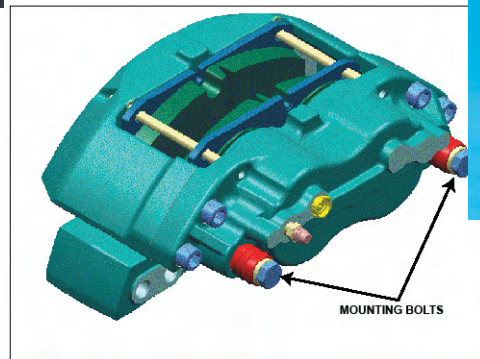
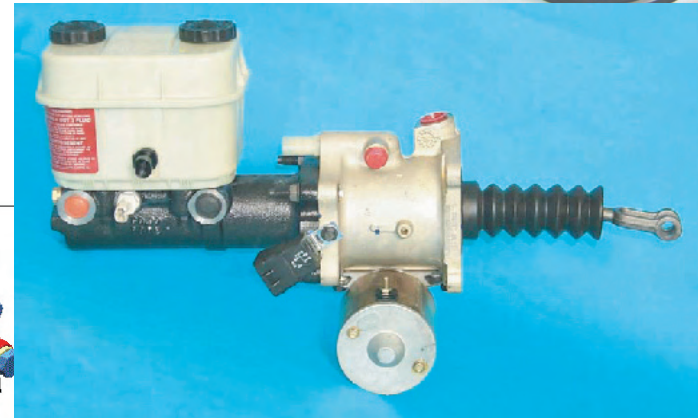
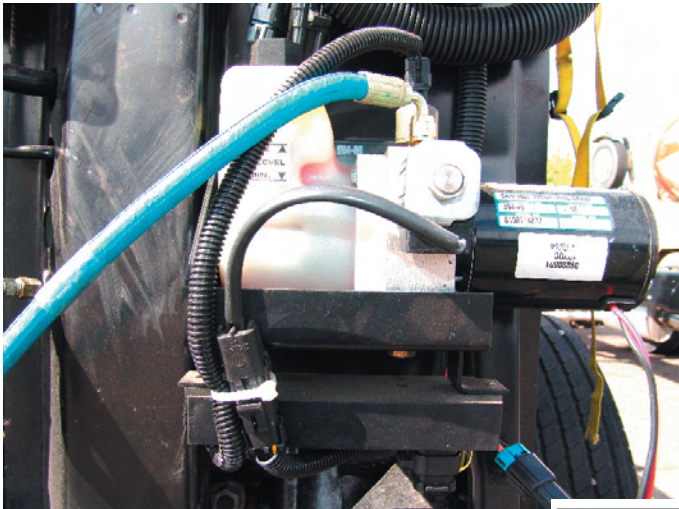


## 2006 BRAKE SYSTEMS



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## FASTENER TIGHTENING SPECIFICATIONS

Description	English	Metric
ABS sensor bolt (Bosch ZOH-T Caliper)	12-16 lb ft	17-21 N·m
ABS sensor bolt (Meritor Quadraulic Caliper)	124 lb in	14 N·m
Anchor Plate Bolt Plug (Bosch ZOH-T Caliper)	16-27 lb ft	22-37 N·m
Banjo bolt (Meritor Quadraulic Caliper)	35 lb ft	47 N·m
Bleed screw (Brembo 52mm Caliper)	124 lb in	14 N·m
Bleed screw (Brembo 68mm Caliper)	177 lb in	20 N·m
Bleed screw (Bosch ZOH-T Caliper)	150 lb in	17 N·m
Bleed screw (Meritor Quadraulic Caliper)	97 lb in	11 N·m
Brake hose fitting (Brembo 52mm Caliper)	164 lb in	18.5 N·m
Brake hose fitting (Brembo 68mm Caliper)	212 lb in	24 N·m
Brake hose fitting (Bosch ZOH-T Caliper)	168 lb in	19 N·m
Brake hose fitting (Meritor Quadraulic Caliper)	350 lb ft	475 N·m
Brake hose hold down clamp bolt (Bosch ZOH-T Caliper)	13 lb ft	17 N·m
Brake hose hold down clamp bolt (Meritor Quadraulic Caliper)	124 lb in	14 N·m
Brake pad retainer spring bolt (Meritor Quadraulic Caliper)	30 lb ft	41 N·m
Brake shield bolts (Brembo 52mm Caliper)	19 lb ft	25 N·m
Brake shield bolts (Brembo 68mm Caliper)	19 lb ft	25 N·m
Brake shield bolts ((Bosch ZOH-T Caliper)	19 lb ft	26 N·m
Brake shield bolts (Meritor Quadraulic Caliper)	lb ft	N·m
Caliper to caliper mounting bracket bolts (Brembo 52mm Caliper)	25 lb ft	34 N·m

Description	English	Metric
Caliper to caliper mounting bracket bolts (Brembo 68mm Caliper)	115 lb ft	84 N·m
Caliper to caliper mounting bracket bolts (Bosch ZOH-T Caliper)	93-107 lb ft	126-145 N·m
Caliper to caliper mounting bracket bolts (Meritor Quadraulic Caliper)	225 lb ft	305 N·m
Caliper mounting bracket to steering knuckle bolts (Brembo 52mm Caliper)	127 lb ft	172 N·m
Caliper mounting bracket to steering knuckle bolts (Brembo 68mm Caliper)	159 lb ft	215 N·m
Caliper mounting bracket to steering knuckle bolts (Bosch ZOH-T Caliper)	206 lb ft	280 N·m
Caliper mounting bracket to steering knuckle bolts (Meritor Quadraulic Caliper – 5/8-inch, 18 bolt)	225 lb ft	305 N·m
Caliper mounting bracket to steering knuckle bolts (Meritor Quadraulic Caliper – 9/16-inch, 18 bolt)	150 lb ft	203 N·m
Cross over tube nuts (Meritor Quadraulic Caliper)	124 lb in	14 N·m
Lining rail Covers (Meritor Quadraulic Caliper)	195 lb in	22 N·m
Rotor to hub bolts (Brembo 52mm Caliper)	140 lb ft	190 N·m
Rotor to hub bolts (Brembo 68mm Caliper)	130 lb ft	176 N·m
Rotor to hub bolts (Bosch ZOH-T Caliper, 9/16-inch OD – 10 bolt pattern)	112 lb ft	152 N·m
Rotor to hub bolts (Bosch ZOH-T Caliper, 9/16-inch OD – 10 bolt pattern)	189 lb ft	256 N·m
Rotor to hub bolts (Meritor Quadraulic Caliper – 5/8-inch, 5 bolt)	110 lb ft	149 N·m
Rotor to hub bolts (Meritor Quadraulic Caliper – 9/16-inch, 18 bolt, with lock nuts)	90 lb ft	122 N·m

Description	English	Metric
Rotor to hub bolts (Meritor Quadraulic Caliper – 9/16-inch, 18 bolt, with plain nuts)	150 lb ft	203 N·m
Splash Shield (Bosch ZOH-T Caliper)	12-16 lb ft	17-21 N·m
Support key bolt (Bosch ZOH-T Caliper)	15 lb ft	20 N·m

## BRAKE SYSTEM SPECIFICATIONS

Description	English	Metric
Brake Pad minimum thickness above metal – discard (Brembo 52mm Caliper)	.125 in	3.175mm
Brake Pad minimum thickness above metal – discard (Brembo 68mm Caliper)	.125 in	3.175mm
Brake Pad minimum thickness above metal – discard (Bosch ZOH-T Caliper)	.125 in	3.175mm
Brake Pad minimum thickness above metal – discard (Meritor Quadraulic Caliper)	.125 in	3.175mm
Brake fluid	DOT 3	
Rotor diameter (Brembo 52mm Caliper)	12.25 in	307mm
Rotor diameter (Brembo 68mm Caliper)	12.88 in	322mm
Rotor diameter (Bosch ZOH-T Caliper)	14.28 in	357mm
Rotor diameter (Meritor Quadraulic Caliper)	15.38 in	390.7mm
Rotor thickness – discard (Brembo 52mm Caliper)	Refer to Marking on Rotor	
Rotor thickness – discard (Brembo 68mm Caliper)	Refer to Marking on Rotor	
Rotor thickness – discard (Bosch ZOH-T Caliper)	Refer to Marking on Rotor	
Rotor thickness – discard (Meritor Quadraulic Caliper)	Refer to Marking on Rotor	

## BRAKE LATHE SPECIFICATIONS (AMMCO)

Data	Rough Cut	Finish Cut
Spindle Speed	150 RPM	150 RPM
Depth of Cut (per side)	0.127 mm (0.005 in)	0.051 mm (0.002 in)
Total Cross Feed (per revolution)	0.152 – 0.254 mm (0.006 – 0.01 in)	0.051 mm max. (0.002 in)
Vibration Dampener	Yes	Yes
Swirl Pattern 120 Grit	No	Yes

## BRAKE LATHE SPECIFICATIONS (ACCU-TURN)

Data	Cut Information
Spindle Speed	150 RPM
Tool Cross Feed (per revolution)	0.076 mm (0.003 in)
Tool Bit Nose Radius	0.396 mm (0.003 in)
Vibration Dampener	Yes
Swirl Pattern 120 Grit	Yes

## INTRODUCTION

### OBJECTIVES OF THIS SECTION

This section is intended to provide information regarding the hydraulic brake system components. This is specific to the W-Series Workhorse Chassis.

Explanations for most components will include purpose, function, operation, and location. Guidance for proper and safe disassembly, inspection, repair, and assembly are provided.

### DESCRIPTION AND OPERATION

There are three brake systems on a Workhorse motor home chassis:

- Service Brake System
- Antilock Brake System (ABS)
- Park Brake System

## SERVICE BRAKE SYSTEM DESCRIPTION

The service brakes are the primary brake system for the chassis. The system uses hydraulic pressure from a foot-pedal operated master cylinder to actuate cylinders that apply the brake pads to the braking surfaces on the brake rotors. The amount of hydraulic pressure in the system (applied by the driver) determines how much pressure is applied to the brake pads on the brake rotors.

Hydraulic pressure created by the master cylinder operation is transmitted through brake lines and hoses to the wheel cylinders and calipers. The hydraulic pressure forces the pistons in the wheel cylinders and/or calipers outward, causing the brakes to be applied.

Braking action occurs as a result of friction between the brake lining and the metal surface of the rotor disc. Brake power is generated when the friction material that has been displaced on the rotor bonds itself to the friction material on the pads. After bonding has occurred, the rotation of the wheel will cause the bond to break apart or shear. This cycle of bonding and shearing is how the brakes stop the vehicle.



## SERVICE BRAKE SYSTEM COMPONENTS

The hydraulic brake system is made up of the following components:

- Master cylinder, reservoir, and fluid level sensor
- Hydraulic brake booster
- Brake rotors
- Brake calipers and pads
- Brake lines and hoses

### Master Cylinder, Reservoir, and Fluid Level Sensor

The W Series chassis uses a Bosch aluminum master cylinder and plastic brake fluid reservoir. The brake fluid reservoir is equipped with a fluid level sensor to alert the driver when the brake fluid level is low.

### Hydraulic Brake Boosters

The W Series chassis use two different styles of hydraulic brake boosters. Refer to the following table for chassis specific applications.

Chassis Series	Booster Design
W16 / W18	Bosch Hydro-Boost™
W20 / W22 / W24 / W25	Bosch Hydro-Max™
W42	Bosch Hydro-Boost™
W52	Bosch Hydro-Max™

### Hydro-Max™ Hydraulic Brake Booster

The Hydro-Max™ system is utilized on all W20/W22/W24/W25 Series chassis. The hydraulic pressure used to operate the power brake booster is normally supplied by the power steering pump. If fluid flow is not available from the pump, the booster's electric backup pump operates to supply the required braking force.

Hydraulic pressure is monitored when the brake is applied. If hydraulic pressure is not available from the power steering pump (engine is off), the backup pump is activated to provide hydraulic pressure for normal brake operation.

During normal system operation, fluid flow from the power steering pump enters the inlet port of the Hydro-Max™ booster, flows through the power piston, around the throttle valve and through the flow switch, exiting through the outlet port. (Refer to the illustration on the following page.)

Force applied to the brake pedal by the vehicle operator is multiplied by the lever ratio of the pedal mechanism to move the pedal rod of the booster. This movement closes the throttle valve, which restricts flow. This restriction of flow, which results in a pressure increase acting on the power piston, applies an amplified force to the master cylinder primary piston. A reaction piston, inside the power piston subassembly, provides the driver "pedal feel" during an application of the brake pedal. Fluid flow through the flow switch opens the backup pump electrical circuit during normal operation.

A separate check valve in the backup pump prevents back-flow through the pump during normal power applications.

In the event normal flow from the power source is interrupted, the backup pump provides the power at a reduced rate for stopping. Upon flow interruption, the integral flow switch closes, energizing a relay, providing electrical power to the backup pump. During backup operation, the pump re-circulates fluid within the booster assembly with pressure built on demand via the throttle valve. Fluid is retained within the booster by the inlet port check valve.



*Figure 5-1 — Hydro-Max™ Booster and Master Cylinder*

## MASTER CYLINDER

In the released position, (refer to the illustration on the following page.) actuators of both the primary and secondary pistons are in with their respective compensating valve stems, which project into the cylinder bore. This contact tilts the valves to an open position, which allows hydraulic fluid in the reservoir sections to communicate with the primary and secondary pressure chambers. Each pressure chamber has a piston/actuator subassembly containing a preloaded (caged) spring and return spring.

Initial forward travel of the primary piston moves the primary actuator away from its compensating valve, permitting the valve to seat. Closure of this valve shuts off the passage between the primary pressure chamber and the reservoir section serving the primary chamber.

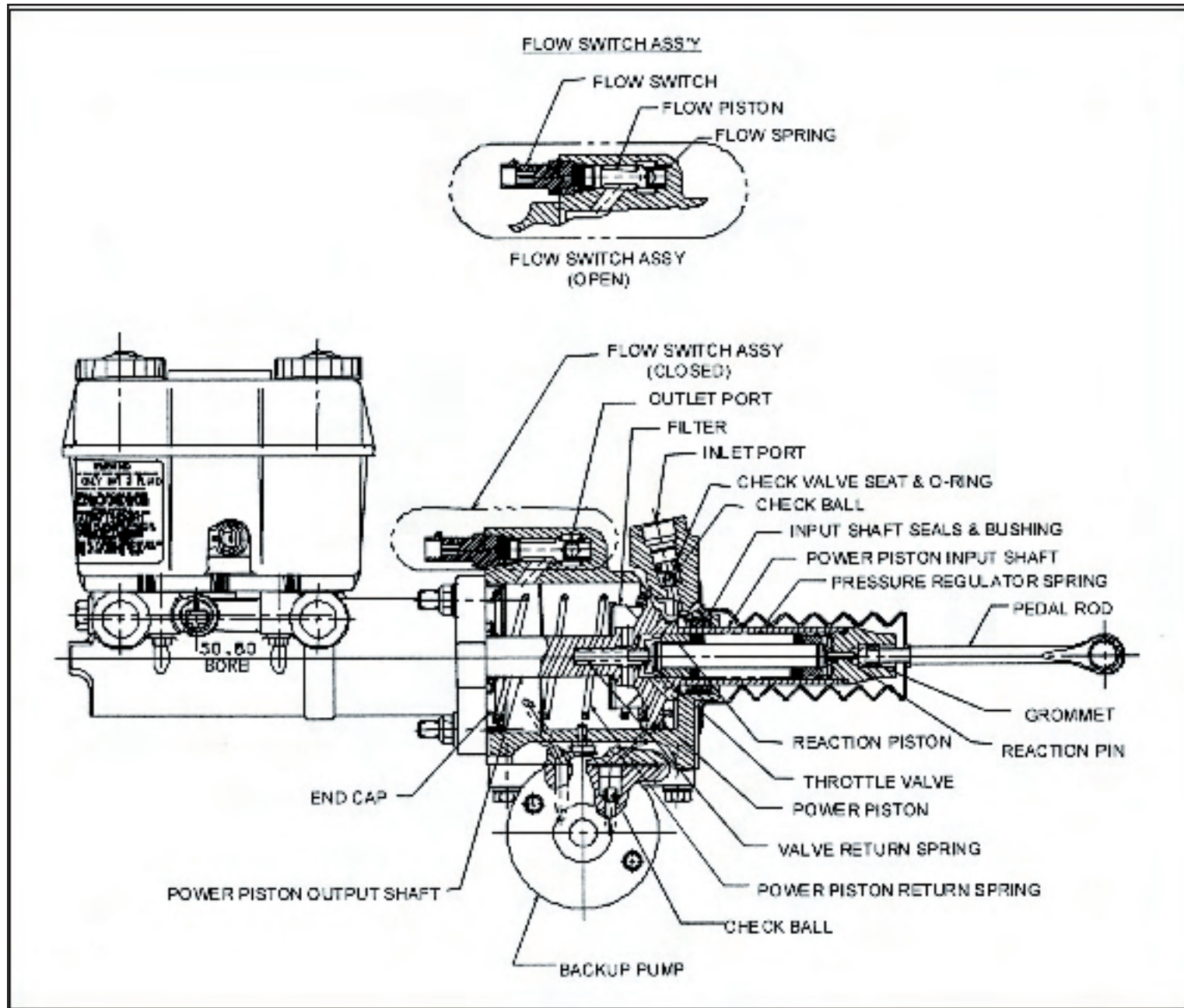


Figure 5-2 — Hydro-Max™ Booster Components

Further movement of the primary piston creates pressure in the primary pressure chamber, causing the secondary piston and actuator to move. As the secondary piston and actuator move, the secondary compensating valve closes, shutting off the passage between the secondary pressure chamber and the reservoir section serving the secondary chamber. Additional movement of the primary piston causes both chambers to build pressure.

When the load on the primary piston is removed, fluid pressure in each chamber, combined with return spring force, causes the primary and secondary pistons to return to their initial released positions. Each actuator opens its respective compensating valve, reopening the passage between the individual reservoir sections and its associated pressure chamber.

Should the rate of release be great enough to cause a partial vacuum in the chamber, the compensating valve will open to allow replenishment of fluid into the cylinder bore.

Any excess fluid remaining at the end of the stroke due to “pumping” and/or volume change due to temperature fluctuation is released to the reservoir as the compensating valves open.

The primary circuit is separated from the secondary hydraulic circuit. Hydraulic leakage in one circuit does not affect the function of the other circuit.

A fluid level indicator switch is available. It illuminates a light on the dash panel to warn of low brake fluid level in the master cylinder reservoir. A low fluid level can result from brake shoe lining wear, or it can occur if there is an external leak in the vehicle brake system.

A differential pressure switch is available. It illuminates a light on the dash panel to warn when there is a pressure differential between the primary and secondary brake circuits caused by a leak in one circuit. This may occur when one circuit leaks or is improperly bled.

A remote reservoir application is available where under-the-hood space constraints prohibit the use of a conventional booster and master cylinder assembly. In a remote application, the master cylinder reservoir is mounted separately from the master cylinder.

### **Basic Operation of Hydro-Max™ Booster Assembly and Master Cylinder**

(Refer to the illustration on the following page to identify the following electrical components of the booster and master cylinder.)

**Backup Pump:** The Hydro-Max™ hydraulic booster has a backup pump which will provide hydraulic boost at a reduced rate if the normal source of fluid is interrupted. The signal for operation of the backup pump comes from the flow switch. If normal flow is interrupted, the flow switch will close and activate the relay, which will turn on the backup pump.

The 12-volt backup pump can draw a steady state maximum of 55 amps at a power steering fluid temperature of 100 degrees F. The Hydro-Max™ Master Cylinder and Booster Components

**Relay:** The function of the relay is to provide current to the backup pump when triggered by the flow switch.

**Flow Switch:** The function of the flow switch is to activate the relay when normal hydraulic power source fluid flow is interrupted, turning on the backup pump. The flow switch has two terminals (A and B). A is positive. B is connected to the booster housing and is used as an optional harness ground. The flow switch itself is grounded through the booster housing.

**Differential Pressure Switch:** The differential pressure switch reacts to a loss of master cylinder hydraulic pressure in either side of the split hydraulic system and can illuminate a warning light at the instrument panel. When pressure is lost in either the primary or secondary circuit of the master cylinder, the switch closes. The electrical switch will remain closed until the malfunction is corrected.

When both systems develop normal pressure, the switch will return to center and open the electrical switch circuit. The switch has two tabs on a common terminal (positive) and is grounded through the master cylinder.

**Fluid Level Switch:** When the fluid reaches a predetermined level (low fluid level), the switch closes and can illuminate a warning light at the instrument panel. The switch has two terminals, positive and negative, which are interchangeable.

**Chassis Ground:** The booster and master cylinder assembly must be provided with a ground path that will carry the maximum current of the backup pump.

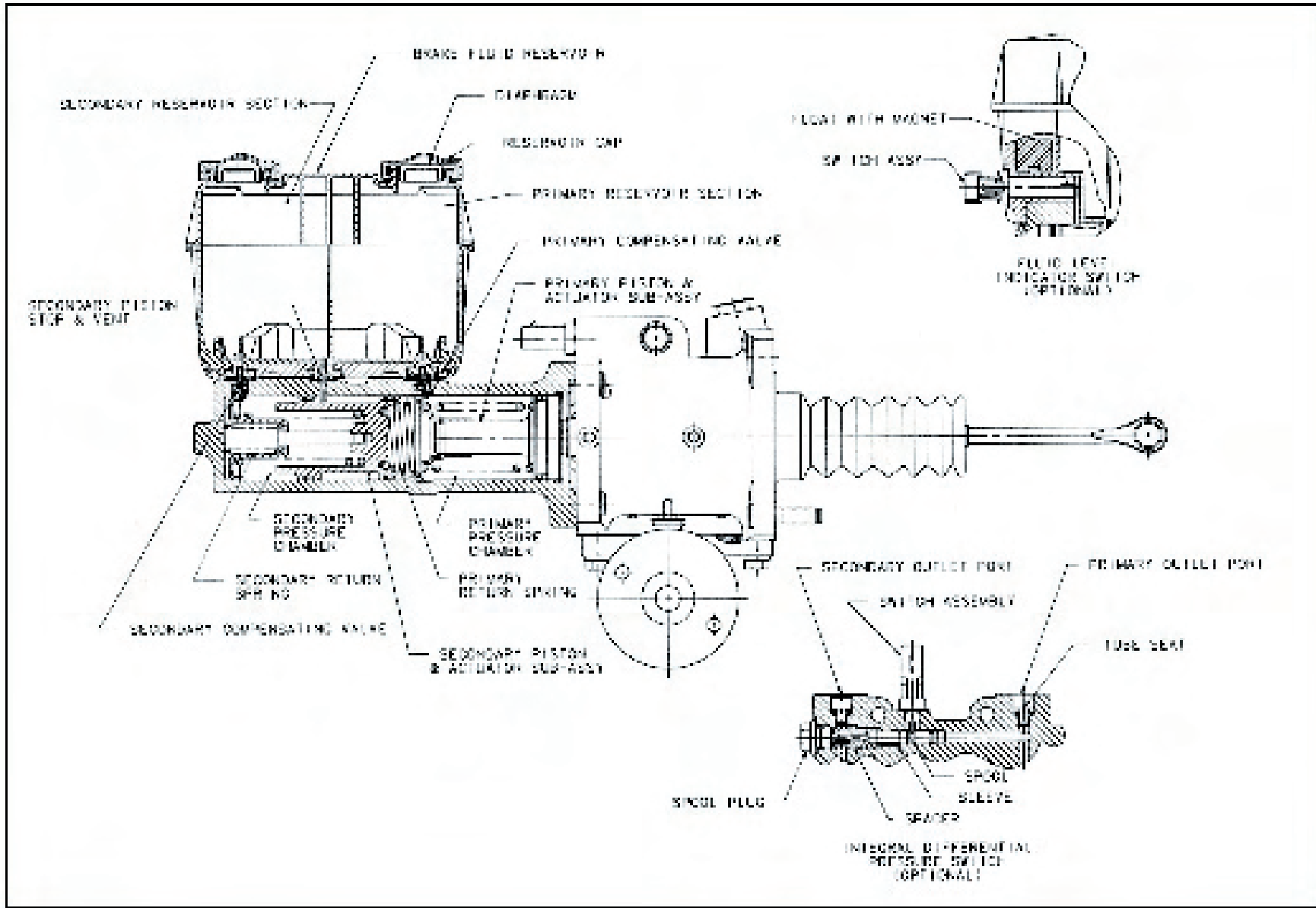


Figure 5-3 — Hydro-Max™ Master Cylinder Components

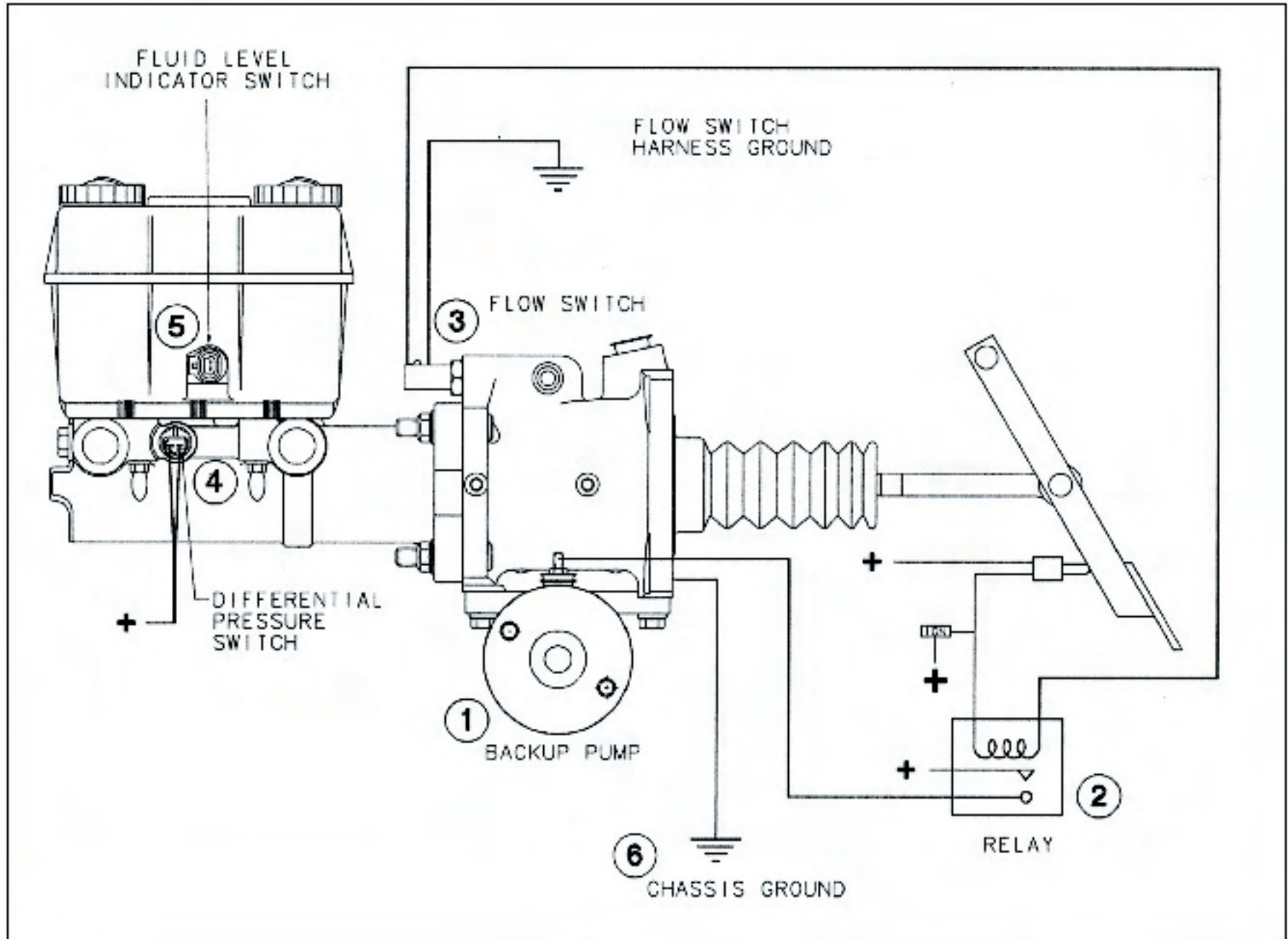


Figure 5-4 — Hydro-Max™ Electrical Components

## HYDRAULIC FLUIDS

The Hydro-Max™ booster uses power steering fluid as the medium of transmitting power.

The master cylinder uses DOT 3 brake fluid per SAE J1703, unless otherwise specified on the top of the reservoir. Service maintenance of motor vehicle brake fluid in motor vehicle brake actuating systems is covered in SAE J1707 information report.

### WARNING

*The booster and the master cylinder use two (2) distinctly different incompatible hydraulic fluids. They must not be mixed. Using the incorrect fluid will permanently damage the seals and can cause the brakes to malfunction.*

## BRAKE FLUID TUBING, HOSES AND FITTINGS

Brake fluid lines (tubing and flexible hose) transmit fluid under pressure between the master cylinder and the brakes. The hoses are the flexible links between wheels or axles and the frame or body. The hoses must withstand fluid pressure with minimal expansion and must be free to flex without damage during normal suspension deflection and wheel turns. The following SAE specifications, or their successors if appropriate,

are recommended for consideration as a minimum requirement when outfitting a vehicle with brake fluid tubing, hoses and fittings. The hoses should conform to SAE J1401 Hydraulic Brake Hose - Automotive. The tubing should conform to SAE J1047 Tubing - Motor Vehicle Hydraulic Brake System. The fittings should conform to SAE J516a - Hydraulic Hose Fittings, or SAE J512 - Automotive Tube Fittings.

### NOTICE

*Contact the Workhorse for specific requirements for individual applications.*

## Booster Fluid Tubing, Hoses and Fittings

The pressure line that supplies fluid to the booster must be a 1/2" diameter flexible or rigid pressure line conforming to SAE J188 and typically designed to run from the steering gear to the Hydro-Max™ inlet. The Hydro-Max™ inlet port utilizes a tube "O" arrangement.

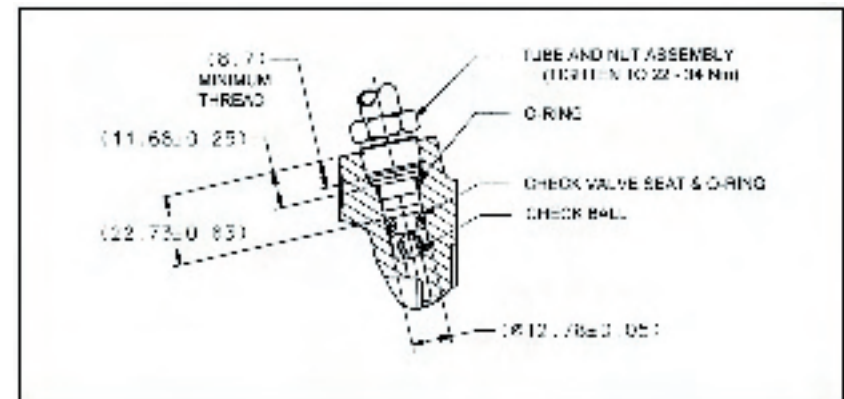


Figure 5-5 — Tube "O" Fitting and O-ring Seal



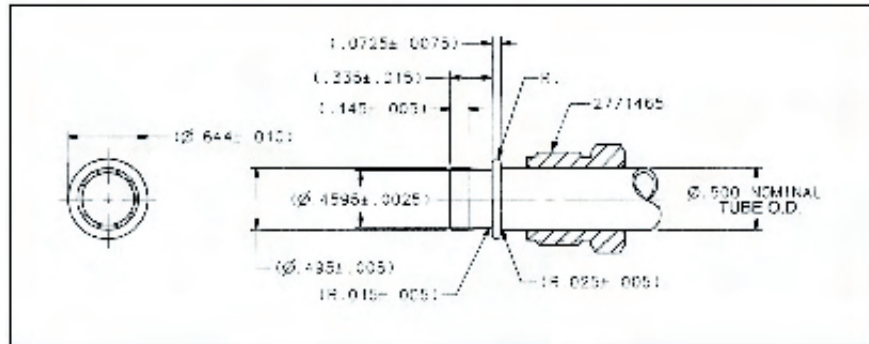


Figure 5-6 — Tube Flare Configuration

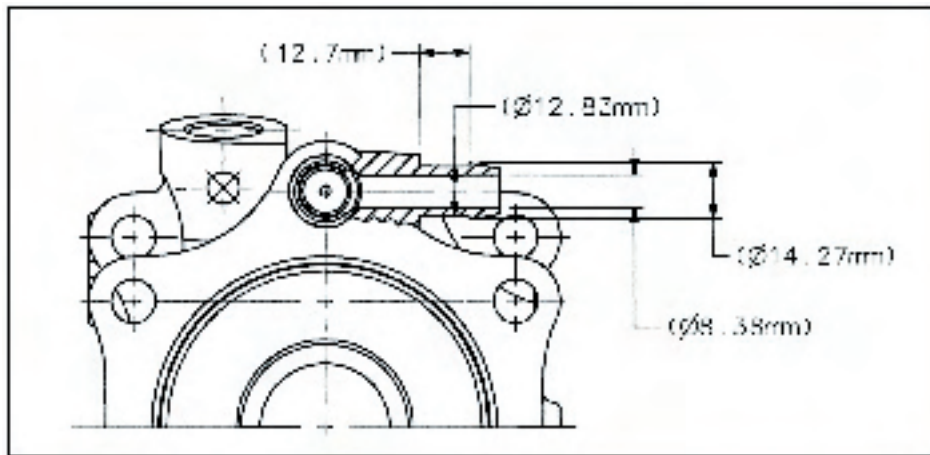


Figure 5-7 — Outlet Port

## Booster Fluid Source

The booster is designed to perform in a flow range of 3.2 to 5.0 gpm. Flow rate through the booster can impact vehicle stopping distance; therefore, the technician may be required to determine the minimum flow rate if poor brake performance is indicated. Flow rates below 3.2 gpm can cause slower response times when the booster is applied. Flow rates higher than 5.0 gpm may contribute to the booster self-applying, which will cause brake drag or fluid overheating.

The power steering pump must be capable of supplying 1,000 psi to the booster plus any additional pressure required by other devices in the system such as a power steering gear.

## Pedal Stop and Proper Spring Load

The pedal stop must be adjusted such that when the brake pedal is fully released, there is no load on the grommet that retains the pedal rod to the Hydro-Max™ booster. When the brake pedal is fully released, the spring load must not be greater than that required to support the pedal weight.

The reason for a properly adjusted pedal stop and for the limitation on spring load is to prevent the spring from pulling on the grommet within the Hydro-Max™ booster and damaging the grommet. The grommet is not designed to be loaded in this manner.

**NOTICE**

*Any adjustment of the brake switch and backup pump must not compromise the adjustment of the pedal stop.*

**Hydro-Max™ Brake System Diagnosis**

Refer to the following tables when diagnosing problems with the Hydro-Max™ master cylinder and booster.

**HYDRO-BOOST™ HYDRAULIC BRAKE BOOSTER**

**System Description**

The hydraulic booster provides power assist using fluid pressure from the power steering pump.

The Hydro-Boost™ system uses hydraulic pressure from the power steering pump to operate the master cylinder. The Hydro-Boost™ unit is located between the master cylinder and the brake pedal. The brake pedal is connected to a valve inside the Hydro-Boost™ unit and allows the driver to control brake application. The operation of the Hydro-Boost™ unit is similar to the vacuum boost unit except that the Hydro-Boost™ unit uses a hydraulic piston and a hydraulic pressure from the power steering pump to create the force to the master cylinder.

**Master Cylinder**

The master cylinder is an aluminum unit. The system uses a conventional front-to-rear brake split. The primary piston provides fluid pressure to the front brakes. The secondary piston provides fluid pressure to the rear brakes. If pressure is lost in either system, the remaining system is capable of stopping the vehicle.

**Reservoir and Cover**

The reservoir is made of plastic. Two clips snap the cap onto the reservoir. A diaphragm between the cover and the reservoir keeps contaminants out of the brake fluid.

Keep the master cylinder reservoir properly filled with brake fluid. This ensures adequate reserve brake fluid and prevents air from entering the hydraulic system. Do not over fill the reservoir. The brake fluid absorbs heat from the brakes, and expands. An over-filled reservoir cannot allow fluid expansion.

**Power Steering Pump**

The power steering pump supplies the Hydro-Boost™ unit with hydraulic pressure the same way the engine manifold vacuum supplies power to the vacuum boost system. The pump, which is driven by the engine, also supplies hydraulic pressure to the power steering gear.

