accidents, ZF hydraulic power steering can have a long service life. To ensure complete operativeness, we recommend that the mechanical steering parts are checked (visual examination of all parts, check for cracks in parts under stress) and the seals replaced at the 3rd inspection (does not apply for Servocom steering manufactured after 01.94) (see Section VIII).

The size of the steering and the mechanical steering transmission are selected in consultation with the vehicle manufacturer in such a way that in the event of failure of the hydraulic steering booster, the actuating force to be applied to the steering wheel does not exceed the maximum considered to be reasonable by the law.

Under ECE–R79, this force, which depends on the permissible total weight of the vehicle, is max. 450 N on the steering wheel turn when the vehicle is steered from straight–ahead driving into a circle of radius 20 m. The speed in this case is approx. 10 km/h and the steering action must take no more than 6 seconds.

The driver should know that if the hydraulic power steering suddenly fails, e.g. through failure of the pump drive, his vehicle can still be steered but will require a considerably greater force to be applied for steering. Since such a situation occurs extremely rarely, and then usually completely unexpectedly, the driver may jump to the mistaken conclusion that the steering system is locked. However, this is not the case. The driver must simply apply the necessary force to carry out the steering action.

In order to avoid damage in the steering gear and steering column, the operating force on the steering wheel (diameter 500 mm) when steering while stationary without hydraulic assistance must not exceed 1000 N (approx. 100 kg).

This important safety information is given for the purpose of clarifying the context and preventing the driver making an incorrect diagnosis.

II. Construction and functioning

1 ZF Servocom, Type 8090-98

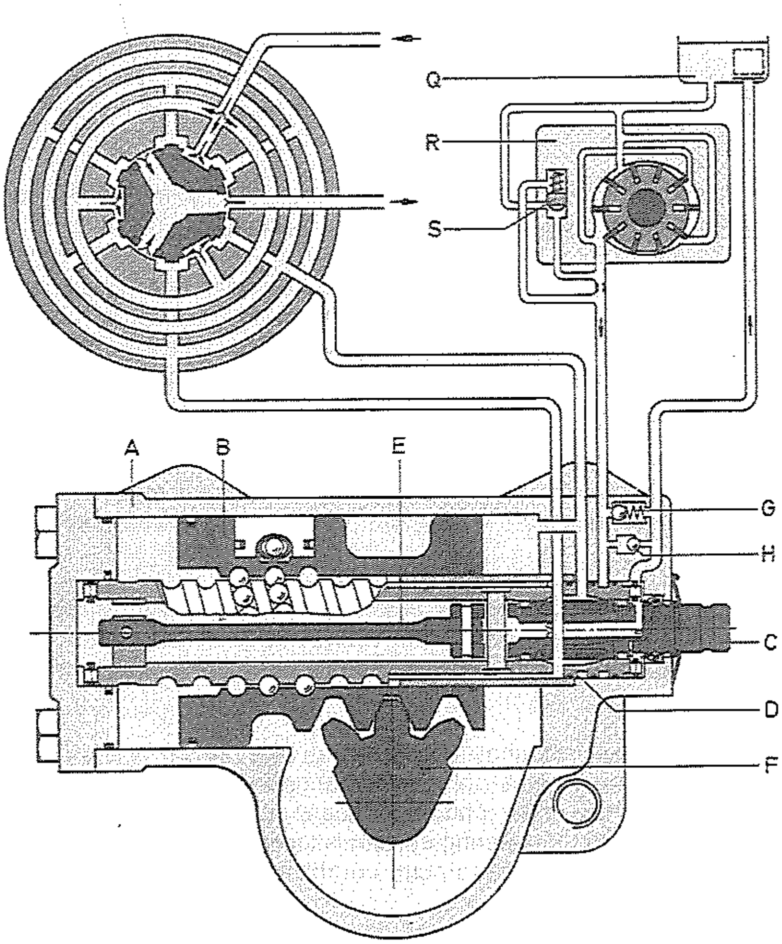
1.1 Construction

The housing of the ZF Servocom contains a control valve, working cylinder and a complete mechanical steering gear.

The pressure oil for the steering is delivered by a motor–driven oil pump which is supplied with oil from an oil tank.

The housing (A) – see also ***Illus. 1*** – is designed as a cylinder for the piston (B), which converts the rotation of the steering shaft (C) and the worm (D) into an axial movement and transfers this to the steering worm sector shaft (F). The toothings of the sector shaft and piston are straight–cut with a high surface quality in such a way that it is only possible to set a unique setting without play on installation in the straight–ahead driving area by means of the two eccentrically designed lateral housing covers.

The piston (B) and worm (C) are connected via a ball chain. When the worm is turned, the balls are collected by a circulating pipe at one end of the chain and fed in again at the other end, thus producing an endless ball chain.



Illus. 1 Valve slide in neutral position

A Housing
B Piston
C Valve slide / steering shaft
D Control sleeve / worm
E Torsion bar
F Steering worm sector shaft

G Pressure relief valve
H Replenishing valve
J Induction port
K Induction port
L Return port
M Return port

N Axial groove
O Axial groove
P Return groove
Q Oil tank
R Wing pump
S Flow control valve

The control valve consists of the valve slide (C) in a needle bearing in the worm, with six control grooves on the circumstance and the control sleeve (D) on the worm, which also has six control grooves. The valve slide, designed with steering shaft connection, turns together with the worm as the steering wheel is turned.

A torsion bar (E), which is pinned with the valve slide (C) and the worm (D), keeps the control valve in the neutral position as long as no opposing force is applied to the steering wheel.
The steering housing contains a pressure relief valve (G) which limits the discharge pressure of the oil pump to the maximum value required. A replenishing valve (H) can also be used, through which oil is sucked from the return if steering is not hydraulically boosted.

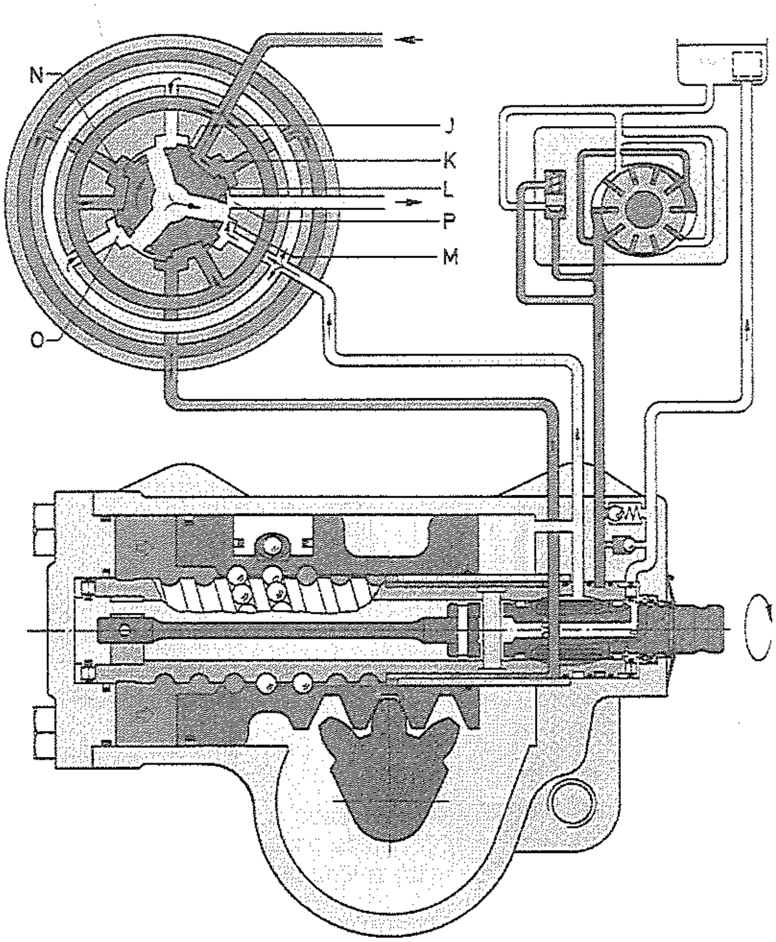
Compared with constant transmission, steering versions with variable transmission are more directly designed in the centre area than outside the centre area. The resulting smaller steering corrections benefit steering behaviour in straight–ahead driving. At the same time, the indirect transmission means that there is a higher hydraulic torque available at the steering arm in parking movement.

If the hydraulic assistance fails, the operating forces on the steering wheel are correspondingly lower in this area. This is achieved through a piston/steering worm sector shaft toothing with differing modulus and angle of pressure.

1.2 Function

Upon transfer of a torque from the steering shaft to the worm, or vice versa, the torsion bar is deformed in the elastic area so that there is torsion between the valve slide and the control sleeve. The control grooves of the valve slide are thereby displaced from the central (neutral) position compared with the control grooves of the control sleeve.

When the steering wheel is released, the torsion bar ensures that the valve is returned to the neutral position.



Illus. 2
Valve slide in working position
Steering wheel turned in clockwise direction

operating pressure

return flow pressure

J Induction port
K Induction port
L Return port
M Return port

N Axial groove
O Axial groove
P Return groove

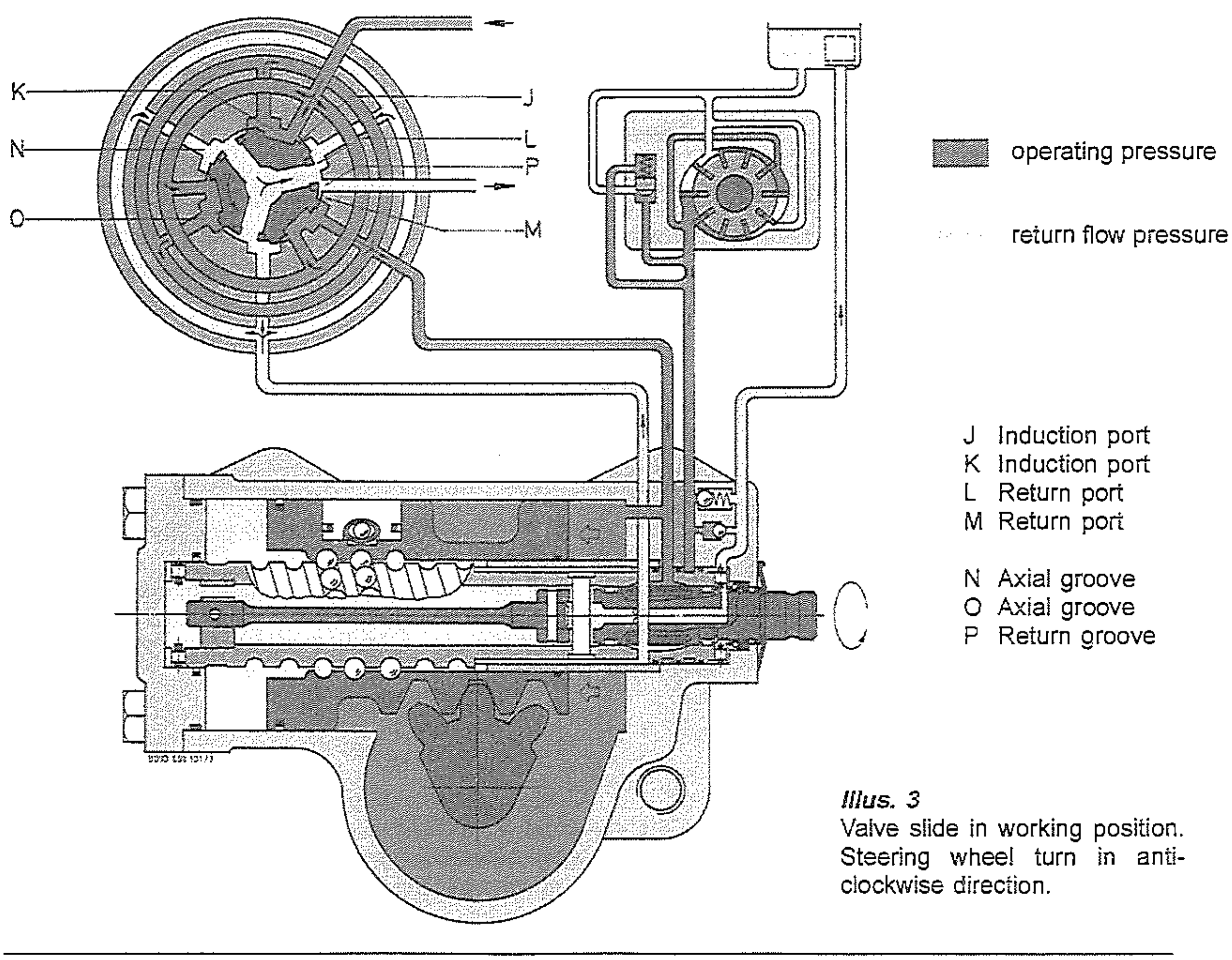
The 3 functional diagrams of ***Illus. 1*** to ***3*** show valve and oil flow in a simplified way for ease of comprehension. These diagrams also show the valve in cross–section so that the connections from the control valve to the cylinder compartments and the functioning of the valve can be shown schematically.

The pressure oil flows into the ring–shaped groove of the control sleeve. It is fed to the arch–shaped control grooves of the internal valve slide through three symmetrically arranged radial holes. The position of the control grooves in the valve slide and control sleeve is set in such a way that if the valve is in a neutral position, the pressure oil can run into the axial grooves (N and O) of the control sleeve, which are also arch–shaped, through the induction ports (J and K). From there the oil is released to each side of the working cylinder via radial holes. As long as the steering valve is in the neutral position, the oil can run into both sides of the working cylinder and to the three return grooves (P) in the valve slide, from where it returns to the oil tank.

When the steering wheel is turned in a clockwise direction, the piston with a right–handed thread is pushed to the right ***(Illus. 2)***. Since the movement of the piston is to be assisted through pressure oil, the oil must now be directed to the left cylinder side.
The control grooves of the valve slide are pushed in a clockwise direction and the induction ports (K) are opened further for the pressure oil supply. However, the induction ports (J) close and block the supply of pressure oil to the axial grooves (O) and the control sleeves.

In the position of the valve described in ***Illus. 2***, the pressure oil flows through the induction ports (K) into the axial grooves (N) of the control sleeve and from there reaches the left cylinder via the planetary thread, so that piston movement is ensured for the hydraulic assistance. The closed induction ports (J) prevent the oil flowing to the oil tank.

The oil from the right cylinder side is compressed. It flows via the opened return ports (M) to the return grooves (P) of the valve slide. From here constant return to the oil tank is ensured through the centrally positioned oil hole in the valve slide.
If the steering wheel is turned in the opposing direction ***(Illus. 3)***, the piston of the working cylinder moves to the left and should be assisted through pressure oil in the right cylinder. The control grooves of the valve slide are pushed in an anticlockwise direction and let the pressure oil flow through the opened induction ports (J) into the axial grooves (O), from where connection to the right cylinder is established. The oil from the left cylinder flows via the planetary thread and the opened return ports (L) to the return grooves (P) of the valve slide. Access to the oil tank is open via the centrally positioned oil hole in the valve slide.



J Induction port
K Induction port
L Return port
M Return port

N Axial groove
O Axial groove
P Return groove

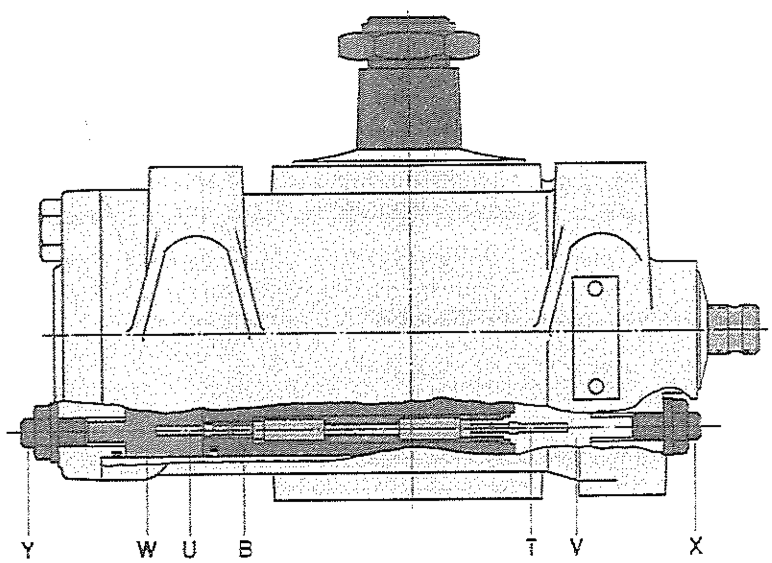
Illus. 3
Valve slide in working position. Steering wheel turn in anticlockwise direction.

1.3 Functioning of the hydraulic steering limiter

The hydraulic steering limiter prevents steering to the wheel locks at full hydraulic pressure. It serves to protect the pump and steering linkage and prevents high oil temperatures.

A double–acting steering limiter valve with spring–weighted valve pins (T and U) extending beyond the right and left piston faces is located in the piston (B) along its longitudinal axis *(Illus. 4)*.

Illus. 4 Steering limiter valves closed



T right valve pin of steering limiter valve
U left valve pin of steering limiter valve

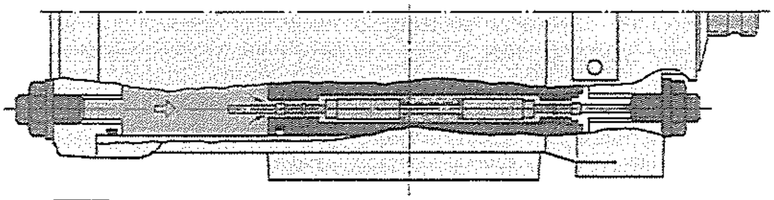
V right cylinder compartment
W left cylinder compartment

X right setting screw
Y left setting screw

When the piston is pushed to the right or left towards the final stop, the valve pins (T and U) are actuated by the setting screws (X and Y) fixed in the housing and cylinder cover. The steering limiter valve remains closed until a valve pin contacts the setting screw.

When the piston moves to the right, for example *(Illus. 5)*, the right valve pin (T) contacts the setting screw (X) before the piston limit position is reached. The valve pin (U) is thereby pushed by the pressure oil, whereby the oil flows from working cylinder compartment (W) into working cylinder compartment (V) and can reach the return. If the piston moves to the left, the process is reversed.

Illus. 5 Piston moves to the right. Right valve pin opened. Oil pressure greatly reduced.



When the steering limiter valve is opened, the steering can continue to be turned with increased force and greatly reduced hydraulic assistance up to the wheel lock or the stop in the steering.

1.4 Setting the mechanically adjustable hydraulic steering limiter, type 8090–98

Note:
In principle, the hydraulic steering limiter is first set by the manufacturer in the test bay according to the engineering instructions of the vehicle companies.
Further setting is carried out after the steering has been installed in the vehicle and in the prescribed inspections by means of a manometer. Adhere to the setting instructions of the vehicle manufacturer.

Setting the hydraulic steering limiter in vehicles using a manometer:

A manometer (pressure range up to 250 bar or hydraulic steering tester) is screwed into the pressure line between the pump and the steering system ***(Illus. 6)*** and the steering axle, if designed as a rigid axle, is relieved through jacking–up.

Attach jack to axle. If the vehicle has independent suspension, the steered wheels must stand on rotary tables for setting of the hydraulic steering limiter; in any case, the steering axle must be loaded in order to compensate approximately for possible deflection errors in measurement.

Turn steering up to wheel lock with engine running at idle speed, oil temperature of steering system above **50°C** or **30°C**, without exerting great force.

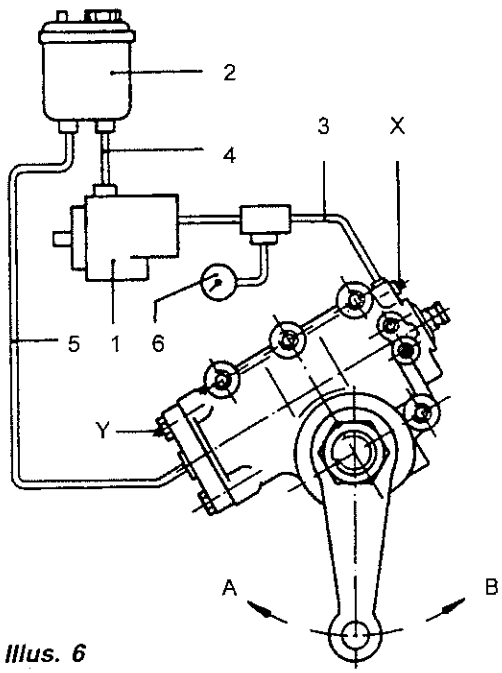
Once the wheel lock has been reached, a brief (max. 5 seconds) continued turning of the steering wheel will overcome the self–aligning force of the steering valve until a fixed steering wheel lock is achieved.

An actuating force on the steering wheel of 100 – 200 N is required to do this.

If the steering limiter is set correctly and the flow rate while the engine is at idle speed does not exceed 16 dm^3/min, e.g. with steering systems with an additional working cylinder, the manometer must now show an oil pressure of

40 to 45 bar at an oil temperature of 50°C, or
45 to 50 bar at an oil temperature of 30°C.

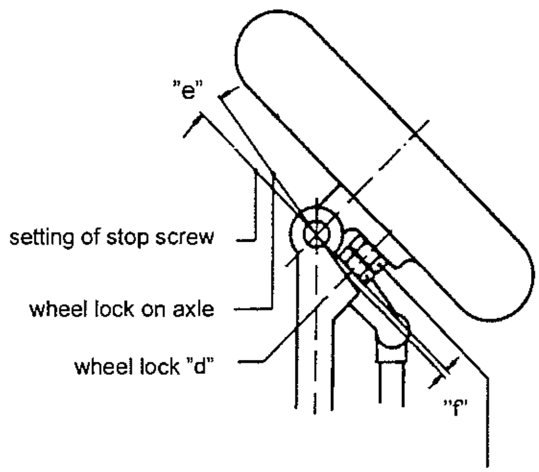
The vehicle manufacturer may prescribe a mode of setting that differs from the abovedescribed (e. g. insertion of a spacer), ***see Illus. 26.***



Illus. 6

X Setting screw of hydraulic steering limiter for steering arm deflection in direction "A"

Y Setting screw of hydraulic steering limiter for steering arm deflection in direction "B"



Illus. 7

Illus. 7 shows the distance "f" which should exist between the wheel lock parts upon response of the hydraulic steering limiter, provided that the vehicle manufacturer prescribes a distance

1 Pump
2 Oil pump
3 Pressure line
4 Suction line
5 Return line
6 Manometer

If the above examination shows that the desired pressure drop has not been achieved, the reason may be that the flow rate is too great (above 16 dm^3/min) or the oil temperature too low. In this case the flow rate of the pump with the engine at idle speed must be measured or the oil temperature increased. For steering systems with higher flow rates, the following setting values apply:

above 16 dm^3/min:	50 to 55 bar at 50°C
	55 to 60 bar at 30°C
above 20 dm^3/min:	70 to 75 bar at 50°C
	75 to 80 bar at 30°C

To make corrections, release the corresponding lock nut and screw the setting screw (X or Y) in or out ***(Illus. 6)***. Release the steering wheel at the same time, so that only the flow pressure builds up during this operation. Then tighten lock nut with 30 Nm.

Attention:
During the setting as soon as in the installed condition it must be secured that the setting screws (x and y) are at least screwed in 3 pitches. Otherwise the caution is present that the screws will be exploded out in the case of maximum pressure.

The second wheel lock is set in a similar fashion.

The setting screw (X) in ***Illus. 6*** must be adjusted if the steering column is moved towards "A" according to ***Illus. 6***. In the same way, setting screw (Y) is adjusted if the steering column turns towards "B".

After this setting, the hydraulic assistance should be active until the wheel lock is reached. To check the setting appropriately, turn the steering wheel, while driving the vehicle slowly and under normal load, until the hydraulic assistance is disconnected.

If the pressure falls too early or too late when the steering column is turned towards "A" or "B", the setting screws (X or Y) must be twisted as described below.

If a higher pressure is measured, the corresponding setting screw must be **screwed in** again (clockwise).

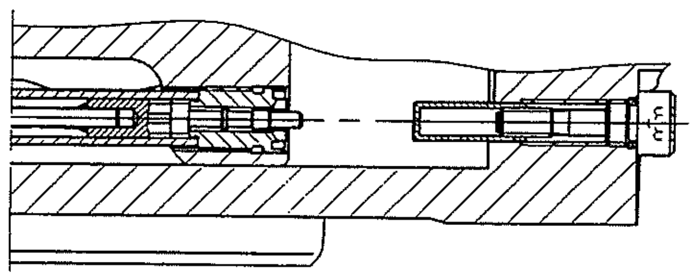
If a lower pressure is measured, the corresponding setting screw must be **screwed out** again (anticlockwise).

Check:
To check this setting appropriately, turn the steering wheel, while driving the vehicle slowly and under normal load, until the hydraulic assistance is disconnected.

1.5 Automatically adjustable hydraulic steering limiter, type 8090–98 (visible externally by hexagon instead of lock nut)

Attention:

Steering systems with automatically adjustable steering limiters must not be mechanically turned to the limit positions if the steering linkage has been removed or the system dismantled. The sliding sleeves would then be pushed into the maximum possible cut–off position and automatic setting in the vehicle would only be possible with new sliding sleeve assemblies (X or Y) ***(Illus. 8)***. If necessary, fit new sliding sleeve assemblies.
Sliding sleeve assemblies and normal setting screws are not interchangeable.



Illus. 8 Starting position of sliding sleeves not yet set

1.5.1 Functioning of automatically adjustable hydraulic steering limiter

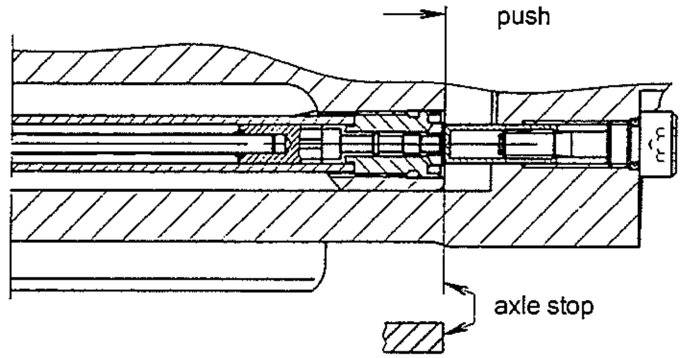
With the automatically adjustable hydraulic steering limiter, screws (X and Y) with pressed–on sliding sleeves are located in place of setting screws.
These function in the same way as with the manually adjustable hydraulic steering limiter. In the limit positions, the valve piston tappets meet the sliding sleeves and open the steering limiter valves (U and T). The opening point is determined by the position of the sliding sleeves on the screws.

1.5.2 Setting

Note:
Setting ***(Illus. 9)*** is only possible after the steering system has been installed in the vehicle. The steering linkage and the axle stops must be mounted and set.

Illus. 9 Setting process

Positioning the sliding sleeves

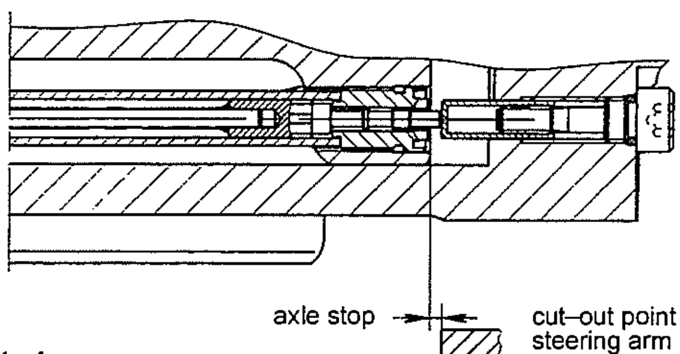


When the above conditions have been met, the steering wheel must be turned to the maximum wheel lock with or without hydraulic assistance. This causes the piston to push the sliding sleeve on the screw to the cut–out position ***(Illus. 9)***. The steering limiter valve is permanently open during this setting process, which is why the steering wheel can only be turned with increased force whether or not there is hydraulic assistance. In order to allow mechanical steering and roughly compensate for errors of deflection which may occur in measurement, for vehicles with independent suspension the steered wheel must be on rotary plates; if the steering axle is designed as a rigid axle, it is sufficient to support the axle with a jack. The steering axle must be loaded in any case.

This process must be carried out in both directions of rotation until a fixed stop has been reached. The sliding sleeves are automatically returned to the correct cut–out position ***(Illus. 10)***.

Illus. 10

Left steering limiter valve open, oil pressure greatly reduced



1.5.3 Correcting the steering arm steering lock

To **increase the steering arm steering lock** (the space between the wheel lock parts is too great): carry out setting as described above.

To **reduce the steering arm steering lock** (the oil pressure at the axle stop does not fall to the value given in Section II Para. 1.4):

Fit new sliding sleeves assembly (20 or 128) [1].

Attention:
It is not permitted to pull the sliding sleeve back to the press fit of the screw.

Tightening torque for sliding sleeve assembly: 15^{+3} Nm.

[1] The numbers in square brackets refer to the key to numbers in figures at the end of the instructions.

2 ZF recirculating ball power steering systems, type 8033–46

2.1 Construction:

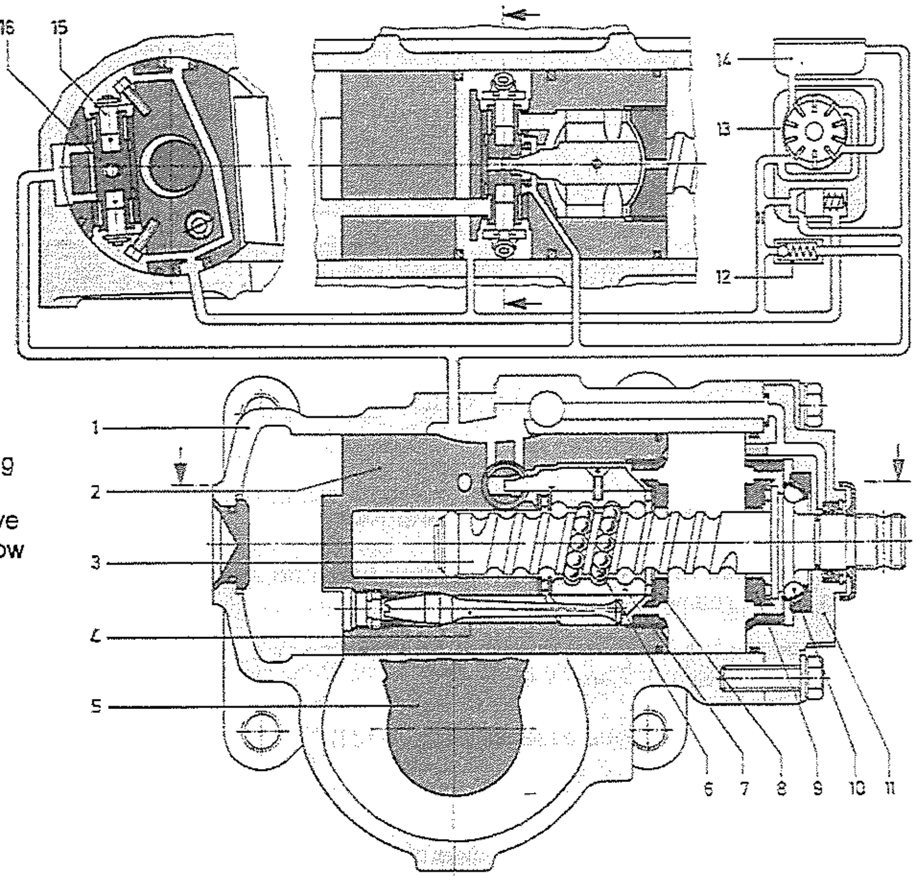
The housing contains a control valve, working cylinder and a complete mechanical steering gear. The pressure oil for the steering is delivered by a motor–driven pressure oil pump which is supplied with oil from an oil tank. The housing (1 or A) is designed as a cylinder for the piston (2 or B) which carries out the task of converting the rotation of the steering shaft into an axial movement and transferring this to the steering worm sector shaft (5 or D). To ensure perfect power transmission, the toothing of the sector shaft is designed in such a way that when the shaft transverse to the piston is adjusted axially, any possible backlash is eliminated. This free play is adjusted using a setting screw and this can be carried out in the vehicle (see Section IV).
The threaded hole of the piston is connected to the worm (3 or E) via a ball chain. When the worm is turned, the balls (6 or F) on one end of the chain are taken up by a circulating pipe and fed back to the other end, thus forming an endless ball chain. The control valve is transverse to the piston. It comprises a valve piston (16) and two fixed recoil pistons (15). One finger of the steering nut (7) meshes with great accuracy into the hole of the valve piston.

2.2 Functioning:

In order to obtain hydraulic assistance while steering, which should be started when the steering wheel is turned, the valve piston must be displaced from the neutral position.

Illus. 11
Recirculating ball power steering, type 8043, steering valve centralised through flexible rod, neutral position

1 Housing
2 Piston
3 Worm
4 Flexible rod
5 Sector shaft
6 Balls
7 Steering nut
8 Threaded ring
9 Threaded ring
10 Angular ball bearing
11 Cover
12 Pressure relief valve
13 Wing pump with flow control valve
14 Oil tank
15 Recoil piston
16 Valve piston



The valve is kept in the neutral position by means of a spring element which may, according to design, be a centralizing spring, a leaf spring or a flexible rod. For this reason force must be applied in order to overcome the pretension.

The piston, interlocked with the sector shaft and the steered wheels, resists any rotary motion. During steering, the steering nut is therefore stressed via the worm and ball chain in the circumferential direction and the elastic threshold overcome. The pressure oil flowing into the steering housing from the motor–driven pump is then directed into the cylinder from which the steering process is being hydraulically assisted.

The pressure oil flows laterally underneath the valve into a longitudinal groove of the piston. To provide a balance of pressure, it is led into an equally large longitudinal groove on the opposite side and passes through transverse holes to reach the faces of the valve piston which are separated from the cylinders by seals. With the valve in a neutral position, the oil flows towards the centre of the valve piston after flowing through feed and return leading edges and from there upwards into a recess of the piston through the corresponding holes. From here it flows out into the return ***(Illus. 11)***. When the valve is displaced, the pressurized side of the piston is separated from the return and the opposite side of the cylinder is connected with the return. The steering valve is fitted with 2 recoil pistons, whose function is to make it more difficult to displace the valves from the neutral position through the oil pressure. The actuating force on the steering wheel thus rises in proportion to the forces acting on the wheels. Steering systems in which a proportional rise of the actuating force is only desired up to a predetermined oil pressure are fitted with an actuating force limiting valve. The valve fitted in the recoil valve ensures that the force on the steering wheel does not rise much further after the cut–off pressure has been reached.

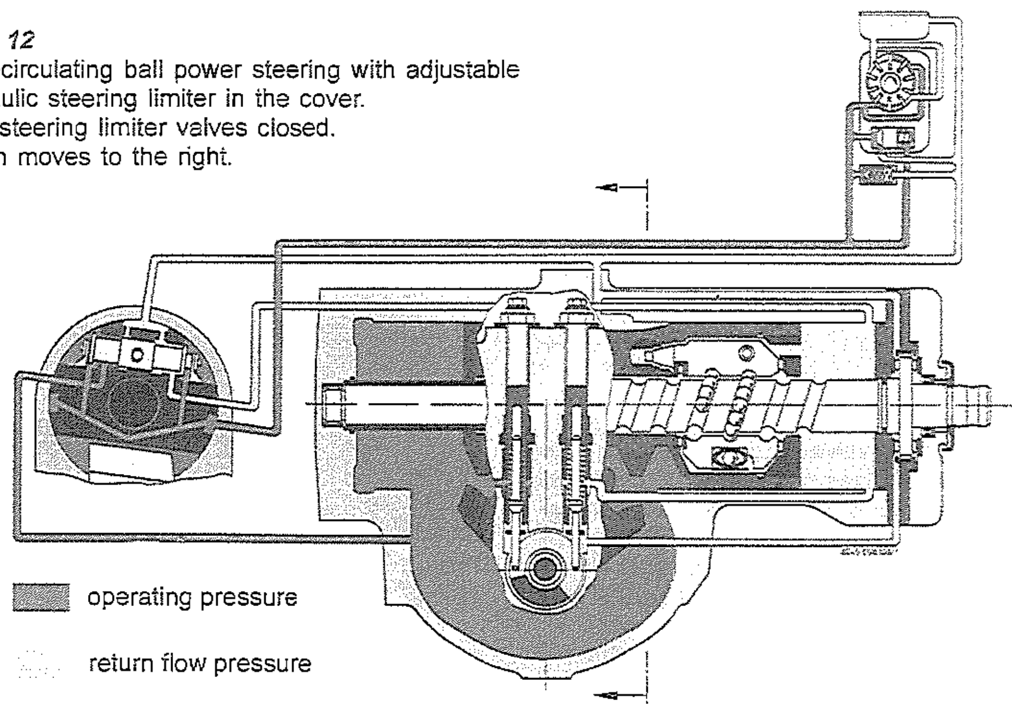
Action of the recoil pistons:
These have a floating bearing in the hole of the valve piston. But they are held axially and secured through connection with retaining plates. The outer faces of both pistons are constantly charged with pressure oil, whereas only one of the inner faces in the working position of the valve is charged with pressure oil. The same applies for the faces in the holes of the valve piston. This produces a force which tries to bring the valve piston back into the neutral position. This property is called "hydraulic reaction".

2.3 Functioning of the hydraulic steering limiter

2.3.1 Adjustable steering limiter

The housing cover is fitted with two valves (55), in each of which 1 valve piston is guided ***(Illus. 12)***. Both valve pistons are actuated by the cam located on the face of the sector shaft. When the sector shaft is turned, the valves remain closed until the cam of the sector shaft meets a valve piston, lifts it and thereby opens the valve ***(Illus. 13)***. The pressure oil of the left cylinder flows through a hole in the housing cover to the left valve, while the pressure oil of the right cylinder reaches the right valve through a hole in the housing.

Illus. 12
ZF recirculating ball power steering with adjustable hydraulic steering limiter in the cover.
Both steering limiter valves closed.
Piston moves to the right.

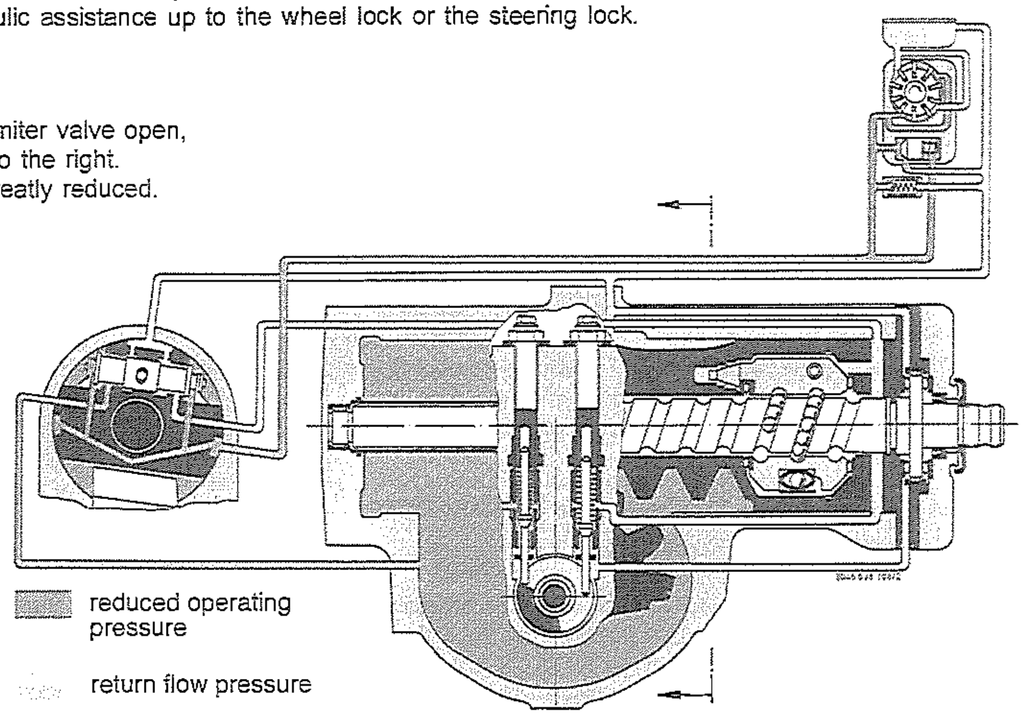


When the sector shaft is turned in a clockwise direction (see ***Illus. 13***, piston moves to the right), the left valve piston is actuated according to a defined steering arm lock, which can be altered by screwing the valve in or out. The pressure oil can then flow through the valve seat from the left cylinder to the return. The position of the steering valve is not changed. The right steering limiter valve remains closed during this process.

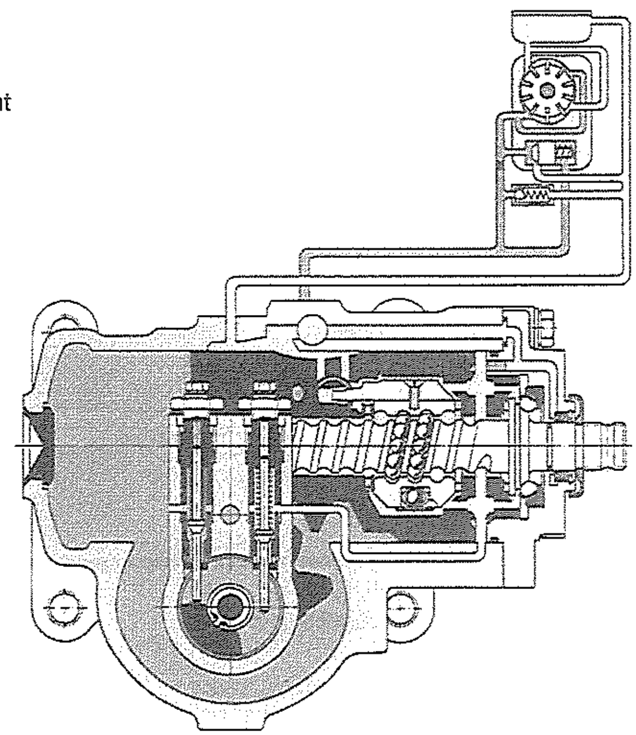
When the sector shaft is turned in an anticlockwise direction, the right valve opens according to a predetermined path, so that the pressure oil can flow from the right cylinder to the return.

If the steering limiter valve is open, the steering can be turned further with increased force and greatly reduced hydraulic assistance up to the wheel lock or the steering lock.

Illus. 13
Left steering limiter valve open,
piston moves to the right.
Oil pressure greatly reduced.



Illus. 14
Recirculating ball power steering, type 8043.
Oil is fed to unpressurized cylinder compartment
via two steering limiter valves.



When the left valve piston is actuated, the pressure oil flows out of the left cylinder into the compartment below the steering limiter valve. The oil pressure building up there lifts the right valve piston from its seat against the spring resistance and permits access to the right cylinder compartment connected with the return.

2.3.2 Non–adjustable steering limiter

a) Steering version 8036 and 8038

The piston head is fitted with a ball valve which is always closed because of the oil pressure in the left or right working cylinder. Not until just before the piston reaches the housing on the left or the worm on the right is the valve actuated by a pin and pressure oil allowed to flow to the return.

b) Steering version 8033 and 8037

When the piston moves to the left, the pressure oil can flow into the housing return channel before the stop is reached via a piston hole located at right angles to the piston axis. When the piston moves to the right, the edge of the piston head releases the return channel in the housing.

2.4 Setting the hydraulic steering limiter, type 8033–46

Note
In principle, the hydraulic steering limiter is first set by the manufacturer in the test bay according to the engineering instructions of the vehicle companies.
Further setting is carried out after the steering is installed in the vehicle and on the prescribed inspections by means of a manometer. Adhere to the setting instructions of the vehicle manufacturer.

Setting the hydraulic steering limiter in the vehicle using a manometer:

A manometer (pressure range up to 250 bar or hydraulic steering tester) is screwed into the pressure line between the pump and the steering gear ***(Illus. 15)***. The steering axle, if designed as a rigid axle, is relieved through jacking. Adhere to instructions of the vehicle manufacturer. If the vehicle has independent suspension, the steered wheels must stand on rotary tables for setting of the hydraulic steering limiter; in any case, the steering axle must be loaded in order to compensate roughly for possible deflection errors in measurement. Without exerting great force, turn steering up to wheel lock with engine running at idle speed, oil temperature of steering system above 50°C.

Once the wheel lock has been reached, a brief (max. 5 seconds) continued tuming of the steering wheel will overcome the resetting force of the steering valve until a fixed steering wheel lock is achieved. To reach this, and depending on the size of the hydraulic reaction, a peripheral force on the steering wheel of approx. 100 – 200 N is required. If the steering limiter is set correctly, the manometer must now show an oil pressure of between **30 and 35 bar**. To make corrections, release the lock nut (a1 or b1) and screw the corresponding valve sleeve (a2 or b2) in and out. Release steering wheel at the same time, so that only the flow pressure builds up during this work. Then tighten lock nut a1 or b1.

Tightening torque for lock nut: 25 to 35 Nm.

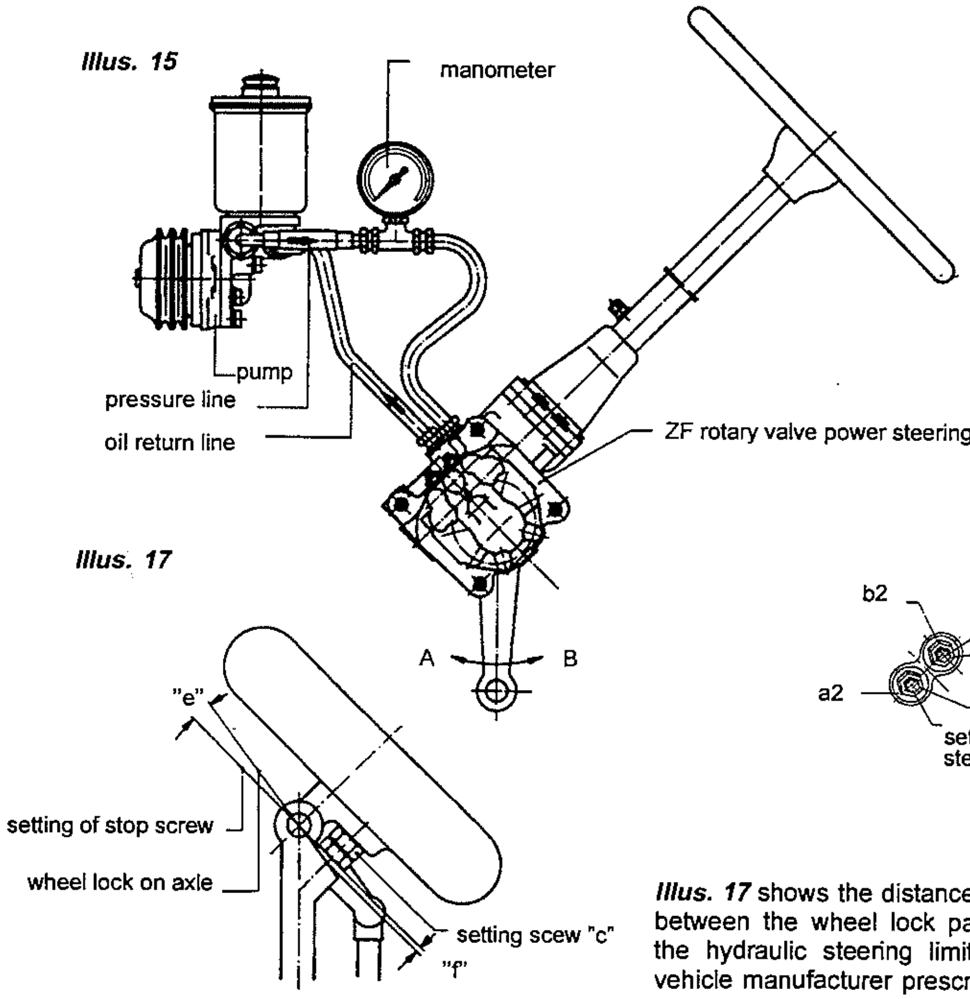
The second wheel lock is set in a similar fashion. The valve (a2) and lock nut (a1) in ***Illus. 16*** must be adjusted if the steering arm is moved towards "A" according to ***Illus. 15***. In the same way, valve (b2) and lock nut (b1) are adjusted if the steering arm turns towards "B".

The vehicle manufacturer may prescribe a mode of setting that differs from the abovedescribed (e. g. insertion of a spacer), ***see Illus. 26***.

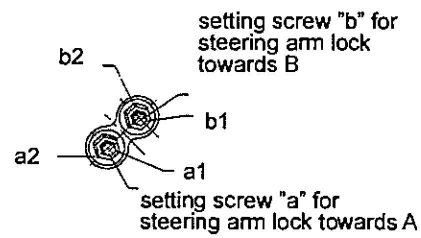
After this setting, the hydraulic assistance should be active until the wheel lock is reached. To check the setting appropriately, turn the steering wheel, while driving the vehicle slowly and under normal load, until the hydraulic assistance is disconnected.

Illus. 15

Illus. 17



Illus. 16



Illus. 17 shows the distance "f" which should exist between the wheel lock parts upon response of the hydraulic steering limiter, provided that the vehicle manufacturer prescribes a distance.

In this position a distance should exist between the wheel lock parts ***(see Illus. 17)***, provided that the vehicle manufacturer prescribes a distance.

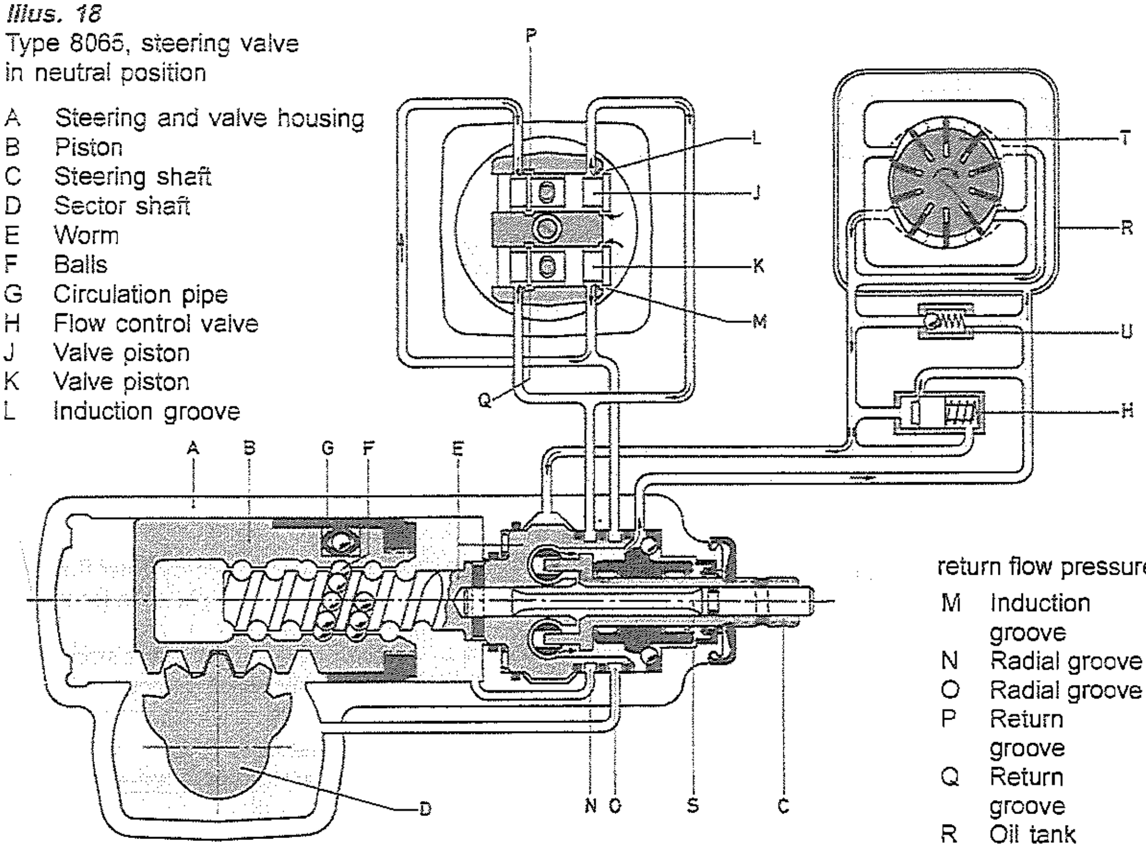
If the pressure falls too early or too late when the steering arm is turned towards "A" or "B", the valve sleeves (a2 and b2) must be twisted as described below.

If a pressure greater than 35 bar is measured, the corresponding steering limiter valve (55) must be **screwed** further **into** the cover (clockwise).

If a pressure lower than 30 bar is measured, the corresponding steering limiter valve (55) must be **screwed** further **out** (anticlockwise).

Check:
To check this setting appropriately, turn the steering wheel, while driving the vehicle slowly and under normal load, until the hydraulic assistance is disconnected.

3. ZF recirculating ball power steering, type 8056–70



Illus. 18
Type 8065, steering valve in neutral position

- A Steering and valve housing
- B Piston
- C Steering shaft
- D Sector shaft
- E Worm
- F Balls
- G Circulation pipe
- H Flow control valve
- J Valve piston
- K Valve piston
- L Induction groove

return flow pressure

- M Induction groove
- N Radial groove
- O Radial groove
- P Return groove
- Q Return groove
- R Oil tank
- S Torsion bar
- T Pressure oil pump
- U Pressure relief valve

3.1 Construction

Design as for steering types 8033–46, but with a different steering valve. The worm head accommodates two valve pistons (J and K) lying transverse to the worm axis, and these rotate together with the worm and the steering shaft in the valve housing of the steering system when the steering wheel is turned. The valve pistons have a cross hole in the centre in which two arms of the steering shaft (C) engage. There is therefore a connection without play between the valve pistons and the steering shaft, which is also connected to the worm via a torsion bar.

3.2 Functioning

When the steering wheel is turned in a clockwise direction, the piston with left–handed thread is pushed to the right. Since the movement of the piston is to be assisted by pressure oil, the oil must now be fed to the right cylinder side. The upper valve piston (J) is pushed to the right and the induction port (L) for the pressure oil supply opened further. By contrast, the lower valve piston (K) moves to the left and the pressure oil supply is interrupted by the closing of the induction groove (M). The return grooves (P and Q) can be seen in the upper valve representation for both valve pistons on the left of the valve piston centre. The pressure oil line of the upper valve piston is connected to the left radial groove (N) in the head of the worm and to the return groove of the lower valve piston (Q). Likewise, the pressure oil line of the lower valve piston is connected to the right radial groove (O) of the worm and the return groove (P) of the upper valve piston.

The pressure oil flows through the induction groove (L) of the upper valve piston to the left radial groove (N) and from there into the right cylinder, so that the piston movement is hydraulically assisted. However, at the same time the pressure oil reaches the return groove (Q) of the lower valve piston, but this is closed and blocks the return of this oil. The oil from the left cylinder is compressed. It flows via the radial groove (O) in the worm to the induction groove (M) of the lower valve piston. This is closed. However, at the same time the oil flows further to the return groove (P) of the upper valve piston, which is open, thus allowing the oil to reach the valve piston centre. From here constant return to the oil tank is guaranteed, as the diagram of the steering system ***(Illus. 18)*** shows.

If the steering wheel is turned in the opposite direction, the piston moves to the right ***(Illus. 19)*** and should be hydraulically assisted through pressure oil in the left cylinder. The lower valve piston is pushed to the right and allows the pressure oil to reach the right radial groove (O) in the worm, from where connection to the left cylinder is established. The pressure oil is also allowed to flow to the return groove (P) of the upper valve piston, but this is closed and prevents the oil flowing out to the valve piston centre. The oil from the right cylinder flows via the left radial groove (N) in the worm to the return groove (Q) of the lower valve piston, which is open, thus permitting access to the valve piston centre and from there to the oil tank.

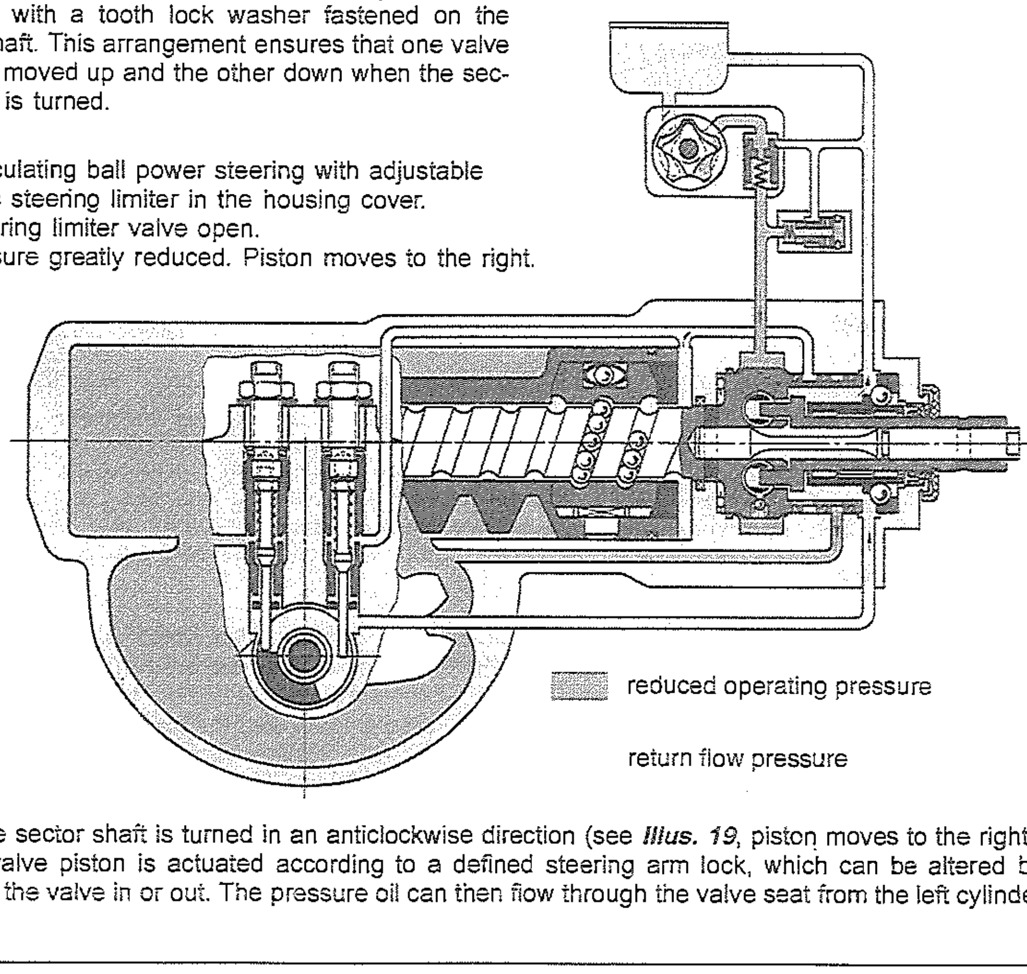
3.3 Functioning of the hydraulic steering limiter

The housing cover is fitted with two valves, in each of which 1 valve piston is guided. Both valve pistons are actuated by the cam located on the face of the sector shaft (60). When the sector shaft is turned, the valves remain closed until the cam of the sector shaft meets a valve piston, lifts it and thereby opens the valve ***(Illus. 19)***.

The valves are connected to the return by holes. The pressure oil of the left cylinder flows through a hole in the housing cover to the left valve, while the pressure oil of the right cylinder reaches the right valve through a hole in the housing.

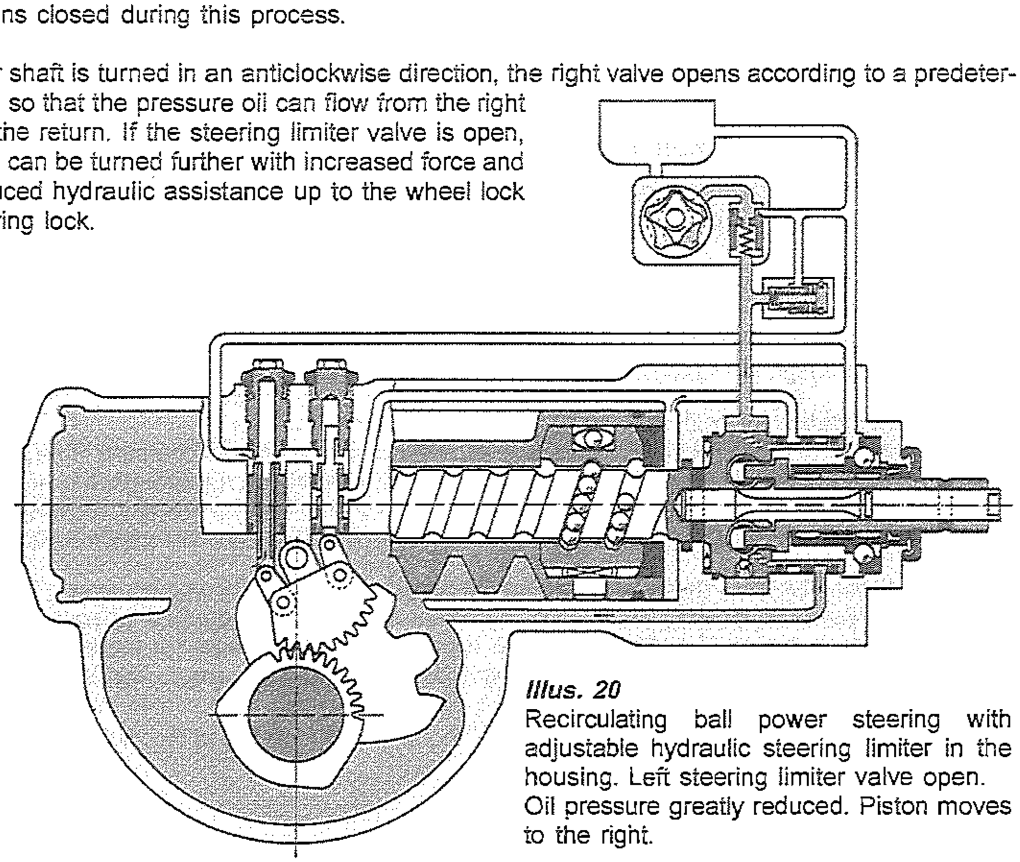
If the steering limiter valves are located in the housing – ***see Illus. 20*** – the valve pistons in the two valve sleeves are connected to a toothed quadrant by means of connecting elements. The toothed quadrant is swivel mounted in the housing cover and engages with a tooth lock washer fastened on the sector shaft. This arrangement ensures that one valve piston is moved up and the other down when the sector shaft is turned.

Illus. 19
ZF recirculating ball power steering with adjustable hydraulic steering limiter in the housing cover.
Left steering limiter valve open.
Oil pressure greatly reduced. Piston moves to the right.



When the sector shaft is turned in an anticlockwise direction (see ***Illus. 19***, piston moves to the right), the left valve piston is actuated according to a defined steering arm lock, which can be altered by screwing the valve in or out. The pressure oil can then flow through the valve seat from the left cylinder compartment to the return. The position of the steering valve is not changed. The right steering limiter valve remains closed during this process.

If the sector shaft is turned in an anticlockwise direction, the right valve opens according to a predetermined path, so that the pressure oil can flow from the right cylinder to the return. If the steering limiter valve is open, the steering can be turned further with increased force and greatly reduced hydraulic assistance up to the wheel lock or the steering lock.



Illus. 20
Recirculating ball power steering with adjustable hydraulic steering limiter in the housing. Left steering limiter valve open. Oil pressure greatly reduced. Piston moves to the right.

3.4 Setting the hydraulic steering limiter, type 8056–70

Install manometer (pressure range up to 250 bar or hydraulic steering tester) as described under Section 2 for ZF rotary valve power steering ***(Illus. 15** to **17)*** and carry out setting.

If the pressure falls too early or too late when the steering arm is turned towards "A" or "B", the valve sleeves (a2 and b2) must be twisted as described below.

a) For steering systems in which the steering limiter valves are installed in the housing cover ***(Illus. 19)***: **If a pressure greater than 35 bar is measured**, the corresponding steering limiter valve (36) must be **screwed** further **into** the cover (clockwise).

   If a pressure lower than 30 bar is measured, the corresponding steering limiter valve (36) must be **screwed** further **out** (anticlockwise).

b) For steering systems in which the steering limiter valves are installed in the housing (Illus. 20):
   If a pressure greater than 35 bar is measured, the corresponding valve sleeve (36) must be **screwed** further **out** (anticlockwise).

   If a pressure lower than 30 bar is measured, the corresponding valve sleeve must be **screwed** further **into** the housing (clockwise).

Tighten lock nut a1 or b1 with **25 to 35 Nm**.

Illus. 17 shows the distance "f" which should exist between the wheel lock parts and be approx. 2mm upon response of the hydraulic steering limiter, provided that the vehicle manufacturer prescribes a setting with spacer.

Check:

To check this setting appropriately, turn the steering wheel, while driving the vehicle slowly and under normal load, until the hydraulic assistance is disconnected.

III. Maintenance, oil change and ventilation

Note:
When the steering system is being filled with hydraulic fluid, there is a danger that particles of dirt will get into the steering oil circuit. In order to avoid malfunctions caused by foreign bodies in the system, the utmost cleanliness must be ensured both on first filling and on refilling.

Before removing the oil tank cover, thoroughly clean the tank and its immediate surroundings so that no dirt can get into the hydraulic fluid.

When cleaning the vehicle with steam–cleaning devices:
Do not direct the steam cleaner straight onto exposed sealing parts of the aggregates belonging to the steering system. Water penetrating protecting caps, shaft seals or seals of universal joints can cause corrosion damage.

Recommendation for cold starts:
For vehicles with long hydraulic pipes, e.g. buses, an increased flow pressure is required for cold starts under 0°C ambient temperature. In order not to damage the pump through too great a pressure, the engine and with it the pump should be run for a few minutes without any movement of the steering wheel. This brings heated oil into circulation and the flow pressure will then normalize.

The following sections show the intervals for inspections of ZF power steering systems in kilometres per hour and in working hours. The figures in km/h must be applied for road vehicles, the figures in working hours for off–road vehicles. With vehicles having neither a tachometer nor a working hour meter, a fuel flow volume corresponding to the intervals should be taken as a guideline (Section VIII, Instructions for inspection).
For single–circuit hydraulic steering systems, the sections referring to the mobility–dependent pump are omitted.

1. Inspection

The general customer service for the respective vehicle encompasses checking all screwed connections and pipes of the power steering system, pumps (depends on engine and mobility), valves and working cylinders for tightness. A thin film of oil can be applied to the piston rods of the working cylinder, but no drops should be allowed to form.

If the steering system is installed subsequently, the installing workshop should carry out this inspection after the first 1000 kilometres or 25 hours of operation.

2. Oil grades

A suitable hydraulic fluid is required for the perfect functioning of the steering system and the pump. The hydraulic fluid also lubricates the steering gear and the pump; only one oil is therefore required for the whole system.

ATF oils, with a viscosity of approx. 26 mm^2/s at 50°C, setting point under –35°C and low frothing inclination, are suitable for filling. Oils with higher viscosity can lead to the ventilating pressure in the suction being too great, producing noises in the pump. For permissible oil grades see list of lubricants TE–ML 09.

3. Oil volume

The hydraulic power steering is supplied from the factory without oil. The volume of oil required for the steering gear, without pipes, oil tank and pump, for the individual steering sizes is:

Type 8033: 0.5 dm^3	Type 8056: 0.8 dm^3	Type 8090: 0.6 dm^3
Type 8036/37: 0.7 dm^3	Type 8058: 1.0 dm^3	Type 8095: 1.5 dm^3
Type 8038: 0.9 dm^3	Type 8060: 1.2 dm^3	Type 8096: 1.7 dm^3
Type 8042: 1.5 dm^3	Type 8062: 1.4 dm^3	Type 8097: 1.9 dm^3
Type 8043/44: 1.4 dm^3	Type 8065: 1.7 dm^3	Type 8098: 2.4 dm^3
Type 8045: 1.9 dm^3	Type 8066: 1.5 dm^3	
Type 8046: 1.6 dm^3	Type 8070/72: 2.6 dm^3	

4. Oil change

Attention
An oil change is only recommended if the steering gear or pump or both have to be repaired or replaced. When doing so, the filters in the oil tanks should also be replaced and the pipes cleaned. An oil change is also required if other oils are used instead of the prescribed ATF oils (see Para. 2, Oil grades), e.g. engine oils or hydraulic fluids.

Before removing the cover of the oil tank, thoroughly clean the tank and its immediate surroundings so that no dirt can get into the hydraulic fluid.

Do not reuse oil that has been drained. Avoid mixing oils.

The oil can be drained as follows:

ZF Servocom:
Jack up steering axle as instructed by the vehicle manufacturer. Unscrew pressure and return pipes. If necessary, remove plug screws (55) from cylinder cover or housing. Then start engine briefly, no more than 10 seconds, until oil is drained from pump and tank. To check, switch engine off and turn steering once more from lock to lock until no more oil runs out. There should be a sizeable residual volume of oil in the steering system. Depending on the degree of contamination of the oil, e.g. scuff from the abrasion of internal parts of the pump, the steering system may need to be evacuated completely. The steering must then be dismounted and opened by a ZF service agency.

ZF recirculating ball power steering with oil drain screw:
Jack up steering axle as instructed by vehicle manufacturer. Unscrew oil drain screw on underside of housing.

ZF recirculating ball power steering without oil drain screw:
Undo the plug screw located on the side of the housing cover. Turn steering until the piston is pushed up to the stop. Then start engine briefly, no more than 10 seconds, until oil is drained from pump and tank.
It is possible that a rather large volume of oil will remain in the steering system. If necessary, we recommend that an oil change is followed by another rinse, i.e. that a second oil change is carried out.

To check, switch engine off and turn steering once more from lock to lock until no more oil runs out. Screw in oil drain screw or plug screw M 12x1.5 and tighten with 40 to 45 Nm.

Avoid mixing oils.

5. Filter change

The filter cartridges in single or multi–chamber oil tanks should be replaced at the same time as the inspection [2].

Attention
Before removing the cover of the oil tank, thoroughly clean the tank and its immediate surroundings so that no dirt can get into the hydraulic fluid.

When removing the used filter cartridges, ensure by closing the lower hole that dirty oil does not run from the filter cartridges back into the oil tank or into the oil circuit. Lubricate filter holders before use. If oil tanks are plastic, remove suction and return pipe. Disassemble oil tank, evacuate, clean and use new filter cartridges.

[2] Slight deviations are permissible if desired by the vehicle manufacturer in order to be able to record the intervals in the vehicle log.

6. Oil filling and ventilation

6.1 Oil filling

Attention:
When the steering system is being filled with hydraulic fluid, there is a danger that particles of dirt will get into the steering oil circuit. In order to avoid malfunctions caused by foreign bodies in the system, the utmost cleanliness must be ensured both on first filling and on refilling.

The steering system and the pump are filled through the filler necks on single and multi–chamber oil tanks. On first filling and oil changes, it is expedient to remove the tank cover (possible for sheet metal oil tanks) and fill hydraulic fluid up to the neck of the tank.

Start the engine at low speed and allow to work at idle speed (for vehicles with mobility–dependent emergency steering pump: drive axle with gear engaged for mobility–dependent drive axle jacked up) in order to fill the complete hydraulic system with oil. During this process, the oil level in the tank falls rapidly. The oil tank must therefore be constantly refilled to avoid the intake of air. We recommend that one mechanic runs the engine while a second pours in as much oil as is drained by the pump.

At a higher engine speed or strong suction flow, smallish air bubbles would be sucked into the pump again and be broken down into tiny bubbles by the working of the pump; this can lead to frothing and prolong the ventilation process accordingly.

When the steering system must be filled for the first time or after repairs, oil must be poured in before the suction pipe is fastened in the pump connection in order to prevent dry running in the start–up phase. Ensure particularly careful ventilation of the suction pipe. In cases where free suction of the radial piston pump is hampered, it is recommended that the suction pipe is first filled with oil.

6.2 Ventilation

When the steering system has been filled so that the oil level no longer falls below the upper marking on the dipstick, run the engine for some time (2–3 minutes) at low speed (for vehicles with mobility–dependent emergency steering pump: drive axle with gear engaged for mobility–dependent drive axle jacked up). The majority of the air will escape from the cylinder compartments. The oil level should be observed during this process. If it falls still further, top up with oil immediately. To accelerate the ventilation process, it is recommended that the steering wheel is turned several times from lock to lock. At the limit positions, do not pull on the steering wheel any more than is necessary to turn the steering. Top up with oil if necessary until the oil remains constant at the upper mark of the dipstick and no air bubbles rise in the oil tank when the steering wheel is turned.

In vehicles with an additional working cylinder, the pipe connections must point up so that the air in the cylinders and pipes can escape. Undo or remove working cylinder if necessary.

For steering versions with automatic ventilation:

Steering versions with automatic ventilation no longer have vent screws. These steering systems automatically force out the air remaining in the housing after the above ventilation process. Automatic bleeder valves only operate in the flow pressure area, which is why unnecessary pressure build–up is to be avoided.

For steering versions with vent screw:

Note:
Do not turn the steering wheel during the ventilation process and run the engine at low speed. Remove plug cap on vent screw. Then open vent screw 1/2–1 revolutions so that air remaining in this part of the housing can escape. As soon as it is only oil that runs out of the hole of the vent screw, close this again and top up with oil. Then turn steering wheel several times by jerks from lock to lock and repeat ventilation process. Top up with oil. Tighten vent screw with 5 Nm. Replace plug cap.

With Servocom steering systems without automatic ventilation (horizontal fitting position of steering shaft bottom), the upper steering limiting screw (20 or 128) provides the ventilation. The lock nut must be loosened for this purpose. The hydraulic steering limiter must be inspected after the ventilation process.

If the above instructions were observed, the oil level in the oil tank must not rise more than 1 to 2 cm when the engine is stopped, depending on the size of the steering system. The residual air still remaining in the housing is not noticeable when driving. It is absorbed and expelled by the oil during driving operation.

Turn engine off and lower steering axle or drive axle.

7. Checking the oil level

The oil level should be checked at intervals of 5000–6000 kilometres or 100–120 hours of operation. Before removing the oil tank cover, thoroughly clean the tank and its immediate surroundings so that no dirt can get into the hydraulic fluid.

Attention:
Too low an oil level can lead to malfunctions causing partial or complete failure of the steering system. If oil has been lost, it is essential that the point of leakage is located and the damage repaired. Repairs to the steering gear should only be carried out in our ZF service agencies.
For vehicles with ZF Servocom RAS (rear axle steering system):
If the oil level is above the upper mark, there may be a leak in the master cylinder of the ZF Servocom RAS. This leads to oil being forced from the ZF Servocom RAS into the front axle steering system.

7.1 Checking oil level with engine stationary

To ensure that no air is sucked in when the engine is started, determine first whether there is any loss of oil with the engine stationary (vehicles for mobility–dependent emergency steering pump: drive axle for mobility–dependent pump not driven). The tank must be topped up with enough oil so that the oil level is approx. 1 to 2 cm above the upper mark of the dipstick.

7.2 Checking oil level with engine running

With the engine running (vehicles with mobility–dependent emergency steering pump: gear engaged and drive axle for the mobility–dependent pump jacked up as instructed by the vehicle manufacturer), the oil level falls a little because the oil requires a pressure of 2 to 4 bar as a result of the flow resistances in order to flow through the steering gear.

Now enough oil is poured in for the oil level to be constantly at the upper mark. The engine can then be stopped again. The oil level must rise max. 1 to 2 cm. If this is exceeded, it shows that air is still trapped in the oil.

Irksome noises may be produced in the steering system if:

1. A filter cartridge is contaminated, replace with new one.
2. Screwed connections on suction side are not sufficiently tightened, so that air is sucked in. Tighten connections, apply varnish paint if necessary.
3. There is too little oil in the system. Top up with oil.

IV. Adjustments to the steering system installed in the vehicle, types 8033–46 and 8056–70

Note:
The measuring and setting tools used must be inspected regularly for accuracy.

1. Eliminating steering free play in straight–ahead driving (setting pressure point)

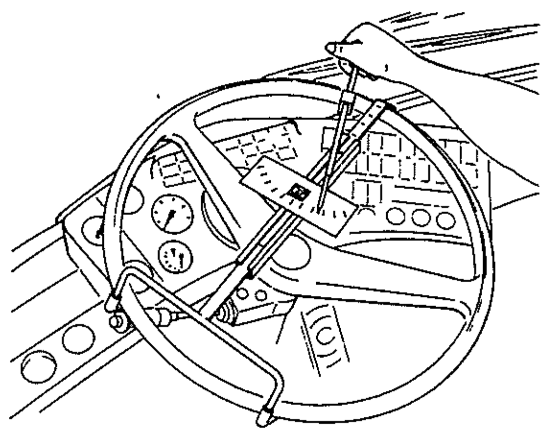
   a) Jack up steering axle.

   b) Turn steering into centre position (roughly found by halving the total number of revolutions of the steering wheel) and remove eccentric rod of steering arm (Section IX).

   c) Undo sealing nut (50 or 27) on housing cover.

   d) Turn steering into limit position and measure the moment of friction required to turn the steering out of straight–ahead driving (approx. 1/2 revolution before end lock). To turn the steering, the tool [6] should be used and this is placed and clamped to the rim of the steering wheel ***(Illus. 21)***.

   e) Then measure moment of friction of steering in pressure point area (centre position). To do this, make 1/2 revolution on tool [6] to left and to right across straight–ahead driving and tighten the adjusting screw (31 or 62) until an increase in moment of friction of 40–60 Ncm is measured over the value measured under Para. d).



Illus. 21

   f) Tighten sealing nut (50 or 27) with a torque of 90 Nm (for lock nut without seal, 70 Nm), while holding the adjusting screw tight. Check set torque again.

It will not improve steering property and the contact ratio in any way if the moment of friction in the straight–ahead driving area is set to be greater than 60 Ncm. Instead, it will produce too great a pressure on the adjacent parts and thereby unnecessary abrasion.

Mount and secure eccentric rod (adhere to tightening torques of vehicle manufacturer).

2. For setting of steering limiter, see Section II.

Free play in the hydraulic power steering with pump stationary and operating

In normal driving, i.e. when the oil pump discharges pressure oil, the torsion bar is twisted and the steering valve offset when the steering wheel is turned or there is a bump. This causes the hydraulic booster to engage. Only a very slight turn of the steering wheel or the sector shaft is required for this control process, so that a perceptible assistance becomes effective.

It is different if the power steering is actuated while the pump is stationary, e.g. when towing. With greater steering forces the whole valve lift of the control valve up to the stop must be overcome before the rotary movement of the steering wheel is transmitted to the sector shaft. There is then a perceptible free play when steering without hydraulic assistance on the steering wheel.

V. Instructions for eliminating external leaks

Attention:
To guarantee safe functioning of the steering system, ensure the utmost cleanliness when carrying out installation. Under no circumstances must force be used when assembling. The resulting damage could lead to the partial or complete failure of the steering function.
The measuring and adjusting tools used for repair must be subjected to a regular inspection for accuracy.

Note:
The numbers in brackets, e.g. (22), refer to the numbers in exploded views and the list of replacement parts.

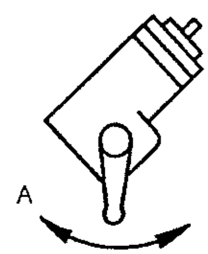
Grades of oil used: Spectron FO 20 from DEA or equivalent calcium complex grease of consistency class 2.

1. Replacing the shaft seal on the steering arm, type 8033–46

1.1 Mark position of universal joint, arrow of protecting cap and steering arm stump to each other and/or check agreement of marking stroke on steering arm stump with clamping slot of universal joint. Remove lower fastening screw on universal joint and pull universal joint from serration of lower steering column. Remove protecting cap (70).

1.1.1 For steering version with intermediate cover

Attention:
When carrying out the following operation, ensure that the worm is not screwed out of the thread of the piston, as there is otherwise the possibility that balls from the planetary thread will fall into the piston hole, which may lead to the steering being locked. This is best prevented if the steering wheel is turned to the full lock at which the piston is in the upper position or the steering arm swings forwards in direction "A" ***(Illus. 22)***. At the same time, the intermediate cover remains on the housing.



Illus. 22

a) Unscrew fastening screws (132). Remove cover (128). Press out shaft seal (129).

b) Use tool [8] to press new shaft seal (129) into cover (128) with sealing lip pointing into housing. Fill cavity between sealing lip and dust lip with grease (see note).

c) Place tool [9] on lower steering arm and fit cover (128). Screw in fastening screws (132) and tighten.

Tightening torques:	M 10:	62 Nm
	M 12x1.5:	115 Nm
	M 14x1.5:	190 Nm

1.2 For steering versions with ring nut in cover or short radius

a) Disconnect retaining ring (130). Remove shaft seal (129) using a suitable hook. Do not damage seal seat while doing so.

b) Place tool [9] on steering arm. Use tool [8] to press new shaft seal (129) into cover (128) with sealing lip pointing into housing. Only insert seal far enough to just guarantee that the retaining ring (130) is in the correct groove and that the vent groove is not covered.

Fill cavity between sealing and dust lip with grease (see note).

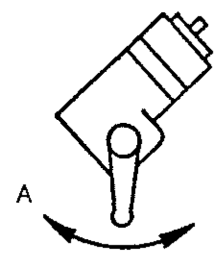
1.2 Apply grease to shaft seal (see note) and fit protecting cap (70). Protecting caps of new design on the housing must be pretensioned. Push universal joint on serration in such a way that the slot of the lower yoke aligns with the marking on the steering arm.

Put hexagon screw through hole of yoke; ensure that hole and free rotation of steering arm stump are congruent. Tighten nut.

Tightening torques:	M 8:	24 Nm
	M 10 x 1.25:	48 Nm

2. Replacing the shaft seal on the steering arm, type 8056–70

Attention:
When carrying out the following operation, ensure that the worm is not screwed out of the thread of the piston, as there is otherwise the possibility that balls from the planetary thread will fall into the piston hole, which may lead to the steering being locked. This is best prevented if the steering wheel is turned to the full lock at which the piston is in the upper position or the steering arm swings forwards in direction "A" ***(Illus. 23)***. At the same time, the intermediate cover remains on the housing.



Illus. 23

a) Mark position of universal joint, arrow of protecting cap and steering arm stump to each other and/or check agreement of marking stroke on steering arm stump with clamping slot of universal joint. Remove lower fastening screw on universal joint and pull universal joint from serration of lower steering arm. Remove protecting cap (160).

b) Disconnect pressure and return line from steering system.

c) Unscrew fastening screws (95 and 134). Remove valve housing. Press out shaft seal (131) from outside in.

d) Use tool [12] to press new shaft seal (131) into valve housing with sealing lip pointing into housing. Fill cavity between sealing lip and dust lip with grease (see note).

e) Place tool [13] on lower steering arm and then fit valve housing carefully. Screw in fastening screws (95 and 134).

Tightening torques:	M 8 x 1- 8.8:	25 Nm
	M 8 x 1- 10.9:	35 Nm
	M 12 x 1.5:	115 Nm
	M 14 x 1.5:	206 Nm

f) Apply grease to shaft seal (see note) and fit protecting cap (160). Push universal joint onto serration in such a way that the slot of the lower yoke aligns with the marking on the steering column.

g) Put hexagon screw through hole of yoke; ensure that hole and free rotation of steering arm stump are congruent. Tighten nut.

Tightening torques:	M 8:	24 Nm
	M10 x1.25:	48 Nm

3. Replacing the shaft ring on the drive bevel gear for versions with angle gear, type 8090–98 and 8056–70

a) Remove lower fastening screw on universal joint. Pull universal joint from serration of bevel gear. Remove protecting cap (314).

b) Undo slotted nut (313) and remove setting screw (312) from housing (301).

c) Press shaft seals (310 and 310.1) from setting screw. Pull o–ring (308) from housing slot.

Attention:
The bevel gear should only be extracted from the housing if absolutely necessary, e.g. for polishing the seal surface, as otherwise the meshing, which must have no free play when the steering gear is in straight–ahead driving position, will no longer be true. In this case, first turn the steering into straight–ahead driving position and then bring the notch on the steering arm congruent with the housing marking.

d) Fit o–ring (308) into radial slot of the housing, behind the tapped hole. Press the two shaft rings (310 and 310.1) into the setting screw (312) (the dust lips seal first) with the sealing lips pointing into the housing. Fill the cavities between the sealing lips with grease (see note).

e) To protect the sealing lips of the shaft seals, place tool [13] on the serration of the bevel gear. Push setting screw (312) on and screw in. Only tighten setting screw until the bevel gear is free of axial play. (The moment of friction of the bearing setting when the angle gear is dismantled must be 40 to 70 Ncm). Fit slotted nut (313) and tighten with 50 Nm, while holding setting screw firmly. Apply grease to shaft seal (see note), slide on protecting cap (314 and 70 or 160).

f) Push universal joint on serration in such a way that the slot in the lower yoke and the marking notch on the bevel gear agree.

g) Put hexagon screw through hole of yoke. Tighten nut.
Tightening torques: M 8: 24 Nm and M 10x1.25: 48 Nm

4. Replacing the shaft seal on the steering shaft, type 8033–46 and 8056–70

Note:
The following operation only applies to steering versions in which the steering shaft is sealed by means of shaft seals (4 or 6) instead of oval seals together with back–up rings, e.g. types 8043 and 8066. If the oval seals are not tight, the steering system must be disassembled. This should only be carried out by ZF service agencies.

a) Remove mounting of steering arm and remove steering arm using tool [7].

Attention:
Under no circumstances should the steering arm be removed by heating or driving in a wedge between the neck of the housing and the steering arm or by hammering, as this causes damage within the steering gear and material changes to the steering arm.

b) Disconnect retaining ring (7 or 3) on housing neck.

c) Remove shaft seal (6 or 4) from the housing neck using a suitable screwdriver or hook.

d) Plush tool [10] or [13] onto steering shaft. Push shaft seal with sealing lip to housing and with grease (see note) between sealing lip and dust lip over the sleeve and press into housing neck using tool [11] or [15].

e) Replace retaining ring (3 or 7). Push dust seal (1.1) with grease (see note) between dust seal and housing up to location on the sector shaft.

f) Push steering arm onto steering shaft; the marks on the steering arm and the shaft must agree. Tighten and secure hexagon nut with torques given in Section X.

VI. Removing and installing pressure relief valve and replenishing valve

1. **Pressure relief valve** – ZF Servocom and ZF recirculating ball power steering, type 8033–46

   a) Unscrew valve core (22 or 23) from housing. The valve core cannot be disassembled. In the event of wear or pressure deviation, the complete valve must be replaced.

   b) Fit greased o–ring (23 or 22) into slot of valve core (22 or 23). Screw in valve core.

   c) Tightening torque: 30 Nm.

2. **Replenishing valve** – ZF Servocom, type 8090–98

   a) Unscrew screw (30) and valve core (32).

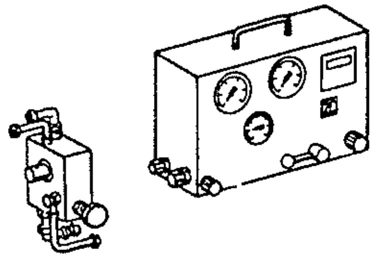
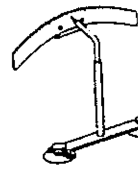
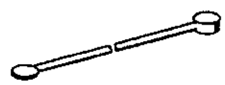
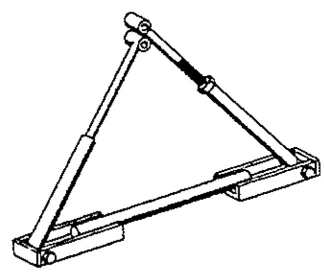
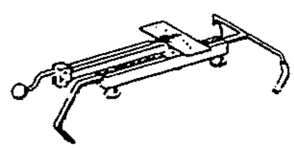
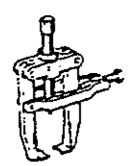
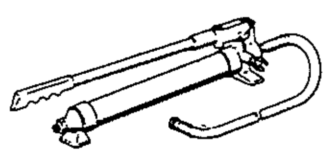
   b) Insert valve core (32) into housing hole. Screw in screw (30) with fitted and greased o–ring (21).

   c) Tightening torque: 30 Nm.

Attention:
With the exception of the work given under Sections IV, V and VI, no other repairs necessitating disassembly of the power steering should be carried out. Repairs going beyond the work described above should be carried out by a ZF service agency.

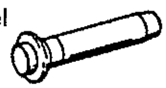
VII. Special tools

a) Tools for inspection

		Tool number
Tool [1] a) Servotest 550 hydraulic steering tester b) Sep. flow control valve 2 dm³/min - Servocom only		7418 798 550 7418 798 539
Tool [2] Dial with pointer for checking free play on steering wheel		7418 798 452
Tool [3] Thrust piece for limiting wheel turn (use special tool prescribed by vehicle manufacturer)		7418 798 556
Tool [4] 1 pair spreaders (use special tool prescribed by vehicle manufacturer)		7418 798 653
Tool [5] Locking device for steering arm (use special tool prescribed by vehicle manufacturer)		7418 798 652
Tool [6] Torque meter for setting pressure point		7418 798 703
Tool [7] Extracting device for steering arm a) Extracting device		7418 798 202
b) Hydr. extracting device consisting of: Hand pump Cylinder		7016 798 201 0646 121 048
Bell for steering shaft diameters up to 45 mm		418 798 214
for steering shaft diameters from 55 mm, useful width 102 mm		7418 798 213
for steering shaft diameters from 55 mm, useful width 120 mm		7418 798 216

b) Tools for repair, type 8033–46

Tool [8]
Inserting sleeve or mandrel for shaft seal (129) – steering arm
a) for version with intermediate cover (122)

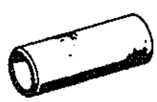


b) for version with ring nut in cover (128) or short radius

Tool [9]
Sleeve for protecting shaft seal (129) on lower steering arm

Tool [10]
Guide sleeve for protecting shaft seal (6) on sector shaft

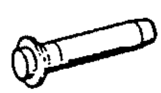
Tool [11]
Guide sleeve or inserting sleeve for shaft seal (6) in housing neck



	8033	8036	8037	8038	8042	8043 8044	8045	8046
Tool [8] a)		8052 798 056		7418 798 051			7418 798 051	
Tool [8] b)	8033 798 001		8037 798 002	7404 798 001				
Tool [9]	7832 798 001	8052 798 003	7359 798 001	7418 798 006				
Tool [10]		7409 798 001		7425 798 002	8065 798 001		7438 798 002	
Tool [11]		7419 798 003		7425 798 002	8065 798 002		7438 798 003	

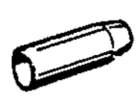
c) Tools for repair, type 8056–70

Tool [12]
Mandrel for shaft seal (131) in valve housing

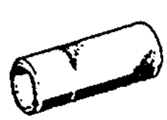


Tool [13]
Guide sleeve for protecting shaft seal (131) on lower steering arm

Tool [14]
Guide sleeve for protecting shaft seal (4) on sector shaft



Tool [15]
Inserting sleeve for shaft seal (4) in housing neck



	8056	8058	8060 8062	8065	8066	8070
Tool [12]	8052 798 051		7418 798 051			
Tool [13]	8052 798 003		7418 798 006			
Tool [14]	8056 798 001	7409 798 001	7425 798 002	8065 798 001		7438 798 002
Tool [15]	8056 798 002	7419 798 003	7425 798 003	8065 798 002		7438 798 003

VIII. Instructions for inspection

Vehicles with ZF hydraulic power steering should be taken to the workshops of the vehicle manufacturer or the ZF service agencies for inspection of the ZF steering systems and ZF oil pumps according to the following mileages and operating hours.

The inspection intervals given below depend on the type of use of the vehicle. For vehicles fitted with neither a tachometer nor an operating hours counter, a fuel flow volume corresponding to the intervals should be used as a guideline.

- **For ZF recirculating ball power steering systems, types 8033–8046, types 8056–8070 and ZF Servocom steering systems produced up to 12/93**

Type of use	1st inspection Inspection in vehicle	2nd inspection Inspection in vehicle	3rd inspection
- Long–distance vehicles	100 000 km 60 000 miles	200 000 km 120 000 miles	300 000 km 180 000 miles
- Vehicles in highway and short–distance use	100 000 km 60 000 miles	175 000 km 105 000 miles	250 000 km 150 000 miles
- Construction vehicles and off–road vehicles	80 000 km 50 000 miles 2 500 op. hrs.	150 000 km 90 000 miles 4 500 op. hrs.	200 000 km 120 000 miles 6 000 op. hrs.

To increase road safety, we recommend that the steering system and pump are disassembled in the 3rd inspection, the mechanical steering parts examined (visual examination of all parts and check for cracks on parts under stress) and new sealing parts are fitted. This work should be carried out by a ZF service agency.

- **For ZF Servocom steering systems produced from 1/94**

Type of use	1st inspection Inspection in vehicle	Additional inspection Inspection in vehicle
- Construction vehicles - Vehicles for short–distance use - Vehicles with high load population	200 000 km 6 000 op. hrs or after no more than 5 years	every 200 000 km 6 000 op. hrs or after no more than 5 years
- Long–distance vehicles - Buses	500 000 km	after every additional 250 000 km

Carrying out the 1st and 2nd inspection

Note:

a) In order to be able to form an idea of the condition of the vehicle and the power steering before carrying out the following inspection, and to compare the performance of the power steering before and after inspection, we recommend a test drive. This is particularly recommended if the driver has a poor opinion of the steering system. Before going on a test drive, check the oil level and ventilation of the steering system.

b) The measuring and adjusting tools used must be subjected to regular inspection.

1. Checking the mechanical functioning of the steering

Attention:
Do not turn steering systems with automatically adjustable hydraulic steering limiter into limit positions when the steering linkage has been removed (see Section II, Para. 1.5).

1.1 Checking seat of the fastening screws

Tighten screws on steering and steering mounting with the torque prescribed by the vehicle manufacturer. Check sheet metal and splint mounting for perfect performance. By alternately turning and straightening the steering wheel while the vehicle is stationary, check whether the steering arm still has a firm seat on the serration of the sector shaft.

1.2 Checking straight–ahead driving position of steering and vehicle

Jack up steering axle as instructed by vehicle manufacturer (if the vehicle does not have a rigid steering axle, the wheels should be on rotary tables). Bring steering into centre position by halving the total number of steering wheel revolutions. Then turn further until markings on steering shaft and housing agree. The wheels steered should be in straight–ahead driving position (this can be checked roughly by placing a measuring strip on both front wheels and back wheels and noting toe–in). Correction is effected by screwing ball joint on eccentric rod in or out.

Attention:
If the steering linkage must be corrected longitudinally, the reason for this may be a previous accident–type incident. It is recommended therefore that the serration on the sector shaft (30) is examined for torsion (remove steering arm to do this), the steering shaft for distorted installation and all other transmission parts for bending or cracks and that the free play is measured according to Para. 7.7. Deformed parts must not be bent straight but should be replaced.

For versions with automatically adjustable hydraulic steering limiter ZF Servocom:
If necessary, install new valve sleeve assemblies (20 or 128) and reset steering limiter – see Section II Para. 1.5.

1.3 Checking free play between piston and sector shaft in centre position

a) Turn steering into centre position (see 1.2) and remove eccentric rod from steering arm.

b) Measure moment of friction when turning across the pressure point area. It should be greater by the following values than outside the pressure point:

Type 8090: 20 - 60 Ncm
Type 8095: 20 - 80 Ncm
Type 8097/8098: 20 - 100 Ncm

Type 8033–46: 40 – 60 Ncm
Type 8056–70: 40 – 60 Ncm

To set pressure point (only types 8033–46 and 8056–70), see Section IV. Adjustment of pressure point with ZF Servocom is only possible when dismounted (ZF service agencies).

1.4 Checking steering lock

Connect eccentric rod temporarily. Turn steering to the left up to lock. Disconnect eccentric rod and turn steering wheel further to ascertain whether there is still steering reserve. Repeat measurement to right. There must be steering reserve on both sides. If this is not the case, the wheel lock screws must be reset. Connect eccentric rod again.

Note:
When the steering linkage has been removed, steering systems with automatically adjustable hydraulic steering limiter (ZF Servocom) may only be turned into limit positions if there is to be a subsequent resetting with new valve sleeve assemblies (128); if necessary, remove valve sleeves and fit plugs for this inspection.

1.5 Checking free play of steering shaft support in steering column

Check whether there is free play by making lateral movements (shaking) on the steering wheel. If there is free play, replace bearing bush.

1.6 Checking circumferential backlash or sluggishness in universal joint or in flexible disk between upper steering shaft and steering gear

If there is free play (produces audible rattling on shaking) or sluggishness, fit new part.

1.7 Checking steering shaft and jacket tube for maximum permissible bend

Jack up steering axle as instructed by vehicle manufacturer. Remove steering wheel and self–aligning bearing ring or ball bearing bush from the jacket tube. Check the permissible bend of steering shaft and jacket tube in accordance with Section X.

2. Checking for external tightness

a) Start engine.

b) Check whether all screwed connections and lines of steering system and seals on steering and pumps are tight. Tighten screwed connections and replace seals if necessary. When fitting new seals, we recommend that you use our special tools.

c) Check all hoses and lines for possible abrasion points and brittle cracks. Replace defective parts.

Attention:
For hose lines and externally visible damage such as cracks, fit only pressure–tested replacement parts recommended by the manufacturer. Note replacement part numbers of vehicle manufacturer.

d) Stop engine.

3. Checking V–belt tension

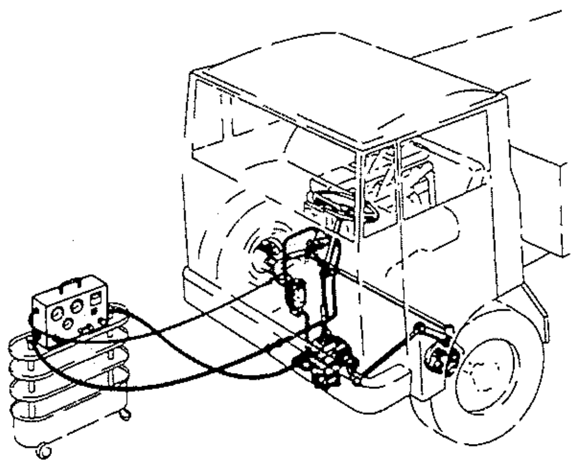
Check tension of V–belts using the usual thumb tests (adhere to instructions of vehicle manufacturer). The V–belts must not overrun even under maximum pressure. Replace defective V–belts.

4. Fitting hydraulic steering tester

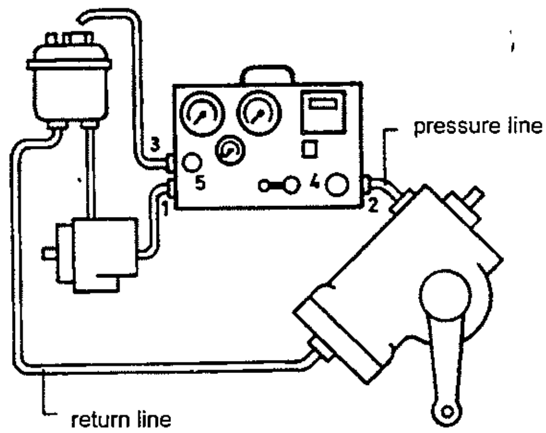
Fit Servotest 550 hydraulic steering tester in the pressure line between oil pump and ZF power steering (see ***Illus. 24*** and ***25***) in such a way that the display instruments can be easily observed from the driver's seat. Connect pressure line from pump with connection "input 1" of tester and connection "output 2" with line to the steering (see separate operating instructions for Servotest 550). Steering systems which have a pressure relief valve positioned according to Section 7 Para. 2b) must be connected to the oil tank from connection "tank 3" of the tester.

It is enough to insert the hose end into the opening of the removed tank cover. See ***Illus. 25*** for diagram of connections. Note oil level and top up if necessary. Ventilate steering system.

Illus. 24
Hydraulic connection diagram for hydraulic steering tester using ZF Servocom steering system as example



Illus. 25
Position of hydraulic steering tester valves after connection (idle position): pressure relief valve 120 bar, throttle valve closed, shutoff valve open.



5. Oil filling
See Section III (maintenance and oils).

6. Ventilation
See Section III (maintenance and oils).

7. Checking hydraulic functioning of steering and pump

Note:
To carry out the following pressure and overflow oil checks, 2 types of steering must be differentiated.

a) Steering systems in which **the pressure relief valve** is located **in the pump or pressure line**. This means that the pressure is relieved before the installed tester. In these steering systems, the maximum pressure, e.g. 100 bar, is indicated on the rating plate of the pump or pressure relief valve.

b) Steering systems in which the **pressure relief valve** is installed **in the steering system or separately in the pressure line between tester and steering**. The valve can thus no longer control the oil pressure if the pressure lines are blocked by the installed shutoff valve of the test device. In these steering systems, the maximum pressure is indicated on the rating plate of the steering or pressure relief valve.

7.1 Checking ZF pump for pressure

Read the maximum pressure from the rating plate of the steering or the pump or the separate pressure relief valve. Run engine until warm. Oil temperature 50°C.

a) For steering systems with pressure relief **before** tester:

With the engine at idle speed, close shutoff valve of tester. Read pressure from manometer.

Attention:
Only operate maximum pressure for a short time, no more than 5 seconds, as otherwise the internal parts of the pump will be too hot, leading to premature wear. Bring shutoff valve into starting position again. The permissible deviation from nominal pressure must be no more than ± 10%.

If the difference is greater, the functioning of the pressure relief and flow control valve must be checked and the valve adjusted if necessary.

Checking the valve:
Remove pressure relief and flow control valve from ZF oil pump. Check valve piston and hole in valve housing for visible wear. The holes in the valve piston must not be clogged. The piston must be able to be moved slightly and must not stick. If necessary, a new valve must be fitted.

If the maximum pressure of the pump is still too low after this check, the internal parts of the pump must be examined for wear. In this case we recommend that the pump is exchanged.

b) For steering systems with pressure relief **behind** tester:

Attention:
If the tester has been installed as described in b), ensure that the engine is only run at idle speed for the complete duration of the pressure testing. An increase in engine speed would result in an immediate, jerky rise in the oil pressure. In this case there is a danger that the pressure line will become defective or the pump will seize up.

With the engine at idle speed and while observing the manometer, close the shutoff valve of the tester slowly until the maximum pressure has been reached. Do not close valve any more (only operate maximum pressure for a short time, no more than 5 seconds, as otherwise the internal parts of the pump will be too hot, leading to premature wear). Bring shutoff valve into starting position again. If the measurement does not show nominal pressure, the functioning of the flow control valve must be checked and the valve adjusted if necessary.

Checking the valve:
Remove flow control valve from ZF oil pump. Check flow control valve piston and hole in valve housing for visible wear. The holes in the valve piston must not be clogged. The piston must be able to be moved slightly and must not stick. If necessary, a new valve must be fitted.

If the maximum pressure of the pump is still too low after this check, the internal parts of the pump must be examined for wear. In this case we recommend that the pump is exchanged.

7.2 Checking ZF oil pump for flow rate using Servotest 550 hydraulic steering tester

Note:
For setpoint values for flow rate, test pressure and test speed, see table. For descriptions and operation of hydraulic steering tester, see separate operating instructions for Servotest 550.

a) Checking minimum flow rate

With engine at idle speed, close shutoff valve until test pressure for pump type is reached. Read off flow rate. Note conversion of engine speed to pump speed.

At a pump pressure of 50 bar (120 bar for pump type 8601), the minimum flow rate is:

for pump type	minimum flow rate dm^3/min	speed rpm
7633	6.0	800
7634	6.0	700
7636	6.0	500
7638	6.0	400
7646	6.5	350
7671	2.6	500
7672	4.5	500
7673	6.1	500
7674	7.5	500

for pump type	minimum flow rate dm^3/min	speed rpm
7677	8.5	500
7681	3.1	500
7683	4.5	500
7684	5.9	500
7685	7.0	500
7686	9.4	500
8601	2.0	1000
8605	5.0	350
8607	5.0	350

b) Checking the controlled flow rate

Increase speed until the capacity of the pump remains constant despite a further increase in speed, approx. 1300 rpm. The pump is now in the limiter area. The setpoint value of the capacity can be read from the respective list of replacement parts for the oil pump.

7.3 Checking the hydraulic steering limiter

a) Mechanically adjustable hydraulic steering limiter

Turn steering wheel clockwise as described under Section II, with steering axle under stress (jack up rigid axle or use rotary tables for independent suspension). Once the wheel lock has been reached, a brief (max. 5 seconds) continued turning of the steering wheel will overcome the resetting force of the steering valve until a fixed steering wheel lock is achieved. To reach this a peripheral force on the steering wheel of approx. 100–200 N is required. In this position, read off the oil pressure on the manometer; this should be no greater than indicated under Section II. For setting of the steering limiter, please refer to Section II. Para 1.4.

b) Automatically adjustable hydraulic steering limiter – ZF Servocom

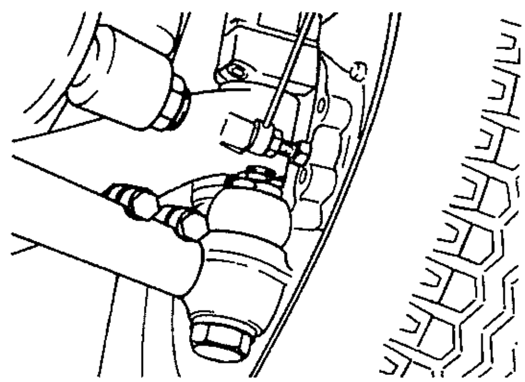
Carry out check as described under a), but with no spacers inserted. If there is no space on the wheel lock parts or the oil pressure does not fall to the value given in Section II Para. 2, fit new sliding valve assemblies (20 or 128) and reset steering limiter according to Section II Para. 1.5.

If the space on the wheel lock parts is too great and the oil pressure falls to the prescribed value, reset steering limiter according to Section II Para. 1.5.

Carry out check in the same way while steering anticlockwise.

7.4 Checking steering system for pressure

Tool [3] or thrust pieces approx. 15 mm thick *(Illus. 26)* are inserted between the wheel lock parts in such a way that the steering lock is restricted 1/2 to 3/4 of a steering wheel revolution before reaching full lock. Restriction of the steering lock should therefore be effected using these thrust pieces, but not in the hydraulic power steering through the working piston on the cylinder.



Illus. 26

Attention:
A tool under pressure may be ejected – avoid direct eye contact with the tool. If the tool locks during steering lock, it is essential that there is sufficient clearance between the wheel and the vehicle chassis for this. There is a danger of the hand being squeezed e.g. when the tool is ejected and the wheel subsequently resettles. Depending on the type of axle, use the special thrust piece specified by the vehicle manufacturer.

With engine at idle speed, turn steering wheel to the right until full lock and continue turning right for approx. 5 seconds with a force of 100–200 N on the steering wheel until the self–aligning force of the steering valve is overcome. The oil pressure is read off on the manometer. The same measurement is carried out steering to the left. If, when steering left or right or in both directions, it is discovered that the oil pressure at a steering force of 100–200 N is below the previously measured oil pressure of the pump, the steering hydraulics are not functioning properly. The cause of the pressure drop may be:

a) Pressure relief valve in the steering system (or separate) is not working properly.

b) There is too much overflow oil in the steering hydraulics (measure overflow oil flow).

7.5 Checking overflow oil using hydraulic steering tester

Note:
For descriptions and operation of hydraulic steering tester, see separate operating instructions for Servotest 550.

a) For steering systems with pressure relief before tester:

Keep 15 mm thick thrust piece between the wheel lock parts. With engine at idle speed, turn steering to full lock and pull on steering wheel with approx. 100–200 N (max. 5 seconds) so that steering valve is fully closed. Read off overflow oil flow and release steering wheel. Repeat check turning in opposite direction.

Attention:
A tool under pressure may be ejected – avoid direct eye contact with the tool. Depending on the type of axle, use the special thrust piece specified by the vehicle manufacturer.

b) For steering systems with pressure relief **behind** tester:

Close shutoff valve (4) completely and throttle valve (5) until there is back pressure 30 bar lower than the maximum pressure measured under 7.1. Open shutoff valve (4) again.

Keep 15 mm thick thrust piece between the wheel lock parts. With engine at idle speed, turn steering to full lock and pull on steering wheel with approx. 100–200 N (max. 5 seconds) so that steering valve is fully closed. Read off overflow oil flow and release steering wheel. Repeat check turning in opposite direction.

Max. permissible overflow oil values:

Type 8033 to 8037:	2.8 dm^3/min
Type 8038 to 8044:	3.0 dm^3/min
Type 8045 to 8046:	3.2 dm^3/min
Type 8056 to 8058:	2.0 dm^3/min
Type 8060 to 8070:	2.5 dm^3/min
Type 8090:	2.0 dm^3/min
Type 8095 to 8098:	2.5 dm^3/min

For ZF–Servocom type 8090–98:

For Servocom steering systems, the functioning of the high–pressure seals must also be checked while the flow rate is low.
Set hydraulic steering tester to flow rate of 2 dm^3/min. Connect separate flow control valve tool [1b] in series.
Repeat overflow oil check as described under a) or b). The overflow oil should not exceed the previously measured value. If this measurement shows a greater overflow oil value than was the case for measurement under a) or b), the cause may be that seals, especially the seals (117 and 123) in the piston or housing cover, are not in exact contact.

For ZF recirculating ball power steering, type 8033–46 and 8056–70:

Repeat overflow oil measurement with pressure of 20 to 30 bar.

The cause of excess overflow oil may be:

a) Pressure relief or replenishing valve in steering not working properly – replace.

b) Steering limiter valve switches off too early – to set, see Section II.

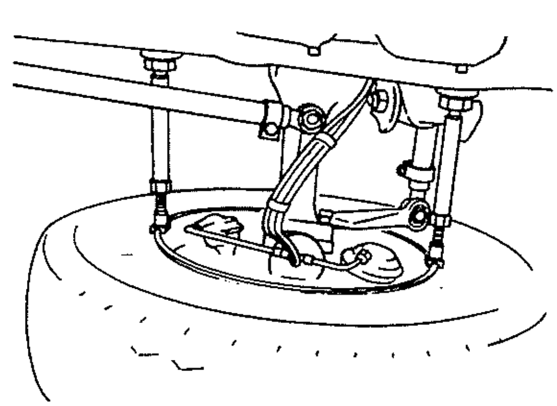
c) Seals in steering are defective – dismantle steering and have repaired by ZF service agency.

7.6 Checking valve restoring force

With the steering arm locked in the centre position, close the control valve by turning the steering wheel, thereby building up the maximum pump pressure. Then slowly release the steering wheel and again set a pump pressure of 10 bar above the flow pressure. The valve must then return to its original position within 1 second, i.e. the oil pressure must fall to at least 0.5 bar above the flow pressure.

7.7 Measuring the free play on the steering wheel with engine running and vehicle stationary in straight–ahead driving position

a) Lock front left wheel (front right wheel in right–hand drive vehicles) into straight–ahead driving position by fitting two expanding devices between wheel rim (front and back) and front spring ***(Illus. 27)***.



Illus.27

b) Place dial on steering wheel and attach pointer on dashboard or windscreen ***(Illus. 28)***.

c) With the engine running, begin to turn steering wheel slowly to the left while observing the manometer.

For ZF–Servocom:
higher engine speed, approx. 1000 rpm
oil temperature: 50–60°C

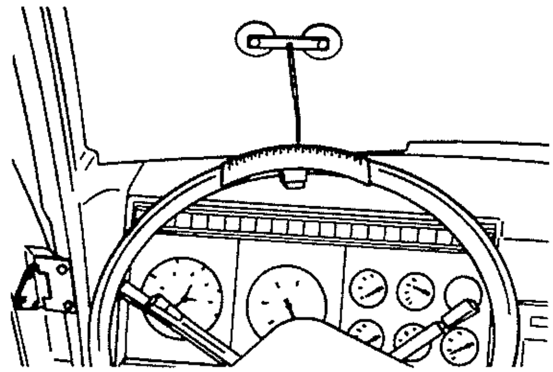
d) When a pressure rise of 1 bar above flow pressure has been reached ***(Illus. 29)***, hold the steering wheel firmly and mark value on scale.
Then turn steering wheel to right, again until a pressure rise of 1 bar has been reached. The total path travelled on the scale is measured.

Max. permissible travel:
Type 8090-98: 40 mm
Type 8033-46: 40 mm
Type 8056-70: 20 mm

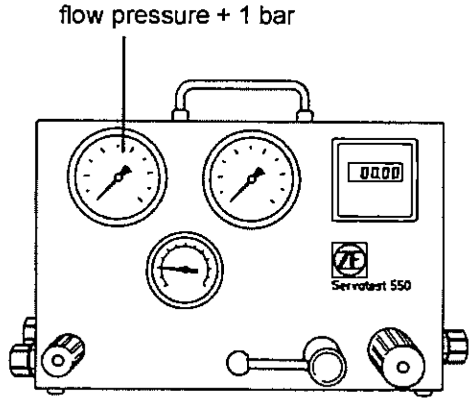
For steering versions with flange–connected or separate angle gear, the free play may be 5 mm greater.

If these conditions are not fulfilled, the measurement must be repeated with the steering arm locked ***(Illus. 30)***, since in the measurement carried out the free play in the ball joints of eccentric and track rods and in the other transmission parts was not eliminated. This check requires a good, play–free condition of the eccentric rod and the ball joint.

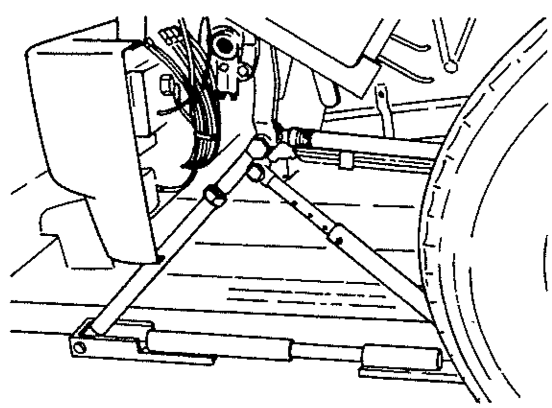
If the travel is greater than indicated even with the steering arm locked, there is mechanical play in the steering gear. This may also be the result of an accident–type impact. The steering gear should then be reconditioned or examined for accident damage by a ZF service agency (check for cracks). Switch off engine. Dismount hydraulic steering tester.



Illus.28



Illus.29



Illus.30

8. Filter change

Attention:
Before removing the oil tank cover, thoroughly clean the tank and its immediate surroundings so that no dirt can get into the hydraulic fluid.

a) Unscrew plug screw from cover of oil tank and remove tank cover.

b) Pull out used cartridge on metal collar. When removing the used filter cartridge, close the lower hole so that dirty oil does not run back into the tank.

If oil tanks are plastic, remove suction and return pipe. Disassemble oil tank, evacuate, clean and fit new filter cartridge.

c) Grease filter holders and fit new filter cartridge with metal collar pointing up.

d) Fill tank with oil up to neck.

e) Start engine. The oil level will fall rapidly. To avoid the intake of air, top up tank with oil immediately. Then ventilate steering system as described in Section III.

Note:
Illus. 26, ***27*** and ***30*** show universal devices provided by ZF. Depending on the type of vehicle, special devices approved by the vehicle manufacturer may also be required.

9. Test drive

After inspection work, a test drive should be carried out to check the vehicle and steering system for perfect functioning and external tightness.

IX. Removing the steering system from the vehicle

1. Thoroughly clean steering system and the directly surrounding area, especially the line connections.
2. Discharge oil as described in Section III, Para. 4.
3. Disconnect pressure and return lines.
4. Close all oil lines to avoid contamination.
5. Pull off steering arm using tool [7].

Attention:
Under no circumstances should the steering arm be removed by heating or by driving in a wedge between the neck of the housing and the steering arm or by hammering, as this causes damage within the steering gear and material changes to the steering arm.
Do not turn steering systems with automatically adjustable hydraulic steering limiters into limit positions when the steering linkage has been removed – see Section II Para. 1.5. If necessary, fit new sliding sleeve assemblies (20 or 128).

6. Disconnect universal joint or flexible coupling between steering gear and steering column or separately installed angle gear. Do not hit the steering shaft axially when dismounting the steering wheel.
7. Remove fastening screws on housing and extract steering system.

X. Installing the steering system in the vehicle

Attention:
To guarantee safe functioning of the total steering system, ensure absolute cleanliness when fitting all aggregates belonging to the system and when connecting the lines. To avoid malfunctions due to foreign bodies or dirt in the steering oil circuit, the sealing plugs on the line connections of steering system, oil pump, working cylinder, valves etc. should only be removed when connecting the lines. If possible, do not remove protective sheaths until installation is complete. Connecting lines and screwed connections must be cleaned and deburred carefully.
Do not turn steering systems with automatically adjustable hydraulic steering limiters into limit positions when the steering linkage has been removed – see Section II Para. 1.5. If necessary, fit new sliding sleeve assemblies (20 and 128).

1. Ensure that contact surfaces of mounting eyes of bearing block and steering system are free of paint and dirt.
2. Place steering gear in bearing block and screw down. Tighten screws with corresponding torque. Depending on the type of vehicle, the steering arm may require prior mounting for reasons of space (see Para. 7).

Attention:
When fastening jacket tube and steering shaft, particularly in the case of a separately installed angle gear with flange–connected jacket tube, it is essential to avoid pretensions which may occur in the steering gear/bearing block due to the retaining connection to the bulkhead or dashboard.
Pretensions can be generated through bending torques, especially in the steering shaft, and depending on size and frequency can in some cases lead to permanent fractures or impair the freedom of the steering gear.

3. To check whether the steering has been correctly installed, proceed as follows:

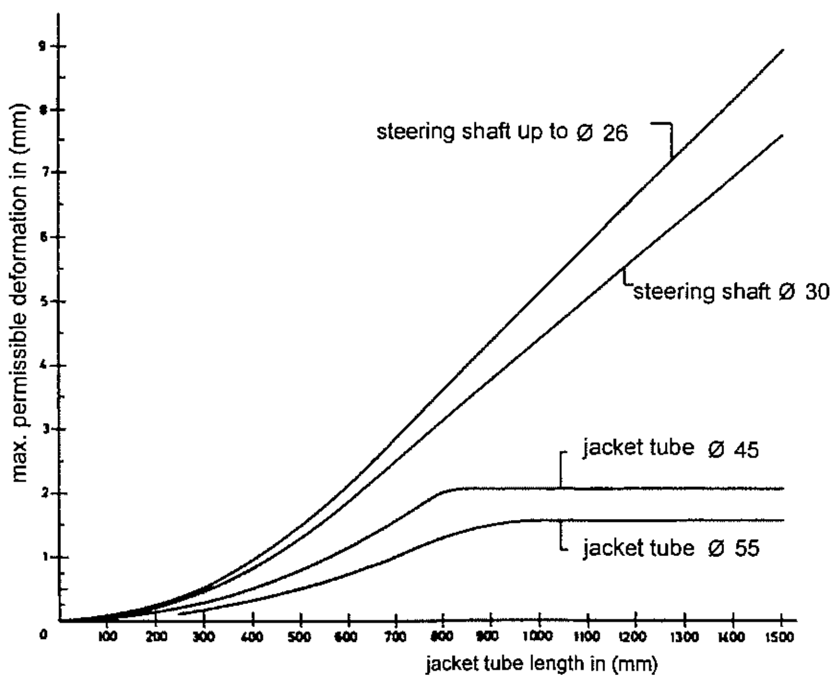
3.1 Check freedom of the steering gear or separately installed angle gear in the assembly with bearing block, steering arm and eccentric rod(s).

3.2 **Checking the permissible deformation of the steering shaft**

a) Raise steering axle in accordance with the instructions of the vehicle manufacturer so that the steering system can be easily turned by hand.

b) Remove steering wheel and dismount ball bearing sleeve or self–aligning bearing from the jacket tube of the separately installed angle gear.

c) By turning the steering shaft at least 360 degrees, establish whether the steering shaft is deformed. The measurement can be carried out using a dial gauge or a depth gauge, although the measurement must always be taken from the same point on the periphery of the jacket tube. The radial run–out measured, divided by 2, gives the deformation of the steering shaft. The maximum permissible deformation depends on the length of the jacket tube and the diameter of the steering shaft (see ***Illus. 31*** and the procedure for determining the length of the jacket tube).



Maximum permissible deformation of jacket tube and steering shaft ***Illus. 31***

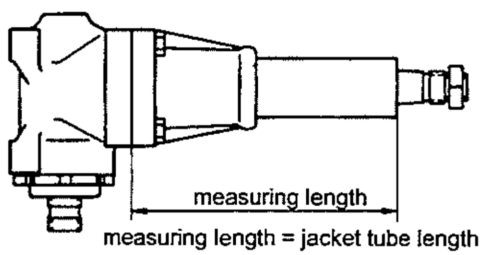
3.3 **Checking the permissible deformation of the jacket tube**

To do this, the steering shaft must be marked on one point on the periphery. Then turn the steering shaft in stages (at least 4 stages) and after each stage, use the depth gauge to measure the distance always from the external diameter of the jacket tube to the point marked on the steering shaft. Since the same steering shaft side faces the measuring point on the periphery of the jacket tube, the run–out of the steering shaft itself is not measured as well. The difference of the distance, largest measurement to smallest measurement, divided by 2, gives the deformation of the jacket tube. The maximum permissible deformation depends on the length and diameter of the jacket tube (see ***Illus. 31*** and the procedure for determining the length of the jacket tube).

Note:
This check must also be carried out during main inspection of the steering system and for vehicles with previous accident damage in the front area.

3.4 Determining the jacket tube length

Measure the length of the jacket tube including jacket tube flange – parting plane jacket tube flange/ housing ***(Illus. 32)***.



Illus. 32

4. Turn steering system into straight–ahead driving position (determined by halving the total number of steering wheel revolutions). The markings on the steering shaft and jacket tube or valve housing must agree.

5. a) Applies for separately installed angle gear with rigid steering column:

Screw in sliding contact and tighten with 5 Nm. Tightening torques for steering wheel nuts:

with cylindrical serration and cone 1:6:

M 18 x1.5:	35 - 45 Nm
M 22 x1.5:	40 - 50 Nm
M 26 x1.5:	60 - 70 Nm

Attention:
Do not hit the steering shaft axially when mounting and dismounting the steering wheel.

b) Applies for steering systems with separate steering column:

Fit universal joint or flexible coupling between steering column and steering gear. In the straight–ahead driving position, the offset yoke part must be at a right angle to the markings on the steering shaft and jacket tube or valve housing. If two joints are used, the diffraction angle should be the same and the yokes on a plane. If such an installation is impossible, parallelity can be reached by offsetting the yokes to each other on the serration.

With aluminium universal joints, hammer blows on the yokes should be avoided as this can lead to destruction or sluggishness. Connect both by using fit bolts and tightening the nuts. Tightening torques for fit bolts:

M 8:	24 Nm
M 10 x 1.25:	48 Nm

When fitting telescopic shafts, note max. permissible lift range.

6. Bring steered wheels of vehicle into straight–ahead driving position. This is reached when the steered wheels are flush or parallel to the second pair of wheels (use measuring strip on front and rear wheel).

7. Push dust seal (1.1) with Spectron FO 20 grease from DEA or equivalent calcium complex grease of consistency class 2 into spaces on sector shaft. Then place steering arm on serration so that markings on steering arm and sector shaft agree. Provisionally tighten nut securing steering arm and turn steering to the left until full lock. Remove steering arm and continue turning steering wheel to determine if there is still steering reserve available. Repeat measurement turning to the right. Tighten nut securing steering arm with the torque listed below and secure to prescribed place by caulking (peening depth: min. 1.5 mm). Connect and tighten eccentric rod.

   For versions with automatically adjustable hydraulic steering limiter:

   Remove steering arm and continue turning steering wheel to determine if there is still steering reserve available. Repeat measurement turning to the right.

   Screw in sliding sleeve assembly (20 and 128) (tightening torque 15+3 Nm).

   Tighten nut securing steering arm with the torque listed below and secure to prescribed place by caulking (peening depth: min. 1.5 mm). Connect and tighten eccentric rod.

   Do not turn steering systems with automatically adjustable steering limiter into limit positions when the steering linkage is dismounted – see Section II Para. 1.5. If necessary, fit new sliding sleeve assemblies (20 or 128).

☞ For versions with conical serration:

Thread	Gear	Tightening torques	Exception
M30x1,5	1 3/8"x36	250 Nm +10%	
M30x1,5	1 1/2"x36	300 Nm +10%	
M30x1,5	1 5/8"x36	330 Nm +10%	
M35x1,5		400 Nm +10%	
M42x1,5		500 Nm +10%	
M45x1,5		550 Nm +10%	MAN: 850 Nm+10%

☞ For cylindrical serration or binding screws:

see tightening torques prescribed by vehicle manufacturer

If the vehicle manufacturers specifies other values, these values must be applied.

8. Connect pressure and return line between pump, steering and working cylinder. If lines must be bent, this should be done when cold in order to avoid scaling.

   For hose lines with externally visible damage such as cracks, only pressure–tested replacement parts released by the manufacturer should be used. Note replacement part number of vehicle manufacturer.

9. Fill system with hydraulic fluid through oil tank.
   See Section III Para. 6.

10. Startup of steering system

    To avoid any particles of dirt still in the steering system getting into the pressure relief valve on first startup, it is recommended that oil flows through the steering system for some minutes at different engine speeds and without the steering wheel being turned. The steering should then be turned several times in both directions, but not to full lock, at average engine speed (until operating temperature is reached).
    Then ventilate steering system (see Section III).

11. Set hydraulic steering limiter.

    See Section II.

12. Check oil level.

    See Section III.

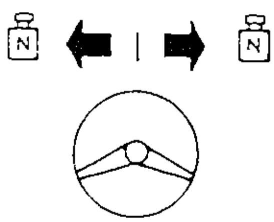
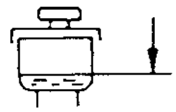
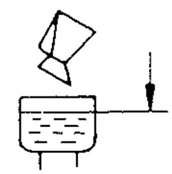
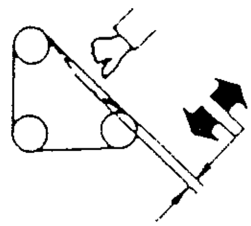
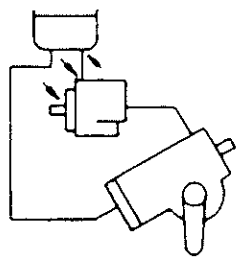
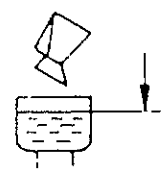
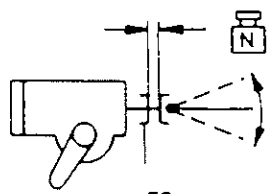
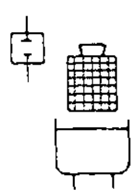
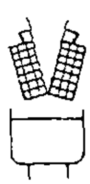
XI. Troubleshooting

ZF hydraulic power steering systems have been developed for heavy use. They are constructed so that no malfunctions can occur with perfect maintenance and under normal operation.

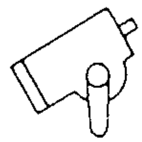
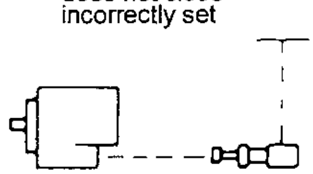
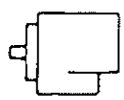
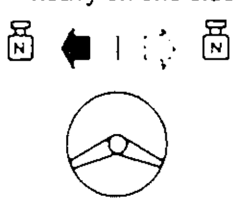
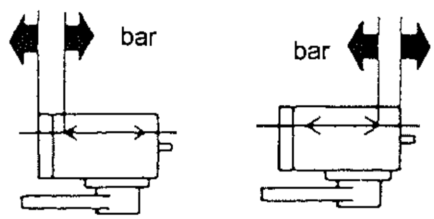
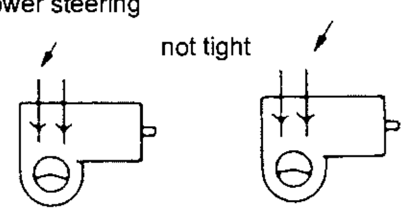
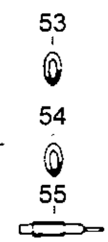
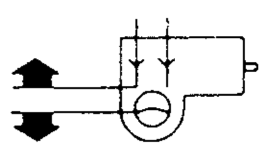
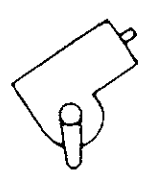
However, if this should not be the case, the following information should help locate and eliminate any problems.

Before examining the steering system for the individual faults, check the oil level with the engine running. The exact procedure for oil filling is described in detail in a separate section.

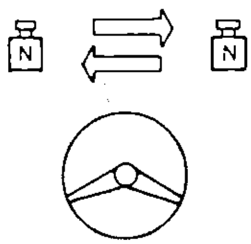
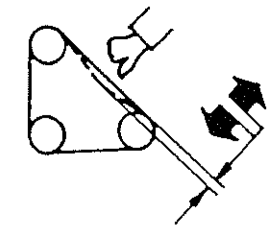
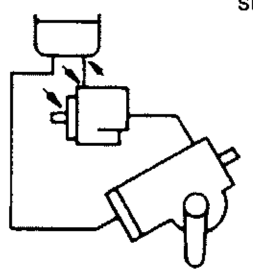
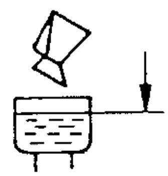
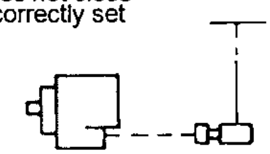
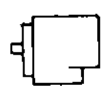
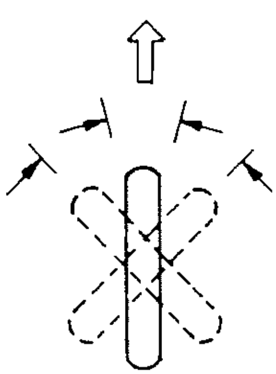
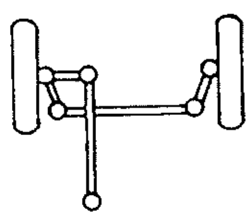
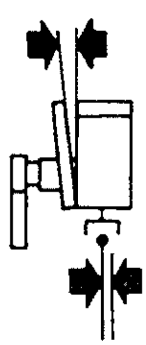
We must also point out that the use of very frothy oils can lead to faults, since such oils can only release air with difficulty, or not at all, once it has penetrated the steering system.

Fault	Cause	Remedy
heavy on both sides 	 	eliminate leakage 
		tension V–belt [1]
		replace seals [1]  ventilate
	 	grind off / replace [1]
	 contaminated/ broken	replace, clean control valve, suction line
		replace, clean control valve, suction line

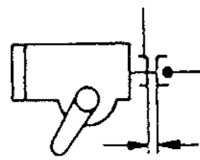
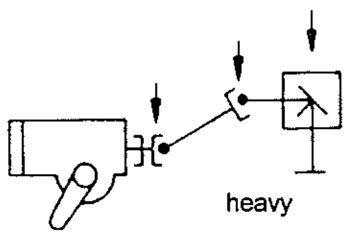
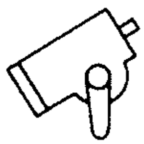
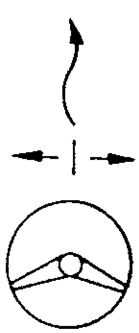
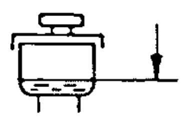
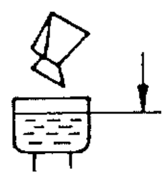
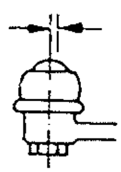
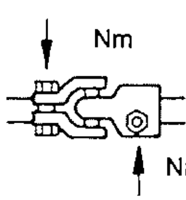
[1] refer to instruction of vehicle manufacturer

Fault	Cause	Remedy
	 internal fault	exchange steering [1]
	does not close – incorrectly set 	clean replace
	 internal fault	exchange pump [1]
heavy on one side 	Servocom 	set section II
	Recirculating ball power steering  	replace
	bar 	set section II
	internal fault 	exchange steering [1]

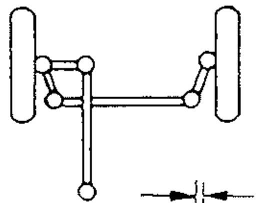
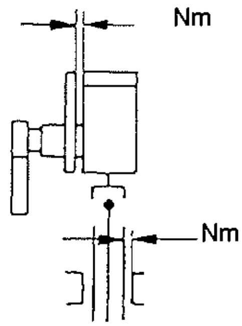
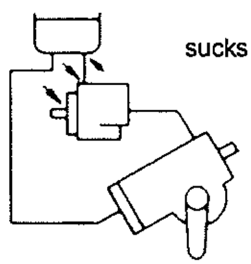
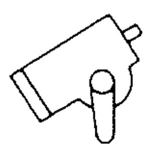
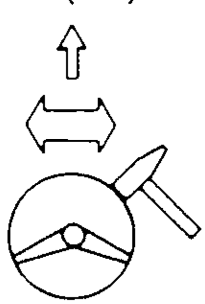
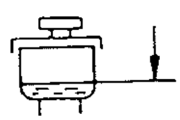
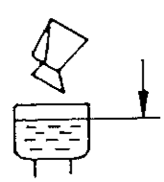
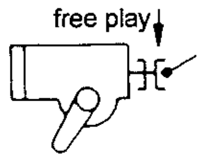
[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
heavy on quick steering 		tension V–belt [1]
	sucks in air 	replace seal  ventilate
	does not close – incorrectly set 	clean replace
	 internal fault	exchange pump [1]
inhibiting return V (km/h) 	 heavy	lubricate [1]
	distorted 	loosen bracing [1]

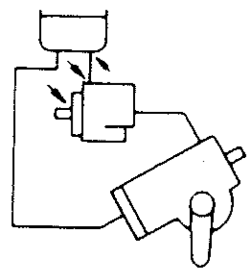
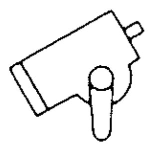
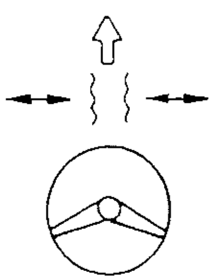
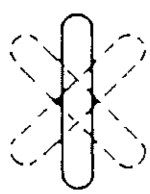
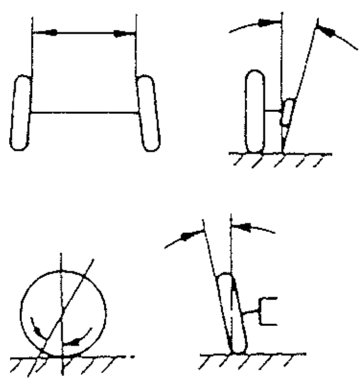
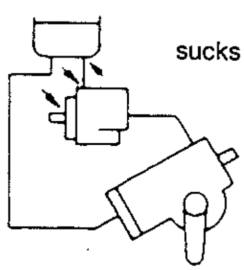
[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
	53  sticks	grind off / replace [1]
	 heavy	lubricate / replace [1]
	 internal fault	exchange steering [1]
not exact V (km/h) 	 min.	eliminate leakage  max. ventilate
		tighten / exchange [1]
	 Nm	tighten / exchange [1]
	Nm  Nm	tighten / exchange [1]

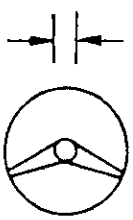
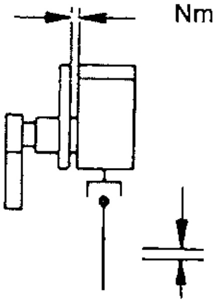
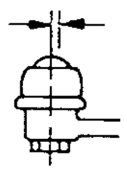
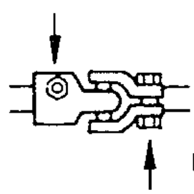
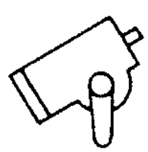
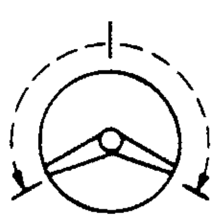
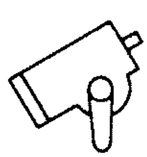
[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
	 heavy	lubricate ☐1
		tighten ☐1
	 sucks in air	replace seals ventilate
	 internal fault	exchange steering ☐1
steering wheel locks V (km/h) 	 min	eliminate leakage  max.
	free play 	replace ☐1

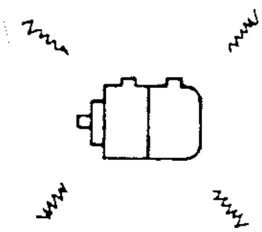
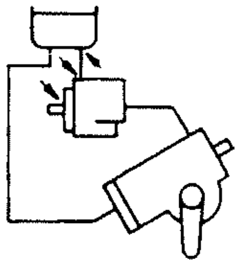
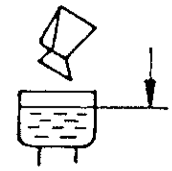
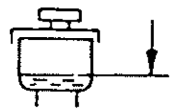
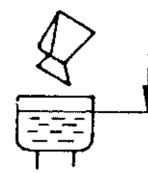
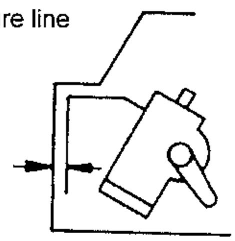
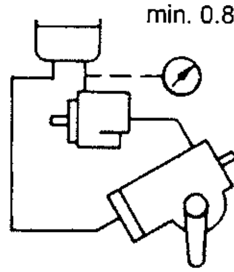
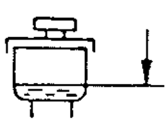
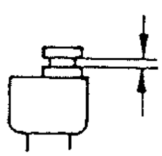
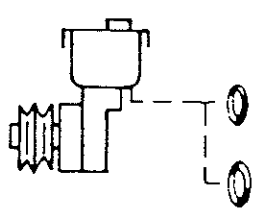
☐1 refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
	 sucks in air	replace seals ventilate
	 internal fault	exchange steering [1]
torsional vibrations V (km/h) 	 imbalance	balance [1]
		set [1]
	 sucks in air	replace seals ventilate

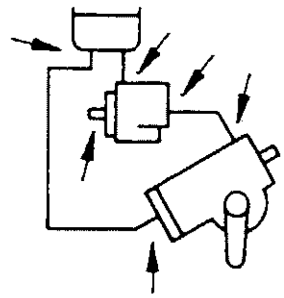
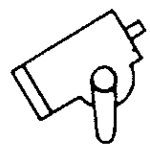
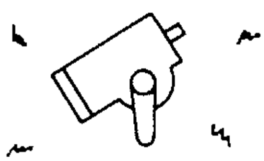
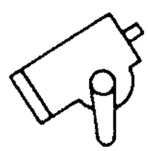
[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
play in steering wheel 	   	tighten / replace [1]
	 internal fault	exchange steering [1]
runs out 	 internal fault	exchange steering [1]

[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
noises 	sucks in air 	replace seals  ventilate
		eliminate leakage 
	pressure line 	rubber retainer [1]
	min. 0.85 bar 	ZF service agency
loss of oil 		close
		replace

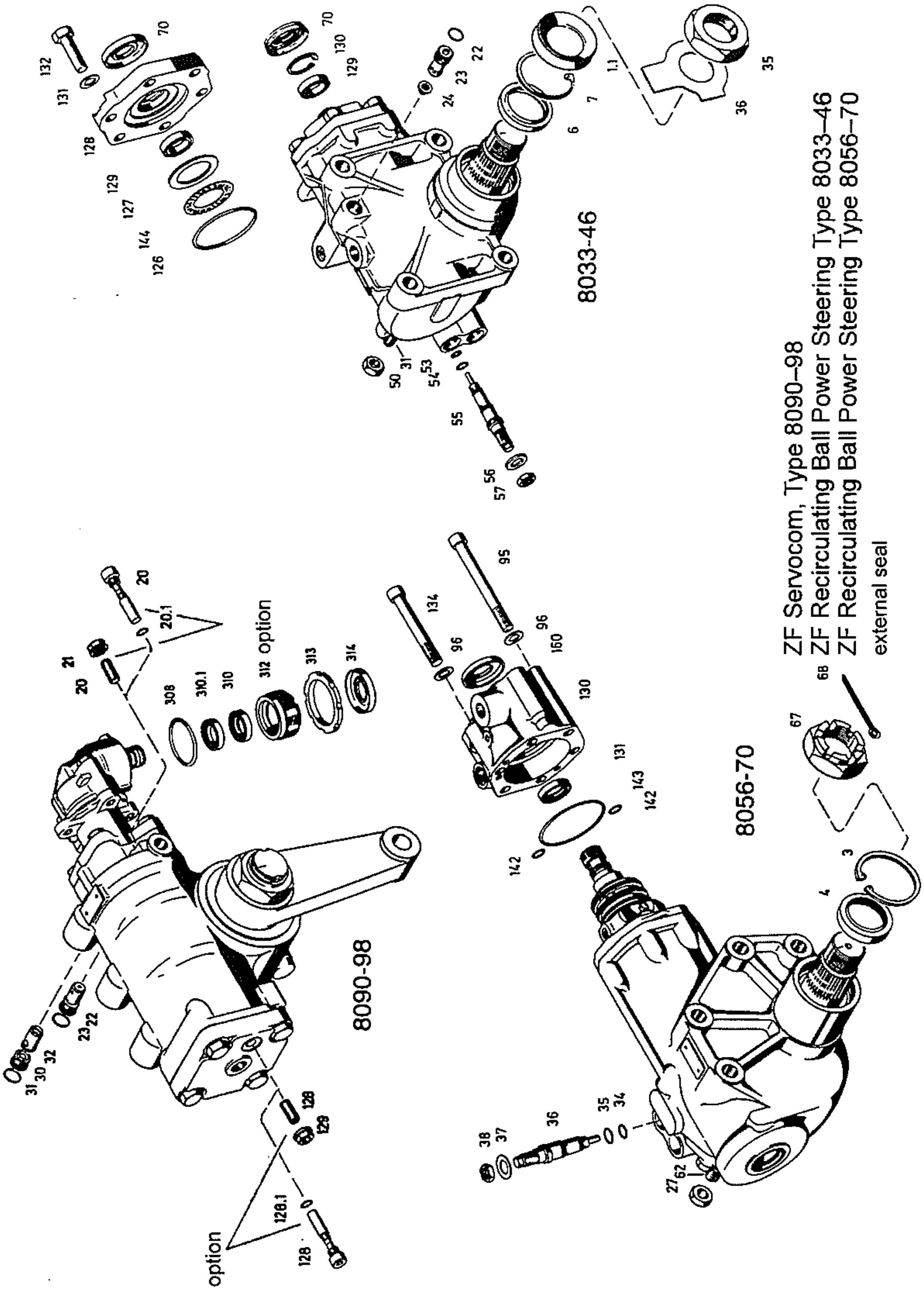
[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
		replace seals tighten lines
	 internal fault	exchange steering [1]
noises 	 internal fault	exchange steering [1]

[1] refer to instructions of vehicle manufacturer

XII. Key to numbers in illustrations and exploded views

1.	Housing
1.1	Dust seal
3	Circlip / Locking ring
4	Shaft seal
6	Shaft seal
7	Circlip / Locking ring
20	Stud / screw
20.1	O–ring
21	Flanged nut / Collar nut
22	Pressure control valve
23	O–ring
24	Screen filter
27	Hexagon nut
30	Screw
31	O–ring / Adjusting screw
32	Feeder valve / Suction valve
34	O–ring
35	O–ring
36	Valve accessories
37	Washer / Disk
38	Hexagon nut
50	Grommet nut
51	Dust seal
53	O–ring
54	O–ring
55	Valve
56	Washer / Disk
57	Hexagon nut
62	Adjusting screw
70	Protective cap
95	Cheese head screw
96	Washer / Disk
122	Intermediate cover
126	O–ring
127	Bearing plate
128	Stud / Cover / Screw
128.1	O–ring
129	Flanged nut / Collar nut
130	Valve housing / Circlip / Locking ring
131	Washer / Shaft seal
132	Hexagon screw
134	Cheese head screw
142	O–ring
143	O–ring
144	Thrust needle cage / Axial needle cage
151	Valve body
152	Valve spring
153	O–ring
154	Setting plate / Adjusting plate
155	Valve guide
156	O–ring
157	Circlip / Locking ring
158	Plug screw
160	Protective cap
306	Bevel gear wheel
308	O–ring
310	External shaft seal
310.1	Internal shaft seal
312	Adjusting screw
313	Slotted nut / Grooved nut
314	Protective cap



ZF Servocom, Type 8090–98
ZF Recirculating Ball Power Steering Type 8033–46
ZF Recirculating Ball Power Steering Type 8056–70

Notes

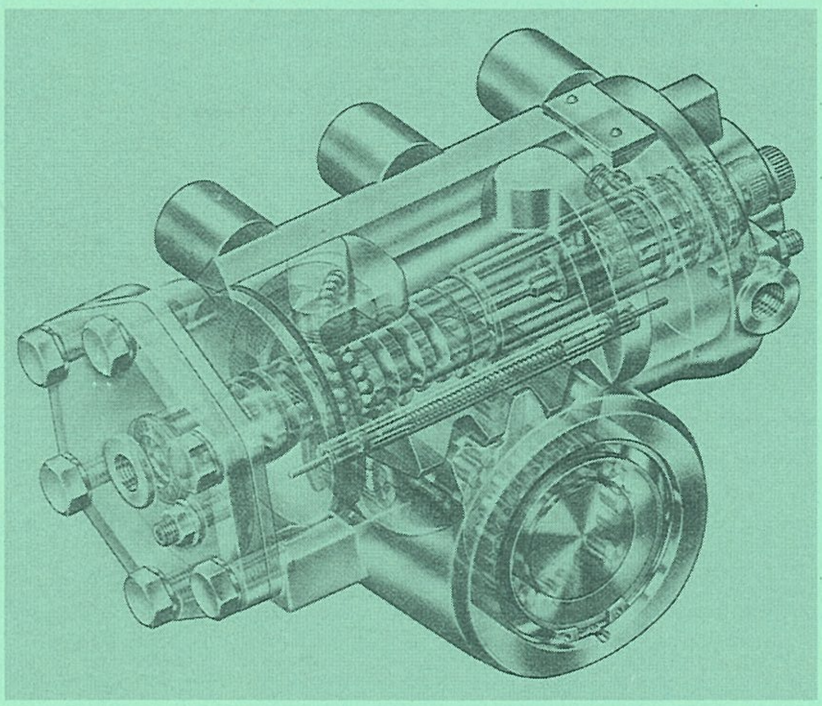
Notes

![ZF logo]

ZF-Servocom

Types 8090 - 8099
(Single and dual-circuit versions)

Repair Manual



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→ The present Manual aims to help the user properly to execute the necessary maintenance and repair work on the ZF product.

→ Read the Manual before starting any inspection and repair work.

→ On completion of the maintenance and repair work, the specialist personnel must make certain that the product is once more operating flawlessly.

→ ***Please note that the ZF product must be repaired only in workshops that***

- ***employ trained personnel***
- ***have the prescribed equipment, including a test rig, crack detector and special tools***
- ***use ZF genuine spare parts.***

→ This Manual is only for foremen and fitters who have undergone practical and theoretical training in our Customer Service School. Together with service information bulletins, it is intended to supplement their knowledge.

→ All work carried out on ZF products must be executed with extreme care and diligence. This applies in particular to products and transmission components from vehicles damaged in accidents.

→ The manufacturer does not, of course, accept any liability for damage and its consequences arising from incorrectly or inexpertly executed repairs.

→ This Manual draws attention to notes on safety as follows:

Note: Where incorrect and careless work can cause damage to the product.

⚠ **Attention:** Where incorrect and careless work can lead to personal injury and endanger life.

→ This Manual is not part of the updating service.

→ The contents of the additional service information bulletins must also be observed.

Contents

Page

I. Disassembly

Attention:
Utmost cleanliness must be maintained when disassembling and storing the parts in order to ensure that the steering operates reliably. Force must never be used when disassembling parts, as this may damage the sealing ring seats, sealing faces, etc. The resultant damage may lead to partial or total failure of the steering.

Notes:

→ The figures in round brackets, e.g. (348), refer to the part numbers used in Chapter VIII and the list of spare parts.

→ The figures in square brackets, e.g. [1], refer to the special tools listed in Chapter VII.

1 Preparing the steering for disassembly

Clamp steering in tool [1] or between the soft jaws of a standard vice.

Turn the steering through from end to end and note the total number of turns (reference value for function tests).

Set the steering to straight-ahead position (half the total number of turns) and check or restore the markings for straight-ahead.

2 Removal and disassembly of the bevel box

2.1 Versions with cross disc (348)

2.1.1 Remove bevel box

Mark position of bevel box and intermediate flange (335).

Unscrew cap screws / hexagon screws (352) with washers (350) ***(Fig.1)***.

Remove complete bevel box.

Remove shim plate (330) and O-ring (333).

2.1.2 Disassembly of intermediate flange (335)

Unscrew cap screws (334).

Remove intermediate flange (335) with cross disc (348) and ball bearing (343).

Remove O-ring (341).

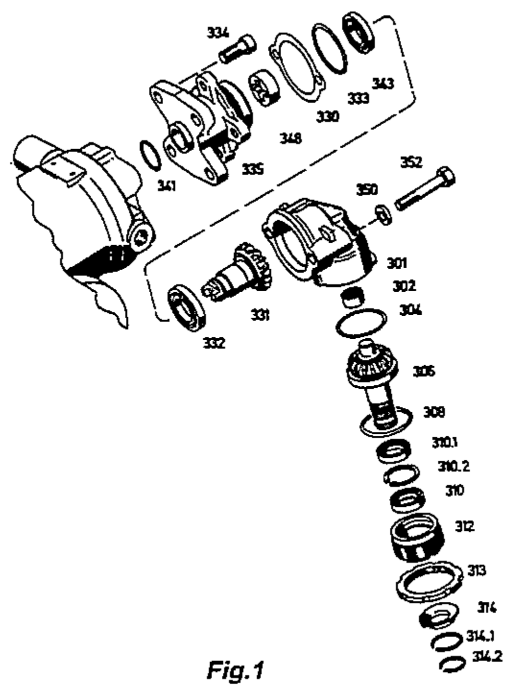


Fig.1

2.1.3 Disassembly of bevel box

Note:
The bevel gear (306) must not be forced off in order to replace the ball bearing, as it cannot be ensured that the notched gearing locks securely when the bevel gear (306) is pressed into position a second time.

Remove snap ring (314.1 and 314.2) and draw dust seal (314) off steering shaft stub.

Unscrew slotted nut (313) and unscrew adjusting screw (312) from housing with tool [25].

Remove O-ring (308). Remove shaft seal (310), retaining ring (310.2) and shaft seal (310.1).

Draw bevel gear (306) out of housing with ball bearing. Remove washer (304).

Note:
Needle sleeve (302) should only be removed if the bearing journal of the bevel gear assembly is found to be damaged. If necessary, needle sleeve (302) can be drawn out with tools [26] and [27].

Dismantle ball bearing (332) and remove bevel gear (331).

2.2 Versions with coupling sleeve (349)

2.2.1 Remove bevel box

Mark position of bevel box in relation to housing (1).

Unscrew hexagon screw (352) and remove complete bevel box *(see Fig.4)*.

Remove coupling sleeve (349), centering ring (346) and O-ring (333).

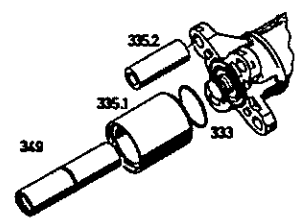


Fig.2

2.2.2 Remove pipes

Remove pipes (335.1 and 335.2). Dismantle O-ring (333) *(Fig.2)*.

2.2.3 Disassembly of bevel box

Remove protecting cap (314) and draw off shaft seal (310) with tool [33] *(see Fig.4)*.

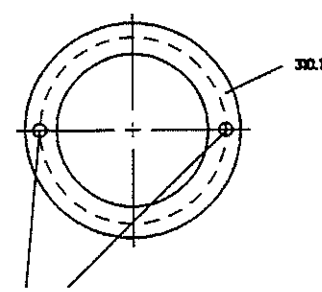


Fig.3

Unspring retaining ring (310.2). Drill holes through shaft seal (310.1) as shown in ***Fig.3*** (diameter of holes approx. 0.3 mm smaller than core diameter of the sheet metal screws required to pull out the shaft seal).

Screw in the sheet metal screws and pull out complete with shaft seal (310.1) with the aid of two pliers.

Unspring retaining ring (310.3) and remove any burr produced *(Fig.4)*.
Clamp bevel gear (306) in soft jaws and drive it out of the housing by knocking against the housing (301) with a plastic mallet.

Unspring retaining ring (310.4), remove any burr produced and remove the bevel gear (331).
Note:
Needle sleeves (302) should only be removed if the bearing journal of the bevel gears (306 and 331) is damaged.

Use tools [27] and [34] for this purpose.

Tool [35] must also be used additionally to remove the lower-level needle sleeve (302).

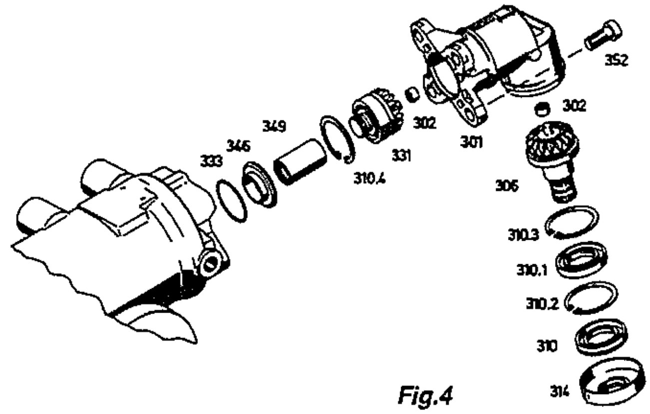


Fig.4

3 **Removal and disassembly of valve housing (203)**

Remove protecting cap (53) and gasket (53.3) *(Fig.5)*.

Mark position of valve housing (203).
Remove piping (225 and 226) and pipe unions (205 and 206) in the case of versions with add-on cylinder (250) ***see Fig.8***.

Unscrew cap screws (204) and lift off valve housing (203).

Remove control sleeve (174), bearing ring (201) and ball cage (200).

Dismantle screw (30) with O-ring (31) and valve insert (32) (replenishing valve).

Unscrew valve insert (22.1) with O-ring (23) (pressure limiting valve).c
Note:
Valve inserts (22.1 and 32) cannot be dismantled. The complete valve insert must be replaced if a fault develops.

Remove sealing elements (8 and 202).

Unscrew adjusting screw (20) and remove O-ring (20.1).

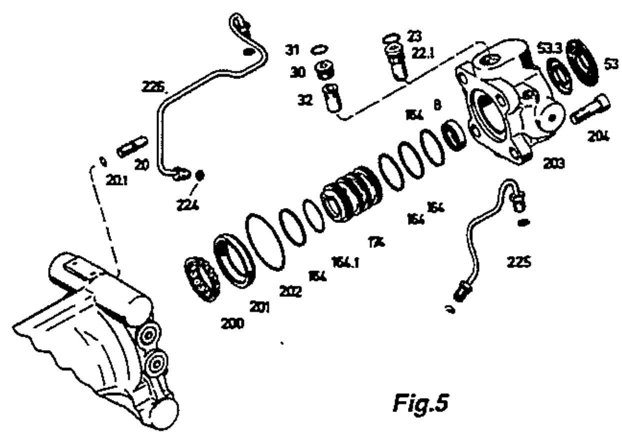


Fig.5

4 **Removal and disassembly of housing cover (221)**

4.1 Versions with valves (36) - steering limiter valves

Unscrew hex nut (38) and remove washers (37) *(Fig.6)*.

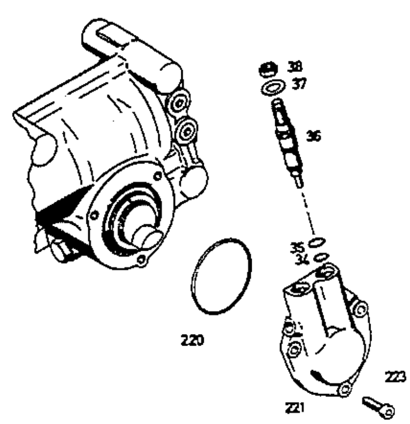


Fig.6

Unscrew valves (36) and remove O-rings (34 and 35). Remove cap screws (223) and lift off housing cover (221).

4.2. For versions with switch (222)

Mark position of cover (221) in relation to housing (1). Unscrew cap screws (223) and remove cover (221) with cam disc (227) and retaining ring (228) ***(Fig.7)***.

Remove O-ring (220). Unspring retaining ring (228) and remove cam disc (227).

Remove switch (222) with washer (222.1).

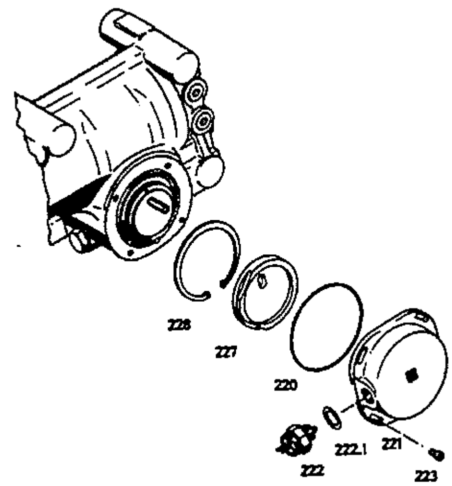


Fig.7

5 Removal and disassembly of add-on cylinder (250)

Unscrew pipe unions (205 and 206).

Unscrew hexagon screws (252) with washers (251) and remove add-on cylinder (250) ***(Fig.8)***.

Unspring retaining rings (261). Prise off cylinder cover (259) and remove O-ring (260).

Draw out piston (258) and remove gaskets (257) and O-rings (256).

Remove gear (254) and bush (253), as well as O-ring (255).

Unscrew Torx screws (250.1).

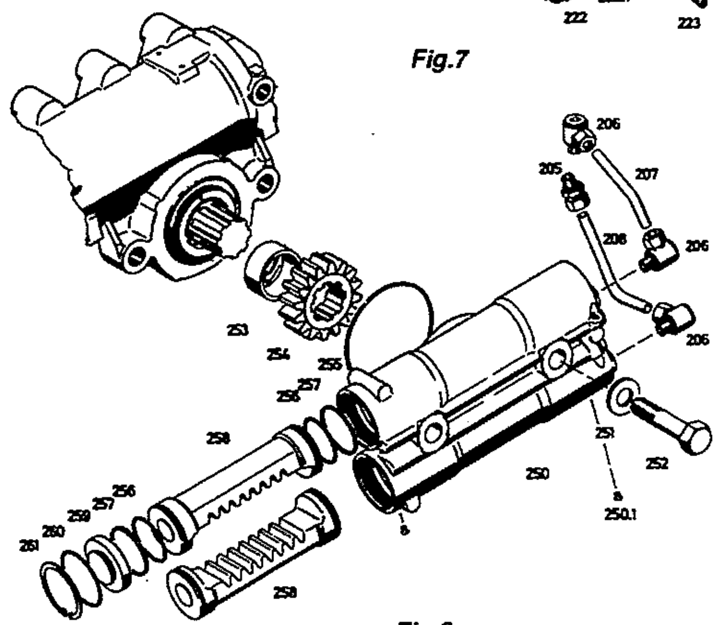


Fig.8

6 Removal and disassembly of cylinder cover (125)

Unscrew hexagon screws (127) with or without washers (126) ***(Fig.9)***.

Note:
Retract piston (101) towards bottom of housing so that the valve tappet of valve insert (109) is not damaged when turning the cylinder cover (125).

Slip steering drop arm onto sector shaft (80).

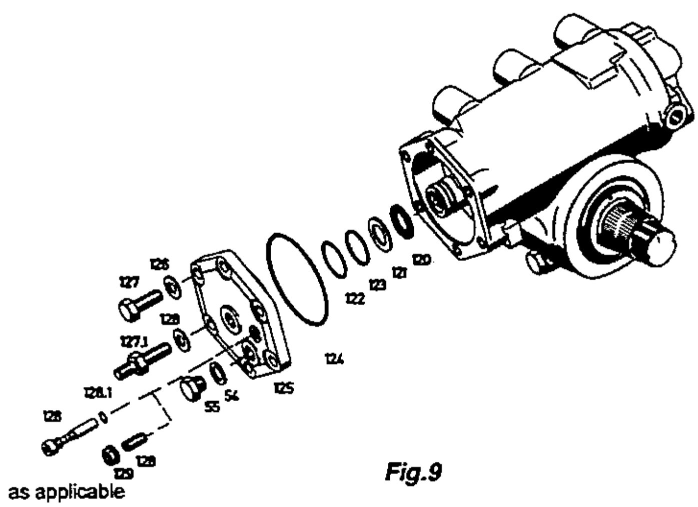


Fig.9

Turn worm (151) to remove cylinder cover (125).

Remove needle cage (120) and washer (121). Remove screw (128) and O-ring (128.1) and set aside for later use (required for function tests, chapter IV).

Remove sealing elements (122, 123 and 124). Unscrew screw plug (55) with sealing ring (54).

Unscrew set screw (128) and collar nut (129).

7 Removal and disassembly of piston (100)

7.1 Draw-piston (100) out of housing (1) together with worm (151), turning the steering drop arm which is still mounted on the sector shaft (80) at the same time *(Fig.10)*.

Attention:
The tappet of the valve insert (109) ***(see Fig. 13)*** installed in piston (101) must not be damaged.

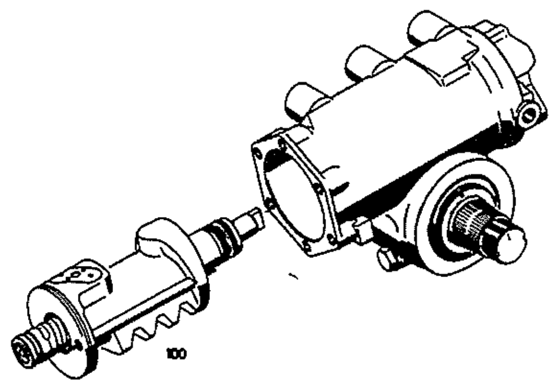


Fig.10

7.2 Remove gasket/plug (112) complete with compensating plate (113.1), gasket (113), sealing elements (114 and 115), pin (113.2) and recirculating half tubes (111) ***(Fig.11)***.

Turn worm (151) to release the balls (110) and carefully set them aside for later use.

Remove sealing elements (116, 117, 118 and 119).

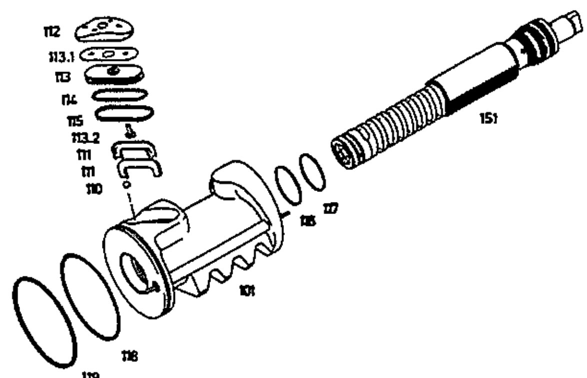


Fig.11

7.3 Check the valve insert (109) installed in piston (101) ***(see Fig.13)*** for radial or axial play, mechanical damage and any internal leaks.

Check caulking of valve insert (109).

The complete valve insert (109) must be replaced if any of the above defects is observed.

7.3.1 Versions with caulked valve insert (109) - steering limiter valve

Position piston (101) upright so that the caulking on valve insert (109) points upwards ***(Fig.12)***.

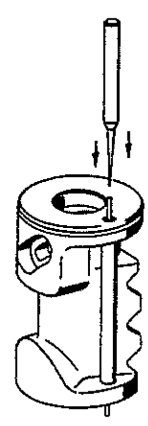


Fig.12

Using a cylindrical punch, dia. 4.5 mm, press tappet inwards and drive valve insert (109) down and out.

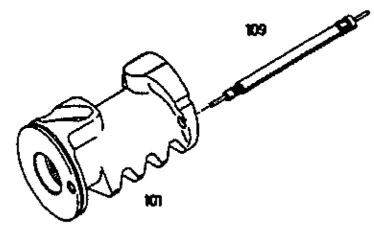


Fig.13

7.3.2 Versions with screwed valve insert (109) - steering limiter valve

Release caulking and screw valve insert (109) out of piston (101) with tool [2] *(Fig.13)*.

8 Disassembly of worm (151)

8.1 Unspring snap ring (155) and pull off sliding tube (156) ***(Fig.14)***.

Remove plug (163) and pin (162).

Remove sealing elements (158, 159, 164).

Further disassembly of the worm (151) is not permitted, since the hydraulic centre is then no longer set correctly.

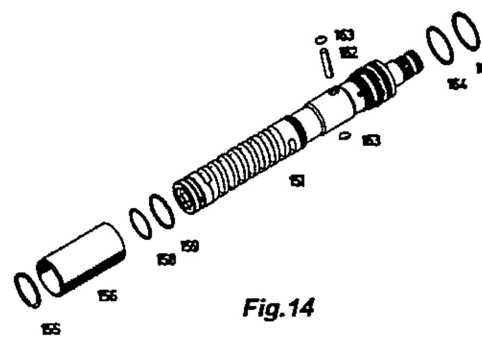


Fig.14

8.2 **Exception:**
Sealing ring (170) may be replaced by specially trained personnel:

Mark position of valve slide (168) and worm (161) ***(Fig.15)***.

Remove caulking from worm (161).

Drive out pin (160).

Pull valve slide (168) out of worm (161) together with torsion bar (165).

Remove O-ring (169) and sealing ring (170).

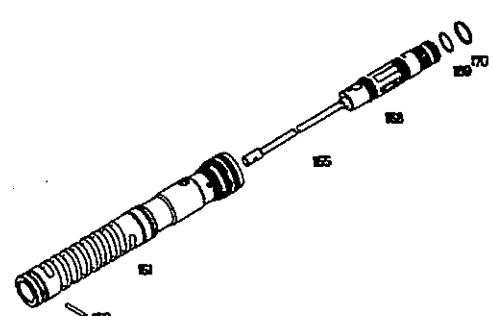


Fig.15

8.3 Additionally required for dual-circuit versions:

Remove sealing elements (172 and 173) *(Fig.16)*.

Remove sealing rings (164) and O-ring (164.1) from control sleeve (174).

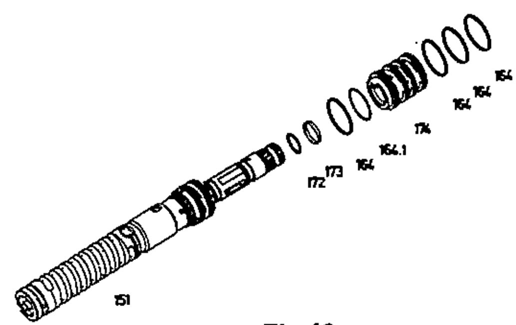


Fig.16

9 Removal of sector shaft (80)

Remove dust seal (51), stop-ring (51.1), gasket (51.2) and plug (52) on both sides *(Fig.17)*.

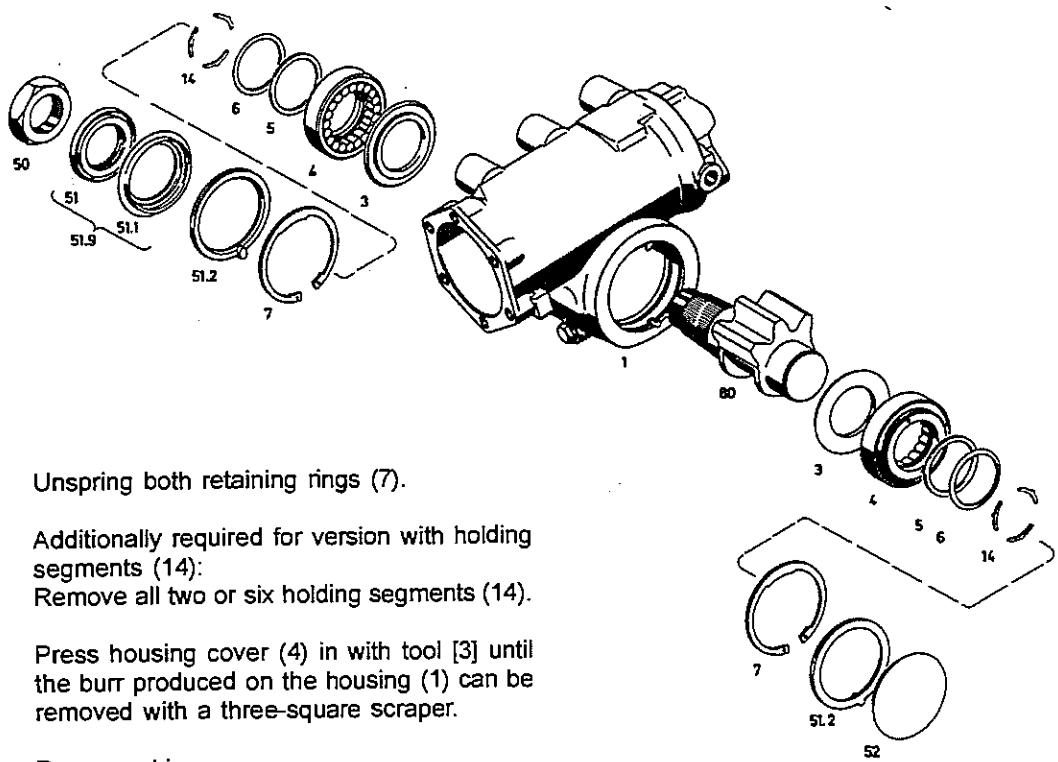


Fig.17

Unspring both retaining rings (7).

Additionally required for version with holding segments (14):
Remove all two or six holding segments (14).

Press housing cover (4) in with tool [3] until the burr produced on the housing (1) can be removed with a three-square scraper.

Remove chips.

Draw housing cover (4) out with tool [4].

Note:
The spindle of tool [4] must not be inserted in the centering bore of the sector shaft (80), otherwise the sector shaft (80) may tilt due to eccentricity.

Draw support rings (6) and gaskets (5) out of the grooves.

Notes:

→ The housing covers (4) must not be refitted in the same position otherwise they cannot be caulked correctly.

→ The individual rolls must not be exchanged between housing covers (4).

→ If one of the rolls is defective, the complete housing cover (4) must be replaced.

Draw washers (3) off the sector shaft (80).

Mark the side on which the notched serration of the sector shaft (80) is installed.

Remove sector shaft (80) from housing (1).

10 Disassembly of housing (1)

10.1 Remove needle cage (10), washer (9) and shaft seal (8) from housing (1) ***(Fig.18)***.

Remove O-rings (2).

Disassemble set screw (20) with collar nut (21) or screw (20) with O-ring (20.1) and set aside for later use (required for function testing).

Unscrew screw plug (55) with sealing ring (54).

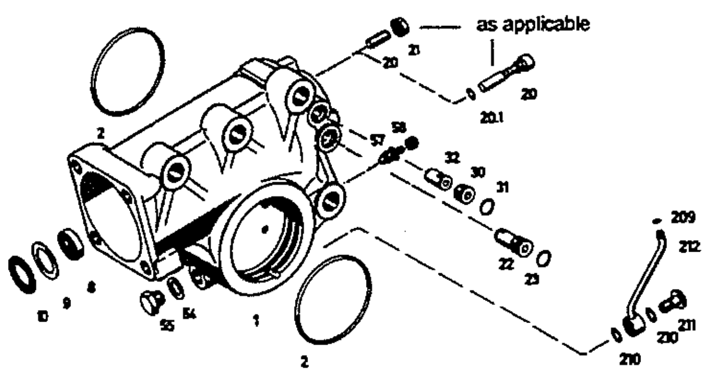


Fig.18

Remove breather (57) with protective cap (58).

Unscrew screw (30) with O-ring (31) and remove valve insert (32) - replenishment valve.

Unscrew valve insert (22) - pressure limiting valve - with O-ring (23).

Note:
Valve inserts (22 and 23) cannot be disassembled. The complete valve inserts must therefore be replaced if a defect develops.

10.2 Additionally required for versions with pipe (212)

Unscrew union screw (211).

Remove pipe (212) with O-rings (209 and 210).

II. Examining the individual parts

→ All parts must be cleaned thoroughly.

Note:
Sealing rings and other rubber parts must not be allowed to come in contact with chlorinated hydrocarbons, as they may swell.

→ All parts must be examined for wear, corrosion, pressure damage or other defects and assessed from the point of view of reusability.

→ Flange faces and sealing faces (e.g. the mating faces of sealing rings) must be repolished or ground if necessary.

Attention:
Experience and a conscientious approach are essential when examining the parts. The fitter must personally decide whether or not the parts need to be replaced.

The following must be examined:

1 Housing (1)

→ Cylinder bore: minor scoring must be eliminated by removing the elevations, e.g. with the aid of a serrated washer.

→ Recesses in retaining rings: any elevations must be removed to avoid scratches when fitting the housing covers (absence of leaks).

→ Running faces of the worm head (151)

→ Screw thread

→ Outer seat of shaft seal must be examined for signs of rubberization

→ Face side of housing must be examined for signs of sag due to sudden, accidental impacts around the axial needle bearing for the worm. Apply a ruler to the machined face side for the protecting cap (53). Housing (1) must be replaced if a distinct sag is evident.

2 Cylinder cover (125)

→ Outer seat of shaft seal must be examined for signs of rubberization

→ Face side of cover must be examined for signs of sag due to sudden, accidental impacts around the axial needle bearing for the worm (151). Apply a ruler to the machined face for the return port. Cylinder cover (125) must be replaced if a distinct sag is evident.

3 Piston (101)

→ Outside diameter

→ Valve insert (109) - steering limiter valve - must be examined for leaks, loose fit, damage (even slight external mechanical damage can cause the valve to jam).

→ Serration must be examined for wear (longitudinal and transverse crack testing using a suitable method, e.g. ferrofluxing).

Attention:
Cracked parts must be scrapped.

→ Recirculating ball screw:
Both piston (101) and worm (151) must be replaced if any signs of damage or wear are observed.

→ Check friction value in assembly with worm (151) - see chapter III.

→ **Caulked valve insert (109) - steering limiter valve:**

Tight fit: radial or axial play and damage are not permissible.

→ **Screwed valve insert (109) - steering limiter valve:**

Check that valve insert (109) is not twisted or damaged.

Caulking

4 Worm (151)

→ Recirculating ball screw: piston (101) and worm (151) must both be replaced if any signs of damage or wear are observed. Check friction value in assembly with piston (101) - see chapter III.

→ Notched serration of valve slide (168)

→ Running surfaces of needle bearings and shaft seal. Indentations on the face-end running surfaces of the needle bearings (10 and 120) may be due to accidental impacts. In this case, the housing (1) and cylinder cover (125) must be examined for signs of sagging around the needle bearing (120).

→ Longitudinal and transverse crack testing (using suitable methods, e.g. ferrofluxing). (The liquid jet must be directed in such a way that the valve body is not wetted so that iron particles cannot enter the control grooves.)

Attention:
Cracked parts must be scrapped.

→ O-ring recesses must be examined for hammer marks

→ The complete worm (151) must be replaced if the O-rings are found to have hardened on account of excessive service temperatures, since the O-ring (169) between valve slide (168) and worm (161) will also have been damaged in this case.

5 Sector shaft (80)

→ Toothed segment

→ Serrations

→ Running surfaces of the sealing rings

→ Running surfaces of the roller bearings

→ Longitudinal and transverse crack testing (using suitable methods, e.g. ferrofluxing).

Attention:
Cracked parts must be scrapped.

→ Caulking points on housing cover (4)

→ Longitudinal scoring on outside diameter

→ Screw thread

→ Radial run–out (warping) of the sector shaft (80) need only be checked if roller bearing imprints due to impacts have been observed, for instance on the face ends of the worm.
Mount the sector shaft (80) between centres and measure the maximum permissible radial run–out on the running surface of the roller bearing on the steering drop arm side, beside the tooth segment. The max. permissible radial run–out must not exceed 0.1 mm.

Additionally required for versions with switch (222):

→ Check grooved pin for tight fit and wear

→ Slot on grooved pin must point towards the middle tooth or be at 180° to it.

6 Housing cover(4)

→ Scoring and rust on outside diameter

→ Sealing faces

7 Needle, cage and roller bearings

→ The corresponding bearings must be replaced if indentations and wear are observed on the running surfaces of the steering elements.

→ Check needles, balls and rollers for signs of wear and damage.

8 Valve insert (22, 22.1 and 32) and breather (57)

→ Outside diameter (scoring, wear, damage and jamming in the valve bore)

→ Ensure that bore holes are clean

9 Additionally required for dual-circuit versions

9.1 Housing cover (221)

→ Screw thread

→ Flange face

→ O-ring seats

→ Pipe / line connections

9.2 Valve housing (203)

→ Screw thread

→ Rubberization on seat of shaft seal

→ Pipe connections

→ Running surface of sealing rings

→ O-ring seats

9.3 Additionally required for versions with add-on cylinder (250)

9.3.1 Add-on cylinder (250)

→ Scoring in cylinder bores

→ O-ring seats

→ Pipe connections

9.3.2 Piston (258)

→ Sealing ring seats

→ Signs of wear on serration (longitudinal and transverse crack testing using suitable methods, e.g. ferrofluxing)

Attention:
Cracked parts must be scrapped.

9.3.3 Gear (254)

→ Signs of wear on serrations (longitudinal and transverse crack testing using suitable methods, e.g. ferrofluxing)

Attention:
Cracked parts must be scrapped.

10 Additionally required for versions with switch (222)

→ Easy movement of actuating cam on switch (222)

→ Check cam ways of cam disc (227) for signs of wear

11 Additionally required for versions with bevel box

→ Bevel gears (306 and 331):
Signs of wear and indentations on serrations
Damage and corrosion on running surfaces of shaft seals

Longitudinal and transverse crack testing (using suitable methods, e.g. ferrofluxing), particularly for cracks at the bottom of the teeth.

Attention:
Cracked parts must be scrapped

→ Intermediate flange (335) and housing (301):
Flange faces, screw thread and sealing ring seats

→ Cross disc (348): signs of wear in driving grooves

→ Screw thread

III. Assembly

Attention:
Utmost cleanliness must be maintained during assembly in order to ensure that the steering operates reliably. Force must never be used when assembling parts, as this may damage the sealing ring seats, sealing faces, etc. The resultant damage may lead to partial or total failure of the steering.

Notes:

→ All parts must be cleaned thoroughly before assembling the steering. Each part must be examined for signs of wear and other defects (see chapter II.) and oiled before being assembled.

→ New gaskets, shaft seals and O-rings must always be fitted and the face ends of the housings and covers ground down to remove any paint residues and damage.

→ In the case of shaft seals, the space between the sealing lip and dust lip must be filled with grease type Spectron FO 20 made by Messrs. DEA or an equivalent calcium complexing grease of consistency class 2.

→ The accuracy of the measuring and adjusting tools used for repairs must be verified at regular intervals.

→ The specified tightening torques apply when tightening screws and bolts with a torque wrench by hand.

→ Before starting the assembly work, the spare parts list must be consulted to determine whether it specifies tightening torques and insertion depths or information on the installed position of special screws and holders. The following values and descriptions apply if nothing is specified in the spare parts list.

1 Preassembly of housing (1)

1.1 Screw in valve insert (22) - pressure limiting valve - with preassembled O-ring (23) (tightening torque: 30+10 Nm) ***(Fig.19)***.

Fit valve insert (32) - replenishing valve - in housing. Fit screw (30) with fitted O-ring (31) (tightening torque: 30+10 Nm).

Screw in breather (57) (tightening torque: 30 Nm) and plug on protective cap (58).

Fit screw plug (55) with sealing ring (54) (tightening torque: M16: 40 Nm; M18: 50 Nm).

Insert O-rings (2) in housing (1).

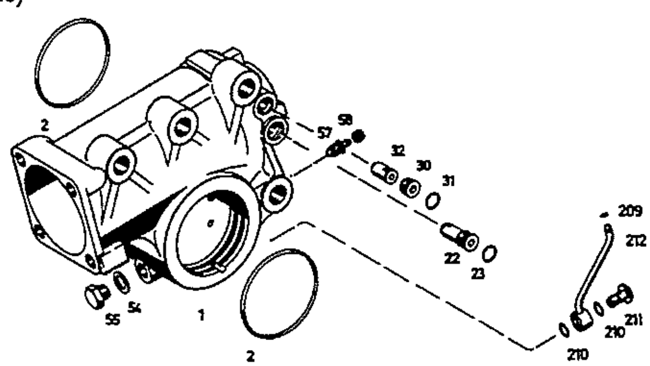


Fig.19

1.2 Additionally required for versions with pipe (212)

Mount pipe (212) with new O-rings (209 and 210). Torque union screw (211) down with 20±2 Nm.

2 Preassembly of housing cover (4)

Notes:

→ The housing covers (4) must not be reinstalled on the same side.

→ The individual rollers must not be interchanged between housing covers (4).

→ The complete housing cover (4) must be replaced if one of the rollers is defective.

Any rollers which have dropped out must be bonded into the housing cover (4) with grease (type of grease, see Note in chapter III.) and a pad fitted in the roller gap.

Fit gasket (5) and support ring (6) in housing cover (4) ***(Fig.20)***.

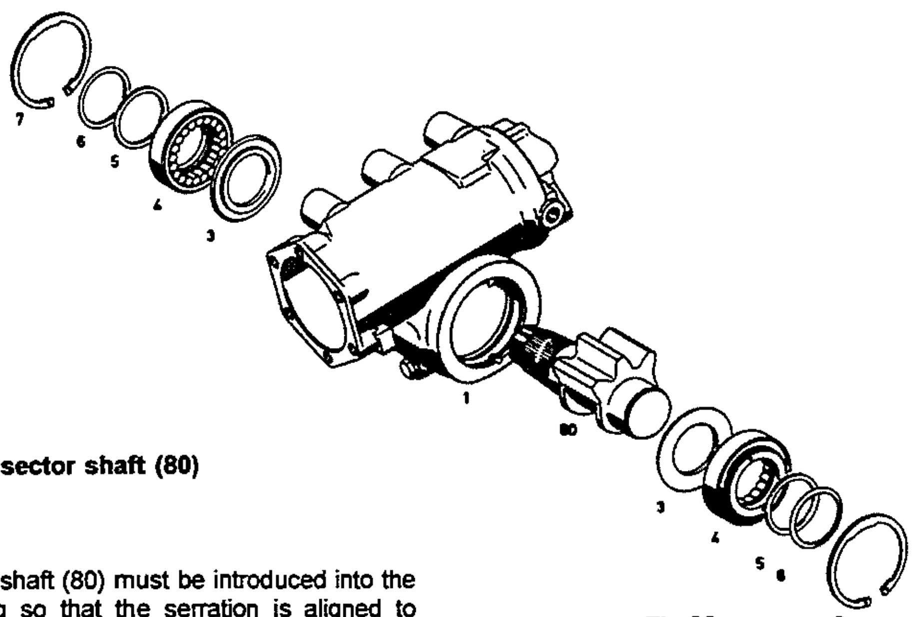


Fig.20

3 Install sector shaft (80)

Sector shaft (80) must be introduced into the housing so that the serration is aligned to receive the steering drop arm as marked during disassembly.

Fit washers (3) on sector shaft (80).

Place housing (1) on a flat surface underneath a hand-operated press with the steering drop arm side facing upwards.

Mount tool [5] on the serration.

Press the preassembled housing cover (4) up to the recess in the retaining ring (7) with tool [3] and with the larger of the two face-end holes or marks facing upwards (towards the piston).

Fit retaining ring (7) so that the gap is on the caulked side opposite the piston (101).

Attention:
Check that retaining rings (7) are seated correctly.

4 Adjustment of recirculating ball element

4.1 Assembly of recirculating ball element

Insert worm (151) into the bore in piston (101) so that the balls (110) from the front piston bore for the recirculating pipe can be filled into the threaded bore of worm (151) *(Fig.21)*.