## Power Piston and Accumulator

The Hydro-Boost™ unit contains a valve, a power piston and an accumulator. When the valve is moved by the brake pedal linkage, hydraulic pressure is applied to the power piston. The pressure forces the power piston to move forward, toward the master cylinder. The movement of the piston causes the output rod to operate the master cylinder. When the brake pedal is pushed harder, more hydraulic pressure is applied to the piston and the brakes are applied harder.

The accumulator stores hydraulic fluid under pressure. If the power steering pump fails, this reserve pressure allows at least two brake applications before complete loss of power assist. The accumulator serves the same function as the vacuum reservoir in the vacuum boost system. The difference is that an accumulator stores hydraulic pressure and a vacuum reservoir stores vacuum pressure. The accumulator has a piston which compresses nitrogen gas as the reserve chamber fills.

### **CAUTION:**

***High pressure can exist in the accumulator circuit with the engine turned off. This can be extremely dangerous!***

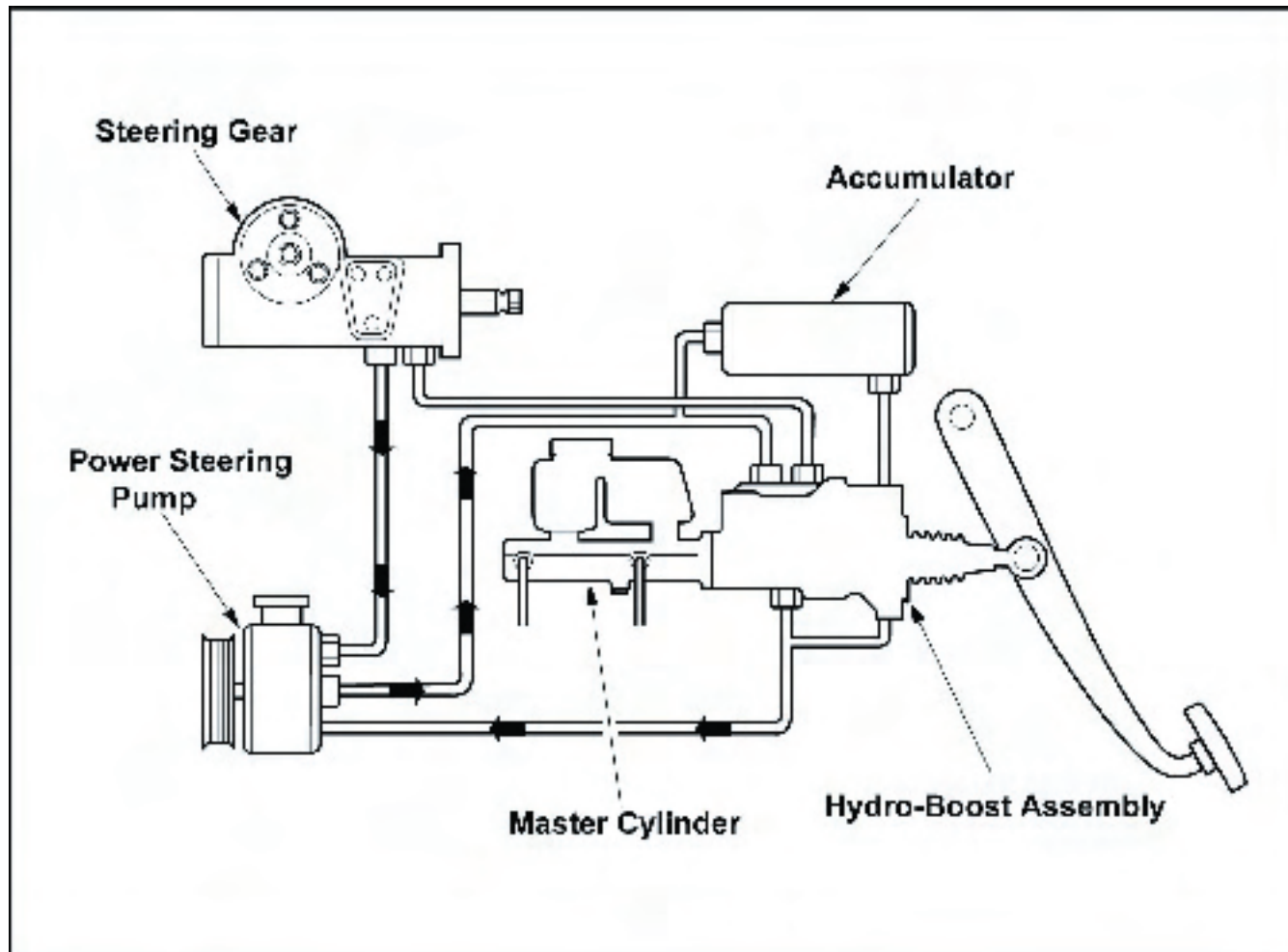


Figure 5-8 — Hydro-Boost System Design

### Braking Position

When the brake pedal is pressed, the pushrod moves the ratio lever which starts the movement of the spool valve. This closes the fluid return port to the pump from the booster pressure chamber and allows hydraulic fluid to enter the booster pressure chamber.

The hydraulic pressure in the booster pressure chamber forces the piston forward, actuating the master cylinder piston.

As the spool valve moves along its bore, the lands prevent fluid flow from the power steering pump to the steering gear. This causes the power steering pump to increase fluid pressure to maintain the same flow rate.

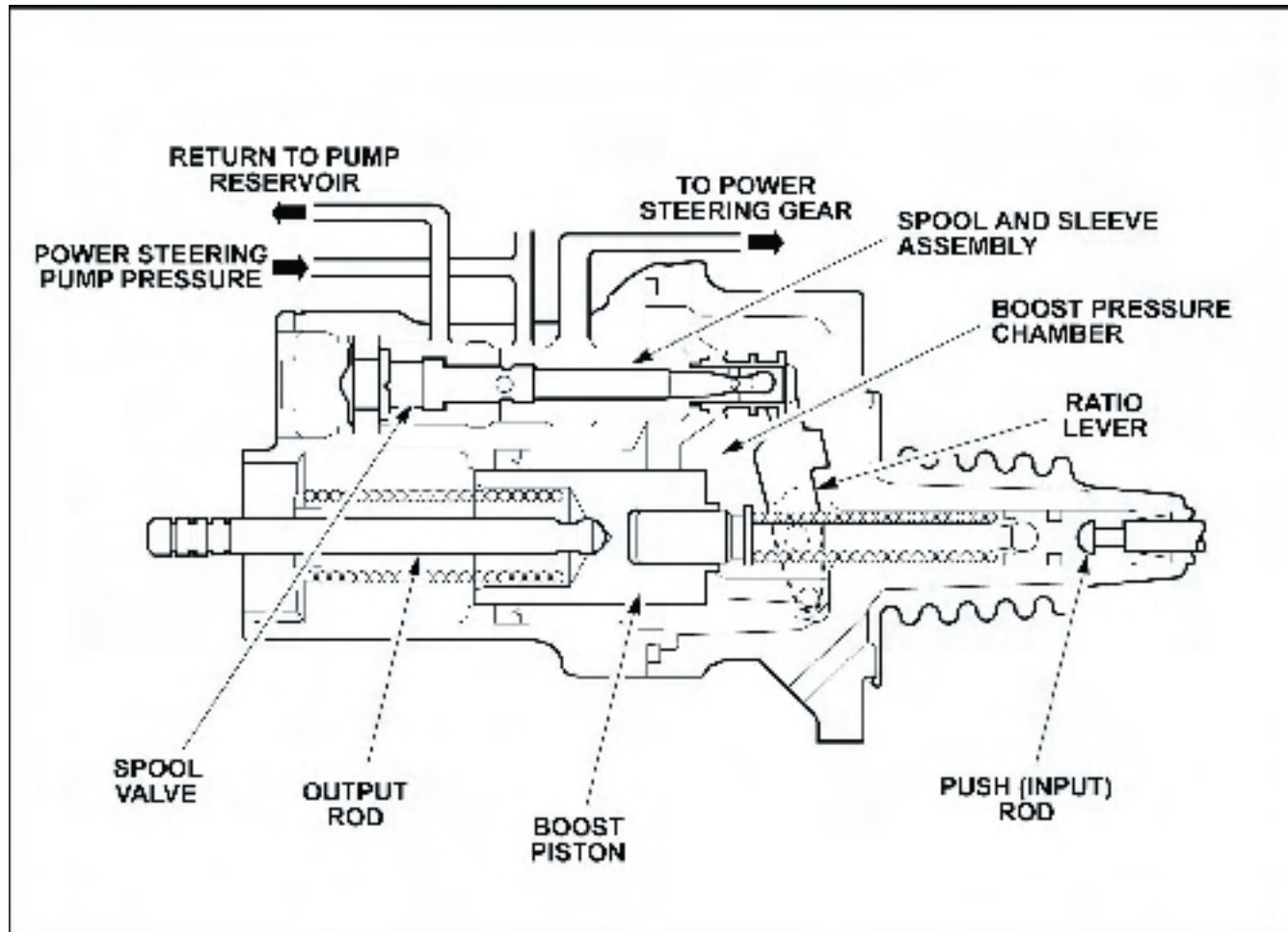


Figure 5-9 — Hydro-Boost™ Internal Components

If pressure is required for power steering during braking, the power steering pump increases the pressure. The spool valve shifts to an open position and allows more fluid to flow to the power steering gear. The system stores enough fluid under pressure for brake application if fluid flow from the power steering pump is not available. The brakes can also be applied manually if the reserve system is depleted.

#### **Released Position – No Braking**

When the brake pedal is released, the spool valve return spring holds the spool valve open. In the open position the spool valve channels hydraulic fluid from the power steering pump directly to the power steering gear, and lands on the spool valve which block the fluid from entering the boost pressure chamber.

**NOTICE**

*No internal components of the Hydro-Boost™ booster are serviced separately. If an internal failure occurs, the booster assembly must be replaced.*

**BRAKE FLUID AND BRAKE FLUID HANDLING**

**CAUTION:**

*Brake fluid may be irritating to the skin or eyes. In case of contact, take the following actions:*

*Eye contact-rinse eyes thoroughly with water.  
Skin contact-wash skin with soap and water.*

**NOTICE**

*Brake fluid will damage electrical connections and painted surfaces. Use shop cloths, suitable containers, and fender covers to prevent brake fluid from contacting these areas. Always re-seal and wipe off brake fluid containers to prevent spills.*

Use Brake Fluid P/N 1052535, or an equivalent DOT-3 motor vehicle brake fluid. Always store brake fluid in a closed, sealed container. Never use previously opened, improperly sealed containers of stored brake fluid.

Always use new brake fluid, or fluid from a properly sealed container.

Re-seal brake fluid containers immediately after use. Brake fluid left in open or improperly sealed containers will absorb moisture. Moisture can lower the brake fluid boiling point, causing the following problems:

- Brake system contamination.
- Corrosion.
- Deterioration of rubber components.

**Substandard Or Contaminated Brake Fluid**

**NOTICE**

*Power steering fluid and brake fluid cannot be mixed. If brake seals contact power steering fluid or steering seals contact brake fluid, seal damage will result.*

Use the correct fluids. The master cylinder and brake system use brake fluid. The hydraulic booster system uses power steering fluid.

If the brake fluid contains improper fluid, water, or other contaminants, the brake fluid may boil or corrode rubber components in the hydraulic brake system.

Evidence of rubber deterioration occurs in the following areas:

- Swollen master cylinder piston seals
- Swelling of the wheel cylinder boots
- Swelling of caliper boots
- Swelling of the master cylinder reservoir diaphragm

If you find rubber deterioration, replace all rubber parts in the brake system, including the hoses. Check for brake fluid on the brake linings. Replace brake linings that are contaminated with brake fluid.

If the brake fluid is contaminated and the master cylinder piston seals are good, check for leaks and excessive heat conditions. If no leaks or excessive heat conditions are found, perform the following procedure:

1. Drain the brake system.
2. Flush the system.
3. Refill the system.
4. Bleed the system.

## **FLUSHING THE BRAKE HYDRAULIC SYSTEM**

Flushing the brake hydraulic system involves running new brake fluid through the system and out the open bleeder valves, until the fluid runs clear. Use Brake Fluid P/N 1052535, or an equivalent DOT-3 motor vehicle brake fluid.

Flush the brake hydraulic system for the following reasons:

- When new hydraulic brake parts are installed
- When contamination may be present. Flushing is the only way to clean contaminated fluid out of the system
- When you do not know the grade of brake fluid in the brake system.
- When mineral oil is present in the brake fluid

## **NORMAL OPERATION NOISES**

Properly operating Hydro-Max™ and Hydro-Boost™ hydraulic brake boosters may produce certain noises. These noises occur, for the most part when the brake pedal is manipulated in a manner not associated with everyday driving habits. The general categories of normal operating noises are (1) hissing noises and (2) clunk/clatter noises.

The boosters may emit normal hissing noises when above-normal brake pedal efforts are applied (40 lbs. and up). The hiss sounds particularly noticeable with the vehicle motionless and will increase in intensity as pedal pressure increases above 40 lbs. and system operating temperature increases. Loud hissing sounds at or below normal (20 to 25 lbs.) pedal effort warrants investigation.

Clunk, clatter or clicking noises will be heard when the brake pedal is quickly released from hard (50 to 100 lbs.) pedal efforts.

## BRAKE SYSTEM TESTING

### IMPORTANT:

*If the vehicle pulls to one side during braking, do not assume the cause is a brake system malfunction. Ensure that the front end alignment is correct before diagnosing the brake system.*

Test the brakes at different speeds with light pedal pressure and with heavy pedal pressure. Avoid locking the wheels. Avoid sliding the tires on the roadway. Locked wheels and sliding tires do not show brake efficiency. A locked wheel and a sliding tire reduce the tire friction on the roadway. Heavily braked, turning wheels will stop the vehicle in less distance.

Test the brakes on a dry, clean, reasonably smooth and level roadway. You cannot accurately test brake performance without these conditions. The tires will not grip the roadway equally if the roadway is wet or greasy or covered with loose dirt. A crowned roadway causes the weight of the vehicle to shift toward one side. The wheels bounce on a rough road way.

The following conditions also affect brake performance: Tires with unequal contact and unequal grip on the road will cause unequal braking.

- The tires must be equally inflated.
- The tread pattern of the right tires and the left tires must be about equal.

When the vehicle is loaded unequally, the most heavily loaded wheels require more braking power than the other wheels. Loose front wheel bearings may cause the following:

- Brake rotor tilt
- Spotty contact with the brake linings
- Erratic braking action

The brakes will pull the vehicle to one side if the front suspension is not aligned correctly. This will be very noticeable if the caster and the camber are not within specifications.

## EXTERNAL CONDITIONS THAT AFFECT BRAKE PERFORMANCE

### Tires

Tires with unequal contact and grip on the road cause unequal braking. Make sure the inflation and tread pattern of the right and left tires is about equal.

### Vehicle Loading

When the vehicle has unequal loading, the most heavily loaded wheels require more braking force than the others.

### Front Wheel Bearings

Loose front wheel bearings permit the rotor to tilt and to have poor contact with the linings. This may cause erratic braking.



## **Front End Alignment**

Misalignment of the front end, particularly camber and caster, causes the brakes to pull to one side.

## **BRAKE FLUID LEAKS**

Use the following procedure in order to test for brake problems that may be caused by fluid leaks:

1. Start the engine and run the engine at idle speed.
2. Shift the transmission into neutral.
3. Maintain constant foot pressure on the brake pedal. If the pedal slowly sinks to the floor, the hydraulic system may have internal leakage, external leakage or improperly adjusted components.
4. Check the fluid level of the master cylinder. A slightly low fluid level in either reservoir can result from normal wear of the front brake lining. An abnormally low fluid level indicates a leak in the hydraulic system.
5. Perform a visual inspection of the hydraulic system.

If you find a leaking component, refer to the applicable replacement or overhaul procedure.

If you find no external leaks, internal leakage may be the cause. The master cylinder serviced as an assembly and must be replaced if a leak is present..

## **Brake Hose And Pipe Inspection**

Inspect the brake hoses and the brake pipes at least two times a year for the following conditions:

- Chafing of the outer cover
- Cracks
- Road damage
- Check that all hose and pipe mounting hardware Replace any leaky or damaged hose or pipe. Repair any insecure mounting hardware.

## DIAGNOSTICS AND TROUBLESHOOTING

### SERVICE BRAKE SYSTEM

#### Master Cylinder Diagnosis

These tests will not find all master cylinder malfunctions. If you cannot find the cause with these tests, refer to Brake System Diagnosis.

Visual Inspection
Check for a cracked casting or brake fluid leaks around the master cylinder. A leak will have at least one drop of fluid. A damp condition is normal.
Check the pedal linkage for binding and for incorrect pushrod length. Disassemble the master cylinder if no brake pedal binding or improper brake pedal travel is found. Refer to Master Cylinder Overhaul.
Check the master cylinder for swollen or elongated primary piston seals. If you find swollen seals, refer to Brake Fluid and Brake Fluid Handling.

#### Brake Hose and Pipe Diagnosis

Inspect all pipes, hoses, and fittings for leaks at regular intervals. The fittings must be tight. All clips, clamps, and unions supporting the pipes and hoses must be securely in place. Ensure that all hoses and tubes do not contact parts of the vehicle. Wipe clean any area suspected of leaking. Leaking fluid will then be easily seen. If a leak is found, tighten, repair, or replace nearby fittings and bolts.

### GENERAL BRAKE SYSTEM DIAGNOSIS

#### Excessive Pedal Effort

Condition	Suggested Correction
Pads worn below minimum thickness specification.	Replace the pads.
Faded, overheated condition, glazed pads, "blued" or heat-checked rotors.	Replace the affected rotor and/or reface the pads, if sufficient brake lining remains.
Grease, oil, and/or brake fluid on the brake linings.	Replace both sets of pads on the affected axle.
Seized or frozen pistons.	Disassemble the calipers to free the pistons, or replace the caliper.

**Pedal Pulsation (Brake Roughness or Chatter)**

Condition	Suggested Correction
Excessive lateral runout of brake rotor.	Install a new rotor if runout exceeds the maximum specification.
Excessive out-of-parallelism of brake rotor.	Check the parallelism (rotor thickness variation) with a micrometer. If the rotor thickness variation is within specification, resurface the rotor. If the rotor thickness is beyond specification, replace the rotor.
Loose or worn steering or suspension parts.	Replace parts and perform an alignment. Excessive front bearing clearance Readjust the bearing to specifications. Vehicle Pulls to One Side

**Leaky Caliper**

Condition	Suggested Correction
Cylinder bore surface scored or corroded	Disassemble calipers, clean bore and replace seals and boots
Caliper piston seal damaged or worn	Disassemble calipers and install new seals and boots
Caliper piston damaged	Replace piston.

**No Braking Effect or Excessive Pedal Travel**

Condition	Suggested Correction
Reservoir fluid level low	Check for causes of fluid leak, repair as required and refill the reservoir. Bleed system as needed.
Air in the hydraulic system	Bleed the system.
Bleeder screw loose or open	Bleed the system and tighten the bleeder screw.
Caliper piston seal damaged	Disassemble the caliper and replace the piston seals. Replace piston if damaged.
Excessive rotor runout or bent rotor	Check rotor with dial indicator. Install new rotor if runout exceeds maximum specified.
Bad or excessively loose wheel bearings	Adjust or replace bearings as needed.
Poor quality brake fluid	Drain and clean system. Replace with recommended brake fluid.
Weak brake hose that expands under pressure	Replace defective hoses.

**Brake Noise Diagnosis – Chatter**

Condition	Suggested Correction
Excessive lateral runout of rotor	Check the runout with a dial indicator. Install new rotor if the runout exceeds the maximum specified.
Lack of rotor parallelism	Check the parallelism with a micrometer. Resurface or install new rotor as required.
Loose wheel bearing	Readjust the bearing to specified torque.

**Brake Noise Diagnosis – Scraping**

Condition	Suggested Correction
Rust or mud build-up on edges of rotor and on caliper housing	Clean or replace as necessary.
Worn pad or pad installed backward	Replace pads in axle sets only with friction surface against the rotor.
Faulty caliper alignment permitting rotor to scrape on housing.	Correct the alignment.

**Brake Noise Diagnosis – Groan**

Condition	Suggested Correction
Pressure on the brake pedal too light	Slightly increase the pedal effort to eliminate noise.

**Brake Noise Diagnosis – Rattle**

Condition	Suggested Correction
Excessive clearance between the shoe and caliper.	Install new pads.
Pad retainer spring missing or not properly positioned.	Install new pad retainer spring or position correctly.

**Brake Noise Diagnosis – Squeal**

Condition	Suggested Correction
Glazed pads	Resurface or replace pads in axle sets only.
Weak pad retainer spring	Install new pad retainer spring.
Pad wear indicator contacting rotor	Install new pads in axle sets only.
Foreign material embedded in linings	Replace pads in axle sets only.

**BRAKE ROTORS**

**HUB AND ROTOR ASSEMBLIES**

The hub and rotor assemblies consist of a hub and rotor, fitted with bearing cups and wheel attachment studs.

For ABS operation, speed sensor reluctor rings are used. There are different types of ABS reluctor rings that may be used:

- Cast-in ABS reluctor ring (typically 100 slots)
- A separate ABS reluctor ring mounted to the inboard end of the hub.
- A separate ABS reluctor ring bolted to the rotor.

There are various hub configurations offered to accept the 19.5-inch (495.3 mm) eight-hole wheels, as well as 22.5-inch (571.5 mm) 10-hole wheels with the hub piloted or stud piloted system.

## BRAKE CALIPERS AND PADS

Depending on which W Series chassis is being examined, it is possible to encounter several different types of brake calipers and pads.

Chassis Model	GVWR (lbs)	Brake System	Caliper Size	Option Code
W16	16,000	Brembo	2X68	JM6
W18	18,000	Brembo	2X68	JM6
W20	20,700	Bosch ZOH-T	2X66	JL9
W22	22,000	Bosch ZOH-T	2X66	JL9
W24	24,000	Meritor Quadraulic	4X70	JM8
W25	25,500	Meritor Quadraulic	4X70	JM8
W42	9,400–10,000	Brembo	2X52	JM3
W42	10,000–14,500	Brembo	2X68	JM6
W52	19,500	Bosch ZOH-T	2X66	JL9

### Brake Rotor Thickness Variation Check

Check thickness variation by measuring the brake rotor thickness at four or more points around the circumference of the brake rotor. Use a micrometer calibrated in ten-thousands of an inch. Make all measurements about 25.4 mm (1 in) in from the edge of the brake rotor.

A brake rotor that varies in thickness by more than 0.05 mm (0.002 in) can cause brake pedal pulsation and/or front end vibration during brake applications. Refinish or replace a brake rotor that does not meet these specifications.

### Brake Rotor Lateral Runout Check

The best way to check lateral runout is with the wheels still installed on the vehicle. This gives a much more accurate reading of the Total Indicated Runout (TIR) under real braking conditions. If equipment is not available to perform the check with the wheels installed, the next best reading can be made with the wheels removed but with the brake caliper still installed.

In some cases, excessive lateral runout can be improved by indexing the brake rotor on the hub that is one or two bolt positions from the original position. If the lateral runout cannot be corrected by indexing the brake rotor, check the hub and bearing assembly for excessive lateral runout or looseness. If the hub and bearing assembly lateral runout exceeds 0.040 mm (0.0016 in), replace the hub and/or bearing assembly if necessary. If the lateral runout is not within specifications, refinish or replace the brake rotor as necessary.

1. Set the parking brake.
2. Block the vehicle wheels.
3. Raise the vehicle.
4. Support the vehicle with safety stands.
5. Remove the tires and wheels.

6. Clean the brake rotor surface.
7. If the vehicle is equipped with standard wheel bearings (non-sealed units), tighten the wheel bearings to zero end play.
8. Fasten a dial indicator to the steering knuckle so that the indicator button contacts the brake rotor surface about 25.4 mm (1 in) from the outer edge.
9. Set the dial indicator to zero.
10. Turn the wheel one complete revolution.
11. Observe the runout indicated on the dial.
12. The (TIR) must not exceed 0.13 mm (0.005 in).
13. Adjust the wheel bearings.

### Brake Rotor Tolerance

During the manufacture of the brake rotor, tolerances of the braking surfaces for flatness, parallelism, and lateral runout are closely held. The maintenance of close tolerances on the shape of the braking surfaces is necessary in order to prevent brake roughness or brake pedal pulsation.

In addition to these tolerances, the surface finish must be held to a specified range of 60 Ra roughness or less. Controlling the braking surface finish avoids problems of hard pedal application, excessive brake fade, brake and steering pulls, and erratic performance. In addition, control of the surface finish can improve brake lining life. Light scoring of the brake rotor surfaces not exceeding 1.5 mm (0.06 in) in depth is normal and not detrimental to brake operation.

## BOSCH HYDRAULIC BRAKE DIAGNOSIS

**IMPORTANT REMINDER:** The first step in diagnosing any customer complaint is to confirm the customer's complaint and determine which category applies.

The flow charts show, which diagnostic steps need to be taken. The brake technician must have the necessary skills needed to perform each step. The flow charts are structured to guide the brake technician to take the quickest and easiest steps first. Often, these first, simple steps will be enough to determine what repair needs to be made.

In all cases, the vehicle manufacturer's service manual must be used for any repair instructions. Brake system warning lights and buzzers are unique to the vehicle manufacturer. The Brake Warning Light and Buzzer Do Not Shut Off flow chart offered in this guide is generic and may not apply to all vehicles. The vehicle manufacturer's service manual must be consulted in order to determine the proper function of these warning devices.

### Exclusions

The ABS portion of the hydraulic brake system is not addressed in detail in this guide since the ABS hardware and software are unique to the specific vehicle manufacturer.

Any diagnosis or repair needs to be done in accordance with the vehicle manufacturer's ABS service manual.

### **Warning Light and Buzzer Do Not Shut Off**

The light and buzzer come on together, typically in response to signals from the parking brake switch, booster flow switch, master cylinder fluid level indicator switch, the master cylinder differential pressure switch or booster backup pump.

### **Booster Backup Pump Runs Continuously**

The booster backup pump can run only if the relay is closed. The relay will be closed only if:

1. The flow switch is closed and there is power to the coil
2. The relay is stuck closed

### **Booster Backup Pump Does Not Run**

The booster backup pump will not run if there is no voltage to the motor or if the motor is damaged (e.g., burned out or jammed).

A no-voltage condition can occur because:

1. Battery is dead
2. Relay is stuck
3. Wires are broken (battery to motor circuit or ignition switch / brake light switch to booster flow switch circuit).
4. Booster flow switch is not closed to ground

### **Brake Pedal Feels Spongy, Soft or Springy**

If the brake pedal does NOT fall with steady foot pressure but feels spongy, soft or springy, the problem is probably caused by air trapped in the brake fluid system. Start by bleeding the brake system at the caliper furthest from the master cylinder and work from the back to the front of the vehicle.

### **Brake Pedal Feels Very Hard**

The most common reasons for a very hard brake pedal are:

1. Insufficient flow or pressure from the power steering pump
2. The ABS hydraulic unit is blocking the flow of brake fluid to the calipers.

### **Potential Master Cylinder and Booster Leak Points**

Most external leakage is easy to detect by wetness and/or appearance of fluid drops. However, slight dampness (no drops or wetness) may not indicate a leak.

Brake fluid mixes with water. Power steering fluid floats on water.

## Brake Drag

### Possible Causes of Brake Drag:

1. Booster does not return
2. Master cylinder does not return
3. Brake pedal does not return
4. ABS traps pressure
5. Brake hoses and tubes collapsed or kinked
6. Brake caliper does not release

Prior to moving master cylinder 1/8 inch away from booster, loosen two diagonally opposed nuts that hold the master cylinder to the booster, by 1/8 inch. Have a power tool ready to loosen the remaining two nuts after the brakes have been applied and released.

## ANTILOCK BRAKE SYSTEM (ABS) DIAGNOSTICS

For diagnostic information related to the ABS system, refer to the ABS information included in this section.

## MAINTENANCE AND REPAIR

This sub-section will discuss and explain specific maintenance and repair procedures.

### SETUP PROCEDURES

Prior to beginning any maintenance or repair procedure, the vehicle must be prepared before beginning work.

1. Park the vehicle on a level surface.
2. Block the wheels to prevent the vehicle from moving.
3. Raise the vehicle, if required, so that the area to be serviced is off of the ground and support the vehicle with safety stands.
4. Determine where safety problems may occur if the system malfunctions.

### CAUTION

*Always protect the system from contamination by capping, plugging or taping exposed lines and ports.*

### CAUTION

*Always secure (or identify) fastener hardware and brackets by tagging, containing or temporarily installing until the main component is to be installed.*

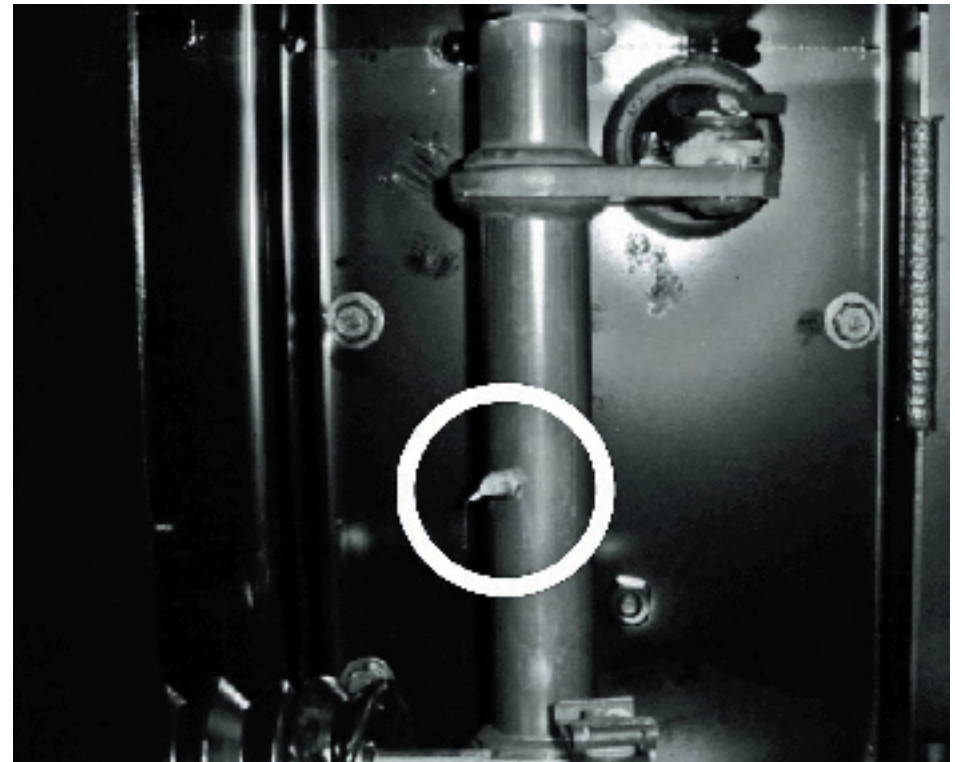


## BRAKE ACTUATION LINKAGE – BELL CRANK SERVICE

A lubrication fitting has been added to the bell crank connecting the brake pedal to the master cylinder. This fitting requires lubrication at each chassis service.

Vehicles without the lubrication fitting require the following steps to lubricate the bell crankshaft:

1. Disconnect the linkage from the bell crank assembly.
2. Remove the bolt retaining the bell crank shaft in the housing.
3. Remove the shaft from the housing and inspect for damage or scoring. If the shaft is damaged, replace the bell crank assembly.
4. Apply a liberal coat of chassis lube to the shaft and into the housing bore.
5. Reinstall the shaft and replace the retaining bolt.
6. Lubricate the linkage pivot points before reconnecting.
7. Check proper operation of the brake linkage to ensure free operation.



*Figure 5-10 — Bell crank lubrication point.*

### **NOTICE**

*If the shaft cannot be completely removed due to interference with the body panels, pull the shaft out as far as possible and complete steps 4 through 7.*

## CALIPER REPLACEMENT (BREMBO 52MM CALIPER)

### Caliper Removal (Brembo 52mm Caliper)

1. Disconnect the brake hose fitting at the caliper. Cap the fitting and tie the brake hose up and out of the way.
2. Remove the two caliper bracket to steering knuckle mounting bolts.

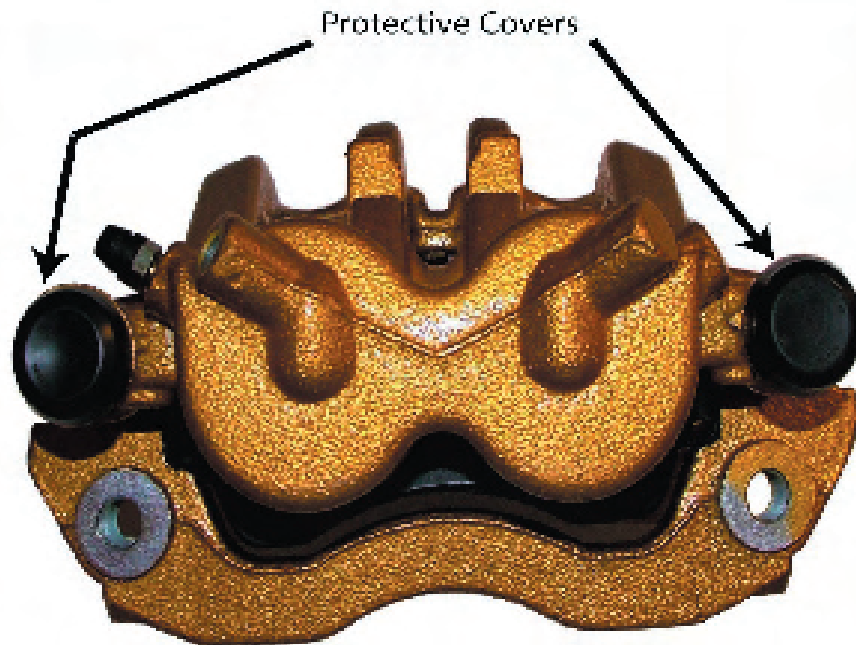


Figure 5-11. Typical caliper mounting bolts

3. Remove the caliper by lifting it from the mounting bracket.
4. Clean up any brake fluid that may have leaked out of the hose or caliper.

### Clean, Dry, and Inspect (Brembo 52mm Caliper)

#### CLEAN PARTS

1. Thoroughly clean the exterior caliper surfaces using a damp cloth.

#### DRY AND INSPECT PARTS

1. Use soft, clean paper or cloth rags, or compressed air to completely dry parts immediately after cleaning them.
2. Carefully inspect each part for wear or damage.
3. Repair or replace worn or damaged parts.

### Caliper Installation (Brembo 52mm Caliper)

1. Install the caliper mounting bracket onto the steering knuckle.
2. Install the two new caliper mounting bolts.
3. Tighten the caliper mounting bolts to 172 N·m (127 lb ft).
4. Remove the cap from the brake hose fitting.
5. Install the brake hose fitting into the port on the caliper.

### CAUTION

*When installing the brake hose, be careful not to twist or kink the brake hose. Make sure that an adequate amount of slack is left in the brake hose to allow the suspension and/or steering components to move through the normal range of motion without placing tension on the brake hose.*

6. Tighten the brake hose fitting to 18.5 N·m (164 lb in).
7. Bleed the system. Refer to *Bleeding the Hydraulic Brake System*.
8. Have an assistant press the brake pedal for at least 30 seconds. While the pedal is pressed, check the brake lines, hoses, and fittings for possible fluid leaks. Make sure that there are no abnormal pressure drops in the circuit and that the rear brake lights illuminate.

### CAUTION

***If leaks are found, correct the leak before returning the vehicle to service.***

9. If rotors were cleaned, or if a new rotor was installed, burnish the pads. Refer to *Burnishing the Rotor and Pads*.

## CALIPER REPLACEMENT (BREMBO 68MM CALIPER)

### Caliper Removal (Brembo 68mm Caliper)

1. Remove the brake pads. Refer to Brake Pad Replacement (Brembo 68mm Caliper).
2. Loosen and remove the brake hose fitting at the caliper.
3. Cap the brake line and tie it up and out of the way.
4. Remove the four caliper bracket to axle mounting bolts.
5. Remove the caliper by lifting it from the mounting bracket.
6. Clean up any brake fluid that may have leaked out of the hose or caliper.

### ***Clean, Dry, and Inspect (Brembo 68mm Caliper)***

#### CLEAN PARTS

1. Thoroughly clean the exterior caliper surfaces using a damp cloth.

#### DRY AND INSPECT PARTS

1. Use soft, clean paper or cloth rags, or compressed air to completely dry parts immediately after cleaning them.
2. Carefully inspect each part for wear or damage.
3. Repair or replace worn or damaged parts.

### Caliper Installation (Brembo 68mm Caliper)

1. Position the caliper on the mounting bracket.
2. Install the four new caliper bracket to axle mounting bolts.
3. Tighten to the caliper mounting bolts to 215 N·m (160 lb ft).
4. Remove the cap from the brake hose fitting.
5. Install the brake hose fitting into the port on the caliper.
6. Tighten the brake hose fitting to 24 N·m (212 lb in).
7. Bleed the brake system. Refer to *Bleeding the Hydraulic Brake System*.
8. Have an assistant press the brake pedal for at least 30 seconds. While the pedal is pressed, check the brake lines, hoses, and fittings for possible fluid leaks. Make sure that there are no abnormal pressure drops in the circuit and that the rear brake lights illuminate.

## CAUTION

***If leaks are found, correct the leak before returning the vehicle to service.***

9. If rotors were cleaned, or if a new rotor was installed, burnish the pads. Refer to *Burnishing the Rotor and Pads*.

## BRAKE CALIPER REPLACEMENT (BOSCH ZOH-T CALIPER)

### Brake Caliper Removal

1. Remove two-thirds of the brake fluid from the master cylinder.
2. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
3. Support the vehicle with safety stands.
4. Mark the relationship of the wheel to hub.
5. Remove the tire and wheel assembly. Refer to *Tire and Wheel Removal and Installation*.
6. Position a C-clamp and tighten until the piston bottoms in the bore.
7. Remove the brake hose retaining fastener.

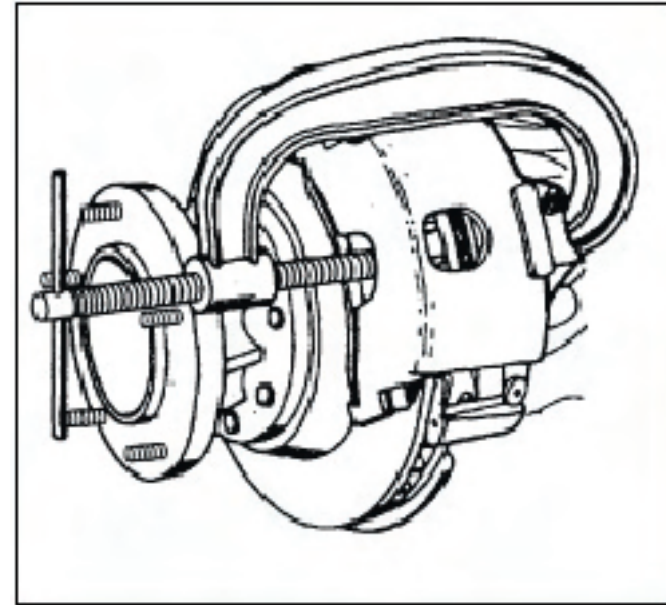


Figure 5-12 — C Clamp Usage

8. Remove the C-clamp.
9. Disconnect brake fluid line from caliper and cap line to prevent brake fluid leakage or contamination in the brake line.
10. Remove upper (top) caliper mounting bolt securing the caliper to the upper guide pin.
11. Remove lower (bottom) caliper mounting bolt securing the caliper to the lower guide pin.
12. Move caliper assembly away from rotor.

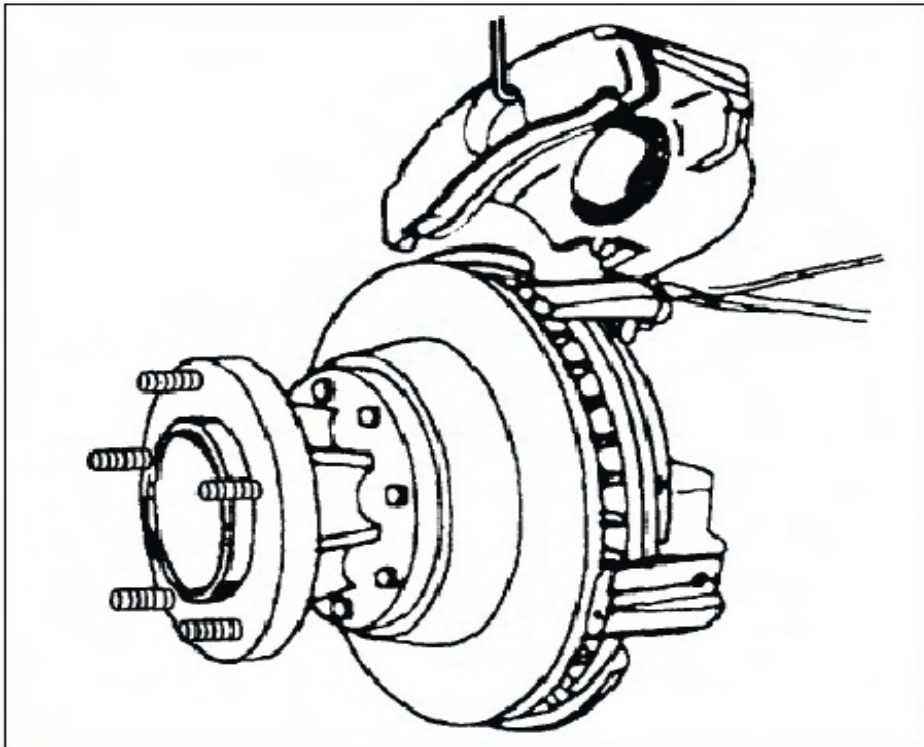


Figure 5-13 Caliper removal

13. Inspect the inside of the caliper assembly for signs of fluid leakage.
14. After the caliper has been removed from the anchor plate, remove contamination, dirt and debris from the exterior of caliper machined faces and around the caliper piston boots. Clean the machined surfaces of the anchor plate and caliper with a wire brush.

### Brake Caliper Installation

1. Lubricate the caliper and anchor plate sliding surfaces with silicone brake grease.

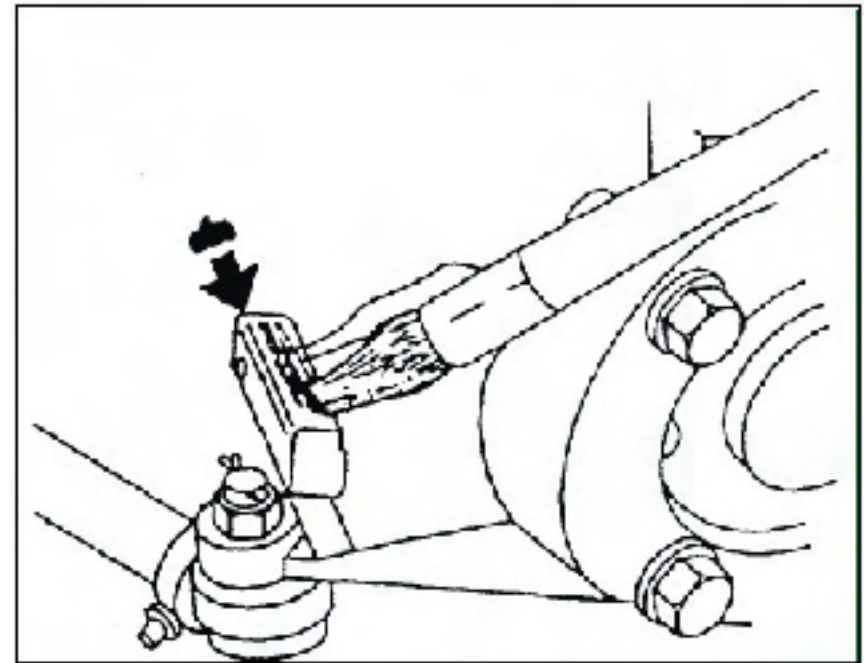


Figure 5-14 — Lubricate caliper slide areas.

### NOTICE

*Make sure the brake hose is not twisted or kinked after installation. Damage to the hose could result.*

2. Align flat on upper (top) guide pin head with the flat on caliper housing upper (top) guide pin boss. Be careful when positioning caliper over the disc brake pads, rotor and upper (top) guide pin head to avoid tearing, cutting or dislodging piston boots or guide pin boots.
3. Install upper (top) mounting bolt FINGER tight, securing the caliper to the anchor plate.
4. Align the flat on the lower pin flange, and then carefully rotate the caliper closed and install lower mounting bolt FINGER tight.

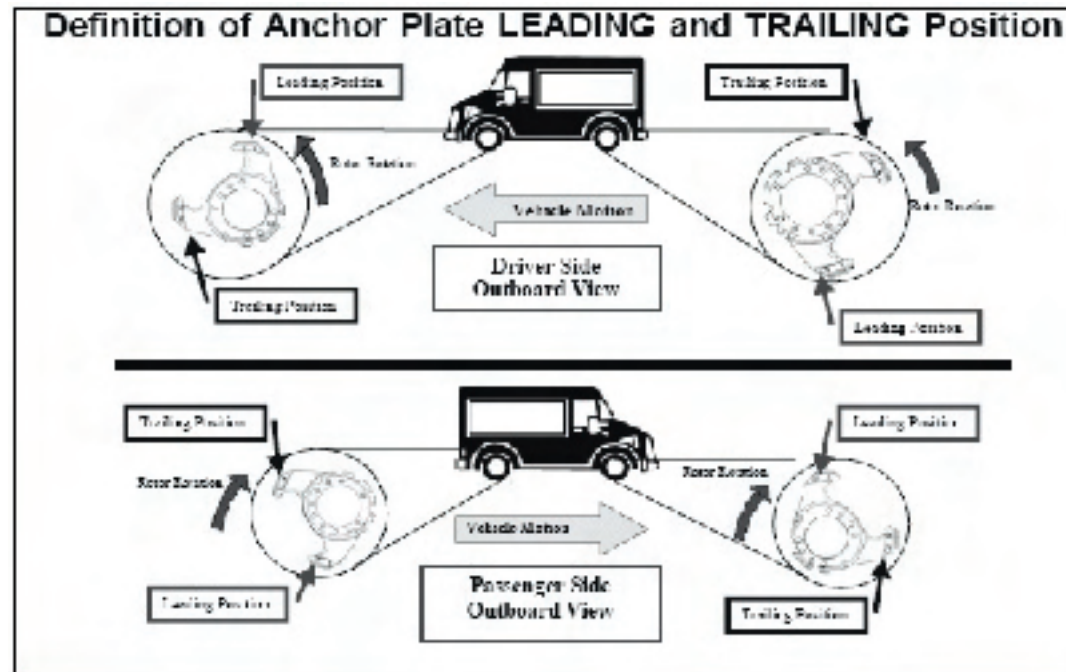


Figure 5-15 — Definition of Leading Trailing

**NOTICE**

*Refer to Fastener Notice in Cautions and Notices.*

5. Torque the mounting bolt as follows:
  - Torque leading bolt to 93-107 lb.-ft. (126-145 N•m)
  - Torque trailing bolt to 93-107 lb.-ft. (126-145 N•m)

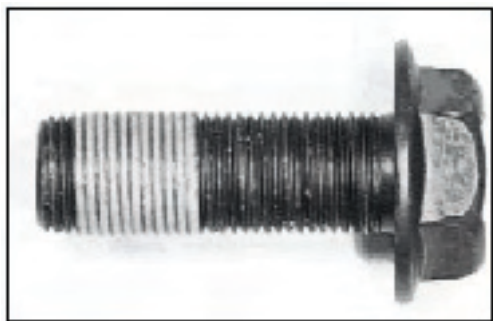


Figure 5-16 — Caliper Mounting Bolt

6. Connect the brake hose to the fluid inlet on the caliper and torque to specifications. Do not allow the brake line hose to become pinched or kinked.
7. Bleed the brake system. Refer to *Hydraulic Brake System Bleeding*.
8. Install the tire and wheel assembly. Refer to *Tire and Wheel Removal and Installation*.

**IMPORTANT:**

*Before moving the vehicle, pump the brake pedal several times in order to make sure the pedal is firm. Do not move the vehicle until a firm pedal is obtained. Check the brake fluid level in the master cylinder after pumping the brakes.*

10. Lower the vehicle.

## BRAKE CALIPER REPLACEMENT (MERITOR QUADRAULIC CALIPER)

1. Remove the brake hose hold down clamp bolt, if equipped.
2. Remove the brake hose/tube from the caliper.
3. Remove four caliper-to-support assembly bolts.

### CAUTION

*Do not disassemble the four bolts joining the two halves of the caliper. Disassemble and Overhaul the Brake Caliper.*

4. Remove the brake caliper.

### Clean, Dry, and Inspect

#### CLEAN PARTS

1. Thoroughly clean the exterior caliper surfaces using a damp cloth.

#### DRY AND INSPECT PARTS

1. Use soft, clean paper or cloth rags, or compressed air to completely dry parts immediately after cleaning them.
2. Carefully inspect each part for wear or damage.
3. Repair or replace worn or damaged parts.

### Brake Caliper Installation

1. Position the caliper on the support.
2. Install the four caliper-to-support assembly bolts.
3. Tighten the bolts to 435.2-489.6 N·m (320-360 lb-ft).

## BRAKE PAD REPLACEMENT

### Brake Pad Replacement (Brembo 52mm Caliper)

#### Brake Pad Removal (Brembo 52mm Caliper)

### CAUTION

*When replacing the brake pads, DO NOT disconnect the brake hose fitting from the caliper.*

1. Check the brake fluid level in the reservoir.

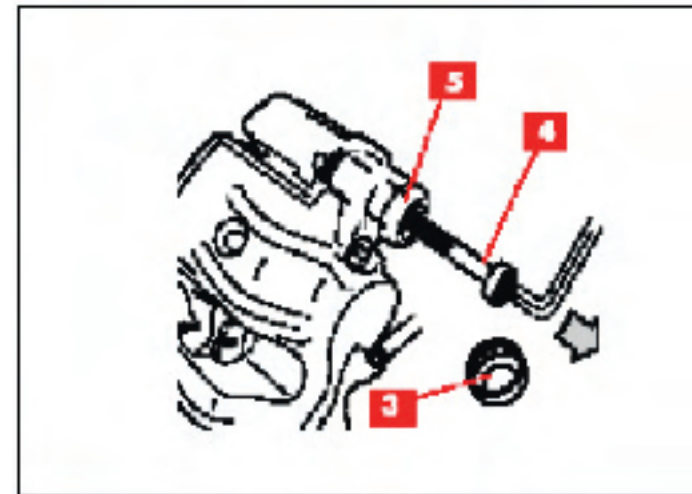


Figure 5-17 — Upper caliper slide bolt removal.

2. Remove the protective cap (3) of the upper caliper slide bolt (4) from the caliper slide (5).
3. Completely remove the upper caliper slide bolt.
4. Take the upper caliper slide bolt (6) out of the caliper slide bracket (7) using a suitable prybar if necessary.

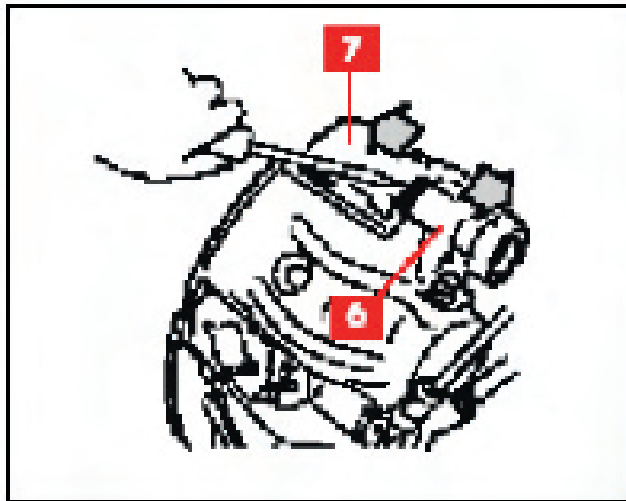


Figure 5-18 — Upper caliper slide removal.

### CAUTION

**Be careful not to damage the boot that protects the guide, by using the screwdriver in an improper way. In case of boot's damage, it is necessary to replace it with a new one.**

5. If you are replacing the caliper on rear wheels with leaf-spring suspension, both caliper slide bolts must be taken out and the caliper-body separated completely from the bracket.

### CAUTION

**The operations for retraction of the pistons described below cause an increase in the brake fluid level in the reservoir. Ensure that the fluid does not overflow, as it can damage the painted parts of the vehicle.**

6. Move the caliper-body away from the bracket (7), rotating it around the other guide until the pads can be taken out of the caliper (see Fig. 19).

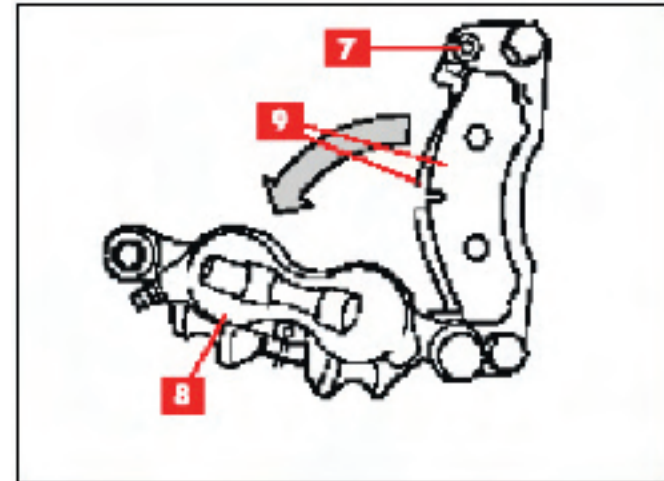


Figure 5-19 — Move caliper away from rotor.

7. Remove worn pads (9) (see Fig. 20).
8. Clean the pad supporting area using suitable materials and products (e.g. a damp cloth).

### CAUTION

**Do not use products that could damage the seals, such as paint thinner, mineral spirits, gasoline, etc.**

9. Check that no damage to the pistons or breakage of the dust covers has occurred.
10. Open the cap of the brake fluid reservoir and check the fluid level.



## CAUTION

*Perform the steps described below with caution. The retraction of pistons can cause brake fluid to spurt from the tank.*

*If the fluid comes in contact with painted parts it will damage them. Make sure the level of fluid in the tank is moderate, draining some fluid if necessary.*

11. Move the pistons backward using a retractor or other suitable tool (see Fig. 20).

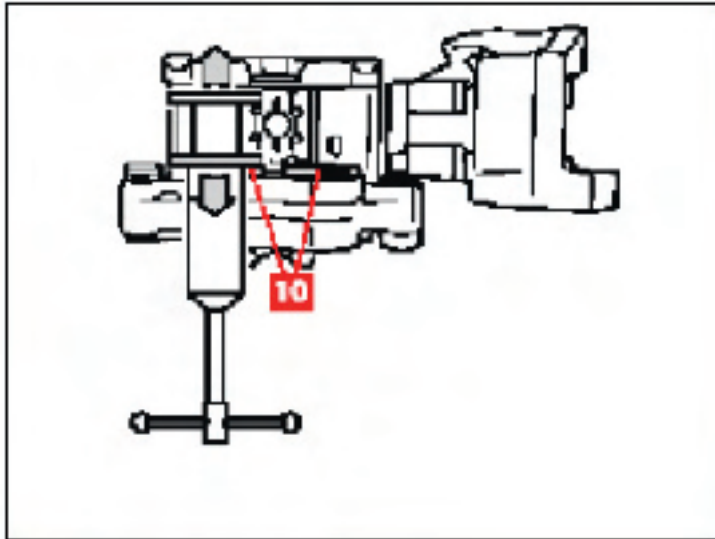


Figure 20 — Move the pistons backward.

## CAUTION

*During retraction of the pistons, ensure that you do not damage the dust covers. The dust covers must not be twisted or allowed trap air. If air is trapped, eliminate it lifting it with a special tool, without damaging the covers.*

12. Clean the pad attachment plate using suitable materials and products. A damp cloth is probably enough. Make sure that pistons are not damaged and dust covers are not broken.

## CAUTION

*Do not use products that could damage the seals, such as paint thinner, mineral spirits, gasoline, etc.*

13. Clean the braking surfaces of the disc with a degreasing product.

### Brake Pad Installation

1. Install the new pads in the caliper bracket.

## CAUTION

*The pads must be inserted with the friction material facing the disc.*

2. Carefully rotate the caliper body around the tightened sliding guide (see Fig. 21).

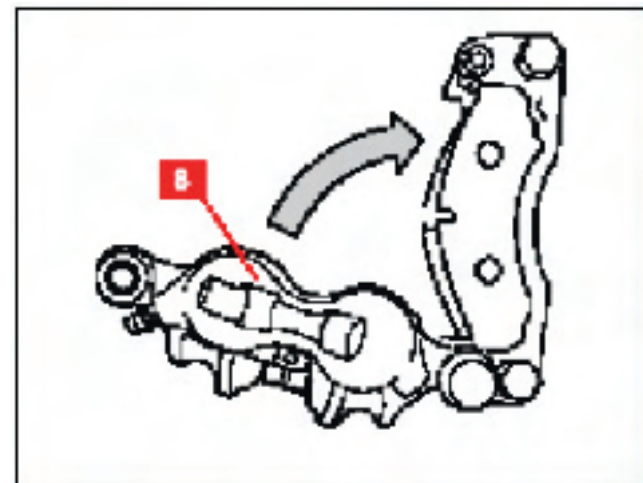


Figure 21 — Rotate caliper back onto rotor.

## CAUTION

*Make sure that the guide covers are not damaged from knocking against the caliper bracket.*

3. Move the caliper-body forward towards the bracket.
4. Carefully clean the guide seat with suitable material and products (e.g. a wet rag).
5. Reinsert the sliding guide in its seat.
6. Insert and tighten a new caliper slide pin(17) to the required torque (see Fig. 22).

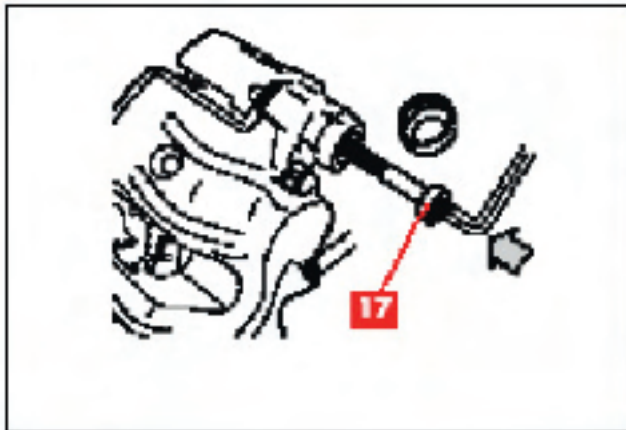


Figure 22 — Install a NEW caliper mounting bolt.

7. If replacing pads on rear wheels with leaf-spring suspension, the caliper-body must be repositioned on the bracket and both guides reinserted.
8. Carefully clean the part (18) to ensure a perfect seal and fit a new protective cap (19) (see Fig. 23).

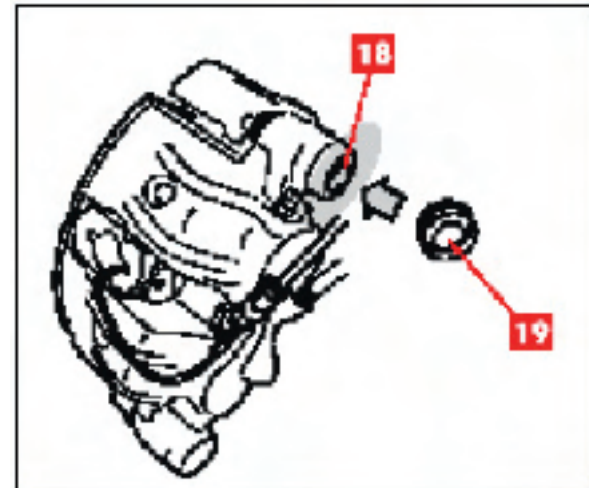


Figure 5-23 — Install protective caps to bolt heads.

## CAUTION

*Each time the pads are changed, all the clamping screws and protective caps must be replaced.*

9. Push the brake pedal repeatedly to move the pistons against the disc, until the pedal force and usual stroke are restored.
10. Check the brake fluid level in the reservoir and top up if necessary.
11. Close the brake fluid tank plug.
12. Burnish the new brake pads before returning the vehicle to the customer..

## CAUTION

*When using new pads that have just been fitted, remember that braking will be less effective during the first brake applications. You should therefore:*

- Reduce your speed
- Avoid sudden or prolonged braking

## Brake Pad Replacement (Brembo 68mm Caliper)

### Brake Pad Removal

## CAUTION

*During all the operations described below, the caliper brake fluid inlet must NOT be disconnected.*

1. Use a pair of pliers to remove the cotter pins from the pad retainer pins.
2. Remove the pad retainer pins.
3. Remove the cap from the brake fluid reservoir.

## CAUTION

*Pushing the caliper pistons back into their bores will cause an increase in the brake fluid level in the reservoir. Ensure that the fluid does not overflow, as it can damage the painted parts of the vehicle.*

4. Check the brake fluid level in the reservoir. If the fluid level is full, use a dedicated siphon tool to remove some of the brake fluid.

5. Slide the caliper outward to apply even pressure on the pistons. Use the old inner brake pad, or a piece of ¼-inch steel across the pistons to protect them. Use a disc brake pad spreader tool to force the pistons back into their bores.
6. Remove the brake pads.

### Clean, Dry, and Inspect

#### CLEAN

1. Clean the pad attachment plate using a damp cloth.
2. Clean the friction surface of the rotor using brake cleaner.

## CAUTION

*Do not use products that could damage the seals, such as paint thinner, mineral spirits, gasoline, etc.*

#### DRY AND INSPECT

1. Inspect the rotors for wear or damage.
2. Check the pistons for wear or damage.
3. Check the dust boots for wear or damage.
4. Repair or replace any worn or damaged parts.

### Brake Pad Installation (Brembo 68mm Caliper)

1. Install the new pads.

## WARNING:

*The pads must be inserted with the friction material facing the rotor.*

2. Install the pad retainer pins. It may be necessary to lift the pads slightly to align the holes in the pads.
3. Use a pair of pliers to install the hitch pins. When the hitch pin is installed, it should be located between the pad and the caliper housing.
4. Pump the brake pedal repeatedly to move the pistons out and press the pads against the rotor. Continue pumping the pedal until the usual pedal force and stroke are restored.
5. Check the brake fluid level in the reservoir. Add fluid if necessary.
6. Install the cap on the brake fluid reservoir.
7. Burnish the pads. Refer to *Burnishing the Rotors and Pads*.

### **WARNING:**

***When new pads have been installed, braking efficiency will be reduced until the brakes have been properly burnished. Reduce vehicle speed and avoid sudden or prolonged braking until the brakes have been burnished.***

### **Brake Pad Replacement (Bosch ZOH-T Caliper)**

#### ***Brake Pad Removal (Bosch ZOH-T Caliper)***

#### **NOTICE**

***Do not allow calipers to hang from the flexible hoses. Doing so can damage the hoses.***

1. Remove the caliper assembly. Refer to *Brake Caliper Replacement (Bosch ZOH-T Caliper)*.
2. Suspend the caliper.

3. Remove inner and outer pads from anchor plate and inspect for wear or damage.
4. Remove slippers. Clean anchor plate abutments and install new slippers. Inspect pins and pin boots for wear or damage. If any damage or defects are found, repair or replace as required.
5. Inspect the inside of the caliper assembly for signs of fluid leakage. If any is found, refer to *Brake Caliper Overhaul*.
6. Check machined surfaces of caliper. If any rust or corrosion is present, carefully clean surfaces with hand-held wire brush.

#### ***Clean, Dry, and Inspect (Bosch ZOH-T Caliper)***

1. Clean away any corrosion from the machined surfaces of the steering knuckle and caliper with a wire brush.

#### ***Brake Pad Installation (Bosch ZOH-T Caliper)***

#### **NOTICE**

***Make sure the brake hose is not twisted or kinked after installation. Damage to the hose could result.***

1. Lubricate the caliper and anchor plate sliding surfaces with Silicone Lube P/N 1801 0909 or the equivalent.
2. Position inner and outer pads over anchor plate slippers with lining material facing rotor.
3. Align flat on upper (top) guide pin head and rotate caliper closed to align with the flat on caliper upper (top) guide pin boss. Be careful when positioning caliper over the disc brake pads, rotor and upper (top) guide pin head to avoid tearing, cutting or dislodging piston boots or guide pin boots.
4. Torque caliper mounting bolt to specified value.

5. Install the brake hose retaining clip fastener and torque to vehicle manufacturer's specification.
6. If any hydraulic lines were opened or removed, bleed brake system.

**IMPORTANT:**

*Before moving the vehicle, pump the brake pedal several times in order to make sure the pedal is firm. Do not move the vehicle until you obtain a firm pedal.*

**Brake Pad Replacement (Meritor Quadraulic Caliper)**

**Brake Pad Removal (Meritor Quadraulic Caliper)**

1. Remove the master cylinder reservoir filler cap. Check the brake fluid level in the reservoir. If necessary, remove fluid to keep the reservoir from overflowing when compressing pistons into the caliper.
2. Remove the pad retainer spring bolt

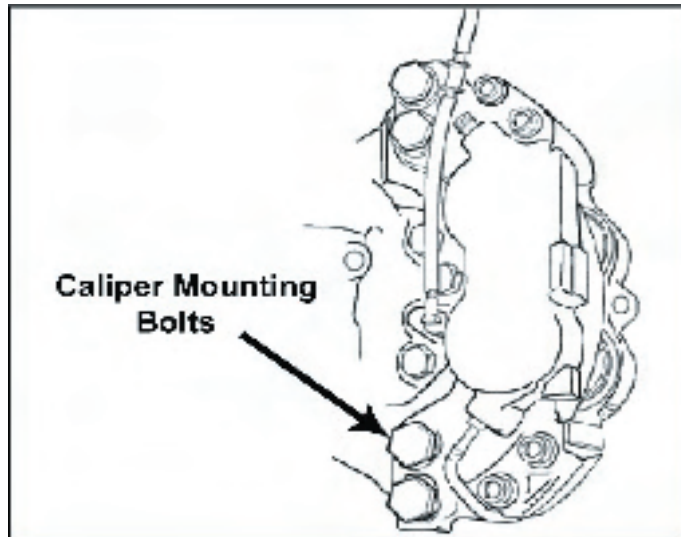


Figure 5-24 — Caliper Mounting Bolt Location

3. Compress the caliper pistons
4. Remove the brake pads.

**Brake Pad Installation (Meritor Quadraulic Caliper)**

1. Inspect the rotor for scoring, warping, cracks, bluing, heat spots or other damage or defects and minimum thickness. Repair or replace if necessary.
2. Inspect the disc brake calipers for leakage, damage or defects to piston boots, seals or pistons. Replace or repair the parts as required.
3. Clean and inspect the lining rail covers. If they are worn, they must be replaced.

**NOTICE**

*The inboard and outboard brake pads are identical, except when they are equipped with a mechanical wear sensor.*

4. Install the brake pads. Ensure that the friction surface is against the rotor. Install the pad retainer spring and tighten the bolt to 30 lb-ft (40 N·m) of torque.

**NOTICE**

*Brake pad clearance adjustment is automatic.*

5. Fill the master cylinder reservoir with new, clean, high-performance DOT 3 brake fluid. Make several brake applications to move the brake pistons and linings out into contact with the brake rotors.
6. Recheck master cylinder reservoir and top off as necessary to manufacturer's recommended level.
7. Bleed the brake system. Refer to *Brake System Bleeding*.

## Bleed Screw Replacement

### *Bleed Screw Removal*

1. Remove the cap from the bleed screw.
2. Loosen the bleed screw.
3. Inside the vehicle, position a spacer between the front edge of the driver seat and brake pedal so that the pedal is pressed throughout the repair. This is done to avoid any leakage of brake fluid from the brake hose.
4. Remove the bleed screw.

### *Inspect*

1. Carefully inspect threads in the caliper bleed port for damage.
2. Repair or replace worn or damaged parts.

### *Bleed Screw Installation*

1. Thread the bleed screw into the port on the caliper.
2. Tighten the bleed screw.
  - On Brembo 52mm calipers, the bleed screw should be tightened to 124 lb in (14 N·m).
  - On Brembo 68mm calipers, the bleed screw should be tightened to 177 lb in 20 N·m.
  - On Bosch ZOH-T calipers, the bleed screw should be tightened to 97 lb in (11 N·m).
  - On Meritor Quadraulic calipers, the bleed screw should be tightened to 150 lb in (17 N·m).
3. Bleed the brakes. Refer to *Brake System Bleeding*.
4. Install the cap on the bleed screw.

## Seal and Dust Boot Replacement (Brembo 52mm Caliper)

### *Seal and Dust Boot Removal (Brembo 52mm Caliper)*

1. Loosen, but do not remove, the fluid line at the caliper.
2. Remove the protective caps (4) of the caliper slide pin guides (6) (see Fig. 25).

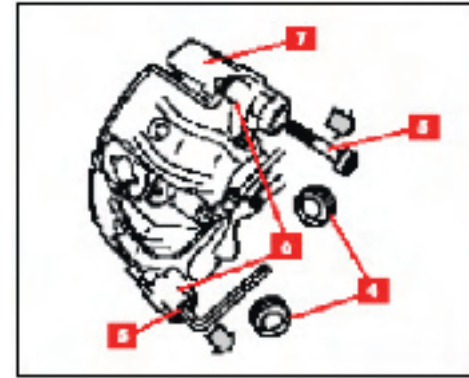


Figure 5-25 — Removal of the screw of the sliding guides

3. Loosen and remove the caliper slide pins (5) of the sliding guides (see Fig. 26).
4. Remove both the two sliding guides (6) from the caliper bracket (7), using a suitable prybar if required (see Fig. 26).

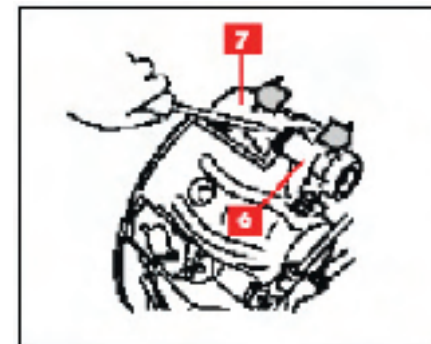


Figure 5-26 — Remove caliper slide pin guides.

5. Lift the caliper-body from the rotor.

### CAUTION

*The brake fluid pipes must remain free, not tensioned. If the pipes are tensioned, they can split with consequent loss of the brake fluid.*

6. Using a felt pen, mark the disc rotation direction on the pads to ensure that they are refitted correctly. When the caliper-body is moved away, the pads may remain attached to the disc due to wear.
7. Remove the pads from the caliper.
8. Place a spacer inside the cab between the seat and the brake pedal so that the pedal remains depressed throughout the procedure.
9. Unscrew completely the caliper feed hose by rotating the caliper.
10. Move the caliper-body away from the vehicle, resting it on a suitable work surface.
11. Remove the protection cap on the bleed port, open the bleed screw and turn the caliper upside down over a container to allow the fluid still inside to drain out completely.
12. Re-close the bleed port.
13. Place a spacer, with dimensions similar to those of the brake disc, between the pistons and the outer side of the caliper-body.
14. Force the pistons from the body by using compressed air from the inlet fitting of the caliper.
15. When pressure is introduced inside the caliper, the pistons will be pushed out of their seats, stopping against the spacer.

16. Remove the spacer from the caliper.
17. Take the pistons out completely, being careful not to damage the external diameter.

### CAUTION

*Damage to the outer surface of the piston will make it unserviceable.*

18. Release the dust boots from their seats.
  19. Remove the seals from the caliper bores.
  20. Unscrew the bleeding screw (5).
  21. Clean carefully the caliper bores using suitable materials and products.
- ### CAUTION
- Do not use products that could damage the seals, such as perchloroethylene thinner, gasoline, etc. Once removed, the seals must not be re-used but replaced with the new ones.*
22. Moisten the new seals and external diameter of the pistons with brake fluid.
  23. Install the new seals in the seats inside the caliper body, ensuring that they are perfectly positioned.
  24. Moisten the pistons around their outer circumference using the brake fluid.
  25. Insert the dust boots (14) on the pistons (12) (see Fig. 27).

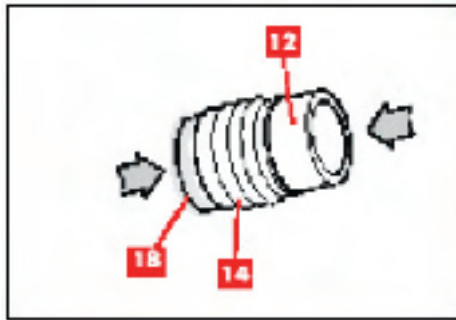


Figure 27 —Insert the dust boots on the piston

26. Moisten the dust boots fitting collar with brake fluid.
27. Insert the dust boots in the bore of the caliper.
28. Insert each piston in its seat, exerting a uniform pressure over the whole of the piston face.
29. Push each piston into its seat as far as it will go.
30. Check the correct position of the dust boot.