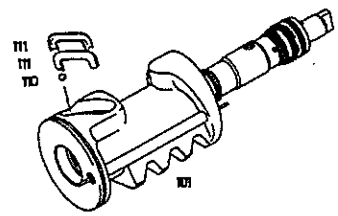


Fig.21

Attention:
37 balls (110) must be used. All the balls (110) used must belong to the same tolerance group.

The balls (110) must be filled in separately and the worm (151) turned slowly at the same time so that all balls (110) are lined up side-by-side (direction of rotation depends on the spiral direction of the worm (151)).

The recirculating ball screw is not full until the first ball (110) inserted reaches the edge of the rear bore in the recirculating pipe (30 balls).

Attention:
None of the balls (110) may drop out of the threaded bore into the longitudinal bore of the piston (101), as this could result in partial or complete failure of the steering.

Place the remaining balls (110) in the recirculating half tube (111).

To facilitate assembly, the outer balls (110) can be bonded into place with grease. Type of grease, see note in chapter III.

Insert both the filled recirculating half tubes (111) into the bore holes.

4.2 Check the friction torque

❑ **New parts**

The friction torque of the recirculating ball element must be measured in a horizontal position using tools [8], [9] and [10] while simultaneously holding the recirculating half tubes (111) tight in the piston (100).

→ In the middle area:

The following friction torques must be obtained when turning the worm through 90°:

Type 8090:	5 - 20 Ncm
Types 8095-8099:	5 - 30 Ncm

→ Outside the middle area:

The friction torque measured in the middle area must increase by no more than 15 Ncm.

- **Used parts**

Check friction torque and tilting clearance (hold recirculating half tubes (111) tight)

The friction torque of the recirculating ball element (111) must be measured in a horizontal position with tools [8], [9] and [10]. ***Fig.22.*** The tilting clearance must be measured in a horizontal position as shown in ***Fig.22.***

Measurement of friction torque

Measurement of tilting clearance

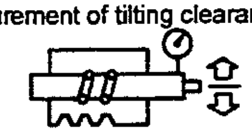


Fig.22

→ In middle area:
The value measured must lie within the following range when worm (151) is turned through 90°.

Upper limit: max friction torque: 8090: 5-20 Ncm
8095-99: 5-30 Ncm

Lower limit: max. tilting clearance: 0.1 mm

→ Outside the middle area:

The friction torque may increase to max. 35 Ncm for type 8090 and to max. 60 Ncm for types 8095-8099.

4.3 If a higher friction torque is obtained, the balls (110) must be removed and replaced with balls from a smaller tolerance group.

If the friction torque is below the permissible minimum value or if the tilting clearance is too large, larger balls (110) must be fitted and the measurement repeated.

Once the correct balls (110) have been chosen, piston (100) must be disassembled again and the selected balls (110) carefully set aside.

5 Preassembly of worm (151)

5.1 Fit O-ring (169) and sealing ring (170). Install torsion bar (165) with valve slide (168) as marked during disassembly. Press in pin (160) and caulk to the same depth and form as before ***(Fig.23)***.

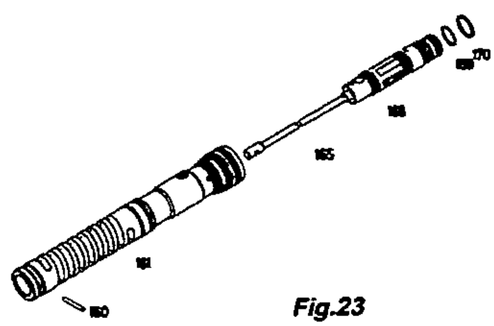


Fig.23

5.2 Place O-ring (158) in radial groove and slip on sealing ring (159) ***(Fig.24)***.

Fit pin (162) with plug (163).
Carefully slide on sliding tube (156).

Fit snap ring (155) and check axial play of sliding tube (156).

The axial play must not exceed max. 0.1 mm and can be corrected by using a different snap ring (155).

Use tool [11] to slip on sealing rings (164) and press them home with tool [12].

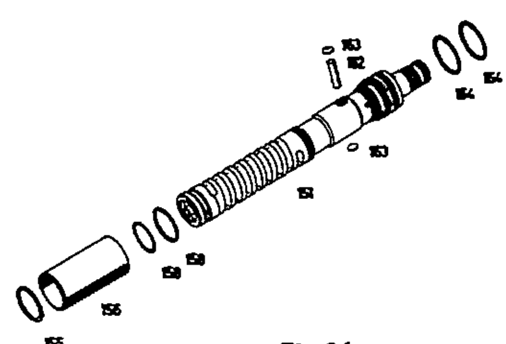


Fig.24

5.3 Additionally required for dual-circuit versions:

Slip O-ring (164.1) and sealing rings (164) onto control sleeve (174) with tool [11] *(Fig.25)*.

Then draw in sealing ring (164) with tool [11].

Mount tool [13] on worm (151).

Fit O-ring (172) and sealing ring (173) and press home with a suitable tool (e.g. hose clip).

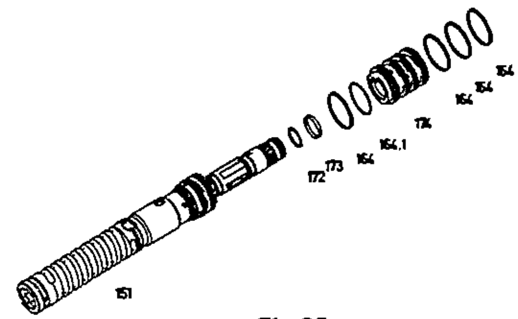


Fig.25

6 Preassembly of piston (100)

Note:
This preassembly is only required if the valve insert (109) - steering limiter valve - was disassembled.

6.1 Versions with caulked valve insert (109) - steering limiter valve

Introduce valve insert (109) as far as possible in piston (100). Mount piston in tool [6] with the caulked area pointing upwards *(Fig.26)*.

At the same time, ensure that valve tappet protruding beyond the piston is introduced into the bore in tool [6].

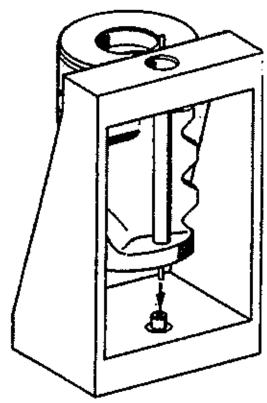


Fig.26

Adjust the supporting screw of tool [6] so that a gap of 0.1 - 0.2 mm is obtained between the fixture and piston when the latter has been fitted *(Fig.27)*.

Screw caulking die of tool [6] onto a pressure pickup and insert it in the upper bore of tool [6].

Caulk the metal edge of the valve insert with a press applying a force of 7000 N + 800 N without backlash.

Attention:
Correct operation of the steering may be impaired if the caulking force is too high or too low.

Check that the valve insert (109) is seated securely.

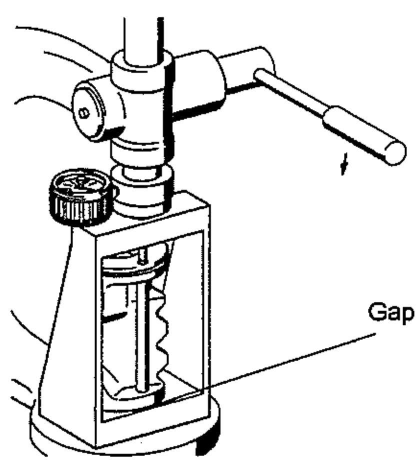


Fig.27

6.2 Versions with screwed valve insert (109) - steering limiter valve

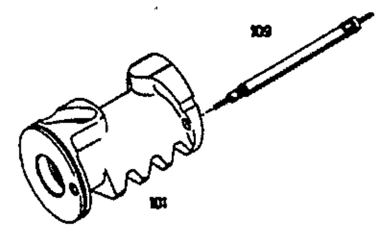


Fig.28

Screw valve insert (109) into piston as far as possible with tool [2] *(Fig.28)* (tightening torque: 15±1 Nm).

Note:
Hold the tube of the valve insert (109) tight when screwing in the valve insert so that only the larger threaded sleeve is entrained.

Align tool [7] with the two cutting edges so that they are centered in the groove. Then press tool [7] towards the piston until it rests against valve insert (109).

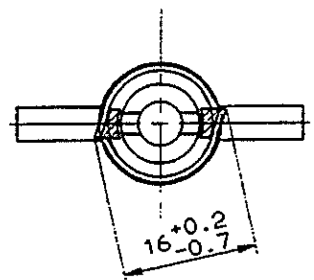


Fig.29

Caulk with tool [7] as shown in ***Fig.29*** (caulk to the same depth on both sides).

Attention:
Check that the valve insert (109) is tightly seated and that the valve tappet moves easily.

7 Assembly of piston (100) and worm (151)

First fit sealing ring (116) and then insert sealing ring (117) ***(Fig.30)***.

Fit O-ring (118) and then slip on gasket (119).

Reinsert worm (151) into piston (100) so that the balls (110) selected earlier can be fitted and the recirculating tube (111) can be inserted in piston (100) ***(see Fig.21)***.

Note for steering versions 8095 to 8099:

New parts (111, 112, 113 and 113.2) must be used if a pin (113.2) was not present during removal.

Place gasket (113) and plug (112) in piston without O-ring (114) or sealing ring (115).

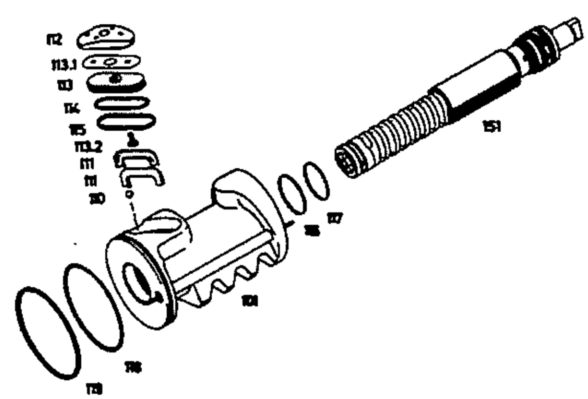


Fig.30

Check that plug (112) is flush with the piston surface *(Fig.31)* or does not exceed the following maximum clearance:

Max. permissible clearance:

Type 8090:	max. 0.1 mm
Types 8095-8099:	max. 0.5 mm
Type 8099: (with add-on cylinder)	max. 0.2 mm

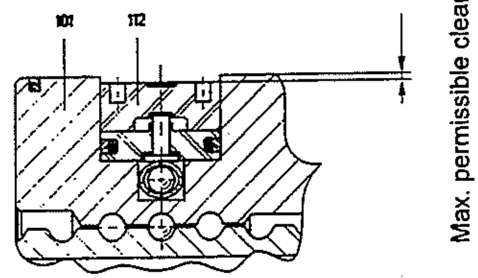


Fig.31

If necessary, insert a compensating plate (113.1) between gasket (113) and plug (112) (even if a compensating plate was not present during removal).

Ensure that the plug does not protrude in a way leading to increased friction.

Remove plug (112), compensating plates (113.1) and gasket (113).

Fit O-ring (114) and sealing ring (115) on gasket (113).

Press pin (113.2) into piston (101) with complete gasket (113).

Place the compensating plates (113.1) and plug (112) selected beforehand on gasket (113) and check again that plug (112) is flush with the piston face or does not exceed the maximum clearance.

8 Installation of piston/worm assembly

8.1 For 1-circuit versions and versions with bevel box

Fill space between sealing lip and dust lip of shaft seal (8) with grease (see note in chapter III.).

Press shaft seal (8) in as far as possible with tool [14] *(Fig.32)*.

Place washer (9) and needle cage (10) in turned recess of housing (1). Washer must be free of grease.

Slip tool [15] onto serration of worm (151).

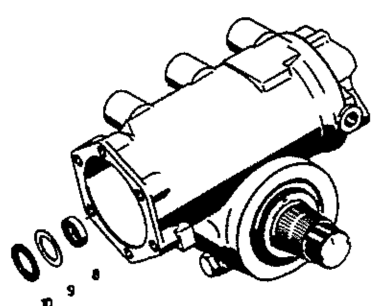


Fig.32

8.2 All versions

Turn sector shaft (80) so that the toothed segment swings towards the cylinder cover (125).

First introduce piston (100) into housing complete with worm (151) until toothed segment engages the first gap in the teeth of piston (100) when swung upwards *(Fig.33)*.

In this position, insert piston (100) completely by turning the sector shaft (80) with the aid of the provisionally attached steering drop arm.

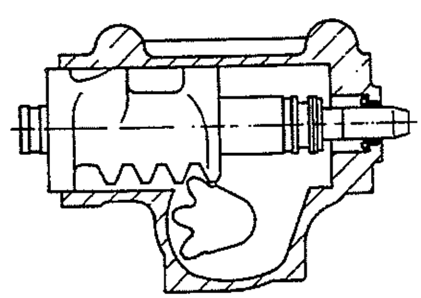


Fig.33

9 Assembly of cylinder cover (125)

Note:
Only for 1-circuit version and versions without bevel box

Screw in screw plug (55) with sealing ring (54).

Tightening torque: M16: 40 Nm
M18: 50 Nm

Place washer (121), which was removed during disassembly, in the recess in cylinder cover (125) with the bevelled side first; needle cage (120) must be fitted without grease *(Fig.34)*.

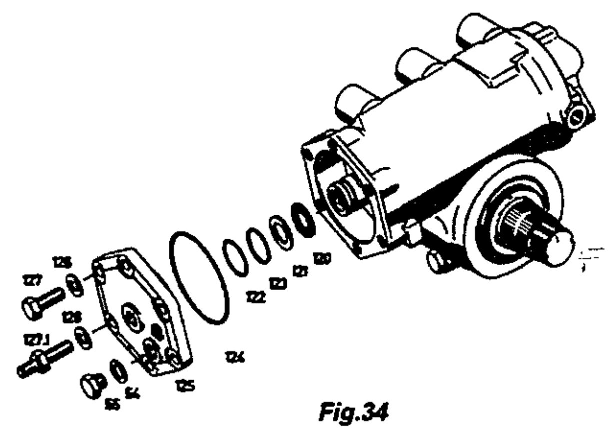


Fig.34

Note:
The following sealing elements should not be fitted until the worm bearing - section 12 - has been adjusted.

Place O-ring (122) in the inner radial groove in cylinder cover (125) and lay sealing ring (123) on top of it.

Place the greased O-ring (124) in the outer radial groove.

Place cylinder cover (125) on housing (1) without damaging the sealing elements.

Attention:
The inserted washer (121) may be too thick if any of the parts housing (1), worm (151) or cylinder cover (125) has been replaced. A complete readjustment as described in section 12 is required in this case.

If present during disassembly, the hex screws (127) with washers (126) must be carefully tightened while constantly turning the steering shaft in order to ensure that the worm bearing is not subjected to axial pressure.

Hex screws (127) and screw (127.1) must be torqued down as specified below.

Type 8090: (M12x1.5)	135 Nm
Type 8095/8096/8097: (M16x1.5)	285 Nm
Type 8098/8099: (M14x1.5)	189 Nm

10 Assembly of valve housing (203)

Note:
Dual-circuit version only

Screw in valve insert (22.1) - pressure limiting valve - with O-ring (23) *(Fig.35)* (Tightening torque: 30+10 Nm).

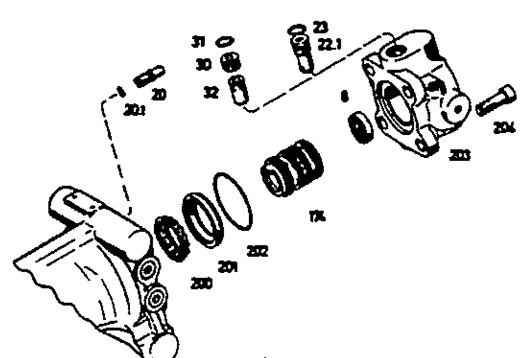


Fig.35

Fit valve insert (32) - replenishing valve - and screw (30) with O-ring (31) (tightening torque: 30+10 Nm).

Press bearing ring (201) into valve housing (203).

Position ball cage (200) on worm (151).

Insert preassembled control sleeve (174) in worm (151) (note position of drivers).

Screw adjusting screw (20) in by at least three turns.

Fill space between sealing lip and dust lip of shaft seal (8) with grease (see note in chapter III.).

Press shaft seal (8) in as far as possible with tool [14].

Mount tool [15] on serration of worm (151).

Insert O-ring (202) and mount valve housing (203) as marked during disassembly.

Torque cap screws (204) down to 140 Nm.

Fit pipes (225 and 226) ***(see Fig.43)*** with new O-rings (224).

Tightening torque:	8096:	12+2 Nm
	8099:	18+2 Nm

11 Check sector shaft position and total turns of steering wheel

Turn the steering through from one end to the other and check that the number of turns equals that counted during disassembly.

Turn steering to straight-ahead position and check that the mark on the sector shaft is at the top and perpendicular to the piston axis ***(Fig.36)***.

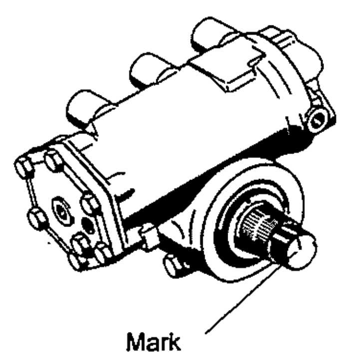


Fig.36

12 Adjustment of worm bearing

Note:
This setting must be checked at room temperature.

Strip paint from face end of housing in order to mount the dial gauge of tool [17].

Secure tools [16] and [17] on the steering shaft stub *(Fig.37)*.

Turn sector shaft (80) until worm (151) axially comes to rest on one side. Set dial gauge to "zero".

Turn sector shaft (80) until worm (151) axially comes to rest on the opposite side without tool [16] being radially entrained and check the permissible axial backlash.

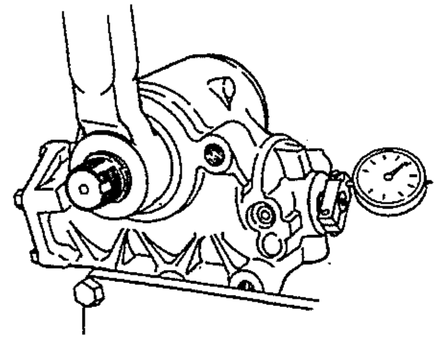


Fig.37

Required values:

Type 8090:	0.005 - 0.025 mm
Types 8095/8096:	0.010 - 0.030 mm
Type 8097:	0.015 - 0.035 mm
Types 8098/8099:	0.020 - 0.040 mm

Fit a different washer (121) to correct a divergent axial backlash.
Remove cylinder cover (125).
Install sealing elements as described in section 9 and fit cylinder cover (125).

13 Set pressure point

Note:
The bevel box must be installed first as described in section 17 in versions with bevel box.

Clamp steering horizontally and mount tools [18] and [19].

Turn housing cover (4) so that the larger of the two face-end bores and the mark point towards piston (100).

Move steering to one of the limit positions.

Measure the friction torque required to turn the steering ouside the straight-ahead range (approx. half a turn short of the limit position).

Turn steering approx. one half-turn to the right and left beyond the middle position with tools [8], [9] and [10]. Measure the associated increase in friction torque.

Required increase in friction torque:

Type 8090:	20-60 Ncm
Type 8095/8096:	20-80 Ncm
Type 8097-8099:	20-100 Ncm

Turn both housing covers (4) with tools [18] and [19], keeping the same angle (in the direction of the arrow), until the required increase in friction torque is obtained *(Fig.38)*.

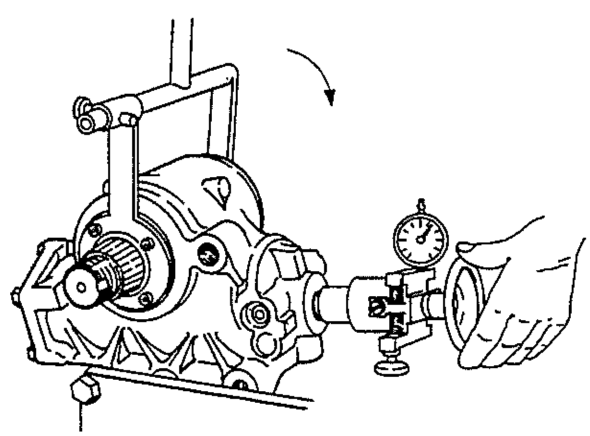


Fig.38

While making the adjustment with tools [18] and [19], use tools [8], [9] and [10] to turn the steering several times approx. one half-turn to the right and left beyond the middle position.

Note:
The max. permissible friction torque should be set if possible when making this adjustment.

14 Caulking housing cover (4)

14.1 Versions with single caulk

14.1.1 Screw tool [20] onto the steering so that it is parallel to the steering. The caulking tool must fit into the caulking groove as accurately as possible ***(Fig.39)***.

Tool [21] must be used additionally for steering versions with a C-value greater than 137 mm.

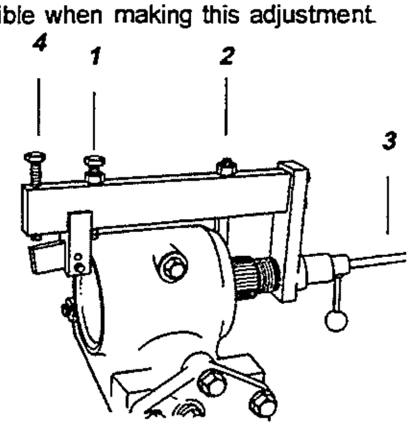


Fig.39

In this position, set adjusting screw ***1*** on the fixture so that the caulking tool is horizontal.

Secure fixing hook ***2*** on the opposite side of the housing at the height indicated by thrust spindle ***3***.

Tighten thrust spindle ***3*** until housing cover (4) comes to rest on retaining ring (7) on the caulking side.

Tighten screw ***4*** on the fixture by hand (without using additional tools) until it rests on the caulking tool.

Turn screw ***4*** through - value specified below - with a torque wrench (maximum value of **18** Nm must not be exceeded, otherwise the tool may break !).

Turns of screw ***4***:	Types 8090-8097: approx. 2.75
	Types 8098/8099: approx. 3.50

Remove fixture and check caulked area. The housing has been caulked correctly when the collar of the housing cover is pressed into the housing groove to the depth specified in the following table.

Caulking depth:

Types 8090/8095/8096:	1.3+0.4 mm
Type 8097:	1.4+0.4 mm
Types 8098/8099:	1.7+0.4 mm

Slight cracks are permissible in the caulking edge at the edge of the groove ***(Fig.40)***.

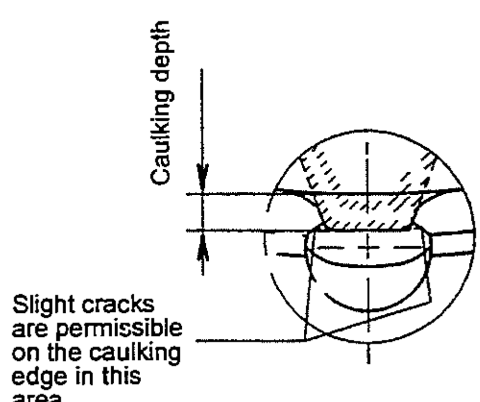


Fig.40

Additionally required for versions with holding segments (14):

Holding segments (14) must be pressed in until flush ***(Fig.41)***.

Fit retaining ring (7) so that the gap is located at the caulking point opposite the piston (100).

Attention:
Check that retaining ring (7) is seated securely.

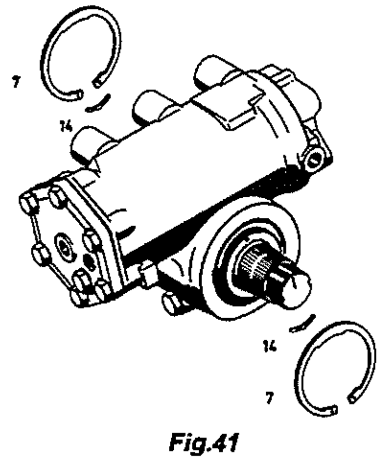


Fig.41

14.1.2 Repeat the complete procedure for the other side as described in section 14.1.1.

14.2 Versions with three-fold caulking

14.2.1 Carry out single caulking on both sides as described in section 14.1.

Remove retaining ring (7) and insert tool [22] (without caulking tool) in the caulking grooves of the housing with the three pilot pins.

Turn tool [22] through 60° in the groove of the retaining ring until one of the two caulking points is reached. Secure tool [22] with a stop pin to prevent it twisting and fit the caulking tool.

Proceed as described in section 14.1. Remove caulking tool. Release stop pin and turn fixture through 120° until the third caulking point is reached.

Proceed as described in section 14.1 for the third caulk.

Dismount tool [22] from the steering and check the caulked area as described in section 14.1.1.

Additionally required for versions with holding segments (14):

Press holding segments (14) in until flush ***(Fig.42)***.

Fit retaining ring (7) so that the gap is located on the caulking point opposite the piston (100).

Attention:
Check that retaining ring (7) is seated securely.

14.2.2 Repeat the complete procedure for the other side as described in section 14.1.1.

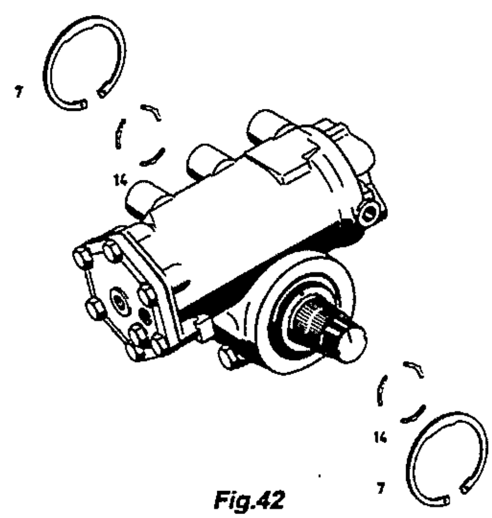


Fig.42

15 Assembly of housing cover (221)

15.1 Dual-circuit versions

Insert O-ring (220) *(Fig.43)*.

Install housing cover (221) with cap screws (223) (tightening torque: 37 Nm).

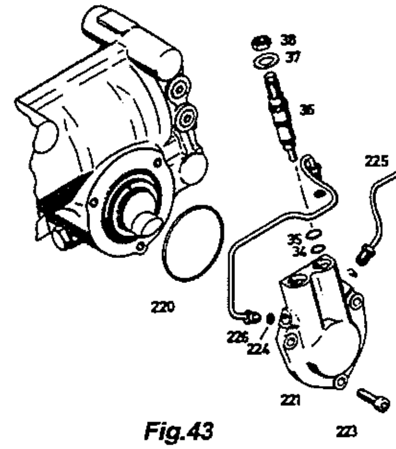


Fig.43

Install pipes (225 and 226) with new O-rings (224).

Tightening torque:	Type 8096:	12+2 Nm
	Type 8099:	18+2 Nm

Screw in valves (36) - steering limiter valves - with O-rings (34 and 35).

Fit hex nut (38) with washer (37) and torque down to 25-35 Nm after adjustment.

15.2 Versions with switch (222)

Note:
The housing cover should not be installed until the setting and functional test - chapter IV. - is complete, otherwise it cannot be tested for leakages.

Insert cam disc (227) in housing cover (221) so that the cam ways point towards switch (222) *(Fig.44)*.

Fit retaining ring (228).

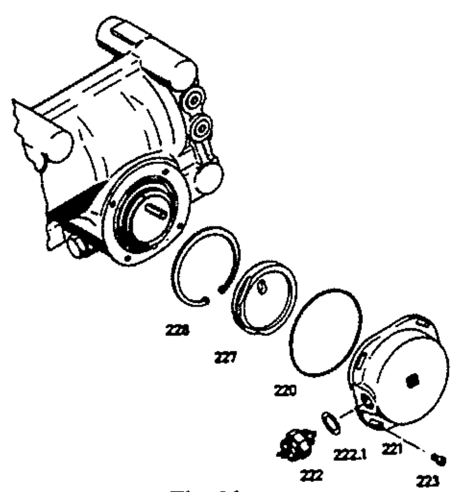


Fig.44

Place O-ring (220) in annular groove of housing cover (221).

Fit complete housing cover (221) as marked during disassembly so that the driver in the sector shaft engages in the longitudinal groove in cam disc (227).

Turn housing cover (221) so that the cam points towards the threaded bore of switch (222) when the steering is in the straight-ahead position.

Torque cap screws (223) down to 5.5 Nm.

Note:
The switching range of switch (222) can be adjusted on a test bench by using washers (222.1) of a different thickness.

Fill cover area with 50 cm^3 oil (oil sort see List of Lubricants TE–ML 09).

Screw in switch (222) with washer (222.1) (tightening torque: 50 Nm).

16 Assembly and installation of add-on cylinder (250)

Set steering to straight-ahead position.

Slide bush (253) and gear (254) as far as possible onto sector shaft (80) ***(Fig.45)***.

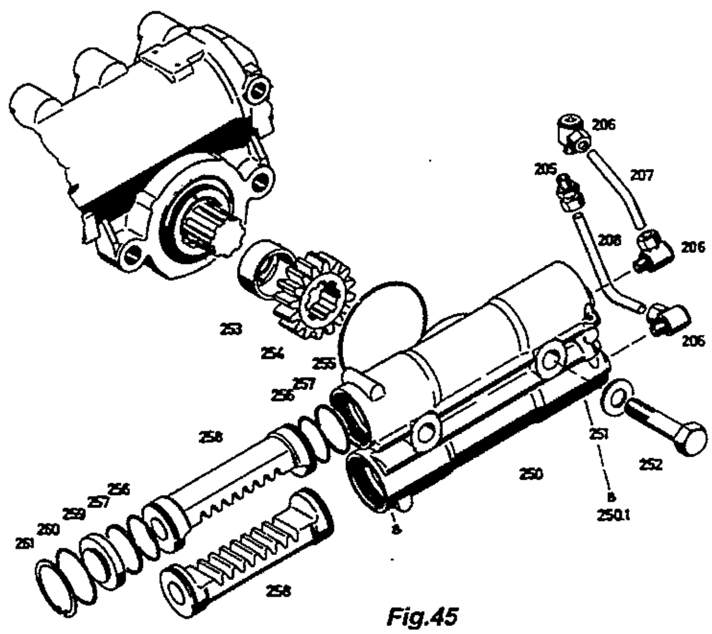


Fig.45

Slip two O-rings (256) and two gaskets (257) onto each piston (258).

Slide both pistons (258) into add-on cylinder (250) up to the middle position (installed value 60.7 ±0.2 mm) ***(Fig.46)***.

Notes:

→ The middle tooth of both pistons (258) is marked on both face ends.

→ The centered bore (with installed breather valve) in pistons (258) must point towards the closed end of add-on cylinder (250).

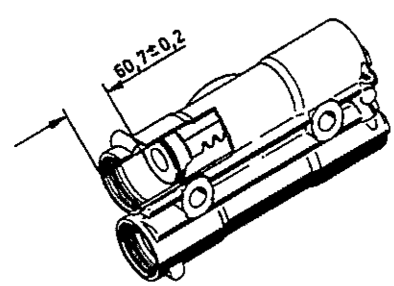


Fig.46

Screw add-on cylinder (250) onto the steering so that the middle tooth of piston (258) engages in the gap in gear (254) in each case *(Fig.47)*.

Screw in hexagon screw (252) with washers (251) (tightening torque: 500 Nm).

Turn steering through from end to end and then back to the straight-ahead position.

Check that the installed value equals 60.7 ±0.2 mm for both pistons (258).

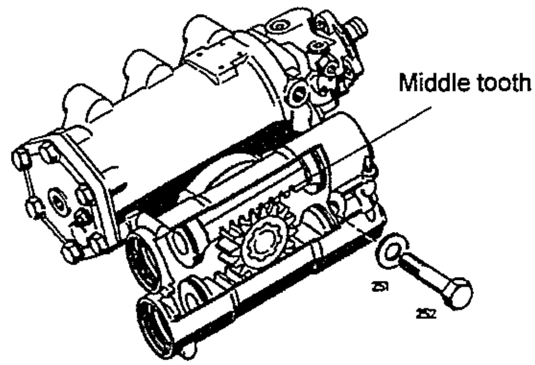


Fig.47

Place O-ring (260) in radial groove of cylinder bore and press cylinder cover (259) in until the retaining rings (261) can be fitted *(see Fig.45)*.

Fit retaining rings (261).

Install pipes (207) and (208).

Tightening torques:

Pipe union (205):	50 Nm
Pipe union (206):	39 Nm
Screw plugs for both pipe unions (205 and 206):	59 Nm

Tighten Torx screw (250.1) with tool [23] (tightening torque: 5 Nm).

17 Preassembly and installation of bevel box

17.1 Versions with cross disc (348)

17.1.1 Fit intermediate flange (335)

Slip O-ring (341) onto intermediate flange (335). Press cross disc (348) and ball bearing (343) onto intermediate flange (335) *(Fig.48)*. Use tool [28] for this purpose.

Secure intermediate flange (335) with cap screws (334) as marked during disassembly (tightening torque: 140 Nm).

Slip shim plate (330) onto intermediate flange (335).

17.1.2 Preassemble bevel box

Press needle sleeve (302) into housing (301) as far as possible with tool [29] *(Fig.48)*.

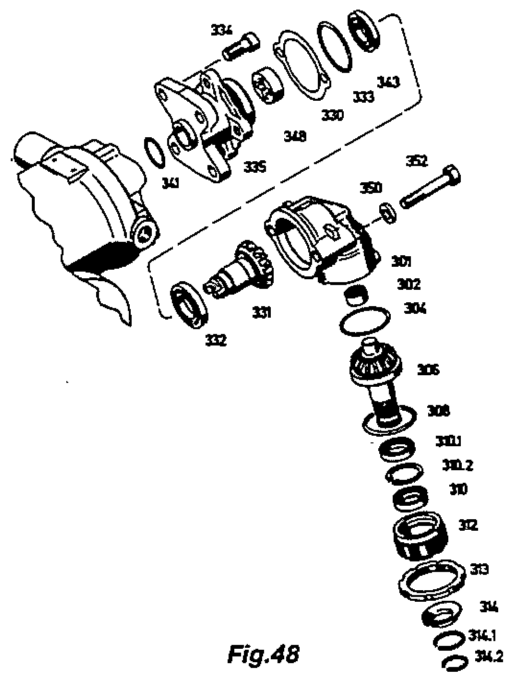


Fig.48

Press ball bearing (332) onto bevel gear (331) with tool [30].

Place 0.35 mm thick washers (304) or the washers (304) removed during disassembly into the housing bore. Slide bevel gear (306) as far as possible into housing (301).

Screw adjusting screw (312) into housing (301) without shaft seals (310 and 310.1), using tool [25] (tightening torque: 50 Nm).

Set bevel box to straight-ahead position. Align notch in steering shaft of bevel box with the mark on the housing.

In this position, mark one tooth on bevel gear (306) in the housing and two opposing teeth on bevel gear (331) in intermediate flange (335) with chalk so that the marked teeth engage when the bevel box is mounted.

17.1.3 Installation of bevel box

Slip on bevel box.

Uniformly screw in screws (352) with fitted washers (350), while simultaneously and constantly turning the steering shaft, until bevel gears (306 and 331) engage without backlash.

Screws (352) must not be turned further if bevel gears (306 and 331) engage before the flange of the bevel box comes to rest.

The remaining gap must be compensated with shim plates (330) in this case.

A thinner shim plate (330) must be used if zero backlash cannot be obtained.

The bevel gear must be precision adjusted when zero backlash has been obtained. Both the shim plates (330) and the washers (304) on bevel gear (306) are used for this purpose.

The bevel gears are correctly set when they engage with virtually no backlash and without jamming (max. backlash 0.04 mm).

Note:
However, the adjustment must be made in straight-ahead position so that the backlash is absolutely zero.

If the backlash is not zero when the steering gear is set to the straight-ahead position, the tooth contact must be relocated by one or more teeth until this requirement is met.

Make a new notch marking the straight-ahead position and take the bevel box off the steering again.

Place a greased O-ring (333) in the radial groove of the intermediate flange (335).

Place the bevel box back on the steering in the position marked after fitting the chosen washers (330).

Screw in screws (352) with fitted washers (350) (tightening torque: 62 Nm).

Unscrew adjusting screw (312) from housing (301).

Place a greased O-ring (308) in the radial groove of housing (301), behind the threaded bore.

Fill space between sealing lip and dust lip of shaft seal (310 and 310.1) with grease, see note in chapter III.

Mount tool [32] on bevel gear (306).

Fit retaining ring (310.2) in adjusting screw (312).

Press inner shaft seal (310.1) in as far as possible with tool [31].

Fit outer shaft seal (310) in adjusting screw (312) flush with face end.

Screw adjusting screw (312) into housing (301) with tool [25] and a torque of 50 Nm.

Tighten slotted nut (313) to a torque of 50 Nm.

Depress cast edge of housing to secure slotted nut (313) and prevent it twisting.

Check set friction value again (required value: max. 80 Ncm).

17.2 Versions with coupling sleeve (349)

17.2.1 Preassembly of bevel box

Press needle sleeves (302) in as far as possible with tool [36]. Install bevel gear (306) ***(Fig.49)***.

Select a retaining ring (310.3) leaving the bevel gear (306) with a max. backlash of 0.06 mm.

Install bevel gear (331).

Choose a retaining ring (310.4) ensuring zero backlash over the largest possible angle of rotation while simultaneously allowing the bevel box to run as smoothly as possible.

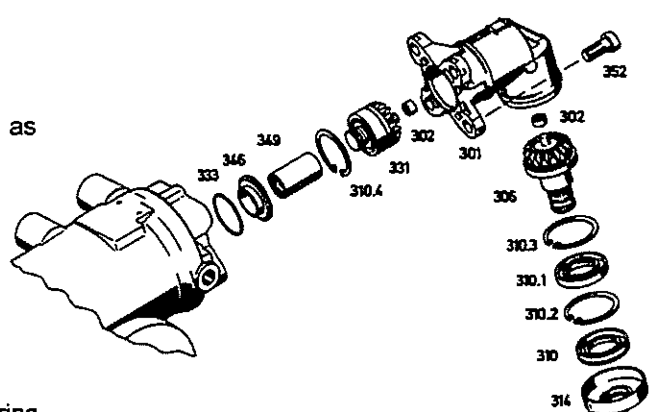


Fig.49

Fit retaining ring (310.4).

Mount tool [38] on bevel gear (306).

Grease space between sealing lip and dust lip of shaft seal (310.1) (see note in chapter III.) and press it in, together with retaining ring (310.2), with tool [37] until they engage completely.

Press a greased shaft seal (310) - see note in chapter III. with regard to the type of grease - in as far as possible with tool [39].

Measure friction torque with tools [8], [9] and [10] (required value: max. 60 Ncm).

Turn to find a zero-backlash area and fit protecting cap (314) with the mark pointing towards the steering gear. Remove former straight-ahead marking.

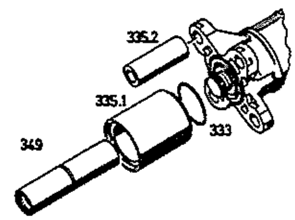


Fig.50

Fit O-ring (333).

Slip on centering ring (346) and coupling sleeve (349).

Note:
Coupling sleeve (349) must be fitted so that the inner chamfer points towards the steering gear.

17.2.2 Fit pipes

Fit O-ring (333). Slip on pipes (335.1 and 335.2) ***(Fig.50).***

17.2.3 Install bevel box

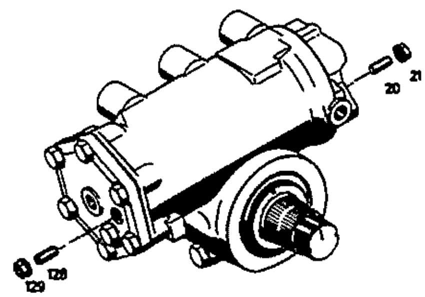


Fig.51

Secure bevel box with cap screws (352) as marked during disassembly (tightening torque: 62 Nm).

Turn steering to straight-ahead position and fit protecting cap (314) with the mark pointing towards the steering gear.

18 Assembly of set screw/screw (20 and 128)

18.1 Versions with collar nut (21 and 129)

Screw set screws (20 and 128) in by at least three turns and secure with collar nuts (21 and 129) (tightening torque: 20+10 Nm) ***(Fig.51).***

18.2 Versions with screws (20 and 128)

Refit the screws (20 and 128) which were removed during disassembly (tightening torque: 12+3 Nm) ***(Fig.52).***

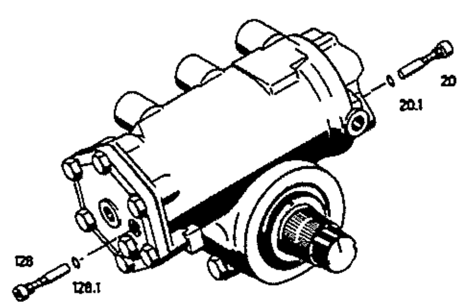


Fig.52

Attention:

→ These screws (20 and 128) may only be used for the functional tests described below.

→ New screws (20 and 128) must be fitted after the functional tests (tightening torque: 12+3 Nm).

→ The steering must subsequently not be turned to either limit position before being installed in the vehicle, otherwise the hydraulic steering limiter cannot be adjusted as specified.

19 Final assembly of steering gear

Note:
The final assembly described here must not be undertaken until the setting and functional tests (chapter IV.) have been completed on the test bench.

19.1 Fit plug (52)

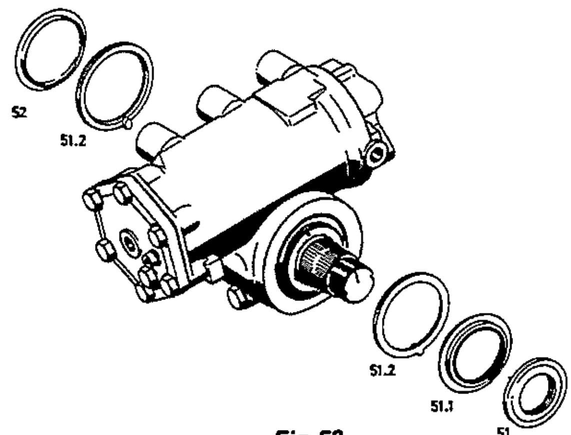


Fig.53

19.1.1 Versions with gasket (51.2)

Oil or grease the inner groove of dust seal (51), the outer circumference of gasket (51.2) and the mating face of gasket (51.2) on housing (1) (see note in chapter III. with regard to type of grease) ***(Fig.53)***.

Insert stop-ring (51.1) in the groove of dust seal (51) and place gaskets (51.2) on the inside of stop-ring (51.1) or plug (52) so that the protruding nose points away from plug (52) and stop-ring (51.1).

Slide the assembled dust seal (51) over the serration of sector shaft (80) by hand (the sector shaft must be kept as free of grease as possible) and press it into housing (1) until stop-ring (51.1) is flush with housing (1).

When fitting dust seal (51), ensure that the nose on gasket (51.2) fits exactly in the groove in housing (1).

On the opposite side of the serration on the sector shaft, press the preassembled plug (52) into housing (1) by hand until it is flush with housing (1).

When fitting plug (52), ensure that the nose on gasket (51.2) fits exactly in the groove in the housing.

Note:
Plug (52) may arch outwards due to air trapped under it during installation. For this reason, insert a small screwdriver between gasket (51.2) and housing (1) so that the trapped air can escape.

19.1.2 Versions without gasket (51.2)

Slip dust seal (51) and plug (52) onto sector shaft (80) after ensuring that the space between the dust lip and housing (1) is filled with grease (see note in chapter III. with regard to the type of grease) ***(Fig.54)***.

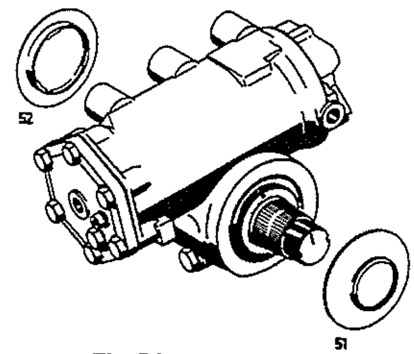


Fig.54

19.2 Fit protecting cap (53)

19.2.1 Versions with gasket (53.3)

Fit gasket (53.3) on the worm stub so that it fits exactly into the recess ***(Fig.55)***.

Press protecting cap (53) on as far as possible with tool [24]. Check assembly value of 5.4-0.2 mm (see illustration).

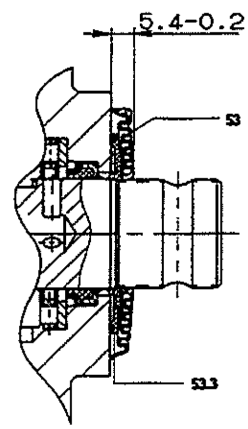


Fig.55

19.2.2 Versions without gasket (53.3)

Fit protecting cap (53) on the worm stub as far as possible with tool [24] after ensuring that the gap between dust lip and housing (1) is filled with grease (see note in chapter III. with regard to the type of grease).

19.2.3 Versions with retaining ring (53.1)

Slip protecting cap (53) onto the worm stub and fit retaining ring (53.1) ***(Fig.56)***.

19.3 Fit dust seal (314)

19.3.1 Bevel box versions with cross disc (348)

Fit dust seal (314) on bevel gear (306) after ensuring that the gap between adjusting screw (312) and dust lip is filled with grease (see note in chapter III. with regard to the type of grease) ***(see Fig.48)***.

Fit snap rings (314.1 and 314.2).

19.3.2 Angular gear versions with coupling sleeve (349)

Fit dust seal (314) on bevel gear (306) ***(see Fig.49)***.

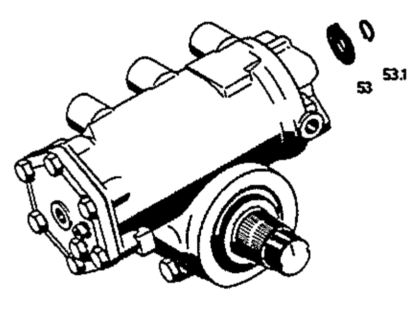


Fig.56

19.3.3 Check that the markings for the straight-ahead position are present as shown in *Fig.57*.

Exception:
The markings may be in a different position in special versions. This is then indicated on the technical cover sheet of the spare parts list.

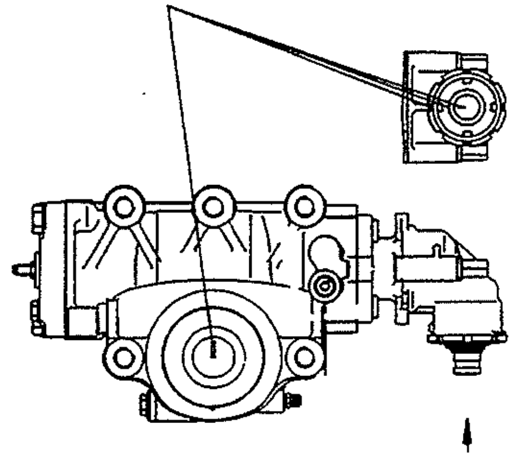


Fig.57

19.4 Versions with automatically adjusted steering limiter

Fit new screws (20 and 128) with new O-rings (20.1 and 128.1) (tightening torque: 12+3 Nm) *(Fig.58)*.

Attention:
The steering must not subsequently be turned to either limit position, otherwise the sliding sleeves of screws (20 and 128) are displaced into their limit position.

This then makes it impossible to adjust the hydraulic steering limiter in the vehicle as specified.

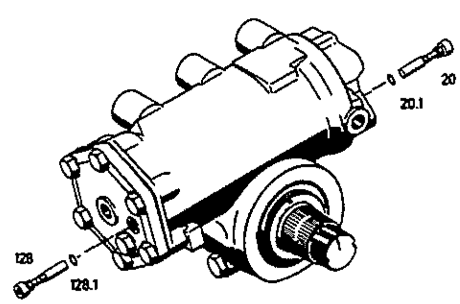


Fig.58

20 Checking the friction torque of the completely assembled steering gear

Mount tools [8], [9] and [10] on the steering shaft. Turn steering through from end to end and measure the friction torque outside the pressure point. Required value, see chapter VI.

The torque may vary by up to 40 Ncm when the steering is turned uniformly.

IV. Setting and functional test

Attention:
Every steering must undergo a setting and functional test on the test bench after being repaired in order to ensure traffic safety. The steering **must not** be installed in the vehicle without functional testing so that its correct function can subsequently be verified in a test drive.

Note:

→ All the required values, tolerances etc. necessary for this functional test are specified in the spare parts list. The values mentioned below apply if nothing is specified in the spare parts list.

→ The notes contained in the Instruction Manual for the test bench apply regardless of the following description.

1 Prepare steering for functional test

Set up completely assembled steering on test bench.

Connect delivery and return lines.

Attention:
Only lines and connections approved for the maximum pressure encountered may be used.

Additionally required for dual-circuit versions:
Seal ports for working cylinder with dummy plugs.

1.1 Bleed the steering:

❑ Versions with automatic bleeding:

These versions are fitted with automatic breather valves. It is therefore not necessary to open any breathers.

To bleed the steering, it must be turned from end to end several times. An unnecessarily high build-up of pressure must be avoided, since the breather valves are only effective in the continuous pressure range.

❑ Versions with breather (57):

Turn the steering so that breather (57) is positioned as near the top as possible.

Adjust the test bench to the flow rate specified below and do not turn the steering wheel.

Remove protecting cap (58) and open breather (57) by roughly one-half or a full turn.

Let air escape and reclose breather (57) when oil emerges.

Rapidly turn steering wheel from end to end several times and repeat bleeding procedure.

Torque breather (57) down to 30 Nm.

Refit protecting cap (58).

1.2 Set test bench: (Test temperature 50° C)

Note:
Test bench must be set to 20 bar above the maximum pressure specified on the rating plate for steering versions with built-in pressure limiter valve.

Pressure	Flow rate		
Type	8090:	150 bar	7 l/min
Type	8090 N:	170 bar	8 l/min
Type	8095:	150 bar	12 l/min
Types	8096-8099:	150 bar	16 l/min

2 Setting and functional test

2.1 Check absence of external leaks

The absence of external leaks must also be checked while carrying out the following tests 2.2 to 3.

2.2 Check maximum pressure

→ Determine the straight-ahead position by halving the total number of turns of the steering wheel or total steering angle.

→ Check or mark the middle on the steering shaft.

→ Lock steering in straight-ahead position.

→ Close steering valve by turning steering wheel in one direction.

→ A maximum pressure corresponding to the value set on the test bench must build up when the steering valve is fully deflected (approx. 100 N manual force applied to the steering wheel).

Note:
A maximum pressure corresponding to the value specified on the rating plate (tolerance: +10%) must build up if the steering is equipped with a pressure limiting valve.

→ Repeat the test for the other direction of rotation.

→ If the maximum pressure is not reached, this may be due to excessive leakage oil in the steering or to a defective pressure limiting valve.

→ If the maximum pressure is exceeded, the pressure limiting valve must be replaced or the setting of the pressure limiting valve on the test bench checked if the steering does not have a built-in pressure limiting valve.

2.3 Check oil leakage

2.3.1 Check oil leakage at a high flow rate

→ Lock steering in straight-ahead position.

→ The leakage oil draining into the return line should be measured at the following pressure when the steering valve is fully deflected (approx. 100 N manual force applied to the steering wheel):

Steering systems with built-in pressure limiting valve:
20 bar below the maximum pressure specified on the rating plate.

Steering systems without pressure limiting valve:
150 bar

Maximum permissible oil leakage:

Type 8090:	1.5 l/min
Types 8095-8099:	2.0 l/min

2.3.2 Check oil leakage at reduced flow rate

→ Set test bench to a flow rate of 2-3 l/min.

→ Check oil leakage as described above. The oil leakage established in section 2.3.1 must not be exceeded.

2.4 Check hydraulic centre

2.4.1 Steering not locked

→ Slowly turn steering through to the end in both directions with tools [8], [9] and [10], letting it go several times in the process.

The steering must not move in either direction of its own accord.

2.4.2 Steering locked in straight-ahead position

→ Turn steering shaft to lock steering valve in one direction until the pressure on the pressure gauge has risen 3 bar above the continuous pressure.

→ Read off the value on tools [9] and [10].

→ Repeat the measurement in the opposite direction.

The difference in torques when steering to the right or left must not exceed 30% referred to the higher value.

2.5 Valve reset

→ Lock steering in straight-ahead position.

→ Set test bench to previous values.

→ Turn steering wheel to close steering valve, thus building up the maximum pressure.

Slowly release the steering wheel and adjust to a pump pressure 10 bar above the continuous pressure.

The valve must then return to the neutral position, i.e. the oil pressure must drop to the continuous pressure within one second.

→ Check steering hitch:

There must not be any perceptible hitch when alternately turning the steering wheel in the other direction three times in succession at approx. 50 bar (hydraulic steering hitch).

2.6 Set hydraulic steering limiter

→ Set counterforce on test bench.

2.6.1 Versions with manually adjusted steering limiter (identified through collar nuts (21 and 129))

→ Turn the steering until the steering drop arm is deflected 47° and the hydraulic steering limiter is tripped.

Note:
Steering systems for which a different special switching range of 35 - 42°, for example, is specified in the spare parts list must be set to the explicitly specified maximum value, e.g. 42°.

→ Turn set screw (20 or 128) until the oil pressure drops to 40 - 50 bar and a considerably greater effort is required to turn the steering outwards.

Attention:
In all cases, ensure that the set screws (20 and 128) are screwed in by at least three turns, otherwise they may be forced out when the maximum pressure is applied.

→ Tighten the collar nut (21 or 129) down to 20+10 Nm.

→ Repeat adjustment for other side.

2.6.2 Versions with automatically adjusted steering limiter (identified through screws (20 and 128))

Note:
The screws (20 and 128) originally fitted are merely used to check whether the steering limiter valve opens, but without adjusting the switching range.

Attention:
The steering limiter may only be adjusted after installation and with new screws (20 and 128) in the case of these versions.

→ Turn steering in one direction and check that the pressure drops to 40 - 50 bar when the steering limiter valve opens.

→ Repeat test for other side.

3 Additionally required for dual-circuit versions

3.1 Check the maximum pressure, the hydraulic centre and valve reset for the second circuit as described in section 2.

3.2 Check oil leakage

3.2.1 Check oil leakage for circuit II

→ Connect delivery and return lines to circuit II.

→ Seal ports for working cylinder of circuit II with dummy plugs.

→ Check oil leakage as described in section 2.3.

Maximum permissible oil leakage for circuit II: 2 l/min

3.2.2 Measure oil leakage for sealing elements (164, 164.1, 172 and 173) separating circuits I and II.

→ Lock steering in straight-ahead position.

→ Then remove the screw plug (55) in the bottom of the housing or screw plug (55) in cylinder cover (125) if the former is not installed or unscrew the corresponding return line and drain off the oil

→ Drain the oil until the oil level in the housing reaches the drainage hole and the flow of oil ceases.

→ Seal the two working cylinder ports in circuit II with dummy plugs. Apply a pressure set to 3 bar above the continuous pressure on the test bench to the delivery line of circuit II. Collect the oil leaking from the housing bore or return line port of circuit I in a beaker for precisely one minute.

Max. permissible oil leakage: 0.001 dm^3/min (1 cm^3/min).

→ This test must be performed statically with the control valve not deflected.

→ Check oil leakage again dynamically at a pressure of 30 bar (set on the test bench), steering valve fully deflected once to the right and left.

3.3 Set hydraulic steering limiter

3.3.1 Steering limiter in piston

Set as described in section 2.6.

3.3.2 Steering limiter in housing cover

Turn steering in one direction until the steering drop arm is deflected as specified in the spare parts list for steering circuit II to trip the hydraulic steering limiter.

Turn valves (36) until the oil pressure drops to 30 - 40 bar and a considerably greater effort is required to turn the steering further outwards.

Torque hex nuts (38) down to 25 - 35 Nm.

4 Remove steering from test bench

Drain off the test oil by turning the steering shaft several times in both directions.

Remove steering from test bench.

Versions with automatically adjusted steering limiter

→ Affix note on settings, order number 7012 782 115, to the steering.

Versions with manually adjusted steering limiter

→ Affix note on settings, order number 7012 782 116, to the steering.

5 Check friction torque of completely assembled steering

Mount tools [8], [9] and [10] on steering shaft.

Turn steering through from end to end and measure friction torque within and beyond the pressure point.

Required values, see chapter VI.

The torque may deviate by up to max. 40 Ncm outside the pressure point when the steering is turned uniformly.

6 Affix repair code number

7 Carry out final assembly as described in chapter III. section 19.

V. Troubleshooting

Notes:

→ The ZF Servocom hydraulic steering has been built for heavy loads. It is designed in such a way that faults cannot develop if it is serviced correctly and operated normally.

→ If faults do develop, however, the following sections will help to locate and eliminate them.→ Before attempting to locate individual faults in the steering, the oil level must be checked with the engine running.

→ At the same time, attention is explicitly drawn to the fact that faults can occur when using oil with a strong tendency to foam, since such oil releases very little or none of the air entrained into the steering system.

Fault	Cause	Remedy
Moves stiffly in both directions	→ Sealing elements (116, 117, 119, 169, 170) defective	→ Replace
	→ Internal fault	→ Repair → Replace
	→ Valve insert (22) defective	→ Replace
For dual-circuit versions also:		
	→ Working cylinder defective	→ Repair → Replace
	→ Sealing elements (159/164) defective	→ Replace
Moves stiffly in one direction	→ Valve insert (109) defective	→ Replace
	→ Sealing element (123) defective	→ Replace
	→ Internal fault	→ Repair → Replace
For dual-circuit versions also:		
	→ Valves (36) defective/ wrongly set	→ Repair → Replace → Adjust
	→ Sealing element (164) defective	→ Replace
Steering hitch	→ Air in oil	→ Bleed

Fault	Cause	Remedy
Obstructed return travel	→ Excessive friction torque in steering	→ Check friction torque - see chapter IV.
Imprecise straight-ahead travel	→ Wrong friction torque	→ Check friction torque - see chapter IV.
Steering wheel knocks	→ Backlash in recirculating ball element or wrong friction torque	→ Check - see chapter III.
	→ Excessive backlash in worm bearing	→ Check - see chapter III.
	→ Centre engagement piston - sector shaft	→ Check - see chapter III.
Backlash in steering wheel	→ Backlash in recirculating ball element or wrong torque	→ Check - see chapter III.
	→ Excessive backlash in worm bearing	→ Check - see chapter III.
	→ Centre engagement piston - sector shaft	→ Check - see chapter III.
Steering drifts	→ Hydraulic centre not OK	→ Replace piston/ worm assembly
Loss of oil	Sealing elements (2, 5, 8, 124, 310 and 310.1) defective	→ Replace - see chapter III.
	→ Leak in lines or connections	→ Repair [1]
Noises	→ Worm defective	→ Repair → Replace
	→ Valve insert (22) and(32) defective	→ Repair → Replace
	→ Air in oil	→ Bleed
	→ Loose connections	→ Retighten

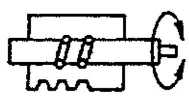
[1] See vehicle manufacturer's manual

VI. Friction torques, adjustment values and tightening torques

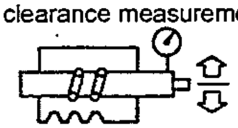
- **Friction torques:**

Recirculating ball element:

Friction torque measurement



Tilting clearance measurement



New parts	Disassembled parts
In middle area: Type 8090: 5-20 Ncm Types 8095-8099: 5-30 Ncm	In middle area: max. 0.1 mm Tilting clearance or for type 8090: max. 20 Ncm for types 8095-8099: max. 30 Ncm
Outside the middle area: Additional increase of max. 15 Ncm	Outside the middle area: Max. increase to for type 8090: 35 Ncm for types 8095-8099: 60 Ncm

Increase in friction torque at the pressure point:

Type	8090:	20-60 Ncm
Types	8095/8096:	20-80 Ncm
Types	8097-8099:	20-100 Ncm

Completely assembled steering outside the pressure point:

Type Transmission constant (e.g. i_1, i_2 ...) and variable (e.g. iv_1, iv_2 ...)	Friction torque [Ncm] without bevel box	Friction torque [Ncm] with bevel box
8090		
i_1 = 15.2 : 1	max. 160	max. 240
iv_1 = 16.6 : 1 / 14.0 :1		
i_2 = 18.0 : 1	max. 140	max. 220
iv_2 = 19.6 : 1 / 16.6 : 1		

8095		
i_1 = 17.0 : 1	max. 180	max. 260
iv_1 = 18.5 : 1 / 15.6 :1		
i_2 = 19.6 : 1	max. 160	max. 240
iv_2 = 21.3 : 1 / 18.1 :1		
i_3 = 23.1 : 1	max. 140	max. 220
iv_3 = 25.2 : 1 / 21.3 :1		
8097		
i_1 = 16.6 : 1	max. 200	max. 280
iv_1 = 18.2 : 1 / 15.4 :1		
i_2 = 18.9 : 1	max. 180	max. 260
iv_2 = 20.6 : 1 / 17.4 :1		
i_3 = 21.8 : 1	max. 160	max. 240
iv_3 = 23.7 : 1 / 20.1 :1		
i_4 = 25.7 : 1	max. 140	max. 220
iv_4 = 28.1 : 1 23.8 : 1		
8098		
i_1 = 18.3 : 1	max. 220	max. 300
iv_1 = 20.1 : 1 / 17.0 :1		
i_2 = 20.7 : 1	max. 200	max. 280
iv_2 = 22.6 : 1 19.2 : 1		
i_3 = 23.9 : 1	max. 180	max. 260
iv_3 = 26.1 : 1 22.1 : 1		

Type Transmission constant (e.g. i_1, i_2 ...) and variable (e.g. iv_1, iv_2...)	**Friction torque [Ncm] without bevel box**		**with bevel box**	
	- add-on cylinder	**+ add-on cylinder**	**- add-on cylinder**	**+ add-on cylinder**
8096				
i_1 = 17.0 : 1	max. 210	-	max. 290	-
iv_1 = 18.5 : 1 / 15.6:1				
i_2 = 19.6 : 1	max. 190	-	max. 270	-
iv_2 = 21.3 : 1 / 18.1:1				
i_3 = 23.1 : 1	max. 170	-	max. 250	-
iv_3 = 25.2 : 1 21.3:1				
8099				
i_1 = 18.3 : 1	max. 250	max. 320	max. 330	max. 400
iv_1 = 20.1 : 1 / 17.0:1				
i_2 = 20.7 : 1	max. 230	max. 300	max. 310	max. 380
iv_2 = 22.6 : 1 19.2:1				
i_3 = 23.9 : 1	max. 210	max. 280	max. 290	max. 360
iv_3 = 26.1 : 1 / 22.2:1				

Adjustment values:

Protecting cap (53) - Fitting value			5.4 - 0.2 mm
Plug (112) - Radial clearance	Type	8090:	max. 0.1 mm
	Types	8095-8099:	max. 0.5 mm
	Type	8099 with add-on cylinder:	max. 0.2 mm
Needle cage (120) - Axial clearance (at room temperature)	Type	8090:	0.005 - 0.025 mm
	Types	8095/8096:	0.010 - 0.030 mm
	Type	8097:	0.015 - 0.035 mm
	Types	8098/8099:	0.020 - 0.040 mm
Sliding tube (156) - Axial clearance			max.0.1 mm
Piston (258) - Installed value			60.7±0.2 mm

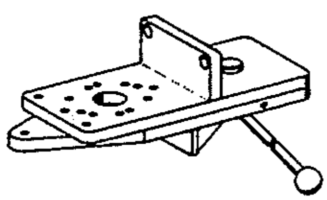
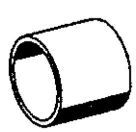
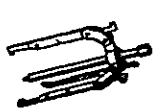
Tightening torques:

Screw (20)			12+3 Nm
Collar nut (21)			20+10 Nm
Valve insert (22)			30+10 Nm
Valve insert (22.1)			30+10 Nm
Screw (30)			30+10 Nm
Hex nut (38)			25-35 Nm
Screw plug (55)		M16:	40 Nm
		M18:	50 Nm
Breather (57)			30 Nm
Valve insert (109)			15±1 Nm
Hexagon screws (127)	Type	8090 (M12x1.5):	135 Nm
	Types	8095/8096/8097 (M16x1.5):	285 Nm
	Types	8098/8099 (M14x1.5):	189 Nm
Screw (128)			12+3 Nm

Collar nut (129)		20+10 Nm
Cap screws (204)		140 Nm
Pipe union (205)		50 Nm
Pipe union (206)		50 Nm
Screw plug for pipe unions (205) and (206)		59 Nm
Union screws (211)		20±2 Nm
Switch (222)		50 Nm
Cap screw (223)	Type 8096 (M8):	37 Nm
	Type 8098 (M6) (version with switch):	5.5 Nm
Pipes (225)	Type 8096:	12+2 Nm
	Type 8099:	18+2 Nm
Pipes (226)	Type 8096:	12+2 Nm
	Type 8099:	18+2 Nm
Torx screw (250.1)		5 Nm
Hexagon screw (252)		500 Nm
Adjusting screw (312)		50 Nm
Slotted nut (313)		50 Nm
Cap screw (334)		140 Nm
Hexagon screw (352)		62 Nm

VII. Special tools

Note:
The special tools listed below refer to the standard version and the design version on the basis of which the entire manual has been compiled. Other tools may consequently be required for the particular unit in question.

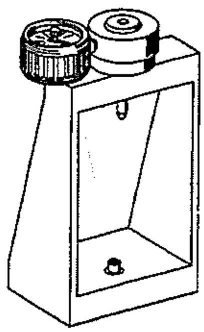
	8090	8095	8096	8097	8098	8099
Tool [1] Assembly vice 	7418 798 654					
Tool [2] Insert for screw–out and screw–in the valve insert (109) 	8098 798 151					
Tool [3] Sleeve for pressing the housing covers (4) 	8090 798 006	8095 798 002		8097 798 002	8098 798 002	
Tool [4] Puller for housing cover (4) 	8090 798 201					

Tool [5]

Guide bush for housing cover (4)

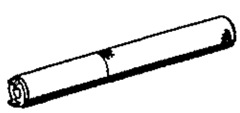
Tool [6]

Peening fixture for valve insert (109)



Tool [7]

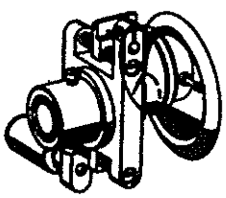
Punch for screwed valve insert (109)



Tool [8]

Insert for tool [9]

	8090	8095	8096	8097	8098	8099
Tool [5]		8043 798 001				
Tool [6]	8090 798 655					
Tool [7]	8098 798 654					
Tool [8] serration	1x54	7/8"x48	1x79	1x75	7/8x48	1x79
	8052 798 552	8043 798 551	7419 798 551	7418 798 553	8043 798 551	7419 798 551
serration		1x79	A6x23x26	1x79	1x79	A6x23x26
		7419 798 551	8065 798 552	7419 798 551	7419 798 551	8065 798 552

	8090	8095	8096	8097	8098	8099
	Valve slide			ø25	ø25,99	
				7421 798 551	8097 798 554	
	Valve slide serration			ø25,99	24/48x22	
				8097 798 554	8038 798 551	
Tool [9] Torque measuring device 	7470 798 703					
Tool [10] Dial gauge: Graduation 0.01 mm 	7470 798 706					
Tool [11] Guide bush for sealing rings (164) 	8090 798 004	8090 798 001				
for dual–circuit version			8090 798 005			8090 798 005

	8090	8095	8096	8097	8098	8099
Tool [12] Pliers for pressing on the sealing rings (164) 	8090 798 652	8090 798 651				
Tool [13] Sleeve for mounting the O–ring (172) and the sealing ring (173) 			8096 798 001			8096 798 001
Tool [14] Mandrel for shaft seal (8) 	8090 798 052	8090 798 051				
Tool [15] Guide bush for shaft seal (8) 	8090 798 002	8090 798 003				

Tool [16]

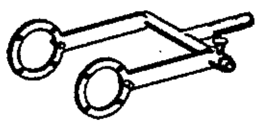
Dial gauge holder for adjustment of axial play–worm

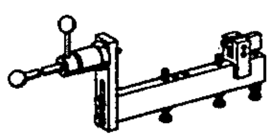
Tool [17]

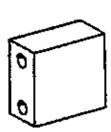
Dial gauge graduation 0.001 mm for tool [16]

Tool	8090	8095	8096	8097	8098	8099
[16]	serration					
	1x54	7/8"x48	1x79	1x75	7/8x48	1x79
	8090 798 101	8095 798 102	8095 798 101	8097 798 101	8095 798 102	8095 798 101
		serration 1x79	serration A6x23x26	1x79	1x79	A6x23x26
		8095 798 101	8097 798 102	8095 798 101	8095 798 101	8097 798 102
				Valve slide ø25	serration 24/48x22	
				8095 798 101	8097 798 101	
				Valve slide ø25.99		
				8097 798 102		
[17]	7016 798 704					

Tool	8090	8095	8096	8097	8098	8099
Tool [18] Adjusting device for pressure point setting	8090 798 151					
Tool [19] Insert for tool [18] (2 pieces are required)	8090 798 551	8095 798 551		8097 798 551	8098 798 551	
Tool [20] Assembly tool for prying over of housing covers (4)	8090 798 654					
Tool [21] Extension for tool [20] for steerings with C–mass >137 mm					8090 798 656	

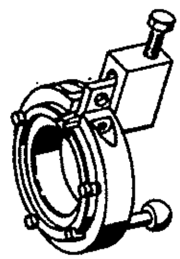






Tool [22]

Assembly tool for threefold prying

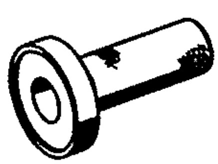


Tool [23]

Insert for torx screw (250.1)

Tool [24]

Mandrel for pressing the protecting cap (53)

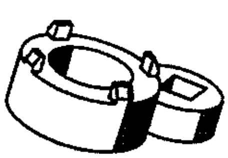


8090	8095	8096	8097	8098	8099
		8096 798 651		8098 798 651	
					7016 798 152
8090 798 053	8095 798 051				

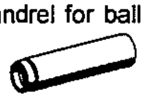
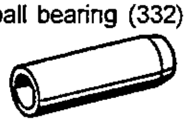
Bevel box with cross disc (348)

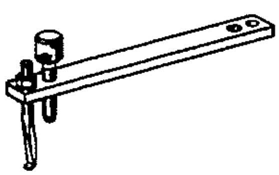
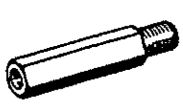
Tool [25]

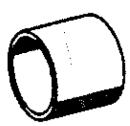
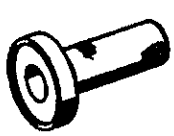
Grooved nut wrench for adjusting screw (312)



8096	8097	8098	8099
1249 898 151			

<table>
<tr><th></th><th>8096</th><th>8097</th><th>8098</th><th>8099</th></tr>
<tr><td>Tool [26]
Puller for needle sleeve (302)
</td><td colspan="4">7421 798 201</td></tr>
<tr><td>Tool [27]
Counter for tool [26]
and [34]
</td><td colspan="4">7421 798 351</td></tr>
<tr><td>Tool [28]
Mandrel for ball bearing (343)
</td><td colspan="4">7421 798 051</td></tr>
<tr><td>Tool [29]
Mandrel for needle sleeve (302)
</td><td colspan="4">7677 798 051</td></tr>
<tr><td>Tool [30]
Press–in sleeve for
ball bearing (332)
</td><td colspan="4">7330 798 053</td></tr>
</table>

	8096	8097	8098	8099
Tool [31] Mandrel for shaft seal (310 and 310.1) 	7418 798 051			
Tool [32] Guide bush for shaft seal (310 und 310.1) 	8090 798 003			
Bevel box with coupling sleeve (349) **Tool [33]** Puller for shaft seal (310) 	8052 798 201			
Tool [34] Puller for needle sleeve (302) 	8098 798 201			
Tool [35] Extension for tool [34] 	8098 798 202			

	8096	8097	8098	8099
Tool [36] Mandrel for needle sleeve (302) 	8098 798 052			
Tool [37] Sleeve for shaft seal (310.1) 	8090 798 006			
Tool [38] Guide bush for shaft seal (310) 	8098 798 003			
Tool [39] Mandrel for shaft seal (310) 	8098 798 051			

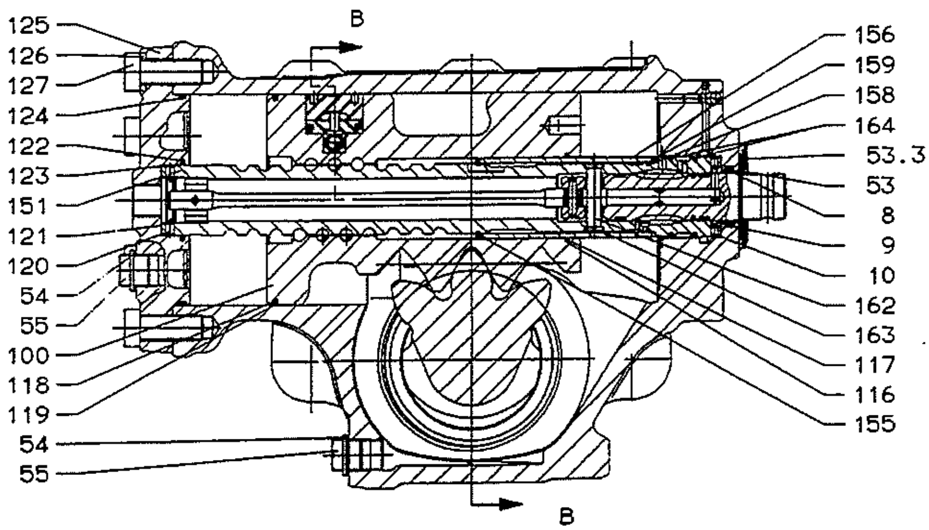
VIII. Key to numbers in figures, sectional drawings and exploded drawings

1.0	Housing
2.0	O-ring
3.0	Washer
4.0	Housing cover
5.0	Gasket
6.0	Support ring
7.0	Retaining ring
8.0	Shaft seal
9.0	Axial-, washer
10.0	Needle cage
11.0	Type plate
12.0	Grooved stud
14.0	Holding segment
20.0	Set screw / Adjusting screw / Screw
20.1	O-ring
21.0	Collar nut
22.0	Valve insert
22.1	Valve insert
23.0	O-ring
30.0	Screw
31.0	O-ring
32.0	Valve insert
34.0	O-ring
35.0	O-ring
36.0	Valve
37.0	Washer
38.0	Hex nut
50.0	Locking nut
51.0	Dust seal
51.1	Stop-ring
51.2	Gasket
51.9	Dust seal
52.0	Plug
53.0	Protecting cap
53.1	Retaining ring
53.3	Gasket
54.0	Sealing ring
55.0	Screw plug
56.0	Protecting sleeve
57.0	Breather
58.0	Protecting cap
63.0	Stick-on label
80.0	Sector shaft
100.0	Piston
101.0	Piston
109.0	Valve insert
110.0	Ball set
111.0	Recirculating half tube
112.0	Gasket/Plug
113.0	Gasket
113.1	Compensating plate
113.2	Pin
114.0	O-ring
115.0	Sealing ring
116.0	Sealing ring
117.0	Sealing ring
118.0	O-ring
119.0	Gasket
120.0	Needle cage
121.0	Washer
122.0	O-ring
123.0	Sealing ring
124.0	O-ring
125.0	Cylinder cover
126.0	Washer
127.0	Hexagon screw
127.1	Screw
128.0	Set screw / Screw
128.1	O-ring
129.0	Collar nut
150.0	Worm
151.0	Worm
155.0	Snap ring
156.0	Sliding tube
157.0	Bush
158.0	O-ring
159.0	Sealing ring
160.0	Pin
161.0	Worm
162.0	Pin

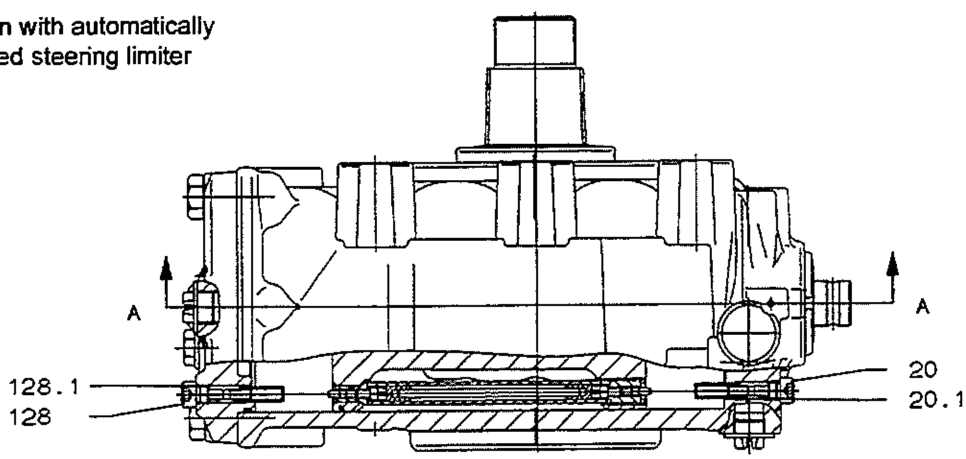
163.0	Plug
164.0	Sealing ring
164.1	O-ring
165.0	Torsion bar
166.0	Needle cage
166.1	Snap ring
167.0	Pin
168.0	Valve slide
169.0	O-ring
170.0	Sealing ring
171.0	Needle cage
172.0	O-ring
173.0	Sealing ring
174.0	Control sleeve
200.0	Ball cage
201.0	Bearing ring
202.0	O-ring
203.0	Valve housing
204.0	Cap screw
205.0	Pipe union
206.0	Pipe union
207.0	Pipe
208.0	Pipe
209.0	O-ring
210.0	O-ring
211.0	Union screw
212.0	Pipe
220.0	O-ring
221.0	Housing cover / Cover
222.0	Steering limiter kit / Switch
222.1	Washer
223.0	Cap screw
224.0	O-ring
225.0	Pipe
226.0	Pipe
227.0	Cam disc
228.0	Retaining ring
250.0	Add-on cylinder
250.1	Torx screw
251.0	Washer
252.0	Hexagon screw
253.0	Bush
254.0	Gear
255.0	O-ring
256.0	O-ring
257.0	Gasket
258.0	Piston
259.0	Cylinder cover
260.0	O-ring
261.0	Retaining ring
301.0	Housing
302.0	Needle sleeve
304.0	Washer
306.0	Bevel gear
308.0	O-ring
310.0	Shaft seal
310.1	Shaft seal
310.2	Retaining ring
310.3	Retaining ring
310.4	Retaining ring
312.0	Adjusting screw
313.0	Slotted nut
314.0	Dust seal / Protecting cap
314.1	Snap ring
314.2	Snap ring
330.0	Shim plate
331.0	Bevel gear
332.0	Ball bearing
333.0	O-ring
334.0	Cap screw
335.0	Intermediate flange
335.1	Pipe
335.2	Pipe
341.0	O-ring
343.0	Ball bearing
346.0	Centering ring
348.0	Cross disc
349.0	Coupling sleeve
350.0	Washer
352.0	Hexagon screw/Screw/ Cap screw

Types 8090 - 8099

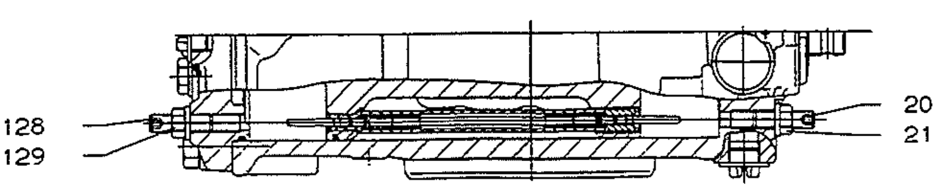
Section A-A



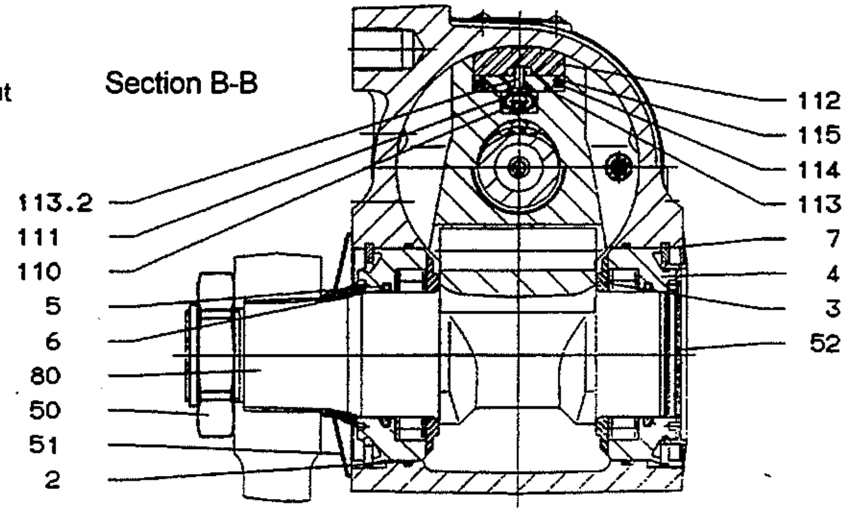
Version with automatically adjusted steering limiter



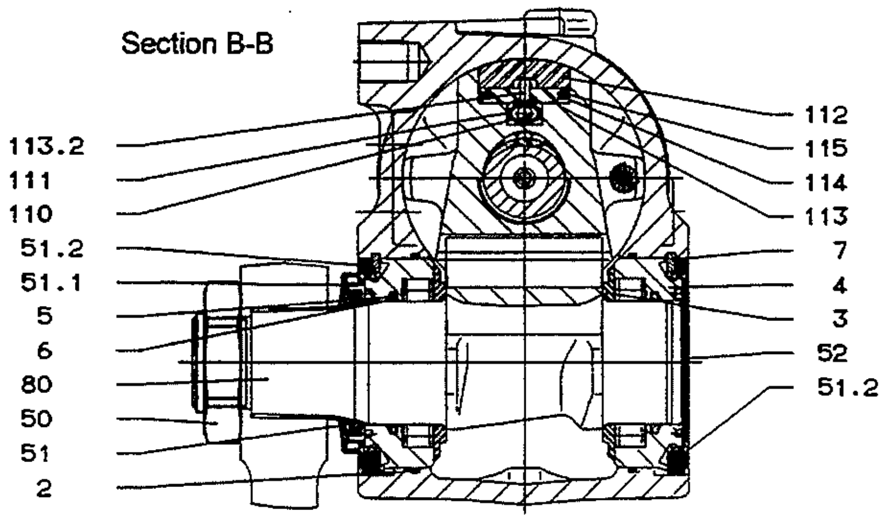
Version with manually adjusted steering limiter



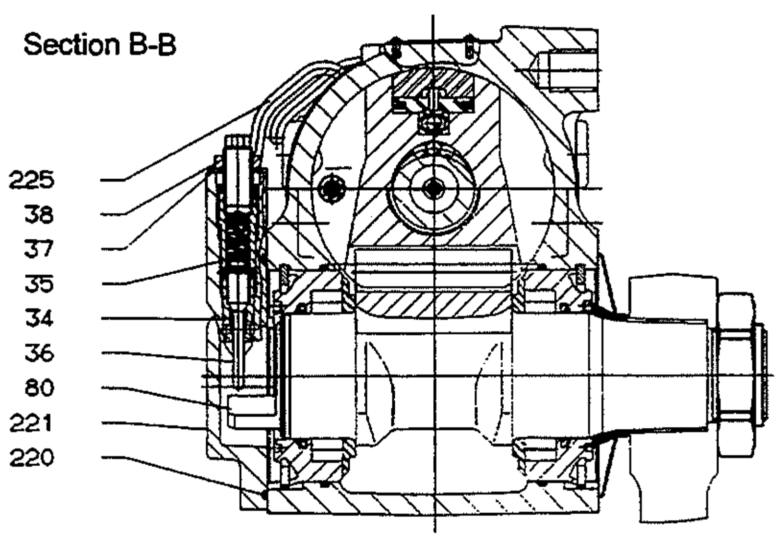
Version without gasket (51.2)



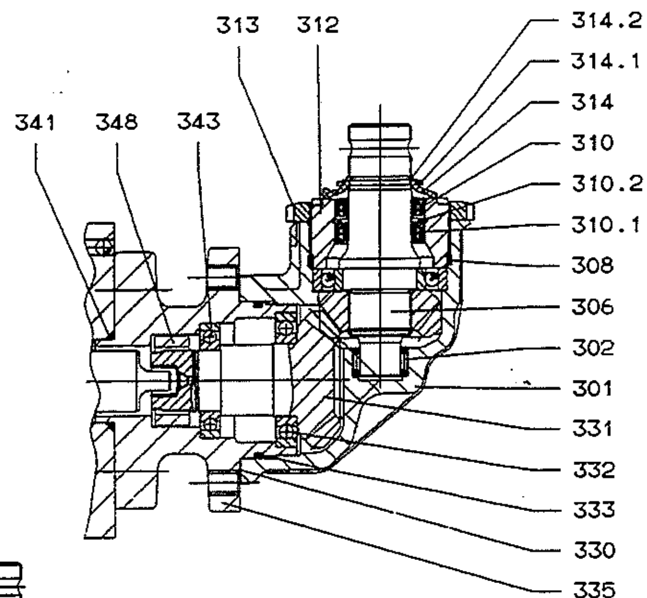
Version with gasket (51.2)

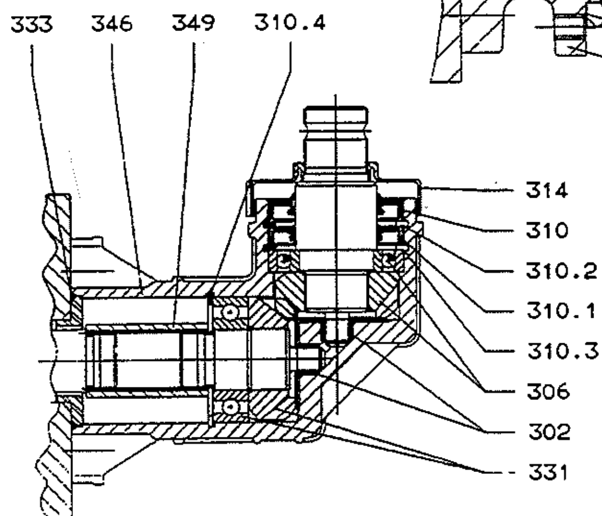


Dual-circuit version with steering limiter in housing cover (221)



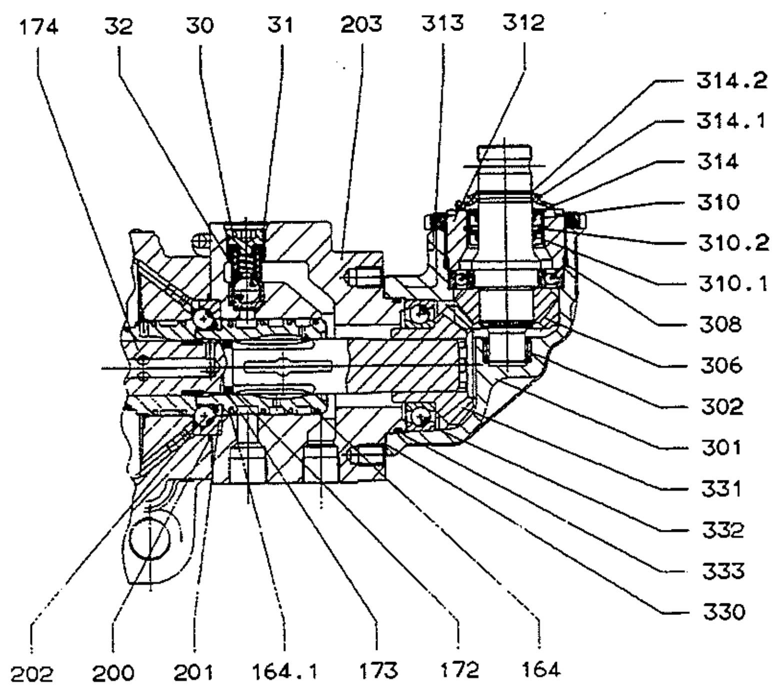
Bevel box with
cross disc (348)

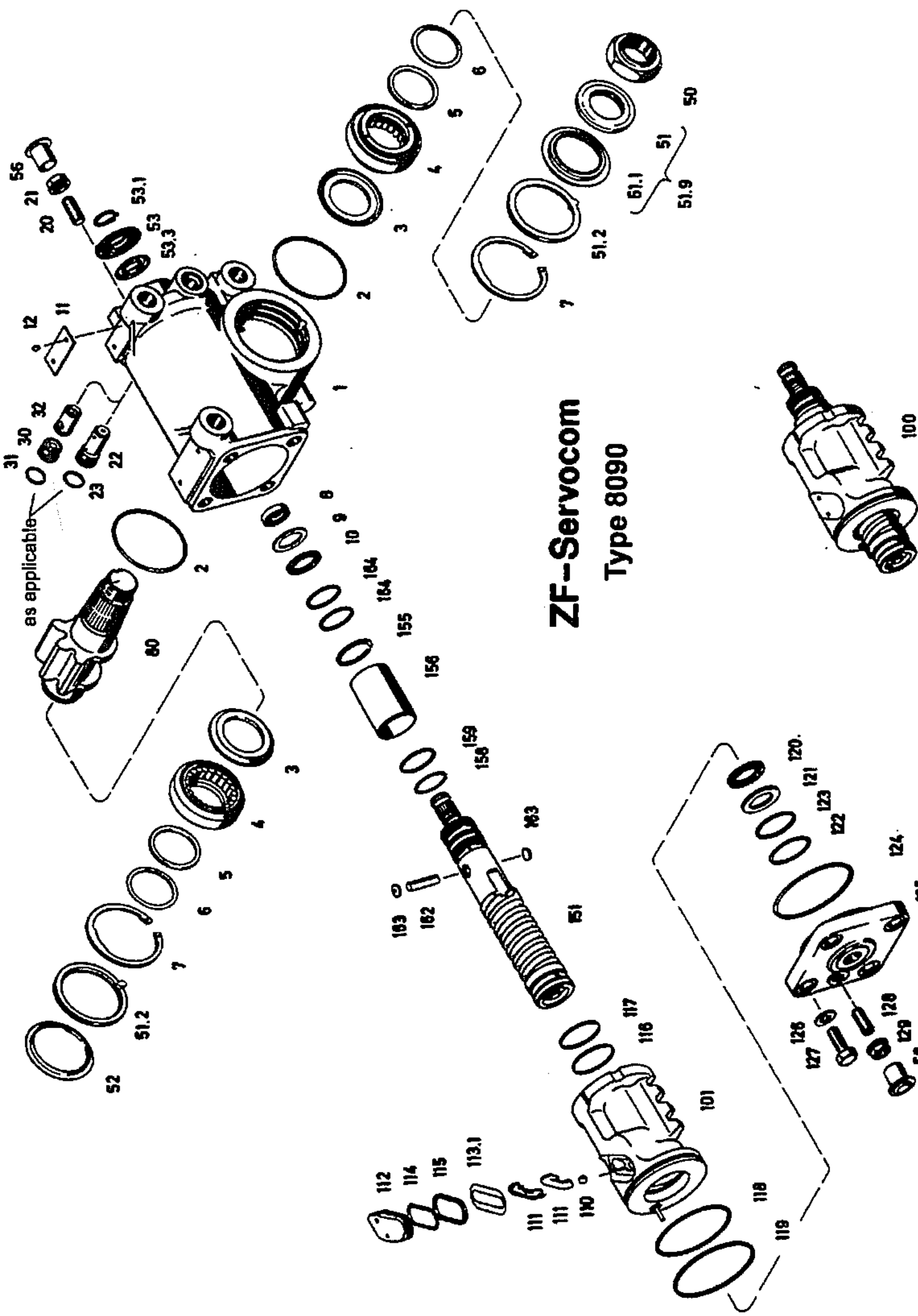


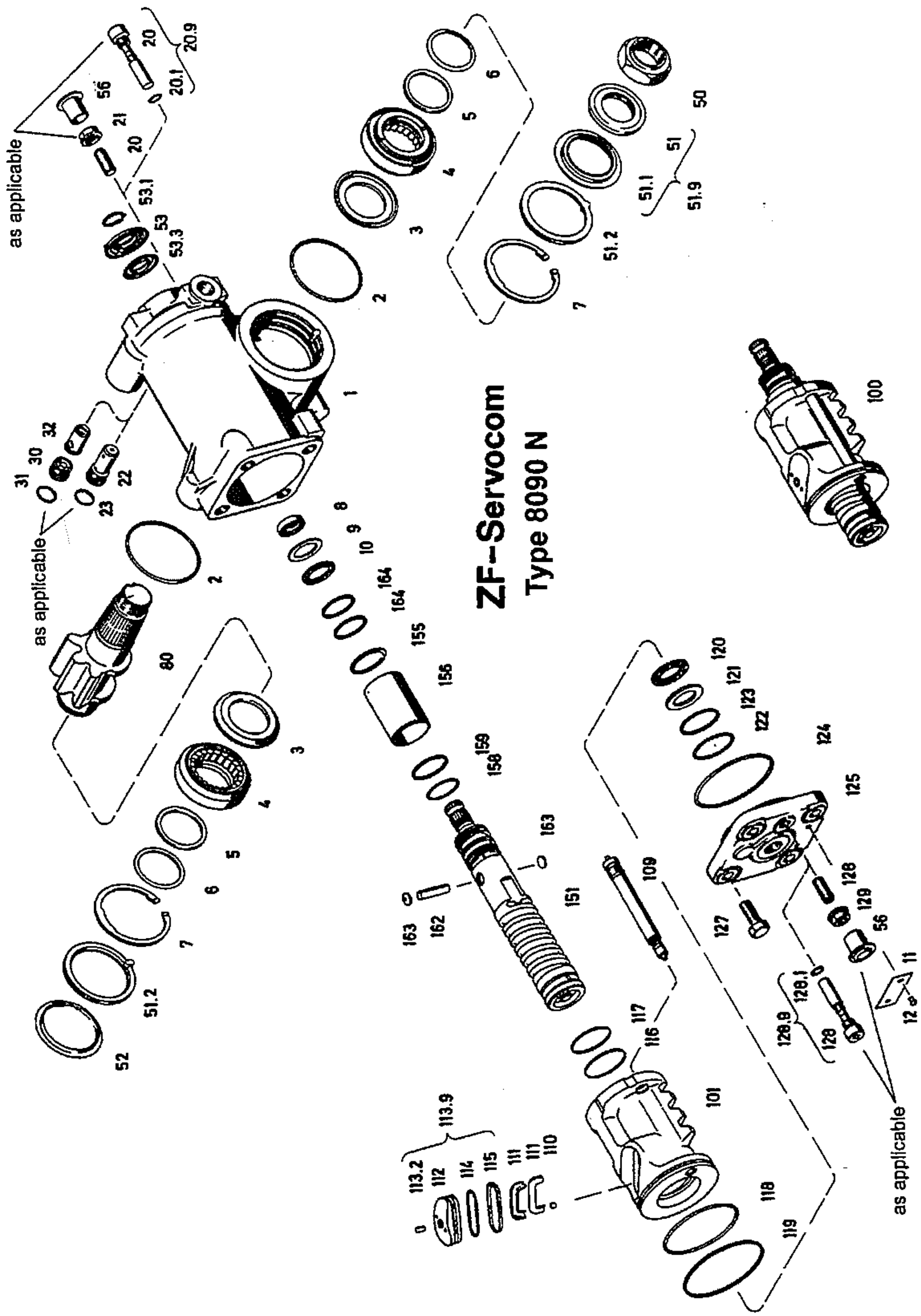


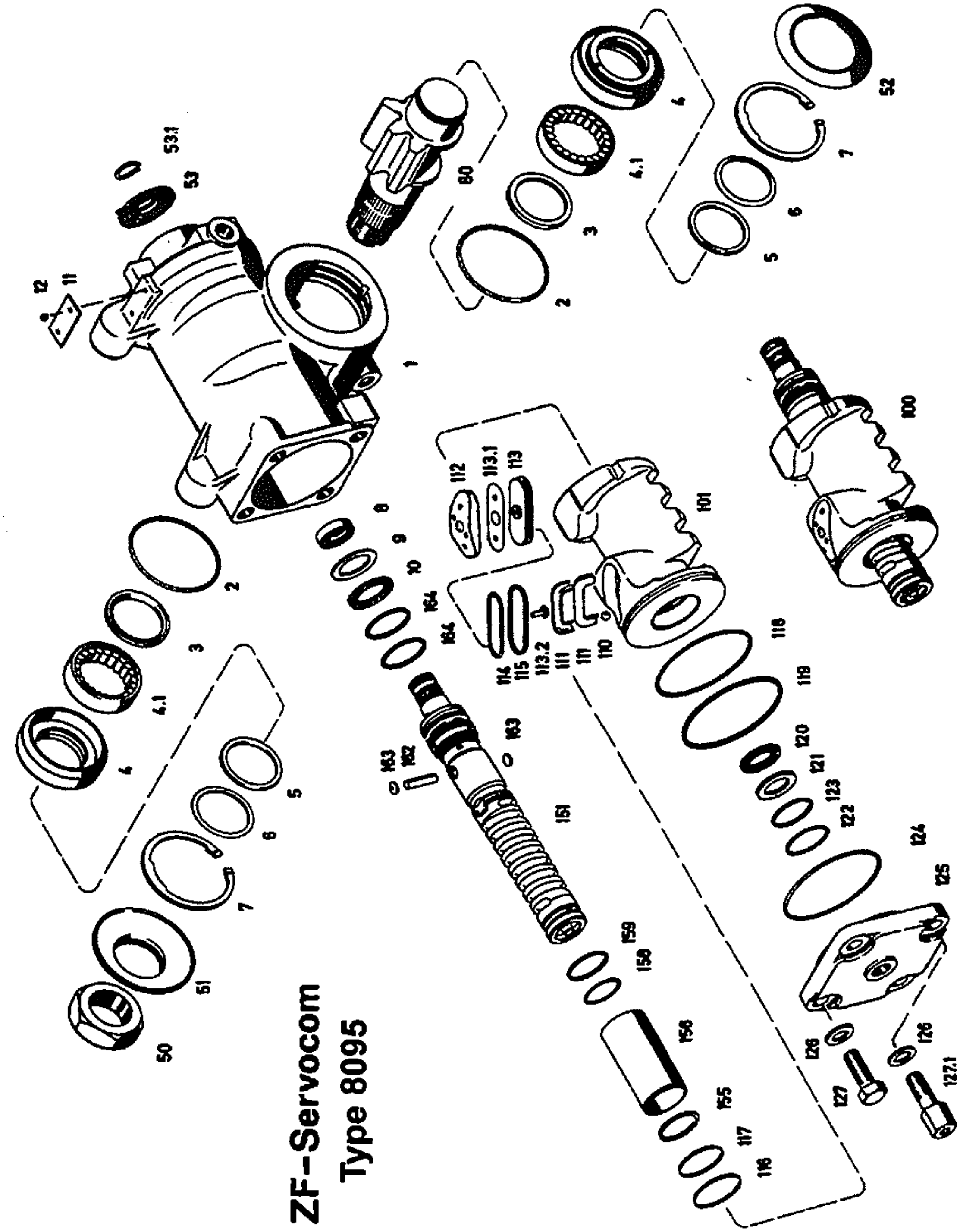
Bevel box with
coupling sleeve (349)

Dual-circuit version
with bevel box




ZF–Servocom
Type 8090
as applicable


ZF-Servocom
Type 8090 N
as applicable
as applicable
as applicable



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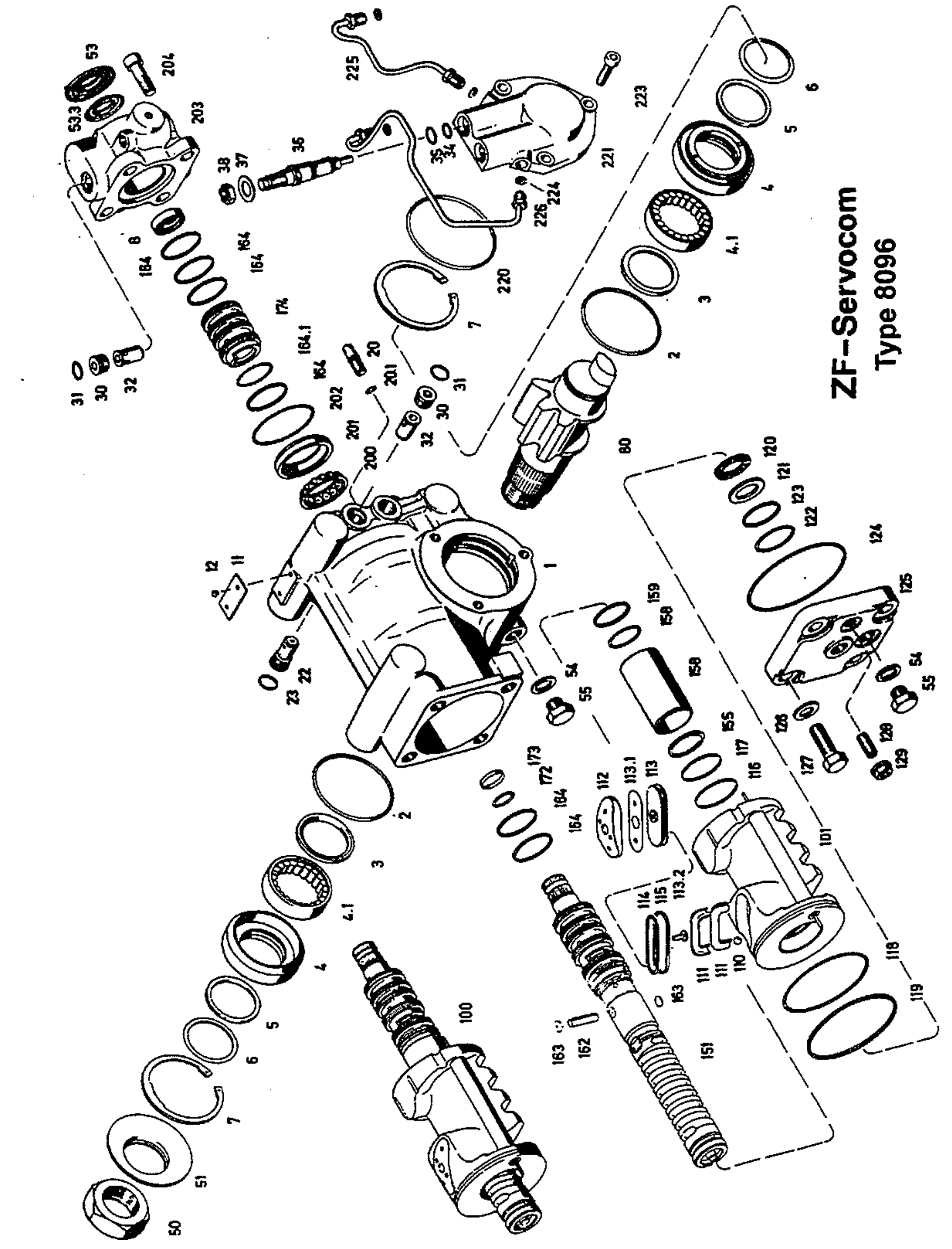
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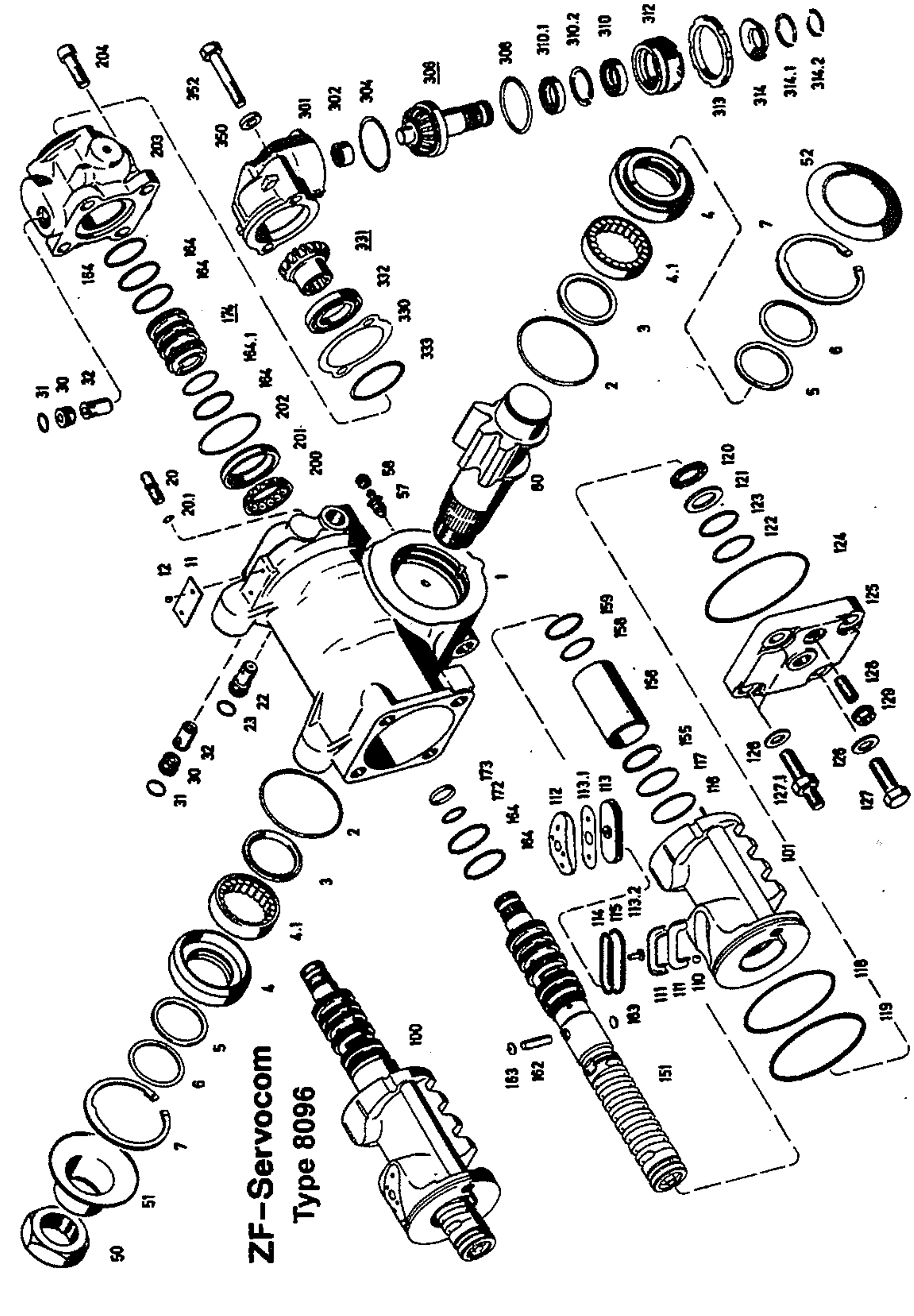
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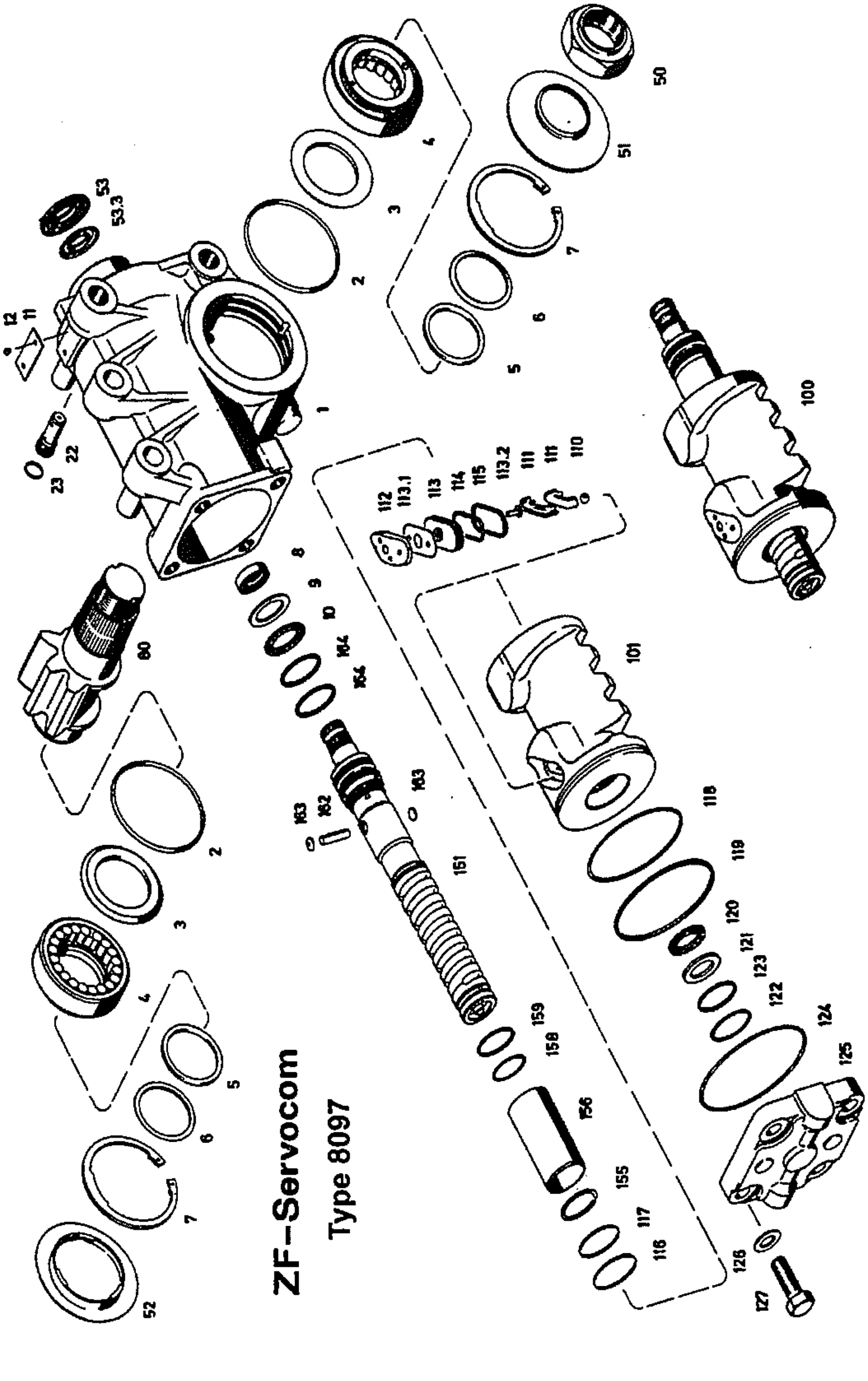
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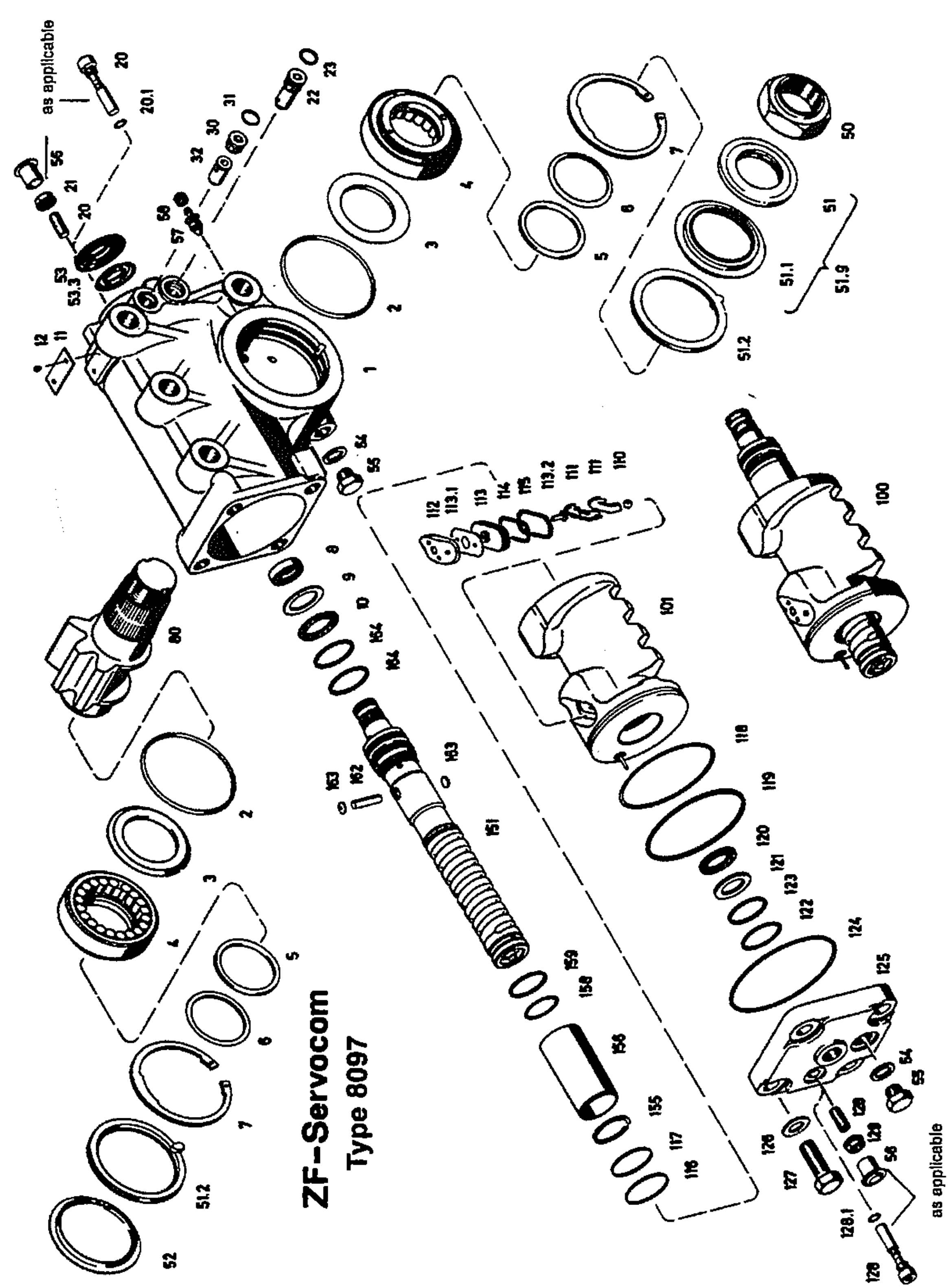
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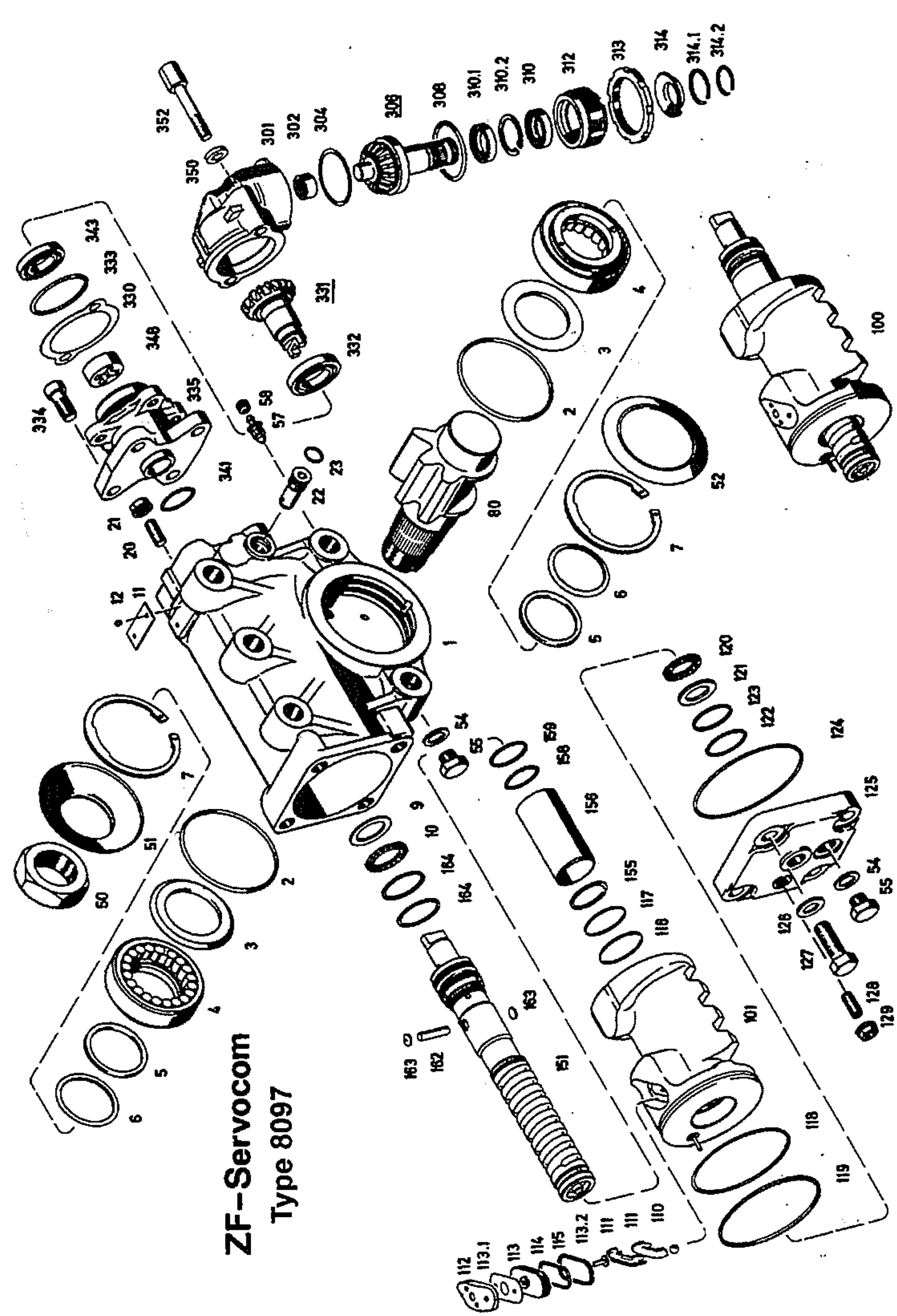
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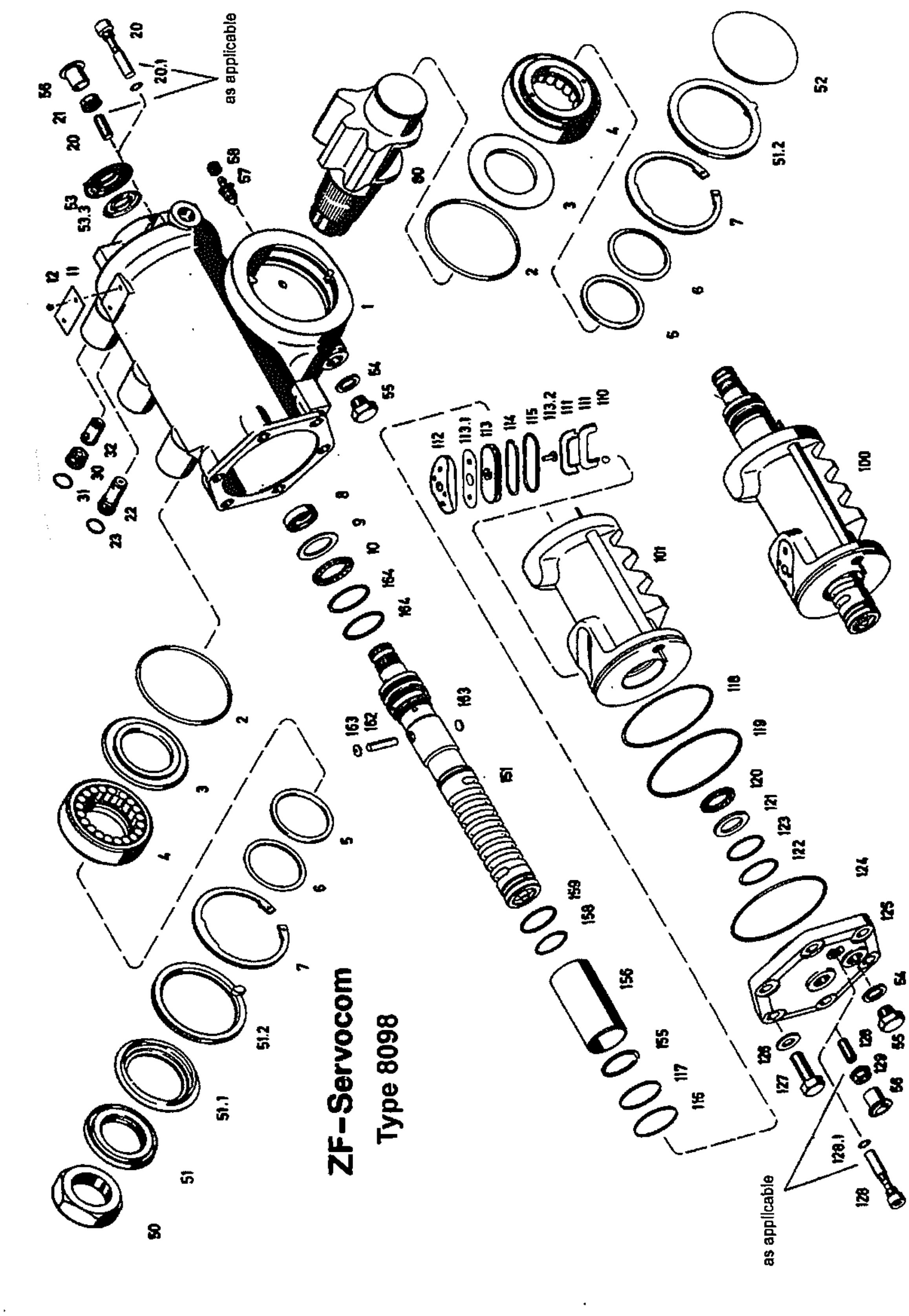
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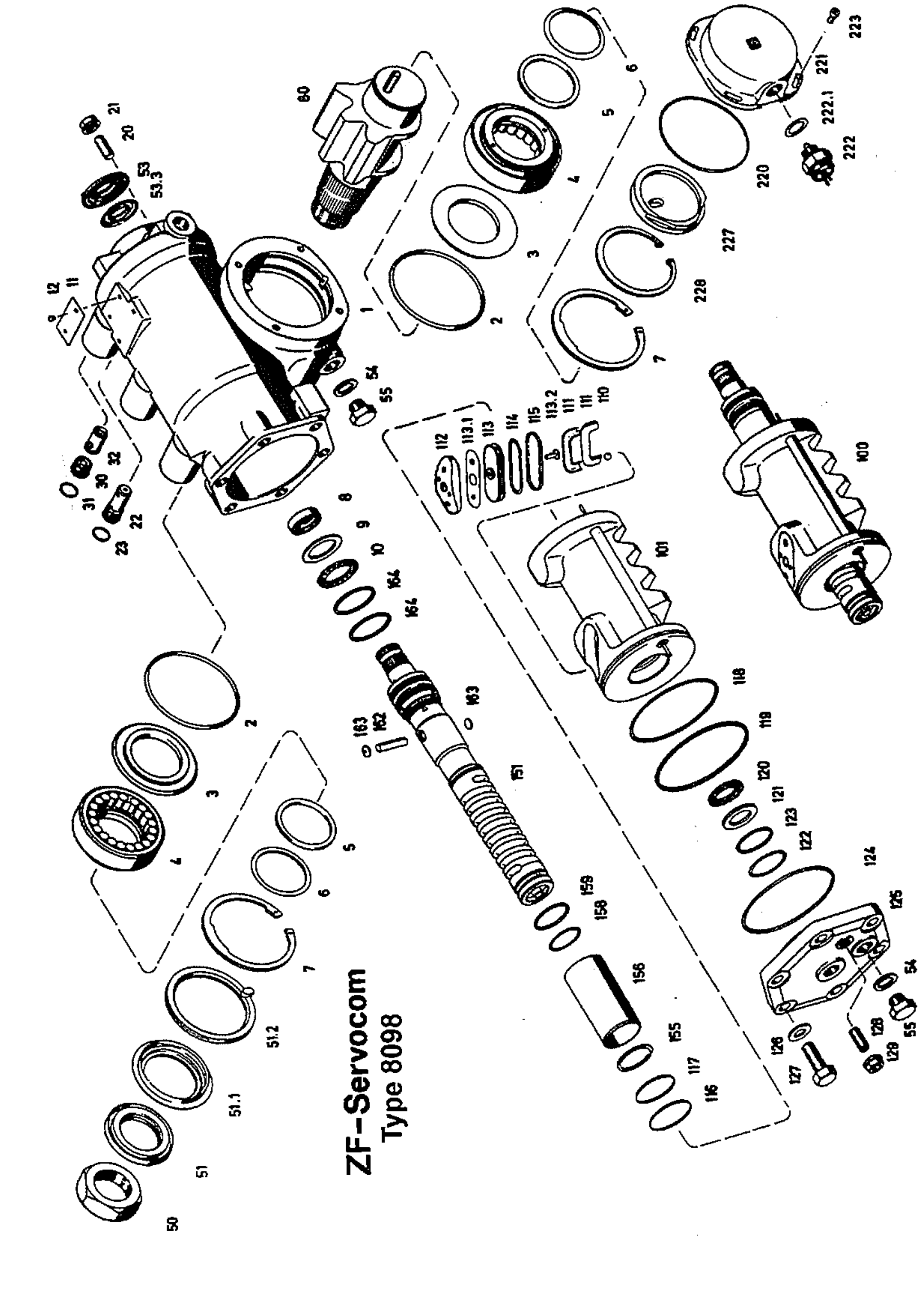
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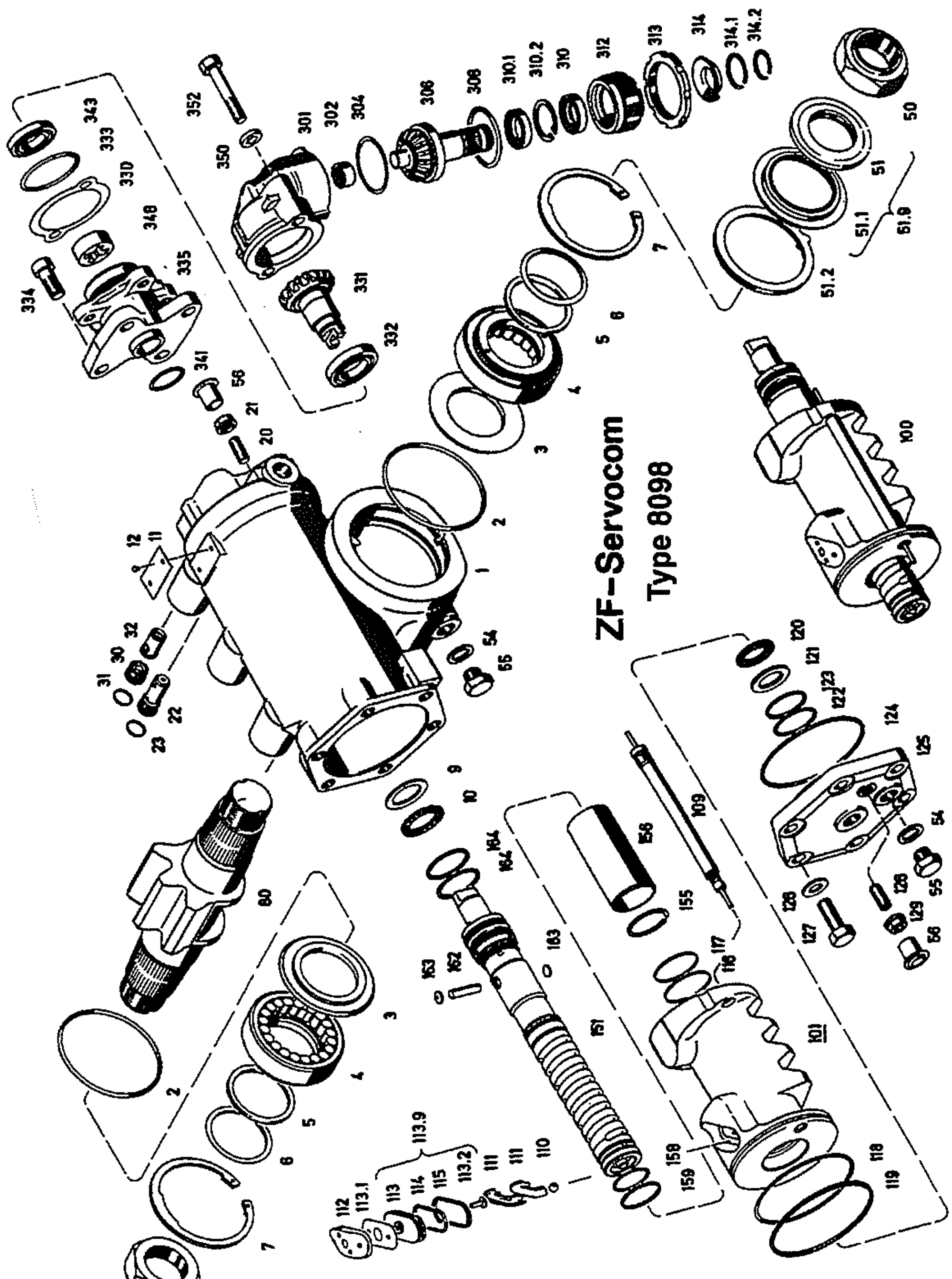
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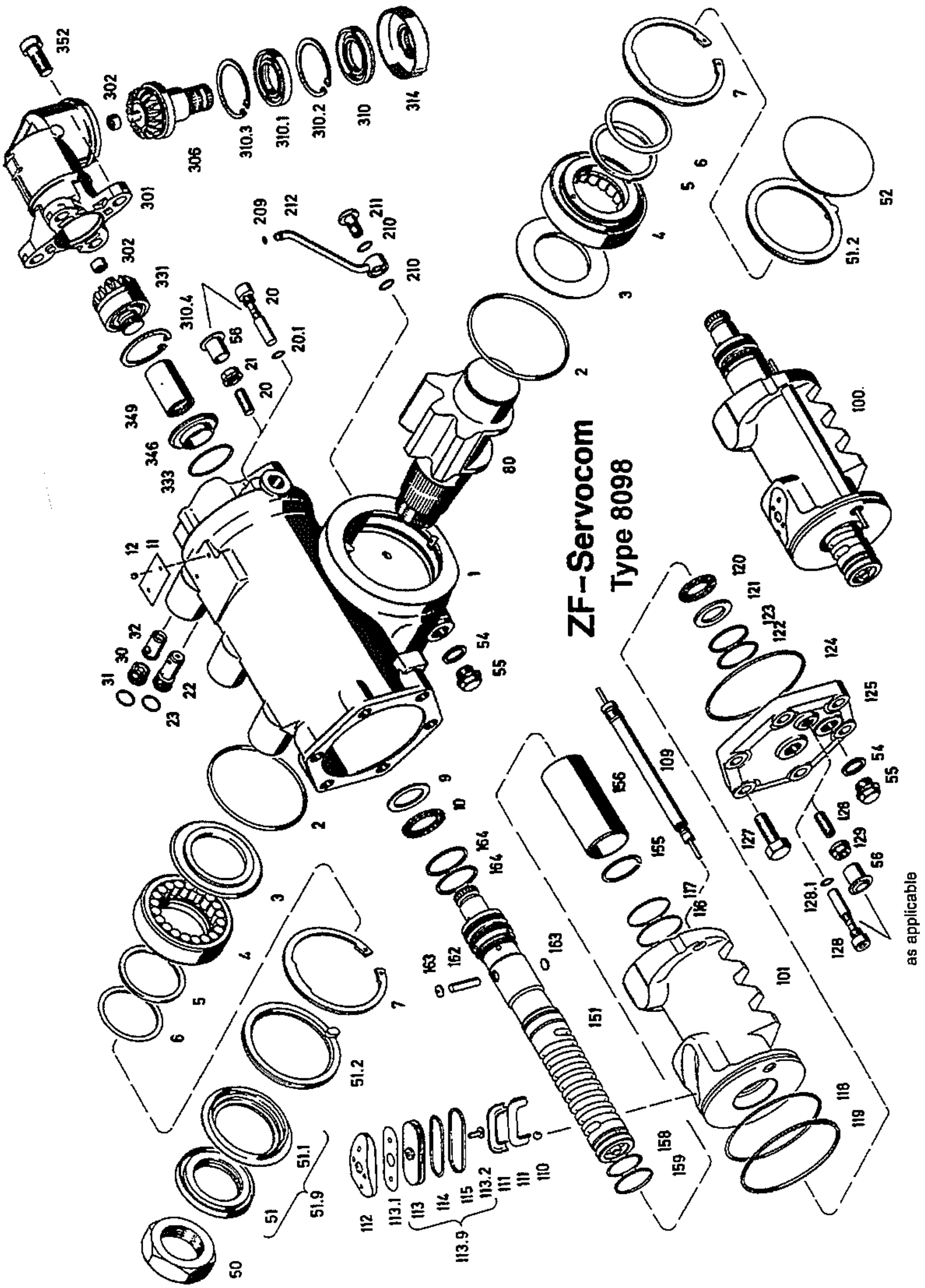
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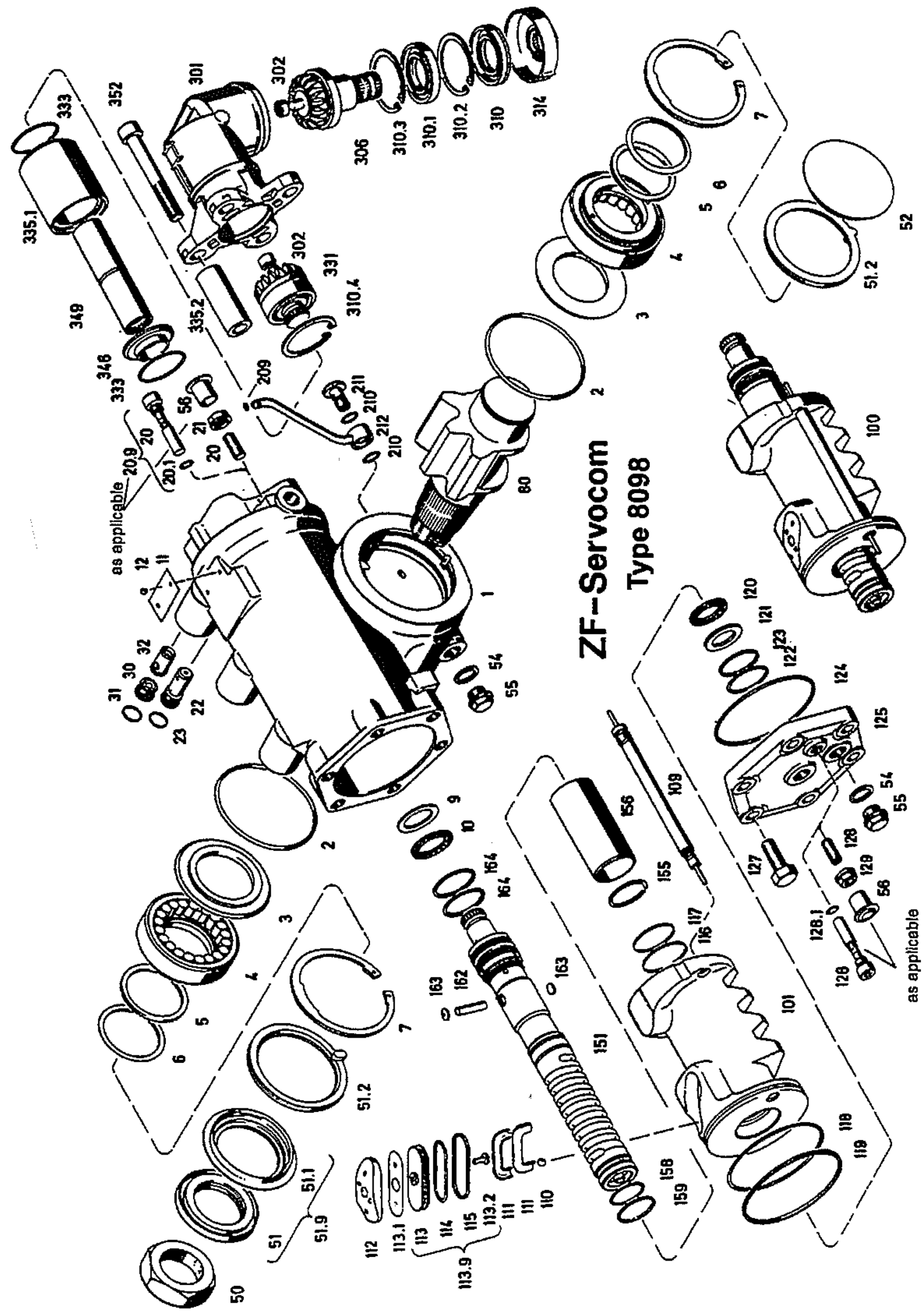
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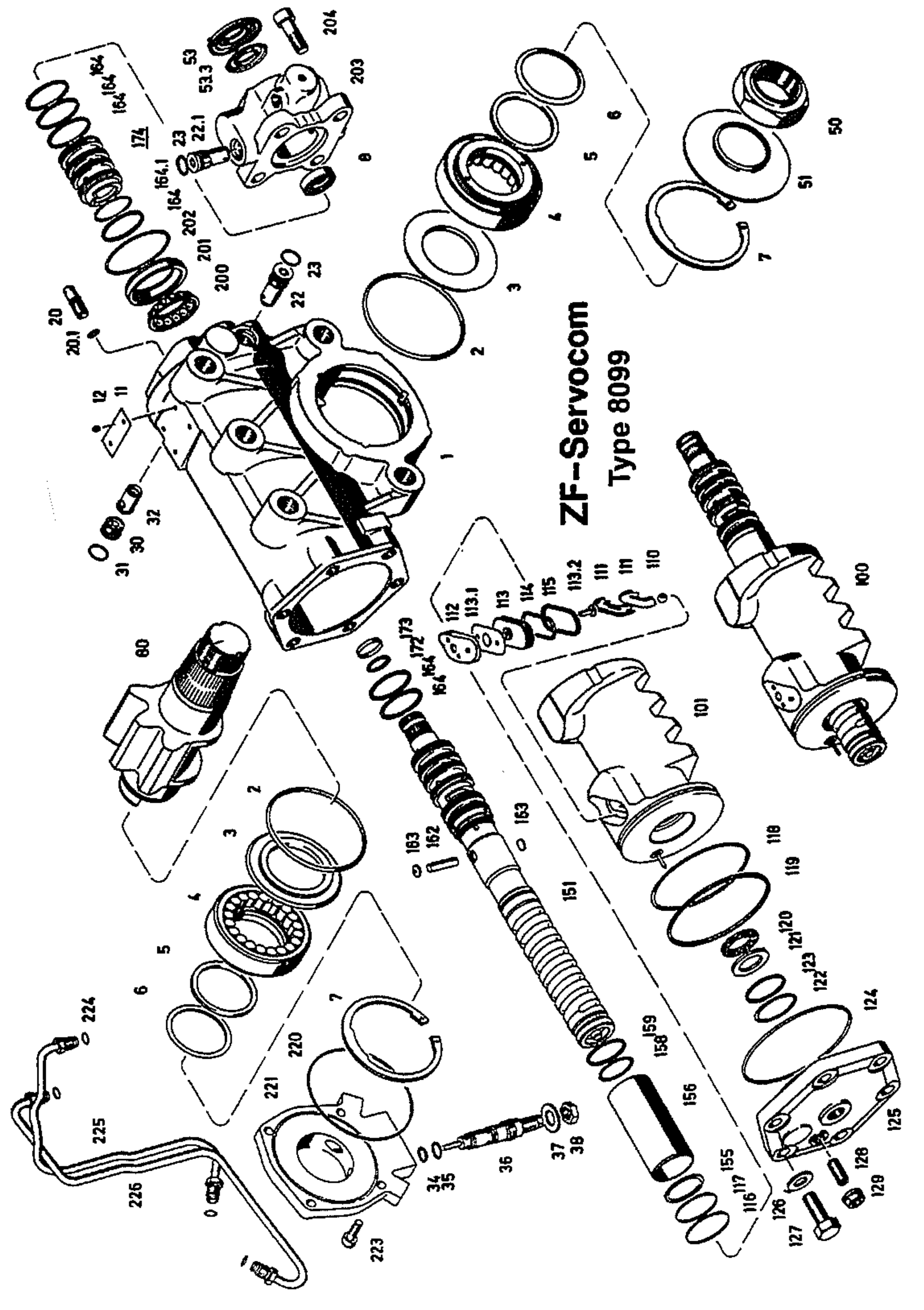
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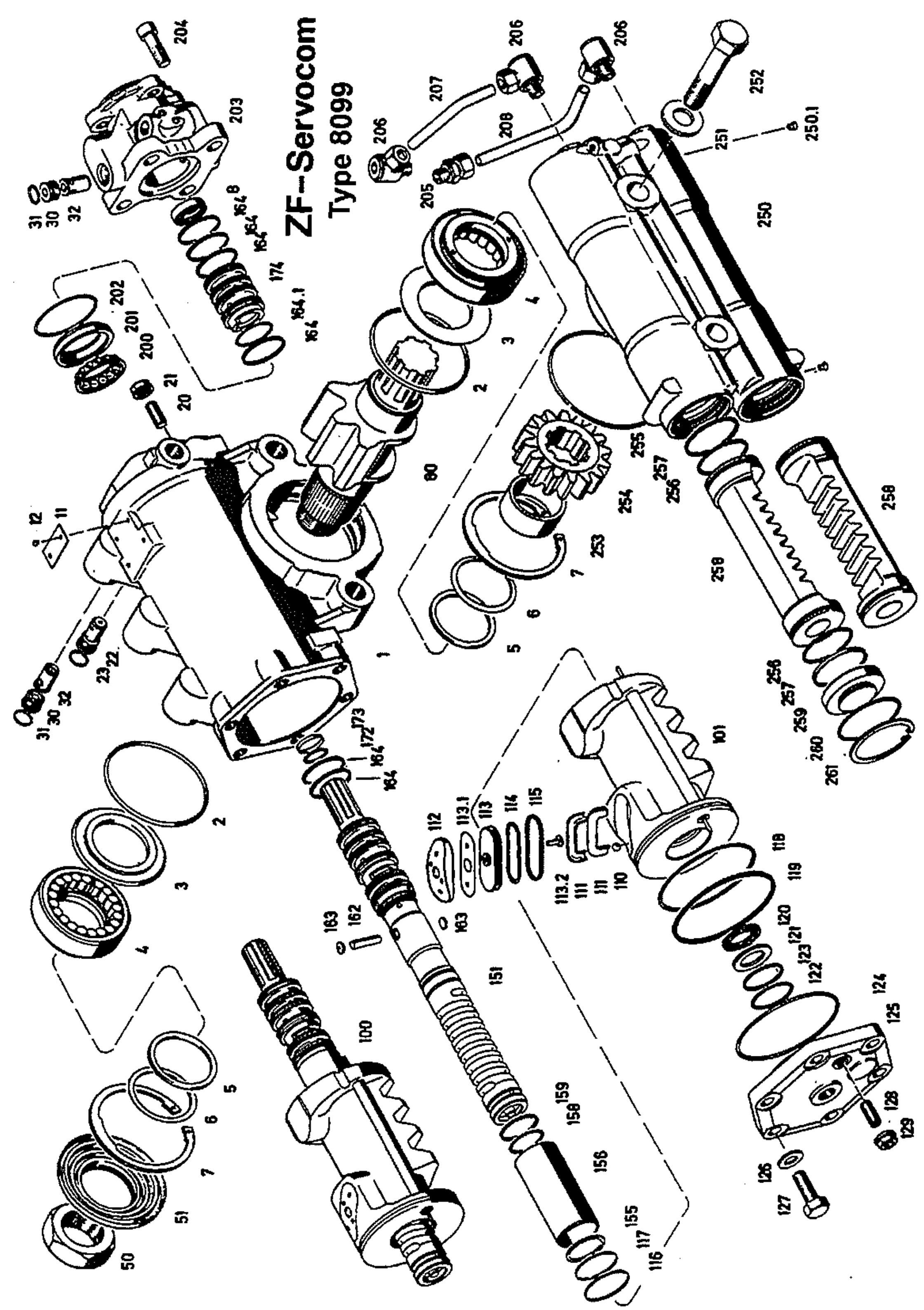

ZF-Servocomtronic®

Supplement to the Repair Manual ZF–Servocom

ZF FRIEDRICHSHAFEN AG
GESCHÄFTSBEREICH LENKUNGSTECHNIK

D - 73522 Schwäbisch Gmünd

Telephone: (07171) 31-0   Telefax: (07171) 31-4396

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Important general information

→ The present Manual aims to help the user properly to execute the necessary maintenance and repair work on the ZF product.

→ Read the Manual before starting any inspection and repair work.

→ On completion of the maintenance and repair work, the specialist personnel must make certain that the product is once more operating flawlessly.

→ ***Please note that the ZF product must be repaired only in workshops that***

- ***employ trained personnel***
- ***have the prescribed equipment, including a test rig, crack detector and special tools***
- ***use ZF genuine spare parts.***

→ This Manual is only for foremen and fitters who have undergone practical and theoretical training in our Customer Service School. Together with service information bulletins, it is intended to supplement their knowledge.

→ All work carried out on ZF products must be executed with extreme care and diligence. This applies in particular to products and transmission components from vehicles damaged in accidents.

→ The manufacturer does not, of course, accept any liability for damage and its consequences arising from incorrectly or inexpertly executed repairs.

→ This Manual draws attention to notes on safety as follows:

Note: Where incorrect and careless work can cause damage to the product.

⚠ **Attention:** Where incorrect and careless work can lead to personal injury and endanger life.

→ This Manual is not part of the updating service.

→ The contents of the additional service information bulletins must also be observed.

Page

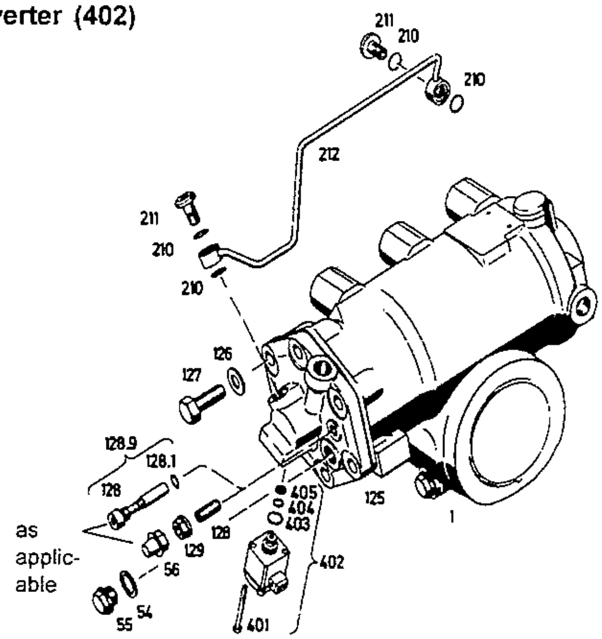
Notes:

→ The processes necessary for the repair of a ZF–Servocomtronic have mostly been described in the Repair Manual ZF–Servocom.

→ Any deviating or additional process will be described in the following.

I. Disassembly

1 Removal of pipe (212) and converter (402)



Screw out union screws (211) and remove pipe (212) with O–rings (210).

Mark position of converter (402).

Turn out two cap screws (401) provided with an internal hexagon.

Remove converter (402) and dismantle O–rings (403 and 404) as well as oil screen (405).

Unscrew hexagon screws (127) with washers (126).

Drive piston (101) back towards bottom of housing so that the valve tappet of valve insert (109) is not damaged when turning the cylinder cover (125).

Remove screw (128) with O–ring (128.1) and set them aside for later use (required for functional tests, chapter IV.).

or:

Remove set screw (128) and collar nut (129).

Unscrew screw plug (55) with sealing ring (54).

Put steering drop arm onto sector shaft (80).

Turn worm (151) or steering drop arm to lift off cylinder cover (125).

Remove needle cage (120) and washer (121).

Remove sealing elements (122, 123 and 124).

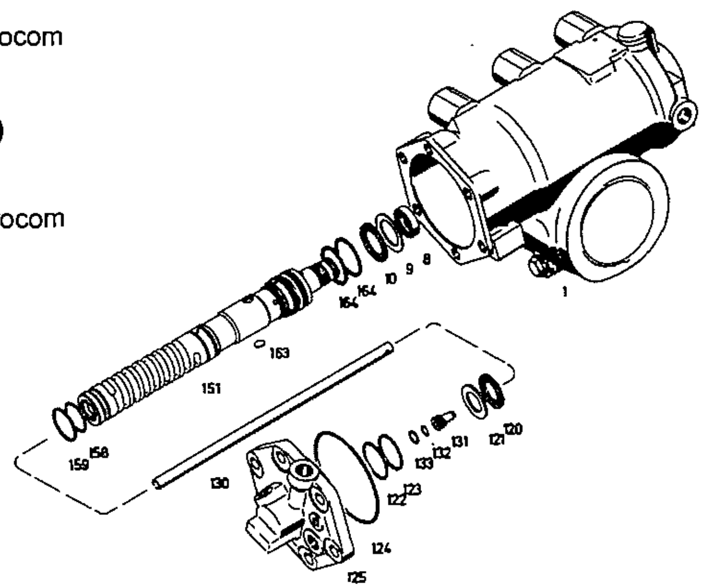
Pull pipe (130) together with reaction piston (131) out of worm (151).

2 Removal of piston (100) and worm (151)

See Repair Manual ZF–Servocom

3 Disassembly of worm (151)

See Repair Manual ZF–Servocom



Pull reaction piston (131) out of pipe (130).

Remove sealing ring (133) and O–ring (132) from reaction piston (131).

4 Removal of sector shaft (80) and disassembly of housing (1)

See Repair Manual ZF–Servocom

II. Examining the individual parts

See Repair Manual ZF–Servocom

1 Cylinder cover (125), reaction piston (131) and converter (402)

→ Tidiness of the bores

2 Reaction piston (131)

→ Free play in cylinder cover (125)

III. Assembly

1 Preassembly of housing (1) and housing cover (4) and installation of sector shaft (80)

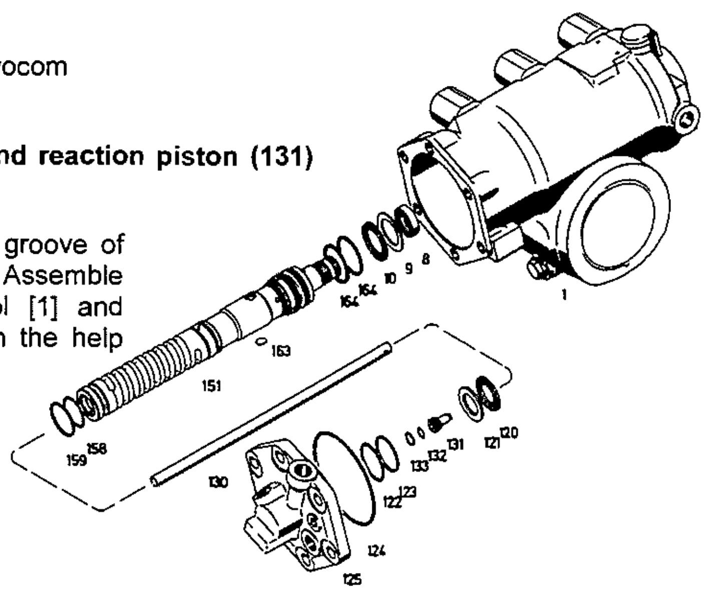
See Repair Manual ZF–Servocom

2 Preassembly of worm (151) and piston (100), installation of piston (100) and worm (151)

See Repair Manual ZF–Servocom

3 Installation of pipe (130) and reaction piston (131)

Insert O–ring (132) into the groove of the reaction piston (131). Assemble sealing ring (133) with tool [1] and press it into the groove with the help of a mounting ring.



Insert pipe (130) and reaction piston (131) in cylinder cover (125).

4 Installation of cylinder cover (125)

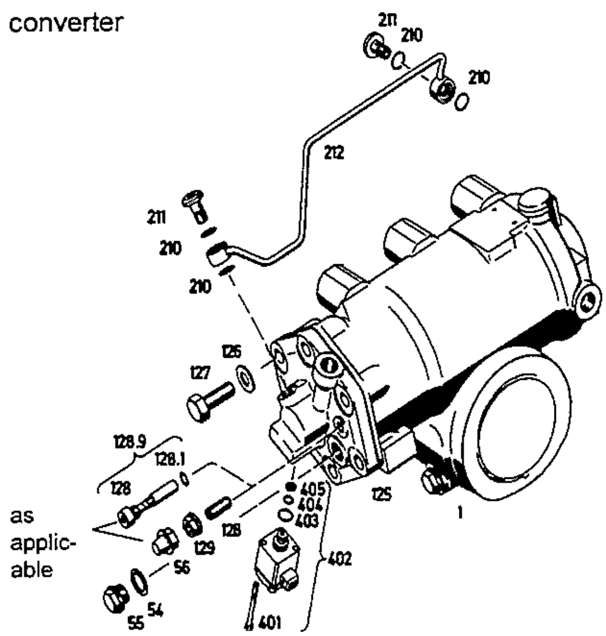
See Repair Manual ZF–Servocom

5 Completing assembly of cylinder cover (125)

Place oil screen (405) in cylinder cover (125).

Place O–rings (404 and 403) in converter (402).

Mount converter (402) as marked upon disassembly with cap screws (401) (tightening torque: 2.9 Nm).



6 Mounting of pipe (212)

Mount pipe (212) with union screws (211) and O–rings (210) (tightening torque: 20±2 Nm).

IV. Setting and functional test

1 See Repair Manual ZF–Servocom

Note:

The checking for oil leakage described in the Repair Manual ZF–Servocom must be performed while the converter is closed. To do so, tool [2] (Servotronictest) must expose the converter to a current that produces a scale reading of 0.65...0.85. Please observe the following description.

2 Functional test of the converter and of the control unit

Note:

Before using the Servotronictest unit, you should read the corresponding operating instructions.

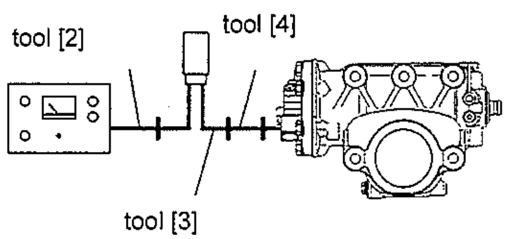
The following functional test refers to the separate checking of the converter and of the control unit. The joint checking of both units is described in the above–mentioned operating instructions.

2.1 Functional test of the converter

→ Set up the steering gear on the test bench. Adjust oil flow, pressure, and oil temperature as required for the hydraulic checking on the test bench (see Repair Manual ZF-Servocom). Lock the steering gear in central position.

→ Connect the Servotronictest (tool [2]) to a 220V mains supply with the help of a power supply unit. Now the ready–to–operate tell–tale lamp must light up.

→ Connect the tools [2, 3, and 4] to the steering gear as described below.



→ Set switch 8 of the Servotronictest to position "0" .

→ Note on the Servotronictest unit:

By slowly turning the control knob 4 (converter) any driving speed can be simulated.

Turning the control knob to the right end position produces a large deflection of the pointer.
A scale reading of 0.65...0.85 means parking, i.e. low actuation force.

Turning the control knob to the left end position produces a smaller deflection of the pointer.
A scale reading 0...0.1 means maximum speed, i.e. high actuation force.

→ Testing in the parking mode

Put switch 8 of the Servotronictest in position "Wandler/converter" and turn control knob 4 (converter) to the right until the scale reading 0.65...0.85 is attained.

With the test bench switched on, turn the steering wheel to either direction until a pressure of 50 bar is built up at the test bench.

If the Servocomtronic and the converter function correctly the actuation momentum at the torque meter should be between 3.5...5.5 Nm, for example.

For the exact value, please refer to the technical data sheet of the spare parts list or the Service Information circulars.

→ Testing in the high speed mode

Turn control knob 4 (converter) of the Servotronictest to the left until the scale reading 0...0.1 is attained.

With the test bench switched on, turn the steering wheel to either direction until a pressure of 50 bar is built up at the test bench.

If the Servocomtronic and the converter function correctly the actuation momentum at the torque meter should be between 9...11 Nm, for example.

For the exact value, please refer to the technical data sheet of the spare parts list or the Service Information circulars.

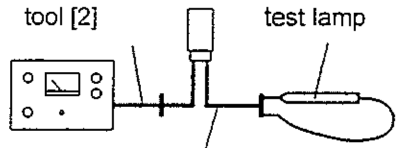
2.2 Functional test of the control unit:

→ Connect the Servotronictest to a 220V mains supply with the help of a power supply unit. Now the ready–to–operate tell–tale lamp must light up.

→ Set switch 8 of the Servotronictest to position "0".

→ Connect tool [3] to Servotronictest (tool [2]).

→ Connect the test lamp directly to the control unit or to the cable leading to the converter as accessibility allows.



→ Set switch 8 of the Servotronictest to position "Tacho/speedometer".

→ Turn control knob 5 (Tacho/speedometer).

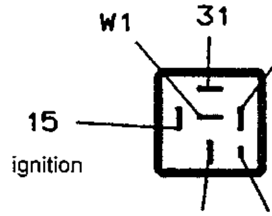
When the control knob is turned to the right end position, the test lamp must light up.

When the control knob is turned to the left end position, the test lamp must go out.

During this test, the scale reading indicated on the Servotronictest rises to max. 0.25.

V. Troubleshooting

Pin layout at the socket of the control unit (plug location):



Trouble		Cause		Remedy
Heavy when steering with the vehicle stationary	→	no on–board voltage	→	check and replace, if necessary – remove the control unit – measure at the socket 2 with the help of a multimeter connecting pin 15 to 31 nom. value: 10...16 V

2 **Attention!** Any measurement between V and 31 must be performed only with a voltmeter. Otherwise the speed signal sensor will be destroyed.

Trouble	Cause	Remedy
	→ wrong control unit	→ check → replace
	→ control unit placed at the wrong plug location	→ check
	→ defective cable connection from control unit to the steering gear	→ check and repair, if necessary – remove control unit – measure at the socket 2 with the help of a multimeter connecting pin W1 to W2 nom. value: 5...9 Ω (at 20 ° 7,5 Ω)
	→ converter plug not engaged	→ check and repair, if necessary
	→ earth contact of converter cable	→ check → replace
	→ earth contact of converter	→ check → replace
	→ defective control unit	→ check → replace
	→ wrong speedometer signal before switching off ignition at a speed > 20 km/h	→ check speed signal sensor 1 2
	→ converter does not close	→ disassemble blow through clean
	→ defective pump	→ check → replace
	→ excessive internal oil leakage	→ check → replace

1 see vehicle manufacturer's manual

2 **Attention!** Any measurement between V and 31 must be performed only with a voltmeter. Otherwise the speed signal sensor will be destroyed.

Trouble		Cause		Abhilfe
Heavy steering when driving, o.k. when vehicle stationary	→	converter opens at too low speed	→	check control unit
			→	replace control unit
	→	wrong control unit	→	check
			→	replace
	→	wrong speedometer signal	→	check speedometer signal 1
			→	replace speedometer signal 1
Steering too easy when driving, o.k. when vehicle stationary	→	defective control unit	→	check
			→	replace
	→	dirt in converter	→	disassemble clean blow through
	→	wrong speedometer signal at speed < 20 km/h	→	check speed signal sensor 1
	→	cable connection to converter in contact with on–board voltage	→	check and replace, if necessary –remove control unit –measure at the socket 2 voltage from pin W1 to 31 nom. value: 0V resistance from pin W2 to 31 nom. value: ∞ Ω i.e. no connection

1 see vehicle manufacturer's manual

2 **Attention!** Any measurement between V and 31 must be performed only with a voltmeter. Otherwise the speed signal sensor will be destroyed.

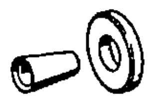
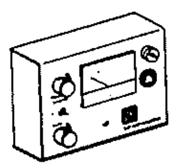
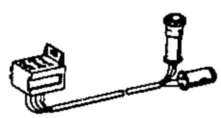
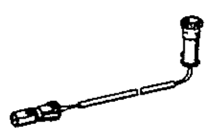
Trouble		Cause		Remedy
	→	wrong control unit	→	check
			→	replace
	→	defect in cable tree	→	check [1]
			→	replace
Alternate heavy and easy steering during travelling	→	wrong speedometer signal	→	check speedometer signal [1]
			→	replace speed signal sensor [1]
	→	defective cable connections	→	check
	→	wrong control unit	→	replace
	→	defective control unit	→	check
			→	replace
Pulsating steering-momentum (tingle at steering wheel) at any driving speed	→	defective control unit	→	check
			→	replace

[1] see vehicle manufacturer's manual
[2] **Attention!** Any measurement between V and 31 must be performed only with a voltmeter. Otherwise the speed signal sensor will be destroyed.

VI. Special tools

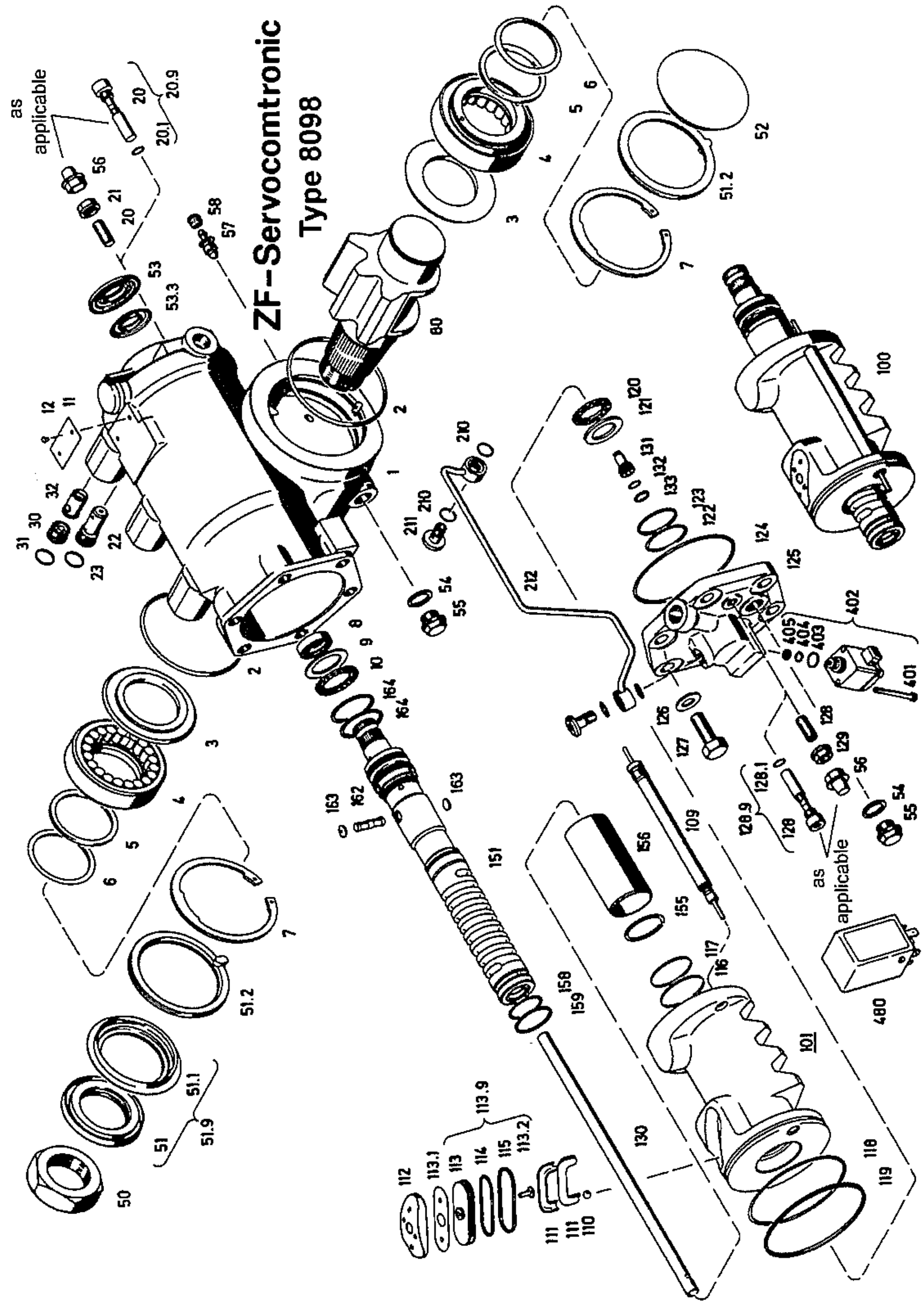
Note:
The special tools listed below refer to the standard version and the design state of the ZF–Servocomtronic on the basis of which the entire manual has been compiled.

Other tools may consequently be required for the particular ZF–Servocomtronic unit to be repaired.

Tool		Part-No.
Tool [1]		
Guide bush		8098 798 004
Mounting ring		8098 798 655
Tool [2]		
Servotronictest		7418 798 545
Power supply unit		7418 798 546
Tool [3]		
Adapter		7038 340 201
Tool [4]		
Adapter cable		7418 798 543

VII. Key to numbers in figures and exploded drawing

130.0	pipe
131.0	reaction piston
132.0	O–ring
133.0	sealing ring
401.0	cap screw
402.0	converter
403.0	O–ring
404.0	O–ring
405.0	oil screen


ZF–Servocomtronic
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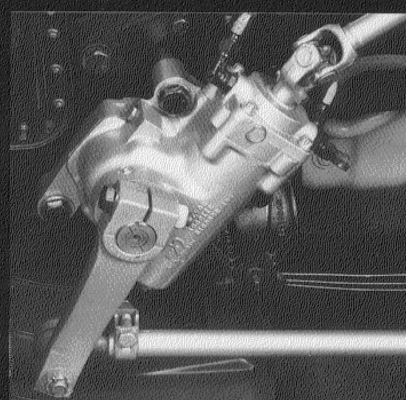
Notes

TRW Automotive
Steering & Suspension Systems

Chart Your Way to Easy Steering



Steering System Troubleshooting Guide

Chart Your Way to Easy Steering

Steering System Troubleshooting Guide

Notice

This guide and the accompanying videotapes were prepared for the purpose of providing general advice concerning the diagnosis and correction of commercial vehicle steering related problems. These materials are intended for use by properly trained, professional mechanics, NOT "Do-it-Yourselfers". These materials should be used in conjunction with service manuals provided by vehicle and component manufacturers. Diagnosis and correction of commercial vehicle steering related problems should only be handled by properly trained, professional mechanics who have the proper equipment, tools, instructions and know-how to perform the work properly and safely.

Definitions

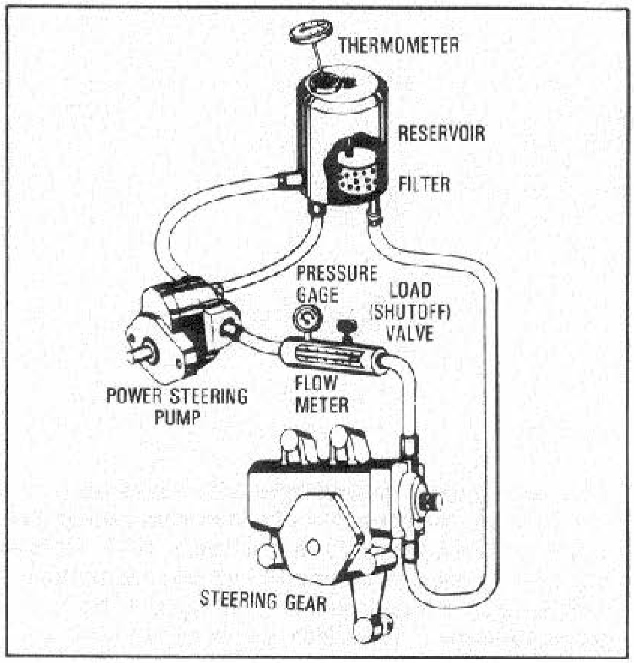
NOTE: **A NOTE gives key information to make a procedure easier or quicker to follow.**

CAUTION: **A CAUTION refers to those procedures that must be followed to avoid damage to a steering component or the gear.**

WARNING: **A WARNING REFERS TO THOSE PROEDURES THAT MUST BE FOLLOWED FOR THE SAFETY OF THE DRIVER AND THE PERSON INSPECTING OR REPAIRING THE GEAR.**

PSSA - (Power Steering System Analyzer)

Some of the tests in this manual require the use of a **Power Steering System Analyzer.** A Power Steering System Analyzer is a combination of a flow meter, shut off valve, and pressure gage. This tool will allow you to measure flow and pressure, and provide a load on the pump in the hydraulic lines of the steering system. This tool is required to correctly analyze a steering system, and TRW recommends that vou **DON'T BEGIN TROUBLESHOOTING A STEERING SYSTEM WITHOUT A PSSA.**



WARNING: THROUGHOUT THIS TROUBLESHOOTING GUIDE, TEST PROCEDURES ARE RECOMMENDED TO HELP LOCATE THE CAUSE OF EACH COMPLAINT. WHILE PERFORMING THESE TESTS, TRW ADVISES THAT YOU <u>TAKE NECESSARY PRECAUTIONS</u> WHEN WORKING WITH INTERNAL VEHICLE COMPONENTS, AND HOT HYDRAULIC FLUID.

Table of Contents

Introduction

Understanding the Complaint

Steering systems for heavy duty trucks are made up of many components from the steering wheel to the road wheel. The purpose of the steering system is to give the driver directional control of the vehicle.

When a driver feels the steering control over his vehicle is not like it should be, it is up to you to decide if there is a problem, and if so, figure out what is causing it. It is always easier to fix something if you really understand the complaint. Some ways you could do this are:

- Talk to the driver and ask a lot of questions like "what, when, where, and how"
- Make sure you can feel or see the problem. Have the driver show you exactly what he means
- Walk around the truck, looking for anything that may be an obvious cause of the problem

To make your job easier and faster, this manual has a section for each of the 10 most common driver complaints. Once you have a good understanding of what the complaint is, choose the section of the book that best matches the problem. Because there are different ways to say the same thing, our definitions of the 10 complaints used in this book are on pages 3 and 4, and also in the glossary at the end of the manual.

Flow Charts

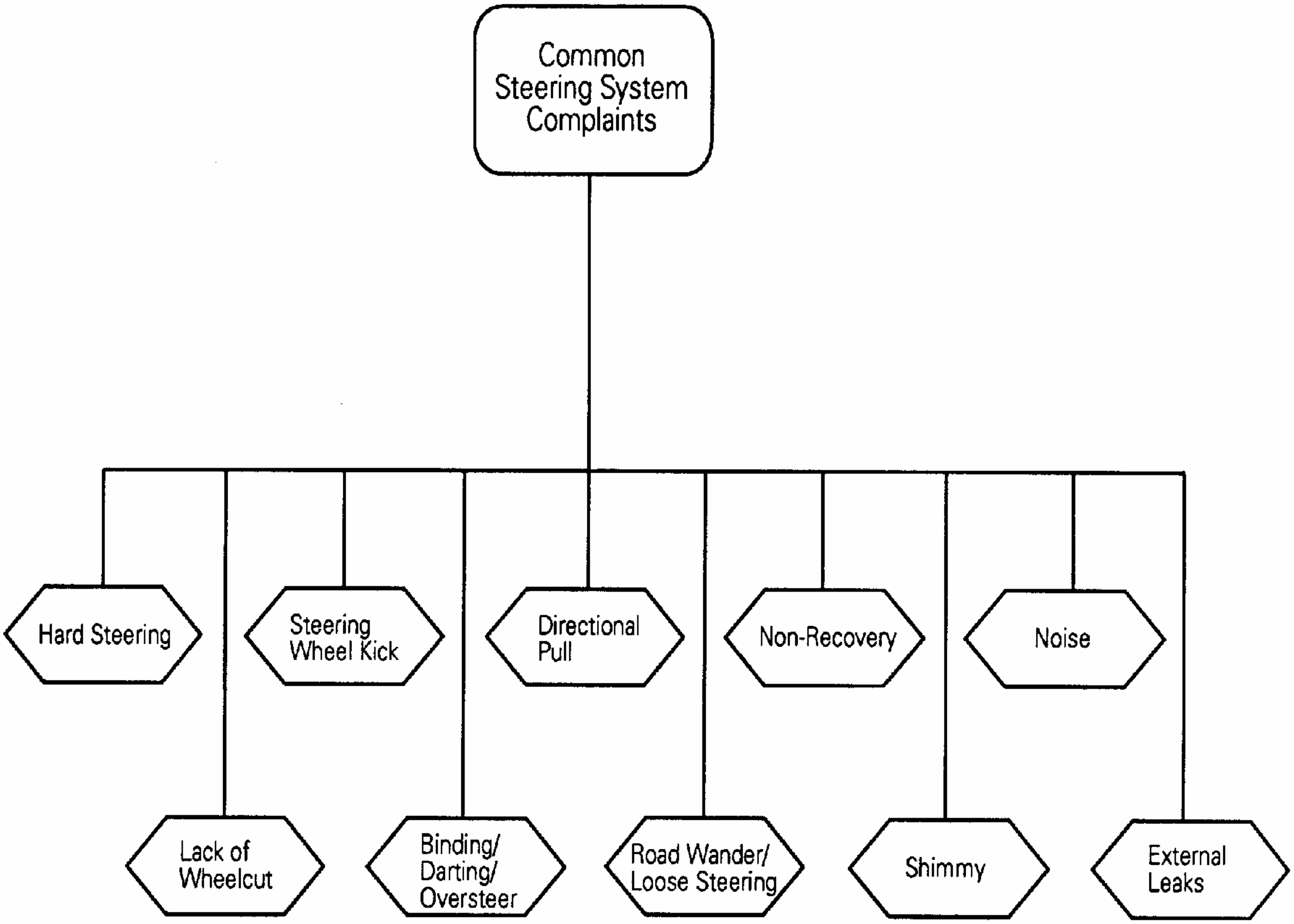
Flow charts are a quick and easy way to find the cause of a steering system problem. There is a flow chart for each of the 10 most common driver complaints at the beginning of each section.

Start the flow charts at the ***BEGIN*** box. If there is a ***QUESTION*** next, answer it either YES or NO, and follow the arrows to the next step. When you get to a ***CAUSE/TEST*** box (or string of boxes) you will begin testing the truck to confirm the cause of the complaint. A string of ***CAUSE/TEST*** boxes means there are several possible causes; you'll have to do the tests to find out which one is the cause for the vehicle you are working on. These boxes are arranged in order of likelihood of being the cause of the complaint; it is important to do them in order. The test number in the lower part of the ***CAUSE/TEST*** box will tell you which test to go to in the pages following the flow chart; find the right test number and follow the test procedure. When you're done with that test, go back to the flow chart, and go on to the next step.

If you identify a problem through a test procedure, it is important that you retest the vehicle to make sure the complaint condition has been corrected.

Warranty

If you have identified that the steering gear on your vehicle needs to be replaced, this doesn't always mean it is warrantable. Please read your manufacturer's warranty carefully before submitting a steering gear for warranty consideration.


Common Steering System Complaints
Hard Steering
Steering Wheel Kick
Directional Pull
Non-Recovery
Noise
Lack of Wheelcut
Binding/ Darting/ Oversteer
Road Wander/ Loose Steering
Shimmy
External Leaks

Definitions of 10 Most Common Complaints

1. Hard Steering
Hard Steering is when steering effort at the steering wheel is more than 200 inch pounds (typically 18-22 lbs at the rim of the steering wheel). Steering is still possible, but there is not enough power assist.

Common phrases used to describe Hard Steering:

- Won't turn
- Locks-up
- Shuts-down
- Hangs-up
- No assist
- Won't turn unless moving

2. Lack of Wheelcut
Common phrases used to describe Lack of Wheelcut:

- Too great of turning radius required
- Wheelcut restricted
- Not enough turns lock to lock

3. Steering Wheel Kick
Steering Wheel Kick is when the road wheels hit a bump that the steering wheel reacts to. The kick is usually dampened out quickly.

Common phrases used to describe Steering Wheel Kick:

- Kickback
- Backlash
- Bump steer

4. Binding/Darting/Oversteer
Binding is a change or increase in steering wheel effort. Binding will usually not require the effort levels described in Hard Steering, unless it is severe. Darting and oversteer are words that mean the driver suddenly gets more turning than he wants.

5. Directional Pull
Common phrases used to describe Directional Pull:

- Steering pulls to the right (or left)
- Truck pulls to the right (or left)
- A constant force is required to keep the truck going straight

6. Road Wander/Loose Steering
Common phrases used to describe Road Wander or Loose Steering:

- Lash in steering
- Lost motion in steering
- Continual corrections are needed at the steering wheel to keep the vehicle from wandering

7. Non-Recovery
Common phrases used to describe Non-Recovery:

- Wheels don't return to straight ahead

8. Shimmy
A severe Shimmy condition can be felt at the steering wheel. Typically once something triggers a Shimmy condition to occur it is sustained until the driver does something (such as slow down) to dampen out the condition.

Common phrases used to describe Shimmy:

- Shake at steering wheel

9. Noise
Common phrases used to describe Noise:

- Steering is noisy
- Clicking or clunking sound is heard when steering

10. External Leakage
Common phrases used to describe External Leaks if they are not obvious:

- Loss of steering fluid
- Continual adding of fluid in reservoir required

Notes

Hard Steering 1

Definition and Common Phrases Used

Hard Steering is when steering effort at the steering wheel is more than 200 inch pounds (typically 18-22 lbs. at the rim of the steering wheel). Steering is still possible, but there is not enough power assist. Different models of steering gears have differently designed effort levels. The diameter of the steering wheel will also affect the rim pull required; be sure the proper size steering wheel is installed. Common phrases used to describe Hard Steering:

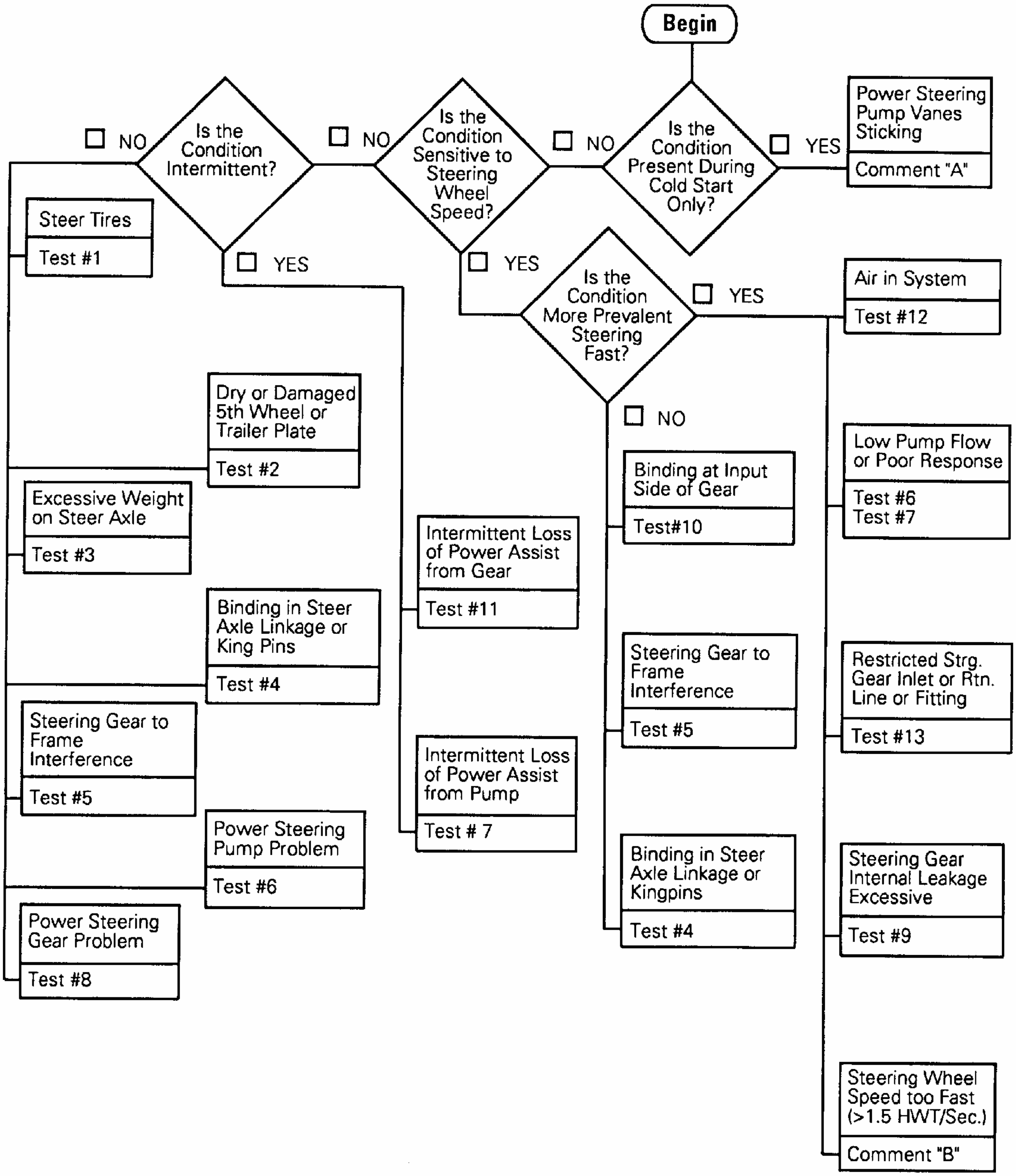
- Won't turn
- Locks-up
- Shuts-down
- Hangs-up
- No assist
- Won't turn unless moving

Explanation of Flow Chart Terms

Is the condition present during cold start only? - Does the hard steering occur during initial start-up? This would be after the vehicle has been sitting long enough to allow the total system, including the fluid, to cool enough to be the same as the outside (ambient) temperature.

Is the condition sensitive to steering wheel speed? - Do you notice a difference in steering effort when turning the wheel fast only, or slow only?

Is the condition intermittent? - Does the hard steering happen randomly? If the problem occurs sometimes but not always, and it does not seem to be related to the steering wheel position, steering direction, or manner of steering, it is intermittent. Examples of what's not an intermittent condition are if hard steering is noticed in a right turn but not a left turn, or if the problem occurs when steering fast but not slow.


Begin
Is the Condition Present During Cold Start Only?
YES
Power Steering Pump Vanes Sticking
Comment "A"
NO
Is the Condition Sensitive to Steering Wheel Speed?
NO
Is the Condition Intermittent?
NO
Steer Tires
Test #1
Dry or Damaged 5th Wheel or Trailer Plate
Test #2
Excessive Weight on Steer Axle
Test #3
Binding in Steer Axle Linkage or King Pins
Test #4
Steering Gear to Frame Interference
Test #5
Power Steering Pump Problem
Test #6
Power Steering Gear Problem
Test #8
YES
Intermittent Loss of Power Assist from Gear
Test #11
Intermittent Loss of Power Assist from Pump
Test # 7
YES
Is the Condition More Prevalent Steering Fast?
YES
Air in System
Test #12
Low Pump Flow or Poor Response
Test #6
Test #7
Restricted Strg. Gear Inlet or Rtn. Line or Fitting
Test #13
Steering Gear Internal Leakage Excessive
Test #9
Steering Wheel Speed too Fast (>1.5 HWT/Sec.)
Comment "B"
NO
Binding at Input Side of Gear
Test#10
Steering Gear to Frame Interference
Test #5
Binding in Steer Axle Linkage or Kingpins
Test #4

Hard Steering Tests

Test Procedure

#1 Tire Check

1. Look for:
   - Tire damage. FIGURE 1.1
   - Uneven or extreme tread wear
   - Mismatched tires
2. Check tire pressure.

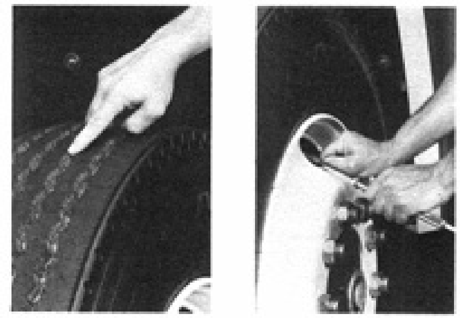


Figure 1.1

#2 Fifth Wheel and Trailer Plate Check

1. Look for dry fifth-wheel or trailer plate. FIGURE 2.1.
2. Look for damage to fifth-wheel or trailer plate.
3. Inspect fifth-wheel for looseness.