### CAUTION

*Incorrect positioning of the dust boots will seriously damage the caliper and affect correct operation.*

31. Tighten the bleeding screw on the caliper body and close it at the prescribed torque.
32. Attach the connector of the feed hose to the caliper (by rotating the caliper itself).
33. Put the caliper-body on the bracket, retightening the main sliding guide to the prescribed torque. Be careful not to damage the boots.

### NOTICE

*The main guide is the first guide the disc turns past during its standard forward direction.*

34. Mount the pads in the caliper, ensuring that the arrows are pointing in the correct direction.

### CAUTION

*Ensure that the friction surfaces do not become dirty with grease; if necessary, all traces of grease must be removed with sand paper.*

### CAUTION

*The pads must be inserted with the friction material facing the disc. Incorrect positioning of the pads will affect braking performance and seriously damage the caliper.*

35. Rotate the caliper-body around the main guide until it is repositioned on the disc.
36. Reconnect the secondary sliding guide, re-tightening the secondary guide bolt to the prescribed torque.
37. Install new protective caps carefully cleaning the seats.
38. Tighten the connector of the feed hose at the prescribed torque.
39. Remove the spacer previously positioned inside the vehicle cab, thus releasing the brake pedal and allowing the circuit to re-open.
40. Loosen the connection between the brake hose and the steel line allowing any twist or kink in the hose to straighten. Tighten at the prescribed torque.
41. Bleed the system.
42. Check every possible fluid leak location (press the brake pedal for at least 30 seconds).



43. Push the brake pedal repeatedly to move the pistons against the disc, until the pedal force and usual stroke are restored.
44. Check the brake fluid level in the reservoir and top off if necessary.

### CAUTION

***If there are fluid leaks from the caliper, repeat all the above operations to ascertain the cause and correct the fault.***

#### ***Clean, Dry, and Inspect (Brembo 52mm Caliper)***

##### *CLEAN PARTS*

*For ground or polished parts*

### CAUTION

***Do not use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts will result.***

Use safety solvent or equivalent to clean the surfaces of ground or polished parts.

*For rough metal parts*

Use a cleaning solvent or weak alkaline solution in a hot solution tank to clean rough metal parts. If a hot solution tank is used, follow the instructions below:

2. Place the rough parts in the hot solution tank.
3. Leave the rough parts in the tank until they are completely cleaned and heated.
4. Remove the rough parts from the tank.

5. Thoroughly wash the rough parts with water until the alkaline solution is completely washed off of the parts.

##### *DRY AND INSPECT PARTS*

1. Use soft, clean paper or cloth rags, or compressed air to completely dry parts immediately after cleaning them.
2. Carefully inspect each part for wear or damage.
3. Repair or replace worn or damaged parts.

#### ***Seal and Dust Boot Installation (Brembo 52mm Caliper)***

1. Lubricate the new seals with brake grease.
2. Install the new seals in the seats inside the caliper body. Make sure the seals are properly seated before continuing.
3. Lubricate the pistons around their outer diameter with brake grease.
4. Install dust boot on the caliper.
5. Install the pistons. Refer to *Caliper Piston Replacement (Brembo 52mm Caliper)*.
6. Install the caliper. Refer to *Caliper Replacement (Brembo 52mm Caliper)*.

#### ***Seal and Dust Boot Replacement (Brembo 68mm Caliper)***

##### ***Seal and Dust Boot Removal (Brembo 68mm Caliper)***

1. Remove the caliper. Refer to *Caliper Replacement (Brembo 68mm Caliper)*.
2. Remove the pistons. Refer to *Caliper Piston Replacement (Brembo 68mm Caliper)*.
3. Remove the dust boots.

4. Remove the piston seals.

**Clean, Dry, and Inspect Parts (Brembo 68mm Caliper)**

CLEAN PARTS

*For ground or polished parts*

**CAUTION**

**Do not use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts will result.**

Use safety solvent or equivalent to clean the surfaces of ground or polished parts.

*For rough metal parts*

Use a cleaning solvent or weak alkaline solution in a hot solution tank to clean rough metal parts. If a hot solution tank is used, follow the instructions below:

1. Place the rough parts in the hot solution tank.
2. Leave the rough parts in the tank until they are completely cleaned and heated.
3. Remove the rough parts from the tank.
4. Thoroughly wash the rough parts with water until the alkaline solution is completely washed off of the parts.

DRY AND INSPECT PARTS

1. Use soft, clean paper or cloth rags, or compressed air to completely dry parts immediately after cleaning them.
2. Carefully inspect each part for wear or damage.
3. Repair or replace worn or damaged parts.

**Seal and Dust Boot Installation (Brembo 68mm Caliper)**

1. Lubricate the new seals and the outside diameter of the pistons with brake grease.
2. Insert the seals into the seats of the caliper.
3. Lubricate the inner and outer edges of the dust boots with brake grease.
4. Install the dust boots in the caliper.
5. Install the caliper pistons. Refer to *Caliper Piston Replacement (Brembo 68mm Caliper)*.
6. Install the caliper. Refer to *Caliper Replacement (Brembo 68mm Caliper)*.

**Seal and Dust Boot Replacement (Bosch ZOH-T Caliper)**

**Seal and Dust Boot Removal (Bosch ZOH-T Caliper)**

1. Remove the caliper. Refer to *Caliper Replacement (Bosch ZOH-T Caliper)*.
2. Remove the caliper pistons. Refer to *Caliper Piston Replacement (Bosch ZOH-T Caliper)*.
3. Remove the dust boots.
4. Remove the seals.

### ***Clean, Dry, and Inspect (Bosch ZOH-T Caliper)***

#### *CLEAN PARTS*

*For ground or polished parts*

#### **CAUTION:**

***Do not use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts will result.***

***Use safety solvent or equivalent to clean the surfaces of ground or polished parts.***

#### *FOR ROUGH METAL PARTS*

Use a cleaning solvent or weak alkaline solution in a hot solution tank to clean rough metal parts. If a hot solution tank is used, follow the instructions below:

1. Place the rough parts in the hot solution tank.
2. Leave the rough parts in the tank until they are completely cleaned and heated.
3. Remove the rough parts from the tank.
4. Thoroughly wash the rough parts with water until the alkaline solution is completely washed off of the parts.

#### *DRY AND INSPECT PARTS*

1. Use soft, clean paper or cloth rags, or compressed air to completely dry parts immediately after cleaning.
2. Carefully inspect each part for wear or damage.
3. Repair or replace worn or damaged parts.

### ***Seal and Dust Boot Installation (Bosch ZOH-T Caliper)***

1. Lubricate the new seals with brake grease.

2. Install the new seals in the seats inside the caliper body. Make sure the seals are properly seated before continuing.
3. Lubricate the pistons around their outer diameter with brake grease.
4. Install dust boot on the caliper.
5. Install the pistons. Refer to *Caliper Piston Replacement (Bosch ZOH-T Caliper)*.
6. Install the caliper. Refer to *Caliper Replacement (Bosch ZOH-T Caliper)*.

### ***Seal and Dust Boot Replacement (Meritor Quadraulic Caliper)***

#### ***Seal and Dust Boot Removal (Meritor Quadraulic Caliper)***

1. Remove the caliper. Refer to *Caliper Replacement (Meritor Quadraulic Caliper)*.
2. Remove the caliper pistons. Refer to *Caliper Piston Replacement (Meritor Quadraulic Caliper)*.
3. Remove the dust boots.
4. Remove the seals.

#### ***Clean, Dry, and Inspect (Meritor Quadraulic Caliper)***

#### *CLEAN PARTS*

*For ground or polished parts*

#### **CAUTION:**

***Do not use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts will result.***

Use safety solvent or equivalent to clean the surfaces of ground or polished parts.

*For rough metal parts*

Use a cleaning solvent or weak alkaline solution in a hot solution tank to clean rough metal parts. If a hot solution tank is used, follow the instructions below:

1. Place the rough parts in the hot solution tank.
2. Leave the rough parts in the tank until they are completely cleaned and heated.
3. Remove the rough parts from the tank.
4. Thoroughly wash the rough parts with water until the alkaline solution is completely washed off of the parts.

#### DRY AND INSPECT PARTS

1. Use soft, clean paper or cloth rags, or compressed air to completely dry parts immediately after cleaning them.
2. Carefully inspect each part for wear or damage.
3. Repair or replace worn or damaged parts.

#### Seal and Dust Boot Installation (Meritor Quadraulic Caliper)

1. Lubricate the new seals with brake grease.
2. Install the new seals in the seats inside the caliper body. Make sure the seals are properly seated before continuing.
3. Lubricate the pistons around their outer diameter with brake grease.
4. Install dust boot on the caliper.
5. Install the pistons. Refer to *Caliper Piston Replacement (Meritor Quadraulic Caliper)*.

6. Install the caliper. Refer to *Caliper Replacement (Meritor Quadraulic Caliper)*.

#### Caliper Piston Replacement (Brembo 52mm Caliper)

##### *Caliper Piston Removal (Brembo 52mm Caliper)*

1. Remove the caliper. Refer to *Caliper Replacement (Brembo 52mm Caliper)*.
2. Loosen the bleed screw, but do not remove it.
3. Place one end of a hose on the tip of the bleed screw and the other end in a container to catch the brake fluid as it drains.
4. Use disc brake pad spreader tool to press both pistons back into their bores, which will force the brake fluid out of the caliper.

#### CAUTION

**While pressing the pistons back into their bores, be careful to not damage the insulating ring and the dust covers. The dust covers must not be twisted or allowed to trap air. If air becomes trapped in the dust cover, use a flat blade to gently lift the edge of the seal to release the air.**

#### CAUTION

**Do not place your fingers in front of the piston in an attempt to catch or protect it when applying compressed air. This could result in serious injury.**

## CAUTION

**To prevent serious personal injury, always wear safe eye protection when you perform vehicle maintenance or service.**

5. Tighten the bleed screw to 14 N·m (124 lb in).
6. Install a block of wood into the caliper in front of the caliper pistons.

## CAUTION

**When removing the pistons from the caliper bore, only direct enough compressed air into the caliper brake fluid inlet to ease the pistons out of the bore. Do not exceed 25 psi (172 kPa). Damage to components will result.**

7. Apply low air pressure (no more than 25 psi [172 kPa] to the fluid port in the caliper to move the caliper pistons out to the wood block.
8. Remove the pistons.
9. Remove the dust boots and the piston seals. Refer to *Seal and Dust Boot Replacement (Brembo 52mm Caliper)*.

### **Clean, Dry, and Inspect (Brembo 52mm Caliper)**

#### CLEAN PARTS

*For ground or polished parts*

## CAUTION

**Do not use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts will result.**

Use safety solvent or equivalent to clean the surfaces of ground or polished parts.

*For rough metal parts*

Use a cleaning solvent or weak alkaline solution in a hot solution tank to clean rough metal parts. If a hot solution tank is used, follow the instructions below:

1. Place the rough parts in the hot solution tank.
2. Leave the rough parts in the tank until they are completely cleaned and heated.
3. Remove the rough parts from the tank.
4. Thoroughly wash the rough parts with water until the alkaline solution is completely washed off of the parts.

#### DRY AND INSPECT PARTS

1. Use soft, clean paper or cloth rags, or compressed air to completely dry parts immediately after cleaning them.
2. Carefully inspect each part for wear or damage.
3. Repair or replace worn or damaged parts.

### **Caliper Piston Installation (Brembo 52mm Caliper)**

1. Install the seals and dust boots. Refer to *Seal and Dust Boot Replacement (Brembo 52mm Caliper)*.
2. Install the pistons in their bores. Make sure the lip of the dust boot is seated in the groove in the piston.
3. Check the dust boot to determine if there is any air trapped in the dust boot. If there is air trapped, use a flat blade tool to gently lift the edge of the dust boot to release the air.

## CAUTION

***Incorrect positioning of the dust boots will seriously damage the caliper and affect correct operation.***

4. Tighten the bleed screw on the caliper and tighten to the prescribed torque.
5. Install the connector of the brake hose to the caliper (by rotating the caliper itself).
6. Put the caliper-body on the bracket, tightening the top guide pin to the prescribed torque. Be careful not to damage the boots.
7. Install the pads in the caliper. If reusing the brake pads, ensure that the arrows applied before disassembly are pointing in the correct direction.

## CAUTION

***Ensure that the friction surfaces do not become dirty with grease; if necessary, all traces of grease must be removed with sand paper.***

## CAUTION

***The pads must be inserted with the friction material facing the disc. Incorrect positioning of the pads will affect braking performance and seriously damage the caliper.***

8. Rotate the caliper-body on the top guide pin until it is repositioned on the disc.

9. Install the lower guide pin, tightening the bolt to the prescribed torque.
10. Install the new protective caps carefully cleaning the seats.
11. Tighten the connector of the feed hose at the prescribed torque.
12. Remove the spacer previously positioned inside the vehicle cab, thus releasing the brake pedal and allowing the pedal to move
13. Loosen the connection between the rubber brake hose and the steel line removing any twist or distortion in the hose. Tighten at the prescribed torque.
14. Bleed the system.
15. Pump the brake pedal repeatedly to move the pistons out until the pads are pressed against the rotor. Continue pumping the brake pedal until pedal force returns to normal and the normal stroke is restored.
16. Check the brake fluid level in the reservoir and refill as necessary.
17. Have an assistant press and hold the brake pedal. While the system is under pressure, check all of the brake fittings, lines, and hoses for possible fluid leaks.
18. Re-check the brake fluid level in the reservoir. Add fluid if necessary.

## CAUTION

***If there are fluid leaks from the caliper, repeat all the above operations to ascertain the cause and correct the fault.***

## Caliper Piston Replacement (Brembo 68mm Caliper)

### Caliper Piston Removal (Brembo 68mm Caliper)

1. Remove the brake pads. Refer to *Brake Pad Replacement (Brembo 68mm Caliper)*.
2. Remove the caliper. Refer to *Caliper Replacement (Brembo 68mm Caliper)*.
3. Use disc brake pad spreader tool to press both pistons back into their bores, which will force the brake fluid out of the caliper.

### CAUTION

**While pressing the pistons back into their bores, be careful to not damage the seal and the dust boots. The dust boots must not be twisted or allowed to trap air. If air becomes trapped in the dust cover, use a flat blade to gently lift the edge of the seal to release the air.**

### CAUTION:

**Do not place your fingers in front of the piston in an attempt to catch or protect it when applying compressed air. This could result in serious injury.**

### CAUTION

**To prevent serious personal injury, always wear safe eye protection when you perform vehicle maintenance or service.**

4. Install a block of wood into the caliper in front of the caliper pistons.

### CAUTION

**When removing the pistons from the caliper bore, only direct enough compressed air into the caliper brake fluid inlet to ease the pistons out of the bore. Do not exceed 25 psi (172 kPa). Damage to components will result.**

5. Apply low air pressure (no more than 25 psi [172 kPa] to the fluid port in the caliper to move the caliper pistons out to the wood block.
6. Remove the pistons.
7. Remove the dust boots and the piston seals. Refer to *Seal and Dust Boot Replacement (Brembo 68mm Caliper)*.

### Clean, Dry, and Inspect (Brembo 68mm Caliper)

#### CLEAN PARTS

*For ground or polished parts*

### CAUTION

**Do not use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts will result.**

Use safety solvent or equivalent to clean the surfaces of ground or polished parts.

*For rough metal parts*

Use a cleaning solvent or weak alkaline solution in a hot solution tank to clean rough metal parts. If a hot solution tank is used, follow the instructions below:

1. Place the rough parts in the hot solution tank.

2. Leave the rough parts in the tank until they are completely cleaned and heated.
3. Remove the rough parts from the tank.
4. Thoroughly wash the rough parts with water until the alkaline solution is completely washed off of the parts.

*DRY AND INSPECT PARTS*

1. Use soft, clean paper or cloth rags, or compressed air to completely dry parts immediately after cleaning them.
2. Carefully inspect each part for wear or damage.
3. Repair or replace worn or damaged parts.

**Caliper Piston Installation (Brembo 68mm Caliper)**

1. Install the seals and dust boots in the caliper. Refer to *Seal and Dust Boot Replacement (Brembo 68mm Caliper)*.

**CAUTION**

*While pressing the pistons back into their bores, be careful to not damage the seal and the dust boots. The dust boots must not be twisted or allowed to trap air. If air becomes trapped in the dust cover, use a flat blade to gently lift the edge of the seal to release the air.*

**CAUTION**

*Do not place your fingers in front of the piston in an attempt to catch or protect it when applying compressed air. This could result in serious injury.*

**CAUTION**

*To prevent serious personal injury, always wear safe eye protection when you perform vehicle maintenance or service.*

2. Use an air nozzle to force compressed air into the caliper through the brake fluid inlet port. The compressed air will force the edges of the seals out. Insert the piston through the seal. Once the leading edge of the piston is through the seal, remove the compressed air.
3. Press the pistons into the bores. Be careful to not damage the seals or the boots. Make sure that after the pistons have been installed that the dust boots are properly seated in the seal groove on the piston.

**CAUTION**

*While pressing the pistons back into their bores, be careful to not damage the seal and the dust boots. The dust boots must not be twisted or allowed to trap air. If air becomes trapped in the dust cover, use a flat blade to gently lift the edge of the seal to release the air.*

4. Use a flat blade tool to lift the edge of the boots to release any air that may be trapped inside.
5. Install the caliper. Refer to *Caliper Replacement (Brembo 68mm Caliper)*.
6. Install the brake pads. Refer to *Brake Pad Replacement (Brembo 68mm Caliper)*.



7. Pump the brake pedal repeatedly to move the pistons out until the pads are pressed against the rotor. Continue pumping the brake pedal until pedal force returns to normal and the normal stroke is restored.
8. Have an assistant press and hold the brake pedal. While the system is under pressure, check all of the brake fittings, lines, and hoses for possible fluid leaks.
9. Check the brake fluid level in the reservoir. Add fluid if necessary.

### Caliper Piston Replacement (Bosch ZOH-T Caliper)

#### Caliper Piston Removal (Bosch ZOH-T Caliper)

1. Remove the caliper. Refer to *Caliper Replacement (Bosch ZOH-T Caliper)*.
2. Loosen the bleed screw, but do not remove it.
3. Place one end of a hose on the tip of the bleed screw and the other end in a container to catch the brake fluid as it drains.
4. Use disc brake pad spreader tool to press both pistons back into their bores, which will force the brake fluid out of the caliper.

#### CAUTION

***While pressing the pistons back into their bores, be careful to not damage the insulating ring and the dust covers. The dust covers must not be twisted or allowed to trap air. If air becomes trapped in the dust cover, use a flat blade to gently lift the edge of the seal to release the air.***

#### CAUTION

***Do not place your fingers in front of the piston in an attempt to catch or protect it when applying compressed air. This could result in serious injury.***

#### CAUTION

***To prevent serious personal injury, always wear safe eye protection when you perform vehicle maintenance or service.***

5. Tighten the bleed screw to 14 N·m (124 lb in).
6. Install a block of wood into the caliper in front of the caliper pistons.

#### CAUTION:

***When removing the pistons from the caliper bore, only direct enough compressed air into the caliper brake fluid inlet to ease the pistons out of the bore. Do not exceed 25 psi (172 kPa). Damage to components will result.***

7. Apply low air pressure (no more than 25 psi [172 kPa]) to the fluid port in the caliper to move the caliper pistons out to the wood block.
8. Remove the pistons.
9. Remove the dust boots and the piston seals. Refer to *Seal and Dust Boot Replacement (Bosch ZOH-T Caliper)*.

### ***Clean, Dry, and Inspect (Bosch ZOH-T Caliper)***

#### **CLEAN PARTS**

*For ground or polished parts*

### **CAUTION**

***Do not use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts will result.***

Use safety solvent or equivalent to clean the surfaces of ground or polished parts.

*For rough metal parts*

Use a cleaning solvent or weak alkaline solution in a hot solution tank to clean rough metal parts. If a hot solution tank is used, follow the instructions below:

1. Place the rough parts in the hot solution tank.
2. Leave the rough parts in the tank until they are completely cleaned and heated.
3. Remove the rough parts from the tank.
4. Thoroughly wash the rough parts with water until the alkaline solution is completely washed off of the parts.

#### **DRY AND INSPECT PARTS**

1. Use soft, clean paper or cloth rags, or compressed air to completely dry parts immediately after cleaning them.
2. Carefully inspect each part for wear or damage.
3. Repair or replace worn or damaged parts.

### ***Caliper Piston Installation (Bosch ZOH-T Caliper)***

1. Install the seals and dust boots. Refer to *Seal and Dust Boot Replacement (Bosch ZOH-T Caliper)*.
2. Install the pistons in their bores. Make sure the lip of the dust boot is seated in the groove in the piston.
3. Check the dust boot to determine if there is any air trapped in the dust boot. If there is air trapped, use a flat blade tool to gently lift the edge of the dust boot to release the air.
4. Pump the brake pedal repeatedly to move the pistons out until the pads are pressed against the rotor. Continue pumping the brake pedal until pedal force returns to normal and the normal stroke is restored.
5. Have an assistant press and hold the brake pedal. While the system is under pressure, check all of the brake fittings, lines, and hoses for possible fluid leaks.
6. Check the brake fluid level in the reservoir. Add fluid if necessary.

### ***Caliper Piston Replacement (Meritor Quadraulic Caliper)***

#### ***Caliper Piston Removal (Meritor Quadraulic Caliper)***

1. Remove the caliper. Refer to *Caliper Replacement (Meritor Quadraulic Caliper)*.
2. Loosen the bleed screw, but do not remove it.
3. Place one end of a hose on the tip of the bleed screw and the other end in a container to catch the brake fluid as it drains.
4. Use disc brake pad spreader tool to press both pistons back into their bores, which will force the brake fluid out of the caliper.

## CAUTION

*While pressing the pistons back into their bores, be careful to not damage the insulating ring and the dust covers. The dust covers must not be twisted or allowed to trap air. If air becomes trapped in the dust cover, use a flat blade to gently lift the edge of the seal to release the air.*

## CAUTION

*Do not place your fingers in front of the piston in an attempt to catch or protect it when applying compressed air. This could result in serious injury.*

## CAUTION

*To prevent serious personal injury, always wear safe eye protection when you perform vehicle maintenance or service.*

5. Tighten the bleed screw to 14 N·m (124 lb in).
6. Install a block of wood into the caliper in front of the caliper pistons.

## CAUTION

*When removing the pistons from the caliper bore, only direct enough compressed air into the caliper brake fluid inlet to ease the pistons out of the bore. Do not exceed 25 psi (172 kPa). Damage to components will result.*

7. Apply low air pressure (no more than 25 psi [172 kPa] to the fluid port in the caliper to move the caliper pistons out to the wood block.
8. Remove the pistons.

Remove the dust boots and the piston seals. Refer to *Seal and Dust Boot Replacement (Meritor Quadraulic Caliper)*.

*Clean, Dry, and Inspect (Meritor Quadraulic Caliper)*

CLEAN PARTS

*For ground or polished parts*

## CAUTION:

*Do not use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts will result.*

Use safety solvent or equivalent to clean the surfaces of ground or polished parts.

*For rough metal parts*

Use a cleaning solvent or weak alkaline solution in a hot solution tank to clean rough metal parts. If a hot solution tank is used, follow the instructions below:

1. Place the rough parts in the hot solution tank.
2. Leave the rough parts in the tank until they are completely cleaned and heated.
3. Remove the rough parts from the tank.
4. Thoroughly wash the rough parts with water until the alkaline solution is completely washed off of the parts.

DRY AND INSPECT PARTS

1. Use soft, clean paper or cloth rags, or compressed air to completely dry parts immediately after cleaning them.

2. Carefully inspect each part for wear or damage.
3. Repair or replace worn or damaged parts.

#### **Caliper Piston Installation (Meritor Quadraulic Caliper)**

1. Install the seals and dust boots. Refer to *Seal and Dust Boot Replacement (Meritor Quadraulic Caliper)*.
2. Install the pistons in their bores. Make sure the lip of the dust boot is seated in the groove in the piston.
3. Check the dust boot to determine if there is any air trapped in the dust boot. If there is air trapped, use a flat blade tool to gently lift the edge of the dust boot to release the air.
4. Pump the brake pedal repeatedly to move the pistons out until the pads are pressed against the rotor. Continue pumping the brake pedal until pedal force returns to normal and the normal stroke is restored.
5. Have an assistant press and hold the brake pedal. While the system is under pressure, check all of the brake fittings, lines, and hoses for possible fluid leaks.
6. Check the brake fluid level in the reservoir. Add fluid if necessary.

#### **Caliper Guide Pin and Dust Boot Replacement 52mm Caliper)**

##### **Guide Pin and Dust Boot Removal (Brembo 52mm Caliper)**

1. Remove the caliper. Refer to *Caliper Replacement (Brembo 52mm Caliper)*.
2. Remove the caliper guide pin.
3. Remove the dust boot.

#### **Clean, Dry, and Inspect (Brembo 52mm Caliper)**

##### **CLEAN**

1. Clean the caliper guide pin bore.
2. Clean the dust boot.

##### **DRY AND INSPECT**

1. Use soft, clean paper or cloth rags, or compressed air to completely dry parts immediately after cleaning them.
2. Inspect the dust boots for tears or other damage.
3. Inspect the guide pin bores for wear or damage.
4. Repair or replace worn or damaged parts.

#### **Guide Pin and Boot Installation (Brembo 52mm Caliper)**

1. Lubricate the following components with brake grease:
  - a. Inside of the caliper guide pin bores in the calipers.
  - b. The outside of the caliper guide pins.
  - c. The inside of the dust boots.
2. Install the dust boots on their seats.
3. Install the guide sleeves.
4. Install the caliper. Refer to *Caliper Replacement (Brembo 52mm Caliper)*.

#### **Caliper Guide Pin and Dust Boot Replacement 68mm Caliper)**

##### **Guide Pin and Dust Boot Removal (Brembo 68mm Caliper)**

1. Remove the caliper. Refer to *Caliper Replacement (Brembo 68mm Caliper)*.

2. Remove the guide sleeves from the caliper.
3. Remove the dust boots from the caliper.

***Clean, Dry, and Inspect (Brembo 68mm Caliper)***

**CLEAN**

1. Clean all the surfaces of the caliper body.
2. Clean the dust boots.
3. Clean the guide pin bores.

**DRY AND INSPECT**

1. Use soft, clean paper or cloth rags, or compressed air to completely dry parts immediately after cleaning them.
2. Inspect the dust boots for tears or other damage.
3. Inspect the guide pin bores for wear or damage.
4. Repair or replace worn or damaged parts.

***Guide Pin and Boot Installation (Brembo 68mm Caliper)***

1. Lubricate the following components with brake grease:
  - a. Inside of the caliper guide pin bores.
  - b. The outside of the caliper guide pins.
  - c. The inside of the dust boots.
2. Install the dust boots on their seats.
3. Install the guide sleeves.
4. Install the caliper. Refer to *Caliper Replacement (Brembo 68mm Caliper)*.

**CAUTION:**

***Be careful not to damage the boots when installing the caliper.***

**Guide Pin and Boot Replacement (Bosch ZOH-T Caliper)**

***Guide Pin and Boot Removal (Bosch ZOH-T Caliper)***

1. Remove the caliper. Refer to *Caliper Replacement (Bosch ZOH-T Caliper)*.
2. Remove the caliper guide pin.
3. Remove the dust boot.

***Clean, Dry, and Inspect (Bosch ZOH-T Caliper)***

**CLEAN**

1. Clean the caliper guide pin bore.
2. Clean the dust boot.

**DRY AND INSPECT**

1. Use soft, clean paper or cloth rags, or compressed air to completely dry parts immediately after cleaning them.
2. Inspect the dust boots for tears or other damage.
3. Inspect the guide pin bores for wear or damage.
4. Repair or replace worn or damaged parts.

***Guide Pin and Boot Installation (Bosch ZOH-T Caliper)***

1. Lubricate the following components with brake grease:
  - a. Inside of the caliper guide pins.
  - b. The outside of the caliper guide pins.
  - c. The inside of the dust boots.
2. Install the dust boots on their seats.
3. Install the guide sleeves.
4. Install the caliper. Refer to *Caliper Replacement (Bosch ZOH-T Caliper)*.

## CALIPER MOUNTING BOLT REPLACEMENT

### CAUTION

**When the caliper mounting bolts are removed, they MUST be replaced with new bolts.**

#### Caliper Mounting Bolt Removal

1. Loosen and remove the caliper mounting bolts.

#### Caliper Mounting Bolt Installation

1. Install the new caliper mounting bolts.
2. Tighten the caliper mounting bolt:
  - The caliper mounting bolts on Brembo 52mm calipers are tightened to 34 N·m (25 lb ft).
  - The caliper mounting bolts on Brembo 68mm calipers are tightened to 115 N·m (85 lb ft).
  - The caliper mounting bolts on Bosch ZOH-T calipers are tightened to 115 N·m (85 lb ft).
  - The caliper mounting bolts on Meritor Quadraulic calipers are tightened to 115 N·m (85 lb ft).

## BRAKE ROTOR REPLACEMENT

### Brake Rotor Removal

1. Remove the brake caliper. Refer to *Brake Caliper Replacement (Front)* or *Brake Caliper Replacement (Rear)*.
2. Remove the hub and brake rotor assembly. Refer to *Wheel Hub, Bearing, and Seal Replacement*; and *Hub and Rotor Assembly Replacement*.
3. Remove the bolts that mount the brake rotor to the hub.
4. Remove the brake rotor.

### Brake Rotor Installation

#### NOTICE

*Any new rotor must have the protective coating removed from the friction surfaces before being placed in service. Use Brake Parts Cleaner P/N 12345754 or the equivalent, and wipe the surface clean with clean cloths. Do not use gasoline, kerosene, or other oil base solvents, which may leave an oily residue. This residue is damaging to the brake lining and is flammable.*

1. Install the brake rotor.

#### NOTICE

*Refer to Fastener Notice in Cautions and Notices.*

#### IMPORTANT

*Threads must be clean and free of grease. Apply 272 Threadlocker P/N 12345493 or the equivalent to the threads of each brake rotor mounting bolt.*

2. Insert the bolts that mount the brake rotor to the hub.
3. Tighten the brake rotor to hub bolts:
  - For units with the 9/16-inch OD bolts, tighten the bolts to 152 N·m (112 lb ft).
  - For units with the 5/8-inch OD bolts, tighten the bolts to 256 N·m (189 lb ft).
4. Install the hub and brake rotor assembly. Refer to *Wheel Hub, Bearing, and Seal Replacement (Independent)* or *Wheel Hub, Bearing, and Seal Replacement (/Beam)*; and *Hub and Rotor Assembly Replacement*.
5. Inspect the brake rotor for runout. Refer to *Brake Rotor Lateral Runout Check*.
6. Clean both sides of the rotor with brake cleaner.

7. Grease the cap or cover (if equipped). Coat the inside of the cap with wheel grease, but do not fill the cap.
8. Install the brake caliper. Refer to Brake Caliper Replacement (Bosch ZOH-T Caliper).

**NOTICE:**

*Workhorse does not recommend wheel stud replacement every time a rotor is replaced (unless the wheel stud is damaged or out of round when verified with a dial indicator.) If it is determined that any stud(s) need replacing, they can be pressed out (if access to a press is available) to minimize any potential for stud/rotor damage. If a press is un available, the studs can be carefully driven out by using a brass mallet. Be sure to wear proper eye/hand protection and administer all safety precautions when performing either procedure.*

### Refinishing Brake Rotors

You do not need to refinish brake rotors when doing routine brake maintenance such as replacing worn brake pad assemblies. Refinish brake rotors only under the following circumstances:

- There is a complaint of brake pulsation.
- There is scoring greater than 1.5 mm (0.060 in).

Brake rotors have a minimum thickness dimension cast into them. This dimension is the minimum wear dimension and not a refinish dimension. Do not use a rotor that will not, after refinishing, meet the specifications shown on the brake rotor. Always replace the rotor with a new rotor. It may be necessary to replace the brake rotors in pairs in order to assure an even braking balance on both wheels.

Accurate control of brake rotor tolerance is necessary for the proper performance of disc brakes. Machining should be done only with precision equipment. Service the machining equipment on a regular basis following the manufacturer's recommended maintenance procedures.

When refinishing brake rotors, make sure the attaching adapters, the tool holders, the vibration dampeners, and the tool bits are in good condition. Always use sharp cutting tools or bits. Use only the replacement cutting bits recommended by the equipment manufacturer. Dull or worn tools leave a poor surface finish that will affect braking performance. Always use vibration dampening attachments when refinishing braking surfaces. These attachments eliminate tool chatter in order to allow for a better surface finish. Make sure these adapters are clean and free of nicks.

The following are two recommended procedures that achieve adequate results using two different off vehicle disc brake lathes. If any other lathe is used, follow that manufacturer's instructions and recommendations.

#### **Accu-turn Brake Lathe**

1. Mount the brake rotor to the brake lathe. Refer to the brake lathe manufacturer's recommended procedure.
2. Locate the deepest score and turn the micrometer knobs until the tool bit bottoms out at the deepest point of the score.
3. Zero the scale.
4. Back out the tool bits.

5. Advance the cutter hand-wheel until the bits have cleared the inner edge of the brake rotor face.
6. Adjust the micrometer knobs for approximately 0.0127 mm (0.005 in) more than the first reading. This will ensure clearing the brake rotor in one cut.
7. Perform one cut procedure. For refinishing information, refer to the *Brake Lathe Specifications (ACCU-TURN)*.
8. Perform swirl refinishing to the brake rotor. Refer to Non Directional Refinishing below.
9. Remove the brake rotor from the brake lathe.
10. Clean the brake rotor using brake cleaner.

#### **Ammco Brake Lathe Method**

1. Mount the brake rotor to the brake lathe. Refer to the brake lathe manufacturer's recommended procedure.
2. Locate the deepest score.
3. Turn the brake rotor micrometer knobs until the tool bit bottoms out at the deepest point of the score.
4. Zero the scale.
5. Back out the tool bits.
6. Advance the cutter hand-wheel until the bits have cleared the inner edge of the brake rotor face.
7. Perform rough and finish cuts. For refinishing information, refer to the *Brake Lathe Specifications (AMMCO)*.
8. Perform swirl refinishing to the brake rotor. Refer to Non-Directional Refinishing below.
9. Remove the brake rotor from the brake lathe.
10. Clean the brake rotor using brake cleaner.

#### **Non-directional Refinishing**

It is very important that you make the brake rotor surface non-directional. Dress the brake surfaces with a sanding disc tool such as the Ammco 8750 Safe Swirl Disc Rotor Grinder, Accu-turn 4331 79 Non-directional Swirl Finisher, or the equivalent. Use 120 grit aluminum oxide sandpaper.

#### STANDARD METHOD

#### **IMPORTANT**

*The finished brake rotor surface should be as close to that of a new brake rotor as possible. Failure to obtain the best possible brake rotor finish can affect braking performance.*

Sand each brake rotor surface using moderate pressure for a minimum of 60 seconds.

#### ALTERNATE METHOD

If the brake lathe is not equipped with an adequate non-directional finishing tool, use a sanding block with 150 grit aluminum oxide sandpaper.

1. Run the brake rotor at the equipment manufacturer's highest recommended cutting speed.

#### **IMPORTANT**

*The finished brake rotor surface should be as close to that of a new brake rotor as possible. Failure to obtain the best possible brake rotor finish can affect braking performance.*

2. Sand each brake rotor surface using moderate pressure for a minimum of 60 seconds.



## Burnishing the Rotors and Pads

For maximum braking efficiency, the rotors must be prepared for operation. This preparation is referred to as burnishing. Burnishing is the process of displacing brake pad friction material onto the rotor.

Brake power is generated when the friction material that has been displaced on the rotor bonds itself to the friction material on the pads. After bonding has occurred, the rotation of the wheel will cause the bond to break apart or shear. This cycle of bonding and shearing is how the brakes stop the vehicle.

If the rotors and pads are not burnished properly, the efficiency of the braking system will be compromised.

Typically, burnishing occurs during the first 10 – 50 stops.

Anytime a rotor is cleaned, it will need to be burnished again to deposit the friction material from the brake pads onto the friction surface of the rotors.

1. Make 10 stops from 45 mph at an average deceleration rate of approximately 15 ft./sec<sup>2</sup> with brake applications at two-mile intervals.
2. Make six stops from 60 mph at an average deceleration rate of 27 ft./sec<sup>2</sup>, with brake applications at 15-second intervals.