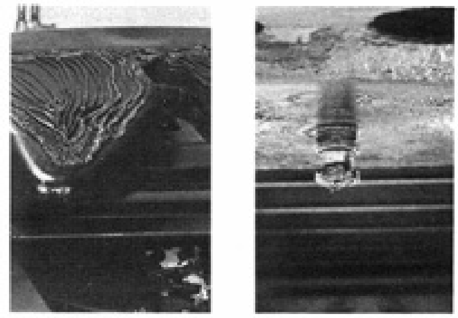


Figure 2.1

#3 Steer Axle Weight Test

1. Have steer axle weighed at load condition which produces complaint and compare to specifications. FIGURE 3.1.

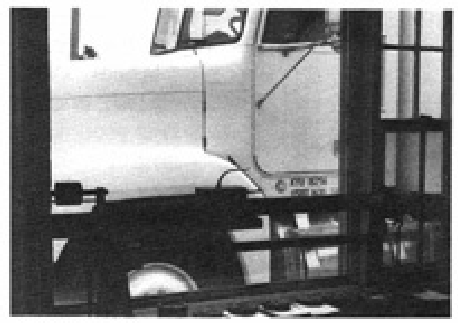


Figure 3.1

#4 Steer Axle and Linkage Binding Test

1. With vehicle steer tires on radius plates (turntables) or equivalent, disconnect the drag link or pitman arm from the steering gear (and linkage from assist cylinder if there is one on the vehicle). FIGURE 4.1.

   CAUTION: Do not steer the gear with linkage removed as mis-adjustment of automatic poppets may result.

2. By hand, pull the tire to one axle stop and release (engine off). The tire should self-return to near straight ahead. FIGURE 4.2.
3. Repeat the test in the opposite direction.
4. If tire does not self-return to near straight ahead, a problem is likely in steer axle king pin bushings/bearings or linkage.

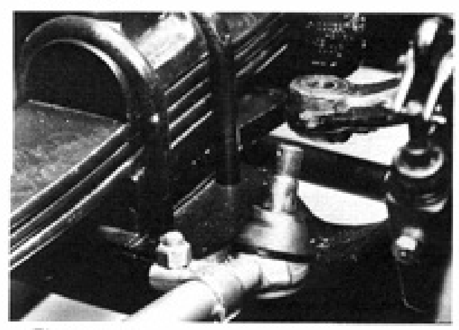


Figure 4.1

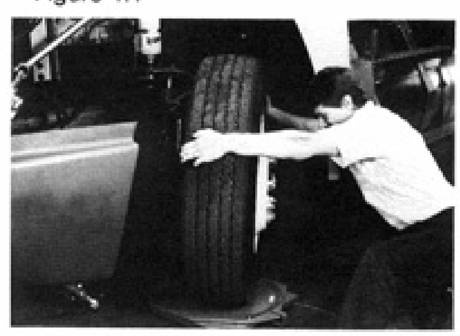


Figure 4.2

Hard Steering Tests (Continued)

Test Procedure

#5 Steering Gear Mounting Test

1. Look for anything between the steering gear and frame that could cause a binding problem. For example: hoses or brackets that have been routed, or are interfering between the steering gear and frame, frame flanges or spring mounting points. FIGURE 5.1. Mounting pads lower than steering gear housing, lack of clearance between frame and steering gear valve housing adaptor, sector shaft adjusting screw and nut mismatched with access adjustment hole in frame.

2. If the steering gear has been mounted to the frame in a way that causes the gear to distort (not be flat), it may cause a steering problem. The use of spacers is alright as long as the gear is mounted securely, and the gear is not distorted when mounting bolts are tightened. FIGURE 5.2. Checking to see if distortion is present on the vehicle may require the following test:

3. With vehicle parked and turned off, steer the wheel slowly checking for a binding-type of feel at the steering wheel. When binding is felt loosen one mounting bolt, and steer the vehicle again. Continue to loosen one mounting bolt at a time and check for improvement in the binding condition. If improvement is made by loosening the bolts, determine by inspection what interference or condition is causing the gear to distort and correct the problem.

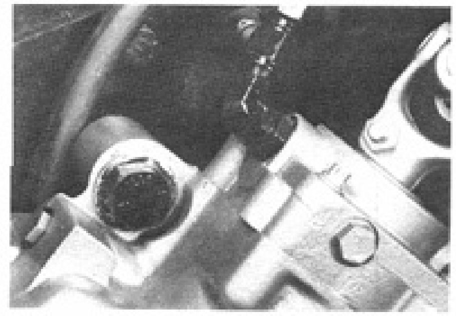


Figure 5.1

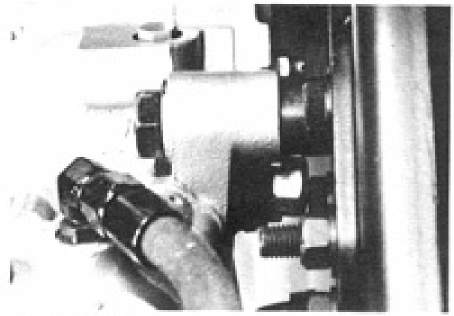


Figure 5.2

#6 Power Steering Pump Test

1. Install temperature gage in reservoir. FIGURE 6.1. Install PSSA in pressure line with shut-off valve fully open. FIGURE 6.2. Park the vehicle outside. Record ambient temperature. Run the engine at governed RPM for 40 minutes to bring the fluid up to an elevated testing temperature. Measure and record the fluid temperature at the start and at 10, 20, 30 and 40 minutes. Do not allow the temperature to exceed 250°

   NOTE: If the temperature goes over 250 °F, or 150 °F above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

2. Run the engine at idle speed.

Figure 6.1

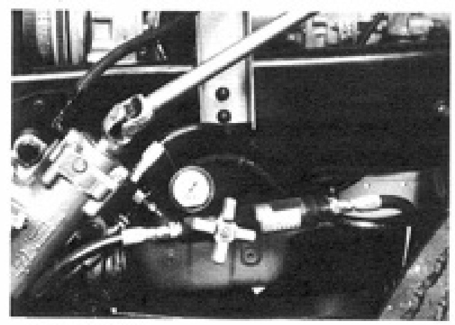


Figure 6.2

Hard Steering Tests (Continued)

Test Procedure

CAUTION: When closing the PSSA shut off valve, do so slowly and keep an eye on the pressure gage. Do not allow the system to exceed 2500 psi for safety of personnel and to prevent damage to the vehicle.

CAUTION: Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up.

3. Measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed. FIGURES 6.3 - 6.7.

Oil Temperature ______________ DEG.
Engine Idle Speed ______________ RPM

	Idle Speed	
	Pressure	Flow (GPM)
Load Valve Open		
	500 PSI	
	1000 PSI	
	1500 PSI	
Load Valve Closed		

4. Now with the load valve fully open, increase the engine speed to governed RPM and measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed: FIGURES 6.3 - 6.7.

Oil Temperature ______________ DEG.
Engine Governed Speed ______________ RPM

	Governed Speed	
	Pressure	Flow (GPM)
Load Valve Open		
	500 PSI	
	1000 PSI	
	1500 PSI	
Load Valve Closed		

5. Determine the recommended flow range and maximum allowable system pressure for the steering system being used by referring to your service manual.

6. Compare the minimum and maximum flows, and the relief pressure you measured to gear and pump specifications.

7. If the minimum measured pump flow is less than the minimum recommended flow for the steering gear used, the pump may not be putting out enough flow

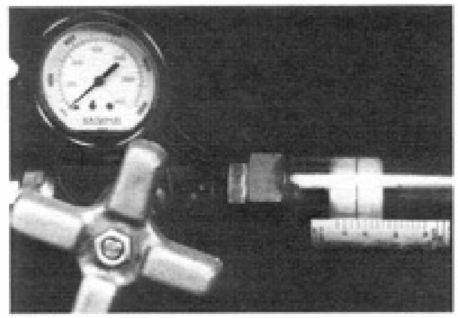


Figure 6.3

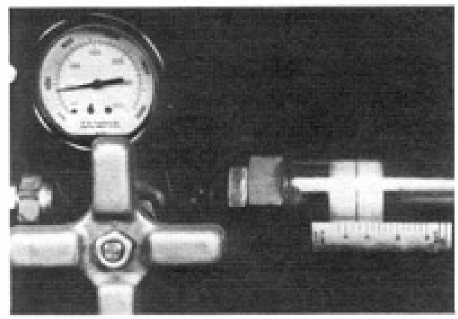


Figure 6.4

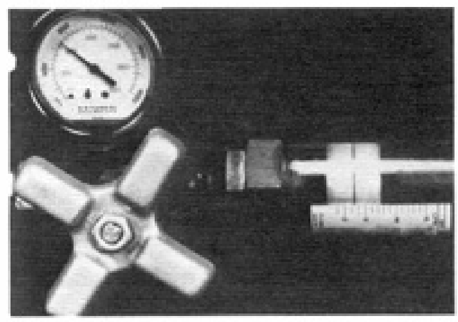


Figure 6.5

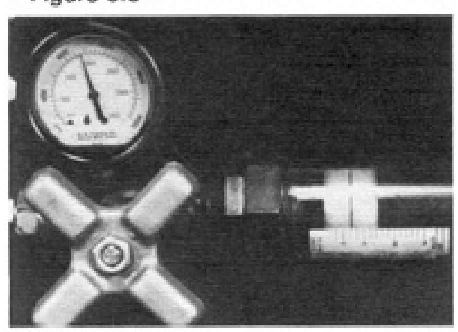


Figure 6.6

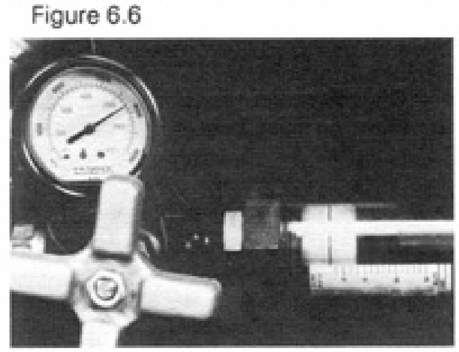


Figure 6.7

Hard Steering Tests (Continued)

Test Procedure

for an adequate steering speed. If the maximum system pressure is lower than that specified for the pump (check your manual), it may not be developing enough pressure to steer. If either case exists, the pump needs to be repaired or replaced.

Figure 7.1

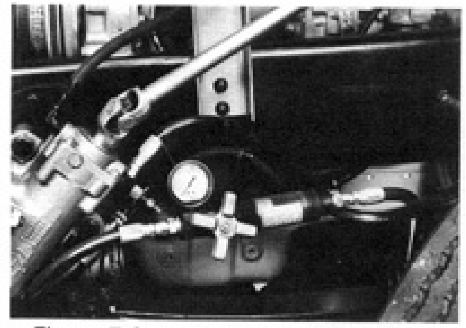


Figure 7.2

#7 Intermittent Loss of Power Assist from Pump Test

1. Install temperature gage in reservoir. FIGURE 7.1. Install PSSA in pressure line with shut-off valve fully open. FIGURE 7.2. Park the vehicle outside. Record ambient temperature. Run the engine at governed RPM for 40 minutes to bring the fluid up to an elevated testing temperature. Measure and record the fluid temperature at the start and at 10, 20, 30 and 40 minutes. Do not allow the temperature to exceed 250°

   NOTE: If the temperature goes over 250 ° F, or 150 ° F above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

   CAUTION: Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up.

2. (Do not allow the pressure to exceed 2500 psi). With the engine at idle, note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading you noted above.

3. With the load valve open run the engine to governed speed and note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading noted above.

4. Conduct this pump response test once at idle and three times at engine governed RPM. If the flow rate does not return immediately, the pump is malfunctioning, which can result in momentary loss of power assist.

Hard Steering Tests (Continued)

Test Procedure

#8 Steering Gear Check

1. Install temperature gage in reservoir. FIGURE 8.1. Install PSSA in pressure line with shut-off valve fully open. FIGURE 8.2. Park the vehicle outside. Record ambient temperature. Run the engine at governed RPM for 40 minutes to bring the fluid up to an elevated testing temperature. Measure and record the fluid temperature at the start and at 10, 20, 30 and 40 minutes. Do not allow the temperature to exceed 250°

   NOTE: Steering systems that have a pump relief valve and an integral steering gear relief valve typically will have the pump relief valve setting approximately 300 PSI or more above the gear's relief valve setting. Check vehicle manufacturer's specifications for correct relief pressure levels.

2. Try to locate the problem by steering the vehicle while parked. Steer in a slow, smooth motion back and forth between axle stops (you may need to load the vehicle). FIGURE 8.3. Hard Steering means 18-22 pounds of force at the rim of the steering wheel that occurs somewhere between the normal poppet trip points. If the poppets are set correctly, hard steering at the poppet trip points will be normal within approximately 1/3 steering wheel turn from axle stop contact points.

3. When hard steering is noticed, note pressure and flow reading of PSSA. FIGURE 8.4.

   If flow is under 1 GPM and pressure is the same as relief pressure measured in the earlier pump test (Test #6) for a gear without a relief valve, or pressure without regard to flow is as specified for a gear with an integral relief valve, the steering gear is performing correctly.

   If flow is over 1 GPM and pressure is far below relief pressure measured in the earlier pump test (Test #6) for a gear without a relief valve, or below the correct relief pressure setting for a gear with an integral relief valve, proceed to step 4.

4. If the steering gear has an integral relief valve, proceed to step 5. If the gear does not have an integral relief valve, the steering gear has excessive internal leakage and needs to be repaired or replaced (see step 7).

5. Remove the integral relief valve components (refer to steering gear service manual for procedure) and install a relief valve plug, special tool J37130, in its place.


Figure 8.1

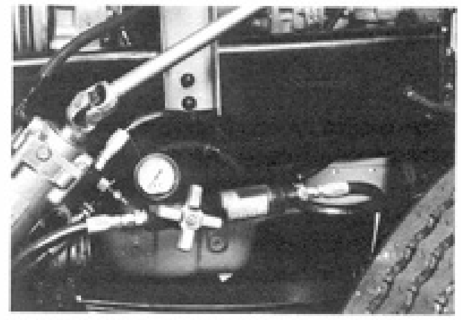


Figure 8.2

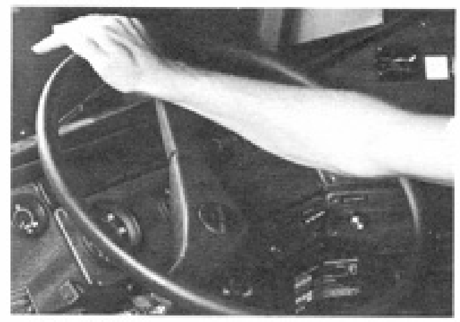


Figure 8.3

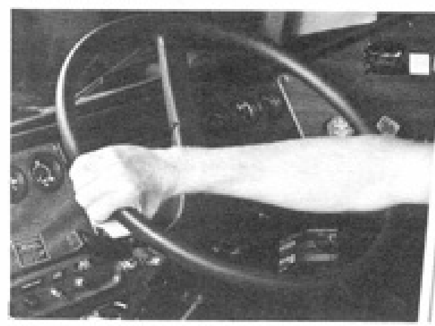


Figure 8.4

Hard Steering Tests (Continued)

Test Procedure

6. Again steer the vehicle back and forth and determine if hard steering is felt. If so, note pressure and flow reading of the PSSA. FIGURE 8.5.

   If hard steering can no longer be produced, the relief valve removed from the gear earlier was not operating properly and should be replaced with one specified for the gear you are working on.

   If hard steering is again noticed, with a noted flow of over 1 GPM and pressure level is far below pump relief as measured during the pump test, the relief valve you removed is OK but the steering gear has excessive internal leakage and needs to be repaired or replaced.

7. One possible source of excessive internal leakage in steering gears is shuttling poppets. This is only true of gears with automatic poppets, and only if the service poppet adjusting screw and sealing jam nut kit has been installed in the end opposite the input shaft. This condition can occur if during the installation of the service kit, the installation instructions were not followed carefully, and the adjusting screw was turned into the housing too far. This will cause the interference fit poppet mechanisms to be continually cycled back and forth, thereby losing their interference fit and set positions within the gear as the vehicle is steered lock to lock.

   To test for shuttling poppets, determine if the hard steering is always noticed at the same wheel cut position rather than at the same steering pressure. As an example, if hard steering occurs 1-1/2 steering wheel rotations right of straight ahead at a pressure of 600 PSI when you first feel it, try to determine the following:

   Begin steering maneuvers from different positions (such as 1/2, 1 and 1-1/2 steering wheel rotations left of straight ahead). From each starting point, turn right until the hard steering occurs. If the hard steering is always found at the same 1-1/2 turns right of straight ahead but at different pressures, it is most likely shuttling poppets. If it occurs at the same pressure level but at different wheel cut positions it is caused by some other internal leak path within the gear. If there is a poppet shuttling problem, the steering gear needs to be replaced or rebuilt with new automatic poppet components.

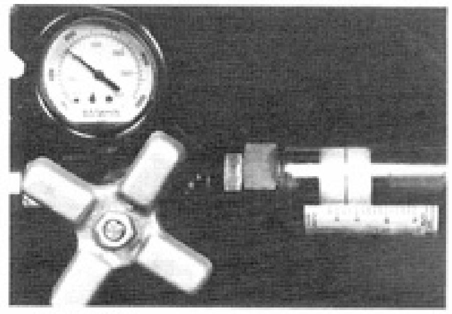


Figure 8.5

Hard Steering Tests (Continued)

Test Procedure

#9 **Measured Internal Leakage Test**

1. Install temperature gage in reservoir. FIGURE 9.1. Install PSSA in pressure line with shut-off valve fully open. FIGURE 9.2.

   WARNING: THIS TEST CAN BE DANGEROUS IF NOT PERFORMED CORRECTLY. KEEP YOUR FINGERS CLEAR OF THE AXLE STOPS AND SPACER BLOCK DURING THIS TEST. MAKE SURE THAT THE SPACER BLOCK CONTACTS THE AXLE STOP SQUARELY. CONTACT THAT IS NOT SQUARE COULD BREAK THE AXLE STOPS OR DANGEROUSLY THROW OR EJECT THE SPACER BLOCK.

2. To test the steering gear for internal leakage, you must first prevent operation of the gear's internal unloading (poppet) valves or relief valve (or both, in some gears). This will allow full pump relief pressure to develop. To prevent operation of the poppets, place an unhardened steel spacer block, about one inch thick and long enough to keep your fingers clear (FIGURE 9.3), between the axle stop at one wheel. FIGURE 9.4. To prevent operation of the relief valve, remove the relief valve cap, o-ring and two piece relief valve, if equipped, from valve housing. Discard the o-ring. Install the relief valve plug, special tool J37130 in its place.

   NOTE: Be sure you reinstall the relief valve and valve cap with new o-ring, back onto the gear after leakage test.

   CAUTION: When running this test, do not hold the steering wheel in the full turn position for longer than 5 to 10 seconds at a time to avoid damaging the pump.

   WARNING: KEEP YOUR FINGERS CLEAR OF THE AXLE STOPS AND SPACER BLOCK DURING THIS TEST. MAKE SURE THAT THE SPACER BLOCK CONTACTS THE AXLE STOP SQUARELY. CONTACT THAT IS NOT SQUARE COULD BREAK THE AXLE STOPS OR DANGEROUSLY THROW OR EJECT THE SPACER BLOCK.

3. With the fluid temperature between 125 and 135°, turn the steering wheel until the axle stops bottom on the spacer block.

4. Apply 20 pounds of force to the rim of the steering wheel during this test to be sure that the steering gear control valve is fully closed. FIGURE 9.5. The pressure gage should now read pump relief pressure, as noted during the pump pressure test (Test #6). You can now read steering gear internal leakage on the flow meter.

5. Repeat this test for the opposite direction of turn

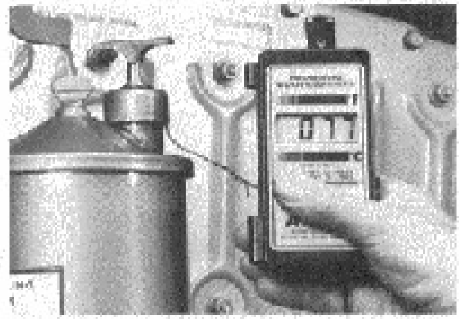


Figure 9.1

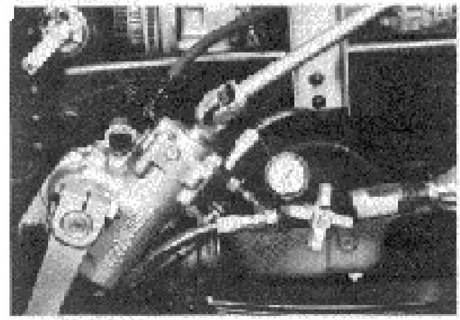


Figure 9.2

Figure 9.3

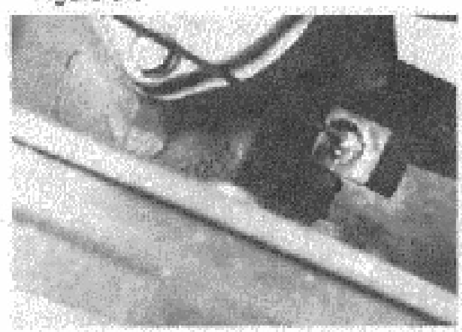


Figure 9.4

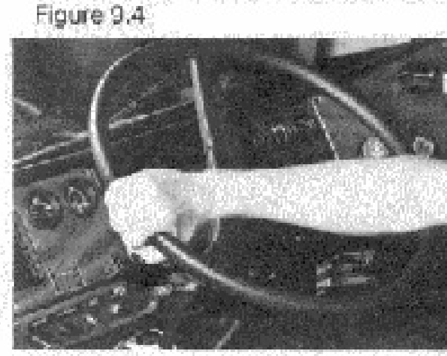


Figure 9.5

Hard Steering Tests (Continued)

Test Procedure

6. If internal leakage is greater than 1.0 gpm and there is no auxiliary hydraulic cylinder in the system, repair or replace the gear. If the internal leakage is greater than 2 gpm, and there is an auxiliary hydraulic cylinder in the system, controlled by the TAS gear, isolate the auxiliary cylinder from the system by disconnecting the auxiliary cylinder hydraulic lines at the TAS unit's auxiliary ports. Plug those ports with suitable pressure plugs or caps. Connect the disconnected lines together if a rotary auxiliary cylinder is in the system. Plug the disconnected lines if a linear auxiliary cylinder is in the system. FIGURE 9.6. Disconnect the linear cylinder from the steering linkage making sure it will clear the steered axle. FIGURE 9.7. Repeat the internal leakage test. If the internal leakage is less than 1.0 gpm, repair or replace the auxiliary cylinder. If the internal leakage is greater than 1.0 gpm, repair or replace the TAS gear.

NOTE: When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed th air from the hydraulic system.

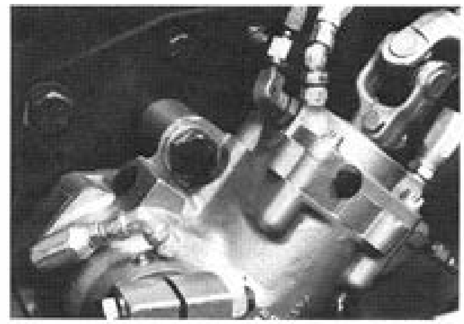


Figure 9.6

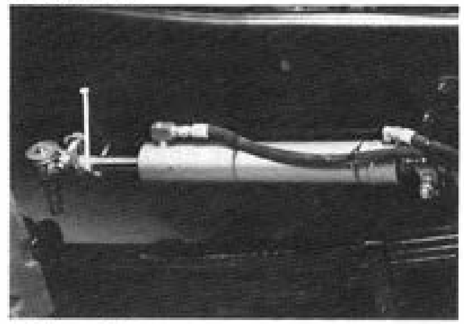


Figure 9.7

#10 Steering Column Binding Test

1. With the vehicle parked, the engine off, and the steer axle jacked-up, slowly steer the vehicle until the binding position is located.

2. With the steering gear at this position, remove the steering column assembly from the steering gear. Note the correct position of the column and steering gear for reassembly after test. FIGURE 10.1.

3. Rotate the steering gear input shaft no more than 1/4 turn each direction and check if binding is still present. FIGURE 10.2. If binding is not felt, correct the steering column problem.

Figure 10.1

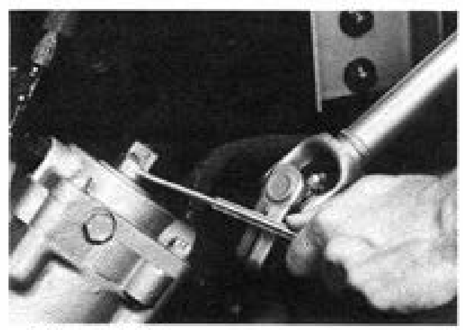


Figure 10.2

#11 Intermittent Loss of Power Assist from Gear Test

1. Install temperature gage in reservoir. FIGURE 11.1. Install PSSA in pressure line with shut-off valve fully open. FIGURE 11.2. Park the vehicle outside. Record ambient temperature. Run the engine at governed RPM for 40 minutes to bring the fluid up to an elevated testing temperature. Measure and record the fluid temperature at the start and at 10, 20, 30 and 40 minutes. Do not allow the temperature to exceed 250° .

Figure 11.1

Hard Steering Tests (Continued)

Test Procedure

NOTE: If the temperature goes over 250 ° F, or 150 ° F above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

2. If the test was stopped because of extreme fluid temperature, there may be several causes including: restricted hoses or fittings, faulty filter in reservoir, excess oil flow, winter fronts, improper components installed, application of non-approved will-fit components. Tests #13 and #6 may help you in finding the cause. If the steering system continues to exceed the maximum recommended operational temperatures, it may be necessary to install an auxiliary oil cooler to maintain the proper steering system oil temperatures.

   NOTE: TRW Commercial Steering Division does not recommend or support the utilization of winter fronts or other methods of restricting the radiator air flow. If vehicle is equipped with winter front or other method of restricting the cooling system air flow, it may be necessary to conduct the 40 minute temperature test (Test #6, step 1) with and without the cooling system restricted to determine worst case temperature.

3. Let the engine idle and then begin steering the vehicle while parked. Steer smoothly from stop to stop with the palm of your hand back and forth several times between the normal poppet trip points to allow the intermittent hard steering to occur. FIGURE 11.3. If hard steering occurs, write down the pressure level and flow rate at the time of the hard steering. FIGURE 11.4. If the flow is above 1 GPM and pressure is far below the normal steering pressure level at the time of hard steering, repair or replacement of the steering gear will be necessary. If the flow is not above 1 GPM, perform Test #6.

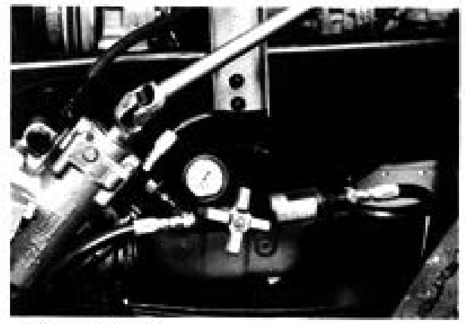


Figure 11.2


Figure 11.3

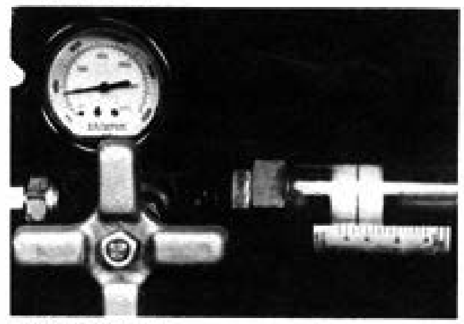


Figure 11.4


Figure 12.1

#12 Air in Hydraulic System Check

1. Inspect reservoir for foaming or air bubbles. FIGURE 12.1. If foaming or bubbles are seen, air is being sucked into the system through cracks or loose fittings on the inlet side of the pump. Look for oil level changes engine off versus engine on. If fluid level increases when the vehicle is shut off, there is an air pocket trapped in the steering gear. The increase may not be noticeable, depending on the size of the pocket.

Hard Steering Tests (Continued)

Test Procedure

2. Bleed the steering gear (if there is a manual bleed screw at the top of the gear). With system at normal operating temperature and engine at proper idle speed and running, open the bleed screw and wait until clean, clear oil begins to flow from the gear. Close the bleed screw and steer the vehicle completely from stop to stop.

3. Repeat the bleeding operation three times, and recheck oil level in reservoir to make sure there is enough oil for the system to operate properly.

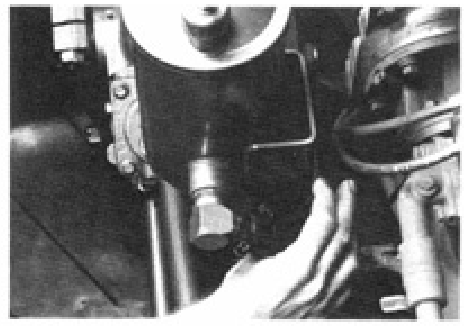


Figure 13.1

Figure 13.2

#13 Restricted Hydraulic Line Check

1. Look at the suction line that goes to the pump (if there is one) to check for kinking or any other obstructions or irregularities on the inside of the hose. FIGURE 13.1.

2. With the PSSA and temperature gage installed (FIGURES 13.2 - 13.3), load valve fully open, and oil at 125 to 135 °, determine a test engine speed (RPM) that causes pump to deliver 3, 4, 5 or 6 GPM (whichever is easier) and note this speed.

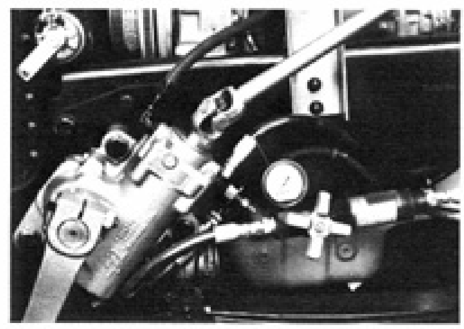


Figure 13.3

3. Remove the PSSA and install a low pressure gage (200-300 PSI maximum with approximately 10 PSI per division) in the pressure line to the steering gear at the pump end. FIGURE 13.4. Install a temperature gage in the power steering reservoir.

CAUTION: Do not allow system pressure to exceed the rating of the gage during the following procedure or damage to the gage will result. Extremely high restrictions may be indicated with the PSSA gage as installed with load valve fully open.

NOTE: Be sure that the steering gear input shaft is not being restrained from recentering because this will cause a false steering gear pressure drop. If there is any question, conduct this test with the steering column removed.

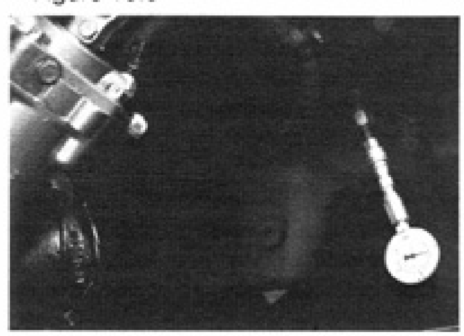


Figure 13.4

4. Bring the power steering fluid temperature to 125 - 135 ° at engine idle, with no steering force applied to the steering wheel. FIGURE 13.5.

5. At the test engine speed selected from step 2 above, measure and record the gage reading and shut off the engine. This measures total system pressure

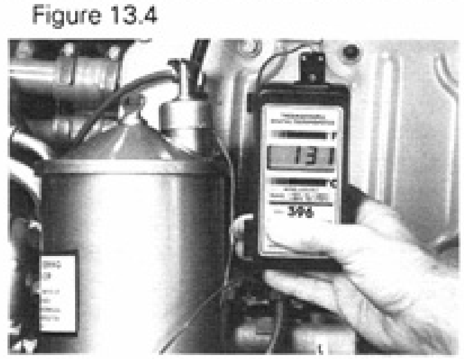


Figure 13.5

Hard Steering Tests (Continued)

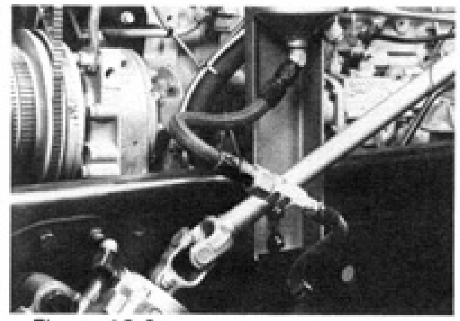


Figure 13.6

Test Procedure

6. Remove the pressure and return lines from the steering gear and connect them together with a fitting that will not restrict the flow. FIGURE 13.6.

7. Start the engine, and run at the RPM identified in step 2 with the fluid temperature between 125-135 °.

8. Measure and record gage reading and shut off engine. This is hydraulic line/reservoir pressure.

9. The difference between the total system pressure gage reading and the hydraulic line/reservoir pressure gage reading is the steering gear pressure drop. For a TAS65 steering gear, at a flow of 3, 4, 5 or 6 GPM, the drop should not be greater than 30, 40, 55 or 70 PSI respectively. The line/reservoir pressure drop for a flow of 3, 4, 5 or 6 GPM should not be greater than 20, 20, 25 or 25 PSI respectively.

Comments

A Some power steering pumps have a temporary state during which the pumping element vanes do not extend. Usually increasing engine speed briefly will correct the problem.

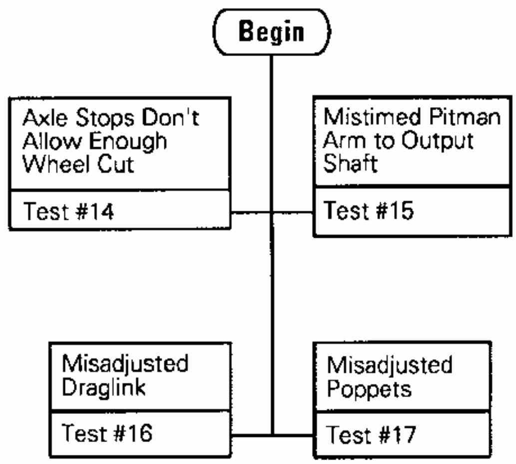
B The maximum speed of steer with power assist for a power steering gear is limited by the pump flow and internal leakage. Recommended minimum flow for a new TAS65 steering gear is 3.0 gallons per minute, and is based on a steering speed capability of 1.5 steering wheel turns per second.

Notes

Reduced Wheelcut 2

Common Phrases Used

- Too great of turning radius required
- Wheelcut restricted
- Not enough turns lock to lock


Begin
Axle Stops Don't Allow Enough Wheel Cut
Test #14
Mistimed Pitman Arm to Output Shaft
Test #15
Misadjusted Draglink
Test #16
Misadjusted Poppets
Test #17

Reduced Wheelcut Tests

Test Procedure

#14 Axle Stops Setting Check

1. Put vehicle steer tires on radius plates (turntables). Check to make sure axle stops are set to manufacturer's specifications. FIGURE 14.1.

Figure 14.1

#15 Pitman Arm and Output Shaft Alignment Check

1. Look to make sure the output shaft timing mark is lined up with the pitman arm timing mark. Some pitman arms have more than one mark, so make sure the right one is used. FIGURE 15.1.

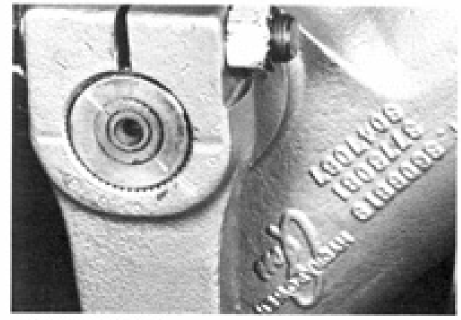


Figure 15.1

#16 Misadjusted Drag Link Check

1. The length of the drag link must be correct for the steering system. Check the length after you make sure the pitman arm/shaft timing marks are aligned, the gear is at its center position, and the road wheels are straight ahead. FIGURE 16.1.

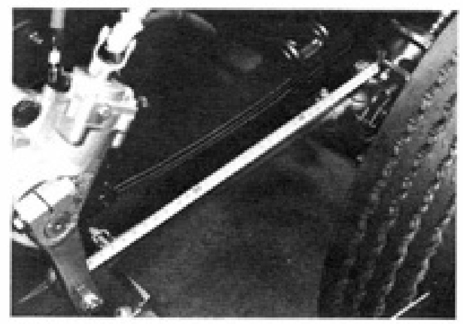


Figure 16.1

#17 Poppet Setting Procedure

1. If you are working on a newly-installed TAS steering gear, refer to the service manual to correctly set the poppets.
2. To set poppets using the adjustable service kit refer to your steering gear service manual.

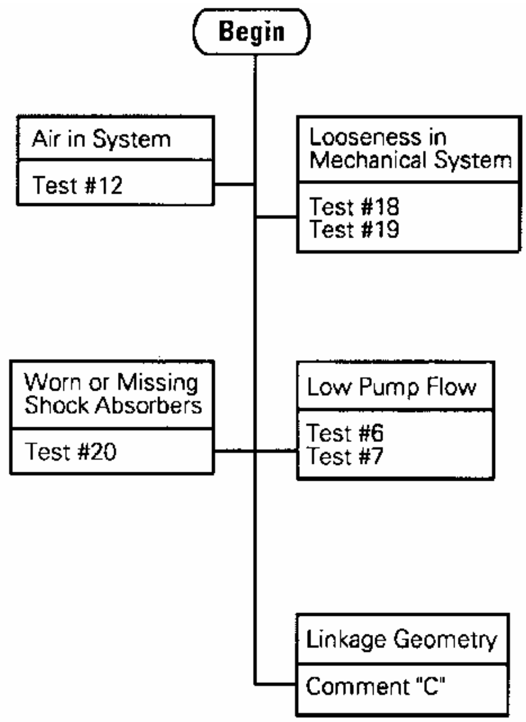
Notes

Steering Wheel Kick 3

Definition and Common Phrases Used

Steering Wheel Kick is when the road wheels hit a bump that the steering wheel reacts to. The kick is usually dampened out quickly. Common phrases used to describe Steering Wheel Kick:

- Kickback
- Backlash
- Bump steer


Begin
Air in System
Test #12
Looseness in Mechanical System
Test #18
Test #19
Worn or Missing Shock Absorbers
Test #20
Low Pump Flow
Test #6
Test #7
Linkage Geometry
Comment "C"

Steering Wheel Kick Tests

Test Procedure

#6 Power Steering Pump Test

1. Install temperature gage in reservoir. FIGURE 6.1. Install PSSA in pressure line with shut-off valve fully open. FIGURE 6.2. Park the vehicle outside. Record ambient temperature. Run the engine at governed RPM for 40 minutes to bring the fluid up to an elevated testing temperature. Measure and record the fluid temperature at the start and at 10, 20, 30 and 40 minutes. Do not allow the temperature to exceed 250°.

NOTE: If the temperature goes over 250 ° F, or 150 ° F above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

2. Run the engine at idle speed.

CAUTION: When closing the PSSA shut off valve, do so slowly and keep an eye on the pressure gage. Do not allow the system to exceed 2500 psi for safety of personnel and to prevent damage to the vehicle.

CAUTION: Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up.

3. Measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed. FIGURES 6.3 - 6.7.

Oil Temperature ______________ DEG.
Engine Idle Speed ______________ RPM

	Idle Speed	
	Pressure	Flow (GPM)
Load Valve Open		
	500 PSI	
	1000 PSI	
	1500 PSI	
Load Valve Closed		

4. Now with the load valve fully open, increase the engine speed to governed RPM and measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed: FIGURES 6.3 - 6.7.


Figure 6.1

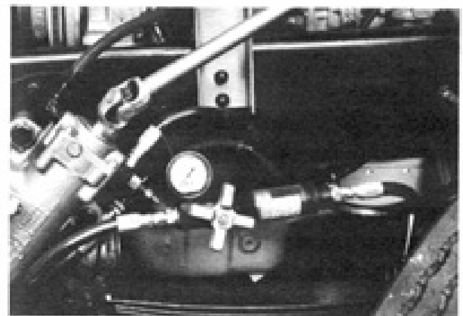


Figure 6.2

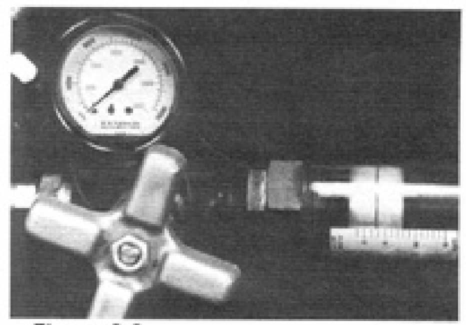


Figure 6.3

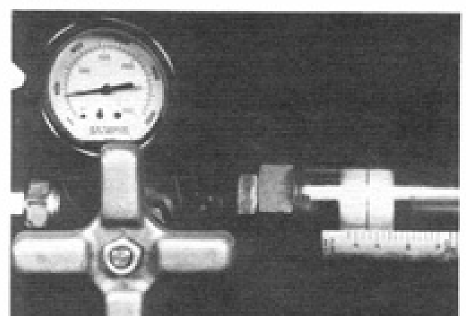


Figure 6.4

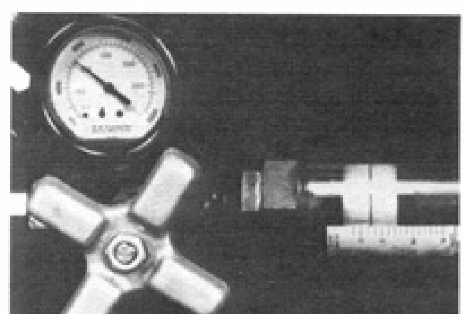


Figure 6.5

Steering Wheel Kick Tests (Continued)

Test Procedure

Oil Temperature ________________ DEG.
Engine Governed Speed ________________ RPM

	Governed Speed	
	Pressure	Flow (GPM)
Load Valve Open		
	500 PSI	
	1000 PSI	
	1500 PSI	
Load Valve Closed		

5. Determine the recommended flow range and maximum allowable system pressure for the steering system being used by referring to your service manual.

6. Compare the minimum and maximum flows, and the relief pressure you measured to gear and pump specifications.

7. If the minimum measured pump flow is less than the minimum recommended flow for the steering gear used, the pump may not be putting out enough flow for an adequate steering speed. If the maximum system pressure is lower than that specified for the pump (check your manual), it may not be developing enough pressure to steer. If either case exists, the pump needs to be repaired or replaced.

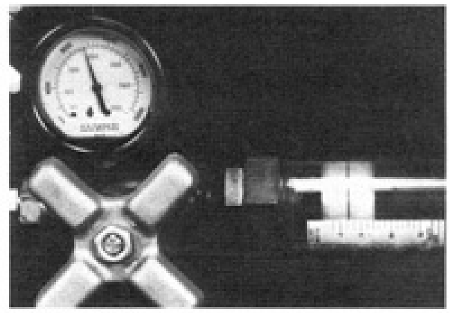


Figure 6.6

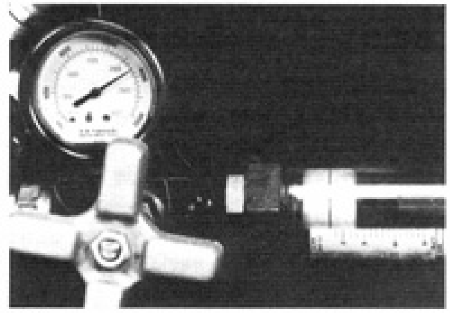


Figure 6.7

#7 Intermittent Loss of Power Assist from Pump Test

1. Install temperature gage in reservoir. FIGURE 7.1. Install PSSA in pressure line with shut-off valve fully open. FIGURE 7.2. Park the vehicle outside. Record ambient temperature. Run the engine at governed RPM for 40 minutes to bring the fluid up to an elevated testing temperature. Measure and record the fluid temperature at the start and at 10, 20, 30 and 40 minutes. Do not allow the temperature to exceed 250°.

NOTE: If the temperature goes over 250 ° F, or 150 ° F above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.


Figure 7.1

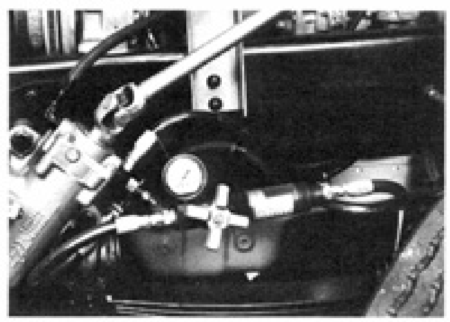


Figure 7.2

Steering Wheel Kick Tests (Continued)

Test Procedure

CAUTION: Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up.

2. (Do not allow the pressure to exceed 2500 psi). With the engine at idle, note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading you noted above.

3. With the load valve open run the engine to governed speed and note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading noted above.

4. Conduct this pump response test once at idle and three times at engine governed RPM. If the flow rate does not return immediately, the pump is malfunctioning, which can result in momentary loss of power assist.

#12 Air in Hydraulic System Check

1. Inspect reservoir for foaming or air bubbles. FIGURE 12.1. If foaming or bubbles are seen, air is being sucked into the system through cracks or loose fittings on the inlet side of the pump. Look for oil level changes engine off versus engine on. If fluid level increases when the vehicle is shut off, there is an air pocket trapped in the steering gear. The increase may not be noticeable, depending on the size of the pocket.

2. Bleed the steering gear (if there is a manual bleed screw at the top of the gear). With system at normal operating temperature and engine at proper idle speed and running, open the bleed screw and wait until clean, clear oil begins to flow from the gear. Close the bleed screw and steer the vehicle completely from stop to stop.

3. Repeat the bleeding operation three times, and recheck oil level in reservoir to make sure there is enough oil for the system to operate properly.

#18 Lash in Steering System Check

1. Two people are needed for this test. One person will turn the steering wheel back and forth one-quarter turn each way from center with the engine idling. The other person should check for looseness at each of the following areas from steering wheel to road wheels: FIGURES 18.1 - 18.5.

Figure 12.1

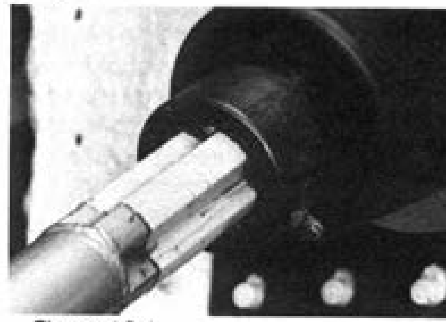


Figure 18.1

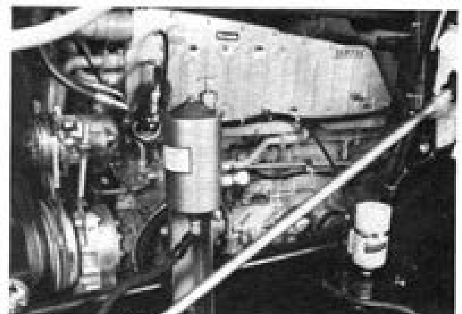


Figure 18.2

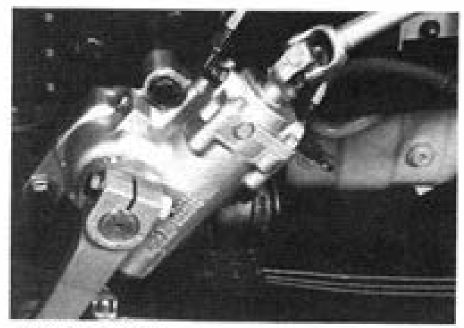


Figure 18.3

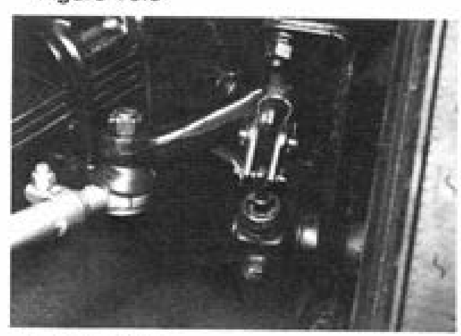


Figure 18.4

Steering Wheel Kick Tests (Continued)

Test Procedure

- Steering wheel to steering column
- U-joints, or slip-joint and/or miter boxes
- Steering column to steering gear input shaft
- Steering gear input shaft to steering gear output shaft
- Pitman arm to output shaft
- Drag link to pitman arm connection
- Drag link ends (sockets) and adjustable areas
- Axle arm to drag link connection
- King pin axle connections (bushings)
- Tie rod arms to tie rod connection
- Tie rod ends (sockets) and adjustable areas
- Steering spindle
- Wheel bearings
- Lug nuts
- Spring to spring pin connectors
- Front axle
- Front axle u-bolts
- Spring hanger brackets/rear shackles

NOTE: Cracked or broken components can cause symptoms similar to loose components but may be more difficult to find.

NOTE: Be sure to check rear drive axles for any looseness. FIGURE 18.6.


Figure 18.5


Figure 18.6

#19 Steering Gear Adjustment Check

1. Check and adjust per service manual if necessary.

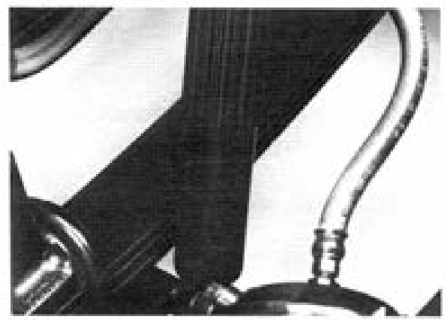


Figure 20.1

#20 Shock Absorber Check

1. Look to see if shocks have been removed. Also look for external oil leak on shocks. Make sure existing shocks are not worn out. FIGURE 20.1.

Comments

C — Vehicle linkages are designed to minimize the effect at the steering wheel during normal steered axle/suspension movements. Be sure that linkage used is as specified by vehicle manufacturer.

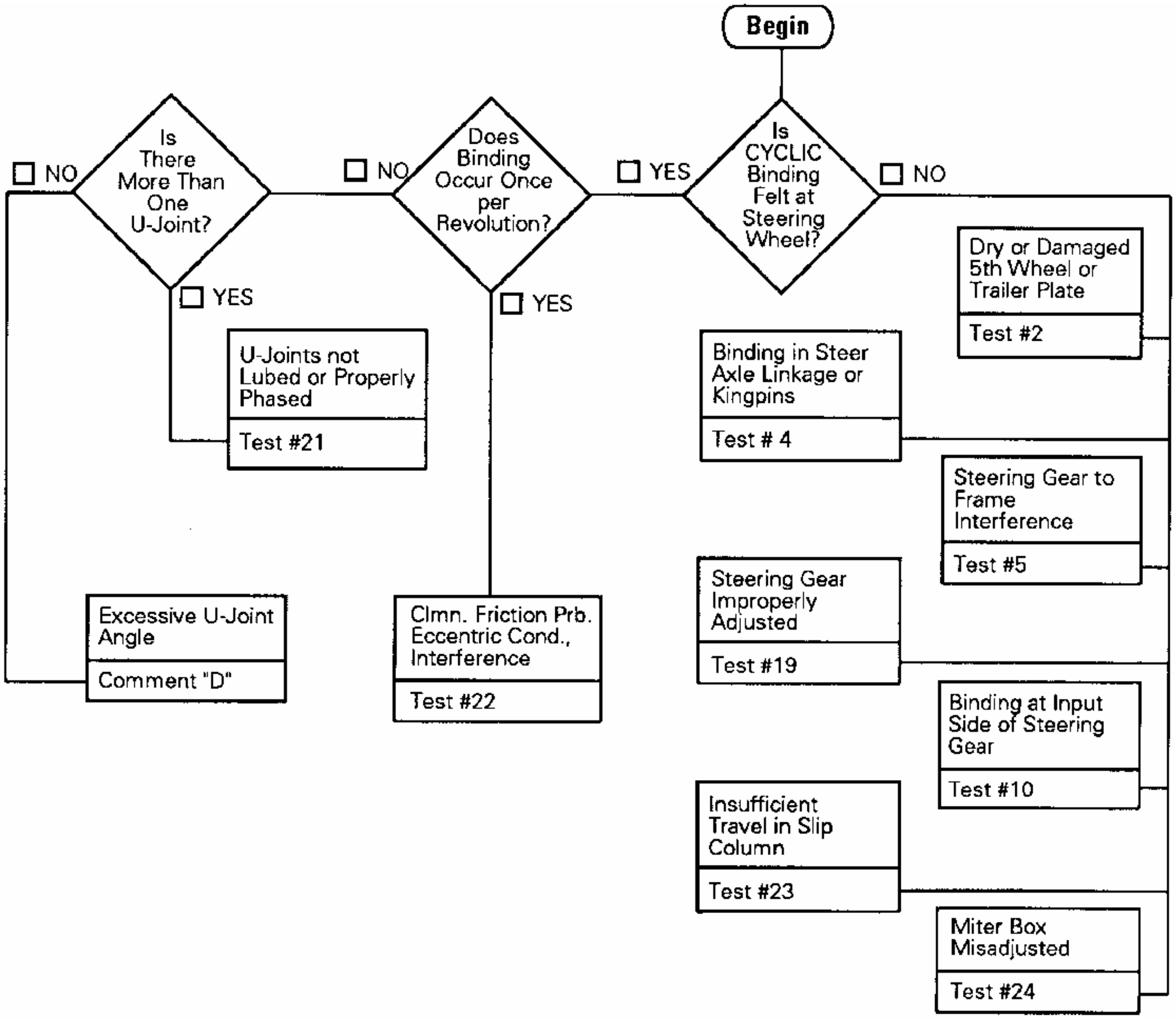
Binding/Darting/Oversteer 4

Definition

Binding is a change or increase in steering wheel effort. Binding will usually not require the effort levels described in Hard Steering, unless it is severe. Darting and oversteer are words that mean the driver suddenly gets more turning than he wants.

Explanation of Flow Chart Terms

Is cyclic binding felt at the steering wheel? - While steering in a slow, smooth manner, is a torque variation encountered which repeats for a given amount of steering wheel rotation. An example would be a hard spot or "lump" felt at the steering wheel once every revolution at the same spot.


Begin
Is CYCLIC Binding Felt at Steering Wheel?
YES
NO
Does Binding Occur Once per Revolution?
NO
YES
Is There More Than One U-Joint?
NO
YES
U-Joints not Lubed or Properly Phased
Test #21
Excessive U-Joint Angle
Comment "D"
Clmn. Friction Prb. Eccentric Cond., Interference
Test #22
Dry or Damaged 5th Wheel or Trailer Plate
Test #2
Binding in Steer Axle Linkage or Kingpins
Test # 4
Steering Gear to Frame Interference
Test #5
Steering Gear Improperly Adjusted
Test #19
Binding at Input Side of Steering Gear
Test #10
Insufficient Travel in Slip Column
Test #23
Miter Box Misadjusted
Test #24

Binding/Darting/Oversteer Tests

Test Procedure

#2 Fifth Wheel and Trailer Plate Check

1. Look for dry fifth-wheel or trailer plate. FIGURE 2.1.
2. Look for damage to fifth-wheel or trailer plate.
3. Inspect fifth-wheel for looseness.

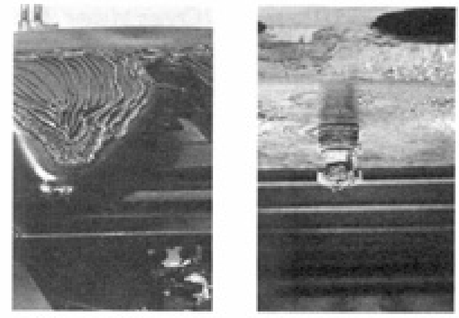


Figure 2.1

#4 Steer Axle and Linkage Binding Test

1. With vehicle steer tires on radius plates (turntables) or equivalent, disconnect the drag link <u>or</u> pitman arm from the steering gear (and linkage from assist cylinder if there is one on the vehicle). FIGURE 4.1.

   CAUTION: Do not steer the gear with linkage removed as mis-adjustment of automatic poppets may result.

2. By hand, pull the tire to one axle stop and release (engine off). The tire should self-return to near straight ahead. FIGURE 4.2.
3. Repeat the test in the opposite direction.
4. If tire does not self-return to near straight ahead, a problem is likely in steer axle king pin bushings/bearings or linkage.

Figure 4.1

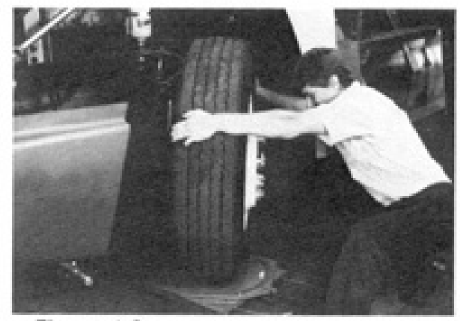


Figure 4.2

#5 Steering Gear Mounting Test

1. Look for anything between the steering gear and frame that could cause a binding problem. For example: hoses or brackets that have been routed, or are interfering between the steering gear and frame. FIGURE 5.1. Frame flanges or spring mounting points, mounting pads lower than steering gear housing, lack of clearance between frame and steering gear valve housing adaptor, sector shaft adjusting screw and nut mismatched with access adjustment hole in frame.
2. If the steering gear has been mounted to the frame in a way that causes the gear to distort (not be flat), it may cause a steering problem. The use of spacers is alright as long as the gear is mounted securely, and the gear is not distorted when mounting bolts are tightened FIGURE 5.2. Checking to see if distortion is present on the vehicle may require the following test:

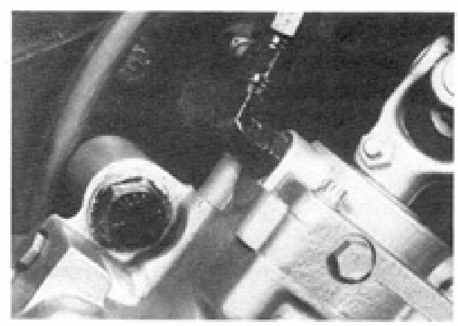


Figure 5.1

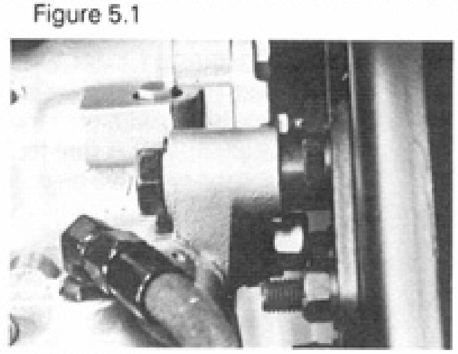


Figure 5.2

Binding/Darting/Oversteer Tests (Continued)

Test Procedure

3. With vehicle parked and turned off, steer the wheel slowly checking for a binding-type of feel at the steering wheel. When binding is felt loosen one mounting bolt, and steer the vehicle again. Continue to loosen one mounting bolt at a time and check for improvement in the binding condition. If improvement is made by loosening the bolts, determine by inspection what interference or condition is causing the gear to distort and correct the problem.

Figure 10.1

#10 Steering Column Binding Test

1. With the vehicle parked, the engine off, and the steer axle jacked-up, slowly steer the vehicle until the binding position is located.

2. With the steering gear at this position, remove the steering column assembly from the steering gear. Note the correct position of the column and steering gear for reassembly after test. FIGURE 10.1.

3. Rotate the steering gear input shaft no more than 1/4 turn each direction and check if binding is still present. FIGURE 10.2. If binding is not felt, correct the steering column problem.

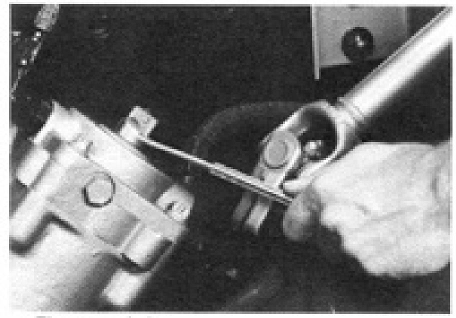


Figure 10.2

#19 Steering Gear Adjustment Check

1. Check and adjust per service manual if necessary.

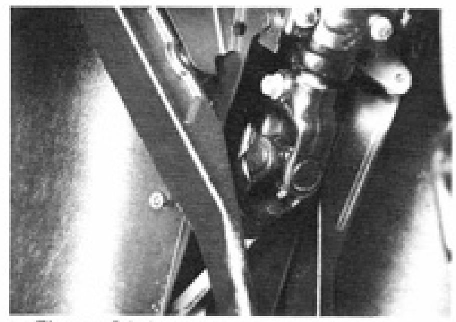


Figure 21.1

#21 U-Joint Phasing and Lubrication Check

1. Make sure u-joints are properly lubricated.

2. Steering column assemblies with more than one universal joint (cardan type) can cause a cyclic binding feel or torque variation at the steering wheel if the u-joints are not in phase with each other. Optimum phasing of a two u-joint system is achieved by placing the yoke at each end of the intermediate shaft in line with the plane of the corresponding u-joint angle. FIGURES 21.1 - 21.2. If a steering column assembly with multiple u-joints is taken apart, it must be reinstalled with the timing marks for slip mechanisms aligned. This is true for both the cross-type and the splined-type two-piece intermediate shaft.

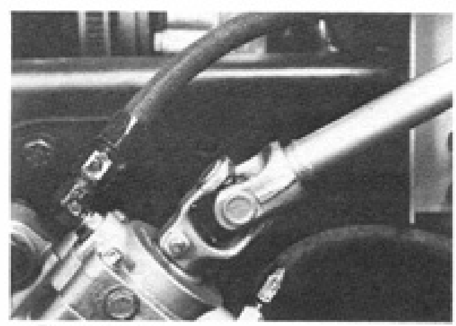


Figure21.2

Binding/Darting/Oversteer Tests (Continued)

Test Procedure

#22 Steering Column Interference Test

1. Position column assembly at the location where interference is noticed, and look for something interfering or rubbing on the rotating column assembly such as brackets, bolts, floorboard, boot, horn wire, turn signal, etc. FIGURE 22.1.

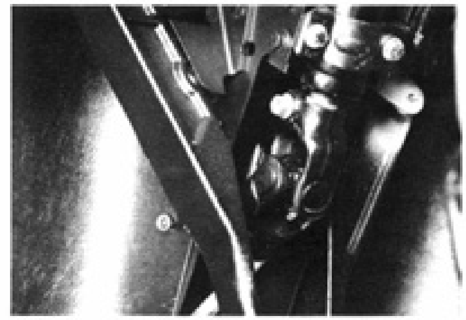


Figure 22.1

#23 Slip Column Travel Test

1. Check the slip column by looking to make sure there is proper travel allowance when in use. FIGURE 23.1.
2. Look for wear or galling. FIGURE 23.2.
3. Check slip column for too much slip force.

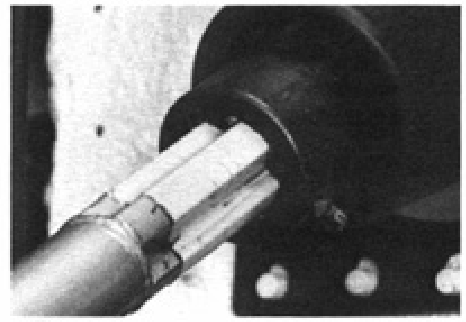


Figure 23.1

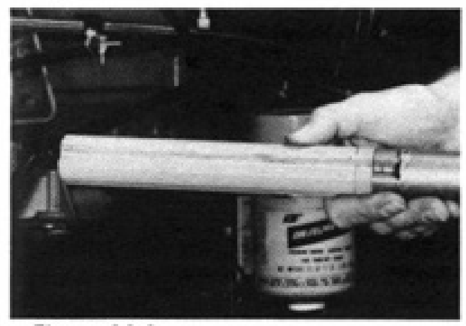


Figure 23.2

#24 Miter Box Misadjusted (if equipped) Test

1. Check and adjust per manufacturer's instructions. FIGURE 24.1.

Figure 24.1

Comments

D A single u-joint operating at an angle will cause a cyclic torque variation at the steering wheel. The amount of torque variation increases with the amount of operating angle. A secondary binding movement that side loads the input shaft also increases with increased u-joint angles. U-joint operating angles of 15 degrees or less will minimize the torque variation felt at the steering wheel.

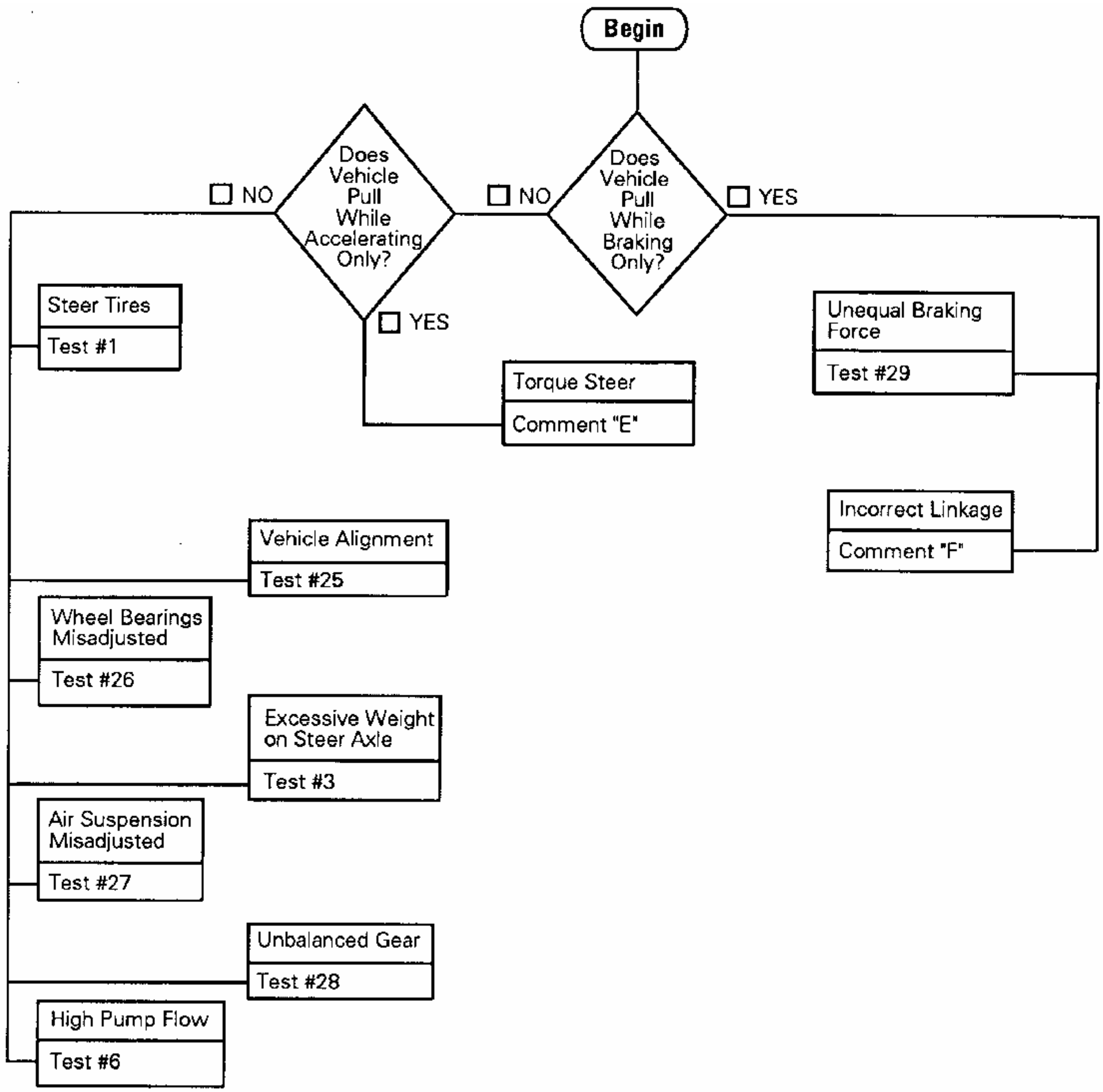
Notes

Directional Pull 5

Common Phrases Used

Common phrases used to describe Directional Pull:

- Steering pulls to the right (or left),
- Truck pulls to the right (or left)
- A constant force is required to keep the truck going straight.


Begin
Does Vehicle Pull While Braking Only?
YES
NO
Unequal Braking Force
Test #29
Incorrect Linkage
Comment "F"
Does Vehicle Pull While Accelerating Only?
YES
NO
Torque Steer
Comment "E"
Steer Tires
Test #1
Vehicle Alignment
Test #25
Wheel Bearings Misadjusted
Test #26
Excessive Weight on Steer Axle
Test #3
Air Suspension Misadjusted
Test #27
Unbalanced Gear
Test #28
High Pump Flow
Test #6

Directional Pull Tests

Test Procedure

#1 Tire Check

1. Look for:
   - Tire damage. FIGURE 1.1.
   - Uneven or extreme tread wear
   - Mismatched tires
2. Check tire pressure.

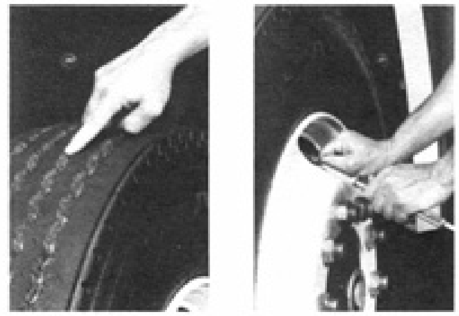


Figure 1.1

#3 Steer Axle Weight Test

1. Have steer axle weighed at load condition which produces complaint and compare to specifications. FIGURE 3.1.

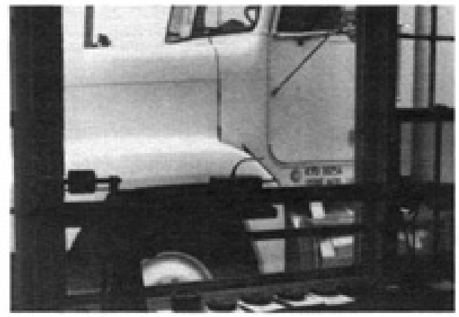


Figure 3.1

#6 Power Steering Pump Test

1. Install temperature gage in reservoir. FIGURE 6.1. Install PSSA in pressure line with shut-off valve fully open. FIGURE 6.2. Park the vehicle outside. Record ambient temperature. Run the engine at governed RPM for 40 minutes to bring the fluid up to an elevated testing temperature. Measure and record the fluid temperature at the start and at 10, 20, 30 and 40 minutes. Do not allow the temperature to exceed 250°.

   NOTE: If the temperature goes over 250 ° F, or 150 ° F above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

Figure 6.1

2. Run the engine at idle speed.

   CAUTION: When closing the PSSA shut off valve, do so slowly and keep an eye on the pressure gage. Do not allow the system to exceed 2500 psi for safety of personnel and to prevent damage to the vehicle.

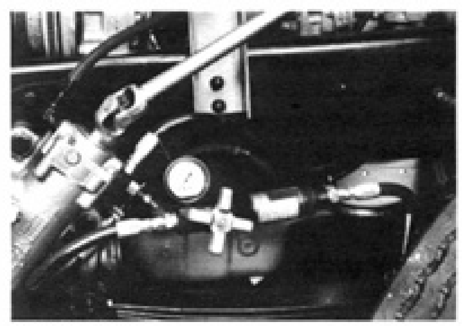


Figure 6.2

   CAUTION: Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up.

3. Measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed. FIGURES 6.3 - 6.7.

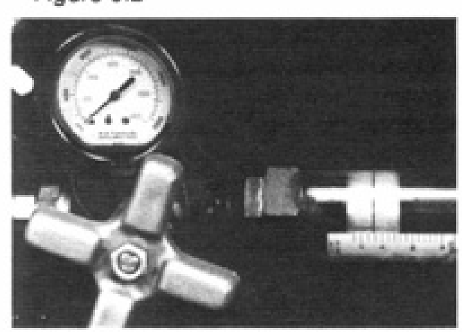


Figure 6.3

Directional Pull Tests (Continued)

Test Procedure

Oil Temperature ________________ DEG.
Engine Idle Speed ________________ RPM

	Idle Speed	
	Pressure	Flow (GPM)
Load Valve Open		
	500 PSI	
	1000 PSI	
	1500 PSI	
Load Valve Closed		

4. Now with the load valve fully open, increase the engine speed to governed RPM and measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed: FIGURES 6.3 - 6.7.

Oil Temperature ________________ DEG.
Engine Governed Speed ________________ RPM

	Governed Speed	
	Pressure	Flow (GPM)
Load Valve Open		
	500 PSI	
	1000 PSI	
	1500 PSI	
Load Valve Closed		

5. Determine the recommended flow range and maximum allowable system pressure for the steering system being used by referring to your service manual.

6. Compare the minimum and maximum flows, and the relief pressure you measured to gear and pump specifications.

7. If the minimum measured pump flow is less than the minimum recommended flow for the steering gear used, the pump may not be putting out enough flow for an adequate steering speed. If the maximum system pressure is lower than that specified for the pump (check your manual), it may not be developing enough pressure to steer. If either case exists, the pump needs to be repaired or replaced.

#25 Alignment Check

1. Check alignment of steered axle and rear drive axles, and trailer axles (if problem only exists with trailer). FIGURE 25.1.

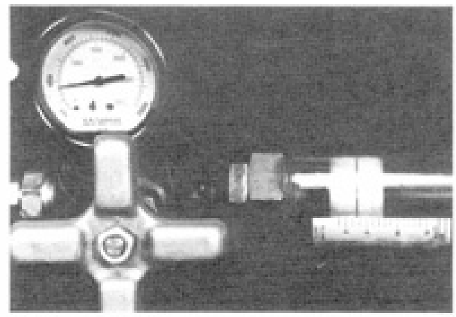


Figure 6.4

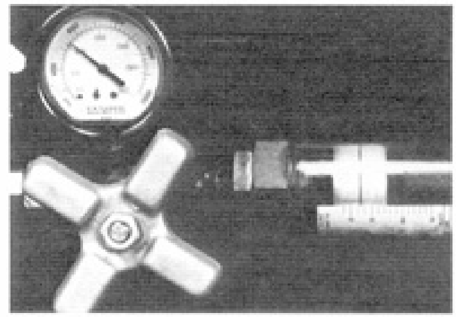


Figure 6.5

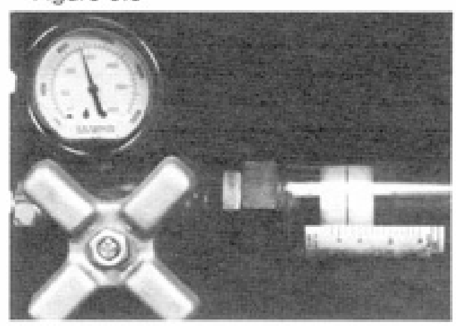


Figure 6.6

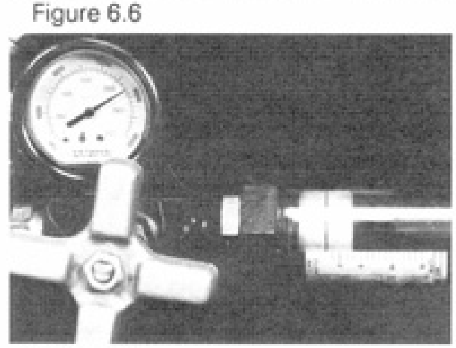


Figure 6.7

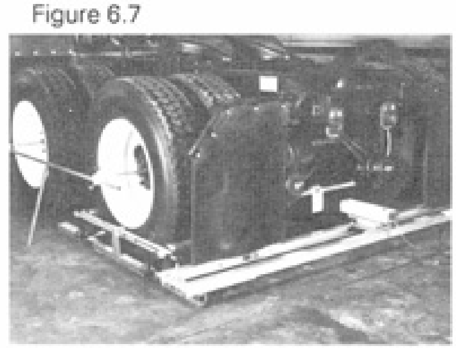


Figure 25.1

Directional Pull Tests (Continued)

Test Procedure

#26 Wheel Bearing Check

1. Verify that adjustment is per manufacturer's specification. FIGURE 26.1.

#27 Air Suspension Adjustment Check

1. Check and set to manufacturer's specifications. FIGURE 27.1.

#28 Gear Control Valve Imbalance Check

1. Install a low pressure gage (200-300 PSI maximum with approximately 10 PSI per division) in the pressure line from pump to gear. FIGURE 28.1.

   CAUTION: Do not allow system pressure to exceed the rating of the gage in the following procedure or damage to the gage will result.

2. At engine idle, slightly turn the steering column by hand in one direction until a pressure rise is observed at the gage. FIGURE 28.2.
3. Stop steering and gently allow the steering column to recenter.
4. Next slightly turn the steering column by hand in the opposite direction while observing the gage and determine if pressure initially rises or falls with initiation of a turn.
5. Repeat test a few times in each direction.
6. If a consistent fall in pressure is associated with the initiation of a turn in one direction, the steering gear's control valve is unbalanced and needs to be replaced.

#29 Unequal Brake Force Check

1. Visually inspect brake assemblies for oil/grease on braking surfaces, and overall condition of brake surfaces. FIGURE 29.1.
2. Adjust or replace brakes if necessary.

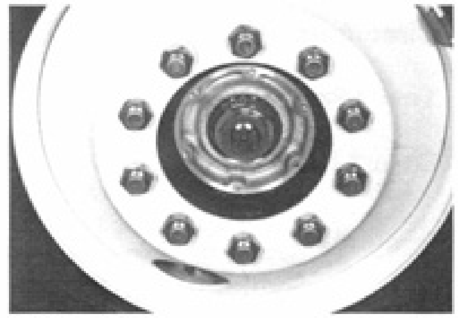


Figure 26.1

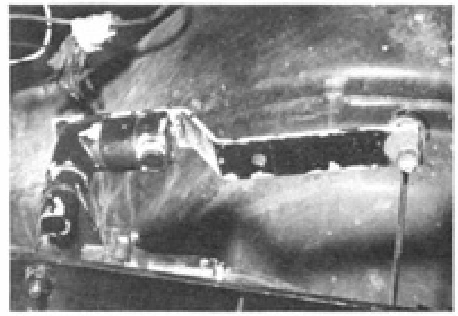


Figure 27.1


Figure 28.1

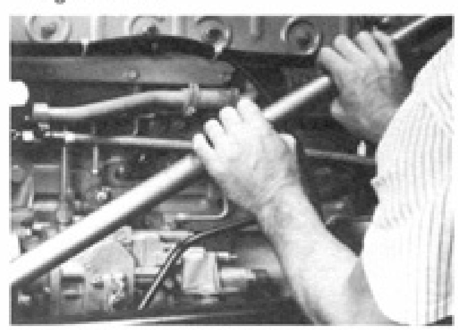


Figure 28.2

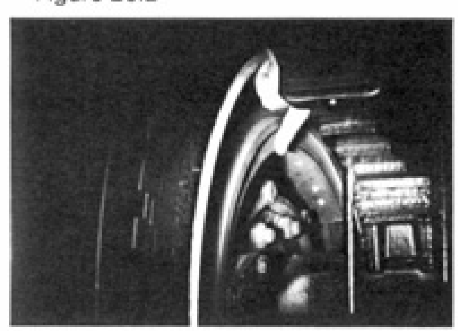


Figure 29.1

Directional Pull Tests (Continued)

Test #Procedure

Comments

E Deflections in the suspension and linkage, front and rear, due to high engine generated torque levels can cause a steering effect. This most often occurs at lower vehicle speeds while accelerating.

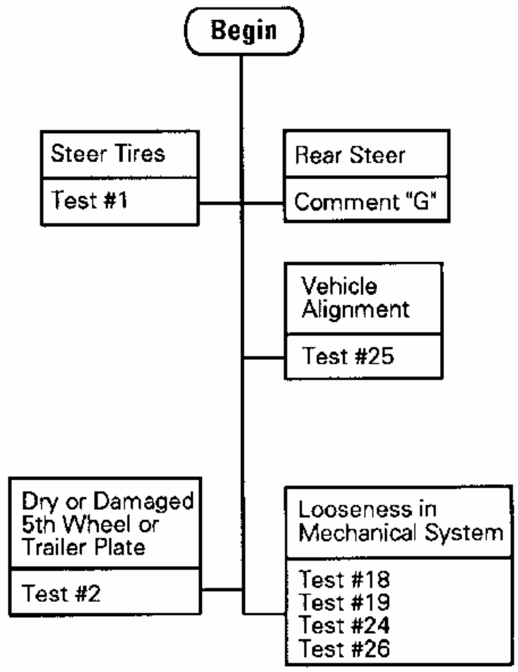
F The location of the axle arm ball center is important during spring wind-up conditions such as severe braking. A steering arm different from that specified by the manufacturer could cause a steering effect while braking.

Road Wander/Loose Steering 6

Common Phrases Used

Common phrases used to describe Road Wander or Loose Steering:

- Lash in steering
- Lost motion in steering.
- Constant correction is needed at the steering wheel to keep the vehicle from wandering



Begin
Steer Tires
Test #1
Rear Steer
Comment "G"
Vehicle Alignment
Test #25
Dry or Damaged 5th Wheel or Trailer Plate
Test #2
Looseness in Mechanical System
Test #18
Test #19
Test #24
Test #26

Road Wander/Loose Steering Tests

Test Procedure

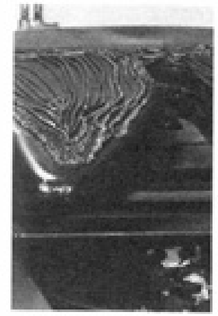
#1 Tire Check

1. Look for:
   - Tire damage. FIGURE 1.1.
   - Uneven or extreme tread wear
   - Mismatched tires
2. Check tire pressure.

Figure 1.1

#2 Fifth Wheel and Trailer Plate Check

1. Look for dry fifth-wheel or trailer plate. FIGURE 2.1.
2. Look for damage to fifth-wheel or trailer plate.
3. Inspect fifth-wheel for looseness.



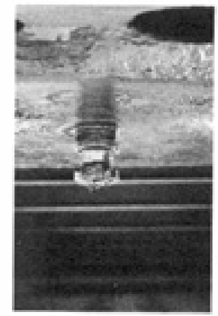


Figure 2.1

#18 Lash in Steering System Check

1. Two people are needed for this test. One person will turn the steering wheel back and forth one-quarter turn each way from center with the engine idling. The other person should check for looseness at each of the following areas from steering wheel to road wheels: FIGURES 18.1 - 18.5.

   - Steering wheel to steering column
   - U-joints, or slip-joint and/or miter boxes
   - Steering column to steering gear input shaft
   - Steering gear input shaft to steering gear output shaft
   - Pitman arm to output shaft
   - Drag link to pitman arm connection
   - Drag link ends (sockets) and adjustable areas
   - Axle arm to drag link connection
   - King pin axle connections (bushings)
   - Tie rod arms to tie rod connection
   - Tie rod ends (sockets) and adjustable areas
   - Steering spindle
   - Wheel bearings
   - Lug nuts
   - Spring to spring pin connectors
   - Front axle
   - Front axle u-bolts
   - Spring hanger brackets/rear shackles

   NOTE: Cracked or broken components can cause symptoms similar to loose components but may be more difficult to find.

   NOTE: Be sure to check rear drive axles for any looseness. FIGURE 18.6.

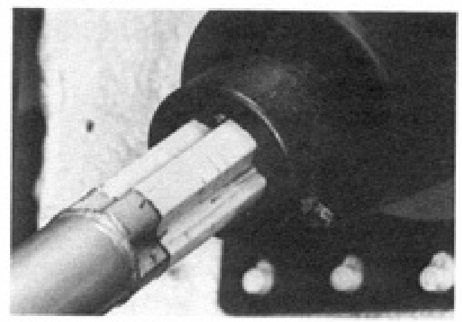


Figure 18.1

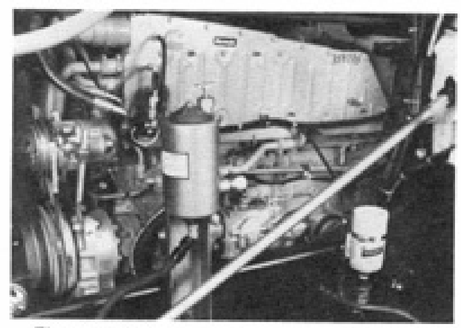


Figure 18.2

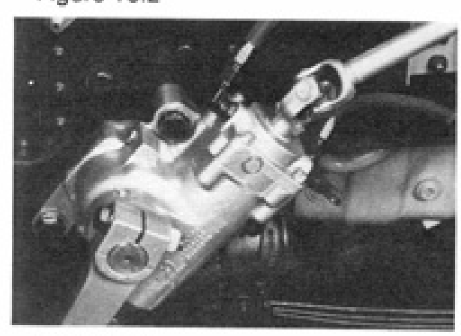


Figure 18.3

Road Wander/Loose Steering Tests (Continued)

Test Procedure

#19 Steering Gear Adjustment Check

1. Check and adjust per service manual if necessary.

#24 Miter Box Misadjusted (if equipped) Test

1. Check and adjust per manufacturer's instructions. FIGURE 24.1.

#25 Alignment Check

1. Check alignment of steered axle and rear drive axles, and trailer axles (if problem only exists with trailer). FIGURE 25.1.

#26 Wheel Bearing Check

1. Verify that adjustment is per manufacturer's specification. FIGURE 26.1.

Comments

G Soft or loosely supported rear suspensions may allow the rear driving axles to become non-square with the centerline of the chassis during load shifting or trailer roll which will tend to produce a steering effect.

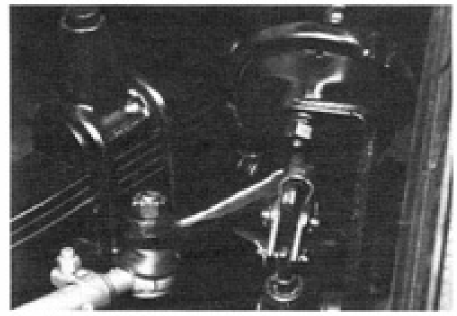


Figure 18.4

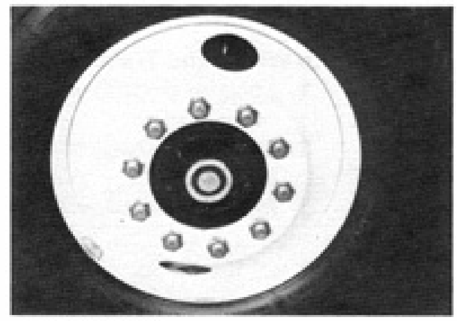


Figure 18.5

Figure 18.6

Figure 24.1

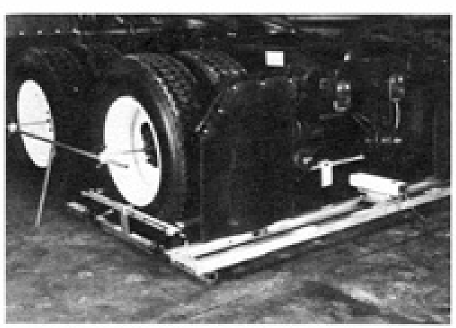


Figure 25.1

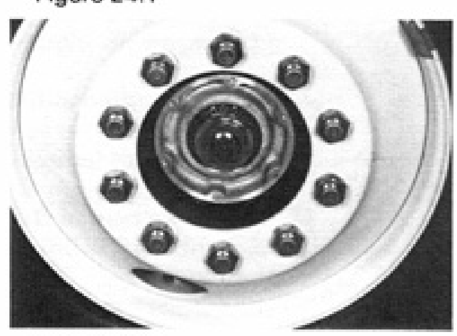


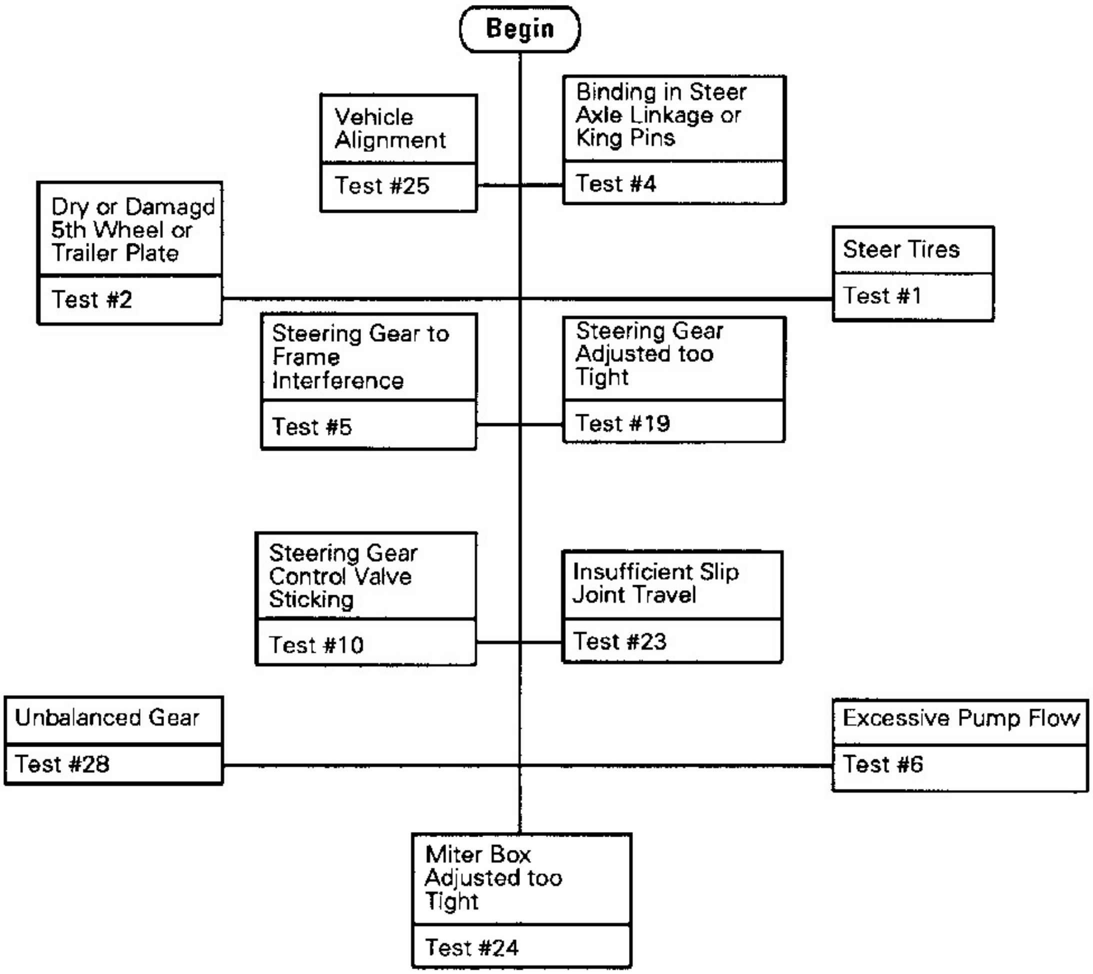
Figure 26.1

Non-Recovery 7

Common Phrases Used

Common phrases used to describe Non-Recovery:

- Wheels don't return to straight ahead.


Begin
Vehicle Alignment
Test #25
Binding in Steer Axle Linkage or King Pins
Test #4
Dry or Damagd 5th Wheel or Trailer Plate
Test #2
Steer Tires
Test #1
Steering Gear to Frame Interference
Test #5
Steering Gear Adjusted too Tight
Test #19
Steering Gear Control Valve Sticking
Test #10
Insufficient Slip Joint Travel
Test #23
Unbalanced Gear
Test #28
Excessive Pump Flow
Test #6
Miter Box Adjusted too Tight
Test #24

Non-Recovery Tests

Test Procedure

#1 Tire Check

1. Look for:
   - Tire damage. FIGURE 1.1.
   - Uneven or extreme tread wear
   - Mismatched tires
2. Check tire pressure.

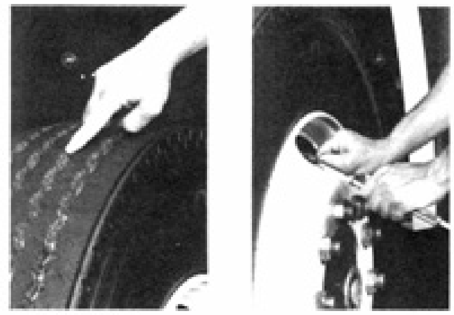


Figure 1.1

#2 Fifth Wheel and Trailer Plate Check

1. Look for dry fifth-wheel or trailer plate. FIGURE 2.1.
2. Look for damage to fifth-wheel or trailer plate.
3. Inspect fifth-wheel for looseness.

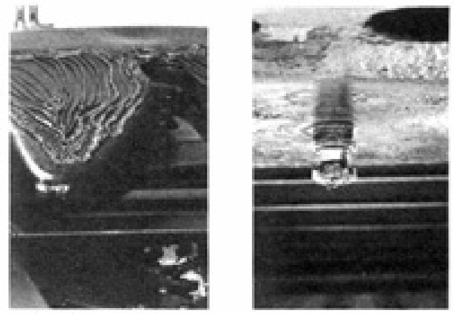


Figure 2.1

#4 Steer Axle and Linkage Binding Test

1. With vehicle steer tires on radius plates (turntables) or equivalent, disconnect the drag link <u>or</u> pitman arm from the steering gear (and linkage from assist cylinder if there is one on the vehicle). FIGURE 4.1.

   CAUTION: Do not steer the gear with linkage removed as mis-adjustment of automatic poppets may result.

2. By hand, pull the tire to one axle stop and release (engine off). The tire should self-return to near straight ahead. FIGURE 4.2.
3. Repeat the test in the opposite direction.
4. If tire does not self-return to near straight ahead, a problem is likely in steer axle king pin bushings/bearings or linkage.

Figure 4.1

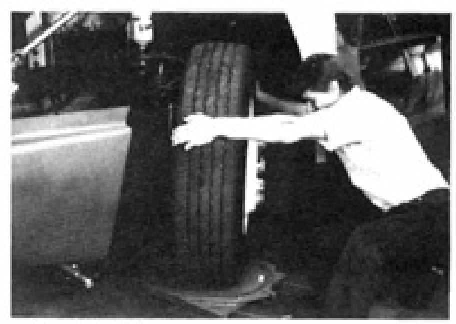


Figure 4.2

#5 Steering Gear Mounting Test

1. Look for anything between the steering gear and frame that could cause a binding problem. For example: hoses or brackets that have been routed, or are interfering between the steering gear and frame. FIGURE 5.1. Frame flanges or spring mounting points, mounting pads lower than steering gear housing, lack of clearance between frame and steering gear valve housing adaptor, sector shaft adjusting screw and nut mismatched with access adjustment hole in frame.

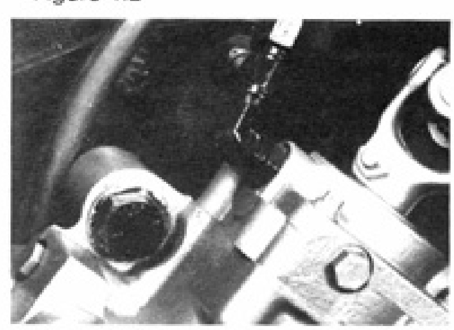


Figure 5.1

Non-Recovery Tests (Continued)

Test Procedure

2. If the steering gear has been mounted to the frame in a way that causes the gear to distort (not be flat), it may cause a steering problem. The use of spacers is alright as long as the gear is mounted securely, and the gear is not distorted when mounting bolts are tightened. FIGURE 5.2. Checking to see if distortion is present on the vehicle may require the following test:

3. With vehicle parked and turned off, steer the wheel slowly checking for a binding-type of feel at the steering wheel. When binding is felt loosen one mounting bolt, and steer the vehicle again. Continue to loosen one mounting bolt at a time and check for improvement in the binding condition. If improvement is made by loosening the bolts, determine by inspection what interference or condition is causing the gear to distort and correct the problem.

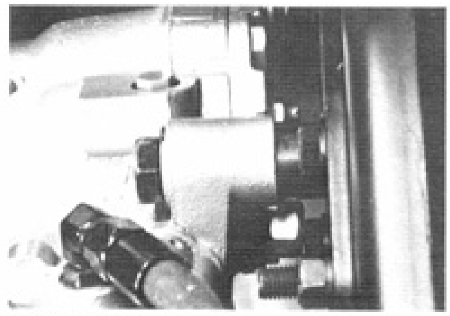


Figure 5.2

Figure 6.1

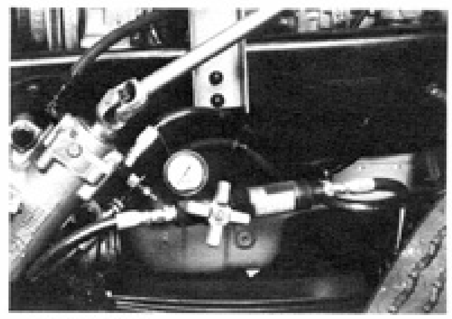


Figure 6.2

#6 Power Steering Pump Test

1. Install temperature gage in reservoir. FIGURE 6.1. Install PSSA in pressure line with shut-off valve fully open. FIGURE 6.2. Park the vehicle outside. Record ambient temperature. Run the engine at governed RPM for 40 minutes to bring the fluid up to an elevated testing temperature. Measure and record the fluid temperature at the start and at 10, 20, 30 and 40 minutes. Do not allow the temperature to exceed 250°.

NOTE: If the temperature goes over 250 ° F, or 150 ° F above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

2. Run the engine at idle speed.

CAUTION: When closing the PSSA shut off valve, do so slowly and keep an eye on the pressure gage. Do not allow the system to exceed 2500 psi for safety of personnel and to prevent damage to the vehicle.

CAUTION: Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up.

Non-Recovery Tests (Continued)

Test Procedure

3. Measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed. FIGURES 6.3 - 6.7.

Oil Temperature	______________	DEG.
Engine Idle Speed	______________	RPM

	Idle Speed	
	Pressure	Flow (GPM)
Load Valve Open		
	500 PSI	
	1000 PSI	
	1500 PSI	
Load Valve Closed		

4. Now with the load valve fully open, increase the engine speed to governed RPM and measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed: FIGURES 6.3 - 6.7.

Oil Temperature	______________	DEG.
Engine Governed Speed	______________	RPM

	Governed Speed	
	Pressure	Flow (GPM)
Load Valve Open		
	500 PSI	
	1000 PSI	
	1500 PSI	
Load Valve Closed		

5. Determine the recommended flow range and maximum allowable system pressure for the steering system being used by referring to your service manual.

6. Compare the minimum and maximum flows, and the relief pressure you measured to gear and pump specifications.

7. If the minimum measured pump flow is less than the minimum recommended flow for the steering gear used, the pump may not be putting out enough flow for an adequate steering speed. If the maximum system pressure is lower than that specified for the pump (check your manual), it may not be developing enough pressure to steer. If either case exists, the pump needs to be repaired or replaced.

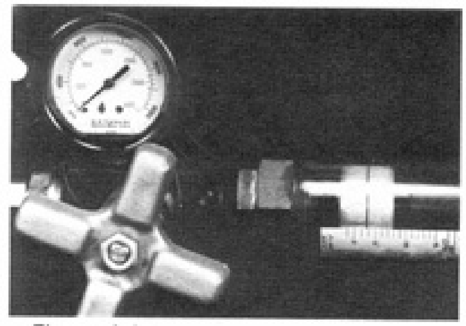


Figure 6.3

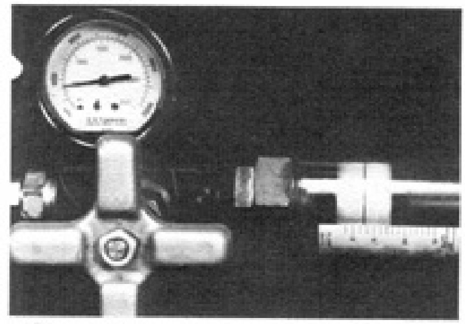


Figure 6.4

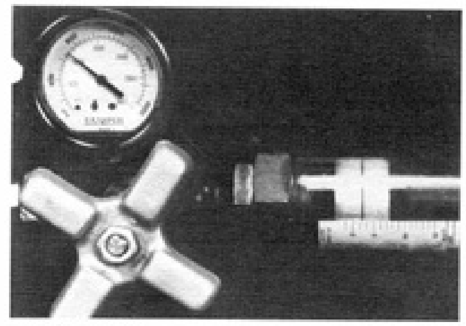


Figure 6.5

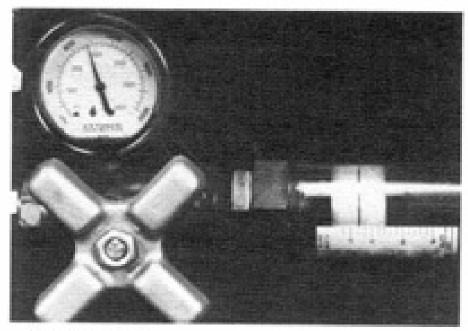


Figure 6.6

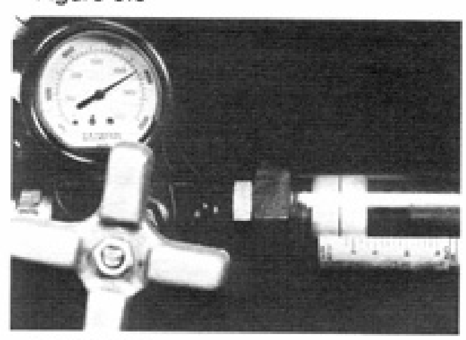


Figure 6.7

Non-Recovery Tests (Continued)

Test Procedure

#10 Steering Column Binding Test

1. With the vehicle parked, the engine off, and the steer axle jacked-up, slowly steer the vehicle until the binding position is located.

2. With the steering gear at this position, remove the steering column assembly from the steering gear. Note the correct position of the column and steering gear for reassembly after test. FIGURE 10.1.

3. Rotate the steering gear input shaft no more than 1/4 turn each direction and check if binding is still present. FIGURE 10.2. If binding is not felt, correct the steering column problem.

#19 Steering Gear Adjustment Check

1. Check and adjust per service manual if necessary.

#23 Slip Column Travel Test

1. Check the slip column by looking to make sure there is proper travel allowance when in use. FIGURE 23.1.

2. Look for wear or galling. FIGURE 23.2.

3. Check slip column for too much slip force.

#24 Miter Box Misadjusted (if equipped) Test

1. Check and adjust per manufacturer's instructions. FIGURE 24.1.


Figure 10.1

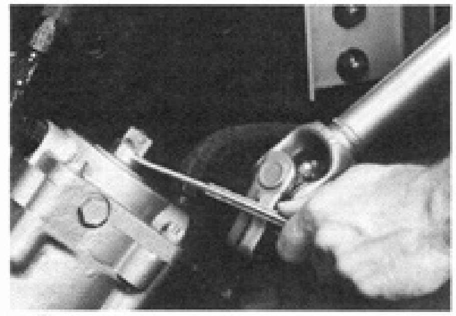


Figure 10.2

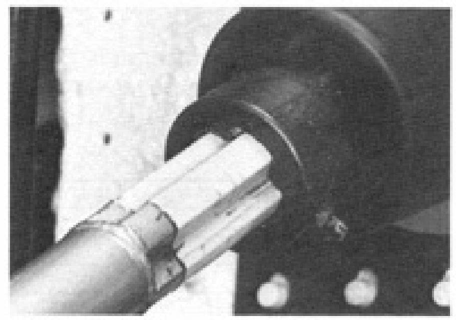


Figure 23.1

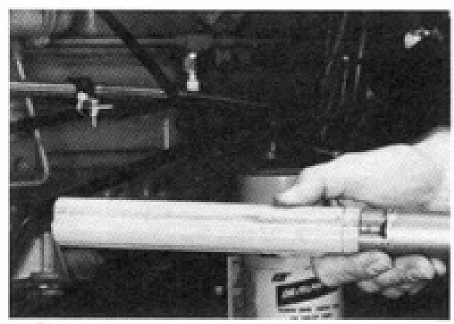


Figure 23.2


Figure 24.1

Non-Recovery Tests (Continued)

Test Procedure

#25 Alignment Check

1. Check alignment of steered axle and rear drive axles, and trailer axles (if problem only exists with trailer). FIGURE 25.1.

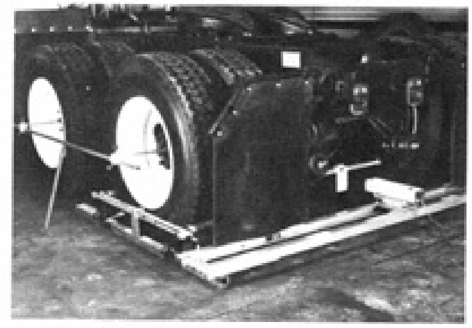


Figure 25.1

#28 Gear Control Valve Imbalance Check

1. Install a low pressure gage (200-300 PSI maximum with approximately 10 PSI per division) in the pressure line from pump to gear. FIGURE 28.1.

   CAUTION: Do not allow system pressure to exceed the rating of the gage in the following procedure or damage to the gage will result.

2. At engine idle, slightly turn the steering column by hand one direction until a pressure rise is observed at the gage. FIGURE 28.2.

3. Stop steering and gently allow the steering column to recenter.

4. Next slightly turn the steering column by hand the opposite direction while observing the gage and determine if pressure initially rises or falls with initiation of a turn.

5. Repeat test a few times in each direction.

6. If a consistent fall in pressure is associated with the initiation of a turn in one direction, the steering gear's control valve is unbalanced and needs to be replaced.

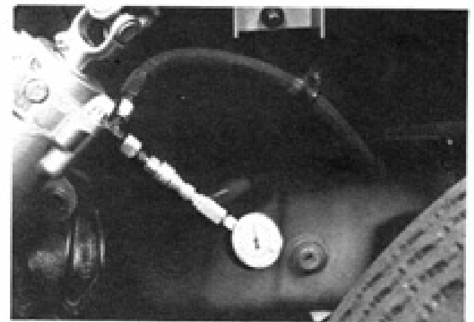


Figure 28.1

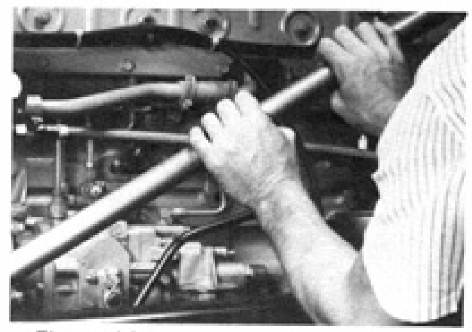


Figure 28.2

Notes

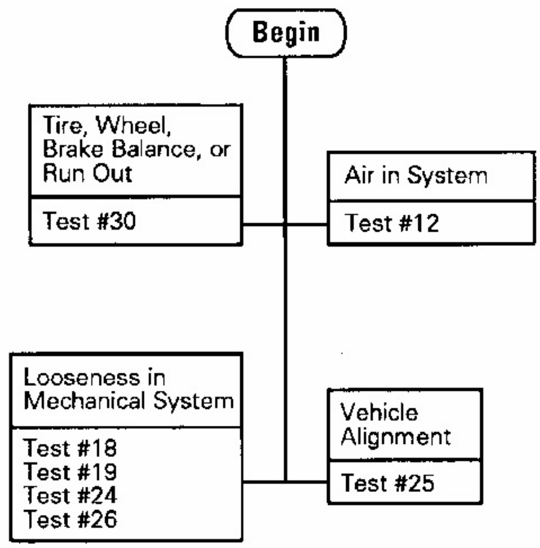
Shimmy 8

Definition and Common Phrases Used

A severe Shimmy condition can be felt at the steering wheel. Typically, once something triggers a Shimmy condition to occur, it is sustained until the driver does something (such as slow down) to dampen out the condition.

Common phrases used to describe Shimmy:

- Shake at steering wheel


Begin
Tire, Wheel, Brake Balance, or Run Out
Test #30
Air in System
Test #12
Looseness in Mechanical System
Test #18
Test #19
Test #24
Test #26
Vehicle Alignment
Test #25

Shimmy Tests

Test Procedure

#12 Air in Hydraulic System Check

1. Inspect reservoir for foaming or air bubbles. FIGURE 12.1. If foaming or bubbles are seen, air is being sucked into the system through cracks or loose fittings on the inlet side of the pump. Look for oil level changes engine off versus engine on. If fluid level increases when the vehicle is shut off, there is an air pocket trapped in the steering gear. The increase may not be noticeable, depending on the size of the pocket.

2. Bleed the steering gear (if there is a manual bleed screw at the top of the gear). With system at normal operating temperature and engine at proper idle speed and running, open the bleed screw and wait until clean, clear oil begins to flow from the gear. Close the bleed screw and steer the vehicle completely from stop to stop.

3. Repeat the bleeding operation three times, and recheck oil level in reservoir to make sure there is enough oil for the system to operate properly.

#18 Lash in Steering System Check

1. Two people are needed for this test. One person will turn the steering wheel back and forth one-quarter turn each way from center with the engine idling. The other person should check for looseness at each of the following areas from steering wheel to road wheels: FIGURES 18.1 - 18.5.

- Steering wheel to steering column
- U-joints, or slip-joint and/or miter boxes
- Steering column to steering gear input shaft
- Steering gear input shaft to steering gear output shaft
- Pitman arm to output shaft
- Drag link to pitman arm connection
- Drag link ends (sockets) and adjustable areas
- Axle arm to drag link connection
- King pin axle connections (bushings)
- Tie rod arms to tie rod connection
- Tie rod ends (sockets) and adjustable areas
- Steering spindle
- Wheel bearings
- Lug nuts
- Spring to spring pin connectors
- Front axle
- Front axle u-bolts
- Spring hanger brackets/rear shackles

NOTE: Cracked or broken components can cause symptoms similar to loose components but may be more difficult to find.

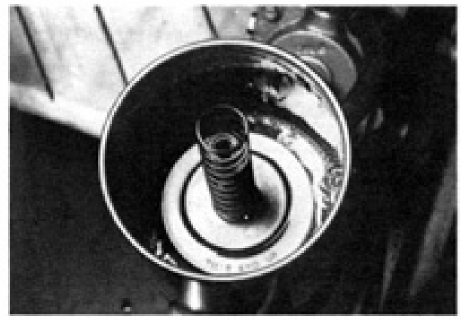


Figure 12.1

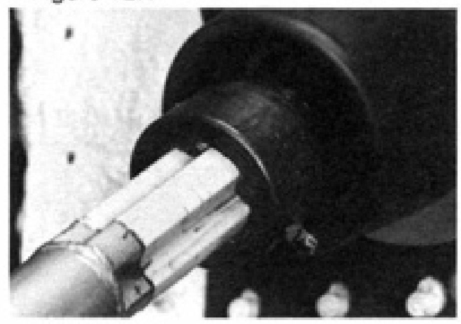


Figure 18.1

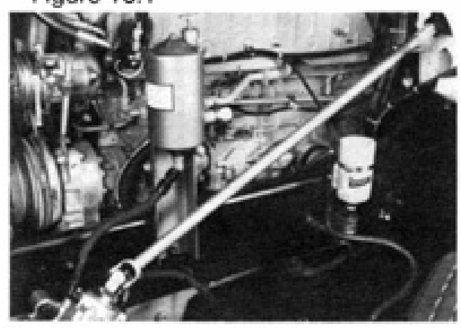


Figure 18.2

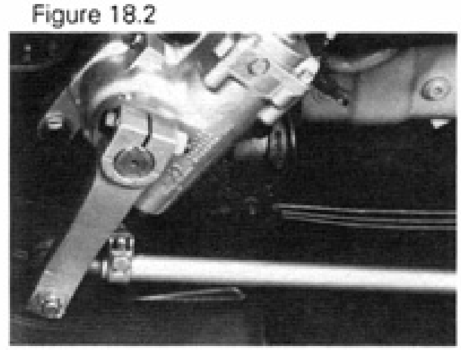


Figure 18.3

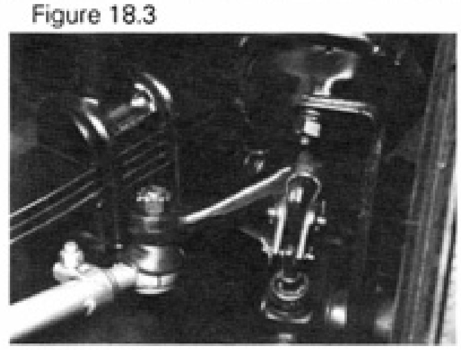


Figure 18.4

Shimmy Tests (Continued)

Test Procedure

NOTE: Be sure to check rear drive axles for any looseness. FIGURE 18.6.

Figure 18.5

#19 Steering Gear Adjustment Check

1. Check and adjust per service manual if necessary.

Figure 18.6

#24 Miter Box Misadjusted (if equipped) Test

1. Check and adjust per manufacturer's instructions. FIGURE 24.1.

#25 Alignment Check

1. Check alignment of steered axle and rear drive axles, and trailer axles (if problem only exists with trailer).

Figure 24.1

#26 Wheel Bearing Check

1. Verify that adjustment is per manufacturer's specification. FIGURE 26.1.

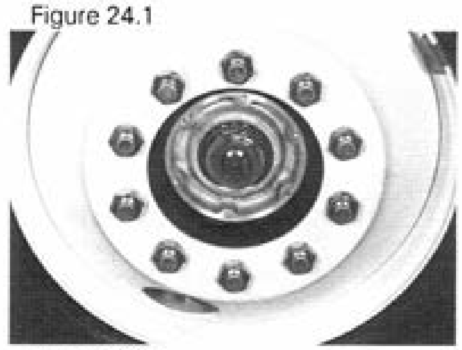


Figure 26.1

#30 Road Wheel Rotating Assembly Check

1. Have wheel assemblies balanced and checked for lateral and radial run out per manufacturer's specifications. Preferred method for checking balance is with wheels still on the vehicle. Balance includes total rotating assembly. FIGURE 30.1.

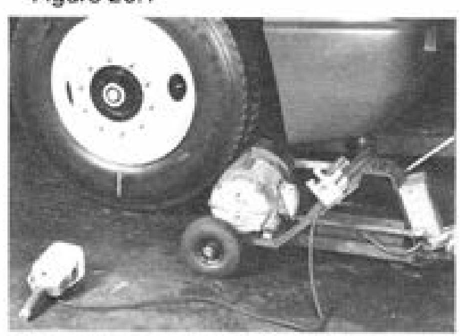


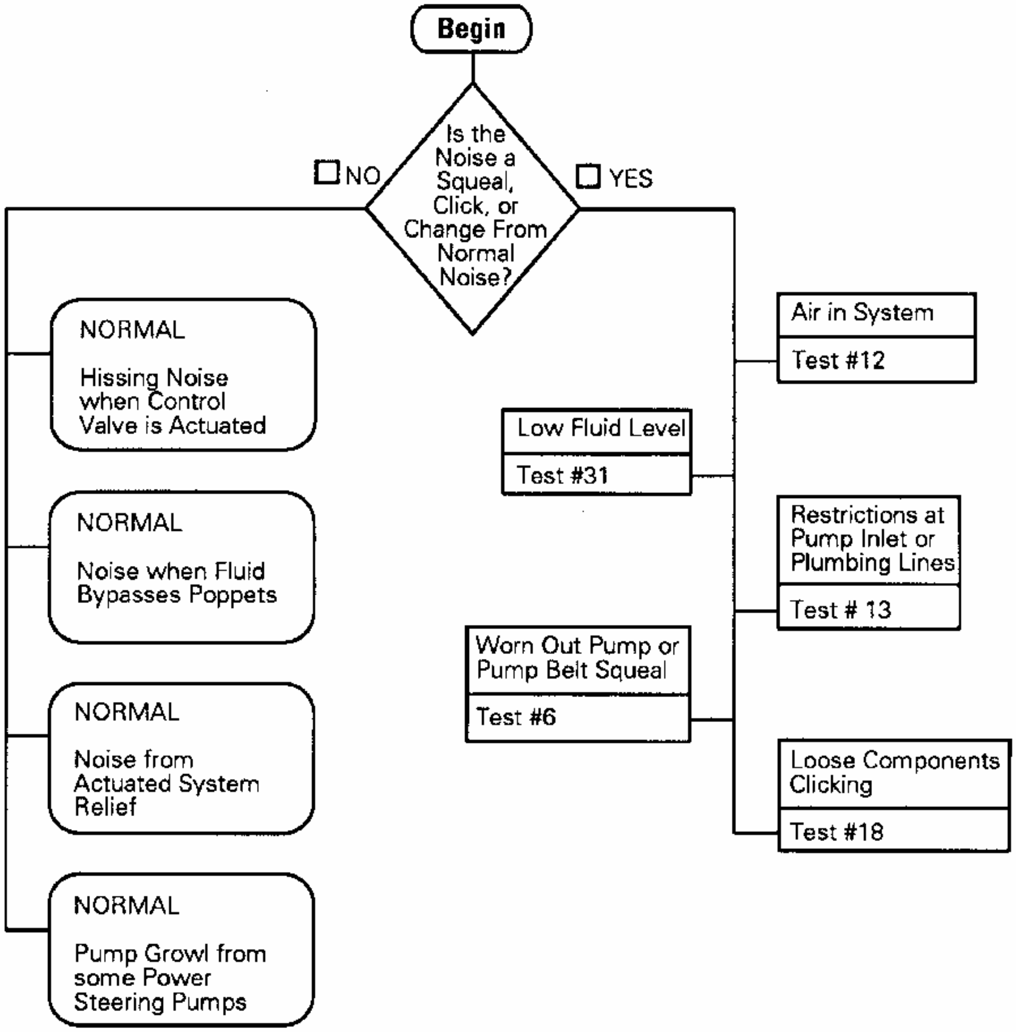
Figure 30.1

Noise 9

Common Phrases Used

Common phrases used to describe Noise:

- Steering is noisy
- Clicking or clunking sound is heard when steering.
- Moaning or grunching at steering gear



Begin
Is the Noise a Squeal, Click, or Change From Normal Noise?
NO
YES
NORMAL
Hissing Noise when Control Valve is Actuated
NORMAL
Noise when Fluid Bypasses Poppets
NORMAL
Noise from Actuated System Relief
NORMAL
Pump Growl from some Power Steering Pumps
Air in System
Test #12
Low Fluid Level
Test #31
Restrictions at Pump Inlet or Plumbing Lines
Test # 13
Worn Out Pump or Pump Belt Squeal
Test #6
Loose Components Clicking
Test #18

Noise Tests

Test Procedure

#6 Power Steering Pump Test

1. Install temperature gage in reservoir. FIGURE 6.1. Install PSSA in pressure line with shut-off valve fully open. FIGURE 6.2. Park the vehicle outside. Record ambient temperature. Run the engine at governed RPM for 40 minutes to bring the fluid up to an elevated testing temperature. Measure and record the fluid temperature at the start and at 10, 20, 30 and 40 minutes. Do not allow the temperature to exceed 250°.

NOTE: If the temperature goes over 250 ° F, or 150 ° F above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

2. Run the engine at idle speed.

CAUTION: When closing the PSSA shut off valve, do so slowly and keep an eye on the pressure gage. Do not allow the system to exceed 2500 psi for safety of personnel and to prevent damage to the vehicle.

CAUTION: Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up.

3. Measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed. FIGURES 6.3 - 6.7.

Oil Temperature ____________ DEG.
Engine Idle Speed ____________ RPM

	Idle Speed	
	Pressure	Flow (GPM)
Load Valve Open		
	500 PSI	
	1000 PSI	
	1500 PSI	
Load Valve Closed		

4. Now with the load valve fully open, increase the engine speed to governed RPM and measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed: FIGURES 6.3 - 6.7.

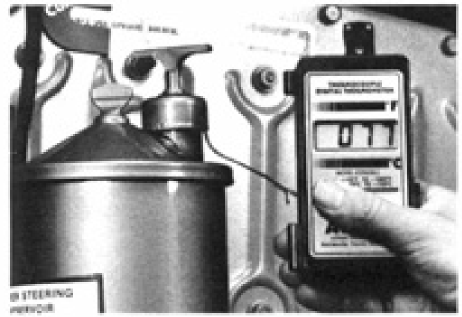


Figure 6.1

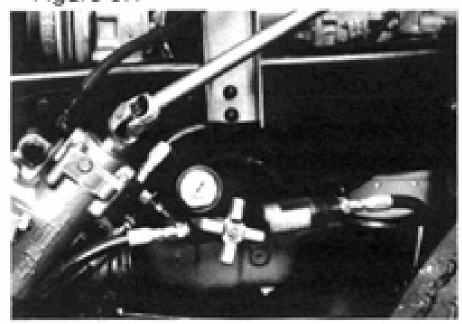


Figure 6.2

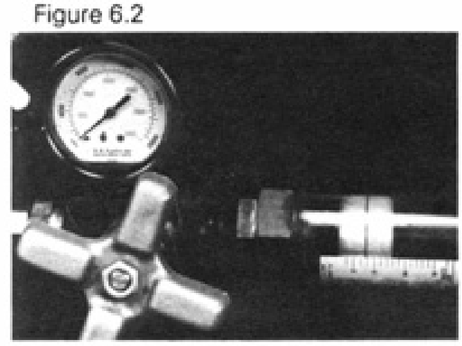


Figure 6.3

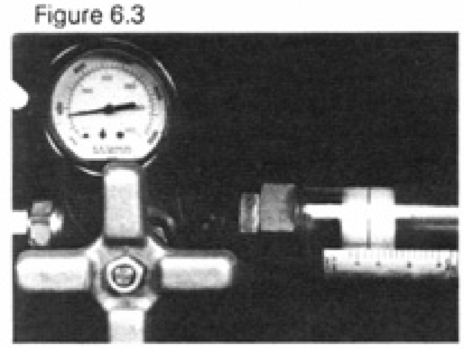


Figure 6.4

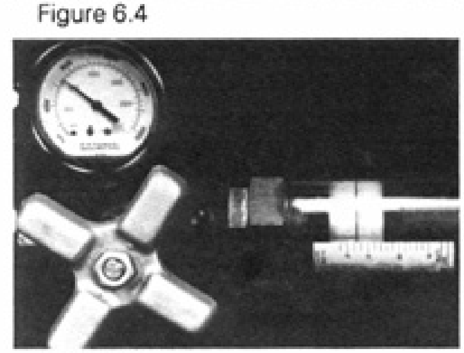


Figure 6.5

Noise Tests (Continued)

Test Procedure

Oil Temperature ______________ DEG.
Engine Governed Speed ______________ RPM

	Governed Speed	
	Pressure	Flow (GPM)
Load Valve Open		
	500 PSI	
	1000 PSI	
	1500 PSI	
Load Valve Closed		

5. Determine the recommended flow range and maximum allowable system pressure for the steering system being used by referring to your service manual.

6. Compare the minimum and maximum flows, and the relief pressure you measured to gear and pump specifications.

7. If the minimum measured pump flow is less than the minimum recommended flow for the steering gear used, the pump may not be putting out enough flow for an adequate steering speed. If the maximum system pressure is lower than that specified for the pump (check your manual), it may not be developing enough pressure to steer. If either case exists, the pump needs to be repaired or replaced.

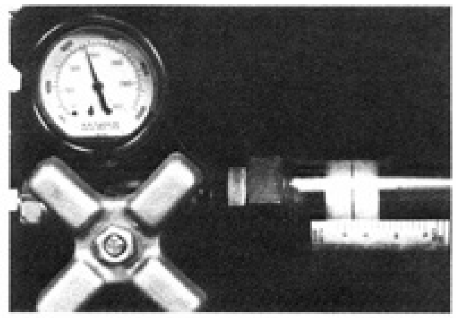


Figure 6.6

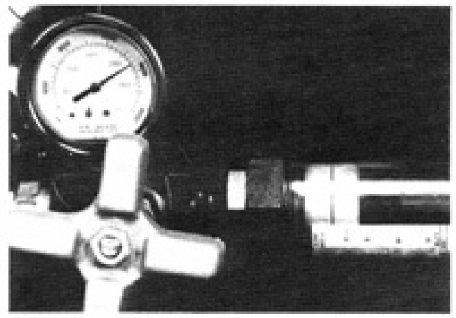


Figure 6.7

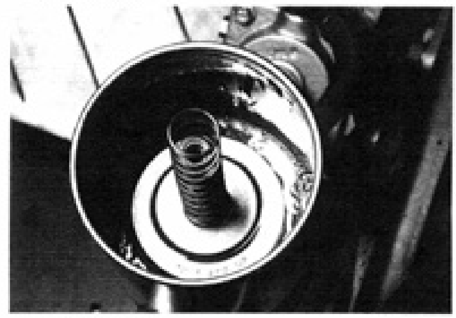


Figure 12.1

#12 Air in Hydraulic System Check

1. Inspect reservoir for foaming or air bubbles. FIGURE 12.1. If foaming or bubbles are seen, air is being sucked into the system through cracks or loose fittings on the inlet side of the pump. Look for oil level changes engine off versus engine on. If fluid level increases when the vehicle is shut off, there is an air pocket trapped in the steering gear. The increase may not be noticeable, depending on the size of the pocket.

2. Bleed the steering gear (if there is a manual bleed screw at the top of the gear). With system at normal operating temperature and engine at proper idle speed and running, open the bleed screw and wait until clean, clear oil begins to flow from the gear. Close the bleed screw and steer the vehicle completely from stop to stop.

3. Repeat the bleeding operation three times, and recheck oil level in reservoir to make sure there is enough oil for the system to operate properly.

Noise Tests (Continued)

Test Procedure

#13 Restricted Hydraulic Line Check

1. Look at the suction line that goes to the pump (if there is one) to check for kinking or any other obstructions or irregularities on the inside of the hose. FIGURE 13.1.

2. With the PSSA and temperature gage installed (FIGURES 13.2 - 13.3), load valve fully open, and oil at 125 to 135 degrees, determine a test engine speed (RPM) that causes pump to deliver either 3, 4, 5 or 6 GPM (whichever is easier) and note this speed.

3. Remove the PSSA and install a low pressure gage (200-300 PSI maximum with approximately 10 PSI per division) in the pressure line to the steering gear at the pump end. FIGURE 13.4. Install a temperature gage in the power steering reservoir.

   CAUTION: Do not allow system pressure to exceed the rating of the gage during the following procedure or damage to the gage will result. Extremely high restrictions may be indicated with the PSSA gage as installed with load valve fully open.

   NOTE: Be sure that the steering gear input shaft is not being restrained from recentering because this will cause a false steering gear pressure drop. If there is any question, conduct this test with the steering column removed.

4. Bring the power steering fluid temperature to 125 to 135 ° at engine idle, with no steering force applied to the steering wheel. FIGURE 13.5.

5. At the test engine speed selected from step 2 above, measure and record the gage reading and shut off the engine. This measures total system pressure

6. Remove the pressure and return lines from the steering gear and connect them together with a fitting that will not restrict the flow. FIGURE 13.6.

7. Start the engine, and run at the RPM identified in step 2 with the fluid temperature between 125-135 °.

8. Measure and record gage reading and shut off engine. This is hydraulic line/reservoir pressure.

9. The difference between the total system pressure gage reading and the hydraulic line/reservoir pressure gage reading is the steering gear pressure drop. For a TAS65 steering gear, at a flow of 3, 4, 5 or 6 GPM, drop should not be greater than 30, 40, 55 or 70 PSI respectively. The line/reservoir pressure drop for a flow of 3, 4, 5 or 6 GPM should not be greater than 20, 20, 25 or 25 PSI respectively.

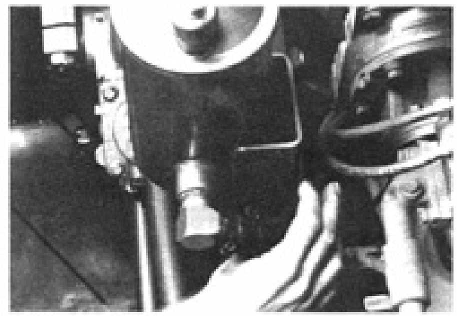


Figure 13.1

Figure 13.2

Figure 13.3

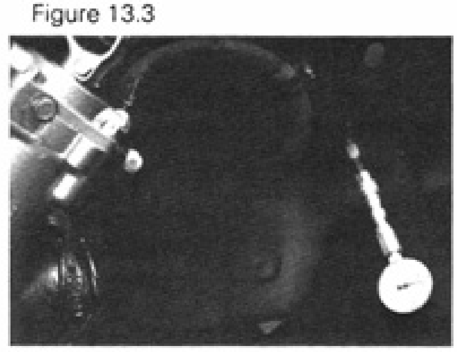


Figure 13.4

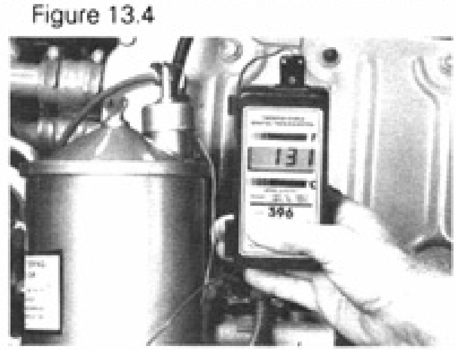


Figure 13.5

Noise Tests (Continued)

Test Procedure

#18 Lash in Steering System Check

1. Two people are needed for this test. One person will turn the steering wheel back and forth one-quarter turn each way from center with the engine idling. The other person should check for looseness at each of the following areas from steering wheel to road wheels: FIGURES 18.1 - 18.5.

   - Steering wheel to steering column
   - U-joints, or slip-joint and/or miter boxes
   - Steering column to steering gear input shaft
   - Steering gear input shaft to steering gear output shaft
   - Pitman arm to output shaft
   - Drag link to pitman arm connection
   - Drag link ends (sockets) and adjustable areas
   - Axle arm to drag link connection
   - King pin axle connections (bushings)
   - Tie rod arms to tie rod connection
   - Tie rod ends (sockets) and adjustable areas
   - Steering spindle
   - Wheel bearings
   - Lug nuts
   - Spring to spring pin connectors
   - Front axle
   - Front axle u-bolts
   - Spring hanger brackets/rear shackles

NOTE: Cracked or broken components can cause symptoms similar to loose components but may be more difficult to find.

NOTE: Be sure to check rear drive axles for any looseness. FIGURE 18.6.

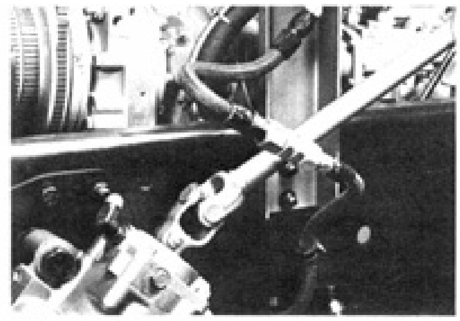


Figure 13.6

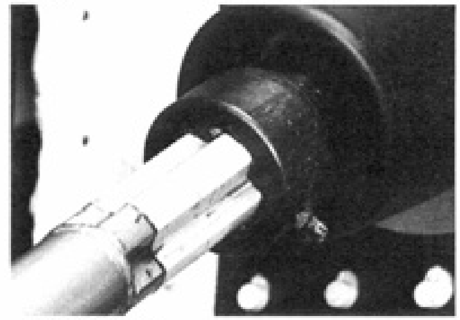


Figure 18.1

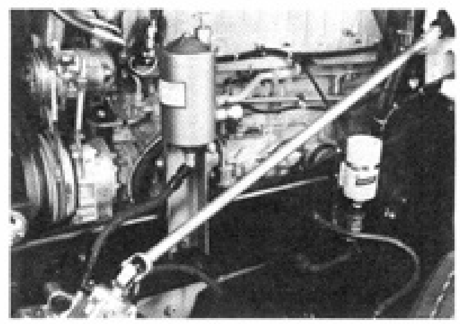


Figure 18.2

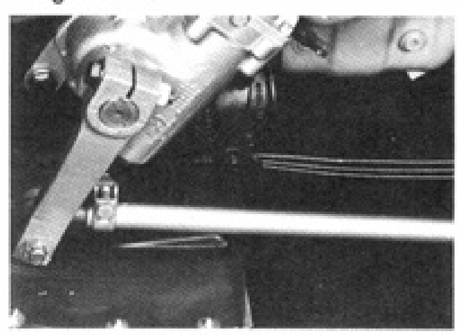


Figure 18.3

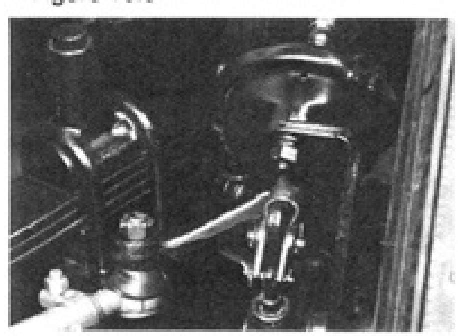


Figure 18.4

Noise Tests (Continued)

Test Procedure

#31 Power Steering Fluid Level Check

1. Check reservoir and make sure there is enough fluid. FIGURE 31.1.

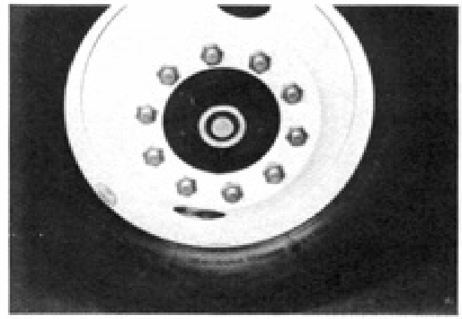


Figure 18.5

Figure 18.6

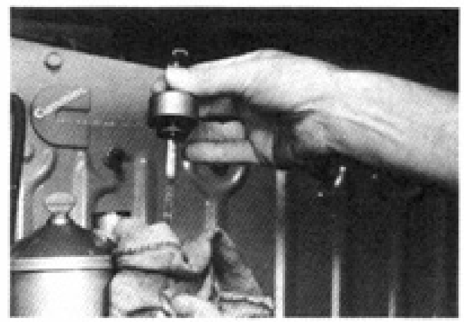


Figure 31.1

Notes

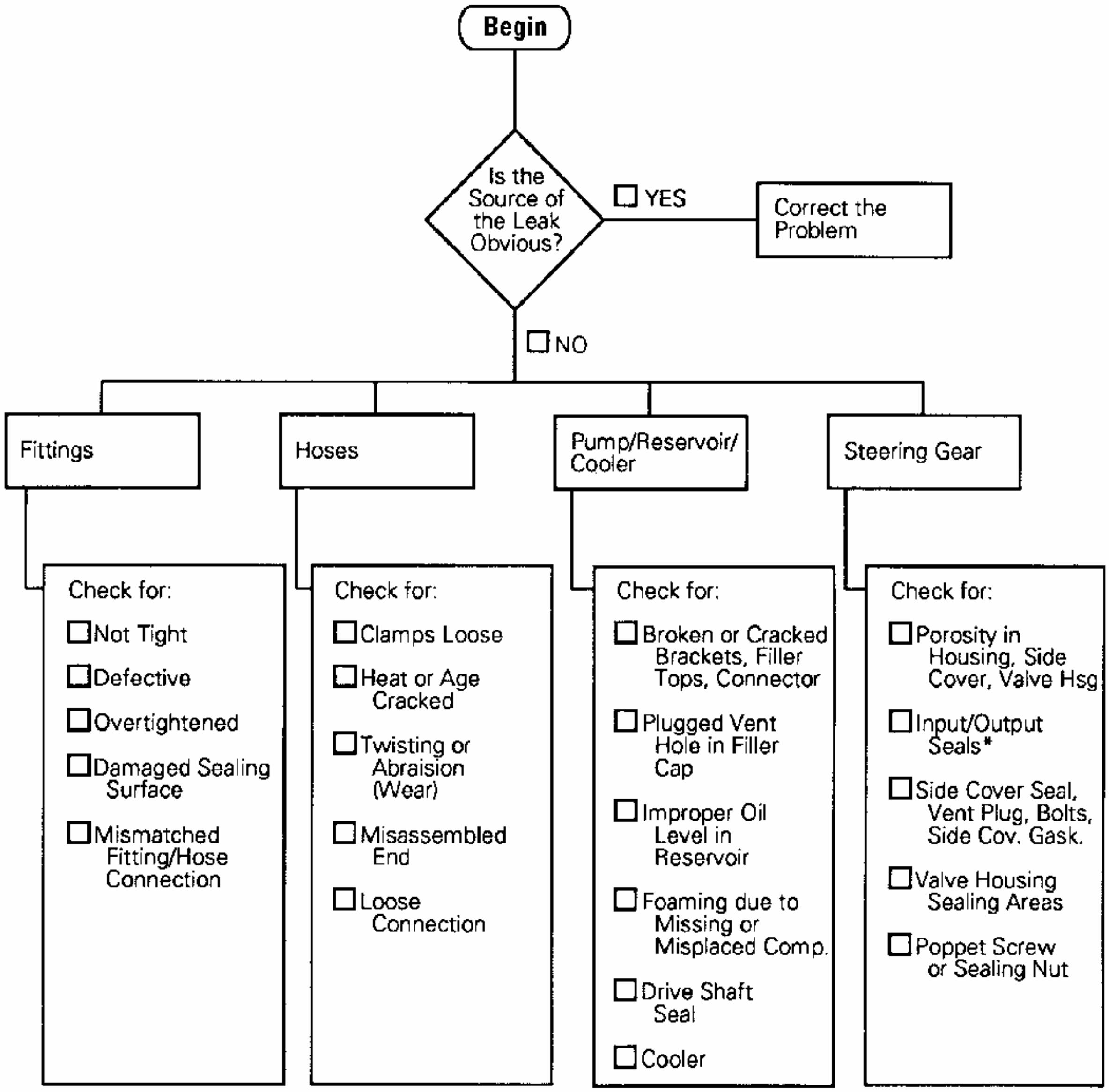
External Leakage 10

Comments and Common Phrases Used

The actual source of external leakage may be difficult to locate because of visual obstruction of components, fan blast, road grime and the fact that fluid tends to run and drip from the lowest point which may not be close to the leakage source. Some leakage may only occur with the engine off while other leakage may require pressure to cause it to occur. The system may have to be cleaned and dried to find the source. The source of the leak needs to be found before removing or changing parts.

Common phrases used to describe External Leaks:

- Loss of steering fluid
- Continual adding of fluid in reservoir required
- Oil on components
- Oil puddle under vehicle after being parked
- Leaks at gear box



***NOTE: If Input Shaft Seal Appears Hardened from Heat, Conduct the 40 Minute Temperature Test (Test #6, Step 1).**

Glossary of Terms

Ambient .. Surrounding on all sides. The temperature around the vehicle.

Binding .. Hindered from free operation. Binding is a change or increase in steering wheel effort. Binding will usually not require the effort levels described in Hard Steering, unless it is severe.

Cyclic .. Happening or appearing at regular intervals.

Cyclic Binding .. While steering in a slow, smooth manner, is a torque variation encountered which repeats for a given amount of steering wheel rotation. An example would be a hard spot or "lump" felt at the steering wheel once per revolution.

Darting .. To move suddenly or rapidly. Darting is when the driver suddenly gets more turning than he wants from his vehicle.

Distort .. Twist out of original shape.

Hard Steering .. When steering effort at the steering wheel is more than 200 inch pounds (typically 18-22 lbs at the rim of the steering wheel). Steering is still possible, but there is not enough power assist.

Oversteer .. The tendency of a vehicle to steer into a sharper turn than intended.

PSSA .. Power Steering System Analyzer. A Power Steering System Analyzer is a combination of a flow meter, shut off valve, and pressure gage. This tool will allow you to measure flow and pressure, and provide a load on the pump in the hydraulic lines of the steering system.

Shimmy .. Abnormal shake or vibration. A severe Shimmy condition can be felt at the steering wheel. Typically once something triggers a Shimmy condition to occur, it is sustained until the driver does something (such as slow down) to dampen out the condition.

Steering Wheel Kick .. Steering Wheel Kick is usually triggered when the road wheels hit a bump that the steering wheel reacts to. The kick is usually dampened out quickly.

Notes

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SECTION 16: SUSPENSION

CONTENTS

ILLUSTRATIONS

1. DESCRIPTION

The vehicle is provided with an air suspension system. The system consists of air springs, height control valves, radius rods, sway bars, tripod and shock absorbers (Fig. 1, 2, 3, 4 and 5). The system operation is fully automatic and maintains a constant vehicle height regardless of load, or load distribution.

The vehicle can also be equipped with systems such as:

- Front Kneeling (w/ Front High-Buoy);
- Front Kneeling (w/ Full High-Buoy);
- Front Kneeling (w/ Front High-Buoy) and Low-Buoy Combination;
- Front Kneeling (w/ Full High-Buoy) and Low-Buoy Combination;

For a description of all these systems, refer to the appropriate heading in this section.

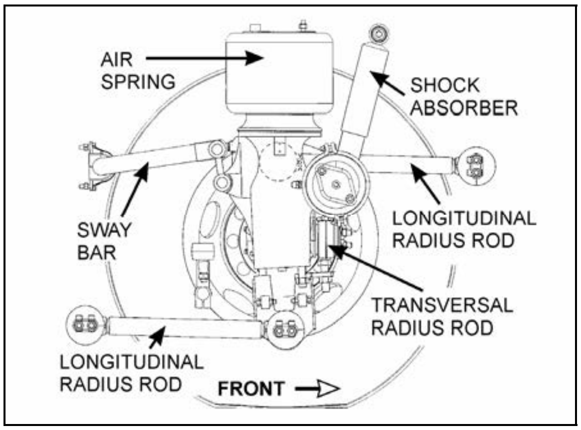


FIGURE 1: FRONT SUSPENSION COMPONENTS 16096

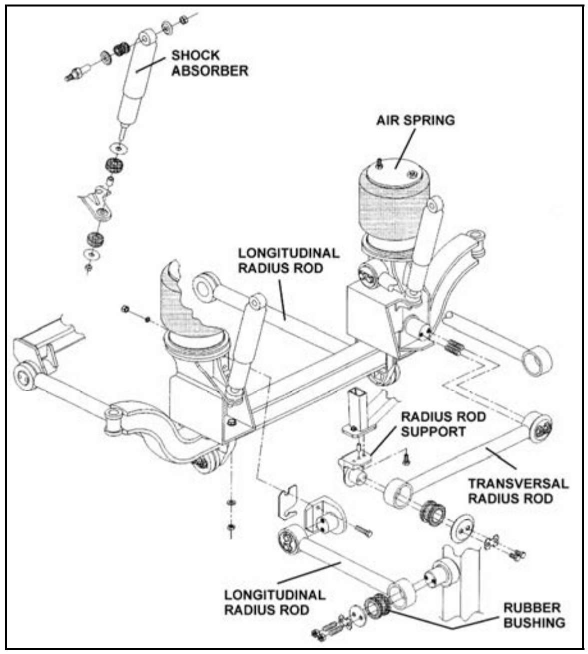


FIGURE 2: DETAILS OF FRONT SUSPENSION 16110

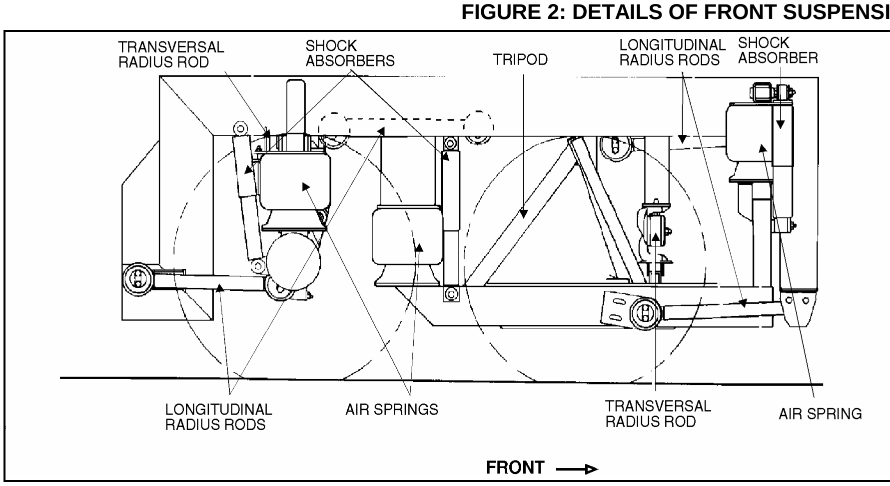


FIGURE 3: REAR SUSPENSION COMPONENTS 16027

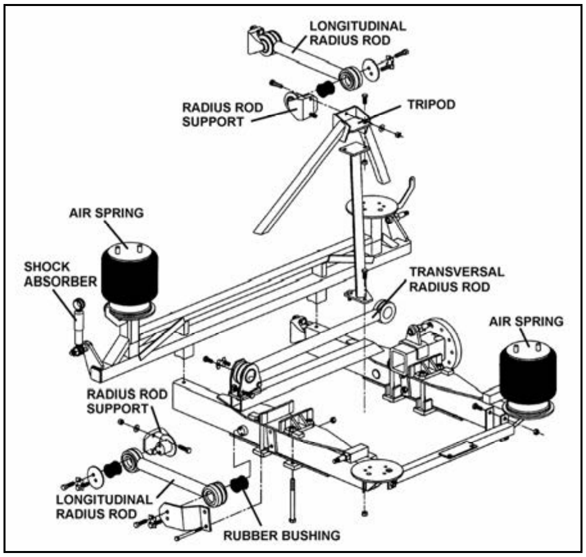


FIGURE 4: DETAILS OF REAR SUSPENSION 16106

2. AIR SPRINGS

The air springs are made from a special compound rubber molded to the proper contour and dimensions. The entire vertical load of the vehicle is supported by these springs. Each of the three axles is provided with air springs that are attached to the subframe and to the axles (Fig. 6).

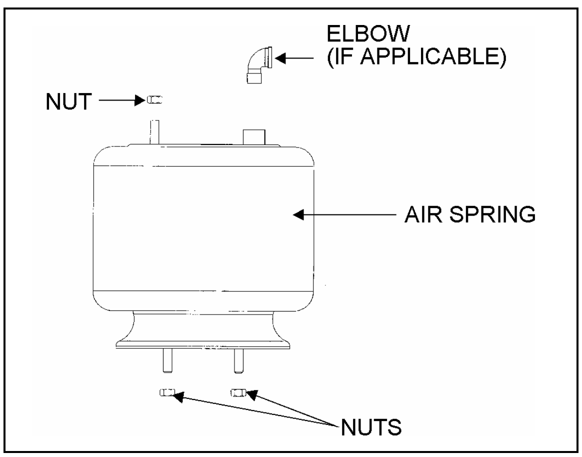


FIGURE 6: AIR SPRING 16052

2.1 INSPECTION

1. Check operation of bellows.
2. Visually inspect bellows for evidence of cracks, punctures, deterioration, or chafing. Replace the bellows if any damage is evident.
3. With the primary air system at normal operating pressure (95 - 125 psi (655 - 860 kPa)), coat all suspension air line connections and bellows mounting areas with a water and soap solution. Bubbles will indicate an air leak, and none is permissible. Repair or replace defective parts.

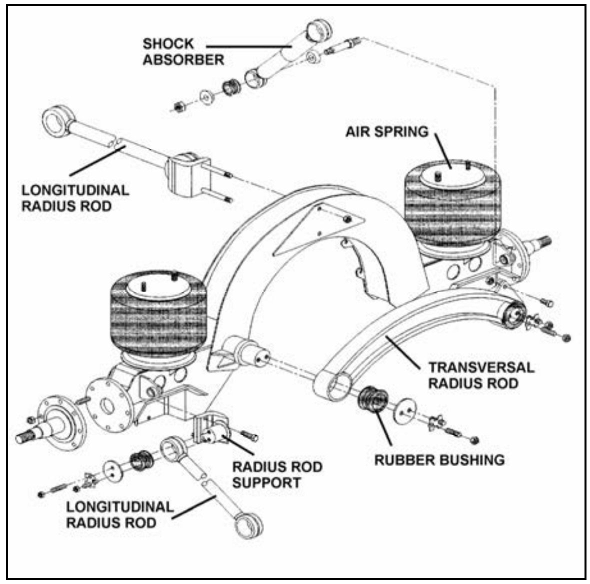


FIGURE 5: TAG AXLE SUSPENSION 16107

Note: *If air spring is removed from vehicle, bellows can be lightly inflated and submerged in water to detect any leakage. If any leakage is detected, replace bellows.*

Warning: *To prevent personal injury, do not apply more than 10 psi (69 kPa) of air pressure to the uninstalled air spring.*

2.2 REMOVAL

Note: *Suspension air springs (front, drive, and tag axles) can be removed without removing the entire axle assembly.*

1. Safely support vehicle at the recommended body jacking points.

   To gain access to a given air spring, the corresponding wheel can be removed as follows.

   a) Jack vehicle until the tire clears the ground, and place safety supports underneath body.

Caution: *Only the recommended jacking points must be used as outlined in Section 18, "Body".*

b) Support the axle with a suitable hydraulic floor jack at the recommended jacking point.

c) Remove wheel.

2. Exhaust compressed air from accessory air tank by opening drain cock under reservoir.
3. Disconnect the height control valve link and pull down the overtravel lever to ensure all air is exhausted from air springs.

Note: *While performing this step, do not change the height control valve overtravel lever adjustment.*

4. Disconnect air line from air spring, remove elbow (if applicable), and cover both the line end and fitting to prevent the entry of foreign matter.
5. Remove the air spring upper nut, and then the two lower nuts. Remove air spring.

2.3 INSTALLATION

1. Compress air spring as necessary, then aligning studs with their holes, position air spring between both the lower and upper supports. Thread the lower nuts and the small upper nut a few turns.

Note: *To facilitate air spring installation, compress it manually then put a piece of tape over the air line threaded fitting. This prevents air from getting back into the bag and keeps it compressed, thus enabling to place the bag in between the mounting plates and greatly easing installation.*

2. Tighten and torque the lower stud nuts, and then the upper one to 20 – 25 Ft-lbs (27 – 34 Nm).
3. Thread the remaining upper nut (large nut) and tighten to 20 – 25 Ft-lbs (27 – 34 Nm).
4. Install elbow (if applicable), then connect air line.
5. Connect the height control valve link.
6. Build up air pressure in system.

Note: *To accelerate this operation, air reservoirs can be filled from an exterior air supply connected to the accessory tank fill valve or to the emergency fill valve.*

7. Check operation of bellows, and with the primary air system at normal operating pressure (95 – 125 psi (655 – 860 kPa)), coat the air line connections and air spring mounting areas with a water and soap solution. Bubbles will indicate an air leak, and none is permissible. Repair or replace defective parts.
8. Reinstall wheel.
9. Remove the hydraulic floor jack from under the axle, then lower vehicle to ground.

3. SHOCK ABSORBERS

Double-action, telescoping-type shock absorbers ensure a smooth ride and enhance vehicle stability on the road. All shock absorbers are eye-type mountings. The front and tag axles are each provided with two shock absorbers while the drive axle is provided with four of them (Fig. 1, 2, 3, 4 and 5).

Shock absorbers are non-adjustable and non-repairable. Maintenance requirements involve replacement of the rubber mounting bushings, and tightening of all shock absorber pins at the proper torque of 500 - 550 Ft-lbs (680 - 750 Nm) when shock absorber replacement occurs. If a shock absorber becomes inoperative, complete unit must be replaced.

Caution: *When a shock absorber is found defective, always replace with a new set on affected axle, except if there has been a recent replacement of one unit. The following method will help in determining if both shock absorbers on the same axle have to be replaced.*

3.1 INSPECTION

Loosen lower mounting of both shocks, then carefully attempt to raise and lower the bottom portion of each shock. Note the rate of effort for distance of travel. Replace both shocks if a definite differential rate is found.

The shock must be bench checked in an upright, vertical position. If checked in any other position, air will enter the cylinder tube and make the shock absorber appear defective.

Proceed as follows to check shock absorbers:

1. With the shock absorber in a vertical position (top end up), clamp the bottom mount in a vise.

Caution: *Do not clamp the reservoir tube or the dust tube.*

2. Rotate the dust tube. Notice any binding condition (may be compared with new unit). Binding condition indicates a scored rod. Units with scored rods should be replaced.
3. Fully extend shocks and check for leaks in the seal cover area. Shock fluid is a very thin hydraulic fluid that has a characteristic odor and dark brown tint. A slight trace of shock fluid around the seal cover area is not a cause for replacement. The shock seal is designed to permit a very slight seepage to lubricate the rod. Units that leak should be replaced.
4. Visually check shock for dents that could cause the shock to bind. Also, check for a bent rod.
5. Extend and collapse shock several times to determine that it has control (resistance) in both rebound and compression.
6. Visually inspect the shock mountings and vehicle mounting for:
   a. Broken mounts;
   b. Extreme bushing wear;
   c. Shifted bushing or sleeve;
   d. Deep cracks in bushing material (shallow surface cracks are normal);
   e. Loose shock absorber pins;
   f. Presence of convex washers, and their position relative to the rubber bushing.

3.2 REMOVAL

1. Remove nuts and washers from shock absorbers on upper and lower mounting pins, taking care to identify the inner and outer washers to ease reinstallation. Refer to figure 7 for details.
2. Remove the shock absorber assembly from pins.
3. Remove the two inner bushings from the shock absorber and discard them.

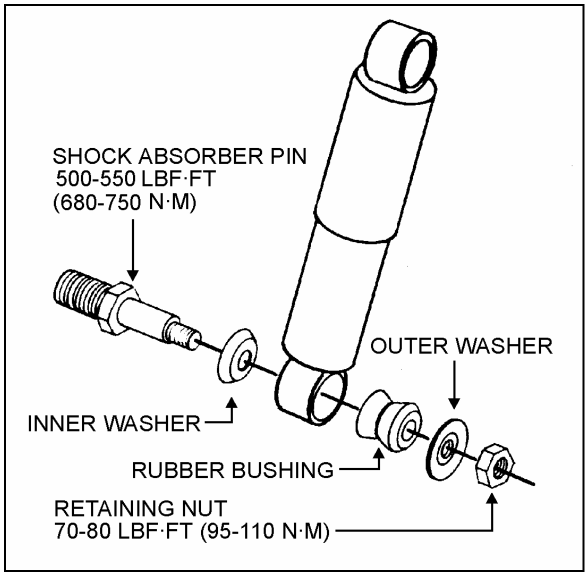


FIGURE 7: SHOCK ABSORBER 16008

3.3 INSTALLATION

1. Ensure that the shock absorber mounting pins are tight and that the threads are not stripped.
2. Install new rubber mounting bushings on shock absorbers (upper and lower).
3. Place the inner washers (with washer convex side facing the shock absorber rubber bushing) on each shock absorber pin (Fig. 8).

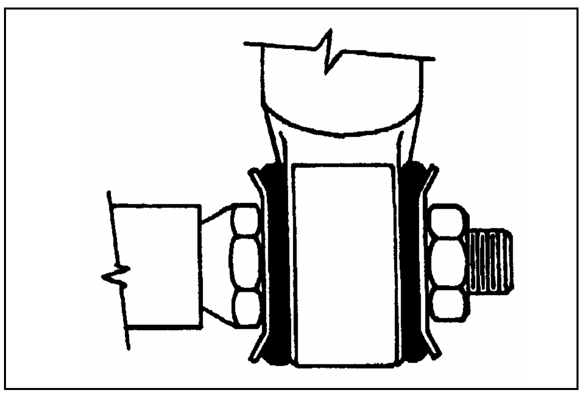


FIGURE 8: TYPICAL SHOCK ABSORBER SETUP 16009

4. Install the shock absorber eyes over the mounting pins, then the outer washers (with washer convex side facing the shock absorber rubber bushing) on each shock extremity.

Note: *If shock absorber pins are removed, they must be reinstalled using "loctite" (see "Parts Specifications" in this section).*

5. Place the lower and upper mounting pin stud nuts and torque to 70 - 80 Ft-lbs (95 – 110 Nm).

4. RADIUS RODS

Radius rods are used to secure the axles in the proper transversal and longitudinal positions. Four radius rods are provided on the front axle suspension (three longitudinal and one transversal), four on the drive axle suspension (three longitudinal and one transversal) and also four on the tag axle with a layout similar to the drive axle. Refer to figures 1, 2, 3, 4 and 5 for details. These rods transmit both braking and driving forces from the axles to the vehicle body.

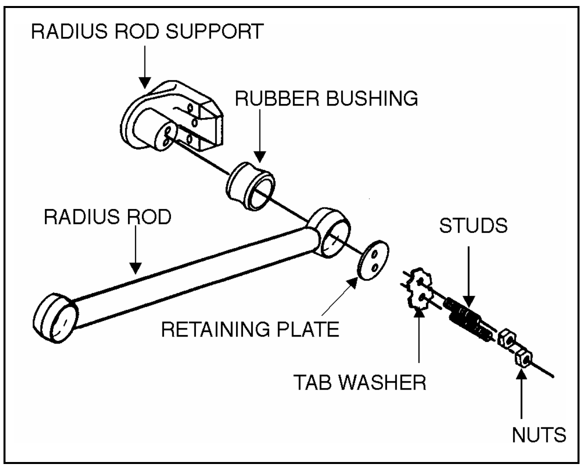


FIGURE 9: TYPICAL RADIUS ROD SETUP 16010

4.1 INSPECTION

The following instructions apply to all radius rods used on this vehicle:

1. Clean all parts thoroughly.
2. Inspect radius rods for distortion and cracks. We recommend the “Magnaflux” process to detect cracks in the radius rod. Any damaged part should be replaced with a new one.

Note: *New bushings should be used when rods are replaced.*

3. The radius rod bushings should be checked periodically for signs of shearing, deterioration, or damage. Any defective part should be replaced with a new one.

4.2 REMOVAL

1. Flatten the tab washer which secures the two retaining nuts (or bolts), then unscrew the nuts (or bolts) at each extremity of the radius rod (Fig. 9).
2. Remove the tab washer and the retaining plates and radius rod ends from anchor pins, then remove the radius rod.

4.3 BUSHING REMOVAL

1. Safely support the radius rod as shown in figure 10.

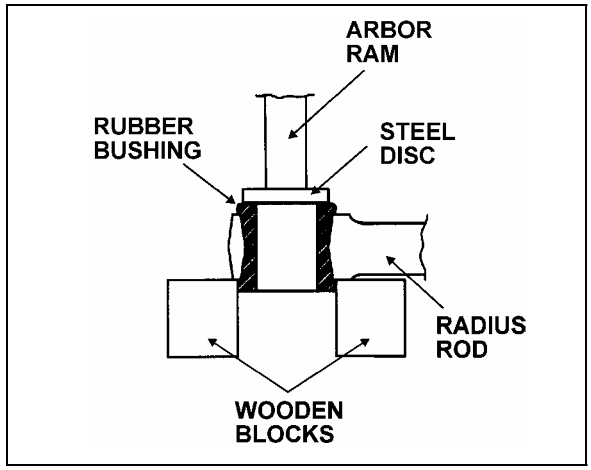


FIGURE 10: RADIUS ROD BUSHING REMOVAL 16011

2. Place a flat steel disc, slightly smaller than the outside diameter of the bushing (Fig. 10).
3. Using an arbor press or a suitable driving tool, press or drive the old bushing out of the rod and discard the bushing.

Caution: *Make sure to prevent the steel disc from contacting the radius rod end.*

4.4 BUSHING INSTALLATION

1. Lightly spray the inner and outer surfaces of radius rod bushing with water.

Caution: *No lubricant whatsoever is to be used on the rubber bushing.*

2. Safely support the radius rod, and place new bushing on top of the radius rod end (Fig. 11).
3. Place a block of wood on top of bushing and press on it manually.
4. If necessary, use an arbor press or a suitable driving tool. Press or drive the bushing into the radius rod end until it extends equally on both sides of the rod.

5. It is also possible to proceed differently. Place radius rod bushing on a plane surface. Spray a light coat of water on the inner and outer surfaces of radius rod bushing.
6. Take radius rod, align the bushing. Tap radius rod on bushing until latter is positioned correctly.

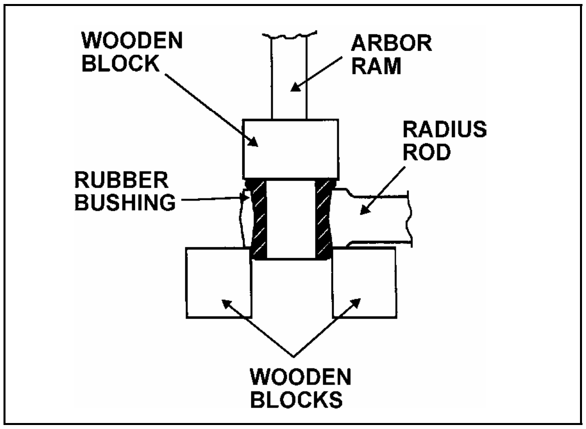


FIGURE 11: RADIUS ROD BUSHING INSTALLATION 16012

4.5 INSTALLATION

1. Lightly spray the radius rod support with water. Place the radius rod end over the radius rod support (Fig. 12).
2. Position the retaining plate. Install the tab washer and nuts (or bolts).

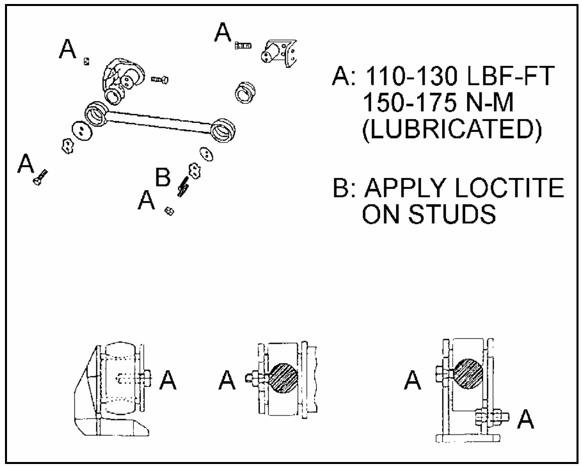


FIGURE 12: RADIUS ROD INSTALLATION 16028

Caution: *Always use new tab washers at installation.*

3. Tighten the nuts (or bolts) lightly, and repeat at the other end.
4. Refer to heading *"Suspension Height Adjustment"* later in this section, and set the vehicle to normal ride height.
5. With the vehicle at normal ride height, apply oil on threads and tighten all radius rod anchor pin nuts or bolts to 110 – 130 Ft-lbs (150 – 175 Nm).

Caution: *It is extremely important upon reconnection of the rods that the proper clearance height between the axle and body be maintained. Otherwise, the rubber bushings in radius rod ends will become preloaded, thus reducing their life span.*

5. SWAY BAR

A sway bar is provided on the front axle to increase vehicle stability. It controls lateral motion (swaying movement) of the vehicle (Fig. 13). Vehicles equipped with an independent front suspension (IFS) are provided with two sway bars. Refer to supplement information on independent front suspension for more details.

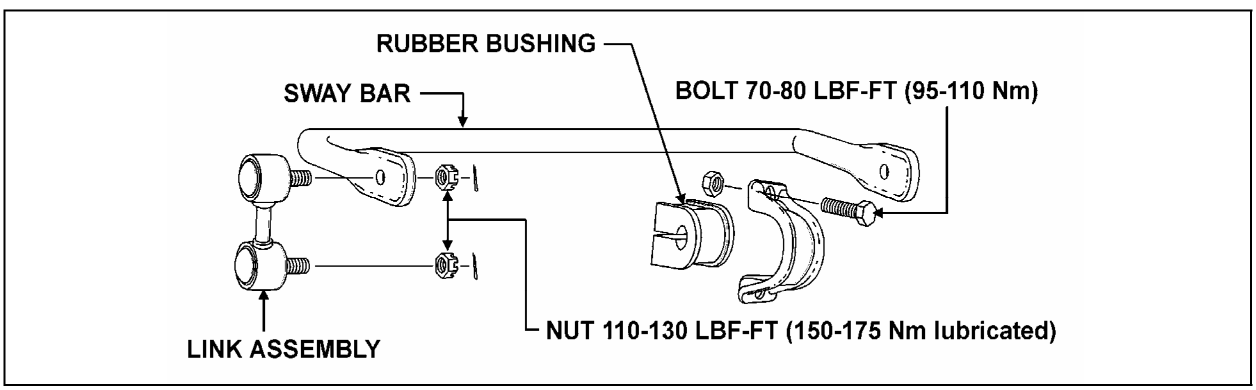


FIGURE 13: I-BEAM FRONT AXLE SWAY BAR 16099

5.1 REMOVAL

1. Disconnect the two links from sway bar.
2. Safely support the sway bar. Unbolt the four bushing collars from subframe.
3. Remove sway bar.

Note: *Sway bar bushings are slitted to ease their removal.*

5.2 INSTALLATION

1. Loosely install the sway bar.
2. Tighten the eight bushing collar nuts to 70 - 80 Ft-lbs (95 - 110 Nm) (Fig. 13).
3. Install two sway bar link upper and lower nuts and tighten to 100 - 130 Ft-lbs (150 - 175 Nm) (Fig. 13).
4. Install a cotter pin on each nut and bend.

6. SUSPENSION AIR SYSTEM

The suspension air system has its own air reservoir (accessory tank) which is located behind the front axle. Pressurized air from the main tank (wet tank) flows through a pressure protection valve (PR-2), installed on the accessory air tank then flows to the accessory air tank.

The pressure protection valve (PR-2) controls the pressure at which compressed air is delivered to the accessory air tank. The valve remains closed until a preset pressure is reached (approximately 70 psi (485 kPa)). It then opens and passes air out the delivery port.

The main use for this valve is to protect the main air system by ensuring at all times a sufficient air pressure in the main system (i.e. air delivered to the accessories will be shut off in case of a decrease in pressure). Maintenance and repair information on the pressure protection valve is supplied in the applicable booklet, annexed to Section 12, *"Brakes and Air System"* under reference number SD-03-2010.

Warning: *Depressurize parts prior to removal.*

6.1 INSPECTION

The following inspection should be performed at established service inspection periods. Performing these procedures will allow substandard performance to be discovered before the condition becomes bad enough to cause operator complaints and failure on a run.

1. Visually inspect the suspension air lines for evidence of chafing on metal parts or other damage.
2. Visually inspect the air springs for cracks, abrasion or other damage.
3. Replace any parts found to be damaged.

6.2 AIR LINE TEST

With the main air system at normal operating pressure (95 – 125 psi (655 – 860 kPa)), coat all suspension air line connections and air spring mountings with a solution of soap and water. Air leakage will produce soap bubbles. Any leak found must be corrected as no air leakage is permissible.

6.3 AIR TANK MAINTENANCE

Refer to Section 12, "Brakes and Air System" under "Maintenance" for complete instructions on air tank maintenance.

7. SUSPENSION HEIGHT ADJUSTMENT

The flow of pressurized air from the accessory air tank to the air springs is controlled by three height control valves. These valves are mounted to the subframe and connected to the axles through an arm and link connection. This connection allows the valves to apportion air pressure in the springs to the vehicle load, maintaining normal ride height.

Immediate response height control valves increase or decrease the air pressure in the suspension system as required. One height control valve is located at center of front axle, and regulates air to front axle air springs in order to maintain the vehicle at the required height. Two are located at the drive axle, one on each inner side of rear wheelhousing. Refer to figure 15.

The appropriate vehicle body height is obtained by measuring the clearance of all the air springs installed on the front and drive axles. The clearance should be 11 11/16" (297 mm) for the air springs installed on the front axle and 11 ½" ± ¼" (292 ± 6 mm) for those installed on the drive axle. Refer to figure 14 to identify the correct location where the measure has to be taken. At this point, it should not be necessary to make an adjustment under normal service conditions. However, if an adjustment is required, change the position of the overtravel lever in relation to the overtravel control body. The lever should be moved up to raise the height of vehicle, and down to lower it. Check that main air pressure is at normal operating pressure and raise the vehicle to the specified height.

Caution: *Because of the ''deadband", always adjust on "fill cycle". If it is necessary to lower vehicle height, release sufficient air to be well below height, and adjust to height through fill cycle.*

To adjust suspension height, proceed as follows:

1. With the vehicle at normal operating air pressure, check the air spring clearance as illustrated in figure 14. This clearance should be 11 11/16" (297 mm) for the front axle air springs and 11 ½" ± ¼" (292 ± 6 mm) for those on the drive axle.

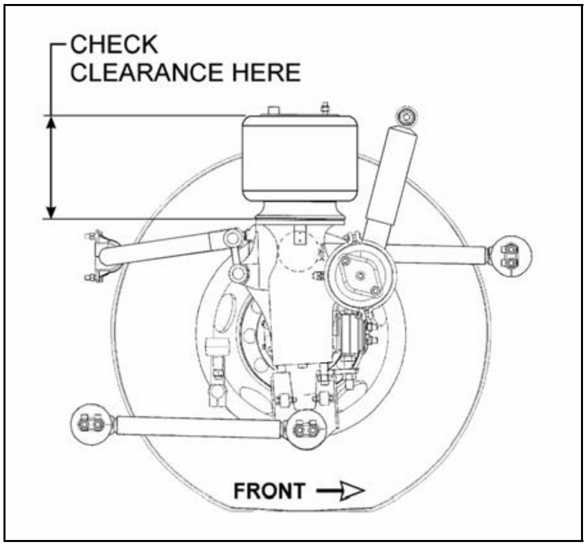


FIGURE 14: TYPICAL AIR SPRING CLEARANCE 16097

Note: *The measure should be taken from under the upper air spring support on subframe to top of the lower air spring support on axle (refer to fig. 14 for more details). If adjustment is required, begin with the drive axle.*

2. Loosen the adjusting nuts on the connecting rod of height control valve to raise or lower the overtravel lever until the desired clearance is reached.
3. If there is not enough play on adjusting nuts, it is possible to make further adjustments by loosening the clamp on the rubber coupling and bringing it up or down.

Note: *Allow suspension to stabilize before taking reading.*

4. When the desired height is obtained, tighten adjusting nuts and clamp.

8. HEIGHT CONTROL VALVES

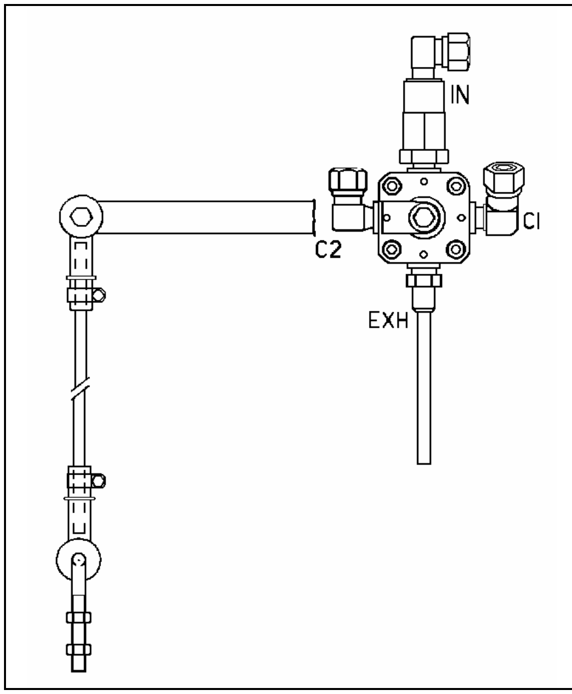


FIGURE 15: HEIGHT CONTROL VALVE 16093

The height control valves automatically add air to, or release air from air springs to maintain constant suspension height regardless of load, or load distribution. Each valve adjusts independently according to the following conditions:

Loading position

As the load increases and lowers the vehicle body, the overtravel lever commands the height control valve to add air to air springs.

Neutral position

When vehicle body reaches the normal ride height, the height control valve overtravel lever reaches the "neutral" position and keeps both the supply and exhaust ports closed to ensure normal ride height is maintained. This condition remains static until the vehicle load is altered.

Unloading position

As the load decreases and raises the vehicle body, the overtravel lever commands the height control valve to release air from air springs.

8.1 MAINTENANCE

The height control valve requires no periodic maintenance. Height control valve linkage operates on rubber bushings and no lubrication should be attempted at this point.

8.1.1 Removal and installation

Before disconnecting any height control valve air lines, securely support the vehicle by its jacking points on the body, and place safety support underneath body. Refer to *"Vehicle Jacking Points"* in Section 18, *"Body"*.

1. Exhaust air from air system by opening the drain cock on accessory air reservoir.
2. Disconnect overtravel lever from link and pull down lever to exhaust remaining air from air springs.
3. Disconnect air supply and delivery lines from the height control valve. Cover ends of the lines with tape.
4. Remove the two nuts retaining the height control valve to the mounting bracket, then remove valve assembly.

Reverse removal procedure to replace height control valve. After installation, check for leakage using a soap and water solution.

8.1.2 Air leakage test

Note: *The following procedure applies when valve assembly has been removed from vehicle.*

1. Clean the exterior of valve assembly.
2. Connect air pressure line to air inlet port, then allow air pressure build-up (70- 100 psi (480 - 690 kPa)).
3. Dip the valve assembly in a container of water, and watch for air bubbles when the overtravel lever is in the center position. No air should escape from any point of the valve assembly.
4. If bubbles appear from the air spring port, this is an indication that the air inlet valve assembly is defective and must be replaced.
5. Remove air pressure line from air inlet fitting and connect it to the air spring port. If bubbles appear at the air inlet check valve port, this is an indication that check valve unit is defective and must be replaced.
6. If bubbles appear at the exhaust port, this is an indication that the exhaust valve assembly is defective and must be replaced.
7. If bubbles appear around edge of valve cover plate, the cover plate gasket must be replaced.
8. If no leaks are found, remove valve assembly from water, then with air pressure still connected to the air spring port, actuate overtravel lever to remove any excess water which may have entered exhaust valve chamber. Remove air line, connect it to the air inlet port, and repeat operation to remove water from the air inlet valve chamber.

9. FRONT KNEELING SYSTEM

The kneeling system is used to lower front of vehicle. This allows passengers to board the vehicle with greater ease. The kneeling action is achieved by exhausting air from the front air springs (bellows). This system bypasses the height control valve to provide a fast up and down movement of the front suspension. Only seven seconds are required to lower vehicle from normal level to the lowered position, and approximately the same time to raise the vehicle back to normal level. The quick response is achieved by an auxiliary air tank installed beside the secondary air reservoir (for exact position, refer to Section 12, *“Brake and Air System”).* This tank provides sufficient air supply to the kneeling system for some successive operations.

The system is provided with two safety features; first, a speed switch will enable the kneeling system to work only under 5 mph (8 km/h). Secondly, the parking brake is automatically applied, and a limit switch will keep it applied as long as the vehicle has not returned to a certain height where the driver will be able to manually remove the parking brake.

The purpose of the hi-buoy function in this system is to raise the front end of the vehicle to allow an extra ground clearance for particular situations. In driving condition, the height control valve is in operation and only the hi-buoy can be operated.

9.1 PRINCIPLE OF OPERATION

Refer to the air system schematic diagram annexed at the end of Section 12, *“Brake and Air System”.*

DOWN (FRONT KNEELING):

Both the bellows control and bellows exhaust solenoid valves are energized, so the air control valves release air from front air springs. The height control valve is bypassed to ensure no air is forwarded to air springs while lowering the front suspension.

UP (FRONT HIGH-BUOY):

Only the bellows control solenoid valve is energized, so the air coming from the kneeling air tank is routed through air control valves, and up to front air springs.

The height control valve is bypassed until the kneeling proximity switch signals the kneeling module to cut off the bellows control solenoid valve, about 1" (25 mm) below normal ride height. The final height adjustment is achieved by the height control valve.

9.2 MAINTENANCE

Since the kneeling action is issued from both the air system and electrical system, refer to Section: 12, *“Brake and Air System”* and Section 06, *“Electrical System”.*

For diagnosis and understanding of the system, refer to wiring diagrams, and to the appropriate air system schematic diagram annexed to Section 12, *“Brake and Air System”.*

9.3 BELLOWS CONTROL SOLENOID VALVES

9.3.1 Removal and installation

1. On the rear side of steering compartment, locate both the bellows control and bellows exhaust solenoid valves.
2. Identify hoses and wires to ease reinstallation. Disconnect solenoid wires and the three flexible black hoses from solenoid valves.
3. Unscrew and remove the control solenoid valve and exhaust solenoid valve assembly. Place on a clean working place.

Reverse removal procedure to reinstall.

Caution*: Any cable tie that has been cut during removal procedure should be replaced with a new one.*

10. HIGH-BUOY SYSTEM

The purpose of the rear high-buoy system is to raise the entire vehicle body about 4” (100 mm) in order to increase ground clearance to board a ferryboat, to jump a curb, etc. This system can be put into service during normal vehicle operation.

10.1 PRINCIPLES OF OPERATION

The rear high-buoy system is added over the front kneeling (with front high-buoy). The front end uses the same valves as the front kneeling (with front high-buoy). A solenoid valve is added to send air to the double shuttle valves for the rear end. It uses the same dash switch as the kneeling (with front high-buoy).

UP:

The air coming from the control valve, flows through double shuttle valves, to supply air springs. The double shuttle valves prevent height control valves from releasing air from air springs.

DOWN:

The control valve, on the dashboard, cuts off air supply, so the double shuttle valves allow height control valves to accomplish their function. Height control valves release air from air springs until suspension returns to its normal position.

10.2 MAINTENANCE

Refer to the air system schematic diagram “Opt. Front Kneeling With Rear High-Buoy Combination” annexed at the end of this Section.

10.3 HIGH-BUOY – PRESSURE REGULATING VALVE

The regulating valve is located in the front service compartment. This valve should be adjusted to 90 psi (621 kPa).

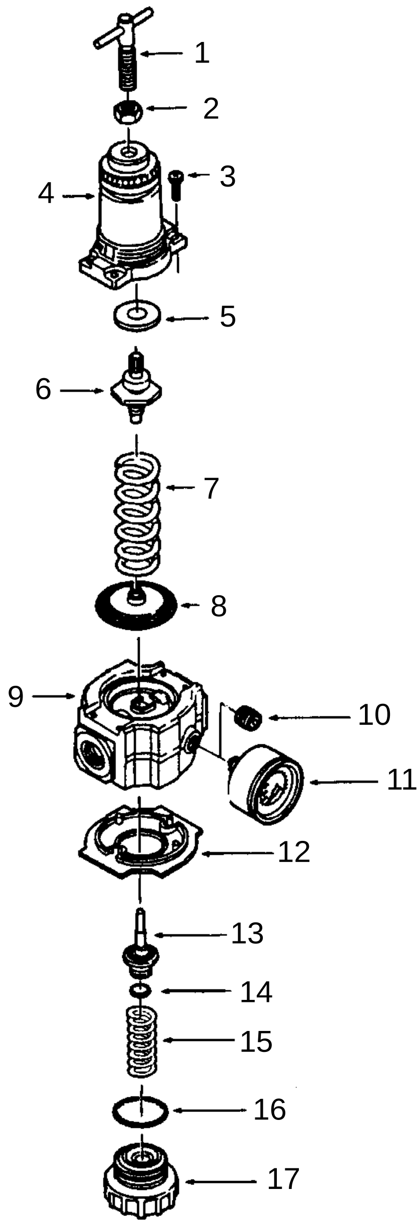


FIGURE 16: REGULATING VALVE 16035

10.3.1 Adjustment

1. Before turning on system air pressure, release jam nut (2, Fig. 16) then turn regulator adjustment counterclockwise until all load is removed from the regulating spring.
2. Turn on system pressure.
3. Turn regulator adjustment clockwise until the desired outlet pressure is reached.
4. To avoid minor readjustment after making a change in pressure setting, always approach the desired pressure from a lower pressure. When reducing from a higher to a lower setting, first reduce the pressure at a lower pressure, then increase it to the desired level of pressure.
5. Tighten jam nut (2, Fig. 16) to lock pressure setting.

10.3.2 Disassembly

1. Shut off inlet pressure and reduce pressure in inlet and outlet lines to zero. Turn regulator adjustment (1, Fig. 16) counterclockwise until all load is removed from regulating spring. Regulator can be disassembled without removal from air line.
2. Disassemble regulator in accordance with the item numbers on the exploded view.

10.3.3 Cleaning

1. Clean parts with warm water and soap. Dry parts and blow out internal passages in body using clean, dry compressed air.
2. Inspect parts. Replace those found to be damaged.

10.3.4 Reassembly

1. Lubricate O-ring (14 and 16, Fig. 16), valve stem (13, Fig. 16), tip of adjusting screw (1, Fig. 16), and the outer circumference and both sides of the thrust washer (9, Fig. 16) with a light coat of good quality O-ring grease.
2. Assemble the regulator as shown on the exploded view.

Torque Table	
Item	Torque in Inch-lbs (Nm)
3 (Screw)	25-35 (2.8-3.9)
17 (Bottom plug)	20-25 (2.3-2.8)

11. LOW-BUOY SYSTEM

The purpose of the low-buoy system is to lower the whole suspension by about 4” (100 mm) in order to reduce the overall height for low clearances. This system can be put into service during normal vehicle operation.

11.1 PRINCIPLES OF OPERATION

On XL2 coaches, the rear low-buoy is added over the front kneeling system. The control valve on the left console panel sends an electric signal from its pressure switch to control the front suspension as if kneeling. It also removes air from a relay valve that exhausts air supply to all leveling valves and the quick release in the rear section. Air from the rear suspension can then be depleted through the check valve-quick release assembly.

DOWN:

The control valve, on the L.H. control panel, cuts off air supply, so air is released from air springs. A relay valve prevents height control valves from supplying air springs.

UP:

The control valve, on the L.H. control panel, supplies air to close the passage between both the delivery and supply ports. A relay valve opens and provides air springs until the suspension reaches the normal ride height.

11.2 MAINTENANCE

Refer to the air system schematic diagram “Opt. Front Kneeling With Rear Low-Buoy Combination” annexed at the end of this Section.

12. TROUBLESHOOTING

Condition	Cause	Correction
Bellows deflate over time	1. Defective check valve assembly. 2. Defective exhaust valve assembly. 3. Leak in air line and/or bellows. 4. Defective valve cover, rubber O-rings or gasket.	1. Replace check valve assembly. 2. Replace exhaust valve assembly. 3. Replace air line or bellows. 4. Replace valve cover, O-rings or gasket.
Bellows raise to full height and fail to exhaust air pressure	1. A clogged exhaust screen in height control valve assembly. 2. A combination clogged exhaust screen and defective air inlet valve assembly.	1. Remove and clean screen. 2. Clean exhaust screen and replace air inlet valve assembly.
Erratic valve action	1. Dirt or foreign matter in the air valve lever chamber. 2. Defectives valves.	1. Remove valve cover and blow out dirt. Install cover using new gasket. 2. Overhaul height control valve assembly
Vehicle body fails to level to satisfactory ride height	1. Improper height control valve overtravel lever adjustment	1. Adjust lever as directed.