### NOTICE

***DO NOT make light pedal applications or ride the brakes before the burnishing process is complete.***

## PARK BRAKE SYSTEM

The parking brake system is a secondary brake system that uses a brake mechanism that is mounted on the tailshaft of the transmission. This brake system is used to prevent the vehicle from rolling while the vehicle is parked. There are two types of park brake systems:

- Lever actuated
- Automatic apply

Chassis Model	GVWR (lbs)	Brake System	Option Code
W16	16,000	Foot operated	STD
W18 w/LQ4 W18 w/L18	18,000	Foot operated Automatic apply	STD J72
W20	20,700	Foot operated	STD
W22	22,000	Foot operated	STD
W24/W25	24,000	Automatic apply	J72
W42	9,400-14,500	Foot operated	STD
W52	19,500	Foot Operated	STD

The lever actuated parking brake system is mechanically operated by a lever and strut or a pedal, which will activate the “drum style” transmission mounted propshaft drum brake.

The automatic apply parking brake is an electro-hydraulic system. This style of parking brake is spring applied and hydraulically released via an electro-hydraulic pump.

## LEVER ACTUATED PARK BRAKE SYSTEM COMPONENTS

The lever or pedal actuated park brake system uses the following components:

- Park brake lever (either foot or hand apply)
- Cable
- Transmission mounted park brake mechanism
- Park brake lever position switch

## AUTOMATIC APPLY PARK BRAKE SYSTEM COMPONENTS

### CAUTION

*Manually apply parking brake and turn off your ignition before removing any fuses or relays from the vehicle.*

*Failure to do so could result in the vehicle moving unexpectedly.*

### J72 Park Brake Description

The J72 (option code) park brake system is made up of two major separate components or systems, the actuator and the brake assembly. Each of the components is serviced as an assembly.

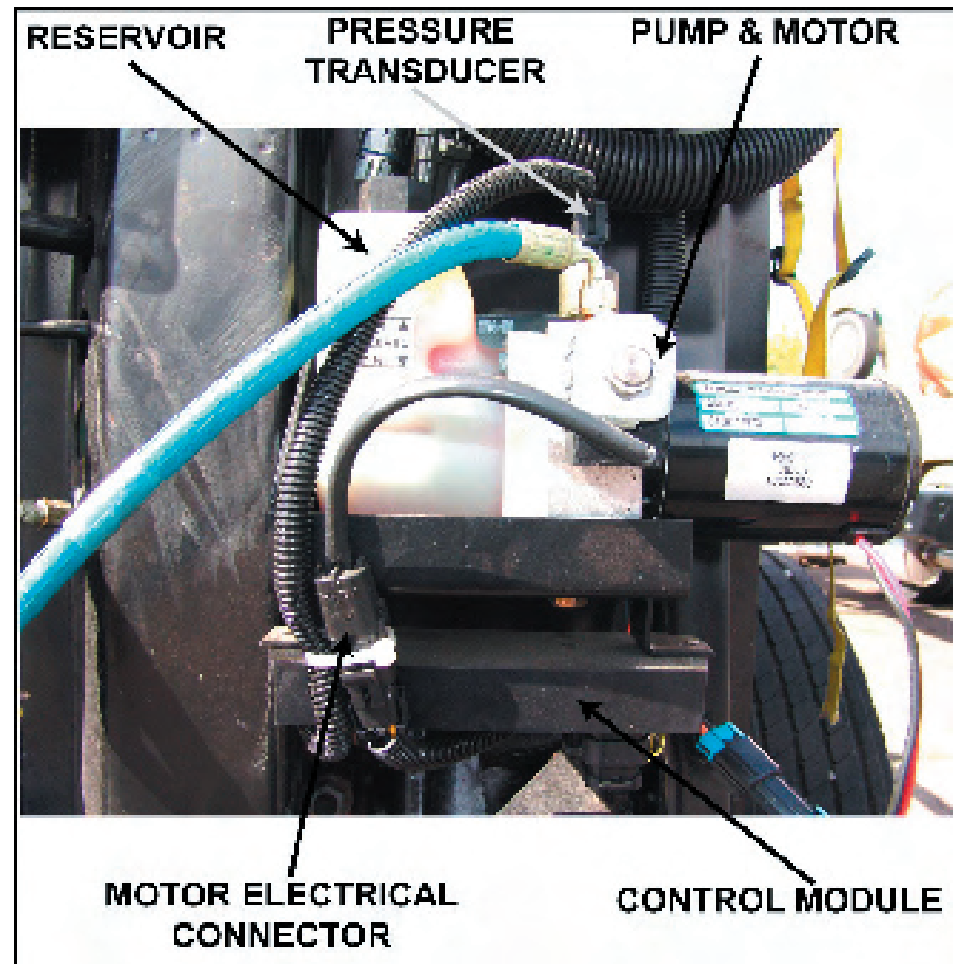


Figure 5-28 — J72 Actuator Assembly

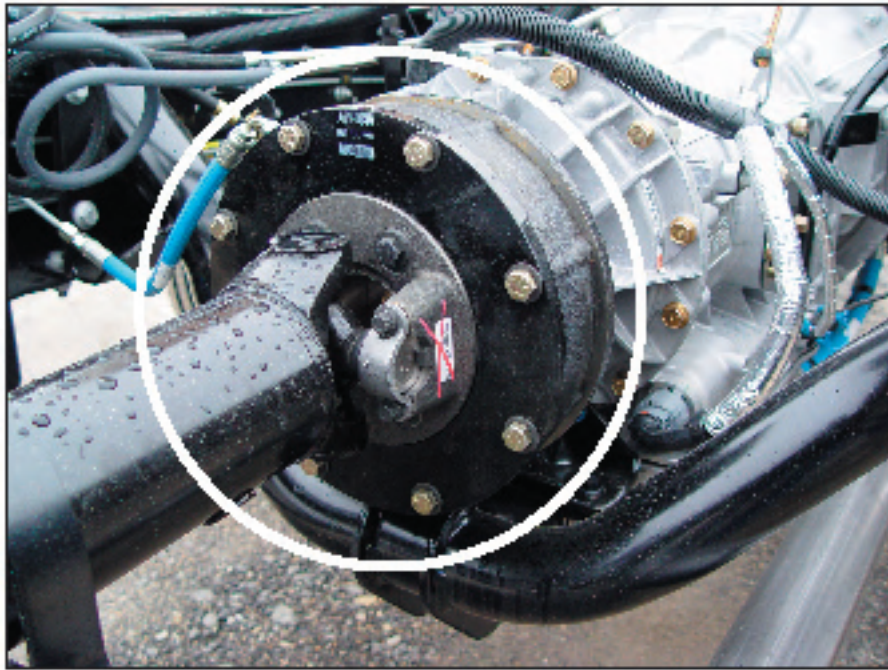


Figure 5-29 — J72 Brake Assembly

### System Overview

The J72 system incorporates a unique full-circle parking brake. The automatic electric/hydraulic parking system controls the transmission/propeller shaft mounted parking brake. This system consists of a pump motor relay, vehicle ignition relay, electric/hydraulic pump, reservoir, proportional relief solenoid valve, pressure transducer, and an electronic control module (ECM).

The ECM monitors seven inputs from the vehicle and controls the pump motor relay, auto-park light, park brake warning light, buzzer, proportional valve, and pressure transducer.

The park brake is released by pushing the park brake switch pull-button in and moving the shift lever on the steering column from the park position or select “D”, “N” or “R” on the push button shift control.

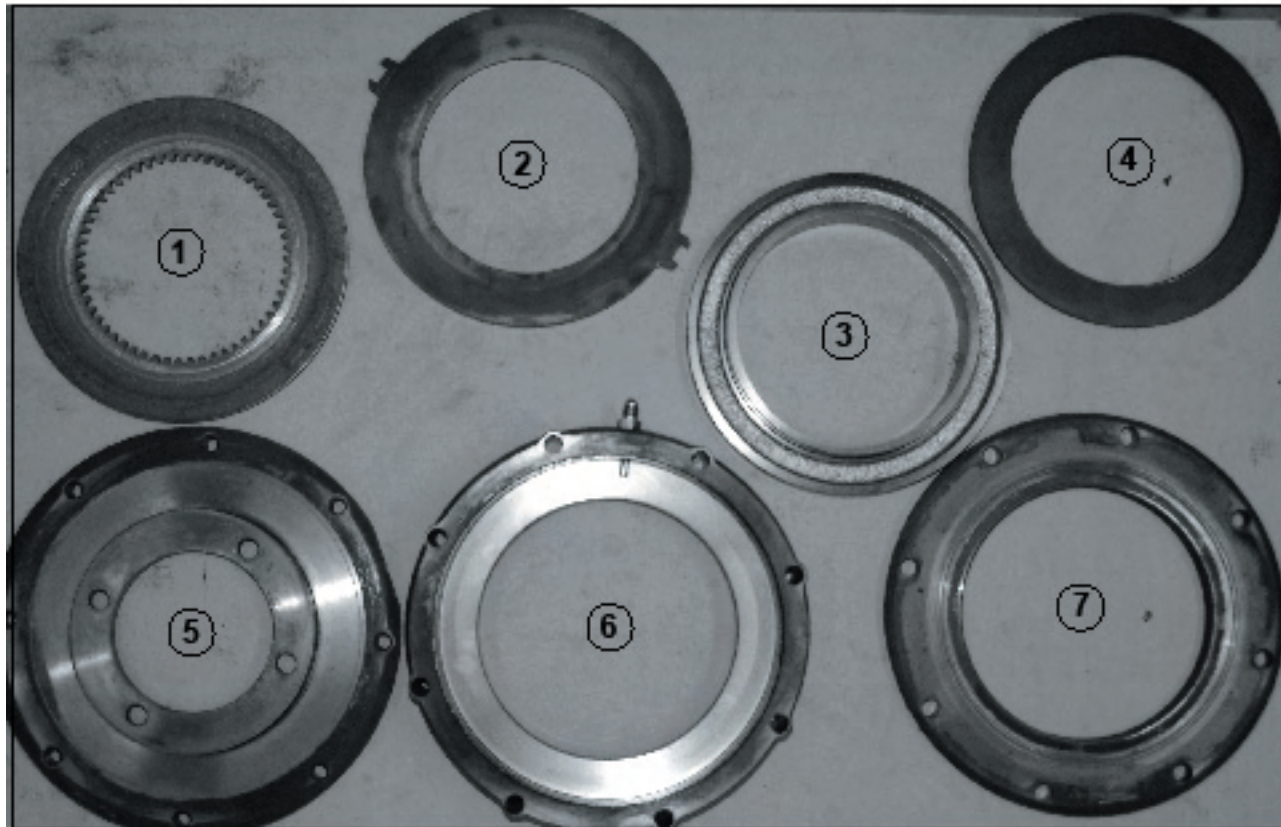
### NOTICE

*Both situations must occur for the brake to release.*

Once the ECM receives the signals from the transmission and button contacts, the ECM closes the solenoid valve and closes the pump/motor relay allowing current to flow to the motor. The pump/motor then supplies fluid to the brake assembly. The brake assembly includes a friction disc clamped by a piston through force of an internal spring. The fluid pressure acts on the piston overcoming the spring tension that clamps the friction disc, releasing the brake. The pump motor will shut off when the transducer reads the fluid pressure of approximately 1400 psi.

The solenoid valve holds pressure in the system while the brake is in a released state. The ECM monitors system pressure from the pressure transducer and energizes the pump motor when system pressure drops below approximately 1200 psi.

Putting the shift lever back to park, selecting “P” on the push button shift control, turning off the ignition, or pulling the push/pull switch prompts the ECM to de-energize the solenoid valve dumping fluid back into the reservoir. As the pressure decreases, the spring force clamps the piston back against the friction disc and applies the park brake.



1	Friction Disk	5	Front Housing Cover
2	Reaction Plate	6	Brake Housing
3	Piston	7	Rear Housing Cove
4	Bellville Spring		

**Figure 5-30 — J72 Brake Components**

**NOTICE**

*The J72 brake should not be disassembled. Doing so may void the warranty. The J72 brake assembly is serviced as an assembly only.*



Figure 5-31 — J72 Brake Assembly Layout

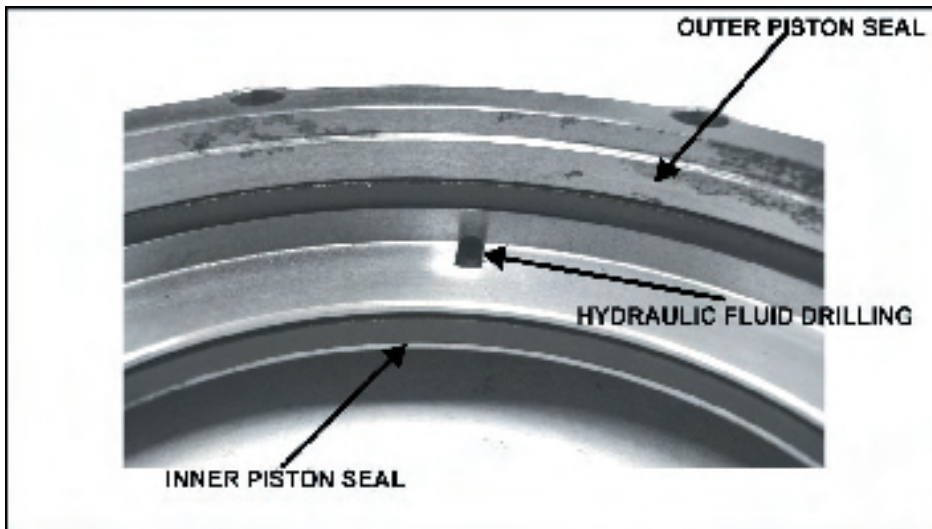


Figure 5-32 — J72 Brake Piston Seals

### ***Auto-Apply Warning Lamp***

The auto-apply warning lamp turns on when the system pressure falls below than 900 psi and the ECM receives the signal from the transmission.

### ***Park Brake Warning Lamp***

The park brake warning lamp illuminates when system pressure falls below 900 PSI or when the parking brake pull-button is pulled out.

### ***Park Brake Pull Switch***

The park brake pull switch is mounted on the instrument panel. This is a manual activation switch for the park brake. This switch is normally closed, pushed in. The body manufacturer determines final location of this switch.

### ***Park Brake Pump Motor Relay***

The park brake pump motor relay is located in the underhood fuse box on the front driver's side of the radiator core support. It receives ground from the ECM and acts as the automatic control circuit for the high voltage current required to run the pump motor. When the ECM supplies ground to the relay switch, the contacts close to complete the feed circuit to the pump motor.

### ***Ignition Relay***

The ignition relay is also located in the underhood fuse box on the front driver's side of the radiator core support. It monitors the vehicle's ignition switch to turn on/off the supply of the fifteen and forty-five amp fused-lines that the ECM and electric motor use. If the relay was not present, the ECM would be continually powered since it would be directly connected to the batteries.

### **Actuator Assembly**

The actuator assembly controls the pressure in the park brake system to either set or release the park brake. The actuator consists of a mounting bracket and the following components:

#### ***Electronic Control Module***

The electronic control module (ECM) is an analog logic device that monitors the various vehicle conditions then controls the actuator accordingly. It is the "black box" mounted underneath the actuator mounting bracket. It connects to the vehicle via a fourteen pin connector, to the proportional solenoid valve via a two pin connector, and a pressure transducer via a three pin connector. The ECM is powered by two different sources.

First, it receives power primarily through a fifteen amp fuse. Secondly, the ECM receives power off of the forty-five amp fused-line that the pump motor relay also uses.

### ***Pump/Motor Assembly***

The pump/motor assembly consists of an electric motor, geared pump, aluminum port block, and a semi-transparent fluid reservoir. The port block holds the proportional solenoid valve and pressure transducer. The pump provides fluid pressure for the system. A pressure relief valve in the port block limits system pressure to around 1700 psi.

#### ***Proportional Solenoid Valve***

The proportional solenoid valve controls when fluid can return to the pump reservoir. When the parking brake is released, the valve is closed to hold pressure in the system. When the parking brake is applied, the valve opens to allow fluid to return to the pump reservoir. If the vehicle is at a speed greater than five miles per hour (5mph) and the pull button is pulled, the valve will remain open for a few moments and then release the pressure slowly for a gradual apply of the brake.

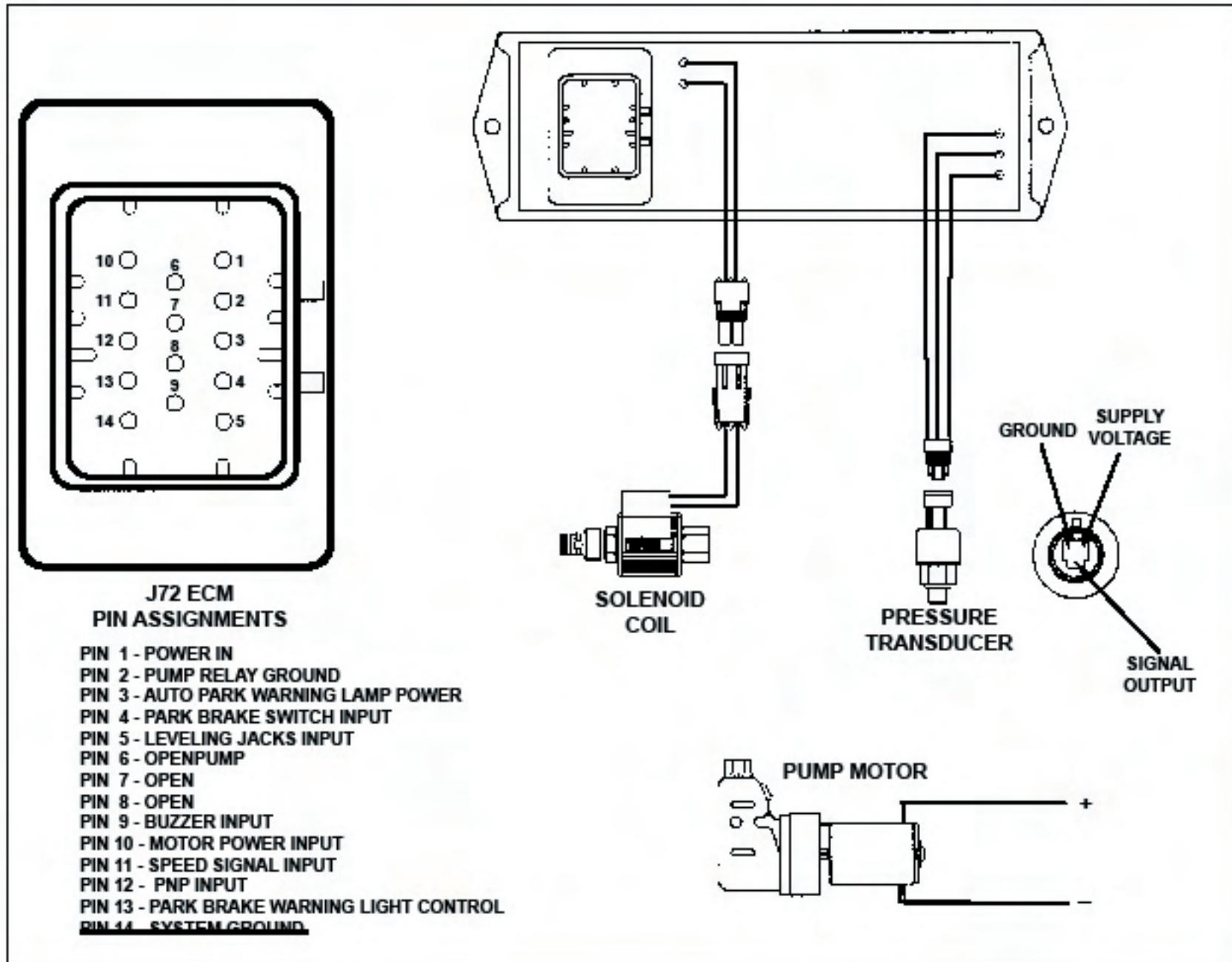


Figure 5-33 — J72 Electrical Circuits

## CAUTION

*The park brake is NOT designed for dynamic stops; if a dynamic stop occurs the park brake assembly must be inspected immediately for any internal damage.*

### Pressure Transducer

The pressure transducer monitors the pressure of the system and relays that information back to the ECM. The critical pressure values are the cut-in and out for the motor which are 1200 psi and 1400 psi, respectively.

## PARK BRAKE SYSTEM DIAGNOSIS

Park brake operational concerns fall into two different areas.

- Brake Does Not Hold
- Brake Will Not Release

### Park Brake Does Not Hold

To test the park brake function, conduct the following steps.

1. Choose a LEVEL location away from people, pets, and buildings.
2. Ensure the vehicle is in PARK.
3. Apply the service brake (foot brake) and start the engine.
4. Place the transmission in DRIVE.
5. Apply the park brake by pulling the park brake button out to the applied position.

6. Slowly release the service brake (foot brake).

## CAUTION

*If the vehicle moves, reapply the foot brake and place the transmission back in PARK. Service the park brake before repeating the test.*

7. If the vehicle does not move, GRADUALLY increase the throttle opening to approximately 1,500 RPM for five seconds, then release the throttle and apply the service brake (foot brake).

Test results:

- a. If the brake holds, no further action is required. Note the results of the test on the Repair Order for future reference.
  - b. If the brake does not hold, the park brake assembly must be replaced.
8. Apply the service brake (foot brake), then release the park brake.
  9. Release and reapply the service brake (foot brake) to relieve any strain in the drivetrain.
  10. Place the transmission in PARK. The auto-apply park brake should set.
  11. Turn the ignition OFF and remove the key.
  12. If the brake did not hold in step 7, chock the wheels and proceed to the repair instructions.



## **Park Brake Will Not Release**

If the J72 park brake will not release, chock the wheels and check the following items.

1. Check the fluid level in the reservoir. Add fluid if the level is below the MIN line.
2. Check the ALT/START fuse.
3. Check the function of the Auto Park Brake Motor Relay by substituting a known good relay of the same type.
4. Check the function of the Auto Park IGN relay by substituting a known good relay of the same type.
5. Check the function of the Park Brake Pull Button relay by substituting a known good relay of the same type.
6. Check for leaks in the hydraulic lines. Correct any leaks found.
7. Check for power to the motor. If power is not present, check for continuity on the power feed circuit. If power is present, check for continuity on the ground circuit.
8. Check for motor function by providing battery voltage to pin A of the motor connector and ground to pin B of the motor connector. If the motor does not function, replace it.

## 9. Perform Park Brake ECM Connector Pin Out Diagnostic Tests:

- Pin 1 – Check for battery voltage on ECM Pin 1. If no voltage is present check the fuse and the circuit.
- Pin 2 – Disconnect the harness from the ECM. Connect a test lead from Cavity 2 and ground. The pump motor should operate. If not check the relay and motor circuit.
- Pin 3 – Backprobe cavity 3 and apply the park brake. Power should be present when the brake is applied and the ignition is in the ON position.
- Pin 4 – Backprobe cavity 4 with the brake applied. Ground should be present when the brake is applied.
- Pin 5 – Backprobe Cavity 5 with the brake applied. Ground should be present.
- Pin 6 through Pin 8 – Not used.
- Pin 9 – Backprobe Cavity 9 with the brake applied. Ground should be present.
- Pin 10 – Check for battery voltage on ECM Pin 10. If no voltage is present check the fuse and the circuit.
- Pin 11 – Pin 11 provides the speed signal from the ABS module.
- Pin 12 – Check for battery voltage on ECM Pin 10 with the vehicle in PARK. If no voltage is present check the fuse and the circuit to the PNP switch.
- Pin 13 – Backprobe Cavity 9 with the brake applied. Ground should be present.
- Pin 14 – Pin 14 supplies the ECM with chassis ground. Backprobe Cavity 14 and check for ground.

## COMPONENT REPLACEMENT (J72 PARK BRAKE)

### Park Brake Assembly Replacement

#### CAUTION

*Block the vehicle wheels to prevent movement before servicing the park brake assembly.*

#### Removal Procedure

1. Raise the vehicle and support the vehicle with safety stands. Refer to Lifting and Jacking the Vehicle in General Information.

#### IMPORTANT

*Ensure the park brake is applied.*

2. Remove the propeller shaft. Refer to Two-Piece Propeller Shaft Replacement or Three-Piece Propeller Shaft Replacement.
3. Disconnect the hydraulic line from the brake assembly. Install a suitable plug in the hydraulic line and cap the brake assembly fitting to minimize fluid loss.
4. Remove the center bolt retaining the yoke to the transmission output shaft. Remove the yoke.

*Figure 5-4. Removing the Park Brake Assembly*

#### IMPORTANT

*Cap the end of the transmission in order to minimize fluid loss.*

5. Inspect the yoke ears for damage and the splines for the following damage:
  - Wear
  - Burrs
  - Twisting

#### CAUTION

*The park brake assembly weighs approximately 45lbs (20 kg). Use a suitable jack to support the brake before removing the attaching bolts. Failure to do so may result in personal injury.*

6. Remove the four bolts attaching the brake assembly to the transmission housing.
7. Remove the brake assembly.

#### Installation Procedure

#### NOTICE

*Refer to Fastener Notice in Cautions and Notices.*

1. Raise the brake assembly into position and align with the mounting holes in the transmission housing.
2. Install the bolts and washers attaching the brake assembly to the transmission housing. Tighten the bolts and washers to 89 lb ft (121 Nm).
3. Install the yoke and attaching bolt. Tighten the bolt to 89 lb ft (121 Nm).
4. Connect the hydraulic line to the brake assembly.
5. Fill the brake actuator reservoir with the specified fluid.

#### NOTICE

*2006 models are filled with Dexron VI.*

6. Install the propeller shaft. Refer to Two-Piece Propeller Shaft Replacement or Three-Piece Propeller Shaft Replacement.
7. Bleed the park brake hydraulic system. See bleeding the park brake in this section.
8. Lower the vehicle.
9. Test the operation of the park brake.

### CAUTION

*Always test the park brake before proper operation before returning the vehicle to the customer.*

## Park Brake Actuator Assembly Replacement

### Removal Procedure

### CAUTION

*Ensure the park brake is applied before removing the actuator. The park brake hydraulic system operates at high pressure. Always relieve pressure by applying the park brake before disconnecting any hydraulic fittings.*

1. Disconnect the electrical connectors from the actuator assembly.
2. Disconnect the Hydraulic line from the actuator assembly. Cap the actuator fitting and plug the line to prevent fluid loss.
3. Remove the bolts attaching the actuator assembly to the bulkhead.

### Installation Procedure

#### NOTICE

*Refer to Fastener Notice in Cautions and Notices.*

1. Ensure that the hydraulic fitting is properly tightened in the actuator housing before installing the hydraulic line. Tighten the fitting to 108 lb in (12 Nm).
2. Install the new actuator assembly and tighten the bolts. Tighten the bolts to 28 lb ft (38 Nm).
3. Connect the hydraulic line to the actuator assembly. Tighten the fitting to 108 lb in (12 Nm).
4. Connect the electrical connection to the actuator assembly.
5. Fill the fluid reservoir with the appropriate fluid.

#### NOTICE

*2006 models use Dexron VI in the hydraulic system.*

6. Bleed the park brake system. See bleeding the park brake in this section.

### CAUTION

*Always test the park brake before proper operation before returning the vehicle to the customer.*

## PARK BRAKE SYSTEM DIAGNOSTICS

### Park Brake System Check

#### NOTICE

*Use care when probing terminals to measure voltage and resistance values. The Digital Multimeter (DMM) probe can damage the connector terminal and cause a poor connection. A damaged terminal condition is very hard to diagnose.*

#### IMPORTANT

*The amount of time it takes for the parking brake to release will vary based on the temperature and battery voltage. In extreme cold weather, it can take up to 15 seconds to release the parking brake. This is normal system operation*

Before beginning diagnosis on the automatic apply park brake system, you need a detailed description of when the condition occurred from the owner. This information can be useful in duplicating the condition. Always begin diagnosis with a visual inspection of all connectors, wiring, wire routing and retention, and system components. Many times a disconnected or loose connector, blown fuse, open circuit breaker, corroded terminal, or miss-routed wire is the cause of a malfunction.

## SYSTEM ADJUSTMENT PROCEDURES (MANUAL APPLY PARK BRAKE)

### Park Brake Cable Adjustment

#### Manual Park Brake Adjustment

##### ADJUSTMENT WITH DRUM OFF – PRIMARY PROCEDURE

1. Use a 12 inch caliper, or inside micrometer, to measure the inside diameter of the drum. Subtract 0.025 inches from the drum inside diameter measurement. Set the measurement caliper to this value, and lock the setscrew.
2. Rotate the axle input flanged yoke so the yoke is in the vertical position to provide clearance for the caliper.
3. Place the pre-adjusted caliper over the shoes at the center of the shoes.
4. To adjust brake, rotate the starwheel until the shoes touch the caliper jaws. It is necessary to move the adjuster lever away from the starwheel.

#### NOTICE

*During adjustment the calipers should be moved up and down around the shoe center points to ensure adjustment at the highest points on the shoes.*

##### ADJUSTMENT WITH DRUM ON – ALTERNATE PROCEDURE

### CAUTION

*Always block vehicle to prevent vehicle movement, such as with suitable wheel chocks. Failure to do this could result in personal injury or property damage.*

1. With the engine off and the battery disconnected, place transmission in gear and fully release the parking brake. Verify that the drum can be rotated by hand. If the drum cannot rotate, it will be necessary to raise the rear wheels off the ground, in order to allow rotation of the drum. To raise the rear wheels put the vehicle transmission in gear, block the front wheels, raise the rear wheels off the ground, and support the vehicle with suitable floor stands.
2. Insert a brake adjusting tool (or flathead screwdriver) through the adjusting slot and move the teeth down ward to expand the brake shoes outward. Continue expanding the shoes until the drum can not be rotated.
3. Now adjust the teeth upward to retract the shoes until the drum just begins to rotate freely (without drag from the shoes).

**NOTICE:**

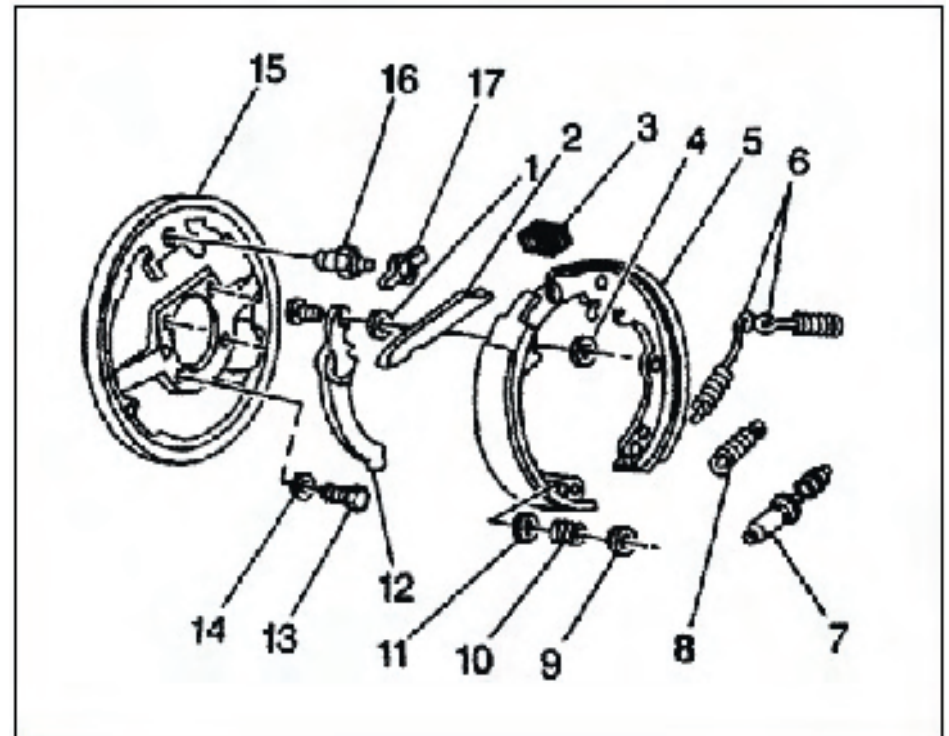
*To decrease shoe spread it is necessary to insert a thin screwdriver through the adjusting slot in the brake backing plate and push the adjusting lever away from the starwheel.*

**PARK BRAKE SERVICE (MANUAL APPLY PARK BRAKE)**

**Park Brake Shoe Replacement**

*Park Brake Shoe Removal*

1. Remove the drum. Refer to *Brake Drum Replacement*.
2. Remove the pull springs.
3. Remove the guide plate (17).



*Figure 5-34 — Park brake components.*

4. Remove the holder pin spring cups (10), the springs, and the washers.
5. Remove the shoe lever strut and the spring.

6. Remove the shoe lever ring.
7. Remove the shoe lever and the washer.
8. Remove the parking brake shoes.
9. Remove the brake shoe adjuster.
10. Remove the brake shoe adjuster spring.

### ***Clean, Dry and Inspect***

#### ***CLEAN***

1. Clean the backing plate and hardware

#### ***DRY AND INSPECT***

1. Inspect all parts for discoloration due to stress. Replace the parts if necessary.
2. Inspect the brake drum for scoring and spots. Machine the drum if needed.
3. Inspect the anchor pin for signs of wear. Replace the anchor pin as needed.
4. Replace the brake shoe and lining assemblies whenever the thickness of any lining is worn to within 0.76 mm (0.030 in) of the shoe. For riveted shoe and lining assemblies, replace when the lining is worn to within 0.76 mm (0.030 in) of any rivet head.

### ***Park Brake Shoe Installation***

#### **NOTICE**

***Lubricate the shoe pads and adjusting screw threads with a thin coat of Lubriplate P/N 1050109 or equivalent. DO NOT ALLOW LUBRICANT TO CONTACT BRAKE LININGS.***

1. Install the brake shoe adjuster and the spring to both sides.
2. Install the parking brake shoes.
3. Install the shoe lever and the ring.
4. Install the shoe lever strut and the spring.
5. Install the holder pin spring washers, the springs, and the cups (10).
6. Install the guide plates (17).
7. Install the pull springs. I
8. Install the drum.
9. Adjust the parking brake. Refer to Park Brake Cable Service/Adjustment (Mechanical Park Brake).

### **Park Brake Pedal Replacement**

#### ***Park Brake Pedal Removal***

1. Release the parking brake.
2. Remove the parking brake pedal to cowl mounting nuts (1).
3. Remove the cable (2) from the pedal assembly.

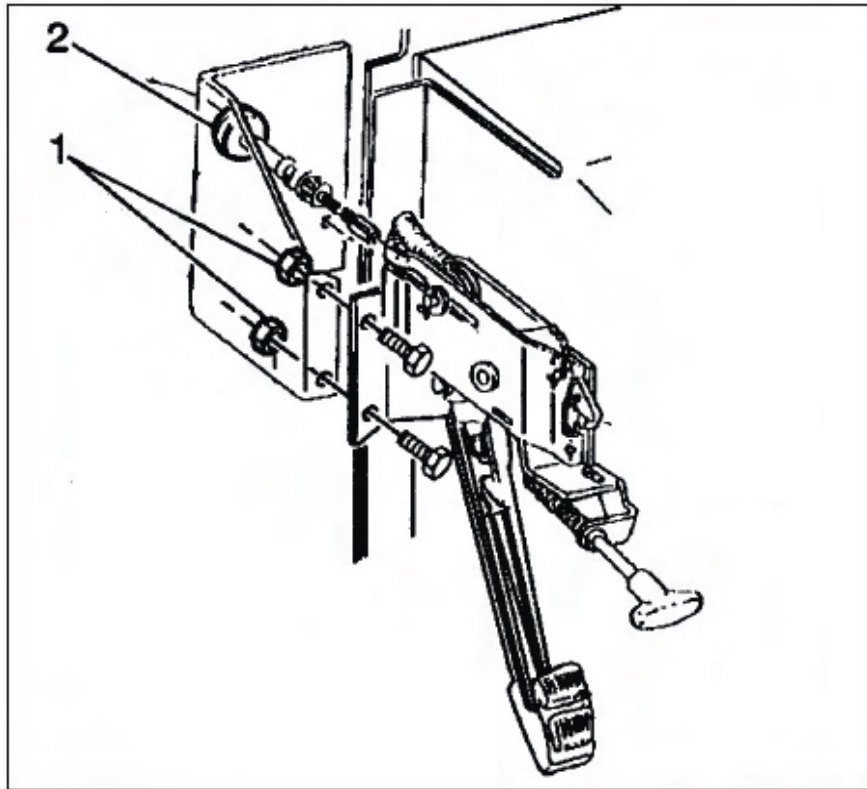


Figure 5-35 — Park brake pedal assembly.

4. Remove the pedal assembly.

#### **Park Brake Pedal Installation**

1. Connect the cable to the pedal assembly.
2. Position the pedal assembly and install the bolts.

#### **NOTICE**

*Refer to Fastener Notice in Cautions and Notices.*

3. Install the parking brake pedal to cowl mounting nuts.
4. Tighten the pedal to cowl mounting nuts to 22 N·m (16 lb ft).
5. Adjust the parking brake. Refer to Park Brake Cable Service/Adjustment (Mechanical Park Brake),

#### **Park Brake Lever Replacement**

##### **Park Brake Lever Removal**

1. Release the parking brake.
2. Remove the parking brake pedal to floor nuts (6) and washers (5).

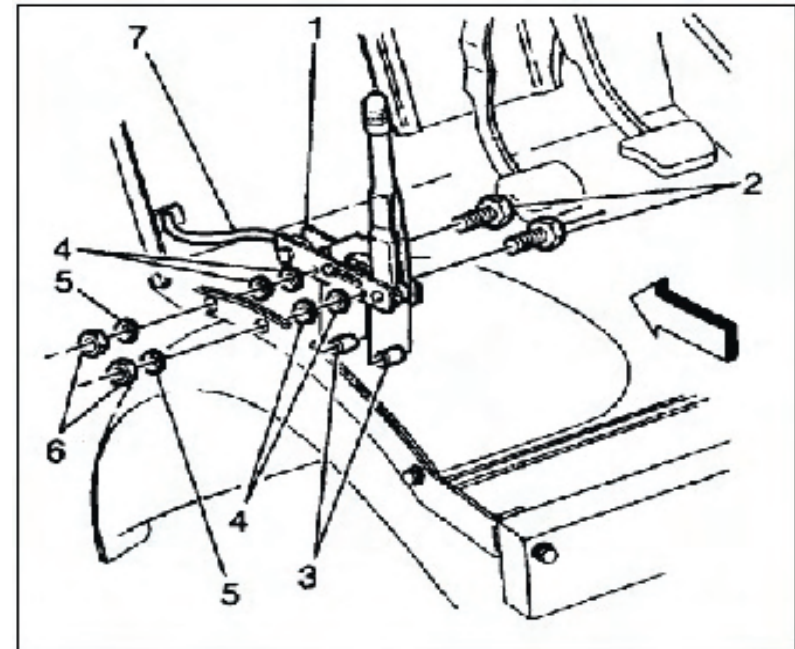


Figure 5-36 — Lever style park brake.

3. Remove the parking brake pedal to floor bolts (2) and washers (4).
4. Remove the spacers (3).

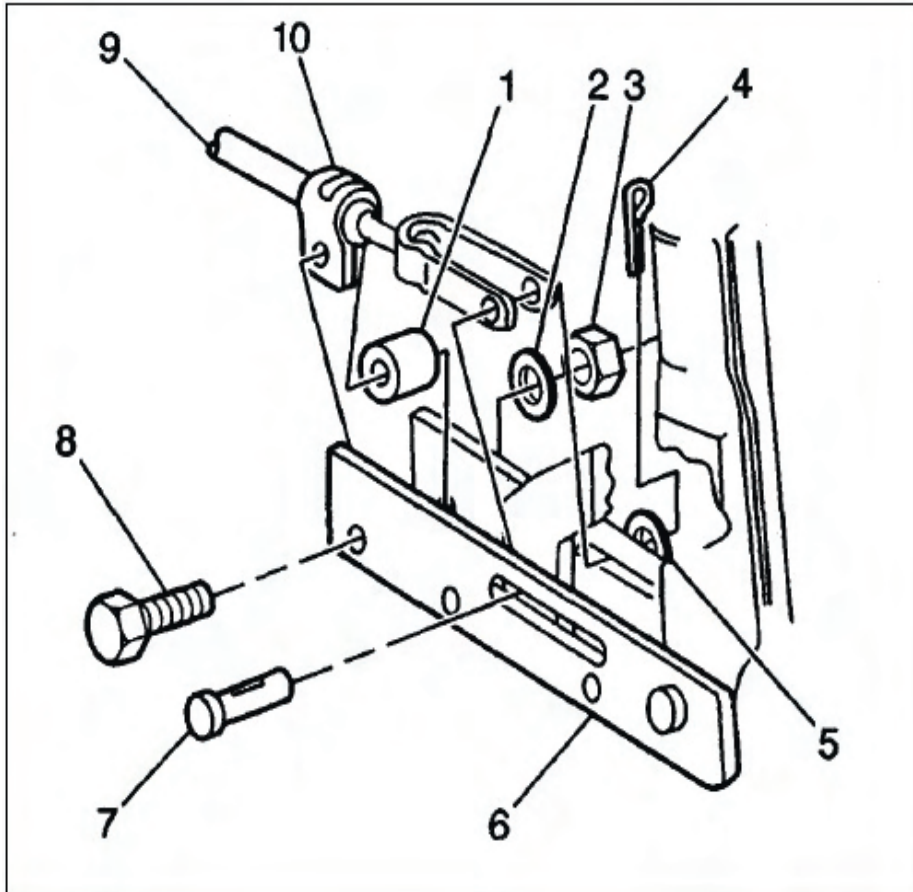


Figure 5-37 — Cable attachment detail.

5. Remove the cotter pin (4) and the washer (5).
6. Remove the clevis pin (7).
7. Remove the cable to parking brake lever nut and washer.
8. Remove the cable to parking brake lever bolts.
9. Remove the spacer (1).

10. Remove the cable (9).
11. Remove the lever assembly (6).

#### Park Brake Lever Installation

1. Install the lever assembly.
2. Install the cable.
3. Install the clevis pin.
4. Install the washer and the cotter pin.
5. Install the spacer.
6. Install the cable to parking brake lever bolt.
7. Install the washer and cable to the parking brake lever nut.
8. Install the spacers (3).
9. Install the washer (4) and the parking brake pedal to floor bolts (2).

#### NOTICE

*Refer to Fastener Notice in Cautions and Notices.*

10. Install the washers (5) and the parking brake pedal to floor nuts (6).
11. Tighten the parking brake to floor nuts to 25 N·m (18 lb ft).
12. Tighten the parking brake lever to cowl nuts to 25 N·m (18 lb ft).



## Park Brake Pull Switch Replacement

### Park Brake Pull Switch Removal

#### CAUTION

**Manually apply parking brake, block wheels, and turn the ignition OFF before removing any fuses or relays or removing the park brake pull button.**

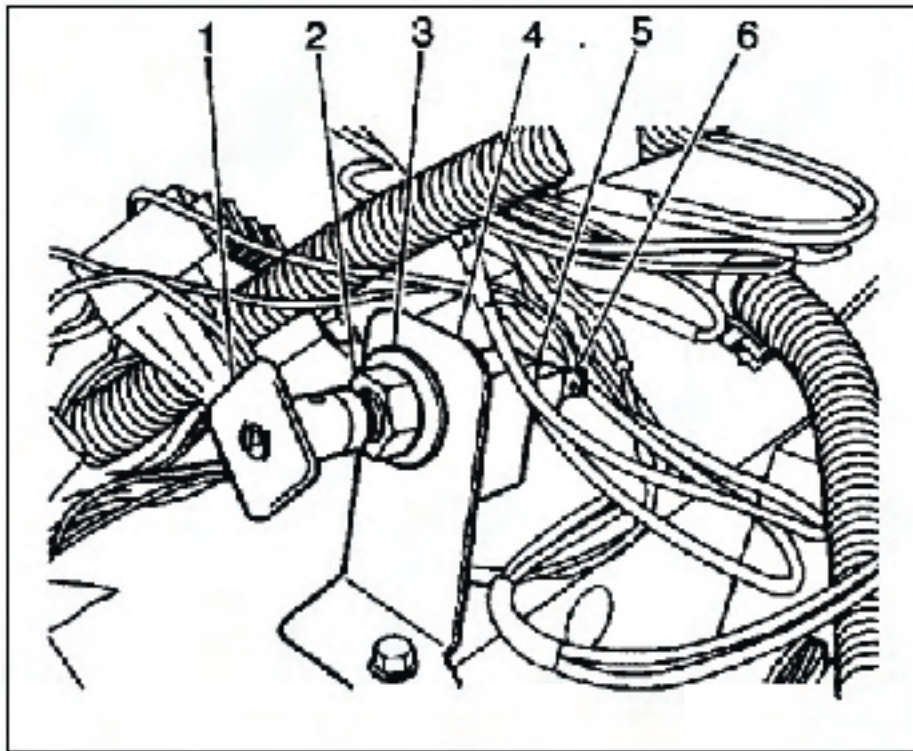


Figure 5-38 — Pull button assembly.

1. Disconnect the electrical connector (6) from the back of the pull switch (5).
2. Remove the pull switch knob retaining pin by using a small hammer and a small drift punch. Gently drive the pin out.

3. Slide the pull switch knob (1) off of the shaft.
4. Remove the pull switch mounting nut (2) and washer (3).
5. Remove the pull switch (5) by sliding it out the back of the mounting bracket (4).

### Park Brake Pull Switch Installation

1. Install the pull switch (5) into the mounting bracket (4).
2. Install the pull switch washer (3) and mounting nut (2).
3. Tighten the pull switch mounting nut to 3 N·m (27 lb in).
4. Install pull switch knob (1) by sliding it onto the pull switch shaft.
5. Install the pull switch knob retaining pin by using a small hammer and a small drift punch. Gently drive the pin in.

## Park Brake Cable Replacement (Pedal Type)

### Park Brake Cable Removal

1. Raise the vehicle and support the vehicle with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Disconnect the nut from the equalizer.
3. Remove the connector.
4. Disconnect the cable from the frame bracket.
5. Bend the retaining fingers.
6. Disconnect the cable from the pedal assembly.
7. Remove the retainer clip bolts and the retainer clips.
8. Remove the cable assembly. Attach a piece of wire to the cable to help in the installation.

### **Park Brake Cable Installation**

1. Install the cable assembly. Ensure the retaining fingers are completely through the holes. Bend the retainers back into place.

#### **NOTICE**

*Refer to Fastener Notice in Cautions and Notices.*

2. Install the retainer clips and the retainer clip bolts.
3. Tighten the retainer clip bolts to 17 N·m (13 lb ft).
4. Connect the cable to the pedal assembly.
5. Connect the cable to the frame bracket.
6. Install the connector.
7. Connect the nut to the equalizer.
8. Adjust the parking brake. Refer to *Park Brake Cable Service/Adjustment*.
9. Lower the vehicle.

### **Park Brake Cable Replacement (Lever Type)**

#### **Park Brake Cable Removal**

1. Raise the vehicle and support the vehicle with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Remove the nut from the equalizer.
3. Remove the connector.
4. Remove the retainer clip bolts and retainer clips.
5. Disconnect the cable from the lever assembly.
6. Remove the retaining fingers.
7. Remove the cable assembly. Attach a piece of wire to the cable to help in the installation.

### **Park Brake Cable Installation**

1. Install the cable assembly.
2. Install the retaining fingers.
3. Connect the cable to the lever assembly.

#### **NOTICE**

*Refer to Fastener Notice in Cautions and Notices.*

4. Install the retainer clips and the retainer clip bolts.
5. Tighten the retainer clip bolts to 17 Nm (13 lb ft).
6. Install the connector.
7. Install the nut to the equalizer.
8. Adjust the parking brake. Refer to *Park Brake Cable Service/Adjustment*.
9. Lower the vehicle.

### **Park Brake Drum Replacement**

#### **Park Brake Drum Removal**

1. Raise the vehicle and support the vehicle with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.

#### **IMPORTANT**

*Ensure the park brake is released.*

2. Remove the propeller shaft. Refer to *Two-Piece Propeller Shaft Replacement* or *Three-Piece Propeller Shaft Replacement*.

#### **CAUTION**

*Cap the end of the transmission in order to minimize fluid loss and prevent the entry of contaminants into the system.*

3. Remove the parking brake drum and yoke assembly mounting bolt and washer.
4. Remove the brake drum and yoke assembly.
5. Remove the yoke from the drum assembly.
6. Inspect the yoke ears for damage and the splines for the following damage:
  - Wear
  - Burrs
  - Twisting

### **Inspect**

When you remove the drum brake, thoroughly clean and inspect the drum for the following problems:

- Cracks
- Deep grooves
- Scores
- Out-of-round

### *SURFACE FINISH*

Slight scoring can be cleaned up with a fine emery cloth. Heavy or extensive scoring causes excessive brake lining wear. The drum braking surface will need machining to remove these scores.

If the drum is grooved and the brake linings are slightly worn, do not machine the drum. Instead, polish the drum braking surface with a fine emery cloth.

Eliminating all of the drum grooves and the ridges on the lining would require removing too much metal and lining material. The grooves and the ridges match and satisfactory service can be obtained by leaving them alone.

### *INSIDE DIAMETER CHECK*

Measure the inside diameter of the brake drum at two or more places around the circumference of the braking surface. The measurements must be made at the same distance in from the edge of the drum.

### *TAPER CHECK*

Measuring a drum for taper involves taking measurements at the inner and the outer edges of the machined surface at two or more places around the drum. These measurements should be equal.

### **Park Brake Drum Installation**

#### **NOTICE**

*Refer to Fastener Notice in Cautions and Notices.*

1. Install the bolts and washers holding the drum assembly to the yoke.
2. Tighten the bolts and washers to 58 N·m (43 lb ft).
3. Install the parking brake drum and yoke assembly.
4. Tighten the bolt to 110 N·m (81 lb ft).
5. Install the propeller shaft. Refer to *Two-Piece Propeller Shaft Replacement* or *Three-Piece Propeller Shaft Replacement*.
6. Adjust the parking brake. Refer to *Park Brake Cable Service/Adjustment*.
7. Lower the vehicle.

## Park Brake Drum Backing Plate Replacement

### *Park Brake Drum Backing Plate Removal*

1. Remove the drum. Refer to *Brake Drum Replacement*.
2. Remove the linings. Refer to *Park Brake Shoe Replacement*.
3. Remove the backing plate mounting bolts and washers.
4. Remove the backing plate.
5. Remove the anchor pin mounting nut and the anchor pin.

### *Park Brake Drum Backing Plate Installation*

#### **NOTICE**

*Refer to Fastener Notice in Cautions and Notices.*

1. Install the anchor pin and the anchor pin mounting nut.
2. Tighten the anchor pin mounting nut to 200 N·m (148 lb ft).
3. Install the backing plate.
4. Install the backing plate mounting bolts and washers.
5. Tighten the backing plate mounting bolts to 41 N·m (30 lb ft).
6. Install the linings. Refer to *Park Brake Shoe Replacement*.
7. Install the drum. Refer to *Brake Drum Replacement*.
8. Adjust the parking brake. Refer to *Park Brake Cable Service/Adjustment*.

## Automatic Apply Park Brake Assembly Replacement

### *Automatic Apply Park Brake Assembly Removal*

#### **IMPORTANT**

*Ensure the park brake is released before trying to remove it.*

1. Remove the propeller shaft. Refer to *Two-Piece Propeller Shaft Replacement* or *Three-Piece Propeller Shaft Replacement*.
2. Disconnect the hydraulic line from the parking brake assembly.

#### **CAUTION**

*Cap the end of the transmission in order to minimize fluid loss and prevent the entry of contaminants into the system.*

3. Remove the parking brake and yoke assembly mounting bolt and washer.
4. Remove the parking brake and yoke assembly.
5. Remove the yoke from the parking brake assembly.
6. Inspect the yoke ears for damage and the splines for the following damage:
  - Wear
  - Burrs
  - Twisting

### *Automatic Apply Park Brake Assembly Installation*

#### **NOTICE**

*Refer to Fastener Notice in Cautions and Notices.*

1. Install the bolts and washers holding the yoke to the parking brake assembly.
2. Tighten the bolts and washers to 58 N·m (43 lb ft).

3. Install the parking brake and yoke assembly.
4. Tighten the bolt to 110 N·m (81 lb ft).
5. Connect the hydraulic line to the parking brake assembly.
6. Tighten the hydraulic fitting.
7. Install the propeller shaft. Refer to *Two-Piece Propeller Shaft Replacement* or *Three-Piece Propeller Shaft Replacement*.
8. Lower the vehicle.

### Automatic Apply Park Brake Pump/Reservoir Assembly Replacement

#### Automatic Apply Park Brake Pump/Reservoir Assy Removal

##### NOTICE

*When replacing any hydraulic components, the hydraulic system should be flushed with Dexron VI transmission fluid.*

This is to ensure that the hydraulic system is free of contaminants such as metal particles that may have been circulated through the system as a result of a component failure.

1. Move the column shift lever to park and apply the manual parking brake.
2. Position a drain pan to catch the fluid that leaks out. Do not reuse the old fluid.
3. Access the panel on the inboard side of the component box.
4. Remove the parking brake pump motor assembly electrical connector.
5. Remove the pressure indicator switch electrical

connector.

6. Remove the hydraulic pipes from the solenoid valve (1).
7. Remove the parking brake pump motor assembly mounting bolts.
8. Remove the parking brake pump motor assembly.
9. Remove the pressure indicator switch from parking brake pump motor assembly.

### Automatic Apply Park Brake Pump/Reservoir Assembly Installation

##### NOTICE

*Refer to Fastener Notice in Cautions and Notices.*

1. Connect the pressure indicator switch to the parking brake pump motor assembly.
2. Tighten the switch to 12 N·m (106 lb in).
3. Install the parking brake pump motor assembly.
4. Install the parking brake pump motor assembly mounting bolts.
5. Tighten parking brake pump motor assembly mounting bolts to 37 N·m (27 lb ft).
6. Install the hydraulic pipes.
7. Tighten the hydraulic pipe fittings to 16 N·m (12 lb ft).
8. Install the pressure indicator switch electrical connector.
9. Install the parking brake pump motor assembly electrical connector.
10. Install the access panel on the inboard side of the component box.
11. Tighten the access panel fasteners to 12 N·m (1 06 lb in).

12. Fill the pump motor reservoir with Dexron III transmission fluid.
13. Cycle the system at least six times.
14. Turn the ignition switch ON and move the shift lever from Park to Neutral.
15. Check the fluid level. Refer to *Checking and Adding Park Brake Fluid*.
16. Release the manual Parking brake.

## ANTILOCK BRAKE SYSTEM (ABS)

The W16 / W18 / W24 / W25 / W42-Series chassis utilize the Meritor WABCO Hydraulic Anti-lock Braking System (ABS). This system is an electronic wheel speed monitoring and control system.

### NOTICE

*Refer to prior model year service publications for diagnostic information for the Kelsey Hayes ABS used on the W20 / W22 Series chassis.*

ABS wheel sensors detect wheel speeds. The sensors generate signals that are transmitted to an Electronic Control Unit (ECU). If the wheels start to lock, the ECU signals the modulator assembly to regulate the brake pressure of each locking wheel.

During an ABS stop, a solenoid valve in the modulator assembly is rapidly pulsed; that is, it opens and closes several times per second to control the brake pressure. When this occurs, drivers may notice a pulsation of the brake pedal.

An ABS indicator lamp on the vehicle dash alerts the driver to a possible system fault and provides blink code information to diagnose the system.

If the ABS indicator lamp comes on during normal vehicle operation, drivers may complete their trip, but are instructed to have their vehicles serviced as soon as possible.

In the unlikely event of an ABS system malfunction, the ABS in the affected wheel will be disabled and will return to normal braking. The other sensed wheels will retain their ABS function.

## ANTILOCK BRAKE SYSTEM (ABS) COMPONENTS

The antilock brake system is made up of the following components:

- Electronic Control Unit (ECU)
- Modulator assembly
- Wheel speed sensors
- Sensor spring clip
- Tooth wheel
- ABS indicator lamp

### ABS Electronic Control Unit (ECU)

#### NOTICE

*Do not open the ECU. Opening the ECU to gain access to the internal components will void the warranty.*

The ECU processes sensor signals and generates solenoid valve commands. The commands are used to reduce, maintain, or reapply brake pressure.

Mounting locations vary, depending upon the chassis. Refer to the vehicle specifications for the exact location. All Workhorse chassis use the frame-mounted style control module.

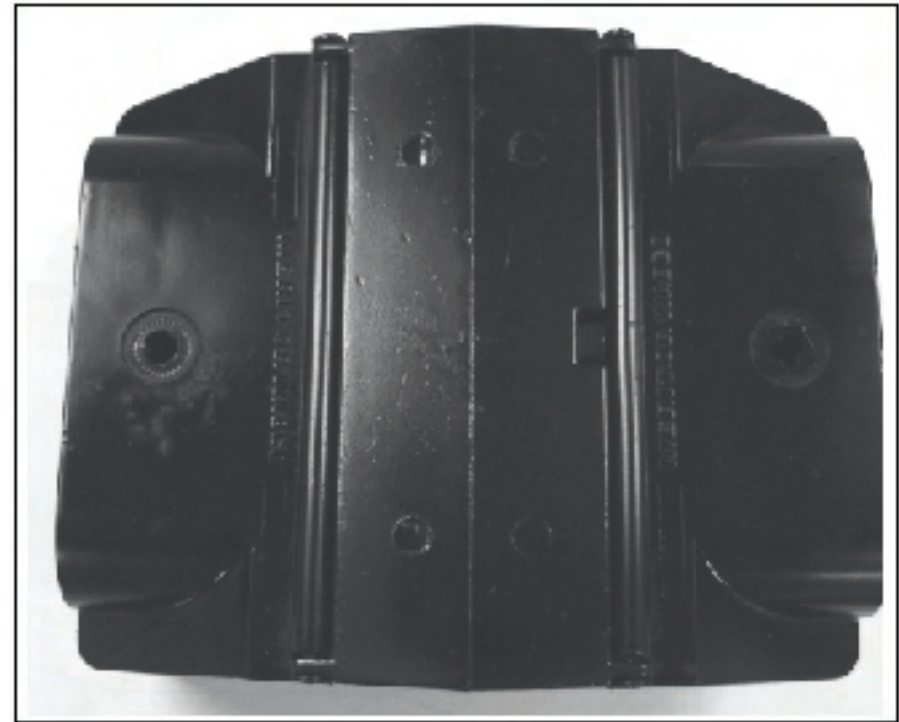


Figure 5-39 — WABCO ABS Electronic Control Unit (ECU)

### Modulator Assembly

The modulator assembly houses the ABS solenoid control valves (one inlet valve and one outlet valve per wheel), a pump motor and two accumulators.

The assembly contains brake fluid and must be handled with appropriate care. It should not be exposed to impact loads, excessive vibrations or compressed air blown into the hydraulic ports.

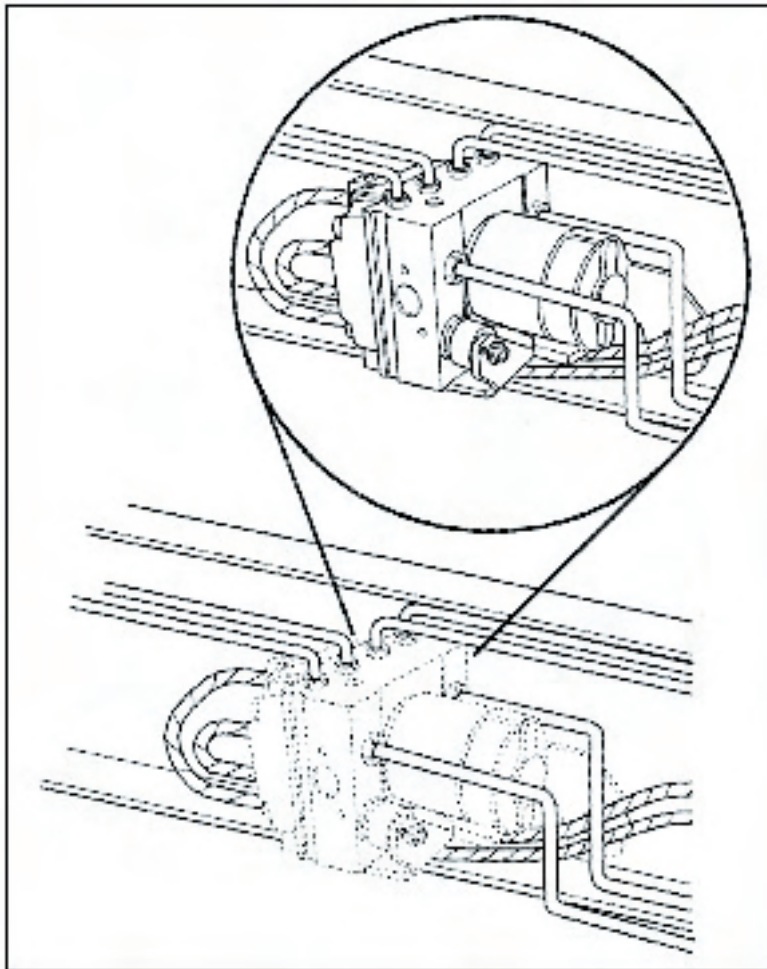


Figure 5-40 — WABCO Hydraulic Control Unit (HCU)

### Wheel Speed Sensors

Each wheel is equipped with a wheel speed sensor (4) that is used to measure the speed of a tooth wheel rotating with the vehicle wheel. The sensors produce an output voltage proportional to wheel speed.

### Sensor Spring Clip

This clip (1) retains the WSS in the mounting bracket (2) and holds it in close proximity to the tooth wheel.

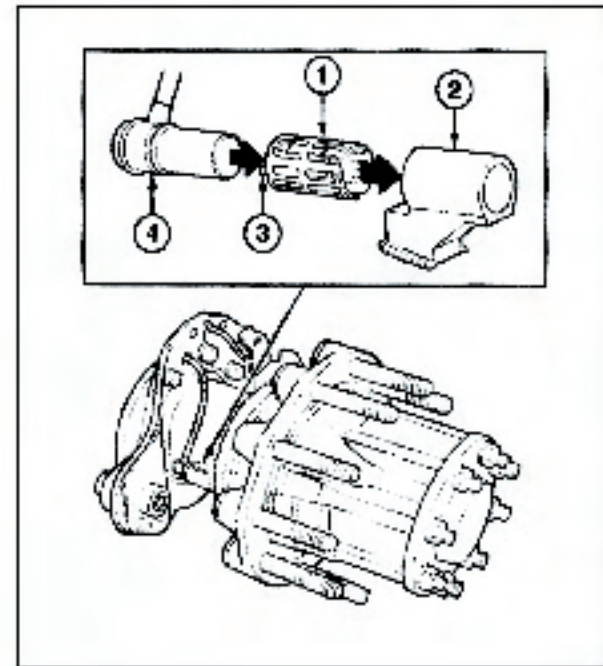


Figure 5-41 — Typical wheel speed sensor installation.

### Tooth Wheel

Each wheel is equipped with a machined or stamped ring that is mounted to a machined surface on the hub.



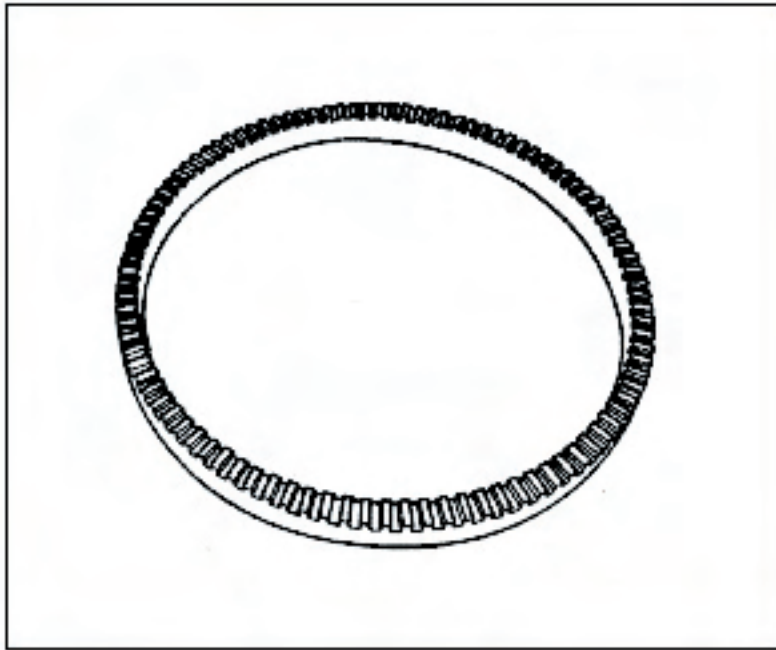


Figure 5-42 — Tooth wheel

### ABS Indicator Lamp

Located on instrument panel, it is used to alerts the driver to an ABS system fault.

## ABS DIAGNOSTIC PROCEDURES

### System Diagnostics

Use Meritor WABCO's PC-based diagnostic program, TOOLBOX™ Software to diagnose hydraulic ABS faults. TOOLBOX™ software is available for download by Workhorse dealers on the WOW system.

Once 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 ABS faults, use the pull-down menu or the HABS icon to select HABS (Hydraulic ABS) from the Main Menu.

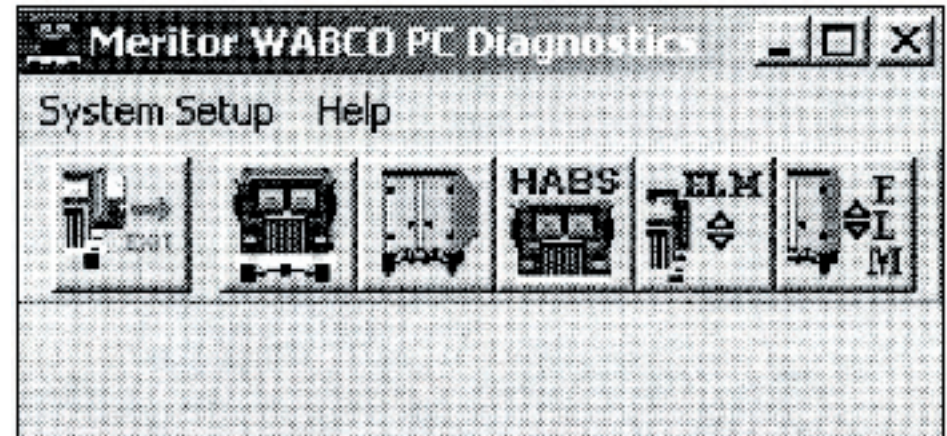


Figure 5-43— TOOLBOX Pull-Down Menu

1. The Hydraulic ABS Main Menu will appear.

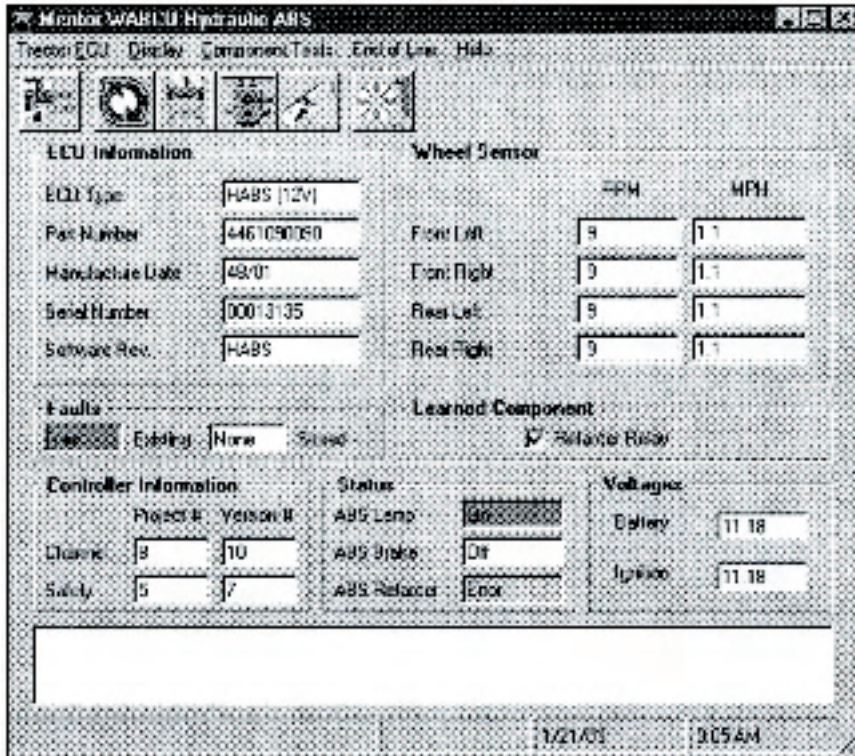


Figure 5-44 — TOOLBOX Main Screen

2. Select the View ECU Faults icon or select Display Faults to use the pull-down menu. This will display the Fault Information screen.

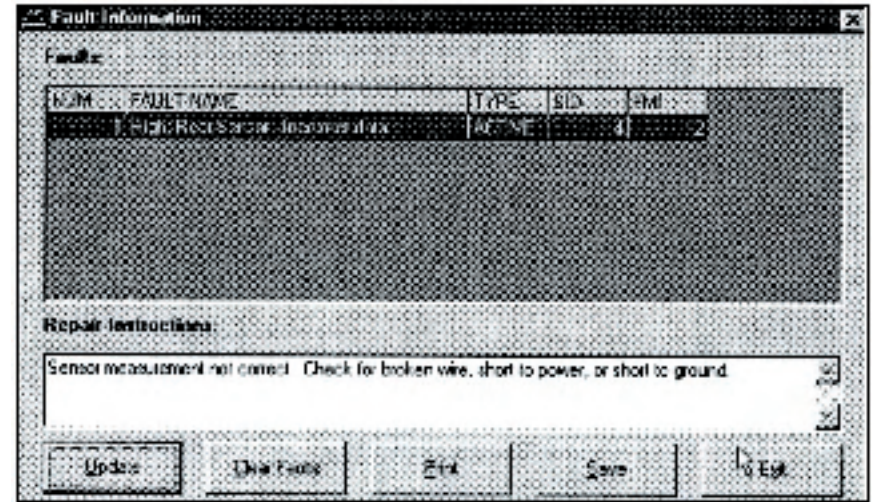


Figure 5-45 — Fault Screen

Use TOOLBOX™ Software to verify the activation of various system components:

- Valve Activation Menu
  - Activate valves, pump, and retarder relay
- Miscellaneous Output Activation Menu
  - Turn ABS indicator lamp on and off
- Reset components in ECU memory.

**NOTICE**

*For complete instructions for using this program, refer to the TOOLBOX™ User's Manual included in this section.*

## Valve, Pump and Retarder Relay Activation

The Valve Activation screen lets you activate the four valves, the pump, and the retarder relay. In addition to checking for proper activation, this screen provides an easy way to make sure the valves are wired properly. Component activation status appears in the status box of this screen.

To activate the ABS valves, pump or retarder relay, select HABS (Hydraulic ABS) from the Main Menu. The Hydraulic ABS Main Menu will appear.

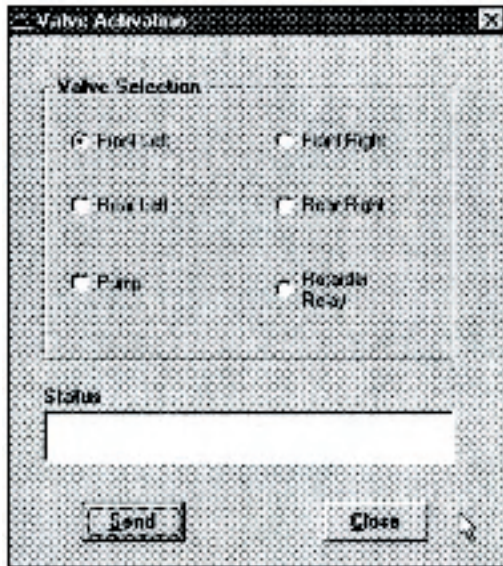


Figure 5-46 — Valve Actuation Menu

Select the Valve Activation icon or select Component Tests, then Valves to use the pull-down menu. This displays the Valve Activation screen.

## Retarder Relay Activation on WABCO Antilock Brake System

### NOTICE

*On some Workhorse vehicles equipped with gasoline engines with Hydra-matic® transmissions and the WABCO Antilock Brake System, it has been noted that the WABCO controller will at times try to seek out the retarder relay. Vehicles equipped with gasoline engines with the Hydra-matic® transmissions **do not** have a retarder relay. If you get a Workhorse vehicle equipped with a gasoline engine, and the WABCO controller is displaying a fault code(s) for a retarder relay, the WABCO controller has to go through a relearn process. The steps are as follows:*

1. Click on Meritor WABCO PC Diagnostics icon. Then select the HABS icon. This will display the Meritor WABCO Hydraulic ABS diagnostic screen.
2. With Meritor WABCO Hydraulic ABS diagnostic screen displayed, click on Component Tests.
3. Under Component Tests, select Reset Memorize.
4. Selecting the Reset Memorize will cause the WABCO controller to go through a relearn process. During this process it should learn that the retarder relay is not installed.
5. Check in the Learned Component box to make sure that the retarder relay box is not checked. If the check is still in the box then click in box to deselect the check mark.
6. Then click on the Restart the ECU icon in the upper left corner. The icon is two arrows formed in a circular pattern.
7. After clicking on the Restart the ECU icon, check if there are any faults existing or stored. If there are write down fault codes, and then clear fault code(s).