13. PARTS SPECIFICATIONS

Front and tag axle air springs

Make........................ Goodyear Tire and Rubber
Model..1200
Type .... Mae West
Nominal diameter ....12” (304 mm)
Supplier number..................................1R12-319
Prévost number......................................630125

Drive axle air springs

Make........................ Goodyear Tire and Rubber
Model..1100
Type ....Double Flare
Nominal diameter ....11.5” (292 mm)
Supplier number..................................1R11-088
Prévost number......................................630104

Front axle shock absorbers

Make...Sachs
Color...Black
Type N45X225HA
Ext. Diam..75 mm
Collapsed length ....15.51” (394 mm)
Extended length ....24.37” (619 mm)
Supplier number......................... 481700000207
Prévost number......................................630252

Drive and tag axle shock absorbers

Make...Sachs
Color...Black
Type N45X225HA
Ext. Diam..75 mm
Collapsed length ....15.51” (394 mm)
Extended length ....24.37” (619 mm)
Supplier number......................... 481700000209
Prévost number......................................630253

Height control valve (MTH, front only)

Make ....Barksdale
Quantity used...1
Supplier number 52321POAQ3-Q62
Prévost number 630157

Height control valve (coach, all axles & MTH, rear only)

Make ....Barksdale
Quantity...2
Supplier number 52321POAQ3-Q26
Prévost number 630156

Bellows control and exhaust solenoid valve assembly

Make ....Norgren

Solenoid valve manifold

Supplier number D0043B
Prévost number 641130

Coil

Voltage... 24 V DC
Current draw ....29 amperes
Supplier number 54932-27
Prévost number 641144

Valve (3 way, 2 positions)

Type ....N/C
Supplier number 411-C-456235W
Prévost number 641357
Type .... N/O
Supplier number 411-D-456236X
Prévost number 641356

Radius rod bushing

Make ....Prévost
Prévost number 630021

Loctite

Make..Loctite

Prévost number......................................680039

Sway bar bushing (Front Axle)

Make.. Prévost

Prévost number......................................630020

Sway bar link

Make................................. Tennaco Automotive

Supplier number.....................................934400

Prévost number......................................630230

Shock absorber bushings

Make.. Monroe

Supplier number.......................................45380

Prévost number......................................630062

Air regulator

Make... Norgren

Recommended pressure sett... 90 psi (621 kPa)

Supplier number.......................R74G-4AT-RMN

Prévost number......................................641352

14. TORQUE SPECIFICATIONS

1- Shock absorber pin .... 500-550 Ft-lbs (680-750 Nm)

2- Shock absorber pin nut .... 70-80 Ft-lbs (95-110 Nm)

3- Radius rod stud .... 20-40 Ft-lbs (27-54 Nm)

4- Radius rod retaining nut or bolt ....110-130 Ft-lbs lubricated (150-175 Nm lubricated)

5- Radius rod support nut ....110-130 Ft-lbs lubricated (150-175 Nm lubricated)

6- Axle attachment nut... 425-475 Ft-lbs (580-645 Nm)

7- Air spring stud nut .... 20-25 Ft-lbs (27-34 Nm)

8- Sway bar link nuts ....110-130 Ft-lbs lubricated (150-175 Nm lubricated)

9- Sway bar bushing collar bolts .... 70-80 Ft-lbs (95-110 Nm)

Note: *During assembly, use “Loctite 242” (Prévost No 680038) with item 1 and 3. After assembly, apply “anti-seize compound” (Prévost No 680064) on all threads nuts.*

SECTION 16: MTH EQUIPPED WITH INDEPENDENT FRONT SUSPENSION (IFS)

CONTENTS

ILLUSTRATIONS

1. INTRODUCTION

This supplement contains service procedures and specifications that apply to the PREVOST converted coach shell vehicles equipped with an independent front suspension.

This text contains information unique to the independent suspension system. In the case you cannot find information on a subject in this supplement section, the information given in the regular sections of the Maintenance Manual will apply.

2. STEERING LINKAGE

Turning motion of the steering wheel is transferred by the steering gear and steering linkage to the steering arms at the right and left front wheels. The steering linkage consists of tie rods connected to the bell crank and the steering arm at the left side of the coach, and to the idler arm and steering arm at the right side of the coach. The bell crank and idler arm are connected by a relay rod. A drag link connected to the bell crank and the pitman arm, which is mounted to the steering gear, transfers the turning motion of the steering wheel to the steering arms. The hydraulic power cylinder provides an added source of assistance and being connected to the R.H. wheel, makes it such that the total steering forces are produced with minimal stress on mechanical linkages (Fig. 1).

Lower and upper A-arms are widely spaced. They are mounted on ball joints. Torque rods prevent rotation of the uprights around the lower and upper ball joints.

If the steering linkage is bent, twisted or worn, steering action of the coach will be seriously affected. Any time steering linkage components are replaced or adjusted, steering geometry and front wheel alignment must be checked as explained in this section of supplement.

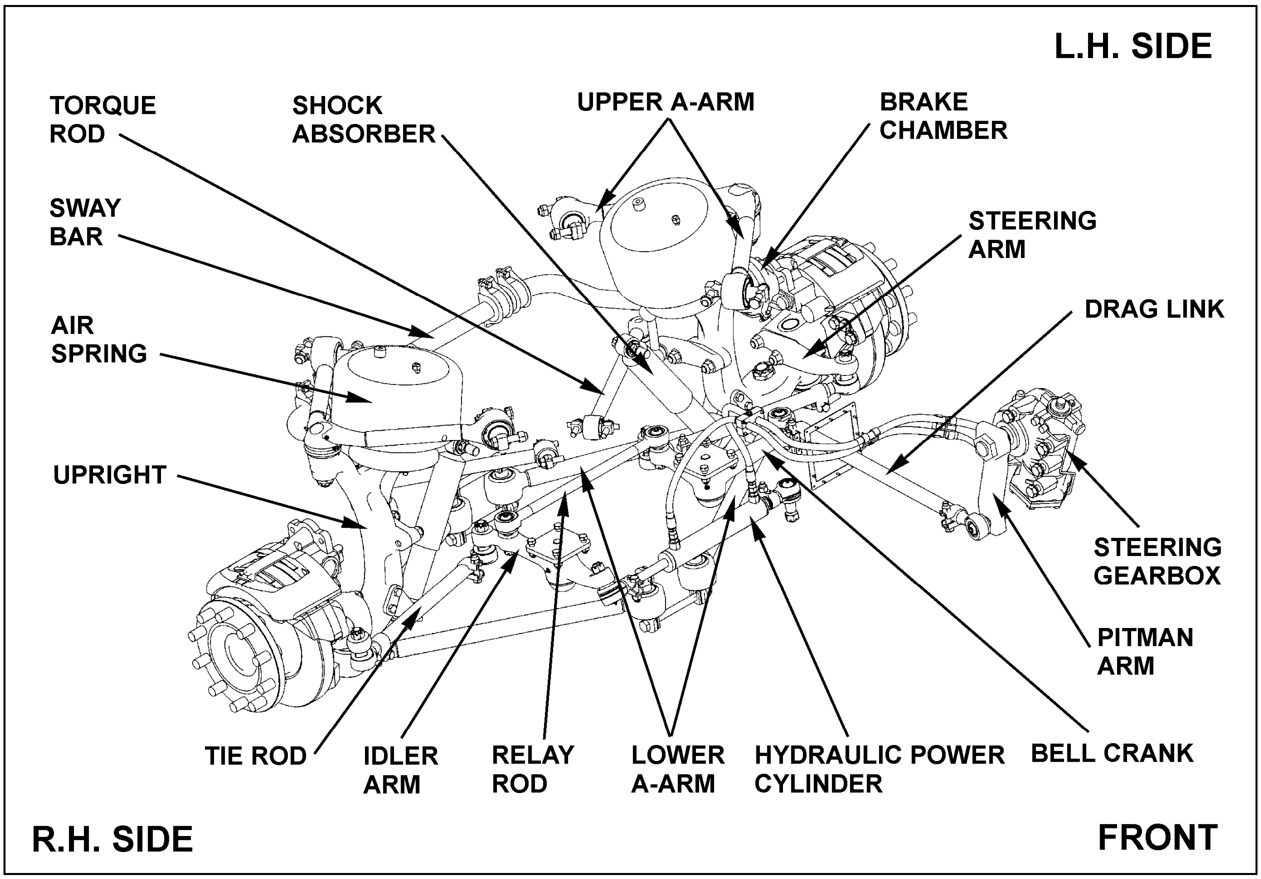


FIGURE 1: SUSPENSION AND STEERING LINKAGE 16124

Turning Angle

The maximum turning angle is set mechanically through the two steering stop screws installed on the swivel assembly. The turning angle (56° + 0° - 1°) mechanical stop is factory adjusted to accommodate the chassis design, and therefore, does not require adjustment on new vehicles.

However, turning angle should be checked and adjusted hydraulically, if necessary, any time a component of the steering system is repaired, disassembled or adjusted.

Before checking the turning angle, be sure the front end is properly aligned as described under paragraph "4. Front End Alignment" in this supplement.

To check steering maximum turning angle, proceed with the following method :

1. Check if front tires rub against the frame or if the steering gear has been serviced.

Caution: *If clamps are not correctly installed, they can interfere with other parts.*

2. For a full left and right turn, check clamps' position and for interfering parts. Refer to figures 2 to 6 for location and positioning of clamps. If readjustment is required, make the proper adjustment.

Note: Prior to steering limiter adjustment, verify vehicle wheel alignment, and ensure that oil level is adequate and that air bleeding is done.

3. If necessary readjust steering limiter. Refer to "ZF-SERVOCOM Repair Manual" annexed to XL2 Maintenance Manual, Section 14, "Steering", under heading: "Setting and Functional Test".

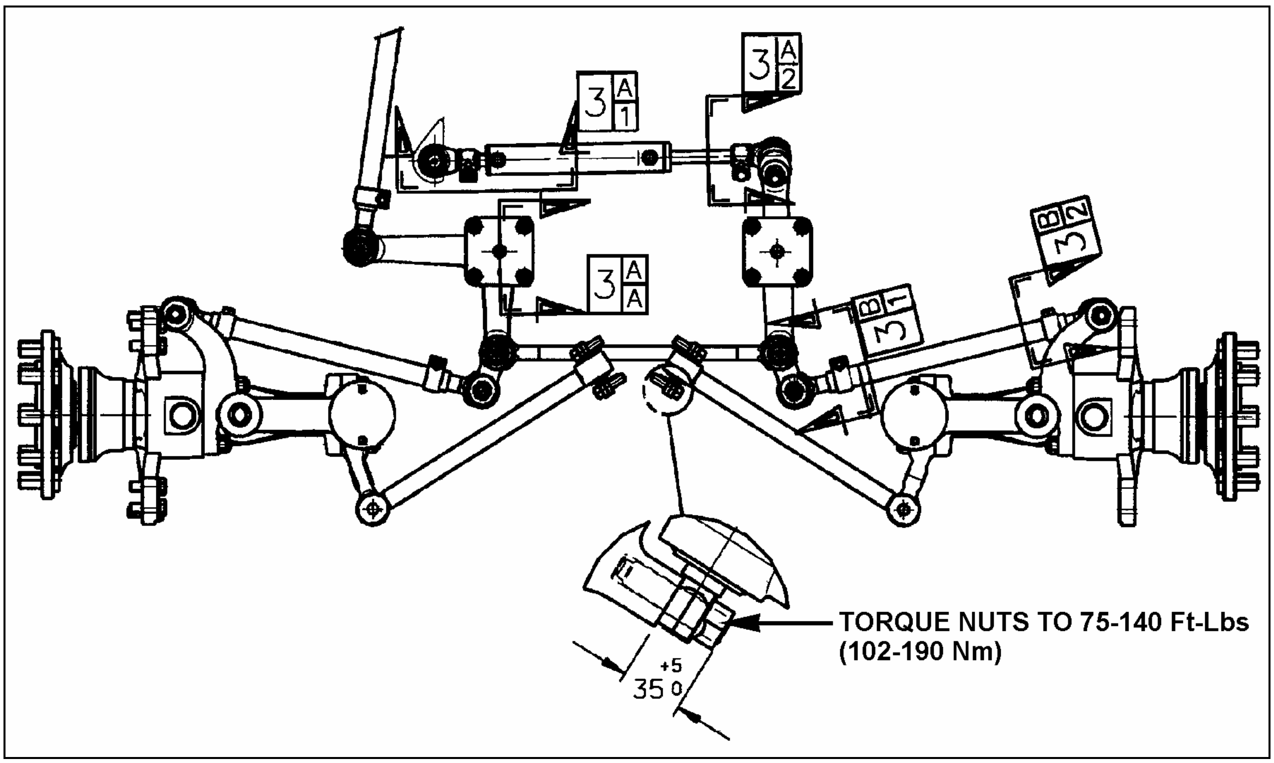


FIGURE 2: LOCATION OF CLAMPS 16126

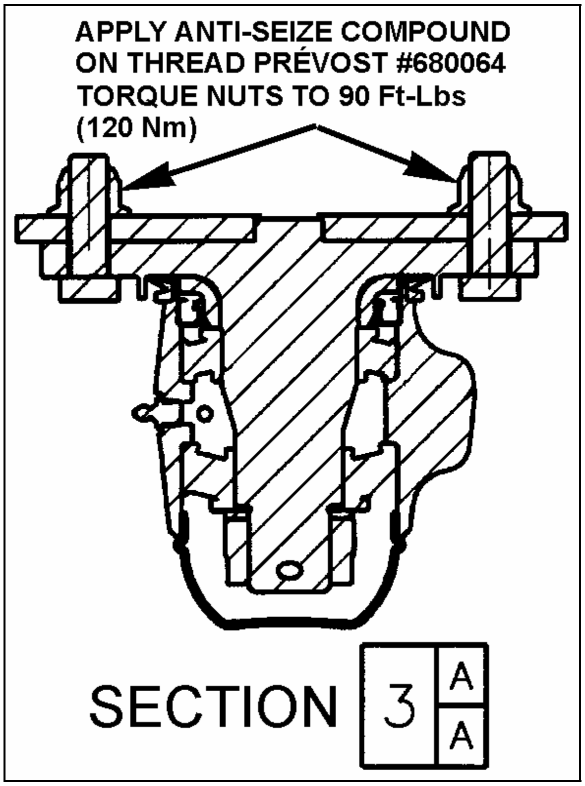


FIGURE 3: CLAMP POSITIONING 16128

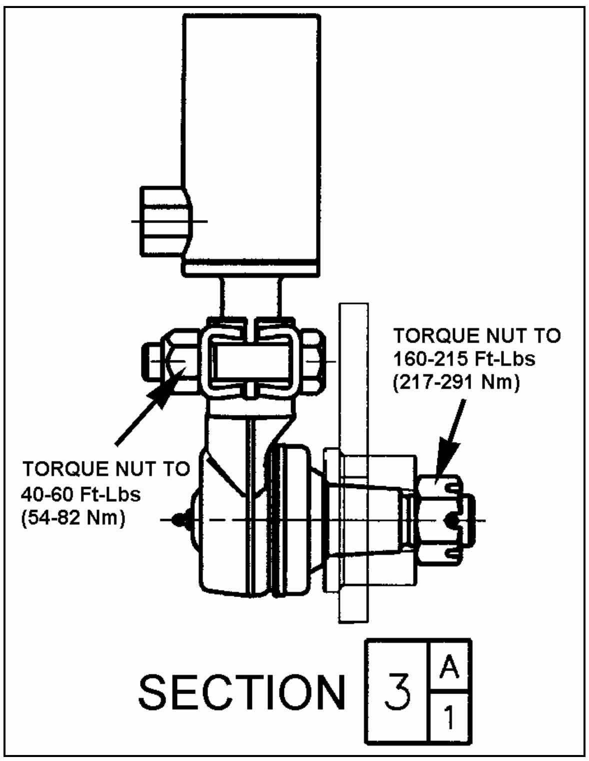


FIGURE 4: CLAMP POSITIONING 16121

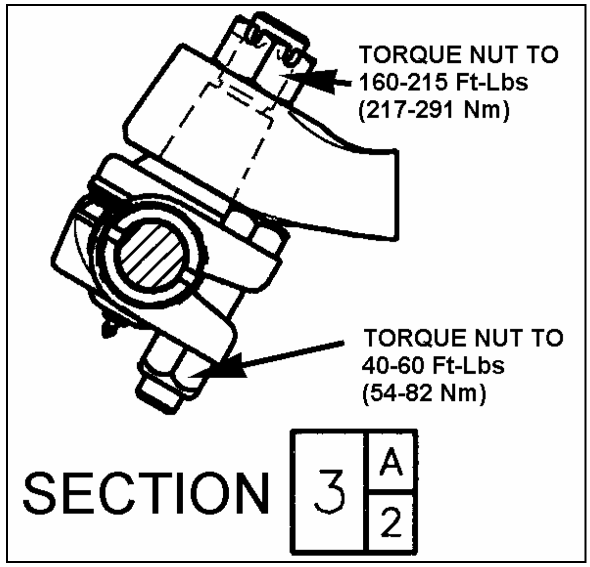


FIGURE 5: CLAMP POSITIONING 16122

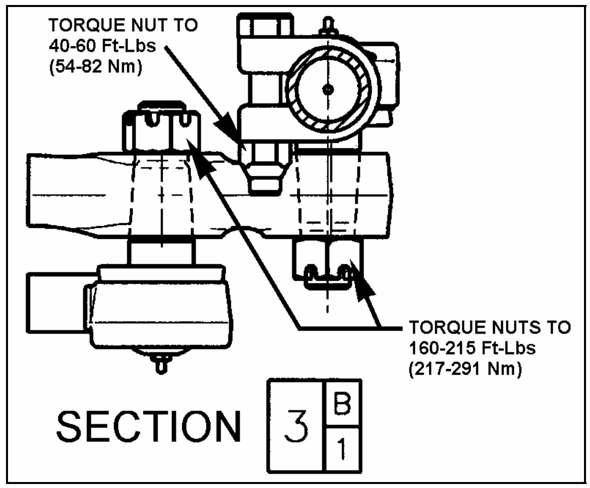


FIGURE 6: CLAMP POSITIONING 16120

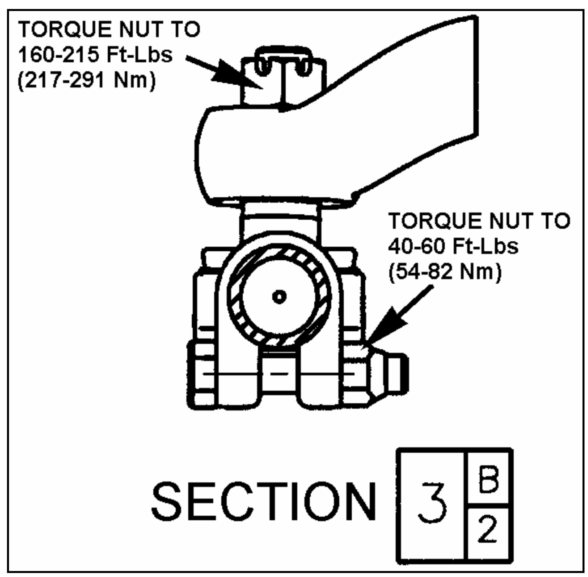


FIGURE 7: CLAMP POSITIONING 16123

2.1 POWER STEERING HYDRAULIC PUMP

Refer to the "TRW Power Steering Pump Service Manual" annexed at the end of Section 14

2.2 STEERING LINKAGE ADJUSTMENT

Note: *Whenever a steering linkage component has been removed and replaced, check steering geometry and front end alignment as directed in this Supplement. Check to insure that all stud nuts and mounting bolts and nuts have been tightened to proper torques listed under "16. Torque Table" at the end of this supplement.*

1. First, align the input shafts marks.
2. Afterwards, the pitman arm should be adjusted with reference marks aligned or to an angle of 90° in relation with the horizontal axis (Fig. 8).
3. Locate centerline of vehicle then install relay rod in boss at steering bell crank and idler arm. Align center of relay rod with centerline of vehicle.
4. Install drag link to pitman arm and adjust opposite end of drag link to fit mounting stud hole in bell crank.
5. Install tie rods, then adjust toe-in as per "Front End Alignment" in this Supplement.

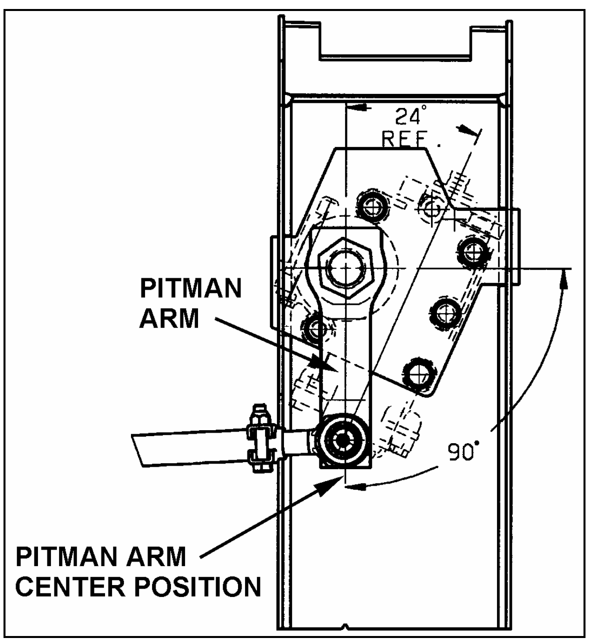


FIGURE 8: PITMAN ARM ALIGNMENT 14037

2.3 PITMAN ARM REMOVAL

1. Remove cotter pin, nut and washer from drag link ball stud at pitman arm.
2. Disconnect drag link from pitman arm, using jaw style pullers (pressure screw type).

Warning: *Always wear approved eye protection when operating pullers.*

Caution: *Do not drive pitman arm on or off pitman shaft as this can damage the steering gear.*

Caution: *Heating of components to aid in disassembly is not allowed because it has a detrimental effect on axle components and steering linkages.*

3. Remove pitman arm fixing nut.
4. Check the radial position of the pitman arm in relation to the sector shaft prior to removal of pitman arm.
5. Add reference marks to the arm and shaft if necessary to ensure correct alignment at reassembly.
6. Use a puller to remove pitman arm.

2.4 PITMAN ARM INSTALLATION

1. Position pitman arm on sector gear shaft with reference marks aligned.
2. Install fixing nut. Tighten nut to 400-450 Ft-lbs (545-612 Nm).

Note: *Use a new nut if the previously removed nut was punched.*

Caution: *Lock nut with sector shaft using a punch mark into the groove (Refer to figure 9).*

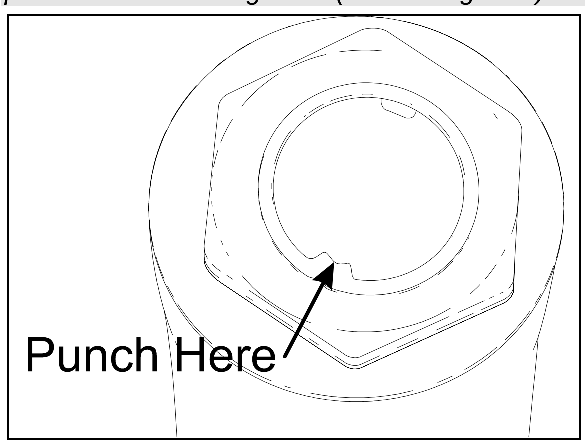


FIGURE 9: FIXING NUT PUNCH MARK 16098

3. Connect drag link to pitman arm. Install washers. Tighten nut to 160-215 Ft-lbs (218-292 Nm). Advance nut to next alignment cotter pin slot and install a new cotter pin.

2.5 DRAG LINK

Drag link assembly consist of three parts; a drag link and two end assemblies. Both end assemblies are identical and they are retained on the drag link with a clamp bolt and nut.

Stud nuts at the pitman arm and bell crank ends of the drag link must be kept tight or hole at ball stud end of drag link and hole in pitman arm may become enlarged as a result of excessive looseness. Subsequent tightening of stud nuts may draw studs too far into holes and dust cover parts may become damaged which can result in component failure.

Drag link end sockets are equipped with lubrication fittings and should be lubricated as directed in "Lubrication Fittings" in this supplement.

2.5.1 Adjustment

It should not be necessary to alter the length of the drag link except when a new link is installed or when removable end assembly has been replaced. If drag link adjustment is necessary, proceed as follows:

1. Position front wheels in straight ahead position.
2. Center steering gear as previously explained in paragraph "2.1 Steering Linkage Adjustment".
3. Remove cotter pin and stud from drag link at bell crank. Locate centerline of vehicle and center of relay rod. With center of relay rod aligned with centerline of vehicle, loosen clamp bolt at socket end (bell crank end) of drag link and adjust length of socket end assembly to fit in boss of bell crank.

Note: *Do not change position of pitman arm.*

4. Install stud nut and torque to 160 Ft-lbs (220 Nm). Align nut with cotter pin slot (tighten) and install a new cotter pin.
5. Torque mounting clamp bolt nut to 40-60 Ft-lbs (54-82 Nm), then test the adjustment. Front wheels should turn from right to left extremities without noticeable binding at drag link ends.

2.6 BELL CRANK AND IDLER ARM

Bell crank and idler arm are equipped with one lubrication fitting and should be lubricated as directed in paragraph "2.9 Lubrication Fittings" at the end of this Supplement.

2.6.1 Bell Crank and Idler Arm Removal

Note: *Use a piece of wire to anchor loosen end of relay rod and tie rod in order to prevent placing an excessive load on opposite socket end.*

Bell crank : Disconnect drag link, tie rod and relay rod from bell crank by removing cotter pins, stud nuts and washers from ball studs. Separate socket assemblies from the bell crank.

Idler arm : Remove cotter pins, nuts and washers from ball studs connecting relay rod and tie rod to idler arm. Separate socket assemblies from idler arm.

Remove nuts and washers from bolt attaching bell crank or idler arm mounting bracket to vehicle understructure. Remove bell crank or idler arm mounting bracket.

2.6.2 Bell crank or Idler Arm Ball Joint Disassembly

1. Remove adjacent link assemblies from bell crank or idler arm as previously described.
2. Remove the cap (Fig. 10).
3. Remove the cotter pin, nut and tongue washer. Remove bearings, grease seal, bearing bushing and the bell crank or idler arm from its mounting bracket stud (Fig. 10).

2.6.3 Bell Crank or Idler Arm Ball Joint Reassembly

Note: *For bearing installation use tool Prévost # 110684.*

1. Install bearing bushing on bell crank or idler arm mounting bracket stud.
2. Install bearing and grease seal in bell crank or idler arm eye (Fig. 10).

Note : *Install grease seal according to figure 8. Grease must be able to exit the bell crank or idler arm mechanism. For grease seal installation use tool Prévost # 110683.*

3. Install bell crank or idler arm on its mounting bracket stud (Fig. 10).
4. Install bearing and nut.

Note: *Apply grease on bearing before installation.*

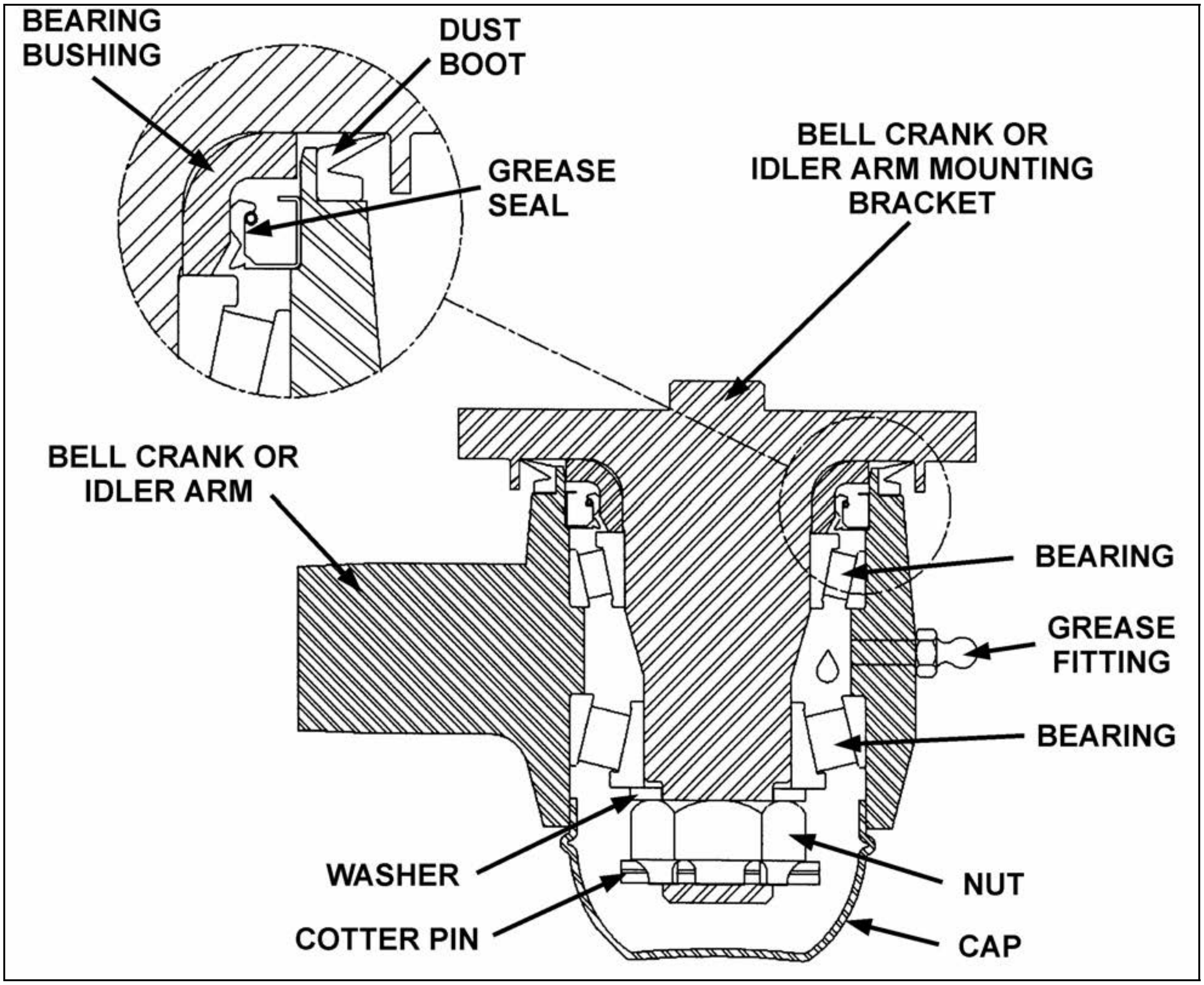


FIGURE 10: BELL CRANK AND IDLER ARM 16109

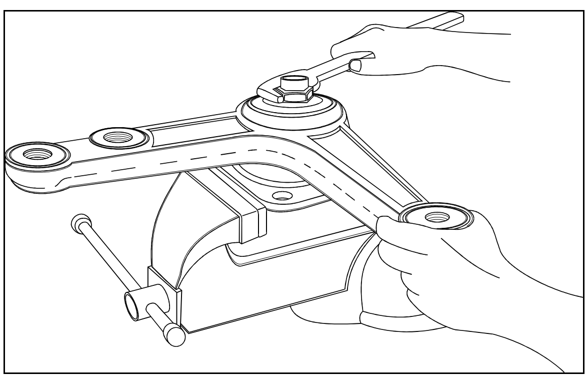


FIGURE 11: BELL CRANK 16044

5. Firmly tighten nut (Fig. 11).
6. Unscrew nut until bell crank or idler arm starts to turn by the application of 1 to 3 pounds load (Fig. 12).

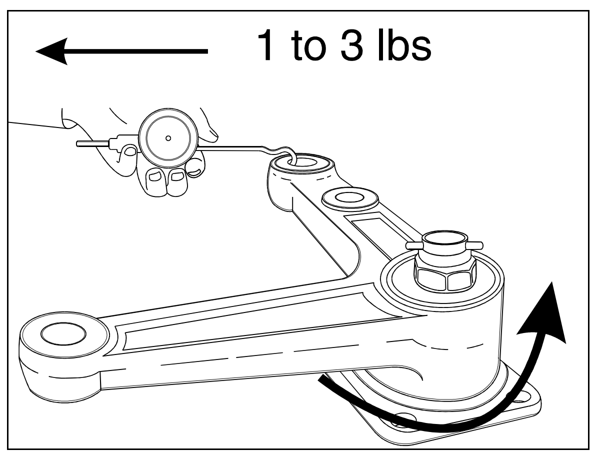


FIGURE 12: BELL CRANK 16045

7. Check for loose bearings by applying an up and down load on bell crank or idler lever (Fig. 12). The lever is not supposed to move in the vertical axis direction.
8. Align nut with cotter pin slot (tighten) and install a new cotter pin.

Note: *Bend cotter pin around the nut (Fig. 10). Do not bend the cotter pin in the direction of the cap, because it may interfere with the cap.*

9. Install the cap.
10. **Bell crank :** Install drag link, tie rod and relay rod as directed herein under each specific subject.
11. **Idler arm :** Install tie rod and relay rod as directed herein under each specific subject.
12. Adjust turning angle as previously directed under paragraph "**Turning Angle**" and check front end alignment as specified in paragraph "6. Front End Alignment" of this supplement.

2.7 RELAY ROD

Relay rod ends are equipped with lubrication fittings and should be lubricated as directed in paragraph "2.9 Lubrication Fittings" in this supplement.

Note: *The relay rod is crimped in place and it is not possible to remove the ball joints.*

2.7.1 Replacement

1. Remove cotter pins from bell crank and idler arm end of relay rod. Loosen nuts flush with end of studs.
2. Use a puller or place a sledge hammer behind the adjacent part to absorb shocks. Strike the studs with a brass hammer to loosen end assemblies.
3. Remove stud nuts and washers then remove studs.
4. Position relay rod studs into bell crank and idler arm then tap stud ends with a brass hammer to seat tapered surfaces.
5. Install washers and stud nuts. Tighten nuts to 160 Ft-lbs (220 Nm) torque. Align cotter pin slot (tighten) and install a new cotter pin.

2.8 TIE RODS

Tie rod ends are connected to the bell crank and left steering arm, and to the idler arm and right steering arm. Each tie rod assembly consists of three parts; a tube and two socket end assemblies. The tie rod ends are threaded into the tube and secured with clamp bolts. Right and left hand threads are provided to ease toe-in adjustment. Tie rod assemblies are interchangeable from the right to the left side of the coach.

Tie rod end sockets require no maintenance other than periodic lubrication and inspection to see that ball studs are tight. Replace socket ends when there is excessive up and down motion, lost motion or end play at ball end of stud.

1. Periodically check bolt nut for tightness.
2. Inspect tie rod for bent condition and inspect tube for damaged threads. If tie rod is bent or threads are damaged, replace the assembly.
3. Lubricate tie rod end fittings as directed in paragraph "2.9 Lubrication Fittings" at the end of this section.

2.8.1 Removal

1. Remove cotter pins and stud nuts which attach tie rod socket ends to bell crank and left steering arm (or idler arm) and right steering arm.
2. Remove tie rod ball stud by tapping on steering arm and bell crank or idler arm with hammer, while using a sledge hammer to absorb shocks.

Note: *If tie rod end assemblies are damaged in any way, they must be replaced.*

2.8.2 Installation

1. Install socket end assemblies on tie rod. Be sure both ends are threaded an equal distance into the tube.
2. Make sure threads on stud and in stud nut are clean and not damaged.
3. Position ball studs (socket ends of tie rod) in holes in steering arm and bell crank or idler arm. Install a ball stud nut on each stud and tighten firmly.
4. Torque stud nuts to 160 Ft-lbs (220 Nm). Align cotter pin slot (tighten) and install a new cotter pin.

Note: *Adjust toe-in as directed in paragraph "6.4.2 Toe-In Adjustment" of this supplement.*

5. Make sure tie rod ends are properly aligned with ball studs, then torque tie rod end clamp bolts to 40-60 Ft-lbs (54-82 Nm).

Note: *If tie rod is not properly aligned with stud, binding will result.*

2.9 STEERING ARMS

The left and right wheel steering arms are secured to a swivel at one end and to a tie rod at the other end.

2.9.1 Removal

1. Remove wheel as directed in Section 13, "Wheel, Hubs And Tires" of the maintenance manual.
2. Remove cotter pin, washer and nut from stud securing tie rod to steering arm. Remove ball stud from steering arm by tapping on arm with a hammer, Placing a sledge hammer underneath steering arm to absorb shocks.
3. Remove cotter pin and nut securing steering arm to swivel assembly. Remove steering arm from swivel.

2.9.2 Installation

1. Insert steering arm in swivel.
2. Torque steering arm to swivel nut to 190 Ft-lbs (260 Nm). Align cotter pin slot (tighten) and install a new cotter pin.
3. Position tie rod ball stud in steering arm and tap with a brass hammer to seat ball stud in steering arm. Install washer and nut on stud. Torque nut to 160-215 Ft-lbs (217-291 Nm). Tighten nut to nearest cotter pin slot and install a new cotter pin.
4. Install wheel as directed in Section 13, "Wheel, Hubs And Tires" under paragraph "3.2 Installation" of the maintenance manual.

2.10 LUBRICATION FITTINGS

All lubrication fittings must be clean before applying lubricant. Also, always be sure equipment used in applying lubricant is clean. Every precaution should be taken to prevent entry of dirt, grit, lint or other foreign matter into lubricant containers. Replace fitting when they become broken or damaged.

Intervals of application given in the following paragraphs are recommended for normal service. More frequent intervals may be applied under severe operating conditions. In selecting proper lubricants, supplier reputation must be considered. The supplier must be responsible for product quality. The diagram (Fig. 13) shows approximate location of steering lubrication fittings.

1. **Drag Link Ends :** Lubricate at two fittings, one at each end of link, every 6,250 miles (10 000 km) with a good quality lithium-base grease NLGI No. 2 (Shell Retinax LX or equivalent).
2. **Relay Rod Ends :** Lubricate at two fittings, one at each end of rod, every 6,250 miles (10 000 km) with a good quality lithium-base grease NLGI No. 2 (Shell Retinax LX or equivalent).
3. **Tie Rod Ends :** Lubricate at four fittings, one at each end of both tie rods, every 6,250 miles (10 000 km) with a good quality lithium-base grease NLGI No. 2 (Shell Retinax LX or equivalent).
4. **Swivel Assembly :** Refer to DANA SPICER MAINTENANCE MANUAL NDS AXLES Lubrication and Maintenance" annexed at the end of section 10.
5. **Idler Arm and Crank bell :** Lubricate at two fittings, one on the idler arm and the other on the crank bell, every 6,250 miles (10 000 km) with a good quality lithium-base grease NLGI No. 2 (Shell Retinax LX or equivalent). Apply grease gun pressure to the fitting until lubricant appears at the top seal.
6. **Upper V-Link Outer Ball Joint :** Lubricate at fitting until you see some grease on the relief valve nearby, every 6,250 miles (10 000 km) with a good quality lithium-base grease NLGI No. 2 (Shell Retinax LX or equivalent).

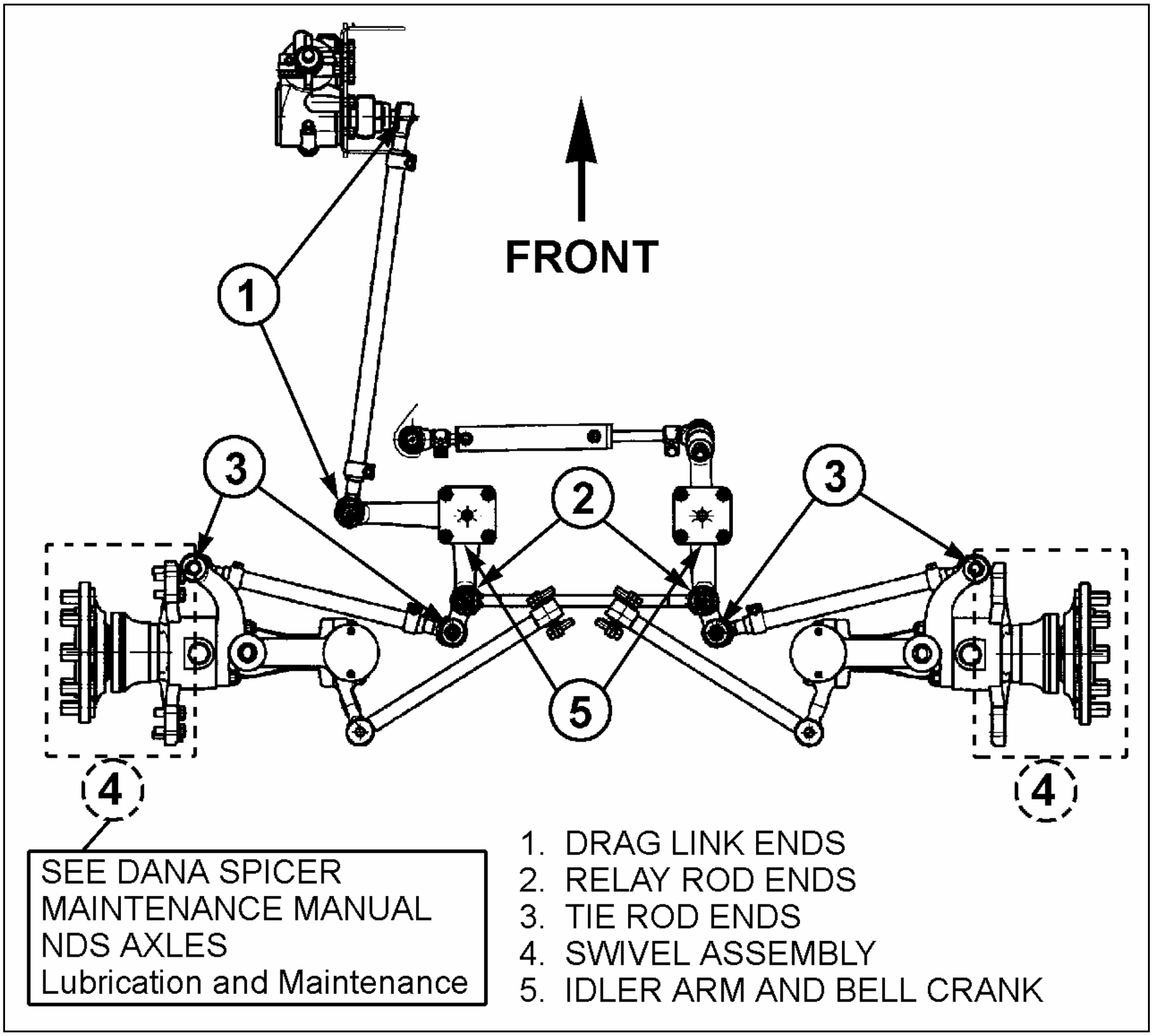


FIGURE 13: LUBRICATION FITTINGS' LOCATION DIAGRAM 16118

3. BALL JOINTS

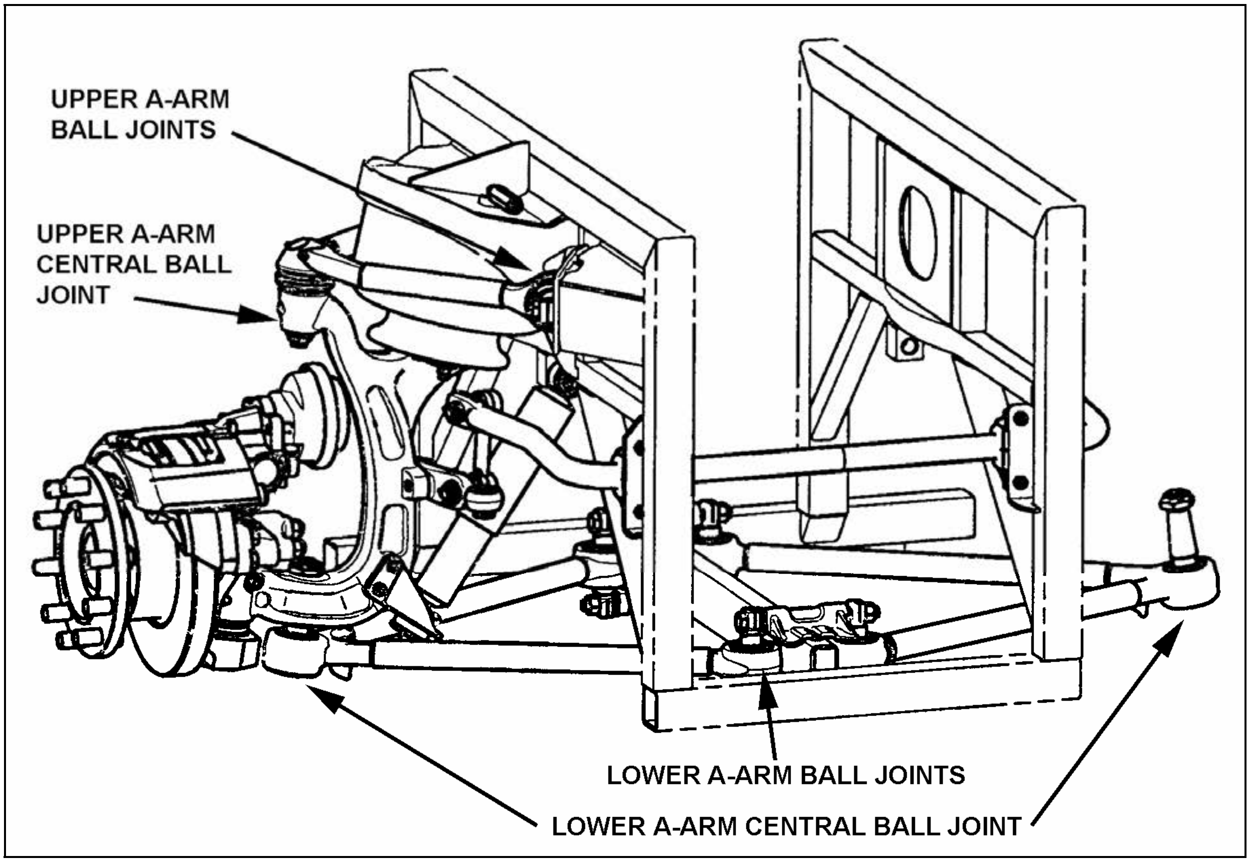


FIGURE 14: BALL JOINTS LOCATION 16137

4. LOWER AND UPPER A-ARM BALL JOINT

The assembly work may be done only by a recognized specialized workshop. Ensure that old and new parts do not get mixed up with each other. It is for this reason that all the old parts are to be scrapped immediately after a joint has been stripped down. A complete repair set must be used for each joint repaired, i.e. use of only part of a repair set is not permissible.

4.1 INSPECTION

Take off the load from the ball joint by lifting the front of the vehicle. Apply a load on the joint in all of the degrees of freedom in an axial, radial, etc. sense with a suitable lever tool. After the load is taken off, the joint has to spring back into its starting position. Free play is not acceptable.

Separation of rubber from ball pin or external joint shell is in accordance with "normal wear characteristics".

When the following characteristics are noted, the joint is to be changed:

-Free play;

-Radial cracking of the external sheet-metal race.

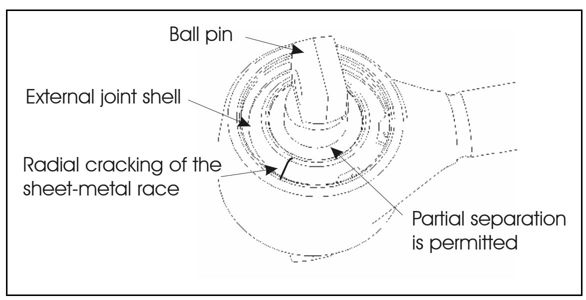


Figure 15: A-ARM BALL JOINTS

4.2 STRIPPING DOWN

Strip down the defective joint through removal of retaining ring, annular spacer and ball pin/bushing assembly and thereafter clean out housing bore and locking circlips groove.

4.3 ASSEMBLY

Execute assembly of the new joint parts in the following sequence:

1. Complete moistening of the contact surface between housing bore and ball pin through application of the grease.

Note: *Apply grease, only in the case of repair kit (Prévost # 611114)).*

2. Insert ball pin/bushing assembly. In case of the two-bolt type, ensure that the bolt bores are in the correct position in relation to the axis of the tube.
3. Place joint in receiving fixture and mount annular assembly tool on the housing. Then locate annular spacer and retaining ring in the housing using axial load with the aid of assembly matrix. If the ends of the annular spacer are not in contact with each other, the thus formed opening must be located at 180° to the opening of the retaining ring. Pay attention during assembly to ensure that the retaining ring eyelets are located at each side of the housing shaft axis (retaining ring eyelet lug points to tube), and that retaining ring is properly engaged in the groove of the housing.
4. When repairing defective ball pin assemblies, the necked down-bolt must regularly be replaced with a new one.

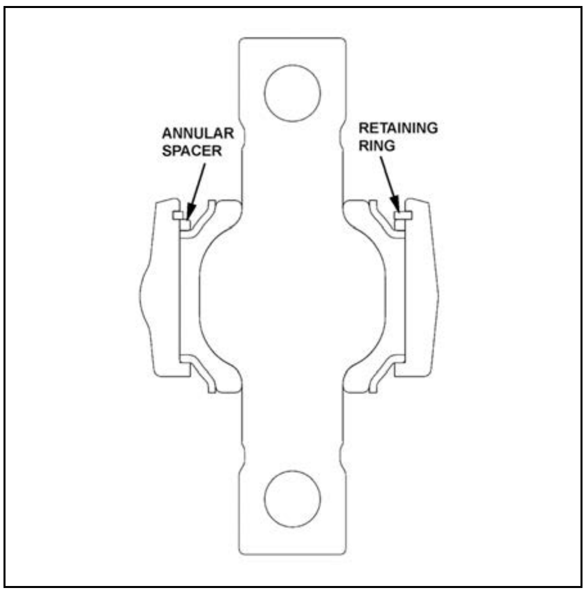


FIGURE 16: LOWER A-ARM BALL JOINTS 16047

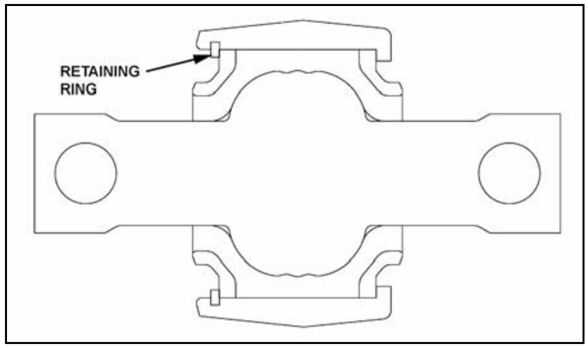


FIGURE 17: UPPER A-ARM BALL JOINTS

5. LOWER A- ARM CENTRAL BALL JOINT

5.1 INSPECTION

Take off the load from the ball joint by lifting the front of the vehicle. Apply a load on the joint in all of the degrees of freedom in an axial, radial, etc. sense with a suitable lever tool. After the load is taken off, the joint has to spring back into its starting position. Free play is not acceptable.

Separation of rubber from ball pin or external joint bushing shell is in accordance with "normal wear characteristics".

When the following characteristics are noted, the joint is to be changed:

- Free play;

- Radial cracking of the external bushing shell.

5.2 STRIPPING DOWN

Strip down the defective joint through removal of retaining ring, annular spacer and ball pin/bushing, assembly and thereafter clean out housing bore and locking circlips groove

5.3 ASSEMBLY

Assemble the new component parts of the joint in the following sequence:

1. Complete moistening of the contact surface between housing bore and ball pin through application of the grease.
2. Place joint in receiving fixture and mount annular assembly tool on the housing. Then locate annular spacer and retaining ring in the housing using axial load with the aid of assembly matrix. If the ends of the annular spacer are not in contact with each other, the thus formed opening must be located at 180° to the opening of the retaining ring. Pay attention during assembly to ensure that the retaining ring eyelets are located at each

side of the housing shaft axis (retaining ring eyelet lug points to tube), and that retaining ring is properly engaged in the groove of the housing.

3. Faultlessly apply grease by mechanical means to bracket-outer core and ball-inner cone. Insert bracket outer cone in fixture with distance ring and then use press tool to apply pressure to press mount with ball-inner cone.

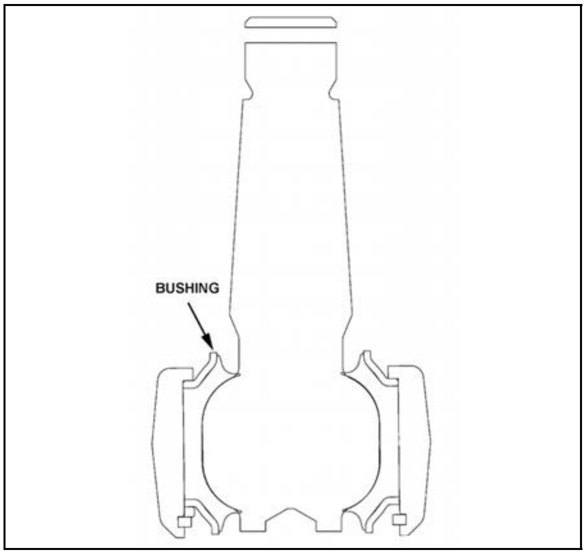


FIGURE 18: LOWER A-ARM CENTRAL BALL JOINT

6. UPPER A-ARM CENTRAL BALL JOINT

6.1 VISUAL INSPECTION

Check the condition of the sealing boot, in particular:

Check if the retainer ring, which secures the sealing boot at the conical section of the ball stud, is still present.

Check if grease is present on the external surface of the sealing boots. Escaped fluid and accumulations of grease on the sealing boot may be the result of the sealing boot's rupturing. In this case, the ball joint must be systematically replaced.

6.2 PLAY MEASUREMENT

1. Raise the vehicle and support through axle jacking points.
2. Using a caliper, measure the dimension A on figure 19.
3. With a lever tool, exert sufficient force under the upper A-arm as to separate the upper A-arm from the upright in order to have the ball joint to its maximum extent. Remeasure the dimension A. If the difference between the two dimensions is greater than 0.060" (1.5mm), then the ball joint should be replaced.

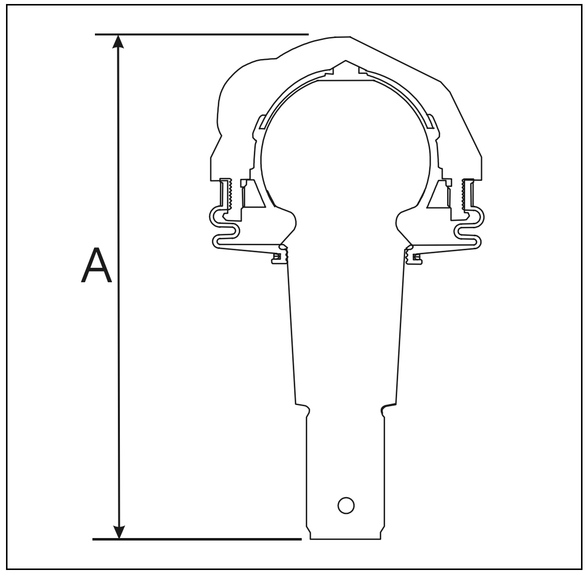


FIGURE 19: UPPER A-ARM CENTRAL BALL JOINT 16116

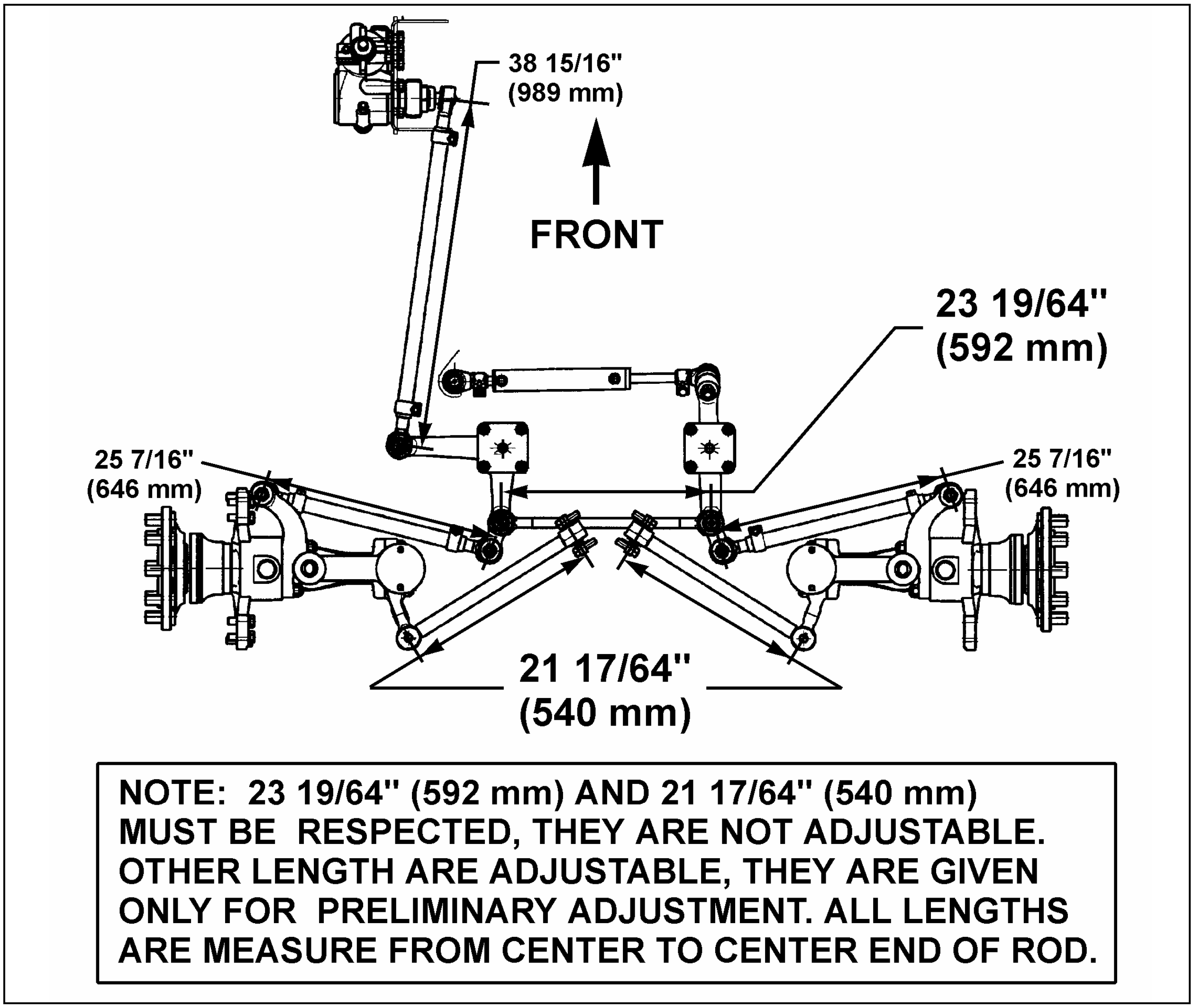


FIGURE 20: STEERING LINKAGE MEASURE 16132

7. FRONT END ALIGNMENT

Proper front end alignment must be maintained to insure ease of steering and provide satisfactory tire life. When making front end alignment inspections, the vehicle must be level and empty with the full weight of the vehicle on the wheels.

Front end alignment inspections fall into two groups : regular service inspections performed at periodic intervals, and inspections to determine the extent of damage after a collision or severe service.

Regular service inspections concern toe-in, camber and caster.

Any variation from the specified alignment will indicate either a need for adjustment or a more thorough inspection to determine if parts replacement is required.

7.1 ALIGNMENT TERMINOLOGY

Wheel Camber

The amount the wheels are inclined from the vertical plane (A, Fig. 18).

Wheel Toe-In

The distance the front wheels are closer together at the front than at the rear of the tires (D minus E, Fig. 18).

King Pin Inclination

The inclination of the king pin from vertical toward the center of the vehicle at the top and outward at the bottom (B, Fig. 18).

Front Axle Caster

The inclination of the king pin from vertical in the fore and aft direction (C, Fig. 18).

7.2 FRONT END INSPECTION

Before checking front end alignment, make the following inspection:

1. Check that the vehicle is at normal ride height (see paragraph "11. Suspension Height Adjustment").
2. Check the tires for proper inflation.
3. Check wheel installation and run-out.
4. Check wheel bearing adjustment.
5. Check tie rods and drag link ends for looseness.
6. Check king pins for looseness.
7. Check if the length of the torque rod is 21 17/64" (540 mm) (Fig. 17). Check if the length of the relay rod is 23 19/64" (592 mm)

7.3 FRONT WHEEL CAMBER

Positive camber is the outward inclination of the wheels at the top, negative or reverse camber is the inward inclination of the wheels at the top. Camber variations may be caused by wear at the wheel bearings, wheel spindle bushings, or bent suspension parts.

Check camber, with an accurate gauge. If camber is incorrect, check suspension parts for wear and replace worn parts. If wear is not perceptible, suspension parts may be bent or lower suspension arm may be improperly shimmed.

Check King pin inclination. If King pin inclination is incorrect, readjust the camber and check king pin inclination again.

Note: *Camber is more important than king pin inclination, so adjust camber and verify king pin inclination.*

Shim the lower suspension arm to adjust camber. If the king pin inclination is incorrect, the wheel king pin assembly may be bent and therefore should be replaced.

Excessive positive camber results in irregular wear of the tires at the outer shoulders. Negative or reverse camber causes wear at the inner shoulders.

Note: *Shim only the lower suspension arm to adjust the front wheel camber.*

7.4 FRONT WHEEL TOE-IN

Toe-in is measured from the center of the tire treads. Measurements at the front and rear of the tires must be made at the same height from the floor. Incorrect toe-in results in excessive tire wear and steering instability with a tendency to wander.

7.4.1 Toe-In Check

1. Check the camber adjustment and adjust if necessary.
2. Hoist the front of the vehicle and spin the wheels marking the centerline of the tire treads.
3. Place the wheels in the straight ahead position and lower the vehicle to rest on the floor.
4. Roll the vehicle ahead several feet. This removes any slack caused by looseness in the wheel bearings or steering connections.
5. Check the distance between the tire centerlines at the front and rear of the front tires. These two measurements must be made at the same height above the floor. The front measurement must be 3/32 ±1/32 of an inch less than the rear measurement.

7.4.2 Toe-In Adjustment

1. Loosen the tie rod clamp bolts.
2. Using a pipe wrench, turn the tie rod tubes to obtain the toe-in measurement specified in step 5 under paragraph "6.4.1 Toe-in Check" of this Supplement.
3. Tighten the tie rod clamp bolts and recheck toe-in.
4. Check that the angular relationship of the pitman arm to the steering gear is as shown in figure 8.

Note: *Use only tie rods to adjust toe-in.*

7.5 FRONT AXLE CASTER

Positive caster is the inclination of the top of the king pins toward the rear of the vehicle. Negative or reverse caster is the inclination of the king pins toward the front of the vehicle. This vehicle is designed with positive caster. The purpose of caster is to provide steering stability by keeping the wheels in a straight ahead position.

Caster variations may be caused by bent upper suspension arm, lower suspension arm, or king pin housing. Caster should be adjusted with shims. Precision instruments should be used to measure caster. Shim bell crank and idler arm to adjust caster.

Variations from the specified caster will affect steering stability, cause wandering, wheel shimmy, and reduce returnability when pulling out of curves.

7.6 MAJOR DAMAGE

If the suspension has sustained major damage, it may be necessary to shim the bell crank and the idler arm to avoid the bump steer or roll steer. Moreover refer to paragraph "6. Front End Alignment".

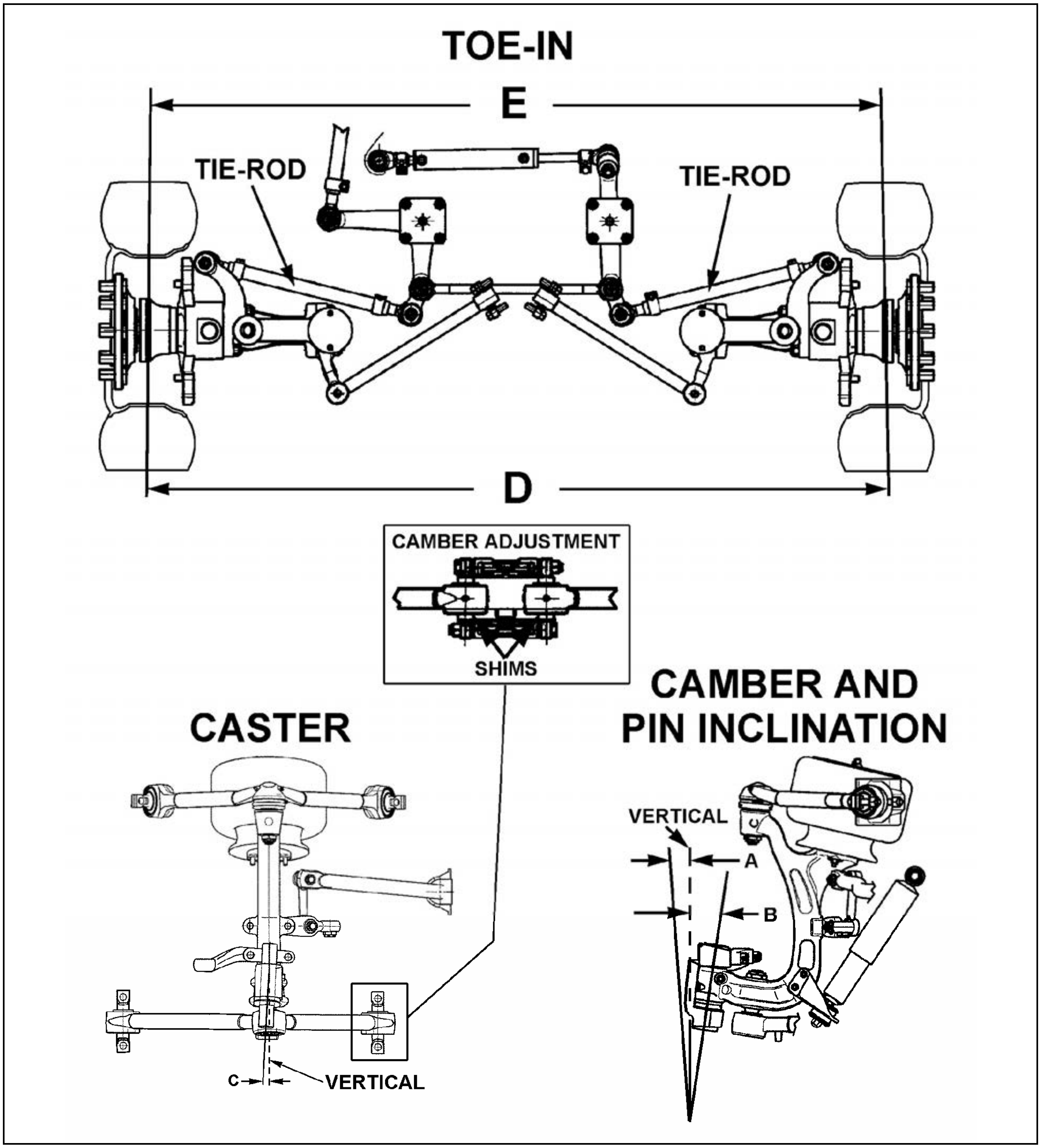


FIGURE 21: FRONT END ALIGNMENT DIAGRAM 16133

ALIGNMENT SPECS (See Figure 20)			
	Minimal	Nominal	Maximal

Load		Non-converted	Converted	Non-converted	Converted	Non-converted	Converted
A	WHEEL CAMBER	0.2	-0.150	0.35	0.0	0.55	0.200
B	KING PIN INCLINATION	8° (not adjustable)					
C	CASTER	2.55		2.8		3.05	
D-E	TOE-IN	0.08		0.13		0.17	

8. FRONT AIR SPRINGS

Two *"rolling lobe"* type air springs are used with the independent front suspension, one at each wheel. These air springs are special and use the complete piston as an extra reservoir to lower the spring stiffness. Front air springs are attached to the subframe and to uprights.

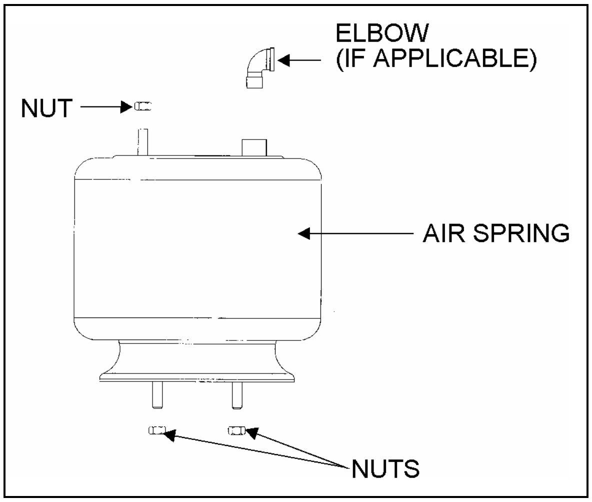


FIGURE 22: AIR SPRINGS 16052

8.1 INSPECTION

1. Check operation of bellows.
2. Visually inspect bellows for evidence of cracks, punctures, deterioration, or chafing. Replace the bellows if damage is evident.
3. With the primary air system at normal operating pressure (95 - 125 psi (655 - 860 kPa)), coat all suspension air line connections and bellow mounting areas with a water and soap solution. Bubbles will indicate an air leak, and none is permissible. Repair or replace defective parts.

Note: *If air spring is removed from vehicle, bellows can be lightly inflated and submerged in water to detect any leakage. If leakage is detected, replace bellows.*

Warning: *To prevent personal injury, do not apply more than 10 psi (69 kPa) air pressure to the unmounted air spring.*

8.2 REMOVAL

Note: *Front air springs can be removed without removing the entire suspension assembly.*

1. Safely support vehicle at the recommended body jacking points and jack up body understructure.
2. To gain access to a given air spring, the corresponding wheel can be removed.

Caution: *Only the recommended jacking points must be used as outlined in Section 18, "Body" in the maintenance manual.*

3. Support the assembly with a suitable jack.
4. Exhaust compressed air from accessory air tank by opening drain cock under reservoir.
5. Disconnect the height control valve link and pull down the overtravel lever to ensure all air is exhausted from air springs.

Note: *While performing this step, do not change the height control valve overtravel lever adjustment.*

6. Disconnect air line from air spring, remove elbow (if applicable), and cover both the line end and fitting to prevent the entry of foreign matter.
7. Remove the air spring upper nut, and then the two lower nuts. Remove air spring and remove the back up plate from the top of the air spring.

8.3 INSTALLATION

Note: *To facilitate air spring installation, compress it manually then put a piece of tape over the air line threaded fitting. This prevents air from getting back into the bag and keeps it compressed, thus enabling to place the bag in between the mounting plates and greatly easing installation.*

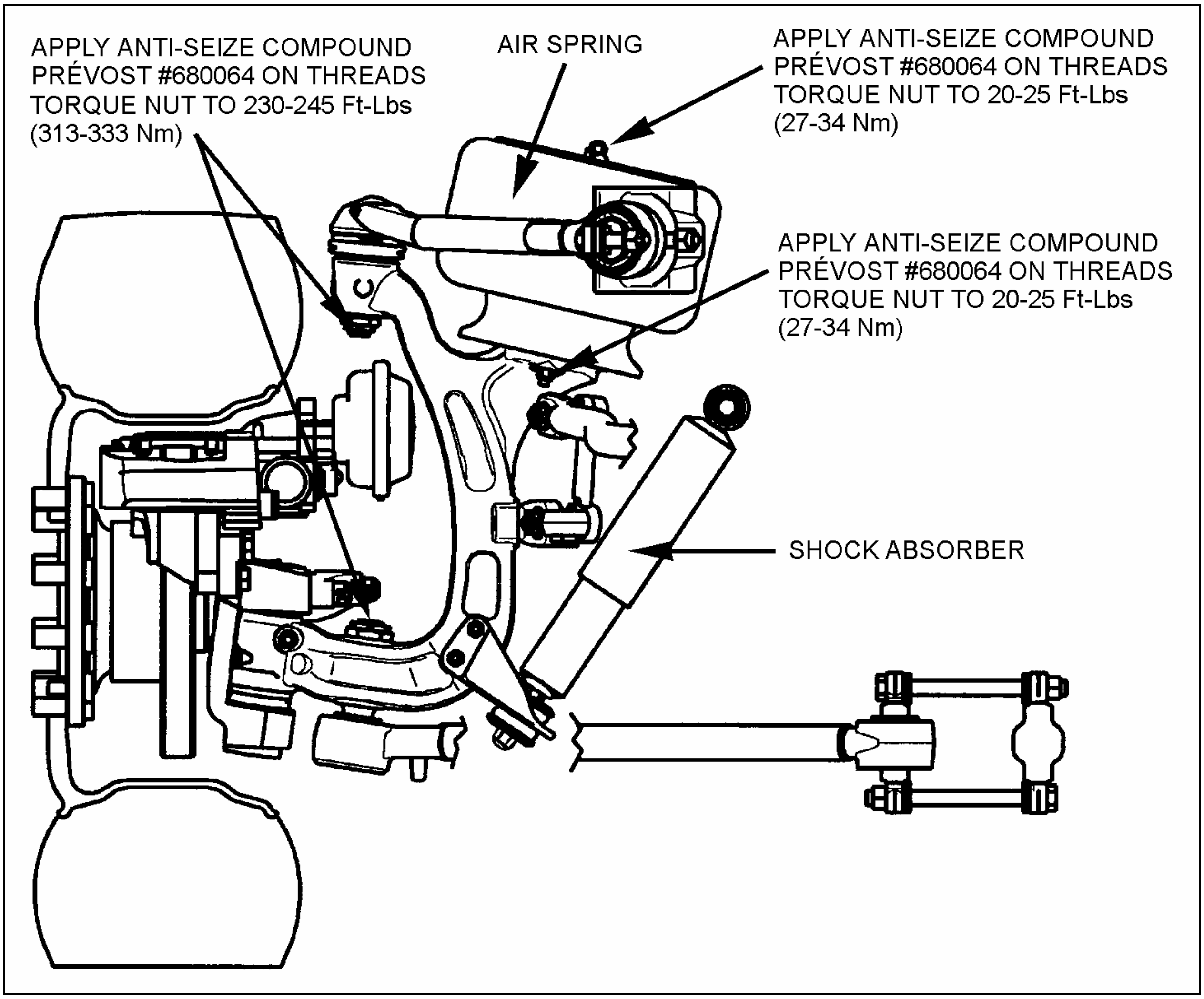


FIGURE 23: AIR SPRING AND SHOCK ABSORBER 16129

1. Compress air spring as necessary, then aligning studs with their holes, position air spring between both the lower and upper supports. Thread the lower nuts and the small upper nut a few turns.
2. Tighten and torque the lower stud nuts, and then the upper nut to 20-25 Ft-lbs (27–34 Nm).
3. Install elbow (if applicable), then connect air line.
4. Connect the height control valve link.
5. Build up air pressure in system.

Note: *To accelerate this operation, air reservoirs can be filled from an exterior air supply connected to the accessory tank fill valve or to the emergency fill valve.*

6. Check operation of bellows, and with the primary air system at normal operating pressure (95 - 125 psi (655 - 860 kPa)), coat the air line connections and air spring mounting areas with a water and soap solution. Bubbles will indicate an air leak, and none is permissible. Repair or replace defective parts.
7. Remove the hydraulic floor jack from underneath shock absorber bracket.

9. SHOCK ABSORBERS

The two front shock absorbers are double-acting and telescopic type. Shock absorbers ensure a smooth ride and enhance vehicle stability on the road. Front shock absorbers have eye-type mountings on the upper side and bayonet type on lower side. Shock absorbers are non-adjustable and non-repairable.

Caution: *When a shock absorber is found defective, always replace with a new set on affected axle, except if there has been a recent replacement of one unit. The following method will help in determining if both shock absorbers on the same axle have to be replaced.*

9.1 SHOCK ABSORBER REMOVAL

1. Remove the nut, washer and rubber joint from shock absorber mounting stud. Discard the rubber joints.
2. Remove the nut and washer from shock absorber mounting pin (upper side), taking care to identify the inner and outer washers to ease reinstallation. Refer to figure 23 for details.
3. Remove the shock absorber from the vehicle.
4. Remove inner: washers, rubber joint and bushings from the shock absorber. Discard bushings and rubber joint.

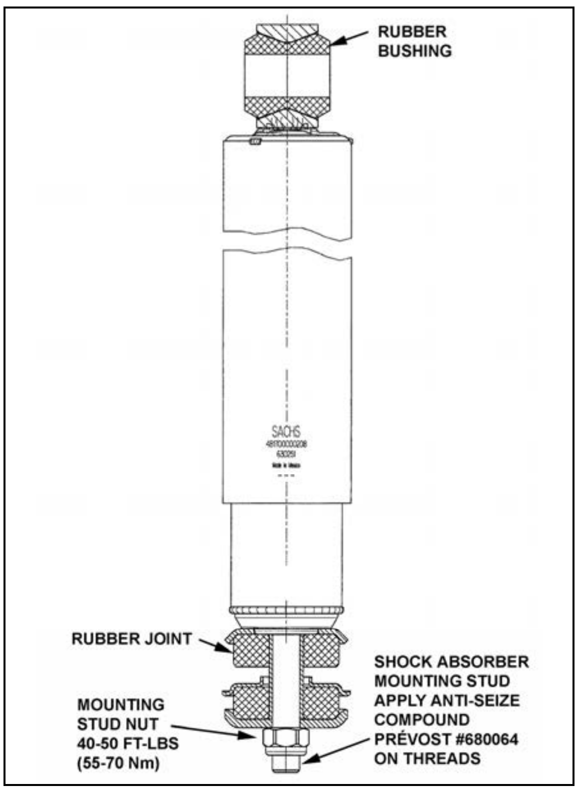


FIGURE 24: SHOCK ABSORBER 16112

9.2 SHOCK ABSORBER INSTALLATION

1. Check that the shock absorber mounting pin torque is proper (350-400 Ft-lbs (475-545 Nm)). Ensure that the stud is clean and not stripped (upper side).
2. Install new rubber (mounting) bushing on shock absorber (upper side).
3. Place the inner washer on shock absorber pin (Fig. 23).
4. Install washer and rubber joint on shock absorber mounting stud (lower side).
5. Install the shock absorber as shown in figure 18 with the mounting stud protruding through the hole in the mounting bracket and the shock absorber eyes over the mounting pins. Install the outer washer.
6. Place a rubber joint and washer on the shock absorber mounting stud. Place the lower shock absorber mounting stud nut and torque to 40-50 Ft-lbs (54–68 Nm).
7. Place the upper mounting pin stud nut and torque to 70-85 Ft-lbs (95–116 Nm).

10. SWAY BAR

A sway bar is provided on the front and drive axles to increase vehicle stability. It controls lateral motion (swaying movement) of vehicle.

10.1 REMOVAL

1. Disconnect the two links from sway bar.
2. Safely support the sway bar. Unbolt bushing collars from subframe.
3. Remove sway bar.

Note: *Sway bar bushings are slit to ease their removal.*

10.2 INSTALLATION

1. Loosely install the sway bar.
2. Torque bushing collar nuts to 60 Ft-lbs (82 Nm).
3. Torque sway bar link upper nuts to 120-140 Ft-lbs (163-190 Nm) on front suspension and to 100-120 Ft-lbs (136-163 Nm) on rear suspension.
4. Torque sway bar link lower nuts to 120-140 Ft-lbs (163-190 Nm) on front suspension and to 70-80 Ft-Lbs (95-110 Nm) on rear suspension.

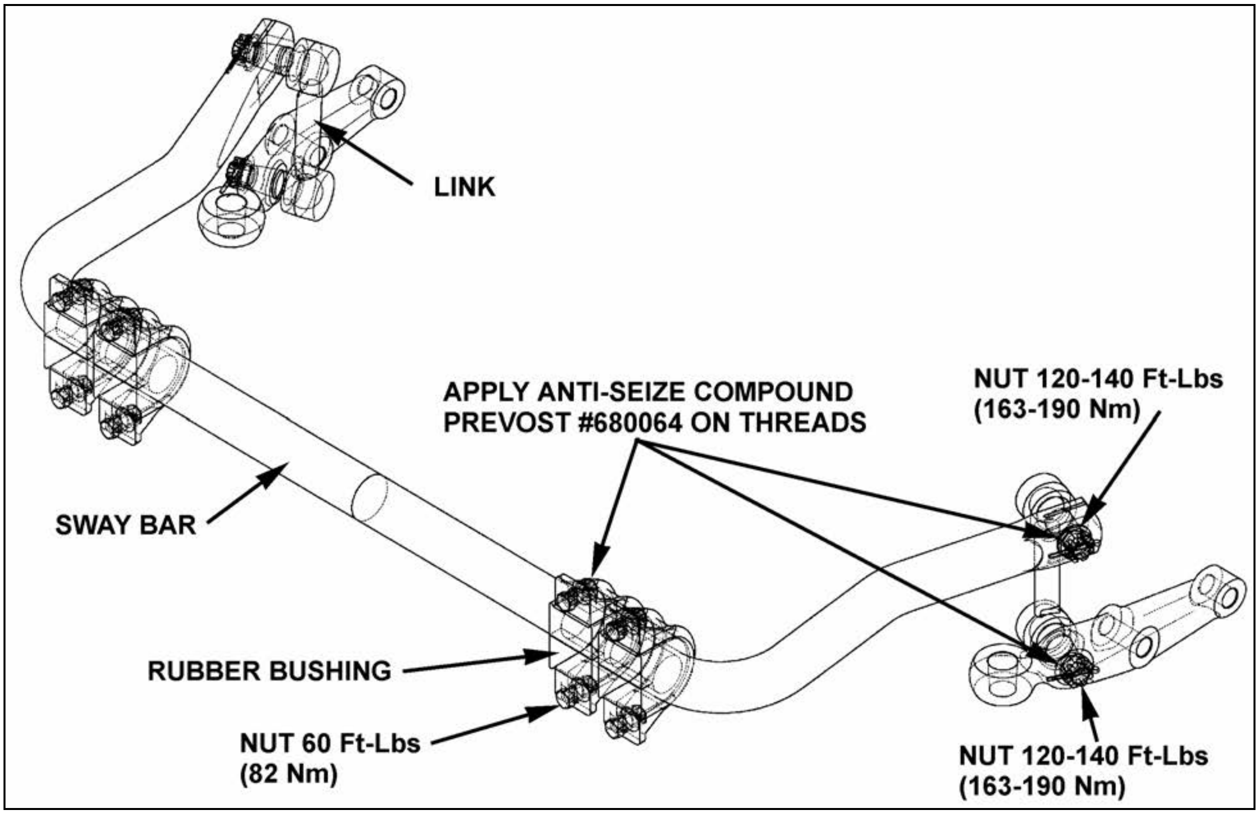


FIGURE 25: SWAY BAR (FRONT SUSPENSION) 16055

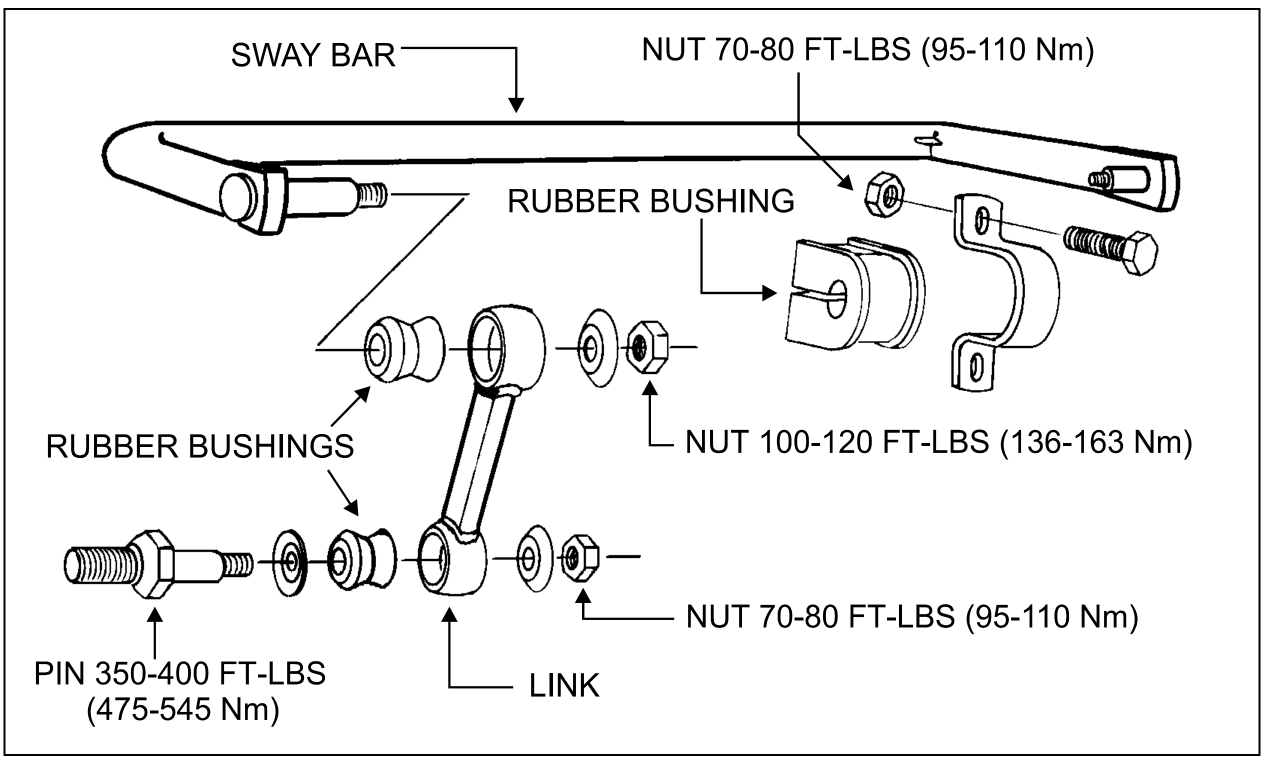


FIGURE 26: SWAY BAR (REAR SUSPENSION) 16014

11. INDEPENDENT FRONT SUSPENSION ADJUSTMENT

Converted coach shells are equipped with "LEVEL-LOW" leveling system. The purpose of the "LEVEL-LOW" is to adjust suspension in three separate points (front, rear right and rear left air springs) in order to level vehicle body. Three height control valves, automatically control air pressure in the three separate points (air springs) and maintains a constant vehicle height regardless of load, or load distribution. The control solenoid valve supplies air to the five way three-position air control valve, which bypasses the height control valve, and opens a passage to allow the air control and exhaust valve to release/supply air from airs springs. To improve road comfort, an expansion air tank is installed in series with each air springs.

In addition to the above suspension components the system also includes: sway bar, upper and lower suspensions, bars and shock absorbers (Fig. 1).

Note: *Only for preliminary adjustment, refer to figure 16. Torque rod length must be fixed to 21 17/64" (540 mm) and relay rod to 23 19/64" (592 mm).*

Caution: *Parts must be replaced by ones with the same part numbers or with equivalent parts, if replacement becomes necessary. Do not use parts of lesser quality or substitute design. Torque values must be used as specified during reassembly to assure proper retention of these parts.*

12. SUSPENSION HEIGHT ADJUSTMENT

The flow of pressurized air from the accessory air tank to the air springs is controlled by three height control valves. The two rear valves are mounted to the subframe and connected to the rear axles through an arm and link connection. The front valve is mounted to the subframe and connected to the front air tank support (Fig. 24). These connections allow the valves to apportion air pressure in the springs to the vehicle load, maintaining normal ride height.

Immediate response height control valves increase or decrease the air pressure in the suspension system as required. One height control valve is located **at center of front sway bar**, and regulates air to front suspension air springs in order to maintain the vehicle at the required height. Two are located at the drive axle, one on each inner side of rear wheelhousing.

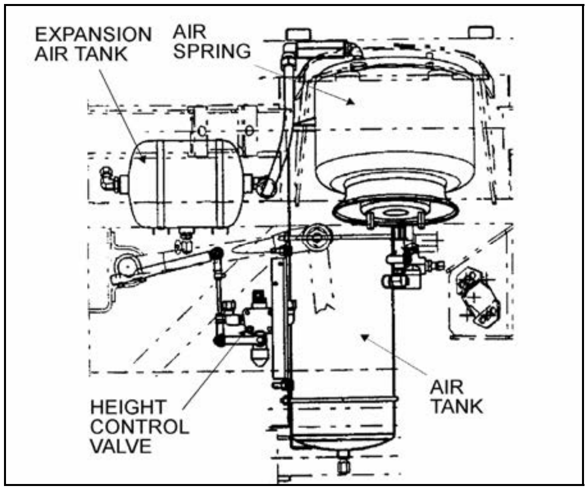


FIGURE 27: HEIGHT CONTROL VALVE LOCATION 16057

The appropriate vehicle body height is obtained by measuring the clearance of all the air springs installed on the vehicle. The two front air springs clearance should be 11 ± ¼" (279 ± 6 mm). Refer to figure 24 to identify the correct area to take measurement. The rear air springs clearance should be 11 ½ ± ¼" (292 ± 6 mm) (refer to Maintenance Manual, Section 16, under "Suspension Height Adjustment" for rear height control valves' adjustment). At this point, it should not be necessary to make an adjustment under normal service conditions. However, if an adjustment is required, change the position of the overtravel lever in relation to the overtravel control body. The lever should be moved up to raise vehicle height, and down to lower it. Check that main air pressure is at normal operating pressure and raise the vehicle to the specified height.

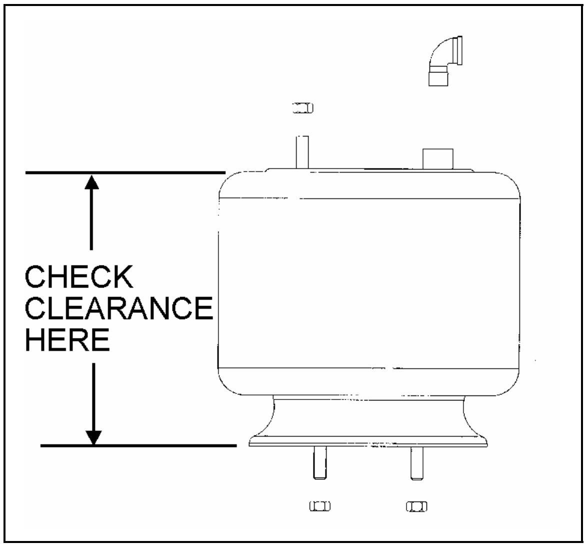


FIGURE 28: TYPICAL AIR SPRING CLEARANCE 16058

Caution: *Always adjust on "fill cycle". If it is necessary to lower vehicle height, release sufficient air to be well below height, and adjust to height or fill cycle.*

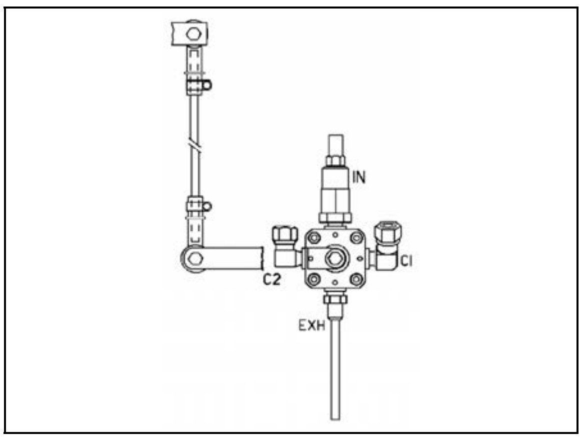


FIGURE 29: FRONT HEIGHT CONTROL VALVE 16100

The normal ride height is obtained by adjusting air spring clearance of both front and rear suspension as follows:

Front air spring clearance

1. With the vehicle at normal operating air pressure (100 - 125 psi (689 - 860 kPa)), measure air spring clearance. This clearance should be 11 ± ¼" (279 ± 6 mm).

Note: *The measurement should be taken from underneath the upper air spring support on subframe to top of the lower air spring support on axle (refer to figure 27 for more details). If adjustment is required, begin with the drive axle.*

2. Loosen the clamp on the height control valve rubber coupling and bring it up or down (Fig. 28).

Note: *Allow suspension to stabilize before taking reading.*

When the desired height is obtained, tighten clamp.

Rear air springs clearance

Refer to XL2 Maintenance Manual, Section 16, under "Suspension Height Adjustment".

13. HEIGHT CONTROL VALVE

The height control valves automatically add air to, or release air from air springs to maintain constant suspension height regardless of load, or load distribution. Each valve adjusts independently according to the following conditions:

13.1 LOADING POSITION

As the load increases and lowers the vehicle body, the overtravel lever commands the height control valve to add air to air springs.

13.2 NEUTRAL POSITION

When vehicle body reaches the normal ride height, the height control valve overtravel lever reaches the "neutral" position and keeps both the supply and exhaust ports closed to ensure normal ride height is maintained. This condition remains static until the vehicle load is altered.

13.3 UNLOADING POSITION

As the load decreases and raises the vehicle body, the overtravel lever commands the height control valve to release air from air springs.

13.4 MAINTENANCE

The height control valve requires no periodic maintenance. Height control valve linkage operates on rubber bushings and no lubrication should be attempted at this location. Inspect the valve for loose joints, air leaks and worn bushings.

13.5 REMOVAL AND INSTALLATION

Before disconnecting a height control valve air line, securely support the vehicle by its jacking points on the body, and place safety supports underneath body. Refer to paragraph *"16. Vehicle Jacking Points"* in Section 18, *"Body"*.

1. Exhaust air from air system by opening all air tank drain cocks. Remove height control valves.
2. Disconnect overtravel lever from link and pull down lever to exhaust remaining air from air springs.
3. Disconnect air supply and delivery lines from the height control valve. Cover line ends with tape to prevent entry of foreign matter.
4. Remove the nuts retaining the height control valve to the mounting bracket, then remove valve assembly.

Reverse removal procedure to replace height control valve. After installation, check for leakage using a soap and water solution.

14. "LEVEL-LOW" LEVELING SYSTEM

The purpose of the *"level-low"* leveling system is to adjust suspension in three separate points (front, rear right and rear left) in order to level vehicle body. This system can be put into service when the ignition key is turned to the *"ON"* position, and must be used only when the parking brake is applied. The *"level-low"* warning light on the dashboard indicates that the selector switch is not in the *"OFF"* position. Level low system controls are located on L.H. side control panel.

14.1 PRINCIPLES OF OPERATION

DOWN:

The (front/rear right/rear left) control solenoid valve supplies air to the (front/rear right/rear left) five-way three-position air control valve, which bypasses the (front/rear right/rear left) height control valve, and opens a passage to allow the air control and exhaust valve to release air from (front/rear right/rear left) air springs.

UP:

The (front/rear right/rear left) control solenoid valve supplies air to the (front/rear right/rear left) five-way three-position air control valve, which bypasses the (front/rear right/rear left) height control valve, and opens a passage to allow the air control and exhaust valve to supply air to (front/rear right/rear left) air springs.

DRIVE:

When the ignition key is turned to the *"ON"* position with selector knob in the *"DRIVE"* position, the drive control solenoid valve supplies air to all five-way three-position air control valves, each one opening a passage to allow height control valves to accomplish their function.

When the ignition key is turned to the *"OFF"* position and selector knob to the *"DRIVE"* position, the air is entrapped between air springs and five-way three-position air control valves to ensure the adjusted level will be kept.

Warning: *Never move vehicle with selector knob in any other position than the "DRIVE" position.*

14.2 MAINTENANCE

Since the kneeling action is issued from both the air system and electrical system, refer to Section: 12, *"Brake and Air System"* and Section 06, *"Electrical System*".

For diagnosis and understanding of the system, refer to wiring diagrams, and to the appropriate air system schematic diagram annexed to Section 12, *"Brake and Air System"*.

15. AIR SYSTEM

The basic air system consists of an air compressor, tanks, valves, filters and interconnecting lines and hoses (refer to Section 12, "Brake and Air System" for complete information). It provides a means for braking, operating controls and accessories, and suspension. An air system schematic diagram is annexed at the end of this supplement for better understanding of the system.

The air coming from the air dryer is first directed to the wet air tank, then to the primary (for the primary brake system), secondary (for the secondary brake system), and accessory (for the pneumatic accessories) air tanks (Fig. 27).

In addition, an expansion air tank is installed in series with each air spring.

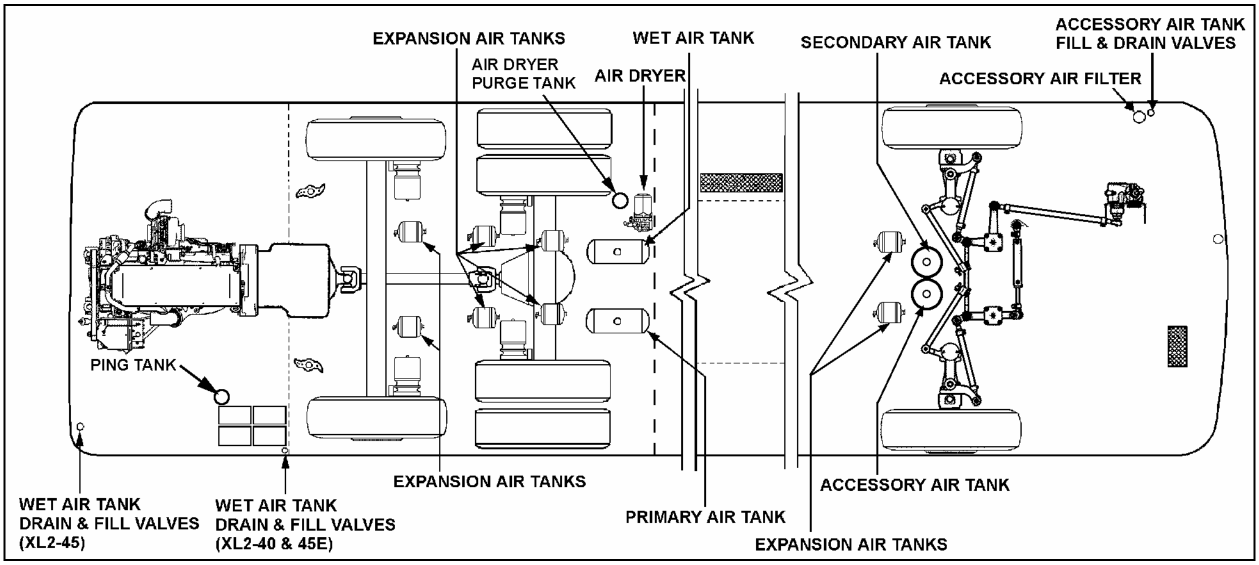


FIGURE 30: LOCATION OF AIR TANKS 24007

15.1 AIR TANK MAINTENANCE

Ensure that the accessory air tank is purged during pre-starting inspection. A good practice is to purge this tank at the end of every driving day by the remote air tank drain valve located in the steering compartment (Fig. 29).

Moreover, purge all tanks by their bottom drain valves at specified intervals.

15.1.1 Wet Air Tank

This tank is installed above L.H. wheel of drive axle, and is provided with a bottom drain valve. It is recommended to **purge** the wet air tank by its bottom drain valve every 12,500 miles (20 000 km), or once a year, whichever comes first.

A remote valve located in engine compartment and accessible through engine R.H. side door is used to **drain** the air dryer (Fig. 30).

15.1.2 Primary Air Tank

The primary air tank is located above R.H. wheel of drive axle.

This tank is provided with a bottom drain valve (Fig. 29). It is recommended to purge the primary air tank by its bottom drain valve every 12,500 miles (20 000 km) or once a year, whichever comes first.

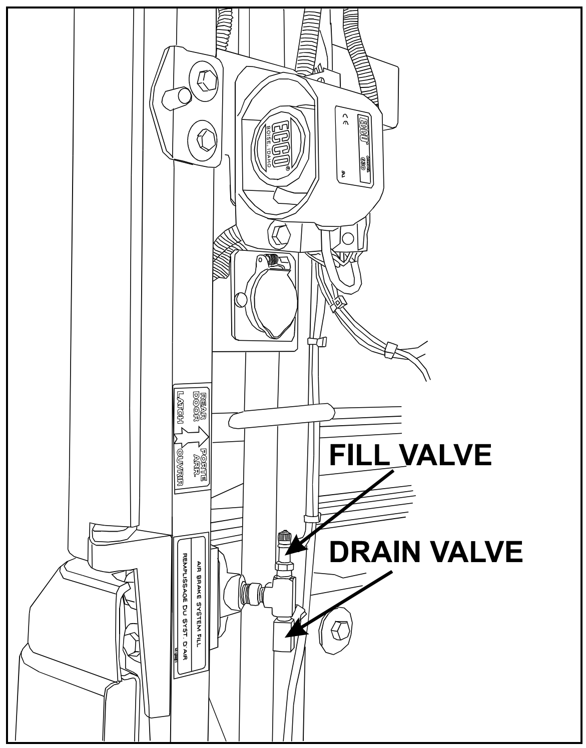


FIGURE 31: REAR VALVE LOCATION 12202

15.1.3 Secondary Air Tank

This tank is located in front wheelhousing, between air springs. The tank is installed vertically and is provided with a bottom drain valve (Fig. 29).

It is recommended to purge the tank by its bottom drain valve, every 12,500 miles (20 000 km) or once a year, whichever comes first.

15.1.4 Accessory Air Tank

The accessory air tank is installed next to the secondary air tank. The tank is installed vertically and is provided with a bottom drain valve (Fig. 29).

It is recommended to purge the tank by its bottom drain valve, every 12,500 miles (20 000 km) or once a year, whichever comes first.

A remote drain valve is located in front service compartment (Fig. 31) underneath the accessory air filter. Refer to Section 12, paragraph "4. Accessory Air Filter" of the maintenance manual for daily purge procedure.

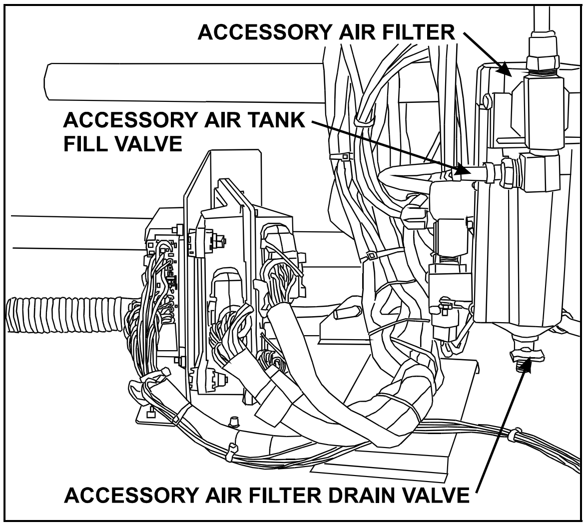


FIGURE 32: FRONT VALVE LOCATION 12201

15.1.5 Expansion Air Tank

Two expansion tanks are located in front wheelhousing. These air tanks are located behind secondary and accessory air tank. Also, six expansion tanks are located near rear air springs (Fig. 29). Expansion tanks are connected in series with air springs. Expansion tanks are used to lower the stiffness of the air spring. They are provided with a bottom drain valve.

It is recommended to purge them, with all other tanks, every 12,500 miles (20 000 km) or once a year, whichever comes first.

15.2 EMERGENCY FILL VALVES

The vehicle is equipped with two air system emergency fill valves to supplement the air system when air pressure is low and engine cannot be operated.

The rear valve is located in engine compartment and accessible from engine R.H. side door (Fig. 30).

Caution: *No other point should be used to supply air system. The maximum allowable air pressure is 125 psi (860 kPa).*

The front valve is located in the front service compartment close to accessory air filter (Fig. 31).

These two air valves are fitted with the same valve stems as standard tires, and can be filled by any standard external air supply line.

The rear valve will supply air for all systems (brakes, suspension and accessories) while the front valve will supply air for accessories only.

Caution: *Air filled through these two points will pass through the standard air filtering system provided by Prévost. Do not fill air through any other points.*

16. HUB UNIT AND SWIVEL ASSEMBLY

Refer to “DANA SPICER Service Manual General Information, Maintenance Manual Model NDS and Maintenance Manual NDS Axles” annexed to section 10 *"Front Axle".*

17. TORQUE TABLE

DESCRIPTION	*QTY*	*REFERENCE*	*TORQUE (DRY) Ft-Lbs / Nm*	
Pitman Arm to Steering Gear Fixing Nut	*1*	*8*	*400-450*	*545-610*
*Drag Link to Pitman Arm Stud Nut***	*1*	*---*	*160-215*	*220-290*
*Drag Link to Bell crank Stud Nut***	*1*	*---*	*160-215*	*220-290*
Drag Link Socket End Clamp Bolt Nut	*2*	*---*	*40-60*	*55-80*
*Relay Rod to Bell crank Stud Nut***	*1*	*---*	*160-215*	*220-290*
*Relay Rod to Idler Arm Stud Nut***	*1*	*5*	*160-215*	*220-290*
*Tie Rod to Bell crank Stud Nut***	*1*	*---*	*160-215*	*220-290*
*Tie Rod to Idler Arm Stud Nut***	*1*	*5*	*160-215*	*220-290*
*Tie Rod to Steering Arm Stud Nut***	*2*	*3*	*160-215*	*220-290*
Tie Rod End Clamp Bolt Nut	*4*	*3*	*40-60*	*55-80*
*Steering Arm to Swivel Nut***	*4*	*---*	*190*	*260*
Torque Rod Stud Nut	*2*	*4*	*160-215*	*220-290*
Idler Arm and Bell Crank Cap Screws	*8*	*9*	*8*	*11*
Torque Rod Mounting Bracket Nut	*4*	*6*	*75-140*	*100-190*
Torque Rod Clamp Nut	*4*	*4*	*53-59*	*72-80*
Jacking Point Bracket Nut	*8*	*19*	*70-80*	*95-110*
Bushing Collar Nut	*8*	*20*	*72-88*	*98-120*
Sway Bar Link Upper Nuts (Rear Suspension)	*2*	*20*	*100-120*	*135-160*
Sway Bar Link Lower Nuts (Rear Suspension)	*2*	*20*	*70-80*	*95-110*

DESCRIPTION	*QTY*	*REFERENCE*	*TORQUE (Lubricated) (Anti-Seize #680064) Ft-Lbs / Nm*	
Idler Arm and Bell Crank Mounting Bracket Nut	*8*	*5*	*90-120*	*120-160*
Shock Absorber Mounting Stud Nut	*2*	*19*	*40-50*	*55-70*
Shock Absorber Pin Nut	*2*	*19*	*70-85*	*95-115*
Air Spring Nut	*3*	*18*	*20-25*	*27-34*
Sway Bar Link Upper and Lower Nuts (Front Suspension)	*2*	*20*	*120-140*	*160-190*
*Upper A-Arm Stud Nut***	*2*	*18*	*230-245*	*315-335*
Lower A-Arm Bracket Nut	*8*	*18*	*375-425*	*510-580*

DESCRIPTION	*QTY*	*REFERENCE*	*TORQUE (Lubricated) (Loctite #242 Blue) Ft-Lbs / Nm*	
Shock Absorber Pin	*2*	*19*	*350-400*	*475-545*
Steering Gear to Mounting Bracket Bolt	*5*	*8*	*355*	*485*

- **Tighten nut to specified torque, then advance to next aligning cotter pin slot and install a new cotter pin.**

18. SPECIFICATIONS

Front Axle Air Springs

Make .... Goodyear Tire and Rubber
Diameter .... 14.5 inches
Air Inlet........ 1/2’’- 14 NPTF
Supplier number 1R14-167
Prévost number 630239

Shock Absorbers

Collapsed length .... 350 mm
Extended Length .... 560 mm
Supplier number 481700000208
Prévost number 630251

Height Control Valve

Make .... Barksdale
Supplier number .... 52321POAQ3-Q26 and 52321POAQ3-Q62
Prévost number .... 630156 and 630157

Steering Gear Box

Make .... ZF-Servocom
Supplier number 8098-988-570
Prévost number 661045

Steering Gear Box (Optional)

Make .... ZF-Servocomtronic
Supplier number 8098-988-571
Prévost number 661044

Power Steering Hydraulic Pump

Make .... TRW
Supplier number PS251616L10200
Prévost number 661070

Power Steering Hydraulic Cylinder

Make .... Hyco
Supplier number 007-0300-0
Prévost number 661076

Shim (Camber Adjustment)

Thickness .... 3.175 mm
Prévost number 160993
Thickness .... 6.35 mm
Prévost number 160992

Sway bar bushing (Drive Axle)

Make .... Prévost
Prévost number 130953

SECTION 16: COACHES EQUIPPED WITH INDEPENDENT FRONT SUSPENSION (IFS)

CONTENTS

ILLUSTRATIONS

1. INTRODUCTION

This supplement contains service procedures and specifications that apply to the PREVOST coaches equipped with an independent front suspension.

This text contains information unique to the independent suspension system. In the case you cannot find information on a subject in this supplement section, the information given in the regular sections of the Maintenance Manual will apply.

2. STEERING LINKAGE

Turning motion of the steering wheel is transferred by the steering gear and steering linkage to the steering arms at the right and left front wheels. The steering linkage consists of tie rods connected to the bell crank and the steering arm at the left side of the coach, and to the idler arm and steering arm at the right side of the coach. The bell crank and idler arm are connected by a relay rod. A drag link connected to the bell crank and the pitman arm, which is mounted to the steering gear, transfers the turning motion of the steering wheel to the steering arms (Fig. 1).

Lower and upper A-arms are widely spaced. They are mounted on ball joints. Torque rods prevent rotation of the uprights around the lower and upper ball joints.

If the steering linkage is bent, twisted or worn, steering action of the coach will be seriously affected. Any time steering linkage components are replaced or adjusted, steering geometry and front wheel alignment must be checked as explained in this section of supplement.

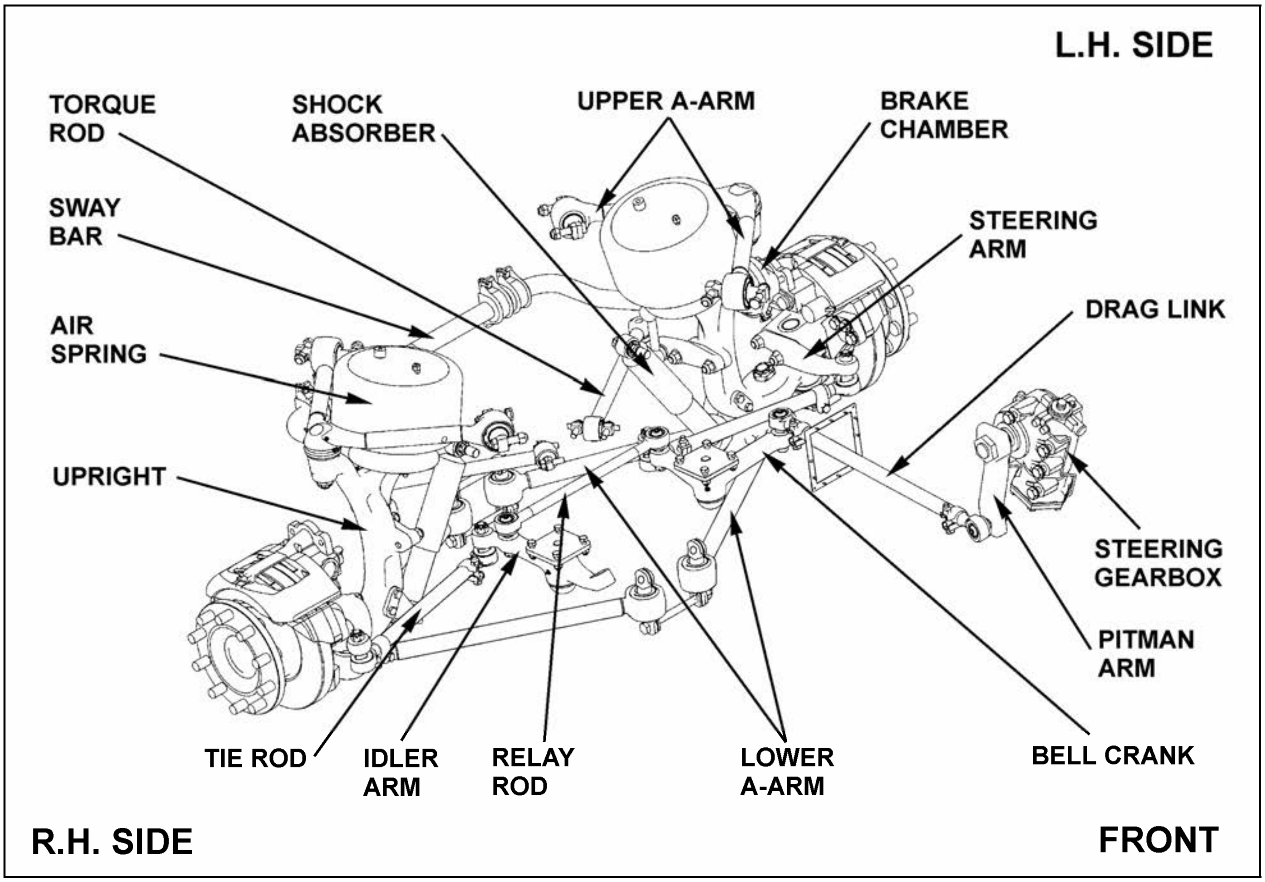


FIGURE 1: SUSPENSION AND STEERING LINKAGE 16125

Turning Angle

The maximum turning angle is set mechanically through the two steering stop screws installed on the swivel assembly. The turning angle (56° + 0° - 1°) mechanical stop is factory adjusted to accommodate the chassis design, and therefore, does not require adjustment on new vehicles.

However, turning angle should be checked and adjusted hydraulically, if necessary, any time a component of the steering system is repaired, disassembled or adjusted.

Before checking the turning angle, be sure the front end is properly aligned as described under paragraph "4. Front End Alignment" in this supplement.

To check steering maximum turning angle, proceed with the following method :

1. Check if front tires rub against the frame or if the steering gear has been serviced.

Caution: *If clamps are not correctly installed, they can interfere with other parts.*

2. For a full left and right turn, check clamps' position and for interfering parts. Refer to figures 2 to 6 for location and positioning of clamps. If readjustment is required, make the proper adjustment.

Note: Prior to steering limiter adjustment, verify vehicle wheel alignment, and ensure that oil level is adequate and that air bleeding is done.

3. If necessary readjust steering limiter. Refer to "ZF-SERVOCOM Repair Manual" annexed to XL2 Maintenance Manual, Section 14, "Steering", under heading: "Setting and Functional Test".

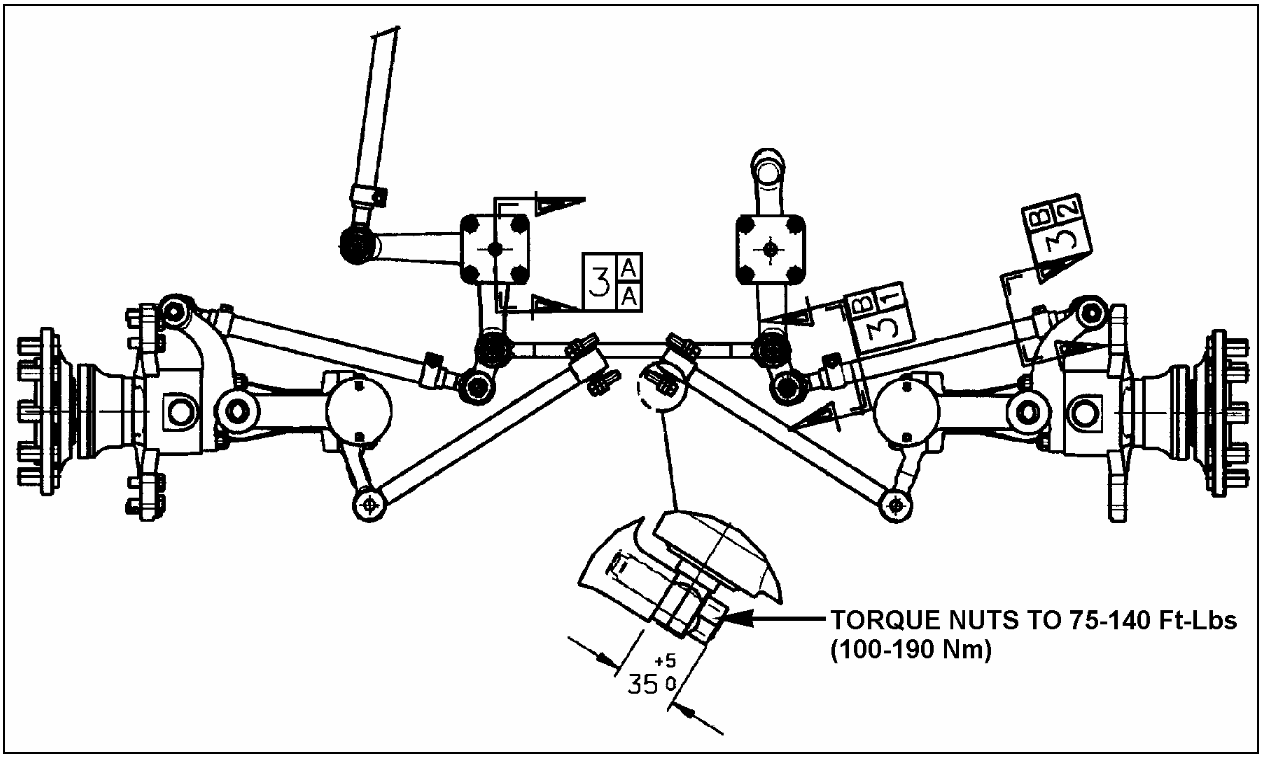


FIGURE 2: LOCATION OF CLAMPS 16127

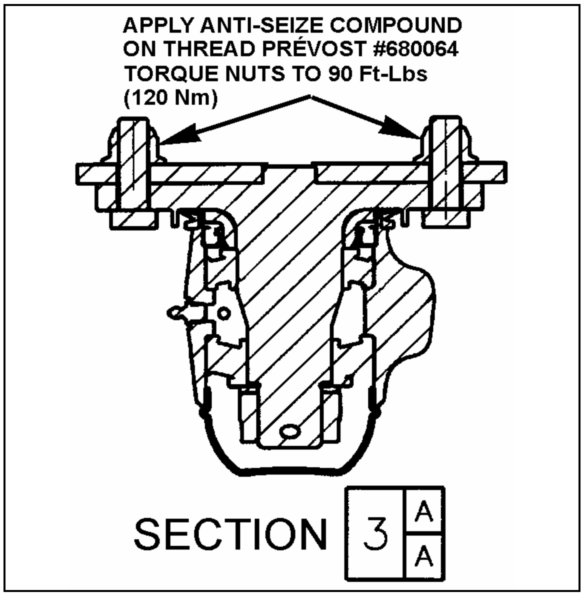


FIGURE 3: CLAMP POSITIONING 16128

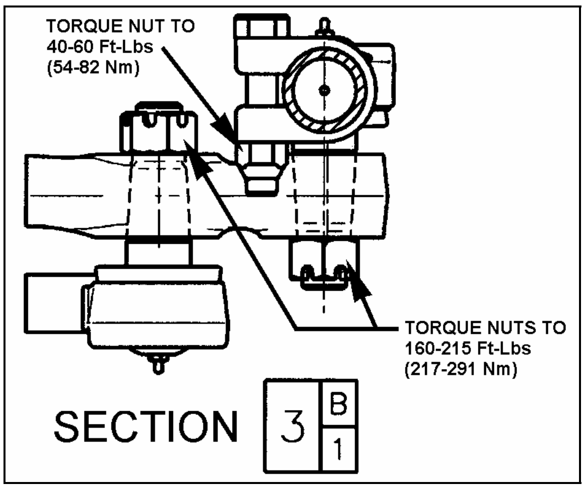


FIGURE 4: CLAMP POSITIONING 16120

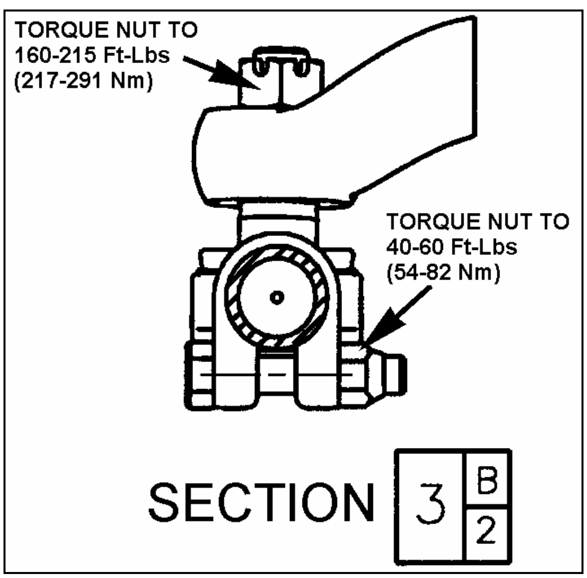


FIGURE 5: CLAMP POSITIONING 16123

2.1 POWER STEERING HYDRAULIC PUMP

Refer to the "TRW Power Steering Pump Service Manual" annexed at the end of Section 14.

2.2 STEERING LINKAGE ADJUSTMENT

Note: *Whenever a steering linkage component has been removed and replaced, check steering geometry and front end alignment as directed in this Supplement. Check to insure that all stud nuts and mounting bolts and nuts have been tightened to proper torques listed under "16. Torque Table" at the end of this supplement.*

1. First, align input shaft marks.
2. Afterwards, the pitman arm should be adjusted with reference mark aligned or to an angle of 90° in relation with the horizontal axis (Fig. 6).
3. Locate centerline of vehicle then install relay rod in boss at steering bell crank and idler arm. Align center of relay rod with centerline of vehicle.
4. Install drag link to pitman arm and adjust opposite end of drag link to fit mounting stud hole in bell crank.
5. Install tie rods, then adjust toe-in as per "Front End Alignment" in this Supplement.

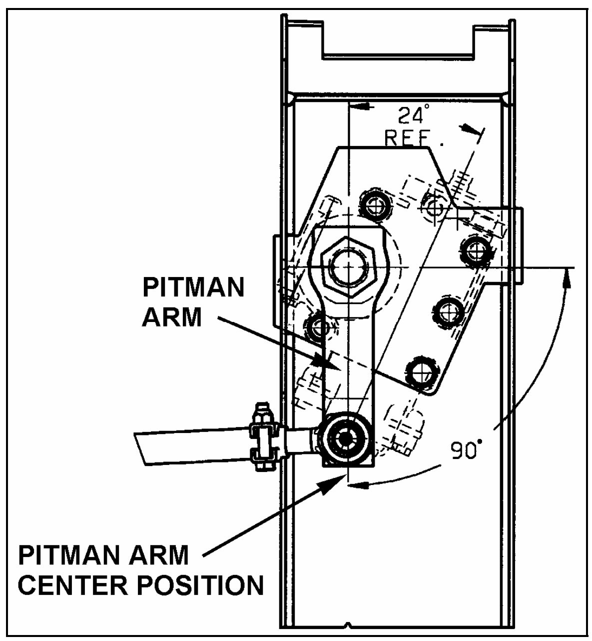


FIGURE 6: PITMAN ARM ALIGNMENT 14037

2.3 PITMAN ARM REMOVAL

1. Remove cotter pin, nut and washer from drag link ball stud at pitman arm.

2. Disconnect drag link from pitman arm, using jaw style pullers (pressure screw type).

Warning: *Always wear approved eye protection when operating pullers.*

Caution: *Do not drive pitman arm on or off pitman shaft as this can damage the steering gear.*

Caution: *Heating of components to aid in disassembly is not allowed because it has a detrimental effect on axle components and steering linkages.*

3. Remove pitman arm fixing nut.
4. Check the radial position of the pitman arm in relation to the sector shaft prior to removal of pitman arm.
5. Add reference marks to the arm and shaft if necessary to ensure correct alignment at reassembly.
6. Use a puller to remove pitman arm.

2.4 PITMAN ARM INSTALLATION

1. Position pitman arm on sector gear shaft with reference marks aligned.
2. Install fixing nut. Tighten nut to 400-450 Ft-lbs (545-610 Nm).

Note: *Use a new nut if the previously removed nut was punched.*

Caution: *Lock nut with sector shaft using a punch mark into the groove (Refer to figure 7).*

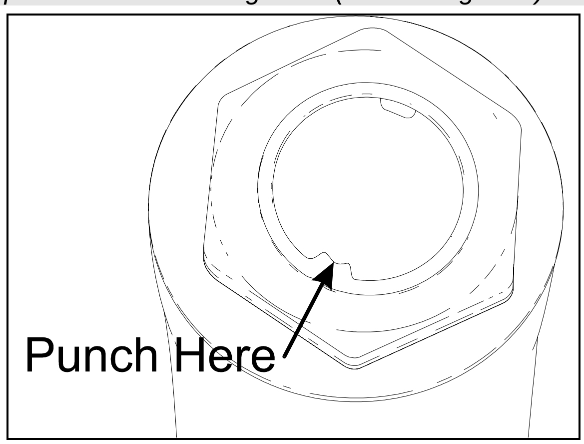


FIGURE 7: FIXING NUT PUNCH MARK 16098

3. Connect drag link to pitman arm. Install washers. Tighten nut to 160-215 Ft-lbs (220-290 Nm). Advance nut to next alignment cotter pin slot and install a new cotter pin.

2.5 DRAG LINK

Drag link assembly consist of three parts; a drag link and two end assemblies. Both end assemblies are identical and they are retained on the drag link with a clamp bolt and nut.

Stud nuts at the pitman arm and bell crank ends of the drag link must be kept tight or hole at ball stud end of drag link and hole in pitman arm may become enlarged as a result of excessive looseness. Subsequent tightening of stud nuts may draw studs too far into holes and dust cover parts may become damaged which can result in component failure.

Drag link end sockets are equipped with lubrication fittings and should be lubricated as directed in "Lubrication Fittings" in this supplement.

2.5.1 Adjustment

It should not be necessary to alter the length of the drag link except when a new link is installed or when removable end assembly has been replaced. If drag link adjustment is necessary, proceed as follows:

1. Position front wheels in straight ahead position.
2. Center steering gear as previously explained in paragraph "2.1 Steering Linkage Adjustment".
3. Remove cotter pin and stud from drag link at bell crank. Locate centerline of vehicle and center of relay rod. With center of relay rod aligned with centerline of vehicle, loosen clamp bolt at socket end (bell crank end) of drag link and adjust length of socket end assembly to fit in boss of bell crank.

Note: *Do not change position of pitman arm.*

4. Install stud nut and torque to 160 Ft-lbs (220 Nm). Align nut with cotter pin slot (tighten) and install a new cotter pin.
5. Torque mounting clamp bolt nut to 40-60 Ft-lbs (55-80 Nm), then test the adjustment. Front wheels should turn from right to left extremities without noticeable binding at drag link ends.

2.6 BELL CRANK AND IDLER ARM

Bell crank and idler arm are equipped with one lubrication fitting and should be lubricated as directed in paragraph "2.9 Lubrication Fittings" at the end of this Supplement.

2.6.1 Bell Crank and Idler Arm Removal

Note: *Use a piece of wire to anchor loosen end of relay rod and tie rod in order to prevent placing an excessive load on opposite socket end.*

Bell crank : Disconnect drag link, tie rod and relay rod from bell crank by removing cotter pins, stud nuts and washers from ball studs. Separate socket assemblies from the bell crank.

Idler arm : Remove cotter pins, nuts and washers from ball studs connecting relay rod and tie rod to idler arm. Separate socket assemblies from idler arm.

Remove nuts and washers from bolt attaching bell crank or idler arm mounting bracket to vehicle understructure. Remove bell crank or idler arm mounting bracket.

2.6.2 Bell crank or Idler Arm Ball Joint Disassembly

1. Remove adjacent link assemblies from bell crank or idler arm as previously described.
2. Remove the cap (Fig.10).
3. Remove the cotter pin, nut and tongue washer. Remove bearings, grease seal, bearing bushing and the bell crank or idler arm from its mounting bracket stud (Fig. 10).

2.6.3 Bell Crank or Idler Arm Ball Joint Reassembly

Note: *For bearing installation use tool Prévost # 110684.*

1. Install bearing bushing on bell crank or idler arm mounting bracket stud.
2. Install bearing and grease seal in bell crank or idler arm eye (Fig. 10).

Note : *Install grease seal according to figure 9. Grease must be able to exit the bell crank or idler arm mechanism. For grease seal installation use tool Prévost # 110683.*

3. Install bell crank or idler arm on its mounting bracket stud (Fig. 10).
4. Install bearing and nut.

Note: *Apply grease on bearing before installation.*

5. Firmly tighten nut (Fig. 8).

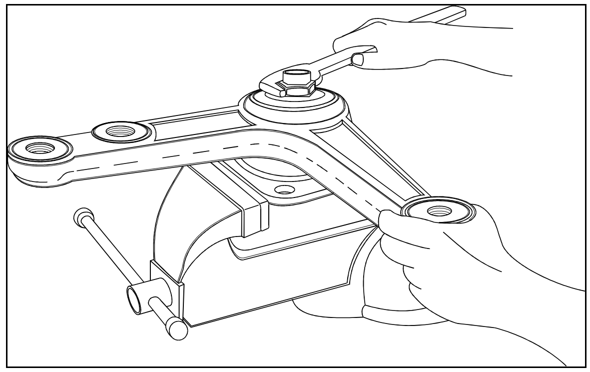


FIGURE 8: BELL CRANK 16044

6. Unscrew nut until bell crank or idler arm starts to turn by the application of 1 to 3 pounds load (Fig. 9).

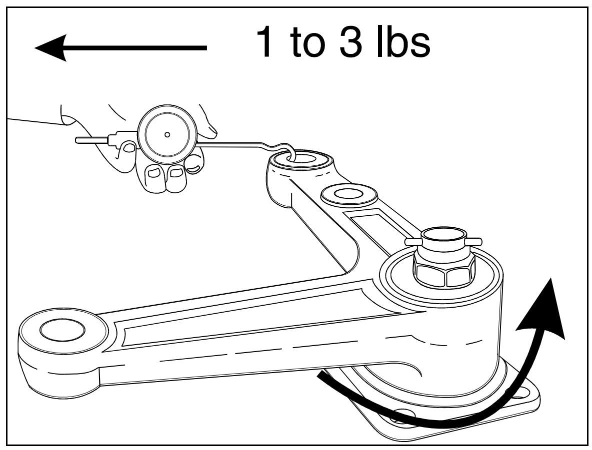


FIGURE 9: BELL CRANK 16045

7. Check for loose bearings by applying an up and down load on bell crank or idler lever (Fig. 10). The lever is not supposed to move in the vertical axis direction.
8. Align nut with cotter pin slot (tighten) and install a new cotter pin.

Note: *Bend cotter pin around the nut (Fig. 10). Do not bend the cotter pin in the direction of the cap, because it may interfere with the cap.*

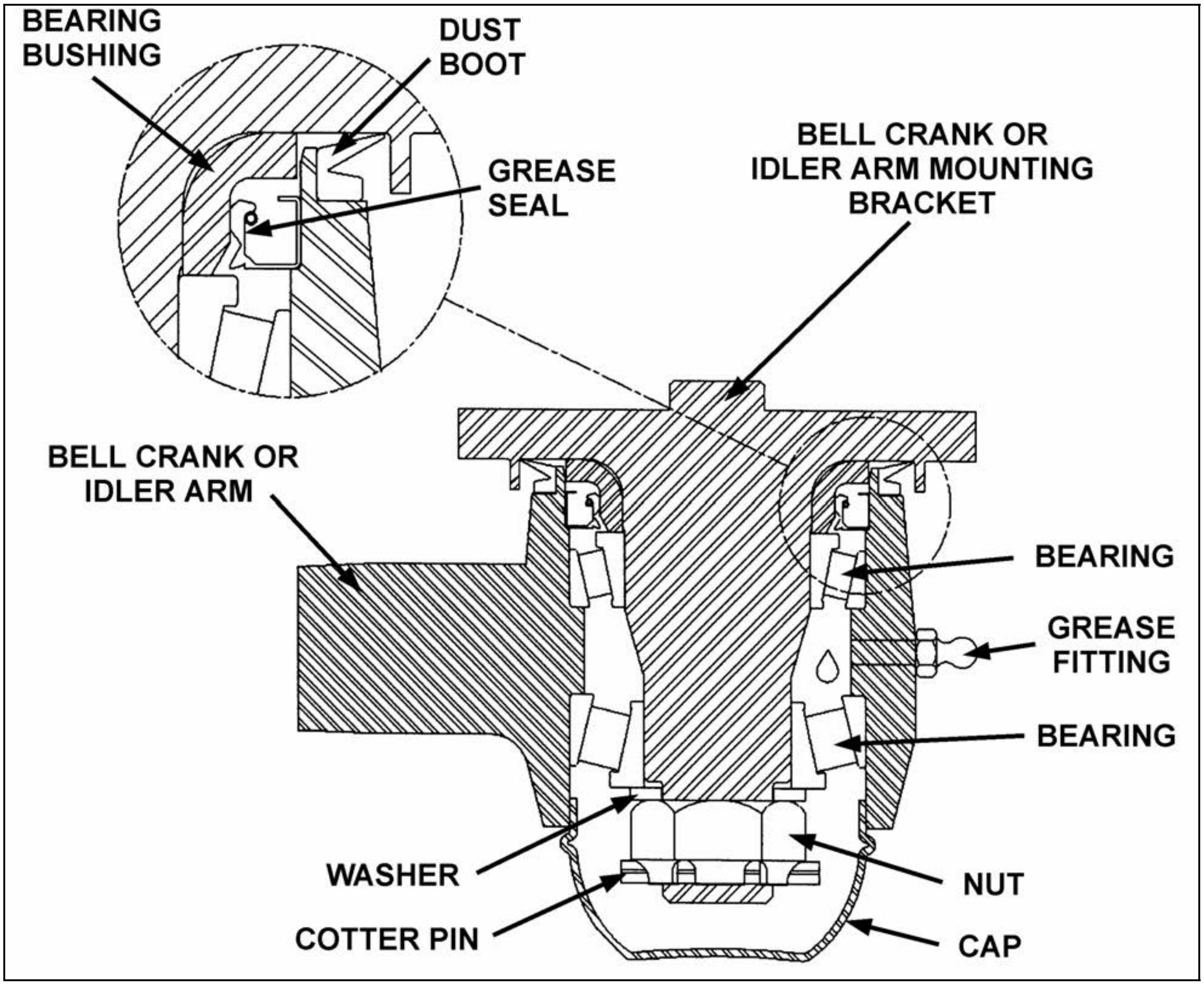


FIGURE 10: BELL CRANK AND IDLER ARM BALL JOINT 16109

9. Install the cap.
10. **Bell crank :** Install drag link, tie rod and relay rod as directed herein under each specific subject.
11. **Idler arm :** Install tie rod and relay rod as directed herein under each specific subject.
12. Adjust turning angle as previously directed under paragraph "**Turning Angle**" and check front end alignment as specified in paragraph "6. Front End Alignment" of this supplement.

2.7 RELAY ROD

Relay rod ends are equipped with lubrication fittings and should be lubricated as directed in paragraph "2.9 Lubrication Fittings" in this supplement.

Note: *The relay rod is crimped in place and it is not possible to remove the ball joints.*

2.7.1 Replacement

1. Remove cotter pins from bell crank and idler arm end of relay rod. Loosen nuts flush with end of studs.
2. Use a puller or place a sledge hammer behind the adjacent part to absorb shocks. Strike the studs with a brass hammer to loosen end assemblies.
3. Remove stud nuts and washers then remove studs.
4. Position relay rod studs into bell crank and idler arm then tap stud ends with a brass hammer to seat tapered surfaces.

5. Install washers and stud nuts. Tighten nuts to 160 Ft-lbs (220 Nm) torque. Align cotter pin slot (tighten) and install a new cotter pin.

2.8 TIE RODS

Tie rod ends are connected to the bell crank and left steering arm, and to the idler arm and right steering arm. Each tie rod assembly consists of three parts; a tube and two socket end assemblies. The tie rod ends are threaded into the tube and secured with clamp bolts. Right and left hand threads are provided to ease toe-in adjustment. Tie rod assemblies are interchangeable from the right to the left side of the coach.

Tie rod end sockets require no maintenance other than periodic lubrication and inspection to see that ball studs are tight. Replace socket ends when there is excessive up and down motion, lost motion or end play at ball end of stud.

1. Periodically check bolt nut for tightness.
2. Inspect tie rod for bent condition and inspect tube for damaged threads. If tie rod is bent or threads are damaged, replace the assembly.
3. Lubricate tie rod end fittings as directed in paragraph "2.9 Lubrication Fittings" at the end of this section.

2.8.1 Removal

1. Remove cotter pins and stud nuts which attach tie rod socket ends to bell crank and left steering arm (or idler arm) and right steering arm.
2. Remove tie rod ball stud by tapping on steering arm and bell crank or idler arm with hammer, while using a sledge hammer to absorb shocks.

Note: *If tie rod end assemblies are damaged in any way, they must be replaced.*

2.8.2 Installation

1. Install socket end assemblies on tie rod. Be sure both ends are threaded an equal distance into the tube.
2. Make sure threads on stud and in stud nut are clean and not damaged.
3. Position ball studs (socket ends of tie rod) in holes in steering arm and bell crank or idler arm. Install a ball stud nut on each stud and tighten firmly.
4. Torque stud nuts to 160 Ft-lbs (220 Nm). Align cotter pin slot (tighten) and install a new cotter pin.

Note: *Adjust toe-in as directed in paragraph "6.4.2 Toe-In Adjustment" of this supplement.*

5. Make sure tie rod ends are properly aligned with ball studs, then torque tie rod end clamp bolts to 40-60 Ft-lbs (55-80 Nm).

Note: *If tie rod is not properly aligned with stud, binding will result.*

2.9 STEERING ARMS

The left and right wheel steering arms are secured to a swivel at one end and to a tie rod at the other end.

2.9.1 Removal

1. Remove wheel as directed in Section 13, "Wheel, Hubs And Tires" of the maintenance manual.
2. Remove cotter pin, washer and nut from stud securing tie rod to steering arm. Remove ball stud from steering arm by tapping on arm with a hammer, Placing a sledge hammer underneath steering arm to absorb shocks.
3. Remove cotter pin and nut securing steering arm to swivel assembly. Remove steering arm from swivel.

2.9.2 Installation

1. Insert steering arm in swivel.
2. Torque steering arm to swivel nut to 190 Ft-lbs (260 Nm). Align cotter pin slot (tighten) and install a new cotter pin.
3. Position tie rod ball stud in steering arm and tap with a brass hammer to seat ball stud in steering arm. Install washer and nut on stud. Torque nut to 160 Ft-lbs (220 Nm). Tighten nut to nearest cotter pin slot and install a new cotter pin.
4. Install wheel as directed in Section 13, "Wheel, Hubs And Tires" under paragraph "3.2 Installation" of the maintenance manual.

2.10 LUBRICATION FITTINGS

All lubrication fittings must be clean before applying lubricant. Also, always be sure equipment used in applying lubricant is clean. Every precaution should be taken to prevent entry of dirt, grit, lint or other foreign matter into lubricant containers. Replace fitting when they become broken or damaged.

Intervals of application given in the following paragraphs are recommended for normal service. More frequent intervals may be applied under severe operating conditions. In selecting proper lubricants, supplier reputation must be considered. The supplier must be responsible for product quality. The diagram (Fig. 11) shows approximate location of steering lubrication fittings.

1. **Drag Link Ends :** Lubricate at two fittings, one at each end of link, every 6,250 miles (10 000 km) with a good quality lithium-base grease NLGI No. 2 (Shell Retinax LX or equivalent).
2. **Relay Rod Ends :** Lubricate at two fittings, one at each end of rod, every 6,250 miles (10 000 km) with a good quality lithium-base grease NLGI No. 2 (Shell Retinax LX or equivalent).
3. **Tie Rod Ends :** Lubricate at four fittings, one at each end of both tie rods, every 6,250 miles (10 000 km) with a good quality lithium-base grease NLGI No. 2 (Shell Retinax LX or equivalent).
4. **Swivel Assembly :** Refer to DANA SPICER MAINTENANCE MANUAL NDS AXLES Lubrication and Maintenance" annexed at the end of section 10.
5. **Idler Arm and Crank bell :** Lubricate at two fittings, one on the idler arm and the other on the crank bell, every 6,250 miles (10 000 km) with a good quality lithium-base grease NLGI No. 2 (Shell Retinax LX or equivalent). Apply grease gun pressure to the fitting until lubricant appears at the top seal.
6. **Upper V-Link Outer Ball Joint :** Lubricate at fitting until you see some grease on the relief valve nearby, every 6,250 miles (10 000 km) with a good quality lithium-base grease NLGI No. 2 (Shell Retinax LX or equivalent).

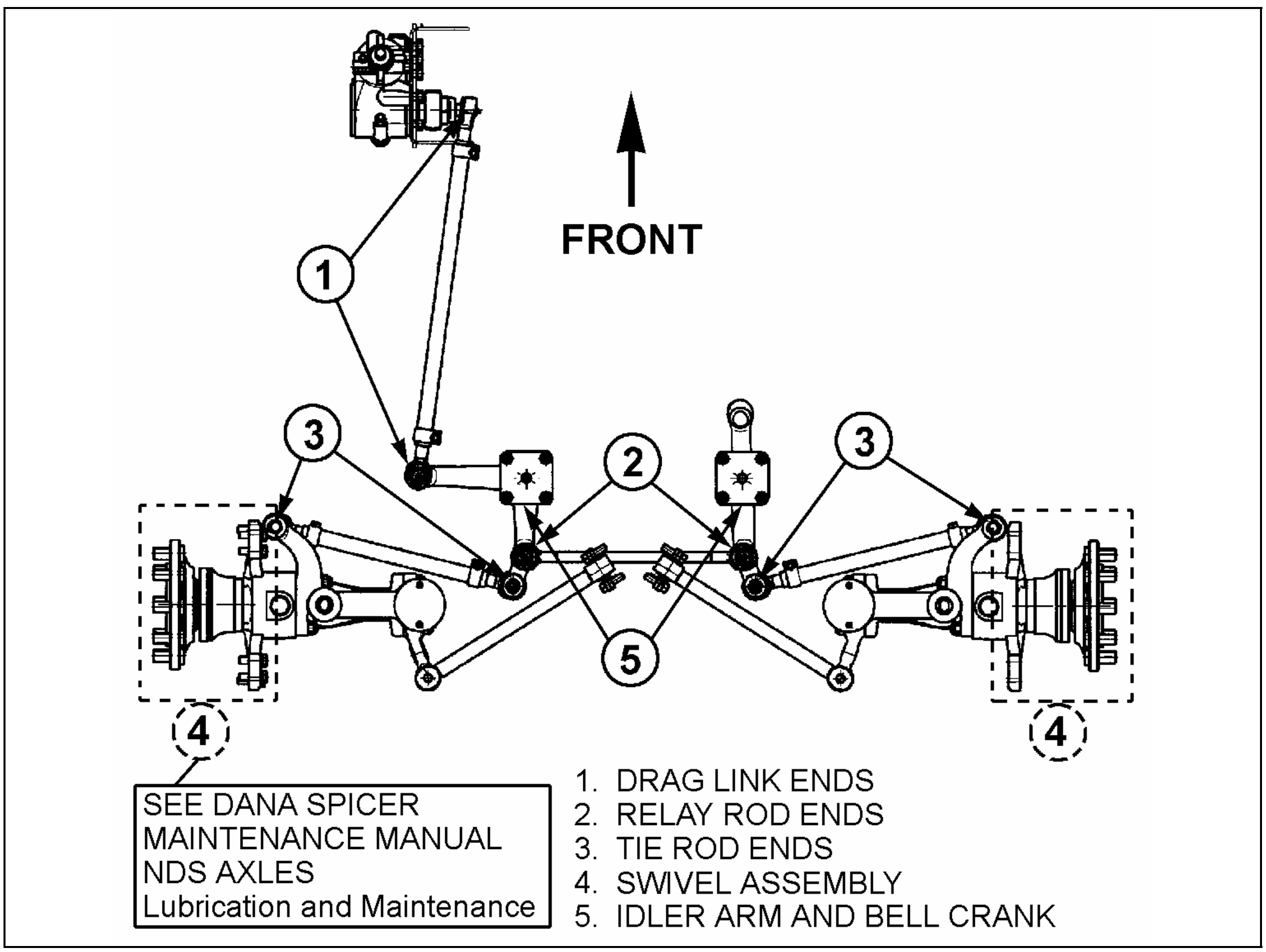


FIGURE 11: LUBRICATION FITTINGS' LOCATION DIAGRAM

3. BALL JOINTS

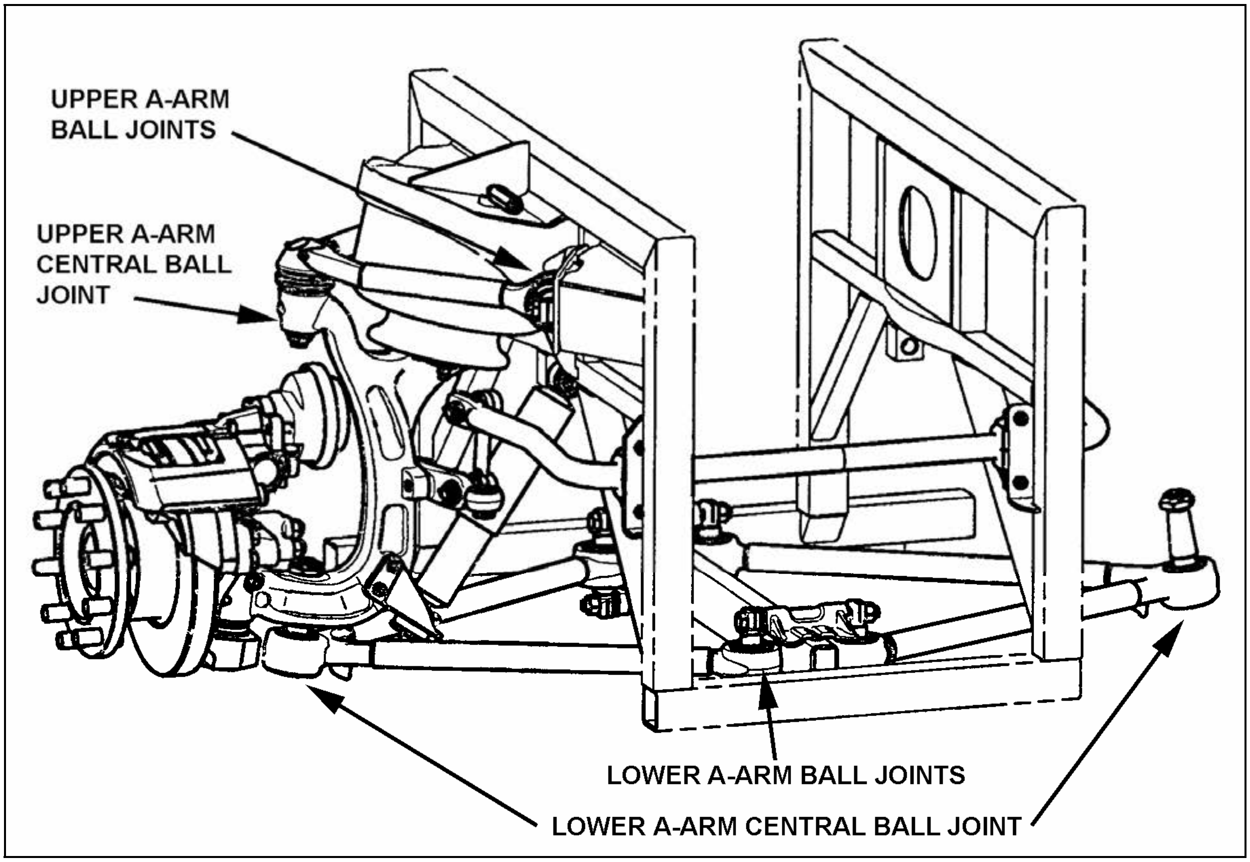


FIGURE 12: BALL JOINTS LOCATION 16137

4. LOWER AND UPPER A-ARM BALL JOINT

The assembly work may be done only by a recognized specialized workshop. Ensure that old and new parts do not get mixed up with each other. It is for this reason that all the old parts are to be scrapped immediately after a joint has been stripped down. A complete repair set must be used for each joint repaired, i.e. use of only part of a repair set is not permissible.

4.1 STRIPPING DOWN

Strip down the defective joint through removal of retaining ring, annular spacer and ball pin/bushing, assembly and thereafter clean out housing bore and locking circlips groove.

4.2 ASSEMBLY

Execute assembly of the new joint parts in the following sequence:

1. Complete moistening of the contact surface between housing bore and ball pin through application of the grease.

Note: *Apply grease, only in the case of repair kit (Prévost # 611114)).*

2. Insert ball pin/bushing, assembly. In case of the two-bolt type, ensure that the bolt bores are in the correct position in relation to the axis of the tube.
3. Place joint in receiving fixture and mount annular assembly tool on the housing. Then locate annular spacer and retaining ring in the housing using axial load with the aid of assembly matrix. If the ends of the annular spacer are not in contact with each other, the thus formed opening must be located at 180° to the opening of the retaining ring. Pay attention during assembly to ensure that the retaining ring eyelets are located at each side of the housing shaft axis (retaining ring eyelet lug points to tube), and that retaining ring is properly engaged in the groove of the housing.

4. When repairing defective ball pin assemblies, the necked down-bolt must regularly be replaced with a new one.

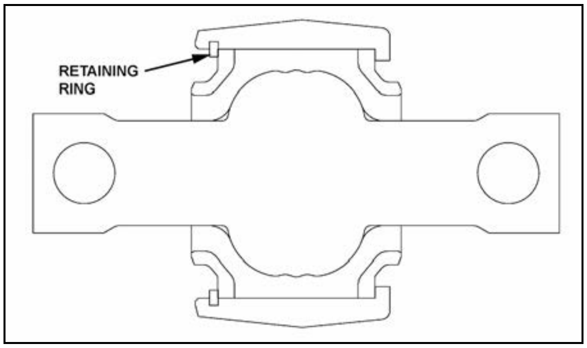


FIGURE 13: UPPER A-ARM BALL JOINTS 16115

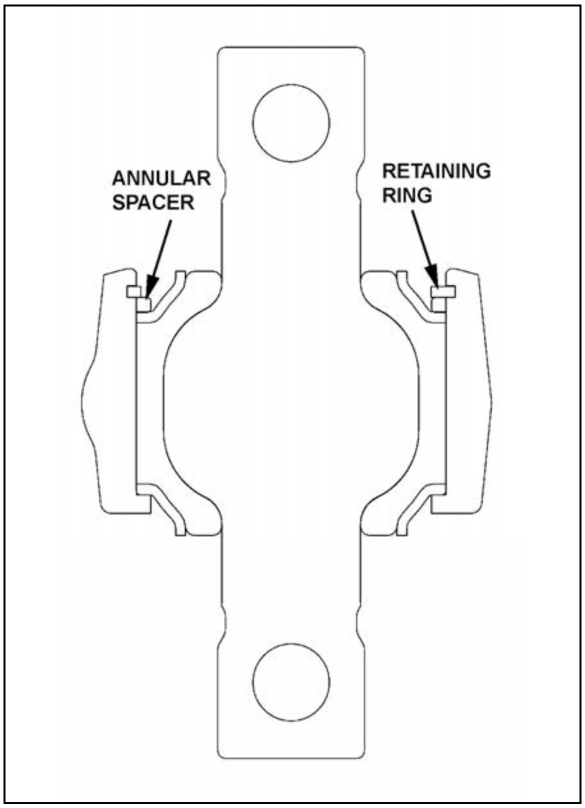


FIGURE 14: LOWER A-ARM BALL JOINTS 16114

5. LOWER A- ARM CENTRAL BALL JOINT

5.1 STRIPPING DOWN

Strip down the defective joint through removal of retaining ring, annular spacer and ball pin/bushing, assembly and thereafter clean out housing bore and locking circlips groove

5.2 ASSEMBLY

Assemble the new component parts of the joint in the following sequence:

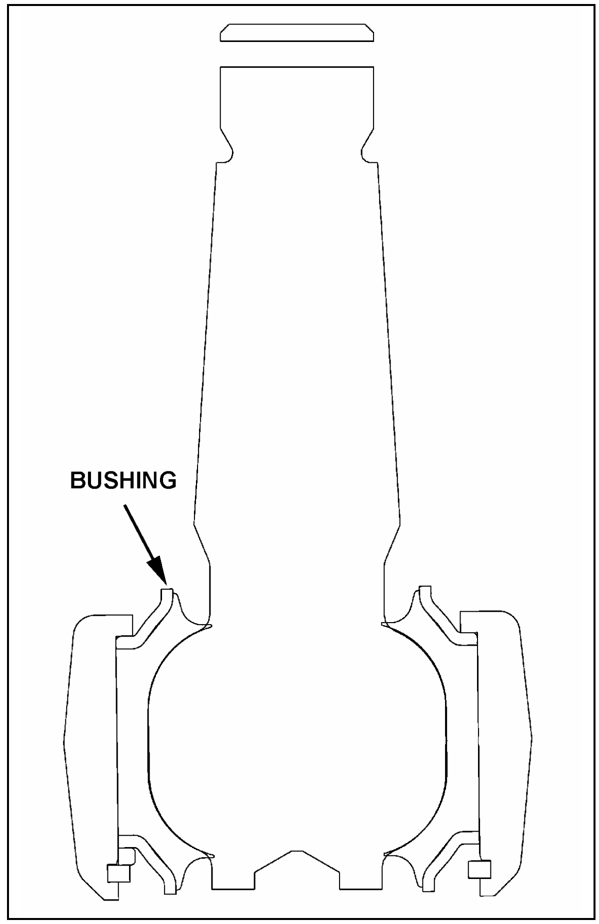


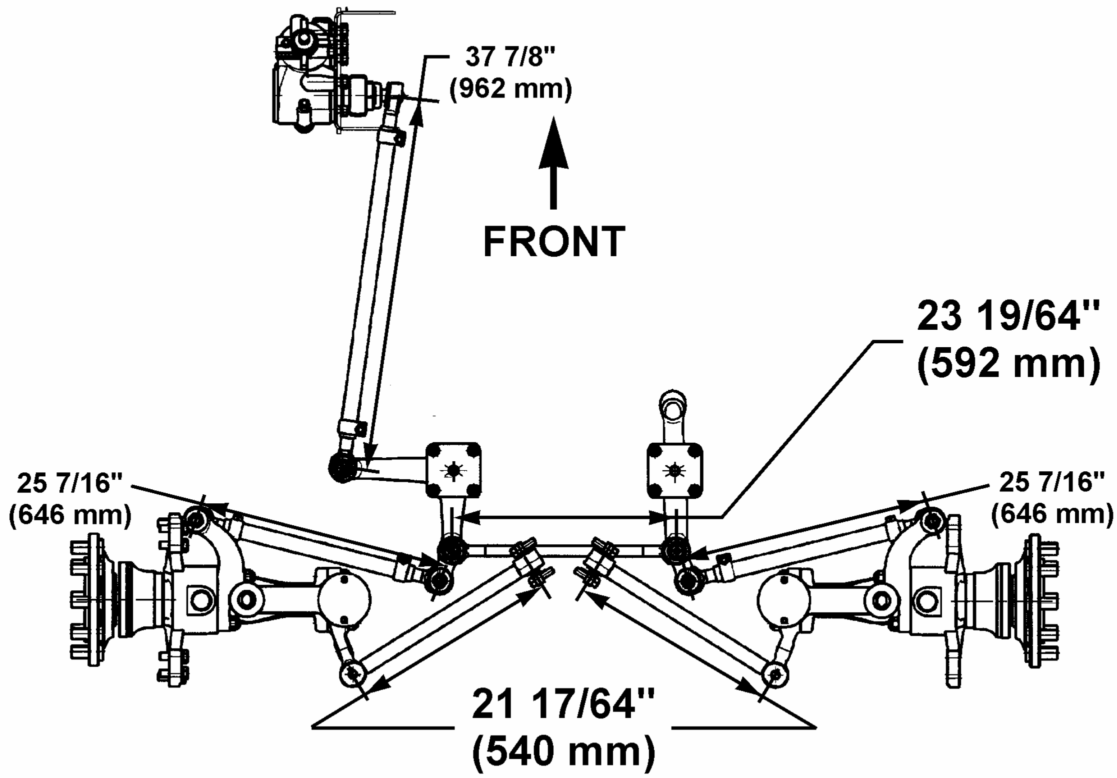
FIGURE 15: LOWER A-ARM CENTRAL BALL JOINT 16113

1. Complete moistening of the contact surface between housing bore and ball pin through application of the grease.
2. Place joint in receiving fixture and mount annular assembly tool on the housing. Then locate annular spacer and retaining ring in the housing using axial load with the aid of assembly matrix. If the ends of the annular spacer are not in contact with each other, the thus formed opening must be located at 180° to the opening of the retaining ring. Pay attention during assembly to ensure that the retaining ring eyelets are located at each side of the housing shaft axis (retaining ring eyelet lug points to tube), and that retaining ring is properly engaged in the groove of the housing.
3. Faultlessly apply grease by mechanical means to bracket-outer core and ball-inner cone. Insert bracket outer cone in fixture with distance ring and then use press tool to apply pressure to press mount with ball-inner cone.

6. UPPER A-ARM CENTRAL BALL JOINT

Check ball joint play and make a visual inspection of the joint boot each time lubrication is performed.

FIGURE 16: UPPER A-ARM CENTRAL BALL JOINT 16116



NOTE: 23 19/64" (592 mm) AND 21 17/64" (540 mm) MUST BE RESPECTED, THEY ARE NOT ADJUSTABLE. OTHER LENGTH ARE ADJUSTABLE, THEY ARE GIVEN ONLY FOR PRELIMINARY ADJUSTMENT. ALL LENGTHS ARE MEASURE FROM CENTER TO CENTER END OF ROD.

FIGURE 17: STEERING LINKAGE MEASURE 16130

7. FRONT END ALIGNMENT

Proper front end alignment must be maintained to insure ease of steering and provide satisfactory tire life. When making front end alignment inspections, the vehicle must be level and empty with the full weight of the vehicle on the wheels.

Front end alignment inspections fall into two groups : regular service inspections performed at periodic intervals, and inspections to determine the extent of damage after a collision or severe service.

Regular service inspections concern toe-in, camber and caster.

Any variation from the specified alignment will indicate either a need for adjustment or a more thorough inspection to determine if parts replacement is required.

7.1 ALIGNMENT TERMINOLOGY

Wheel Camber

The amount the wheels are inclined from the vertical plane (A, Fig. 16).

Wheel Toe-In

The distance the front wheels are closer together at the front than at the rear of the tires (D minus E, Fig. 16).

King Pin Inclination

The inclination of the king pin from vertical toward the center of the vehicle at the top and outward at the bottom (B, Fig. 16).

Front Axle Caster

The inclination of the king pin from vertical in the fore and aft direction (C, Fig. 16).

7.2 FRONT END INSPECTION

Before checking front end alignment, make the following inspection:

1. Check that the vehicle is at normal ride height (see paragraph "11. Suspension Height Adjustment").
2. Check the tires for proper inflation.
3. Check wheel installation and run-out.
4. Check wheel bearing adjustment.
5. Check tie rods and drag link ends for looseness.
6. Check king pins for looseness.
7. Check if the length of the torque rod is 21 17/64" (540 mm) (Fig. 15). Check if the length of the relay rod is 23 19/64" (592 mm)

7.3 FRONT WHEEL CAMBER

Positive camber is the outward inclination of the wheels at the top, negative or reverse camber is the inward inclination of the wheels at the top. Camber variations may be caused by wear at the wheel bearings, wheel spindle bushings, or bent suspension parts.

Check camber, with an accurate gauge. If camber is incorrect, check suspension parts for wear and replace worn parts. If wear is not perceptible, suspension parts may be bent or lower suspension arm may be improperly shimmed.

Check King pin inclination. If King pin inclination is incorrect, readjust the camber and check king pin inclination again.

Note: *Camber is more important than king pin inclination, so adjust camber and verify king pin inclination.*

Shim the lower suspension arm to adjust camber. If the king pin inclination is incorrect, the wheel king pin assembly may be bent and therefore should be replaced.

Excessive positive camber results in irregular wear of the tires at the outer shoulders. Negative or reverse camber causes wear at the inner shoulders.

Note: *Shim only the lower suspension arm to adjust the front wheel camber.*

7.4 FRONT WHEEL TOE-IN

Toe-in is measured from the center of the tire treads. Measurements at the front and rear of the tires must be made at the same height from the floor. Incorrect toe-in results in excessive tire wear and steering instability with a tendency to wander.

7.4.1 Toe-In Check

1. Check the camber adjustment and adjust if necessary.
2. Hoist the front of the vehicle and spin the wheels marking the centerline of the tire treads.
3. Place the wheels in the straight ahead position and lower the vehicle to rest on the floor.

4. Roll the vehicle ahead several feet. This removes any slack caused by looseness in the wheel bearings or steering connections.
5. Check the distance between the tire centerlines at the front and rear of the front tires. These two measurements must be made at the same height above the floor. The front measurement must be 3/32 ±1/32 of an inch less than the rear measurement.

7.4.2 Toe-In Adjustment

1. Loosen the tie rod clamp bolts.
2. Using a pipe wrench, turn the tie rod tubes to obtain the toe-in measurement specified in step 5 under paragraph "6.4.1 Toe-in Check" of this Supplement.
3. Tighten the tie rod clamp bolts and recheck toe-in.
4. Check that the angular relationship of the pitman arm to the steering gear is as shown in figure 6.

Note: *Use only tie rods to adjust toe-in.*

7.5 FRONT AXLE CASTER

Positive caster is the inclination of the top of the king pins toward the rear of the vehicle. Negative or reverse caster is the inclination of the king pins toward the front of the vehicle. This vehicle is designed with positive caster. The purpose of caster is to provide steering stability by keeping the wheels in a straight ahead position.

Caster variations may be caused by bent upper suspension arm, lower suspension arm, or king pin housing. Caster should be adjusted with shims. Precision instruments should be used to measure caster. Shim bell crank and idler arm to adjust caster.

Variations from the specified caster will affect steering stability, cause wandering, wheel shimmy, and reduce returnability when pulling out of curves.

7.6 MAJOR DAMAGE

If the suspension has sustained major damage, it may be necessary to shim the bell crank and the idler arm to avoid the bump steer or roll steer. Moreover refer to paragraph "6. Front End Alignment".

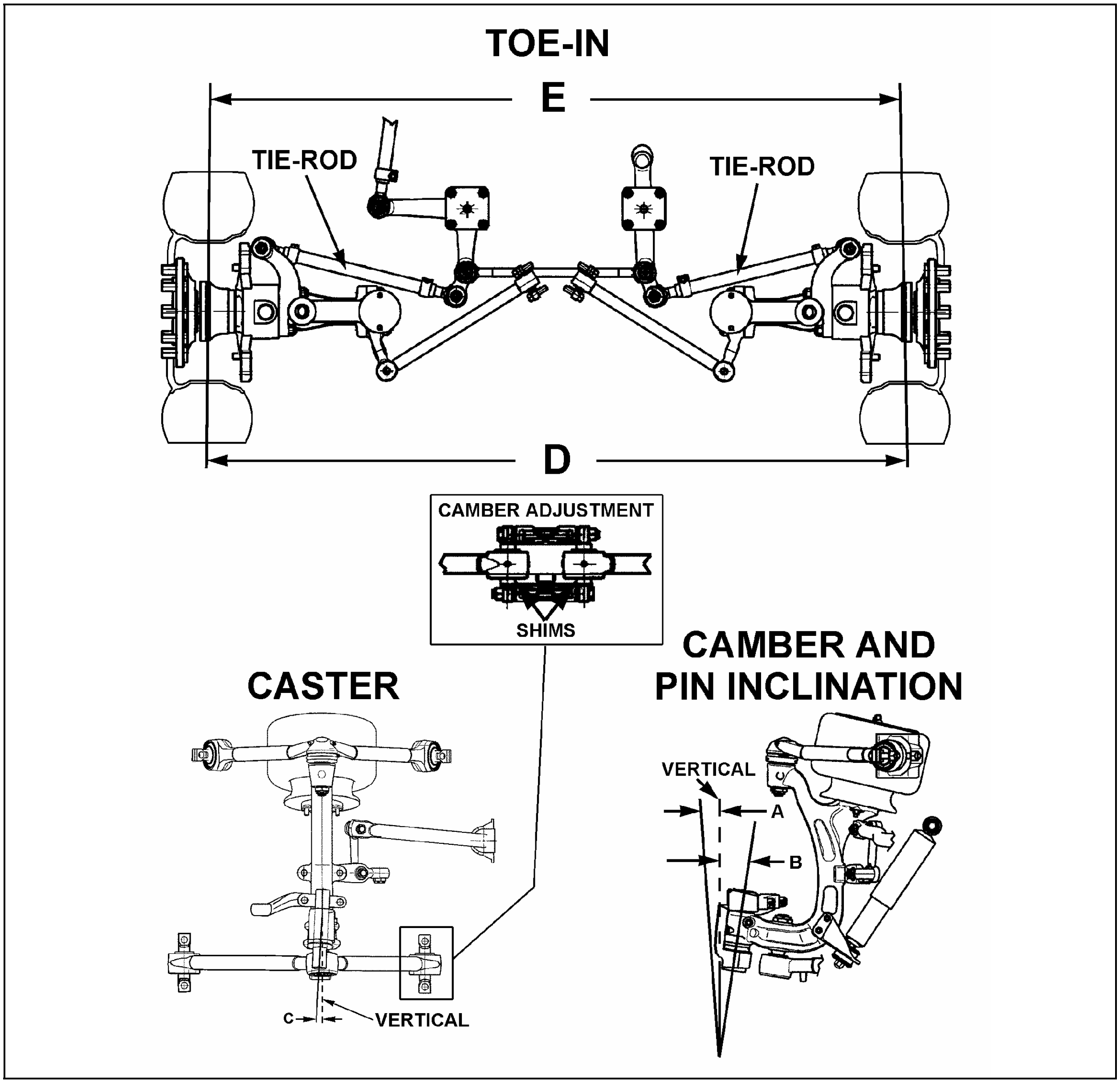


FIGURE 18: FRONT END ALIGNMENT DIAGRAM 16134

ALIGNMENT SPECS (See Figure 18)				
		Minimal	Nominal	Maximal
A	WHEEL CAMBER	0.0	0.150	0.35
B	KING PIN INCLINATION	8° (not adjustable)		
C	CASTER	2.35	2.6	2.85
D-E	TOE-IN	0.08	0.13	0.17

8. FRONT AIR SPRINGS

Two *"rolling lobe"* type air springs are used with the independent front suspension, one at each wheel. These air springs are special and use the complete piston as an extra reservoir to lower the spring stiffness. Front air springs are attached to the subframe and to uprights.

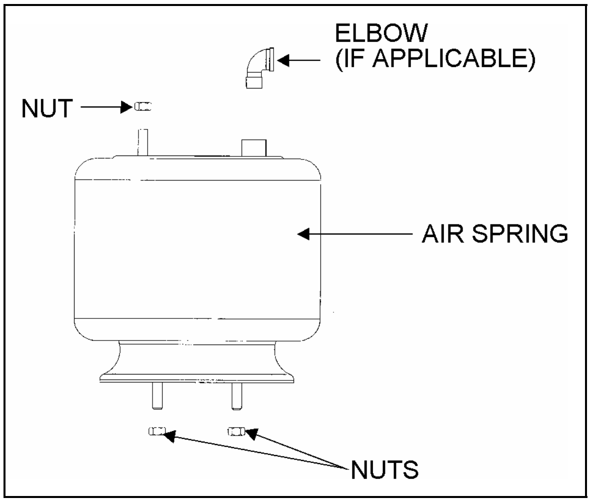


FIGURE 19: AIR SPRINGS 16052

8.1 INSPECTION

1. Check operation of bellows.
2. Visually inspect bellows for evidence of cracks, punctures, deterioration, or chafing. Replace the bellows if damage is evident.
3. With the primary air system at normal operating pressure (95 - 125 psi (655 - 860 kPa)), coat all suspension air line connections and bellow mounting areas with a water and soap solution. Bubbles will indicate an air leak, and none is permissible. Repair or replace defective parts.

Note: *If air spring is removed from vehicle, bellows can be lightly inflated and submerged in water to detect any leakage. If leakage is detected, replace bellows.*

Warning: *To prevent personal injury, do not apply more than 10 psi (69 kPa) air pressure to the unmounted air spring.*

8.2 REMOVAL

Note: *Front air springs can be removed without removing the entire suspension assembly.*

1. Safely support vehicle at the recommended body jacking points and jack up body understructure.
2. To gain access to a given air spring, the corresponding wheel can be removed.

Caution: *Only the recommended jacking points must be used as outlined in Section 18, "Body" in the maintenance manual.*

3. Support the assembly with a suitable jack.
4. Exhaust compressed air from accessory air tank by opening drain cock under reservoir.
5. Disconnect the height control valve link and pull down the overtravel lever to ensure all air is exhausted from air springs.

Note: *While performing this step, do not change the height control valve overtravel lever adjustment.*

6. Disconnect air line from air spring, remove elbow (if applicable), and cover both the line end and fitting to prevent the entry of foreign matter.
7. Remove the air spring upper nut, and then the two lower nuts. Remove air spring and remove the back up plate from the top of the air spring.

8.3 INSTALLATION

Note: *To facilitate air spring installation, compress it manually then put a piece of tape over the air line threaded fitting. This prevents air from getting back into the bag and keeps it compressed, thus enabling to place the bag in between the mounting plates and greatly easing installation.*

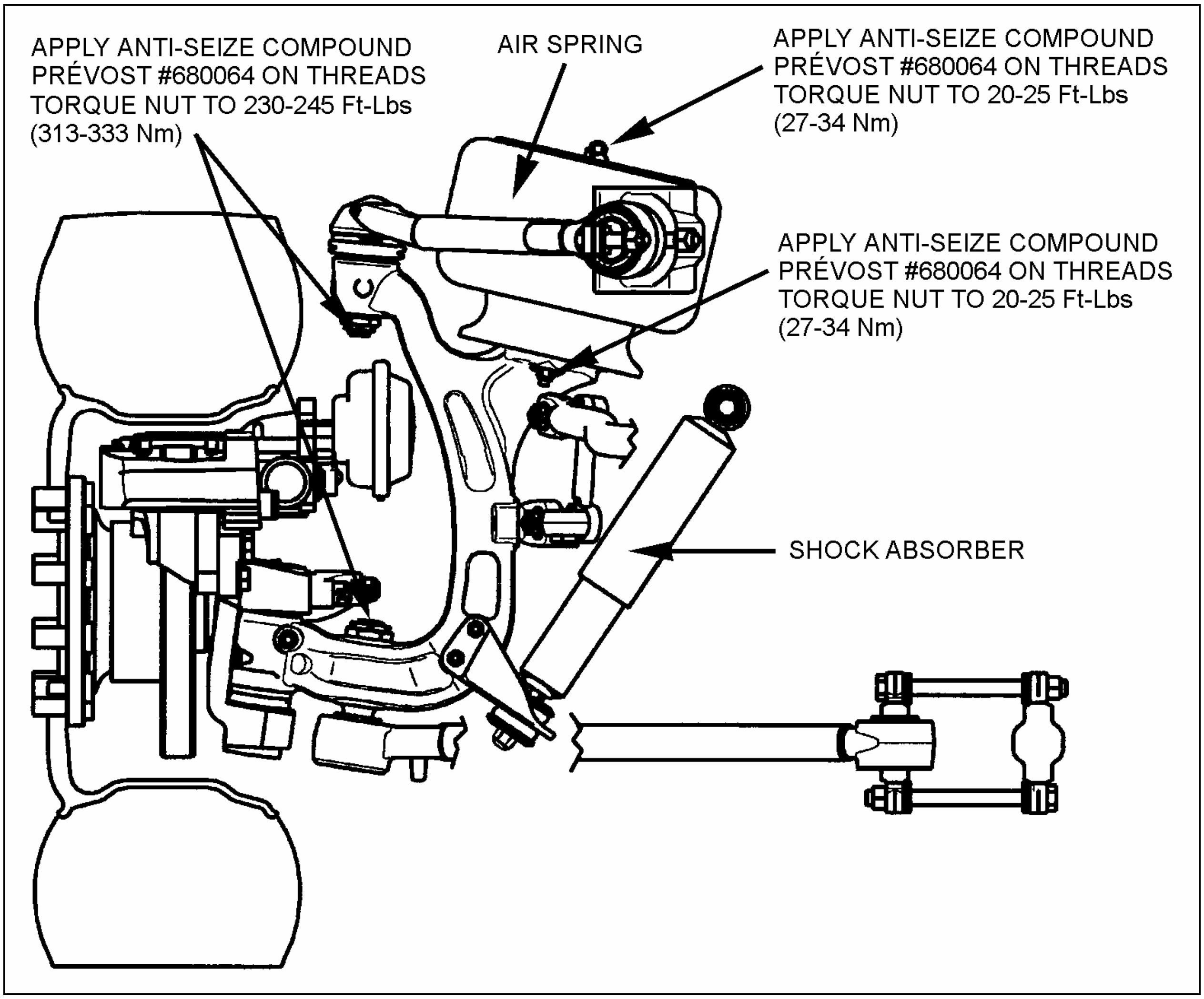


FIGURE 20: AIR SPRING AND SHOCK ABSORBER 16129

1. Compress air spring as necessary, then aligning studs with their holes, position air spring between both the lower and upper supports. Thread the lower nuts and the small upper nut a few turns.
2. Tighten and torque the lower stud nuts, and then the upper nut to 20-25 Ft-lbs (27–34 Nm).
3. Install elbow (if applicable), then connect air line.
4. Connect the height control valve link.
5. Build up air pressure in system.

Note: *To accelerate this operation, air reservoirs can be filled from an exterior air supply connected to the accessory tank fill valve or to the emergency fill valve.*

6. Check operation of bellows, and with the primary air system at normal operating pressure (95 - 125 psi (655 - 860 kPa)), coat the air line connections and air spring mounting areas with a water and soap solution. Bubbles will indicate an air leak, and none is permissible. Repair or replace defective parts.
7. Remove the hydraulic floor jack from underneath shock absorber bracket.

9. SHOCK ABSORBERS

The two front shock absorbers are double-acting and telescopic type. Shock absorbers ensure a smooth ride and enhance vehicle stability on the road. Front shock absorbers have eye-type mountings on the upper side and bayonet type on lower side. Shock absorbers are non-adjustable and non-repairable.

Caution: *When a shock absorber is found defective, always replace with a new set on affected axle, except if there has been a recent replacement of one unit. The following method will help in determining if both shock absorbers on the same axle have to be replaced.*

9.1 SHOCK ABSORBER REMOVAL

1. Remove the nut, washer and rubber joint from shock absorber mounting stud. Discard the rubber joints.
2. Remove the nut and washer from shock absorber mounting pin (upper side), taking care to identify the inner and outer washers to ease reinstallation. Refer to figure 21 for details.
3. Remove the shock absorber from the vehicle.
4. Remove inner: washers, rubber joint and bushings from the shock absorber. Discard bushings and rubber joint.

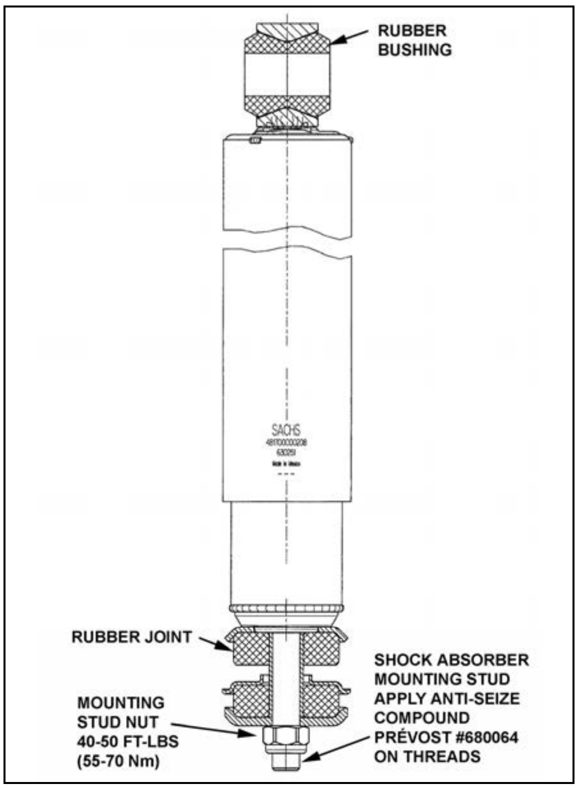


FIGURE 21: SHOCK ABSORBER 16112

9.2 SHOCK ABSORBER INSTALLATION

1. Check that the shock absorber mounting pin torque is proper (350-400 Ft-lbs (475-545 Nm)). Ensure that the stud is clean and not stripped (upper side).
2. Install new rubber (mounting) bushing on shock absorber (upper side).
3. Place the inner washer on shock absorber pin (Fig. 19).
4. Install washer and rubber joint on shock absorber mounting stud (lower side).
5. Install the shock absorber as shown in figure 18 with the mounting stud protruding through the hole in the mounting bracket and the shock absorber eyes over the mounting pins. Install the outer washer.
6. Place a rubber joint and washer on the shock absorber mounting stud. Place the lower shock absorber mounting stud nut and torque to 40-50 Ft-lbs (55–70 Nm).
7. Place the upper mounting pin stud nut and torque to 70-85 Ft-lbs (95–115 Nm).

10. SWAY BAR

A sway bar is provided on the front and drive axles to increase vehicle stability. It controls lateral motion (swaying movement) of vehicle.

10.1 REMOVAL

1. Disconnect the two links from sway bar.
2. Safely support the sway bar. Unbolt bushing collars from subframe.
3. Remove sway bar.

Note: *Sway bar bushings are slit to ease their removal.*

10.2 INSTALLATION

1. Loosely install the sway bar.
2. Torque bushing collar nuts to 60 Ft-lbs (82 Nm).
3. Torque sway bar link upper nuts to 120-140 Ft-lbs (163-190 Nm) on front suspension and to 100-120 Ft-lbs (136-163 Nm) on rear suspension.
4. Torque sway bar link lower nuts to 120-140 Ft-lbs (163-190 Nm) on front suspension and to 70-80 Ft-lbs (95-110 Nm) on rear suspension.

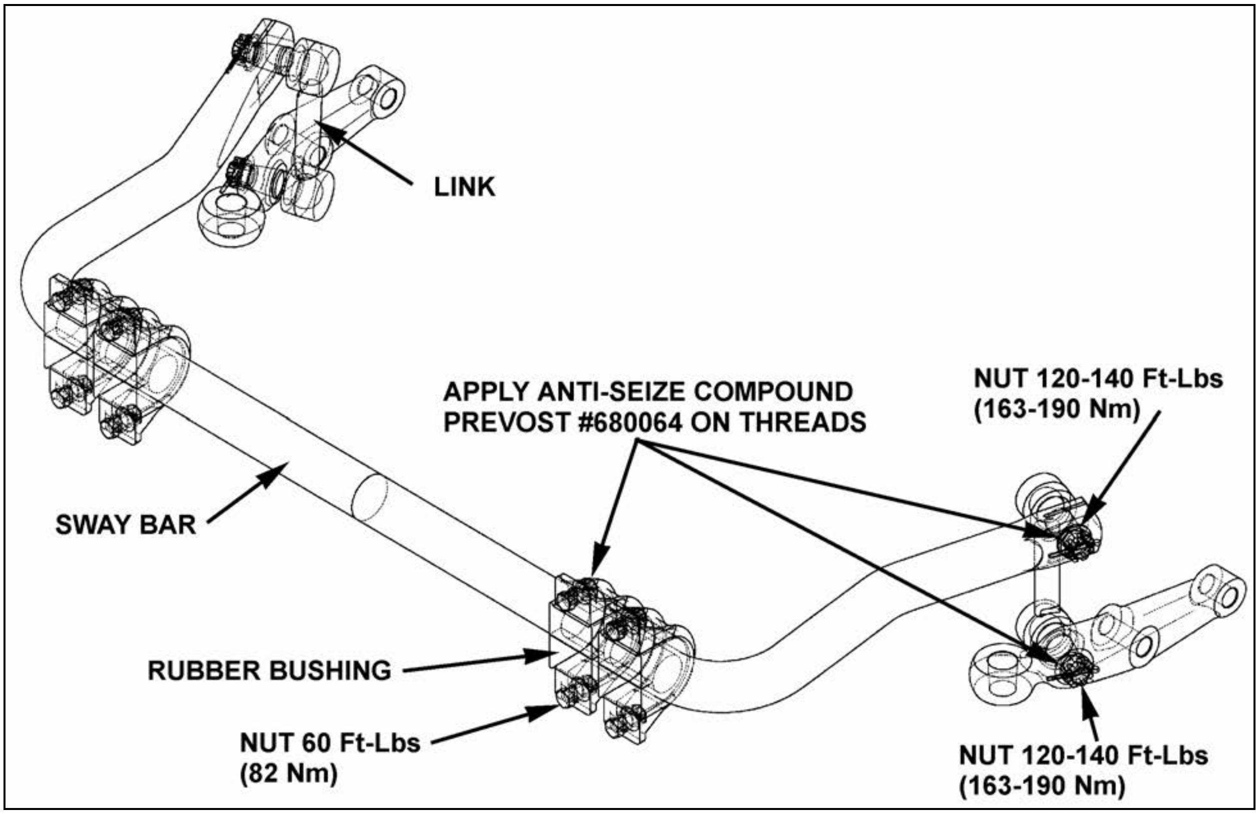


FIGURE 22: SWAY BAR (FRONT SUSPENSION) 16055

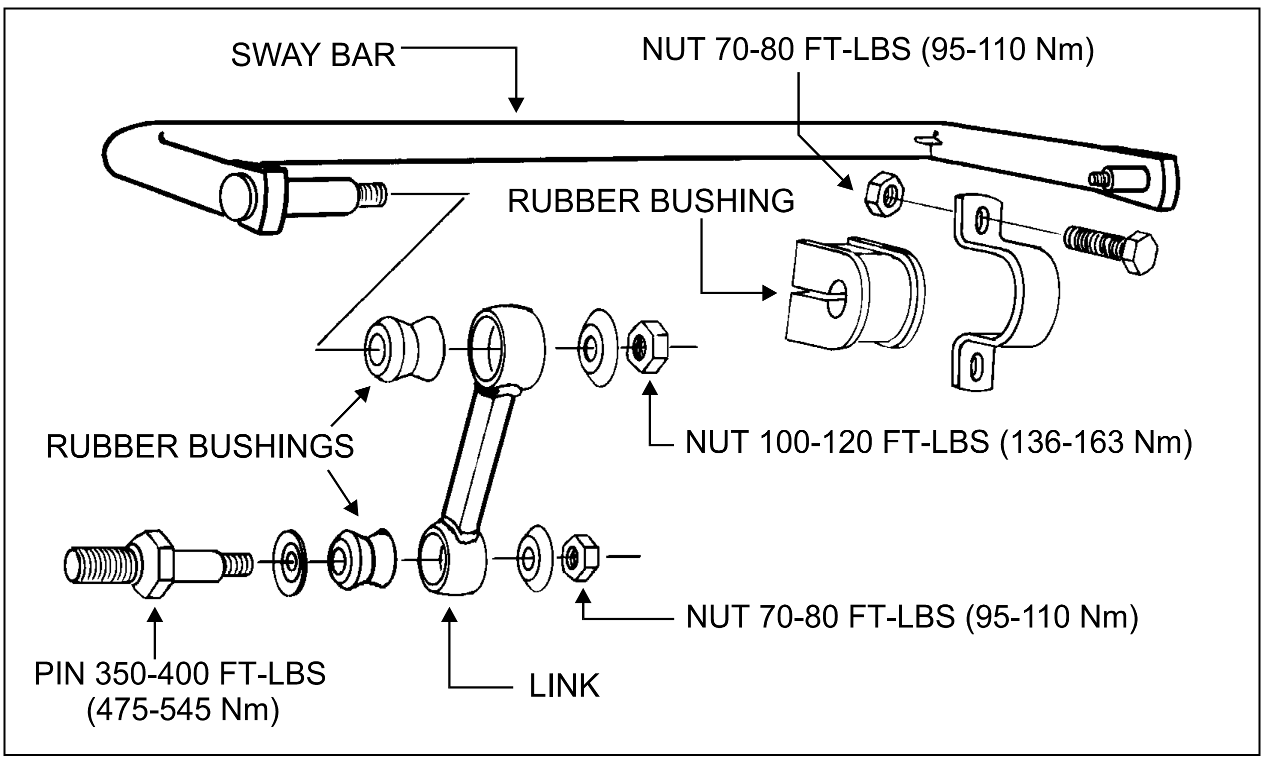


FIGURE 23: SWAY BAR (REAR SUSPENSION) 16014

11. SUSPENSION HEIGHT ADJUSTMENT

The flow of pressurized air from the accessory air tank to the air springs is controlled by three height control valves. The two rear valves are mounted to the subframe and connected to the rear axles through an arm and link connection. The front valve is mounted to the subframe and connected to the front air tank support. These connections allow the valves to apportion air pressure in the springs to the vehicle load, maintaining normal ride height.

Immediate response height control valves increase or decrease the air pressure in the suspension system as required. One height control valve is located **at center of front sway bar**, and regulates air to front suspension air springs in order to maintain the vehicle at the required height. Two are located at the drive axle, one on each inner side of rear wheelhousing.

The appropriate vehicle body height is obtained by measuring the clearance of all the air springs installed on the vehicle. The two front air springs clearance should be 11 ± ¼“ (279 ± 6 mm). Refer to figure 22 to identify the correct area to take measurement. The rear air springs clearance should be 11 ½ ± ¼" (292 ± 6 mm) (refer to Maintenance Manual, Section 16, under "Suspension Height Adjustment" for rear height control valves' adjustment).