8. If retarder relay box is checked then go through steps 2 through 7 again. Steps may have to be repeated a couple of times before WABCO controller learns there is no retarder relay installed on the vehicle. Once the controller learns there is no retarder relay the box will remain unchecked.
- a. If retarder relay box remains unchecked then proceed to step 10. If it still remains checked after going through steps 2-7 then proceed to step 9.
9. If the WABCO HABS diagnostic screen is still showing the retarder relay box checked, then check pin cavity 7 in the J1 connector at the WABCO ECU. In the 2006 electrical schematics for W-16, W-18, and W42, the electrical schematics will show that there is no wire in pin cavity number 7 in the J1 connector. Make sure there is no wire in that pin cavity number 7 in the J1 connector.
10. Test drive vehicle to make sure fault code(s) do not return.

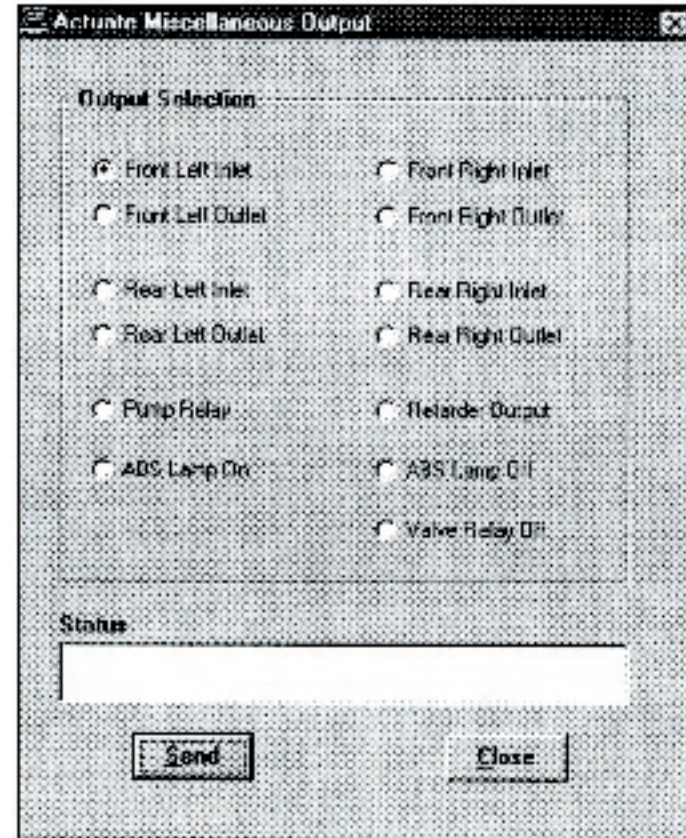


Figure 5-47 — Actuate Miscellaneous Output Screen

### Reset Memorized

This is an automatic default and cannot be de-selected. It indicates the ECU has memorized the installed retarder relay. Once the ECU has seen a retarder, it expects to see it every time the vehicle is powered up.

Because there are times when an ECU is moved to another vehicle — or during diagnostic testing — you may want the ECU to disregard this learned component. Use the Reset Memorized command for this purpose.

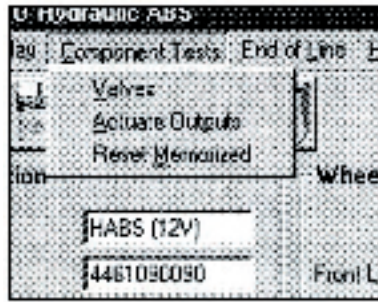


Figure 5-48 — Reset Memorized Option Screen

Select Component Tests from the Hydraulic ABS Main Menu. Then, select Reset Memorized from the pull-down menu to reset the Learned Component screen.

### Fault Information Screen

The Fault Information Screen contains a description of the fault. Repair instructions for each fault appear at the bottom of the screen.

Faults that occur after the screen is displayed will not appear until a screen update is requested. Use the UPDATE button to refresh the fault information table.

After making the necessary repairs, use the CLEAR FAULTS button to clear the fault. Use the update button to refresh the fault information table and display the new list of faults.

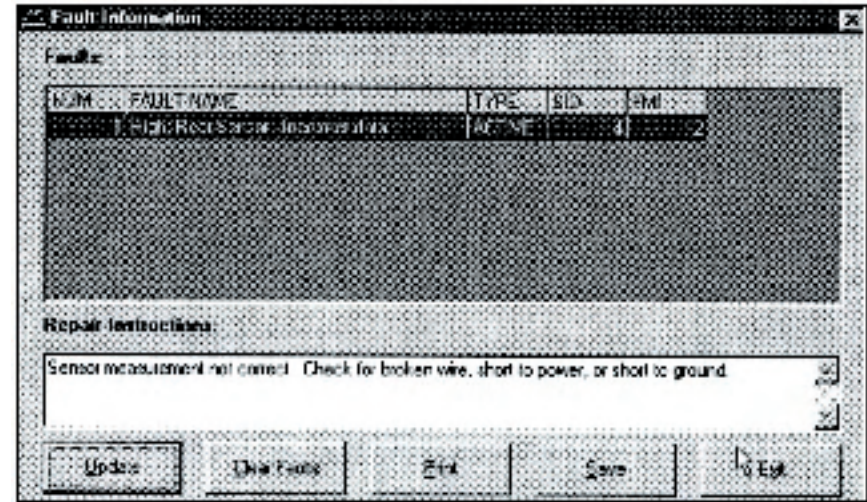


Figure 5-49 — Fault Screen

### ABS Indicator Lamp Activation

To activate the ABS indicator lamp, select HABS (Hydraulic ABS) from the Main Menu. The Hydraulic ABS Main Menu will appear.

Select the Miscellaneous Output Activation icon or select Component Tests to use the pull-down menu to display the Actuate Miscellaneous Output screen. This screen provides a check of the ABS indicator lamp. In addition, it provides a way to check either inlet or outlet activity of the valves, pump or retarder relay. Component activation status appears in the status box of this screen.

## STANDARD SYSTEM TESTING

### Test Equipment: Digital Multimeter (DMM)

Use of a DMM with automatic polarity sensing is recommended. This eliminates the concern of the polarity of the meter leads during voltage measurements.

### System Requirements and Component Tests

#### *Tire Size Range*

For proper hydraulic ABS operation, front and rear tire sizes must be within 16% of each other. Calculate the tire size with the following equation:

### **CAUTION**

***When troubleshooting or testing the ABS system, do not damage the connector terminals.***

### *Voltage Check*

Voltage must be between 9.5 and 14 volts for the 12-volt hydraulic ABS to function properly. Check voltage as follows:

1. Turn ignition ON.
2. Check for proper voltage:
  - ECU: Pins 9 and 3 and 9 and 2 on the black connector.
  - If voltage is not between 9.5 and 14 volts, verify proper wiring connections. Make corrections as required.

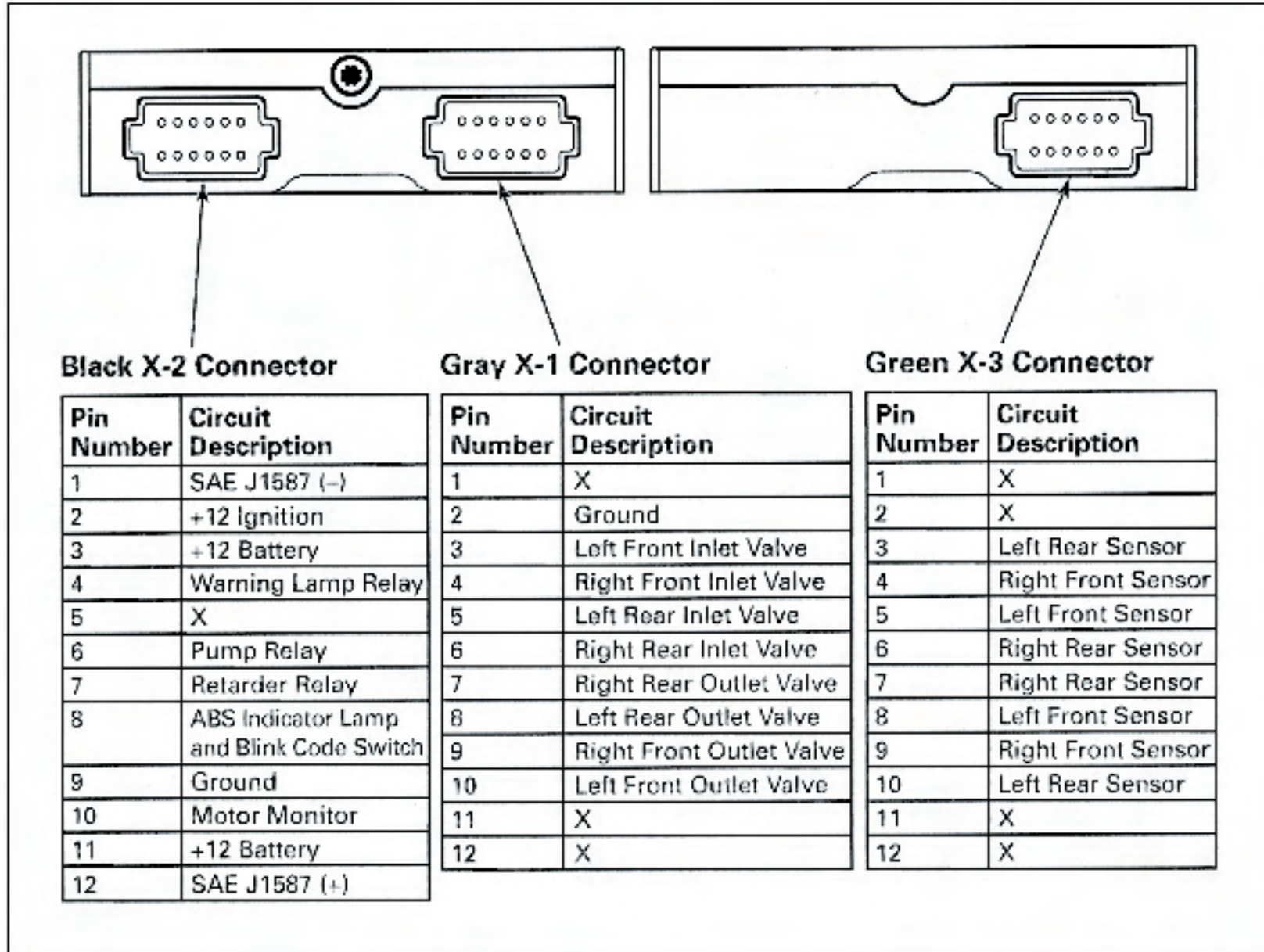


Figure 5-50 — ABS Control Module Connectors

## Standard Component Testing

### ABS Indicator Lamp

If the ABS indicator lamp does not come on after the ignition is turned on, or it comes on but does not go out after three seconds, check all ABS fuses or circuit breakers and replace if necessary. Check the wiring to the ABS diagnostic switch and the indicator lamp and repair or replace the wiring as required. When checking the indicator lamp, follow these steps:

1. Check voltage potential at the lamp socket.
2. Check continuity of the wires to the socket.
3. Replace the bulb.

#### NOTICE

*A complete wiring diagram for the ABS system is available in the vehicle wiring diagram. The following electrical schematic is provided here for reference only. Circuit numbers may not match actual Workhorse circuits.*

### ABS Blink Code Switch

Workhorse motor home and commercial chassis **do not** utilize the optional blink code switch. All diagnostics should be performed using the TOOLBOX™ software as described in this section.

### Wheel Speed Sensor Adjustment

On steering axles, the sensor is accessible on the in-board side of the steering knuckle while on drive axles, the sensor is accessible on the in-board side of the rear axle spindle.

To adjust the sensor, push the sensor in until it contacts the tooth wheel.

#### IMPORTANT

- Do not pry or push sensors with sharp objects
- Sensors will self-adjust during wheel rotation.

#### NOTICE

*No gap is allowable at installation. During normal operation a gap not to exceed 0.040-inch is allowable.*

### Sensor Output Voltage Test

The voltage measured across the sensor output must be at least 0.2 volts AC when the wheel is turned at 30 RPM. Test the sensor output voltage as follows:

1. Turn the ignition off.

## 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.**

2. Raise the vehicle off the ground.
3. Disconnect the appropriate connector from the ECU.

Sensor	Pins - C707 (Green)
Left Front	5 and 8
Right Front	4 and 9
Left Rear	3 and 10
Right Rear	7 and 6

4. Raise the vehicle off the ground. Put safety stands under the axle.
5. Rotate the wheel by hand at 30 RPM 1/2 revolution



per second.

6. Measure the voltage at the connector sockets.

If the minimum voltage is less than 0.2 VAC, push the sensor in until it touches the tooth wheel and remeasure. If it is still too low, replace the sensor. Sensor output voltage must be at least 0.2 volts AC at 30 rpm.

### **Sensor Resistance Test**

Normally there should be between 900 to 2000 ohms measured between the two pins. A resistance measurement should be taken with an ohmmeter. Make sure that the ignition is turned off. You may start with either Step A or Step B whichever is easiest to access.

#### **STEP A**

To measure the resistance at the sensor connector, disconnect the sensor from the sensor extension cable. Connect the ohmmeter to the two sockets on the sensor cable.

- If the reading is not between 900 and 2000 ohms, replace the sensor. Turn the ignition back on and use TOOLBOX™ to verify that the fault is not active.

### **NOTICE**

*The ABS light will not go out until the vehicle has moved and the sensors have detected good signals.*

- If the reading is between 900 and 2000 ohms, the sensor itself is good. The rest of the cabling all the way to the ECU needs to be checked.

#### **STEP B**

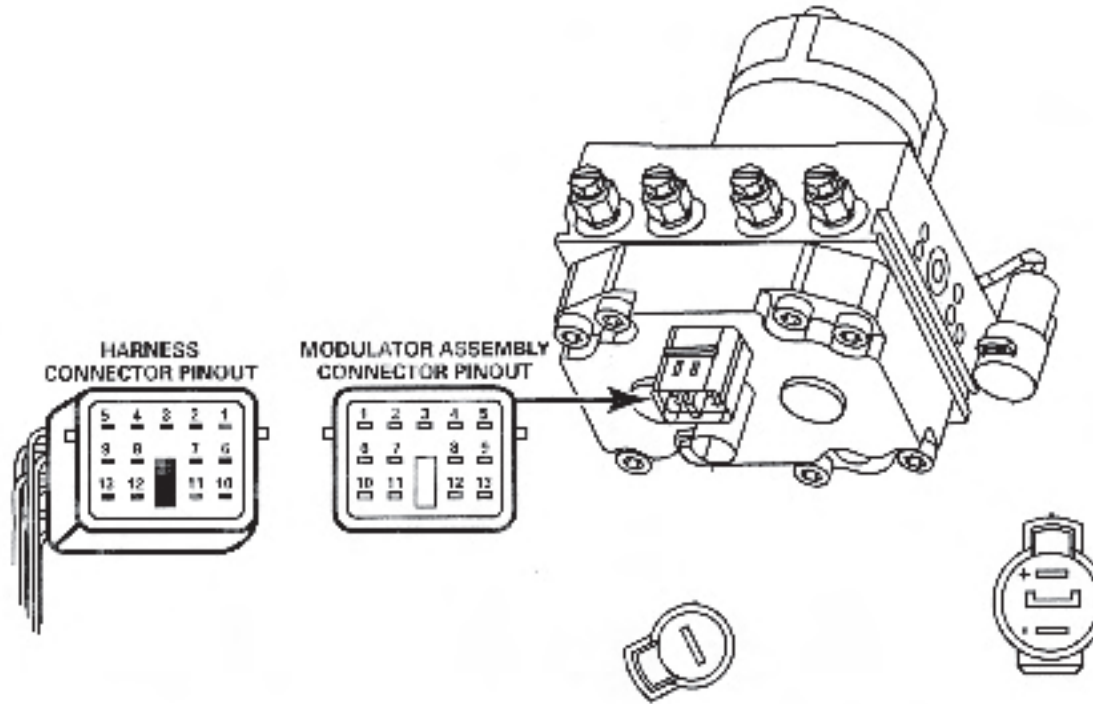
To measure the resistance at the ABS unit through all the cabling and the sensor, disconnect the ABS ECU cable from the ECU and connect the ohmmeter from the two sockets in the ECU cable for this sensor.

- If the reading is not between 900 and 2000 ohms, there is an open in the cabling somewhere. Refer to the vehicle wiring diagram for connectors and pin outs and then check for continuity from sensor to ECU.
- If the reading is between 900 and 2000 ohms, the sensor and cabling is good. Reconnect the ABS ECU and turn on the ignition. Use TOOLBOX™ to check if the fault is still active. If it is still active, replace the ABS ECU.

### **Modulator Assembly Testing**

Refer to the following graphic when conducting tests on the modulator assembly components.

*Figure 5-45 — ABS Modulator Assembly*



Pin Number	Circuit Description	Pin Number	Circuit Description
1	Outlet Valve RL	8	Reference Ground
2	Inlet Valve RL	9	-----
3	-----	10	Outlet Valve RR
4	Inlet Valve FR	11	Inlet Valve RR
5	Outlet Valve FR	12	Inlet Valve FL
6	-----	13	Outlet Valve FL
7	-----		

***Inlet Valve Open Check***

Normally there should be between 6.0 to 7.0 ohms measured between the pin of the valve and ground. A resistance measurement should be taken with an ohmmeter. Make sure that the ignition is turned off. You may start with either Step A or Step B whichever is easiest to access.

*STEP A*

To measure the resistance at the ABS Modulator Unit connector, disconnect the valve cable from the unit. Connect the ohmmeter across each valve solenoid coil to ground.

- If the reading is not between 6.0 and 7.0 ohms, clean the electrical contacts on the connector and check the resistance again. If still out of range, replace the ABS valve. Turn the ignition back on and use TOOLBOX™ to verify that the fault is not active.
- If the reading is between 6.0 and 7.0 ohms, the valve itself is good. The rest of the cabling all the way to the ECU needs to be checked.

*STEP B*

To measure the resistance at the ABS unit through all the cabling and the valve, disconnect the ABS ECU cable from the ECU and connect the ohmmeter between the sockets for the solenoid coil in the ECU cable for this valve see table below and ground.

- If the reading is not between 6.0 and 7.0 ohms, there is

an open in the cabling somewhere. Refer to the vehicle wiring diagram for connectors and pin outs and then check for continuity from valve to ECU.

- If the reading is between 6.0 and 7.0 ohms, the valve and cabling is good. Reconnect the ABS ECU and turn on the ignition. Use TOOLBOX™ to check if the fault is still active. If it is still active, replace the ABS ECU.

**Outlet Valve Open Check**

Normally there should be between 3.0 to 4.0 ohms measured between the pin of the valve and ground. A resistance measurement should be taken with an ohmmeter. Make sure that the ignition is turned off. You may start with either Step A or Step B whichever is easiest to access.

*STEP A*

To measure the resistance at the ABS Modulator Unit connector, disconnect the valve cable from the unit. Connect the ohmmeter across each valve solenoid coil to ground.

- If the reading is not between 3.0 and 4.0 ohms, clean the electrical contacts on the connector and check the resistance again. If still out of range, replace the ABS valve. Turn the ignition back on and use TOOLBOX™ to verify that the fault is not active.
- If the reading is between 3.0 and 4.0 ohms, the valve itself is good. The rest of the cabling all the way to the ECU needs to be checked.

*STEP B*

To measure the resistance at the ABS unit through all the cabling and the valve, disconnect the ABS ECU cable from the ECU and connect the ohmmeter between the sockets for the solenoid coil in the ECU cable for this valve.

- If the reading is not between 3.0 and 4.0 ohms, there is an open in the cabling somewhere. Refer to the vehicle wiring diagram for connectors and pin outs and then check for continuity from valve to ECU.
- If the reading is between 3.0 and 4.0 ohms, the valve and cabling is good. Reconnect the ABS ECU and turn on the ignition. Use TOOLBOX™ to check if the fault is still active. If it is still active, replace the ABS ECU.

## COMPONENT REMOVAL AND INSTALLATION

### Sensors

#### *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  $-40^{\circ}$  to  $300^{\circ}\text{F}$  ( $-40^{\circ}$  to  $150^{\circ}\text{C}$ ).

#### **NOTICE**

*When replacing a Meritor WABCO ABS sensor, you MUST also replace the spring clip and lubricate the bore of the sensor bushing or mounting block.*

## Wheel Speed Sensor Replacement — Front Axle

### *Removal*

### **WARNING**

*To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.*

*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.*

*To avoid damage to the electrical system or ABS components, when welding on an ABS-equipped vehicle disconnect the power connector from the ECU.*

1. Apply the parking brakes. Chock the rear tires to prevent vehicle movement. If necessary, raise the front tires off the ground. Put safety stands under the axle.
2. Disconnect the fasteners that hold the sensor cable to other components.
3. Disconnect the sensor cable from the chassis harness.
4. Remove the sensor from the sensor holder. Twist and pull the sensor to remove it from the sensor bracket. Do not pull on the cable.

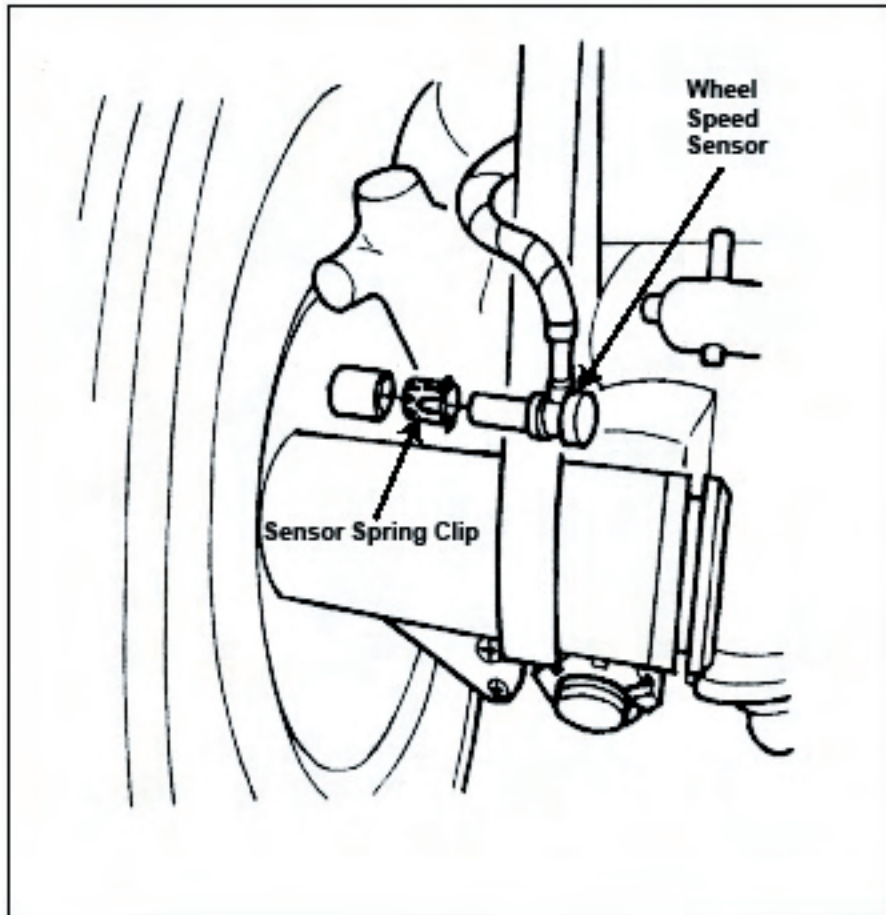


Figure 5-46 — Typical Front WSS Installation

### Installation

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.

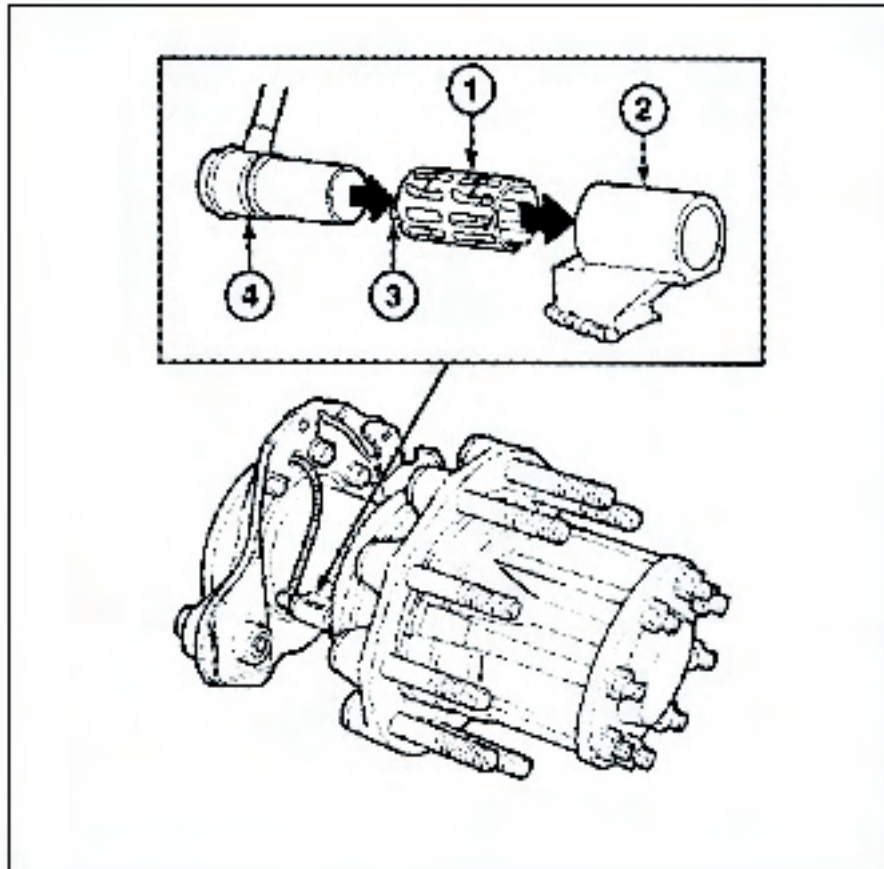
5. With the tabs on the inboard side, push the sensor spring clip into the bushing in the steering knuckle until the clip stops.
6. Push the sensor completely into the sensor spring clip until it contacts the tooth wheel.
7. Fasten the sensor cable with tie wraps every 12 inches. Properly bundle and store excess cable in the subframe.
8. Remove the blocks and safety stands.
9. Perform a voltage output check to ensure proper installation. Refer to “Sensor Output Voltage Test” in this section.

### Wheel Speed Sensor Replacement — Rear Axle

#### Removal

1. Apply the parking brake. Chock the front tires to prevent vehicle movement.
2. Raise the rear tires off of the ground. Put safety stands under the axle.
3. If the rear tire must be removed to gain access to the sensor, release the parking brake to release the brake shoe. Remove the wheel and tire assembly from the axle.
4. Remove the sensor from the mounting block in the axle housing. Use a twisting motion if necessary. Do not pull on the cable.
5. Disconnect the sensor cable from the chassis harness.
6. Remove the sensor cable from any cable clamps or clips.

- Remove the sensor spring clip from the sensor bracket.



1	Spring Clip	3	Installation Direction
2	Mounting Bracket	4	Speed Sensor

Figure 5-47 — Typical Rear WSS Installation

### Installation

- Connect the new sensor cable to the chassis harness.
- Press the sensor spring clip into the sensor bracket, located on the rear axle, until it stops. Make sure the tabs are on the inboard side.
- Apply a Meritor WABCO-recommended lubricant to the sensor.
- Push the sensor completely into the spring clip until it contacts the tooth wheel.
- Re-attach the sensor cable to the cable clamps or clips.
- Fasten the sensor cable with tie wraps every 12 inches. Properly bundle and store excess cable in the sub frame.
- Replace the tire, remove the safety stands, lower the vehicle and remove the chocks from the front tires.
- Perform a voltage output check to ensure proper installation. Refer to “Sensor Output Voltage Test” in this section.

### Modulator Assembly

#### Modulator Assembly Removal

### CAUTION

**The modulator assembly contains hydraulic brake fluid, a caustic substance. Remove the valve carefully so that fluid does not leak and cause skin irritation or damage to components.**

- Apply the parking brakes. Chock the front and rear tires to prevent vehicle movement.

2. Place a container under the modulator assembly to catch leaking brake fluid.
3. Disconnect the electrical harness connectors from the modulator assembly.
4. Mark the six brake lines for ease of installation. Disconnect the lines from the modulator assembly.
5. Remove the three mounting capscrews, washers and nuts that attach the modulator assembly and bracket assembly to vehicle.

**NOTICE**

*Whenever any hydraulic system fitting is loosened or disconnected, the entire system must be bled to remove any air that may have entered.*

6. Remove the modulator assembly and bracket.

**Modulator Assembly Installation**

1. Position the modulator assembly and bracket in place on the vehicle.
2. Tighten the three mounting nuts to 132 lb-in (15 N•m).
3. Connect and tighten brake line connections as follows:
  - Two small adapters - 108 lb-in (12 N•m).
  - Four large adapters - 132 lb-in (15 N•m).
4. Bleed the brake system, per the following instructions.
5. Connect the electrical harnesses to the modulator assembly.

**ABS BRAKE BLEEDING PROCEDURES**

**General**

The following brake bleeding methods explain how to bleed the hydraulic ABS modulator assembly during installation, or in the event of air in the brake system. There are instructions for both pressure and manual bleeding procedures.

These instructions include the procedure for bleeding both the master cylinder and the brake system. In some cases, for example, if you are replacing only the modulator assembly, it may not be necessary to bleed the master cylinder.

**NOTICE**

*The modulator assembly must be handled with appropriate care and should not be exposed to excessive impact or compressed air at the hydraulic ports prior to assembly.*

**WARNING**

*Failure to bleed the system whenever any hydraulic system fitting is loosened or disconnected will allow air to remain in the system. This will prevent the hydraulic pressure in the brake system from rising enough to apply the brakes properly. This will cause the stopping distance to increase and can result in serious personal injury.*

*Properly discard hydraulic brake fluid that is removed from the brake system. Hydraulic brake fluid that is removed can be contaminated and can cause damage, loss of braking and serious personal injury.*

## CAUTION

*Use only the DOT 3 hydraulic brake fluid. Do not use or mix different types of hydraulic brake fluid. The wrong hydraulic brake fluid will damage the rubber parts of the brake caliper and can cause damage, loss of braking and serious personal injury.*

## CAUTION

*Hydraulic brake fluid is a caustic substance. Contact with hydraulic brake fluid can cause skin irritation. Do not let hydraulic brake fluid touch any painted surfaces, as it will remove the paint.*

*Hydraulic brake fluid may also damage certain non-metal surfaces. Do not let fluid get on brake pads, shoes, rotors or disks.*

## Pressure Fill and Bleed

Pressure fill and bleed is the preferred method for bleeding the service brake system. It requires the use of a special pressure bleeder kit, consisting of a tank, pressure pump and valve, gauge, tubing and adapter. These kits are available from a number of manufacturers and include instructions for use.

### Pressure Fill and Bleed Procedure

1. Apply the parking brake and chock the tires. Turn the ignition OFF and disconnect the battery terminals.

## NOTICE

*The ignition must remain off for the entire bleed procedure; energizing the unit during bleeding must be impossible.*

2. Fill the pressure bleeder with new DOT 3 hydraulic brake fluid.
3. Follow the manufacturer's instructions to connect the pressure bleeder to the brake master cylinder reservoir.
4. Set filling pressure to 20 to 30 psi (1.5 to 2.0 bar).
5. Turn on bleed equipment until fluid level in reservoir reaches approximately 0.875-inches (20 mm).
6. Release pressure for 3 to 5 seconds. Apply pressure for 5 to 10 seconds.
7. Repeat Steps 5 and 6 approximately 10 times. After releasing the pressure, air bubbles should rise up into the reservoir.

## CAUTION

*Do not let the brake master cylinder fluid get below the minimum level during the bleeding operation. Keep the master cylinder reservoir filled with new DOT 3 brake fluid.*

*Failure to keep the brake reservoir level above minimum could result in more air entering system, making it impossible to effectively bleed the system.*

8. Bleed the brake system:
  - Set filling pressure to 20 to 30 psi (1.5 to 2.0 bar).
  - Put a wrench on the brake actuator bleeder fitting. Start with the farthest from the modulator, (typically the right rear), then attach a length of clear plastic tubing to the bleeder fitting. Make sure the tube fits snugly.

## NOTICE

*Both the tubing and container must be able to withstand the effects of hydraulic brake fluid.*



9. Submerge the tubing in a container of clean hydraulic brake fluid.
10. Loosen the bleeder fitting until the fluid begins to flow (about 3/4 turn). Let the hydraulic fluid flow out of the fitting until it is free of air bubbles.
11. Tighten firmly to secure the fitting.
12. Repeat Steps 5 through 8 to bleed the remaining three brake actuators. Bleed in sequence of the longest to shortest circuit from the modulator assembly.
13. Turn off bleed equipment and remove pressure. Remove bleed device and check fluid level in reservoir. Fill if required. Replace reservoir cap and dispose of used brake fluid.
14. Remove wheel chocks.

#### **Manual Bleed Procedure**

1. Apply the parking brake and chock the tires. Turn the ignition OFF and disconnect the battery terminals.

#### **NOTICE**

*The ignition must remain off for the entire bleed procedure; energizing the unit during bleeding must be impossible.*

2. Fill the reservoir with DOT 3 hydraulic brake fluid.
3. Depress the brake pedal five times using the stroke between 1/3 travel and maximum travel in 5 seconds.
4. Release the pedal for 5 to 10 seconds. Air bubbles will rise into the reservoir while depressing and releasing pedal.
5. Repeat Steps 3 and 4 another three times, or until sufficient pedal resistance is felt.

#### **WARNING**

*Do not let the brake master cylinder fluid get below the minimum level during the bleeding operation. Keep the master cylinder reservoir filled with new DOT 3 brake fluid.*

*Failure to keep the brake reservoir level above minimum could result in more air entering system, making it impossible to effectively bleed the system.*

6. Bleed the brake system. Put a wrench on the brake actuator bleeder fitting. Start with the farthest from the modulator, (typically the right rear), then attach a length of clear plastic tubing to the bleeder fitting. Make sure the tube fits snugly.
7. Submerge the tubing in a container of clean brake fluid.

#### **NOTICE**

*Both the tubing and container must be able to withstand the effects of brake fluid.*

8. Depress the brake pedal 10 to 15 times, using the maximum available stroke.
9. Loosen the bleeder fitting until the fluid begins to flow, (about 3/4 turn), while depressing the brake pedal through its maximum available stroke.
10. Tighten the fitting firmly prior to releasing the brake pedal.
11. Repeat Steps 6 through 8 several times until the discharged fluid is free of air bubbles.
12. Repeat Steps 3 through 9 to bleed the remaining three brake actuators. Bleed in sequence of the longest to the shortest circuit from the modulator.

13. Check the travel of the brake pedal. If a firm resistance is felt the manual bleeding procedure is complete.
14. Check the fluid level in reservoir and fill if required.  
Replace reservoir cap and dispose of used brake fluid.
15. Remove wheel chocks.

## WABCO TOOLBOX™ User's Manual

Meritor WABCO TOOLBOX™ Software is a PC-based diagnostics program that runs in Windows® 98, Me, NT, 2000 or XP. TOOLBOX™ Software provides PC diagnostic capabilities for Meritor WABCO tractor and trailer pneumatic ABS, hydraulic ABS and the electronic leveling module (ELM) for both tractor and trailer. The program provides four basic functions:

- Displays both constant (e.g., ECU number) and changing (e.g., RPMs) information from the system under test.
- Displays both active and stored system faults, as well as the appropriate repair instructions.
- Provides a link to service information testing procedures, etc. (ABS and HABS only)
- Activates system components to verify system integrity, correct component operation and installation wiring.

### System Requirements

- Pentium-based personal computer
- Microsoft Windows® 98, Me, 2000 or XP. Internet Explorer version 3.02 or higher must be installed.

### NOTICE

*You must have Administrator Privileges to install and run TOOLBOX™ Software on Windows® NT.*

- 64 MB RAM
- Approximately 10.0 MB hard disk space for each program. 60 MB hard disk space for full install

- CD-ROM drive
- RS232 to SAE J1708 or RS232 to PLC converter cable
- Serial Port. RS232-SAE J1708 interface adapter required

Follow the instructions included with TOOLBOX™ Software to install the program on your computer. The installation screen offers three types of installations:

- Typical
- Compact
- Custom

Select Typical or Compact to install tractor, trailer and hydraulic ABS diagnostic programs. Select Custom to install only one or two of these programs.

After installation, Meritor WABCO TOOLBOX™ Software will be available on your desktop as an icon and under the Windows® start menu.