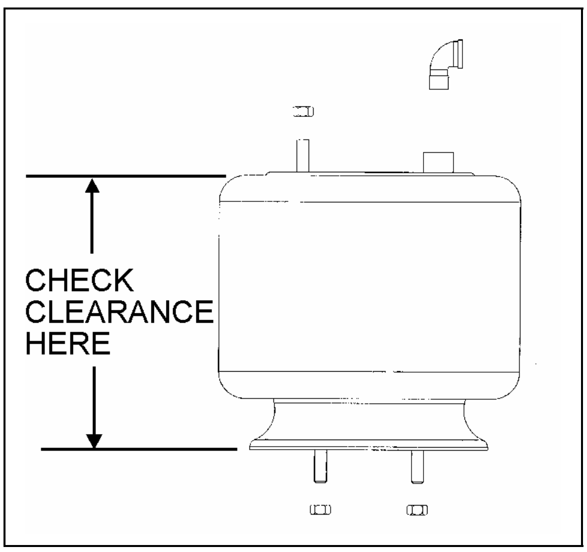


FIGURE 24: TYPICAL AIR SPRING CLEARANCE 16058

At this point, it should not be necessary to make an adjustment under normal service conditions. However, if an adjustment is required, change the position of the overtravel lever in relation to the overtravel control body. The lever should be moved up to raise vehicle height, and down to lower it. Check that main air pressure is at normal operating pressure and raise the vehicle to the specified height.

Caution: *Always adjust on "fill cycle". If it is necessary to lower vehicle height, release sufficient air to be well below height, and adjust to height or fill cycle.*

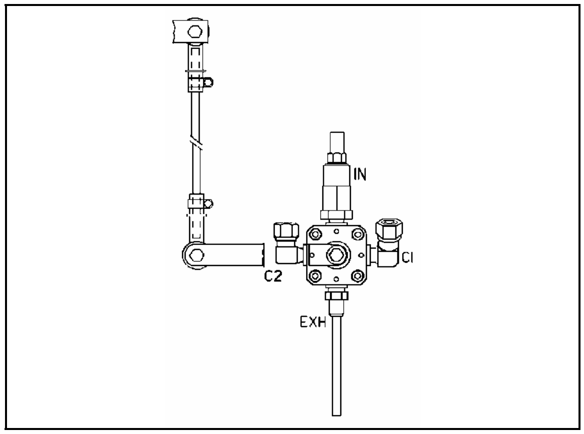


FIGURE 25: FRONT HEIGHT CONTROL VALVE 16100

The normal ride height is obtained by adjusting air spring clearance of both front and rear suspension as follows:

Front air spring clearance

1. With the vehicle at normal operating air pressure (100 - 125 psi (689 - 860 kPa)), measure air spring clearance. This clearance should be 11 ± ¼“ (279 ± 6 mm).

Note: *The measurement should be taken from underneath the upper air spring support on subframe to top of the lower air spring support on axle (refer to figure 22 for more details). If adjustment is required, begin with the drive axle.*

2. Loosen the clamp on the height control valve rubber coupling and bring it up or down (Fig. 23).

Note: *Allow suspension to stabilize before taking reading.*

When the desired height is obtained, tighten clamp.

Rear air springs clearance

Refer to XL2 Maintenance Manual, Section 16, under "Suspension Height Adjustment".

12. HEIGHT CONTROL VALVE

The height control valves automatically add air to, or release air from air springs to maintain constant suspension height regardless of load, or load distribution. Each valve adjusts independently according to the following conditions:

12.1 LOADING POSITION

As the load increases and lowers the vehicle body, the overtravel lever commands the height control valve to add air to air springs.

12.2 NEUTRAL POSITION

When vehicle body reaches the normal ride height, the height control valve overtravel lever reaches the "neutral" position and keeps both the supply and exhaust ports closed to ensure normal ride height is maintained. This condition remains static until the vehicle load is altered.

12.3 UNLOADING POSITION

As the load decreases and raises the vehicle body, the overtravel lever commands the height control valve to release air from air springs.

12.4 MAINTENANCE

The height control valve requires no periodic maintenance. Height control valve linkage operates on rubber bushings and no lubrication should be attempted at this location. Inspect the valve for loose joints, air leaks and worn bushings.

12.5 REMOVAL AND INSTALLATION

Before disconnecting a height control valve air line, securely support the vehicle by its jacking points on the body, and place safety supports underneath body. Refer to paragraph *"16. Vehicle Jacking Points"* in Section 18, *"Body"*.

1. Exhaust air from air system by opening all air tank drain cocks. Remove height control valves.
2. Disconnect overtravel lever from link and pull down lever to exhaust remaining air from air springs.
3. Disconnect air supply and delivery lines from the height control valve. Cover line ends with tape to prevent entry of foreign matter.
4. Remove the nuts retaining the height control valve to the mounting bracket, then remove valve assembly.

Reverse removal procedure to replace height control valve. After installation, check for leakage using a soap and water solution.

13. AIR SYSTEM

The basic air system consists of an air compressor, tanks, valves, filters and interconnecting lines and hoses (refer to Section 12, "Brake and Air System" for complete information). It provides a means for braking, operating controls and accessories, and suspension. An air system schematic diagram is annexed at the end of this supplement for better understanding of the system.

The air coming from the air dryer is first directed to the wet air tank, then to the primary (for the primary brake system), secondary (for the secondary brake system), and accessory (for the pneumatic accessories) air tanks (Fig. 24).

In addition, an expansion air tank is installed in series with each air spring.

13.1 AIR TANK MAINTENANCE

Ensure that the accessory air tank is purged during pre-starting inspection. A good practice is to purge this tank at the end of every driving day by the remote air tank drain valve located in the steering compartment (Fig. 26).

Moreover, purge all tanks by their bottom drain valves at specified intervals.

13.1.1 Wet Air Tank

This tank is installed above L.H. wheel of drive axle, and is provided with a bottom drain valve. It is recommended to **purge** the wet air tank by its bottom drain valve every 12,500 miles (20 000 km), or once a year, whichever comes first.

A remote valve located in engine compartment and accessible through engine R.H. side door is used to **drain** the air dryer (Fig. 25).

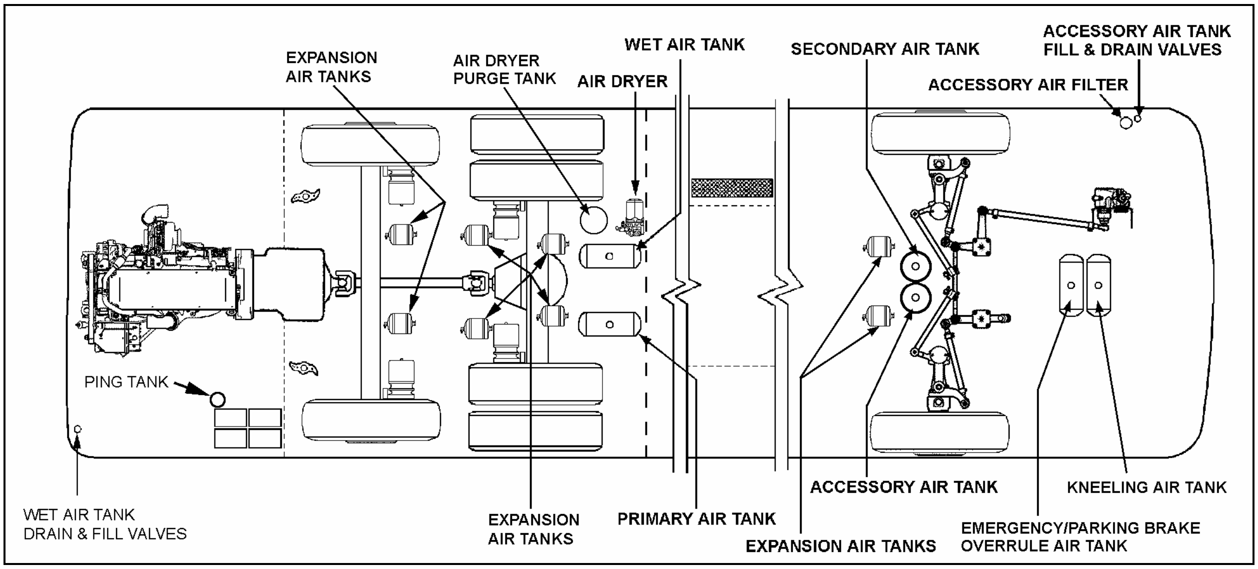


FIGURE 26: LOCATION OF AIR TANKS 24007C

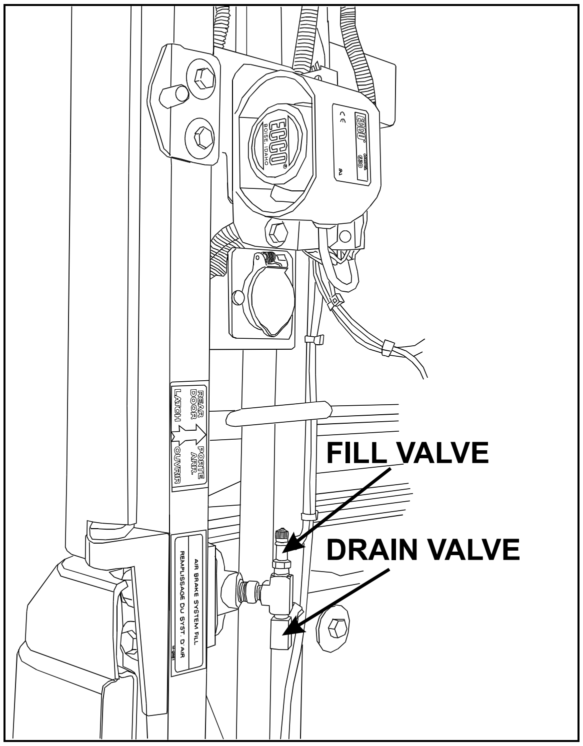


FIGURE 27: REAR VALVE LOCATION 12202

13.1.2 Primary Air Tank

The primary air tank is located above R.H. wheel of drive axle.

This tank is provided with a bottom drain valve (Fig. 24). It is recommended to purge the primary air tank by its bottom drain valve every 12,500 miles (20 000 km) or once a year, whichever comes first.

13.1.3 Secondary Air Tank

This tank is located in front wheelhousing, between air springs. The tank is installed vertically and is provided with a bottom drain valve (Fig. 24).

It is recommended to purge the tank by its bottom drain valve, every 12,500 miles (20 000 km) or once a year, whichever comes first.

13.1.4 Accessory Air Tank

The accessory air tank is installed next to the secondary air tank. The tank is installed vertically and is provided with a bottom drain valve (Fig. 24).

It is recommended to purge the tank by its bottom drain valve, every 12,500 miles (20 000 km) or once a year, whichever comes first.

A remote drain valve is located in front service compartment (Fig. 26) underneath the accessory air filter. Refer to Section 12, paragraph "4. Accessory Air Filter" of the maintenance manual for daily purge procedure.

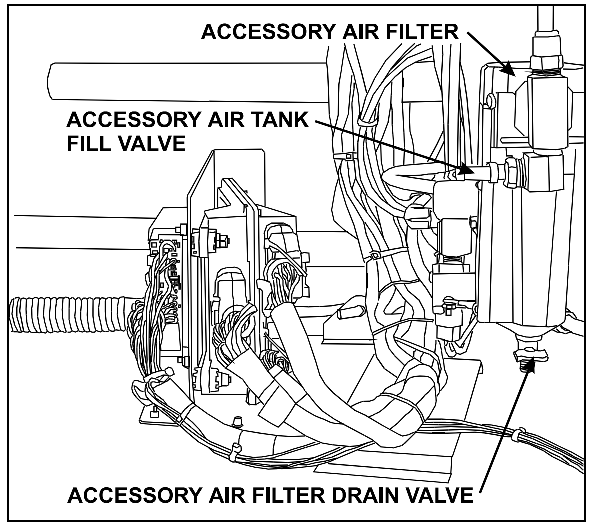


FIGURE 28: FRONT VALVE LOCATION 12201

13.1.5 Expansion Air Tank

Two expansion tanks are located in front wheelhousing. These air tanks are located behind secondary and accessory air tank. Also, six expansion tanks are located near rear air springs (Fig. 24). Expansion tanks are connected in series with air springs. Expansion tanks are used to lower the stiffness of the air spring. They are provided with a bottom drain valve.

It is recommended to purge them, with all other tanks, every 12,500 miles (20 000 km) or once a year, whichever comes first.

13.2 EMERGENCY FILL VALVES

The vehicle is equipped with two air system emergency fill valves to supplement the air system when air pressure is low and engine cannot be operated.

The rear valve is located in engine compartment and accessible from engine R.H. side door (Fig. 25).

Caution: *No other point should be used to supply air system. The maximum allowable air pressure is 125 psi (860 kPa).*

The front valve is located in the front service compartment close to accessory air filter (Fig. 26).

These two air valves are fitted with the same valve stems as standard tires, and can be filled by any standard external air supply line.

The rear valve will supply air for all systems (brakes, suspension and accessories) while the front valve will supply air for accessories only.

Caution: *Air filled through these two points will pass through the standard air filtering system provided by Prévost. Do not fill air through any other points.*

14. HUB UNIT AND SWIVEL ASSEMBLY

Refer to “DANA SPICER Service Manual General Information, Maintenance Manual Model NDS and Maintenance Manual NDS Axles” annexed to section 10 *"Front Axle".*

15. TORQUE TABLE

DESCRIPTION	*QTY*	*REFERENCE*	*TORQUE (DRY) Ft-Lbs / Nm*	
Pitman Arm to Steering Gear Fixing Nut	*1*	*8*	*400-450*	*545-610*
*Drag Link to Pitman Arm Stud Nut**	*1*	*---*	*160-215*	*220-290*
*Drag Link to Bell crank Stud Nut**	*1*	*---*	*160-215*	*220-290*
Drag Link Socket End Clamp Bolt Nut	*2*	*---*	*40-60*	*55-80*
*Relay Rod to Bell crank Stud Nut**	*1*	*---*	*160-215*	*220-290*
*Relay Rod to Idler Arm Stud Nut**	*1*	*5*	*160-215*	*220-290*
*Tie Rod to Bell crank Stud Nut**	*1*	*---*	*160-215*	*220-290*
*Tie Rod to Idler Arm Stud Nut**	*1*	*5*	*160-215*	*220-290*
*Tie Rod to Steering Arm Stud Nut**	*2*	*3*	*160-215*	*220-290*
Tie Rod End Clamp Bolt Nut	*4*	*3*	*40-60*	*55-80*
*Steering Arm to Swivel Nut**	*4*	*---*	*190*	*260*
Torque Rod Stud Nut	*2*	*4*	*160-215*	*220-290*
Idler Arm and Bell Crank Cap Screws	*8*	*9*	*8*	*11*
Torque Rod Mounting Bracket Nut	*4*	*6*	*75-140*	*100-190*
Torque Rod Clamp Nut	*4*	*4*	*53-59*	*72-80*
Jacking Point Bracket Nut	*8*	*19*	*70-80*	*95-110*

DESCRIPTION	QTY	REFERENCE	TORQUE (DRY) Ft-Lbs / Nm	
Bushing Collar Nut	*8*	*20*	*72-88*	*98-120*
Sway Bar Link Upper Nuts (Rear Suspension)	*2*	*20*	*100-120*	*135-160*
Sway Bar Link Lower Nuts (Rear Suspension)	*2*	*20*	*70-80*	*95-110*

DESCRIPTION	QTY	REFERENCE	TORQUE (Lubricated) (Anti-Seize #680064) Ft-Lbs / Nm	
Idler Arm and Bell Crank Mounting Bracket Nut	*8*	*5*	*90-120*	*120-160*
Shock Absorber Mounting Stud Nut	*2*	*19*	*40-50*	*55-70*
Shock Absorber Pin Nut	*2*	*19*	*70-85*	*95-115*
Air Spring Nut	*3*	*18*	*20-25*	*27-34*
Sway Bar Link Upper and Lower Nuts (Front Suspension)	*2*	*20*	*120-140*	*160-190*
*Upper A-Arm Stud Nut******	*2*	*18*	*230-245*	*315-335*
Lower A-Arm Bracket Nut	*8*	*18*	*375-425*	*510-580*

DESCRIPTION	QTY	REFERENCE	TORQUE (Lubricated) (Loctite #242 Blue) Ft-Lbs / Nm	
Shock Absorber Pin	*2*	*19*	*350-400*	*475-545*
Steering Gear to Mounting Bracket Bolt	*5*	*8*	*355*	*485*

- **Tighten nut to specified torque, then advance to next aligning cotter pin slot and install a new cotter pin.**

16. SPECIFICATIONS

Front Axle Air Springs

Make .... Goodyear Tire and Rubber
Diameter .... 14.5 inches
Air Inlet.. 1/2''- 14 NPTF
Supplier number 1R14-167
Prévost number 630239

Shock Absorbers

Collapsed length.. 350 mm
Extended Length .... 560 mm
Supplier number 481700000208
Prévost number 630251

Height Control Valve

Make .... Barksdale
Supplier number .... 52321POAQ3-Q26 and 52321POAQ3-Q62
Prévost number .... 630156 and 630157

Steering Gear Box

Make .... ZF-Servocom
Supplier number 8098-988-570
Prévost number 661045

Steering Gear Box (Optional)

Make .... ZF-Servocomtronic
Supplier number 8098-988-571
Prévost number 661044

Power Steering Hydraulic Pump

Make .... TRW
Supplier number PS251616L10200
Prévost number 661070

Shim (Camber Adjustment)

Thickness .... 3.175 mm
Prévost number 160993
Thickness .... 6.35 mm
Prévost number 160992

Sway bar bushing (Drive Axle)

Make .... Prévost
Prévost number 130953

SECTION 18: BODY

ILLUSTRATIONS

1. VEHICLE EXTERIOR

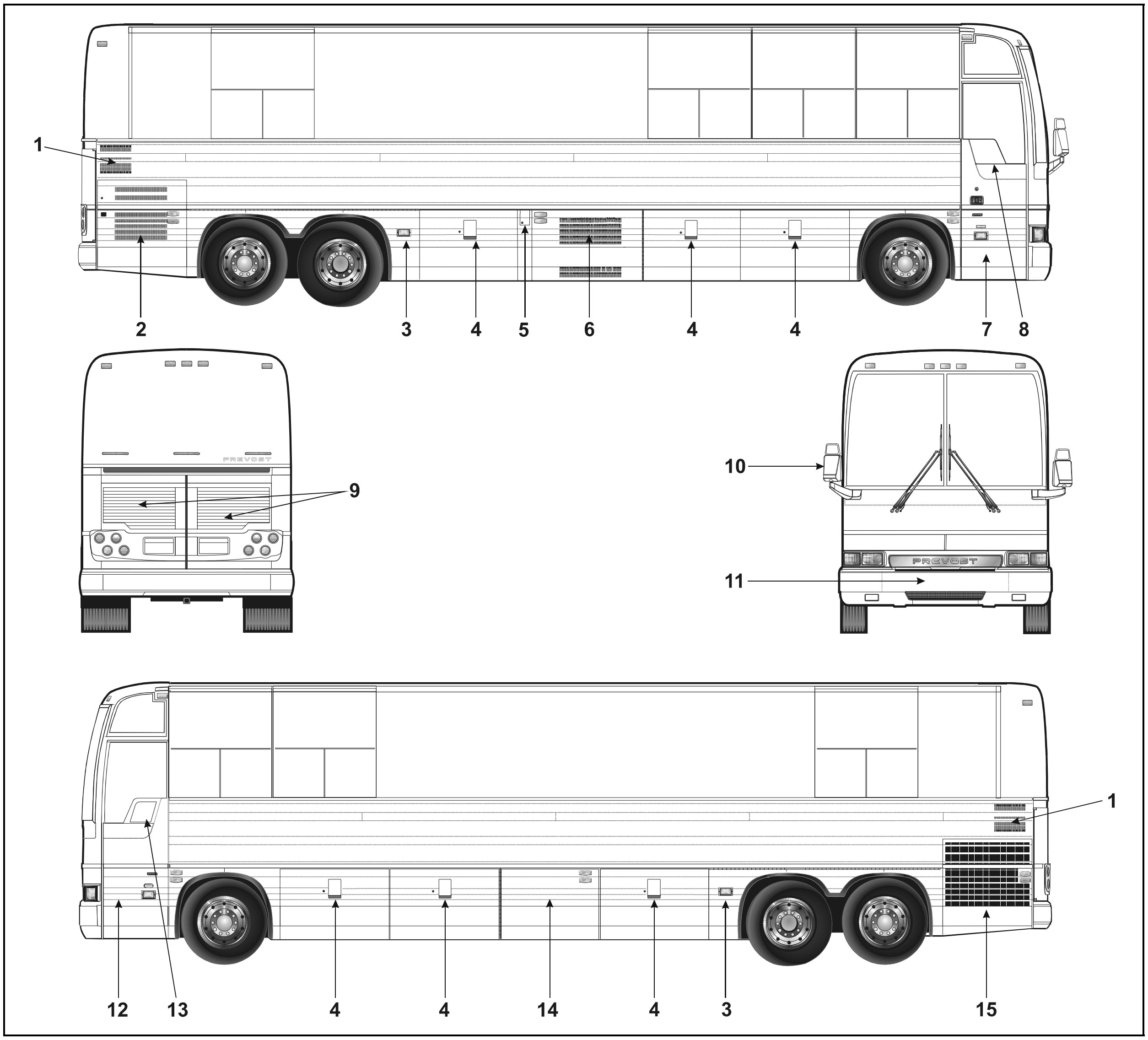


FIGURE 1: XL2-40 CONVERTED VEHICLE EXTERIOR VIEW (TYPICAL)

1. Engine air intake duct
2. Engine compartment R.H. side door
3. Hinged rear fender
4. Baggage compartment
5. Fuel filler door
6. Condenser or Baggage compartment
7. Entrance door
8. Entrance door power window
9. Engine compartment rear doors
10. Rear-view mirror
11. Reclining bumper
12. Front service compartment
13. Driver's power window
14. Evaporator or Baggage compartment
15. Radiator door

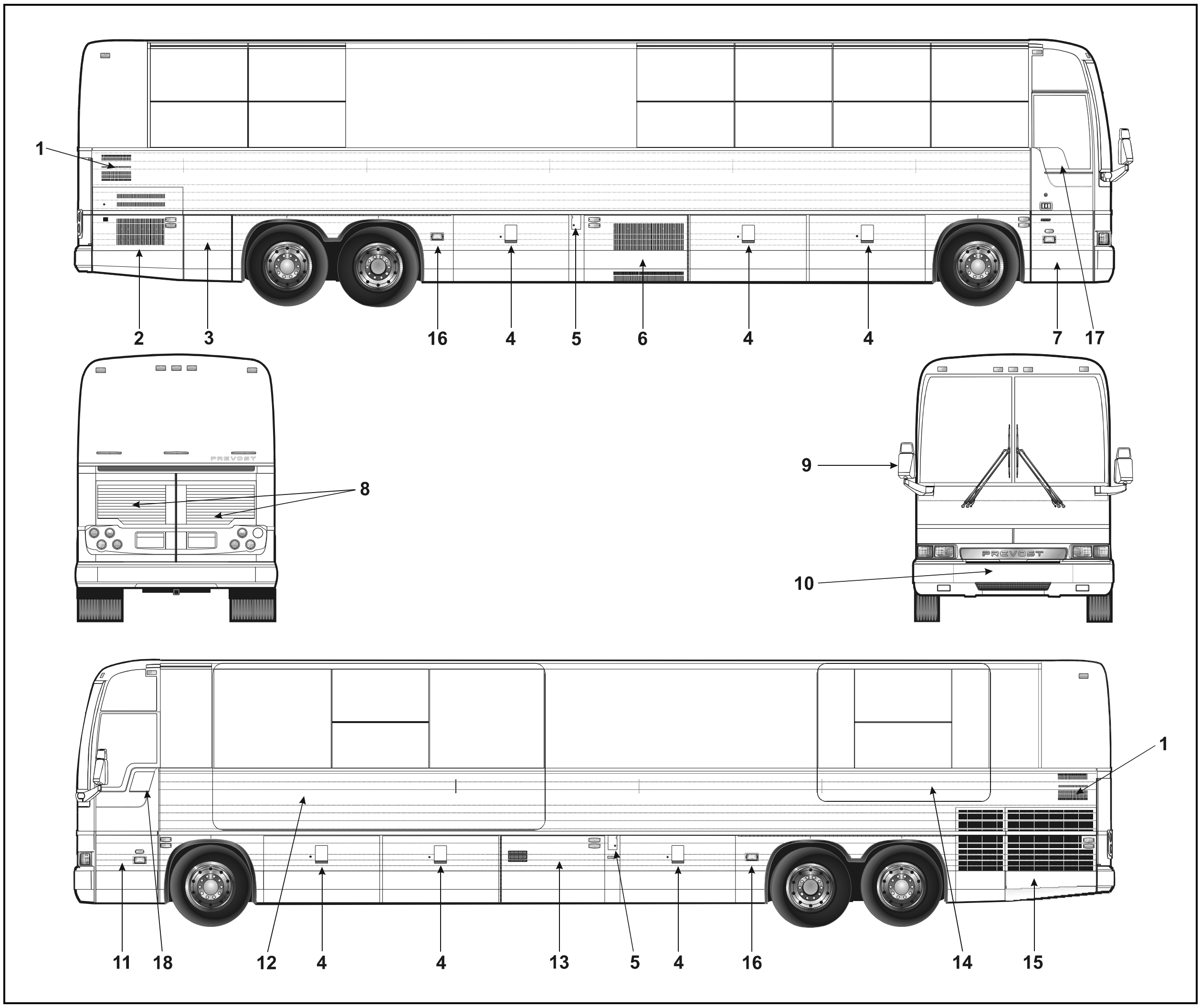


FIGURE 2: XL2-45 CONVERTED VEHICLE EXTERIOR VIEW (TYPICAL) 18362

1. Engine air intake duct
2. Engine compartment R.H. side door
3. R.H. side rear service compartment
4. Baggage compartment
5. Fuel filler door
6. Condenser compartment or Baggage compartment
7. Entrance door
8. Engine compartment rear doors
9. Rear-view mirror
10. Reclining bumper
11. Front service compartment
12. Front Slide-Out (Optional)
13. Evaporator compartment or Baggage compartment
14. Rear Slide-Out (Optional)
15. Radiator door
16. Hinged rear fender
17. Entrance door power window
18. Driver's power window

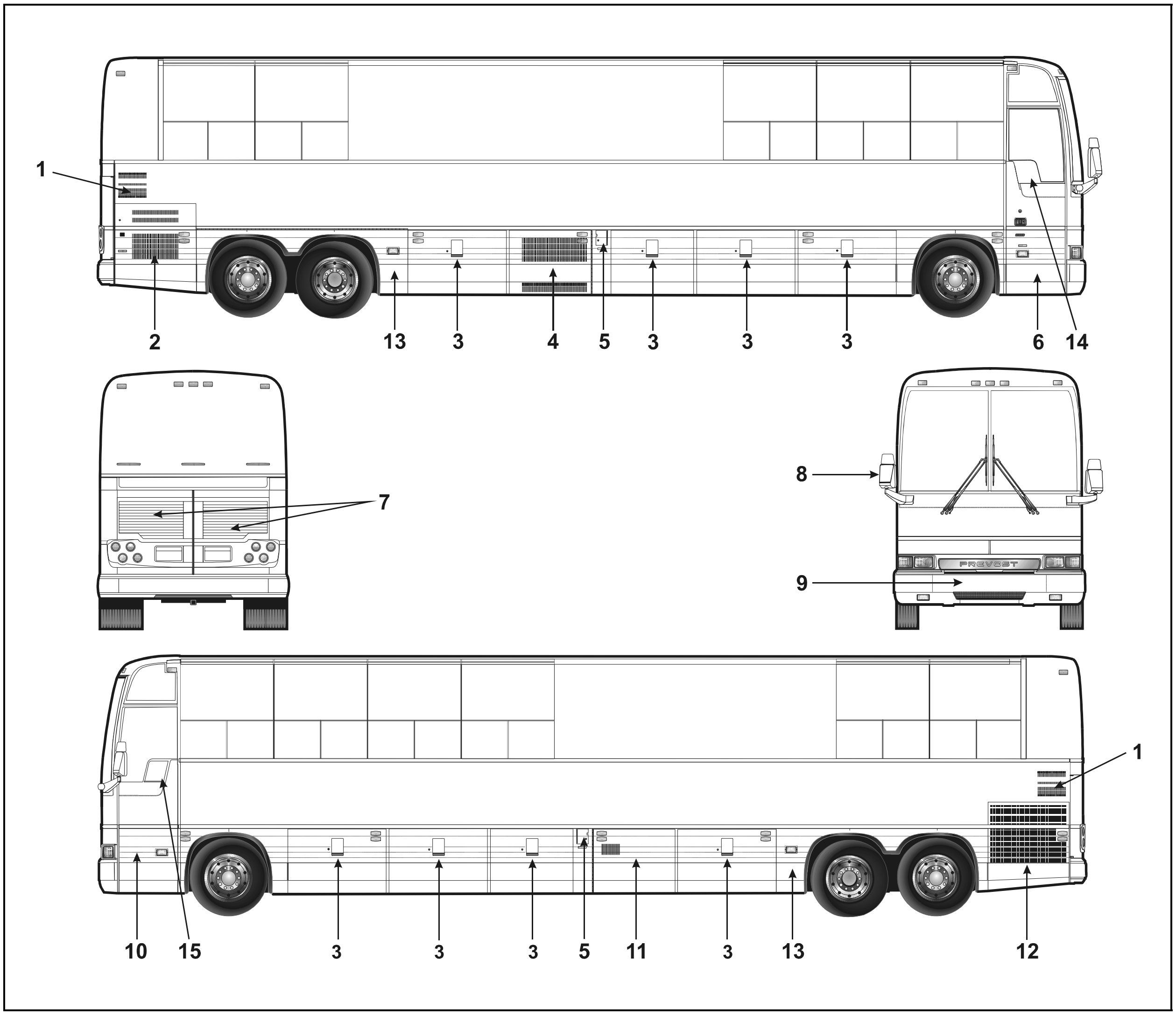


FIGURE 3: XL2-45E CONVERTED VEHICLE EXTERIOR VIEW (TYPICAL) 18369

1. Engine compartment R.H. side door
2. Engine air intake duct
3. Baggage compartment
4. Fuel filler door
5. Condenser or Baggage compartment
6. Entrance door
7. Engine compartment rear doors
8. Rear-view mirror
9. Reclining bumper
10. Front service compartment
11. Evaporator or Baggage compartment
12. Radiator door
13. Hinged rear fender
14. Entrance door power window
15. Driver's power window

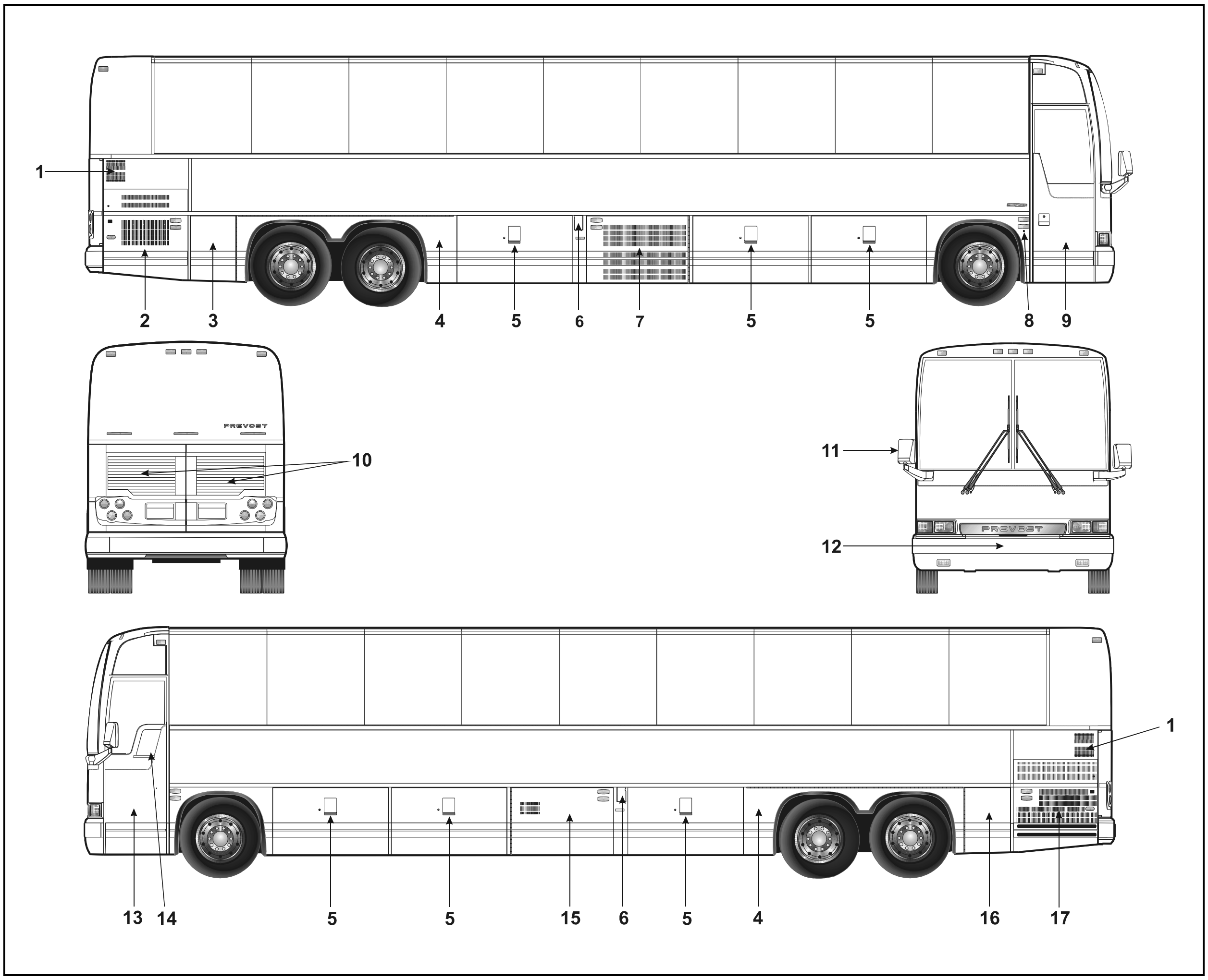


FIGURE 4: XL2-45 COACH EXTERIOR VIEW (TYPICAL) 18367

1. Engine air intake duct
2. Engine compartment R.H. side door
3. Main Power compartment
4. Hinged rear fender
5. Baggage compartment
6. Fuel filler door
7. Condenser compartment
8. Entrance door control switch
9. Entrance door
10. Engine compartment rear doors
11. Rear-view mirror
12. Reclining bumper
13. Front service compartment
14. Driver's power window
15. Evaporator compartment
16. L.H. Rear service compartment
17. Radiator door

2. STRUCTURE

The body of the XL2 vehicles is an integral structure made of 14, 16 and 18 gauge welded and braced high tensile steel and stainless steel members. All stainless exterior panels are glued to anti-corrosion coated members. The complete structure is protected against corrosion prior to assembly. The front and rear caps are made of molded fiberglass. The main roof is made of high tensile aluminum panels riveted to the roof structure. The floor is made of 2 layers of ½" (13 mm) thick plywood separated by a 1/8" (3 mm) insulation to reduce power train and road noises.

Welding

Since welding is a procedure that may be carried out either as specific instructions from Prévost or by an independent decision of the owner, the following information pertaining to welding should be read before beginning any welding procedure. The prohibitions and requirements outlined below must be followed during welding procedure:

1. Welding must be done only by a qualified and experienced person.
2. Adequate ground contacts and shields must be positioned as required to protect components from damage due to heat, contact by weld splatter, arcing, or other potentially damaging events associated with welding.
3. The following precautions are to be taken to protect the electronic control components. Refer to section 00, paragraph 3: “PRECAUTIONS TO BE OBSERVED BEFORE WELDING” in this manual.
4. Always wear the appropriate safety equipment.
5. Weld in clean and well ventilated area, and always have an appropriate fire extinguisher within your reach.

3. EXTERIOR MAINTENANCE

Regular washing to remove dust and dirt is recommended. See *"Operator's Manual"* for more details on washing and cleaning your vehicle.

3.1 CORROSION PREVENTION

Preventive maintenance is a key factor in avoiding corrosion and must be considered as part of the regular service intervals. The entire underside of the vehicle is sprayed with a heavy application of asphalt base undercoating.

The operating environment the vehicle is subjected to will largely influence the amount of dirt and corrosion that will accumulate over a given period. Corrosion is one of the most costly factors of part failure and shortened part life. It is, however, an item that can be controlled when it is conscientiously looked after and the proper steps are taken in a timely manner.

Certain areas of the coach are more vulnerable to corrosion than others, and it is these areas that should be addressed. For example, the rear baggage compartment bulkhead in the rear wheelhousing area contains many key components and should be examined regularly for corrosion. Other areas include the front wheelhousing area and the engine compartment.

Road splash will affect undercarriage, condenser coil and engine compartment. These areas must be thoroughly cleaned to remove dirt accumulations from flanges, channels and ledges. These places accumulate dirt and salt and hold it in direct contact with steel and aluminum surfaces. Use an understructure high pressure spray as part of a regular wash. Damaged undercoating or paint should be promptly repaired before corrosion can start.
Frequency of wash periods depends on operating conditions. During periods of exposure to salt, daily washing as described above is recommended. If underbody parts show evidence of rust or corrosion, treat as follows:

1. Remove dirt, grease and oil by solvent washing.
2. Remove corrosion as well as all loose coating by cleaning with a wire brush or sandblasting.

Caution: *Sandblasting can be used for cleaning bulkheads, brackets and other structural members. It should not be used for exterior side paneling. Extreme care should be taken not to sandblast excessively.*

3. Apply correct primer, paint and undercoating after removing all corrosion to prevent further damage.

3.2 PREVENTIVE MAINTENANCE SCHEDULE

Note: *TECTYL 185 GW rust inhibitor may have been applied on your vehicle underbody as an option, if this is the case, follow this procedure thoroughly. For future application of product, refer to paragraph 3.3 in this section.*

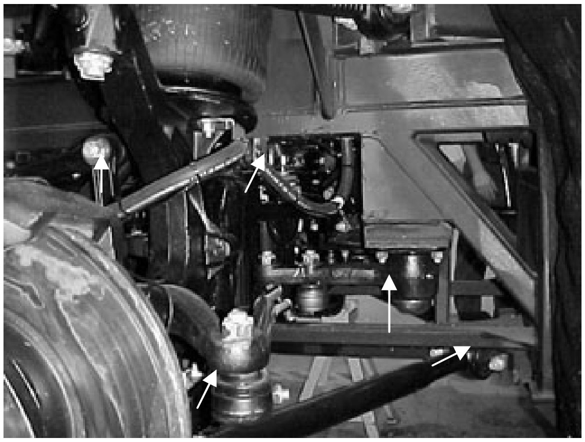
DESCRIPTION	INTERVALS		MAINTENANCE	CORRECTIVE ACTION	REFERENCE
	MONTHS	KM MILES			
BODY, EXTERNAL WINDOW FRAME	6	40 000 25 000	VISUALLY INSPECT SEALING BEADS CONDITION	REPAIR OR REPLACE SEALING BEADS IF NECESSARY	
VEHICLE UNDERBODY	12	100 000 60 000	USE A LOW PRESSURE SPRAY TO CLEAN UNDER-STRUCTURE AND VISUALLY INSPECT FOR CALCIUM DEPOSIT, CORROSION OR ANY DIRT ACCUMULATED ONTO EXPOSED SURFACES. VISUALLY INSPECT SEALING BEADS CONDITION. VISUALLY INSPECT IF UNDERFLOOR IS PEALING. VISUALLY INSPECT WHEELHOUSING COATING. MAKE SURE DISCHARGE TUBES ARE FREE FROM OBSTRUCTIONS	APPLY UNDERCOATING LOCALLY AS NECESSARY. APPLY UNDERCOATING LOCALLY AS NECESSARY REMOVE ANY OBSTRUCTION OR REPLACE DEFECTIVE TUBE	
SUSPENSION AND UNDERSTRUCTURE	12	100 000 60 000	VERIFY THE CONDITION OF ALL SUSPENSION AND UNDERSTRUCTURE FASTENERS AND CLAMPS	TIGHTEN OR REPLACE DEFECTIVE OR MISSING FASTENERS	
FLOOR COVERING	3	20 000 12 500	VISUALLY INSPECT IF FLOOR COVERING IS SHOWING SIGNS OF DETERIORATION SUCH AS CUTS, BURNS, ETC. ALSO, VISUALLY INSPECT SEALANT ALONGSIDE TRACKS. INSPECT WALL PANELS FROM BOTTOM TO WINDOWS	REPAIR OR REPLACE DEFECTIVE COVERING. MAKE SURE PROPER SEALANT IS USED.	
FLOOR CLEANING			CLEAN FLOOR COVERING AS NECESSARY		

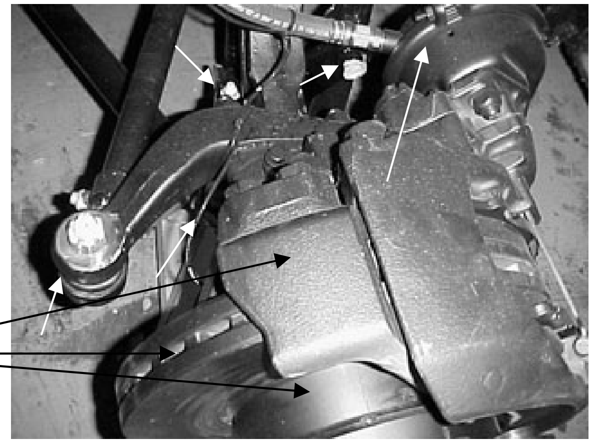
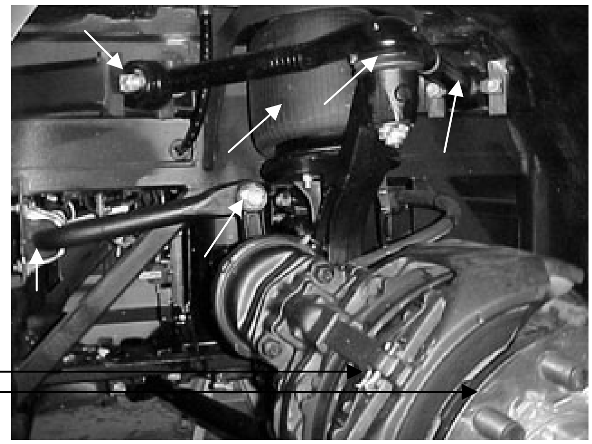
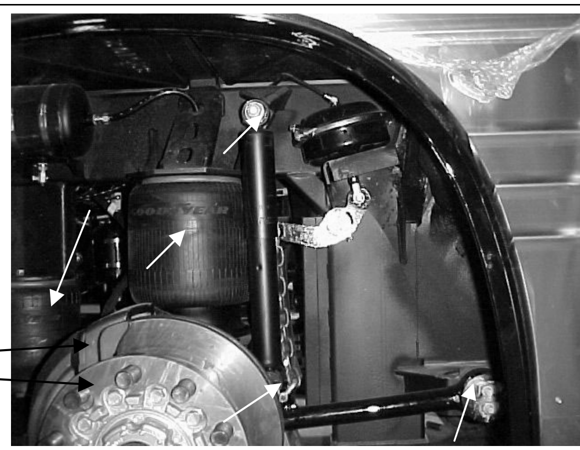
WARNING: Failure to follow this preventive maintenance schedule will result in warranty void.

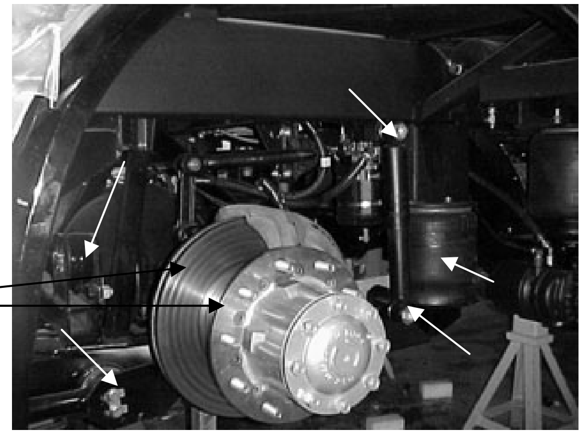
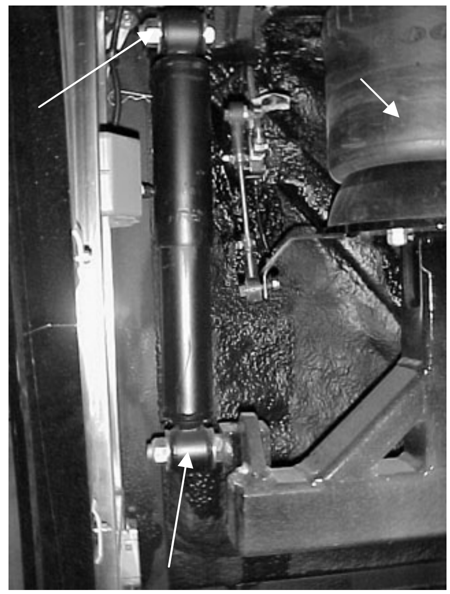
3.3 RUST INHIBITOR APPLICATION

Material: Tectyl 185 GW
R1KG21

Safety Rules: Use safety glasses
Supplied air hood
Solvent-resistant rubber gloves

1.0 Wash both wheelhousing mechanical parts before masking.	A water-hose nozzle is recommended. Water may be hot to reduce washing time especially during winter. If parts are soiled with oil, clean using R1KG21. Avoid rubber parts.
2.0 Dry all water sprayed parts. Surface temperature and dew point must be respected before applying rust inhibitor.	Air pressure system may be used, refer to annex 1 for surface temperature and dew point.
3.0 **Front wheelhousing** a) Mask all rubber joints. Braking system must also be protected (refer to arrows). Commercial aluminum foil may be used for masking.	
3.1 **Front wheelhousing** Front view	
3.2 **Front wheelhousing**	

3.3 **Front wheelhousing** (Entire braking system)	
4.0 **Rear wheelhousing** a) Mask all rubber joints. Braking system must also be protected (refer to arrows). Commercial aluminum foil may be used for masking (Entire braking system)	
4.1 **Rear wheelhousing** (Entire braking system)	

4.2 **Rear wheelhousing** (Entire braking system)	
4.3 **Rear wheelhousing**	
5.0 Close off wheelhousing using masking paper.	Prevent rust inhibitor from coming in contact with paint. To close off wheelhousing, a polythene sheet may be used.
6.0 Apply TECTYL 185 GW black rust inhibitor onto wheelhousing mechanical parts.	A spray gun and pumping system are required to apply the rust inhibitor. If the application is done inside a paint room, select high speed ventilation. **Minimum required thickness is 10 mils wet or 5 mils dry**.
7.0 Remove all masking material 30 minutes after application.	

ANNEX 1

1. Check and confirm that dew point and surface temperature are in accordance with to the following criteria:

   Surface temperature > 10°C

   Surface temperature > or = to dew point + 3°C

Note: *Use the following table to determine dew point*.

2. Check and confirm that TECTYL temperature is between 10°C and 35°C.

DEW POINT

	Relative Humidity (%)										
	10	20	30	40	50	60	70	80	90	100	
Temp (c)											
0	---	-16	-11	-8	-5	-3	-1	0	1	3	
1	---	-15	-10	-7	-5	-3	-1	1	2	4	
2	---	-14	-10	-6	-4	-1	0	2	3	5	
3	---	-13	-9	-5	-3	-1	1	2	4	6	
4	---	-13	-8	-5	-2	0	2	4	5	7	
5	---	-11	-7	-4	-1	1	3	5	6	8	
6	---	-11	-8	-3	0	2	4	6	7	9	
7	-18	-10	-6	-2	0	2	5	6	8	10	
8	-17	-9	-5	-1	1	4	6	7	9	11	
9	-16	-9	-4	-1	2	4	6	9	10	12	
10	-16	-8	-3	0	3	5	7	10	11	13	
11	-15	-7	-3	1	4	6	9	10	12	14	
12	-14	-6	-1	2	5	7	10	11	13	15	
13	-14	-6	-1	2	6	8	10	12	14	16	
14	-13	-5	0	4	6	9	11	14	15	17	
15	-12	-4	1	4	7	10	12	14	16	18	
16	-11	-4	1	5	9	11	13	15	17	19	
17	-10	-3	2	6	9	12	14	16	18	20	
18	-10	-2	3	7	10	13	15	17	19	21	
19	-9	-1	4	8	11	14	16	18	20	22	
20	-9	0		5	9	12	15	17	19	21	23
21	-8	0		5	10	13	16	18	20	22	24
22	-7	1		6	11	14	16	19	21	23	25
23	-6	2		7	11	15	17	20	22	24	26
24	-6	2		8	12	16	19	21	23	25	27
25	-5	3		9	13	16	20	22	24	26	28
26	-4	4		10	14	17	20	23	25	27	29
27	-4	5		11	15	19	21	24	26	28	30
28	-3	6		11	16	19	22	25	27	29	31
29	-2	6		12	17	20	23	26	28	30	32
30	-1	7		13	17	21	24	27	29	31	33
31	-1	8		14	19	22	25	27	30	32	34
32	0	9		15	20	23	26	29	31	33	35

4. FIBERGLASS REPAIR

All repairs to fiberglass parts consist of filling the damaged area with fiberglass cloth and resin or strand fiberglass and resin. The repair is allowed to harden, then finishing operations may be performed. Use of the various materials is determined by the type of repair to be made. Large holes, torn sections and separate joints require the adhesive qualities of the resin and the reinforcing qualities of the fiberglass. Small dents, scratches or pits can be repaired using resin and strand fiberglass and filler mixed into paste. Instructions for either mix are explained under their respective headings in this section.
For best results when making repairs, temperature should be between 70 and 75 ^{o}F (21-24 ^{o}C). Some people experience a skin reaction to resins. In such cases, wipe resin off with denatured alcohol or a good thinner. Use of protective hand cream is recommended.

Warning: *Always wear a respirator and goggles when grinding or sanding.*

Extreme care must be taken if the sander is electrically operated, as dust from some resins is combustible when subjected to sparks or open flames. The proper tool for sanding resin is a low speed, air driven disc sander with a water attachment or a dry sander having a vacuum bag. Either will eliminate flying glass and resin dust.
The following additional tools and materials will assist in making repairs: hacksaw blade, assorted files, emery paper or cloth (150 or finer), scissors or tin snips, wax paper or cellophane sheets, a 3" (75 mm) paint roller, paint brush, putty knife, acetone and one or more heat lamps.

4.1 REPAIR USING FIBERGLASS CLOTH

Where necessary, sand paint away around damaged area and scrape away undercoating, if any, and wipe clean with solvent. Grind or file the damaged area to form a "V" at the broken or cracked portion. Sides of "V" should have a shallow pitch for maximum bonding area.

Note: *Roughening the surface improves adhesion of resin.*

If part is warped from original shape, use clamping equipment to straighten the surface. Preheat area to be repaired with one or two heat lamps placed 18 to 24 inches (450-610 mm) from repair.

Caution: *Temperature should not exceed 140 ^{o}F (60 ^{o}C) during 30 minutes in order to avoid distortion.*

Cut fiberglass cloth with scissors or tin snips, 1 to 3 inches (25-75 mm) larger than area to be repaired. Build area to desired height.

Mix resin and hardener following instructions on their containers. Saturate layers of fiberglass with mixture and place laminates over damaged area. Smooth out wrinkles and make sure general contour of area is maintained. Bubbles and wrinkles can be eliminated with a roller.

Caution: *The pot life of the mix is approximately 15 minutes. Any accidental contamination to the skin, clothing, tools, etc. must be removed within this period. Use acetone to remove uncured resin.*

Heat resin material again by placing heat lamps 18 to 24 inches (450-610 mm) from repaired area. Allow 12 to 15 minutes for repair to cure. After repair is cured, grind, file or sand to contour. Files other than body files may be more suitable. Featheredge and finish sanding.

If small pits or irregularities appear after making repair, correct by using a liberal amount of chopped strand or filler mixed with resin to form a paste. Refer to heading *"Repair using Fiberglass Paste"* in this section.

4.2 REPAIR USING FIBERGLASS PASTE

Fiberglass paste is used for repairing small dents, scratches, and pits. Paste is made by mixing resin, hardener and fiberglass strand or filler to the consistency of putty. Where necessary, sand paint away around damaged area. On underside of coach, scrape away undercoating from damaged area, and wipe clean with solvent.

Preheat the area to be repaired using heat lamps. Mix desired quantities of resin and hardener according to manufacturer's instructions. Add powdered fiberglass strand into mixture to thicken it into a putty state.

Note: *If repair is made on a vertical surface, adding powdered filler material to mixture will reduce tendency of hot resin to flow or run.*

Apply the material with a putty knife or similar object, building material up to the desired contour. For deep filling and on vertical surfaces, several layers of material may be used.

A hacksaw blade, held flat to adjacent contour and then moved in a sawing action across the repair when the resin is in a gel state, will remove excess resin from repair. Finish repair with the same procedure as when using fiberglass cloth.

4.3 TYPICAL FIBERGLASS REPAIR PROCEDURE

Remove all loose particles or damaged material using a power sander or rasp. Clean area, overlapping hole approximately 1" to 1-½" (25-40 mm) all around. Remove all dirt, grease and paint from area to ensure good bonding surface. Feather the cleaned area all around (Fig. 5).

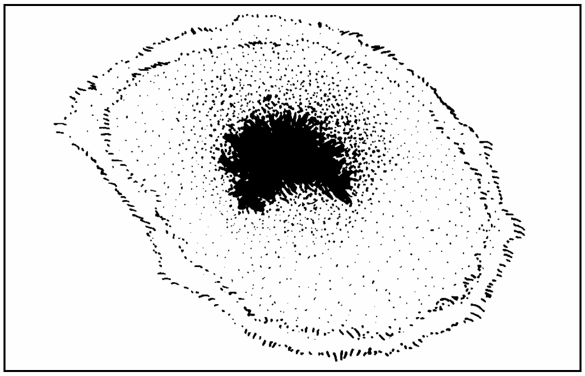


FIGURE 5: FIBERGLASS REPAIR 18089

Cut a piece of fiberglass mat slightly larger than area being repaired. Impregnate mat with general purpose polyester resin catalyzed normally. Use a clean paint brush to apply the polyester resin. Apply impregnated mat over hole and press onto surface with brush to obtain good adherence. Another coat of general purpose polyester resin can be applied at this time (Fig. 6).

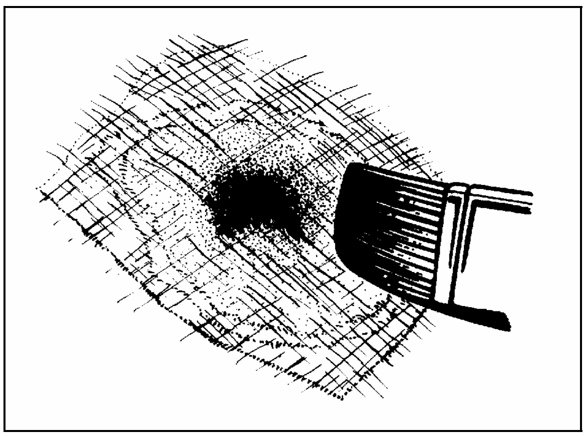


FIGURE 6: FIBERGLASS REPAIR 18090

Note: *Remove all air between surfaces being joined. Allow area to harden and sand surface to remove any wax.*

Apply another mat, followed by a cloth patch, and another mat. All layers must be thoroughly impregnated with polyester resin, brushed well and free of air. Apply more layers of mat and cloth as required until the desired strength and thickness is obtained, minimum two 1-½ oz (43 g) mats and one 9 oz (255 g) cloth (Fig. 7).

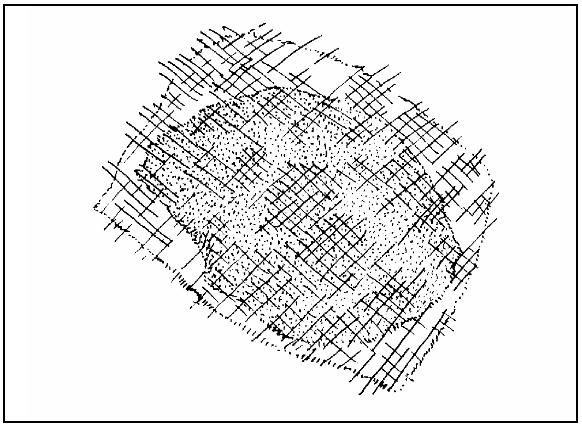


FIGURE 7: FIBERGLASS REPAIR 18091

Allow area to harden and contour the area with coarse sandpaper #100 (Fig. 8).

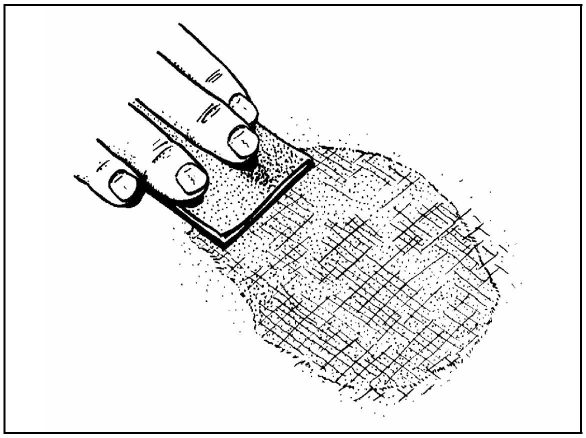


FIGURE 8: FIBERGLASS REPAIR 18092

Cover the area with a layer of resin putty and allow to dry for approximately 15 to 20 minutes (Fig. 9).

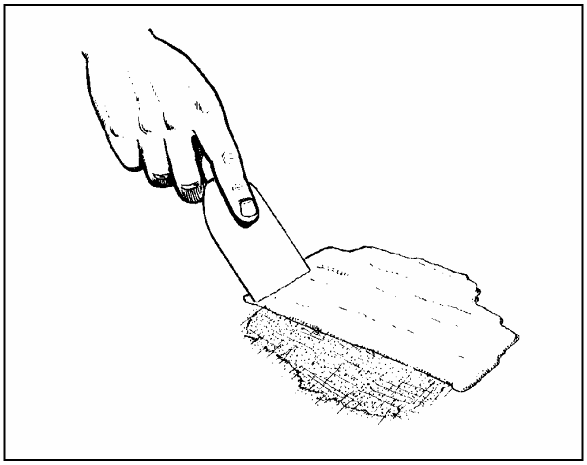


FIGURE 9: FIBERGLASS REPAIR 18093

Smooth off surface with coarse sandpaper #100 to desired shape. Further smooth surface with fine sandpaper #120 until repaired surface matches surrounding area paneling. Prime and paint the area to match surrounding paintwork.

5. PAINTING

5.1 NEW PAINT CARE

Our paint supplier recommends that you follow these simple precautions the first months of your new vehicle's life.

Caution: *Apply these recommendations after repainting vehicle.*

During the first 30 days:

- Do not use a commercial bus wash. Stiff brushes or sponges could mar the finish and damage the surface. Wash the vehicle by hand only and with cool water and a very mild bus wash solution. Be careful to use only a soft cloth or sponge;
- Wash vehicle in the shade, never in direct sunlight;
- Do not "dry wipe" vehicle –always use clean water. Dry wiping could scratch the finish;
- Avoid extreme heat and cold. Park vehicle in the shade whenever possible;
- Do not park under trees which drop sap or near factories with heavy smoke fallout. Tree sap and industrial fallout may mar or spot a freshly painted surface;
- Trees are also likely to attract birds. Bird droppings are highly acidic and will damage a freshly painted surface. Bird droppings, tree sap and industrial fallout should be washed off as soon as possible;
- Do not spill oil, gasoline, antifreeze, transmission fluid or windshield solvent on new finish. IMMEDIATELY rinse off any such spill with clean water, DO NOT WIPE;
- Do not drive on gravel roads. Paint finish easily chips during the first 30 days;
- Do not scrape ice or snow from the surface. A snow scraper can act like a paint scraper if the finish is new. Brush off loose material with a soft snow brush.

During the first 90 days:

- Do not wax or polish the vehicle. This will allow the finish to dry and harden completely.

5.2 PAINT TOUCHUP

When paint touchup or partial repainting is necessary, refer to the vehicle's paint scheme for color codes and paint brand.

Prévost recommends using the original paint brand to ease color matching.

In the event you sand through to the gelcoat surface you should prime the area with Standox "Non Stop Fill Primer (ST-11000)".

If you sand through to metal surface, first prime with Standox "Etch Primer (ST-11858)" then with Standox "Non Stop Fill Primer (ST-11000)".

Caution: *Be sure to heed all paint manufacturer's recommendations, especially concerning paint dilution and application.*

5.3 PAINTING

The standard paint used on the exterior of the vehicle is Standox Basislack. It is a high gloss polyurethane enamel finish designed for exposure to extreme conditions. Other types of paint may be called for as options by owner but are not dealt with in this section.

5.3.1 Safety

Care should be exercised in storing, handling, mixing, and applying paint and chemicals listed in this manual. The topcoat, primer, solvent, catalysts, accelerators, and cleaners are highly volatile and/or toxic if not properly used. Observe all safety instructions marked on the different packaging, as well as the following:

1. Do not smoke in the paint room or in adjacent area exposed to residue fumes.
2. Wear respirators approved by the governing safety and health regulations.
3. Maintain adequate ventilation at all times.
4. Dispose of any leftover paint mix properly.
5. Wear rubber gloves, rubber apron, and face shield during all phases of paint and chemical handling.

5.3.2 SURFACE PREPARATION AND PAINT APPLICATION

	Aluminum and / or Stainless Steel	Fiberglass	Comments
Surface Preparation	Sand using P-150 grit sandpaper. It is recommended to sandblast rivets and panel edges with OLIMAG 35-70 blast media.	Sand using P-180 or P-240 sandpaper.	Do not use paint remover over aluminum or fiberglass.
Cleaning	STANDOX silicone remover ST-11654 (68-2989)		
Priming	STANDOX Reactive Etch Primer ST-13908 * Wait 30 minutes then apply STANDOX Non-Stop Füllprimer ST-11000 (68-2973)	STANDOX Non-Stop Füllprimer ST-11000 (68-2973)	Refer to product Technical Data sheet for proper mixing
Basecoat	Refer to paint scheme or coach record for proper color code and paint brand. We recommend using the same paint brand to ease color matching.		Refer to product Technical Data sheet for proper mixing
Clearcoat	STANDOX 2K MS Rapid Clear ST-11760 (68-2979) Allow 16 hours for drying		Refer to product Technical Data sheet for proper mixing

If assistance or technical information on STANDOX products is needed, please dial: 1 (800) 551-9296

6. BODY REPAIR

Note: *The purpose of this procedure is to explain the steps to be followed in order to get a good adherence. These steps are of the uppermost importance to obtain 100 % adherence. For a complete description of the procedure, refer to the applicable video.*

6.1 FRONT FACE

6.1.1 Prévost Car Embossed Body Panel

Removal

For removal of embossed body panel, you will need :

Olfa knife,
Razor sharp window scraper.

- Lower spare wheel compartment door.
- Insert from underneath a knife with a thin sharp blade (Olfa type), cut lower Sika bead (refer to figures 10 and 11).

Note: *Sika bead is located 1 inch (25 mm) from bottom of body panel.*

- Make several passes with the knife to ensure Sika bead is truly cut which will facilitate bending of the body panel.
- Bend body panel upwards in order to access the upper bead. Upper bead is located about ¼" (4 mm) from top of body panel.
- Cut upper bead and double-face self adhesive tape.
- Use a sharp scraper type tool to remove the Sika bead and double-face self adhesive tape residue from the fiber glass surface.

Note: *To ensure maximum adherence of Sika glue, do not leave any Sika bead or double-face self adhesive tape residue.*

Caution: *You only have 10 minutes to install the body panel once the adhesive is applied before the adhesive starts to dry.*

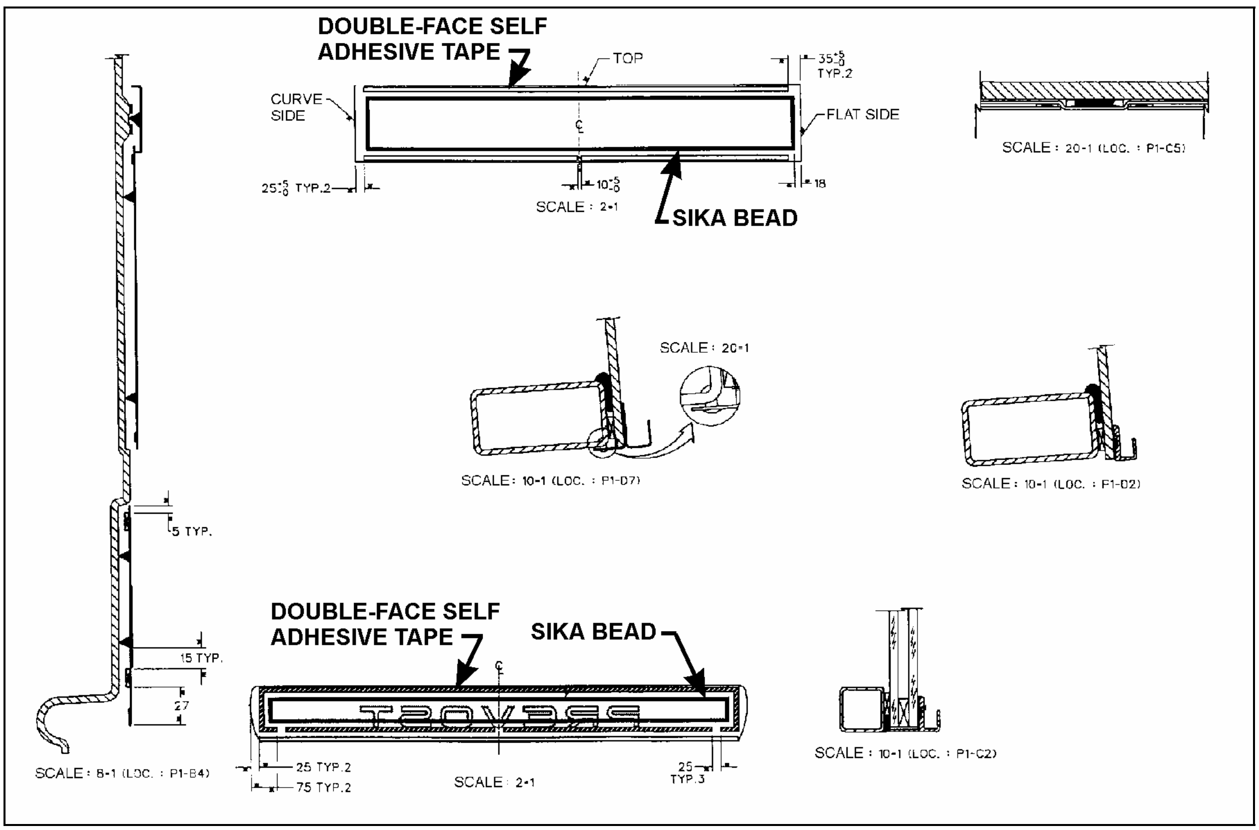


FIGURE 10: FRONT FACE BODY PANELS INSTALLATION

Installation

Preparation of stainless steel surface.

The purpose of this procedure is to show you the proper way to install the Prévost embossed body panel onto the XL2 vehicle.

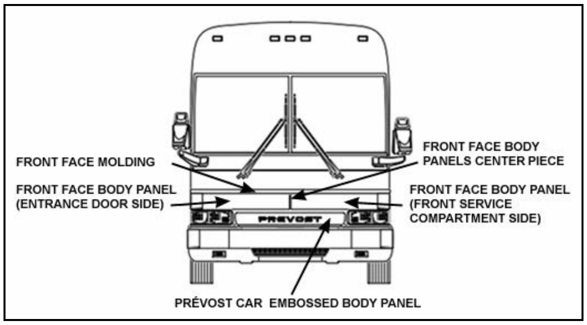


FIGURE 11: VIEW OF FRONT FACE

First of all you must prepare the stainless steel panel surface ("Gelcoat" scratch side) before installing it onto the fiber glass surface.

You will need for this preparation:

Latex gloves, because we will be using adhesive.
"Scotch Brite" pad for scratching.
Chix cloth for removing any residue from scratching.
"Sika cleaner 205" for stainless steel surface treatment. Allow 2 minutes for drying in the case of stainless steel. It is important to check the expiration date on product.
You will be using "Chix" cloth for the application of "Sika cleaner 205".
Once the surface is treated, you will apply a double-face self adhesive tape "Pro-foam 1/8 by ½" to mechanically hold the stainless steel body panel in position until the adhesive is cured.
And you will be using "SiKaflex 252" adhesive sealant.

Refer to figure 10 for more information on procedure.

- First of all, remove protective plastic lamination.
- Using a scratch pad "Scotch Brite", scratch a 2 inch wide surface around the perimeter of the panel where the adhesive will be applied. The purpose being to create scratches onto the surface to increase adherence.
- Use a Chix cloth and anti-silicone to remove any dust or residue.
- Before applying Sika cleaner, fold "Chix" cloth twice for proper width. Apply an even coat onto the treated surface. Allow 2 minutes for drying in the case of stainless steel.
- After this treatment, a bluish tint will appear on the stainless steel surface due to alcohol evaporation and salt deposits which will increase adherence.

Note: *Discard waste according to applicable environmental regulations, use dangerous waste containers. For more information on the application of double-face self adhesive tape near the top edge, refer to figure 10.*

- Draw a line 4 mm (¼ ") from the top edge, using a felt-tip pen.
- Align "Pro-Foam" self adhesive tape with the previously traced line and cut the end.
- The second application of "Pro-foam" self adhesive tape is near the bottom edge.
- Draw a line 27 mm (1") from bottom edge. Align "Pro-Foam" self adhesive tape with the previously traced line.
- Apply also a strip of self adhesive tape at each end of body panel.
- To prevent water accumulation, a 25 mm width dripping space must be provided underneath the "V" as well as two more at each end of the tape.

Sikaflex 252 Adhesive Sealant Application

- Check Sikaflex 252 adhesive sealant for expiration date.
- Sika bead is represented as checked lines, refer to figure 10 for more information.
- Sika bead must be uninterrupted to ensure maximum sealing. Cut ¼ of V shape nozzle length for proper flow of glue. Perforate cartridge tip.
- Apply Sika bead along the perimeter of body panel 15 mm (5/8") from double-face self adhesive tape.
- Once the body panel is compressed, the Sika bead will spread until it touches the tape.

Note: *Sika adhesive bead height must be greater than double-face self adhesive tape.*

- Peel the back from the self adhesive tape. In order to prepare fiber glass surface, scratch surface of the vehicle where the adhesive will be applied, use a Chix cloth and anti-silicone to remove any dust or residue.

Caution*: Do not damage painted surface.*

- Apply masking tape to protect paint during surface treatment.

- Apply an even coat of Sika 205 cleaner onto the complete surface.
- Allow at least 10 minutes for drying in the case of fiber glass.
- Lightly compress the perimeter of Prévost embossed body panel, avoiding the center, then compress using a dry erasable marker board brush so as not to scratch or damage the stainless steel surface. Ideally two persons should perform this installation.
- Remove masking tape.

6.1.2 Front Face Body Panel and Molding

For removal of front face body panel and molding, you will need :

Drill with drill bits,
Lever or similar tool,
Olfa knife,
“C”-clamp,
Razor sharp window scraper.

Front Face Molding Removal

- First of all, pry loose the front face molding using the lever. Save molding if only the body panel needs to be changed.
- Using the Olfa knife, cut the Sika bead and the double-face self adhesive tape. Remove the Sika bead and self adhesive tape residue with the scraper.
- Refer to figure 10 for more information on procedure.

Front Face Body Panel Removal

- Using a drill and a 1/8” drill bit remove the rivets fixing the vertical molding. The stainless steel molding is located on the entrance door or service door frame side depending on body panel to be removed.
- Using the Olfa knife, cut the Sika bead and the double-face self adhesive tape. Remove the Sika bead and self adhesive tape residue with the scraper.
- Pry loose the front face body panel using the lever.
- While somebody cuts the Sika bead and double-face self adhesive tape, another person pulls the body panel using the “C”-clamp to exert tension.
- Using the window scraper, remove any Sika bead or self adhesive tape residue left on the fiber glass surface.

Preparation of New Front Face Body Panel

- In order to prepare stainless steel panel, use a Chix cloth to remove any dust or residue.
- Using a scratch pad “Scotch Brite”, scratch a 2 inch wide surface around the perimeter of the panel where the adhesive will be applied.

Note: *It is important to support underneath the curved surface so as not to change the angle of the body panel and therefore prevent deformation*

- Use again a Chix cloth and anti-silicone to remove any dust or residue from scratching.
- Check expiration date before applying Sika 205 cleaner.
- Fold “Chix” cloth twice for proper width.
- Apply an even coat onto the treated surface.
- Discard waste according to applicable environmental regulations, use dangerous waste containers.
- Allow 2 minutes for drying in the case of stainless steel.
- Draw a line 5 mm from the top edge, using a felt-tip pen (refer to figure 10).
- Apply double-face self adhesive tape 1/16 x ¼, 5 mm from top.
- Draw a line 25 mm from curved side edge and 35 mm from flat side edge.
- Align “Pro-Foam” self adhesive tape with the previously traced lines.
- Cut a portion of self adhesive tape in the center of body panel for draining purposes.

Preparation of Front Face molding

- In order to prepare stainless steel molding, use a Chix cloth and anti-silicone to remove any dust or residue.
- Using a scratch pad “Scotch Brite”, scratch surface of the molding where the adhesive will be applied.

Note: *It is important to support underneath the curved surface so as not to change the angle of the molding and therefore prevent deformation*

- Use again a Chix cloth and anti-silicone to remove any dust or residue from scratching.
- Check expiration date before applying Sika 205 cleaner.

- Fold “Chix” cloth twice for proper width.
- Apply an even coat onto the treated surface.
- Discard waste according to applicable environmental regulations, use dangerous waste containers.
- Allow 2 minutes for drying in the case of stainless steel.

Preparation of Vehicle Fiber Glass Surface

- In order to prepare fiber glass surface, scratch surface of the vehicle where the adhesive will be applied, use a Chix cloth to remove any dust or residue.

Caution: *Do not damage painted surface.*

- Apply masking tape to protect paint during surface treatment.
- Apply an even coat of Sika 205 cleaner onto the two surfaces.
- Allow at least 10 minutes for drying in the case of fiber glass.
- Apply 1/8” by ½” double-face self adhesive tape onto each fiber glass boss where the front face molding will be installed.

Sikaflex 252 Adhesive Sealant Application

- Check Sikaflex 252 adhesive sealant for expiration date.
- Cut ¼ of V shape nozzle length for proper flow of glue. Perforate cartridge tip.
- Apply Sika bead along the perimeter of body panel ½” from double-face self adhesive tape.
- Peel the back from the self adhesive tape.

Caution: *You only have 10 minutes to install the body panel before the adhesive starts to dry.*

Front Face Body Panel Installation

- To hold in position the body panel during drying process, apply ¼ by 1/32” self adhesive tape onto the front face body panel center piece and peel back. Ideally two persons should perform this installation.
- Starting from the middle of the vehicle, compress the front face body panel using a dry erasable marker board brush so as not to scratch or damage the stainless steel surface.
- Open entrance door being careful not to move the body panel. Fix vertical stainless steel molding using 1/8” stainless steel rivets.
- Apply Sika bead between the two double-face self adhesive tape previously installed on each fiber glass boss.
- Install horizontal front face molding, aligning it with the door molding and compress using a dry erasable marker board brush.
- Remove masking tape.

6.1.3 Spare Wheel Compartment Door Body Panel

For the removal of spare wheel compartment door body panel,

You will need :

A hammer,
Screwdriver,
Locking pliers,
Putty knife,
Heat gun,
And isopropyl alcohol.

- Lower and remove front bumper.
- Remove spare wheel compartment door.
- First of all, using a lever or rigid screwdriver, pry loose body panel edge.
- Using a pair of locking pliers, gradually separate stainless steel body panel from door frame.
- Use the screwdriver to detach completely the stainless steel body panel from door frame.

Door Frame Preparation

- Start cleaning the door frame by removing double-face self adhesive tape.
- Use a heat gun and putty knife to remove the dried off Ciba 8535 epoxy glue residue.

Warning: *Make sure that heat gun nozzle does not get any closer than 4 inches from the surface.*

Warning: *Because of its great toxicity, care should be taken not to use a buffer or other sanding method for glue removal.*

- Then, using a scratch pad “Scotch Brite”, scratch the perimeter of door frame where the adhesive will be applied.
- Wear latex gloves and use a “Chix” cloth with isopropyl alcohol in order to remove any residue from scratching left onto the stainless steel surface.

Note : *Apply evenly around the perimeter of the panel. Use two clothes, first one applies product while second one immediately dries surface off before product evaporation.*

Body Panel Preparation

- Using a scratch pad "Scotch Brite", scratch a 2 inch wide surface around the perimeter of the panel where the adhesive will be applied.
- Use a Chix cloth and anti-silicone to remove any dust or residue.
- Clean the perimeter of the panel using isopropyl alcohol. Use two clothes, first one applies product while second one immediately dries surface off before product evaporation.

Sikaflex 252 Adhesive Sealant Application

- Check Sikaflex 252 adhesive sealant for expiration date.
- Cut ¼ of V shape nozzle length for proper flow of glue. Perforate cartridge tip.
- Apply Sika bead along the perimeter of body panel ½" from double-face self adhesive tape.
- Peel the back from the self adhesive tape.
- **Caution:** You only have 10 minutes to install the body panel before the adhesive starts to dry.

Stainless Steel Body Panel Installation

- Stainless steel body panel must be installed within 45 minutes.
- Align body panel with door frame and lightly press perimeter of body panel.
- Allow to dry for 6 hours before handling.

Note : *If for any reason you must remove the body panel from the door frame and the 6 hours have elapsed, you must wait* ***7 days*** *so that glue has time to cure.*

6.1.4 Windshield

For the removal or installation of windshield, you will need :

A rope,
A plastic spatula to lift the rubber seal lip,
A metal rod or screwdriver to clean the seal groove,
A filler insertion tool,
Goggles and protective gloves.

- From inside of vehicle, remove center post and interior finishing panels surrounding the windshield. In this case, we are replacing the R.H. side windshield.
- From outside of vehicle, remove filler located inside rubber seal to ease damaged windshield removal.
- From inside of vehicle, push against the top L.H. side corner of windshield for the removal of a R.H. side windshield. If the L.H. side windshield had to be removed, you would have to push against the top R. H. side corner.

Note: *We are referring to the L.H and R.H. side as viewed from the inside of the vehicle.*

- At the same time, another person gradually lifts the rubber lip from the vehicle exterior using a plastic spatula from top to bottom.
- Remove the entire damaged windshield and broken glass if applicable.
- If applicable, using a screwdriver or metal rod, remove black butyl sealant residue from rubber seal then clean with Sika 205.

Windshield Installation

Note : *Rubber seal may have to be replaced if it was used on several windshield replacements.*

- Spray rubber seal with soapy water to ease windshield insertion.
- Insert rope into rubber extrusion leaving enough length at each corner to make a loop. Spray soapy water onto rope and rubber extrusion (Fig. 12).
- Slide windshield into rubber seal groove starting with the bottom curved side edge. Using a plastic spatula, move the rubber seal lip aside to gradually insert the windshield into the groove.

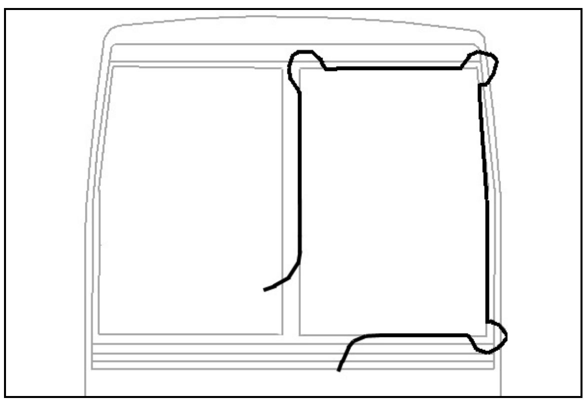


FIGURE 12: WINDSHIELD INSTALLATION USING ROPE

- Spray soapy water on a regular basis to ease this operation.
- Using the same type of plastic spatula, repeat the same operation from inside of vehicle, gradually inserting the windshield into the groove.

Note: *Make sure windshield bottom edge is well inserted into the rubber seal groove before proceeding with the sides.*

- Then, working from both sides of windshield bottom to top, gradually move the rubber seal lip aside to insert the windshield into the groove. Use also soapy water on the inside of vehicle to insert the windshield into the rubber seal groove.
- Insert the top curved corner then finish with the top of windshield.
- At the top of windshield, clean surface between fiberglass and rubber extrusion using Sika 205 (Fig. 13).
- Apply Sika 221 black between fiberglass and rubber extrusion
- Spray filler and rubber seal groove generously with soapy water.
- Using the special filler insertion tool, insert the filler into the rubber seal groove.
- Gradually insert filler into the rubber seal groove ensuring to leave a 2 inch excess length at the filler extremity.

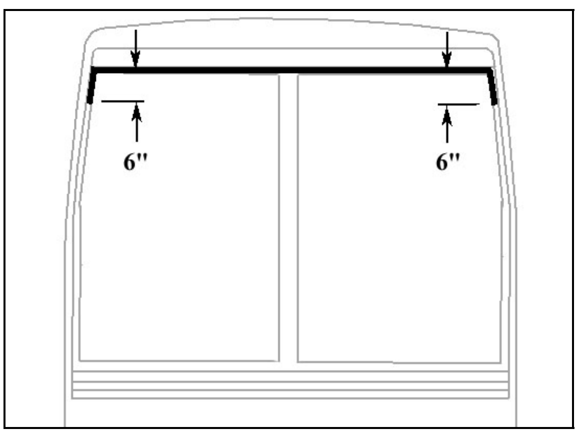


FIGURE 13: APPLICATION 0F SIKA 221 BLACK

- Every 6 inches or so, it is important to compress the filler due to its tendency to contract during drying process.
- When filler insertion is almost complete, cut filler leaving ¼" of excess length to thwart filler contraction over time then insert filler into groove.
- Reinstall center post and interior finishing panels.
- Clean windshield surface of butyl residue.

6.2 ENTRANCE DOOR OR FRONT SERVICE DOOR BODY PANEL

For the removal of entrance door or front service door body panel, you will need :

Pneumatic "Zip gun" type tool;
Razor sharp window scraper;

- Before removing body panel, you can to ease repair uninstall entrance door or front service door from vehicle. If applicable, remove reflector, keyless system keyboard and cornering light.
- You must also remove horizontal finishing molding located underneath the window. This molding is glued and will have to be replaced because it will be damaged at removal.
- Remove interior finishing panel to access rub rail fixing bolts, then remove rub rail.
- Using the "**Zip Gun**", cut Sika bead located ¼ inch (7-8 mm) from each body panel edge and around cornering light.
- Separate body panel from door.
- Remove from door surface Sika bead and double-face self adhesive tape residue using a razor sharp window scraper.
- Use a Chix cloth and anti-silicone to remove any dust or residue.

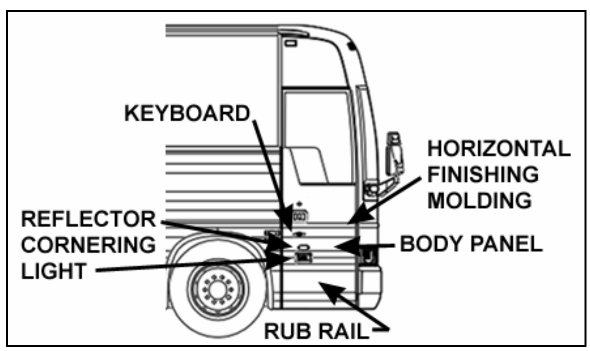


FIGURE 14: ENTRANCE DOOR BODY PANEL

Door Surface Preparation

- First of all, check Sika 205 cleaner expiration date.
- Before applying Sika cleaner, fold "Chix" cloth twice for proper width.

- Apply an even coat onto the door frame perimeter and allow to dry for 2 minutes (maximum 2 hours).
- Discard waste according to applicable environmental regulations, use dangerous waste containers.

Stainless Steel Body Panel Preparation

- Check that new body panel is the required one and is free of defects or scratches.
- Wear latex gloves and use a “Chix” cloth with isopropyl alcohol in order to remove any dirt or oily film left onto the stainless steel surface.

Note : *Apply evenly around the perimeter of the panel. Use two clothes, first one applies product while second one immediately dries surface off before product evaporation.*

- Using a scratch pad “Scotch Brite”, scratch a 2 inch wide surface around the perimeter of the panel where the adhesive will be applied. The purpose being to create scratches onto the surface to increase adherence.
- Use again a chix cloth and anti-silicone to remove any dust or residue.
- Before applying Sika cleaner, fold “Chix” cloth twice for proper width.
- Apply an even coat onto the treated surface.
- Allow 2 minutes for drying in the case of stainless steel (maximum 2 hours).
- Apply a double-face self adhesive tape 1/8 by ½ inch on each side and at the top of body panel and around cornering light. Apply tape 1/8 inch from body panel edges and flush with cornering light perimeter.
- Peel back from double-face self adhesive tape.

Sikaflex 252 Adhesive Sealant Application

- Check Sikaflex 252 adhesive sealant for expiration date.
- Using a “V” shape nozzle, apply Sika bead ¼ inch (6-7 mm) from double-face self adhesive tape on all three sides of body panel and around cornering light.
- Once the body panel is compressed, the Sika bead will spread until it touches the tape.

Note: *Sika adhesive bead height must be greater than double-face self adhesive tape.*

Note : *You only have 15 minutes to install body panel once the adhesive is applied.*

- Peel the back from the self adhesive tape.
- Carefully center and align body panel edges with the door fiber glass surface.
- Ideally two persons should perform this installation.
- Lightly compress the body panel along the double-face self adhesive tape, then compress using a dry erasable marker board brush so as not to scratch or damage the stainless steel surface.
- Apply masking tape on both body panel sides.
- Using a caulking nozzle and “SIKAFLEX 221” adhesive, fill the cavity to seal both body panel sides and around cornering light.
- Wearing surgical gloves, smooth down the joint with your finger.
- Remove masking tape and protective plastic lamination.

6.2.1 Entrance Door or Front Service Door Lower Body Panel

For the removal of entrance door or front service door lower body panel, you will need :

Pneumatic “Zip gun” type tool;
Razor sharp window scraper;

- Remove interior finishing panel to access rub rail fixing bolts, then remove rub rail.
- Remove two lower body panel fixing rivets.
- Using the “**Zip Gun**”, cut Sika bead located on each lower body panel side.
- Remove lower body panel.
- Remove Sika bead residue using a razor sharp window scraper.
- Use a Chix cloth and anti-silicone to remove any dust or residue.

Door Surface Preparation

- First of all, check Sika 205 cleaner expiration date.

- Before applying Sika cleaner, fold "Chix" cloth twice for proper width.
- Apply an even coat onto the door frame perimeter and allow to dry for 2 minutes.
- Discard waste according to applicable environmental regulations, use dangerous waste containers.

Stainless Steel Body Panel Preparation

- Check that new body panel is the required one and is free of defects or scratches.
- Wear latex gloves and use a "Chix" cloth with isopropyl alcohol in order to remove any dirt or oily film left onto the stainless steel surface.

Note : *Apply evenly around the perimeter of the panel. Use two clothes, first one applies product while second one immediately dries surface off before product evaporation.*

- Using a scratch pad "Scotch Brite", scratch a 2 inch wide surface on each side of the panel where the adhesive will be applied. The purpose being to create scratches onto the surface to increase adherence.
- Use again a Chix cloth and anti-silicone to remove any dust or residue.
- Before applying Sika cleaner, fold "Chix" cloth twice for proper width.
- Apply an even coat onto the treated surface.
- Allow 2 minutes for drying in the case of stainless steel.

Sikaflex 252 Adhesive Sealant Application

- Check Sikaflex 252 adhesive sealant for expiration date.
- Using a "V" shape nozzle, apply Sika bead 1 inch (25 mm) from both lower body panel side edges.

Note : *You only have 15 minutes to install body panel once the adhesive is applied.*

- Insert lower body panel bottom edge under the door and underneath the upper panel and carefully center and align lower body panel side edges with the door fiber glass surface.
- Ideally two persons should perform this installation.
- Lightly compress the body panel along the Sika bead, then compress using a dry erasable marker board brush so as not to scratch or damage the stainless steel surface.
- Fix lower body panel using two rivets.
- Apply masking tape on both lower body panel sides.
- Using a caulking nozzle and "SIKAFLEX 221" adhesive, fill the cavity to seal both body panel sides.
- Wearing surgical gloves, smooth down the joint with your finger.
- Remove masking tape and protective plastic lamination.

6.3 BAGGAGE COMPARTMENT OR REAR SERVICE COMPARTMENT DOOR BODY PANEL

For the removal and installation of baggage compartment or rear service compartment door stainless steel body panel, you will need :

A drill with drill bits;
Pneumatic "Zip gun" type tool;
Razor sharp window scraper or putty knife;

- Open damaged compartment door and unfasten rub rail fixing bolts. Remove rub rail.
- Unfasten bolts and disconnect cable if necessary in order to remove door from vehicle.
- Preferably install the door onto a work surface where it can be solidly fixed.

Door Lower Panel

Door lower panel is riveted only, not glued. If panel needs to be changed, remove fixing rivets using a drill and drill bits. Line up new panel and secure using 6 stainless steel rivets.

Body Panel Removal

- In the following procedure, only the door upper part needs to be changed.

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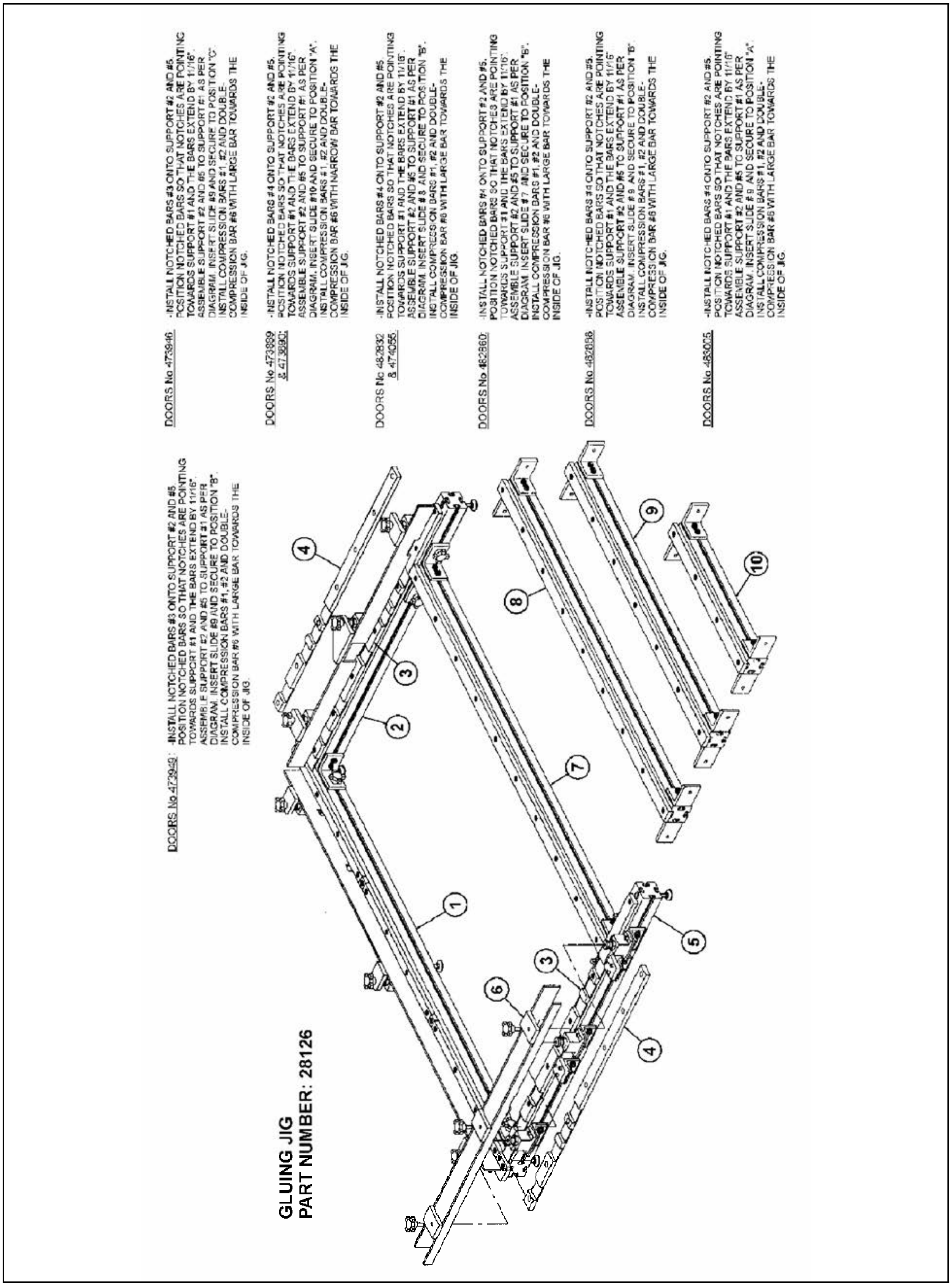


FIGURE 15: GLUING JIG SETUP DIAGRAM

- Using a drill with drill bits, remove the door upper part fixing rivets.
- 9 rivets are located in the door handle opening and 2 at the door upper edge.
- Using the “Zip Gun”, cut Sika bead located ½ inch from the door panel perimeter edge.
- Wearing gloves, goggles and ear plugs, pry loose body panel using a “Zip gun” or lever starting from the door lower part.
- Use a second person equipped with a pair of locking pliers to bend the body panel as you cut the Sika bead. Bend body panel enough to reach around the handle and continue to detach completely the stainless steel body panel from door frame
- Using the window scraper, remove any Sika bead or self adhesive tape residue left on the fiber glass.

Body Panel Preparation

- Using a scratch pad “Scotch Brite”, scratch a 2 inch wide surface on the panel two sides and bottom part where the adhesive will be applied. The purpose being to create scratches onto the surface to increase adherence.
- Use a Chix cloth and anti-silicone to remove any dust or residue.
- Before applying Sika 205 cleaner, fold “Chix” cloth twice for proper width.
- Apply an even coat onto the treated surface.
- Allow 5 minutes for drying in the case of stainless steel.

Door Frame Preparation

- Using the window scraper, remove any Sika bead residue left on the door frame surface.
- First of all, check Sika 205 cleaner expiration date.
- Before applying Sika cleaner, fold “Chix” cloth twice for proper width. Apply an even coat onto the treated surface.
- Discard waste according to applicable environmental regulations, use dangerous waste containers.
- Allow 2 minutes for drying in the case of stainless steel.

Note: *In the case of baggage compartment door, apply wax paste around handle opening frame and at door frame upper part.*

Gluing Jig Installation

- For best results, it is important that gluing jig installation for baggage and rear service door be performed properly according to part number and dimensions.
- For more information, refer to gluing jig setup diagram (Fig. 14).

Rear Service Door

- Lay down stainless steel body panel into the gluing jig as per setup diagram. Ensure it is lined up and set square with the reference marks.
- Heat Sikaflex 255 adhesive for at least 15 minutes, apply adhesive as per previously removed panel.
- Carefully lay down door metallic frame onto the stainless steel body panel inserting the upper part into the panel curved lip.
- Install compression bars to compress and hold body panel during curing process.
- Once cured, apply masking tape on both body panel sides.
- Using a caulking nozzle and “SIKAFLEX 221” adhesive, fill the cavity to seal both body panel sides.
- Wearing surgical gloves, smooth down the joint with your finger.
- Remove masking tape and protective plastic lamination.

Baggage Compartment Door

- Install gluing jig for a baggage compartment door. Refer to the included setup diagram according to part number and door dimensions.
- Lay down stainless steel body panel into the gluing jig as per setup diagram. Ensure it is lined up and set square with the reference marks.
- Heat Sikaflex 255 adhesive for at least 15 minutes, apply adhesive as per previously removed panel.
- Apply Sika 221 around handle opening frame.

- Carefully lay down door metallic frame onto the stainless steel body panel inserting the upper part into the panel curved lip.
- Carefully flip door frame and body panel over and install 9 rivets in the door handle opening and 2 at door upper part.
- Flip door frame and body panel over again and install compression bars to compress and hold body panel during curing process.
- Once cured, apply masking tape on both body panel sides.
- Using a caulking nozzle and "SIKAFLEX 221" adhesive, fill the cavity to seal both body panel sides.
- Wearing surgical gloves, smooth down the joint with your finger.
- Remove masking tape and protective plastic lamination.

6.4 MTH SIDE PANEL REPLACEMENT PROCEDURE

Material :

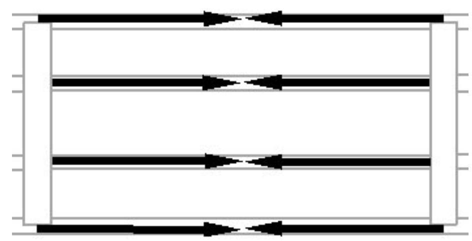
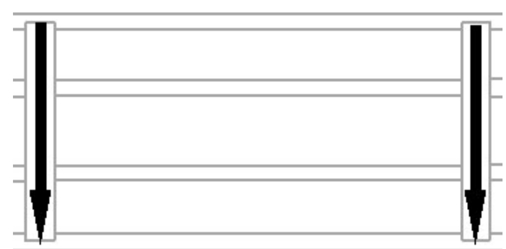
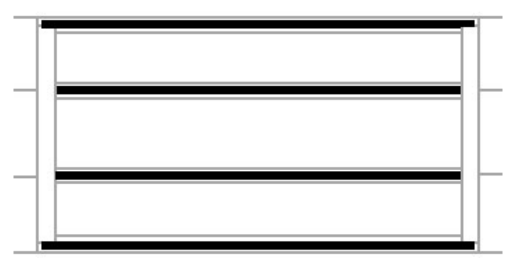
Anti-silicone (682989)	√	**Scotchbrite gray (680226)**	√	**Sika 206 G+P 1 liter (683446)**	√
	√	**Sika Aktivator (683661)**	√	**Sika 221 gray**	√
CHIX cloth (682384)	√			**Sika 252 black**	√
Blue cloth (682383)	√			**Sika 221 + Booster**	√

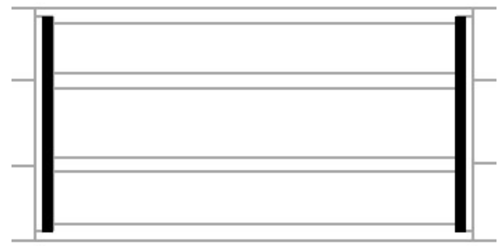
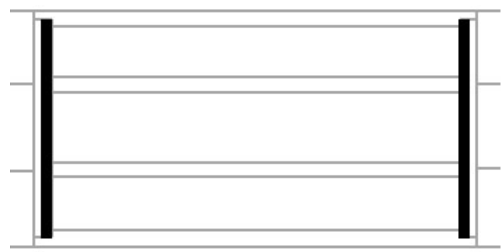
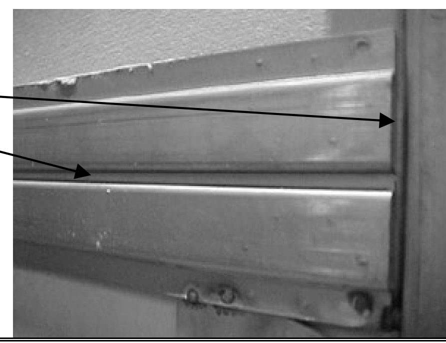
Equipment :

Glue Gun	√	

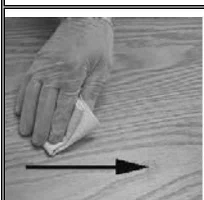
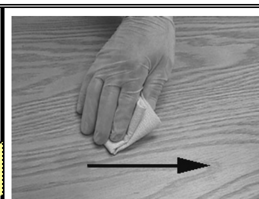
SECTION 1 SIDE PANEL GLUED WITH CIBA (Ciba on the horizontal tubing, Sika on the vertical tubing)			
1.00		**Removal**	
	A)	Remove finishing molding. Insert a screwdriver into snap-on finishing molding joint. Bend finishing molding enough to be able to fix a pair of locking pliers. Using the pair of locking pliers, pull the stainless steel molding and at the same time gradually cut Sika bead with a sharp knife.	Be careful not to damage the adjacent surfaces.
	B)	Using a hammer and punch, drive out rivet shanks from top and bottom finishing molding supports. Use a #11 titanium drill bit to remove rivet heads.	
	C)	Use the pair of locking pliers to remove top and bottom finishing molding supports.	
	D)	Insert a flat screwdriver between the side panel and the vehicle chassis, in the top left and right corners. Make sure to separate side panel from backers at each end.	Be careful not to damage the adjacent surfaces.
	E)	Use the c-clamp to peel the side panel from the back structural panel and at the same time gradually cut Sika bead with a sharp knife.	
	F)	Use a heat gun and putty knife to remove the dried off Ciba epoxy glue residue.	- Make sure that heat gun nozzle tip is at least 4" from surface. - Because of its great toxicity, care should be taken not to use a buffer or other sanding method for glue removal.

	G)	Remove Sika bead using putty knife or pneumatic knife.	- Never heat Sikaflex glue in order to remove it - It is not necessary to remove 100% of SikaFlex.
	H)	Check panel horizontal supports for straightness using a straight edge. Take measurements with a ruler.	Tolerance: 1mm towards the outside and 1.5mm towards the inside.
1.05	**Side Panel Positioning**		
	A)	Install side panel onto the vehicle, align and center panel with adjacent panels and temporary fix using two 1/8 '' rivets at top (2 for side panels and 3 for engine air intake panels).	**Make sure that side panel is centered or that gap is between 3 and 4.5 mm with adjacent panels.**
	B)	Install conforming jig vertical supports onto the panel and drill holes into the temporary fixed vertical supports.	
	C)	Remove vertical supports and side panel.	

1.10	**Vehicle Surface Preparation**		
	A)	Clean horizontal supports using anti-silicone See PR000001 section A.	
	B)	Clean vertical "backers" using anti-silicone even if some Sika 252 residue is present. See PR000001 section A.	
	C)	Use the belt sander to sand horizontal supports (grit coarse) **For an aluminum surface, you have 3 hrs maximum between sanding and the application of glue.**	

	D)	**NOT APPLICABLE IF VERTICAL BACKERS ARE GRIT BLAST** Use the orbital sander (Scotchbrite grit 7446B) or a 2" disc grinder (grit coarse) to sand vertical backers. **For an aluminum surface, you have 3 hrs maximum between sanding and the application of glue.**	**CAUTION: Sand a 1 7/8″ to 2 ¼″ width surface.** 
	E)	Clean all sanded surfaces using anti-silicone See PR000001 section A.	
	F)	Apply Sika Aktivator onto the vertical backers See PR000001 section C.	
	G)	Install a neoprene foam tape at the center of panel horizontal supports and at each end if needed.	

PR000001 Section A   Alcohol or Anti-silicone

	***1.* Apply** **CHIX cloth**		***2.* Dry immediately** **Blue cloth**

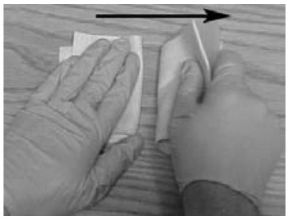
***3.* Allow to dry**

Mandatory	**Minimum time : Wait for product to evaporate**
	After 2 hours: Start cleaning operation again

Before applying any other product	If surface seems dusty, greasy or with finger marks, start cleaning operation again.

PR000001 Section C Sika Aktivator

Glass

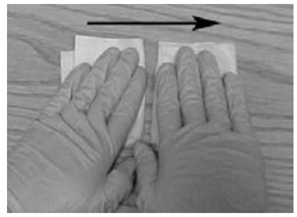


Plastic scraper

CHIX cloth

CHIX cloth

Other application



CHIX cloth

CHIX cloth

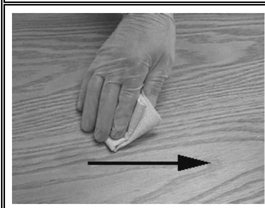
1. **Apply and dry immedi-ately**

2. **Allow to dry**

Mandatory	**Minimum time :5 minutes**
	After 2 hours: Remove dust using dry Chix cloth and start cleaning operation again

Optional: **Before applying any other product**	If surface seems dusty, remove dust using dry Chix cloth and start cleaning operation again.
	If surface seems greasy or with finger marks, start cleaning operation again.

PR000001 Section D Sika Primer 206 G+P



1. **Shake bottle to mix product**

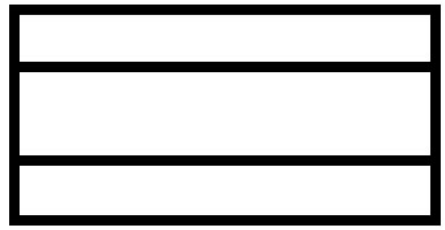
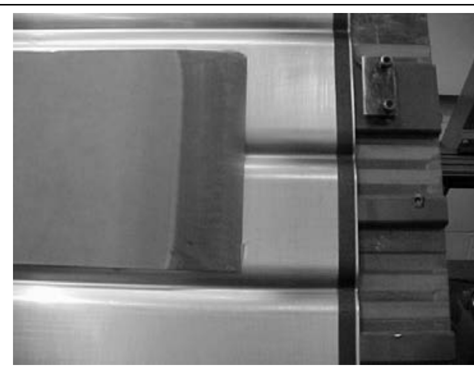
2. **Apply a thin layer**

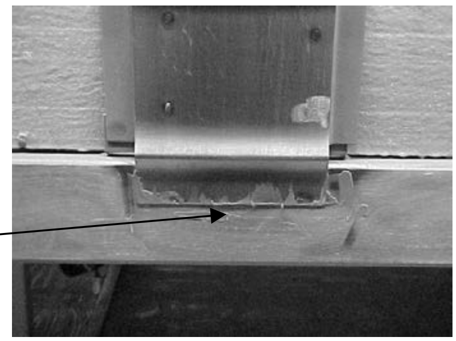
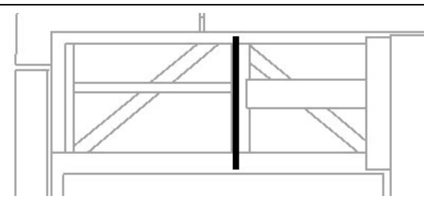
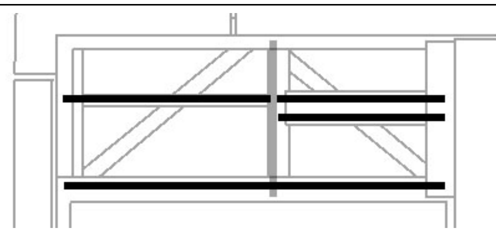
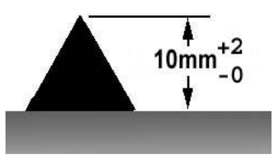
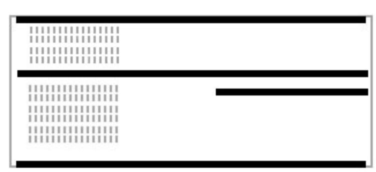
Chiffon CHIX

3. **Allow to dry**

Mandatory	**206 G+P**	**Minimum time: 10 minutes**
		After 2 hours: Remove dust using damp cloth (pure water)
		After 8 days : Reactivate with Aktivator as per section "C"

Optional: **Before applying any other product**	If surface seems dusty, remove dust using Chix damp cloth (pure water).
	If surface seems greasy or with finger marks, reactivate with Aktivator.

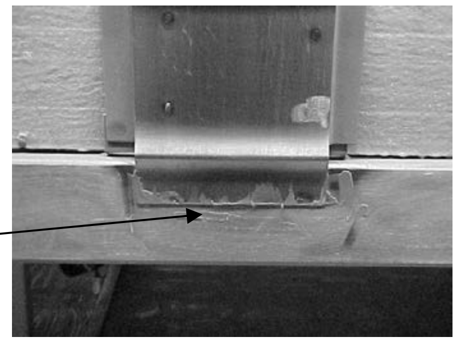
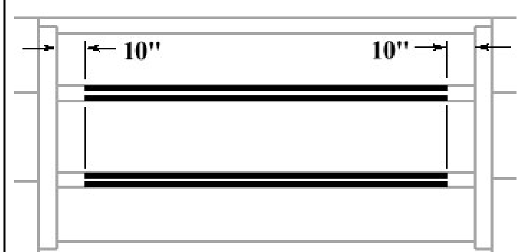
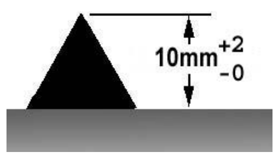
1.15 *	**Side Panel Preparation**		
	A)	Use a Chix cloth and anti-silicone to remove any dust or residue from the whole side panel surface	**For all Service Centers or if side panel is dusty**
	B)	Clean using anti-silicone See PR000001 section A.	
	C)	Sand using Scotchbrite	
	D)	Clean using anti-silicone See PR000001 section A.	
	E)	Apply Sika Aktivator onto a 2″ +/- ½″ width surface. See PR000001 section C.	
	F)	Install a 1/16″ x 1/4″ neoprene foam tape at each side panel end, 1 mm from panel edge. Make sure foam tape reaches bottom of creases.	
1.20	**Preparation of Ciba Epoxy Glue Cartridges**		You need about 7 cartridges for a large side panel. Use a constant and controlled source of heat. Maximum temperature is 120 °F.
	A)	Before applying glue, heat Ciba glue cartridges to reduce viscosity and speed up process. Make sure glue temperature is correct and you have sufficient cartridges.	
	B)	Perforate cartridge tip and install mixing nozzle. Cut mixing nozzle at 3rd notch.	
	C)	Insert cartridge into the gun.	
	D)	• Before applying glue, heed this procedure: If a new mixing nozzle is used, install mixing nozzle onto the cartridge and insert into the gun. Take a sample of glue before applying. When changing cartridge without changing the mixing nozzle, take a sample of glue then install mixing nozzle onto the cartridge.	

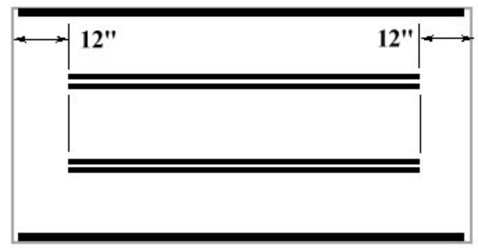
1.25 *	**Engine Air Intake Panel Installation**		
	To know the time allotted between glue application and final installation; refer to annex 4		
	Always check color of glue before applying (charcoal gray). If the color turns black or white during application, remove this portion using a putty knife and clean with thinner		
	A)	If more than one hour has elapsed between the first cleaning and the application of glue or if in doubt, clean panel and vehicle surface again using anti-silicone See PR000001 section A.	
	B)	Seal each vertical "backer" end. Seal top and bottom part of vertical backer using Sika 221 gray or Ciba 8535.	
	C)	Apply bead (¼″ minimum dia.) Sika 252 onto structure.	
	D)	Apply bead (¼″ minimum dia.) Ciba onto structure.	
	E)	Apply Sika 252 onto air intake panel 1″ +¼″ / -0 from panel edge 	
	F)	Apply Ciba onto air intake panel **Make sure that Ciba and Sika beads adjoin.** (¼″ minimum dia.)	
	G)	Install air intake panel using rivets and conforming jigs.	

1.30 Side Panel Installation

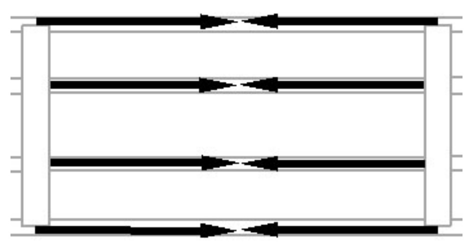
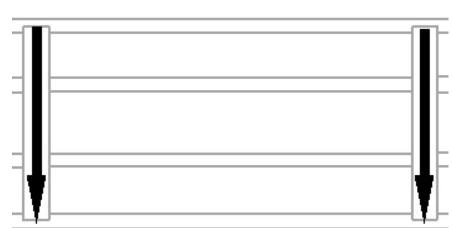
To know the time allotted between glue application and final installation; refer to annex 4

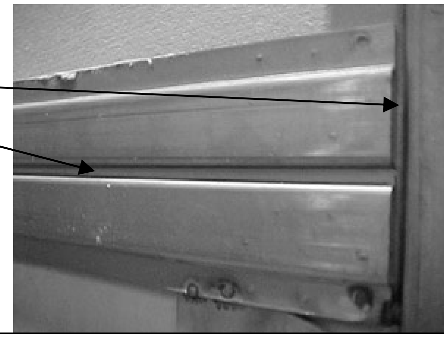
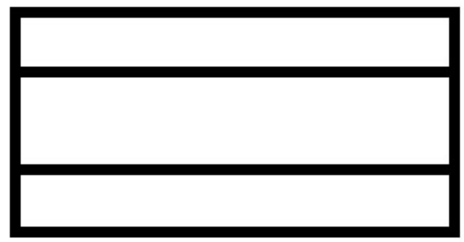
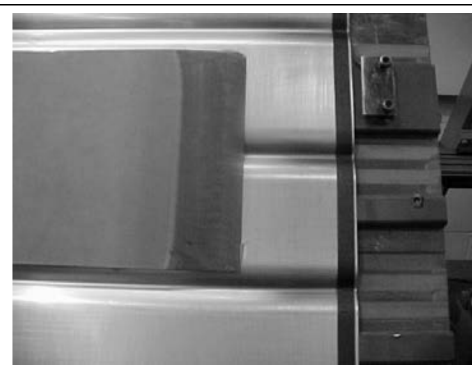
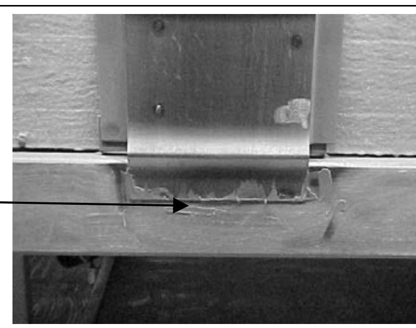
Always check color of glue before applying (charcoal gray). If the color turns black or white during application, remove this portion using a putty knife and clean with thinner

A)	If more than one hour has elapsed between the first cleaning and the application of glue or if in doubt, clean panel and vehicle surface again using anti-silicone See PR000001 section A.	
B)	Seal each vertical “backer” end. Seal top and bottom part of vertical backer using Sika 221 gray or Ciba 8535.	
C)	**MTH W5 only.** Apply Sika 252 or 255 onto the awnings reinforcement plates Height of bead 3/8″ +1/8″ / -0.	
D)	Apply Ciba onto horizontal supports (¼″ minimum dia.)	
E)	Apply Sika 252 onto side panel 1″ +¼″ / -0 from panel edge 	

F)	Apply Ciba onto side panel **Make sure that Ciba and Sika beads adjoin.** (¼″ minimum dia.)	
G)	Carefully install panel onto the vehicle and hold it in place using the pre-drilled holes and rivets. Check positioning using backers.	Make sure that side panel is centered or that gap is between 3 and 4.5 mm with adjacent panels.
H)	Fix conforming jig vertical supports onto the panel using the pre-drilled holes and screws. Apply pressure.	40 psi ±2 air pressure and check gap between panels.
I)	Install horizontal pressure bars onto the vertical supports.	
J)	Wait allotted curing period	See Annex 4
K)	Remove conforming jigs and seal 1/8″ rivet heads using Sika 221.	
L)	**Side Panel Upper Joint** 1) Clean surface using anti-silicone See PR000001 section A. 2) Apply Sika Aktivator See PR000001 section C. 3) Apply Sika 252 to seal structural tubing and side panel upper edge	
M)	If necessary, clean excess of CIBA glue in the joints.	
N)	If the first or last side panel was replaced, the vertical joint must be redone. Apply masking tape on each side of side panel joint. Use a caulking nozzle and grey Sikaflex 221 adhesive to fill the cavity between the panel and vehicle back plate. Clean using Sika 205. Allow 5 minutes minimum for drying. Wear surgical gloves and smooth down the joint with your finger.	

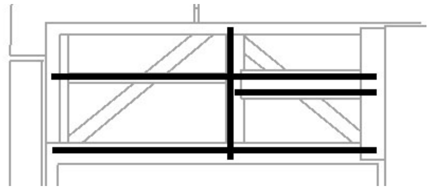
SECTION 2 SIDE PANEL GLUED WITH SIKA

2.00		**Removal**	
	A)	Remove top and bottom finishing moldings. Insert a screwdriver into snap-on finishing molding joint. Bend finishing molding enough to be able to fix a pair of locking pliers. Using the pair of locking pliers, pull the stainless steel molding and at the same time gradually cut Sika bead with a sharp knife.	Be careful not to damage the adjacent surfaces You need to remove the finishing molding support and rivets in the case of engine air intake panel.
	B)	Insert a flat screwdriver between the side panel and the vehicle chassis, in the top left and right corners.	
	C)	Use the c-clamp to peel the side panel from the back structural panel as far as the middle and at the same time gradually cut Sika bead with a sharp knife. Do the same for the other corner.	Ideally, the hoist or chain block must be fastened to the floor while pulling from a 45^{o} angle so as not to damage the vehicle structure
	D)	Remove as much glue as possible from the structure using a putty knife or pneumatic knife without damaging 206 G+P primer.	Never heat SikaFlex adhesive to remove.
	E)	Check panel horizontal supports for straightness using a straight edge. Take measurements with a ruler.	Tolerance: 1mm towards the outside and 1.5mm towards the inside.
2.05		**Side Panel Positioning**	
	A)	Install side panel onto the vehicle, align and center panel with adjacent panels and temporary fix using two 1/8 ‘’ rivets at top (2 for side panels and 3 for engine air intake panels).	**Make sure that side panel is centered or that gap is between 3 and 4.5 mm with adjacent panels.**
	B)	Install conforming jig vertical supports onto the panel and drill holes into the temporary fixed vertical supports.	
	C)	Remove vertical supports and side panel.	
2.10		**Vehicle Surface Preparation**	
	A)	Clean horizontal supports using anti-silicone See PR000001 section A.	
	B)	Clean vertical “backers” using anti-silicone. See PR000001 section A.	
	C)	If necessary, touch up with primer See PR000001 section D.	
	D)	Reactivate all surfaces using Sika Aktivator See PR000001 section C.	

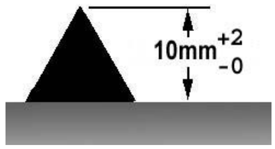
	E)	Install a neoprene foam tape at the center of panel horizontal supports and at each end if needed.	
2.15 *	**Side Panel Preparation**		
	If you receive a side panel with 206G+P primer already applied, reactivate surface as per PR000001 section D. You don't have to perform step a) to e) hereafter. Refer to the date written onto the panel.		
	A)	Use a Chix cloth to remove any dust or residue from the whole side panel surface	**For all Service Centers or if side panel is dusty**
	B)	Clean using anti-silicone See PR000001 section A.	
	C)	Sand using Scotchbrite	
	D)	Clean using anti-silicone See PR000001 section A.	
	E)	Apply Sika 206 G+P Primer See PR000001 section D.	
	F)	Install a 1/16″ x 1/4″ neoprene foam tape at each side panel end, 1 mm from panel edge. Make sure foam tape reaches bottom of creases.	
2.20	**Engine Air Intake Panel Installation**		
	A)	If more than one hour has elapsed between the first cleaning and the application of glue or if in doubt, see PR000001 section D.	
	B)	Seal each vertical "backer" end. Seal top and bottom part of vertical backer using Sika 221 gray	

<table>
<tr><td></td><td>C)</td><td>Apply a bead of Sika 221+booster onto structure

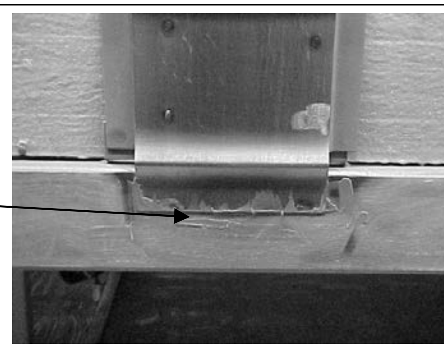
(¼″ minimum dia.)

Time allotted between glue application and final installation: 30 minutes maximum</td><td></td></tr>
<tr><td></td><td>D)</td><td>Apply a bead of Sika 221+booster onto air intake panel 1″ +¼″ / -0 from panel edge.

Time allotted between glue application and final installation: 30 minutes maximum

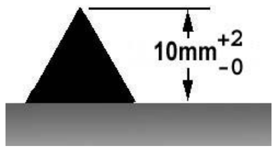
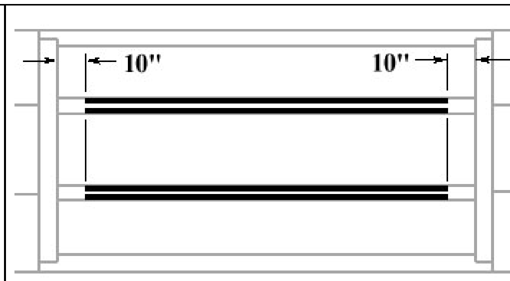
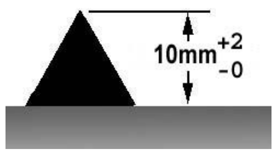

</td><td></td></tr>
<tr><td></td><td>E)</td><td>Install air intake panel using rivets and conforming jigs.</td><td>Conforming Jig Installation Time: 4 hours

Time before moving vehicle: 8 hours</td></tr>
<tr><td>2.25</td><td colspan="3">Side Panel Installation</td></tr>
<tr><td></td><td>A)</td><td>If more than one hour has elapsed between the first cleaning and the application of glue or if in doubt, see PR000001 section D.</td><td></td></tr>
<tr><td></td><td>B)</td><td>Seal each vertical “backer” end.

Seal top and bottom part of vertical backer using Sika 221 gray</td><td></td></tr>
<tr><td></td><td>C)</td><td>MTH W5 only.

Apply Sika 252 or 255 onto the awnings reinforcement plates

Height of bead 3/8″ +1/8″ / -0.</td><td></td></tr>
</table>

D)	Apply Sika 221+booster onto horizontal supports **Time allotted between glue application and final installation: 30 minutes maximum**  	
E)	Apply Sika 221+booster onto side panel 1″ +¼″ / -0 from panel edge **Time allotted between glue application and final installation: 30 minutes maximum**  	
F)	Carefully install panel onto the vehicle and hold it in place using the pre-drilled holes and rivets. Check positioning using backers.	Make sure that side panel is centered or that gap is between 3 and 4.5 mm with adjacent panels.
G)	Fix conforming jig vertical supports onto the panel using the pre-drilled holes and screws. Apply pressure.	40 psi ±2 air pressure and check gap between panels.
H)	Install horizontal pressure bars onto the vertical supports..	
I)	Wait allotted curing period	**Conforming Jig Installation Time: 4 hours** **Time before moving vehicle: 8 hours**
J)	Remove conforming jigs and seal 1/8″ rivet heads using Sika 221.	
K)	**Side Panel Upper Joint** 1) Clean surface using anti-silicone See PR000001 section A. 2) Apply Sika Aktivator See PR000001 section C. 3) Apply Sika 252 to seal structural tubing and side panel upper edge	
L)	If necessary, clean excess of Sika glue in the joints.	

	M)	If the first or last side panel was replaced, the vertical joint must be redone. Apply masking tape on each side of side panel joint. Use a caulking nozzle and grey Sikaflex 221 adhesive to fill the cavity between the panel and vehicle back plate. Clean using Sika 205. Allow 5 minutes minimum for drying. Wear surgical gloves and smooth down the joint with your finger.	

SIDE PANEL REPAIR OR REPLACEMENT

MTH – XL2

Note: All defects and solutions proposed hereafter can be used with any side panel.

DEFECT	*SOLUTION*	*NOTE*
1. Improper positioning of vertical bead (especially engine air intake panel).	Replace side panel	Refer to procedure
2. Impossible to seal side panel.	Replace side panel	Refer to procedure
3. Ungluing of vertical or horizontal bead.	Replace side panel	Refer to procedure
4. Improper conforming of side panel at horizontal supports level.	From inside of vehicle, reapply adhesive between horizontal supports and side panel, see annex # 1	Check horizontal supports for straightness using a straight edge by measuring side panel.
5. Small water infiltration through a vertical joint without ungluing.	Seal from inside of vehicle, see annex #2	Use Sikaflex 221
6. Major water infiltration through engine air intake panel without ungluing.	Depending on the case, replace or repair side panel, see annex # 3	

ANNEX # 1 (Side panel glued with Ciba only)
For this operation, you must remove interior insulation, insert a small tube connected to Ciba cartridge mixing nozzle and inject the glue between horizontal supports and side panel. Ensure to fill in under horizontal supports so as to trap the adhesive between support and side panel.

ANNEX # 2
When performing water test, a small water infiltration through vertical joint is possible. Ensure that no ungluing is occurring at joint level then seal vertical joint from inside of vehicle. Ensure to completely dry the area before sealing. Seal using Sikaflex 221 gray.

ANNEX # 3
If there is water infiltration through engine air intake panel and first rear side panel joint, it is likely that water infiltrates through air intake panel itself or through joint between two panels. Before repairing, ensure that vertical joint lower portion is filled with Sikaflex 221 adhesive up to Ciba adhesive and ensure that engine air intake panel adhesion is proper. If there is still evidence of water infiltration, you must replace engine air intake panel. If water infiltration is through vertical joint, you must replace first rear side panel.

	ANNEX 4 TABLE OF ALLOTTED CURING PERIODS (CIBA adhesive) (NO-HEAT CONFORMING JIGS)				
Room Temperature	Conforming Jig Installation Time	Complete stop of vehicle (without moving)	Time before moving vehicle ±10^{o}F with room temperature	Polishing after the application of adhesive or before vehicle back in operation	Time allotted between glue application and final installation
87^{O}F	4 HRS	8HRS	8HRS	16HRS	25m
77^{O}F	6HRS	12HRS	12HRS	24HRS	45m
72^{O}F	7HRS	14HRS	14HRS	28HRS	50m
67^{O}F	8HRS	16HRS	16HRS	32HRS	1HR
<67^{O}F	*NO APPLICATION OF ADHESIVE IS ALLOWED*				

6.5 LATERAL FIXED WINDOW

Depending on the method chosen for fixed side window removal or installation, you may need:

Drill equipped with a sharp pointed rod into which a small hole was drilled;
Razor sharp window scraper;
Braided windshield wire and a pair of handles;
Gloves, goggles or face shield.

Fixed Window Removal

1st Method

Note*: This method is used only in the case of a regular fixed side window. For the fixed upper portion of awning or sliding windows, you must use method number 2.*

- Apply a sticky plastic film onto all of window outside surface for safety reason.
- Using a drill equipped with the special sharp pointed rod, drill through the window seal into one of the bottom corners, from a 30º angle with reference to the vehicle.
- This procedure requires accuracy and it is possible not to succeed on the first attempt. From the inside of vehicle, a second person ensures the rod passes through.
- Remove the rod, thread the wire into the small hole. Reinsert the rod and the wire into the hole far enough so that the person inside the vehicle can pull the rod using a pair of pliers.

- Attach the wire ends to the specially designed handles.
- Pull in turn from the inside and the outside of vehicle to gradually cut the Sika bead on the window perimeter.
- When you reach top corner, detach wire from the outside handle, secure it to a fish wire or rod and thread it underneath the aluminum molding behind the rivets.
- Detach wire from fish wire and continue cutting using the handle.
- Cut Sika bead until you come back to starting point, then you can remove the window by carefully pushing it out from the inside of vehicle.

2nd Method

- Apply a sticky plastic film onto all of window outside surface.
- To limit as much damage as possible, remove any interior molding in the way. Install a plastic film on the window interior surface and secure using masking tape onto all of window perimeter.

Note : *Do not stretch plastic film and leave enough play to be able to push window out without tearing the plastic film.*

- Using a ball peen hammer, hit one of the window bottom corners from the **outside**.
- Carefully push window out and lift it up sufficiently to separate it from the aluminum molding.
- Attach the windshield wire to a fish wire and thread it underneath the aluminum molding behind the rivets.
- Detach wire from fish wire and continue cutting using the handle.
- Make a notch at each window top corner to make sure you pass underneath the remaining pieces of glass.
- Remove the aluminum molding and clean up the frame using the window scraper.
- Before starting window frame treatment, make sure window frame is truly clean and free of pieces of glass.
- First of all, check Sika 205 cleaner expiration date.
- Before applying Sika cleaner, fold “Chix” cloth twice for proper width.
- Apply an even coat onto the window frame and allow to dry for 10 minutes.
- Discard waste according to applicable environmental regulations, use dangerous waste containers.
- Apply masking tape before applying Sika glue to protect paint and adjacent window during surface treatment.

Window Surface Treatment

- Use “Spray Away” or “ESSEX GC-800” window cleaner (Prévost #683926) around window perimeter and edges to remove any oily film while inspecting for damages.
- Wipe clean using a dry cloth.
- Repeat previous step using a second dry cloth to ensure window is truly clean and allow to dry for 1 minute.
- Install two stops into the aluminum extrusion one inch from each window edge.

Preparation Of Window When Using Sikatack Ultrafast 2 Adhesive

- Check “SIKA 205” product expiration date.
- Before applying Sika cleaner, fold “Chix” cloth twice for proper width.
- Apply an even coat onto the window casement and allow to dry for 2 minutes.
- Apply Sika 206 G+P primer onto the window casement and allow to dry for 10 minutes.

Fixed Side Window Installation Using Sikatack Ultrafast 2

- Use “Sikatack Ultrafast 2” adhesive.
- Check product expiration date.
- Always heat adhesive first for 15 minutes in an oven.

Note : *You only have 10 minutes to install window once the SIKA ULTRAFAST 2 product is applied.*

- Using a triangular nozzle, apply a Sikatack Ultrafast 2 bead on all of window frame perimeter. Apply a second bead on frame top.

- Two persons may then install window by inserting the top part into the aluminum extrusion and then carefully rest the window casement against the frame aligning the bottom part.
- Install two stops into the aluminum extrusion one inch from each window edge.

Window Temporary Fixing Using Sikatack Ultrafast 2 Adhesive

1st Method

- From the outside, lean a straight edge against each window side to guide the person in charge of the suction jig installation. The window must be on the same level than the adjacent one(s).
- From the inside, remove finishing molding, install the cups onto the glass surface, 6 inches from bottom of window and screw down the jig ends onto the frame metallic structure to adjust depth.

***Note** : The person outside the vehicle must guide throughout this procedure.*

- Finally, maximum watertightness is achieved when you notice the bead running over towards the inside.
- Allow drying for at least 6 hours.

2nd Method

- From the outside, use a ram or a jack equipped with a padded surface at one end and secured to the other end.
- This equipment must be easily adjustable and compress the window against the frame.
- Lean the padded surface 6 inches from the bottom of window, use a straight edge and adjust the equipment so that the window is level with the adjacent one(s).
- Finally, maximum watertightness is achieved when you notice the bead running over towards the inside.
- Allow drying for at least 6 hours.

6.6 DRIVER'S WINDOW AND UPPER LATERAL WINDOW

For the removal of driver's window or upper lateral window, you will need :

Pneumatic «Zip gun» type tool;
Razor sharp window scraper;
“Olfa” knife;
Face shield.

- In the case of driver's window only, open front service compartment door.
- Mark the position of the driver's window for future reference.
- From inside of vehicle, cut Sika bead around window perimeter using a “Zip gun” while another person hold the window from the outside.

***Note:** Wear ear plugs during this operation.*

- Then, move outside of vehicle and cut Sika bead to free window while somebody else hold the window from the inside.
- Carefully remove window from frame, ask for help if needed.
- Using a razor sharp window scraper, remove from window frame Sika bead and double-face self adhesive tape residue.
- First of all, check Sika 205 cleaner expiration date.
- Before applying Sika cleaner, fold “Chix” cloth twice for proper width.
- Apply an even coat onto the inside of window frame and allow to dry for 2 minutes (maximum 2 hours).
- Discard waste according to applicable environmental regulations, use dangerous waste containers.
- Apply masking tape before applying Sika glue to protect paint and adjacent window during surface treatment.

Window surface treatment

- Use Spray Away or “ESSEX GC-800” window cleaner (Prévost #683926) around window perimeter and edges to remove any oily film while inspecting for damages.
- Wipe clean using a dry cloth.
- Repeat previous step using a second dry cloth to ensure window is truly clean and allow to dry for 1 minute.
- Check “SIKA 205” product expiration date.

- Before applying Sika cleaner, fold “Chix” cloth twice for proper width.
- Apply an even coat onto the inside of window frame and allow to dry for 2 minutes.

Driver’s Window Installation

- Use “Sikatack Ultrafast 2” adhesive.
- Check product expiration date.
- Always heat adhesive first for 15 minutes in an oven.

Note : *You only have 10 minutes to install window once the SIKA ULTRAFAST 2 product is applied.*

- Apply a double-face self adhesive tape 1/8 by ¼ inch inside window frame to prevent glue from reaching the inside of the vehicle and to mechanically hold the window until the adhesive is cured. Peel the back from the tape.
- To support the window, position two “Quick Grip” type pliers at the base of the frame.
- Using the caulking nozzle, seal the top edge with SIKA ULTRAFAST 2.
- Change for a triangular nozzle with a 15 mm opening, apply a Sika bead on all 4 window edges beside the double-face self adhesive tape.
- Center and align the window base using the two pliers while pressing firmly the window perimeter against the frame.
- If this has not been done already, apply masking tape near the window edge adjacent to front face before doing finishing joint. Using a caulking nozzle and Sika Utrafast 2 adhesive, complete a finishing joint and scrape the excess with a plastic scraper.

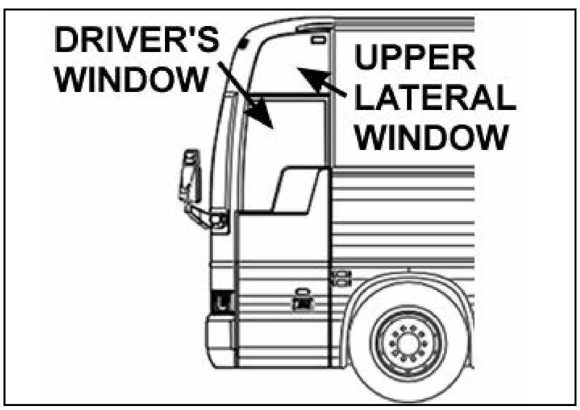


FIGURE 16: DRIVER'S OR UPPER LATERAL WINDOW

- Complete a second finishing joint at the window top making sure there are no cavity.
- Carefully remove masking tape.
- Wet “Ultrafast 2” adhesive every 15-20 minutes using water to accelerate the curing process.
- Do not move the vehicle for 2 hours.

Upper Lateral Window Installation

- Use “Sikatack Ultrafast 2” adhesive.
- Check product expiration date.
- Always heat adhesive first for 15 minutes in an oven.

Note : *You only have 10 minutes to install window once the SIKA ULTRAFAST 2 product is applied.*

- Apply a double-face self adhesive tape 1/8 by ¼ inch inside window frame to prevent glue from reaching the inside of the vehicle and to mechanically hold the window until the adhesive is cured. Peel the back from the tape.
- Remove the lens from the clearance light.
- Change for a triangular nozzle with a 15 mm opening, apply a Sika bead on all 4 window edges beside the double-face self adhesive tape.
- Center the window while pressing firmly the window perimeter against the frame.
- If this has not been done already, apply masking tape before doing finishing joint. Using a caulking nozzle and Sika Utrafast 2 adhesive, complete a finishing joint and scrape the excess with a plastic scraper.
- Carefully remove masking tape.
- Wet “Ultrafast 2” adhesive every 15-20 minutes using water to accelerate the curing process.
- Do not move the vehicle for 2 hours.

6.7 ENGINE COMPARTMENT DOOR BODY PANEL

For the removal of engine compartment door body panel, you will need :

A pneumatic “Zip gun” type tool,

Razor sharp window scraper to remove Sika adhesive residue,
A pair of locking pliers,
And isopropyl alcohol.

- Remove damaged engine compartment door from vehicle (refer to Maintenance Manual, in this section).
- Install the damaged door onto an appropriate support.
- Wearing gloves, goggles and ear plugs, pry loose body panel using a “Zip gun” or lever starting from the edge opposite the curved side.

Caution: *Do not damage painted surface.*

- Use the “Zip gun” to detach completely the stainless steel body panel from door frame.
- Use a second person equipped with a pair of locking pliers to pull the body panel as you cut the Sika bead.

Warning: *Be very careful when pulling the body panel, somebody could get hurt if the body panel suddenly detach from the door surface without notice.*

Note: *Refer to figure 16 for more information on procedure.*

Door Frame Preparation

- Using the window scraper, remove any Sika bead or self adhesive tape residue left on the fiber glass surface.
- First of all, check Sika 205 cleaner expiration date.
- Before applying Sika cleaner, fold “Chix” cloth twice for proper width. Apply an even coat onto the treated surface.

Note : *Make sure not to get any Sika cleaner onto the surrounding painted surfaces.*

- Discard waste according to applicable environmental regulations, use dangerous waste containers.
- Allow 2 minutes for drying in the case of fiber glass (maximum 2 hours).

Body Panel Preparation

- Check that new body panel is the required one and is free of defects or scratches.
- Wear latex gloves and use a “Chix” cloth with isopropyl alcohol in order to remove any dirt or oily film left onto the stainless steel surface.

Note : *Apply evenly around the perimeter of the panel. Use two clothes, first one applies product while second one immediately dries surface off before product evaporation.*

- Then, using a scratch pad “Scotch Brite”, scratch the perimeter of door where the adhesive will be applied.

Note : *It is important to support underneath the curved surface so as not to change the angle of the body panel and therefore prevent deformation.*

- Use a Chix cloth and anti-silicone to remove any dust or residue.
- Apply an even coat of Sika cleaner onto the treated surface and allow 2 minutes (max. 2 hours) for drying in the case of stainless steel.
- Refer to figure 15 and apply a double-face self adhesive tape 1/16 by ½ inch.
- Always leave a length of self adhesive tape on each side of the body panel, sufficient enough to be able to peel the back from the tape when installing the body panel.

Sikaflex 221 Adhesive Application

- Use a “V” shape nozzle, cut the tip and apply Sika bead ¾ inch (15 mm) from double-face self adhesive tape.
- Before applying body panel, draw a line onto the door fiber glass surface, 3 mm from bottom of body panel curved side edge.

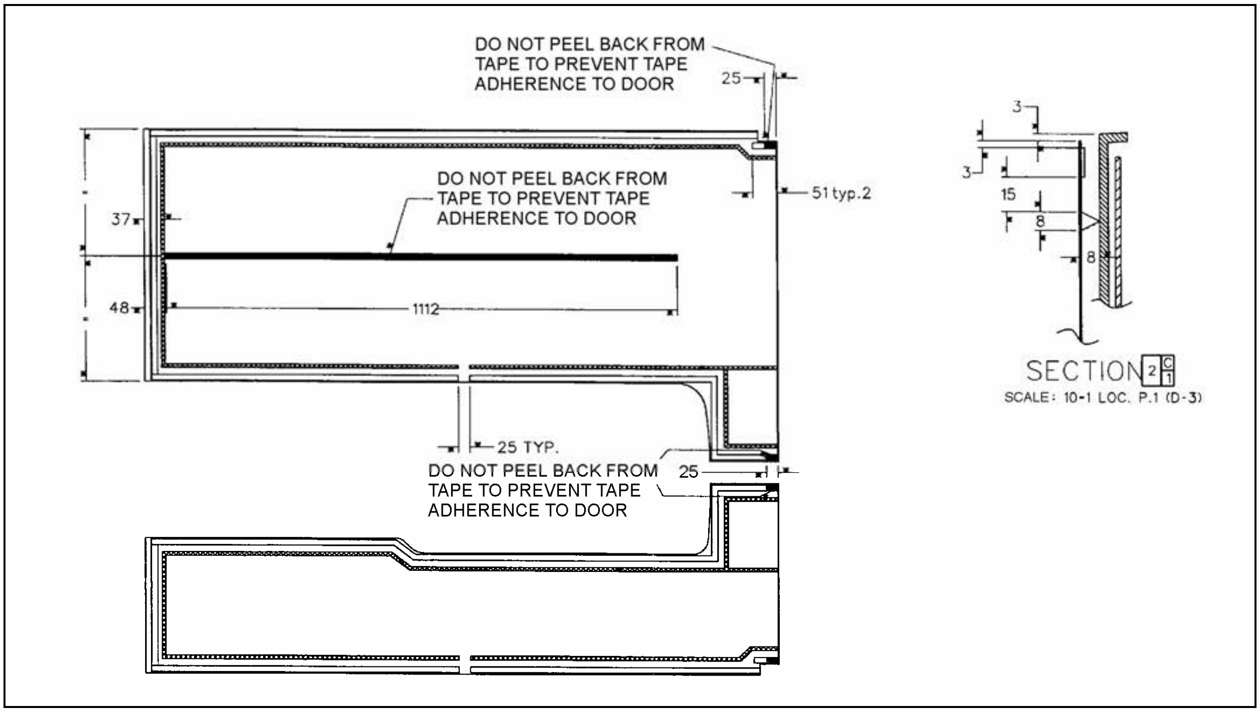


FIGURE 17: ENGINE COMPARTMENT DOOR BODY PANEL INSTALLATION

- Ideally two persons should perform this installation.
- Carefully center and align body panel with the line located 3 mm from bottom while the second person keep the self adhesive tape extremities outside the body panel.
- Peel the back from the self adhesive tape located underneath the curved side and fix the body panel using the special positioning pliers.
- Once the curved side edge is aligned with the line located 3 mm from bottom, lightly compress the body panel along the double-face self adhesive tape starting from the top towards the bottom, peeling the back from the tape at the same time.
- Repeat for each body panel side.
- Finally, compress using a dry erasable marker board brush so as not to scratch or damage the stainless steel surface.

7. ENTRANCE DOOR

7.1 COACH ENTRANCE DOOR

An air operated “sedan type” entrance door, with an air door cylinder and damper assembly are installed under the right hand dash. The opening and closing door speed cycle is adjustable by a damper mounted in parallel with the door cylinder on the door hinge (Fig. 18). Door activation is controlled by a relay panel, located near the defroster and wiper motors. The accessory air reservoir supplies air to this system.

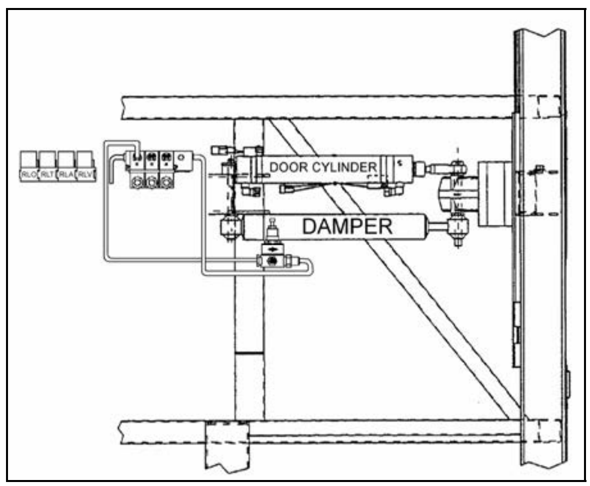


FIGURE 18: DOOR CYLINDER AND DAMPER

The door is held in the closed position during coach operation by a two air cylinder locking mechanisms (Fig. 19). Air cylinders with return spring in the cylinder body are used. Air cylinders are controlled by an electrically operated solenoid valve energized by a rocker switch located under the right hand dashboard.

To open the door, initial movement of the rocker switch de-energizes the air lock solenoid valve, venting the door locking cylinders. The return locking spring pulls the door lock away from the latch, unlocking the door. Door movement starts only when pressure in the central air door lock is below 10 psi. The “air cylinder open solenoid valve” opens and allows air to flow to the door cylinder, “the air cylinder close solenoid valve” exhausts air from the rod side of the cylinder.

To close the door, initial movement of the switch energizes the “air cylinder close solenoid valve” and air flows to the cylinder by its rod side port. The “air cylinder open solenoid valve” exhausts air from cylinder. When entrance door latch is grounded with the door frame, the air lock solenoid valve is de-energized and loads the door lock cylinders. The cylinder moves the door lock in a position which engages a latch on the entrance door, holding the door positively closed.
Emergency exit valve, which opens the air valve circuit should be used only in emergencies, or when the door control system does not function properly.

Refer to the air system schematic diagram annexed at the end of section 12, “Brakes” and to page 22 of the wiring diagram.

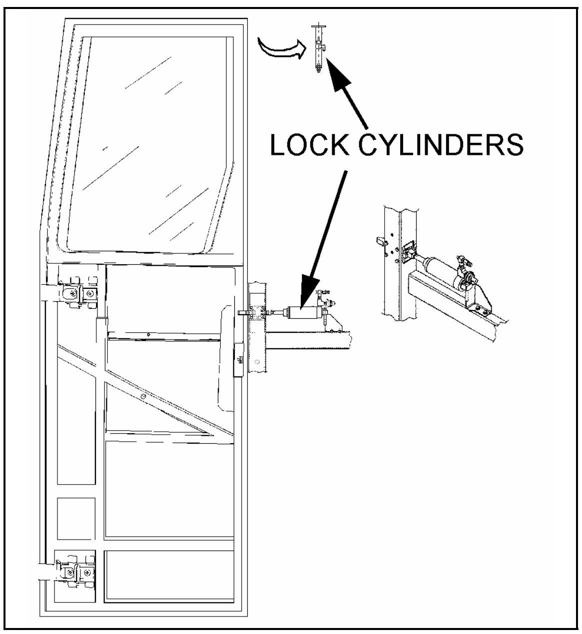


FIGURE 19: COACH ENTRANCE DOOR

7.1.1 Operation

The air-operated door is controlled from inside the coach by two push-button switches located on the R.H. dashboard.

Opening and closing of the door from outside the coach is accomplished by a momentary toggle switch located near the coach model nameplate (Fig. 20).

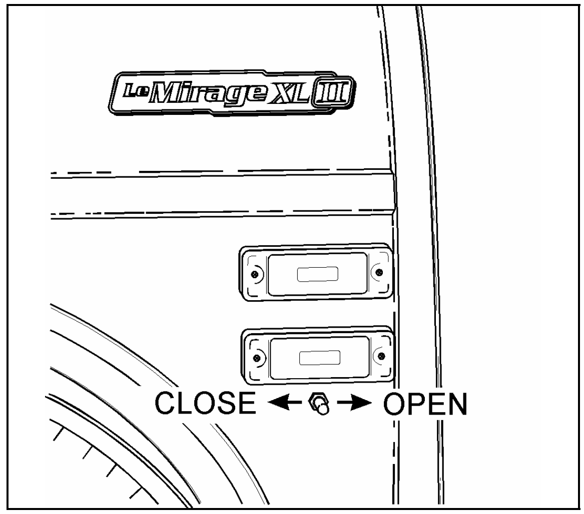


FIGURE 20: ENTRANCE DOOR CONTROL SWITCH

To close the door, the switch must be pushed towards the rear of the coach and held in position until the door has completed its movement.

To open the door, the switch must be pushed towards the front of the coach and held in position. When the door reaches the fully opened position, the system will keep pressure in the cylinder locking the door in that position. The door can be stopped in any position by releasing the switch. The door is not locked in position when not fully opened or closed.

If the door has been locked with the key, a lever on the door can be moved to unlock.

7.1.2 Emergency Exit Valves

From inside the vehicle, an emergency exit valve located near the door on the dash panel, releases the pressure from the lock cylinder. From the exterior, an emergency exit valve located in the front service compartment, also releases the air from the lock cylinder.

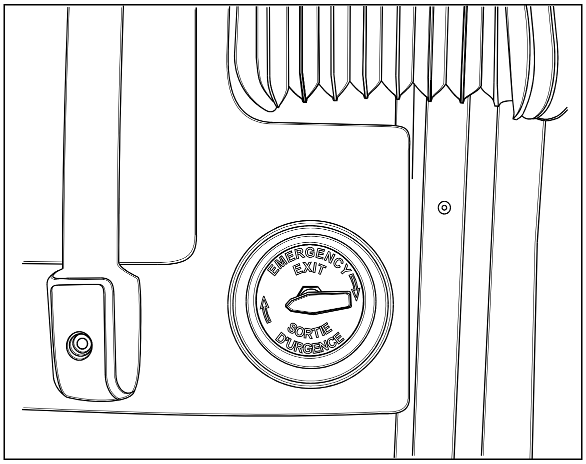


FIGURE 21: EMERGENCY EXIT VALVE 18321

Without Air and/or Without Electricity
If the air pressure drops while the coach has or hasn't any electricity, the spring loaded cylinders will unlatch the door. In such a case, unlock the door by moving the lever on the door or by using the key, then open the door manually.

With Air but Without Electricity
From inside the vehicle, turn the emergency exit valve to the "UNLOCK" position. Move the lever. From the exterior, turn the emergency exit valve to the "UNLOCK" position. Open the door. Close it, lock with the key and reset the outside emergency exit valve to the "NORMAL" position.

7.1.3 Door Cycle Speed Adjustment

To do any adjustment, remove the two panels located next to the door hinge, as well as the door's upper hinge control.

Caution: *It is important to make sure that damper does not reach end of stroke when door is completely closed or opened. The door cylinder must stop the door on opening. Screw or unscrew rod end to adjust if necessary.*

To adjust opening and closing cycle speed on damper (Fig. 22):

1. Remove the damper from the vehicle and hold it vertically with the lower eye or pin attachment in a vice. Use clamp plates to prevent damage.
2. Fully close the damper while turning the dust cap or piston rod slowly CCW until it is felt that the cams of the adjusting nut engage in the recesses of the foot valve assembly (Fig. 22).

Note: *In figure 22, if there is an indentation (B) in the dust cap (C) and the cover shows two holes (A), the damper is fitted with a bump rubber (D). If so, fully extend the damper and insert a round bar or screwdriver through the holes. Push the bump rubber down and remove. Remove the split plastic collar (E) (if fitted) from the piston rod.*

3. The damper may have already been adjusted. Therefore check whether the damper is adjusted or not by keeping it closed and gently turning further CCW, counting at the same time the half-turns until a stop is felt. Stop turning and do not force.
4. While keeping the damper closed, make two CW half-turns. In case of prior adjustment, add the number of half-turns previously counted. The total range is about five half-turns. Pull the damper out vertically without turning for at least 3/8" (1cm) to disengage the adjusting mechanism. The dust cap or piston rod may now be turned freely.

Note: *Where a bump rubber was installed, refit same inside the dust cap and by fully closing the damper, the rubber will seat again at top of the dust cap. Refit the split plastic collar E (Fig. 22).*

5. The damper can now be refitted in the vehicle.
6. Reinstall panels and entrance door hinge cover.

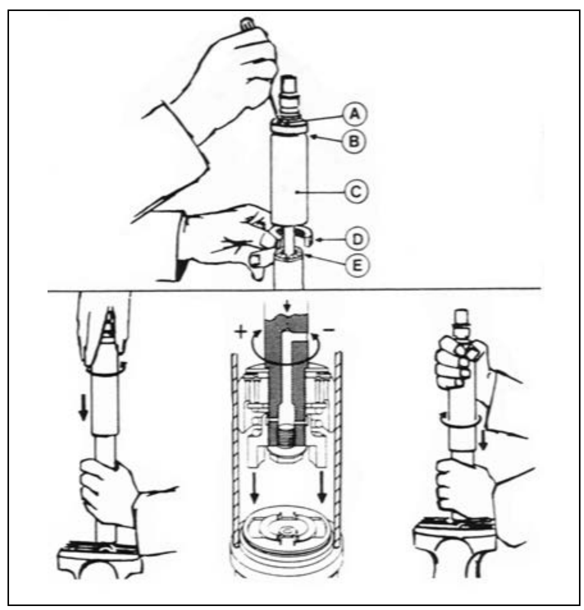


FIGURE 22: DAMPER

7.1.4 Horizontal and Vertical Adjustment

Before attempting to correct any door operating problem by adjusting any part of the air cylinder assembly, first perform the following mechanical checks and procedure.
Check around the perimeter of the door for binding. If any binding is found, adjust as follows:

1. Remove the screws and the plastic molding covering each of the hinges.

Note: *Ask an assistant to help you to perform the following adjustments.*

2. Remove the Allen button head screw and the washer retaining the rod end with bearing to the upper hinge. See figure 23.
3. Support the door with a wooden block and a hydraulic jack.
4. Loosen the horizontal bolts retaining the door to the hinges. Adjust the door horizontally and vertically with the jack. Tighten the bolts to 30-36 ft-lbf (40-50 N•m). Remove the jack and the wooden block.

Caution: *Make sure the front side door does not interfere with the exterior panel.*

5. Pull and fasten the rod end to the hinge with the washer and the button screw.
6. Screw the plastic moldings covering the hinges.

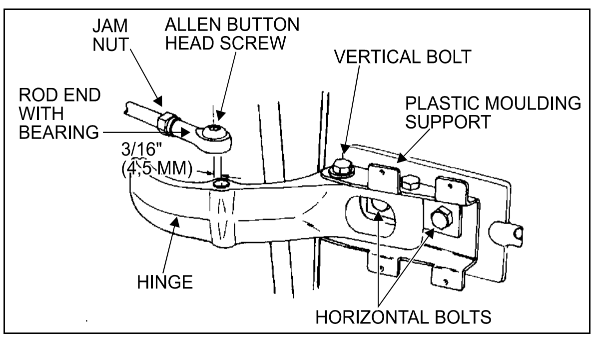


FIGURE 23: UPPER DOOR HINGE 18058

7.1.5 Seal Compression Adjustment

1. Turn the emergency exit valve to the "UNLOCK" position and close the door.
2. From the outside of vehicle, insert a straight edge in the gap along the door outside perimeter. Measure the distance between the door frame and the door outside surface at the door four corners (refer to figure 24).

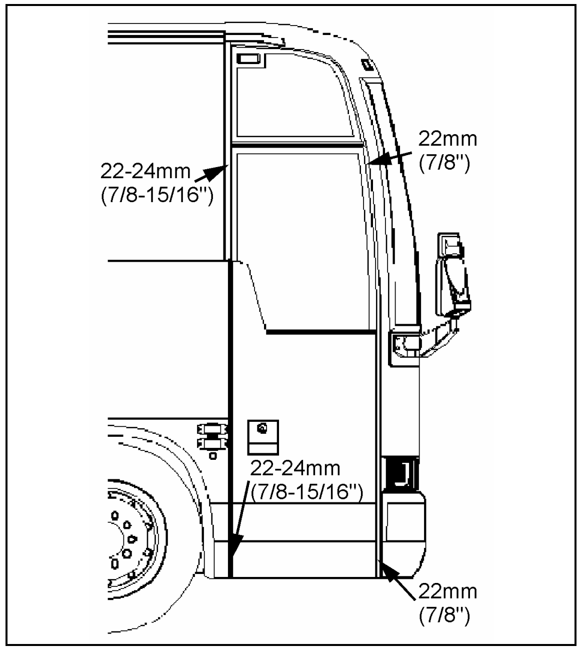


FIGURE 24: SEAL COMPRESSION ADJUSTMENT

Note: *The front measurements are the most important. If required, ask an assistant to help you to perform the following adjustments.*

3. If required loosen the bolts retaining the door to the hinges. Adjust the bolts to obtain the proper seal compression.

7.1.6 Door Seal Replacement

1. Inspect the seal; if cracked or torn, it must be replaced:
2. Remove the old seal and with a sharp edge knife, scrape tape left on the fiberglass door surface.
3. Sand the surface of the door where a new seal will be applied with 240 grit sandpaper.
4. Clean the surface with alcohol.

Caution: *Wear rubber gloves and do not smoke when cleaning.*

5. Peel of protective paper from the seal. Position the seal flush with the top, sides and lower edges of the door.
6. Progress slowly all around the door.
7. Cut the seal and glue both ends with LOCTITE 414 glue.
8. To assure bonding, press a small roller on top of the new seal.

7.1.7 Troubleshooting

SYMPTOM	PROBABLE CAUSE	REMEDY
DOOR WILL NOT OPEN FROM EXTERIOR SWITCH.	Manual door locks engaged.	Release manual door locks.
	Upper and lower solenoid locks do not disengage.	Check voltage at solenoid locks when door is open. If the voltage is 24 volts then replace solenoid #641217. Else, check circuit power.
	Relay module do not receive current.	Reset breaker "ON" or check batteries power supply.
	Opening solenoid door does not receive current.	Check voltage at opening solenoid door. If the voltage is 24 volts then replace it. Else replace control relay.
	Switch malfunction.	Replace switch.
DOOR WILL NOT CLOSE FROM EXTERIOR SWITCH.	Switch malfunction.	Replace switch.
	Solenoid failure.	Check voltage at solenoid. If the voltage is 24 volts then replace solenoid. Else replace control relay.
DOOR WILL NOT OPEN FROM INTERIOR SWITCH.	Manual door locks engaged.	Release manual door locks (open position) from vehicle exterior.
	Upper and lower solenoid locks do not disengage.	Check voltage at solenoid locks when door is open. If the voltage is 24 volts then replace solenoid #641217. Else, check circuit power and replace control relay.
	Module relay does not receive electric current.	Reset breaker "ON" or check batteries power supply.
	Door opening solenoid does not receive current.	Check voltage at door opening solenoid. If the voltage is 24 volts then replace it. Else replace control relay.
	Switch malfunction.	Replace switch.
	Upper lock stays engaged	Lubricate upper lock assembly. Check wear and replace parts if necessary.
DOOR WILL NOT CLOSE FROM INTERIOR SWITCH.	Switch malfunction.	Replace switch.
	Door closing solenoid does not receive electric current.	Check voltage at door closing solenoid. If the voltage is 24 volts then replace it. Else replace control relay.
DOOR WILL NOT OPEN AFTER DRAINING AIR FROM SYSTEM BY EMERGENCY VALVE(S).	Manual door locks engaged.	Release manual door locks (open position) from vehicle exterior.
	Damper cylinder blocks the door.	Adjust or replace damper cylinder.
	The upper lock blocks the door.	Adjust upper lock. Lubricate upper latch bolt. Adjust upper latch height.
DOOR LOCKS STAY ENGAGED WHEN DOOR IS OPEN.	Power supply is cut at solenoid.	Place switch in open position.
	Lock solenoid does not disengage.	Check voltage at solenoid lock when door is OPEN. If the voltage is 24 volts then replace solenoid #641217. Else, check circuit power and replace control relay.
DOOR DO NOT LOCK WHEN DOOR IS CLOSED.	Emergency valve is open.	Close emergency valve.
	Lock solenoid stays electrified.	Check latch bolt ground on door frame. If needed clean locks for better contact. Check ground circuit.
	Lock solenoid works in reverse.	Reverse air hoses at solenoid locks.
	Relay does not function.	Replace relay.

7.1.8 Lubrication

Part	Lubricant	Frequency
Latches Upper door catch Door cylinder rod end with bearing grease fitting	Low temperature grease	Every six months
Door locking mechanism	White grease	Every six months
Key hole Damper pins Hinges	Low viscosity oil	Every six months

7.2 ENTRANCE DOOR (MTH)

There are three ways of unlocking the entrance door from the inside of vehicle. The two first consist in actuating the rocker switch on the dashboard, but this last operation will also unlock the baggage compartments. Finally, you can unlock the door by sliding its lock lever to the left. If the orange tab on the door lock lever is visible, the door is unlocked.

You may lock/unlock the entrance door from the outside with the lock key provided with the vehicle. Turn key CCW to lock and CW to unlock the entrance door.

7.2.1 Keyless entry system

With this system, you can lock or unlock the entrance door as well as the baggage and service compartment doors. The keyboard is located below the entrance door handle. The module is pre-programmed by the manufacturer and this code can not be deleted. Moreover, you can program your own entry code. Refer to the "Owner's Manual" for instructions on how to program your own entry code.

When you use the keyless entry system, the keyboard and stepwell lights illuminate. Do not push the buttons with a key, pencil or any other hard object as it could damage the buttons.

Although each button is provided with two digits separated by a vertical line, there is only one contact per button. Always press the center of the button (between the two digits, on the vertical line).

If you let more than five seconds pass between each button press, the system shuts down, and you have to enter your code again. If the keyless entry system does not work properly, use the key to lock or unlock entrance or compartment doors. To know more about the keyless system, refer to the "Owner's Manual".

Note: *You must unlock the entrance door before you unlock with the appropriate key any baggage or service compartment doors.*

7.2.2 Door adjustment

Check around the perimeter of the door for binding. If any binding is found, adjust as follows:

7.2.3 Horizontal and Vertical Adjustments

1. Remove the screws and the plastic molding covering each of the hinges.

Note: *Ask an assistant to help you to perform the following adjustments.*

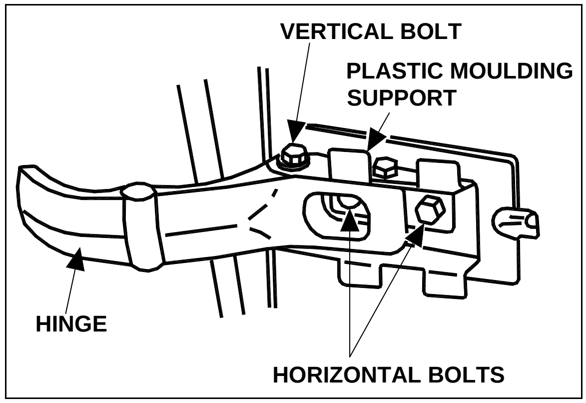


FIGURE 25: ENTRANCE DOOR (MTH) 18058

2. Support the door with a wooden block and a hydraulic jack.
3. Loosen the horizontal bolts retaining the door to the hinges. Adjust the door horizontally and vertically with the jack. Tighten the bolts to 30-36 ft-lbf (40-50 N•m). Remove the jack and the wooden block.
4. Check door fit.
5. Using the screws, fasten the plastic trim to cover the hinges.

7.2.4 Seal Compression Adjustment

1. Close the door, from the outside of vehicle, insert a straight edge in the gap along the door outside perimeter. Measure the distance between the door frame and the door outside surface at the door four corners (refer to figure 24).

Note: *The front measurements are the most important. If required, ask an assistant to help you to perform the following adjustments.*

2. If required loosen the bolts retaining the door to the hinges. Adjust the bolts to obtain the proper seal compression.

7.2.5 Door Seal Replacement

1. Inspect the seal; if cracked or torn, it must be replaced:
2. Remove the old seal and with a sharp edge knife, scrape tape left on the fiberglass door surface.
3. Sand the surface of the door where a new seal will be applied with 240 grit sandpaper.
4. Clean the surface with alcohol.

Caution: *Wear rubber gloves and do not smoke when cleaning.*

5. Peel of protective paper from the seal. Position the seal flush with the top, sides and lower edges of the door.
6. Progress slowly all around the door.
7. Cut the seal and glue both ends with LOCTITE 414 glue.
8. To assure bonding, press a small roller on top of the new seal.

7.2.6 Door Lubrication

Part	Lubricant	Frequency
Latches Upper door catch	Low temperature grease	Every six months
Door locking mechanism	White grease	Every six months
Key hole Hinges	Low viscosity oil	Every six months

7.2.7 Door Latch mechanism

Generally, when the latch mechanism malfunctions, a number of causes may be responsible for this situation. No single procedure will correct this situation. It is best to remove the protective cover and to look for binding, used or bent parts. Operate the latch mechanism and try to find where any binding occurs. Replacing a part or slightly bending a rod should be enough. Remember, having a global understanding of the mechanical activity will generally lead you to the cause of the problem, and ultimately to an easy repair.

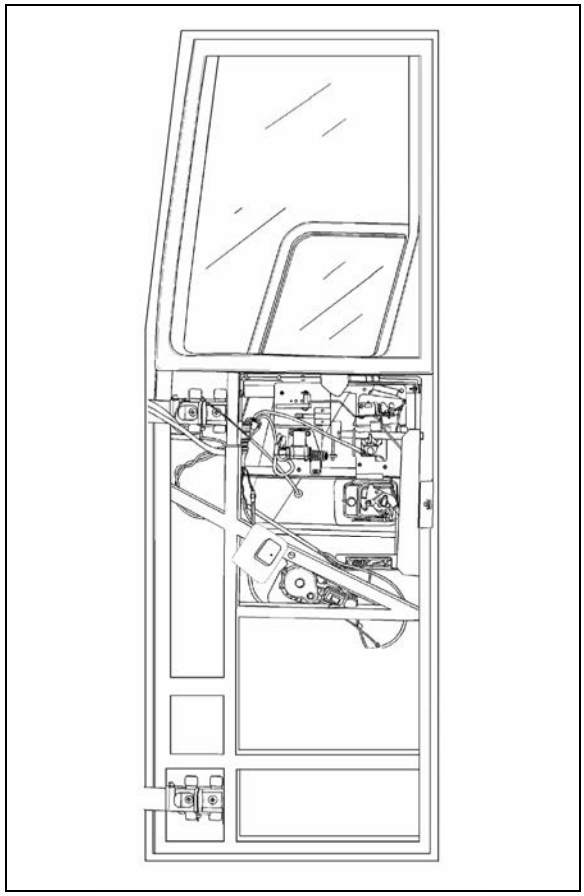


FIGURE 26: ENTRANCE DOOR (MTH, TYPICAL)

8. BUMPER REMOVAL AND INSTALLATION

8.1 FRONT BUMPER

The front bumper is hinged to give access to the spare wheel and tire compartment. Pull the handle located in the front service to open the spare wheel and tire compartment. Bumper must first be tilted down before its removal. Two people are required to remove and install the front bumper. Safely support the bumper and remove the two bolts on each bumper side to separate the bumper from the spare wheel compartment door. To install bumper, reverse the removal procedure.

Warning: *Front bumper is heavy. Use proper lifting equipment to support the bumper during the removal and installation operations to avoid personal injury.*

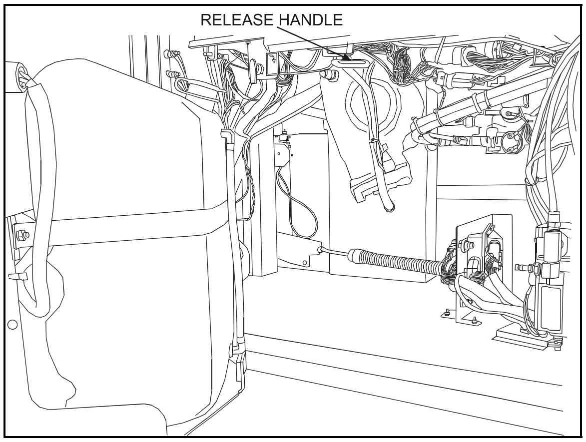


FIGURE 27: FRONT BUMPER RELEASE HANDLE

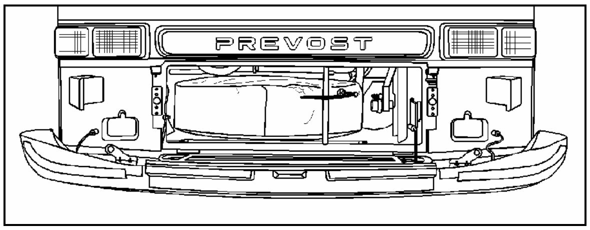


FIGURE 28: FRONT BUMPER

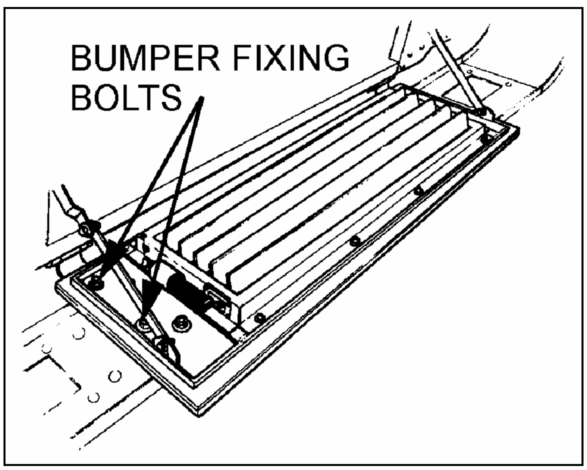


FIGURE 29: FRONT BUMPER REMOVAL

8.2 REAR BUMPER REMOVAL

MTH and coach model rear bumpers are very similar, so is their removal and installation.

1. Remove three bolts on each side holding bumper to vehicle and remove bumper.
2. To install bumper, reverse the procedure.

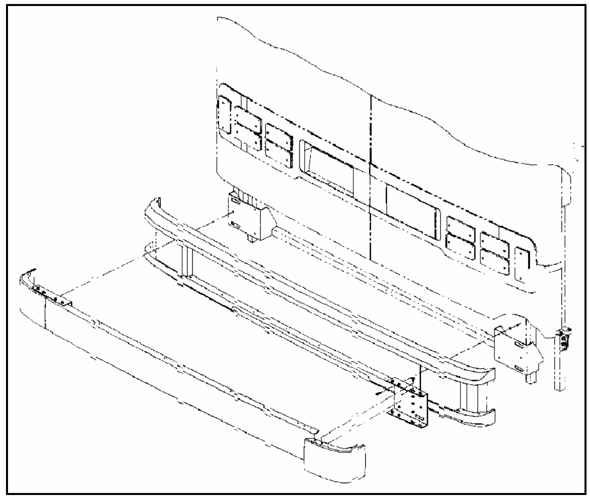


FIGURE 30: REAR BUMPER

9. DRIVER'S OR ENTRANCE DOOR POWER WINDOW

Driver's and entrance door power windows are similar, only the door opening mechanism is different. If the window or regulator is defective, it must be replaced. The following instructions refer to figure 31 or 32:

9.1 DRIVER'S POWER WINDOW

9.1.1 Window Removal and Installation

1. Open the door and remove the door finishing panel.
2. Remove the screws holding the window to the lifting mechanism. Move aside the holding plate.
3. Lower the window completely to detach from the opening.
4. Reverse the procedure to install.

9.1.2 Regulator Removal and installation

1. Open the door and remove the door finishing panel.
2. Remove the screws holding the window to the lifting mechanism. Move aside the holding plate.
3. Unfasten the two bolts fixing the regulator assembly. Disconnect connector from regulator.
4. Reverse the procedure to reinstall.

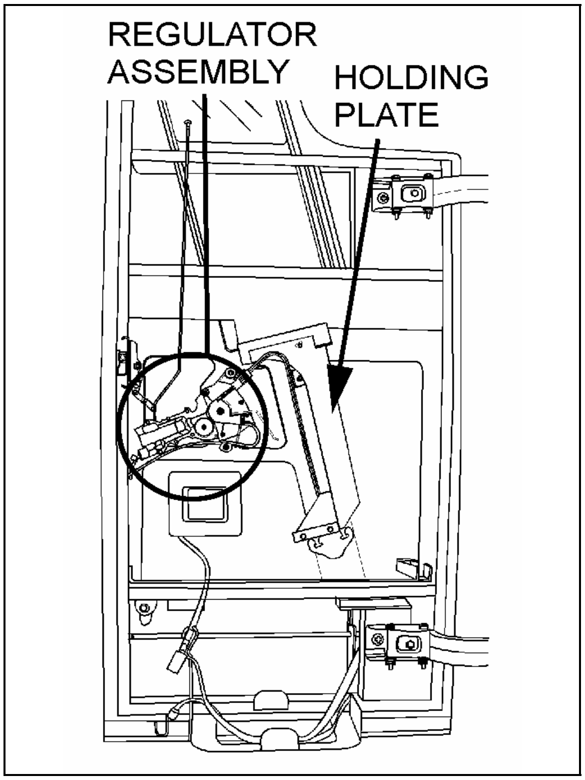


FIGURE 31: DRIVER'S POWER WINDOW

9.2 ENTRANCE DOOR POWER WINDOW

9.2.1 Window Removal and Installation

1. Open the door and remove the door finishing panel.
2. Remove the four bolts fixing the entrance door locking mechanism support to the door.
3. Remove the screws holding the window to the lifting mechanism. Move aside the holding plate.
4. Remove the assembly by slipping it under the vehicle structural members.
5. Lower the window completely to detach from the opening.
6. Reverse the procedure to reinstall.

9.2.2 Regulator Removal and Installation

1. Open the door and remove the door finishing panel.
2. Remove the screws holding the window to the lifting mechanism. Move aside the holding plate.
3. Unfasten the two bolts fixing the regulator assembly. Disconnect connector from regulator.
4. Remove the regulator assembly by slipping it under the vehicle structural members.
5. Reverse the procedure to reinstall.

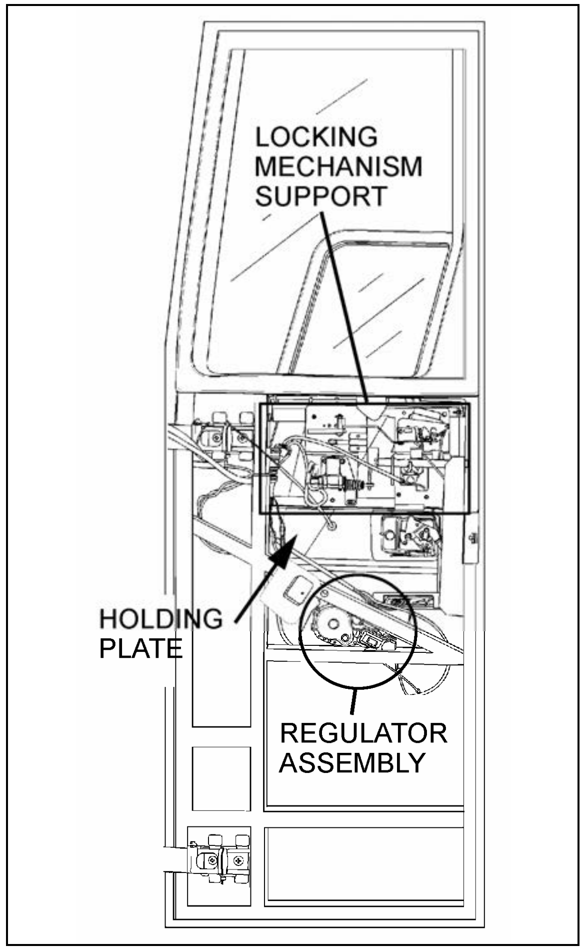


FIGURE 32: ENTRANCE DOOR POWER WINDOW

10. ROOF ESCAPE HATCH

The vehicle can be equipped with one or two escape hatches. The escape hatch is designed to provide years of reliable service with a minimum of maintenance. All components are rust proof, and moving parts are Teflon coated to eliminate need for lubrication. Should water infiltrate the vehicle from the escape hatch, refer to the heading "Sealing" in this section for procedures on how to seal this area.

Caution: *Use of lubricants, paints, or other coatings such as graffiti deterring sprays are not recommended.*

Suggested maintenance includes periodic inspection of fasteners for evidence of loosening due to tampering, and regular cleaning with mild soap and water.
Although there are other cleaning solutions available, some contain solvents and other chemicals that can attack the high strength materials used in the production of the escape hatch.

Caution: *Ensure that cleaning solutions are compatible with the materials used on the escape hatch.*

Graffiti removing cleaners often contain acetone, ether, lacquer thinner, or other solvents known to destroy the high strength properties of many plastics. Use of these cleaners must be avoided. Graffiti-resisting coatings often leave a sticky residue that interferes with smooth up/down movement of the hatch mechanism. Some of these coatings also contain solvents that will reduce the strength of certain components.

Caution: *Use of these coatings is at considerable risk and should be avoided.*

10.1 REPAIR

All components used in the production of the escape hatch are available as service parts, except for one hinge that represents a possible hazard when improperly reattached to a hidden tapping plate, itself often damaged whenever the hinge is damaged. The tapping plate is permanently laminated between the inner and outer cover assemblies, and it cannot be inspected or replaced. It is therefore necessary to replace the entire assembly following damage to the hinge. See figure 34.

Caution: *Hinge assembly is critical and hinge should never be removed from cover assembly. Fasteners used in this assembly are special and have critical torque requirements and tamper-resistant heads to discourage tampering.*

10.2 SEALING

1. Open and tilt up the escape hatch cover.
2. Join the 2 ends of the rubber seal.

Caution: *Seal joint should be toward rear of vehicle.*

3. Apply rubber adhesive CA-40 (Prévost # 681285) in the gap between the seal ends.
4. Apply Sikaflex 221 sealant (Prévost # 680532) along the outline of the escape hatch on the roof of vehicle.

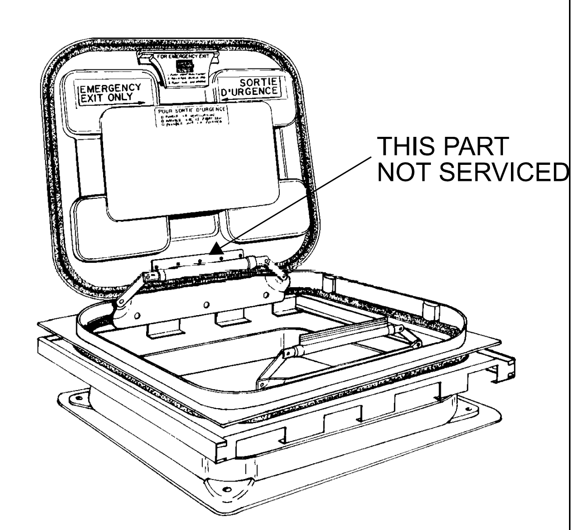


FIGURE 33: ESCAPE HATCH 18104

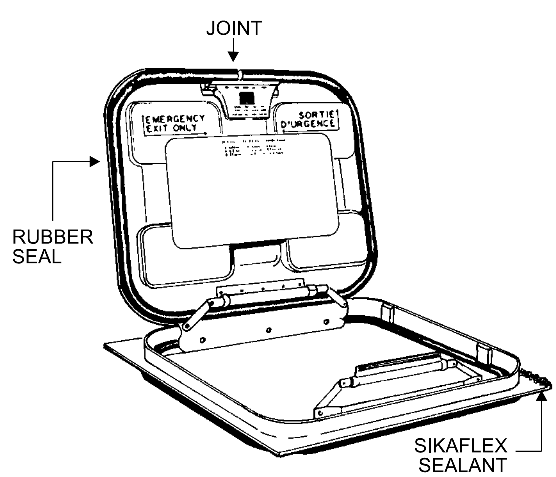


FIGURE 34: ESCAPE HATCH 18105

10.3 ESCAPE HATCH PANEL ASSEMBLY

The frame of the escape hatch is riveted to the roof of the vehicle. The escape hatch panel assembly can be replaced as a unit and a new panel assembly installed in the existing frame. To remove the panel assembly, remove the 4 bolts fastening the 2 hinges to the escape hatch frame and retain the 4 flat washers. Reinstall the panel assembly by fastening the 2 hinges with the 4 bolts and flat washers removed earlier.

Caution: *When installing, roof escape hatch's hinge must be toward the front of vehicle, to prevent the hatch from being ripped out if accidentally opened while vehicle is running.*

10.4 ESCAPE HATCH FRAME

When necessary, the escape hatch frame can be removed and replaced in the following way:

1. Support the frame from inside the vehicle.
2. Remove rivets.
3. Cut the rubber seal with a sharp edge knife and remove the hatch frame.
4. On vehicle top, using the knife, remove as much as possible the remaining rubber seal.
5. Drill holes (if needed) in the new metal frame.
6. Clean both vehicle top and new hatch frame with SIKA 205.
7. Apply rubber adhesive SIKA 221 under the hatch frame surface.
8. Install the frame in place and fix it with rivets.
9. Remove excess adhesive and clean all around.

11. PASSENGER SEATS

XLII-45 coaches can be equipped with any of 3 basic seat models and installed in a variety of seating arrangements:

1. The *"Tourismo 2"* seat is the base model and is available in heights of 40" (102 cm) and 42" (107 cm). Seating arrangement includes 2 card tables which can be folded and removed, and pivoting seats ahead of each card table. Each pair of seats is built on a welded steel frame fastened to the side wall and on a track-mounted pedestal.
2. The *"Silhouette"* seat is an optional model with each pair also built on a welded steel frame and mounted the same way as the *"Tourismo 2"* seat. Standard seating arrangement with "Silhouette" seat includes 2 card tables and 2 pivoting seats. Seating capacity is the same as with the *"Tourismo 2"* seat.
3. The *"V.I.P."* seat model is an optional seat. *"V.I.P."* seats are mounted on one row of paired seats built on a common frame on one side of the vehicle, and a row of single seats on the other side of the vehicle with an off-center aisle. Each *"V.I.P."* seat has its own set of armrests.

Each seat has a easily removable bottom cushion. Upholstery is clipped on the cusion frame for cleaning or replacement. To remove the fabric, simply unclip from the frame. The *"Tourismo 2"* and *"Silhouette"* seats have 3 armrests. The aisle and center armrests can be folded up and down manually, while the window armrest is fixed.

11.1 ROTATING SEATS

1. Remove 1 wing nut holding each seat bottom cushion from under the seat frame.
2. Lift front part of cushions and remove cushions.
3. Remove 4 wing screws fastening seat assembly to seat frame.
4. Pull seat toward aisle and rotate.
5. Align mounting holes and reinstall 4 wing screws.
6. Reinstall seat bottom cushions with wing nuts.

11.2 REMOVING FIXED SEATS

Note: *Seats on one row are not interchangeable with seats of the other row.*

To remove fixed seats, proceed as follows:

1. Remove 1 nut holding each seat bottom cushion from under the front part of the seat frame.
2. Lift front part of cushions and remove cushions.
3. Remove 4 finishing screws holding plastic cover between side wall and seat frame.
4. Remove 2 cap screws, nuts, and washers holding seat frame to side wall and retain the 2 holding brackets. See figure 35.
5. Remove 2 nuts and washers holding seat frame to pedestal rods. See figure 36.

Note: *Bottom end of rod is coated with Locktite and threaded in a steel block which slides in the floor track. Removal of rod is possible if loosened from block. Otherwise, slide rod and block assembly to the front end of track after removing all seats located in front.*

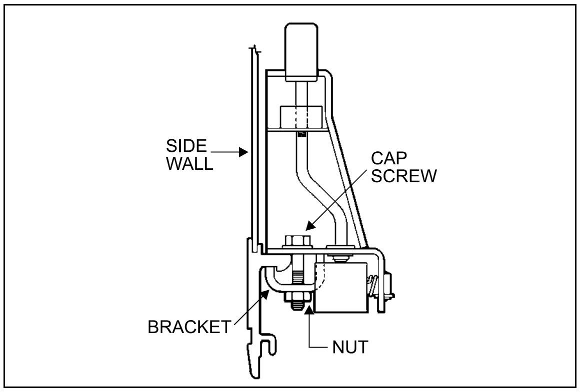


FIGURE 35: ARMREST 18106

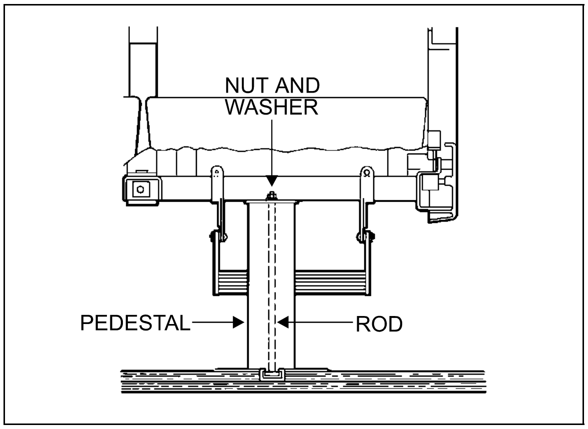


FIGURE 36: SEAT PEDESTAL ASSEMBLY 18107

6. Remove seat assembly.
7. Reverse the above procedure to install seat assembly.

Note: *On newer vehicles, the rod consists of a carriage bolt inserted in a square plate sliding in the floor track. Removal is possible only by the front or rear end of track.*

11.3 UPHOLSTERY MAINTENANCE

Coach seats are lightweight, with foam-padded backs and cushions. For both appearance and wearability, best results are obtained if upholstery is cleaned at regular intervals before dirt, dust and grit have been ground into the fabric. Seat fabric is made of 50% wool, 33% cotton, 9% nylon, and 8% acrylic.