### NOTICE

*An RS232 to J1708 or RS232 to PLC converter box attached to the communications port on your computer (COM1 or COM2) is required. Converter boxes that have been tested and proven satisfactory are Noregon, Nexiq, B&B Devices, Kent-Moore and Dearborn Group.*

1. Attach the RS232 to J1708 converter cable from your computer's serial port to the converter box.
2. Attach the diagnostic cable (Deutsch) to the vehicle.

## TOOLBOX™ Start-up

At start-up, select the TOOLBOX™ Software icon from Desktop or from the Windows® Start Menu to display the MAIN MENU.

Most TOOLBOX™ features are accessible through pull down menus. Many of these features may also be accessed by a shortcut icon.

At the Main Menu you may select a shortcut icon to:

- Exit TOOLBOX™
- Go to Tractor ABS diagnostics
- Go to Trailer ABS diagnostics
- **Go to Hydraulic ABS (HABS) diagnostics (WCC Chassis)** OR Go to Hydraulic Power Brake (HPB) diagnostics
- Go to Electronic Leveling Module (ELM) for Tractors
- Go to Electronic Leveling Module (ELM) for Trailers

## System Setup

Select System Setup from the Main Menu

### Language

Select Language from the System Setup menu. The default is English. To change the default to French or Spanish (ABS only):

1. Select the appropriate language.
2. Click OK to accept the selection.

Click on Select ECU from the System Setup menu, then select the type of ABS to be tested. Click on the appropriate Meritor WABCO product icon to display the Main Menu for that program.

**Roll Call** displays all actively broadcasting ECU's.

### NOTICE

*TOOLBOX™ diagnostics cover only Meritor WABCO ECU's.*

### COM Port

The correct Vendor, Protocol and Device selections are essential. TOOLBOX™ will not operate correctly if these selections are not accurate. **For assistance, contact the Workhorse Technical Assistance Center at (877) 246-7731.**

From the System Setup pull down menu, select COM Port to display the Device Settings menu. Current settings will be shown.

### Vendor

To change these selections, click on the down arrow for a list of vendor choices. Select the appropriate vendor.

Click on the down arrow for the protocol choices.

### Device

Click on the down arrow for the device choices. Select the device and port to which the data cable is connected.

Click OK to accept the selections and close the Device Settings window.

## Help

Select the Help icon for help in using Meritor WABCO TOOLBOX™ Software. Help is accessible from all TOOLBOX™ pages. Search by title or type in a specific topic.

## System Information

Select System Information and follow the screen prompts to print a report of system hardware: operating system version, drivers, etc. Run this report whenever you contact the Workhorse Technical Assistance Center.

## Update Application (Versions 5.0 and Higher)

Select Update Application to download future revisions to TOOLBOX™. This option is available for TOOLBOX™ version 5.0 and higher. Follow the screen prompts to complete the download.

## About

Select About from the pull down menu for information about Meritor WABCO TOOLBOX™ Software, including the version number.

## Hydraulic ABS

### NOTICE

*TOOLBOX™ Software must be connected to the vehicle and the vehicle ignition must be ON in order to display information.*

## Hydraulic ABS Menus and Toolbars

Select Hydraulic ABS from the TOOLBOX™ Main Menu. TOOLBOX™ will recognize the HABS or Hydraulic Power Brake (HPB) ECU and display the appropriate screen. If you are working with HPB, refer to the HPB section of this manual.

The Main Screen provides icons and pull down menu task selections. It also provides information about the current status of Meritor WABCO HABS.

ECU information is read once from the ECU and does not change. All other information (e.g., wheel sensors, voltages and fault information) is read and updated continuously.

### NOTICE

*Double click on Yes in the Existing or Stored Faults fields of the HABS Main Screen to bring up the Fault Information screen. Service Information may also be observed from this screen.*

From the Main Screen, you can select Restart, Exit or Help.

## Tractor ECU (Use for all Workhorse chassis)

Select Tractor ECU from the HABS Main Screen. A pull down menu will appear.

## Restart

Select Restart to refresh (update) ECU information.

## Exit

Select Exit to exit HABS and return to the TOOLBOX™ Main Menu.

### **Display**

Select Display from the HABS Main Screen. A pull down menu will appear.

### **Faults**

Select Faults to display the Fault Information screen.

#### **NOTICE**

*The Fault Information Screen is also accessible from the HABS Main Menu.*

The Fault Information screen contains a description of each fault, including the type of fault (Active or Stored), SID and FMI number.

Repair instructions for the fault appear at the bottom of the screen. For detailed repair instructions, click on the fault to display a troubleshooting information sheet. Bookmark and Thumbnail tabs at the side of the troubleshooting information sheet provide additional information. A sample troubleshooting information sheet appears in the Appendix. This screen also provides a link to the appropriate system schematic.

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 and display a new list of faults.

After making any required repairs, use the Clear Faults button to clear the fault. Clear each fault as it is repaired. Use the Save or Print button to save or print the fault information data. Select Exit to close this screen.

### **Component Tests**

Select Component Tests from the HABS Main Screen. A pull down menu will appear.

### **Valves**

Select Valves to display the Valve Activation screen. The Valve Activation screen lets you activate the four valves, the pump and the retarder relay. In addition to checking for correct activation, this screen provides an easy way to make sure the valves are wired correctly — and that wiring is not reversed.

Click on the valve or pump you wish to test, then click on the Send button to actuate the component. Component activation status appears in the status box field. Use the Close button to close this screen.

### **Actuate Outputs**

Select Actuate Outputs to display the Actuate Miscellaneous Output screen. This screen provides a check of the ABS indicator lamp. In addition, it provides a way to check either inlet or outlet activity of the valves, pump or retarder relay.

Click on the component you wish to test, then click on the Send button to actuate the component. Component activation status appears in the status box field. Use the Close button to close this screen.

### **Reset Memorized**

Select Reset Memorized to display the Learned Component screen.

Relay is an automatic default and cannot be de-selected. It indicates the ECU has memorized the installed retarder relay. Once the ECU has seen a retarder, it expects to see it every time the vehicle is powered up. Because there are times when an ECU is moved to another vehicle — or during diagnostic testing — you may want the ECU to disregard this learned component. Use the Reset Memorized command for this purpose.

### **Wheel Speed**

Select Wheel Speed to display the Wheel Speed screen. Use the Wheel Speed screen to verify that sensors are connected at each wheel. Speed at a sensed wheel (FL, FR, RL, RR) indicates sensors are installed, but does not verify correct sensor installation.

### **End of Line**

The End of Line Brake Bleed Procedure is accessed from the HABS main screen. Use the Brake Bleed feature to bleed the expansion chambers.

### **NOTICE**

*Before connecting the vehicle to the computer, bleed the circuit and master cylinder.*

## **WARNING**

*Failure to bleed the system whenever any hydraulic system fitting is loosened or disconnected will allow air to remain in the system. This will prevent the hydraulic pressure in the brake system from rising enough to apply the brakes correctly. This will cause the stopping distance to increase and can result in serious personal injury.*

*Correctly discard hydraulic brake fluid that is removed from the brake system. Hydraulic brake fluid that is removed can be contaminated and can cause damage, loss of braking and serious personal injury.*

*Use only DOT 3 hydraulic brake fluid. Do not use or mix different types of hydraulic brake fluid. The wrong hydraulic brake fluid will damage the rubber parts of the brake caliper and can cause damage, loss of braking and serious personal injury.*

## **CAUTION**

*Do not let the brake master cylinder fluid get below the minimum level during the bleeding operation. Keep the master cylinder reservoir filled with new DOT 3 brake fluid. Failure to keep the brake reservoir level above minimum could result in more air entering system, making it impossible to effectively bleed the system.*

## CAUTION

**Hydraulic brake fluid is a caustic substance. Contact with hydraulic brake fluid can cause skin irritation. Do not let hydraulic brake fluid touch any painted surfaces, as it will remove the paint. Hydraulic brake fluid may also damage certain non-metal surfaces. Do not let fluid get on brake pads, shoes, rotors or disks.**

1. Apply the parking brake and block the tires. Turn the ignition off.
2. Perform brake bleed procedure for wet module, bleeding the circuit and master cylinder if required, prior to connecting laptop to truck.
3. Connect laptop to the vehicle using the J1587 diagnostic port in the cab of the truck.
4. Launch Meritor WABCO TOOLBOX™ Diagnostic Software.
5. From the Main Menu select the HABS icon.
6. Select End of Line from the HABS Main Menu.
7. Select Bleed Procedure from the End of Line Menu.
8. Choose axle to bleed from the select axle screen.
9. Follow on-screen prompts.  
Click OK to continue.  
Click OK to continue.
10. Repeat procedure two additional times on this axle.  
This should eliminate all of the air in the chamber.
11. Perform manual bleed on this axle.
12. Repeat Steps 8-11 for the other axle.
13. Test drive the vehicle after bleeding the brakes.
  - If a firm brake pedal resistance is felt and the brake pedal pushes back when you perform an ABS stop, the system bleed procedure is complete.
  - If there is no firm pedal resistance, check the brake system for defects (leaks, etc.) and make the necessary repairs, then repeat the bleed procedure.



## MERITOR WABCO FAULT CODES

### NOTICE

*The following "Blink Codes" are designated by a two-digit number. To determine the actual blink code use the following example:*

*23 = 2 blinks pause 3 blinks*

### Blink Code 21

**SAE Fault Code: SID 43 — FMI 3**

**Description: Right Front Inlet Valve Shorted to Battery Voltage**

The ABS ECU has detected that the inlet solenoid valve X1-4 is shorted to battery voltage. Check the cables from the ECU to the valve for damage.

### Blink Code 21

**SAE Fault Code: SID 43 — FMI 5**

**Description: Right Front Inlet Valve Open**

The ABS unit has detected an open circuit between the pins that connect to the left front ABS inlet valve on the X1 connector pins 4 & 2. The open circuit may be caused by a bad solenoid valve, or an open in the cable/sockets. Use an ohmmeter to check the resistance and determine the bad component.

### Blink Code 21

**SAE Fault Code: SID 43 FMI 6**

**Description: Right Front Inlet Valve Shorted to Ground**

The ABS ECU has detected that the inlet solenoid valve X1-4 is shorted to ground. Check the cables from the ECU to the valve for damage.

### Blink Code 21

**SAE Fault Code: SID 49 — FMI 3**

**Description: Right Front Outlet Valve Shorted to Battery Voltage**

The ABS ECU has detected that the outlet solenoid valve X1-9 is shorted to battery voltage. Check the cables from the ECU to the valve for damage.

### Blink Code 21

**SAE Fault Code: SID 49 — FMI 5**

**Description: Right Front Outlet Valve Open**

The ABS unit has detected an open circuit between the pins that connect to the left front ABS outlet valve on the X1 connector pins 9 & 2. The open circuit may be caused by a bad solenoid valve, or an open in the cable/sockets. Use an ohmmeter to check the resistance and determine the bad component

### **Blink Code 21**

**SAE Fault Code: SID 49 — FMI 6**

**Description: Right Front Outlet Valve Shorted to Ground**

The ABS ECU has detected that the outlet solenoid valve X1-9 is shorted to ground. Check the cables from the ECU to the valve for damage.

### **Blink Code 22**

**SAE Fault Code: SID 14 FMI 3**

**Description: ABS Valve Relay Internal Shorted to 12V**

The ABS ECU has detected a short to 12V on the internal valve relay. Clear the fault with TOOLBOX™ software and cycle the ignition. If fault repeats, replace ABS ECU.

### **Blink Code 22**

**SAE Fault Code: SID 42 — FMI 3**

**Description: Left Front Inlet Valve Shorted to Battery Voltage**

The ABS ECU has detected that the inlet solenoid valve X1-3 is shorted to battery voltage. Check the cables from the ECU to the valve for damage.

### **Blink Code 22**

**SAE Fault Code: SID 42 — FMI 5**

**Description: Left Front Inlet Valve Open**

The ABS unit has detected an open circuit between the pins that connect to the left front ABS inlet valve on the X1 connector pins 2 & 3. The open circuit may be caused by a bad solenoid valve, or an open in the cable/sockets. Use an ohmmeter to check the resistance and determine the bad component.

### **Blink Code 22**

**SAE Fault Code: SID 42 — FMI 6**

**Description: Left Front Inlet Valve Shorted to Ground**

The ABS ECU has detected that the inlet solenoid valve X1-3 is shorted to ground. Check the cables from the ECU to the valve for damage.

### **Blink Code 22**

**SAE Fault Code: SID 48 — FMI 3**

**Description: Left Front Outlet Valve Shorted to Battery Voltage**

The ABS ECU has detected that the outlet solenoid valve X1-10 is shorted to battery voltage. Check the cables from the ECU to the valve for damage.

### **Blink Code 22**

**SAE Fault Code: SID 48 — FMI 5**

**Description: Left Front Outlet Valve Open**

The ABS unit has detected an open circuit between the pins that connect to the left front ABS outlet valve on the X1 connector 10 & 2. The open circuit may be caused by a bad solenoid valve, or an open in the cable/sockets. Use an ohmmeter to check the resistance and determine the bad component.

### **Blink Code 22**

**SAE Fault Code: SID 48 FMI 6**

**Description: Left Front Outlet Valve Shorted to Ground**

The ABS ECU has detected that the outlet solenoid valve X1-10 is shorted to ground. Check the cables from the ECU to the valve for damage.

### **Blink Code 23**

**SAE Fault Code: SID 45 — FMI 3**

**Description: Right Rear Inlet Valve Shorted to Battery Voltage**

The ABS ECU has detected that the inlet solenoid valve X1-6 is shorted to battery voltage. Check the cables from the ECU to the valve for damage.

### **Blink Code 23**

**SAE Fault Code: SID 45 — FMI 5**

**Description: Right Rear Inlet Valve Open**

The ABS unit has detected an open circuit between the pins that connect to the left front ABS inlet valve on the X1 connector pins 6 & 2. The open circuit may be caused by a bad solenoid valve, or an open in the cable/sockets. Use an ohmmeter to check the resistance and determine the bad component.

### **Blink Code 23**

**SAE Fault Code: SID 45 — FMI 6**

**Description: Right Rear Inlet Valve Shorted to Ground**

The ABS ECU has detected that the inlet solenoid valve X1-6 is shorted to ground. Check the cables from the ECU to the valve for damage.

### **Blink Code 23**

**SAE Fault Code: SID 51 — FMI 5**

**Description: Right Rear Outlet Valve Open**

The ABS unit has detected an open circuit between the pins that connect to the left front ABS outlet valve on the X1 connector pins 7 & 2. The open circuit may be caused by a bad solenoid valve, or an open in the cable/sockets. Use an ohmmeter to check the resistance and determine the bad component.

### **Blink Code 23**

**SAE Fault Code: SID 51 — FMI 6**

**Description: Right Rear Outlet Valve Shorted to Ground**

The ABS ECU has detected that the outlet solenoid valve X1-7 is shorted to ground. Check the cables from the ECU to the valve for damage.

### **Blink Code 23**

**SAE Fault Code: SID 51 — FMI 3**

**Description: Right Rear Outlet Valve Shorted to Battery Voltage**

The ABS ECU has detected that the outlet solenoid valve X1-7 is shorted to battery voltage. Check the cables from the ECU to the valve for damage.

### **Blink Code 24**

**SAE Fault Code: SID 44 — FMI 3**

**Description: Left Rear Inlet Valve Shorted to Battery Voltage**

The ABS ECU has detected that the inlet solenoid valve X1-5 is shorted to battery voltage. Check the cables from the ECU to the valve for damage.

### **Blink Code 24**

**SAE Fault Code: SID 44 — FMI 5**

**Description: Left Rear Inlet Valve Open**

The ABS unit has detected an open circuit between the pins that connect to the left front ABS inlet valve on the X1 connector pins 5 & 2. The open circuit may be caused by a bad solenoid valve, or an open in the cable/sockets. Use an ohmmeter to check the resistance and determine the bad component.

### **Blink Code 24**

**SAE Fault Code: SID 44 — FMI 6**

**Description: Left Rear Inlet Valve Shorted to Ground**

The ABS ECU has detected that the inlet solenoid valve X1-5 is shorted to ground. Check the cables from the ECU to the valve for damage.

### **Blink Code 24**

**SAE Fault Code: SID 50 — FMI 3**

**Description: Left Rear Outlet Valve Shorted to Battery Voltage**

The ABS ECU has detected that the outlet solenoid valve X1-8 is shorted to battery voltage. Check the cables from the ECU to the valve for damage.

**Blink Code 24**

**SAE Fault Code: SID 50 — FMI 5**

**Description: Left Rear Outlet Valve Open**

The ABS unit has detected an open circuit between the pins that connect to the left front ABS outlet valve on the X1 connector pins 8 & 2. The open circuit may be caused by a bad solenoid valve, or an open in the cable/sockets. Use an ohmmeter to check the resistance and determine the bad component.

**Blink Code 24**

**SAE Fault Code: SID 50 — FMI 6**

**Description: Left Rear Outlet Valve Shorted to Ground**

The ABS ECU has detected that the outlet solenoid valve X1-8 is shorted to ground. Check the cables from the ECU to the valve for damage

**Blink Code 27**

**SAE Fault Code: SID 251 — FMI 5**

**Description: Power Supply Ground Reference Missing**

The ABS ECU has detected the supply voltage ground reference wire is broken or shorted to plus voltage. Check the wiring.

**Blink Code 31**

**SAE Fault Code: SID 2 — FMI 1**

**Description: Right Front Wheel Sensor Air Gap Too Large**

The ABS ECU has detected that the output voltage signal of the wheel sensor is too low. Check for loose wheel bearings or excessive hub run out. Push the wheel sensor all the way in until it contacts the tooth wheel. Do not pry or push sensors with sharp objects. Sensors will self-adjust during wheel rotation. To check the amplitude with a voltmeter, disconnect the X3 connector from the ECU and measure across pins 4 and 9.

**Blink Code 32**

**SAE Fault Code: SID 1 — FMI 1**

**Description: Left Front Wheel Sensor Air Gap Too Large**

The ABS ECU has detected that the output voltage signal of the wheel sensor is too low. Check for loose wheel bearings or excessive hub run out. Push the wheel sensor all the way in until it contacts the tooth wheel. Do not pry or push sensors with sharp objects. Sensors will self-adjust during wheel rotation. To check the amplitude with a voltmeter, disconnect the connector X3 from the ECU and measure across pins 5 and 8.

### **Blink Code 33**

**SAE Fault Code: SID 4 — FMI 1**

**Description: Right Rear Wheel Sensor Air Gap Too Large**

The ABS ECU has detected that the output voltage signal of the wheel sensor is too low. Check for loose wheel bearings or excessive hub run out. Push the wheel sensor all the way in until it contacts the tooth wheel. Do not pry or push sensors with sharp objects. Sensors will self-adjust during wheel rotation. To check the amplitude with a voltmeter, disconnect the X3 connector from the ECU and measure across pins 7 and 6.

### **Blink Code 34**

**SAE Fault Code: SID 3 — FMI 1**

**Description: Left Rear Wheel Sensor Air Gap Too Large**

The ABS ECU has detected that the output voltage signal of the wheel sensor is too low. Check for loose wheel bearings or excessive hub run out. Push the wheel sensor all the way in until it contacts the tooth wheel. Do not pry or push sensors with sharp objects. Sensors will self-adjust during wheel rotation. To check the amplitude with a voltmeter, disconnect the X3 connector from the ECU and measure across pins 10 and 3.

### **Blink Code 41**

**Fault Code: SID 2 — FMI 10**

**Description: Right Front Wheel Sensor Speed Drop Out**

The ABS ECU has detected a temporary loss of wheel speed signal. Adjust the air gap by pushing the sensor all the way until it touches the tooth wheel. Check sensor and cabling for intermittent contact.

### **Blink Code 42**

**SAE Fault Code: SID 1 — FMI 2**

**Description: Left Front Wheel Sensor Measurement Not Correct**

The ABS ECU has detected an incorrect measurement across the sensor on the X3 connector pins 5 and 8. Check electrical resistance of the sensor and the wiring at the ECU and at the harness plugs. Check for a broken wire, a short to battery voltage or a short to ground.

### **Blink Code 42**

**SAE Fault Code: SID 2 — FMI 2**

**Description: Right Front Wheel Sensor Measurement Not Correct**

The ABS ECU has detected an incorrect measurement across the sensor on the X3 connector pins 4 and 9. Check electrical resistance of the sensor and the wiring at the ECU and at the harness plugs. Check for a broken wire, a short to battery voltage or a short to ground.

### **Blink Code 42**

**SAE Fault Code: SID 1 — FMI 10**

**Description: Left Front Wheel Sensor Speed Drop Out**

The ABS ECU has detected a temporary loss of wheel speed signal. Adjust the air gap by pushing the sensor all the way until it touches the tooth wheel. Check sensor and cabling for intermittent contact.

### **Blink Code 43**

**Blink Code**

**SAE Fault Code: SID 4 — FMI 2**

**Description: Right Rear Wheel Sensor Measurement Not Correct**

The ABS ECU has detected an incorrect measurement across the sensor on the X3 connector pins 7 and 6. Check electrical resistance of the sensor and the wiring at the ECU and at the harness plugs. Check for a broken wire, a short to battery voltage or a short to ground.

### **Blink Code 43**

**SAE Fault Code: SID 4 — FMI 10**

**Description: Right Rear Wheel Sensor Speed Drop Out**

The ABS ECU has detected a temporary loss of wheel speed signal. Adjust the air gap by pushing the sensor all the way until it touches the tooth wheel. Check sensor and cabling for intermittent contact.

### **Blink Code 44**

**SAE Fault Code: SID 3 — FMI 2**

**Description: Left Rear Wheel Sensor Measurement Not Correct**

The ABS ECU has detected an incorrect measurement across the sensor on the X3 connector pins 10 and 3. Check electrical resistance of the sensor and the wiring at the ECU and at the harness plugs. Check for a broken wire, a short to battery voltage or a short to ground.

### **Blink Code 44**

**SAE Fault Code: SID 3 — FMI 10**

**Description: Left Rear Wheel Sensor Speed Drop Out**

The ABS ECU has detected a temporary loss of wheel speed signal. Adjust the air gap by pushing the sensor all the way until it touches the tooth wheel. Check sensor and cabling for intermittent contact.

### **Blink Code 51**

**SAE Fault Code: SID 2 — FMI 13**

**Description: Right Front Wheel Sensor Tire Mismatch**

The ABS ECU has detected wheel speeds that indicate that the tire size or tooth wheel doesn't match the other wheels. The front and rear tire sizes must be within 14%. All tooth wheels must have the same number of teeth.

### Blink Code 52

**SAE Fault Code: SID 1 — FMI 13**

**Description: Left Front Wheel Sensor Tire Mismatch**

The ABS ECU has detected wheel speeds that indicate that the tire size or tooth wheel doesn't match the other wheels. The front and rear tire sizes must be within 14%. All tooth wheels must have the same number of teeth.

### Blink Code 53

**SAE Fault Code: SID 4 — FMI 13**

**Description: Right Rear Wheel Sensor Tire Mismatch**

The ABS ECU has detected wheel speeds that indicate that the tire size or tooth wheel doesn't match the other wheels. The front and rear tire sizes must be within 14%. All tooth wheels must have the same number of teeth.

### Blink Code 54

**SAE Fault Code: SID 3 — FMI 13**

**Description: Left Rear Wheel Sensor Tire Mismatch**

The ABS ECU has detected wheel speeds that indicate that the tire size or tooth wheel doesn't match the other wheels. The front and rear tire sizes must be within 14%. All tooth wheels must have the same number of teeth.

### Blink Code 73

**SAE Fault Code: SID 13 — FMI 3**

**Description: Retarder Relay Shorted to Battery Voltage**

The ABS ECU has detected a short to battery voltage on the retarder relay output X2-7. Check the wiring. X2-7 should go to one end of the retarder relay only.

### Blink Code 73

**SAE Fault Code: SID 13 FMI 5**

**Description: Retarder Relay Open Circuit**

The ABS ECU has detected that the retarder relay output is not connected to a load. Check the wiring. X2-7 should go to one end of the retarder relay.

### Blink Code 73

**SAE Fault Code: SID 13 — FMI 6**

**Description: Retarder Relay Shorted to Ground**

The ABS ECU has detected a short to ground on the retarder relay output X2-7. Check the wiring. X2-7 should go to one end of the retarder relay only.



**Blink Code 74**

**SAE Fault Code: SID 23 — FMI 5**

**Description: Warning Light Open**

The ABS ECU has detected an open circuit on the warning lamp output pin X2-8. Check wiring and bulb. This can also be caused by activating the blink code switch for greater than 16 seconds. Clear the fault with TOOLBOX™ software and cycle the ignition. If fault repeats, replace ABS ECU.

**Blink Code 77**

**SAE Fault Code: SID 54 — FMI 4**

**Description: Hydraulic Pump Motor Failure # 2**

The ABS ECU has detected a failure in the hydraulic pump motor. A low level at the motor monitor pin X2-10 has been with the pump motor being activated. Check the hydraulic pump and the pump wiring.

**Blink Code 77**

**SAE Fault Code: SID 54 — FMI 7**

**Description: Hydraulic Pump Motor Failure # 3**

The ABS ECU has detected a failure in the hydraulic pump motor. Check the hydraulic pump and the pump wiring.

**Blink Code 77**

**SAE Fault Code: SID 54 — FMI 3**

**Description: Hydraulic Pump Motor Failure # 1**

The ABS ECU has detected a failure in the hydraulic pump motor. A high level at the motor monitor pin X2-10 has been detected without the pump motor being activated. Check the hydraulic pump and the pump wiring.

**Blink Code 78**

**SAE Fault Code: SID 30 — FMI 3**

**Description: Pump Motor Relay Shorted to 12V**

The ABS ECU has detected a short to battery voltage on the Pump Motor relay output X2-6. Check the wiring. X2-6 should go to one end of the Pump Motor relay only.

**Blink Code 78**

**SAE Fault Code: SID 30 — FMI 5**

**Description: Pump Motor Relay Open Circuit**

The ABS ECU has detected an open circuit on the Pump Motor relay output X2-6. Check the wiring. X2-6 should go to one end of the retarder relay.

**Blink Code 78**

**SAE Fault Code: SID 30 — FMI 6**

**Description: Pump Motor Relay Shorted to Ground**

The ABS ECU has detected a short to ground on the Pump Motor relay output X2-6. Check the wiring. X2-6 should go to one end of the Pump Motor relay only.

**Blink Code 78**

**SAE Fault Code: SID 30 — FMI 7**

**Description: Pump Motor Relay Sticky Pump Relay**

The ABS ECU has detected a sticky pump relay. The pump motor may be permanently running. Check the relay and replace if necessary.

**Blink Code 81**

**SAE Fault Code: SID 14 — FMI 4**

**Description: ABS Valve Relay Internal Shorted to Ground**

The ABS ECU has detected a short to ground on the internal valve relay. Clear the fault with TOOLBOX™ software and cycle the ignition. If fault repeats, replace ABS ECU.

**Blink Code 82**

**SAE Fault Code: SID 251 — FMI 3**

**Description: Power Supply High Voltage**

The ABS ECU has detected the supply voltage to be too high for more than 5 seconds. Check the alternator and battery. Check for faulty valve relay or wiring.

**Blink Code 81**

**SAE Fault Code: SID 251 — FMI 4**

**Description: Power Supply Low Voltage**

The ABS ECU has detected the supply voltage to be too low for more than 5 seconds. Check the supply wire, battery and fuse. Check for faulty valve relay or wiring.

**Blink Code 83**

**SAE Fault Code: SID 254 — FMI 12**

**Description: Internal Error**

The ABS ECU has detected an internal fault. Clear the fault with TOOLBOX™ software and cycle the ignition. If fault repeats, replace ABS ECU.

**Blink Code 84**

**SAE Fault Code: SID 253 — FMI 2**

**Description: EEPROM Checksum Error**

The ABS ECU has detected a checksum error in the parameters in the EEPROM. Clear the fault with TOOLBOX™ software and cycle the ignition. If fault repeats, replace ABS ECU.

**Blink Code N/A**

**SAE Fault Code: SID 55 — FMI 2**

**Description: Brake Light Switch Failure**

The ECU has detected a failure in the brake light switch. The brake light switch data is erratic. Check for short to 12V or short to ground.

**Blink Code N/A**

**SAE Fault Code: SID unk — FMI unk**

**Description: Unknown SID/FMI**

The ABS ECU has reported a System ID and Failure Mode Identifier that is not recognized by this document. Please contact: **Workhorse Technical Assistance Center at (877) 246-7731.**

## DIAGNOSTIC TROUBLE CODES

### DTC P0608

#### *Circuit Description*

The PCM creates the vehicle speed output signal by pulsing the circuit to ground. The PCM pulses the circuit at the same rate as the vehicle speed signal input. The PCM monitors the voltage on the vehicle speed output circuit. If the PCM determines the voltage is out of the normal operating range, a DTC sets.

#### *DTC Descriptor*

This diagnostic procedure supports the following DTC:

- DTC P0608 Vehicle Speed Output Circuit

#### *Conditions for Running the DTC*

- The engine speed is greater than 400 RPM.
- The ignition voltage is greater than 6 volts but less than 18 volts.

#### *Conditions for Setting the DTC*

- The PCM detects that the commanded state of the driver and the actual state of the control circuit do not match.
- The condition must be present for a min. of 5 seconds.

#### *Action Taken When the DTC Sets*

- The PCM stores the DTC information in memory.
- The PCM records the operating conditions at the time the DTC sets. The PCM displays the failure information in the Failure Records on the scan tool.

#### *Conditions for Clearing the DTC*

- The history DTC clears after 40 malfunction-free warm-up cycles.
- The DTC becomes history when the conditions for setting the DTC are no longer present.
- The PCM receives the clear code command from the scan tool.

#### *Diagnostic Aids*

##### **IMPORTANT:**

*Remove any debris from the PCM connector surfaces before servicing the PCM. Inspect the PCM connector gaskets when diagnosing/replacing the PCM. Ensure that the gaskets are installed correctly. The gaskets prevent water intrusion into the PCM.*

Using Freeze Frame and/or Failure Records data may aid in locating an intermittent condition. If you cannot duplicate the DTC, the information included in the Freeze Frame and/or Failure Records data can aid in determining how many miles since the DTC set. The Fail Counter and Pass Counter can also aid determining how many ignition cycles the diagnostic reported a pass and/or a fail. Operate the vehicle within the same freeze frame conditions (RPM, load, vehicle speed, temperature etc.) that you observed. This will isolate when the DTC failed.

For an intermittent, refer to Testing for Intermittent Conditions and Poor Connections .

<b>DTC P0608</b>				
<b>Step</b>	<b>Action</b>	<b>Value(s)</b>	<b>Yes</b>	<b>No</b>
Schematic Reference: Instrument Cluster Schematics Connector End View Reference: Master Electrical Component List				
1	Did you perform the Diagnostic System Check – Vehicle?	—	Go to Step 2	Go to Diagnostic System Check – Vehicle
2	1. Turn the ignition OFF. 2. Raise the vehicle drive wheels. Refer to Lifting and Jacking the Vehicle. 3. Start the engine. 4. Place the transmission into drive for an automatic transmission or third gear for manual transmission.  Does the vehicle speedometer indicate a vehicle speed?	—	Go to Diagnostic Aids	Go to Step 3
3	1. Turn the ignition OFF. 2. Disconnect the powertrain control module (PCM) connector C2. 3. Turn the ignition ON, with the engine OFF. 4. Measure the voltage from the vehicle speed signal circuit of the PCM to a good ground.  Does the voltage measure greater than the specified value?	9.5 V	Go to Step 4	Go to Step 6
4	Test the vehicle speed signal circuit for a short to voltage. Refer to Circuit Testing and Wiring Repairs.  Did you find and correct the condition?	—	Go to Step 8	Go to Step 5
5	Inspect for poor connections at the harness connector of the PCM. Refer to Testing for Intermittent Conditions and Poor Connections and Connector Repairs.  Did you find and correct the condition?	—	Go to Step 8	Go to Step 7
6	Repair the short to ground in the vehicle speed signal circuit. Refer to Wiring Repairs.  Did you complete the repair?	—	Go to Step 8	—

<b>DTC P0608</b>				
<b>Step</b>	<b>Action</b>	<b>Value(s)</b>	<b>Yes</b>	<b>No</b>
7	Replace the PCM. Refer to Control Module References for replacement, setup, and programming.  Did you complete the replacement?	—	Go to Step 8	—
8	1. Use the scan tool in order to clear the DTCs. 2. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text.  Does the DTC reset?	—	Go to Step 2	System OK

## DTC P0609

### *Circuit Description*

The powertrain control module (PCM) converts the data from the vehicle speed sensor to a 128k pulses/mile signal. The electronic brake control module (EBCM) uses the vehicle speed signal from the PCM in order to calculate the rear wheel speed.

### *DTC Descriptors*

This diagnostic procedure supports the following DTC:

- DTC P0609 Vehicle Speed Output Circuit 2

### *Conditions for Running the DTC*

- The ignition is ON.
- The vehicle is not moving.

### *Conditions for Setting the DTC*

The PCM detects low voltage on the vehicle speed signal circuit for 45 seconds.

### *Action Taken When the DTC Sets*

If equipped, the following actions occur:

- The EBCM disables the ABS/TCS/DRP.
- The ABS indicator turns ON.
- The TRACTION OFF indicator turns ON.
- The red brake warning indicator turns ON.

### *Conditions for Clearing the DTC*

- Repair the condition responsible for setting the DTC.
- Use a scan tool in order to clear the DTC.
- After the DTC is cleared and the ignition is ON, the ABS indicator may remain ON until the EBCM completes a power-up self-test. This test concludes when the vehicle reaches a speed greater than 13 km/h (8 mph) and the wheel speeds are verified by the EBCM.

### *Diagnostic Aids*

Thoroughly inspect connections or circuitry that may cause an intermittent malfunction. Refer to the following:

- Testing for Electrical Intermittents
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs
- Connector Repairs

### *Test Description*

The numbers below refer to the step numbers on the diagnostic table.

3. This step tests for a voltage signal from the PCM.
4. This step tests for a missing or erratic vehicle speed signal from the PCM. An assistant may be required to perform this test.

<b>DTC P0609</b>				
<b>Step</b>	<b>Action</b>	<b>Values</b>	<b>Yes</b>	<b>No</b>
Schematic Reference: Antilock Brake System Schematics Connector End View Reference: Master Electrical Component List				
1	Did you perform the Diagnostic System Check – Vehicle	—	Go to Step 2	Go to Diagnostic System Check - Vehicle
2	1. Use a scan tool in order to clear the DTCs. 2. Operate the vehicle at a speed greater than the specified value.  Does the DTC set?	19 km/h (12 mph)	Go to Step 3	Go to Diagnostic Aids
3	1. Turn OFF the ignition. 2. Disconnect from the electronic brake control module (EBCM), the harness connector containing the vehicle speed signal circuit. 3. Turn ON the ignition. 4. Use a DMM in order to measure the DC voltage between the vehicle speed signal circuit and a good ground.  Does the voltage measure greater than the specified value?	10 V	Go to Step 4	Go to Step 7
4	1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle. 2. Place the transmission in neutral (N). 3. Set up the DMM in order to measure the DC voltage between the vehicle speed signal circuit and a good ground. 4. Spin the rear wheels as fast as possible by hand for at least 30 seconds and while ensuring the driveshaft is rotating, observe the DMM.  Does the voltage measure within the specified range the entire time the driveshaft is rotating?	5-7 V	Go to Step 5	Go to Step 7
5	Inspect for poor connections at the harness connector of the EBCM. Refer to Testing for Intermittent Conditions and Poor Connections and Connector Repairs.  Did you find and correct the condition?	—	Go to Step 10	Go to Step 6



<b>DTC P0609</b>				
<b>Step</b>	<b>Action</b>	<b>Values</b>	<b>Yes</b>	<b>No</b>
6	Replace the EBCM. Refer to Control Module References for replacement, setup, and programming.  Did you complete the replacement?	—	Go to Step 10	—
7	Test the vehicle speed signal circuit for an open, a short to ground or a short to voltage. Refer to Circuit Testing and Wiring Repairs.  Did you find and correct the condition?	—	Go to Step 10	Go to Step 8
8	Inspect for poor connections at the harness connector of the powertrain control module (PCM). Refer to Testing for Intermittent Conditions and Poor Connections and Connector Repairs.  Did you find and correct the condition?	—	Go to Step 10	Go to Step 9
9	Replace the PCM. Refer to Control Module References for replacement, setup, and programming.  Did you complete the replacement?	—	Go to Step 10	—
10	1. Use the scan tool in order to clear the DTCs. 2. Operate the vehicle within the Conditions for Running the DTC as specified in the supporting text.  Does the DTC reset?	—	Go to Step 3	System OK