11.3.1 Routine Cleaning

All that is required to remove the dirt is a gentle beating with the hand or the back of a brush. This will bring the dirt to the surface where it is easily removed with a vacuum or brush in the direction of the pile which can easily be recognized by running a hand lightly over the pile. If the fabric become excessively dirty, particles of grit will cause gradual wear, reducing the life span of the fabric.

11.3.2 Dry Cleaning

If covers are to be removed for cleaning, dry cleaning is recommended since washing might cause some shrinkage, preventing the covers from being reapplied to the seats without damage. Other than spot cleaning the covers while they are in place, dry cleaning is not recommended, since the resulting fumes could be hazardous in the confines of the coach and the solvent could be detrimental to the foam padding of the seats.

11.3.3 Cleaning With Covers in Place

The most effective and economical method to clean the fabric seat covers is by washing with either an approved foam upholstery cleaner or with a mild household detergent.
Thoroughly vacuum the upholstery. Remove any spots or stains before the seats are washed to avoid a cleaning ring.
Dilute household detergent or liquid foam cleaner according to directions on the container. Pour a small quantity into a flat pan and work into a thick foam with a sponge or brush.
Apply only the foam to the fabric with a sponge or brush. Clean a small area of the fabric at a time with the foam. DO NOT SOAK. Rub vigorously. Sponge the suds from the fabric with a clean sponge or cloth moistened with water. Rinse the sponge or cloth often and change the water when it becomes dirty.
Allow the upholstery to dry completely before the coach goes back into service. To speed up drying, excess moisture can be blown off the fabric with compressed air.

Caution: *Oil in the air line will soil the fabric. Blow the line clear and test air discharge against a plain white piece of paper. It is also effective to press the edge of a flat hardwood stick down on the cushion and slowly draw it across the fabric.*

Even very soiled areas can be returned to their original appearance by a thorough cleaning, but a regular schedule of cleaning that keeps the upholstery reasonably clean at all times will greatly enhance the life span of upholstery.

12. TARABUS FLOOR COVERING REPAIR OR REPLACEMENT

On XL2 vehicles equipped with “Tarabus” covering, it is possible to replace or repair this covering. The purpose of this paragraph is to explain the steps to be followed to ensure the best results and adherence.

MATERIAL

Part No	Description	Qty
680028	Adhesive, Tarabus Floor Covering (White)	A/R
684655	Adhesive, Contact (3M)	3.8L
684654	Adhesive, Contact (3M)	18.9L
680532	Sikaflex 221 Gray	A/R

Note : *Material can be obtained through regular channels.*

1. Remove number of passenger seats required to perform repair.
2. Cut and remove damaged section of floor covering.

Note: *It would be preferable to cut under two rows of seats so that repair is not as noticeable.*

3. Clean plywood using a scraper.

Note: *Make sure that no staples are sticking out beyond surface. Adjacent plywood sheets must be leveled.*

4. Fill up holes and imperfections using MAPI PRP 110 then sand.
5. Remove dirt and adhesive residue.

Caution: *Do not leave floor covering folded down except temporarily during installation.*

6. Apply floor covering adhesive (680028) onto plywood using a serrated spreader with 1/8-inch serration. If required, apply contact adhesive (3M) (684655 or 684654) onto aluminum molding and also onto section of floor covering, which will be in contact with molding (refer to figure 35).

Note: *Allow adhesive to dry (3 to 5 minutes).*

7. Compress floor covering using a roller so as to remove any trapped air bubble.
8. Apply Sikaflex 221 gray sealant (680532) alongside passenger seat fixing tracks (refer to figure36).

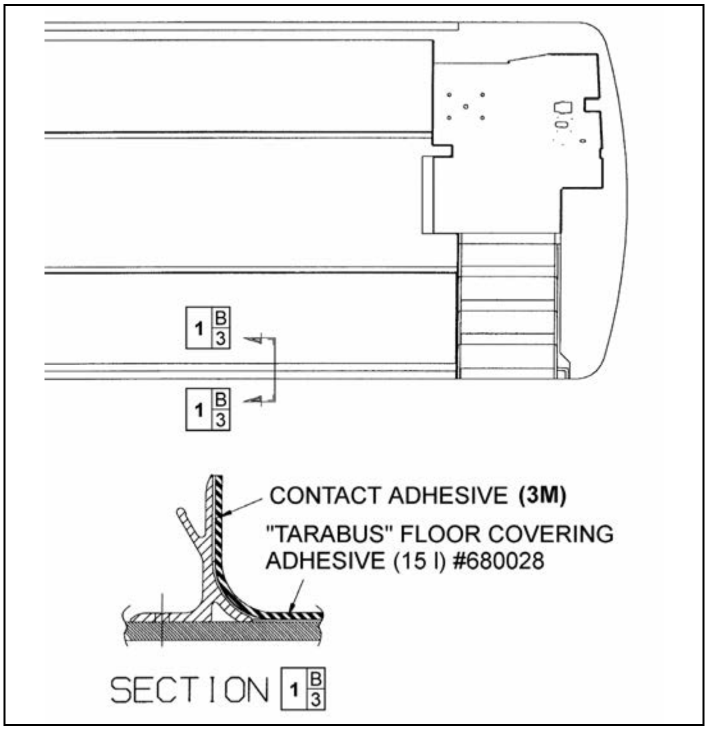


FIGURE 37: TARABUS FLOOR COVERING ADHESIVE APPLICATION

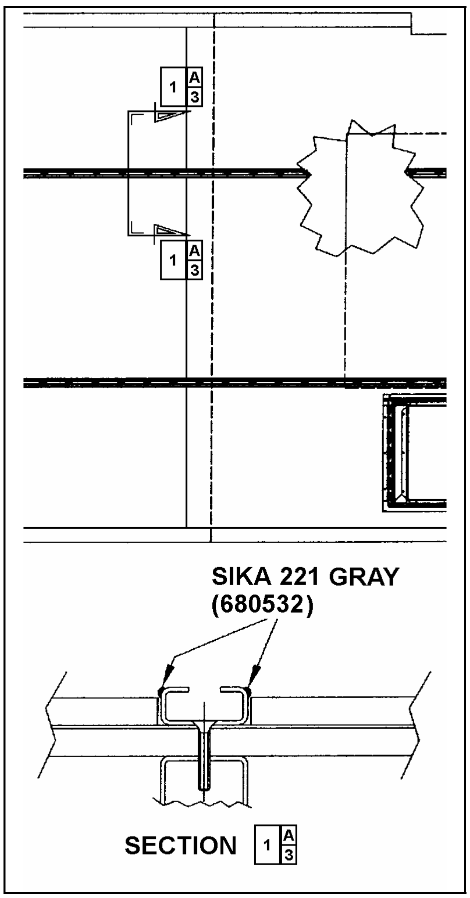


FIGURE 38: APPLICATION OF SIKA 221 GRAY

12.1 FRONT STEPS REPLACEMENT PROCEDURE

MATERIAL

Part No	Description	Qty
682989	Anti-silicone	A/R
683097	Sika 205 (1 liter)	A/R
685101	Sika Remover 208	A/R
683916	Sika 215 (1 liter)	A/R

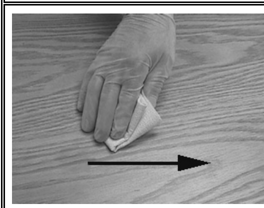
1. Cut and remove damaged step(s).
2. Remove dirt and adhesive residue.

Note: *In wintertime, condensation and cold temperature may greatly influenced bonding parameters. Working area must be at a temperature sufficient to prevent reaching condensation point. Mechanically preheat working area (heat lamp or heat gun) or wait until vehicle reaches room temperature.*

PREPARATION OF "TARABUS" FLOOR COVERING

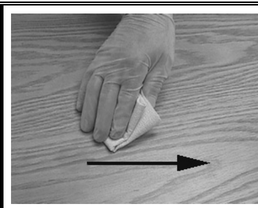
1. Sand under step using "Scotchbrite".
2. Clean using anti-silicone (refer to Section A).

Section A Alcohol or Anti-silicone



1. **Apply**

CHIX cloth



2. **Dry immediately**

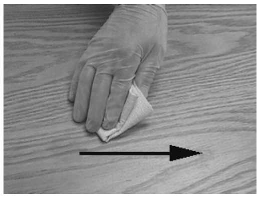
Blue cloth

3. **Allow drying**

Mandatory	**Minimum time : Wait for product to evaporate**	
	After 2 hours: Start cleaning operation again	
Before applying any other product	If surface seems dusty, greasy or with finger marks, start cleaning operation again.	

3. Apply Sika Primer 215 (refer to Section D).

Section D Sika Primer 215



1. **Shake bottle to mix product**

2. **Apply a thin layer**

CHIX cloth

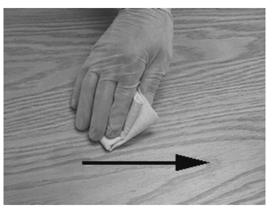
3. **Allow drying**

Mandatory	**215**	**Minimum time : 20 minutes**
		After 2 hours : Remove dust using damp cloth (pure water)
Before applying any other product		If surface seems dusty, dust using damp cloth.
		If surface seems greasy or with finger marks, reactivate with Aktivator.

PREPARATION OF FIBERGLASS

1. Clean using anti-silicone (refer to Section A).
2. Apply Sika 205 (refer to Section B).

Section D Sika Primer 215



1. **Apply**

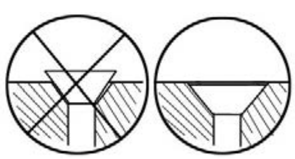
CHIX cloth

2. **Allow drying**

Mandatory	**Minimum time**	**- For a smooth surface (aluminum, stainless, steel, fiberglass (gelcoat side), etc.):**	**2 minutes**
		- For a porous surface (fiberglass (non gelcoat side), etc.)	**10 minutes**
	After 2 hours : Reactivate surface with Sika 205		
Before applying any other product	If surface seems dusty, greasy or with finger marks, start operation again.		

XL2 VEHICLE FRONT STEPS GLUING

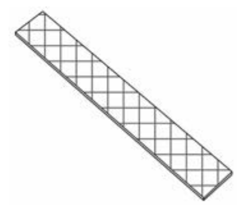
1. Use step nosing to measure and cut necessary length of white safety strip.
2. Use a screw to check depth of countersinking in step nosing. Screw top must not stick out beyond the aluminum surface. Countersink if needed.



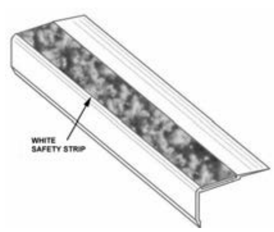
3. Apply some Sika 252 onto the step; make sure to cover the whole surface of the step. Use a serrated spreader with 1/8-inch serration to spread Sika.
4. Apply a bead of Sika 221 onto the perimeter of the step.
5. Install step and press with hands. If Sika overflows, clean with Sika 208. Repeat previous stages for each step if applicable.
6. Remove protective film from double-coated self adhesive tape located underneath step nosing, position step nosing then press. Drill and fix using screws.

7. Clean top of step nosing using Sika 205 (refer to Section B).

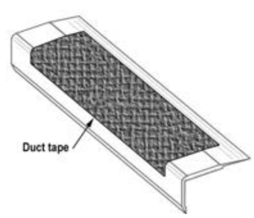
8. Apply some Sika 221 onto white safety strip, spread with a spatula to cover the whole surface.



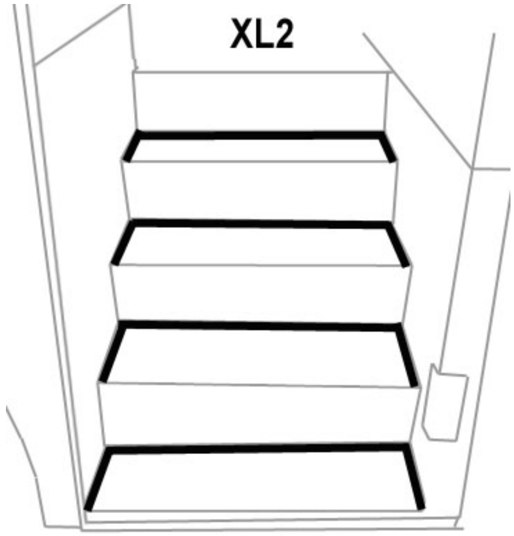
9. Position white safety strip then press using hands. If Sika overflows, clean with Sika 208.



10. Temporarily fix white safety strip with a piece of duct tape, leaving 1 to 2 inches free at each end.



11. Apply some masking tape onto the step perimeter, clean using Sika 205 (refer to Section B) then apply a bead of Sika 252 black. Smooth out the joints then remove masking tape.
12. Install weights onto the steps. Minimum waiting time: 2 hours.



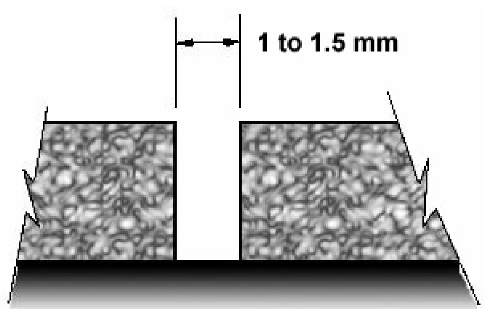
12.2 WELDING OF JOINT BETWEEN WHITE SAFETY STRIP AND “TARABUS” FLOOR COVERING

1. Pre-heat welding torch;

   Set welding torch to position #4.5 (temperature of 500 °C),

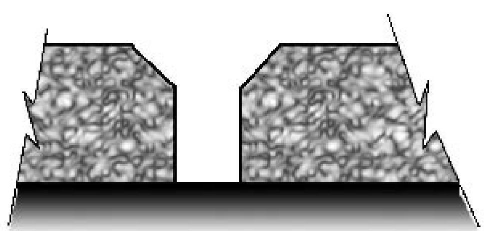
   Heating time: 5 minutes.

2. Before welding, visually ensure that a 1 to 1.5 mm gap exists between white safety strip and “Tarabus” floor covering. Use a knife if this is not the case.



Note: *There should be no excess of adhesive on top of surfaces, clean if required using “All-Sol”.*

3. Chamfer the joint.



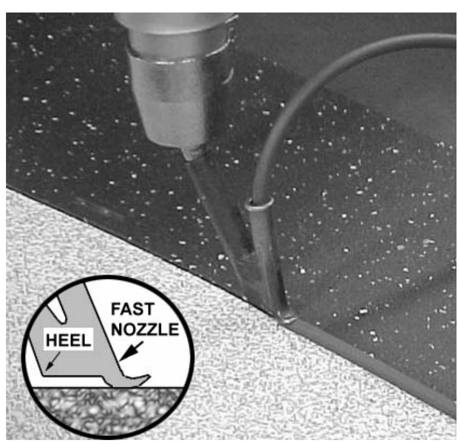
Note: *The chamfer width must always be less than the filler bead diameter (between 2.5 and 3 mm).*

4. Use chamfer knife. **Be careful not to overcut or to cut to the side to prevent damaging “Tarabus” covering.**

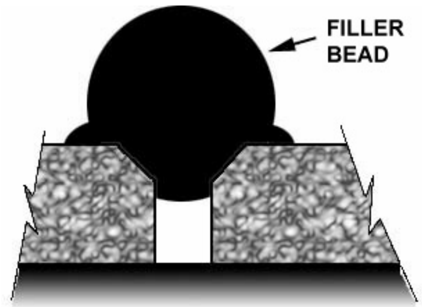
5. Add (about 6 inches) some length to the required length of filler bead to make the joint then cut.
6. Take position with welding torch. The proper position is with a slight slope to the rear.

7. Once the welding torch is ready, insert the filler bead into the nozzle and immediately start welding. Move in a regular manner while pressing slightly with torch.

8. The heel of the fast nozzle must not lean against “Tarabus” covering (always parallel to the surface).

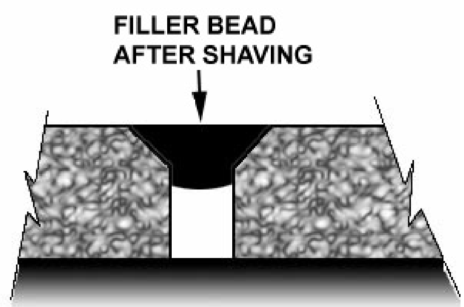


9. Allow cooling down of filler bead (about 5 minutes).



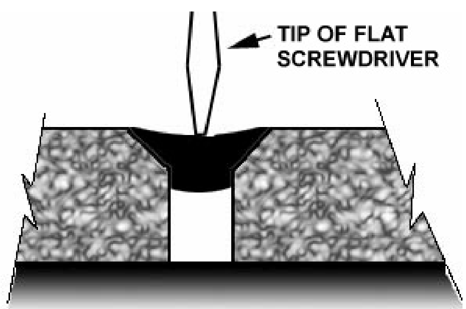
10. Shave filler bead to make it level to the floor. Use supplied knife designed for that purpose.

Note: *To facilitate the cut, you can spray some soapy water onto the joint.*

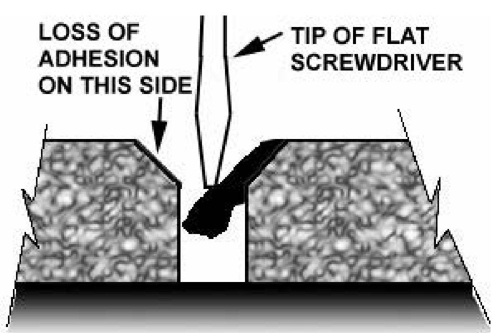


Caution: *The procedure for turning the torch off must absolutely be followed. If this step is not taken, the element may burn.*

11. Set temperature potentiometer to "0" position. Fan will evacuate residual heat. Leave the torch in operation as it is for 3 minutes.
12. Perform adhesion test using the tip of a flat screwdriver; apply a slight pressure on the joint.



13. If welding was not performed properly, there will a loss of adhesion on one side. If this is the case, repair the joint.



12.3 REPAIR OF A WELDED JOINT

Note: *In wintertime, condensation and cold temperature may greatly influenced bonding parameters. Working area must be at a temperature sufficient to prevent reaching condensation point. Mechanically preheat working area (heat lamp or heat gun) or wait until vehicle reaches room temperature.*

1. Using a knife, remove portion of joint to be repaired.

Note: *Loss of adhesion may be local. If this is the case, repair may also be local.*

2. Chamfer the joint again as indicated in paragraph 12.2, Section: WELDING OF JOINT BETWEEN WHITE SAFETY STRIP AND “TARABUS” FLOOR COVERING.
3. Re-weld the joint as indicated in paragraphs 6, 7 and 8. Use your thumb to hold the filler bead end.

Warning: *Nozzle is hot.*

4. Always add an extra inch of filler bead at the beginning and at the end of repair.
5. Perform steps indicated in paragraphs 9, 10 and 11.

13. COACH SIDE WINDOWS

Nine passenger side windows are provided on each side on XL2-45. They are made of fixed, single or double-glazed, heat absorbing AS-3 glass. Windows are mounted in painted aluminum extrusions, which hold the glass in place from the top rail of the coach. The extrusion also serves as a hinge to allow the window to swing open when needed. The single-glazed windows are made of tinted tempered safety glass, while the double-glazed windows are made of tinted tempered safety glass outside and clear tempered glass inside.

13.1 EMERGENCY EXIT WINDOWS

Three of the windows on curb side of the XLII-45 serve as emergency exits, while there are four on driver’s side. See figure 39. Except for the top window side, the three other glass sides are unprotected, which causes the workers to be exceptionally careful when manipulating or installing such windows.

In addition, when it becomes necessary to lay down the unprotected edges of the glass window, never use a steel or concrete floor support. It is recommended to use a wooden support, even better, a padded surface.

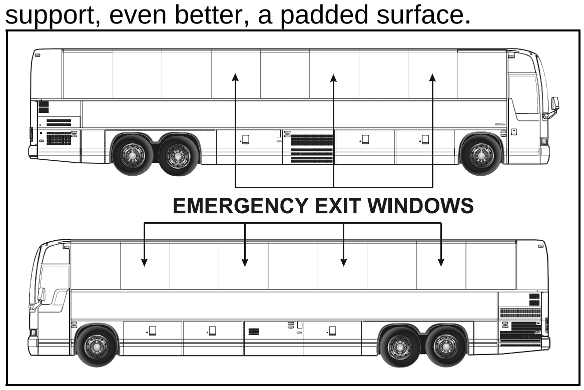


FIGURE 39: XL2-45 COACH 18419

An emergency exit window can be opened by pulling the lower part of the release bar to disengage the safety latches, and then by pushing out the window frame (Fig. 40).
Emergency operating instruction decals are affixed under each emergency exit window. To close the window, pull back the window and push down the release bar.

13.1.1 Emergency Exit Release Bar

The emergency exit release bar system is generally maintenance free.
It has been designed to answer the twenty pound resistance criteria for opening the emergency window. If this handle should be replaced:

1. remove the screws and bolts securing it to the emergency exit window;
2. to install a new release bar, reverse the procedure.

Note: *Check the legal twenty pound maximum resistance to be sure to comply to regulations.*

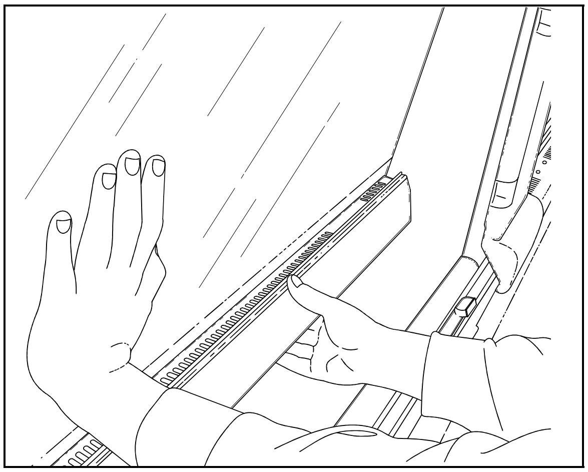


FIGURE 40: EMERGENCY EXIT WINDOW

13.1.2 Emergency Exit Window Adjustment

Emergency exit windows should be checked periodically for easy opening and closing. Pulling the lower part of the release bar with both hands placed near the safety latches should disengage both locks on the window simultaneously. The tension required to release the window should not exceed twenty pounds (9 kg) of force.
The release bar mechanism itself has been designed such as no adjustments are necessary.
If too much effort is required to disengage the locks when pulling the release bar or if the window doesn't close tightly or rattles, check for interference by foreign objects or nearby parts into mechanism, such as the microswitch, rubber seal, wires, etc. Correct situation immediately.

Note: *Tangs on the lock must be in a horizontal position.*

13.1.3 Emergency Exit Window Replacement

1. Lift the bar release system;
2. Remove the stop blocks from the top exterior of the window.
3. Push the glass window out ninety degrees (90°).

Warning: *The window may fall out.*

4. The window is free and can be unhooked.
5. Reverse the procedure to install a new emergency exit window.

14. BODY PANELS AND DOORS

Each of the doors should be checked for proper operation. This includes latching. Also, inspect each of the doors for damage, missing, or loose parts. Repair or replace those parts as needed. Unless otherwise noted, body panels and doors should be aligned and centered with surrounding panels. In general, a gap of ¼ inch (6 mm) is desirable between panels.

15. BAGGAGE COMPARTMENT DOORS

The baggage compartment doors on the vehicle are of identical design. The doors are pantograph, vertical-lift type and are fully sealed. Each door has a flush-mounted latch handle. To open, lift latch handle, then pull door outward and up. The door is held open by 2 gas-charged cylinders. To close, leave latch handle in the open position, pull downward on door and push down on latch to secure door. The door lower arm is spring loaded to secure effort required to close the door (Fig. 41).

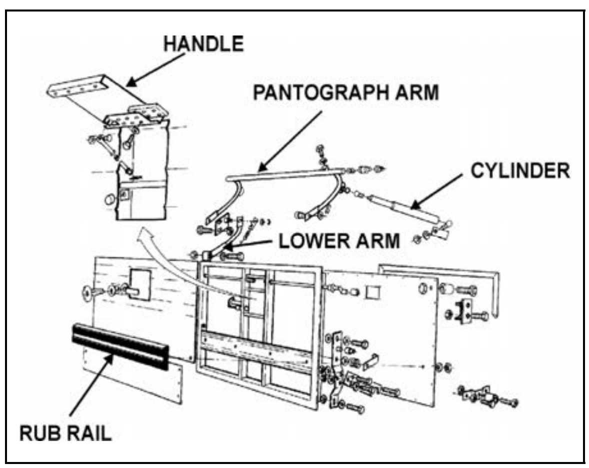


FIGURE 41: BAGGAGE COMPARTMENT DOOR 18145

If a door does not remain in the fully open position, one or both cylinders on that door is (are) defective. To test the cylinders, first support the door in the open position with proper equipment. Disconnect the rod end of one cylinder and retract the rod. If strong resistance is felt, the cylinder is in good condition and can be reinstalled. If the rod retracts with little effort, the cylinder is defective and should be replaced at once. Use the same procedure to test the other cylinder on that door.

15.1 DOOR REMOVAL

Caution: *Two people are required to remove the baggage compartment doors.*

1. Maintain the door halfway open by placing a wooden block between one of the pantograph arms and the upper frame.
2. Remove cap screw, lock washer and flat washer retaining lower arm to door
3. Remove spring pins and lock washers fastening the pantograph arms to the door.

Warning: *Support the door properly to prevent it from falling.*

4. Spread the pantograph arms away from the door and remove door.
5. Inspect all pivot points and bushings for wear and damage. Check tension of gas-charged cylinders and replace if necessary.

15.2 PANTOGRAPH ARMS REMOVAL AND INSTALLATION

1. Disconnect rod end of gas-charged cylinders from the pantograph arms.
2. Loosen jam nut and cap screw locking the horizontal member of the pantograph to the pivot pin.
3. Slide pantograph assembly to the right and remove assembly from the vehicle.
4. To install, perform the removal instructions in reverse.

15.3 DOOR INSTALLATION

1. Use a wooden block to support the pantograph arms horizontally.
2. Support the door and insert each pantograph arm into the pivot pins on the side of the door.
3. Install washer and spring pin to fasten each arm to its pivot pin.
4. Fasten lower arm to the door with flat washer, lock washer and cap screw.
5. Remove wooden block and close baggage compartment door.

Door should be adjusted to leave a gap of 3/16" (5 cm) above the top edge of the door. To adjust, loosen the bolts retaining lock plate support and position the door correctly. Tighten the bolts after the adjustment.
If the baggage door locks to tightly or too loosely, the position of the catch striker is misadjusted. To adjust, loosen the catch striker retaining bolts, position the striker correctly and tighten the retaining bolts.
If the lower part of the baggage door does not close evenly with the side of the vehicle, adjust the lock plates by loosening their retaining bolts and positioning the locking plates correctly (Fig. 42).

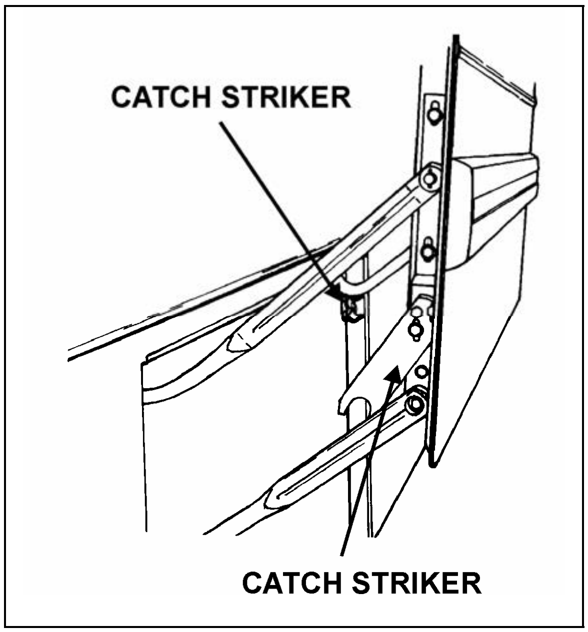


FIGURE 42: BAGGAGE DOOR CATCH STRIKER 18146

16. ENGINE COMPARTMENT DOORS

Engine compartment doors may be adjusted for proper fit by untightening hinge bolts:

1. Loosen the bolts, (1, 2 Fig. 43) holding the hinge to the vehicle structure to shift the door "UP or DOWN".
2. Loosening the bolts (3, Fig. 43) allows the door to be shifted "LEFT or RIGHT" and "IN or OUT".
3. Adjust the doors position depending on the gap needed between exterior finishing panels.
4. Tighten the bolts.
5. Check that the doors swing freely and close properly. It may be necessary to adjust the door latch to get proper fit and operation.

To adjust the latch mechanism (4, Fig. 43) and the striker pin:

1. Open the doors to access the striker pin.
2. Slightly loosen the striker pin.
3. Using a hammer, adjust the striker pin to center it in the door latch mechanism.
4. Tighten the striker pin.
5. Check doors fit and operation.

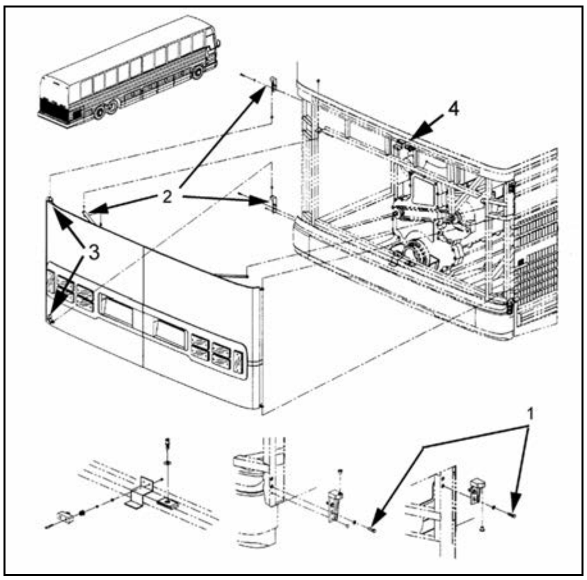


FIGURE 43: ENGINE COMPARTMENT DOORS

17. RADIATOR DOOR ADJUSTMENT

Radiator door may be adjusted for proper fit by untightening hinge bolts:

1. Loosen the bolts, (1, Fig. 44) holding the hinge to the vehicle structure to shift the door "IN or OUT" and "UP or DOWN".
2. Loosening the bolts (2, Fig. 44) allows the door to be shifted "LEFT or RIGHT" and "UP or DOWN".
3. Adjust the door position depending on the gap needed between exterior finishing panels.
4. Tighten the bolts.
5. Check that the door swings freely and closes properly. It may be necessary to adjust the door latch to get proper fit and operation.

To adjust the latch mechanism (3, Fig. 44) and the striker pin:

1. Open the door to access the striker pin.
2. Slightly loosen the striker pin.
3. Using a hammer, adjust the striker pin to center it in the door latch mechanism.
4. Tighten the striker pin.
5. Check door fit and operation.

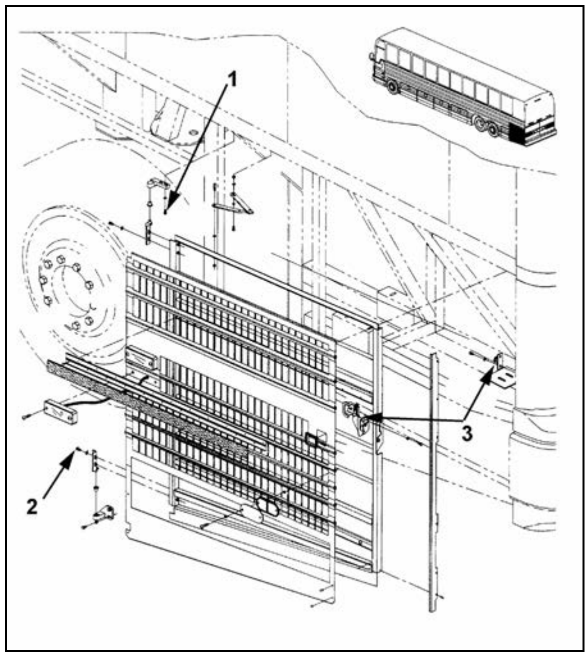


FIGURE 44: RADIATOR DOOR

18. ENGINE COMPARTMENT R. H. SIDE DOOR

Engine compartment R. H. side door may be adjusted for proper fit by untightening hinge bolts:

1. Loosen the bolts, (1, Fig. 45) holding the hinge to the vehicle structure to shift the door "IN or OUT" and "UP or DOWN".
2. Loosening the bolts (2, Fig. 45) allows the door to be shifted "LEFT or RIGHT" and "UP or DOWN".
3. Adjust the door position depending on the gap needed between exterior finishing panels.
4. Tighten the bolts.
5. Check that the door swings freely and closes properly. It may be necessary to adjust the door latch to get proper fit and operation.

To adjust the latch mechanism (3, Fig. 45) and the striker pin:

1. Open the door to access the striker pin.
2. Slightly loosen the striker pin.
3. Using a hammer, adjust the striker pin to center it in the door latch mechanism.
4. Tighten the striker pin.
5. Check door fit and operation.

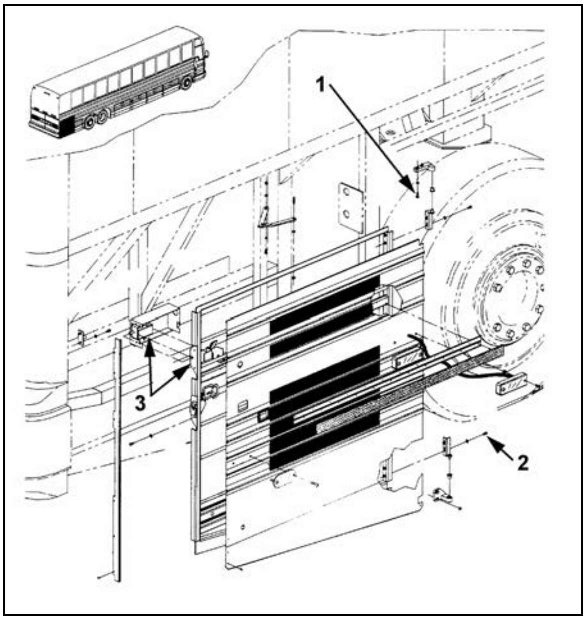


FIGURE 45: ENGINE COMPARTMENT R. H. SIDE DOOR

19. CONDENSER DOOR ADJUSTMENT

1. Open the condenser door.
2. Loosen the screws fixing the hinge to hinge attachment or hinge to door assembly. Loosening the screws allows the condenser door assembly to be shifted "LEFT or RIGHT" and "UP or DOWN" or “IN and OUT”.
3. Adjust condenser door assembly position at the hinge.
4. Tighten the screws.
5. Respect the required gap between exterior finishing panels.
6. Check that the door swings freely and closes properly. It may be necessary to adjust the door latch to get proper fit and operation.

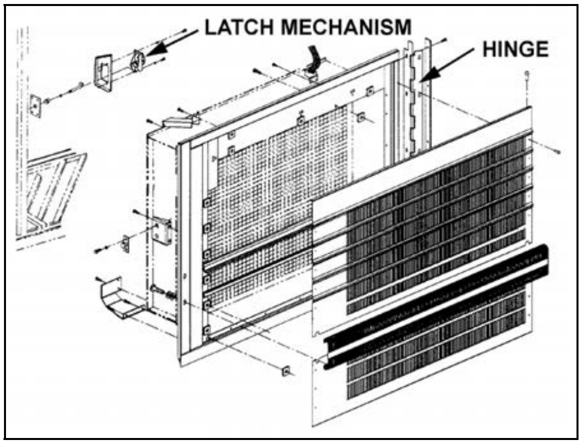


FIGURE 46: CONDENSER DOOR

20. EVAPORATOR DOOR ADJUSTMENT

1. Open the evaporator door.
2. Loosen the screws fixing the hinge to hinge attachment or hinge to door assembly. Loosening the screws allows the evaporator door assembly to be shifted "LEFT or RIGHT" and "UP or DOWN" or “IN and OUT”.
3. Adjust evaporator door assembly position at the hinge.
4. Tighten the screws.
5. Respect the required gap between exterior finishing panels.
6. Check that the door swings freely and closes properly. It may be necessary to adjust the door latch to get proper fit and operation.

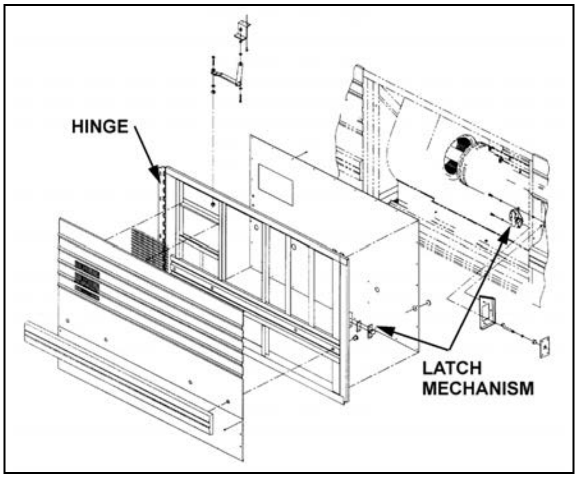


FIGURE 47: EVAPORATOR DOOR

21. FUEL FILLER DOOR

1. Open the fuel filler door.
2. Loosen the screws holding the panel to hinge assembly.
3. Adjust the fuel filler door position according to distance required between exterior finishing parts.
4. Tighten the nuts.
5. Check that the door swings freely and closes properly.

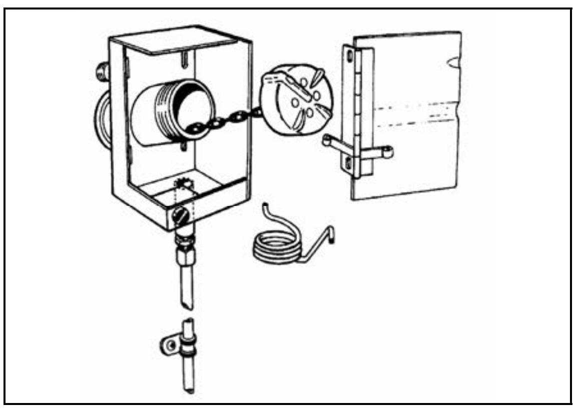


FIGURE 48: FUEL FILLER DOOR

22. FRONT SERVICE COMPARTMENT DOOR

For adjustment of the front service compartment door, refer to paragraph 7 in this section.

23. L.H. SIDE REAR SERVICE COMPARTMENT DOOR

1. Open the L. H. side rear service compartment door.
2. Loosen the screws fixing the hinge to hinge attachment or hinge to door assembly. Loosening the screws allows the L. H. side rear service compartment door assembly to be shifted "LEFT or RIGHT" and "UP or DOWN" or “IN and OUT”.
3. Adjust L. H. side rear service compartment door assembly position at the hinge.
4. Tighten the screws.
5. Respect the required gap between exterior finishing panels.
6. Check that the door swings freely and closes properly. It may be necessary to adjust the door latch to get proper fit and operation.

To adjust the latch mechanism and the striker pin:

1. Open the door to access the striker pin.
2. Loosen slightly the striker pin.
3. Using a hammer, adjust the striker pin to center it in the door latch mechanism.
4. Tighten the striker pin.

Check door fit and operation.

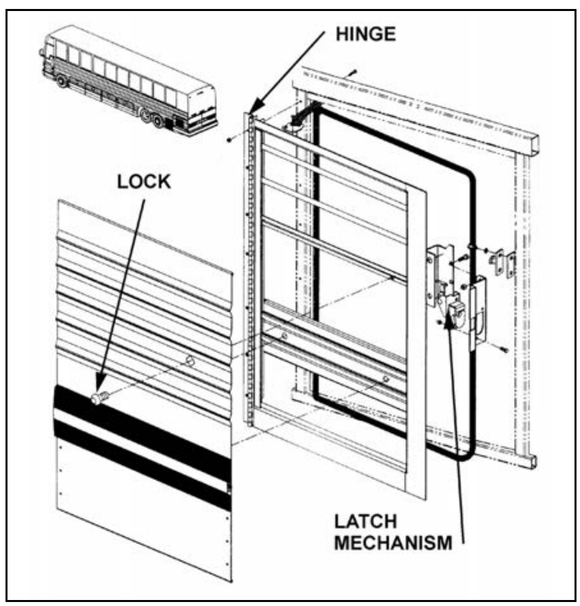


FIGURE 49: L.H. SIDE REAR SERVICE COMPARTMENT DOOR

24. R.H. SIDE REAR SERVICE COMPARTMENT OR MAIN POWER COMPARTMENT DOOR

To adjust the R. H. side rear service compartment (MTH) or main power compartment (Coaches) door:

1. Open the compartment door.
2. Loosen the screws fixing the hinge to hinge attachment or hinge to door assembly. Loosening the screws allows the compartment door assembly to be shifted "LEFT or RIGHT" and "UP or DOWN" or “IN and OUT”.
3. Adjust compartment door assembly position at the hinge.
4. Tighten the screws.
5. Respect the required gap between exterior finishing panels.
6. Check that the door swings freely and closes properly. It may be necessary to adjust the door latch to get proper fit and operation.

To adjust the latch mechanism and the striker pin:

1. Open the door to access the striker pin.
2. Loosen slighly the striker pin.
3. Using a hammer, adjust the striker pin to center it in the door latch mechanism.
4. Tighten the striker pin.

Check door fit and operation.

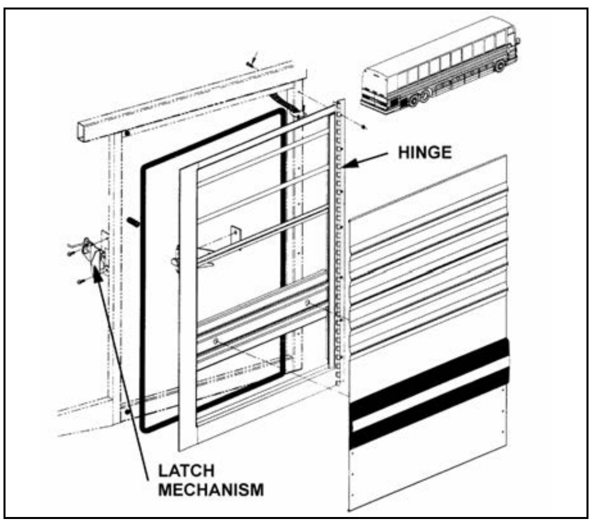


FIGURE 50: R.H. SIDE REAR SERVICE COMPARTMENT OR MAIN POWER COMPARTMENT DOOR

25. FENDERS

On the "XL2" series vehicle, rear fenders are hinged for maintenance on brakes and suspension. Each rear fender panel has two mechanical spring loaded holding devices fixing it to the vehicle’s structure. Push the spring type rod sideways to disengage the lock.
Front rubber fender may be removed using the following procedure:
Remove the nuts on the inside of the fender. Remove the fender from the vehicle. To reinstall, reverse the procedure.

26. REAR CAP

The fiberglass rear cap does not need any maintenance except painting as needed. It is held in place with adhesive. If ever it has to be replaced, make an appointment at a Prévost service center near you. For minor damages, refer to section 4 "Fiberglass Repair" and section 5 "Painting".

27. FRONT CAP

The fiberglass front cap does not need any maintenance except painting as needed. It is held in place with adhesive. If ever it has to be replaced, make an appointment at a Prévost service center near you. For minor damages, refer to section 4 "Fiberglass Repair" and section 5 "Painting".

28. XL2 SMOOTH SIDE PANEL REPLACEMENT PROCEDURE

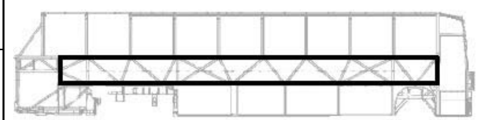
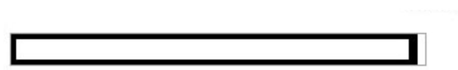
Material :

Anti-silicone (682989)	√	Scotchbrite gray (680226)	√	Sika 221 gray	√
CHIX cloth (682384)	√	Sika 205 1liter (683097)	√	Sika 252 black	√
Blue cloth (682383)	√				

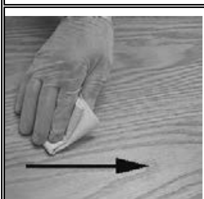
Equipment :

Glue gun	√	
Pencil	√	

SECTION 1 SMOOTH SIDE PANEL REMOVAL			
1.00	**REMOVAL**		
	A)	Remove finishing molding. Insert a screwdriver into snap-on finishing molding joint. Bend finishing molding enough to be able to fix a pair of locking pliers. Using the pair of locking pliers, pull the stainless steel molding and at the same time gradually cut Sika bead with a sharp knife.	Be careful not to damage the adjacent surfaces.
	B)	Using a hammer and punch, drive out rivet shanks from top and bottom and from front and rear finishing molding supports. Use a #11 titanium drill bit to remove rivet heads.	
	C)	Grind tig weld spots at each end of side panel.	
	D)	Safely support or temporary fix side panel.	**Warning: Panel weights over 200 pounds**
	E)	Insert a flat screwdriver between the side panel and the vehicle chassis, in the top left and right corners. Make sure to separate side panel from structure.	Be careful not to damage the adjacent surfaces.
	F)	Use the c-clamp to separate the side panel from the back structural panel and at the same time gradually cut Sika bead with a sharp knife.	Ideally, the hoist or chain block must be fastened to the floor while pulling from a 45^{o} angle so as not to damage the vehicle structure
	G)	Remove as much glue as possible from the structure using a putty knife or pneumatic knife without damaging 206 G+P primer.	Never heat SikaFlex adhesive to remove.
	H)	Check panel horizontal supports for straightness using a straight edge. Take measurements with a ruler.	Tolerance : 1mm towards the outside and 1.5mm towards the inside.

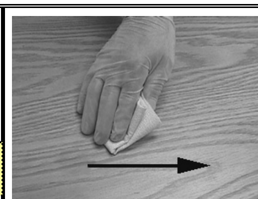
SECTION 2 PREPARATION OF SURFACES			
2.00		**VEHICLE SURFACE PREPARATION**	
	A)	Clean using "anti-silicone" until all clothes come clean. See PR000001 section A.	
	B)	Use the belt sander (grit coarse) Use a new paper on each vehicle side.	
	C)	Clean using " anti-silicone " until all clothes come clean. See PR000001 section A.	
	D)	Apply – Sika 205 See PR000001 section B.	
2.05		**SIDE PANEL PREPARATION**	
	A)	Clean using “ anti-silicone ” until all clothes come clean. See PR000001 section A.	
	B)	Use the belt sander (grit coarse) Use a new paper on each vehicle side panel.	
	C)	Clean using “ anti-silicone ” until all clothes come clean. See PR000001 section A.	
	D)	Apply – Sika 205 See PR000001 section B.	

PR000001 Section A Alcohol or Anti-silicone



1. **Apply**

CHIX cloth



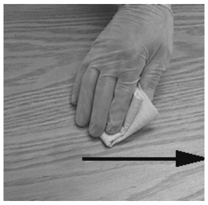
2. **Dry immediately**

Blue cloth

3. **Allow to dry**

Mandatory	**Minimum time : Wait for product to evaporate**
	After 2 hours: Start cleaning operation again
Before applying any other product	If surface seems dusty, greasy or with finger marks, start cleaning operation again.

Section B   Sika 205

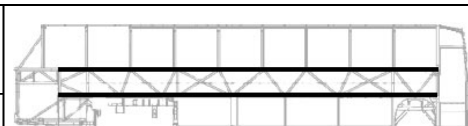
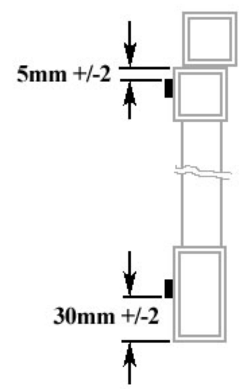
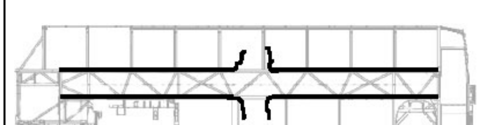


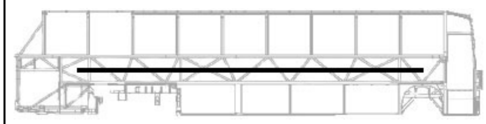
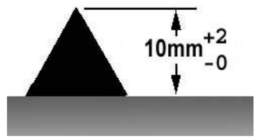
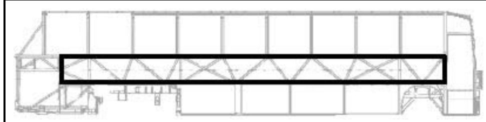
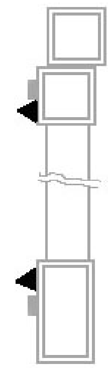
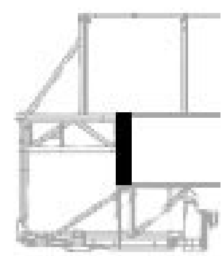
1. Apply

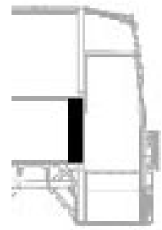
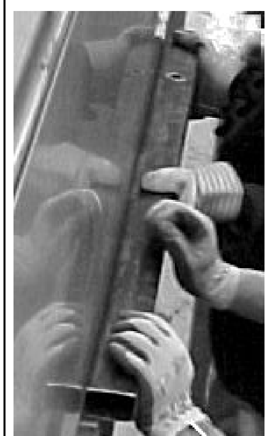
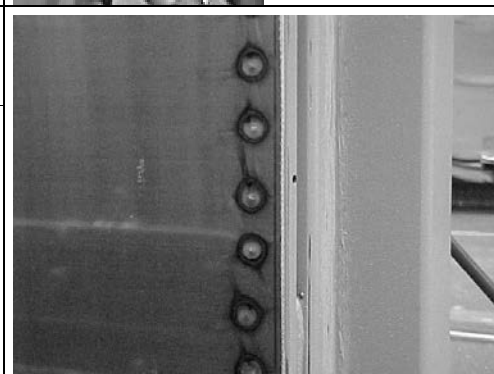
CHIX cloth

2. Allow to dry

Manda-tory	**Minimum time**	**- For a smooth surface (aluminum, stainless, steel, fiber glass (gelcoat side), etc.):**	**2 minutes**
		- Pour a porous surface (fiber glass (non gelcoat side), etc.)	**10 minutes**
	After 2 hours : Reactivate surface with Sika 205		
Before applying any other product	If surface seems dusty, greasy or with finger marks, start operation again.		

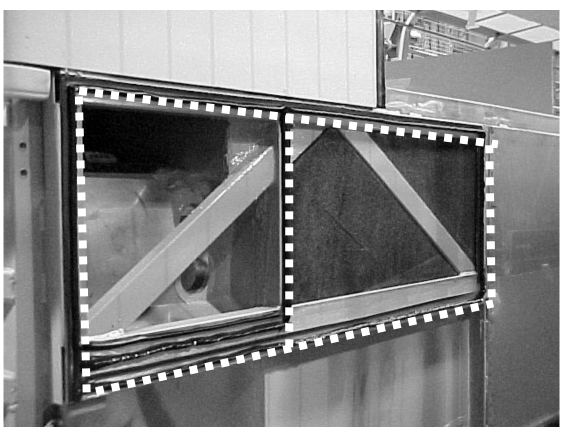
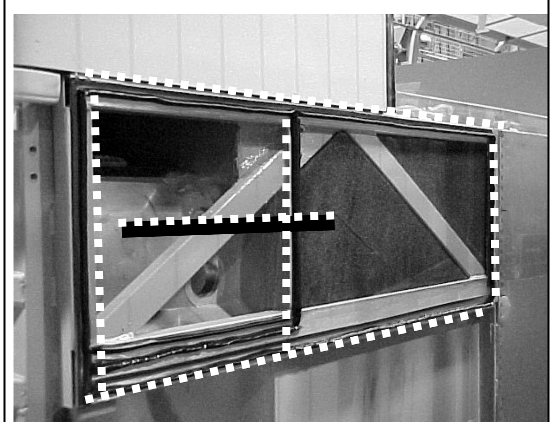
SECTION 3 SIDE PANEL INSTALLATION			
3.00	A)	Using a pencil, mark the double-face self adhesive tape position onto vehicle side.	
	B)	Apply double-face tape as per marking.	
	C)	Compress tape	
	D)	Remove protective film from double-face self adhesive tape center section.	

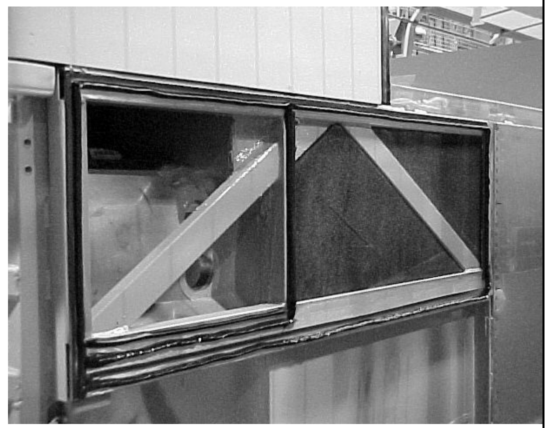
3.05		Install foam tape onto middle reinforcement then compress.	
3.10		Apply Sika 252  – Onto vehicle surface – Cut nozzle as per template – Use the guide for the application Bead must be continuous for the whole perimeter.	 
3.15	A)	Install side panel onto support jig.	
	B)	Position side panel in front of vehicle structure	
	C)	Perform final adjustment to make sure that side panel is true and square	– 30 mm. ± 2 with reference to bottom tubing – Side panel lined up with longitudinal "flat bar"
	D)	Sand rear of side panel 2" wide	
	E)	Perform tig spot welding	Quantity of "tig spot": 29 minimum.
3.20	A)	Install pulling equipment at the other end of side panel	
	B)	Make a final adjustment in height	

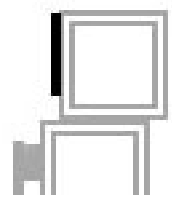
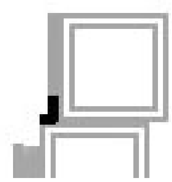
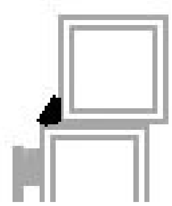
	C)	Sand front of side panel 2" wide	
	D)	Pull side panel so that panel moves 1/8”	Make sure the equipment pulls along the whole width of side panel
	E)	Perform tig spot welding	Quantity of "tig spot": 29 minimum.
3.30	Remove pulling equipment		
3.40	A)	Remove protective film from double-face self adhesive tape.	
	B)	Compress top and bottom section of side panel	
3.50	A)	Cut excess of side panel. Make sure that cut is parallel with tubing.	
	B)	Grind side panel end to line up with door tubing.	
3.60	To seal each panel end, apply masking tape on each side of side panel joint. Use a caulking nozzle and grey Sikaflex 221 adhesive to fill the cavity between the panel and vehicle structure. Clean using Sika 205. Allow 5 minutes minimum for drying. Wear surgical gloves and smooth down the joint with your finger.		

SECTION 4 ENGINE AIR INTAKE PANEL INSTALLATION

4.00	Make sure that sealing of structure has been performed properly	
4.05	Prepare vehicle surface as for side panel.	Refer to step # 2.00
4.10	Prepare air intake panel as for side panel	Refer to step # 2.05

4.15	Install foam tape 1/8" X ¼" onto structure, as shown in picture Coach 	MTH 
4.20	Install foam tape 1/16" X ¼ onto air intake panel top and bottom pleat	
4.25	Apply a bead of 252 onto structure as per picture Important: Make sure bead is continuous Triangular bead: 10mm x 8mm	

	Coach	MTH
		
4.30	Install panel onto structure	Use a jig to make sure that panel is lined up with engine door tubing.
4.40	Use a brush to compress Sika bead	

5.00 *	**Finition Joint**		
	A)	Install a protective tape onto the tubing above welding	
	B)	Apply Sika 205 Use a plastic spatula inside a Chix cloth to ensure that Sika 205 reaches as far as the corner. See PR000001 section B.	
	C)	Apply Sika 252 black at the junction of both tubing. Smooth down the joint	
	D)	Remove protective tape	

29. REAR VIEW MIRRORS (RAMCO)

Your vehicle is equipped with two exterior mirrors.
The mirrors may be equipped with an optional electric heating system which serves to minimize ice and condensation on the mirror glass in extreme weather conditions. Integral thermostats are installed in both mirrors to avoid continuous heating. Use the appropriate switch on the dashboard to activate the defroster system on both mirrors simultaneously. The mirrors can easily be adjusted by using the remote controls located on the L.H. side control panel. The mirrors have easy to replace glass in case of breakage. Remote control motors can also be replaced.

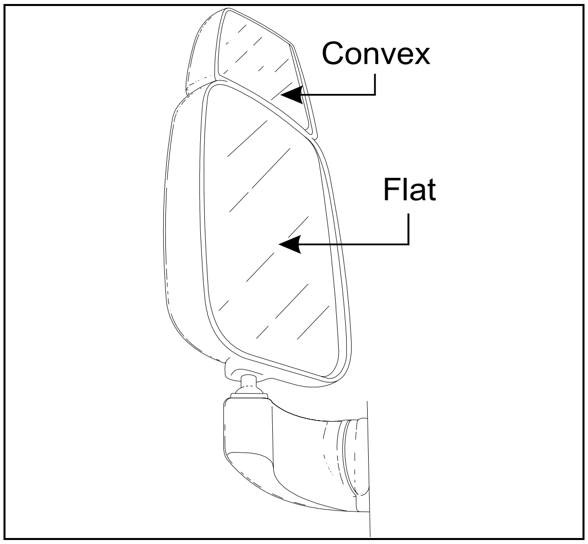


FIGURE 51: REAR VIEW MIRROR (RAMCO) 18398A

29.1 ADJUSTMENT

At the base of the mirror arm, loosen the mounting bolt to swing arm in or out.
To pivot the mirror head, loosen the setscrews on each side of the ball stub at the base of the mirror head to facilitate the adjustment.

29.2 DISASSEMBLY

At end of mirror arm, loosen the setscrews to relieve tension on the ball stem. Remove the ball stem from the arm.
Remove the four screws fastening the mirror arm base to the coach.

29.3 ASSEMBLY

Mount the mirror arm base to the coach.
Insert the ball stem into the mirror arm and tighten the socket setscrews.

Note: *Position the ball cup halves so the joint between them lies on the centerline of the arm. Ensure that the setscrews are not on the joint between the cup halves.*

29.4 REPLACEMENT OF MIRROR GLASS

Remove the broken glass.
Position new glass in mirror head and press to lock the Velcro in place.

29.5 HEATED / REMOTE CONTROLLED REAR VIEW MIRRORS

Heated/remote controlled external rear view mirrors may be provided to prevent the mirrors from frosting up in cold weather.
The remote controlled external rear view mirrors attach to support arms using a pivot collar secured by setscrews. Loosening the setscrews allows the whole head assembly to turn on the support arm for initial adjustment. A mounting bolt and washer hold the arm support to the mounting bracket. The arm support can be moved to position the mirror head into or away from the coach body.
The mirror heat switch is located to the left of the driver on the dashboard. This switch must be activated before the mirror heating element will energize. Once energized, the mirror heating element is kept at a sustained temperature (between 60-80°F) by a thermostat. Refer to wiring diagram annexed in the technical publication box.

Caution: *Do not attach stick-on type convex mirror accessories to the heated mirror glass. This could impede uniform heat distribution on the mirror surface which could break the mirror.*

29.5.1 Mirror Control

The remote control pointer knob(s) for the mirrors is (are) mounted on the L.H. side control panel. The harness to the mirror head runs through the arm support. The remote motor is mounted to the mirror head behind the mirror glass.
Turn pointer knob to the left for mirror head adjustments and to the right for convex mirror adjustment, then push down on either of the button’s (4) sides to adjust the selected mirror viewing angle.

29.5.2 Disassembly

At end of mirror arm, loosen the setscrews to relieve tension on the ball stud. Remove the ball stud. Remove the ball stud from the arm and gently pull the harness out until the connector is exposed.

Remove the four screws fastening the mirror arm base to the coach. Slide the harness free of the mirror arm base.

29.5.3 Assembly

Attach a stiff wire (snake) to the end of the harness and insert the wire through the mirror arm base and arm, gently pull the harness through the arm and disconnect the "snake".

Connect the mirror head harness. Insert the harness connector back into the mirror arm.

Insert the ball stud into the mirror arm and tighten the socket setscrews.

Note: *Position the ball cup halves so the joint between them lies on the centerline of the arm. Ensure that the setscrews are not on the joint between the cup halves.*

29.5.4 Convex & Flat Mirror Removal

The mirror glass assembly is mounted to the control mechanism or to mirror base with Velcro strips. Remove the mirror glass by gently pulling the lens to release the Velcro. Disconnect the heater grid at the two connectors.

Connect the connectors of the new mirror's grid to the harness. Install the lens by positioning the lens in the mirror frame and pressing to lock the Velcro in place.

30. VEHICLE JACKING POINTS

The vehicle can be lifted by applying pressure under body jacking points or front and drive axle jacking points. When it is necessary to lift the vehicle, care should be taken to ensure that the pressure is applied only on the specified areas. Equipment for lifting the front of the vehicle must have a combined lifting capacity of at least 20,000 lb. (9 100 kg). Equipment for lifting the rear of the vehicle must have a combined lifting capacity of at least 40,000 lb. (18 200 kg).

Warning: *DO NOT tow or jack vehicle with people on board.*

Warning: *When it is necessary to raise the vehicle, care should be taken to ensure that pressure is applied only at the points indicated in figures 52, 53, 54, 55 and 56.*

Warning: *Extra lift capacity may be required if luggage or any other type of load (e.g. conversion equipment) are onboard the vehicle.*

Caution: *The suspension of the vehicle must be in the normal ride position before jacking. The "Level Low" system on a motorcoach must be in the "DRIVE" position prior to turning the ignition key "OFF".*

Twelve jacking points are located on the vehicle: three are located on each side of the frame and two are located under each axle. Refer to the following illustrations for the location of jacking points.

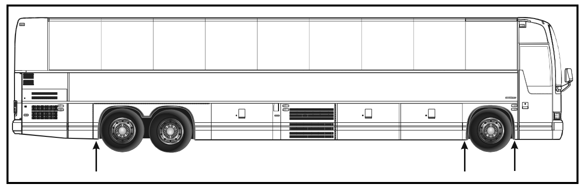


FIGURE 52: JACKING POINTS ON FRAME 11020

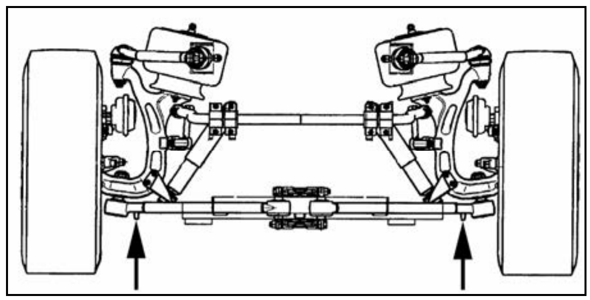


FIGURE 53: JACKING POINTS ON IND. SUSPENSION 16095

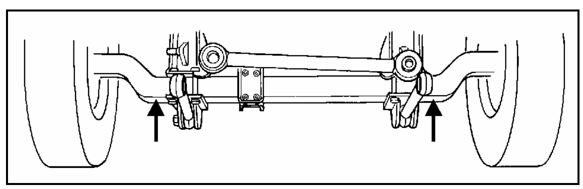


FIGURE 54: JACKING POINTS ON FRONT AXLE 18084

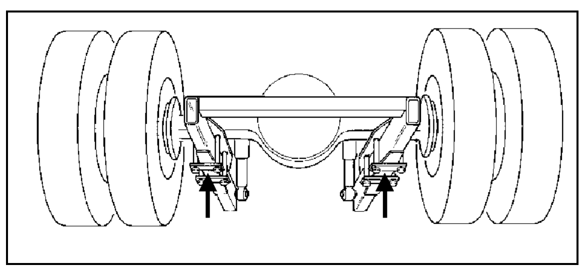


FIGURE 55: JACKING POINTS ON DRIVE AXLE OEH3B762

Warning: *Always unload or retract the tag axle before jacking the vehicle from the front and drive axle jacking points to prevent damage to suspension components.*

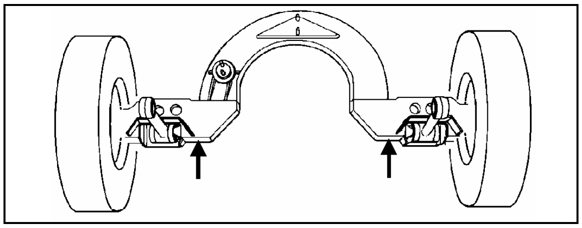


FIGURE 56: JACKING POINTS ON TAG AXLE OEH3B764

Warning: *The jacking points on the tag axle must be used for raising the tag axle only.*

Several kinds of hydraulic jacks can be used. Only jack at the specified jacking points. Jack must support the following capacities:

Front axle: 20,000 lb. (9 100 kg);

Drive axle: 40,000 lb. (18 200 kg).

30.1 HYDRAULIC JACK

To raise: turn release valve clockwise. Insert handle in socket and raise by pumping.

To lower: remove handle and turn the release valve slowly counterclockwise.

Always keep ram and extension screw retracted when jack is not in use.

Service: Check oil level when jack fails to raise to full height. Lower ram completely with release valve open and jack in upright position, remove filler plug and refill to level of filler hole with hydraulic jack oil. Never use brake fluid.

Warning: *Jack is intended for lifting only. Do not get under the vehicle or load for any reason unless it is properly supported with safety stands and securely blocked.*

Warning: *Do not overload jack above rated capacity. Prevent "side loading", make sure load is centered on ram. Do not push or tilt load off jack.*

31. TOWING THE VEHICLE

The vehicle can be transported on a low bed semi-trailer of adequate gross axle weight capacity. When transporting a vehicle, apply parking brake and shut down the engine. Block all wheels and secure vehicle with tie-downs. Check that overall height will clear obstacles on the route to follow, and obtain required permits.
The vehicle can also be towed by lifting the front axle or by towing from the front with all wheels on the ground. These two methods are described below under their respective headings. Whatever the method used, the vehicle should be towed by truck operators authorized and experienced in towing highway coaches.
Observe normal precautions including, but not limited to, the ones listed below when towing the vehicle:

- Make sure the parking brake is released before towing.
- Do not allow passengers to ride onboard the towed vehicle.
- Tow the vehicle at a safe speed as dictated by road and weather conditions.
- Accelerate and decelerate slowly and cautiously.

To prevent damage to the vehicle, use the two tow eyes located under the back bumper and/or fixed to the vehicle's frame between the front axle and the front bumper. Use only a solid link tow bar and a safety chain to tow the vehicle. If required, connect an auxiliary air supply to the vehicle so brakes can be operated while towing.

Warning: *During a towing operation, the driver should be alone inside the vehicle.*

Caution: *To prevent damage to the drive train components, disconnect axle shafts or driveshaft before towing. Do not attempt to push or pull-start a vehicle equipped with an automatic transmission.*

Note: *Make sure axle shafts or driveshaft are installed correctly after towing. Tighten axle shaft and driveshaft nuts to the correct torque settings. Do not invert shafts.*

31.1 LIFTING AND TOWING

The towed vehicle must be lifted from under the front axle only. The tow truck must be equipped with the proper lifting equipment to reach under the front axle since no other lifting points are recommended. Lifting and towing from any other point are unauthorized as it may cause serious damage to the structure. Do not unload or raise the tag axle when lifting and towing to prevent overloading the drive axle.

1. Remove both drive axle shafts to prevent damage to the transmission. Plug axle tube to prevent oil loss. Refer to Rockwell's *"Maintenance manual no.5"* annexed at the

end of Section 11, Rear axle, in this manual for correct procedure.

Caution: *Transmission lubrication is inadequate when towing. With either automatic or semi-automatic transmission, the drive axle shafts must be removed to avoid serious damage to the transmission.*

2. Operate the engine when towing to maintain brake system air pressure. If the engine cannot be operated, connect an external air pressure line from the tow truck to the emergency fill valve in the engine compartment.
3. The emergency fill valve in the front service compartment does not supply air pressure to the brake system. The air pressure must be a minimum of 75 psi (520 kPa), and the line should be attached to the air line with a clip-on chuck.

Caution: *Do not tow the vehicle without external air pressure applied to the emergency fill valve if the engine does not operate. Without brake system air pressure, the brakes may apply automatically if system air drops below 40 psi (275 kPa). If failure prevents releasing the parking brakes with air pressure, disengage the parking brakes mechanically.*

4. Lift the vehicle from under the front axle, and adequately secure the underside to the tow vehicle lifting attachment with chains.
5. Observe safety precautions when towing.

31.2 TOWING WITHOUT LIFTING

Caution: *When towing vehicle without lifting, use only a tow truck with a solid link tow bar and related equipment. All other means of towing are unauthorized. Tow only from the front of the vehicle.*

1. Remove both drive axle shafts to prevent damage to the transmission. Plug axle tube to prevent oil loss. Refer to Rockwell's *"Maintenance manual no.5"* annexed at the end of Section 11, Rear axle, in this manual for correct procedure.

Caution: *Transmission lubrication is inadequate when towing. With either automatic, semi-automatic or manual transmission, the drive axle shafts must be removed to avoid serious damage to the transmission.*

2. Operate the engine when towing to maintain brake system air pressure. If the engine cannot be operated, connect an external air pressure line from the tow truck to the emergency fill valve in the engine compartment. The emergency fill valve in the front service compartment does not supply air pressure to the brake system. The air pressure must be a minimum of 75 psi (520 kPa), and the line should be attached to the air line with a clip-on chuck.

Caution: *Do not tow the vehicle without external air pressure applied to the emergency fill valve if the engine does not operate. Without brake system air pressure, the brakes may apply automatically if system air drops below 40 psi (275 kPa). If failure prevents releasing the parking brakes with air pressure, disengage the parking brakes mechanically.*

3. Position the tow truck so that the tow bar contacts the front bumper of the vehicle.
4. Attach the tow truck chains only in the tow eyes of the vehicle under the bumper and take up all the slack.
5. Attach safety chains as applicable.
6. Observe safety precautions when towing.

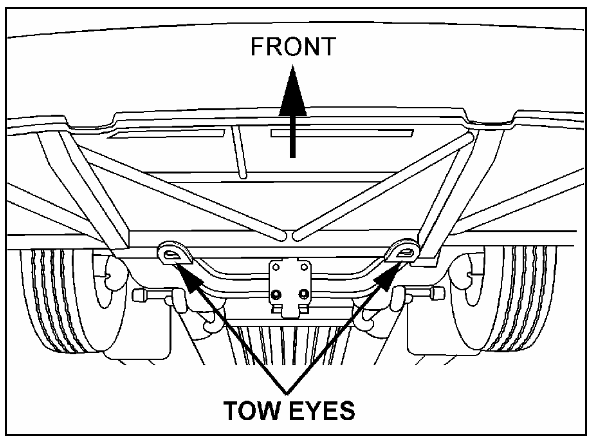


FIGURE 57: TOW EYES

32. SPECIFICATIONS

Door cylinder
Manufacturer .... Bimba
Type .... Pneumatic
I.D. .... 1½" (mm)
Stroke .... 8" (mm)
Prévost number 780595

Damper
Manufacturer .... Koni
Prévost number 780565

Lock cylinder (upper)
Manufacturer .... Bimba
Type .... Air, single action, 1/8 NPT, hexagonal rod
I.D. .... 7/8" (22 mm)
Stroke .... 1" (25 mm)
Supplier number D-51127-A
Prévost number 641392

Lock cylinder (central)
Manufacturer .... Bimba
Type .... Air, single action, ¼ NPT
I.D. .... 1¾" (45 mm)
Stroke .... 1" (25 mm)
Supplier number 241-P
Prévost number 641209

Manifold solenoid
Manufacturer .... Norgren
Type .... 4 ports, 1/8 NPT
Voltage .... 24 VDC
Power consumption .... 6 watts
Maximum pressure .... 150 psi (1035 kPa)
Prévost number 641448

Solenoid valve (Latching valve)
Manufacturer .... Humphrey
Model 310
Operating range .... 0 to 125 psi (0 to 860 kPa)
Voltage .... 24 VDC
Voltage tolerance .... +10%, -15% of rated voltage
Power consumption .... 4 watts
Leak rate (max allowed) .... 0.245 in3/min @ 100 psi (4cc/min @ 690 kPa)
Type of operation .... Direct solenoid
Lubrication .... Not required (factory pre-lubed)
Filtration .... 40 micron recommended
Prévost number 641412

Pressure switch assembly
Prévost number 452831

SECTION 22: HEATING AND AIR CONDITIONING

CONTENTS

ILLUSTRATIONS

1. HEATING AND AIR CONDITIONING

The coach's interior is pressurized by its Heating, Ventilation, Air Conditioning (HVAC) units. Air flow and controls divide the vehicle in two sections: driver's and Central (passenger) sections. Vehicles equipped with a Central System are provided with a special air duct which allows a variable percentage of outside fresh air to be drawn into the vehicle and then mixed with recirculated air.

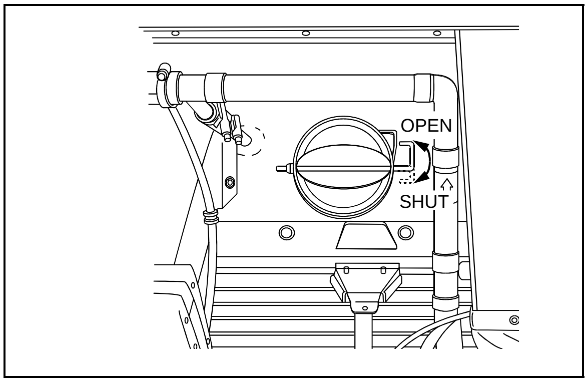


FIGURE 1: ADJUSTABLE AIR DUCT 22175

The adjustable air intake damper is located in the evaporator compartment (see *"18. BODY"* for compartment location). The damper should normally be left open. However, under extreme temperature conditions, it can be closed to block the addition of ambient air and heat or cool the air inside vehicle as desired. As soon as extreme heating or cooling is no longer required, the damper should be reopened. The interior of vehicle should always be slightly pressurized to prevent dust and moisture from entering vehicle. The HVAC systems have been designed to allow circulation of some outside fresh air, so windows should be kept closed at all times. In the event of ventilation failure, emergency escape hatch(es) (see *"18. BODY"*) can be used to provide air circulation, by simply pushing hatch upwards.

Note: *Auxiliary A/C system (if so equipped) operates independently from main system, it has its own condenser, evaporator and compressor.*

Note: *Driver's HVAC system operates independently from main system, even though it uses the same compressor.*

Note: *Vehicles equipped with a TM-16HD Seltec compressor (driver's or auxiliary A/C) have a time delay relay installed on the electrical circuit with a reaction time of 48 seconds before magnetic clutch is engaged.*

2. AIR CIRCULATION

2.1 DRIVER'S AREA

Fresh air is taken from a plenum behind the front bumper and enters the mixing box through an adjustable damper. Returning air is taken through a front dash panel into the mixing box. The "Driver A/C-Heating Recirc.-Fresh Air" control is located on the R.H. dashboard control panel. Mixed air goes through cooling and heating coils, fans and discharge ducts.

Both right and left discharge ducts defrost one half of the windshield. The driver can also, with the "Main Windshield Defroster" control divert some air flow to the console, from which he can direct vent to his knees and/or upper body with adjustable HVAC register and to his feet with the appropriate button (see operator's manual).

Two additional air outlets are installed on vehicles equipped with the Central HVAC ducting system. One is located in the stepwell for snow melting. The other air outlet is located behind the driver, on his L.H. side. This air outlet can be rotated to direct Air flow.

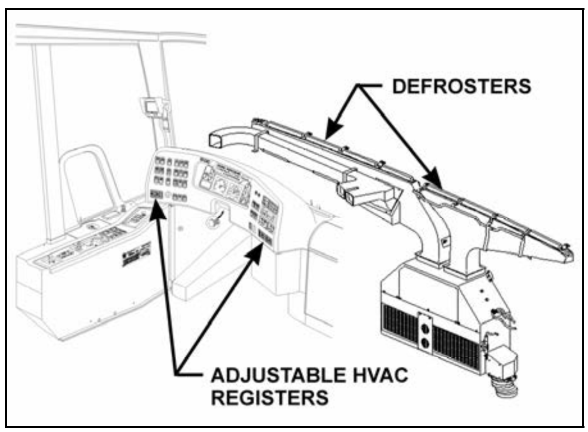


FIGURE 2: DRIVER'S AIR CIRCULATION 22171

2.2 CENTRAL AREA (Passenger/Cabin)

Fresh air enters the vehicle on the L.H. side, through the manually adjustable damper (Fig. 1) located in evaporator compartment. The damper can be fully opened for normal operation or closed for extreme weather or highly polluted areas (Refer to the XL2 Operator's Manual for more details). Return air is drawn from inside the vehicle through the register duct (Fig. 3).

A double blower fan unit, which is activated by the evaporator motor, draws mixed air through an air filter, cooling and heating coils, then forces this air in the ventilation ducts along the walls, and finally exhausts it just below side windows.

XL2 coaches are also equipped with a parcel rack ventilation system, a three-position rocker switch

(0FF - 1st speed - 2nd speed) located on R.H. dashboard panel controls the speed of both fans. Return air is drawn just below the middle side windows through an air filter into the parcel rack fan; discharge air is fed to the rotating registers through the ventilation duct.

The parcel rack registers are used to control air flow for the passenger seats. One register per seat direct air flow by pointing or rotating register. Open or close register to adjust air flow.

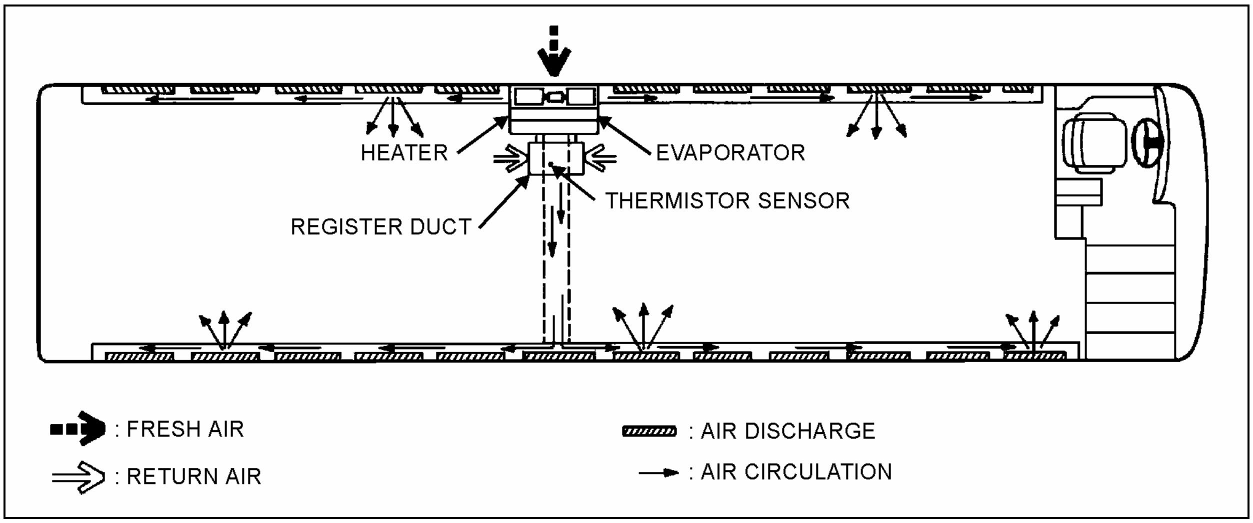


FIGURE 3: CENTRAL HVAC SYSTEM AIR CIRCULATION 22063

3. DRIVER'S HVAC SYSTEM OPERATION

The temperature control in the driver's area is provided directly by the HVAC control unit mounted on the dashboard R.H. panel (Fig. 4 and 5).

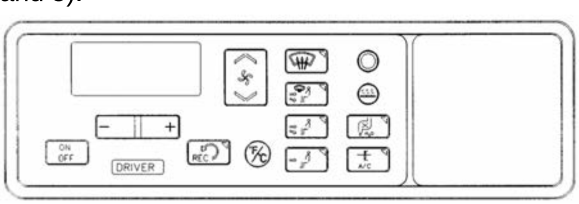


FIGURE 4: DRIVER'S HVAC SYSTEM CONTROL UNIT 22184

Note: *The driver's area air temperature sensor is located behind the grill of the R.H. side console or inside the footwell, at the ceiling at the right of the steering column (Refer to fig.12).*

3.1 VEHICLES EQUIPPED WITH A TM-16HD SELTEC COMPRESSOR

This system is completely independent, it has its own condenser, evaporator and compressor.

3.2 VEHICLES EQUIPPED WITH A CENTRAL SYSTEM

The driver's HVAC unit piping is paralleled with the main HVAC unit piping. Both units use the same refrigerant and coolant, and are linked to the same condenser and compressor, even if they are individually controlled. It requires the main HVAC unit to engage the A/C compressor magnetic clutch. Consequently, the driver's unit cannot be operated in the A/C mode alone.

4. CENTRAL HVAC SYSTEM OPERATION

The HVAC control unit located on the dashboard R.H. panel, enables the selection of the temperature in the passenger area (or the living space for a converted vehicle) (refer to the Operator's Manual for details).

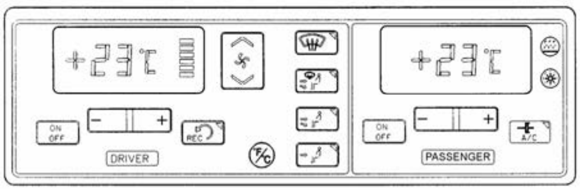


FIGURE 5: CENTRAL HVAC SYSTEM CONTROL UNIT 22184

Temperature control is provided in conjunction with a thermistor sensor inside register duct, located amidships on L.H. side of vehicle (Figs. 3 & 6).

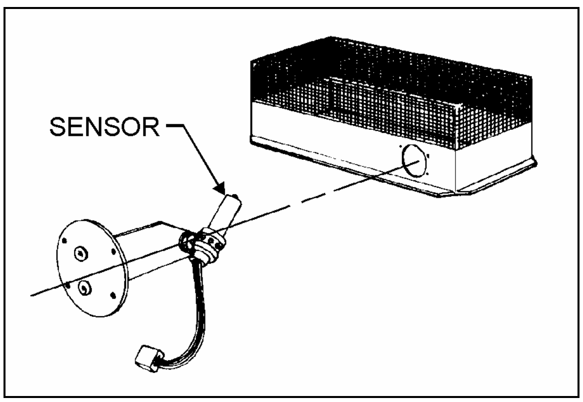


FIGURE 6: THERMISTOR SENSOR 22064

The flow of water to the vehicle's main heater core is controlled by an electric water valve which is open or closed depending on selected temperature. A red LED, located on HVAC control unit, illuminates when heating mode is selected. A green LED illuminates when compressor clutch is in operation.

The evaporator fan motor, located in evaporator compartment, is protected by a 120 amps, manually resettable circuit breaker. The condenser fans, located in the condenser compartment, also have circuit protection via 40 amps manually resettable circuit breakers. The breakers are located in the A/C junction box in the evaporator compartment.

Note: *The outside temperature sensor is located behind the front bumper on the L.H. side.*

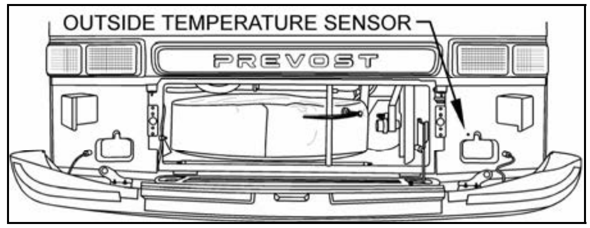


FIGURE 7: LOCATION OF OUTSIDE TEMPERATURE SENSOR 22195

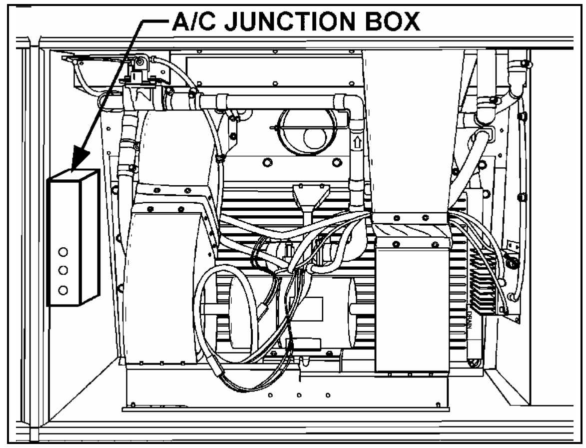


FIGURE 8: LOCATION OF A/C JUNCTION BOX IN EVAPORATOR COMPARTMENT 06414

To operate A/C system when vehicle is stationary, run engine at fast idle. During operation of A/C system, windows should be kept closed and door(s) not left open longer than necessary. In order to prevent battery discharge, A/C & heating system will not operate when charging system is malfunctioning.

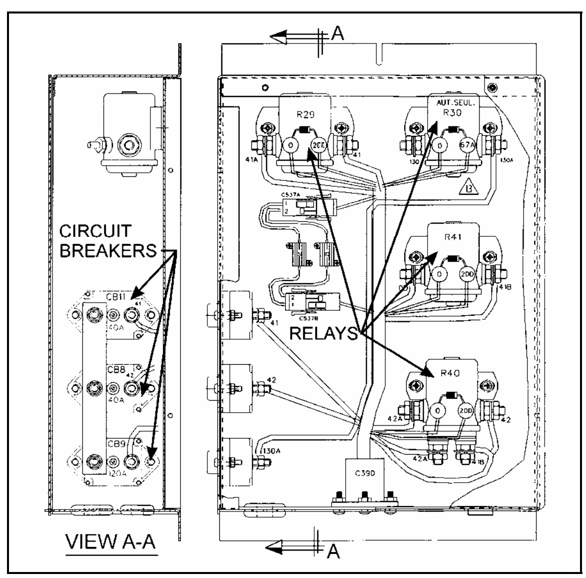


FIGURE 9: A/C JUNCTION BOX 06317

4.1 PARCEL RACK A/C (XL2 COACHES)

Optional small A/C evaporator coils may be added to both parcel racks existing air system. These auxiliary A/C system components are separate and completely independent of driver's and central systems and permits a wider temperature range in the passenger's area. The three-position rocker switch used to control the fans, also controls the A/C system.

5. HVAC UNIT MAINTENANCE

No special maintenance is required on the central, driver's and auxiliary HVAC units, with the exception of cleaning their respective coils and air filters, plus periodic inspection for broken drains, hoses and charging of system.

5.1 COIL CLEANING

Note: *Squeeze rubber hose located underneath the appropriate compartment to eliminate the accumulated water and dirt when you make routine maintenance.*

Check the external surface of the coil at regular intervals for dirt or any foreign matter.
For the driver's HVAC unit, flush the coil from inside. For the evaporator, back flush the coil (Fig. 10) every 12,500 miles (20 000 km) or once a year, whichever comes first.

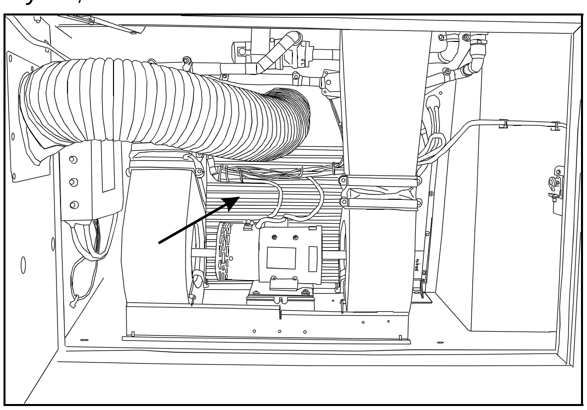


FIGURE 10: EVAPORATOR COIL CLEANING 22244

For the condenser coil, back flush the coil (Fig. 11) every 6,250 miles (10 000 km) or twice a year, whichever comes first.

Caution: *Use a water jet or water mixed with low air pressure to clean the coil.*

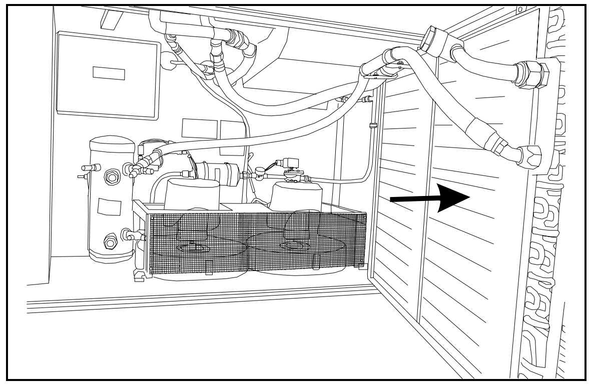


FIGURE 11: CONDENSER COIL CLEANING 22243A

Caution: *Direct the pressure straight through the coil to prevent bending of fins and do not use extremely high pressure. Do not use hot water, steam or caustic soap.*

5.2 DRIVER'S HVAC UNIT AIR FILTER

The driver HVAC system is located behind the dashboard's R.H. side lateral plastic panel. To gain access to the A/C filters, unscrew the R.H. lateral console's grill located at the top step of the entrance door steps. Slide out the R/A and F/A filters. To clean filters back flush with water, then dry with air, every 12,000 miles (20 000 km) or once a year, which-ever comes first (Fig. 12).

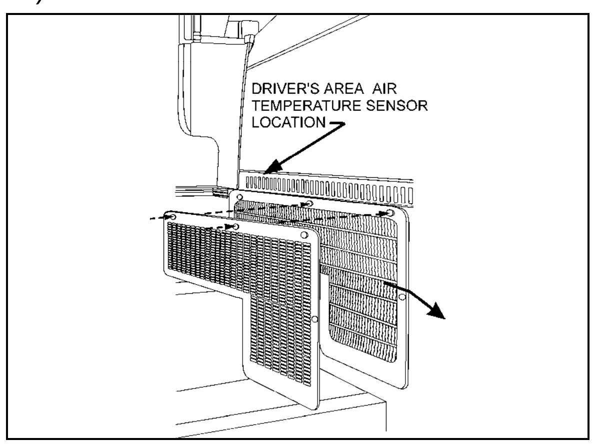


FIGURE 12: DRIVER'S AREA AIR FILTERS 22193

5.3 MAIN HVAC UNIT AIR FILTER

The main or cabin air filter is located in the evaporator compartment. To access the filter on XL2 coaches, open baggage compartment door located in front of the evaporator compartment (L.H. side). Open access panel by turning the three screws of panel ¼ of a turn, unsnap both fasteners on top of filter, and slide out filter

(Fig. 13). On MTH, to gain access, open evaporator compartment door. Remove filter panel by unscrewing the six fixing screws. Slide out the filter for cleaning (Fig. 14). To clean filter, back flush with water or soapy water, then dry with air every 12,000 miles (20 000 km) or once a year, whichever comes first.

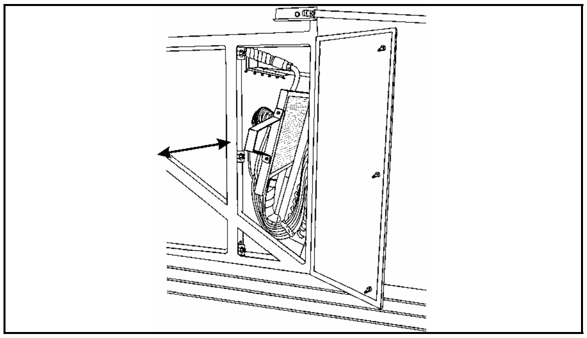


FIGURE 13: MAIN HVAC UNIT AIR FILTER 22179

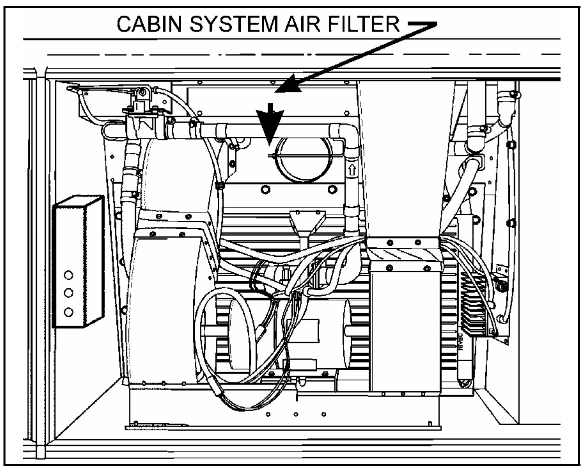


FIGURE 14: CABIN SYSTEM AIR FILTER REMOVAL 22178

***Caution**: Do not use high pressure water jet to avoid damaging filter.*

***Caution:** Be sure not to reverse filter upon installation*

5.4 PARCEL RACK FAN AIR FILTER

A/C evaporator coils may be installed in both parcel rack air systems. Only the air filters are serviceable. The air filters are accessible from inside the parcel racks. Slide out the filters, then back flush with water, dry with air and replace. This procedure should be done every 12,000 miles (20,000 km) or once a year, whichever come first.

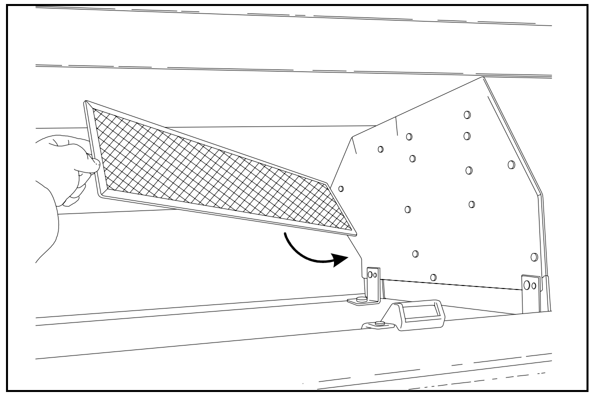


FIGURE 15: PARCEL RACK FAN AIR FILTER 22201

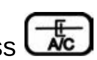
For A/C unit, ball valves are added on supply and return lines in the condenser compartment. They have service port to evacuate the A/C parcel rack circuit. When work has to be done on an evaporator coil unit, it will be easier to remove it and repair it on a bench.

6. DIAGNOSIS OF MAIN HVAC UNIT PROBLEMS

6.1 TROUBLESHOOTING MODE

Troubleshooting the HVAC system is made easier when entering the *"Troubleshooting Mode"*. The Troubleshooting Mode is used while driving the vehicle to diagnose a low or high pressure in the HVAC system.

To enter the Troubleshooting Mode, proceed as follows:

1. Check that HVAC system in passenger section is OFF.
2. First press 

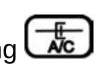
 and hold, then press 

 and hold both buttons for 2 seconds.
3. Passenger section display should indicate 00 to show that Troubleshooting Mode is activated.

***Note:** To return to Normal Operating Mode, turn the HVAC system OFF in the passenger section.*

Low Pressure

The Telltale panel located in center dashboard should indicate 

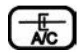
 when pressing 

 on the passenger section panel if a low pressure condition is present.

Note: *The telltale indicator will only illuminate if Troubleshooting Mode was entered and a low pressure condition is present.*

High Pressure

The Telltale panel located in center dashboard should indicate 

when pressing 

on the passenger section panel if a high pressure condition is present.

Note: *The telltale indicator will only illuminate if Troubleshooting Mode was entered and a high pressure condition is present.*

6.2 CONTINUITY CHECK

A continuity check is automatically performed at HVAC system start-up. If an open or short-circuit occurs, the corresponding switch LED or the display will blink for 10 seconds. The probes are checked at least every 5 minutes.

Circuit	Switch LED or Display
F/A damper driver	Driver Rec
Damper mix Driver “Liquid Solenoid Valve”	Driver air 4th switch Driver display “Set Point” (AC)
Driver “Hot Water Valve”	Driver display “Set Point” (HE)
Passenger “Hot Water Valve”	Passenger display “Set Point” (HE)
A/C Clutch Relay	A/C Clutch
Exterior Probe	Display “Text”. (---)
Driver interior probe	Driver display “Set Point” (---)
Passenger interior probe	Passenger display “Set Point” (

7. EVAPORATOR MOTOR

(Central HVAC system only)

The evaporator motor is installed in the evaporator compartment (L.H. side of vehicle) (Fig. 16). It is a 27.5 volt, 2 HP (1.5 kW) motor which activates a double blower fan unit.

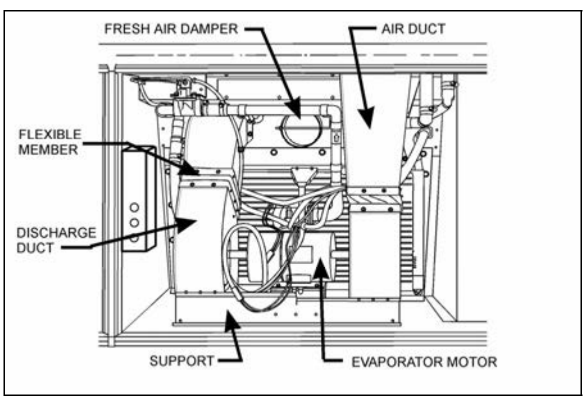


FIGURE 16: HVAC COMPARTMENT 22178

7.1 REMOVAL

1. Set the battery master switch to the *“OFF”* position.
2. Open the last L.H. side baggage compartment door. Pull the black release button located on the L.H. side in order to unlock and open the evaporator compartment door.
3. Identify the L.H. side discharge duct inside compartment and remove the Phillips head screws retaining the flexible member to duct.
4. Repeat step 3 for the R.H. side air duct.
5. Disconnect the discharge air sensor connector. Remove the cable tie securing wire.
6. From under the vehicle, remove the eight bolts retaining the evaporator fan motor support. Remove the complete unit from the evaporator compartment (Fig. 17).

Caution: *Never support evaporator motor by its output shafts while moving it.*

7. On a work bench, unscrew the fan square head set screws, the Phillips head screws retaining cages to support and slide out the

assemblies from the evaporator motor output shaft.

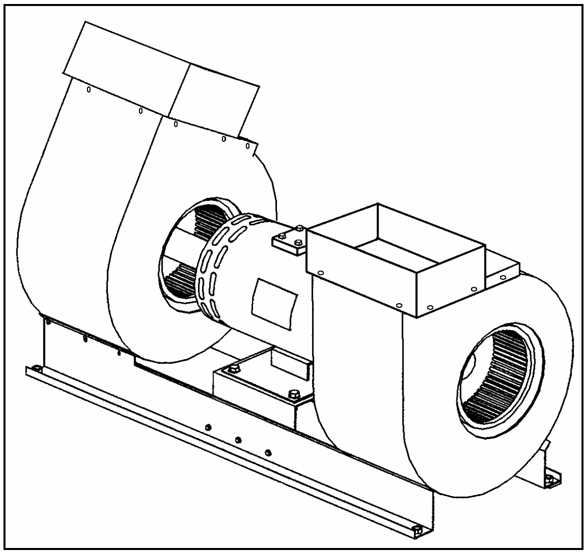


FIGURE 17: EVAPORATOR MOTOR ASSEMBLY 22208

7.2 INSTALLATION

To reinstall the evaporator motor, reverse "Evaporator Motor Removal" procedure.

7.3 CHECKING OPERATION OF BRUSH IN HOLDER

Lift brush slightly 1/8 inch (3 mm) and release it. Brush must produce a dry noise.

7.4 BRUSH WEAR INSPECTION AND REPLACEMENT

Caution: *Only use replacement brushes recommended by the manufacturer. Not doing so will void warranty.*

Replace the brushes if less than ¾ inch (19 mm). New brush length is 1-¼ inch. Clean brushes with a clean cloth impregnated with gasoline or alcohol.

Warning: *Cleaning products are flammable and may explode under certain conditions. Always handle in a well ventilated area.*

To replace brushes, proceed as follows:

1. Set battery master switch to the “OFF” position.
2. Remove the protective screen band from the motor housing by pulling down the spring loaded fastener.
3. Lift the spring, remove and replace brushes as per the standard procedure.
4. Reverse installation procedure.

7.5 BRUSH OLDER ADJUSTMENT

Note: *The brush holders are mounted on a support that can rotate. Rotating that support will move all the brush holders at the same time.*

1. Remove the screws securing the grille and remove the grille. Locate the 2 bolts fixing the mechanism permitting the rotation of the brush holder support.
2. Loosen (do not remove) the bolts just enough to release the mechanism.
3. Move gently the exposed brush holder in order to have a distance of 10mm (3/8") maximum between the brush holder face and a reference line passing through the center of the 2 bolts on the motor housing.

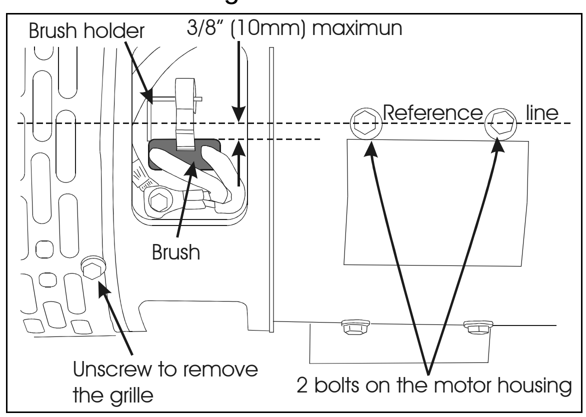


FIGURE 18: EVAPORATOR MOTOR

7.6 CHECKING COMMUTATOR

The surface must be polished. A brown-black colored surface is normal and indicates a good switching. Ensure there is no evidence of arcing or metal chips.

7.7 SPEED CONTROLLER MODULE

The evaporator motor speed controller module is mounted on the R.H. side wall inside the evaporator compartment (MTH only) (Fig. 16). The purpose of this electronic module is to limit the evaporator motor speed to 75% of its full rated speed throughout the heating mode and cooling mode. The module will then gradually increase the motor speed.

8. CENTRAL AIR CONDITIONING SYSTEM

The schematic of Figure 18 shows the central and auxiliary A/C system and its components. The central system is equipped with a 6 cylinder, 05G-134A Carrier compressor with an air conditioning capacity of 7½ tons. The receiver tank and filter dryer are mounted inside the condenser compartment.

XL2 Coaches may be supplied with central and auxiliary A/C system (Fig. 18). XL2 Converted vehicles (Shells) may be supplied with central or driver's A/C system only (Fig. 18 and 19). Auxiliary and driver's A/C systems come with a 6 cylinder, TM-16HD Seltec compressor with an air conditioning capacity of 2 tons.

8.1 A/C CYCLE

Refrigeration may be defined as "the transfer of heat from a place where it is not wanted to a place where it is unobjectionable". Components required for a closed circuit refrigeration system are shown in Figures 18 and 19.

The air conditioning system used on XL2 series vehicle is of the *"Closed"* type using *"R-134a".*

1. The refrigerant flowing to the compressor is compressed to high pressure and reaches a temperature higher than the surrounding air. It is passed through the air-cooled fins and tubes of the condenser causing the hot, high pressure gas to be condensed into a liquid form.
2. The liquid refrigerant flows to the receiver tank, then back to the condenser sub-cooler. It leaves the condenser and passes through a filter dryer where moisture, acids and dirt are removed and then through a moisture indicator which indicates if any moisture is present in the system.
3. By its own pressure, the liquid refrigerant flows through a thermal expansion valve where the pressure drop causes the refrigerant to vaporize in a vapor-liquid state at a low temperature pressure.
4. The cold low pressure refrigerant passes through the main and the driver's evaporator coils which absorbs heat from the air passing over the fins and tubes, and changes into gas. In this form, the refrigerant is drawn into the compressor to repeat the air conditioning cycle.
5. The success of the air conditioning system depends on retaining the conditioned air within the vehicle. All windows and intake vents should be closed. An opening of approximately 8 in^2 (5162 mm^2) could easily neutralize the total capacity of the system.
6. Other causes of inadequate cooling are dirty coils or filter. Dirt acts as an insulation and is also serves as a restriction to the air flow.
7. The refrigeration load is not constant and varies. It is also affected by outside temperature, relative humidity, passenger load, compressor speed, the number of stops, etc.
8. The compressor will load or unload depending on operating conditions.

8.2 REFRIGERANT

The A/C system of this vehicle has been designed to use Refrigerant 134a as a medium. Regardless of the brand, only R-134a must be used in this system. The chemical name for this refrigerant is Ethane, 1, 1, 1, 2-Tetrafluoro.

Warning: *Refrigerant in itself is nonflammable, but if it comes in contact with an open flame, it will decompose.*

8.2.1 Procurement

Refrigerant is shipped and stored in metal cylinders. It is serviced in 30 and 100 pound (13,6 and 45 kg) cylinders. Approximately 24 pounds (10,9 kg) are used in the system. If vehicle is equipped with only a driver's A/C system, then 7.0 lbs (3,2 kg) (W0) or 7.5 lbs (3,4 kg) (W5 and WE) are used and approximately 5.5 lbs (2,5 kg) are used in an auxiliary A/C system.

It will be impossible to draw all the refrigerant out of the cylinder. However, the use of warm water when charging the system will assure the extraction of a maximum amount of refrigerant from the cylinder.

8.2.2 Precautions in Handling Refrigerant

1. Do not leave refrigerant cylinder uncapped.
2. Do not subject cylinder to high temperatures, do not weld or steam clean near system or cylinder.
3. Do not fill cylinder completely.
4. Do not discharge vapor into an area where a flame is exposed.
5. Do not expose the eyes to liquid refrigerant.

All refrigerant cylinders are shipped with a heavy metal screw cap. The purpose of the cap is to protect the valve and safety plug from damage. It is a good practice to replace the cap after each use of the cylinder for the same reason. If the cylinder is exposed to the sun's radiant heat pressure increase resulting may cause release of the safety plug or the cylinder may burst.

For the same reason, the refrigerant cylinder should never be subjected to excessive temperature when charging a system. The refrigerant cylinder should be heated for charging purposes by placing it in 125°F (52°C) water. Never heat above 125°F (52°C) or use a blowtorch, radiator, or stove to heat the cylinder. Welding or steam cleaning on or near any refrigerant line or components of the A/C system could build up dangerous and damaging pressures in the system.

If a small cylinder is ever filled from a large one, never fill the cylinder completely. Space should always be allowed above the liquid for expansion. Weighing cylinders before and during the transfer will determine the fullness of the cylinders

Warning: *One of the most important precautions when handling refrigerant consists in protecting the eyes. Any liquid refrigerant which may accidentally escape is approximately -40°F (-40°C). If refrigerant comes in contact with the eyes, serious injury could result. Always wear goggles to protect the eyes when opening refrigerant connections.*

8.2.3 Treatment in Case of Injury

If liquid refrigerant comes in contact with the skin, treat the injury as if the skin was frost-bitten or frozen. If liquid refrigerant comes in contact with the eyes, consult an eye specialist or doctor immediately. Give the following first aid treatment:

1. Do not rub the eyes. Splash eyes with cold water to gradually bring the temperature above the freezing point.
2. Apply drops of sterile mineral oil (obtainable at any drugstore) in the eyes to reduce the possibility of infection. The mineral oil will also help in absorbing the refrigerant.

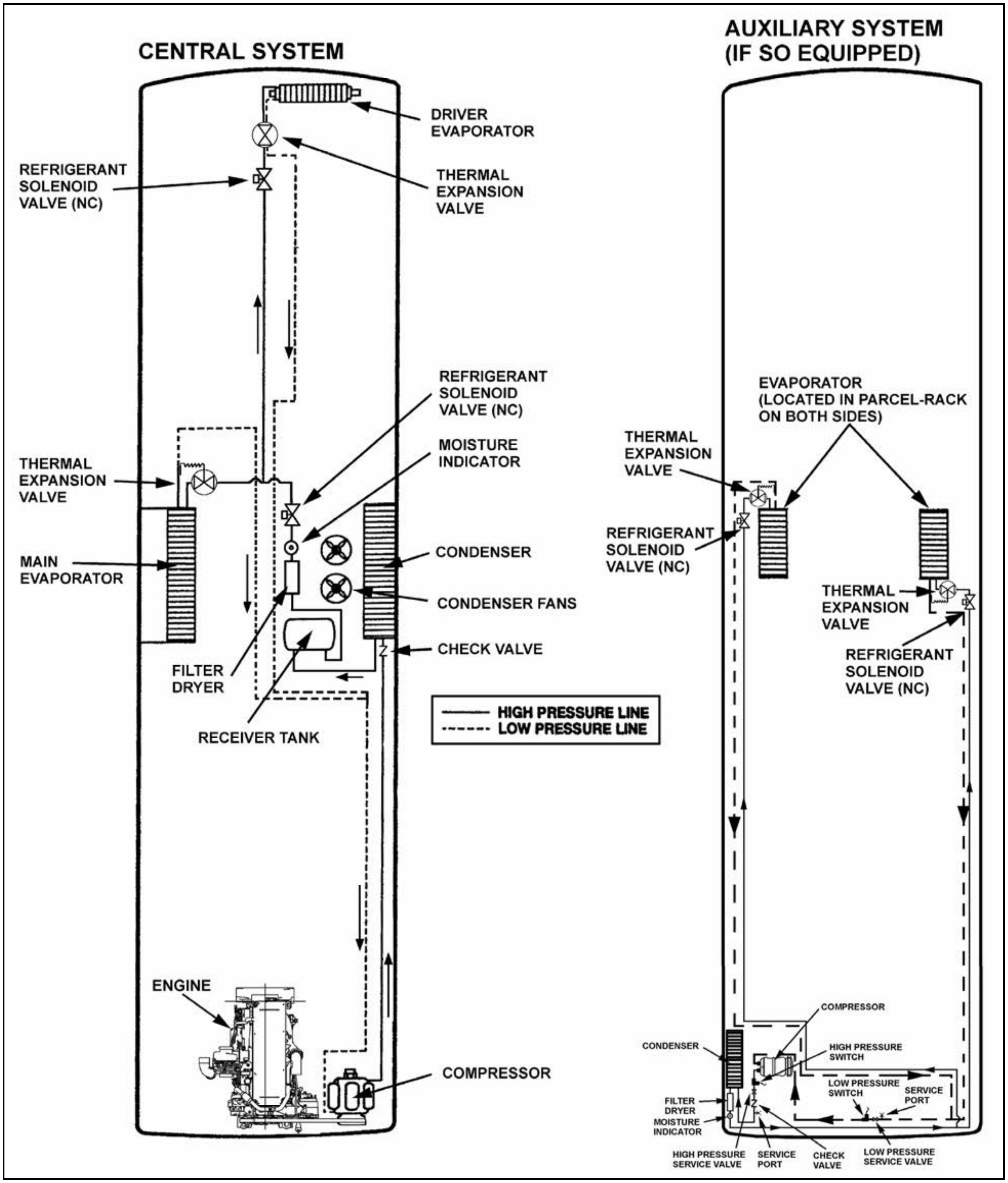


FIGURE 19: REFRIGERANT CIRCUIT (CENTRAL AND AUXILIARY SYSTEMS) 22247

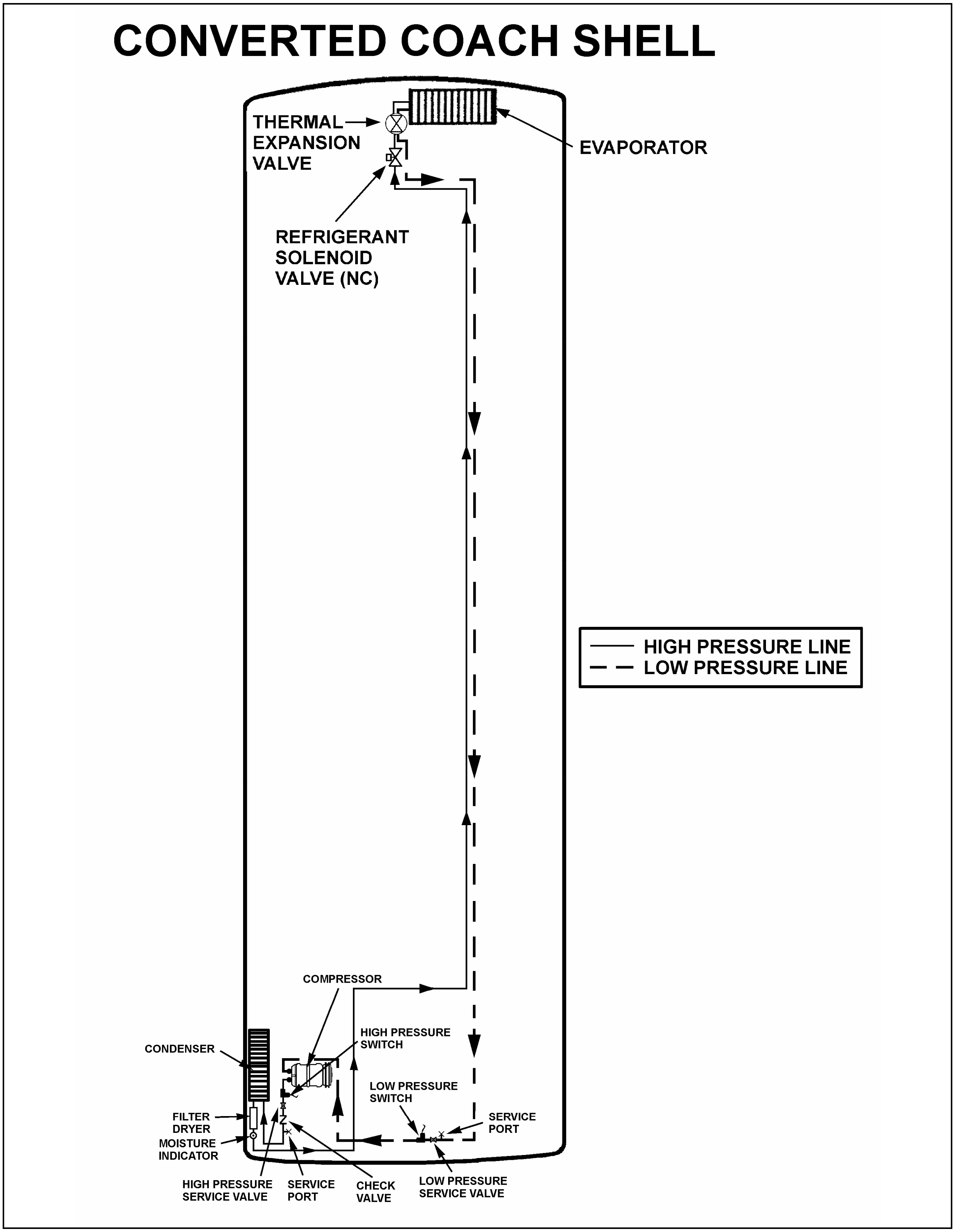


FIGURE 20: REFRIGERANT CIRCUIT (DRIVER'S AUXILIARY SYSTEM) 22246

8.2.4 Precautions in Handling Refrigerant Lines

1. All metal tubing lines should be free of kinks, because of the resulting restrictions on the flow of refrigerant. A single kink can greatly reduced the refrigeration capacity of the entire system.
2. The flexible hose lines should never be allowed to come within a distance of 2-½" (6,3 cm) from the exhaust manifold.
3. Use only sealed lines from parts stock.
4. When disconnecting any fitting in the refrigeration system, the system must first be discharged of all refrigerant. However, proceed very cautiously, regardless of gauge readings. If there happens to be liquid refrigerant in the line, disconnect fittings very slowly, keeping face and hands away so that no injury can occur. If pressure is noticed when fitting is loosened, allow it to bleed off very slowly.

Warning*: Always wear safety goggles when opening refrigerant lines.*

5. In the event that any line is opened to the atmosphere, it should be immediately capped to prevent entrance of moisture and dirt.
6. The use of the proper wrenches when making connections on O-ring fittings is important. The use of improper wrenches may damage the connection. The opposing fitting should always be backed up with a wrench to prevent distortion of connection lines or components. When connecting the flexible hose connections, it is important that the swaged fitting and the flare nut, as well as the coupling to which it is attached, be held at the same time using three different wrenches to prevent turning the fitting and damaging the ground seat.
7. The O-rings and seats must be in perfect condition. The slightest burr or piece of dirt may cause a leak.
8. O-rings should be coated with refrigeration oil and installed on the line before the line is inserted into the fitting to prevent damaging the O-ring. If leaks are encountered at the couplings or connectors, no attempt should be made to correct the leaks by tightening the connections beyond the recommended torque. The O-rings are designed to seal at the specified torque and overtightening the connection does not result in a satisfactory and permanently sealed connection. The connection must be disassembled and the cause of the leak (damaged O-ring, defective lines, etc.) corrected. Use new O-ring.

8.2.5 Auxiliary System Refrigerant Lines

- From the inside of the coach, remove the mirror located inside the lavatory to access the Y connector separating the system two sides. Also a small access panel located in front of the lavatory entrance door, near the ceiling enables to reach the R.H. side supply and return line fittings.
- The L.H. side supply and return line fittings are accessible by removing the rearmost overhead storage compartment separator.

8.3 PUMPING DOWN

This procedure is intended to reduce refrigerant loss, on central system only, by isolating it in the compressor and the receiver tank, as well as in their connecting line, in order to carry out repairs on other sections of the air conditioning system (lines and components).

Note: *Before attempting any repair between compressor and receiver tank, use a recovery unit to remove refrigerant from the system.*

Note: *On vehicles equipped with an auxiliary or driver's A/C system only, refer to “Auxiliary Air Conditioning system and components": paragraph 10.11 “OIL RETURN OPERATION” and 10.3.3 “Refrigerant Recovery”, further in this section.*

Warning: *To prevent any injury, when air conditioning system must be opened, refer to previous paragraph “PRECAUTIONS IN HANDLING REFRIGERANT”.*

Caution: *The filter dryer must be changed each time a line in the system is opened.*

Procedure

1. Energize passenger side liquid solenoid valve.

2. Run the system for 10 minutes, shut it OFF, then close the receiver tank outlet valve by turning it clockwise, backseat the suction service valve on the compressor, install an appropriate pressure gauge set, and turn the valve forward ¼ turn to enable a visual check of the suction pressure.
3. Disconnect the *"Low Pressure Switch"* connector (mounted near the A/C compressor, and install a jumper wire.

Note: *This jumper wire will allow the clutch to remain engaged after pressure drops below 15 psi (103,5kPa).*

4. Start the engine, press the *"Passenger ON/OFF"* switch then the A/C switch, adjust *"A/C Temperature"* control to maximum A/C.
5. Run the compressor until pressure reaches 1-2 psi (7-14 kPa).

Note: *During this operation, care must be taken not to fill the receiver tank over the upper sight glass. If so, stop process immediately. Always allow refrigerant piping and units to warm up to the ambient air temperature before opening system or sweating will take place inside the lines.*

5. Stop engine, and close compressor outlet valve by turning it clockwise until valve is properly seated.
6. Close compressor suction valve by turning it clockwise until it is properly seated.
7. Wait until pressure gauge reaches 1 to 2 psi (7 to 14 kPa). To accelerate procedure, lightly open compressor suction valve until pressure reaches this value.

8.4 ADDING REFRIGERANT (VAPOR STATE)

Use the suction service valve on the compressor to add a small quantity of refrigerant to the system. Backseat the valve and connect a charging line from the refrigerant cylinder to the valve. Tighten connection at level of refrigerant cylinder and open tank end slightly to purge air from the charging line. Tighten the charging line at the compressor. Screw in the stem of suction valve approximately two turns. Start the engine and run at fast idle. Add sufficient refrigerant to bring the level in lower sight glass of receiver tank to mid-point. Always charge the system with the cylinder upright and the valve on top to avoid drawing liquid out of the cylinder.

8.5 EVACUATING SYSTEM

1. Open both receiver valves by turning "out" (normal position).
2. Remove the caps from the two 90° adapters on the suction, discharge valves and connect two hoses to the vacuum.
3. Place the two compressor valves, suction and discharge, in neutral position by turning each one 3 to 4 turns "in" from the "out" position.
4. Open the solenoid valve by energizing or manually bypass.
5. Start the vacuum pump. Open the large (suction) shutoff valve and close the small vacuum gauge valve.
6. The pressure will drop to approximately 29 inches vacuum (14.2 psi or 97,9 kPa) (the dial gauge only gives a general idea of the absolute system pressure.
7. Backseat the compressor valves by turning "out" all the way.
8. Shut down the vacuum pump.
9. Remove the hoses.
10. Reinstall the caps at the suction valve take-off points.

8.5.1 Double Sweep Evacuation Procedure

1. Remove any remaining refrigerant from the system using a refrigerant recovery machine.
2. Connect the evacuation manifold, vacuum pump, hoses and micron gauge to the unit.
3. With the unit service valves closed (back seated) and the vacuum pump and the thermistor valves open, start the pump and draw the manifold and hoses into a very deep vacuum. Shut the vacuum pump off and see if the vacuum holds. This is to check the setup for leaks.
4. Midseat the system service valves.

5. Open the vacuum pump and the thermistor valves. Start the pump and evacuate to a system pressure of 2000 microns.
6. Close the vacuum pump and the thermistor valves, turn off the vacuum pump (closing the thermistor valve protect the valve from damage).
7. Break the vacuum with clean refrigerant (or dry nitrogen) and raise the pressure to approximately 2 PSIG. Monitor the pressure with the compound gauge.
8. Remove the refrigerant with the recovery machine.
9. Repeat steps #5 – 8 one time.
10. After the second "sweep", change the filter drier (if you have not done so) and evacuate to 500 microns.
11. Evacuating the system below 500 microns on systems using the Carrier 05G compressor may risk drawing air into the system past the carbon shaft seal.
12. Check to insure that vacuum holds. (If the pressure continues to rise, it indicates a leak or moisture in the system).
13. Charge the system with the proper amount of refrigerant using recommended charging procedures.

Note: *This method will aid in preventing unnecessary system failures by ensuring that the refrigeration system is free of contaminants.*

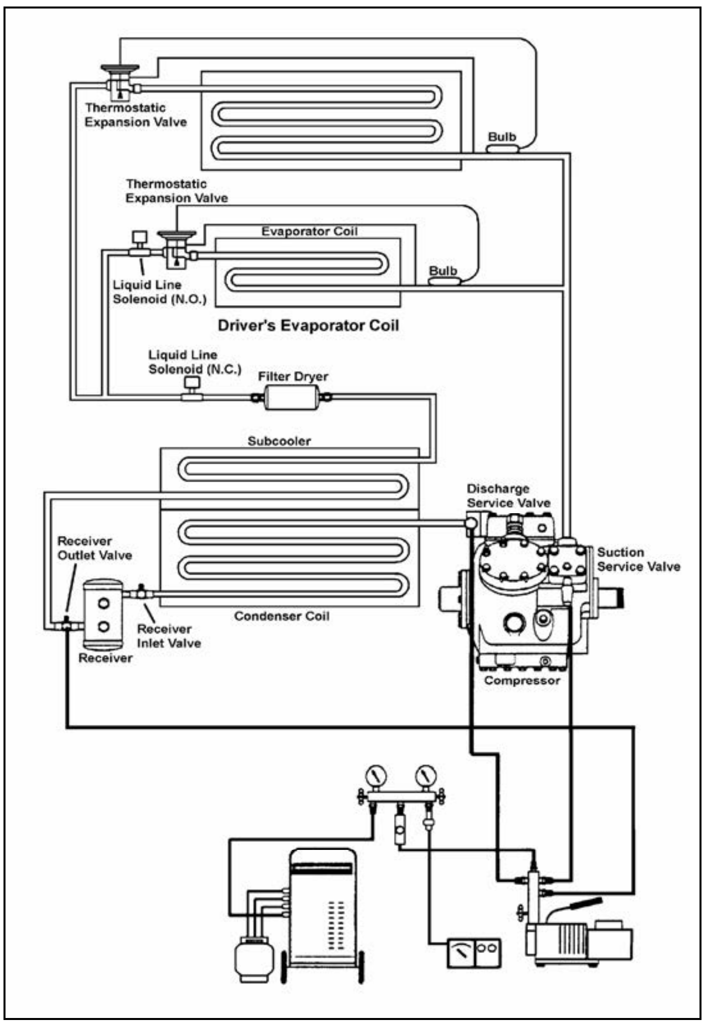


FIGURE 21: DOUBLE SWEEP EVACUATION SET-UP

8.6 CHARGING SYSTEM

When a system has been opened or if there are any questions about the air or moisture in the system, evacuate the system. Charging of an evacuated system may be accomplished by forcing liquid R-134a directly into the receiver tank. This may be accomplished by placing the refrigerant cylinder upside down on a scale with the valves at the bottom. This ensures that only liquid will enter the receiver tank.

When charging an empty system, weigh the amount of refrigerant put into the system. This will eliminate any possibility of overfilling. A nominal charge requires 24 pounds (10,9 kg). If the vehicle is equipped with an auxiliary system, a full charge requires 5.6 lbs (2,6 kg), if the vehicle is equipped with a driver's system only, the system requires 4 lbs (1,8 kg).

1. Backseat the two compressor shutoff valves ("out").
2. Install the test gauges at the shutoff valves noting that the 400 psi (2758 kPa) gauge is connected to the discharge.
3. Turn in the two shutoff valves 3 to 4 turns.
4. Open the lower receiver valve by turning “out” all the way.
5. Backseat the upper receiver valve by turning out all the way.
6. Remove the cover cap from the service fitting in the top receiver valve.
7. Attach a charging hose to the R-134a tank. Open the tank valve slightly permitting R-134a to escape thus purging the hose of air.
8. Connect the charging hose to the service fitting.
9. Open the R-134a tank valve.
10. To build up pressure in the receiver tank, heat the receiver tank with a heating blanket.
11. Turn in the upper receiver valve several turns. The R-134a will now enter the system.
12. The proper charge of R-134a is 24 lbs (10.89 kg). When the scale indicates this amount of charge, backseat the receiver valve and close the R-134a tank valve.
13. Disconnect the charging hose. Replace the cover caps.
14. The system is now ready for operation.

Caution: *The evacuation of the system must be made by authorized and qualified personnel only. Refer to local laws for R-134a recuperation.*

8.7 REFRIGERANT SYSTEM CLEAN-OUT AFTER COMPRESSOR FAILURE

Although the vast majority of reciprocating refrigerant compressors manufactured today are extremely reliable, a small percentage do fail. These failures usually result in minor or extensive system contamination depending on the severity of the failure. When an open type compressor becomes damaged internally, this provokes small particles of bearings, steel, brass, copper, and aluminum and, in severe cases, carbonized oil, which could contaminate the system. To prevent repeated failures, the problem which caused the failure should be corrected, and depending upon the severity of the failure, the system should be thoroughly cleaned out using one of the clean-out procedures mentioned.

8.7.1 Determining Severity of Failure

The severity of compressor failure can be categorized as minor or major. A failure is considered minor when the contamination is limited to the compressor with little or no system contamination. A major failure, or burnout, results in extensive system contamination as well as compressor damage. Extensive system contamination can be determined by withdrawing a small sample of compressor oil and checking its color, odor and acidity. A Virginia Chemical "TKO" one step acid test kit is one of several compressor oil test kits that may be used. A high acid content would indicate a major failure or burnout. A small amount of refrigerant gas may be discharged. A characteristic burned odor would also indicate severe system contamination.

8.7.2 Clean-out after Minor Compressor Failure

1. Be sure to correct the problem which caused the failure.
2. Change liquid line filter dryer
3. Run the unit for 2 hours on high speed cool only.
4. Check compressor oil level to ensure compressor is not overcharged with oil. Sometimes a significant amount of oil is pumped out of the compressor to other parts of the system when a compressor fails. This oil will return to the replacement compressor when it is started, causing an overcharge of oil in the sump of the replacement compressor. In this case, it is important that the oil level be adjusted to the proper level.
5. Withdraw a sample of the compressor oil and check its color, odor, and acidity, using instructions supplied above. If the oil is contaminated, change the oil and filter dryer, and repeat the procedure until the system is clean.

8.7.3 Clean-out After Major Compressor Failure

1. Reclaim the refrigerant into a refrigerant bottle through a filter dryer to filter out contaminants.
2. Remove the failed compressor and repair it if possible.
3. Install new or repaired compressor.
4. Change the filter dryer.
5. Circulate clean R-134a or nitrogen with the reclaimer to clean out many of the contaminants collected in the coil valves, TXV (Thermal Expansion Valve), solenoid valves, check valves, and any other mechanical component that may have collected contaminants.
6. Evacuate and charge the system normally.
7. Run the unit for 8 hours and monitor the pressure drop across the filter dryer. Also check the liquid line dryer for signs of restriction. If the pressure drop across the filter dryer exceeds 12 to 14 psig (82,75 to 96,5 kPa) with a 40°F (5°C) evaporator coil temperature, stop the unit and change the liquid line and suction line filter dryer. After 4 or 5 hours of operation, stop the unit and replace the filter dryer.
8. After 8 hours of operation, stop the unit and remove a sample of the compressor oil and check its color, odor, and acidity, using instructions supplied above. If the oil is contaminated, replace the oil and repeat step 7. If the oil is not contaminated, change the filter dryer again and replace the moisture-liquid indicator.
9. After approximately 7 days of operation, recheck the compressor oil for cleanliness and acidity.

9. CENTRAL A/C SYSTEM COMPONENTS

9.1 COMPRESSOR (CENTRAL SYSTEM)

9.1.1 Belt Replacement

Warning: *Set the battery master switch to the “Off” position. For greater safety, set the engine starter selector switch in engine compartment to the “Off” position.*

1. Open engine compartment rear doors and locate the belt tensioner pressure releasing valve (Fig. 21), mounted above the engine R.H. side door next to the air pressure regulator, then turn handle clockwise in order to release pressure and tension on belts.
2. Slip the old belts off and the new ones on.
3. Reset belt tensioner pressure releasing valve (Fig. 21) to 50 psi (345 kPa) for coaches and to 45 psi (310 kPa) for MTH to apply tension on the new belts as explained in Section 12.

Note: *Both belts must always be replaced simultaneously to ensure an equal distribution of load on each of them.*

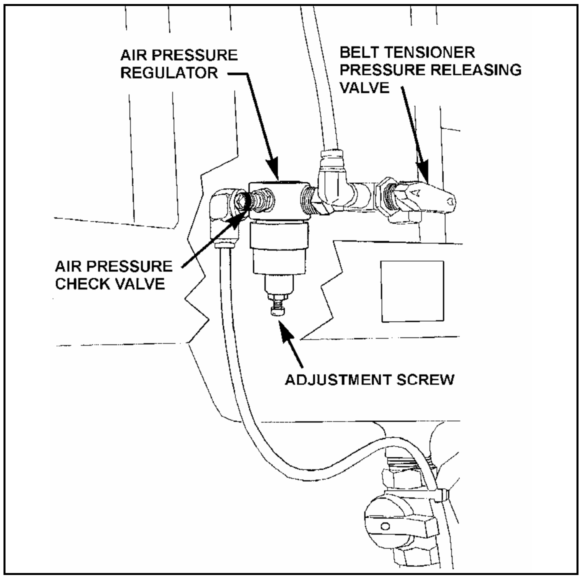


FIGURE 22: AIR PRESSURE REGULATOR 12200

Note: *For proper operation of the air bellows, adjust the* ***upper*** *tensioning bracket to provide a ¼" (7 mm) gap between stopper and bracket with the pneumatic system under normal pressure and the air pressure regulator set as per paragraph #3 (Fig. 22).*

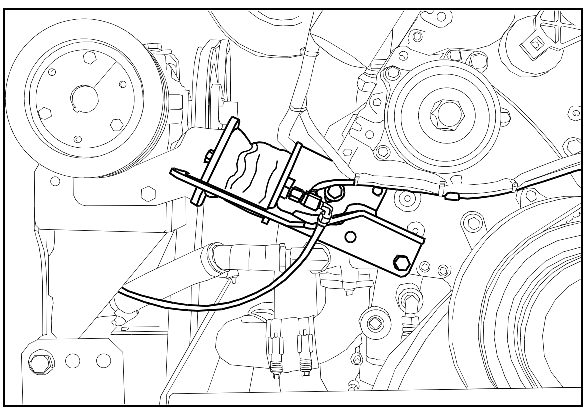


FIGURE 23: BELT TENSIONER 01059

9.1.2 Pulley Alignment

In order to avoid skipping, disengagement and a premature wear of compressor belt, it is necessary to align compressor pulley with the crankshaft pulley. Before performing the following procedure, release air from belt tensioners by means of the air pressure releasing valve. After completing these procedures reset belt tensioner air pressure regulator to 50 psi (345 kPa) or 45 psi (310 kPa).

9.1.3 Longitudinal Compressor Alignment

1. Rest an extremity of a straight edge of approximately 46 inches (117 cm) against the upper part of the outer face of crankshaft pulley, positioning the other end close to the compressor clutch pulley (Figs. 23 & 25).
2. Check the distance between each extremity of straight edge (1. Fig. 25) and the first drive belt. If they are different, loosen the compressor support bolts and with a hammer, knock support to slide it in order to obtain the same distance; then tighten bolts.

9.1.4 Horizontal Compressor Alignment

1. Rest an extremity of the straight edge against the upper part of the outer face of compressor pulley, positioning the other end close to the crankshaft pulley.
2. Check the distance between each extremity of straight edge (1, Fig. 25) and drive belt. If they are different, loosen the pillow block compressor bolts and with a hammer, knock compressor pillow block to slide it, in order to obtain the same distance; then tighten bolts.

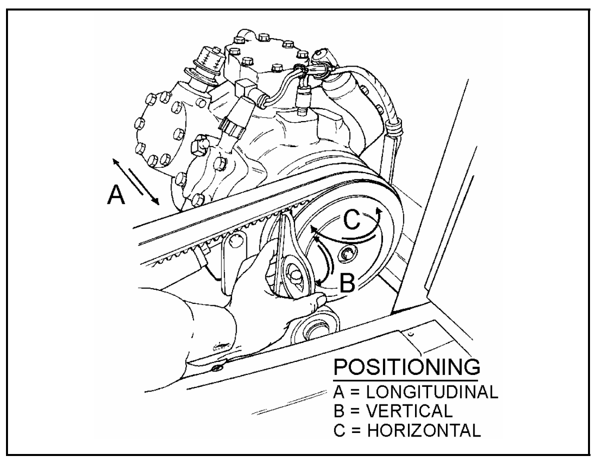


FIGURE 24: COMPRESSOR ALIGNMENT 22072

9.1.5 Vertical Compressor Alignment

Rest a short "angle and level indicator" on the outer side face of the crankshaft pulley, adjust the level indicator inclination at 0° and check if the compressor pulley is at same angle (Figs. 23 & 25). If it is not the same, shim under the appropriate pillow block in order to obtain the correct angle.

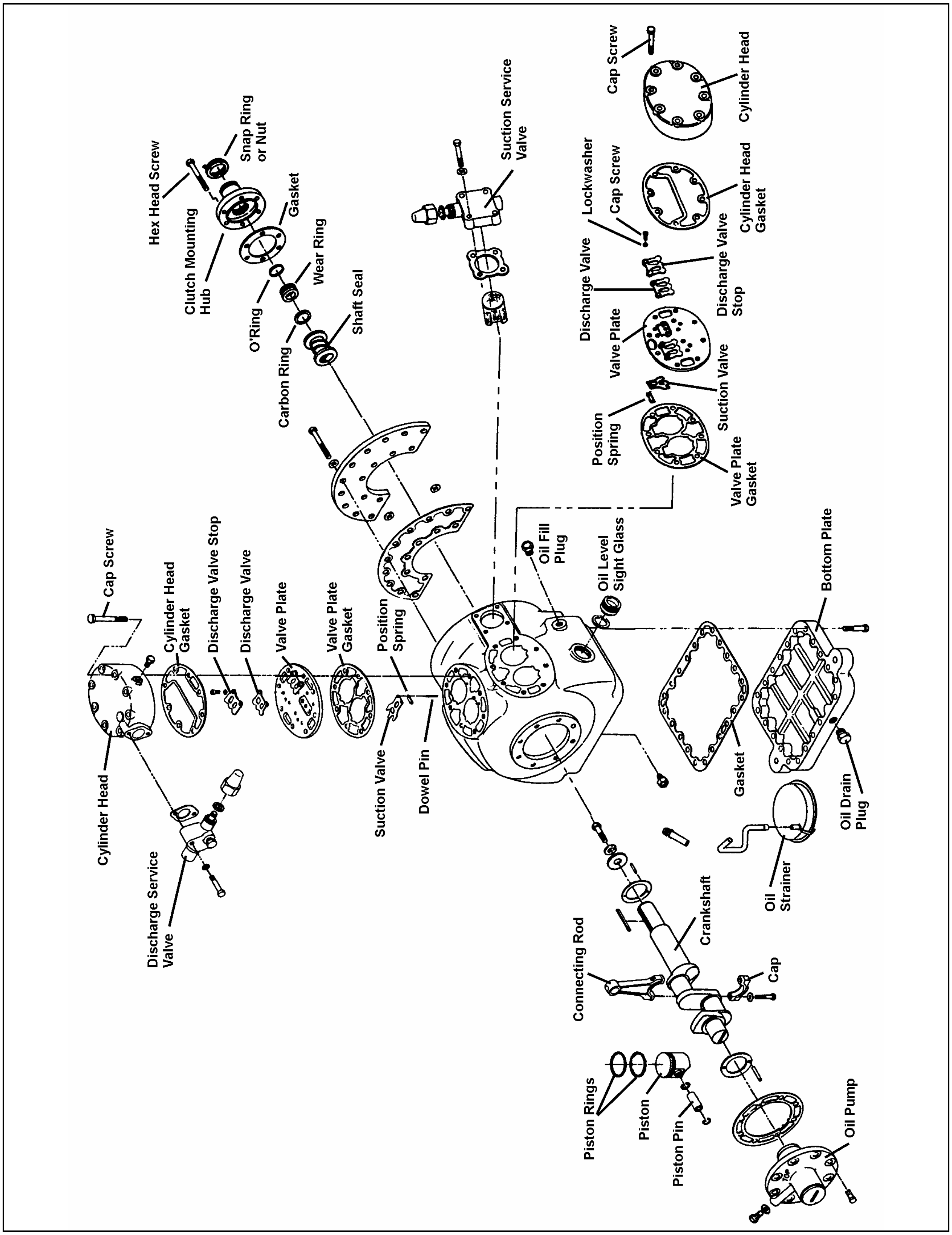

Cap Screw
Cylinder Head
Gasket
Discharge Valve Stop
Discharge Valve
Valve Plate
Valve Plate
Gasket
Position
Spring
Cylinder Head
Discharge Service
Valve
Suction Valve
Dowel Pin
Hex Head Screw
Clutch Mounting
Hub
Snap Ring
or Nut
Gasket
Wear Ring
O'Ring
Shaft Seal
Carbon Ring
Suction Service
Valve
Cap Screw
Cylinder Head
Lockwasher
Cap Screw
Cylinder Head
Gasket
Discharge Valve
Discharge Valve
Stop
Valve Plate
Suction Valve
Position
Spring
Valve Plate
Gasket
Oil Fill
Plug
Oil Level
Sight Glass
Bottom Plate
Gasket
Oil Drain
Plug
Oil
Strainer
Crankshaft
Connecting Rod
Cap
Piston Rings
Piston
Piston Pin
Oil Pump

FIGURE 25: EXPLODED VIEW OF 05G COMPRESSOR

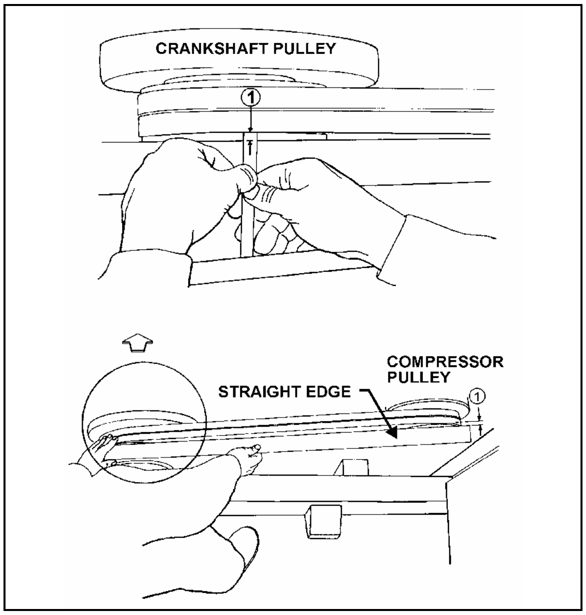


FIGURE 26: COMPRESSOR ALIGNMENT 22040

9.1.6 Compressor Maintenance

For the maintenance of the A/C compressor, see the *"Carrier Compressor Operation and Service Manual"* included at the end of this section.

Caution: *Use only Castrol SW 68 (POE) oils with refrigerant 134a.*

9.1.7 Troubleshooting Guide

A preliminary check may be made by simply feeling the cylinder heads with the unit in operation at ambient temperatures of 35°F (2°C) and over. The cylinder heads are internally divided into suction and discharge valves. The lower half of the cylinder head is the suction side, and it should be relatively cool to the touch, as opposed to the hot upper discharge side. If a valve plate or head gasket is blown, or a compressor unloader is stuck open, partially compressed refrigerant vapor will be circulated between the suction and discharge sides of the head. The affected cylinder head will then have a relatively even temperature across its surface and be neither as hot as the normal discharge temperature nor as cool as the normal suction temperature.

Blown Head Gaskets

Symptom:

- Loss of unit capacity at low temperature.
- Even cylinder head temperature.

Cause:

- Improperly torqued cylinder head bolts.
- Improperly positioned gasket at assembly.
- Warped cylinder head.
- Severe liquid refrigerant floodback.

Blown Valve Plate Gaskets

Symptom:

- Loss of unit capacity at medium and low temperatures.
- Very hot cylinder head surface.
- Higher than normal suction pressure.

Cause:

- Improperly torqued cylinder head bolts.
- Severe liquid refrigerant floodback.
- Oil slugging caused by an overcharge of oil or flood starts.
- Discharge valves not seated properly (liquid drainback during shutdown).

Broken Suction Valves

Symptom:

- Loss of unit capacity at all temperatures.
- Compressor unable to pull extremely low vacuum with suction service valve frontseated.

Cause:

- Repeated liquid refrigerant floodback.
- Flooded starts.
- Overcharge of oil.

- Discharge valves not seated properly (liquid drainback during shutdown).
- Expansion valve not controlling properly.

Unloader Valve Stuck Open

Symptom:

- Loss of unit capacity at all temperatures.
- Higher than normal suction pressure.
- Even cylinder head temperature.

Cause:

- Unloader body stem bent.
- Foreign material binding unloader piston or plunger.

9.2 MAGNETIC CLUTCH

Refer to Carrier service information entitled “Housing-Mounted Electric Clutch” at the end of this section for the description and maintenance of the magnetic clutch.

9.2.1 HVAC Control Unit and Clutch Operation

When A/C system is actuated using switch, the corresponding switch LED will turn on, the A/C ON indicator LED will turn on and the clutch will engage.

Note: *If the outside temperature is inferior to 25°F (-4°C), the A/C ON indicator LED will turn off and the clutch will disengage. The indicator LED will turn back on and the clutch will reengage when the outside temperature reaches 35°F (2°C).*

The A/C ON indicator LED will also turn off and the clutch will disengage if a low (5 – 30 psi) or a high pressure (350 – 245 psi) condition is present.

Note: *You must first enter the Troubleshooting Mode to be able to visualize on the telltale panel the low or high pressure condition (refer to paragraph 6.1).*

Note: *The indicator LED will turn back on and the clutch will reengage 45 seconds after the low or high pressure condition was corrected.*

9.3 CONDENSER

The central A/C system condenser coil is hinge mounted on the R.H. side of the vehicle on the A/C condenser door (Fig. 27). The condenser coil for vehicles equipped with an auxiliary or a driver's A/C system only, is mounted on the outer face of engine radiator. Since condenser’s purpose is to dissipate heat from the hot refrigerant, it is important to keep the cooling coils and fins clean. A clogged coil will cause high discharge pressure and insufficient cooling.

9.3.1 Condenser Fan Motors

Two fan motors (Fig. 26), 28.5 V - (0.6 HP - 0.42 kW) and cages are installed in the condenser compartment on R.H. side of vehicle in order to ventilate the condenser coil. They are mounted on a support, fastened to the floor. The fans pull outside air through the condenser coil and discharge it through an opening at bottom of compartment. When temperature drops inside condenser, the pressure in the refrigerant line also drops and it is, therefore, no longer required to cool condenser. Consequently, when pressure drops to 130 psi, the motors will run at low speed and if the pressure continues to drop to 90 psi, a pressure switch stops the motors so that fans do not operate needlessly. When pressure rises to 120 psi, the pressure switch reactivates the motors. If the pressure rises to 170 psi, the motors will switch to high speed.

For details about electrical wiring, refer to *“A/C and Heat system”* in the master wiring diagram.

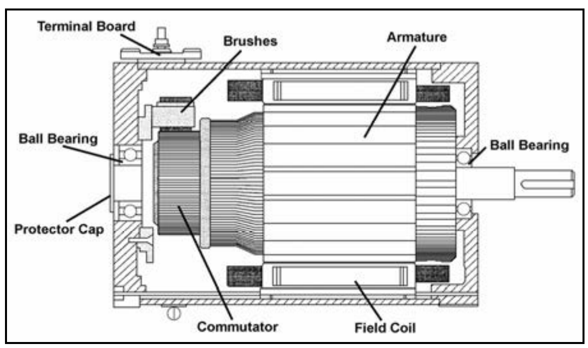


FIGURE 27: CONDENSER FAN MOTOR 22234

9.3.2 Condenser Fan Motor Removal

1. Set the battery master switch to the *“Off”* position.

2. Remove the two *"Phillips"* head screws retaining the fan motor protective cover to the square tubing. Remove the protective grill from mounting support.
3. Disconnect wiring from terminals on motor. Tag each wire to aid in identification at time of reconnection.
4. Support motor, and remove bolts which attach motor to mounting bracket. Remove the motor.

9.3.3 Preliminary Disassembly

1. Remove the brushes.
2. Unscrew the flange retaining screws on the shaft end side (opposite to the commutator end frame), and separate flange from frame (Fig. 26).
3. Remove flange and armature assembly by pushing bearing shaft toward the commutator end frame.
4. Separate flange from armature.

9.3.4 Disassembly

1. Perform preliminary disassembly.
2. Carefully note the position of the brush holder ring and the connections on the flange support.
3. Unscrew and remove the flange on the commutator end frame.
4. Remove the brush holder ring.
5. Finally, separate the following parts: brush holders, brush boxes, terminal board, bearings, etc.

9.4 RECEIVER TANK

The receiver tank is located in the condenser compartment (Fig. 27). The function of the receiver tank is to store the liquid refrigerant. During normal operation, the level of the refrigerant should be approximately at the mid-point of the lower sight glass.

In case of extreme pressure there will be a rise in the liquid receiver tank. A pressure relief valve will break at 450 psi (3103 kPa) and relieve the receiver tank pressure.

The receiver tank incorporates an inlet valve on the inlet side (upper section) which allows the tank to be isolated or serviced. An outlet valve on the outlet side (lower section) permits complete isolation from the rest of the system.

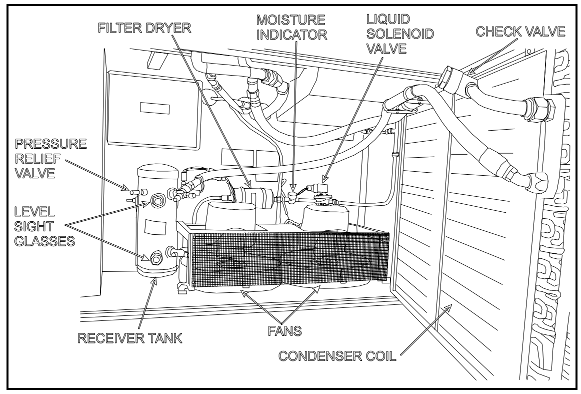


FIGURE 28: A/C CONDENSER COMPARTMENT 22243B

9.5 FILTER DRYER

A filter dryer, also located in the condenser compartment, is installed on the liquid refrigerant line after the receiver tank. It is used to absorb moisture and foreign matter from refrigerant before it reaches the expansion valves.

The filter should be replaced if the system has been opened or after a prolonged exposure, when the moisture indicator sight glass turns to pink.

A filter dryer, located close to engine compartment L.H. side rear door, is installed on vehicles equipped with an auxiliary A/C system or a driver's system only. Its function is similar to that of filter used on main systems. Replace only when system is opened or a problem occurs.

9.5.1 Replacement

The filter is of the disposable type. When replacement is required, remove and discard the complete unit and replace with a new unit of the same type according to this procedure:

1. Isolate the refrigerant in the receiver tank by following the "Pumping Down" procedure explained in this section
2. Change the filter dryer as a unit.

3. Add a small quantity of refrigerant R-134a to the low side of the system. Check for leaks. Return the system to normal operation.

Caution: *Do not use carbon tetrachloride or similar solvents to clean parts. Do not use steam guns. Use mineral spirits or naphtha. All parts should be thoroughly cleaned. Use a stiff brush to wash dirt from grooves, holes, etc.*

Warning: *Cleaning products are flammable and may explode under certain conditions. Always handle in a well ventilated area.*

9.5.2 Moisture Indicator

The moisture sensitive element consists of a color changing ring which is reversible from pink to blue and vice versa as the moisture content in the refrigerant changes. Pink indicates a wet refrigerant, light violet (caution) and blue indicates a dry refrigerant.

Since temperature changes affect the solubility, color change will also vary with the refrigerant temperature. The following table shows the color change for R-134a at various moisture levels and liquid line refrigerant temperatures.

COLOR INDICATOR			
TEMPERATURE	BLUE (ppm)	LIGHT VIOLET (ppm)	PINK (ppm)
75°F (24°C)	Below 5	5-15	Above 15
100°F (38°C)	Below 10	10-30	Above 30
125°F (52°C)	Below 15	15-45	Above 45
p.p.m.= parts per million (moisture content)			

A moisture level of less than 15 p.p.m. for R-134a indicated in the blue color range of the above table is generally considered dry and safe. A color indication of light blue to light violet indicates the caution range of moisture level. For positive protection, the drying of the system should be continued until the color of the element turns to deep blue.

The liquid refrigerant is readily visible through the center opening of the moisture element where the presence of bubbles indicates a shortage of refrigerant or restriction in line.

Moisture is one of the main causes of chemical instability or contamination in air conditioning systems. If moisture is present, it can corrode the valves, condenser and evaporator coils, compressor and other components causing a malfunction and eventual failure of the system. Uncontrolled moisture in the system can result in very expensive multiple component replacements if not corrected at an early stage. The moisture indicator permits an early detection of moisture in the system and when corrected by a desiccant charge, system contamination is greatly minimized.

9.6 LIQUID REFRIGERANT SOLENOID VALVE

The flow of liquid refrigerant to the driver's and main evaporators is controlled by a normally-closed solenoid valve. The driver's liquid solenoid valve is located on the ceiling of the spare wheel and tire compartment and is accessible through the reclining bumper.

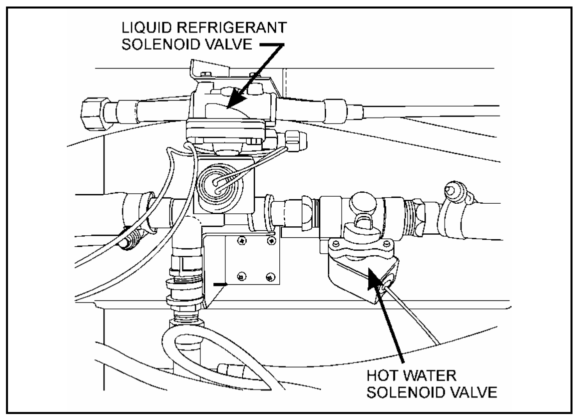


FIGURE 29: DRIVER'S EVAPORATOR LIQUID SOLENOID VALVE 22181

Note: *An identical refrigerant solenoid valve is used on the auxiliary A/C system and is located near the auxiliary A/C unit.*

9.6.1 Manual Bypass

This type of solenoid valve is equipped with a manual operating stem. The 3/16" square stem located on the bonnet is exposed when the seal cap is removed. To manually open valve, turn stem ½ turn counterclockwise. To manually close valve, turn stem clockwise until tight against seat. Manual stem must be in closed position for automatic electric operation.

9.6.2 Coil Replacement

1. Disconnect connector from the coil connector.
2. Take out the retaining screw at the top of the coil housing. The entire coil assembly can then be lifted off the enclosing tube.
3. Place the new coil and yoke assembly on the enclosing tube. Lay data identification plate in place.
4. Insert the coil retaining screw, rotate housing to proper position and tighten screw securely.
5. Connect connector from coil connector.

9.6.3 Valve Disassembly

1. Remove the coil as stated previously.
2. Pump down the system as stated earlier in this section.
3. Remove the four socket head screws which hold the body and bonnet together (Fig. 29).
4. Carefully lift off the bonnet assembly (upper part of the valve) so that plunger will not fall out. The diaphragm can now be lifted out.

Note: *The above procedure must be followed before brazing solder-type bodies into the line.*

Caution: *Be careful not to damage the machined faces while the valve is apart.*

9.6.4 Valve Reassembly

1. Place the diaphragm in the body with the pilot port extension up.
2. Hold the plunger with the synthetic seat against the pilot port.

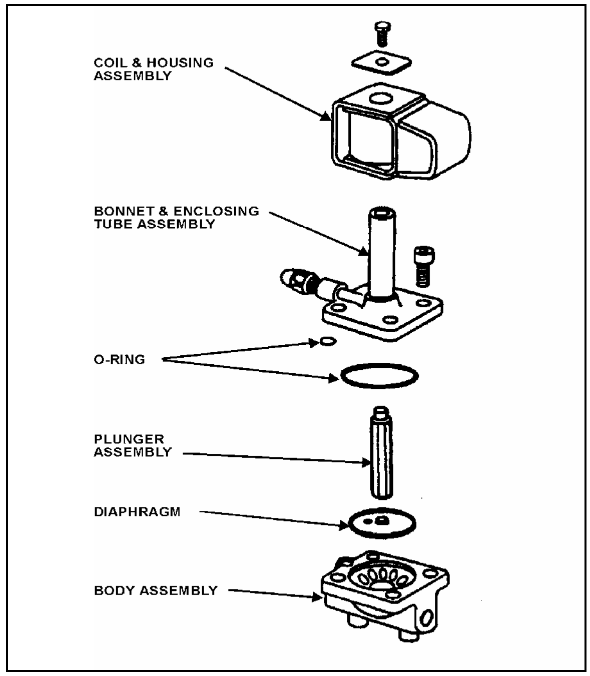


FIGURE 30: REFRIGERANT SOLENOID VALVE 22044

3. Make sure the bonnet O-rings are in place. Lower the bonnet assembly over the plunger, making sure that the locating sleeve in the bonnet enters the mating hole in the body.
4. Insert the four socket head screws and tighten evenly.
5. Replace the coil as stated previously.
6. Add a small quantity of refrigerant R-134a to the low side of the system. Check for leaks. Return the system to normal operation.

9.7 EXPANSION VALVE

9.7.1 Central System

The expansion valve for the central system is a thermo-sensitive valve with a remote control bulb head attached to the evaporator outlet line and is accessible by the evaporator coil access door (Fig. 13 & 30). The valve regulates the flow of refrigerant liquid into the evaporator coils and is controlled by the suction gas temperature leaving the evaporator. The bulb head senses the refrigerant gas temperature as it leaves the evaporator. High temperature will cause expansion and pressure on the power head and spring. Such action causes the assembly valve to open, allowing a flow of refrigerant liquid into the evaporator.

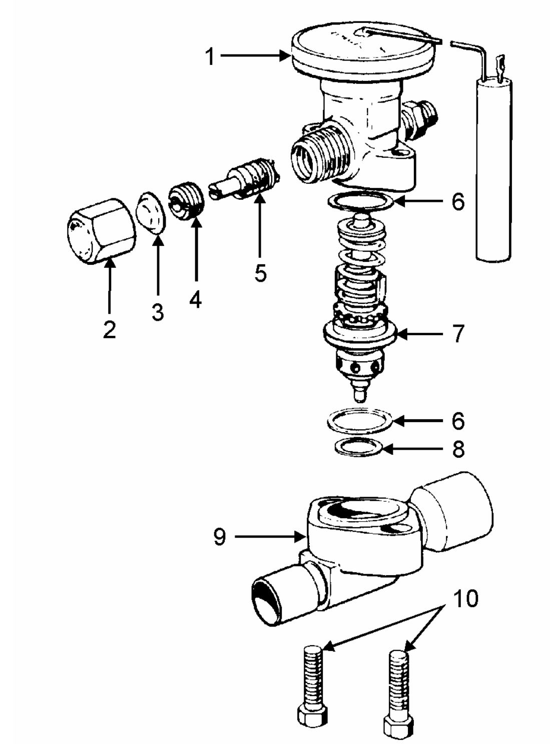
The remote bulb and power assembly is a closed system. The pressure within the remote bulb and power assembly corresponds to the saturation pressure of the refrigerant temperature leaving the evaporator and moves the valve pin in the opening direction. Opposed to this force, on the under side of the diaphragm and acting in the closing direction, is the force exerted by the superheat spring. As the temperature of the refrigerant gas at the evaporator outlet increases above the saturation temperature corresponding to the evaporator pressure, it becomes superheated. The pressure thus generated in the remote bulb and power assembly surpasses the combined pressures of the evaporator pressure and the superheat spring, causing the valve pin to move in the opening direction. Conversely, as the temperature of the **refrigerant** gas leaving the evaporator decreases, the pressure in the remote bulb and power assembly also decreases and the combined evaporator and spring pressures cause the valve pin to move in the closing position.

As the operating superheat is raised, the evaporator capacity decreases, since more of the evaporator surface is required to produce the superheat necessary to open the valve. It is obvious, then, that it is most important to adjust the operating superheat correctly and that a minimum change in superheat to move the valve pin to full open position, is of vital importance because it provides savings in both initial evaporator cost of operation. Accurate and sensitive control of the refrigerant liquid flowing to the evaporator is necessary to provide maximum evaporator capacity under load conditions. The spring is adjusted to give 12 to 16^{o} F (-11.1 to -8.8 ^{o} C) of superheat at the evaporator outlet.

This ensures that the refrigerant leaving the evaporator is in a completely gaseous state when drawn into the suction side of the compressor. Liquid would damage the compressor valve, piston and heads if allowed to return in the suction line.

A vapor is said to be superheated when its temperature is higher than the saturation temperature corresponding to its pressure. The amount of the superheat is, of course, the temperature increase above the saturation temperature at the existing pressure.

As the refrigerant moves along in the evaporator, the liquid boils off into a vapor and the amount of liquid decreases until all the liquid has evaporated due to the absorption of a quantity of heat from the surrounding atmosphere equal to the latent heat of vaporization of the refrigerant. The gas continues along in the evaporator and remains at the same pressure. However, its temperature increases due to the continued absorption of heat from the surrounding atmosphere. The degree to which the gas refrigerant is superheated is related to the amount of refrigerant being fed to the evaporator and the load to which the evaporator is exposed.



1. POWER ELEMENT
2. CAP - SEAL NUT
3. BONNET - SEAL (FLARE)
4. PACKING NUT
5. ADJUSTING STEM & PACKING ASSY
6. GASKET
7. CAGE ASSY
8. GASKET
9. BODY FLANGE
1O. CAPSCREW

FIGURE 31: EXPANSION VALVE 22045

Superheat Adjustment

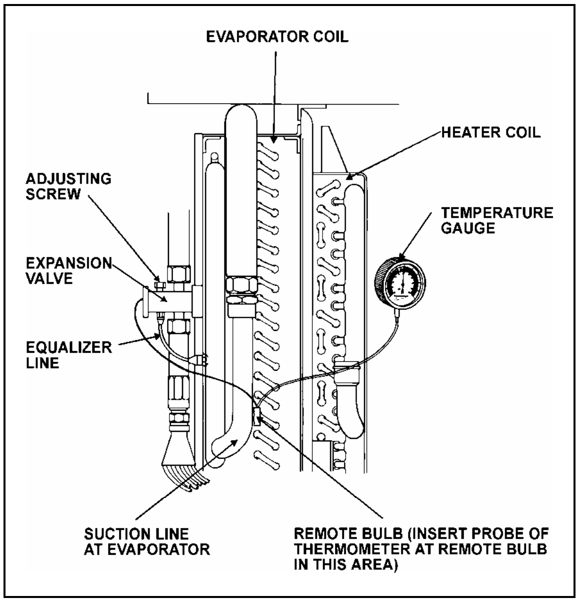


FIGURE 32: SUPERHEAT ADJUSTMENT INSTALLATION 22046

The starting method of adjusting the superheat is to unscrew completely the main evaporator expansion valve adjusting screw, then screw in 13 turns clockwise for 134A (Fig. 31). Afterwards, the following procedure should be followed:

1. Operate coach for at least one-half hour at fast idle with temperature control set at 82^{o}F (27,7^{o}C), Then set temperature to minimum to keep the compressor on 6 cylinders.
2. Install pressure gauge at the evaporator suction header. You may install the pressure gauge at compressor suction, but then add 3 psi to reading.
3. Install a remote reading thermometer to the evaporator outlet line near the existing remote bulb (Fig. 31).
4. Apply thermostatic tape around the bulb and evaporator outlet line to get a true reading of the line temperature.
5. Block condenser if necessary to keep pressure over 150 psi.
6. Check approximately 5 readings of pressure at 2-minute intervals and convert to temperature using the temperatures & pressures table (page 31). Likewise check the temperature reading at the remote bulb at the same 2-minute intervals and record the low and high swing readings of the needle (refer to Fig. 32).

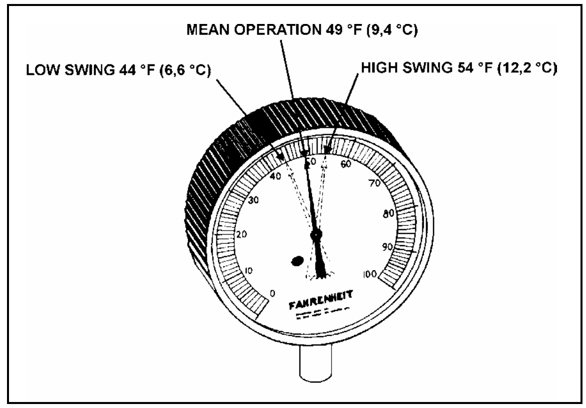


FIGURE 33: HIGH & LOW SWING TEMPERATURE AT REMOTE BULB 22047

Example of readings taken at fig. 32:

A/C pressure gauge converted to temperature at expansion valve fitting	Temperature on remote bulb	
40°F(4,4°C)	Low-swing 44°F (6,6°C)	High swing 54°F (12,2°C)
Formula for superheat 49°F-40°F=9°F (9,4°C-4,4°C = 5°C)	Average of low and high swing is 49°F (9,4°C)	

Note: *The low swing of the superheat should be a minimum of 4°F (2,2°C) higher at the remote bulb and have an average of 8 to 12°F (4 to 6°C) higher range at the bulb than the fitting at the expansion valve.*

Note: *To reduce the superheat, flow of refrigerant is increased by turning adjusting screw of expansion valve lower evaporator temperature counterclockwise. To increase temperature or increase superheat, flow of refrigerant is reduced by turning adjustment screw of expansion valve clockwise.*

6. Regulate suction pressure to temperature reading according to temperature chart or to

the R-134a temperature scale on the pressure gauge.

Example: Suction pressure 30 psi (207 kPa) converted to 32°F (0°C) on chart. If temperature reading is 40°F (4,4°C), subtract 32°F (0°C) and the result will be 8°F (4,4°C) of superheat.

Caution: *Before proceeding to the expansion valve adjustment, check for restriction on suction side for plugged filter dryer and partially open valves. These conditions will give a high superheat.*

Maintenance

1. Pump down the system as previously indicated in this section.

2. Disconnect the external equalizer line from the under side of the power head, and unclamp the remote control bulb from the evaporator coil outlet line.

3. Remove the two cap screws holding the power assembly to the valve body flange. Lift off the power assembly and remove the cage assembly.

4. When reassembling, replace with the new gaskets in proper location. Make sure the two lugs on the cage assembly fit into grooves provided in the power assembly. Do not force the valves together. The cage must fit properly before tightening the body flange. Tighten bolts evenly.

5. Check for leaks.

Safety Instructions

1. Make sure the valve is installed with the flow arrow on the valve body corresponding to the flow direction through the piping system.

2. Before opening any system, make sure the pressure in the system is brought to and remains at the atmospheric pressure. Failure to comply may result in system damage and/or personal injury.

9.7.2 Driver's System

The function and operation of the expansion valve for the driver'' system are similar to the main system, but no superheat adjustment is required (see figures 18 and 19).

9.8 TORCH BRAZING

Use an electrode containing 35% silver.

Caution: *When using heat near a valve, wrap with a water saturated rag to prevent overheating of vital parts.*

Warning: *Before welding any part of refrigeration system, make sure the area is well ventilated.*

9.9 TROUBLESHOOTING

9.9.1 Expansion Valve

PROBABLE CAUSE	PROBABLE REMEDY
LOW SUCTION PRESSURE-HIGH SUPERHEAT	
EXPANSION VALVE LIMITING FLOW:	
Gas in liquid line due to pressure drop in the line or insufficient refrigerant charge.	Locate cause of line flash and correct by use of any of the following methods. Add R-134a. Replace or clean filter dryer.
Inlet pressure too low from excessive low condensing temperature. Resulting pressure difference across valve too small.	Increase head pressure. Verify pressure switch for fan speed control.
Superheat adjustment too high.	Adjust superheat as outlined under "Superheat Adjustment".
Power assembly failure or partial loss of charge.	Replace power assembly or replace valve.
Air filter screen clogged.	Clean or replace air filter screen.
Plugged lines.	Clean, repair or replace lines.
LOW SUCTION PRESSURE-LOW SUPERHEAT	
Uneven or inadequate evaporator loading due to poor air distribution or liquid flow.	Balance evaporator load distribution by providing correct air or liquid distribution.
HIGH SUCTION PRESSURE-HIGH SUPERHEAT	
Compressor discharge valve leaking.	Replace or repair valve.
HIGH SUCTION PRESSURE-LOW SUPERHEAT (DEFECTIVE UNLOADER)	
Valve superheat setting too low.	Adjust superheat as outlined under "Superheat Adjustment".
Compressor discharge valves leaking.	Replace or repair discharge valve.
Incorrect superheat adjustment.	Superheat adjustment 12 to 16°F.
FLUCTUATING DISCHARGE PRESSURE	
Insufficient charge.	Add R-134a to system.

PROBABLE CAUSE	PROBABLE REMEDY
HIGH DISCHARGE PRESSURE	
Air or non-condensable gases in condenser.	Purge and recharge system.
Overcharge or refrigerant.	Bleed to proper charge.
Condenser dirty.	Clean condenser.

9.9.2 A/C

TROUBLE	CAUSE
Low suction pressure and frosting at dryer outlet.	Clogged filter.
Low Oil Level.	Check for oil leaks and for leaking oil seal. Do not attempt to check oil level unless system has been stabilized at least 20 minutes. See oil level verification.
Excessively cold suction line.	Loss of contact between the expansion valve bulb and the suction line or sticking of the expansion valve. Check for foreign matter and clean, repair or replace the valve.
Excessively cold suction line and noisy compressor.	Check superheat adjustment. Check remote bulb contact. Check expansion valve for sticking.
Compressor squeaks or squeals when running.	Check oil level. Replace oil seal.
Noisy or knocking compressor.	Check for broken internal parts. Overhaul if required.
Compressor vibrates.	Check and tighten compressor mounting bolts and belt tension.
Low refrigerant level	Check for refrigerant leaks and add refrigerant if required.
Suction pressure rises faster than 5 pounds per minute after shutdown.	Check compressor valve for breakage or damage.
Insufficient cooling.	Check for refrigerant leaks. Check condition of air filter and motors.
Insufficient air flow.	Dirty or iced evaporator. Dirty air filter. Blowers inactive. Clogged ducts.
No flow of refrigerant through expansion valve.	Filter dryer is clogged. Remote bulb has lost charge or expansion valve is defective.
Expansion valve hisses. Bubbles in moisture and liquid indicator.	Gas in liquid line. Add refrigerant.
Loss of capacity Superheat too high.	Clogged filter. Obstructed or defective expansion valve. Reset superheat adjustment. Check for clogged external equalizer line, or filter dryer.
Reduced air flow: a. Dirty or clogged air filter; b. Evaporator motor inoperative; or c. Plugged return air ducts.	Dirty or iced evaporator coil. Clean air filter screen. Check return ducts for obstructions. Check blower motor.

<table>
<tr><th>TROUBLE</th><th>CAUSE</th></tr>
<tr><td></td><td></td></tr>
<tr><td>Frequent starting and stopping on low pressure control switch.</td><td>Lack of refrigerant. Check for leaks. Recharge.</td></tr>
<tr><td>Compressor intermittently starts and stops.</td><td>Intermittent contact in electrical control circuit. Compressor valves not in operating position.</td></tr>
<tr><td>Non-condensable in the refrigeration system.</td><td>Leak on system, system in vacuum in low temp. Specific symptom, pressure in system will not correspond to ambient temperature on shutdown. Only non-condensable will cause this.

(Example: Pressure of idle R-134a system in 80°F (26.6°C) room should be 86.4 psi (595.7 kPa). See temperature chart in this section.)

An evaporator just does a proper cooling job without sufficient air. Shortage of air can be caused by the following:

• Dirty filters; or
• Dirty coils.</td></tr>
<tr><td colspan="2">Testing condenser pressure.

Note: R-134A pressure is function of the temperature variation.

Example, for an exterior temperature of 100°F.
Exterior temperature (100°F) + 30°F = 130°F. Refer to paragraph "10.11 Temperature & Pressure".
Note the corresponding pressure for a temperature of 130°F., 199.8 psi.
Read the condenser pressure, example 171.9 psi.
171.9 psi 199.8 psi, the pressure in the condenser is inferior to the pressure corresponding to the exterior temperature, then condenser pressure may be to low. Check for refrigerant leaks and add refrigerant if necessary. If the pressure corresponding to the condenser temperature is superior to the pressure corresponding to the exterior temperature, then air cooled condenser pressure may be to high. Most frequent causes are:

Reduced air quantity. This may be due to:
• Non-condensable in system;
• Dirt on the coil;
• Restricted air inlet or outlet;
• Dirty fan blades;
• Incorrect rotation of fan;
• Fan speed too low;
• Fan motor going out on overload; or
• Prevailing winds.
• Too much refrigerant in system. Remove refrigerant if necessary.</td></tr>
</table>

9.10 TEMPERATURES & PRESSURES

VAPOR-PRESSURE			
TEMPERATURE		PRESSURE	
°F	°C	psi	kPa
-100	-73.3	27.8	191.7
-90	-67.8	26.9	185.5
-80	-62.2	25.6	176.5
-70	-56.7	23.8	164.1
-60	-51.1	21.5	148.2
-50	-45.6	18.5	127.6
-40	-40.0	14.7	101.4
-30	-34.4	9.8	67.6
-20	-29	3.8	26.2
-10	-23	1.8	12.4
0	-18	6.3	43.4
10	-12	11.6	80
20	-7	18.0	124.1
30	-1	25.6	176.5
40	4	34.5	237.9
50	10	44.9	309.6
60	16	56.9	392.3
70	21.1	70.7	487.5
80	27	86.4	595.7
90	32.2	104.2	718.5
100	38	124.3	857.0
110	43.3	146.8	1012.2
120	49	171.9	1185.3
130	54.4	199.8	1377.6
140	60	230.5	1589.3
150	65.6	264.4	1823.0
160	71	301.5	2078.8
170	76.7	342.0	2358.1

VAPOR-PRESSURE			
TEMPERATURE		PRESSURE	
°F	°C	psi	kPa
180	82.2	385.9	2660.8
190	87.8	433.6	2989.7
200	93.3	485.0	3344.1
210	98.9	540.3	3725.4

9.11 LEAK TESTING

Some methods such as nitrogen pressure and soap, and electronic sniffer can be used for leak testing. However, the most common method used is a "Halide" torch consisting of an acetylene tank, a burner and a suction test hose. Proceed as follows:

Warning: *Do not inhale fumes from leak detector.*

The flow of acetylene to the burner causes a suction in the test line. Any gas refrigerant present will be drawn through the hose and into the burner where it decomposes into free acids.

These acids come in contact with the hot copper reaction plate in the burner, causing color reaction in the flame. A small concentration is indicated by a green tint and a large concentration by an intense blue. Do not confuse this change in color with the change caused by shutting off the air supply through the hose by holding the end too close to an object.

The procedure for testing is:

1. Adjust flame so that the top of the cone is approximately level or within one-half inch above the plate.
2. Probe end of suction test tube around all joints, valves, etc. When a leak has been found at a soldered joint, that section of the system must be pumped down. Do not solder as pressure will force hot solder out. If the system is empty, it is more economical to put in just enough R-134a to produce about 15 psi (103 kPa). The pressure can be raised to about 150 psi (1034 kPa) with dry nitrogen.

Note: *This gas is put into the suction and discharge shutoff valves at the compressor. The receiver valves must be opened. If no leaks are found, dump this mixture, evacuate the system and fill with refrigerant.*

10. AUXILIARY AIR CONDITIONING SYSTEM AND COMPONENTS

10.1 COMPRESSOR

MODEL	TM-16HD
TYPE	Swash-plate type
Number of cylinders	6
Bore	36 mm (1.42”)
Stroke	26.7 mm (1.05”)
Displacement	163 cm³ (10cu.in)
Permissible speed	700-6000 rpm
Refrigerant	HFC-134a
Lubricant	ZXL100PG 180 cm³
Mass	4.9 kg (10.9 lbs)

10.2 MAGNETIC CLUTCH

TYPE	Electromagnetic single-plate dry clutch
Rated Voltage	24 volts DC
Current consumption	3.75 amperes (max)
Stalling torque	49 Nm (36.1 Ft-Lbs) min
Rotation	CW/CCW
Mass	2.2 kg (4.9 lbs)

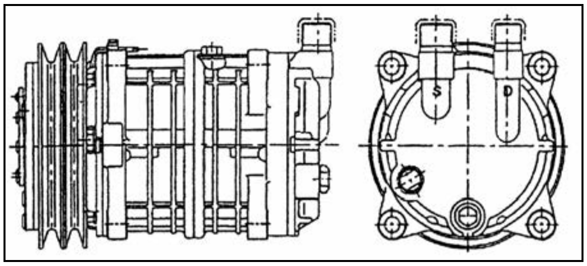


FIGURE 34: SELTEC TM-16HD COMPRESSOR

10.3 MAINTENANCE PRECAUTIONS

10.3.1 Work Area

Because the components of air conditioning systems are especially sensitive to moisture, dirt and dust, always observe the following procedures:

- Work indoors whenever possible.
- Select a level work area.
- Keep work area clean.
- Select a work area with adequate ventilation.

Warning: *Refrigerant itself is not harmful, but excessive accumulation in a closed area can cause oxygen deficiency.*

- Keep open flame and flammables away from the vehicle in which the air conditioning system is being serviced. **Open flame is especially dangerous during Freon leak testing.**

Warning: *Contact with flame and high temperatures can generate toxic gases.*

10.3.2 Refrigerant Handling

Never directly heat refrigerant cylinder or put in hot water heated above 40°C (104°F) since it may cause release of the safety plug or the cylinder may burst. When it is necessary to heat refrigerant cylinder for charging in cold weather, use warm water at a temperature below 40°C (104°F).

Warning: *Do not put the charge valve in the warm water.*

- Never store refrigerant cylinder in direct sunlight, near flame, or where the temperature exceeds 40°C (104°F). Always store refrigerant cylinder in a cool dry place.
- Never throw or strike refrigerant cylinder and never handle roughly.

10.3.3 PAG Oil Handling

Whenever a part replacement has to be done on the system, additional task about PAG oil will have to be performed.

The compressor has little reserve and is lubricated by the oil refrigerant mixture. To perform correctly, the compressor needs the mixture to be from 3% to 6% of Poly Alkaline Glycol (PAG) oil.

When a compressor has to be top off due to a severe lost, the amount of oil to be added should be evaluated with the refrigerant charge or a compressor oil change should be performed to rise up the compressor oil charge to 180 ml or the written charge on the nameplate.

- The oil should be free from moisture, dust, metal shavings, etc.
- Do not mix with other oils.
- The moisture content of the oil increases when exposed to the air for prolonged period. Therefore, after use, seal the container immediately.

DO NOT MIX PAG AND POE OR MINERAL OILS!

10.3.4 Refrigerant Recovery

Some air conditioning system refrigerant compounds are chlorofluorocarbons, and therefore may be damaging the earth's ozone layer. Consequently, the release of refrigerant into the atmosphere must be avoided. Whenever refrigerant is to be released from the air conditioning system, a refrigerant recovery unit must be used to recover the refrigerant. This refrigerant can then be recycled and reused, which is both environmentally safe and economical.

For complete system recovery, any of the High and Low service ports can be used (Refer to fig. 18 & 19). Energize liquid solenoid valve and measure the quantity of oil recovered. For the compressor only, use the service valve port and close the valves. The service valves open permits full flow of refrigerant to service port. Service valve closed permits flow of refrigerant from compressor to service port.

10.3.5 Compressor Handling

Do not strike, drop or turn the compressor upside down. If the compressor is knocked over or turned upside down, rotate the compressor's magnetic clutch 5 to 6 times by hand to circulate the oil which has settled in the cylinder. Sudden rotation with oil in the cylinder can cause valve damage and adversely affect durability.

10.4 COMPRESSOR REMOVAL

10.4.1 When the compressor is operational

- Perform the "OIL RETURN OPERATION" (Refer to paragraph 10.9).

10.4.2 When the compressor is inoperable

- Perform the "Refrigerant Recovery" operation (Refer to paragraph 10.3.4).
- Remove the compressor.

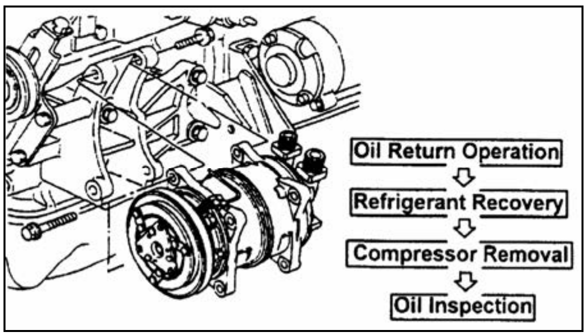


FIGURE 35: COMPRESSOR REMOVAL

10.5 INSTALLATION PRECAUTIONS

The new compressor is filled with the specified quantity of compressor oil and nitrogen gas (N^2). When mounting the compressor on the vehicle, take the following steps:

- Loosen the discharge side connector's cap and gently release N^2 from compressor (Refer to figure 35).

Note: *Take care not to let the oil escape.*

- Slowly rotate the compressor's magnetic clutch several times by hand to distribute the oil which has settled in the cylinders (Refer to figure 36).

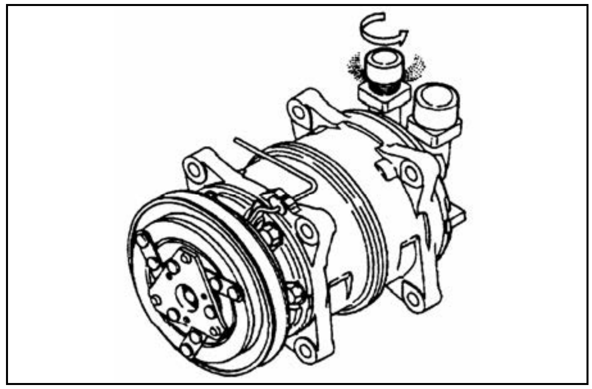


FIGURE 36: LOOSENING THE DISCHARGE SIDE CONNECTOR'S CAP

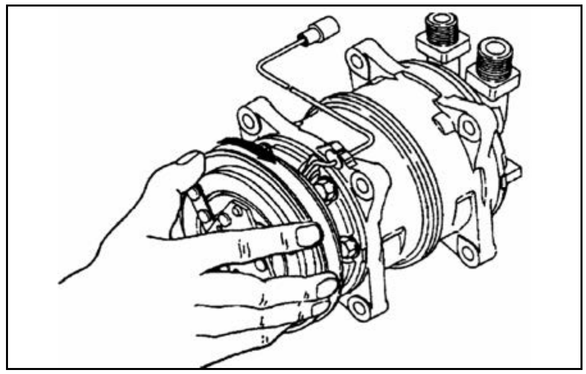


FIGURE 37: ROTATING MAGNETIC CLUTCH

- When using the old compressor in the system, the compressor should be installed after changing the oil.

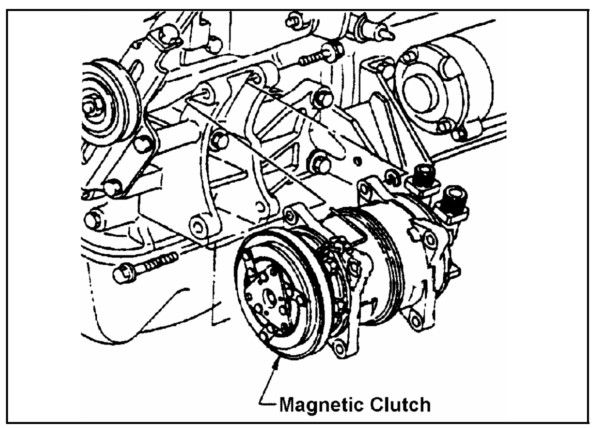


FIGURE 38: COMPRESSOR INSTALLATION

10.6 COMPRESSOR OIL CHANGE

Each compressor is delivered filled with the specified quantity of compressor oil, depending on the type of air conditioning system. A label describing the amount/type of compressor oil is attached to the compressor.

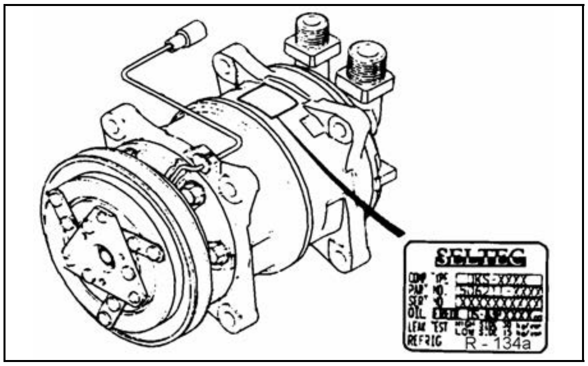


FIGURE 39: COMPRESSOR OIL LABEL

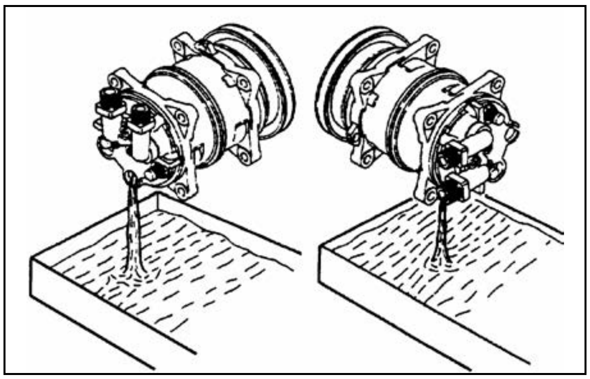


FIGURE 40: DRAINING THE OIL

- Check oil for contamination. Refer to PARAGRAPH 10.8: “COMPRESSOR OIL CONTAMINATION”.
- Tighten the oil drain plug with a new o’ring lightly coated with clean compressor oil to specified torque.

Torque: 13-15 Nm (9.4-10.8 Ft-Lbs)

- Add new compressor oil through the suction-side connector with the amount specified on the label (180 ml).

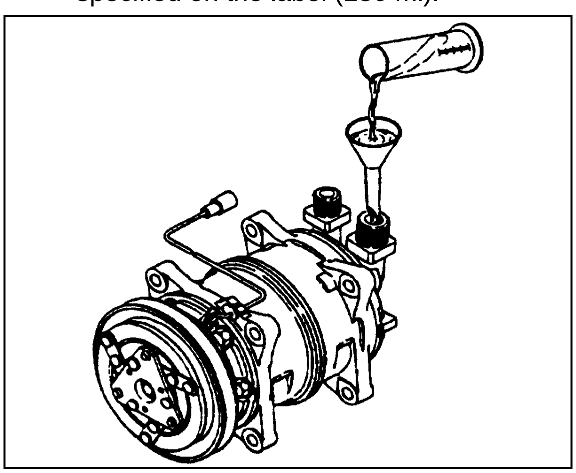


FIGURE 41: ADDING NEW COMPRESSOR OIL

10.6.1 Evacuating System Before Adding Refrigerant (Driver’s or Auxiliary System)

When a system has been opened for repairs, change the filter dryer and evacuate the system. XL2-45 coaches equipped with an auxiliary system or XL2 MTH equipped with a driver’s system must use high-pressure service port located on the other side of check valve and low-pressure port located alongside rear truss. (Fig. 18 and 19). It would be good practice to open solenoid valve.

1. Connect two hoses equipped with a micron gauge between the high-pressure service port, the low-pressure service port and the vacuum pump.
2. With the unit service valves open and the vacuum pump valves open, start the pump and draw the manifold and hoses into a very deep vacuum (700 microns).
3. Close manifold valve
4. Shut down the vacuum pump.
5. Check to insure that vacuum holds. (If the pressure continues to rise, it indicates a leak or moisture in the system).
6. Charge the system with the proper amount of refrigerant through the service port near the check valve using recommended charging procedures.
7. Remove the hoses.

10.7 OIL ADDITION

The chart below shows the approximate amount of oil to be added to the system when replacing a component.

Component replaced	Typical amount of oil
Evaporator	50 cm³ (1.7 ozs)
Condenser	30 cm³ (1.0 ozs)
Filter-Dryer	10 cm³ (0.3 ozs)

The amount of oil recovered with the refrigerant recovery should be added at the same time.

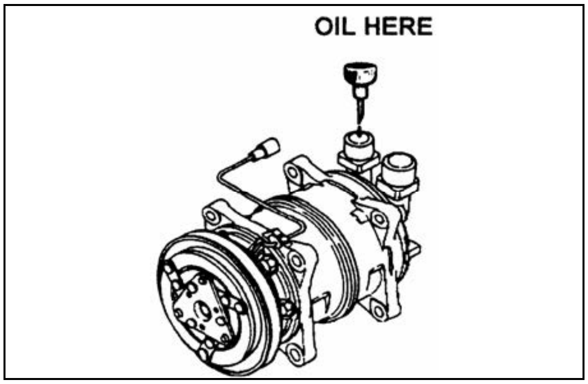


FIGURE 42: ADDING OIL AFTER REPLACING A COMPONENT

10.8 COMPRESSOR OIL CONTAMINATION

Unlike engine oil, no cleaning agent is added to the compressor oil. Even if the compressor is run for a long time, the oil never becomes turbid as long as there is nothing wrong with the compressor or its method of use. Inspect the extracted oil for any of the following conditions:

- Dirt in the oil.
- Change to a varnish color.
- Presence of foreign substance, metal shavings, etc. in the oil. When the oil extracted from the compressor is as described above, replace the oil as follows:

1. Clean the interior of the system with approved method.
2. Replace the filter-dryer.
3. Supply with new oil as specified in paragraph 10.6: "COMPRESSOR OIL CHANGE".

10.9 OIL RETURN OPERATION

There is a close affinity between oil and refrigerant. During normal operation, part of the oil recirculates with the refrigerant in the system. Therefore, when checking the amount of oil in the system or replacing any system component, the compressor must be run in advance to ensure return. This procedure is as follows:

- If the amount of refrigerant in the system has decreased, charge to the proper amount.
- Start the engine and select fast idle.
- Set the fan speed to full air/full A/C and let run for 20 minutes.

10.10 OIL CHECK INTERVAL

Unlike engine oil, it is not necessary to frequently check or change the compressor oil. However, it is necessary to check and replenish or replace the compressor oil in the following cases:

- Whenever the compressor, evaporator, condenser or filter-dryer is replaced.
- Whenever refrigerant has leaked from the system, evaluate the amount of oily spot.
- Whenever refrigerant is suddenly released from the cooling cycle, replenish the compressor (180 ml) plus 150 ml.
- Whenever any oil-related problems occur in the cooling cycle.

10.11 LEAK TEST PROCEDURE WITH COMPRESSOR REMOVED

When a compressor is repaired, it must be checked prior to installation.

- Install the discharge and suction caps to the connector.

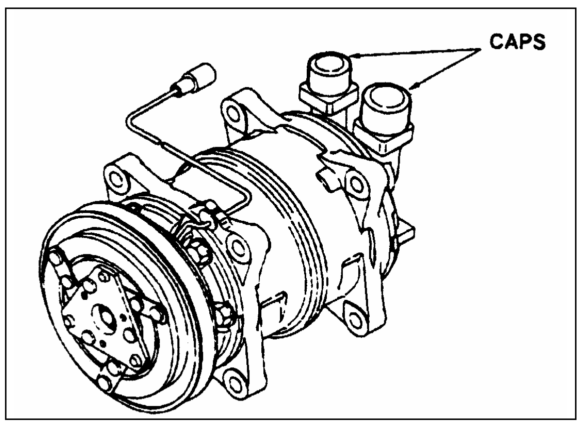


FIGURE 43: DISCHARGE AND SUCTION CAPS

- Fill the compressor with refrigerant through connector's suction port raising the pressure to at least 0.5 Mpa (70 psi).
- Check the compressor for leaks using a leak detector.

Note: *Never leave the compressor upside down for longer than 30 seconds. This is because the oil inside the compressor will enter the cylinders, causing liquid compression which will damage the compressor's suction and delivery valves.*

10.12 TIGHTENING TORQUES

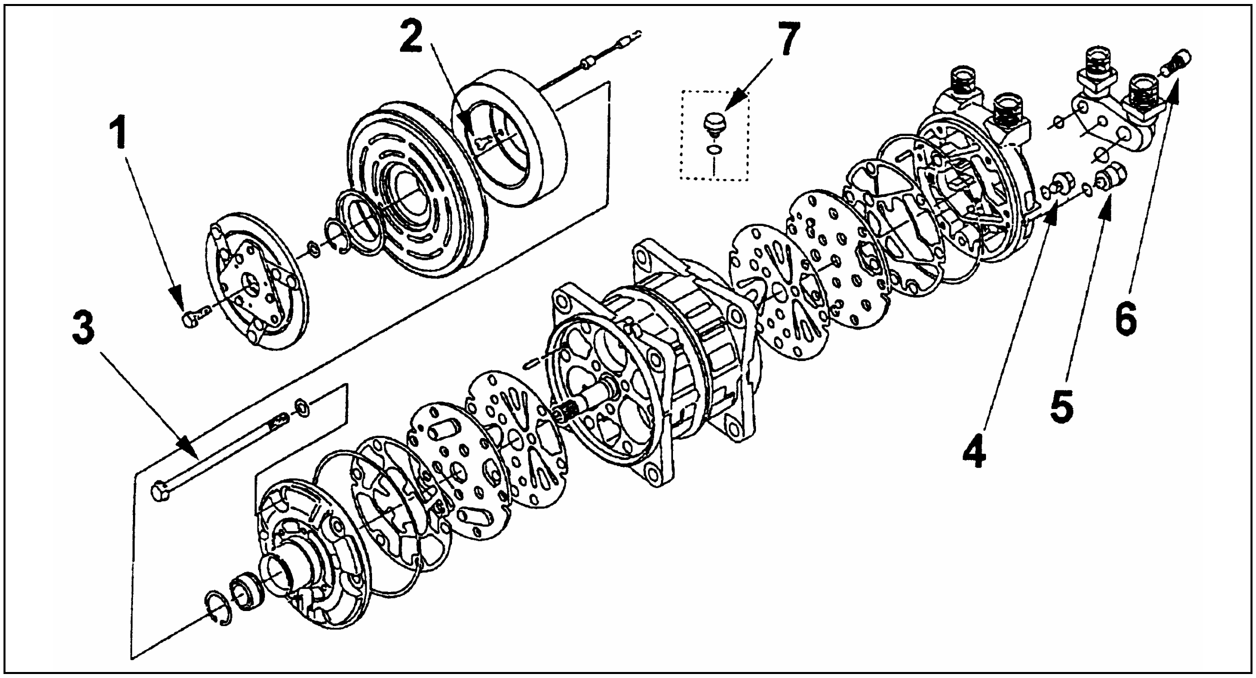


FIGURE 44: TIGHTENING TORQUES

PART	THREAD SIZE	TIGHTENING TORQUE
1. Bolt Armature	M6 x 1.0	12 - 14 Nm (8.7 - 10.1 Ft-Lbs)
2. Field Coil Screw	M5 x 0.8	4 - 6 Nm (2.9 - 4.3 Ft-Lbs)
3. Body Bolt	M8 x 1.25	20 – 24 Nm (14.5 – 17.3 Ft-Lbs)
4. Oil Drain Plug	M8 x 1.25	13 – 15 Nm (9.4 – 10.8 Ft-Lbs)
5. Pressure Relief Valve	3/8 – 24UNF	13 – 15 Nm (9.4 – 10.8 Ft-Lbs)
6. Connector Bolt	M8 x 1.25	20 – 24 Nm (14.5 – 17.3 Ft-Lbs)
7. Oil Filler Plug	M8 x 1.25	13 – 15 Nm (9.4 – 10.8 Ft-Lbs)

11. HEATING SYSTEM

The schematics of Figures 44 and 45 show respectively, the central heating system and the driver's heating system with their components.

In addition to the normal heating provided by the engine, a preheating system (104,000 Btu/hr) (optional on coaches only) may have been installed in the vehicle.

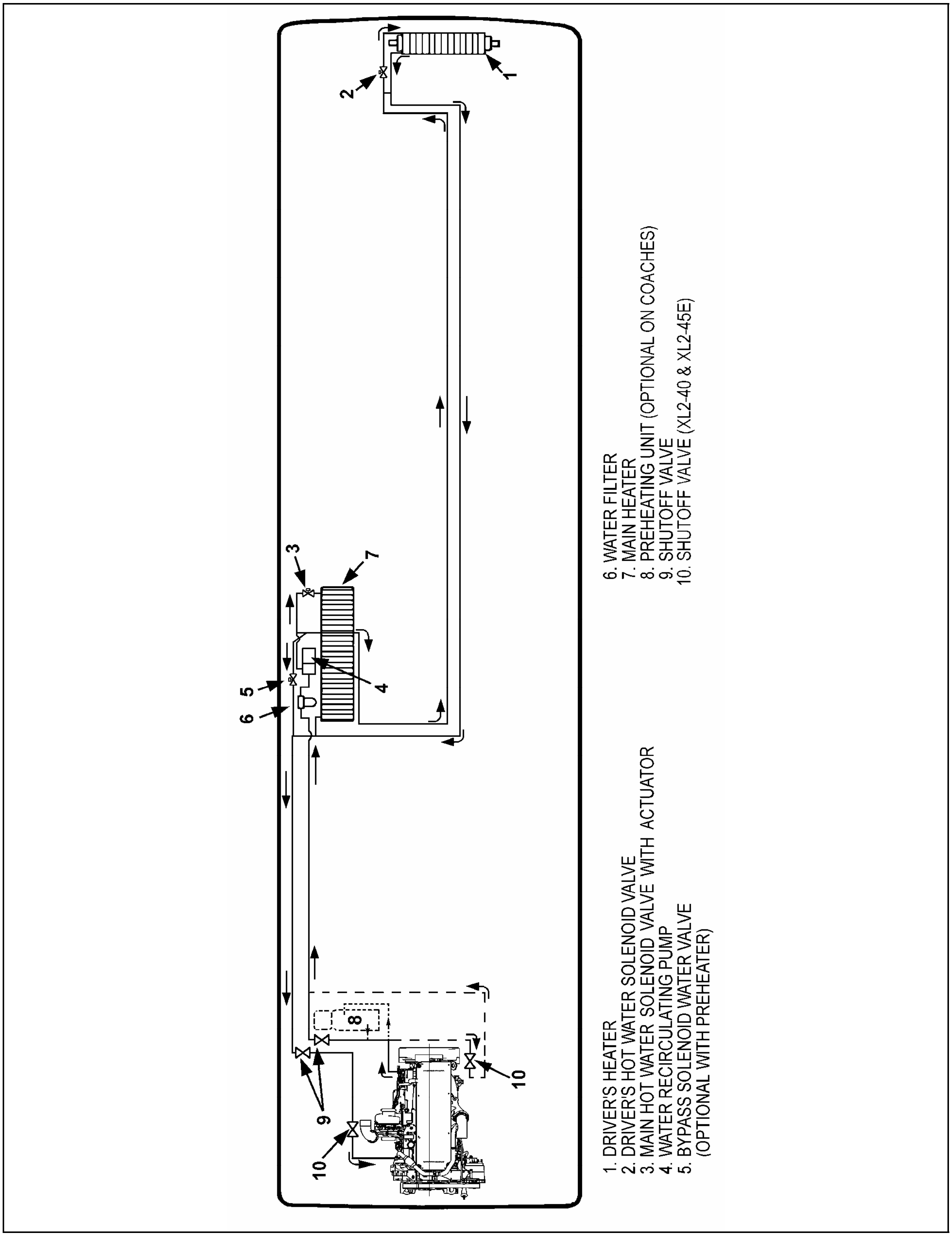


FIGURE 45: CENTRAL HEATING SYSTEM COMPONENTS 22237

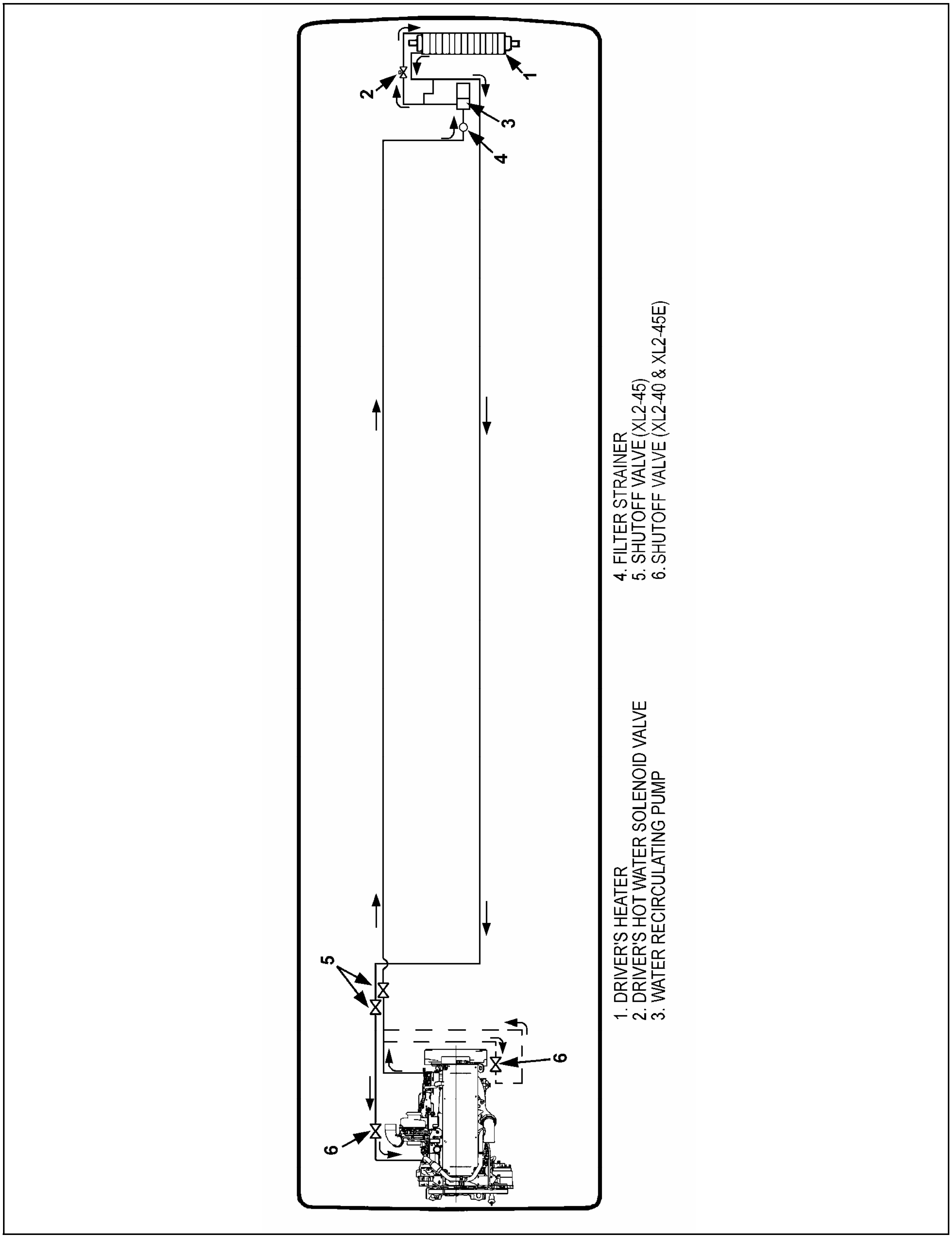


FIGURE 46: DRIVER'S HEATING SYSTEM COMPONENTS (VEHICLES EQUIPPED WITH DRIVER'S SYSTEM ONLY) 22238

11.1 DRAINING HEATING SYSTEM

To drain the entire system, refer to Section 05, *"Cooling"*. If only the driver's or main heater core must be drained, refer to the following instructions.

11.1.1 Draining Driver's Heater Core

1. Stop engine and allow engine coolant to cool.
2. Locate the normally open water solenoid valve on the ceiling of the spare wheel compartment (Fig. 46), disconnect its wiring connector, then connect a 24-volt external power source, using jumper cables, to close valve.

Warning: *Before proceeding with the following steps, check that coolant has cooled down.*

3. Loosen hose clamp, install an appropriate container to recover coolant, and disconnect silicone hose from water solenoid valve.
4. From inside of vehicle, remove the two finishing panels in front of unit. Remove the three screws fixing the unit front panel. Open the manual vent located inside the HVAC unit, on the driver's side (Fig. 47) to ensure an efficient draining.

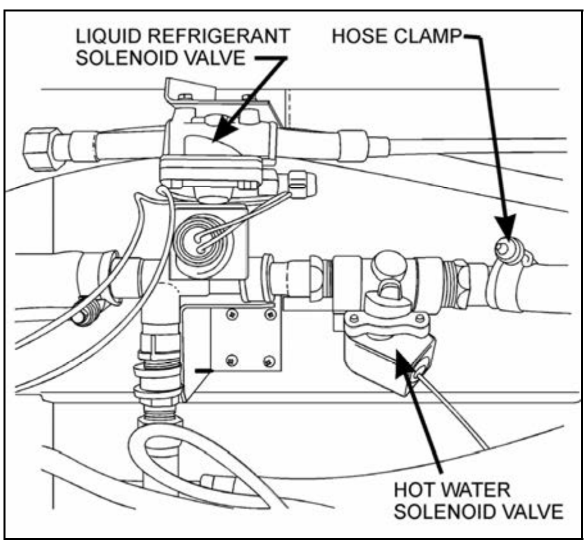


FIGURE 47: CEILING OF THE SPARE WHEEL COMPARTMENT 22181

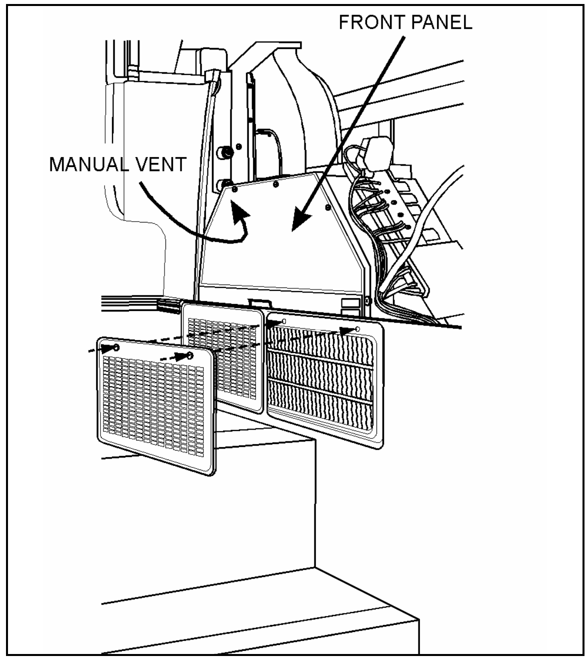


FIGURE 48: DRIVER'S HVAC UNIT 22172

11.1.2 Draining Main Heater Core

1. Stop engine and allow engine coolant to cool.
2. Close both heater line shutoff valves.

On XL2-40 & 45E vehicles, the valves are located in engine compartment. One is on the R.H. side of compartment and is accessible through engine compartment R.H. side door (Fig. 48).

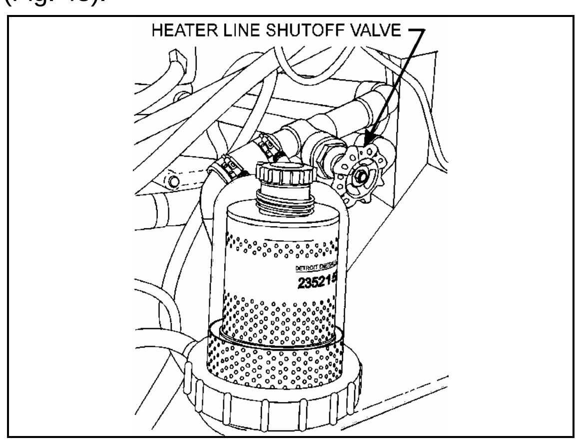


FIGURE 49: HEATER LINE SHUTOFF VALVE 05070

Another valve is located in the engine compartment under the radiator fan gearbox (Fig. 49).

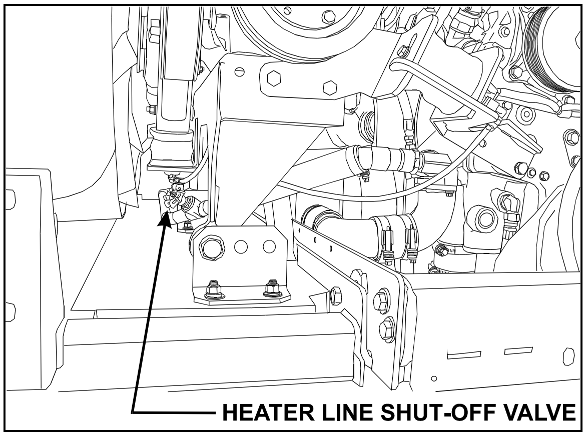


FIGURE 50: ENGINE COMPARTMENT 05078

On XL2-45 vehicles, one valve is located in the engine compartment, under the radiator fan gearbox (Fig. 49), another valve is located in the engine compartment behind splash guard panel at rear of vehicle (behind L.H. side tag axle wheel) (Fig. 50).

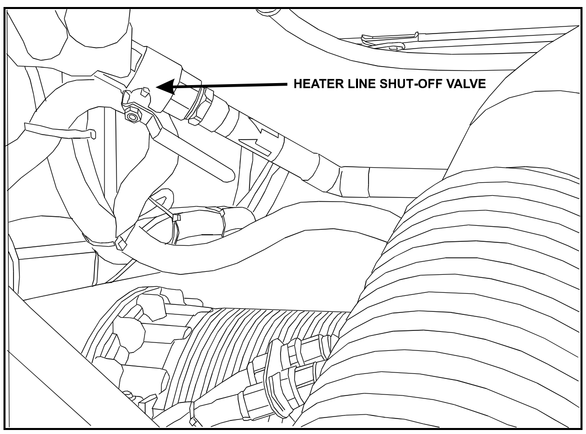


FIGURE 51: HEATER LINE SHUT-OFF VALVES 05067

3. Open the last L.H. side baggage compartment door, then pull the black release button located on the L.H. side in order to unlock and open the evaporator compartment door.

Warning: *Before proceeding with the following step, check that coolant has cooled down.*

4. Open drain cock in bottom of heater core, then open manual vent located on top of heater core (Fig. 51) in order to allow air to enter while draining.

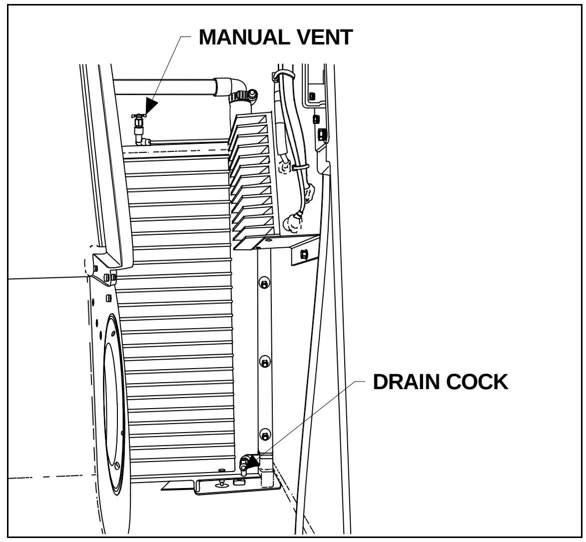


FIGURE 52: EVAPORATOR COMPARTMENT 22128

11.2 FILLING HEATING SYSTEM

1. Ensure that the drain hose is reconnected and the manual vents and drain cock are closed.
2. Open the surge tank filler cap and slowly fill the system to level of filler neck.
3. After initial filling, the water valves should be open and the water recirculating pump should be energized to assist in circulating coolant through the heating system. To perform this operation, start the engine, switch on the HVAC control unit, both driver and passenger sections, and set temperature to their maximum positions in order to request the heating mode in each of these sections.
4. When coolant level drops below the surge tank filler neck, slowly fill the system to level of filler neck.
5. Once the level has been stabilized, replace cap.

11.3 BLEEDING HEATING SYSTEM

Whenever the heating system has been drained and refilled, or the system has run low on coolant and coolant has been added, it is necessary to bleed air from heating system. Locate the manual vents illustrated in Figures 47 and 50, and open them momentarily until no air escapes from the lines.

11.4 SOLDERING

Before soldering any part of the system, make sure the area is well ventilated. Use (stay clean) flux sparingly and apply solder (95-5 round wire 1/8 inch [3,1 mm]). After completing repairs, test for leaks.

When using heat at or near a valve, wrap with a water saturated rag to prevent overheating of vital parts.

11.5 DRIVER'S WATER SOLENOID VALVE

A two-way normally open, internal pilot-operated solenoid valve designed for smooth closing is used to control the coolant flow through the driver's heating unit. It is mounted on the coolant inlet line of the driver's heating unit, and is accessible through the spare wheel compartment (see fig. 47). The valve cannot be manually bypassed.

11.5.1 Improper Operation

1. Faulty control circuit: Check the electric system by energizing the solenoid. A metallic clicking noise indicates that the solenoid is operating. Absence of clicking indicates a loss of power or a defective solenoid. Check for open breaker, open-circuited or grounded coil, broken lead wires.
2. Burned-out coil: Check for open-circuited coil. Replace coil if necessary.
3. Low voltage: Check voltage across the coil leads. Voltage must be at least 85% of nameplate rating.
4. Excessive leakage: Disassemble valve and clean all parts. Replace worn or damaged parts with a complete spare part kit for best results.

11.5.2 Coil Replacement

Turn off electrical power supply and disconnect lead wires. Proceed in the following manner:

1. Remove retaining cap or clip, spacer, name plate and housing.
2. Slip spring washer, insulating washer, coil and insulating washer off the solenoid base sub-assembly. Insulating washers are omitted when a molded coil is used.
3. Coil is now accessible for replacement. Reassemble by reversing sequence of disassembly. Refer to exploded view (Fig. 52) for identification and location of parts.

Note: *Solenoid must be completely reassembled, as the housing and internal parts complete the magnetic circuit.*

Caution: *When metal retaining clip disengages, it springs upwards.*

11.5.3 Valve Disassembly

1. Drain driver's heating unit as previously explained in this section under paragraph *"Draining Heating System".*
2. Disconnect connector from coil connector.
3. Disassemble valve in an orderly fashion paying careful attention to exploded view (Fig. 52) provided for identification of parts.
4. Remove retaining cap and slip the entire solenoid enclosure off the solenoid base subassembly.

Caution: *When metal retaining clip disengages, it springs upwards.*

5. Unscrew solenoid base sub-assembly and remove core, plug nut gasket, plug nut assembly and solenoid base gasket.
6. Remove the four bonnet screws and valve bonnet, disc holder subassembly, disc holder spring, diaphragm/spring subassembly and body gasket.
7. All parts are now accessible for cleaning or replacement. Replace worn or damaged parts with a complete spare part kit for best results.

Caution: *Do not damage valve seat in any manner, as its sealing feature will be affected, thus resulting in continuous leakage.*

11.5.4 Valve Reassembly

1. Reassemble in reverse order of disassembly, paying careful attention to exploded view provided for identification and placement of parts (Fig. 52).
2. Replace body gasket and diaphragm/spring subassembly. Locate bleed hole in

diaphragm/spring subassembly, approximately 45° from valve outlet.

3. Replace disc holder spring and holder subassembly.
4. Replace valve bonnet screws. Torque bonnet screws in a criss-cross manner to 95 ± 10 inch-pounds.
5. Install solenoid base gasket, plugnut assembly and plugnut gasket. Position core (small end up for A-C construction) on plugnut assembly. For D-C construction, be sure plugnut assembly and core are installed with mated ends together.
6. Replace solenoid base subassembly and torque to 175 ± 25 inch-pounds.
7. Refill heating system as previously stated under paragraph *"Filling Heating System*", then bleed air from the driver's heating unit as stated previously under paragraph *"Bleeding heating system".*
8. After maintenance, operate the valve a few times to be sure of proper opening and closing.

Note: *Should diaphragm/spring subassembly become disassembled, be sure to replace the diaphragm/spring support with lip facing upward towards the valve bonnet.*

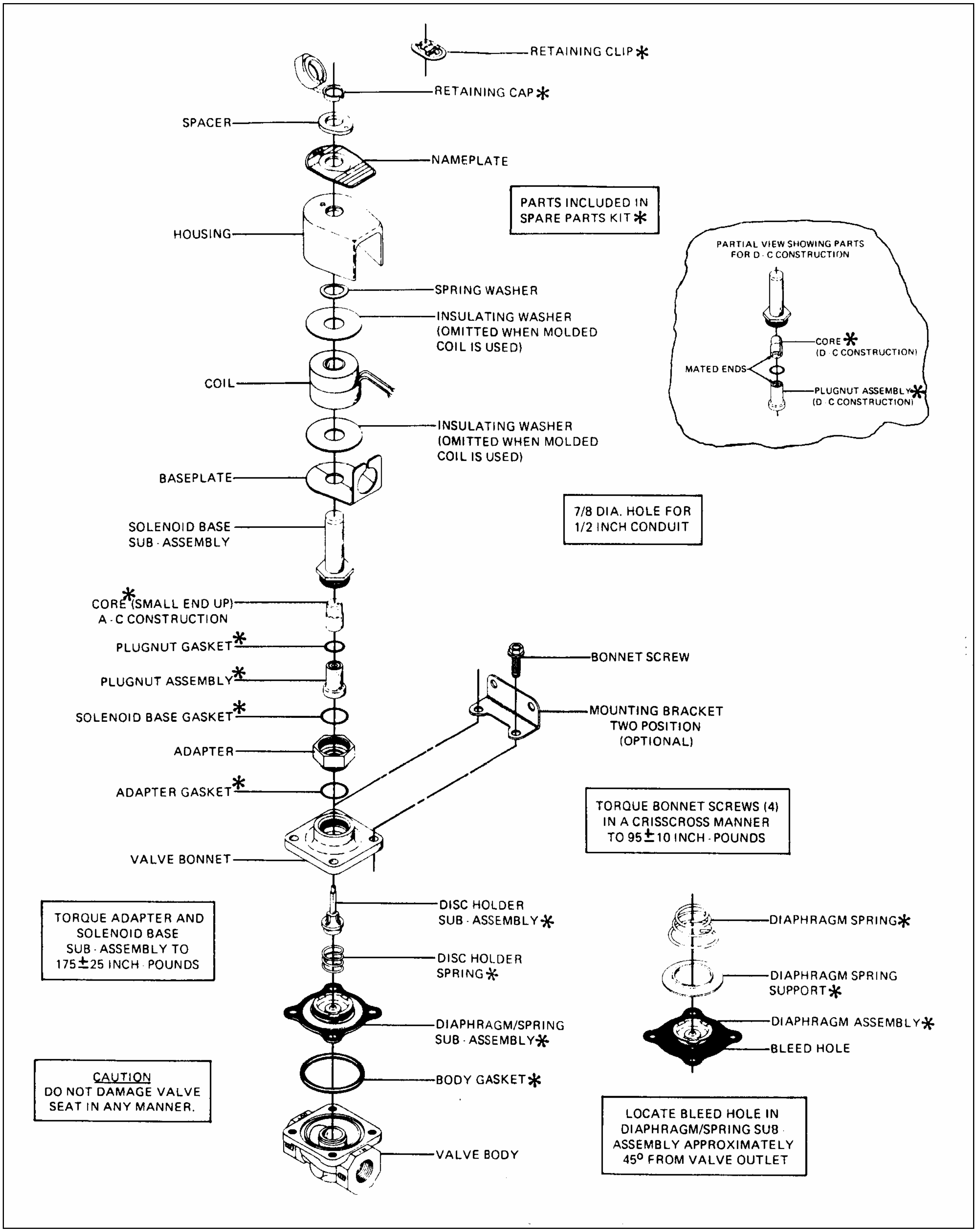


FIGURE 53: DRIVER'S WATER SOLENOID VALVE 22052

11.6 CENTRAL HOT WATER PNEUMATIC VALVE ASSEMBLY

11.6.1 Description

The flow of hot water to the vehicle's central heater core is controlled by a pneumatic NO water valve assembly. The valve, located in the evaporator compartment, is designed so that the pilot solenoid valve, which is part of the assembly opens and closes a port which directs air pressure to the actuator casing, thereby opening or closing the valve.

When the vehicle is operating with no current to the pilot solenoid valve, no air pressure is admitted to the actuator casing, the cylinder spring pushes up against the cylinder, thereby keeping the water valve open.

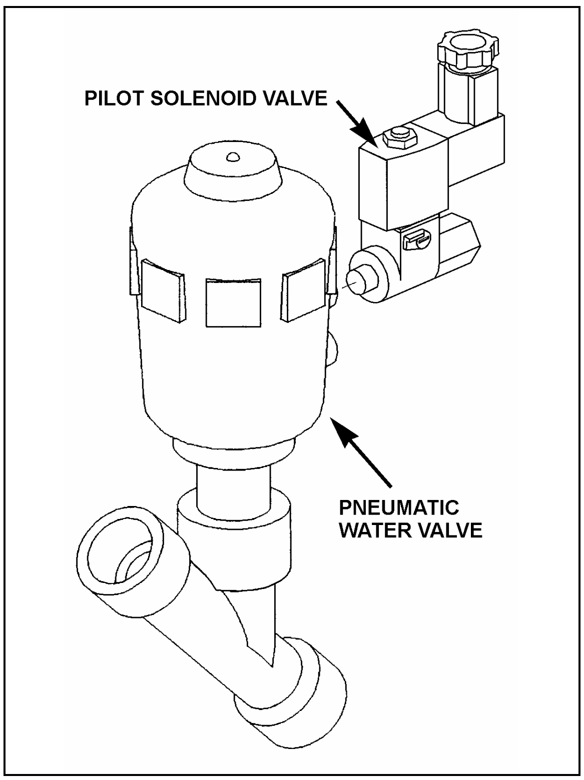


FIGURE 54: CENTRAL HOT WATER PNEUMATIC VALVE ASSEMBLY 22240

The central heater water valve requires a minimum amount of maintenance. The valve should be free of dirt sediment that might interfere with its operation. No other maintenance is needed unless a malfunction occurs.

11.6.2 Pneumatic Water Valve Disassembly

1. Shut off air supply pressure and electrical current to the pilot solenoid valve. Disconnect wires.
2. The water valve need not be removed from the line. Unscrew nipple, the actuator casing, tube, spindle and closure member can be removed (Fig. 54).
3. Remove the snap ring using a pair of pliers.
4. You can now access all seals for replacement

   Pneumatic water valve replacement seal kits:

- Water Side: 871311
- Actuator Side: 871312

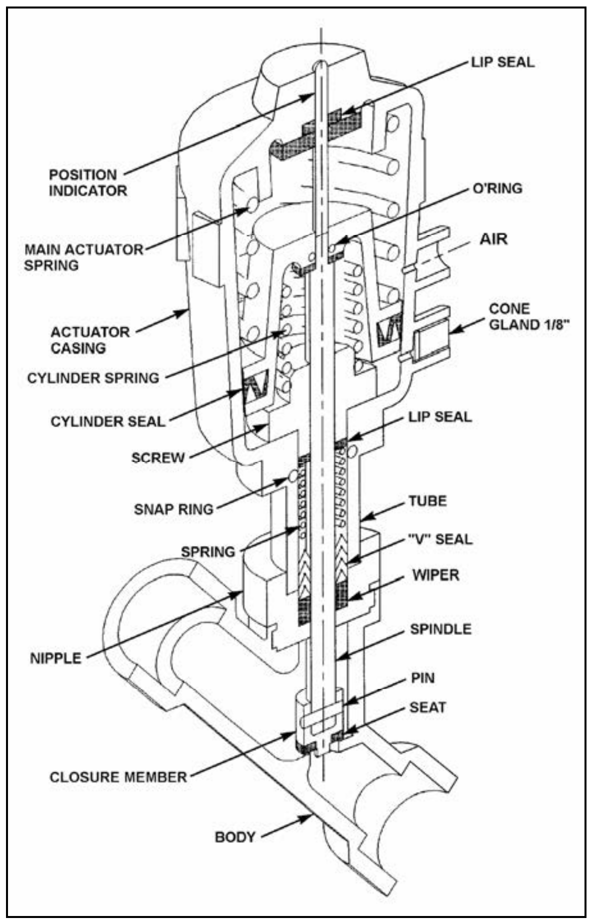


FIGURE 55: PNEUMATIC WATER VALVE 22241

11.6.3 Pneumatic Water Valve Reassembly

1. Assemble the actuator casing, tube, nipple, spindle and closure member.
2. Tighten the nipple in place in the body cavity as per figure 54. Fasten pilot solenoid vale to the pneumatic water valve. Reconnect air supply pressure and electrical current to the pilot solenoid valve.
3. Check for proper operation.

11.6.4 Pilot Solenoid Valve

1. No maintenance is needed unless a malfunction occurs.
2. A pilot solenoid valve replacement seal kit is available: 871311.

11.6.5 Valve Troubleshooting

PROBLEM	PROCEDURE
Valve fails to close.	1. Check electrical supply with a voltmeter. It should agree with nameplate rating. 2. Check pressure at pilot solenoid valve inlet. It must be at least equal to the minimum pressure stamped on the nameplate. It should not go below minimum while valve is operating.
Valve fails to open.	1. Check that the closure member assembly, and that main actuator and cylinder springs are free to travel. 2. Check that there is no restriction to the air escaping from the actuator casing. 3. Make sure that pilot solenoid valve operates properly.

11.7 WATER RECIRCULATING PUMP

11.7.1 Description

This vehicle is provided with a water recirculating pump which is located in the evaporator compartment (vehicles with central system) (Fig. 55) or in the reclining bumper compartment (optional with driver's system). The water recirculating pump consists of a centrifugal pump and an electric motor which are mounted on a common shaft in a compact assembly. A pilot between the pump end and motor cover ensures proper alignment of the complete assembly.

The motor is equipped with prelubricated sealed ball bearings which require no maintenance. A self-adjusting mechanical shaft seal is incorporated in this assembly to prevent coolant leakage between the pump cavity and armature shaft. This seal derives its lubrication from the liquid pumped, and **it will be destroyed if permitted to operate dry.**

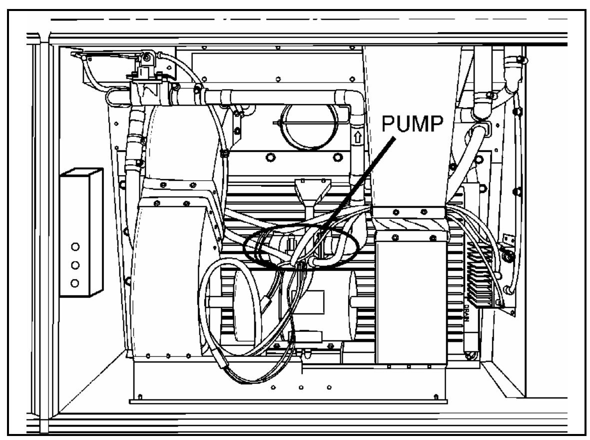


FIGURE 56: PUMP LOCATION (SHELL) 22178A

The pump requires no periodic maintenance other than replacement of motor brushes. Replacement of motor brushes can be performed without removing the pump assembly. Visual inspection of the pump, to determine if the shaft seal is intact, should be made while the pump is in operation. If there is evidence of coolant leakage, the unit must be disassembled for corrective measures. Disassembly of the pump will be necessary only in the case of a seal leak, bearing failure, or motor failure.

11.7.2 Removal

1. Stop engine and allow engine coolant time to cool.
2. Close shutoff valves. Refer to *"05 COOLING"* under heading *"Draining Cooling System"* for location of valves.
3. Disconnect the electrical wiring from the motor.

Warning: *Before proceeding with the following steps, make sure that coolant has cooled down.*

4. **Fig. 57 only:** Remove the drain plug at rear of pump and place a container to recover the residual coolant in the line.

Note: *On driver's A/C system, remove residual coolant through coolant strainer. Also check strainer's condition; clean or replace if necessary.*

5. **Fig. 57:** Disconnect water lines from pump at flange connections.
6. **Fig. 56:** Disconnect water lines from pump at connections between hoses and copper pipes (leave hoses connected to pump).
7. Remove the two clamps holding the pump motor to its mounting bracket. Remove the pump with the motor as an assembly.

11.7.3 Disassembly

-For converted vehicle (shell) central A/C pump, see Fig. 58.
-For coach central A/C pump, or driver's A/C pump, see Fig. 59.

1. **Fig. 56:** Remove two brush caps (5) and two brush assemblies (4). When removing brushes, note the position of the brush in the tube. Brush life is significantly decreased if brushes are not replaced properly.
1. **Fig. 57:** Remove two brush caps (16) and two brush assemblies (15). When removing brushes, note the position of the brush in the tube. Brush life is significantly decreased if brushes are not replaced properly.
2. **Fig. 56:** Remove the pump cover (item #11) by first removing the 4 head screws. Remove cover carefully to prevent damaging the O-ring (12) (disconnect hoses from cover only if required).
2. **Fig. 57:** Remove the pump cover (item #2) by first removing the 8 head screws. Remove cover carefully to prevent damaging the gasket (3).
3. **Fig. 56:** Remove O-ring (12).
3. **Fig. 57:** Remove gasket (3).
4. **Fig. 56:** Remove two hex nuts (7) retaining pump assembly to motor.
4. **Fig. 57:** Remove two hex nuts and lock washers (7 & 8) retaining pump assembly to motor.
5. **Fig. 57 only:** Remove the pump from the motor as follows:
   a. Install puller tool assembly (MP Co. Part No. 24702 or equivalent) to pump body (12) using four screws removed from the pump cover (2).
   b. Tighten the puller screw to press the motor shaft out of the impeller hub. The pump is now free from the motor.
   c. Remove the puller tool.
6. **Fig. 56:** Remove acorn nut (9) and gasket (10), then remove impeller (8) and components of the pump seal assembly (14).
6. **Fig. 57:** Remove impeller (4) and components of the pump seal assembly (5).

Caution: *Do not scratch or mar the sealing surface of this seat, as its sealing feature will be affected, thus resulting in continuous leakage.*

Inspection

Components removed from the recirculating pump and motor assembly should be compared with new parts to determine the degree of wear.

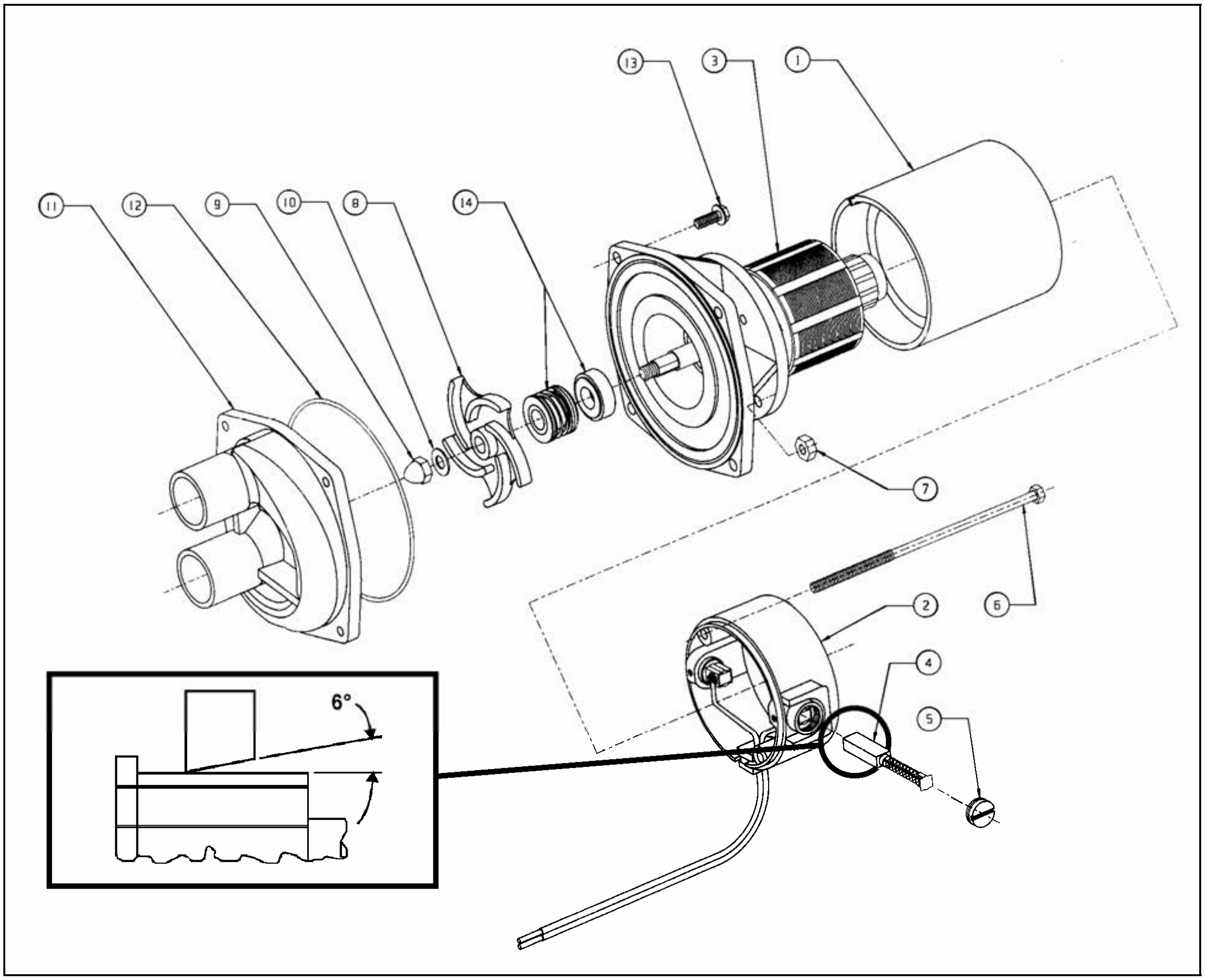


FIGURE 57: WATER RECIRCULATING PUMP (CONVERTED VEHICLE - CENTRAL A/C) 22091

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
	MOTOR			**IMPELLER**	
	Motor Ass'y - Items 1-7	1	8	Impeller	1
1	Stator	1	9	Acorn Nut	1
2	End Frame Assembly	1	10	Gasket	1
3	Armature adapter Ass'y	1		**COVER**	
4	Brush Assembly	2	11	Cover - Housing	1
5	Cap (brush holder)	2	12	O-ring	1
6	Case bolt 10-32 X 5	2	13	Screw	4
7	10-32 Hex Nut	2		**SEAL**	
			14	Seal Assembly	1

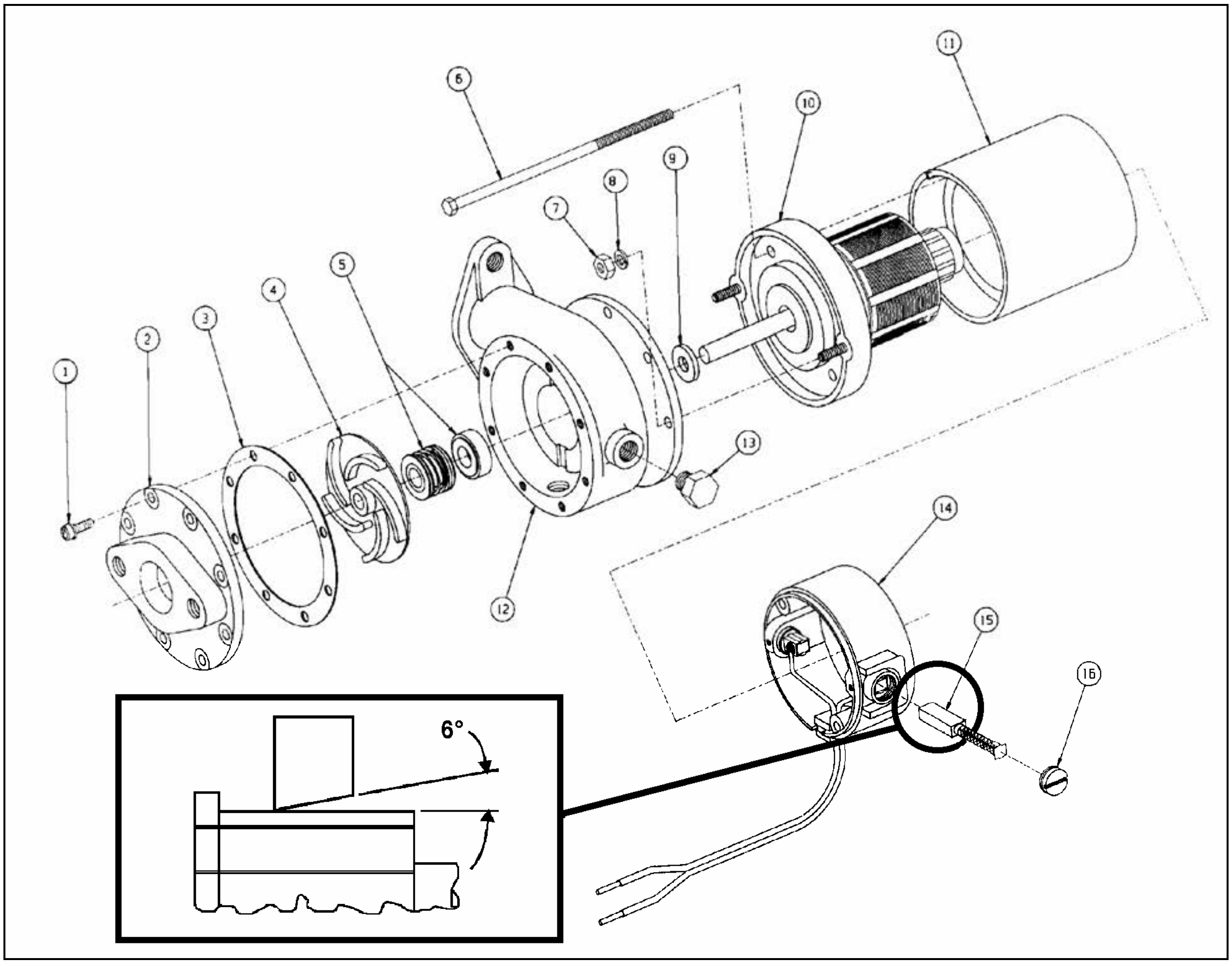


FIGURE 58: WATER RECIRCULATING PUMP (COACH - CENTRAL A/C OR DRIVER'S A/C) 22056

ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
	MOTOR			**IMPELLER**	
	Motor Assembly	1	4	Impeller - Brass	1
11	Stator	1		**HOUSING**	
14	End Frame Assembly	1	12	Body - Brass	1
10	Armature adapter Assembly	1	2	Cover - Brass	1
15	Brush Assembly	2	1	Screw and Washer Assembly	8
16	Cap (brush holder)	2	3	Gasket	1
6	Case bolt 10-32 X 5	2	9	Slinger	1
7	10-32 Hex Nut	2	13	Drain Plug - 1/8" NPT Brass	2
8	#10 Lock Washer	2		**SEAL**	
			5	Seal Ass'y - Silicon Carbide/Carbon	1

11.7.4 Brushes

1. When removing brushes, note the position of the brush in the tube. Brush life is shortened if the brushes are not replaced properly.
2. Examine brushes for the following:

   a. Wear
   Replace the brushes if less than 25% of the usable brush is left (less than 0.300 inch [8 mm]).

   b. Chipped edges
   Chips can be caused by improper handling or installation. Badly chipped brushes should be replaced regardless of their length.

   c. Annealed brush spring
   This can be detected by noting the resiliency of the spring. Annealing is caused by failing to tighten the brush caps properly, thus not providing a good low resistance contact between the terminal and the brush tube. Replace brushes showing evidence of annealed springs.

   d. Frayed or broken pigtail
   An improperly installed brush may have the pigtail (shunt) pinched under the terminal or between the coils of the spring. If the pigtail is badly frayed or broken, replace the brush.

3. Observe the following factors when replacing brushes:

   a. The face of a new brush is carefully cut to cause proper seating during the *"wear-in"* period.

   b. Improper installation can harm both the brush and the commutator.

   c. Replacement brushes should be of the proper grade.

   d. New brushes have a six (6) degree angle. The brush should always be inserted so that the angle is open away from the pump end of the assembly (inset, Figs. 56 & 57).

   e. Brush performance will be affected if the spring and terminal are not properly placed in the brush tube. The spring should be free over its entire length and the terminal should make good contact with the metal brush tube insert.

11.7.5 Bearings

1. Rotate the motor shaft. If the ball bearings show evidence of wear, they should be replaced.

Note: *When removing the armature from the motor, the number of washers and their arrangement should be noted. Improper numbers and/or installation of washers can cause improper tracking of brushes, which will result in excessive preloading of bearings and noisy operation.*

2. To help prevent damaging the armature winding and/or the commutator, when removing the bearings, the use of a bearing puller is recommended.
3. Replacement bearings should be pressed into the same exact location as the original bearings.
4. It is recommended that a suitable sealant (such as Loctite or equivalent) be used between the shaft and the bearing, if the fit is not tight enough to prevent the shaft from spinning inside the inner race.
5. After replacing the bearings, check the position of the commutator in the motor by looking down into the brush tube. Neither the riser nor the edge of the commutator should be visible.

11.7.6 Commutator

1. The commutator is a precise assembly. Although it is solidly built and made of a fairly tough material, it can be easily ruined by careless handling.
2. The commutator should be refinished only on equipment which provides good concentricity and the proper finish.
3. The commutator should be refinished if a micrometer reading shows a difference between *"in track"* and *"off track"* diameter of 0.187" (4,7 mm) or more.

4. The commutator should be carefully undercut with a 0.025" (0,6 mm) or less slot width.
5. A 25 to 50 micromesh finish is desirable on a new or refinished commutator.
6. The commutator should not be touched with the fingers since sweat and body oils will rapidly discolor and oxidize its surface.

11.7.7 Miscellaneous

1. **Fig. 57 only:** Check the shaft slinger (9) to make sure it is tight on the motor shaft. If the slinger slips on the shaft, it should be replaced.
2. **Fig. 56:** Inspect seal assemblies (14) to determine wear. If the seal has leaked, or is badly worn, it is recommended that a complete new seal assembly be installed.
2. **Fig. 57:** Inspect seal assemblies (5) to determine wear. If the seal has leaked, or is badly worn, it is recommended that a complete new seal assembly be installed.
3. **Fig. 57 only:** The impeller (4) is a press fit on the armature shaft. This press fit must be maintained to prevent the impeller from slipping. Install a new impeller if necessary.

11.7.8 Assembly

1. **Fig. 57 only:** Install slinger (9) on the motor shaft.
2. **Fig. 57:** Assemble body (12) to the motor.
3. **Fig. 56:** Install seal assembly (14).
3. **Fig. 57:** Install seal assembly (5).
4. **Fig. 56:** Insert impeller (8) and secure with acorn nut (9) and gasket (10).
4. **Fig. 57:** Install impeller (4) in the following manner:
   a. Place the impeller on a flat surface with the vanes against the flat surface.
   b. Invert the motor and pump body assembly, then pilot the pump shaft into the impeller bore. **DO NOT HAMMER** on the motor shaft extension at rear of motor.
   c. Press on motor and pump body until the machined face of the pump body is flush with the face of the flat surface on which the impeller is resting. The face of the impeller vanes must now be flush with the machined face of the pump body.
5. **Fig. 56:** Install O-ring (12).
5. **Fig. 57:** Install gasket (3). This gasket serves both to seal the cover and to establish the proper clearance between the face of the impeller and the pump cover.
6. **Fig. 56:** Attach cover (11) to the pump body using four screws (13).
6. **Fig. 57:** Attach cover (2) to the pump body using eight screw and washer assembly (1).
7. **Fig. 56:** Install motor brushes assembly (4) and brush caps (5).
7. **Fig. 57:** Install motor brushes assembly (15) and brush caps (16).

11.7.9 Installation

<u>Figure 56 pumps:</u>

1. Connect water lines to pump (hoses to copper pipes). Use a soapy water solution to help insert water lines.
2. Position the pump and motor assembly on the mounting bracket. Position the mounting clamps over the motor and secure with mounting bolts.
3. Connect electrical wiring to the pump motor.
4. Open shutoff valves. Refer to *"05 COOLING"* under heading *"Draining Cooling System"* for location of valves.

5. Fill the cooling system as previously instructed in this section under *"10.2 Filling Heating System"*, then bleed the system as previously instructed in this section under *"10.3 Bleeding Heating System"*.

Figure 57 pumps:

1. Apply gasket cement to the pump body line adapter and to the line flanges, put the two gaskets in place, and connect water lines to the pump at the flange connections. Position the pump and motor assembly on the mounting bracket. Position the mounting clamps over the motor and secure with mounting bolts.
2. Apply pipe sealant on threads of drain plug, and screw it in place.
3. Connect electrical wiring to the pump motor.
4. Open shutoff valve. Refer to *"05 COOLING"* under heading *"Draining Cooling System"* for location of valves.
5. Fill the cooling system as previously instructed in this section under *"10.2 Filling Heating System"*, then bleed the system as previously instructed in this section under *"10.3 Bleeding Heating System"*.

11.8 WATER FILTER

11.8.1 Description

This vehicle is provided with a cleanable water filter, which is located in the evaporator compartment behind the R.H. side air duct. The filter uses the micronic principle of filtration which utilizes an accordion -pleated design for a maximum filtering area. A relief valve integrated to the filter element allows bypass of the filter in case of heavy restrictions.

Vehicles equipped with driver's A/C system only are provided with a water filter located in reclining bumper compartment.

11.8.2 Maintenance

Filter maintenance consists in changing the element at break-in 3000 miles (4 800 km), and subsequently every 50,000 miles (80 000 km) or once a year, whichever comes first.

Note: *Service water filter each time soldering is performed at any point on coolant piping; operate heating system a few minutes first, so that soldering residues are routed to the strainer.*

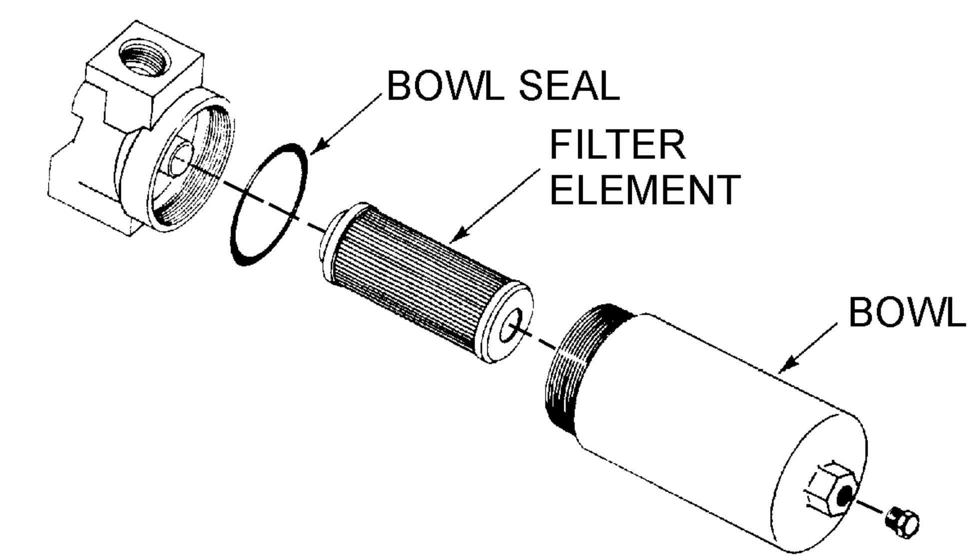


FIGURE 59: WATER FILTER 22057

11.8.3 Servicing (Vehicles with central A/C system)

1. Stop engine and allow engine coolant time to cool.
2. Close shutoff valves. Refer to *"05 COOLING"* under heading *"Draining Cooling System"* for location of valves.

Warning: *Before proceeding with the following steps, make sure that coolant has cooled down.*

3. Rotate bowl (Fig. 58) counterclockwise and remove.
4. Remove filter element (Fig. 58) from housing. Discard all disposable elements. These elements are not cleanable.
5. Place new, clean element in housing, centering it on location in the head.
6. Inspect bowl seal and replace if necessary.
7. Replace bowl. Rotate clockwise and hand tighten.
8. Correct coolant level in surge tank as instructed previously in this section under *"Filling Heating System"*.

11.8.4 Servicing (Vehicles with driver's A/C system)

1. Stop engine and allow engine coolant time to cool.
2. Close shutoff valves. Refer to *"05 COOLING"* under heading *"Draining Cooling System"* for location of valves.

Warning: *Before proceeding with the following steps, check that coolant has cooled down.*

3. Unscrew the filter retaining plug.
4. Remove strainer, then clean inside strainer housing.
5. Using water under pressure, flush the strainer from the outside.
6. Reinstall strainer, then tighten the retaining plug.
7. Open shut-off valves.
8. Correct coolant level in surge tank as instructed previously in this section under *"10.2 Filling Heating System"*.

11.9 BY-PASS SOLENOID WATER VALVE (OPTIONAL)

This valve is optional and is installed only on vehicles equipped with a preheater. The valve is located in the evaporator compartment. This valve is similar to the driver’s solenoid valve (refer to Fig. 53 for part names).

11.9.1 To Remove or Change the Coil

- Stop engine and allow engine coolant time to cool.
- Close shutoff valves. Refer to *"05 COOLING"* under heading *"4.7 Draining Cooling System"* for location of valves.

<u>To remove the solenoid coil:</u>

First take out the retaining screw at the top of the coil housing. The entire coil assembly can be lifted off the enclosing tube.

<u>To reassemble:</u>

Make sure that the parts are placed on the enclosing tube in the following order:

1. Be sure to change electrical data plate according to coil specifications change.
2. Place coil and yoke assembly on the enclosing tube. Lay data identification plate in place.
3. Insert the coil retaining screw, rotate housing to proper position and tighten screw securely.

11.9.2 To Take the Valve Apart

<u>To disassemble:</u>

This valve may be taken apart by removing the socket head screws which hold the body and bonnet together. After removing the screws, carefully lift off the bonnet assembly (upper part of the valve). Don’t drop the plunger. The diaphragm can now be lifted out. Be careful not to damage the machined faces while the valve is apart.

Note: *The above procedure must be followed before brazing solder type bodies into the line.*

<u>To reassemble:</u>

Place the diaphragm in the body with the pilot port extension up. Hold the plunger with the synthetic seat against the pilot port. Make sure the bonnet O-rings are in place, the bonnet assembly over the plunger, and that the locating sleeve in the bonnet enters the mating hole in the body. Insert body screws and tighten uniformly.

11.10 PREHEATING SYSTEM (OPTIONAL ON COACHES ONLY)

The preheater is located inside engine compartment and is accessible through L.H. side rear service compartment (refer to figure 60).

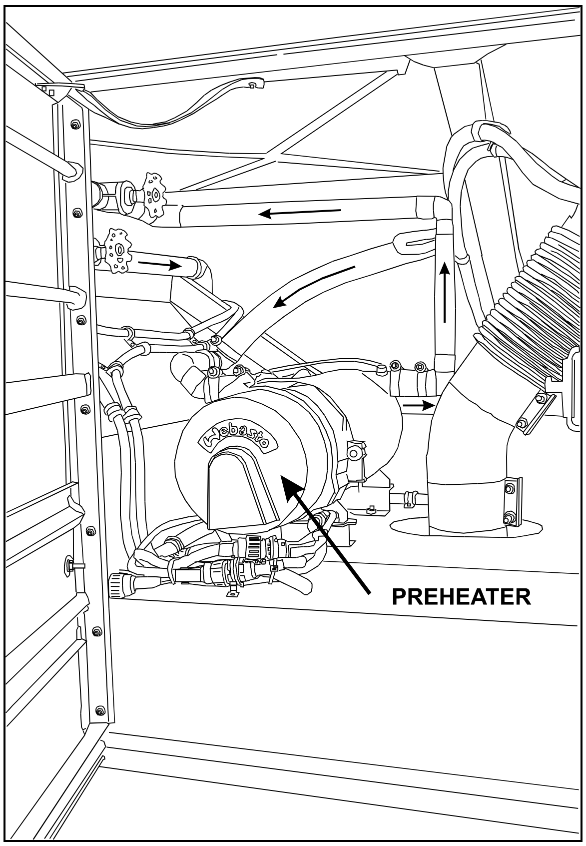


FIGURE 60: L.H. SIDE REAR SERVICE COMPART. 22245A

This Auxiliary Preheating System is used for preheating and retaining the heat of water-cooled engines. It can be used before starting the engine to ease it's starting and to provide immediate inside heat upon operation of the heating system. It can also be used with engine running to maintain coolant heat and maintain the set temperature inside vehicle.

The heater operates independently from the vehicle engine. It is connected to the cooling and heating circuits, the fuel system and the electrical system of the vehicle.

The pilot lamp turns on when the heater is switched on. Combustion air flows in to flush out the combustion chamber and the water circulation pump is put into operation. The fuel metering pump conveys fuel in precise doses to the combustion chamber where fuel and combustion air form a combustible mixture which is ignited by the glow plug.

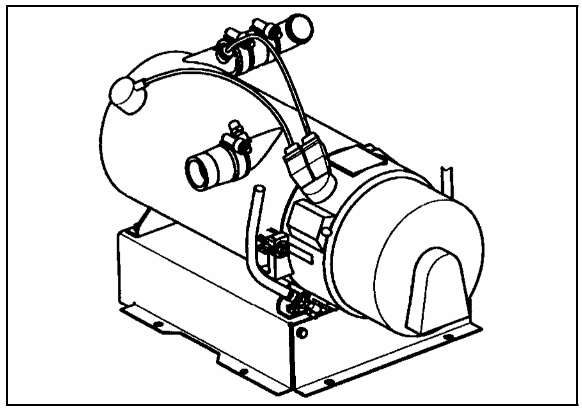


FIGURE 61: WEBASTO PREHEATER (104,000 BTU) 22224

Once the flame sensor has signaled to the control unit that combustion has taken place correctly, the glow spark plug and ignition coil are switched off.

The hot combustion gases are diverted at the end of the flame pipe, then pass through the indirect heating surfaces of the heat exchanger and transmit their heat to the water passing through the heat exchanger.

The heat is thermostatically controlled and operates intermittently, i.e. the switched-on times of the burner vary depending on the heat requirement. The water temperature depends on the setting of the built-in water thermostat.

The water circulation pump remains in operation as long as the heater is operating, even in the regulation intervals and during the delayed cutout of the switched-off heater. The pump can also be operated independently from the heater by means of an appropriate circuit. The heater can be switched on at any time, even during the delayed cutout period. Ignition takes place once this delay time is over.

When the heater is switched off, the fuel supply is interrupted. The flame goes out, and at the same time a delayed cutout of some 2.5 minutes begins. The combustion air still flowing flushes the remaining combustion gases out of the chamber and cools off the hot parts on the exhaust side of the heat exchanger, while the water circulation pump, still running, transmits the heat present in the heat exchanger, thus preventing local overheats. Once the delayed cutout time is over, both the combustion air blower and the water circulation pump switch off automatically. A cutout will take place in case of any failure of the preheater.

11.10.1 Operation

Switch on the heater. The operation indicator lamp comes on and the heater motor and circulating pump begin to run. After about 10-25 seconds the solenoid valve opens and fuel is sprayed into the combustion chamber. At the same time, the electronic ignition unit produces high voltage (8000 V) and the mixture of fuel and air in the combustion chamber is ignited by the spark on the ignition electrodes. The flame is indicated by the flame detector, then the electronic ignition unit stops producing high voltage and combustion continues by itself (spark on electrodes is required only to ignite the flame). At this moment, the heater is working and producing heat.

If the heater is switched off by the on/off switch, the solenoid valve interrupts fuel supply, combustion stops and indicator lamp turns off. Combustion air fan still blows air, cleaning the combustion chamber of any fumes and cooling down the combustion chamber. Coolant circulation pumps coolant, making a purge cycle for approximately 2-3 minutes, thus protecting the heater against overheating.

If the heater is not switched off by the on/off switch, the control thermostat will switch off the heater when coolant temperature reaches 165° ± 6°F (75° ± 3°C) and turns it on at 154° ± 9°F (68° ± 5°C). During this time, the heater (combustion) is off and the indication lamp and coolant pump are on. Combustion air fan blows air for 2-3 minutes and then turns off.

11.10.2 Preheating System Timer

The timer, located on L.H. lateral console is used to program the starting and stopping time of the preheating system. The system indicator light, located on the timer, illuminates when the system is functional.

Caution: *The preheating system should not operate for more than one hour before starting engine as this could discharge batteries.*

Warning: *Preheating system must not operate when vehicle is parked inside or during fuel fill stops.*

Note: *Preheating system uses the same fuel as the engine.*

In case of failure:

1. Shut off and turn on again.
2. Check main circuit breaker and overheat fuse.
3. Have system repaired in a specialized shop.

11.10.3 Timer Operating Instructions (Webasto)

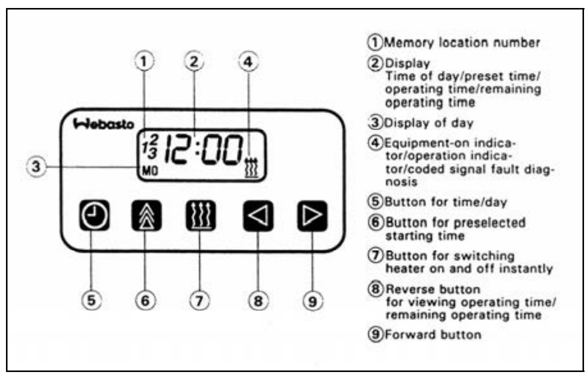


FIGURE 62: WEBASTO 18327

These instructions refer to the timer illustrated in figure 61. They are the same instructions provided in the Webasto instruction booklet, provided with your vehicle.

Remaining Operating Time

The remaining operating time refers to the period of time the heater still continues to remain in operation. It may be changed while the heater is in operation.

Setting the Digital Timer

After the power has been connected, all symbols on the digital display are flashing. The time of the day and the day of the week must be set.

All flashing symbols of the timer can be set by means of the Forward (9) or Reverse (8) buttons.

When buttons (8) and (9) are pressed for more than 2 seconds, the quick digit advance mode is activated.

Setting the Time and Day of the Week

1. Press button (5) for more than 2 seconds (time display flashes).
2. Press (8) or (9) button to set the time of day.
3. Wait 5 seconds. The time of day is stored (time of week flashes).
4. Press (8) or (9) button to set the correct day of week.
5. Wait 5 seconds. The day of week is stored.

Viewing the Time (Ignition ON)

Continuous display of current time and day of the week.

Viewing the Time (Ignition OFF)

Briefly press button (5) to display current time and day for 5 seconds.

SWITCHING HEATER ON (INSTANT HEATING)

With Ignition ON:

Press button (7). Heater is switched on (continuous operation) and continues to operate until button (7) is pressed again or ignition is switched off.

Note: *If the ignition is switched off while heater is in operation, the remaining operating time of 5 minutes flashes on the display and the heater will continue to operate for this period of time.*

With Ignition OFF:

Press button (7). Heater is switched on for preset operating time (the factory-set heater operating duration is 60 minutes)

SWITCHING HEATER OFF

Press button (7). The heater starts its after-run cycle and switches off thereafter.

Presetting Operating Duration

1. Press button (6). Memory location number flashes.

Note: *By repeatedly pressing button (6), starting time 2 or 3 can be preset.*

2. Press button (8) or (9) until correct startup time is set.
3. Wait 5 seconds. Preset starting time is stored and day of week flashes.
4. Press button (8) or (9) to select the correct startup day of week.
5. Wait 5 seconds. The startup day of week is stored.

The number of memory location remains on the display. The timer is now in the programmed mode and will switch the heater in a the preset time.

Note: *We recommend that memory locations 1 and 2 be used for presetting times within 24 hours of setting the timer. Memory location 3 can be used for a starting time within the next 7 days of setting the timer.*

Recalling Preset Times

Press (6) repeatedly until the desired memory location number and preset time are displayed.

Canceling Preset Time

Press button (6) repeatedly until no more memory location number is visible on the display.

Setting Operating Time

1. With heater off, press button (8). Operating time flashes.
2. Press button (8) or (9) to set the operating time (between 1 and 120 minutes)
3. Wait 5 seconds. Operating time is stored.

The heater remains in operation for the preset time (except for continuous operation).

Setting the Remaining Operating Time

1. With heater in operation, press button (8). Remaining operating time flashes.
2. Set remaining time with button (8) or (9).
3. Wait 5 seconds. Remaining operating time is stored.

Fault Diagnosis by Coded Light Signals

On heaters equipped with a fault diagnosis system using coded light signals, the equipment-on indicator/operation indicator flashes. Please consult your Webasto dealer.

11.10.4 Troubleshooting and Maintenance

Refer to the Webasto manual for more information.

Note: *If there are no heater faults, the heater will go through a normal start cycle and regulate based on thermostat setting.*

Note: *Switch on the preheating system briefly about once a month, even during the warm season.*

Caution: *When welding on the vehicle, disconnect the preheater module connector in order to protect this system from voltage surges.*

Caution: *To avoid running down the batteries, do not turn on the preheating system for more than one hour before starting the engine.*

Warning: *The preheating system uses the same fuel as the engine. Do not operate in a building or while refueling. Operate only in a well-ventilated area.*

12. SPECIFICATIONS

Main evaporator motor

Make...US MOTOR
Type T-17
Voltage .... 27.5 V DC
Current draw .... 68 amps
Horsepower...2
Revolution .... 1st :1400 rpm, 2nd : 1880 rpm nominal
Insulation...Class F
Motor Life ....20 000 hours
Brush life ....10 000 hours
Motor supplier number D5092VPRC8
Motor Prevost number...563008
Brush Prevost number 562951

Condenser fan motors

Make...US MOTOR
Type TF-12
Voltage .... 28.5 V DC
Current draw .... 20 amps
Horsepower...0.57
Revolution ....1950 rpm
Insulation...Class F
Motor ....20 000 hours
Brush life ....10 000 hours
Qty...2
Supplier number... D591Y440PRC2
Prevost number...562579
Brush supplier number...9DB21003
Brush Prevost number 561914

Evaporator air filters (Central system) (Coach)

Make....................Permatron Corp.
Type....................Polypropylene
Supplier number....................IN 1X10X37 EXACT
Prevost number....................All vehicles (Top) 373336
Prevost number....................XL-40 vehicles (Bottom) 373338
Prevost number....................XL-45 vehicles (Bottom) 373337

Evaporator air filters (Central system) (Shell)

Make....................Permatron Corp.
Supplier number....................IN 13X21X1 NOMINAL
Prevost number....................(Qty = 3) 871034

Driver's unit evaporator motors

Make....................MCC
Voltage....................24 V DC
Quantity....................1
Supplier number....................25-0250
Prevost number....................871135

Driver's unit evaporator air filter

Make....................MCC
TYPE....................Recirculating air 6-¼" x 28" Washable
Supplier number....................260593
Prevost number....................871147

Make....................MCC
TYPE....................Fresh air 3-5/8" X 5-1/4" Washable
Supplier number....................260594
Prevost number....................871144

Refrigerant

Type....................Optional R-22 and Standard R-134a
Quantity (standard)....................24 lbs (10.89 Kg)
Quantity (A/C Aux. system located in overhead compartments)....................4 lbs (1.8 Kg)

Compressor (Central system)

Make ..... Carrier Transicold

Capacity, option R-134a ..... 41 CFM

Capacity, option R-22 ..... 37 CFM

Model, option R-134 ..... 05G-134A

Model, option R-22 ..... 05G-22

No. of cylinders 6

Bore ..... 2” (50,8 mm)

Operating speed ..... 400 to 2200 rpm (1750 rpm. Nominal)

Minimum speed (for lubrification) ..... 400 rpm

Nominal horsepower 15

Oil pressure at 1750 rpm ..... 15 to 30 psi (103-207 kPa)

Oil capacity ..... 1.13 U.S. gal (4,3 liters)

Weight ..... 142 lbs (64,5 kg)

Approved oils

-Castrol ..... SW 68 (POE)

Supplier number, option R-134a 68PD541-104-38

Supplier number, option R-22 ..... 68PD537-104-39

Prevost number, option R-134a 950314

Prevost number, option R-22 950207

A/C Compressor (Driver's and auxiliary systems)

Make ..... Seltec

Model TM-16HD

Weight ..... 10.9 lbs (4,9 kg)

Supplier number 18-00074-11

Prevost number 950372

Approved oil ..... ZXL100PG (PAG)

Prevost number 950382

Compressor unloader valve

Make.......... Carrier Transicold
Type .... Electric (AMC)
Voltage .... 24 V DC)
Watts 15
Supplier number (without coil) 17-40407-20
Prevost number (without coil) 950095
Coil supplier number 22-50030 (1)
Coil Prevost numbert.......... 950096

Magnetic clutch

Make.......... Carrier Transicold
Type .... Housing mounted 9” dia., 2-B grooves
Voltage .... 24 V DC
Coil resistance at 68 ^{o}F (20 ^{o}C).......... 5.15 – 5.69 ohms
Supplier number.......... 50-01122-90
Prevost number.......... 950204

Compressor V belts

Make.......... Dayco
Model (matching set of 2) BX97
Prevost number (with Delco 270/300 Amp Alternator) 506664

Compressor V belt

Make.......... Dayco
Model.......... BX100
Prevost number (with two BOSH Alternators) 506681

Condenser coil (Driver's and auxiliary systems)

Make.......... Valeo
Supplier number..........
Prevost number..........

Condenser coil (Central system) (XL2-40 vehicles and, XL2-45 & 45E Shells)

Make.. Carrier Transicold

Aluminum

Supplier number..68GF67-194-2

Prevost number..870654

Copper

Supplier number..68GF67-194-3

Prevost number..870729

Condenser coil (Central system) (XL2-45 Coach)

Make.. Carrier Transicold

Aluminum

Supplier number..68BC2-107

Prevost number..950259

Copper

Supplier number..68BC2-107-1

Prevost number..950260

Evaporator coil (Central system)

Make.. Carrier Transicold

Supplier number..68BE2-105

Prevost number..871070

Receiver tank (with sight glasses)

Make.. HENRY

Maximum pressure.. 450 psig

Supplier number..ARL-1217

Prevost number..950261

Filter Dryer assembly

Make.. AC&R HENRY

Supplier number..815031-XH9

Prevost number..950262

Moisture indicator

Make .... Henry

Supplier number MI-30-7/8S

Prevost number 950029

Driver's refrigerant liquid solenoid valve

Make .... Parker

Type .... Normally closed with manual bypass

Voltage .... 24 V DC

Amperage draw .... 0.67 amps

Watts 16

Supplier number (without coil) RB9MP3-MM
Prevost number (without coil) 95-0054

Coil supplier number .... R23MM 24 V DC-CB

Coil Prevost number 950055

Repair kit Prevost number 950056

Driver's hot water solenoid valve

Make .... Asco

Type .... Normally open (without manual bypass)

Voltage .... 24 V DC

Current draw .... 0.47 amp.

Watts 11.2

Pressure range .... 0 to 100 psi

Max. temperature .... 220^{o}F

Supplier number (with coil) 106-269-1

Prevost number (with coil) 870812

Coil Prevost number 870960

Repair kit Prevost number 870872

Hot water solenoid valve (Central system)

Make .... Burkert

Type .... Normally open

Voltage .... 24 V DC

Supplier number SYST-2000-456023-6012-427923B

Prevost number 871252
Seal kit, Water Side 871311
Seal kit, Actuator Side 871312
Seal kit, Pilot Solenoid Valve 871313

Water recirculating pump (Central system - Coach) & (Driver's system - Coach & Shell)

Make .... M.P. pumps
Voltage .... 24 V DC
Supplier number 28689
Prevost number 871052

Water recirculating pump (Central system - Shell)

Make .... M.P. pumps
Voltage .... 24 V DC
Housing .... Aluminum
Supplier number 29232
Prevost number 871032

Water filter (Central system)

Make .... Parker
Supplier number (with element) 15CN1238WP
Prevost number (with element) 871028
Element supplier number 925566
Element Prevost number 871029

Water filter (small A/C system)

Make .... BRAUKMANN
Supplier number T300B
Prevost number 870807

Driver’s expansion valve

Supplier number, option R-134a 26-0190
Supplier number, option R-22 26-0384
Prevost number, option R-134a 950221
Prevost number, option R-22 950282

Expansion valve (Central system)

Make.. Alco
Model...TCLE 5-1/2
Supplier number.. 21059366
Prevost number.. 950320

Bypass solenoid water valve

Make... Parker Hanninfin
Bypass supplier number RB21ME7-MM
Bypass Prevost number... 870886
Coil supplier number R-23MM24VDC-CB
Coil Prevost number.. 870886
Repair kit supplier number 76754
Repair kit Prevost number 870980

Preheating system

Make.. WEBASTO
Model... THERMO 300
Capacity ....104 000 Btu/h (30 kW)
Heating medium ....Coolant
Rated voltage .... 24 V DC
Operating voltage .... 20-28 V DC
Electric power consumption (without coolant recirc. Pump)...110 watts
Fuel consumption..1,2 US gallons/hr (4,5 liters/hr)
Supplier number.. 9002092A
Prevost number... 871202

Carrier

TRANSICOLD

Compressor

MODEL
05G and
05G BUS

OPERATION AND SERVICE

62-02756 $6.00

Carrier

TRANSICOLD

OPERATION AND SERVICE MANUAL

MODEL 05G and 05G BUS COMPRESSOR

UNITED TECHNOLOGIES CARRIER TRANSICOLD

Carrier Transicold Division, Carrier Corporation, P.O. Box 4805, Syracuse, N.Y. 13221 U. S. A.

Carrier Transicold E.T.O. Boite Postale Nr. 16 Franqueville – Saint–Pierre 76520 Boos, FRANCE

Replaces: 62-03432-01 and T-199-02

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SECTION 1
DESCRIPTION

1.1 INTRODUCTION

This operation and service manual covers the Carrier Transicold Model 05G compressors. These compressors are designed for refrigeration (trailer) or air conditioning (bus & rail) applications. (See Figure 1-1) The following table list the special tools for the 05G compressors.

PART NO.	SPECIAL TOOLS
07-00219	Wrench, Compressor Sight Glass
07-00223	Pliers, Compressor Unloader Ring
07-00240-01	Wrench, Spanner (for Housing Mounted Clutch)
07-00241	Rotor Installation Tool (for Housing Mounted Clutch)
07-00242-01	Bearing Retaining Nut Socket **(3.5″)** (Housing Mounted Clutch)
07-00242-02	Bearing Retaining Nut Socket **(3″)** (for Housing Mounted Clutch)
07-00260-00	Acid Test Kit
07-00265-01	Totaltest Kit (Package of 1)
07-00266-00	Replacement Tubes for Totaltest Kit
58-00869-00	Filter, Felt (Suction Sock for System Clean Up)

1.2 GENERAL DESCRIPTION

The Model 05G compressors are of the open-drive reciprocating type. A crankshaft, connecting rods, pistons, and reed type valves accomplish vapor compression. Compressor wear is minimized by splash lubrication and by force feed lubrication. There are three types of oil pumps (Vane, Gear and Low Profile Gear) driven directly from the end of the compressor crankshaft. (See Figure 1-3)

CAUTION

The gear oil pump must be set to rotate in the same direction as the crankshaft. (Refer to section 3.4)

The tapered end of the crankshaft, which extends outside the crankcase, is adaptable to a variety of direct drive or belt–driven clutch mechanisms. A mechanical seal prevents refrigerant leakage where the rotating shaft passes through the crankcase.

The compressor is equipped with flanges for connecting suction and discharge service valves. Connections are also provided for pressure gauges and safety cutout switches. Sight glasses installed on both sides of the crankcase, provides a means for checking oil level in the compressor crankcase. A drain plug facilitates draining of oil from the crankcase and an oil fill plug enables addition of oil when necessary. A bottom plate provides access through the bottom of the crankcase for maintenance.

WARNING

Do not operate compressor unless suction and discharge service valves are open.

Capacity of the Model 05G compressor is determined by piston displacement and clearance, suction and discharge valve size, compressor speed, suction and discharge pressure, type of refrigerant, and unloader valves.

1.3 COMPRESSOR REFERENCE DATA

Model	05G–37CFM	05G–41CFM
Displacement	37CFM	41CFM
No. Cylinders	6	
Bore	50.8 mm (2.00 in)	
Stroke	49.2 mm (1.937 in)	54.36 mm (2.14 in)
Weight	62 kg (137 lbs)	
SPEED (RPM) FOR OIL PUMP		
Vane	900 to 2200	
Gear	500 to 2200	
Low Profile Gear	500 to 2200	

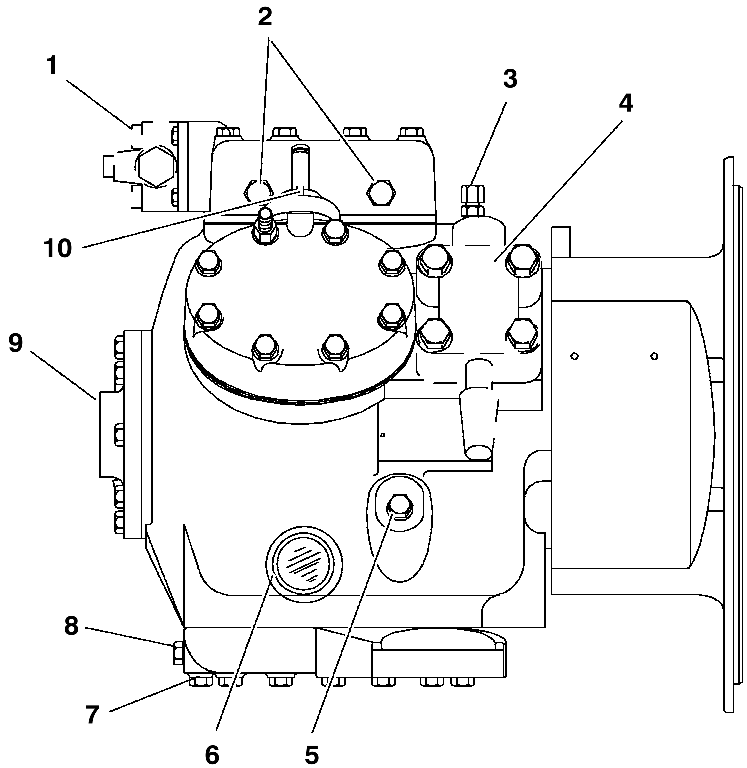
NOTE

The oils below are suitable for use with evaporator temperatures above –40°F (–40°C).

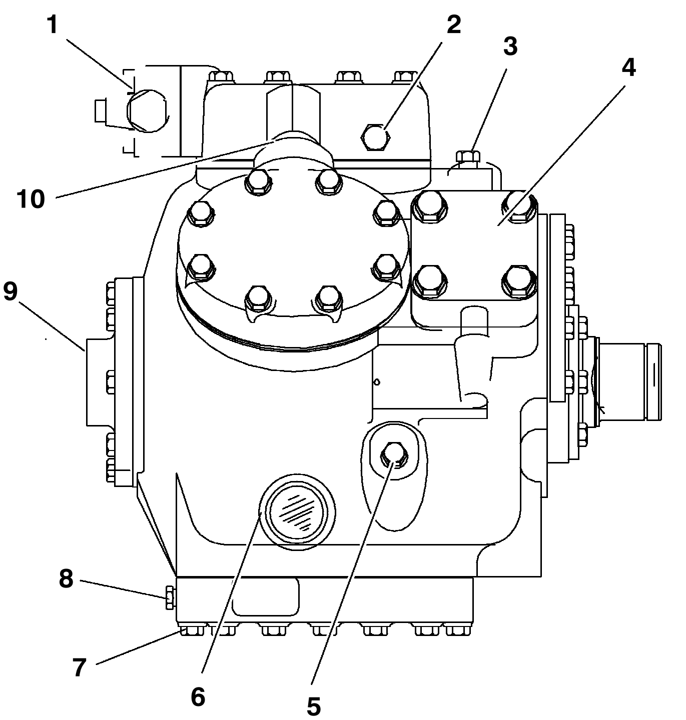
Approved Oil for REFRIGERATION USE (TRAILER)	
Refrigerant	**Oil**
R-12, R-22, R-500 or R-502	Zerol: 150 Synthetic P/N 07-00274
R-404A	Castrol Icematic: SW-68C
	Mobil Arctic: EAL 68
	ICI: Emkarate RL68H

Approved Oil for AIR CONDITIONING USE (BUS AND RAIL)	
Refrigerant	**Oil**
R-12 or R-22	Calumet Refining: R030
	Texaco: WF68
	Witco: 4GS Suniso
R-134a	Castrol Icematic: SW-68C
	Mobil Arctic: EAL 68
	ICI: Emkarate RL68H

Revised 10/96



REFRIGERATION COMPRESSOR (TRAILER)



AIR CONDITIONING COMPRESSOR (BUS & RAIL)

1. Discharge Service Valve
2. High Pressure Connection
3. Low Pressure Connection
4. Suction Service Valve
5. Oil Fill Plug
6. Oil Level Sight Glass
7. Bottom Plate
8. Oil Drain Plug
9. Oil Pump (See Figure 1-3)
10. Unloader

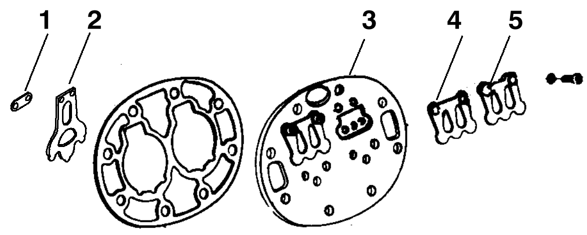
Figure 1-1. Model 05G Compressor

1.4 DETAILED DESCRIPTION

1.4.1 SUCTION AND DISCHARGE VALVES

The compressor uses reed type suction and discharge valves made of highest quality steel for long life. The valves operate against hardened integral seats in the valve plate.

The downstroke of the piston admits refrigerant gas through the suction valve, and then compresses this gas on the upstroke, thereby raising it's temperature and pressure. The compressed gas is prevented from re-entering the cylinder on it's next downstroke by the compressor discharge valve. (See Figure 1-2)



1. Position Spring
2. Suction Valve
3. Valve Plate
4. Discharge Valve
5. Discharge Valve Stop

Figure 1-2. Suction & Discharge Valve

1.4.2 SUCTION & DISCHARGE SERVICE VALVES

The suction and discharge service valves used on the compressor are equipped with mating flanges for connection to flanges on the compressor. These valves are provided with a double seat and a gauge connection, which allows servicing of the compressor and refrigerant lines (See Figure 1-1).

Turning the valve stem counterclockwise (all the way out) will *backseat* the valve to open the suction or discharge line to the compressor and close off the gauge connection. In normal operation, the valve is backseated to allow full flow through the valve. The valve should always be backseated when connecting the service manifold gauge lines to the gauge ports.

Turning the valve stem clockwise (all the way forward) will *frontseat* the valve to close off the suction or discharge line to isolate the compressor and open the gauge connection.

To measure suction or discharge pressure, midseat the valve by opening the valve clockwise about 2 turns. With the valve stem midway between frontseated and backseated positions, the suction or discharge line is open to both the compressor and the gauge connection.

1.4.3 LUBRICATION SYSTEM

There are three types of oil pumps (Vane, Gear and Low Profile Gear) driven directly from the end of the compressor crankshaft (See Figure 1-3). Force-feed lubrication of the compressor is accomplished by a oil pump driven directly from the compressor crankshaft. Refrigeration oil is drawn from the compressor crankcase through the oil filter screen and pick up tube to the oil pump located in the bearing head assembly. The crankshaft is drilled to enable the pump to supply oil to the main bearings, connecting rod bearings, and the shaft seal.

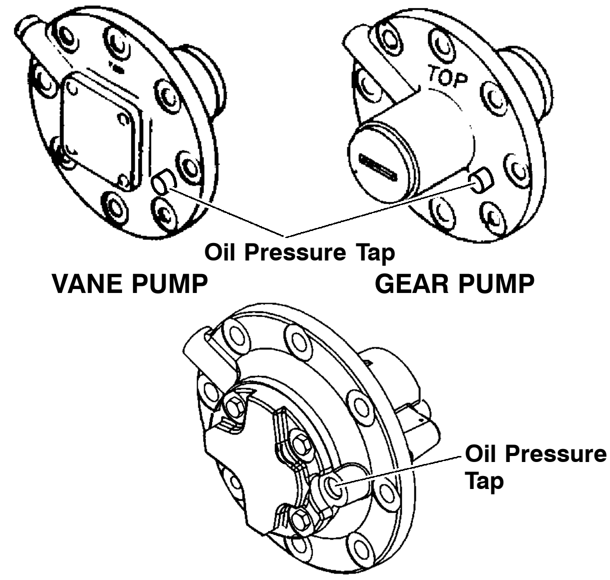


Figure 1-3. Oil Pumps

CAUTION

The Gear oil pump must be set to rotate in the same direction as the crankshaft. (Refer to section 3.4)

The oil flows to the pump end main bearings, connecting rod bearings and seal end main bearings, where the oil path is divided into two directions. The largest quantity flows to the oil relief valve, which regulates oil pressure at 15 to 18 psi (2.09 to 2.30 kg/cm^2) above suction pressure. When the oil pressure reaches 15 to 18 psi above suction pressure, the relief valve spring is moved forward allowing oil to return to the crankcase. The remaining oil flows through an orifice and into the shaft seal cavity to provide shaft seal lubrication and cooling. This oil is then returned to the crankcase through an overflow passage.

An additional oil pressure relief valve, built into the Gear and Low Profile Gear Oil Pump, is open at speeds above 400 rpm to relieve a portion of the oil pressure to the crankcase in order to maintain oil pressure below an acceptable maximum. At low speeds, the valve is closed to ensure adequate oil pressure at 400 rpm. At speeds above 1900 rpm, the oil pressure will be 25 to 30 psi (2.8 to 3.1 kg/cm^2) above suction pressure.

The crankcase pressure equalization system consists of two oil return check valves and a 1/8-inch pressure equalization port between the suction manifold and crankcase. Under normal conditions, check valves are open and allow for oil return to the crankcase. Under flooded start conditions, pressure rises in the crankcase and closes the check valves, preventing excess oil loss. The equalization port allows for release of excessive pressure, that has built up in the crankcase, to the suction manifold; this ensures that the oil loss is kept to a minimum.

1.5 COMPRESSOR UNLOADER

The 6 cylinder 05G compressor can be applied with 2 bank of unloading.

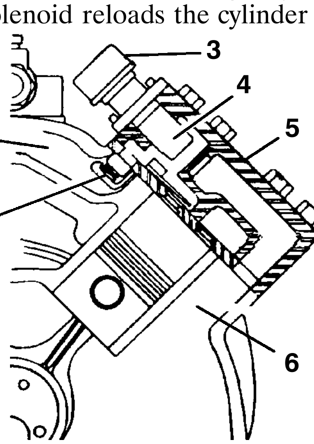
There are two types of compressor unloader systems; the first one is the hot gas bypass and the second is the suction cutoff. They are easily distinguished from each other by observing the bottom side of the compressor cylinder head, it is either blank (Hot gas bypass) or has a cover plate (Suction cutoff).

The two types of compressor unloader systems can be controlled with either a pressure actuated valve or an electrically actuated (solenoid) valve.

1.5.1 HOT GAS BYPASS UNLOADER

The compressor is equipped with an unloader for capacity control. This consists of a self-contained, cylinder head bypass arrangement (See Figure 1-4) which is electronically controlled by the temperature controller.

The capacity controlled cylinder is easily identified by the solenoid which extends from the side of the cylinder head. When the solenoid energizes, the cylinder unloads allowing discharge gas to circulate as shown in Figure 1-5. The unloaded cylinder operates with little or no pressure differential, consuming very little power. A de-energized solenoid reloads the cylinder as shown in Figure 1-6.



1. Discharge Check Valve
2. Discharge Manifold
3. Solenoid Valve
4. Piston Bypass Control Valve
5. Cylinder Head
6. Suction Manifold

Figure 1-4. Compressor Unloader – Hot Gas Bypass

a. Major Working Parts

1. Solenoid and valve system
2. Spring loaded piston type bypass control valve
3. Spring loaded discharge check valve

b. Unloaded Operation

Pressure from the discharge manifold (Figure 1-5, item 15) passes through the strainer (9) and bleed orifice (8) to the back of the piston bypass valve (7). Unless bled away, this pressure would tend to close the piston (6) against the piston spring (5) pressure.

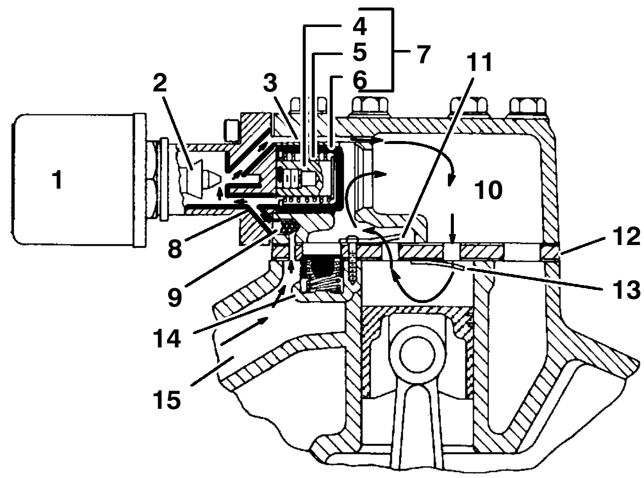
With the solenoid valve (1) *energized* the solenoid valve stem (2) will *open* the gas bypass port (3).

Refrigerant pressure will be bled to the suction manifold (10) through the opened gas bypass port . A reduction in pressure on the piston bypass valve will take place because the rate of bleed through the gas bypass port is greater than the rate of bleed through the *bleed orifice* (8).

When the pressure behind the piston has been reduced sufficiently, the valve spring will force the piston bypass valve *back*, *opening* the gas bypass from the discharge manifold to the suction manifold.

Discharge pressure in the discharge manifold will close the discharge piston check valve assembly (14) isolating the compressor discharge manifold from the individual cylinder bank manifold.

The *unloaded* cylinder bank will continue to operate *fully unloaded* until the solenoid valve control device is *de-energized* and the gas bypass port is closed.



1. Solenoid Valve
2. Valve Stem
3. Gas Bypass Port
4. Spring Guide
5. Spring
6. Piston
7. Piston Bypass Valve
8. Bleed Orifice
9. Strainer
10. Suction Cavity
11. Cylinder Discharge Valve
12. Valve Plate
13. Cylinder Suction Valve
14. Discharge Piston Check Valve Assembly
15. Discharge Manifold

Figure 1-5. Compressor Cylinder Head Unloaded – Hot Gas Bypass

c. Loaded Operation

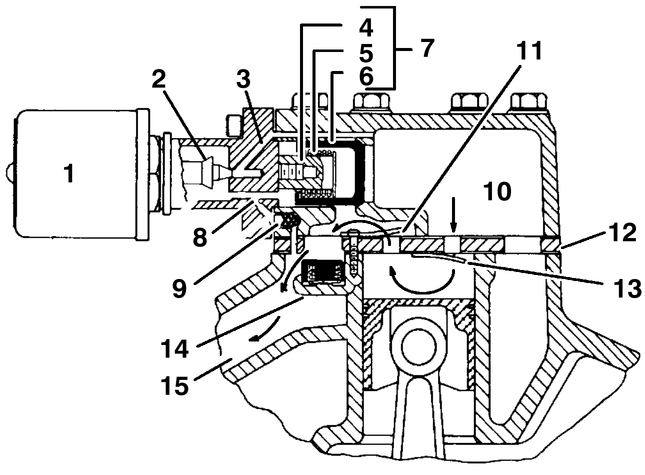
Discharge pressure bleeds from the discharge manifold (Figure 1-6, item 15) through the strainer (9) and (8) bleed orifice to the solenoid valve stem (2) chamber and the back of the piston bypass valve (7).

With the solenoid valve (1) *de-energized* the solenoid valve stem will *close* the gas bypass port (3).

Refrigerant pressure will overcome the bypass valve spring (5) tension and force the piston (6) *forward closing* the gas bypass from the discharge manifold to the suction manifold (10).

Cylinder discharge pressure will force open the discharge piston check valve assembly (14). Refrigerant gas will pass into the compressor discharge manifold.

The loaded cylinder bank will continue to operate fully loaded until the solenoid valve control device is energized and the gas bypass port is opened.



1. Solenoid Valve
2. Valve Stem
3. Gas Bypass Port
4. Spring Guide
5. Spring
6. Piston
7. Piston Bypass Valve
8. Bleed Orifice
9. Strainer
10. Suction Cavity
11. Cylinder Discharge Valve
12. Valve Plate
13. Cylinder Suction Valve
14. Discharge Piston Check Valve Assembly
15. Discharge Manifold

Figure 1-6. Compressor Cylinder Head Loaded – Hot Gas Bypass

1.5.2 SUCTION CUTOFF UNLOADER

The compressor is equipped with unloaders for capacity control. This consists of a self-contained, suction cut-off arrangement which is electronically controlled by the temperature controller.

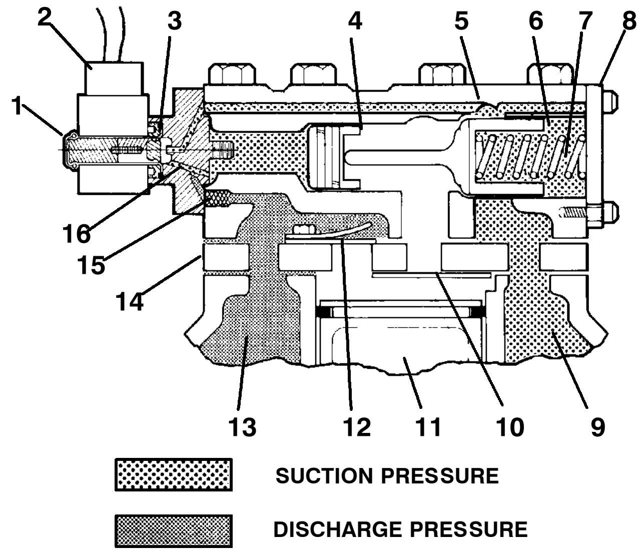
The capacity controlled cylinders are easily identified by the solenoid which extends from the side of the cylinder head. When the solenoid energizes, cylinders unload, preventing suction gas from being drawn into the cylinder (See Figure 1-7). The unloaded cylinders operate with little or no pressure differential, consuming very little power. A de-energized solenoid reloads the cylinders as shown in Figure 1-8.

a. Major Working Parts

1. Solenoid and valve system
2. Unloader piston assembly
3. Spring and cover plate

b. Unloaded Operation

When the unloader valve solenoid energizes, the capacity control valve port opens (item 3, Figure 1-7). This allows the discharge gas behind the unloader piston assembly (item 4) to vent back to the suction side. The unloader valve spring (item 7) at this point, can move the unloader valve body to the left, blocking the unloader suction port. The cylinder bank is now isolated from the compressor suction manifold to unload these two cylinders. No refrigerant is allowed into the cylinders and no compression takes place.

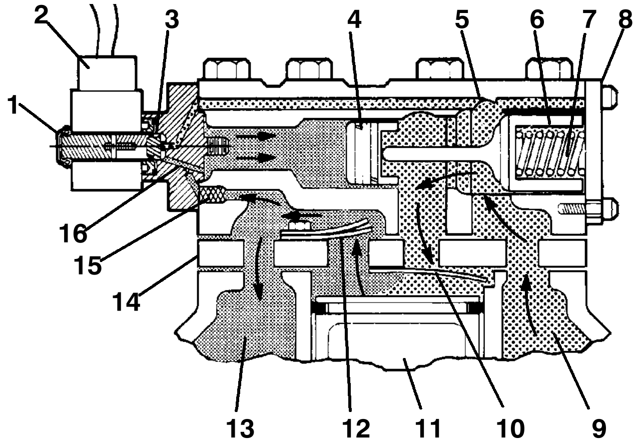


1. Solenoid Valve
2. Coil
3. Capacity Control Valve (Open)
4. Unloader Piston
5. Cylinder Head
6. Valve Body
7. Valve Spring
8. Cover Plate
9. Suction Manifold
10. Suction Valve
11. Piston
12. Discharge Valve
13. Discharge Manifold
14. Valve Plate
15. Strainer
16. Bleed Orifice

Figure 1-7. Compressor Cylinder Head (Unloaded) – Suction Cutoff

c. Loaded Operation

When the unloader valve solenoid de-energizes, the capacity control valve port closes (item 3, Figure 1-8). This allows discharge pressure to build-up behind the unloader piston assembly. The high pressure will compress the unloader valve spring, opening the unloader suction port. Suction gas can now be drawn into the cylinders, running the bank fully loaded.



1. Solenoid Valve
2. Coil
3. Capacity Control Valve (Closed)
4. Unloader Piston
5. Unloader Head
6. Valve Body
7. Valve Spring
8. Cover Plate
9. Suction Manifold
10. Suction Valve
11. Piston
12. Discharge Valve
13. Discharge Manifold
14. Valve Plate
15. Strainer
16. Bleed Orifice

Figure 1-8. Compressor Cylinder Head (Loaded) – Suction Cutoff

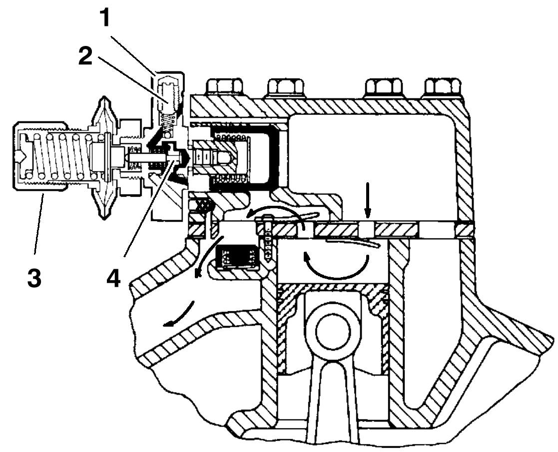
1.5.3 PRESSURE-OPERATED UNLOADERS

There are two types of compressor unloader systems; the first one is the hot gas bypass and the second is the suction cutoff. They are easily distinguished from each other by observing the bottom side of the compressor cylinder head, it is either blank (Hot gas bypass) or has a cover plate (Suction cutoff).

The two types of compressor unloader systems can be controlled with either a pressure actuated valve or an electrically actuated (solenoid) valve.

The pressure–operated unloaders are controlled by suction pressure and actuated by discharge pressure. The unloader valve controls two cylinders. On startup, controlled cylinders do not load up until differential between suction and discharge pressure is 10 psi (1.7 kg/cm^2).

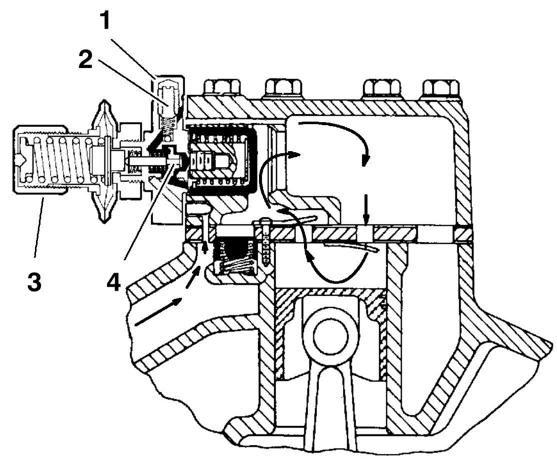
During *loaded operation*, when suction pressure is above the valve control point, the poppet valve will close. Discharge gas bleeds into the valve chamber; the pressure closes the bypass piston; and the cylinder bank loads up. Discharge gas pressure forces the check valve open, permitting gas to enter the discharge manifold. See Figure 1-9.



1. Sealing Cap
2. Pressure Differential Adjustment Screw
3. Control Set Point Adjustment Nut
4. Poppet Valve

Figure 1-9. Pressure-Operated Unloader Loaded Operation

During *unloaded operation*, when suction pressure drops below the valve control point, the poppet valve will open. Discharge gas bleeds from behind the bypass piston to the suction manifold. The bypass piston opens, discharge gas is recirculated back to the suction manifold and the cylinder bank is unloaded. Reduction in discharge pressure causes the check valve to close, isolating the cylinder bank from the discharge manifold. See Figure 1-10.



1. Sealing Cap
2. Pressure Differential Adjustment Screw
3. Control Set Point Adjustment Nut
4. Poppet Valve

Figure 1-10. Pressure-Operated Unloaded – Unloaded Operation

SECTION 2

COMPRESSOR REPLACEMENT

2.1 COMPRESSOR REMOVAL

Refer to the operation and service manual covering the equipment in which the compressor is installed for specific removal instructions. A general removal procedure is given below.

a. If compressor is completely inoperative, frontseat the suction and discharge service valves to trap the refrigerant in the unit. If the compressor will operate, pump down the unit; then, frontseat the suction and discharge service valves.

b. Ensure power source is removed from any controls installed on the compressor.

c. Remove refrigerant using a refrigerant recovery system.

d. Disconnect refrigerant lines at service valve flange connections on the compressor; retain hardware.

e. Remove any components necessary to gain access to the compressor or to enable removal.

f. Disconnect the drive mechanism at the compressor.

g. Remove mounting hardware and remove compressor from unit.

h. If compressor is to be repaired, refer to section 3 for repair procedures. if a replacement compressor is to be installed, refer to section 2.2 for replacement procedures.

2.2 COMPRESSOR REPLACEMENT

Consult the unit service parts list for the correct replacement.

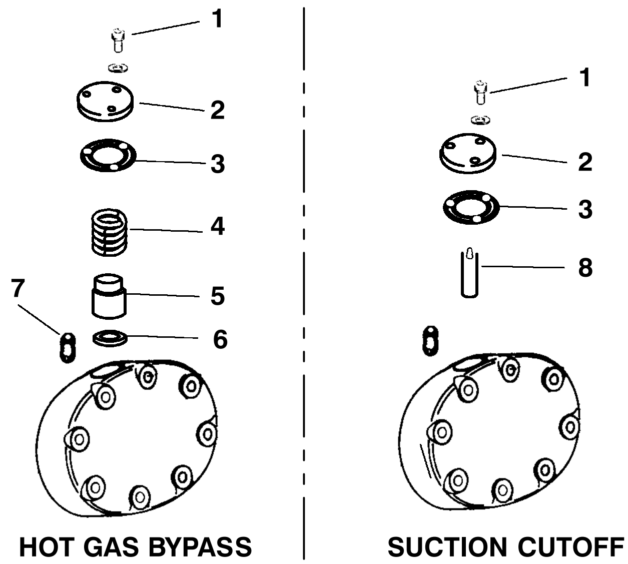
Service replacement compressors are furnished without suction and discharge service valves and unloader valves. The service valves are normally retained on the unit to isolate the refrigerant lines during compressor replacement. Blank-off pads are installed on the service replacement compressor valve flanges. These pads must be removed prior to installing the compressor. If the defective compressor is to be returned for overhaul or repair, install the pads on the compressor for sealing purposes during shipment.

Service replacement compressors are furnished with cylinder head bypass piston plugs installed on the unloader flanges in lieu of the unloader valves. The unloaders (if used) must be removed from the defective compressor and transferred to the replacement compressor prior to installation. Refer to section 2.2.1.

If the defective compressor is to be returned for overhaul or repair, install the plugs on the compressor for sealing purposes during shipment.

2.2.1 INSTALLING COMPRESSOR UNLOADERS

a. Remove the three socket head capscrews holding piston plug to cylinder head of the replacement compressor. See Figure 2-1.



1. Capscrews
2. Flange Cover
3. Gasket
4. Spring
5. Bypass Piston Plug
6. Seat Ring
7. Strainer
8. Sleeve Plug

Figure 2-1. Removal of Piston Plug

b. Remove flange cover, gasket, spring, bypass piston plug, and seat ring. A tapped hole is provided in piston plug for use with a jackscrew to enable removal of the plug. One of the socket head capscrews may be used as a jackscrew.

c. Remove the three socket head capscrews holding unloader in the cylinder head of the defective compressor; remove the unloader and retain the capscrews.

NOTE

Capscrews removed from the bypass piston plug flange cover are not interchangeable with capacity control unloader valve capscrews. When installing the unloaders, be sure to use the unloader capscrews.

d. Using a new gasket and unloader ring pliers (P/N 07-00223), install the unloaders in the cylinder heads of the replacement compressor. Refer to Table 3-1, for required torque values.

e. If the defective compressor is to be returned for overhaul or repair, install the bypass piston plug, spring, seat ring and flange cover onto the cylinder heads.

2.2.2 INSTALLING COMPRESSOR

WARNING

Midseat service valves or by other means relieve pressure in replacement compressor before removing plugs.

CAUTION

The high capacity oil pump must be set to rotate in the same direction as the crankshaft. (Refer to Section 3.4)

a. Install the compressor by reversing the procedure of section 2.1. Install new locknuts on compressor mounting bolts and new gaskets on suction and discharge service valves.

b. Check oil level in sight glass (See Figure 2-2). If necessary, add or remove oil.

c. Leak test, evacuate, and dehydrate the compressor.

d. Fully backseat suction and discharge service valves.

e. Run the compressor and check for leaks and noncondensibles in the refrigerant system.

f. Check refrigerant level.

g. Recheck compressor oil level.

h. Check operation of compressor unloaders (if installed).

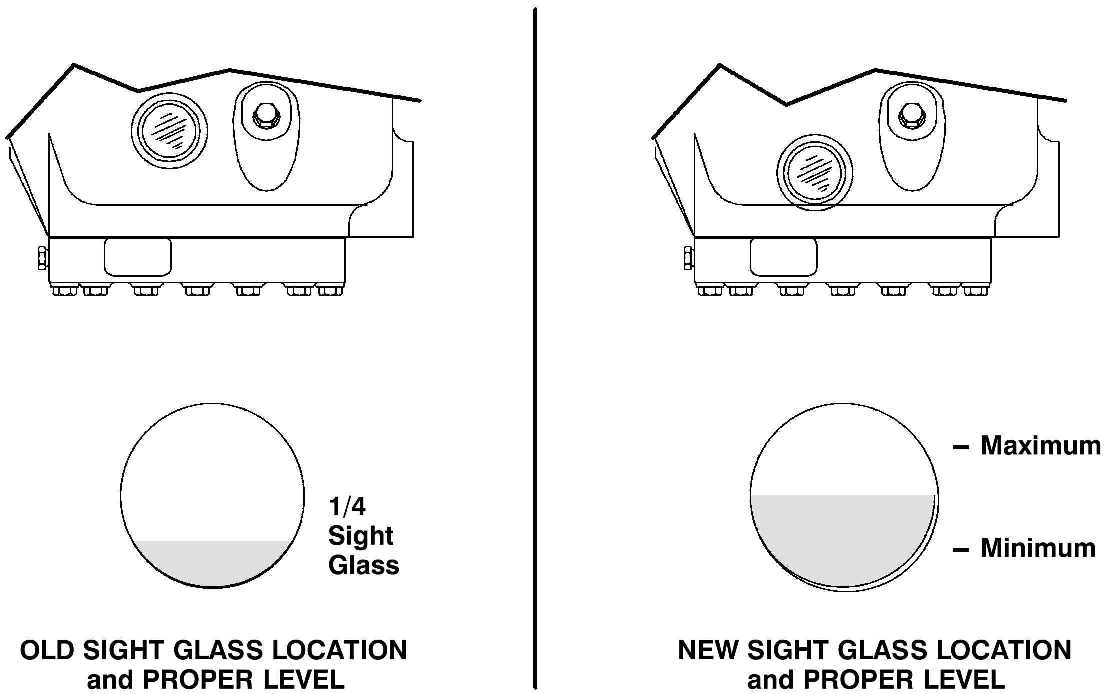


Figure 2-2. Oil Level in Sight Glass

SECTION 3

COMPRESSOR MAINTENANCE

3.1 INTRODUCTION

Prior to disassembly of the compressor, oil must first be drained from the crankcase. Place the compressor in a position where it will be convenient to drain the oil. Remove the oil fill plug to vent the crankcase. Loosen the drain plug and allow the oil to drain out slowly.

If dismantled parts are to be left overnight or longer, dip them in clean compressor oil (to prevent rusting) and store in protected area.

Refer to Table 3-1 for torque values for tightening bolts.

3.2 INSPECTION AND PREPARATION FOR REASSEMBLY

a. Clean all parts with an approved solvent. Use a stiff bristle brush to remove dirt from grooves and crevices.

b. Inspect all parts for wear and overall condition. Replace any defective or excessively worn parts.

c. Inspect suction and discharge valve seats (on valve plate).

d. If unloaders are installed, inspect operation of unloader.

e. After cleaning, ensure all moving parts are coated with compressor oil before reassembly.

f. Use only new gaskets during reassembly. Ensure all gaskets (includes cylinder head, valve plate, and unloader or bypass plug gaskets) are installed dry.

3.3 CYLINDER HEAD AND VALVE PLATE

a. Disassembly

WARNING

Do not unscrew capscrews all the way before breaking seal. Entrapped pressure could result in injury.

1. Loosen cylinder head capscrews. If the head is stuck, tap it lightly with a wooden or lead mallet to free it. Be careful not to drop the head or damage the gasket sealing surface. Remove cylinder head capscrews and gasket. (See Figure 3-1)

2. Remove the discharge valve capscrews, lock washers, stops, and valves.

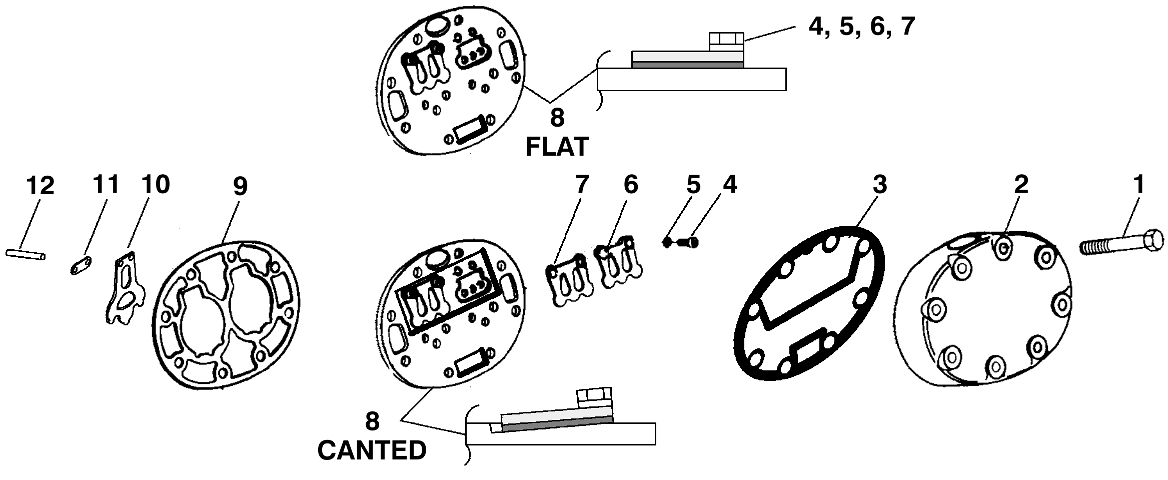
3. Free the valve plates from the cylinder deck by using the discharge valve capscrews, without washers, as jackscrews through the outermost tapped holes in the valve plate after the valve stops and valves have been removed. Remove the valve plate gasket.

4. Discard valves and gaskets. Use only new valves and gaskets when assembling cylinder head and valve plate assemblies.

b. Reassembly

Some 05G compressors for refrigeration use only may have “canted” valve plates. The “canted valve” design allows a reduction in the distance between the discharge valve and the top of the piston. When piston is at TDC the volume of the compression chamber is smaller, contributing to increased compressor efficiency.

1. Install only new valves and gaskets, and do not interchange valves.



1. Capscrew
2. Cylinder Head
3. Cylinder Head Gasket
4. Capscrew
5. Lockwasher
6. Discharge Valve Stop
7. Discharge Valve
8. Valve Plate
9. Valve Plate Gasket
10. Suction Valve
11. Position Spring
12. Dowel Pin

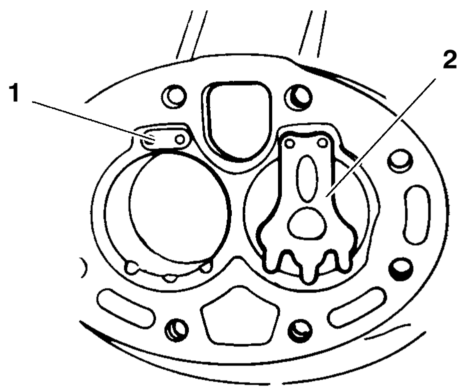
Figure 3-1. Cylinder Head & Valve Plate

2. Install suction valve positioning spring on dowel pins. Assemble positioning spring springs with spring ends bearing against cylinder deck. The spring will bow outward in the middle. (See Figure 3-2)

3. Place suction valve on dowel pins, over the positioning spring.

4. Place valve plate and new valve plate gasket on cylinder deck, ensuring that the valve plate is properly positioned on the four dowel pins.

5. Using a small screwdriver, operate the suction valves to ensure that the valve tips are not being held by the valve plate gasket. (See Figure 3-3)



1. Positioning Spring
2. Suction Valve

Figure 3-2. Installing Suction Valves

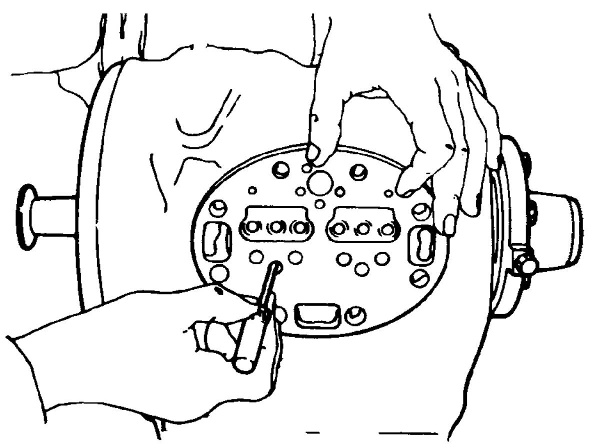


Figure 3-3. Checking Suction Valve

6. Install discharge valve and discharge valve stop with capscrews and lock washers.

7. Install capscrews, cylinder head and new cylinder head gasket with flat side to valve plate, ensuring that the gasket and cylinder head are properly positioned on the valve plate. Torque the capscrews, in a diagonal pattern, to a value shown in Table 3-1.

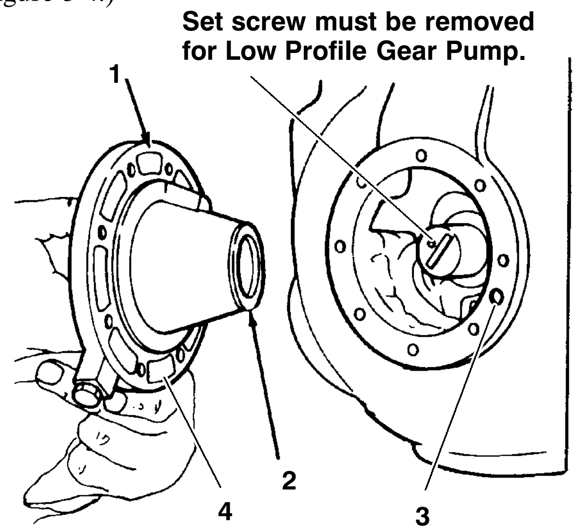
3.4 OIL PUMP AND BEARING HEAD

There are three types of oil pumps (Vane, Gear and Low Profile Gear) driven directly from the end of the compressor crankshaft.

3.4.1 LOW PROFILE GEAR PUMP

a. Removal

Remove eight capscrews and remove oil pump bearing head assembly, gasket and thrust washer. (See Figure 3-4.)

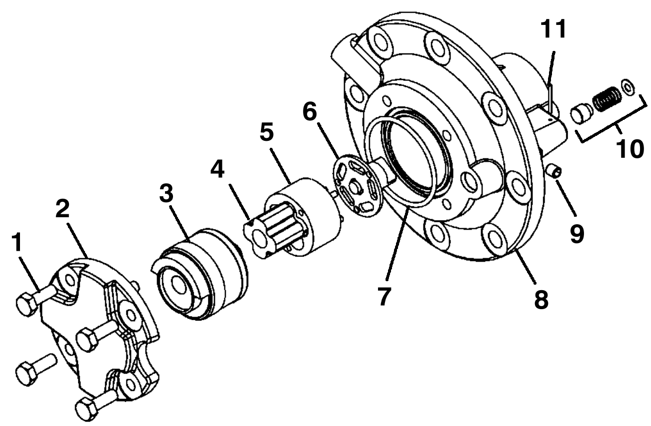


1. Oil Pump & Bearing Head
2. Thrust Washer
3. Oil Pickup Tube
4. Oil Inlet Port

Figure 3-4. Oil Pump and Bearing Head Assembly

b. Disassembly, & Inspection

If it was determined that the oil pump was not operating properly, the entire oil pump and bearing head assembly must be replaced. Replacement parts for the pump are not available. However, in the event the pump requires inspection or cleaning, disassembly and reassembly by referring to Figure 3-5. Clean all parts; coat all moving parts with compressor oil before proceeding with reassembly.



1. Capscrews
2. Cover
3. Reversing Assembly
4. Pinion
5. Gear
6. Drive
7. O-Ring
8. Oil Pump & Bearing
9. Set Screw
10. Relief Valve
11. Pin

Figure 3-5. Low Profile Gear Oil Pump

c. Reassembly

CAUTION

Set screw on crankshaft must be removed for Low Profile Gear Pump (See Figure 3-4).

1. Set screw on crankshaft must be removed for Low Profile Gear Pump.

2. Install the pump end thrust washer on the two dowel pins located on the bearing head. (See Figure 3-4.)

CAUTION

Ensure that thrust washer does not fall off dowel pins while installing oil pump.

3. Install the bearing head assembly with a new gasket on the compressor crankshaft. Carefully push oil pump on by hand ensuring that the thrust washer remains on the dowel pins, the tang on the end of the drive engages the slot in the crankshaft, and the oil inlet port on the pump is aligned with the oil pickup tube in the crankcase. The pump should mount flush with the crankcase and should be oriented as shown in Figure 1-1.

4. Align the gasket and install the eight capscrews in the mounting flange. Refer to Table 3-1, for applicable torque values.

3.4.2 GEAR PUMP

a. Removal

Remove eight capscrews and remove oil pump bearing head assembly, gasket and thrust washer. (See Figure 3-4.)

b. Disassembly, & Inspection

If it was determined that the oil pump was not operating properly, the entire oil pump and bearing head assembly must be replaced. Replacement parts for the pump are not available. However, in the event the pump requires inspection or cleaning, disassembly and reassembly instructions are provided below.

1. Remove pump cover and O-ring. (See Figure 3-6.)

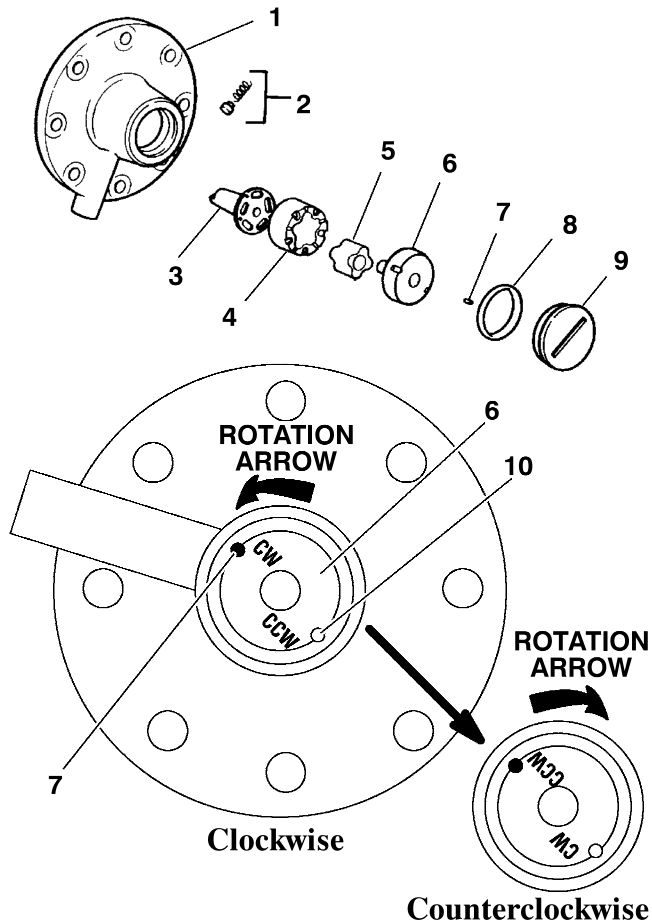
2. Note direction of pump by location of pin in eccentric. The stamping in the eccentric next to the pin shows the direction the pump will rotate, *as viewed from the crankshaft end of the compressor*.

3. If direction of oil pump is not the same rotation as the crankshaft, remove pin. Pin can be removed by holding eccentric in, tipping top of pin slightly outward, and turning pump bottom side up; pin should fall out or use magnet to remove pin.

4. The remainder of the pump components can now be removed, if so desired, by pushing out the drive segment from the crankshaft end of the bearing head.

5. Remove the relief valve assembly by removing the retainer pin.

6. Clean all parts; coat all moving parts with compressor oil before proceeding with reassembly. Mark outside of pump at the short groove for ease of installing pin at a later time. Check wear between items 3 & 4 Figure 3-6.



1. Oil Pump & Bearing Head
2. Relief Valve
3. Drive Segment
4. Five-Lobed Rotor
5. Four-Lobed Rotor
6. Eccentric
7. PIn
8. O-Ring
9. Cover
10. Vent Hole

Figure 3-6. Gear Oil Pump

7. Insert drive segment and five-lobed rotor, ensuring that the pins on the rotor are inserted into the appropriate holes in the drive segment drive wheel.

8. Install the four-lobed rotor inside the five-lobed rotor, ensuring that the end with the counter bore is installed toward the drive segment.

9. Install the eccentric in direction indicated (CW or CCW) as so desired so oil pump rotates in the same direction as the crankshaft. The stamping in the eccentric next to the pin shows the direction the pump will rotate, *as viewed from the crankshaft end of the compressor*.

10. Install the pin in the shortest of the two grooves inside the bearing head.

11. Install the O-ring and pump cover.

12. Install the relief valve assembly.

c. Reassembly

1. Install the pump end thrust washer on the two dowel pins located on the bearing head. (See Figure 3-4.)

CAUTION

Ensure that thrust washer does not fall off dowel pins while installing oil pump.

2. Install the bearing head assembly with a new gasket on the compressor crankshaft. Carefully push oil pump on by hand ensuring that the thrust washer remains on the dowel pins, the tang on the end of the drive segment engages the slot in the crankshaft, and the oil inlet port on the pump is aligned with the oil pickup tube in the crankcase. The pump should mount flush with the crankcase and should be oriented as shown in Figure 1-1.

3. Align the gasket and install the eight capscrews in the mounting flange. Refer to Table 3-1, for applicable torque values.

3.4.3 VANE PUMP

a. Removal

1. Remove four capscrews, gaskets and remove oil pump cover; this will free the oil feed guide retaining spring, cover gasket, and the oil feed guide. (See Figure 3-7.)

2. Remove the two drive segment capscrews and lock washer and remove the drive segment.

3. Remove eight capscrews and remove oil pump bearing head assembly and gasket. (See Figure 3-4.)

b. Disassembly, & Inspection

If it was determined that the oil pump was not operating properly, it is recommended that the entire oil pump and bearing head assembly be replaced to ensure trouble-free operation. However, if the cause of oil pump failure can be determined in the field and replacement parts for the pump are available, the pump can be repaired. The pump end bearing is integral with the bearing head and is not replaceable.

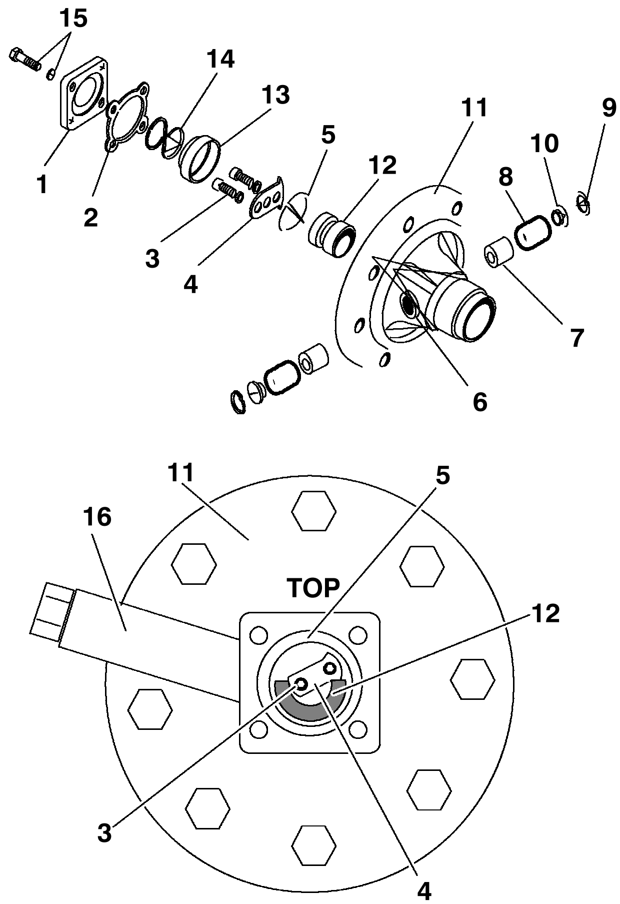
1. Remove the plunger snap ring with snap ring pliers. As each snap ring is removed, the spring guide, plunger spring, and plunger may be removed from the cylinder in the bearing head. Identify parts to ensure replacement in same cylinder.

2. Push the pump rotor out of the bearing head by forcing against the rotor. Apply force from the bearing side and remove rotor from the opposite side. The pump rotor retaining ring will come out with the rotor.

3. Clean all parts; coat all moving parts with compressor oil before proceeding with reassembly.

4. Insert the pump rotor into the bearing head from the side opposite the bearing, with the rotor retaining ring in place on the rotor. Install the rotor retaining ring with the chamfered edge in. Compress the retaining ring (close gap) in order to fit the rotor and ring into their proper positions.

5. Insert one of the plungers into a cylinder in the bearing head (flat end in); then insert the plunger spring and spring guide. Insert retaining ring with ring pliers. Force the spring guide down to compress the plunger spring and to allow the retaining ring to fit into its locking groove. Follow the same procedure to reassemble the other plunger spring, guide and snap ring in its plunger cylinder.



1. Oil Pump Cover
2. Cover Gasket
3. Capscrews and Lockwashers
4. Oil Pump Drive
5. Rotor Retaining Ring
6. Pump Vane Cylinder
7. Pump Vane
8. Vane Spring
9. Retaining Ring
10. Spring Guide
11. Bearing Head
12. Pump Rotor
13. Oil Feed Guide
14. Retainer Spring
15. Capscrews and Washers
16. Oil Inlet Passage

Figure 3-7. Vane Oil Pump

c. Reassembly

1. Install the bearing head assembly with a new gasket on the compressor crankshaft. Carefully push oil pump on by hand ensuring that the bearing head mounts flush to the crankcase body. The top of the bearing head is marked on the mounting flange.

2. Align the gasket and install the eight capscrews in the mounting flange. Refer to Table 3-1, for applicable torque values.

3. Install the drive segment with the two capscrews and lock washer.

4. Insert the oil feed guide with the large diameter in. Insert the guide retaining spring so that it fits over the smaller diameter of the feed guide. The pump cover can now be installed.

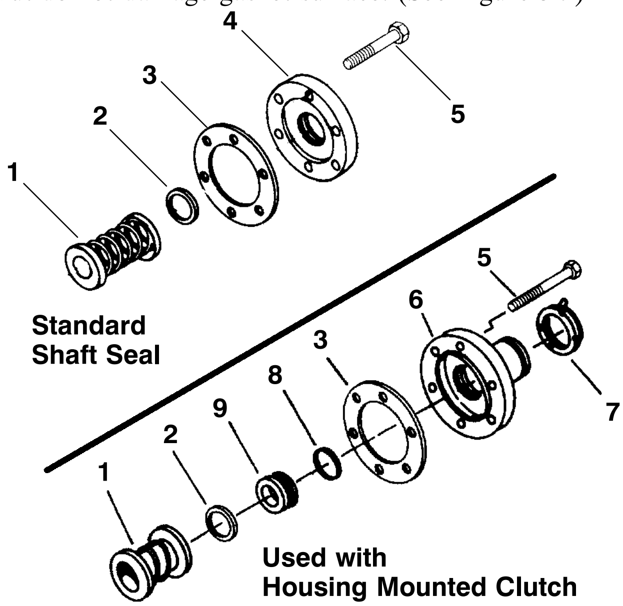
5. Place the pump cover, with a new gasket, over the guide retaining spring and compress the spring to enable installation of the cover capscrews.

3.5 SHAFT SEAL

a. Disassembly

1. Remove 6 capscrews, remove shaft seal cover or clutch mounting hub and carbon washer. (See Figure 3-8)

2. Tap seal end of crankshaft to loosen seal grip on shaft. Using two long screwdrivers, pry out the shaft seal but do not damage gasket surface. (See Figure 3-9)



1. Shaft Seal
2. Carbon Ring
3. Gasket
4. Seal Plate
5. Hex Head Screw
6. Clutch Mounting Hub
7. Snap Ring or Nut
8. O-Ring
9. Wear Ring

Figure 3-8. Shaft Seal

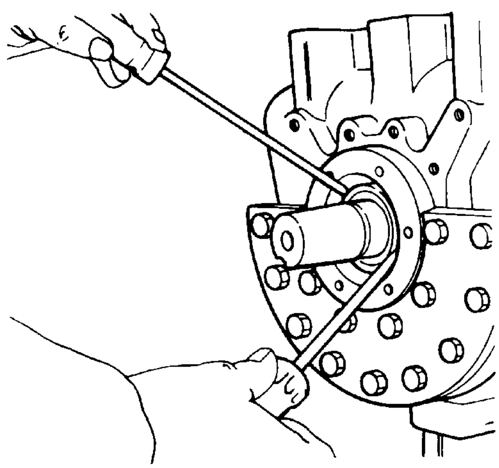


Figure 3-9. Shaft Seal Removal

b. Reassembly

1. Install new shaft seal assembly, cover gasket, and cover plate only. Never install a used seal assembly or gasket. A new carbon washer should never be installed in a used cover plate. When installing the seal assembly, use care not to damage carbon washer or seal seat.

2. Remove new carbon washer from new seal assembly. Lubricate shaft and neoprene seal bellows where it contacts the shaft. Slide seal assembly onto shaft until neoprene bellows start to grip the shaft.

3. Install the **OLD** carbon washer in the new seal seat. Install two capscrews in opposite sides of the old cover plate. Draw up capscrews evenly to properly position new seal assembly against shoulder on shaft. Remove capscrews and old carbon washer and cover plate.

4. Lubricate new carbon washer and carbon washer seal seat with refrigerant oil. Install new carbon washer in seal seat, taking care not to damage the carbon washer or the seat. Ensure that notches in carbon washer are aligned with two small knurls inside the seal seat. Install the new cover plate and gasket. Draw capscrews down evenly to prevent damage to carbon washer.

NOTE

Do not touch carbon washer sealing surface with your fingers.

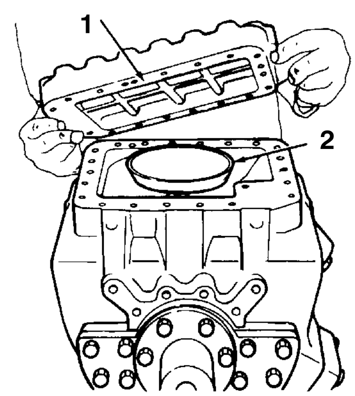
3.6 COMPRESSOR RUNNING GEAR REMOVAL

In order to disassemble Piston, Rod and Rings, first the cylinder head, oil pump and shaft seal must be disassembled (Refer to sections 3.3, 3.4 and 3.5).

a. Bottom Plate, Strainer, and Connecting Rod Caps

1. Turn the compressor over, bottom side up, and remove the bottom plate. (See Figure 3-10) Scrape off gasket.

2. Remove the oil strainer.

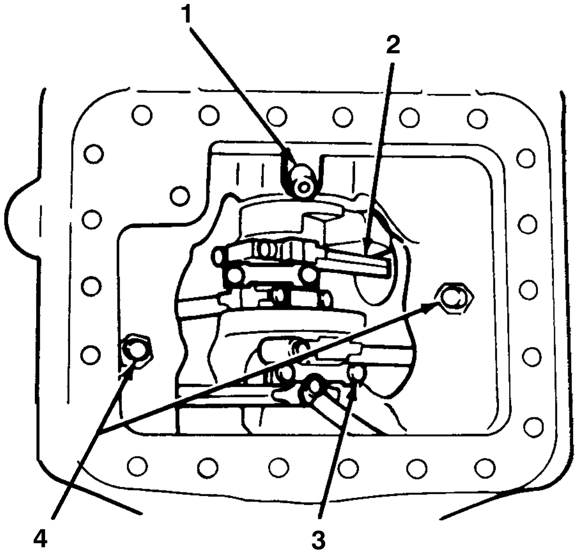


1. Bottom Plate
2. Oil Strainer

Figure 3-10. Bottom Plate Removal

3. Match mark each connecting rod cap and connecting rod for correct reassembly. Remove the capscrews, flat washers and connecting rod caps. It is recommended that the capscrews and flat washers be discarded and new capscrews (special) and flat washers be installed during compressor reassembly. (See Figure 3-11)

4. Push the piston rods down so that the piston rings extend below the cylinders. Remove and discard piston rings. Use only new rings when reassembling the compressor. (See Figure 3-12.)



1. Oil Pressure Relief Valve
2. Connecting Rod and Cap
3. Capscrew
4. Check Valves

Figure 3-11. Bottom Plate and Oil Strainer Removed

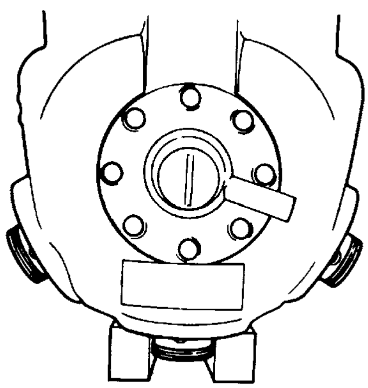


Figure 3-12. Piston Rings Removed

b. Crankshaft and Seal End Thrust Washer

CAUTION

Do not allow crankshaft to drop on connecting rods inside the crankcase when removing the crankshaft.

1. Push piston rod assemblies out of the way and remove crankshaft and seal end thrust washer.

2. Remove and check operation of oil return check valves (See Figure 3-11). The check valves are free floating devices and can easily be checked visually.

3. Remove and check oil pressure relief valve (See Figure 3-11). The oil pressure relief valve is a spring loaded device which can be checked by using a small piece of stiff wire to ensure that the spring can be depressed.

4. Remove piston rod assemblies.

c. Pistons, Rods, and Rings

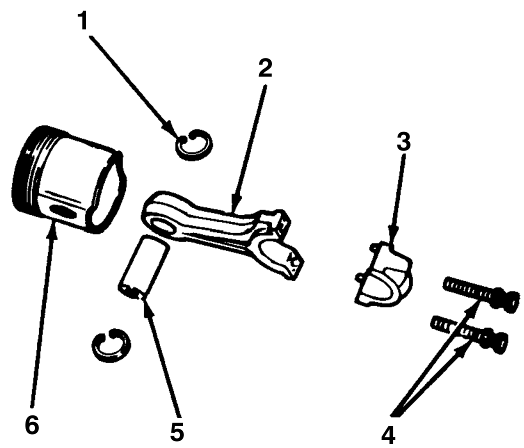
1. Piston and pin, and connecting rod and rod cap are matched sets and must not be interchanged. That is, if either the piston or piston pin is to be replaced, you must replace both of them. Likewise, if a connecting rod or rod cap must be replaced, both must be replaced.

2. Match mark and disassembly pistons, pins, connecting rods, and caps. (See Figure 3-13)

3. Check wear dimensions of disassembled parts to determine if they are worn beyond limits given in Table 3-2.

4. If parts are worn beyond limits, replace them in matched sets as specified above.

5. Coat piston pins with compressor oil and reassembly pistons, pins, and connecting rods in matched sets.



1. Lock Ring
2. Connecting Rod
3. Connecting Rod and Cap
4. Capscrew
5. Piston Pin
6. Piston

Figure 3-13. Connecting Rod, Piston, and Pin

d. Seal End Main Bearings

1. Inspect seal end main bearings. Check wear dimensions to determine if they are worn beyond limits given in Table 3-2.

2. If worn beyond limits remove seal end main bearings.

3.7 COMPRESSOR RUNNING GEAR REASSEMBLY

a. Seal End Main Bearings

1. When installing new seal end main bearings the oil groove is on top of the compressor with V grooves pointing to each other. When installed, there must be a 5/16 inch (7.93 mm) gap between the two bearings (See Figure 3-14).

2. Line boring seal end main bearings.

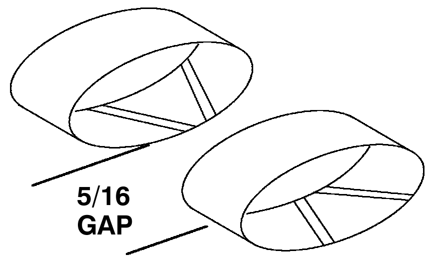


Figure 3-14. Seal End Main Bearings

b. Pistons, Rods, and Rings

Prior to installing new piston rings, it is necessary to break the hard glazed surface of the cylinder in order to reduce the wearing-in period of the new rings. Break the glaze by honing lightly in an up and down rotating motion. Clean thoroughly after breaking glaze.

Some 05G compressors for refrigeration use only may have contoured pistons (See Figure 3-15). When installing contoured pistons into compressor, check suction valve and contoured piston are in the same orientation.

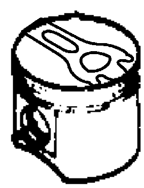


Figure 3-15. Contoured Piston

1. The gap between the ends of the piston rings can be checked with a feeler gauge by inserting the ring into the piston bore about one inch below the top of the bore. Align the ring in the bore by pushing it slightly with a piston. The maximum and minimum allowable ring gaps are shown in Table 3-2.

2. Install the piston and rod assemblies up through the bottom of the crankcase and into the cylinders. Allow pistons to extend beyond the top of the cylinder to enable installation of piston rings. Pistons must be installed so that the chamfer, on the connecting rod, faces toward the crankshaft journals. Center rods on each crankshaft throw may be installed in either direction. (See Figure 3-16)

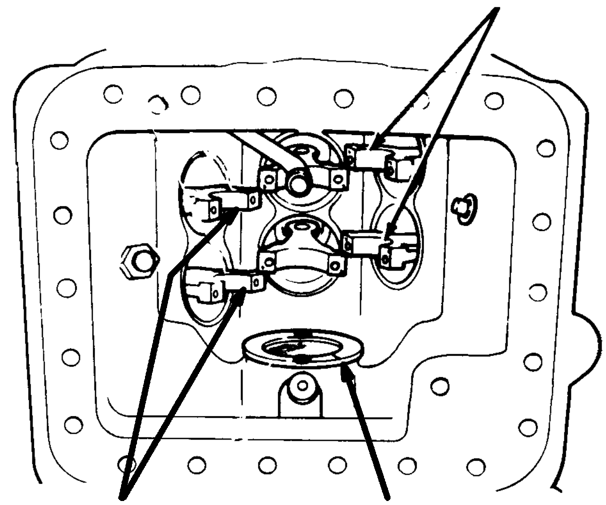


Figure 3-16. Installing Piston Rod Assemblies and Seal End Thrust Washer

3. Depending on date of manufacture, the compressor may be fitted with double or single ring pistons. Double ring and single ring pistons may be installed in the compressor, as long as matched pistons are used on each bank.

4. Old double ring pistons (with wider lower ring groove), the oil ring is installed in the groove nearest the bottom and the compression ring in the groove nearest the top. The oil ring is notched on the outside circumference. This notch must be installed towards the bottom. (See Figure 3-17)

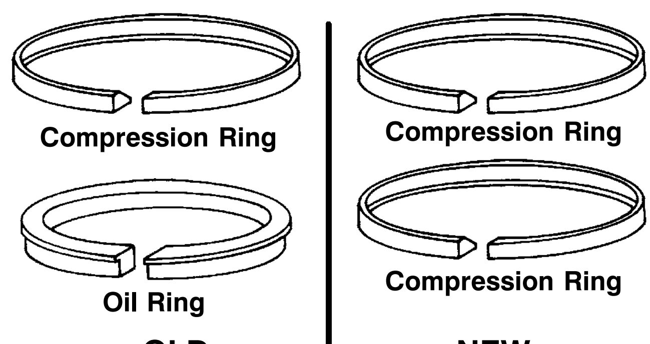


Figure 3-17. Piston Rings

5. The compression ring is chamfered on the inside circumference. This ring is installed with the chamfer towards the top. If using a double ring piston, stagger the ring end gaps so they are not aligned.

6. Measure side clearance between ring and ring groove in piston. Maximum dimensions are provided in Table 3-2.

c. Crankshaft and Seal End Thrust Washer

1. Two brass thrust washers are used. The pump end thrust washer is positioned on two dowel pins located on the bearing head and is installed with the oil pump and bearing head assembly. The seal end thrust washer is positioned just ahead of the seal end main bearing on two dowel pins installed in the crankcase. Both thrust washers should be inspected for wear and scoring before reassembly (Refer to Table 3-2).

2. Install the seal end thrust washer on the two dowel pins. (See Figure 3-16) Ensure piston rods are pushed out of the way and install the crankshaft.

CAUTION

Do not allow crankshaft to drop on connecting rods inside the crankcase when installing the crankshaft.

d. Bottom Plate, Strainer, and Connecting Rod Caps

1. Do not tap piston with hammer if rings are caught at entrance to the cylinder. Using a ring compressor, squeeze rings sufficiently to allow piston to be pushed down into the cylinder. Ensure that ring ends are staggered so that the gaps are not aligned, and lightly tap piston down into the cylinder. (See Figure 3-18) The ring compressor can be easily fabricated from a piece of sheet metal.

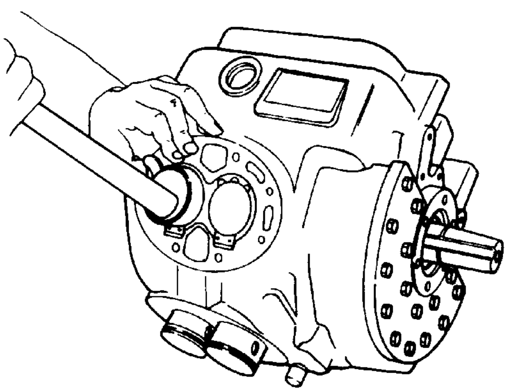


Figure 3-18. Installing Pistons

2. Install connecting rod caps on connecting rods using new capscrews (special) and flat washers. Reuse of the old capscrews is not recommended. Ensure that the caps are installed on the dowel pins. Torque capscrews to torque value shown in Table 3-1. Ensure freedom of movement of crankshaft after capscrews are torqued on each rod cap.

3. Check operation and reinstall check valves and relief valve. (See Figure 3-11). The check valves are free-floating devices and can easily be checked visually. The relief valve is a spring-loaded device which can be checked by using a small piece of stiff wire to ensure that the spring mechanism can be depressed.

4. Clean and reinstall the oil strainer.

5. Using a new gasket, install the bottom cover plate. See figure 1-1 for relative location of compressor mounting flanges. Torque cover capscrews, in a diagonal pattern, to the torque value shown in Table 3-1.

6. Reassembly the cylinder head, oil pump and shaft seal (Refer to sections 3.3, 3.4 and 3.5).

3.8 SUCTION STRAINER

NOTE

Suction strainer has been preformed to fit into suction cavity.

Remove and clean the suction strainer. (See Figure 3-19) Check it for damage. If it is damaged, replace suction strainer. Install suction strainer and suction service valve using a new gasket.

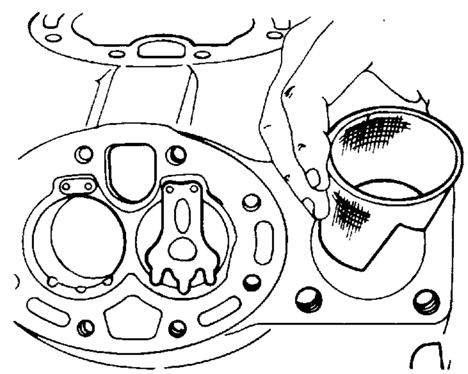


Figure 3-19. Installing Suction Strainer

3.9 ADDING OIL

Add the proper oil charge to the compressor through the oil fill plug. Refer to section 2.2.2 for the required oil charge. Refer to unit operation manual for other methods of adding oil to compressor.

3.10 INSTALLING COMPRESSOR

Refer to section 2.2.2 and the unit service manual to install the compressor. Allow compressor to run for 4 to 5 hours before checking new shaft seal assembly for leaks.

Table 3-1. Torque Values

SIZE DIAMETER (INCHES)	THREADS PER INCH	TORQUE RANGE FT-LB	TORQUE RANGE MKG	USAGE
1/16	27 (pipe)	8 to 12	1.11 to 1.66	Pipe Plug – Crankshaft
1/8	27 (pipe)	15 to 20	2.07 to 2.77	Oil Return Check Valve – Crankcase
1/4	20 (pipe)	20 to 25	2.77 to 3.46	Pipe Plug – Gauge Connection
1/4	20	10 to 12	1.38 to 1.66	Connecting Rod Capscrew
1/4	28	6 to 10	0.83 to 1.38	Oil Pump Drive Segment (Vane Pump)
		12 to 16	1.66 to 2.21	Unloader Valve
5/16	18	16 to 20	2.21 to 2.77	Cover Plate – Plate End
				Bearing Head (Vane Pump)
		20 to 30	2.77 to 4.15	Discharge Service Valve
3/8	16	40 to 50	5.53 to 6.92	Pump End Bearing Head
				Bottom Plate – Crankcase
				Cylinder Head
				End Flange
				Shaft Seal Cover
1/2	13	55 to 80	7.61 to 11.06	Suction Service Valve
#10	32	4 to 6	0.55 to 0.83	Oil Pump Drive Segment (Vane Pump)
1-1/2	18 NEF	35 to 45	4.84 to 6.22	Oil Level Sight Glass

NEF – National Extra Fine

Table 3-2. Wear Limits

PART NAME	FACTORY MAXIMUM		FACTORY MINIMUM		MAXIMUM WEAR BEFORE REPAIR	
	INCHES	MM	INCHES	MM	INCHES	MM
SEAL END						
End Play (Seal Removed)	0.035	0.8890	.030	0.7620	–	–
Main Bearing Diameter	1.8760	47.6504	–	–	.002	0.051
Main Bearing Journal Diameter	–	–	1.8725	47.5615	.002	0.051
PUMP END						
Main Bearing Diameter	1.3760	34.9504	–	–	.002	0.051
Main Bearing Journal Diameter	–	–	1.3735	34.8869	.002	0.051
CONNECTING ROD						
Connecting Rod Diameter	1.3768	34.9707	–	–	.0020	0.051
Piston Pin Bearing	0.6883	17.4752	0.6878	17.4701	.001	0.0254
CRANKSHAFT						
Crankpin Diameter	–	–	1.3735	34.8869	.0025	0.0635
Throw – Height **(37 CFM)**	0.9698	24.6329	0.9678	24.5821	–	–
Throw – Height **(41 CFM)**	1.072	27.2288	1.070	27.1780	–	–
THRUST WASHER (Thickness)						
Pump End	0.145	3.6830	0.144	3.658	.0250	0.6350
Seal End	0.157	3.987	0.155	3.937	.0250	0.6350
CYLINDERS and PISTONS						
Bore	2.0010	50.8254	–	–	.002	0.051
Piston (Diameter)	–	–	See Figure 3-20		.002	0.051
Piston Pin (Diameter)	–	–	0.6873	17.4574	.001	0.025
Piston Ring Gap	0.013	0.3302	0.005	0.127	.025	0.635
Piston Ring Side Clearance	0.002	0.051	0.001	0.0254	.002	0.051

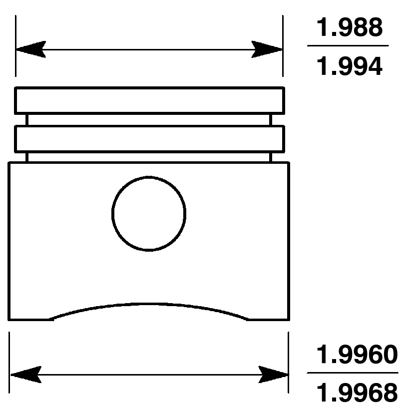


Figure 3-20. Piston Dimension (Wear Limits)

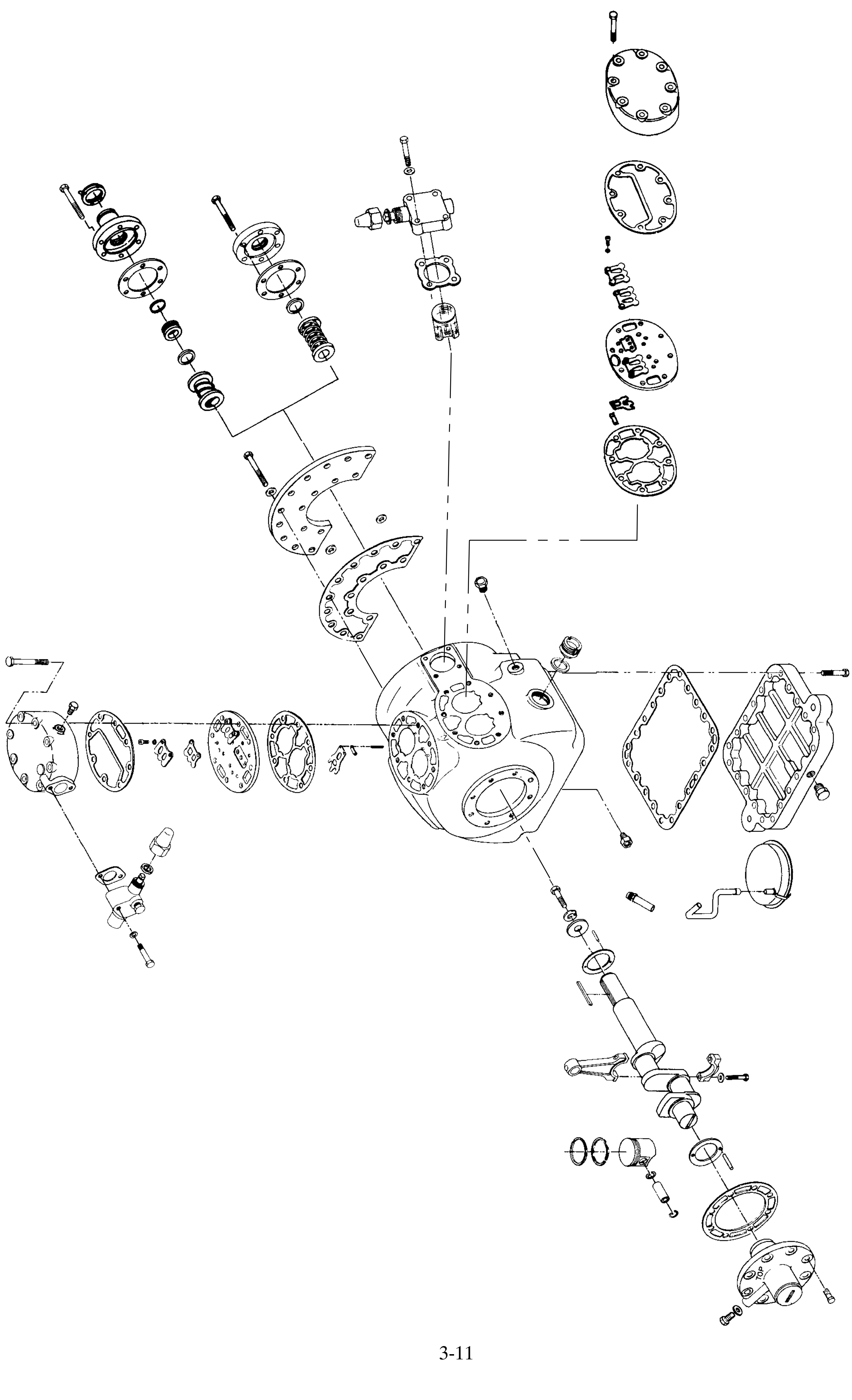


Figure 3-21. Compressor Exploded View

Carrier
Transicold

Transport
Air Conditioning

MODEL O5G
(Three Port Valve Plate)
BUS COMPRESSOR

Service Parts List

T-200PL Rev F

Carrier
TRANSICOLD

Service Parts List

Model 05G
(Three Port Valve Plate)
Bus Compressor

CONTENTS

Carrier Transicold. A member of the United Technologies Corporation family. Stock symbol UTX.
Carrier Transicold Divsion, Carrier Corporation, P.O. Box 4805, Syracuse, N.Y. 13221 U. S. A.

Carrier
A United Technologies Company

INTRODUCTION

This parts list identifies service replacement parts for the Model 05G Bus Compressors listed in the Model Chart below. To find replacement parts, determine the major group in which the replacement parts are located (refer to the Table of Contents) and turn to the appropriate page for the illustrated parts breakdown of the replacement parts. A detailed list of the tools needed to service the O5G compressor is found inthe Service Tool List catalog 62-03213.

MODEL CHART

<table>
<tr><th>PART NO.</th><th>MODEL</th><th>OIL/APPLICATION</th><th>REMARKS</th></tr>
<tr><td>17-44053-02</td><td>05GX-37CFM for Shaft Mounted Clutch</td><td>Mineral Oil / R-12 / R-22</td><td rowspan="7">Remanufactured compressors (less service valves), with plugged heads for use with or without unloaders.</td></tr>
<tr><td colspan="3">COMPRESSORS FOR HOUSING MOUNTED CLUTCH</td></tr>
<tr><td>17-44054-02</td><td>05GX–37CFM</td><td>Mineral Oil / R-12</td></tr>
<tr><td>17-44065-00</td><td>05GX–37CFM</td><td>No Oil / R-134a</td></tr>
<tr><td>18-00059-169</td><td>05GX-37CFM W/Special Crankshaft</td><td>Alkyl Benzene Oil / R-22</td></tr>
<tr><td>17-44061-00</td><td>05GX-37CFM</td><td>POE Oil / R-134a</td></tr>
<tr><td>17-44062-00</td><td>05GX-41CFM</td><td>POE Oil / R-134a</td></tr>
</table>

ORDERING INSTRUCTIONS

All orders and inquiries for parts must include: Unit Serial Number, Part no., description of part as shown on list and quantity required. Address all correspondence for parts to the following address:

CARRIER TRANSICOLD DIVISION
Replacement Components Group, TR-20
P.O. Box 4805, Syracuse, NY 13221.
or
Fax to: (315) 432-3778

GENERAL NOTES

To find replacement parts consult table of contents, and turn to the appropriate page for the illustrated breakdown of replacement parts. The following letter designations are used to classify parts throughout this list.

A/R *As Required*

NS *Not Shown* in the illustration

NSA *Non-Stock Assembly* – order components listed under the assembly.

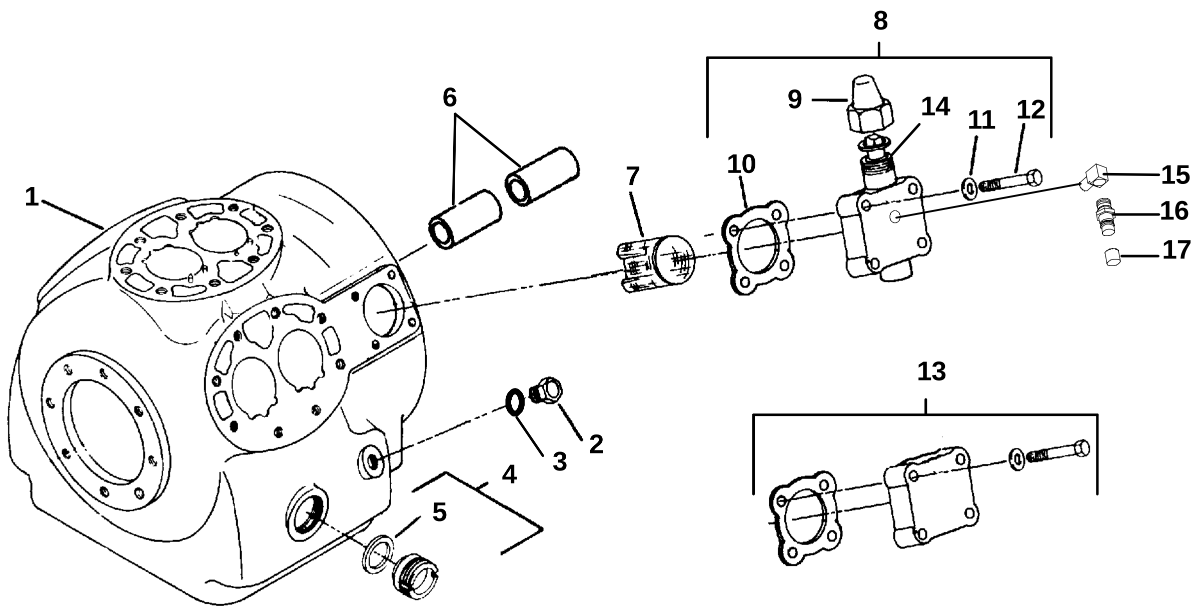
NSI *Non-Stock Item* – may be available on special order.

NSS *Not Sold Separately* – order next higher assembly or kit.

PL *Purchase Locally*

NLO *No Longer Offered*

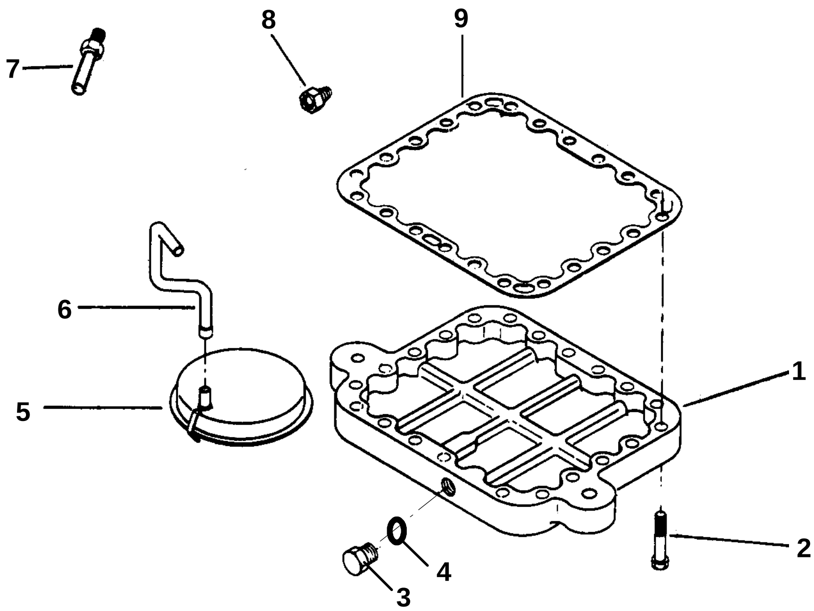
1 CRANKCASE AND SUCTION SERVICE VALVE



Fittings 15, 16, 17can also be found in the Performance Parts Service Tool Catalog Number 62-03213

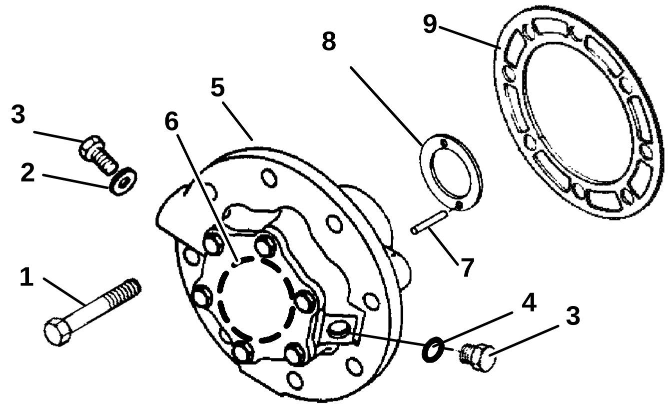
Item	Part Number	Description	Qty
1	NSA	Crankcase	1
2	--CA--63AA-051	Pipe Plug, 1/4-18NPT (package of 20)	3
	17-44037-00	Plug, O-Ring, 7/16-20 – Includes:	1
3	42-00243-07	O-Ring	1
4	17-10218-00	Sight Glass, Oil Level - Includes:	2
5	17-10218-02	Gasket	1
6	17-44015-00	Bearing, Main Seal End (Requires Line Boring)	2
7	17-44005-00	Strainer, Suction	1
8	17-31062-00	Valve, Service, 1-1/8 ODF - Includes:	1
9	17-10812-00	Cap, Service Valve (Plastic)	1
8	17-40002-01	Valve, Service, 1-3/8 ODF - Includes:	1
9	17-10812-00	Cap, Service Valve (Plastic)	1
10	17-40005-05	Gasket, Service Valve (Fiber)	1
11	17-40007-00	Gasket, Capscrew, 1/2 Inch	4
12	17-13020-00	Capscrew, 1/2-13 x 2-1/2 Inches Long - SAE Grade 8	4
9	17-10806-10	Cap, Service Valve (Brass)	1
10	17-44141-00	Gasket, Service Valve (Metal)	1
13	17-13006-00	Kit, Valve Pad Blank Off, 4 Bolt Suction Service Valve	1
14	17-13022-00	Packing, Service Valve Stem (package of 10)	1
15	40-00524-00	Elbow, 1/4 NPT x M13, Brass (for R-134a)	1
16	40-00520-00	Coupling, M13, R-134a, Brass – Includes:	1
17	40-00520-02	Cap, Service Port	1
16	O6DA-403---844	Valve, Access (1/4 Flare, Schrader) (for R-12, R-22)	1
17	--DD--19CA-061	Cap, 1/4 Flare, Schrader	1

2 COMPRESSOR BASE GROUP

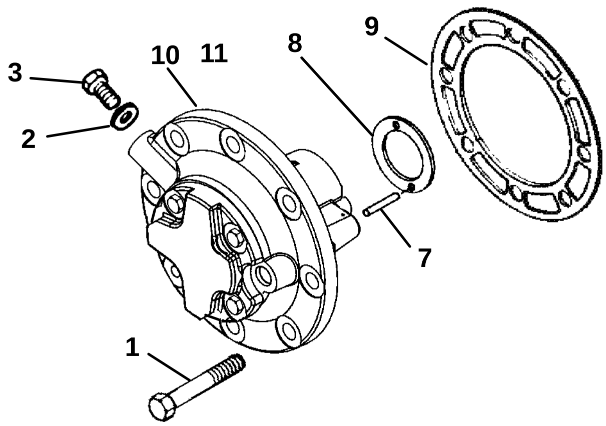


Item	Part Number	Description	Qty
1	17-44035-00	Plate, Bottom, Aluminum	1
	17-44026-00	Plate, Bottom, (Power Pack Compressors)	1
2	17-44117-00	Capscrew, Hex Head, 3/8-16 x 2-1/4 Inches Long - SAE Grade 8	22
3	--CA--63AA-051	Pipe Plug, 1/4-18NPT (package of 20)	1
	17-44037-00	Plug, O-Ring, 7/16-20 – Includes:	1
4	42-00243-07	O-Ring	1
5	17-40020-00	Oil Filter Screen Assembly	1
6	17-40021-00	Tube, Oil Suction	1
7	17-44011-00	Oil Relief Valve	1
8	17-40042-00	Oil Return Check Valve Assembly	2
9	17-40033-05	Gasket, Bottom Plate	1

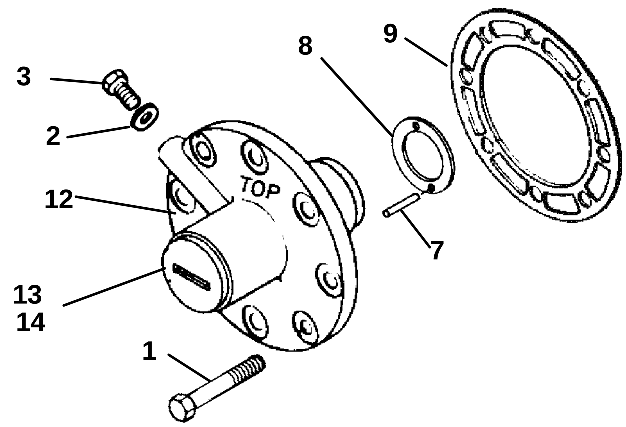
3 BEARING HEAD AND OIL PUMP



UNIVERSAL PUMP



LOW PROFILE PUMP (NLO)

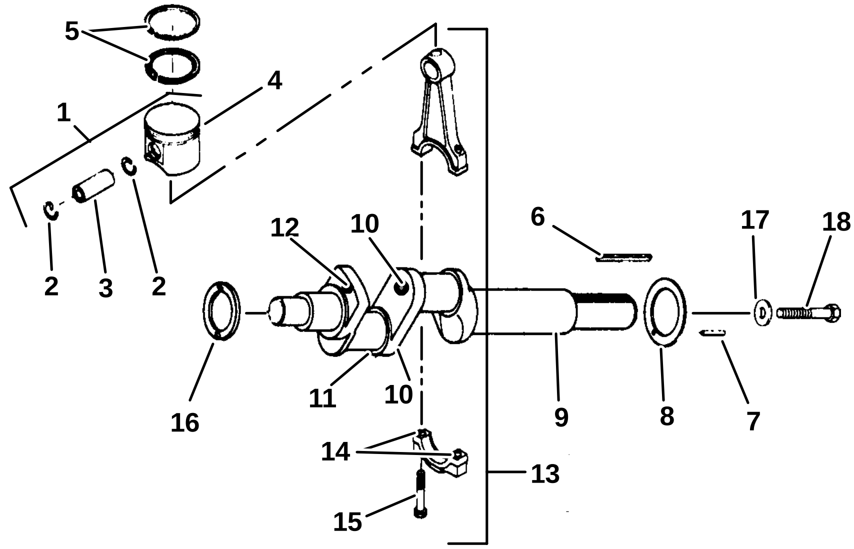


GEAR PUMP (NLO)

Item	Part Number	Description	Qty
1	17-10308-00	Capscrew, Hex Head, 3/8-16 x 1-1/4 Inches Long - SAE Grade 5	8
2	17-40019-00	Gasket, Capscrew	1
3	--AA--06GS-228	Capscrew, 3/8-16 x 3/4 Inch Long (package of 20)	1
	17-44037-00	Plug, O-Ring, 7/16-20 – Includes:	1
4	42-00243-07	O-Ring	1
5	17-44137-00	Oil Pump and Bearing Head (Universal Gear Pump)	1
6	17-44139-00	O-Ring, Pump Cover Plate	1
7	17-40204-00	Pin, Roll, 1/8 x 1/2 Inch	2
8	17-55009-01	Thrustwasher, Pump End	1
9	17-40078-05	Gasket, Bearing Head (Fiber)	1
	17-44022-00	Gasket, Bearing Head (Metal)	1
10	SEE NOTE	Oil Pump and Bearing Head Assembly (Low Profile Gear Pump)	1
11	42-00045-01	O-Ring	1
12	SEE NOTE	Oil Pump and Bearing Head Assembly (Gear Pump) - Includes:	1
13	17-44033-01	Cover Assembly, Screw - Includes:	1
14	17-44033-02	Gasket, O-Ring	1

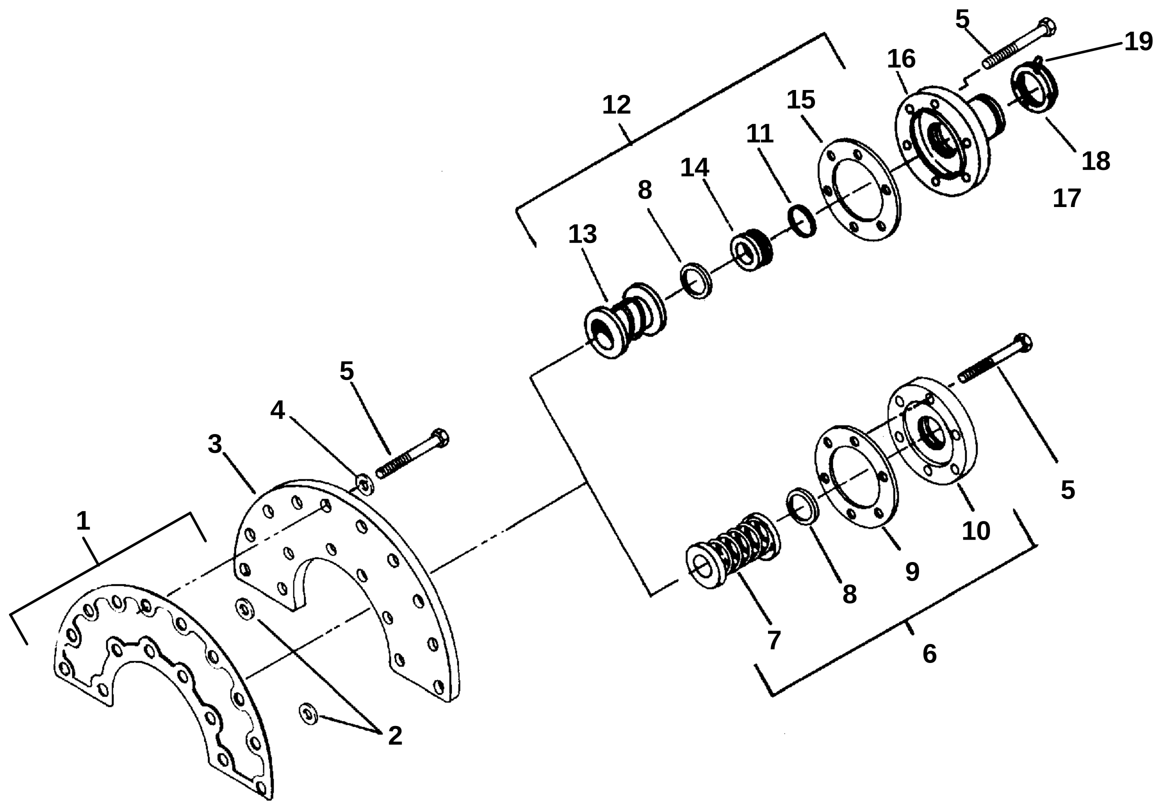
NOTE: Low Profile and Gear Oil Pump Bearing Head Assemblies are no longer offered use the Universal Gear Pump (Item 5).

4 CRANKSHAFT, ROD AND PISTON GROUP



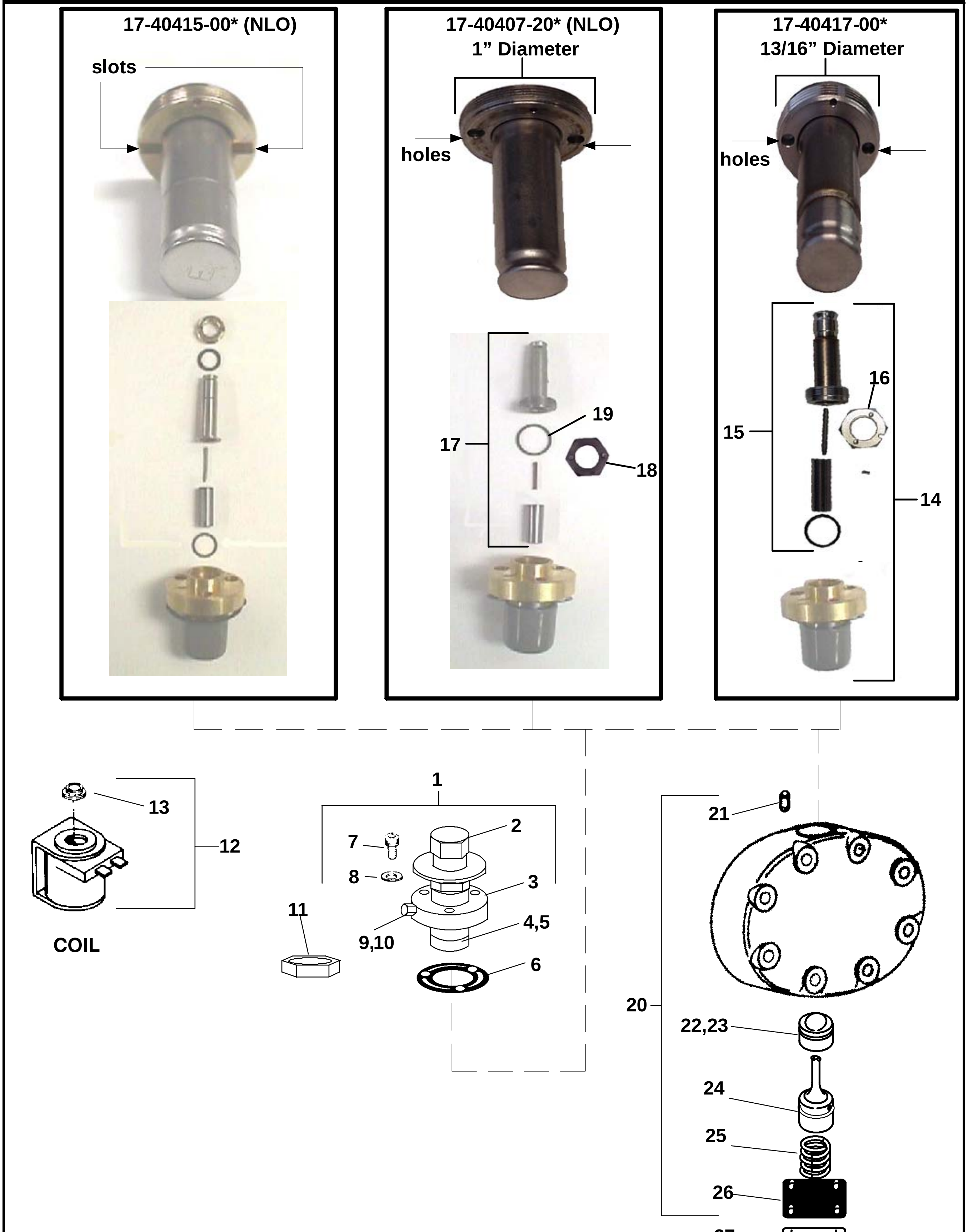
Item	Part Number	Description	Qty
1	17-44045-01	Piston and Pin (Standard - O5G37) Includes:	6
	17-44045-03	Piston and Pin (.020 Inch Oversize - O5G37) Includes:	6
	17-44121-01	Piston and Pin (Standard - O5G41) Includes:	6
	17-44122-01	Piston and Pin (.020 Inch Oversize - O5G41) Includes:	6
2	17-40053-00	Retainer, Piston Pin	2
3	NSS	Pin, Piston	1
4	NSS	Piston	1
5	17-40055-00	Ring, Compression (Standard)	12
	17-55025-00	Ring, Compression (.020 Inch Oversize)	12
	17-40054-00	Ring, Oil (Used on old 5G37 pistons with wider lower ring groove)	A/R
6	17-40324-00	Key, Crankshaft, 1/4 x 1/4 x 1-1/2 Inches Long (For Shaft Mounted Clutch)	1
	68G2-9072	Key, Crankshaft (For Housing Mounted Clutch)	1
7	17-44036-00	Pin, Spiral, 1/8 x 1/2 Inch Long	2
8	17-44008-00	Thrustwasher, Seal End	1
9	17-40410-00	Crankshaft Assembly (O5G37 Gear Pump) - Includes:	1
	17-40412-00	Crankshaft Assembly (O5G41 Gear Pump) - Includes:	1
10	17-40317-00	Expansion Plug	2
11	--AF--55CQ-164	Setscrew, 1/4-28 x 1/2 Inch Long	1
12	34-00300-07	Capscrew, Hex Head, 1/4-20 x 7/8 Inch Long - Grade 5	1
13	17-40056-02	Connecting Rod and Cap Assembly (Standard) - Includes:	6
	17-55023-00	Connecting Rod and Cap Assembly (.010 Inch Undersize) - Includes:	A/R
14	17-40057-00	Pin, Dowel	2
15	17-55008-00	Capscrew (Special)	2
16	17-55009-01	Thrustwasher, Pump End	1
17	34-00616-00	Washer, 13/32 ID x 1-1/2 OD x 3/16 Thick	1
18	34-00613-07	Capscrew, Hex Head, 3/8 UNF x 7/8 Inch Long - SAE Grade 8	1

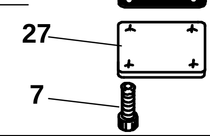
5 SHAFT END GROUP



Item	Part Number	Description	Qty
1	17-44118-00	Gasket, Shaft End Cover	1
2	17-44014-00	Gasket, Flange Spacer	2
3	17-44127-00	Flange, Shaft End	1
4	17-40019-00	Gasket, Capscrew	21
5	17-10308-00	Capscrew, 3/8-16 x 1-1/4 Inches Long - SAE Grade 5	21
6	17-44145-00	Seal Assembly (Shaft Mounted Clutch) - Includes:	1
7	NSS	Spring, Shaft Seal	1
8	17-44131-01	Washer, Carbon	1
9	17-44004-06	Gasket, Seal Cover – Steel	1
10	NSS	Seal Cover, Shaft	1
11	17-44043-02	O-Ring Used with Silicone Carbide	1
12	17-44150-00	Seal Assembly (Silicone Carbide, Housing Mounted Clutch) - Includes:	1
8	17-44131-01	Washer, Carbon	1
13	NSS	Spring, Shaft Seal	1
14	NSS	Ring,Wear	1
11	17-44043-02	O-Ring	1
15	17-44004-05	Gasket, Seal Cover – Fiber	1
9	17-44004-06	Gasket, Seal Cover – Steel	1
16	17-44041-01	Hub, Clutch Mounting - Includes:	1
17	17-44042-00	Ring, Felt and Retainer	1
18	34-01161-00	Nut, Hub, With Grease Fitting Port (Fitting Not Included)	1
19	40-01132-00	Fitting, Grease, 1/4–18	1

6 UNLOADERS



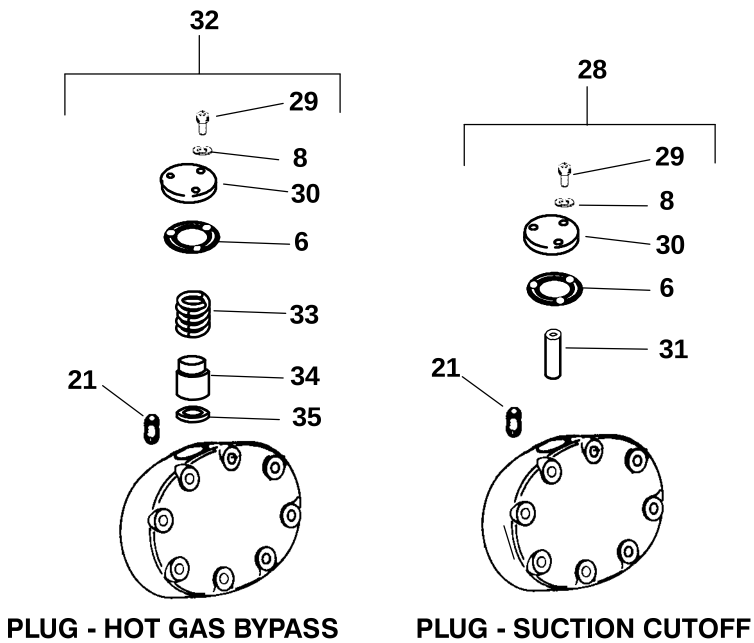


*** NOTE:** If Unloader 17-40415-00 needs stem repair,
Unloader 17-40417-00 is to be substituted, entirely.
17-40417-00 Replaces all previous unloaders.

6	UNLOADERS (Continued)		
Item	**Part Number**	**Description**	**Qty**
1	17-55018-01	Valve Assembly (Pressure) – Includes:	A/R
2	NSS	Power Assembly, Unloader (Suction Pressure Activated)	1
3	NSS	Body Assembly, Valve	1
4	17-40409-00	Piston (For Hot Gas Bypass Unloaders) – Includes:	1
5	17-55010-00	Ring, Piston	1
6	17-40104-07	Gasket, Unloader Valve	1
7	17-40111-00	Screw, Socket Head, 1/4–28 x 3/4 Inch Long	1
8	17-40104-20	Gasket, Socket Head Screw, 1/4 Inch	1
9	17-55028-00	Cap, Adjustment Screw	1
10	42-50019-00	O-Ring, Adjustment Screw Cap	1
11	34-01139-00	Nut, Unloader Adjuster Lock	1
12	22-02567-00	Coil, Valve, 12 VDC with Spade Terminal - Includes:	A/R
	14-00143-07	Coil, Valve, 12 VDC with 6 inch wire leads - Includes:	A/R
	22-50030-00	Coil, Valve, 24 VDC with 42 inch wire leads - Includes:	A/R
	22-02567-01	Coil, Valve, 24 VAC with Spade Terminal - Includes:	A/R
	16-00149-00	Coil, Valve, 115 VAC with 42 inch wire leads - Includes:	A/R
	17-10829-00	Coil, Valve, 230 VAC with 42 inch wire leads - Includes:	A/R
13	17-40408-02	Cap, Snap	1
14	17-40417-00	Valve Assembly (Electric) – Includes:	A/R
3	NSS	Body Assembly, Valve	1
4	17-40409-00	Piston (For Hot Gas Bypass Unloaders) – Includes:	1
5	17-55010-00	Ring, Piston	1
6	17-40104-07	Gasket, Unloader Valve	1
7	17-40111-00	Screw, Socket Head, 1/4–28 x 3/4 Inch Long	1
8	17-40104-20	Gasket, Socket Head Screw, 1/4 Inch	1
15	17-40418-00	Kit, Valve Stem Repair (For 17-40417–00) – Includes:	1
16	NSS	Tool, Installation Remover (13/16 Inch Nut)	1
17	16-00143-01	Kit, Valve Stem Repair (For 17-40407-20- NLO) – Includes:	1
18	NSS	Tool, Installation Remover (1 Inch Nut)	1
19	17-55022-00	O-Ring	1
20	17-21055-00	Kit, Repair (For Suction Cutoff Unloaders) – Includes:	2
21	17-40108-00	Strainer	1
22	17-21047-00	Ring, Piston	1
23	NSS	Piston	1
24	NSS	Body, Valve	1
25	17-21044-00	Spring, Compression	1
26	17-21046-00	Gasket, Valve Cover	1
27	17-21045-00	Cover, Valve	1
7	17-40111-00	Screw, Socket Head, 1/4–28 x 3/4 Inch Long	4

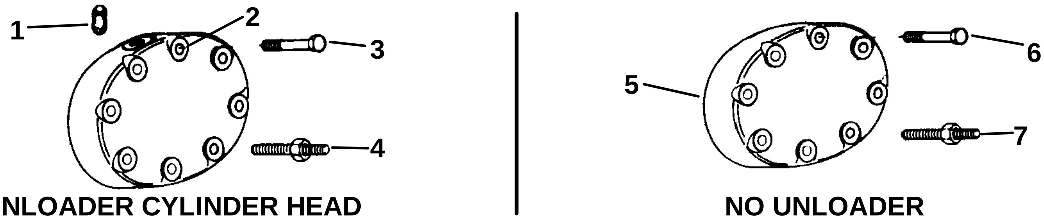
NOTE: 17-40407-20 and 17-40415-00 Unloader Assemblies are no longer offered, use Item 14.

6 UNLOADERS (Continued)



Item	Part Number	Description	Qty
28	17-21056-00	Kit, Plug (Suction Cutoff To Fully Loaded) – Includes:	A/R
29	17-10721-00	Screw, Socket Head, 1/4–28 x 1 Inch Long	3
30	NSS	Plate, Cover	1
31	NSS	Sleeve, Plug	1
6	17-40104-07	Gasket, Unloader Valve	1
8	17-40104-20	Gasket, Socket Head Screw, 1/4 Inch	1
32	17-55013-00	Kit, Plug (Hot Gas Bypass To Fully Loaded) – Includes:	A/R
33	NSS	Spring	1
34	NSS	Plug	1
35	17-55014-00	Ring, Seat	1
6	17-40104-07	Gasket, Unloader Valve	1
8	17-40104-20	Gasket, Socket Head Screw, 1/4 Inch	1
21	17-40108-00	Stainer	1
29	17-10721-00	Screw, Socket Head, 1/4–28 x 1 Inch Long	3
30	NSS	Plate, Cover	1

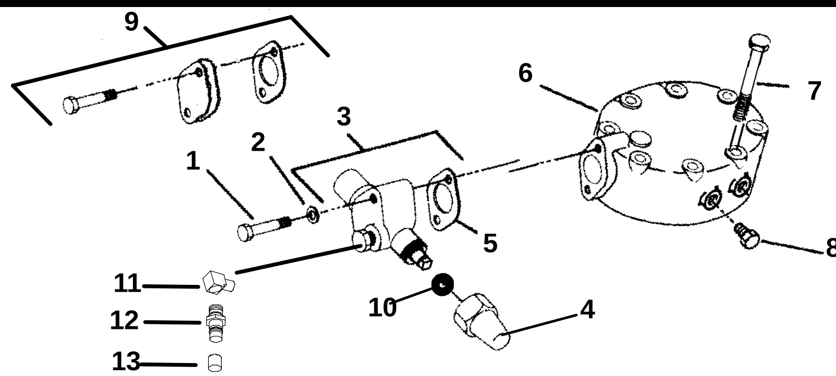
7 CYLINDER HEAD (SIDE)



Item	Part Number	Description	Qty
1	17-40108-00	Strainer	2
2	17-21041-00	Cylinder Head – Side Banks (Suction Cutoff Unloader)	2
	17-40104-05	Cylinder Head – Side Banks (Hot Gas Bypass Unloader)	2
	17-44084–00	Cylinder Head – Side Banks –Shaved (Hot Gas Bypass Unloader)	A/R
3	17-10224-05	Capscrew, Hex Head, 3/8-16 x 3-1/4 Inches Long - SAE Grade 8	16
4	17-44017-00	Stud, Cylinder Head, 3/8-16 x 4-1/4 Inches Long	A/R
5	17-40015-00	Cylinder Head – Side Bank (No Unloader)	2
6	17-44116-00	Capscrew, Hex Head, 3/8-16 x 2-3/4 Inches Long - SAE Grade 8	16
7	17-44017-01	Stud, Cylinder Head, 3/8-16 x 3-3/4 Inches Long	A/R

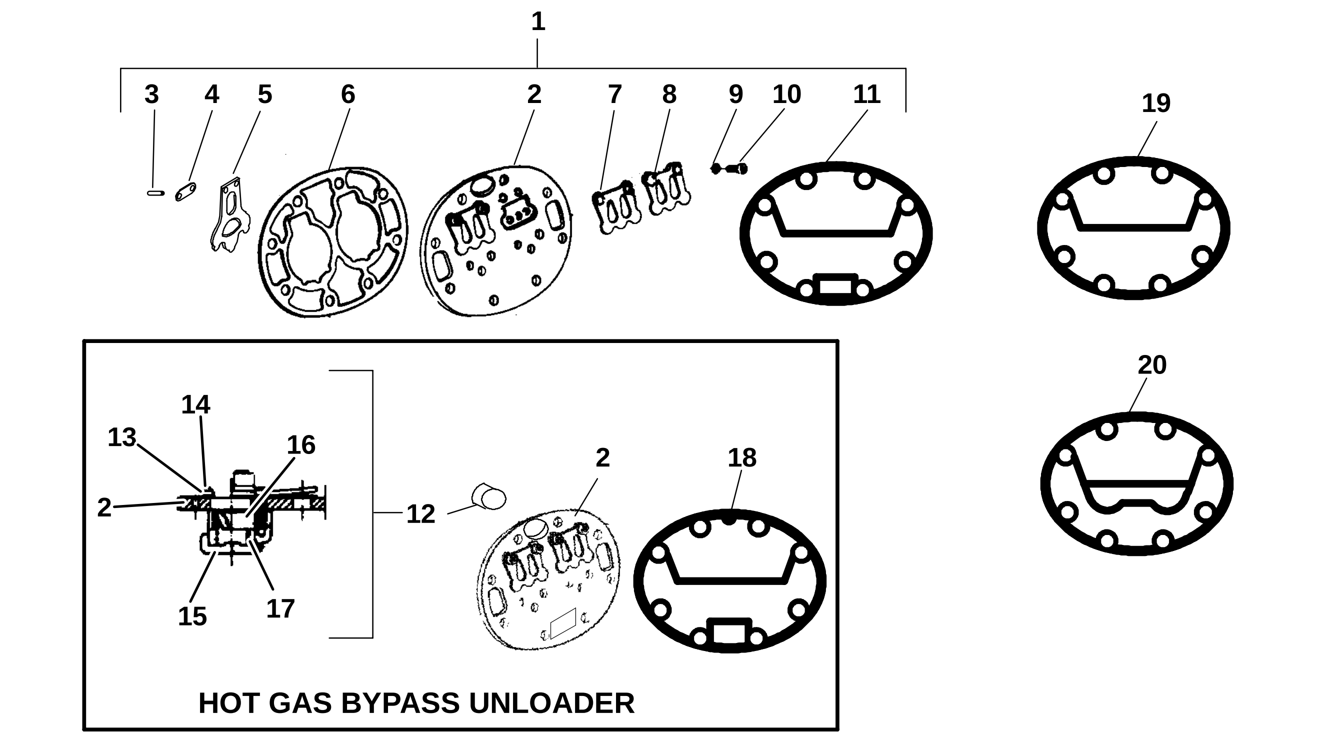
8 CYLINDER HEAD (CENTER)

Fittings 11, 12, 13 can also be found in the Performance Parts Service Tool Catalog Number 62-03213



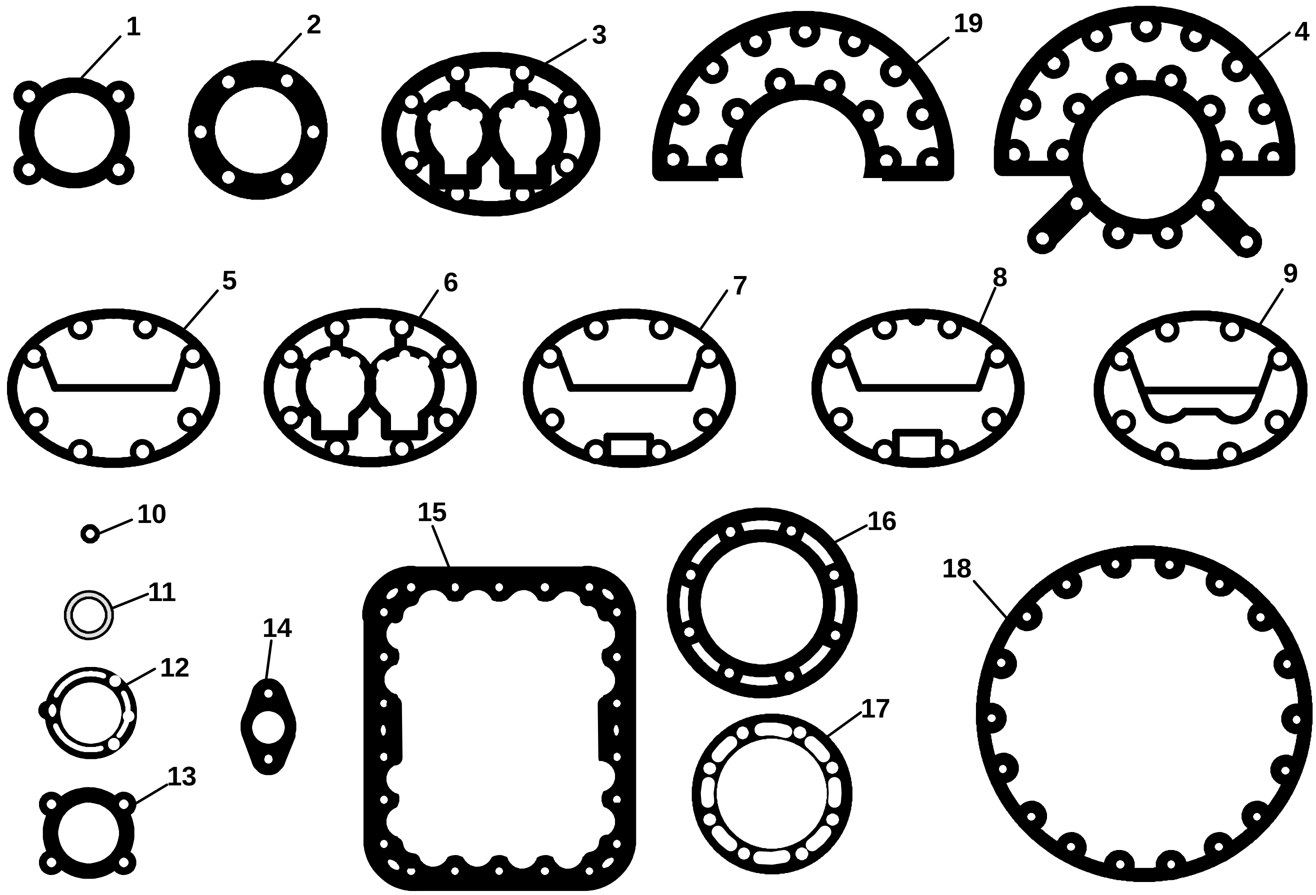
Item	Part Number	Description	Qty
1	17-40012-00	Capscrew, Hex Head, 5/16-18 x 2 Inches Long - SAE Grade 8	2
2	17-40013-00	Gasket, Capscrew, 5/16 Inch	2
3	17-01042-04	Valve, Service 7/8 Inch ODF (1/8 Inch FPT Guage Port)- Includes:	1
	14-00206-01	Valve, Service 7/8 Inch ODF (M15 Guage Port For R-134a) - Includes:	1
4	17-10812-00	Cap, Service Valve (Plastic)	1
5	17-10811-05	Gasket, Service Valve (Fiber)	1
	17-44138-00	Gasket, Service Valve (Metal)	1
4	17-10806-10	Cap, Service Valve (Brass)	1
6	17-40016-01	Cylinder Head - Center Bank	1
7	17-10224-05	Capscrew, Hex Head, 3/8-16 x 3-1/4 Inches Long - SAE Grade 8	8
8	--CA--63AA-051	Pipe Plug, 1/4-18NPT (package of 20)	2
9	17-13004-00	Kit, Valve Pad Blank Off, 2 Bolt Suction Service Valve	1
10	17-13022-00	Packing, Service Valve Stem	1
11	40-00524-01	Elbow, 1/8 MPT x M15 - Brass (for R-134a)	1
12	40-00520-01	Coupling, M15, High Side - Brass – Includes:	1
13	40-00520-03	Cap, Service Port	1
11	40-00060-08	Elbow, 1/8 MPT x 1/4 FPT - Brass (for R–12, R-22)	1
12	O6DA-403---844	Valve, Access (1/4 Flare, Schrader)	1
13	--DD--19CA-061	Cap, 1/4 Flare, Schrader	1

9 VALVE PLATE ASSEMBLY



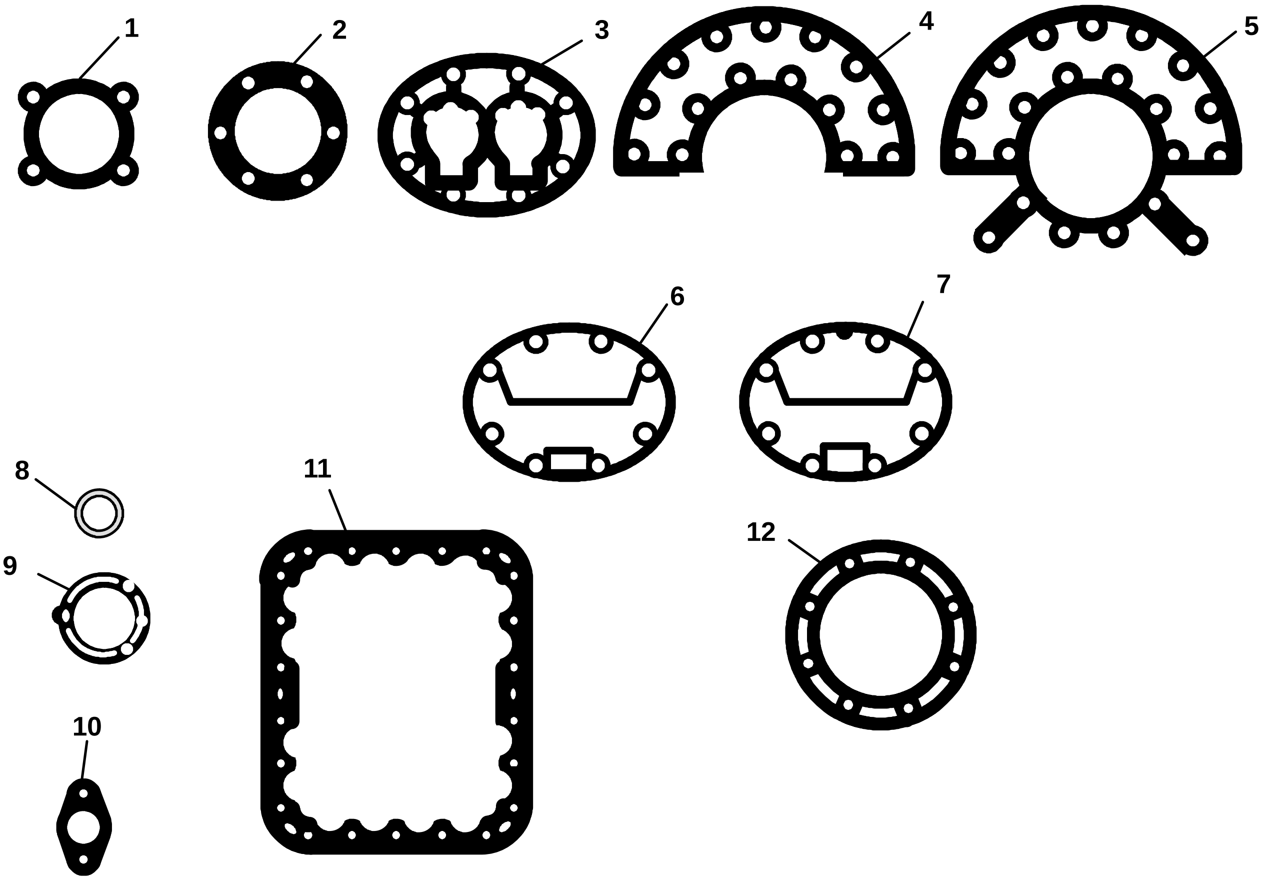
Item	Part Number	Description	Qty
1	17-44106-00	Valve Plate, Flat, Side Bank With Hot Gas Bypass Unloader - Includes:	1
	17-44107-00	Valve Plate, Flat, Center & Side With Suction Cutoff Unloader - Includes:	1
	17-44099-00	Valve Plate, Flat, Side Bank With No Unloader - Includes:	1
2	NSS	Valve Plate	1
3	17-40057-00	Dowel, Pin Suction Valve	4
4	17-40083-00	Spring, Suction Valve Position	2
5	17-44111-00	Valve, Suction (0.018 Inch Thick) - O5G and O5K	2
6	17-44007-06	Gasket, Valve Plate, O5G	1
	17-55002-00	Gasket, Valve Plate, O5K	1
7	17-40086-00	Valve, Discharge	2
8	17-44160-00	Stop, Discharge Valve	2
9	17-10715-00	Lockwasher, 1/4	4
10	17-44113-00	Capscrew, HexHead, 1/4-28 x 3/8 Inch Long	4
11	17-44123-00	Gasket, Center Cylinder Head	1
12	17-55012-00	Unloader Check Valve (Hot Gas Bypass Unloader) - Includes:	1
13	NSS	Lockwasher, #6	2
14	NSS	Screw, Round Phillips Head, #6-32 x 1/2 Inch Long	2
15	NSS	Body Check Valve	1
16	17-40104-08	Piston, Check Valve	1
17	17-40104-09	Spring, Check Valve	1
18	17-44126-00	Gasket, Side Cylinder Head (Hot Gas Bypass Unloader)	1
19	17-44124-00	Gasket, Side Cylinder Head (No Unloader)	1
20	17-44125-00	Gasket, Side Cylinder Head (Suction Cutoff Unloader)	1

10 GASKET SET - FIBER UNIVERSAL



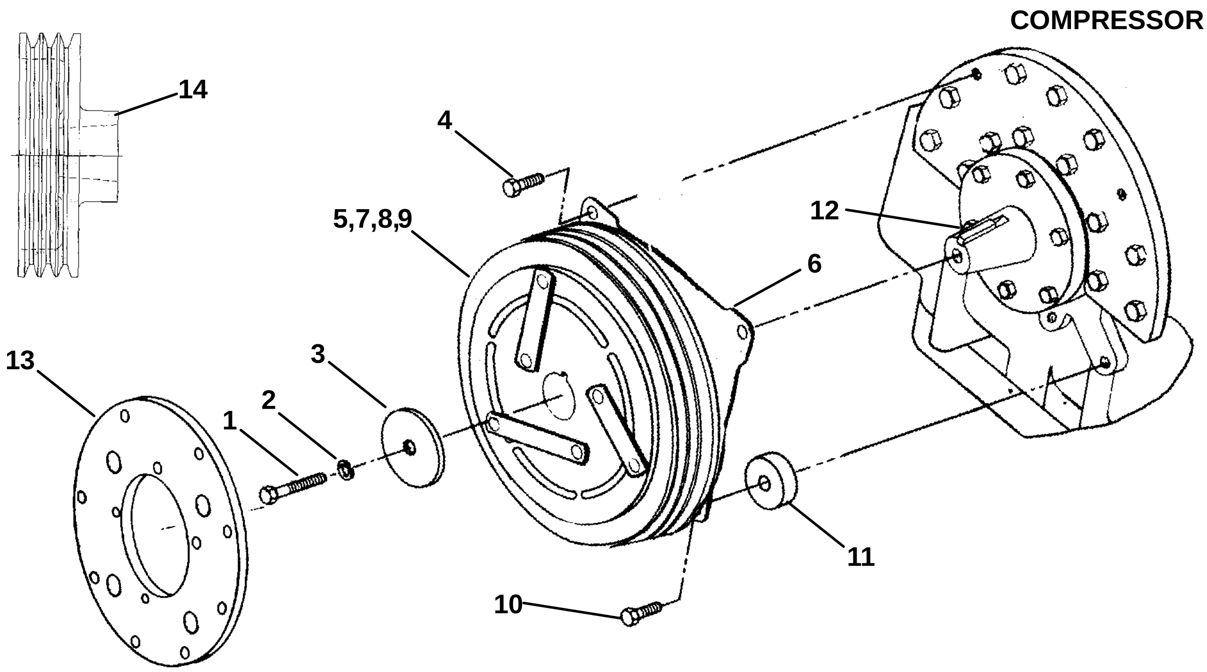
Item	Part Number	Description	Qty
-	17-55020-20	Gasket Set, Universal - Includes:	1
1	17-40005-05	Gasket, Suction Service Valve - 4 Bolt	1
2	17-44004-06	Gasket, Shaft Seal, O5G with Standard Cover Plate - Steel	1
3	17-44007-06	Gasket, Valve Plate, O5G	3
4	17-44119-00	Gasket, End Flange, O5G - Metal - Includes:	1
5	17-44124-00	Gasket, Cylinder Head - Side Bank (No Unloader)	2
6	17-55002-00	Gasket, Valve Plate, O5D (Not Used For This Compressor)	3
7	17-44123-00	Gasket, Cylinder Head - Center	1
8	17-44126-00	Gasket, Cylinder Head - Side Bank (Hot Gas Bypass Unloader)	2
9	17-44125-00	Gasket, Cylinder Head - Side Bank (Suction Cutoff Unloader)	2
10	17-40316-00	Gasket, Oil Supply Tube, O5D (Not Used For This Compressor)	1
11	17-44021-00	Gasket, Sight Glass - Metal	2
12	17-40104-07	Gasket, Unloader Body	2
13	17-40075-05	Gasket, Oil Pump Cover	1
14	17-10811-05	Gasket, Service Valve (2 Bolt) - 1-3/4 Inch Center	2
15	17-40033-05	Gasket, Bottom Plate	1
16	17-44022-00	Gasket, Pump End Bearing Head	1
17	17-40319-05	Gasket, Shaft Seal, O5D (Not Used For This Compressor)	1
18	17-40029-05	Gasket, Motor End Cover	1
19	17-44118-00	Gasket, End Flange – Metal	1

11 GASKET SET - METAL



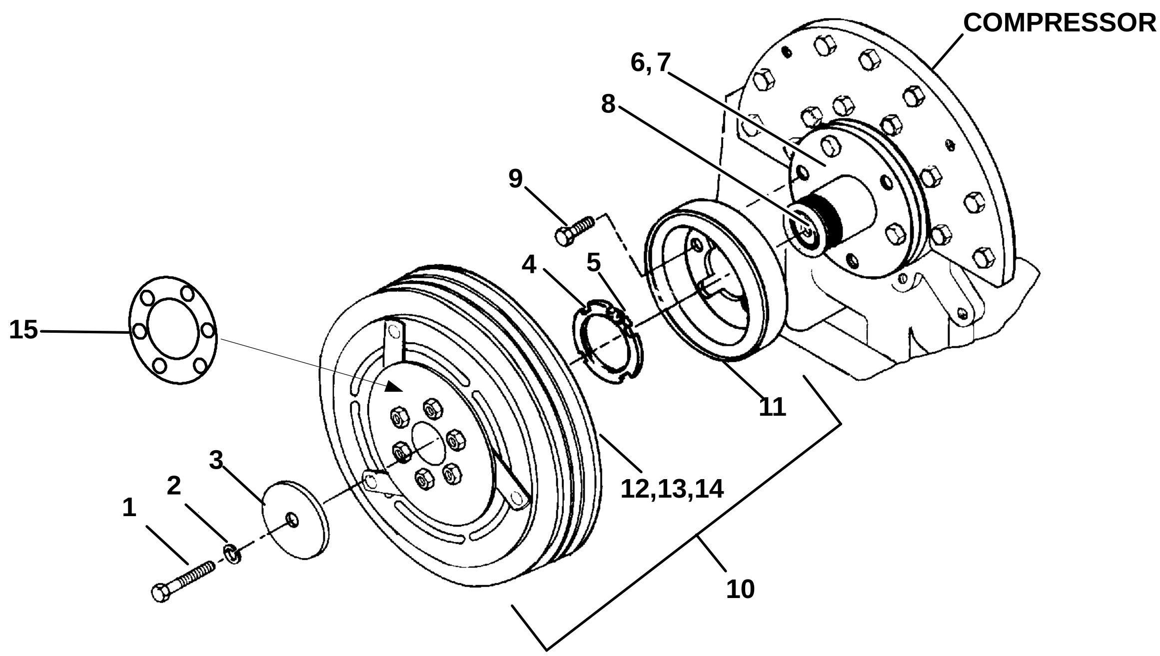
Item	Part Number	Description	Qty
-	17-55026-00	Gasket Set, Metal - Includes:	1
1	17-44141-00	Gasket, Suction Service Valve - 4 Bolt	1
2	17-44004-06	Gasket, Shaft Seal	1
3	17-44007-06	Gasket, Valve Plate	3
4	17-44118-00	Gasket, End Flange	1
5	17-44119-00	Gasket, End Flange	1
6	17-44123-00	Gasket, Cylinder Head - Center	1
7	17-44126-00	Gasket, Cylinder Head - Side Bank (hot Gas Bypass Unloader)	2
8	17-44021-00	Gasket, Sight Glass	2
9	17-40104-07	Gasket, Unloader Body	2
10	17-44138-00	Gasket, Service Valve - 2 Bolt	2
11	17-44129-00	Gasket, Bottom Plate	1
12	17-44022-00	Gasket, Pump End Bearing Head	1

12 CLUTCH ASSEMBLY - SHAFT MOUNTED



Item	Part Number	Description	Qty
1	34-00613-07	Capscrew, Hex Head, 3/8 UNF x 7/8 Inch Long - SAE Grade 8	1
2	--AU--11AR-241	Washer, Lock, Spring, 3/8 Inch	1
3	34-00616-00	Washer, 13/32 ID x 1-1/2 OD x 3/16 Inch Thick	1
4	17-40037-05	Capscrew, Hex Head, 3/8-16 x 1 Inch Long	2
5	50-01108-00	Clutch, 24 VDC, 2-C Grooves, 9 Inch Diameter	1
	50-01110-00	Clutch, 24 VDC, 3-3V Grooves, 8.48 Inch Diameter	1
	50-01110-01	Clutch, 12 VDC, 3-3V Grooves, 8.48 Inch Diameter	1
	50-01114-00	Clutch, 12 VDC, 2-B Grooves, 8.64 Inch Diameter	1
6	50-50011-00	Coil, 24 VDC	1
	50-50014-00	Coil, 12 VDC	1
7	50-50015-00	Ring, Retaining - External	1
8	50-50016-00	Ring, Retaining - Internal	1
9	50-50017-00	Bearing	1
10	17-10308-00	Capscrew, Hex Head, 3/8-16 x 1-1/4 Inches Long - SAE Grade 8	2
11	68-G---2--8522-1	Spacer, 1-3/8 OD x 1/2 Inch Thick - CRES	2
12	17-40324-00	Key, Crankshaft, 1/4 x 1/4 x 1-1/2 Inches Long	1
13	50-01115-00	Plate, Adapter (Used with 50-01114 Clutch)	1
14	68-G---2--1823	Sheave, Power Takeoff, 3-3V Grooves, 6 Inch Diameter, (On Allison Transmission)	1

13 CLUTCH ASSEMBLY - HOUSING MOUNTED (WARNER - GRAY IN COLOR)

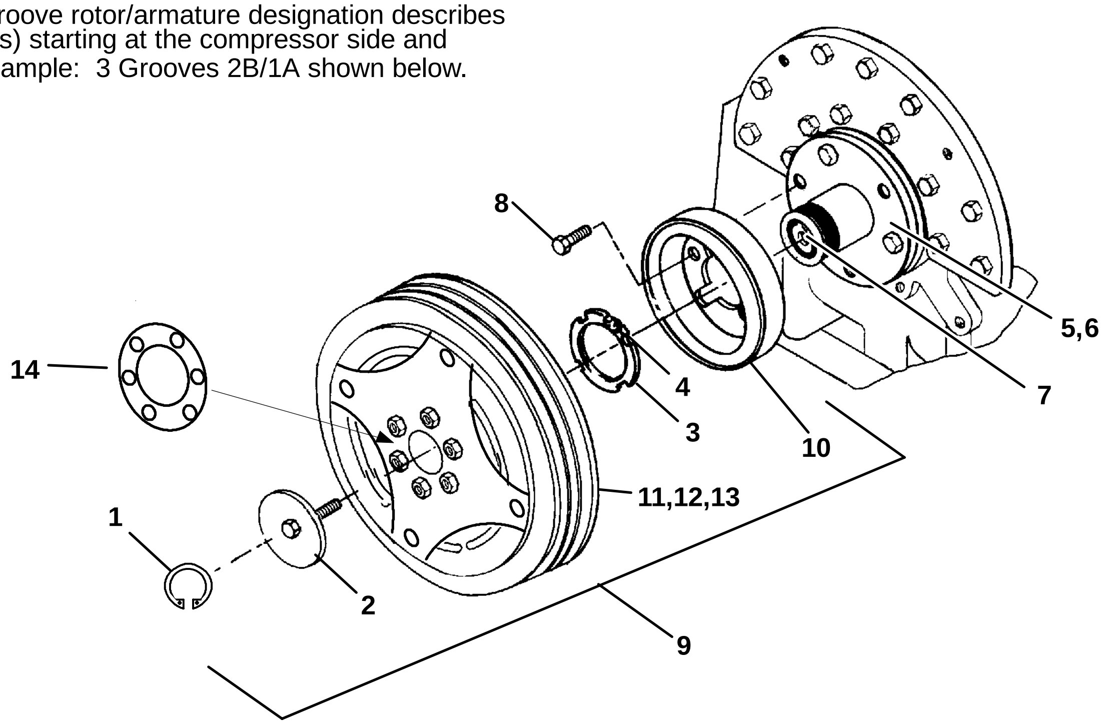


Item	Part Number	Description	Qty
NS	76-50013-00	Kit, Conversion Shaft to Housing Mounted Clutch	A/R
1	34-00613-07	Capscrew, Hex Head, 3/8-24 x 7/8 Inch Long - SAE Grade 8	1
2	--AU--11AR-241	Washer, Lock, Spring, 3/8 Inch	1
3	34-00616-00	Washer, 13/32 ID x 1-1/2 OD x 3/16 Inch Thick	1
4	34-01161-00	Nut, Hub, With Grease Fitting Port (Fitting Not Included)	1
	34-06083-00	Nut, Hub Without Grease Fitting Port	1
5	40-01132-00	Fitting, Grease, 1/4–18	1
6	17-44041-01	Hub, Clutch Mounting - Includes:	1
7	17-44042-00	Ring, Felt and Retainer	1
8	68-G---2--9072	Key, Crankshaft, Special	1
9	17-10308-00	Capscrew, Hex Head, 3/8-16 x 1-1/4 Inches Long - SAE Grade 8	1
10	50-01122-01	Clutch, Assembly, 24 VDC, 2-C Grooves, 9 Inch Diameter - Includes:	1
11	50-01122-50	Coil, 24 VDC	1
12	50-01122-85	Rotor/Armature, 2-C Grooves, 9 Inch Diameter - Includes:	1
13	34-01186-00	Ring, Snap	1
14	04-00130-00	Bearing, Rotor	1
10	50-01122-04	Clutch, Assembly, 12 VDC, 2-C Grooves, 9 Inch Diameter - Includes:	1
11	50-01122-41	Coil, 12 VDC	1
12	50-01122-85	Rotor/Armature, 2-C Grooves, 9 Inch Diameter - Includes:	1
13	34-01186-00	Ring, Snap	1
14	04-00130-00	Bearing, Rotor	1
10	50-01122-02	Clutch, Assembly, 24 VDC, 3-3V Grooves, 8.48 Inch Diameter - Includes:	1
11	50-01122-50	Coil, 24 VDC	1
12	50-01122-86	Rotor/Armature, 3-3V Grooves, 8.48 Inch Diameter - Includes:	1
13	34-01186-00	Ring, Snap	1
14	04-00130-00	Bearing, Rotor	1

13 CLUTCH ASSEMBLY - HOUSING MOUNTED (WARNER - GRAY IN COLOR) - Continued			
Item	**Part Number**	**Description**	**Qty**
10	50-01122-07	Clutch, Assembly, 24 VDC, 2-B Grooves, 9 Inch Diameter - Includes:	1
11	50-01122-50	Coil, 24 VDC	1
12	50-01122-90	Rotor/Armature, 2-B Grooves, 9 Inch Diameter - Includes:	1
13	34-01186-00	Ring, Snap	1
14	04-00130-00	Bearing, Rotor	1
10	50-01122-12	Clutch, Assembly, 24 VDC, 2-5V Grooves, 8.7 Inch Diameter - Includes:	1
11	50-01122-50	Coil, 24 VDC	1
12	50-01122-91	Rotor/Armature, 2-5V Grooves, 8.7 Inch Diameter - Includes:	1
13	34-01186-00	Ring, Snap	1
14	04-00130-00	Bearing, Rotor	1
10	50-01122-14	Clutch, Assembly, 24 VDC, 2-5V Grooves, 10.5 Inch Diameter - Includes:	1
11	50-01122-50	Coil, 24 VDC	1
12	50-01122-93	Rotor/Armature, 2-5V Grooves, 10.5 Inch Diameter - Includes:	1
13	34-01186-00	Ring, Snap	1
14	04-00130-00	Bearing, Rotor	1
15	50-01122-65	Shim, .010 Inch Thick	5
	50-01122-66	Shim, .020 Inch Thick	1

14 CLUTCH ASSEMBLY - HOUSING MOUNTED (LINNIG - GOLD IN COLOR)

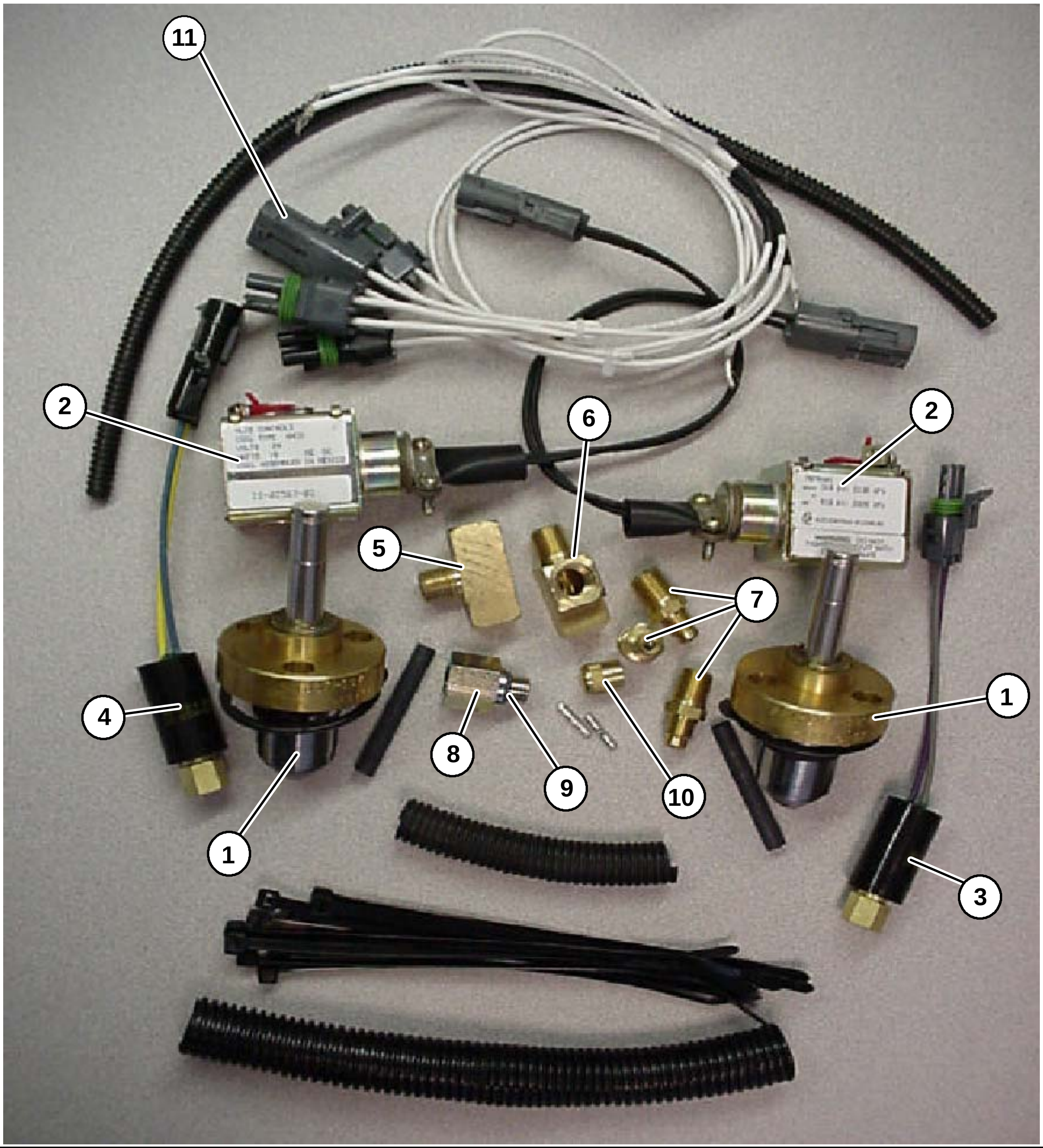
Note: Multiple groove rotor/armature designation describes groove location(s) starting at the compressor side and working out. Example: 3 Grooves 2B/1A shown below.



Item	Part Number	Description	Qty
NS	76-50013-00	Kit, Conversion Shaft to Housing Mounted Clutch	A/R
1	34-50035-00	Ring, Snap	1
2	34-50034-00	Bolt, Retaining, Special	1
3	34-01161-00	Nut, Hub, With Grease Fitting Port (Fitting Not Included)	1
	34-06083-00	Nut, Hub Without Grease Fitting Port	1
4	40-01132-00	Fitting, Grease, 1/4–18	1
5	17-44041-01	Hub, Clutch Mounting - Includes:	1
6	17-44042-00	Ring, Felt and Retainer	1
7	68-G---2--9072	Key, Crankshaft, Special	1
8	17-10308-00	Capscrew, Hex Head, 3/8-16 x 1-1/4 Inches Long - SAE Grade 8	1
9	50-00226-09	Clutch Assembly, 24 VDC, 4 Grooves (2A/2B), 10.35 Inch Dia. - Includes:	1
10	50-00226-50	Coil, 24 VDC	1
11	50-00226-501	Rotor/Armature, 4 Grooves (2A/2B), 10.35 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1
9	50-00226-09	Clutch Assembly, 24 VDC, 4 Grooves (A/B/2C), 10 Inch Dia. - Includes:	1
10	50-00226-50	Coil, 24 VDC	1
11	50-01130-13	Rotor/Armature, 4 Grooves (A/B/2C), 10 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1
9	50-00226-18	Clutch Assembly, 12 VDC, 4 Grooves (2B/2A), 10.35 Inch Dia. - Includes:	1
10	50-00226-41	Coil, 12 VDC	1
11	50-50040-11	Rotor/Armature, 4 Grooves (2B/2A), 10.35 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1

14	CLUTCH ASSEMBLY - HOUSING MOUNTED (LINNIG - GOLD IN COLOR) - continued		
Item	**Part Number**	**Description**	**Qty**
9	50-00226-19	Clutch Assembly, 24 VDC, 4 Grooves (2B/2A), 10.35 Inch Dia. - Includes:	1
10	50-00226-50	Coil, 24 VDC	1
11	50-50040-11	Rotor/Armature, 4 Grooves (2B/2A), 10.35 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1
9	50-01130-03	Clutch Assembly, 24 VDC, 3-3V Grooves, 8.48 Inch Diameter - Includes:	1
10	50-00226-50	Coil, 24 VDC	1
11	50-50040-02	Rotor/Armature, 3-3V Grooves, 8.48 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1
9	50-01130-20	Clutch Assembly, 12 VDC, 2-B Grooves, 10.35 Inch Diameter - Includes:	1
10	50-00226-41	Coil, 12 VDC	1
11	50-50040-03	Rotor/Armature, 2-B Grooves, 10.35 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1
9	50-01130-21	Clutch Assembly, 24 VDC, 2-B Grooves, 10.35 Inch Diameter - Includes:	1
10	50-00226-50	Coil, 24 VDC	1
11	50-50040-03	Rotor/Armature, 2-B Grooves, 10.35 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1
9	50-01130-22	Clutch Assembly, 12 VDC, 2-C Grooves, 10 Inch Diameter - Includes:	1
10	50-00226-41	Coil, 12 VDC	1
11	50-50040-12	Rotor/Armature, 2-C Grooves, 10 Inch Diameter - Includes:	1
12	50-50040-05	Ring, Snap	1
13	50-50040-04	Bearing	1
14	50-00226-65	Shim, .012 Inch Thick	5
	50-00226-66	Shim, .039 Inch Thick	1

15 UNLOADER KITS, BUS - PRESSURE TO ELECTRIC



15 UNLOADER KIT - PRESSURE TO ELECTRIC - R-134a ONLY - 24 VDC

Item	Part Number	Description	Qty
	74-50111-00	Kit, Convert Pressure Hot Gas Bypass to Electric Unloader (24 VDC), Includes:	2
1	17-40417-00	Unloader Valve	2
2	68PD-2-102-3	Solenoid Coil - 24 VDC	2
3	12-00334-02	Switch, Pressure (UPS2) - R-134a	1
4	12-00334-03	Switch, Pressure (UPS1) - R-134a	1
5	40-00249-01	Fitting, Tee, Male Branch, 1/4 FPT x 1/4 FPT x 1/4 MPT	1
6	40-00243-01	Fitting, Tee, Street, 1/4 MPT x 1/4 x 1/4 FPT	1
7	06DA403-844	Valve, Access (1/4 Flare, Schrader)	3
8	40-00528-02	Connector, 1/4 FPT x 7/16-20 Straight Thread With O-Ring - Includes:	1
9	42-00243-07	O-Ring	1
10	DD19CA061	Cap, 1/4 Flare, Schrader	1
11	22-50222-00	Wire Harness	1

Item	Part Number	Description	Qty
15	**UNLOADER KIT - PRESSURE TO ELECTRIC - R-22 ONLY - 24 VDC**		
	74-50111-01	Kit, Convert Pressure Hot Gas Bypass to Electric Unloader (24 VDC), Includes:	2
1	17-40417-00	Unloader Valve	2
2	68PD-2-102-3	Solenoid Coil - 24 VDC	2
3	12-00334-00	Switch, Pressure (UPS2) - R-22	1
4	12-00334-01	Switch, Pressure (UPS1) - R-22	1
5	40-00249-01	Fitting, Tee, Male Branch, 1/4 FPT x 1/4 FPT x 1/4 MPT	1
6	40-00243-01	Fitting, Tee, Street, 1/4 MPT x 1/4 x 1/4 FPT	1
7	06DA403-844	Valve, Access (1/4 Flare, Schrader)	3
8	40-00528-02	Connector, 1/4 FPT x 7/16-20 Straight Thread With O-Ring - Includes:	1
9	42-00243-07	O-Ring	1
10	DD19CA061	Cap, 1/4 Flare, Schrader	1
11	22-50222-00	Wire Harness	1
15	**UNLOADER KIT - PRESSURE TO ELECTRIC - R-134a ONLY - 36 VDC**		
	74-50111-02	Kit, Convert Pressure Hot Gas Bypass to Electric Unloader (36 VDC), Includes:	2
1	17-40417-00	Unloader Valve	2
2	14-50086-00	Solenoid Coil - 36 VDC	2
3	12-00334-02	Switch, Pressure (UPS2) - R-134a	1
4	12-00334-03	Switch, Pressure (UPS1) - R-134a	1
5	40-00249-01	Fitting, Tee, Male Branch, 1/4 FPT x 1/4 FPT x 1/4 MPT	1
6	40-00243-01	Fitting, Tee, Street, 1/4 MPT x 1/4 x 1/4 FPT	1
7	06DA403-844	Valve, Access (1/4 Flare, Schrader)	3
8	40-00528-02	Connector, 1/4 FPT x 7/16-20 Straight Thread With O-Ring - Includes:	1
9	42-00243-07	O-Ring	1
10	DD19CA061	Cap, 1/4 Flare, Schrader	1
11	22-50222-00	Wire Harness	1
15	**UNLOADER KIT - PRESSURE TO ELECTRIC - R-22 ONLY - 36 VDC**		
	74-50111-03	Kit, Convert Pressure Hot Gas Bypass to Electric Unloader (36 VDC), Includes:	2
1	17-40417-02	Unloader Valve	2
2	14-50086-00	Solenoid Coil - 36 VDC	2
3	12-00334-00	Switch, Pressure (UPS2) - R-22	1
4	12-00334-01	Switch, Pressure (UPS1) - R-22	1
5	40-00249-01	Fitting, Tee, Male Branch, 1/4 FPT x 1/4 FPT x 1/4 MPT	1
6	40-00243-01	Fitting, Tee, Street, 1/4 MPT x 1/4 x 1/4 FPT	1
7	06DA403-844	Valve, Access (1/4 Flare, Schrader)	3
8	40-00528-02	Connector, 1/4 FPT x 7/16-20 Straight Thread With O-Ring - Includes:	1
9	42-00243-07	O-Ring	1
10	DD19CA061	Cap, 1/4 Flare, Schrader	1
11	22-50222-00	Wire Harness	1

NO TAG UNLOADER KIT - PRESSURE TO ELECTRIC - R-134a ONLY			
Item	**Part Number**	**Description**	**Qty**
	74-50111-00	Kit, Convert Pressure Hot Gas Bypass to Electric Unloader (24 VDC), Includes:	2
1	17-40417-00	Unloader Valve	2
2	68PD–2–102-3	Solenoid Coil - 24 VDC	2
3	12-00334-02	Switch, Pressure (UPS2) - R-134a	1
4	12-00334-03	Switch, Pressure (UPS1) - R-134a	1
5	40-00249-01	Fitting, Tee, Male Branch, 1/4 FPT x 1/4 FPT x 1/4 MPT	1
6	40-00243-01	Fitting, Tee, Street, 1/4 MPT x 1/4 x 1/4 FPT	1
7	O6DA-403---844	Valve, Access (1/4 Flare, Schrader)	3
8	40-00528-02	Connector, 1/4 FPT x 7/16-20 Straight Thread With O-Ring - Includes:	1
9	42-00243-07	O-Ring	1
10	--DD--19CA-061Z	Cap, 1/4 Flare, Schrader	1
11	22-50222-00	Wire Harness	1

NO TAG UNLOADER KIT - PRESSURE TO ELECTRIC - R-22 ONLY			
Item	**Part Number**	**Description**	**Qty**
	74-50111-01	Kit, Convert Pressure Hot Gas Bypass to Electric Unloader (24 VDC), Includes:	2
1	17-40417-00	Unloader Valve	2
2	68PD–2–102-3	Solenoid Coil - 24 VDC	2
3	12-00334-00	Switch, Pressure (UPS2) - R-22	1
4	12-00334-01	Switch, Pressure (UPS1) - R-22	1
5	40-00249-01	Fitting, Tee, Male Branch, 1/4 FPT x 1/4 FPT x 1/4 MPT	1
6	40-00243-01	Fitting, Tee, Street, 1/4 MPT x 1/4 x 1/4 FPT	1
7	O6DA-403---844	Valve, Access (1/4 Flare, Schrader)	3
8	40-00528-02	Connector, 1/4 FPT x 7/16-20 Straight Thread With O-Ring - Includes:	1
9	42-00243-07	O-Ring	1
10	--DD--19CA-061	Cap, 1/4 Flare, Schrader	1
11	22-50222-00	Wire Harness	1

NO TAG UNLOADER KIT - PRESSURE TO ELECTRIC - R-22 ONLY - 36 VDC			
Item	**Part Number**	**Description**	**Qty**
	74-50111-03	Kit, Convert Pressure Hot Gas Bypass to Electric Unloader (36 VDC), Includes:	2
1	17-40417-02	Unloader Valve	2
2	14-50086-00	Solenoid Coil - 36 VDC	2
3	12-00334-00	Switch, Pressure (UPS2) - R-22	1
4	12-00334-01	Switch, Pressure (UPS1) - R-22	1
5	40-00249-01	Fitting, Tee, Male Branch, 1/4 FPT x 1/4 FPT x 1/4 MPT	1
6	40-00243-01	Fitting, Tee, Street, 1/4 MPT x 1/4 x 1/4 FPT	1
7	O6DA-403---844	Valve, Access (1/4 Flare, Schrader)	3
8	40-00528-02	Connector, 1/4 FPT x 7/16-20 Straight Thread With O-Ring - Includes:	1
9	42-00243-07	O-Ring	1
10	--DD--19CA-061	Cap, 1/4 Flare, Schrader	1
11	22-50222-00	Wire Harness	1

PART NUMBER INDEX

PART NUMBER INDEX

O

Symbols

Housing-Mounted Clutch Installation

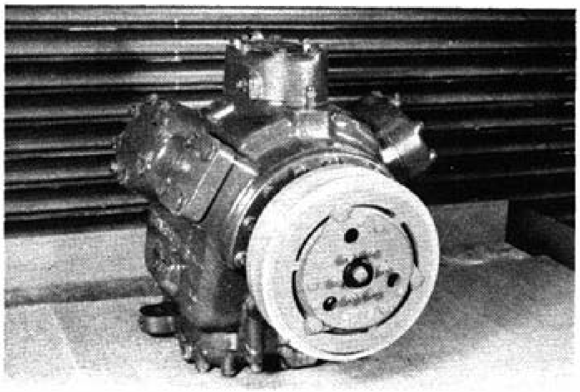
The procedure on the attached pages should be followed carefully when servicing the Carrier Transicold housing-mounted clutch. The following tools are recommended when removing and replacing this clutch:

TOOL LIST

DESCRIPTION	CTC PART NO. (WHERE APPLICABLE)
Spanner Wrench	07-00240-01
Rotor Installation Tool	07-00241
Socket Bearing Retaining Nut-Large	07-00242-01
Socket Bearing Retaining Nut-Small	07-00242-02
3/8″ Socket Set	
Torque Wrench	
3 Leg Puller w/ 3 1/4-20 UNC Cap Screws	
1 - Bolt 7/8-14 UNC x 2″ Long	
Feeler Gauge .020 .030 .060	
Grease Gun, Manual, 0.1 Oz Per Stroke	
Depth Gauge 0-1/2″	
Ohmmeter	

05G COMPRESSOR HOUSING MOUNTED CLUTCH

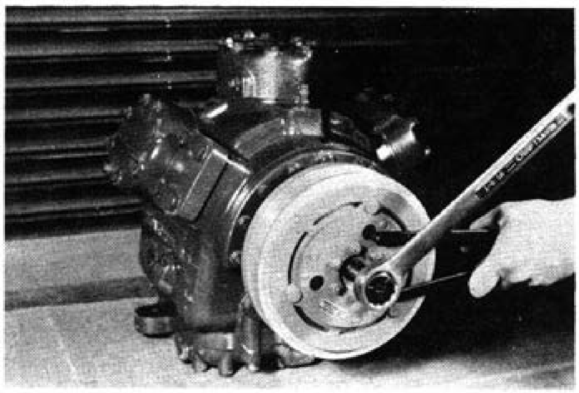
The new housing-mounted electric clutch, HMC, eliminates drive belt loading on the 05G crankshaft, and applies this load directly to the crankcase of the compressor. The following procedure should be followed carefully whenever it becomes necessary to remove and replace the HMC.



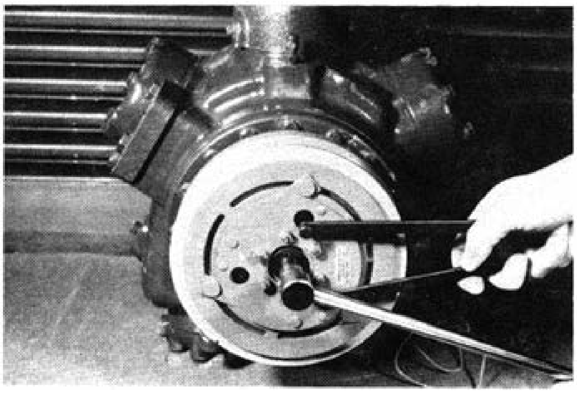
Housing-Mounted Clutch Removal

CAUTION: Remove drive belt before attempting to remove clutch.

1. Remove armature as a complete assembly by removing retaining capscrew (3/8-24 x 1-1/4″ Lg.), lock washer, and special 3/8 washer from compressor crankshaft. Use special CTD tool P/N 07-00240-01 to prevent crankshaft rotation, as shown.

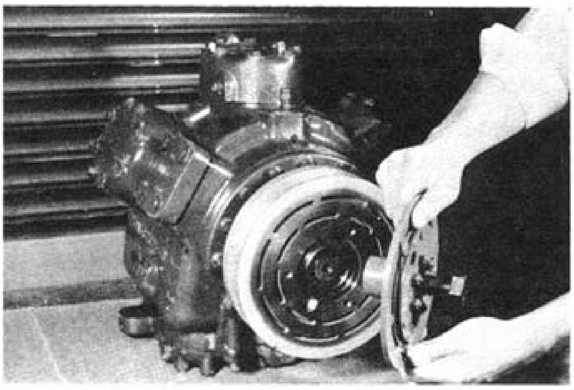


2. Install a 7/8-14 x 2″ capscrew into the center hole of the armature assembly. Use this capscrew as a jacking bolt to remove the armature assembly. Use tool 07-00240-01 as in Step 1 to prevent crankshaft rotation.

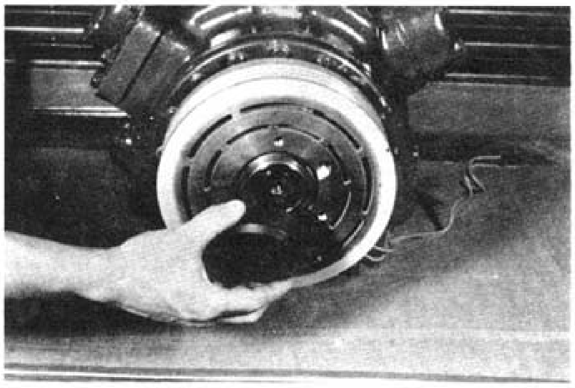


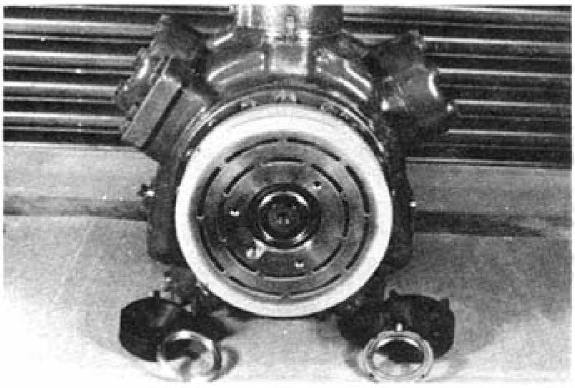
Note: Do not use a puller or pry against the armature hub or bumper plate, as this could cause damage to these parts.

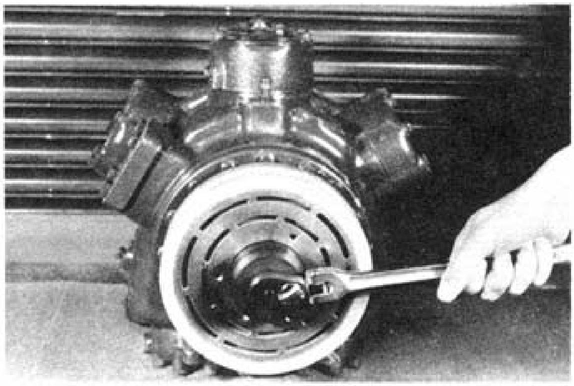
3. Remove the clutch armature assembly from the compressor crankshaft as a complete assembly, as shown.



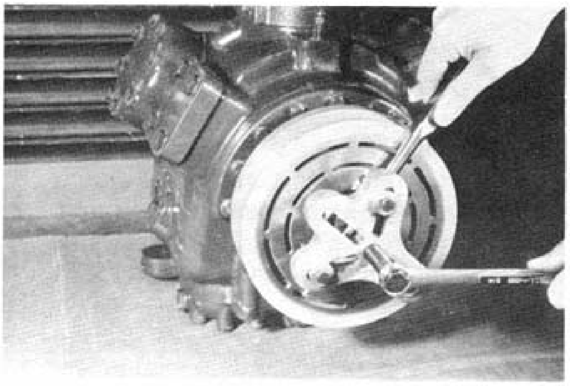
4. Remove the rotor retaining nut with special CTD tool P/N 07-00242-01.





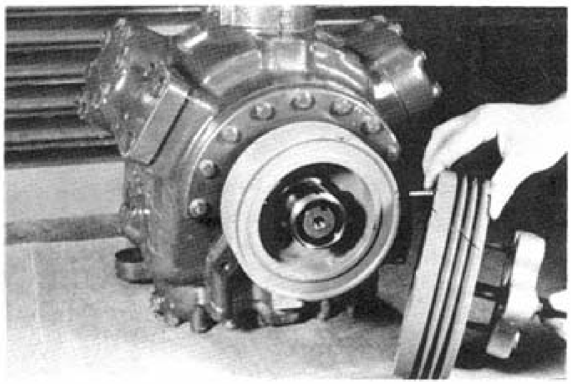


5. Install a flange-type gear puller into the three 5/16-18 tapped holes in the clutch rotor assembly, as shown.

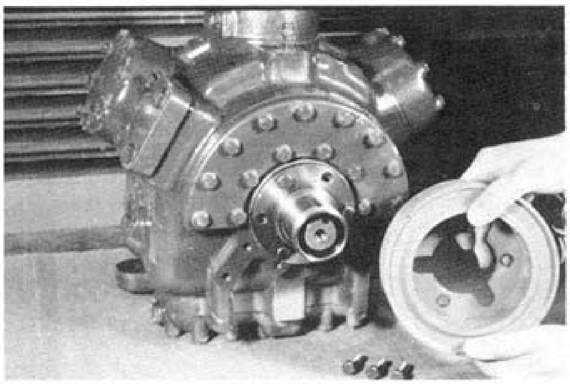


CAUTION: Use a washer or other protective device to prevent damage to crankshaft and threaded hole in the crankshaft by the puller. Never use a puller in the belt grooves, as damage to the rotor may result. Use a pry bar as shown to prevent rotation of the clutch rotor.

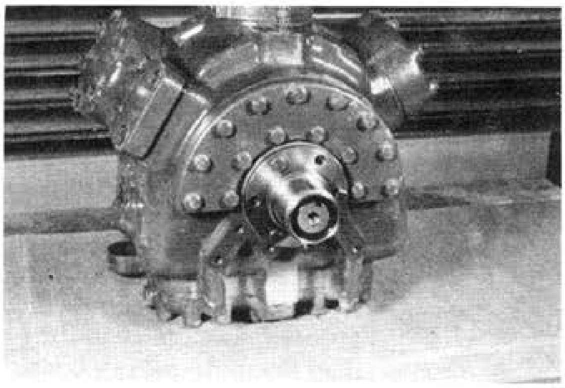
6. Once the rotor has been pulled from the clutch bearing mounting hub, carefully lift the rotor assembly away from the compressor, as shown.



7. To remove the clutch coil, disconnect the coil's electrical cable from the wiring harness. Then remove only the three 3/8-16 capscrews holding the coil to the flange of the clutch bearing mounting hub, and carefully remove the coil, pulling straight out from the flange. Do not pry coil off, as it may bend the mounting plate.



Housing-Mounted Clutch Installation



1. Prior to installing the HMC, inspect for dents, nicks, or burrs on the clutch bearing mounting hub and clutch assembly. Correct if any are found, and clean clutch mounting hub and ID of clutch bearing with a chlorinated base or naphtha type solvent.

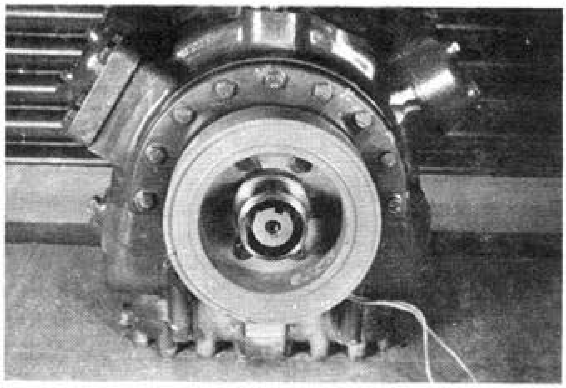
2. Inspect coil for damaged power leads, bent or cracked mounting plate, or burned or cracked potting material.

3. Check coil for electrical continuity, resistance, and shorts to ground.

Resistance at 68°F:	Lead to Lead	24 VDC coil	5.15-5.69 ohms
		12 VDC coil	1.92-2.12 ohms
	Lead to Ground	12/24 VDC coil	INF or open

Replace coil if above conditions are not met.

4. Slide the coil onto the clutch bearing mounting hub so that the lead wires exit between the 3 and 5 o'clock position, as shown.



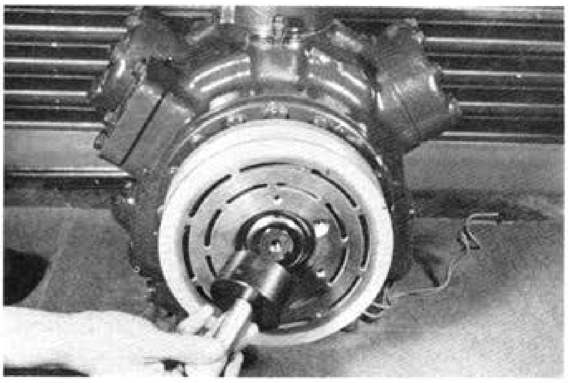
5. Secure the coil to the bearing mounting hub flange with the three 3/8-16 capscrews removed in Step 7 of Clutch Removal. Torque capscrews to 25-30 ft-lb (3.46-4.15 MKG).

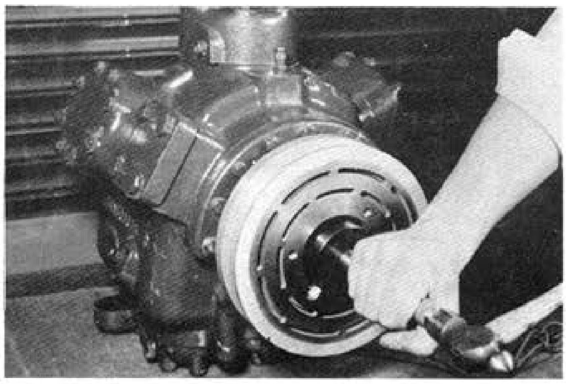
   CAUTION: Do not draw coil onto the clutch bearing mounting hub flange with the capscrews, as this may distort the coil.

6. To ease the installation of the rotor onto the clutch bearing mounting hub, preheat the inner race of the rotor bearing by placing an electric heater inside the bearing bore (a 75-100 watt outdoor post lamp style bulb applied for 15-30 minutes may be used).

   CAUTION: Do not heat bearing with an open flame or heat bearing above 175°F.

7. After preheating bearing, slide rotor assembly onto clutch bearing mounting hub. To facilitate seating of the bearing on the hub, place CTD tool P/N 07-00241 against the inner race of the bearing and tap gently with a hammer, as shown.

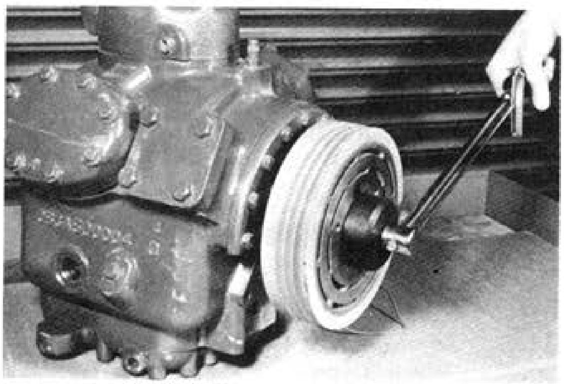




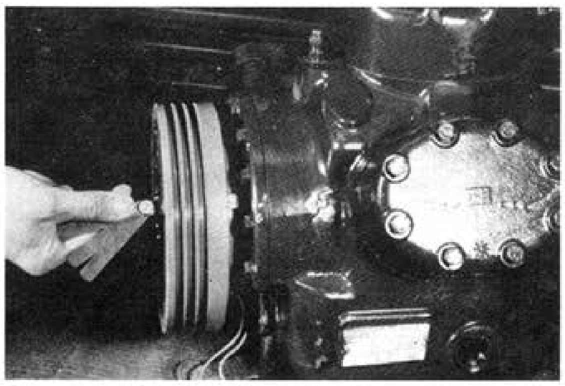
8. Install bearing retaining nut on clutch mounting hub and use torque wrench to tighten.

   If the smaller nut without the grease fitting is used, torque nut to 50 ft-lb. with CTD tool P/N 07-00242-02. The taper on the nut faces the bearing.

   If the larger nut with the grease fitting is used, torque the nut with CTD tool P/N 07-00242-01. Due to the self-locking feature of the nut, the installation torque may vary. When installing the nut, observe the torque required to turn the nut onto the hub. After the nut seats the bearing against the hub, apply a torque 50 ft-lb. greater than the installation torque.

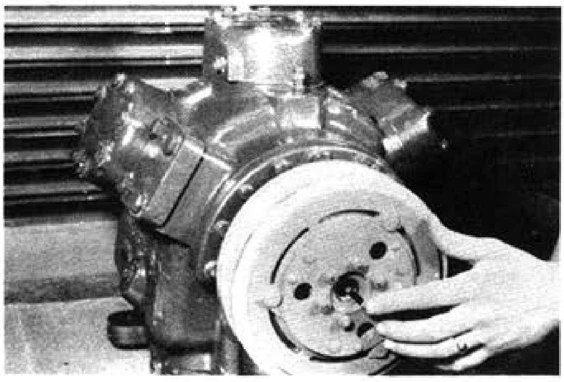


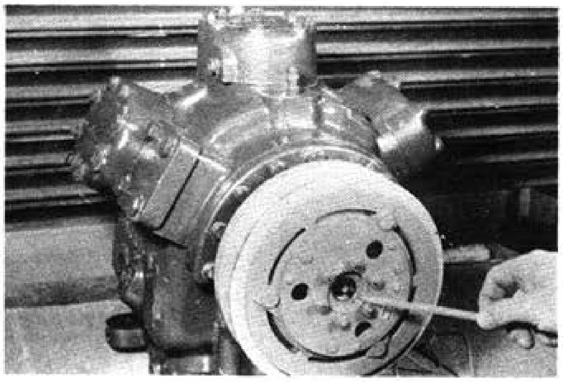
9. Check coil to rotor clearance by inserting .020 thick by .156 wide (max.) feeler gauge through an outer slot in rotor, as shown. Insert the feeler gauge so it extends beyond the rear face of the rotor and rotate the rotor one full turn. There should be no rubbing or binding.



10. Place armature and hub assembly onto the compressor crankshaft and insure the hub seats on the crankshaft properly.

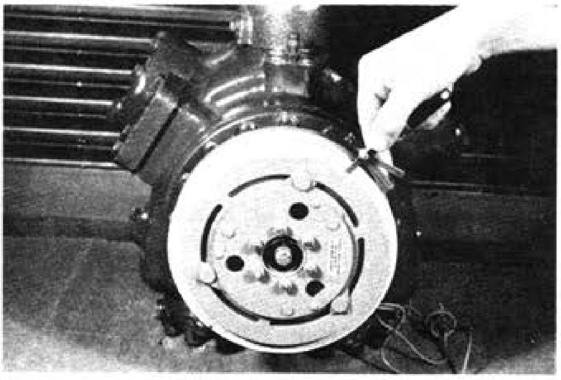
11. Insert the special key CTD P/N 68G2-9072 (1.75 x .250 x .199) in the keyway until outer end of key is flush with the hub's counter bore, as shown.





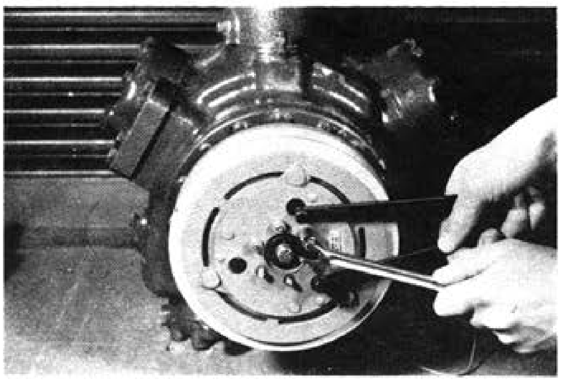
12. Secure armature assembly to crankshaft with the 3/8 special flat washer, lock washer, and 3/8-24 x 1-1/4" lg. capscrew removed in Step 1 of Clutch Removal. Torque capscrew to 16-20 ft-lb using CTD tool P/N 07-00240-01 to prevent crank shaft rotation.

Steps 13-19 are for new clutch installation only. After the initial adjustment, shim stack should not be changed.



13. Measure the air gap between the armature and rotor surfaces, as shown.

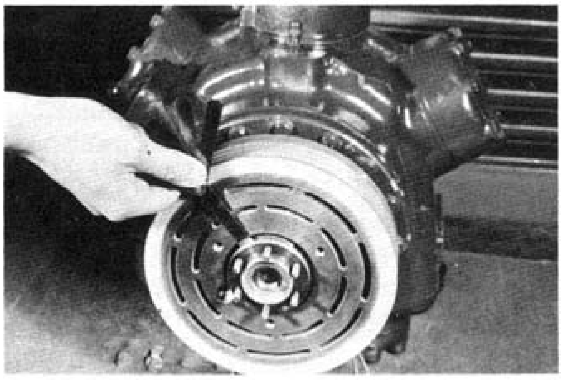
14. Record this measurement and determine the amount of shims that must be removed to obtain a 030/.060 air gap. The shims consist of (one) .010 and (six) .020 shims.



15. Remove the six armature plate to armature hub retaining nuts and washers. Use CTD tool P/N 07-00240-01 to prevent armature rotation, as shown.

16 Remove the required number of shims to obtain an air gap of .030/.060.

17. Insert a .020 feeler gauge between the outside edge of the clutch bearing mounting hub and the inside edge of the armature mounting hub, as shown. The clearance should be .020 or greater.



18. Reinstall armature plate, washers, and retaining nuts and torque to 7 ft-lb using CTD tool P/N 07-00240-01 to prevent crankshaft rotation.

19. Recheck air gap to confirm that you have obtained the .030/.060 clearance.

FIELD SERVICE PROCEDURES

1. Greasing of Clutch Bearing

The clutch bearings are pre-greased by the bearing manufacturer with the proper operating charge. Do not add grease to the bearing for at least 5000 hours of bus operation.

CAUTION: Over-greasing of the bearing will cause the bearing to operate at higher temperatures that may result in:

1. Blowing grease through the bearing seals onto the clutch friction faces, causing clutch slippage. A slipping clutch tends to run extremely hot, resulting in forcing more grease from the bearing, thereby increasing slippage and burning the magnetic coil.
2. Reduction in torque transmission capacity.

Recommended frequency for adding grease:

Up to 5000 hours bus operation	None
After initial 5000 hours	Add 0.1 oz SR1-2 grease during pre-season A/C system checkout (i.e., once per year during a Spring month)

Grease required must be "Chevron SR1-2" or CTD Engineering approved equal.

Procedure for Adding Grease to the Clutch Bearing

The grease fitting is located in the clutch bearing retaining nut. Access to the grease fitting is accomplished by removing the armature assembly as in Steps 1, 2, and 3 of HMC Removal.

NOTE: The removal of the armature in order to add grease to the bearing is deliberate to insure that all grease spillage can be cleaned from the clutch, reducing the potential for clutch slippage and the resulting loss of clutch torque transmission capacity.

Any unauthorized modification of the clutch armature to facilitate greasing of the bearing will void the clutch and compressor warranties.

It is recommended that a hand operated grease gun with approximately 0.1 oz delivery per stroke be used to add grease to the bearing. Grease gun must contain "Chevron SR1-2" grease.

Wipe the grease fitting clean of all dirt and foreign materials.

Attach grease gun to grease fitting. Insert 0.1 oz grease into bearing (1 to 2 strokes of the gun).

CAUTION: Do not give extra strokes "for good measure" as premature clutch performance degradation may result.

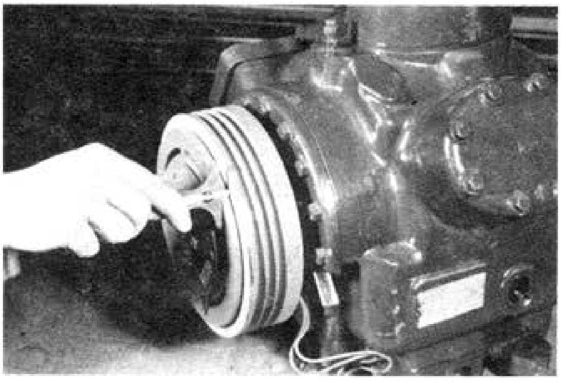
After adding grease to the bearing, wipe all grease spillage from clutch faces, retaining nut, and hubs. If you can see it, wipe it up.

Reinstall armature assembly and torque retaining nut to 16-20 ft-lb. torque, as in Steps 10, 11, and 12 of HMC Assembly.

2. Inspection for Wear

CAUTION: Insure bus or compressor drive engine is not operating. Take extra precautions to prevent inadvertent engine starting while clutch is being serviced.

A) With clutch coil de-energized, measure distance from face of armature to face of rotor, as shown. Feeler gauges inserted between the rotor and armature friction faces is not recommended due to the uneven wear on friction surfaces.



Energize the clutch coil and repeat the measurement. If the difference between the first and second measurements exceeds .110 inches, the clutch rotor and armature are to be replaced.

NOTE: Do not attempt to readjust the armature travel by removing shims. A catastrophic clutch failure may result. After initial (new) air gap adjustment the shim stack should never be changed.

B) Never mix rotor and armature assemblies between used assemblies or new and used assemblies.

CAUTION: If either the armature or rotor assemblies are defective, both assemblies must replaced.

C) If raised ribs on friction face are worn flat or nearly flat, replace armature and rotor assemblies.

CONTENTS

ILLUSTRATIONS

1. AUDIO AND VIDEO EQUIPMENT DESCRIPTION

The power amplifier is mounted on a sound system junction plate which is located in the first baggage compartment, L.H. side (Fig. 1), to access, open the first baggage compartment. In addition to the public address (PA) systems, options for AM/FM stereo radio and cassette player, CD changer, karaoke, wireless microphone, video system with monitors, scenic viewer and digital processor controller may be featured.

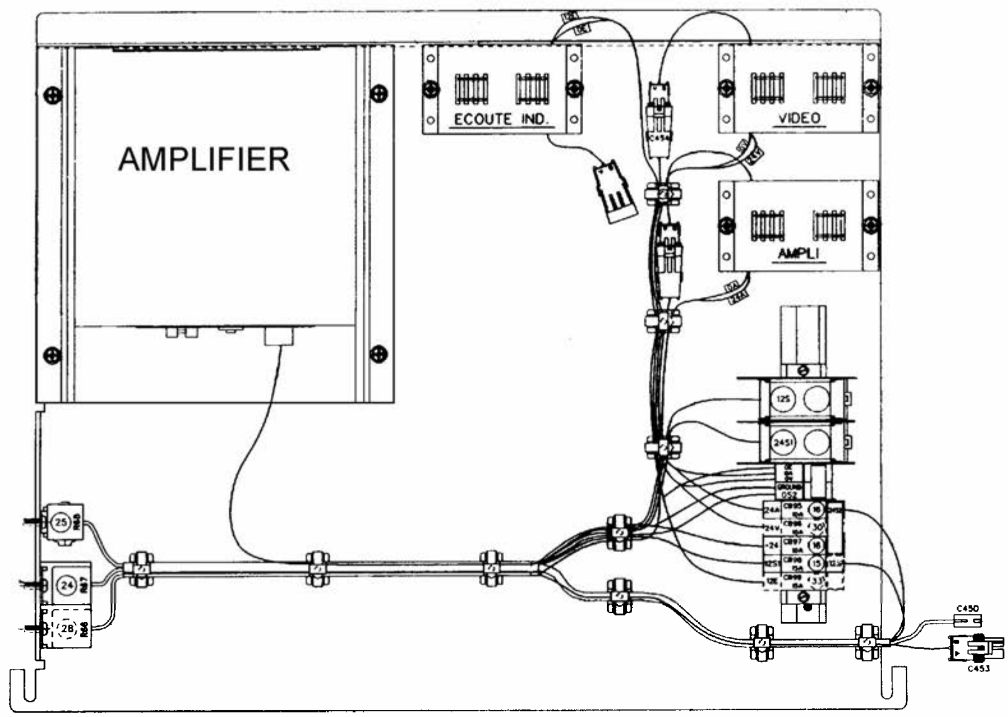
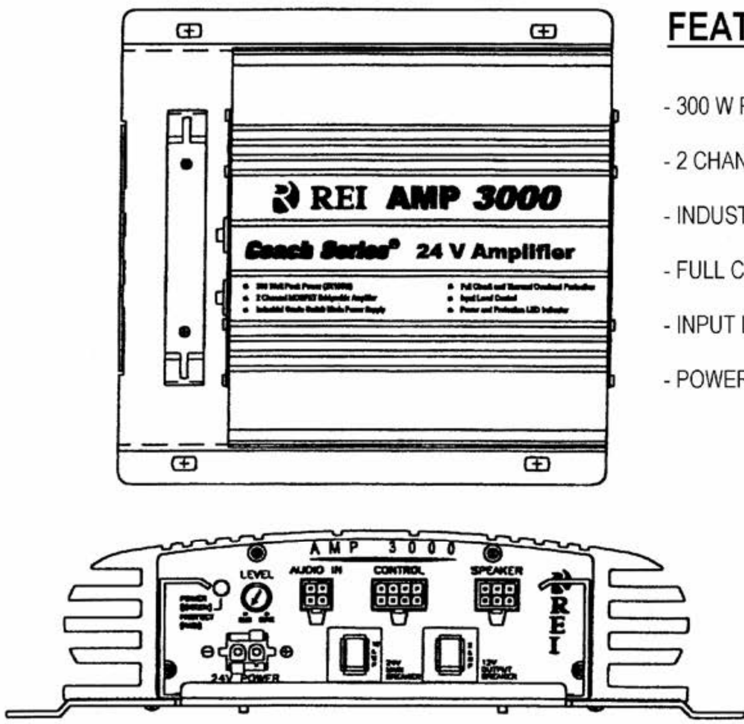


FIGURE 1: SOUND SYSTEM JUNCTION PLATE 23059

Each service module mounted to the underside of the parcel racks contains a 40-watt speaker. The fifteen speakers in the passenger section are wired in stereo and are powered by the amplifier. A microphone outlet mounted in the driver's area is provided as standard equipment.

1.1 AMP-3000 (HIGH POWER AMPLIFIER)



FEATURES

- 300 W PEAK POWER (2X150W)
- 2 CHANNEL MOSFET BRIDGEABLE AMPLIFIER
- INDUSTRIAL GRADE SWITCH MODE POWER SUPPLY
- FULL CIRCUIT AND THERMAL OVERLOAD PROTECTION
- INPUT LEVEL CONTROL
- POWER AND PROTECTION LED INDICATORS

FIGURE 2: AMP-3000 AMPLIFIER 23318

The AMP-3000 brings an added dimension to your stereo equipment and increases the total output of the system. The amplifier will perform with any unit operating in a 24-volt with negative ground electric system. The AMP-3000 is located on the first baggage compartment ceiling. To access, open the first baggage compartment door.

Set the volume control on the radio, then adjust the input control on the amplifier for an average listening level. This gives the best balance between radio output and system signal-to-noise ratio (Fig. 2).

Caution: *The low level input adjustment for this amplifier has been preset according to system specifications.*

1.1.1 Removal

Remove the amplifier as follows:

1. Set the battery master switch to the ''OFF'' position. Refer to Section 6: ''Electrical System'' for switch location.
2. Remove the sound system junction plate from its location. To perform this step, disconnect wiring connectors, remove cable ties and remove the bolts retaining the sound system junction plate.
3. Remove the four screws retaining the amplifier to its sound system junction plate.
4. Reverse the removal procedure to install the amplifier.

1.2 AM/FM RADIO

1.2.1 AM/FM Radio Cassette and Disc CD Changer

The audio system is composed of an AM/FM radio cassette player ''Panasonic, model CQ-R145CAHH (Fig. 3). Also, the vehicle may be equipped with a 8 disc CD changer and two additional Hi-Fi speakers in the driver's area. A roof antenna as well as different microphone outlets, can be installed as optional equipment.

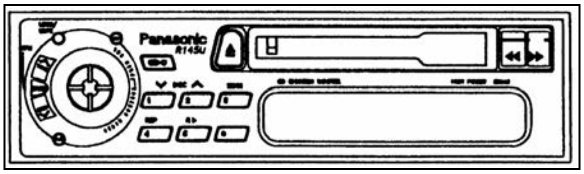


FIGURE 3: PANASONIC CQ-R145CAHH 23329

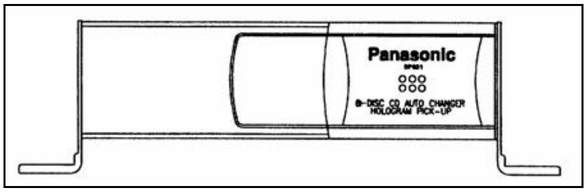


FIGURE 4: 8-DISC CD CHANGER 23332

1.2.2 AM/FM Radio / CD 1 Disc

This audio system is composed of an AM/FM radio CD player Panasonic model CP-DP101U (Fig. 5). Also, the vehicle may be equipped with two additional Hi-Fi speakers in the driver's area. A roof antenna as well as different microphone outlets, can be installed as optional equipment.

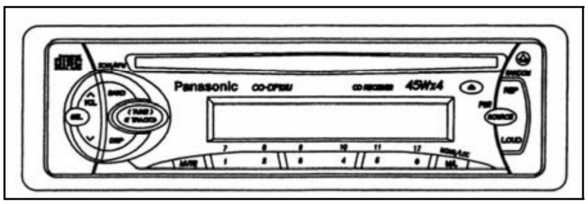


FIGURE 5: PANASONIC CP-DP101U 23317

Note: *Before attempting to solve an electrical problem on the sound system, refer to the master wiring diagrams.*

Instructions for proper use of the radio are included in the *''Panasonic Owner's Manual''* which is provided in the technical publication box delivered with the vehicle. The radio is a serviceable component and should only be serviced by a qualified electronics technician. Refer to *''Panasonic Service Centers''* guide included in the technical publication box.

1.2.3 Removal

To remove the radio from its location, proceed as follows:

1. Place the battery master switch in the ''OFF'' position.
2. Remove the dashboard panel cover.
3. Disconnect the electrical cable connectors from radio and unfasten back plate securing screw.
4. To separate the radio from its support, push in the dismounting pins included with the Panasonic Owner's Manual.
5. Push the unit through the front instrumentation panel.
6. Install a new unit by reversing the procedure.

1.3 CONTROL HEAD

The system 2000 (Fig. 6) is designed exclusively for coach operations. A complete system will control the following equipment:

- A specially designed 70 watt per channel RMS amplifier, capable of driving up to twenty-six, four ohm speakers.
- Six, custom designed ten-inch color monitors that incorporate a unique anti-theft locking slide mount. This makes installation and removal very easy.
- A specially modified VHS video cassette player that allows the operator convenient control over its functions.
- A digital audio processor that incorporates a centralized system control. The system 2000 microprocessor allows the operator to control up to three audio selections, permitting custom tailoring of each channel's sound quality. There are three microphone inputs for the PUBLIC ADDRESS SYSTEM (PAS), which are switchable between internal and external speakers. The unit contains a separate video section for the VCP that allows the driver to control his own separate audio selections.

Instructions for proper use of the control head are included in the ''*REI Operator's Manual''* which is provided in the technical publication box delivered with the vehicle.

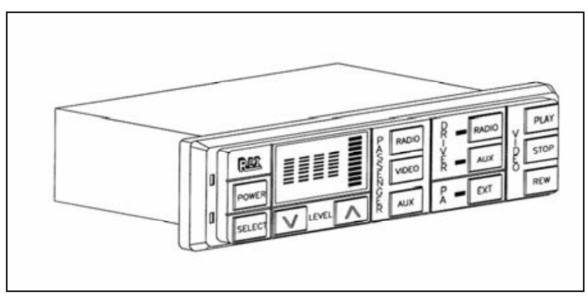


FIGURE 6: CONTROL HEAD 23070

1.3.1 Removal

To remove the control head from its location, proceed as follows:

1. Place the battery master switch in the ''OFF'' position.
2. Remove the dashboard panel cover.
3. Disconnect the electrical cable connectors from radio and unfasten back plate securing nut.
4. To separate the control head from its support, push in the dismounting pins included with the REI Operator's Manual.
5. Push the unit through the front instrumentation panel.
6. Install a new unit by reversing the procedure.

1.4 VIDEO CASSETTE PLAYER (VCP)

The VCP is located in the first parcel compartment on the driver's side (Fig 7 & 8). Instructions for proper use of the VCP are included in the *''Operator's Manual''* which is provided in the technical publication box.

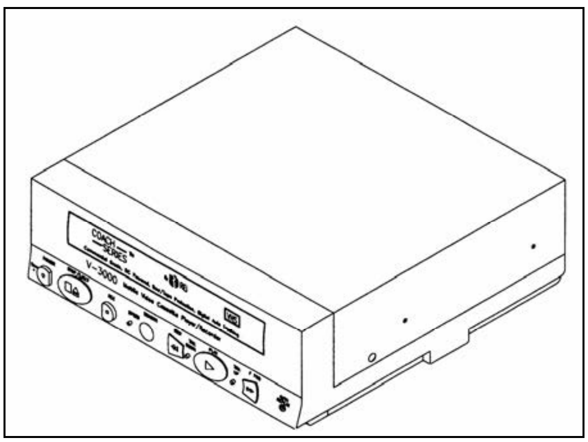


FIGURE 7: V-3000 VCP **23330**

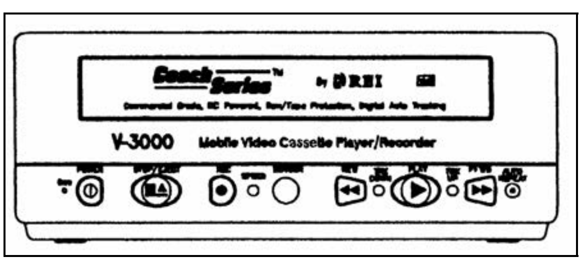


FIGURE 8: FRONT VIEW OF V-3000 VCP 23331

1.4.1 Removal

1. Place the battery master switch in the ''OFF'' position.
2. Remove the VCP/VCR mounting locknuts from rubber mounts.
3. Disconnect wiring.
4. Remove VCP/VCR unit from parcel compartment.

1.4.2 Installation

1. Install VCP/VCR unit into parcel compartment aligning rubber mount studs with mounting holes. Insert mount studs through mounting holes.
2. Install locknuts on mount studs.
3. Reconnect wiring.
4. Place the battery master switch in the ''ON'' position.

1.5 BOOM-TYPE MICROPHONE

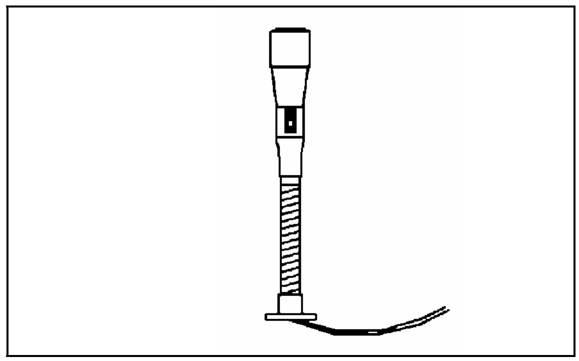


FIGURE 9: BOOM-TYPE MICROPHONE 23083

1.5.1 Removal

1. Place the battery master switch in the ''OFF'' position.
2. Remove the mounting screws at mounting flange.
3. Disconnect wiring.

1.5.2 Installation

1. Reconnect wiring.
2. Align mounting flange with holes and install screws.
3. Remove spacer block mounting screws.
4. Insert spacer block and install mounting screws.
5. Place the battery master switch in the ''ON'' position.

1.6 HANDHELD PRIORITY MICROPHONE

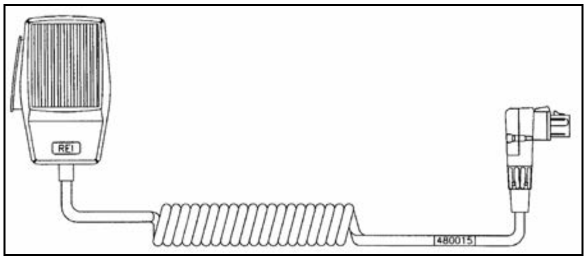


FIGURE 10: HANDHELD PRIORITY MICROPHONE 23216

1.7 RUBBER COATED MICROPHONE c/w 10 Feet cord and connector

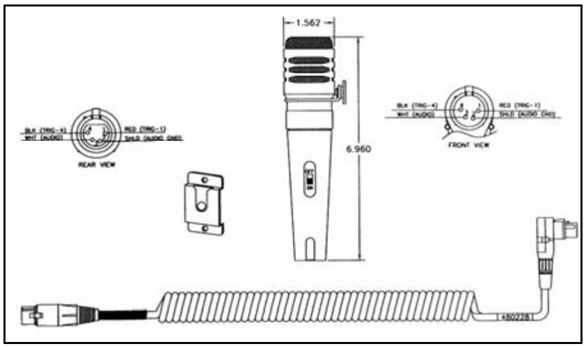


FIGURE 11: RUBBER COATED MICROPHONE 23217

1.8 WIRELESS MICROPHONE

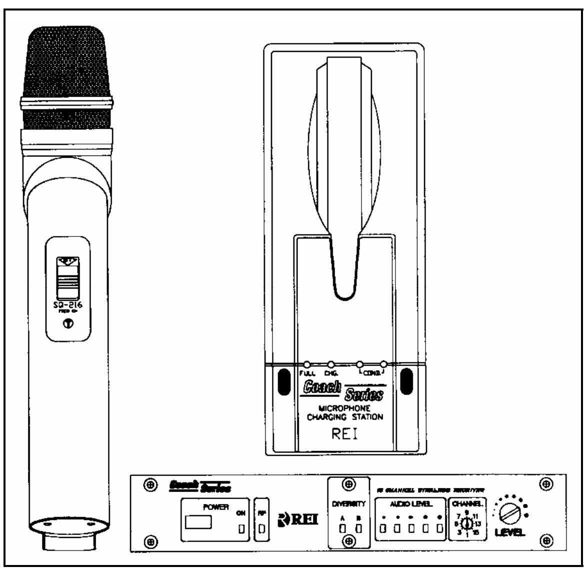


FIGURE 12: WIRELESS MICROPHONE 23226

The system 2000 16 channel wireless microphone, Receiver and Charging Cradle are custom designed units that allow for wireless PA communication from anywhere on the coach. The unit consists of a receiver mounted in the parcel area directly behind the driver, and a rechargeable hand-held microphone and charging unit. Instructions for proper use of the microphone are included in the *''REI Operating Manual''* which is provided in the technical publications box delivered with the vehicle.

1.9 TV TUNER

For TV tuner control descriptions, refer to fig. 13.

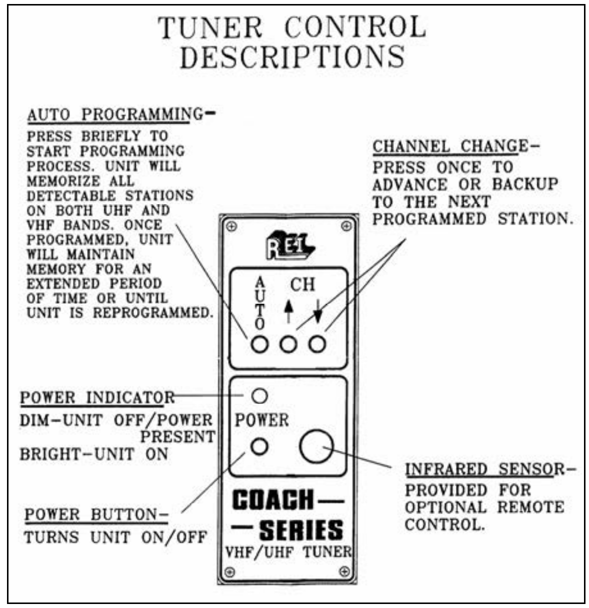


FIGURE 13: TUNER CONTROLS DESCRIPTION 23061

1.10 KARAOKE

The modified Panasonic DVD Player powers up automatically when the video system is activated. The unit can be controlled with the plug-in remote control, or the control head, which has access to the PLAY and STOP commands.

If so equipped, instructions for proper use of the Karaoke system are included in the *''Operating Manual''* that is provided in the technical publications box delivered with the vehicle.

1.10.1 Karaoke Panasonic Sound System – MOBILE DVD PLAYER DV1500

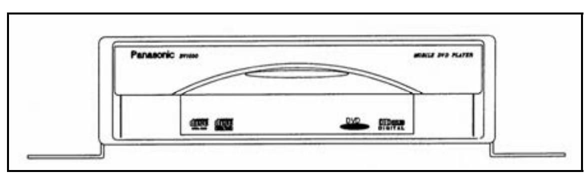


FIGURE 14: MOBILE DVD PLAYER DV1500 23214

1.11 DRIVER'S SPEAKERS

The driver's speakers are mounted one on each side. This arrangement provides the driver with clear stereo sound. Controls for the driver's audio allow selection between the radio and the auxiliary audio (independent of the passenger's speakers) or muting the speakers.

1.12 MONITOR

For monitor adjustment, refer to figure 15.

1.12.1 Removal

The front and side, ten-inch color monitors are slide mounted and retained by key locks. A LED indicator is provided on the back to indicate when the unit is ''ON''. The red button is the monitor ON/OFF switch and the pin style button is the circuit breaker reset button.

1. Place the battery master switch in the ''OFF'' position.
2. Unlock the monitor slide and pull towards the front of the monitor.
3. After removal, cover mount location using the monitor cover assembly and lock.

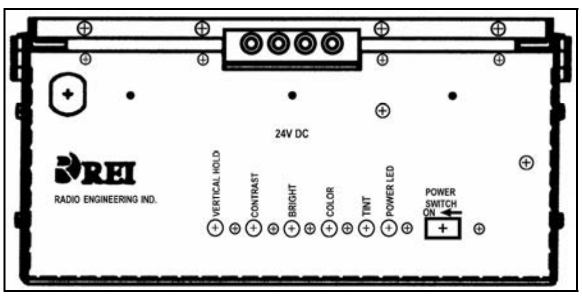


FIGURE 15: MONITOR HOUSING REAR PANEL 23333

1.12.2 Installation

1. Remove monitor cover assembly located over mounting bracket if needed.
2. Align the monitor mount with the slide and slide monitor into place.
3. Lock the monitor or cover to prevent removal.

Note: *Make sure connections are not bent or damaged. If monitor is not being replaced, immediately install the mounting cover.*

1.13 SCENIC VIEWING SYSTEM

The scenic viewing system enables the passengers to view the road ahead of the vehicle. This system is composed of a camera, a dashboard mounted ON/OFF switch and the audio – video switching box located in the first parcel compartment on the driver's side (Figs. 16 & 17).

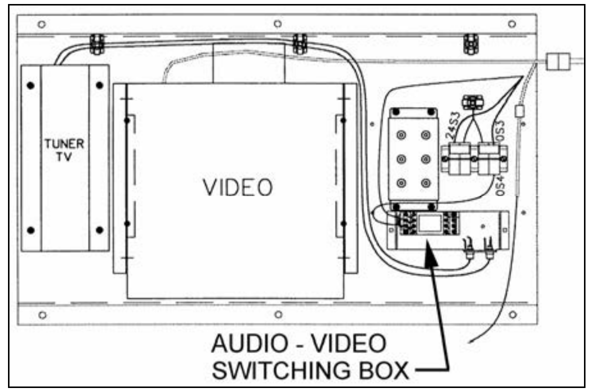


FIGURE 16: INSTALLATION IN PARCEL COMPARTMENT 23333

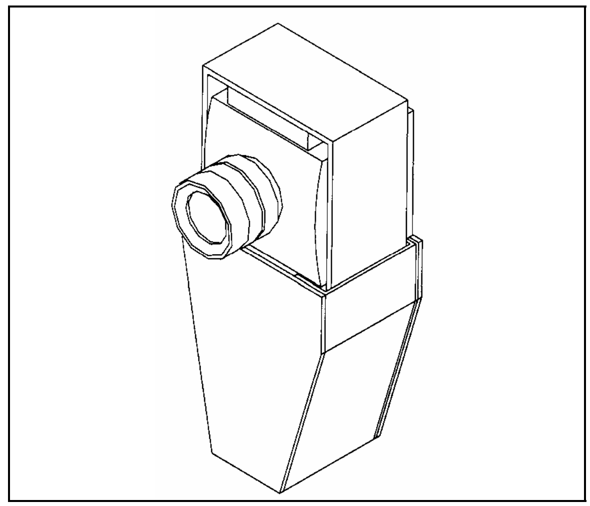


FIGURE 17: SCENIC VIEW CAMERA 23221

1.14 ROOF ANTENNA INSTALLATION

1. Find the desire location and drill a hole according to specification.
2. To remove dirt and grease, wash hole edge with alcohol.
3. If so equipped, remove foam padding ring from antenna to free the metal surface (foam can produce air bulbs in new rubber seal).
4. With SIKA 205, wash the vehicle hole edge and the antenna base surface, wait at least two (2) minutes for chemical evaporation.
5. Apply new seal SIKA 221 on both, vehicle hole edge and antenna base.
6. Fix the antenna in place.

7. Remove excess seal and complete a finishing joint all around the antenna base.

2. HUBODOMETER

2.1 DESCRIPTION

An optional wheel hubodometer (Fig. 18) may have been installed on the R.H. side of the drive axle. It indicates the total distance in miles or kilometers covered by the coach since it has left the factory, including road testing.

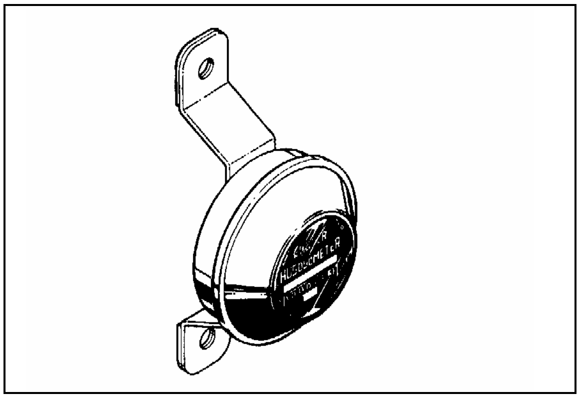


FIGURE 18: HUBODOMETER 23024

2.2 OPERATION

The hubodometer is calibrated for a specific wheel size (diameter). Wheel rotation causes a mechanism inside the hubodometer to record distance after a predetermined number of rotations. The unit should be serviced at a competent speedometer repair facility.

Note: *Do not use paint, solvent or thinner on hubodometer face or on plastic hubcaps. Do not weld on hubodometer.*

2.3 REMOVAL

To remove the unit, remove the two lock nuts and washers securing it to the wheel hub, and pull the unit off the studs.

2.4 INSTALLATION

Place the hubodometer unit over the wheel hub studs. Replace the lock washers and nuts. Torque stud nuts to 110-165 Ft·lbs (150-225 Nm).

3. BACK-UP CAMERA AND MONITOR

An optional back-up camera is available which provides the driver with visual assistance when backing-up. The camera is automatically activated when the transmission is put in reverse gear and the ignition switch is "ON". The TV monitor is mounted on top of the dashboard. Refer to the Operator’s Manual under “Controls & Instruments".

4. COLD STARTING AID (ETHER)

The vehicle can be equipped with an electrically-operated type ether cold starting aid designed to ease engine starting when temperature is low.

On vehicles equipped with cold starting aid, the system consists of the main following parts:

- Ether starting aid switch
- Ether cylinder
- Solenoid valve (24 V)
- Thermal cutout valve
- Atomizer

The control rocker switch is located on the dashboard. This switch is provided with a locking mechanism to avoid accidental use when engine is running. To activate the ether starting aid, proceed as follows:

1. Prior to cranking engine, press down rocker switch for three seconds to fill solenoid valve.
2. Release switch to discharge shot.
3. Allow three seconds for shot to discharge.
4. Start engine, use additional shots if necessary to keep engine running.

Caution: *This practice should be performed only when absolutely necessary. Excessive use of fluid could result in serious engine damage.*

The ether cylinder and solenoid valve assembly are mounted on the engine compartment wall and are accessible from the engine compartment R.H. side door.
The thermal cutout valve is mounted on the engine (radiator side). Its function is to prevent discharge of ether when engine is warm (over 90 F (32 C)). The atomizer is installed on top of the air intake duct (Fig. 19).

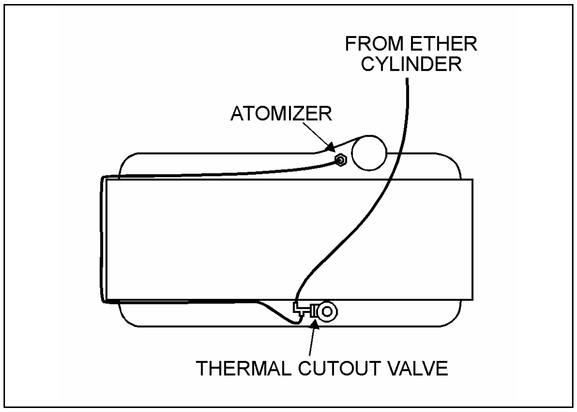


FIGURE 19: ENGINE 23032

4.1 PREVENTIVE MAINTENANCE

During the summer months, remove cylinder to avoid high temperature actuation of the cylinder safety relief device. Always screw valve cap into solenoid valve opening to prevent entrance of road dirt. When removing cylinder, be careful to prevent dirt from entering the valve.

4.2 TROUBLESHOOTING (IF SYSTEM IS NON-FUNCTIONING)

Warning: *During the following test, direct free end of tube away from personnel and all sources of ignition as this fuel is extremely flammable. Avoid breathing vapors and contacting fuel with skin. Never smoke during test.*

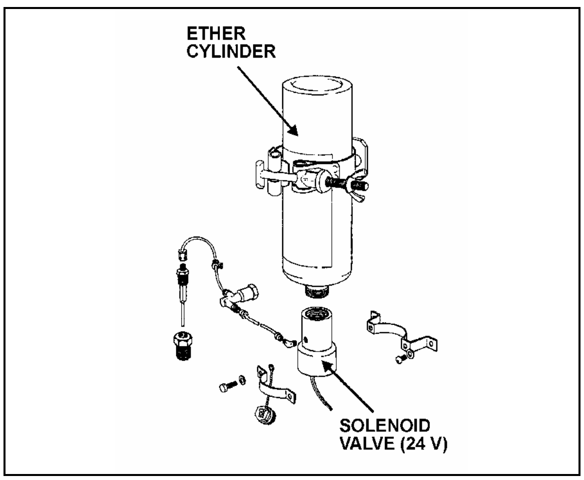


FIGURE 20: COLD STARTING AID 23048

1. Check cylinder for hand tightness and fuel supply (Fig. 20). Empty cylinder weight is approximately 17 oz (480 g); full cylinder weight is approximately 35 oz (990 g). If cylinder is empty, replace it. Before replacing cylinder, install new valve gasket in solenoid valve.
2. If still not functioning, disconnect tubing at solenoid valve fitting. Actuate solenoid valve. (Ask an assistant to actuate solenoid valve using the rocker switch on the dashboard).
   - If solenoid valve is non-functioning, check electric circuit, (refer to wiring diagrams). If sound, remove and replace the solenoid valve. If not, repair electric circuit.
   - If valve is functioning, reassemble valve fitting and connect tube. Disconnect tube at thermal cutout valve from port "Tube from valve".
3. Actuate the solenoid valve.
   - If fuel is not discharged from tube, remove tube and blow out or replace.
   - If fuel is discharged, connect tube to thermal cutout valve, and disconnect other tube.
4. Actuate the solenoid valve.
   - If fuel is not discharged, replace the cutout valve.

Note: *If engine coolant temperature is 90°F (32°C) or over, it is normal that fuel is not discharged as the valve is in closed position.*

   - If fuel is discharged, connect tube to thermal cutout valve, and disconnect tube from atomizer.
5. Actuate the solenoid valve.
   - If fuel is not discharged from tube, fuel line is clogged. Remove tube and blow out or replace.
   - If fuel is discharged, replace the atomizer.

5.3 THERMAL CUTOUT VALVE QUICK TEST

1. Engine coolant temperature must be below 90 F (32 C).
2. Temporarily disconnect tube at thermal cutout valve from port *"Tube to atomizer"*.
3. Actuate solenoid valve (Ask an assistant to actuate solenoid valve by means of the rocker switch on the dashboard). Fuel should be discharged through the thermal cutout valve.

Warning: *Avoid breathing vapors and contacting fuel with skin. Never smoke during test.*

4. Reconnect tube to thermal cutout valve.
5. Start engine, using cold starting aid if necessary. Stop engine when it reaches operating temperature.
6. Disconnect tube at thermal cutout valve as in step 2, and repeat step 3. No fuel should be discharged.

5. DESTINATION SIGN

DESCRIPTION

The destination sign is located at upper front of the vehicle. Two models are available.

5.1 ELECTRICAL DESTINATION SIGN (OPTIONAL)

The lighting is provided with a fluorescent tube, which is activated by means of a rocker switch located on the dashboard. The destination sign is electrically operated, two rocker switches mounted side by side on the destination sign control its motor. The unwinding speed control switch determines the rolling speed without actuating it. The selecting switch (momentary type) controls and actuates the rolling direction (fig. 21).

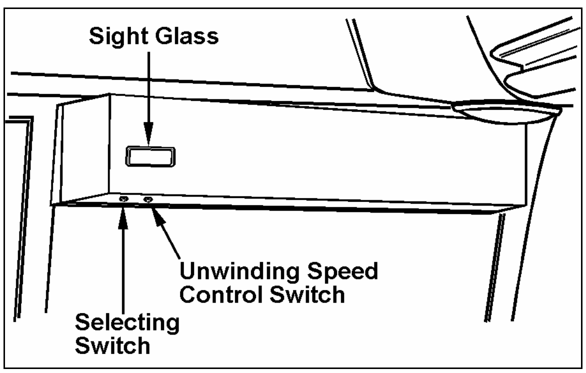


FIGURE 21: DESTINATION SIGN – ELECTRICAL 23122

5.1.1 Maintenance

Inspect the following items regularly:

1. Check for free and easy mechanism movement.
2. Check for loose items on the sign mechanism, such as wire, loose clips, hanging tape, etc.
3. Check tension and condition of the two drive belts and replace as required.
4. Periodic lubrication is **NOT** recommended.

5.1.2 Destination Sign Light Replacement

Refer to Section 06, Electrical System, paragraph "*13.4.7 Destination Sign Light - Bulb Removal and Replacement*" and "*13.4.8 Destination Sign - Fluorescent Removal and Replacement*".

5.1.3 Electric Motor Removal and Installation

To remove the electric motor:

1. Remove the six Phillips-head screws and washers retaining the destination sign cover, then carefully remove the cover from its location.
2. Disconnect wires from electrical motor.
3. Remove both screws retaining motor to destination sign frame (Fig. 22).
4. Slide motor upwards, then remove the drive belt.
5. Remove motor through the opening intended for this purpose.

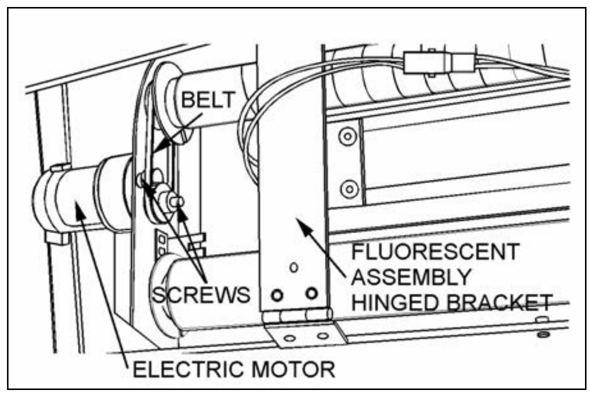


FIGURE 22: DESTINATION SIGN-ELECTRIC MOTOR 23034

6. Install the motor by reversing the above procedure.

5.1.4 Sign Curtain Repair

In the event a destination sign curtain is torn, it can be repaired with 3M polyester tape or any equivalent cellophane tape. When repairing a tear, the tape should be used on both sides of the curtain.

5.2 ELECTRONIC DESTINATION SIGN (OPTIONAL)

To change the destination, depress the selecting switches until the desired destination appears in the LCD display.

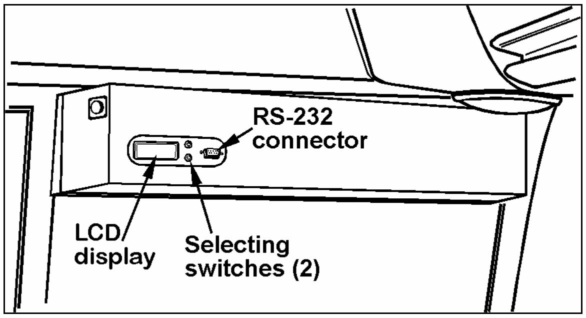


FIGURE 23; DESTINATION SIGN – ELECTRONIC 23123

Note: *The destination sign must be programmed with a computer connected to the RS-232 connector prior to first use. Follow the instructions on the computer disk to install and run the software.*

Note: *All destination sign models are equipped with lights (bulb light or fluorescent) which illuminates automatically when the headlight or fog light switch is activated.*

6. LAVATORY

6.1 DESCRIPTION

The lavatory is located in the rear R.H. corner of the coach. It is equipped with a chemical flush toilet, bathroom tissue dispenser, washbasin, towel dispenser, waste container, mirror, ashtray, and a cleaning cabinet. A liquid soap dispenser and moist towel dispenser are optional.

Locking the lavatory door from the inside will illuminate a fluorescent light in the lavatory and two outside signs to indicate occupation. One sign is located on the outer wall of the lavatory and another sign is located over the windshield. An indicator light on the dashboard will illuminate to inform the driver when the lavatory is occupied. A night-light is permanently lit in the lavatory when the ignition switch is in the ON position.

If emergency assistance is required, the lavatory occupant can actuate a buzzer that will sound in driver's area. The buzzer's push-button (c/w instruction label) is located on the inner curbside wall of lavatory.

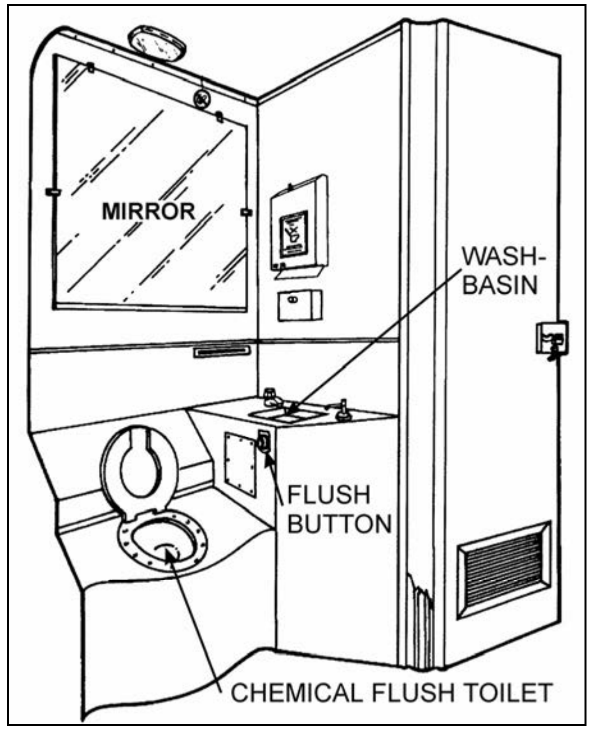


FIGURE 24: LAVATORY 23335

The lavatory has it's own ventilation system that operates only when ignition switch is in the "ON" position. An auxiliary sump tank (Fig. 27) (optional) allows main tank to be drained by manually opening an interconnecting tank valve (5, Fig. 28). Lavatory can then be operated for longer periods until coach can be serviced at a facility equipped for disposal.

The fresh water tank, located behind compartment mirror (Fig. 27), is equipped with a thermal drain valve that will drain the tank when water temperature approaches the freezing point preventing damage to the tank (Fig. 27). The fresh water supplies water to the washbasin by gravity. Two tubes are connected on top of the tank. One serves as overflow as well as a vent tube and runs along the curbside wall to the engine R.H. side compartment (6, Fig. 28) while the other tube is connected to the fresh water fill connection which is also located in engine R.H. side compartment (1, Fig. 28). A third tube connected in the bottom of the fresh water tank allows fresh water to flow to the washbasin faucet. Water from washbasin drain tube flow to the main sump tank.
Also, a drain hole located on lavatory floor drain water splashed on the floor to the engine R.H. side compartment.

6.2 MAINTENANCE

The servicing procedure for the lavatory is described in the *"Operator's Manual"* included in the technical publications box delivered with the vehicle.

6.3 VENTILATION FAN

6.3.1 Description

The lavatory ventilation fan, mounted in engine compartment behind the oil reserve tank (Fig. 25), serves two purposes. It exhausts objectionable odors and provides a constant air circulation in the lavatory compartment by heating or cooling the lavatory with the vehicle ambient air. Air flows in the lavatory compartment through a vent grill located on the lavatory door and exhausts through a grill located next to the toilet.

Note: *This fan runs constantly when the ignition switch located on the dashboard is in the "ON" position.*

6.3.2 Maintenance

The frequency of preventive maintenance should be determined according to vehicle mileage and operating conditions. However, it is recommended to check this item every 50,000 miles (80 000 km) or once a year, whichever comes first.

Remove fan and motor assembly. Check for fan housing wheel and motor free operation. When defective motor occurs, new motor must be installed.

6.3.3 Removal and Installation

1. With the engine compartment rear doors opened, remove hose clamp securing duct to ventilation fan inlet, and disconnect duct.
2. Disconnect the ventilation motor wiring connector.
3. Remove the support bracket screw. Remove the three bolts fixing the ventilation fan housing support. Remove the ventilation fan assembly from its location.
4. The unit can now be disassembled and motor replaced.
5. Reverse previous steps to reinstall ventilation fan assembly on vehicle.

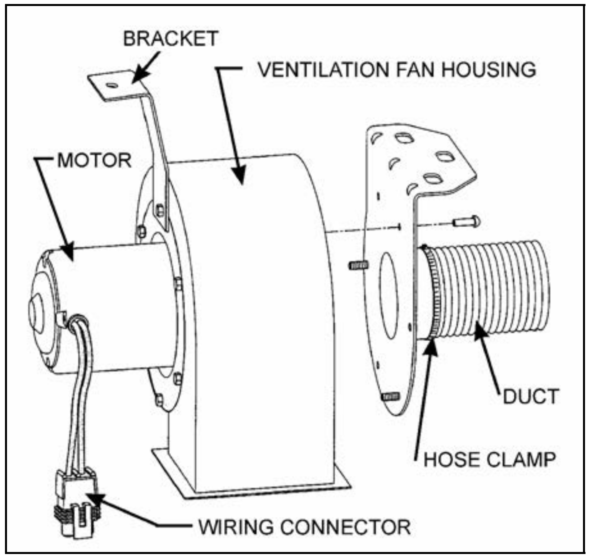


FIGURE 25: VENTILATION FAN INSTALLATION 23222

6.4 DOOR LOCK

Lavatory door lock has inside and outside handles, as well as an inside latch to lock door from inside the compartment. If the lock fails to release, the door can be opened from the outside using a special key which is supplied to the driver. Lock assembly can be removed from the door, then readily disassembled and parts replaced, if necessary (Fig. 26). A thin coat of lubricant on all moving parts will ensure trouble-free operation.

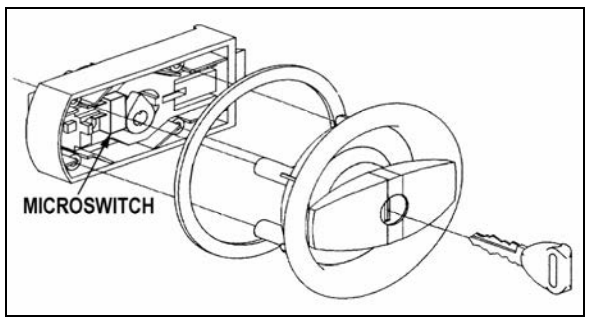


FIGURE 26: DOOR LOCK 23320

6.5 LAVATORY LIGHT

The lavatory light is installed on ceiling. A microswitch, which is mounted inside the latch housing, is activated by the door lock mechanism upon locking to energize the circuit. This switch is readily serviced by removing the four Phillips-head screws securing the housing to the door interior frame.

Proceed as Section 06, Electrical System, *Dome, Rear Roof and Lavatory Lights*" for lights replacement.

6.6 LAVATORY NIGHT-LIGHT

The lavatory night-light is illuminated as soon as the ignition switch is set to the *"ON"* position. See Section 06, Electrical System, "*Parcel Rack / Lavatory Night Light - "Bulb Removal and Replacement*" for lights replacement.

6.7 EMERGENCY BUZZER

The lavatory emergency buzzer is mounted on the inner curb side wall of lavatory and sounds when the emergency call push-button switch in the lavatory compartment is activated. For specific wiring information, refer to wiring diagrams. To remove the emergency call push-button switch, proceed as follows:

1. Remove both phillips-head screws retaining pushbutton switch plate to wall.
2. Remove steel plate located on L.H. side of pushbutton switch.
3. Remove switch through this opening, taking care to disconnect electric wires.

6.8 FRESH WATER TANK

One panel allows access to the fresh water tank. It is located behind the toilet mirror. Remove the tank as follows:

1. Remove the mirror.
2. Remove the fresh water tank tubings, bolts, and different connectors.
3. Remove the tank from the wall.
4. Reverse previous steps to reinstall fresh water tank assembly on vehicle.

6.8.1 Fresh Water Tank Draining

The fresh water tank can be drained by simply opening the fresh water drain cock (Fig. 28). Don't forget to close cock when draining is done.

Note: *The fresh water reservoir is equipped with a thermal valve which is set to open at about 35^{o}F, thereby automatically draining the reservoir in near-freezing temperatures.*

Routine draining and filling of lavatory tanks should be performed by maintenance personnel only. If engine or heating failure occurs in extreme weather conditions, emergency draining of water tanks should be performed under the most suitable conditions and should at all times be supervised by driver.

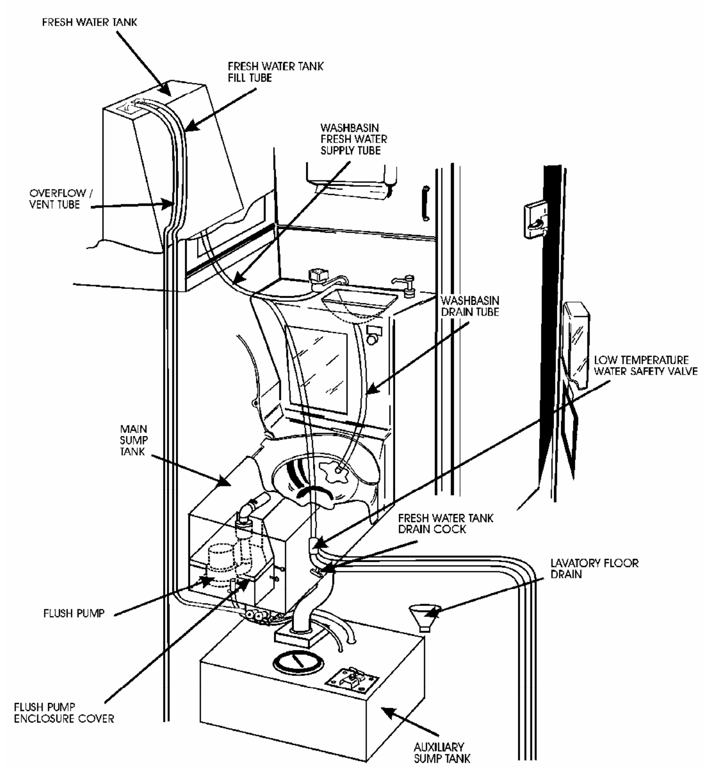


FIGURE 27: FUNCTIONING OF LAVATORY 23051

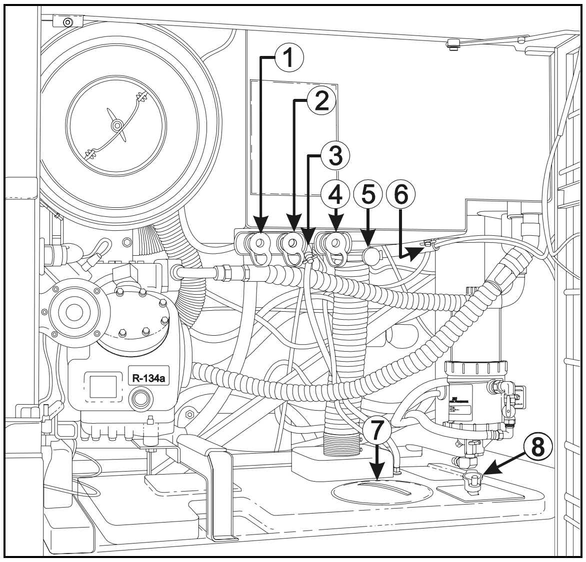


FIGURE 28: F/W TANK SERVICE VALVES 23317

1..............................Fresh water tank fill connection
2..............................Main sump tank fill connection
3..............................Main sump tank overflow cock
4..............................Cleaning kit hose connector
5..............................Main sump tank drain valve
6..............................Fresh water tank drain cock
7..............................Auxiliary sump tank access cap
8..............................Auxiliary sump tank drain valve

6.8.2 Fresh Water tank Filling

Connect the fresh water supply hose to the fresh water reservoir fill connection (Fig. 28) located in the curb-side engine compartment. Fill the reservoir until the overflow tube leaks, signaling that the reservoir is full.

Warning: *Never put antifreeze in fresh water tank; antifreeze is toxic.*

Warning: *If tank has not been drained for an extended period of time, draining and filling operations must be repeated three (3) times in order to clean tank and eliminate contaminated water.*

6.9 LIQUID SOAP DISPENSER

A liquid soap dispenser may have been installed as optional equipment. To refill dispenser, proceed as follows:

1. Turn cover slightly clockwise until it stops.

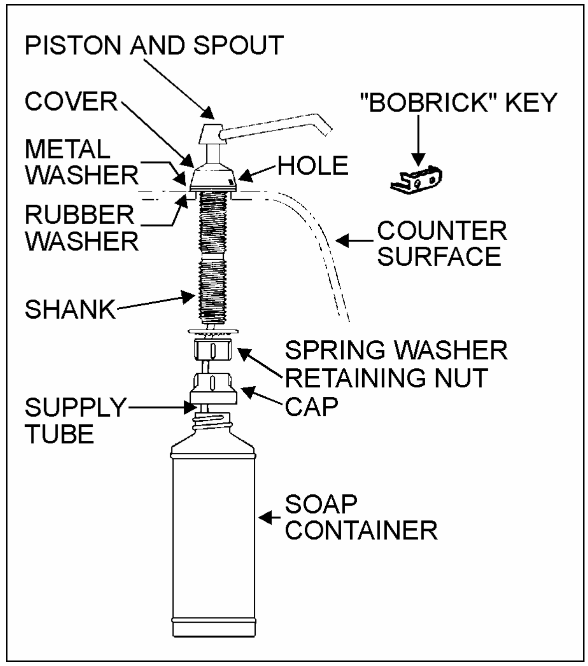


FIGURE 29: LIQUID SOAP DISPENSER 23039

2. Insert projection at end of *"BOBRICK"* key into rectangular hole in cover (Fig. 29). Push straight in. While holding *"BOBRICK"* key in, turn cover counterclockwise about 1/8 turn.

Caution: *Do not use "BOBRICK" key to turn cover.*

3. Lift out piston and spout, cover and supply tube.
4. Fill dispenser with soap. This model can dispense vegetable oil soaps, synthetic detergents, and lotion soaps.

Caution: *Never use abrasive cleaners.*

5. Replace supply tube, piston, and spout mechanism reversing the steps above.
6. Secure the cover by turning clockwise until lock snaps into position.

Note: *The dispenser requires priming when extremely viscous lotion soaps are used. Remove piston and spout, cover and supply tube assembly. Pump water into assembly, then replace into dispenser.*

6.10 FLUSH PUSH-BUTTON

The green flush push-button is located near the toilet. Press on push-button to actuate a pneumatic timer located on the other side of wall. This timer allows an electric current flow during a preset time to a pump into the sump tank.

6.10.1 Pneumatic Timer Removal and Installation

1. Unscrew and remove the flush push-button locking ring.
2. Remove steel plate located on L.H. side of pushbutton switch.
3. Remove pneumatic timer through this opening, taking care to disconnect electric wires.

Note: *Care must be taken to avoid losing the spacers installed on the mounting sleeve.*

4. Reverse the above procedure to reinstall timer. The recommended torque for the lock nut is 15 Ft·lbs (21 Nm).

6.10.2 Timer Adjustment

Timer can be adjusted from 0.2 second to 3 minutes by turning the time adjustment screw clockwise to increase time, and counterclockwise to decrease time. To gain access to the time adjustment screw, repeat steps 1, 2 and 3 in the previous paragraph "*6.10.1 Pneumatic Timer Removal and Installation*".

6.11 FLUSH PUMP

The submersible-type flush pump is mounted inside an enclosure in the sump tank (Fig. 27). The enclosure is provided with a screened side which, serves as a strainer to prevent solid matters from entering the pump.

The pump requires no periodic maintenance other than cleaning of the strainer side using a water jet introduced through the circular cap opening, once the sump tank is completely drained. The pump can run dry periodically without damage. However, for maximum seal life, the run dry periods should be kept to a minimum.

Caution: *If vehicle is stored for an extended period of time, make sure to clean the strainer as solid matter will tend to pack, and will necessitate replacement of strainer.*

6.11.1 Flush Pump Removal

1. Remove the toilet to gain access to the pump enclosure.
2. Remove the flush pump enclosure cover
3. Unsnap the flush pump.

6.12 SUMP TANKS

6.12.1 Main Sump Tank Draining

When recirculating water in the toilet is soiled, drain main sump tank. If equipped with the optional auxiliary sump tank, drain the main sump tank contents into the auxiliary tank and perform the filling procedure of the main tank.

6.12.2 Main Sump Tank Filling

Open the main sump tank overflow cock and connect a water supply hose to the toilet sump tank fill connection. The main tank is full when water starts flowing through the clear overflow tube. Close main sump tank overflow cock when the tank is full.

Caution: *In cold weather, add 2 gallons (9 liters) of antifreeze (e.g.: ethylene glycol) in the toilet before filling main tank.*

6.12.3 Auxiliary sump Tank Draining

Remove drain cap located under auxiliary sump tank then turn the auxiliary sump tank drain valve lever counterclockwise eight or nine times. Remove the access cap and flush tank with clean water. To close, turn the valve lever several times clockwise until the rubber bladder seals the drain hole. Reinstall access and drain caps.

Caution: *Lavatory tanks should be serviced only at suitably equipped stations.*

Note: *It is unlawful to dump sump tank contents in any location other than those designated as such.*

When a full draining is required, clean main tank by repeating the draining and filling operations while leaving the auxiliary sump tank drain cock opened. Close cocks and pour a pack of commercial toilet deodorant (Prévost part #900329) in toilet before adding the antifreeze and starting final filling of main tank.

Warning: *The toilet deodorant contains products that can be very irritating to skin. Use rubber gloves when handling and then clean toilet seat.*

Warning: *Antifreeze must comply with the effective environmental act.*

Caution: *When cold weather is expected and there is no antifreeze in the tank, both sump tanks must be drained.*

Note *If there is no antifreeze solution in the tank, there is less risk of freezing if engine is operating due to the heat it produces.*

Note: *New coaches are delivered with the sump and fresh water tanks empty. Fill with water before putting the coach in service.*

7. AIR HORN VALVE

The air horn valve is located in the front service compartment and the air horn valve button is on the steering wheel center.

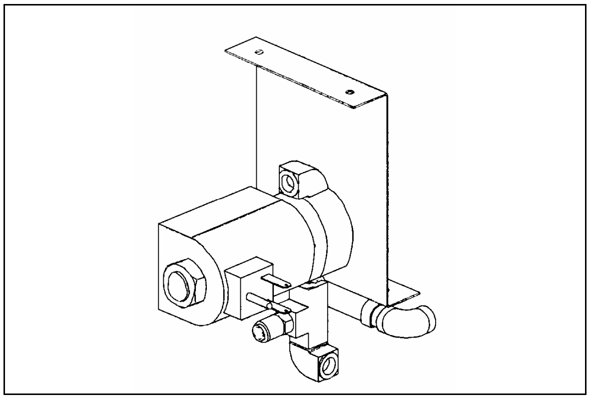


FIGURE 30: AIR HORN VALVE 23230

7.1 AIR HORN VALVE MAINTENANCE

When needed, the air horn valve can be serviced or replaced using the following procedure:

1. Unplug the cable connector;
2. Disconnect the air tubes;
3. Loosen the retaining bolts;
4. Service or replace the air horn valve;
5. Reinstall by reversing procedure.

8. WINDSHIELD WIPERS AND WASHERS

8.1 GENERAL DESCRIPTION

Note: *When installing a wiper motor, arm or blade, follow recommended procedures to prevent misalignment, binding or malfunction. Check the windshield washer liquid hoses, fittings and connectors to be sure they are properly connected and seal with no restriction to the flow of washer liquid. Check that wiper arms have the proper sweep position and the washer nozzles are aimed so that spray is within the proper wiper pattern.*

The windshield wipers are controlled by one electric wiper motor that is accessible for maintenance after removing the appropriate access panel beside the footwell (refer to figure 31).

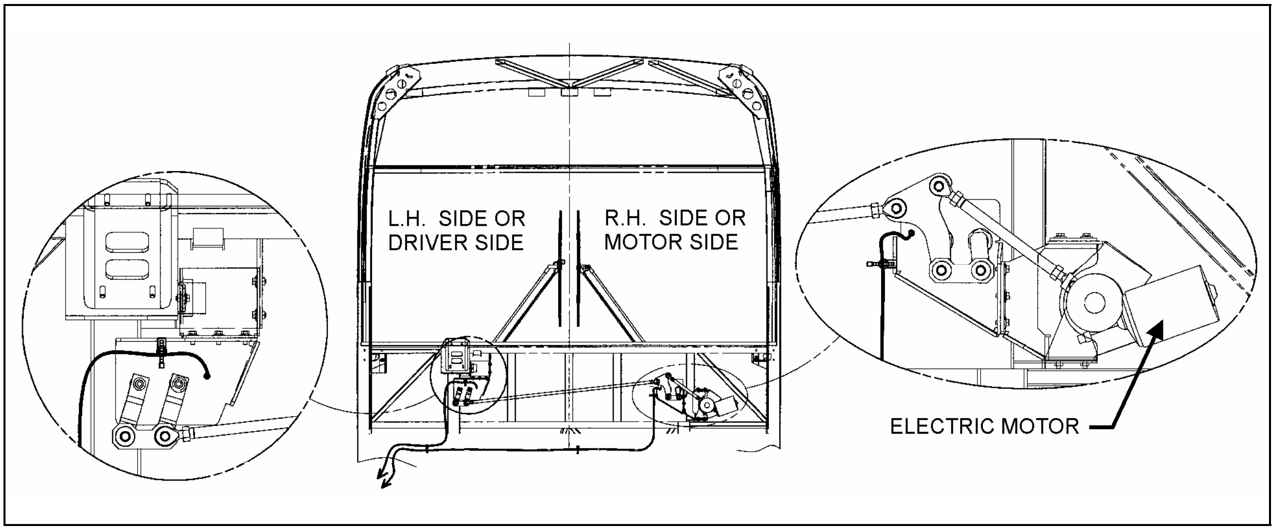


FIGURE 31: WINDSHIELD WIPER INSTALLATION 23287

Turn the multifunction lever forward to activate windshield wipers (item 2, fig. 32). The first position operates the wipers at low speed and the second position operates the wipers at high speed. Turning the lever backwards will operate the wipers in the intermittent mode.

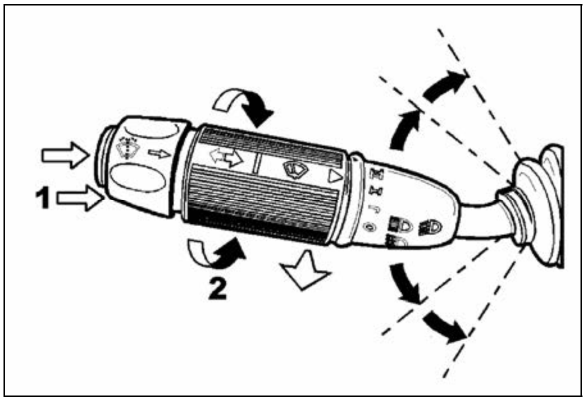


FIGURE 32: MULTIFUNCTION LEVER 23133

The windshield washer pumps are electrically operated and are controlled by a washer control ring on the multifunction lever (item 1, fig. 32).

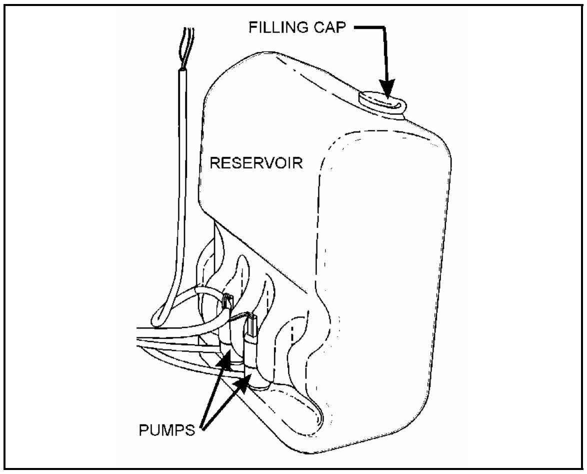


FIGURE 33: WINSHIELD WASHER RESERVOIR 23220

The windshield washer reservoir is located in the front service compartment (Fig. 33). This unit pumps the washer liquid to the spray nozzles where it is dispersed across the windshield.

8.2 WIPER ARM

Check operation of the wipers for proper blade sweep and angle.

Caution: *Do not attempt to manually move the wiper arms to make wiper blade sweep adjustments as damage to the wiper linkage or motor may occur. If it is necessary to adjust the sweep of blades, remove the arms and make adjustment by positioning the arms using serration on the wiper arm pivot shafts.*

8.2.1 Wiper Arms Positioning

1. Reinstall the wiper arms and position as shown in figure 36. Before positioning the wipers at their final position, tighten the nuts to 9 Ft-lbs (12 Nm) at first.
2. To find the final position of the wiper arms, lift then release the wiper arm so if falls back on the windshield

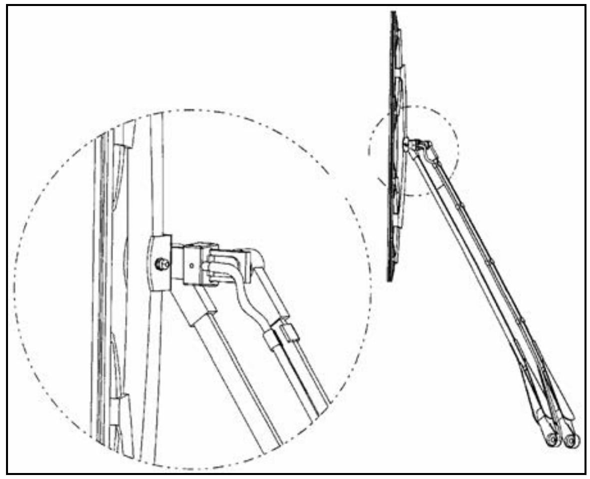


FIGURE 34: WINDSHIELD WIPER (MOTOR SIDE) 23335

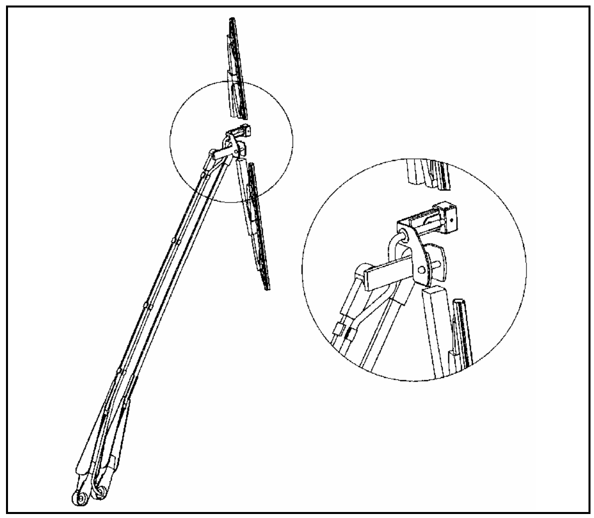


FIGURE 35: WINDSHIELD WIPER (DRIVER SIDE) 23334

3. When the final position is found, tighten the wiper arm nuts to 22 Ft-lbs (30 Nm). Wait 30 minutes and tighten again to 22 Ft-lbs.
4. Lower the protective cover.
5. Connect the windshield washer tubing at the base of the wiper arm.
6. Check the adjustment on a wet windshield.

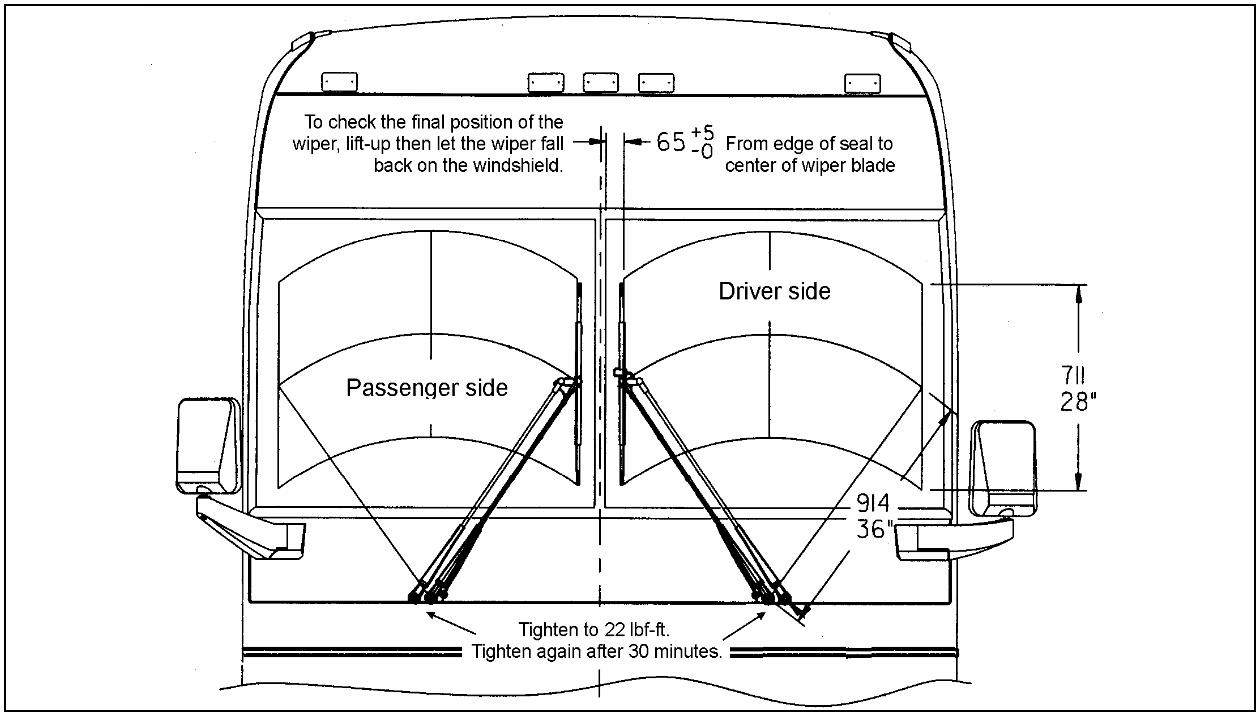


FIGURE 36: WIPER ARMS POSITIONING 23253

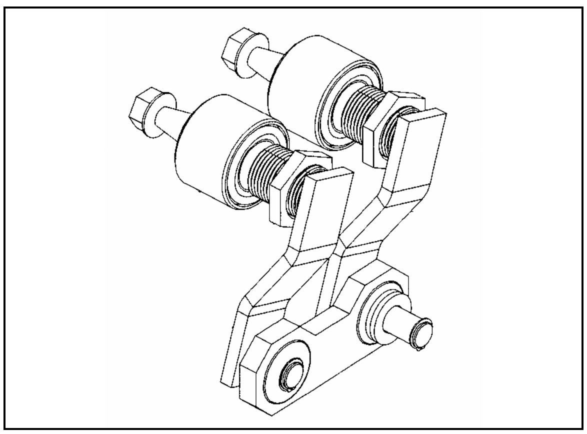


FIGURE 37: DRIVING MECHANISM (DRIVER SIDE) 23334

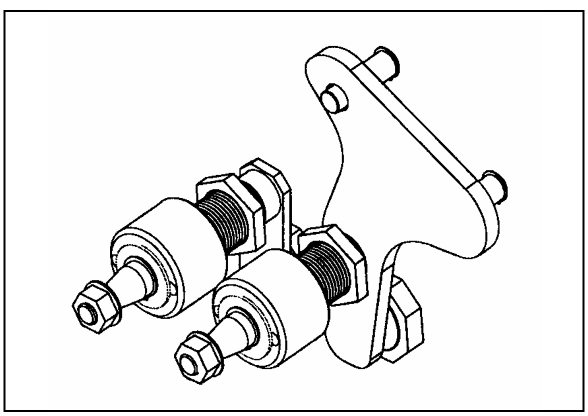


FIGURE 38: DRIVING MECHANISM (MOTOR SIDE) 23254

8.3 WINDSHIELD WIPER MOTOR

8.3.1 Windshield Wiper Motor Replacement

The windshield wiper motor is located at lower front of the vehicle, behind the defroster panel. Refer to figure 31 for motor location.

Warning: *Park vehicle safely, apply parking brake, stop engine and set battery master switch to the ''OFF'' position prior to working on the vehicle.*

1. Remove the Phillips-head screws retaining the defroster panels, and remove panels.
2. Disconnect wiring connector from the windshield wiper motor.
3. Loosen clamping screw retaining the lever at the end of the motor driving shaft.
4. Remove the three bolts holding the motor to the steel plate.
5. Remove the windshield wiper motor (Prévost #800328), reverse removal procedure to reinstall.

8.4 TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
FAIL TO SPRAY WASHER FLUID	A. Reservoir empty. B. If below 32°F (0°C), improper washer fluid frozen. C. Contamination in tubing or nozzles. D. Tubing damage. E. Tubing bent (kinked) or off one or more connections.	A. Add proper fluid. B. Store coach or parts in heated area, then purge system with low-temperature solution. C. Remove with compressed air, if severely clogged, replace items. D. Replace section. E. Realign tubing and/or refit. Trim end to ensure proper fit or replace.
INADEQUATE SPRAYING	A. Tubing failure.	A. Replace tubing.
SLOW OPERATION	A. Improper solution. B. Jet stream improperly directed. C. Check if valve is stuck in the open position.	A. Replace with proper type solution. B. Reposition nozzles. C. Remove, clean or replace.

9. SPECIFICATIONS

AMPLIFIER

Make.. R.E.I.
Model.. AMP-3000
Power source ....24 volts DC Negative ground
Current ....8 Amps maximum
Frequency Response.. 10-30,000 Hz
Output.. 90 watts/channel maximum power
.... 65 watts/channel RMS at 4 ohm @ 0.5 T.H.D.
Signal to noise ratio..86 dB
Supplier number.. 700771
Prévost number.. 901056

AM/FM RADIO CASSETTE PLAYER

Make.. Panasonic
Model.. CQ-R145CAHH
Power source ....12 volts
Supplier number.. 700760
Prévost number.. 901032

8 DISC CD CHANGER

Make.. R.E.I.
Supplier number.. 700739
Prévost number.. 901057

AM/FM RADIO CD PLAYER

Make.. Panasonic
Model.. CP-DP101U
Power source ....12 volts
Supplier number.. 700788
Prévost number.. 901053

SPEAKER

Make.. Robert Bosch
Max. power..90 watts
RMS power ....40 watts
Freq. response.. 45 Hz - 24 kHz
Sensitivity ....92 dB
Impedance .... 4 ohms
Supplier number.. RPSPKR54
Prévost number.. 900765

CONTROL HEAD

Make.. R.E.I.
Model.. C-2000
Supplier number.. 700227
Prévost number.. 900803

VIDEO CASSETTE PLAYER (VCP)

Make.. R.E.I.
Model.. V-3000
Supplier number.. 700749
Prévost number.. 901030

BOOM-TYPE MICROPHONE
Make........ R.E.I.
Supplier number........ 480076BK
Prévost number........ 900763

HANDHELD PRIORITY MICROPHONE
Make........ R.E.I.
Supplier number........ 480015
Prévost number........ 900808

RUBBER COATED MICROPHONE
Make........ R.E.I.
Supplier number........ 480228
Prévost number........ 900745

16 CHANNEL WIRELESS MICROPHONE
Make........ R.E.I.
Supplier number........ 700598
Prévost number........ 900954

16 CHANNEL WIRELESS MICROPHONE CHARGING STATION
Make........ R.E.I.
Supplier number........ 700532
Prévost number........ 900953

16 CHANNEL WIRELESS MICROPHONE RECEIVER
Make........ R.E.I.
Supplier number........ 700599
Prévost number........ 900952

TV TUNER
Make........ R.E.I.
Power source........ 24V
Supplier number........ 700471
Prévost number........ 900814

KARAOKE
Make........ Panasonic
Model........ MOBILE DVD PLAYER DV1500
Supplier number........ 700761
Prévost number........ 901033

TV MONITOR
Make........ R.E.I.
Power source........ 24V
Supplier number........ 700800
Prévost number........ 901070

HUBODOMETER (US model: miles)
Make........ Stemco
Supplier number........ 650-0593
Prévost number........ 650002

HUBODOMETER (Canada model: km)

Make....................Stemco
Supplier number....................650-0025
Prévost number....................650117

ELECTRIC DESTINATION SIGN (FLUORESCENT TUBE)

Make.................... General Electric
Length .... 30" (76 cm)
Outside diameter.................... 1" (25 mm)
Wattage....................20
Color....................Cool white
Quantity....................1
Supplier number....................F30T8 CW4
Prévost number....................830120

ELECTRONIC DESTINATION SIGN

Make....................Pocatec
Supplier number....................9000230
Prévost number....................940050

LAVATORY VENTILATION FAN MOTOR

Make....................Aurora
Type RG500EF
Voltage .... 24 volts DC
Rotation....................R.H.
Supplier number....................131.40.50
Prévost number....................870844

LAVATORY FLUORESCENT TUBES

Make.................... General Electric
Model....................F15T8CW
Length .... 18" (45 cm)
Wattage....................15
Quantity....................2
Prévost number....................830102

EMERGENCY BUZZER SWITCH (PUSH BUTTON)

Make.................... Cole Hersee Co.
Voltage ....24 V
Supplier number....................40224
Prévost number....................562117

FRESH WATER TANK

Make....................Prévost
Capacity .... 18 US gal (68 liters)
Prévost number....................401591

FLUSH PUSH BUTTON PNEUMATIC TIMER
Make...Furnas
Type ...Resettable
Time ... 0,2 to 180 seconds
Supplier number...55-AA
Prévost number...900348

FLUSH PUMP
Make... RULE 2000
Model number ... 12 - 24 V
Power source ... 24 volts DC
Capacity ...1450 GPH
Prévost number...900960

AIR HORN
Make... Allied Signal Inc.
Supplier number...101493
Prévost number...640093

AIR HORN VALVE
Make... Allied Signal Inc.
Supplier number...228672
Prévost number...640128

WINDSHIELD WIPER MOTOR
Make...BOSCH
Supplier number...0390442401
Prévost number...800328

WIPER (BLADE)
Make...BOSCH
Supplier number...3398110095
Prévost number...800329

WIPER ARM
Make...BOSCH
Supplier number... 6002UWA060
Prévost number...800331

SECTION 24: LUBRICATION

CONTENTS

ILLUSTRATIONS

1. LUBRICATION

The efficiency and life expectancy of mechanical equipment is largely dependent upon proper lubrication and servicing. All mechanical components rely on a lubricating film between moving parts to reduce friction, prevent wear and oxidation. Proper lubrication also helps cool the parts and keep dirt particles away from mating surfaces. Efficient lubrication depends upon using the right type of lubricant, at specified intervals and by filling to correct capacities. Past experience shows that many service problems can be traced to an improper lubricant or to incorrect lubrication procedures.

A comprehensive maintenance and lubrication program is important to ensure the long service life this vehicle was designed for and to avoid costly repairs and associated downtime caused by premature part failure.

A lubrication schedule is included in this section to give the location of key service points on the vehicle as well as the lubricant specifications for each component to be serviced. Specific instructions on how to check and service different components are covered in their respective sections in this maintenance manual.

The recommended lubrication intervals are based on normal operating conditions and mileage accumulation.

Shorten the intervals if your vehicle operates in more severe conditions. Severe conditions include heavy towing, high vehicle weight or operation in mountainous areas. Some parts and equipment referred to in this section may not be installed on your vehicle. Check your vehicle's "Coach Final Record" for equipment list.

Dispose of used lubricants and filters in an environmentally safe manner, according to federal and/or local recommendations.

1.1 FIRST SERVICE ON NEW VEHICLE

Perform the following maintenance procedures after the first 3,000 miles (5 000 km) of operation (unless otherwise specified). Once initial maintenance is performed, refer to recommended intervals in the lubrication schedule.

Repeat a component's initial maintenance procedure when it has undergone a major repair.

1.1.1 Differential

Factory-filled oil in differential on new vehicle should be replaced after 3,000 miles (5 000 km) of initial operation or after major servicing.

1.1.2 Coolant Strainer

The coolant strainer is designed to recover the soldering residues trapped inside the coolant lines during their initial assembly; perform initial cleaning once vehicle has run approximately 3,000 miles (5 000 km), then according to the lubrication and servicing schedule.

Note: *If additional soldering has been performed on any point of coolant piping, clean coolant system strainer as outlined for a new vehicle at 3,000 miles (5 000 km).*

1.1.3 Allison World Automatic Transmission

Change oil and filter cartridges after first 5,000 miles (8,000 km) of initial operation, then according to the lubrication and servicing schedule.

1.1.4 ZF-ASTRONICTransmission

No initial oil or filter change necessary. Refer to regular lubrication and servicing schedule.

1.1.5 Engine

Since engine break-in has been done in factory, there is no special break-in, so oil should be changed according to the lubrication and servicing schedule intervals. Since some oil consumption by engine is normal, check oil level daily with engine stopped and add to FULL mark on dipstick if necessary. Furthermore, the engine oil filter should be replaced each time the engine oil is changed.

2. LUBRICATION AND SERVICE SCHEDULE

Following this service schedule is the most economical and easiest way to ensure your vehicle performs at its best, safest and longest. Also, unscheduled maintenance will be minimized since inspection should expose potential problems before they become major ones.

2.1 ENGINE OIL CHANGE INTERVALS

The engine oil change intervals are related to the operating conditions, such as vehicle load, speed, etc., and may vary. It is recommended however, that the oil change be performed after every 12,500 miles (20 000 km).

The drain intervals may then be gradually increased or decreased with experience on a specific lubricant, considering the recommendations of the oil supplier (analysis of drained oil can be helpful), until the most practical service condition has been established.

Solvents should not be used as flushing oils. Dilution of the fresh refill oil supply can occur, which may be detrimental for the engine.

Engine oil temperature should be checked every 25,000 miles (40 000 km) to determine oil cooler efficiency. This check should be made by inserting a steel jacketed thermometer in the dipstick opening, immediately after stopping a hot, loaded engine. If the oil temperature exceeds the coolant temperature by more than 60 °F (33 °C), the oil cooler may be clogged.

For detailed oil specifications, refer to *"Detroit Diesel Series 60 Service Manual"* under heading *"Lubricating Oil for Detroit Diesel Engines"*.

2.1.1 Engine Oil Reserve Tank

An oil reserve tank with a capacity of 8.4 US quarts (8,0 liters) (optional) is connected to the crankcase by a hose with a shutoff valve, allowing oil to be added to crankcase by opening valve. Comparison of oil levels in sight gauge, before and after adding oil to crankcase, shows approximately how much oil has been added.

Filling of this tank can be made by opening the rear engine doors. The tank is mounted on R.H. side of engine compartment, over the A/C compressor.

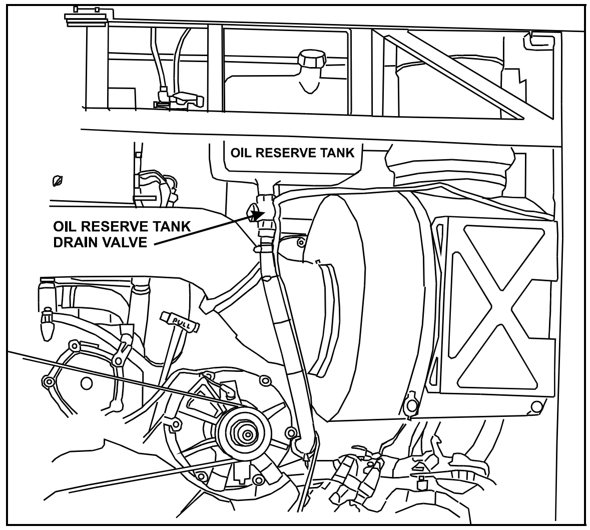


FIGURE 1: ENGINE OIL RESERVE TANK 01063

2.2 COLD WEATHER OPERATION

The proper selection of the engine oil grade will ease cold weather starting (refer to the lubrication and servicing schedule for the engine oil grade recommendation). Other practical considerations, such as the use of batteries, cables and connectors of adequate size, proper setting of voltage regulator, ether starting aid, oil and coolant heater systems, and proper fuel selection will ease cold weather starting.

2.3 FLEXIBLE HOSE MAINTENANCE

The performance of engine and equipment are greatly related to the ability of flexible hoses to supply lubricating oil, air, coolant, and fuel oil. Maintenance of hoses is an important step to ensure efficient, economical, and safe operation of the engine and related equipment.

2.3.1 Pre-Starting Inspection

Check hoses daily as part of the pre-starting inspection. Examine hose for leaks, and check all fittings, clamps, and ties carefully. Ensure that hoses are not resting on or touching shafts, couplings, heated surfaces including exhaust manifolds, any sharp edges, or other obviously damaging areas. Since all machinery vibrates and moves to a certain extent, clamps and ties can fatigue with time. To ensure proper support, inspect fasteners frequently and tighten or replace them as necessary.

2.3.2 Leaks

Investigate leaks immediately to determine if fittings have loosened or cracked, and also if hoses have ruptured or worn through. Take corrective action immediately. Leaks are not only potentially detrimental to machine operation, but can also result in added expenses caused by the need to replace lost fluids.

Caution: *Personal injury and/or property damage may result from fire due to the leakage of flammable fluids, such as fuel or lube oil.*

2.3.3 Service life

The limited service life of a hose is determined by the temperature and pressure of the gas or fluid within it, the time in service, its installation, the ambient temperatures, amount of flexing, and the vibration it is subjected to. With this in mind, it is recommended that all hoses be thoroughly inspected at least every 500 operating hours or after 15,000 miles (24 000 km). Look for surface damage or indications of damaged, twisted, worn, crimped, brittle, cracked, or leaking lines. Hoses having a worn outer surface or hoses with a damaged metal reinforcement should be considered unfit for further service.

It is also recommended that all hoses in this vehicle be replaced during major overhaul and/or after a maximum of five service years. Quality of replacement hose assemblies should always be equal to or superior to those supplied by the Original Equipment Manufacturer.

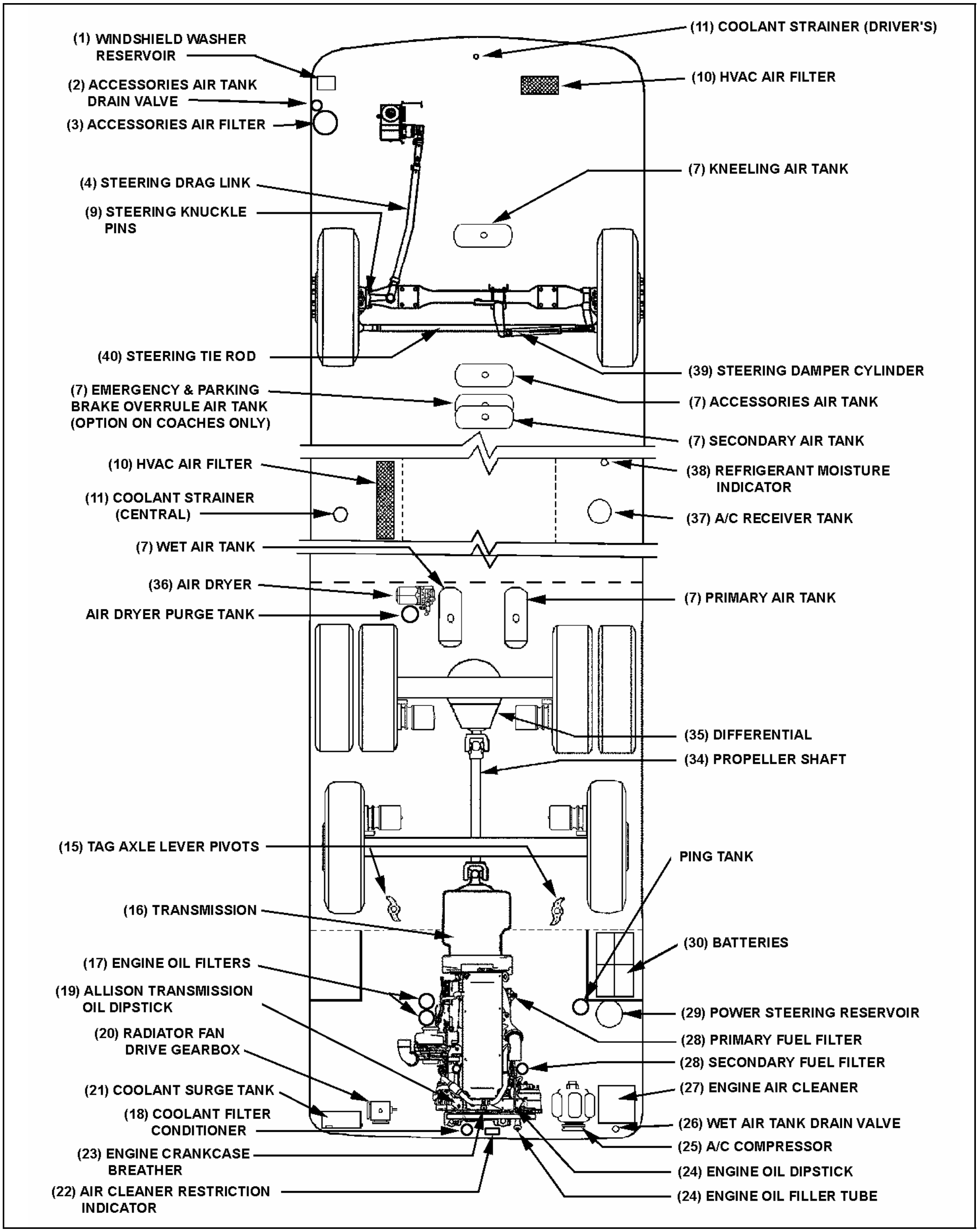


FIGURE 2: LUBRICATION AND SERVICING POINTS ON I-BEAM FRONT SUSPENSION VEHICLES 24023

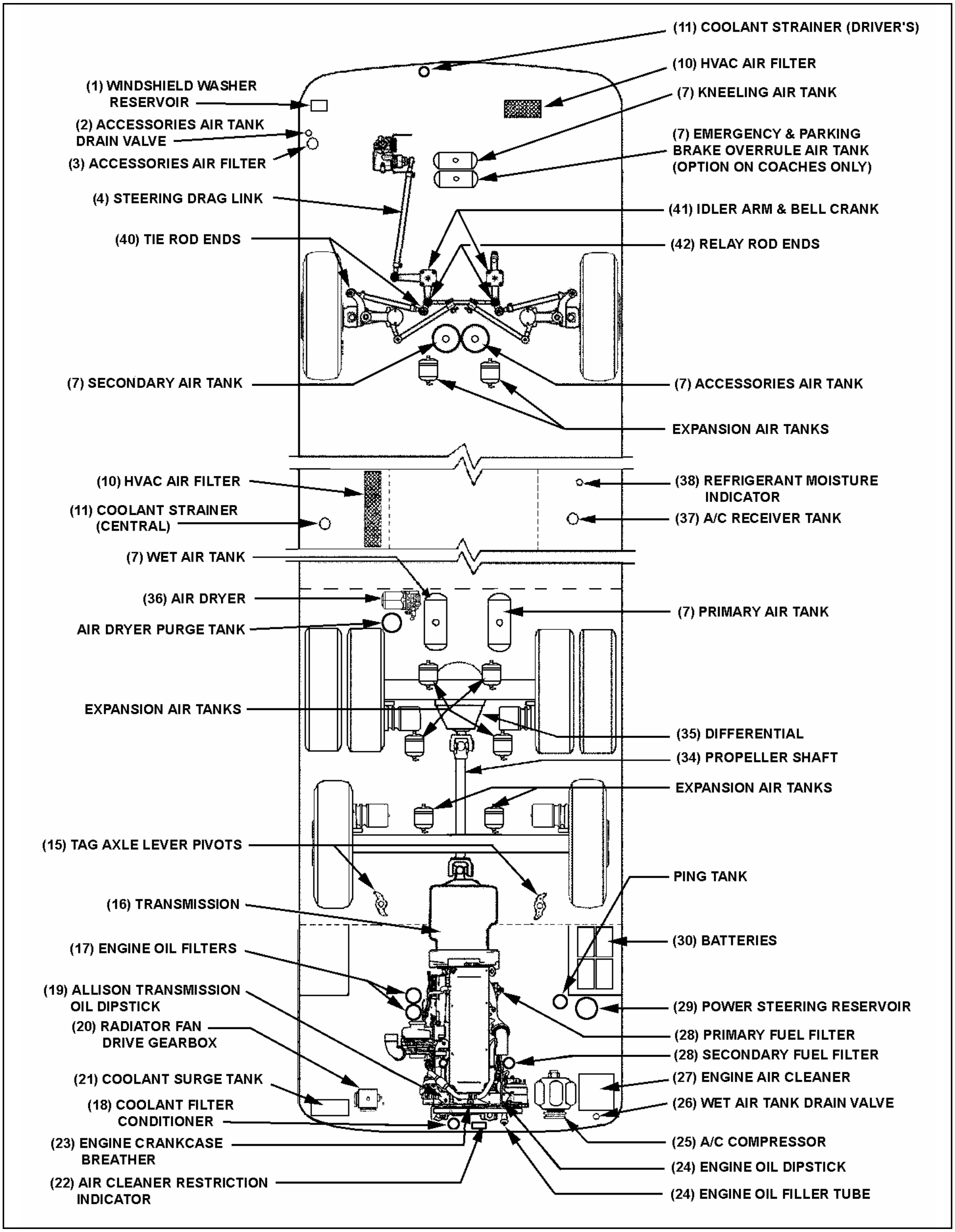


FIGURE 3: LUBRICATION AND SERVICING POINTS ON INDEPENDENT FRONT SUSPENSION VEHICLES 24024

2.4 WALK-AROUND INSPECTION

It is good practice to make a basic visual inspection of key areas on the vehicle every day (or before every trip for private coaches) and to correct any problem found.

OUTSIDE THE VEHICLE	
ITEM*	DESCRIPTION
---	Check for leaks under vehicle and in engine compartment.
---	Check that baggage and service compartment doors close properly.
---	Inspect tires and wheels for correct tire pressure, wear or damage and for missing wheel studs and nuts.
1	Check windshield washer fluid level and add if necessary.
---	Check condition of windshield wiper blades.
---	Verify proper operation of all road lights, signal lights, brake lights, marker lights and back-up lights; Replace light bulbs as required.
2, 26	Drain accumulated water in accessory and wet air tanks.

ENGINE COMPARTMENT	
ITEM*	DESCRIPTION
24	Check engine crankcase oil level; Add if necessary.
19	Check Allison transmission oil level (can be checked from push-button shift selector); Add if necessary.
29	Check power steering reservoir fluid level; Add if necessary.
21	Check coolant surge tank fluid level; Add if necessary.
28	Drain accumulated water in primary fuel filter/water separator (if equipped). Visually check fuel filter cartridge (Fuel-Pro 382 equipped vehicles only).
22, 27	Check air cleaner restriction indicator; Replace air cleaner when red signals locks in full view.

INSIDE THE VEHICLE	
ITEM*	DESCRIPTION
---	Check for proper operation of the entrance door.
---	Check that emergency exit windows and roof escape hatches can be opened, then close all windows and hatches securely.
---	Verify proper operation of windshield wiper/washer.
---	Adjust and clean mirrors as needed for adequate rear-view vision.
---	Start engine and check for proper operation of all gauges and indicator lights.
---	Check for proper operation of electric and air horns and back-up alarm.
---	Perform a brake test. Check both primary and secondary pressure gauges.

* Item numbers refer to figures 2 and 3.

2.5 LUBRICATION AND SERVICING SCHEDULE

2.6 LUBRICANT AND COOLANT SPECIFICATIONS

ITEM*	DESCRIPTION	SPECIFICATIONS
24	Engine Oil	SAE Viscosity Grade: 15W40 API Classification: CI-4
29	Power Steering Oil	Automatic Transmission Oil (Dexron-IIE or Dexron-III)
18, 21	Engine Coolant	Low silicate, ethylene glycol coolant 50% antifreeze/water solution is normally used Antifreeze concentration should be between 30% and 67%
25	A/C Compressor Oil	Polyolester Oil, HFC 134a compatible: Castrol SW-68 (POE) or equivalent
35	Differential Oil	Multigrade gear oil meeting MIL-L-2105-D: 85W/140. If temperature drops below 10°F (-12°C), 80W90 should be used. Below -15°F (-26°C), 75W90 should be used. (In extreme conditions or for better performance, full synthetic gear oil can be used.)
20	Fan Gearbox Oil	Synthetic oil: Mobil SHC 630
19	Allison Automatic Transmission Oil	Dexron-IIE, Dexron-III or TranSynd
19	ZF-ASTronic Transmission Oil	Castrol Syntrans Grade SAE 75W-85 (Synthetic)
---	Multi Purpose Grease	Good quality lithium-base grease: NLGI No.2 Grade is suitable for most temperatures NLGI No.1 Grade is suitable for extremely low temperatures

* Item numbers refer to figures 2 and 3.

2.7 PART NUMBER SPECIFICATIONS

ITEM*	DESCRIPTION	PRÉVOST NO
17	Engine Oil Filters	#510458
29	Power Steering Reservoir Oil Filter	#660528
27	Engine Air Cleaner Filter	#530197
38	Refrigerant Filter Dryer Unit	#950262
28	Engine Primary Fuel Filter	#510137
28	Engine Primary Fuel Filter With Water Separator (Optional)	#531407
28	Engine Secondary Fuel Filter	#510128
28	Secondary “Racor” Fuel Filter	#531390
18	Engine Coolant Precharge Unit	#550629
18	Engine Coolant Filter/Conditioner	#550630
10	A/C And Heating Driver's Air Filter	#871147--871144
10	A/C And Heating Cabin's Air Filter	#871051
16	Allison World (WT) Automatic Transmission Oil Filter Kit	#571709
11	Coolant Strainer	#871029
3	Accessories Air Filter	#641340
36	Air Dryer Cartridge	#641244
---	Alternator drive belt, 85-1/2 in. (2 alternators)	#5060055
---	Alternator drive belt, 72 in. (1 alternator, limp home)	#5060056
---	Fan gearbox drive belt	#506688
---	Compressor drive belt BX100	#506864
---	Windshield wiper blade	#800329

* Item numbers refer to figures 2 and 3.

LUBRICATION AND SERVICING SCHEDULE	Item	Months	DISTANCE TRAVELED[1] (miles/km)																																LUBRICANT &/OR PART[2]
			6 250 / 10 000	12 500 / 20 000	18 750 / 30 000	25 000 / 40 000	31 250 / 50 000	37 500 / 60 000	43 750 / 70 000	50 000 / 80 000	56 250 / 90 000	62 500 / 100 000	68 750 / 110 000	75 000 / 120 000	81 250 / 130 000	87 500 / 140 000	93 750 / 150 000	100 000 / 160 000	106 250 / 170 000	112 500 / 180 000	118 750 / 190 000	125 000 / 200 000	131 250 / 210 000	137 500 / 220 000	143 750 / 230 000	150 000 / 240 000	156250 / 250 000	162 500 / 260 000	168 750 / 270 000	175 000 / 280 000	181 250 / 290 000	187 500 / 300 000	193 750 / 310 000	200 000 / 320 000	
GENERAL																																			
Flexible hoses, thoroughly inspect all hoses	-	12																																	-------
Front discharge tube, qty:2, check to see if clogged [3]	-	3																																	-------
01 ENGINE																																			
Air cleaner, inspect, clean, replace element if required	27	6																																	Filter #530197
Engine, change oil and filters. Oil SAE 15W40, API CI-4	17	12																																	Filter #510458
Engine crankcase breather, clean breather steel mesh	23	12																																	-------
03 FUEL																																			
Change primary & secondary fuel filters, fill with clean fuel before installation	28	12																																	Primary #510137 ; prim. w/sep #531390 ; secondary #510128
05 COOLING																																			
Radiator fan drive gearbox,check oil level, add if necessary	20	6																																	Mobil SHC 630 #180217
Radiator fan drive gearbox, change oil	20	12																																	Mobil SHC 630 #180217
Coolant filter/Conditioner, replace element	18	12																																	Filter #550630
Coolant surge tank, test coolant solution	21	12																																	-------
Cooling system, drain, flush and refill	18/ 21	24																																	Engine coolant
06 ELECTRICAL																																			
Battery terminals, clean and coat terminals	30	12																																	Battery terminal coating

[1] Proceed to maintenance operation at distance indicated on odometer or specified number of month, whichever comes first.
[2] See paragraph 2.5 & 2.6 of this section for lubricant and part number specifications.
[3] Discharge tubes are rubber tubes located under vehicle

LUBRICATION AND SERVICING SCHEDULE	Item	Months	DISTANCE TRAVELED[1] (miles/km)																																LUBRICANT &/OR PART[2]
			6 250 / 10 000	12 500 / 20 000	18 750 / 30 000	25 000 / 40 000	31 250 / 50 000	37 500 / 60 000	43 750 / 70 000	50 000 / 80 000	56 250 / 90 000	62 500 / 100 000	68 750 / 110 000	75 000 / 120 000	81 250 / 130 000	87 500 / 140 000	93 750 / 150 000	100 000 / 160 000	106 250 / 170 000	112 500 / 180 000	118 750 / 190 000	125 000 / 200 000	131 250 / 210 000	137 500 / 220 000	143 750 / 230 000	150 000 / 240 000	156250 / 250 000	162 500 / 260 000	168 750 / 270 000	175 000 / 280 000	181 250 / 290 000	187 500 / 300 000	193 750 / 310 000	200 000 / 320 000	
07 TRANSMISSION																																			
Allison World Automatic transmission, change oil (standard oil) and filters	16	12																																	Oil Dexron-IIE or Dexron-III Filters #571709
Allison World Automatic transmission, change oil (only if filled with TranSynd synthetic fluid) and filters [3]	16	12																																	TranSynd Synthetic Fluid; Filters #571709
ZF-Astronic Automatic Transmission, change oil & filter after 185 000 miles (300 000 km)	16	24																																	Castrol Syntrans grade SAE 75W-85
Transmission oil cooler, replace unit if vehicle is equipped with transmission retarder	43	24																																	Prévost #550712
09 PROPELLER SHAFT																																			
Grease one fitting on each universal joint and slip joint	34	6																																	Multipurpose grease
11 REAR AXLE																																			
Differential, check oil level, add if necessary	35	6																																	Multigrade gear oil
Differential, change oil, clean breathers	35	24																																	Multigrade gear oil
Tag axle lever pivot, grease one fitting on each pivot	15	6																																	Multi purpose grease
12 BRAKE & AIR																																			
Air tanks, drain water from all tanks	7	12																																	-------
Accessories air filter, change filter element	3	24																																	Filter element #641340
Air dryer, change cartridge	36	24																																	Cartridge #641244 or 641278

[1] Proceed to maintenance operation at distance indicated on odometer or specified number of month, whichever comes first.
[2] See paragraph 2.5 & 2.6 of this section for lubricant and part number specifications.

[3] When the transmission contains a mixture of fluids (defined as the quantity of non-TranSynd fluid remaining in the transmission after a fluid change combined with the quantity of TranSynd required to fill the transmission to the proper level), perform the fluid and filter change at 25 000 miles (40 200km) or 1 year, whichever comes first.

LUBRICATION AND SERVICING SCHEDULE	Item	Months	DISTANCE TRAVELED[1] (miles/km)																																LUBRICANT &/OR PART[2]
			6 250 / 10 000	12 500 / 20 000	18 750 / 30 000	25 000 / 40 000	31 250 / 50 000	37 500 / 60 000	43 750 / 70 000	50 000 / 80 000	56 250 / 90 000	62 500 / 100 000	68 750 / 110 000	75 000 / 120 000	81 250 / 130 000	87 500 / 140 000	93 750 / 150 000	100 000 / 160 000	106 250 / 170 000	112 500 / 180 000	118 750 / 190 000	125 000 / 200 000	131 250 / 210 000	137 500 / 220 000	143 750 / 230 000	150 000 / 240 000	156250 / 250 000	162 500 / 260 000	168 750 / 270 000	175 000 / 280 000	181 250 / 290 000	187 500 / 300 000	193 750 / 310 000	200 000 / 320 000	
14 STEERING																																			
Drag link ends, grease one fitting at each end	4	6																																	Multi purpose grease
Relay rod ends, grease one fitting at each end	36	6																																	Multi purpose grease
Steering tie rod ends, grease one fitting at each end	40	6																																	Multi purpose grease
Idler arm, grease fitting	41	6																																	Multi purpose grease
Bell crank, grease fitting	41	6																																	Multi purpose grease
Steering damper cylinder, grease one fitting at rod end	39	6																																	Multi purpose grease
Steering knuckle pins, grease two fittings per knuckle	9	6																																	Multi purpose grease
Power steering reservoir, replace oil and filter cartridges	29	12																																	Cartridge #660987
16 SUSPENSION																																			
Upper A-Arm Ball Joint, grease fitting	42	6																																	Molykote longterm 2/78 grease (preferably) or lithium NLGI no2 or no1
22 HEATING & AIR CONDITIONING																																			
A/C compressor, check oil level, add if necessary	25	6																																	Polyolester oil
A/C receiver tank, check refrigerant level, add if necessary	37	6																																	HFC 134A
Refrigerant moisture indicator, replace filter dryer unit according to moisture indicator (as needed)	38	6																																	Filter #950262
A/C and Heating air filters, clean or replace all elements	10	6																																	Driver #871147 , passenger #871051
Coolant strainer, check, clean, change cartridge if required	11	12																																	Cartridge #871029
Condenser discharge tube, qty:2, check to see if clogged [3]	-	3																																	-------
Evaporator discharge tube, qty:6, check to see if clogged [3]	-	3																																	-------

[1] Proceed to maintenance operation at distance indicated on odometer or specified number of month, whichever comes first.
[2] See paragraph 2.5 & 2.6 of this section for lubricant and part number specifications.
[3] Discharge tubes are rubber tubes located under vehicle